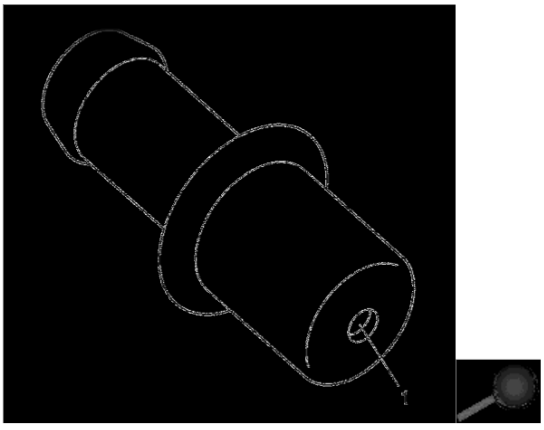
Crankcase Ventilation System Description



A crankcase ventilation system is used to consume crankcase vapors created during the combustion process instead of venting them to the atmosphere.

Fresh air is supplied through a filter to the crankcase, the crankcase mixes the fresh air with the blow-by gases and then passed through a positive crankcase ventilation (PCV) orificed tube into the intake manifold.

The PCV orificed tube restricts the flow rate of the blow-by gases using an orifice (1) located at the end of the tube. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the throttle body in order to be consumed by normal combustion.

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Component Description (LFX)

The High Feature V6 (VIN Code Identifier "3" for both cars and trucks) RPO LFX is a 3.6 Liter VVT (Variable Valve Timing) engine with direct injection. The LFX has E85-compatible valves and seats with special materials and coatings that require slightly different service procedures from gasoline valves. The direct injection system places the high pressure injectors in the cylinder heads. This engine incorporates 2 intake and 2 exhaust valves per cylinder, and uses a dual overhead cam design with individual intake and exhaust camshafts. A camshaft position actuator is mounted on each camshaft. The cylinders are arranged in 2 banks of 3 with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

Crankcase

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each main bearing cap incorporates 6 bolts bolting the cap into the engine block. Along with 2 outer and 2 inner bolts, 2 side bolts are used in the deep skirt block. To prevent aeration, oil return from the valvetrain and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. A knock sensor is located on the each side of the exterior of the engine block. The crankshaft position sensor is located on the right side of the exterior of the engine block.

Crankshaft

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. The crankshaft is internally balanced, and has an integral oil pump drive machined into the nose in front of the front main journal.

Connecting Rods and Pistons

The connecting rods are steel and have full floating piston pins. The piston pins are a slip fit in the bronze bushed connecting rod. Round wire retainers are used to retain the piston pin into the piston. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The piston uses two low tension compression rings and one multi-piece oil control ring. The top of the piston contains a shaped portion for the direct injection system to aid in fuel-air charge mixture and even combustion.

Camshaft Drive System

The camshaft drive system consists of one primary timing drive chain driven by the crankshaft sprocket. The primary timing drive chain drives two intermediate drive shaft sprockets. Each oil-pressure-fed intermediate drive shaft sprocket drives separate secondary timing drive chains. Each secondary timing drive chain drives the respective cylinder head's intake and exhaust camshaft position actuators.

The primary timing drive chain uses two stationary timing drive chain guides and a hydraulically-actuated tensioner with built-in shoe. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. The tensioner is equipped with an oiling jet to spray oil onto the timing components during engine operation. The secondary timing drive chains use a stationary timing drive chain guide and movable timing drive chain shoe. The secondary timing drive chain shoe is under tension from a hydraulically-actuated tensioner. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

© 2014 General Motors. All rights reserved.

cardiagn.com

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes valve timing as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and driveability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains this position during start-up conditions. Under other engine operating conditions, the camshaft position actuator is controlled by the engine control module (ECM) to deliver optimal intake and exhaust valve timing for performance, driveability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover, to accurately determine the position of each camshaft. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

The camshaft front journal has several drilled oil holes to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. The center camshaft bolt hole is counterbored to allow oil to flow around the camshaft bolt and to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position.

Radially outward from the center of the journal is a set of 4 drilled camshaft position actuator oil holes. Oil in this group of oil holes is used to move the camshaft from the default position to a specific set position as determined by the ECM. Seal rings are used at the front and rear of the front camshaft journal to prevent oil leakage from the camshaft position actuator hydraulic system. The seal is made from a plastic compound that resists wear and has a diagonal end gap to enhance sealing. The camshaft position actuator is mounted to the front end of the camshaft and the timing notch in the nose of the camshaft aligns with the dowel pin in the camshaft position actuator to ensure proper cam timing and camshaft position actuator oil hole alignment.

Cylinder Heads

The cylinder heads are cast aluminum with powdered metal valve seat inserts and valve guides. The cylinder heads also feature integrated exhaust manifolds; the exhaust manifolds are incorporated into the head casting. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). In the E85 fuel compatible LFX engine, the valves and seats are constructed with specialized materials and coatings to perform properly in the E85 fuel environment. The intake valves in the LFX engine are slightly larger than those in the LFW engine to allow the additional air necessary for a 3.6L displacement engine.

Separate exhaust and intake camshafts are supported by bearings machined into the cylinder head. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The engine coolant temperature (ECT) sensor is threaded into the cylinder head. With direct injection, the high pressure

cardiagn.com

injectors are located in machined bores below the intake ports. A stainless steel, high pressure fuel rail is attached to the intake side of the head.

Induction System

The intake manifold assembly is used to deliver a dry-air charge to the combustion chamber. Fuel is introduced directly to the cylinder during the intake stroke. As the piston approaches top-dead center, the air-fuel mixture is ignited by the spark plug. An electronically controlled throttle (ETC), through the ECM, coordinates the input from the driver with various control components.

Right and Left Bank Designation

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear, non-front-cover side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RH) and Bank 2 (LH).

cardiagn.com

Engine Component Description (LFW)

The RPO LFW, VIN Code Identifier "5" is a 3.0 Liter VVT (Variable Valve Timing) engine with direct injection. The LFW has E85-compatible valves and seats with special materials and coatings that require slightly different service procedures from gasoline valves. The direct injection system places the high pressure injectors in the cylinder heads. This engine incorporates 2 intake and 2 exhaust valves per cylinder, and uses a dual overhead cam design with individual intake and exhaust camshafts. A camshaft position actuator is mounted on each camshaft. The cylinders are arranged in 2 banks of 3 with a 60 degree included angle. The right bank of cylinders are number 1-3-5 and the left bank of cylinders are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

Crankcase

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each main bearing cap incorporates 6 bolts bolting the cap into the engine block. Along with 2 outer and 2 inner bolts, 2 side bolts are used in the deep skirt block. To prevent aeration, oil return from the valvetrain and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. A knock sensor is located on the each side of the exterior of the engine block. The crankshaft position sensor is located on the right side of the exterior of the engine block.

Crankshaft

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. The crankshaft is internally balanced, and has an integral oil pump drive machined into the nose in front of the front main journal.

Connecting Rods and Pistons

The connecting rods are steel and have full floating piston pins. The piston pins are a slip fit in the bronze bushed connecting rod. Round wire retainers are used to retain the piston pin into the piston. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The piston uses two low tension compression rings and one multi-piece oil control ring. The top of the piston contains a shaped portion for the direct injection system to aid in fuel-air charge mixture and even combustion.

Camshaft Drive System

The camshaft drive system consists of one primary timing drive chain driven by the crankshaft sprocket. The primary timing drive chain drives two intermediate drive shaft sprockets. Each oil-pressure-fed intermediate drive shaft sprocket drives separate secondary timing drive chains. Each secondary timing drive chain drives the respective cylinder head's intake and exhaust camshaft position actuators.

The primary timing drive chain uses two stationary timing drive chain guides and a hydraulically-actuated tensioner with built-in shoe. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. The tensioner is equipped with an oiling jet to spray oil onto the timing components during engine operation. The secondary timing drive chains use a stationary timing drive chain guide and movable timing drive chain shoe. The secondary timing drive chain shoe is under tension from a hydraulically-actuated tensioner. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

© 2014 General Motors. All rights reserved.

cardiagn.com

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes valve timing as engine operating conditions vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and driveability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains this position during start-up conditions. Under other engine operating conditions, the camshaft position actuator is controlled by the engine control module (ECM) to deliver optimal intake and exhaust valve timing for performance, driveability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover, to accurately determine the position of each camshaft. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

The camshaft front journal has several drilled oil holes to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. The center camshaft bolt hole is counterbored to allow oil to flow around the camshaft bolt and to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position.

Radially outward from the center of the journal is a set of 4 drilled camshaft position actuator oil holes. Oil in this group of oil holes is used to move the camshaft from the default position to a specific set position as determined by the ECM. Seal rings are used at the front and rear of the front camshaft journal to prevent oil leakage from the camshaft position actuator hydraulic system. The seal is made from a plastic compound that resists wear and has a diagonal end gap to enhance sealing. The camshaft position actuator is mounted to the front end of the camshaft and the timing notch in the nose of the camshaft aligns with the dowel pin in the camshaft position actuator to ensure proper cam timing and camshaft position actuator oil hole alignment.

Cylinder Heads

The cylinder heads are cast aluminum with powdered metal valve seat inserts and valve guides. The cylinder heads also feature integrated exhaust manifolds; the exhaust manifolds are incorporated into the head casting. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). In the E85 fuel compatible LFW engine, the valves and seats are constructed with specialized materials and coatings to perform properly in the E85 fuel environment.

Separate exhaust and intake camshafts are supported by bearings machined into the cylinder head. The front camshaft bearing cap is used as a thrust control surface for each camshaft. In addition to the thrust bearing surfaces on the front camshaft bearing caps, there is a plastic thrust washer installed between the camshaft position actuator and the forward face of the cylinder head/camshaft thrust cap to supplement camshaft thrust control. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The engine coolant temperature (ECT) sensor is

cardiagn.com

threaded into the cylinder head. With direct injection, the high pressure injectors are located in machined bores below the intake ports. A stainless steel, high pressure fuel rail is attached to the intake side of the head.

Induction System

The intake manifold assembly is used to deliver a dry-air charge to the combustion chamber. Fuel is introduced directly to the cylinder during the intake stroke. As the piston approaches top-dead center, the air-fuel mixture is ignited by the spark plug. An electronically controlled throttle (ETC), through the ECM, coordinates the input from the driver with various control components.

Right and Left Bank Designation

Right hand (RH) and left hand (LH) designation through the engine mechanical section are viewed from the rear, non-front-cover side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RH) and Bank 2 (LH).

cardiagn.com

Engine Component Description (LWR)

The High Feature V6 VIN Code 4 RPO LWR is a 3.6L engine incorporating two intake and two exhaust valves per cylinder. The LWR is designed for use with LPG fuels. Individual intake and exhaust camshafts (DOHC) with camshaft position actuators are mounted on each cylinder head. The cylinders are arranged in two banks of three with a 60 degree included angle. The right bank of cylinders, known also as Bank 1, are number 1-3-5 and the left bank of cylinders, Bank 2, are 2-4-6, viewed from the flywheel end of the engine. The engine firing order is 1-2-3-4-5-6.

Crankcase

The cylinder block is constructed of aluminum alloy by precision sand-casting with cast in place iron cylinder liners. Each steel main bearing cap incorporates six bolts bolting the cap into the engine block. Along with two outer and two inner bolts, two side bolts are used in the deep skirt block. To prevent aeration, oil return from the valvetrain and cylinder heads is channeled away from the rotating and reciprocating components through oil drain back passages incorporated into the cylinder heads and engine block. Pressure-actuated piston oil cooling jets are mounted between opposing cylinders. A knock sensor is located on each side of the exterior of the engine block. The crankshaft position sensor is located on the right side of the exterior of the engine block.

Crankshaft

The crankshaft is a hardened, forged steel design with 4 main bearings. Crankshaft thrust is controlled by the upper portion of number 3 main bearing. The crankshaft position reluctor wheel is pressed onto the rear of the crankshaft in front of the rear main journal. A micro encapsulated adhesive is used on the reluctor wheel to aid retention. The crankshaft is internally balanced, and has an integral oil pump drive machined into the nose in front of the front main journal.

Connecting Rods and Pistons

The connecting rods are steel and have full floating piston pins. The piston pins are a slip fit in the bronze bushed connecting rod. Round wire retainers are used to retain the piston pin into the piston. The cast aluminum pistons incorporate a polymer-coated skirt to reduce friction. The piston uses two low tension compression rings and one multi-piece oil control ring.

Camshaft Drive System

The camshaft drive system consists of one primary timing drive chain driven by the crankshaft sprocket. The primary timing drive chain drives two intermediate drive shaft sprockets. Each intermediate drive shaft sprocket drives separate secondary timing drive chains. Each secondary timing drive chain drives the respective cylinder head's intake and exhaust camshaft position actuators.

The primary timing drive chain uses two stationary timing drive chain guides and a hydraulically-actuated tensioner with built-in shoe. The tensioner minimizes timing drive chain noise and provides accurate valve action by keeping slack out of the timing drive chains and continuously adjusting for timing drive chain wear. The tensioner incorporates a plunger that adjusts out with wear allowing only a minimal amount of backlash. The tensioner is equipped with an oiling jet to spray oil onto the timing components during engine operation. The secondary timing drive chains use a stationary timing drive chain guide and movable timing drive chain shoe. The secondary timing drive chain shoe is under tension from a hydraulically-actuated tensioner. All tensioners are sealed to the head or block using a rubber coated steel gasket. The gasket traps an adequate oil reserve to ensure quiet start-up.

Camshaft Position Actuator System

The engine incorporates a camshaft position actuator for each intake and exhaust camshaft. Camshaft phasing changes the inlet and exhaust valve timing as engine operating conditions

© 2014 General Motors. All rights reserved.

cardiagn.com

vary. Dual camshaft phasing allows the further optimization of performance, fuel economy and emissions without compromising overall engine response and driveability. Variable valve timing also contributes to a reduction in exhaust emissions. It optimizes exhaust and inlet valve overlap and eliminates the need for an exhaust gas recirculation (EGR) system.

The camshaft position actuator is a hydraulic vane-type actuator that changes the camshaft lobe timing relative to the camshaft drive sprocket. Engine oil is directed by a camshaft position actuator oil control valve to the appropriate passages in the camshaft position actuator. Oil acting on the vane in the camshaft position actuator rotates the camshaft relative to the sprocket. At idle, both camshafts are at the default or "home" position. At this position, the exhaust camshaft is fully advanced and the intake is fully retarded to minimize valve overlap for smooth idle. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains this position during start-up conditions. Under other engine operating conditions, the camshaft position actuator is controlled by the Engine Control Module (ECM) to deliver optimal intake and exhaust valve timing for performance, driveability and fuel economy. The camshaft position actuator incorporates an integral trigger wheel, which is sensed by the camshaft position sensor mounted in the front cover to accurately determine the position of each camshaft. Each camshaft position actuator has a specific timing drive mark for right or left bank application, as the camshaft position actuators are common bank to bank. The exhaust camshaft position actuator has a different internal configuration than the intake camshaft position actuator since the exhaust camshaft position actuator phases in the opposite direction relative to the inlet camshaft position actuator.

The camshaft position actuator oil control valve (OCV) directs oil from the oil feed in the head to the appropriate camshaft position actuator oil passages. There is one OCV for each camshaft position actuator. The OCV is sealed and mounted to the front cover. The ported end of the OCV is inserted into the cylinder head with a sliding fit. A filter screen protects each OCV oil port from any contamination in the oil supply.

The camshaft front journal has several drilled oil holes to allow camshaft position actuator control oil to transfer from the cylinder head to the camshaft position actuator. The center camshaft bolt hole is counterbored to allow oil to flow around the camshaft bolt and to the camshaft position actuator. Oil in this oil passage is used to move the camshaft position actuator to the default or home position. Radially outward from the center of the journal is a set of four drilled camshaft position actuator oil holes. Oil in this group of oil holes is used to move the camshaft from the default position to a specific set position as determined by the ECM. Seal rings are used at the front and rear of the front camshaft journal to prevent oil leakage from the camshaft position actuator hydraulic system. The seal is made from a plastic compound that resists wear and has a diagonal end gap to enhance sealing. The camshaft position actuator is mounted to the front end of the camshaft and the timing notch in the nose of the camshaft aligns with the dowel pin in the camshaft position actuator to ensure proper cam timing and camshaft position actuator oil hole alignment.

cardiagn.com

Cylinder Heads

The cylinder heads are cast aluminum with powdered metal valve seat inserts and valve guides. Two intake valves and two exhaust valves are actuated by roller finger followers pivoting on a stationary hydraulic lash adjuster (SHLA). Separate exhaust and intake camshafts are supported by four bearings machined into the cylinder head. The front camshaft bearing cap is used as a thrust control surface for each camshaft. Each spark plug is shielded by a tube that is pressed into the cylinder head. Each spark plug ignition coil is also mounted through the spark plug tube. The engine coolant temperature (ECT) sensor is threaded into the cylinder head. The LWR engine has valves and seats made of specialized materials and coatings to perform properly with the LPG fuel.

Induction System

The intake manifold consists of two components. Two short bolts in the lower intake manifold and four long bolts, that pass through both manifolds, mount the intake manifold assembly to the cylinder heads. Additionally two bolts mount the upper intake manifold to the lower intake manifold. The throttle body, manifold absolute pressure (MAP) sensor, Evaporative Emissions (EVAP) solenoid and tubes, fuel rail support bracket, fuel injector wiring harness bracket and brake booster hose are mounted to the upper intake manifold. The fuel injector wiring harness, fuel rail assembly, and fuel injectors are mounted to the lower intake manifold. The

Positive Crankcase Ventilation (PCV) tubes clip to the fuel rail. There is no Variable Intake Manifold (VIM) valve in the LWR engine.

An electronically controlled throttle (ETC), through the ECM, coordinates the input from the driver with various control components.

cardiagn.com

New Product Information (LFX)

The purpose of New Product Information is to highlight or indicate important changes from the previous model year.

Changes may include one or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes on the engine utilize metric threads.
- Cylinder head, front cover, and crankshaft main bearing cap bolts now apply a two-step, torque and angle tightening strategy.
- Certain fasteners may not be used again. Bolts, studs, or other fasteners that must be replaced will be called out in the specific service procedure.
- There are high strength stainless steel fuel lines that require extreme care and proper order and torque when tightening the connections. Refer to specific service procedures for details.

Changed Engine Specifications

A few specifications have been revised for the new LFX engine. Refer to Engine Mechanical Specifications.

New Sealants and/or Adhesives

Sealers and adhesives, as required, are identified within the specific service procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers.

Disassembly and Assembly Procedure Revisions

The LFX engine is very similar to the LFW; an LFX may be generally thought of as a "big-bore" LFW. Changes between the LFW and LFX consist mostly of slightly different valve sizes and a longer-stroke fuel pump configuration to provide the additional fuel for the larger displacement. Of course service parts and assemblies between the LFW and LFX are unique and RPO-specific service procedures must be followed, but there is a strong overall similarity between the LFW and LFX.

Engine Mechanical Diagnostic Procedure Revisions

Diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow should always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to Diagnostic Starting Point - Vehicle.

New Special Tools Required

There are no special tools unique to the LFX engine.

A Component Comparison from the Previous Year

© 2014 General Motors. All rights reserved.

cardiagn.com

As noted above, the LFX engine is very similar to the LFW engine. It can in many respects be thought of as a "big-bore" LFW. However, there are differences. Refer to Engine Component Description.

cardiagn.com

Lubrication Description

A structural diecast aluminum oil pan incorporates an oil suction tube and a windage tray. The oil suction tube is bolted into the oil pan and seals to the bottom of the block with O-ring gasket. The windage tray is bolted to the upper portion of the oil pan and reduces friction losses at high speed.

A crankshaft driven gerotor oil pump with internal pressure-relief valve is mounted to the front of the engine block and pulls oil from the oil suction tube through the lower passage in the engine block. The oil pump then directs the flow of pressurized oil back through the upper passage in the block to the left side of the engine block where the oil filter adapter is mounted.

An oil filter adapter is mounted with a gasket to the left side of the engine block.

RWD Applications: The oil filter adapter incorporates a top-access, cartridge style oil filter. The filter is accessed through a screw on cap with an O-ring gasket. The oil filter adapter cap has a built-in oil bypass valve. The oil filter adapter housing incorporates a drain back control valve and a threaded oil pressure sending unit. Oil flows through the lower passage in the oil filter adapter up to and through the oil filter cartridge. Filtered oil travels back through the upper passage of the oil filter adapter and back into the engine block.

FWD Applications: An oil filter adapter is mounted with a gasket to the left side of the engine block. The oil filter adapter incorporates a bottom-access, spin-on oil filter. The oil filter adapter housing incorporates a threaded oil pressure sending unit. Oil flows through the lower passage in the oil filter adapter to and through the oil filter. Filtered oil travels back through the upper passage of the oil filter adapter and back into the engine block.

Oil is directed up and across the engine block front through several drilled passages. These front passages feed oil to each cylinder head, oil to the passage for the main bearings and piston oil jets, oil to the right and left secondary idler sprockets, and oil to the primary timing drive chain tensioner.

Each cylinder head passage directs oil into the cylinder head where it is directed to oiling circuits for the stationary hydraulic lifter assemblies (SHLAs) and the camshaft bearing journals. Oil is also directed through 2 passages each with a spring-loaded check-ball valve to the 2 chambers where the camshaft position actuator oil control solenoid valves are mounted. Each chamber contains a camshaft position actuator oil control solenoid valve with built-in oil filter screen. One camshaft position actuator oil control solenoid valve is used to control the exhaust camshaft position actuator and 1 camshaft position actuator oil control solenoid valve is used to control the intake camshaft position actuator. The engine control module (ECM) electrically controls each camshaft position actuator oil control solenoid valve. When energized by the ECM the camshaft position actuator oil control solenoid valve directs oil to pass up through the cylinder head front camshaft bearing cap. Oil passes through the camshaft bearing cap passage into oil holes drilled into the side of the front camshaft journal and onto the front of the camshaft mounting surface. Oil passes through to matching passages in the camshaft position actuator. Oil is directed by the camshaft position actuator oil control solenoid valve to the appropriate passage in the system to pressurize oil on the vanes on the inside of the of the camshaft position actuator. Oil acting on the vanes rotates the camshaft mounted to the inner camshaft position actuator rotor relative to the sprocket mounted to the outer camshaft position actuator housing. An internal lock pin locks the inner rotor to the outer camshaft position actuator housing at idle and maintains the camshaft position actuator in the home or default position during start-up conditions. Oil pressure directed by the camshaft position actuator oil control solenoid valve unlocks the pin and allows the camshaft position actuator to function. An additional passage in the cylinder head also directs oil to the secondary timing drive chain tensioner mounted to each cylinder head.

The oil passage that supplies oil to the main bearings also supplies oil to pressure-actuated piston-cooling oil jets. Each oil jet is mounted between opposing cylinder bores and directs oil to the 2 bores to provide extra cooling and control piston temperatures.

Oil is directed from the front passages to the front of the block where the right and left secondary idler sprockets and the primary timing drive chain tensioner are mounted. Each camshaft timing drive chain tensioner relies on a gasket in order to maintain an oil reserve after the engine is turned

© 2014 General Motors. All rights reserved.

cardiagn.com

OFF. All camshaft timing drive chain tensioners incorporate a small oil jet to supply an oil spray onto the camshaft timing drive chain components.

Oil returns to the oil pan sump either through the camshaft timing drive chain area or through the cast oil drain back passages on the outboard walls of the cylinder heads and engine block.

cardiagn.com

Cleanliness and Care

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice correct cleaning and protection procedures to the machined surfaces and to the friction areas.

Caution: Engine damage may result if an abrasive paper, pad, or motorized wire brush is used to clean any engine gasket surfaces.

Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

Warning: Refer to Battery Disconnect Warning.

Disconnect the negative battery cables before you perform any major work on the engine. For more information on the disconnection of the battery, refer to Engine Electrical.

cardiagn.com

© 2014 General Motors. All rights reserved.

Separating Parts

In addition to the room temperature vulcanizing (RTV) sealant's sealing capabilities, the RTV sealants may form an adhesive bond between the components. This may make the components difficult to remove or to separate. Pry points have been provided in the components that utilize RTV as the sealing system. Pry points are positioned so they can be used without damaging other vital engine components.

cardiagn.com

© 2014 General Motors. All rights reserved.

Replacing Engine Gaskets

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use incorporated pry points to separate components using an RTV sealing system.
- Do not try to separate RTV sealed components by prying against other engine components.
- Pry points are positioned so no other vital engine components are damaged when they are used.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.
  Do not use any other method or technique to remove the sealant or the gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.
    This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant, or equivalent, that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

  Important: Do not overtighten the fasteners.
- Tighten the fasteners to the proper specifications.

cardiagn.com

© 2014 General Motors. All rights reserved.

Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

Sealant Types

Note: The correct sealant and amount of sealant must be used in the correct location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Anaerobic sealant room temperature vulcanizing (RTV)
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

Anaerobic Type Room Temperature Vulcanizing (RTV) Sealant

Anaerobic type room temperature vulcanizing (RTV) sealant cures in the absence of air. This type of sealant is used where 2 components, such as the intake manifold and the cylinder block, are assembled together.

Use the following information when using RTV sealant:

- DO NOT use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

  Caution: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.
- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

  Note: DO NOT wait for the RTV sealant to skin over.
- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes.

  Note: DO NOT overtighten the fasteners.
- Tighten the fasteners in sequence, if specified, and to the correct torque specifications.

Anaerobic Type Gasket Eliminator Sealant

© 2014 General Motors. All rights reserved.

cardiagn.com

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid parts, such as castings, are assembled together. When 2 rigid parts are disassembled and no sealant or gasket is readily noticeable, then the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
  The surfaces to be sealed must be clean and dry.

Caution: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.

Note:

- Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.
- DO NOT overtighten the fasteners.
  - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
  - Tighten the fasteners in sequence, if specified, and to the correct torque specifications.
  - After correctly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

  Note:
  - Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than 5 minutes, may result in incorrect clamp load of assembled components.
  - DO NOT overtighten the fasteners.
- Tighten the fasteners in sequence, if specified, and to the correct torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

cardiagn.com

- DO NOT use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

  Caution: Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.
- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

  Note: DO NOT overtighten the fasteners.
- Tighten the fasteners in sequence, if specified, and to the correct torque specifications.

cardiagn.com

Tools and Equipment

- Special tools are listed and illustrated throughout this section with a complete listing at the end of the section. These tools (or their equivalents) are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools will also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the correct tightening of various fasteners.
- To correctly service the engine assembly, the following items should be readily available:
  - Approved eye protection and safety gloves
  - A clean, well-lit, work area
  - A suitable parts cleaning tank
  - A compressed air supply
  - Trays or storage containers to keep parts and fasteners organized
  - An adequate set of hand tools
  - Approved engine repair stand
  - An approved engine lifting device that will adequately support the weight of the components

cardiagn.com

© 2014 General Motors. All rights reserved.

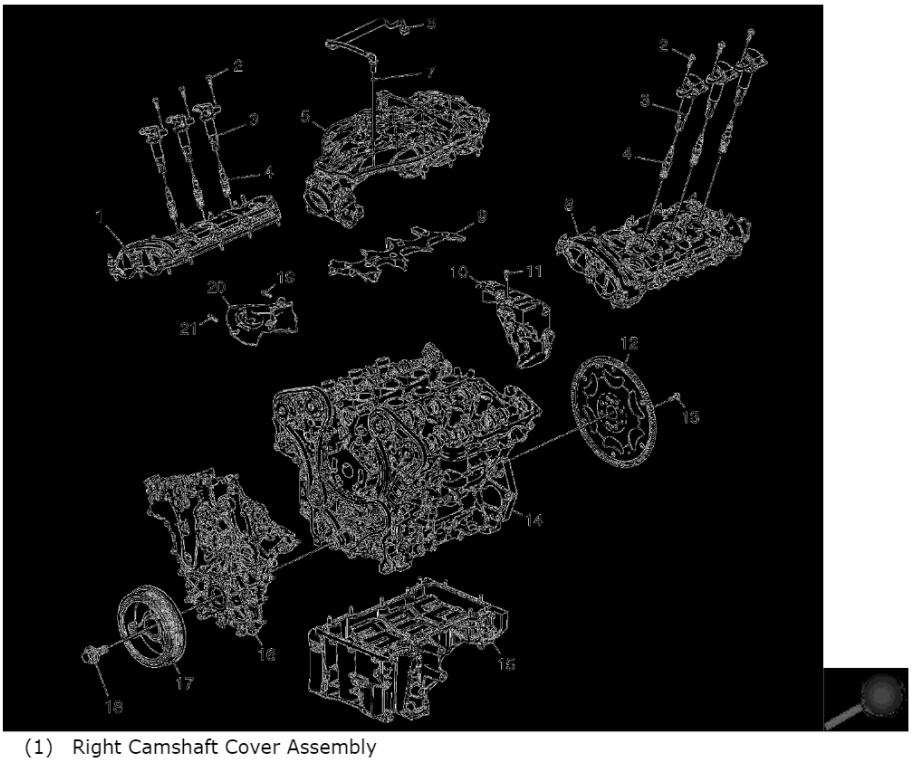
Disassembled Views

Figure 1: Engine Covers and Component Assemblies (1 of 2) (LF1, LFW or LFX)
Figure 2: Engine Covers and Component Assemblies (2 of 2) (LF1, LFW or LFX)
Figure 3: Camshaft Cover Assembly
Figure 4: Camshaft Timing Components
Figure 5: Intake Manifold (LF1, LFW or LFX)
Figure 6: Fuel Rail (LF1, LFW or LFX)
Figure 7: Cylinder Head Assemblies
Figure 8: Engine Front Cover
Figure 9: Oil Pump
Figure 10: Engine Block Assembly
Figure 11: Piston, Rings, Bearing and Connecting Rod
Figure 12: Oil Pan Assembly
Figure 13: Oil filter Adapter

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Covers and Component Assemblies (1 of 2) (LF1, LFW or LFX)



(1) Right Camshaft Cover Assembly
(2) Ignition Coil Bolt
(3) Ignition Coil
(4) Spark Plug
(5) Intake Manifold Assembly
(6) Positive Crankcase Ventilation (PCV) Tube
(7) PCV Tube O-ring Seal
(8) Left Camshaft Cover Assembly
(9) Fuel Rail Noise Shield
(10) Fuel Pump Cover
(11) Fuel Pump Cover Bolt
(12) Engine Flywheel
(13) Engine Flywheel Bolt
(14) Engine Assembly
(15) Oil Pan Assembly
(16) Engine Front Cover Assembly
(17) Crankshaft Balancer
(18) Crankshaft Balancer Bolt

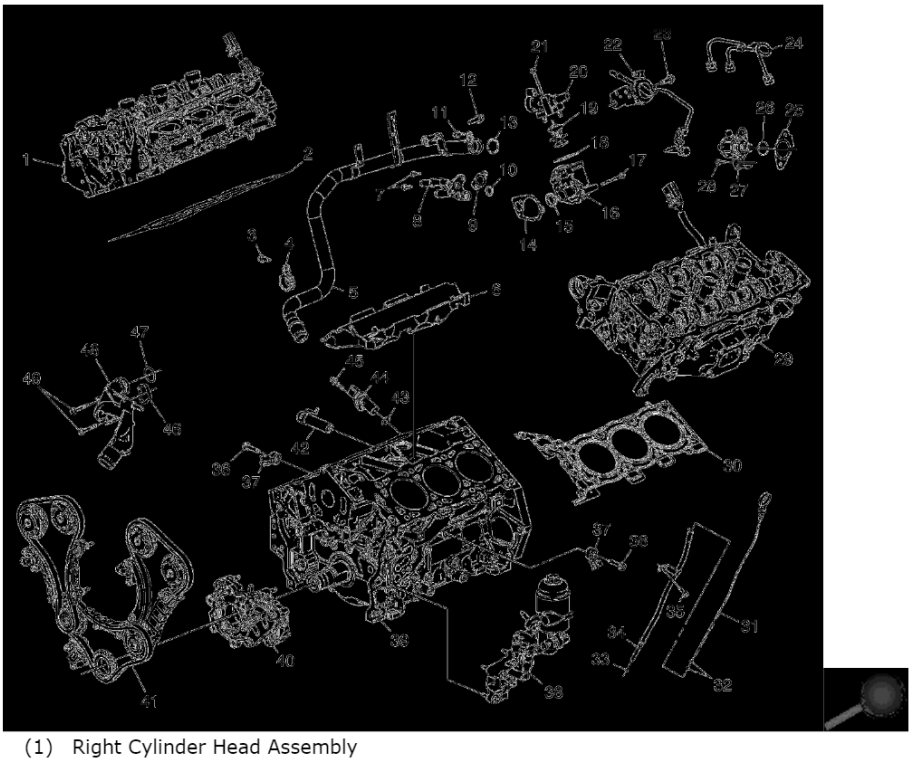
© 2014 General Motors. All rights reserved.

cardiagn.com

(19) Crankshaft Position Sensor Heat Shield Bolt– Large
(20) Crankshaft Position Sensor Heat Shield
(21) Crankshaft Position Sensor Heat Shield Bolt– Small

cardiagn.com

Engine Covers and Component Assemblies (2 of 2)



(1) Right Cylinder Head Assembly
(2) Right Cylinder Head Gasket
(3) Coolant Pipe Bracket Bolt – Small
(4) Coolant Pipe Clamp
(5) Coolant Pipe
(6) Lower Fuel Rail Noise Shield
(7) Water Inlet/Outlet Pipe Bolts
(8) Water Inlet/Outlet Pipe
(9) Water Inlet/Outlet Pipe Gaskets
(10) Water Inlet/Outlet Pipe O-ring
(11) Coolant Pipe Bracket Bolt – Small
(12) Coolant Pipe Bracket Bolt – Large
(13) Coolant Pipe O-ring
(14) Engine Cooling Thermostat Gasket
(15) Engine Cooling Thermostat Lower Housing Seal
(16) Engine Cooling Thermostat Lower Housing
(17) Engine Cooling Thermostat Lower Housing Bolt
(18) Engine Cooling Thermostat Seal

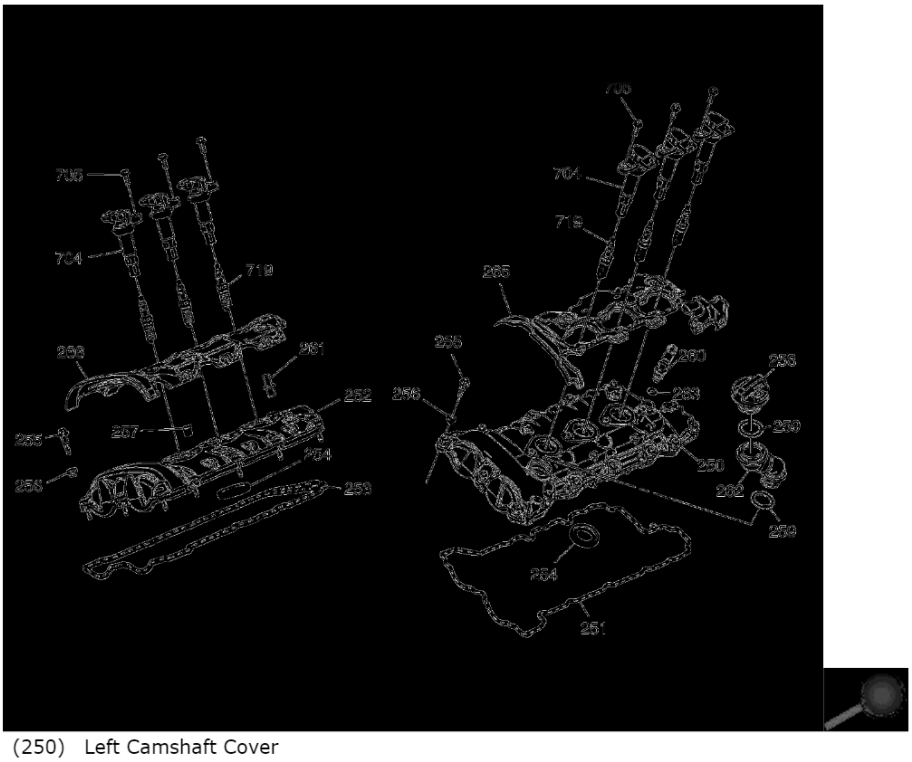
© 2014 General Motors. All rights reserved.

cardiagn.com

(19) Engine Cooling Thermostat
(20) Engine Cooling Thermostat Housing
(21) Engine Cooling Thermostat Housing Bolt
(22) Fuel Feed Pipe Assembly
(23) Fuel Feed Pipe Assembly Bolt
(24) Fuel Feed Intermediate Pipe Assembly
(25) Fuel Pump Gasket
(26) Fuel Pump O-ring Seal
(27) Fuel Pump
(28) Fuel Pump Bolt
(29) Left Cylinder Head Assembly
(30) Left Cylinder Head Gasket
(31) Oil Level Indicator
(32) Oil Level Indicator Handle O-ring
(33) Oil Level Indicator Tube O-ring
(34) Oil Level Indicator Tube
(35) Oil Level Indicator Tube Bolt
(36) Knock Sensor Bolt
(37) Knock Sensor
(38) Oil Filter Adapter Assembly
(39) Engine Short Block Assembly
(40) Oil Pump Assembly
(41) Timing Drive Assembly
(42) Engine Coolant Heater Assembly
(43) Crankshaft Position Sensor O-ring
(44) Crankshaft Position Sensor
(45) Crankshaft Position Sensor Bolt
(46) Water Outlet Seal
(47) Water Outlet O-ring
(48) Water Outlet
(49) Water Outlet Bolt

cardiagn.com

Camshaft Cover Assembly



(250) Left Camshaft Cover
(251) Left Camshaft Cover Gasket
(252) Right Camshaft Cover
(253) Right Camshaft Cover Gasket
(254) Camshaft Cover Spark Plug Port Seal
(255) Camshaft Cover Bolt
(256) Camshaft Cover Bolt Insulator
(257) Ignition Coil Bolt Thread Insert
(258) Oil Fill Cap
(259) Oil Fill O-ring
(260) Left Camshaft Cover PCV Fitting
(261) Right Camshaft Cover PCV Fitting Orifice
(262) Oil Fill Tube
(263) Left Camshaft Cover PCV Fitting O-ring
(265) Left Camshaft Housing Cover Insulator
(266) Right Camshaft Housing Cover Insulator
(704) Ignition Coil
(705) Ignition Coil Bolt

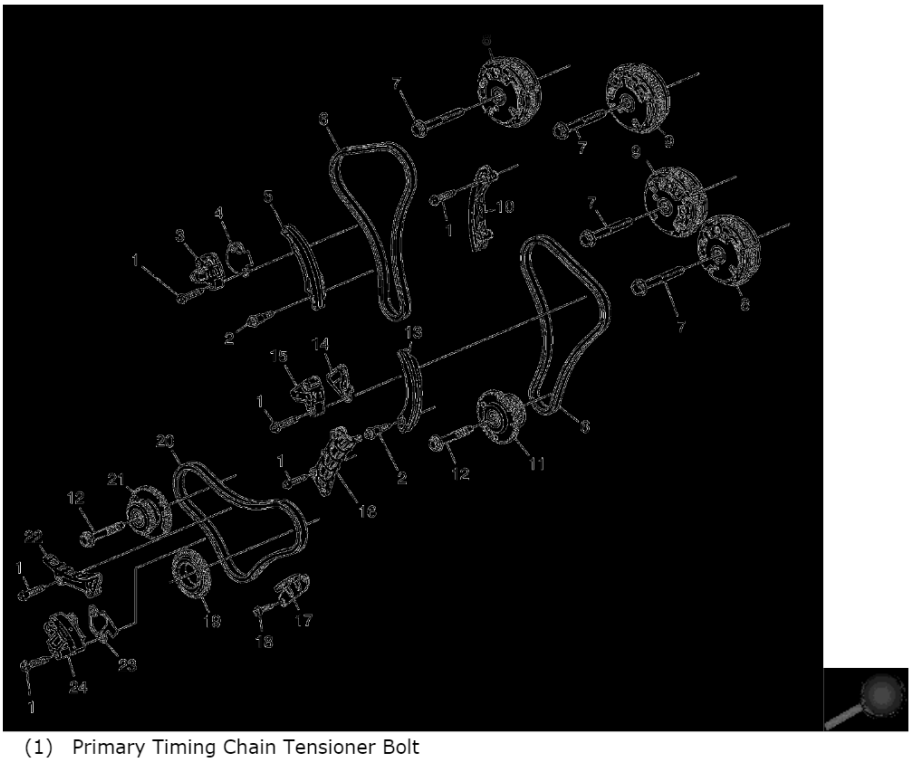
© 2014 General Motors. All rights reserved.

cardiagn.com

(719) Spark Plug

cardiagn.com

Camshaft Timing Components



(1) Primary Timing Chain Tensioner Bolt
(2) Left Secondary Timing Chain Shoe Bolt
(3) Right Secondary Timing Chain Tensioner
(4) Right Secondary Timing Chain Tensioner Gasket
(5) Right Secondary Timing Chain Guide
(6) Secondary Timing Chain
(7) Camshaft Position Actuator Bolt
(8) Exhaust Camshaft Position Actuator
(9) Intake Camshaft Position Actuator
(10) Right Secondary Timing Chain Guide
(11) Left Camshaft Timing Chain Idler Sprocket
(12) Camshaft Intermediate Drive Shaft Sprocket Bolt
(13) Left Secondary Timing Chain Guide
(14) Left Secondary Timing Chain Tensioner Gasket
(15) Left Secondary Timing Chain Tensioner
(16) Left Secondary Timing Chain Guide
(17) Lower Primary Timing Chain Guide
(18) Lower Primary Timing Chain Guide Bolt

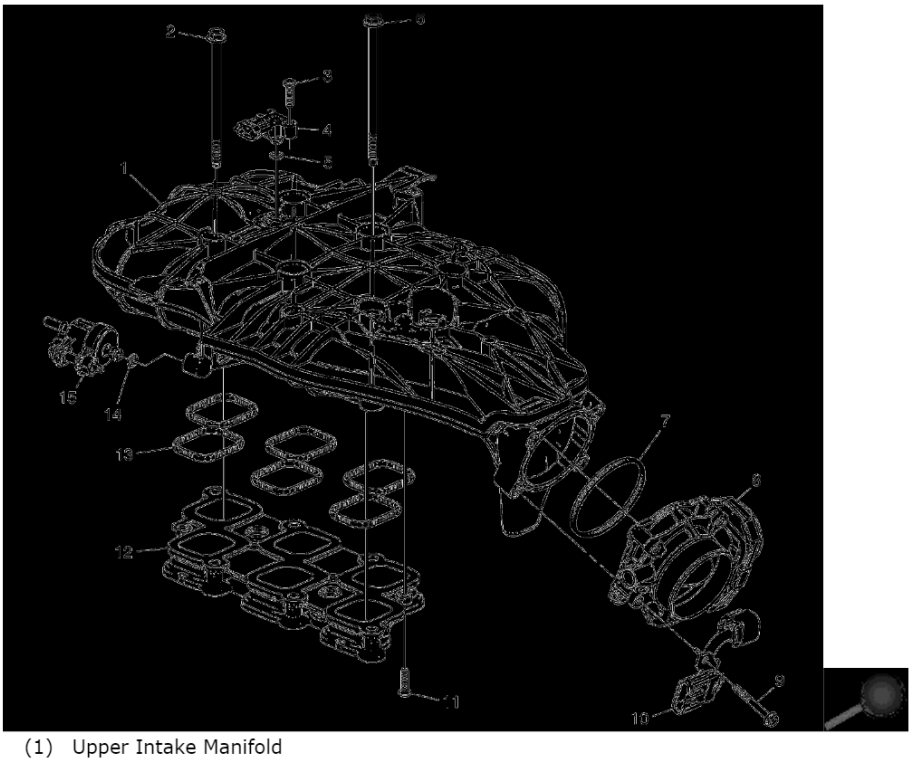
© 2014 General Motors. All rights reserved.

cardiagn.com

(19) Crankshaft Sprocket
(20) Primary Timing Chain
(21) Right Camshaft Timing Chain Idler Sprocket
(22) Upper Primary Timing Chain Guide
(23) Primary Timing Chain Tensioner Gasket
(24) Primary Timing Chain Tensioner

cardiagn.com

Intake Manifold (LF1, LFW or LFX)

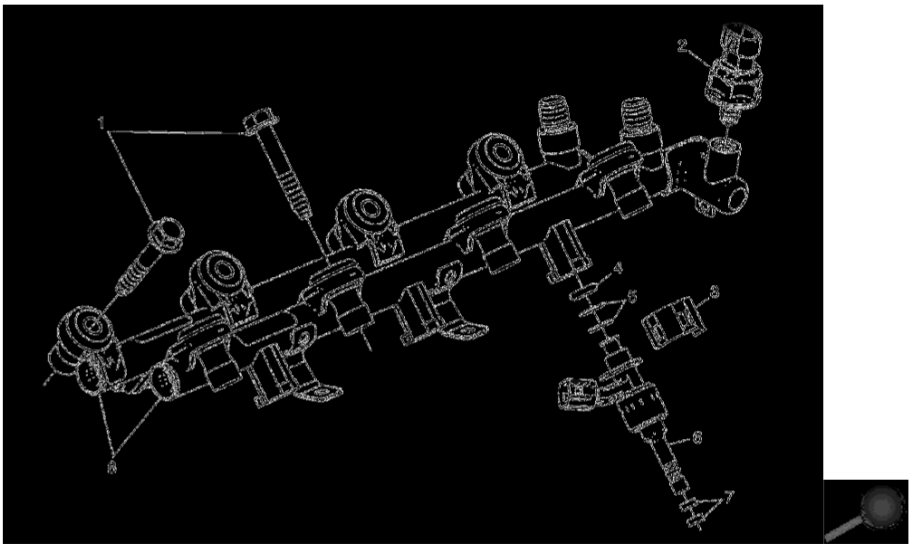


(1) Upper Intake Manifold
(2) Upper Intake Manifold Bolt – Short
(3) MAP Sensor Bolt
(4) MAP Sensor
(5) MAP Sensor O-ring Seal
(6) Upper Intake Manifold Bolt – Long
(7) Throttle Body Gasket
(8) Throttle Body
(9) Throttle Body Bolt
(10) Throttle Body Jumper Harness
(11) Lower Intake Manifold Bolt
(12) Lower Intake Manifold
(13) Upper Intake Manifold Gasket
(14) EVAP Solenoid O-ring Seal
(15) EVAP Solenoid

cardiagn.com

© 2014 General Motors. All rights reserved.

Fuel Rail

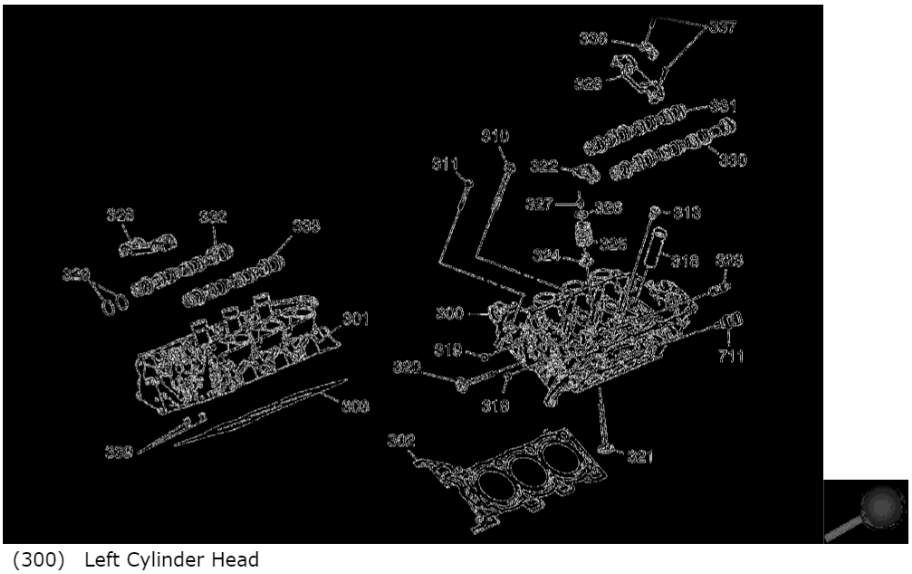


(1) Fuel Rail Bolt
(2) Fuel Pressure Sensor
(3) Fuel Injector Retainer
(4) Fuel Injector O-ring Seal
(5) Fuel Injector Spacer
(6) Fuel Injector
(7) Fuel Injector Teflon Seal
(8) Fuel Rail

cardiagn.com

© 2014 General Motors. All rights reserved.

Cylinder Head Assemblies



(300) Left Cylinder Head
(301) Right Cylinder Head
(302) Left Cylinder Head Gasket
(303) Right Cylinder Head Gasket
(310) Cylinder Head Bolt
(311) Cylinder Head Front Bolt
(313) Cylinder Head Water Jacket Hole Threaded Plug
(318) Spark Plug Wire Sleeve
(319) Cylinder Head Oil Gallery Expansion Plug – 14 mm
(320) Exhaust Valve
(321) Intake Valve
(322) Valve Rocker Arm
(323) Hydraulic Valve Lash Adjuster
(324) Valve Stem Oil Seal
(325) Valve Spring
(326) Valve Spring Cap
(327) Valve Stem Key
(328) Cylinder Head Camshaft Front Thrust Bearing Cap
(328) Cylinder Head Camshaft Front Thrust Bearing Cap
(329) Camshaft Oil Seal Ring
(330) Left Exhaust Camshaft
(331) Left Intake Camshaft
(332) Right Intake Camshaft
(333) Right Exhaust Camshaft

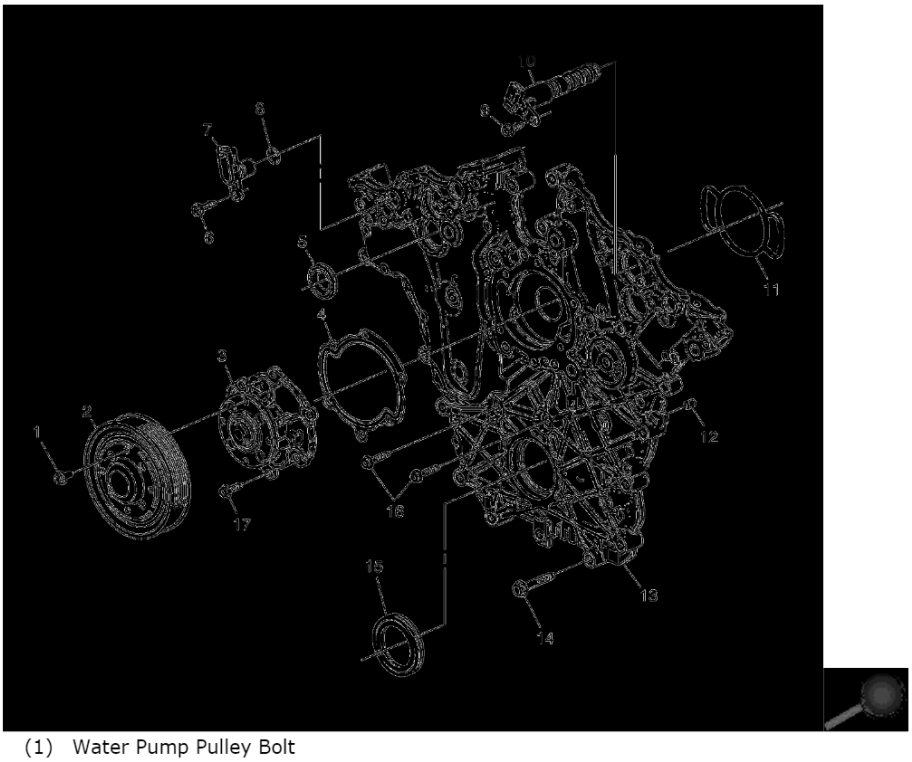
© 2014 General Motors. All rights reserved.

cardiagn.com

(336) Cylinder Head Camshaft Cap – Intermediate
(337) Cylinder Head Camshaft Cap Bolt
(339) Cylinder Head Oil Gallery Check Valve
(711) Engine Coolant Temperature Sensor

cardiagn.com

Engine Front Cover

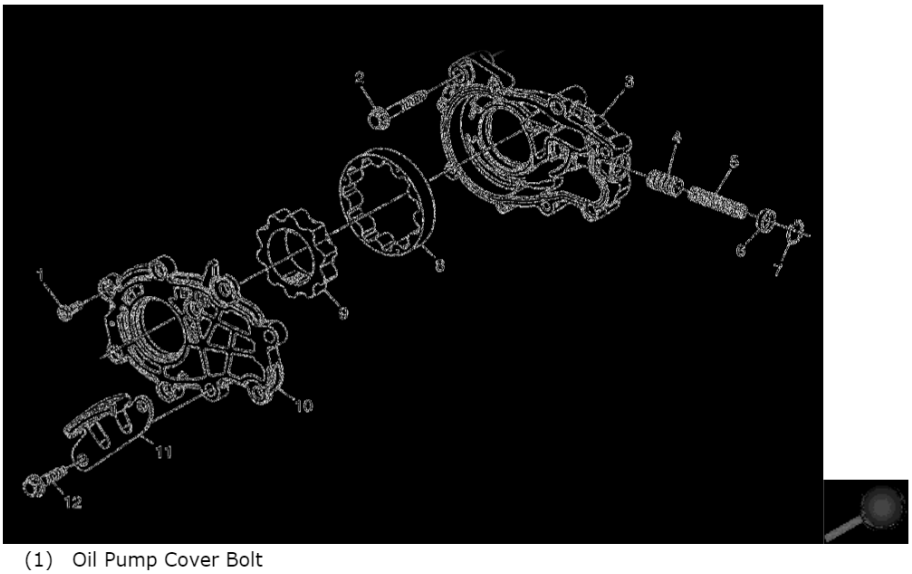


(1) Water Pump Pulley Bolt
(2) Water Pump Pulley
(3) Water Pump Assembly
(4) Water Pump Pulley Gasket
(5) Camshaft Position Actuator Solenoid Valve Seal
(6) Camshaft Position Sensor Bolt
(7) Camshaft Position Sensor
(8) Camshaft Position Sensor O-ring Seal
(9) Camshaft Position Actuator Solenoid Valve Bolt
(10) Camshaft Position Actuator Solenoid Valve
(11) Engine Front Cover Gasket
(12) Engine Front Cover Locating Pin
(13) Engine Front Cover
(14) Engine Front Cover Bolt
(15) Engine Front Cover Seal
(16) Engine Front Cover Bolt
(17) Water Pump Bolt

© 2014 General Motors. All rights reserved.

cardiagn.com

Oil Pump

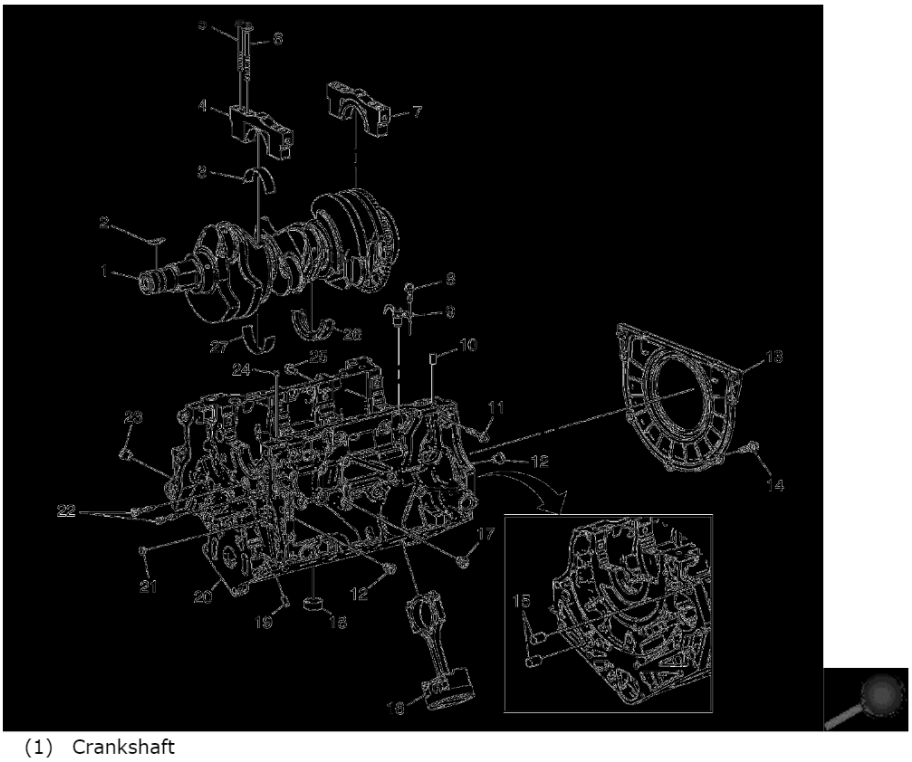


(1) Oil Pump Cover Bolt
(2) Oil Pump Bolt
(3) Oil Pump Housing
(4) Oil Pressure Relief Valve
(5) Oil Pressure Relief Valve Spring
(6) Oil Pressure Relief Valve Bore Plug
(7) Oil Pressure Relief Valve Bore Plug Retainer Clip
(8) Oil Pump Driven Gear
(9) Oil Pump Drive Gear
(10) Oil Pump Cover
(11) Lower Primary Timing Chain Guide
(12) Lower Primary Timing Chain Guide Bolt

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Block Assembly



(1) Crankshaft
(2) Crankshaft Key
(3) Crankshaft Lower Bearing
(4) Crankshaft Bearing Cap
(5) Crankshaft Bearing Cap Outboard Bolt
(6) Crankshaft Bearing Cap Inboard Bolt
(7) Crankshaft Bearing Thrust Cap
(8) Piston Oil Nozzle Bolt
(9) Piston Oil Nozzle
(10) Oil Pan Locating Pin
(11) Crankshaft Bearing Cap Side Bolt - Long
(12) Engine Block Oil Gallery Threaded Plug - 14 mm
(13) Crankshaft Rear Oil Seal Housing Assembly
(14) Crankshaft Rear Oil Seal Housing Assembly Bolt
(15) Transaxle Locating Pin
(16) Piston and Connecting Rod Assembly
(17) Engine Block Coolant Drain Threaded Plug - 14 mm
(18) Engine Block Core Coolant Expansion Plug - 34.3 mm

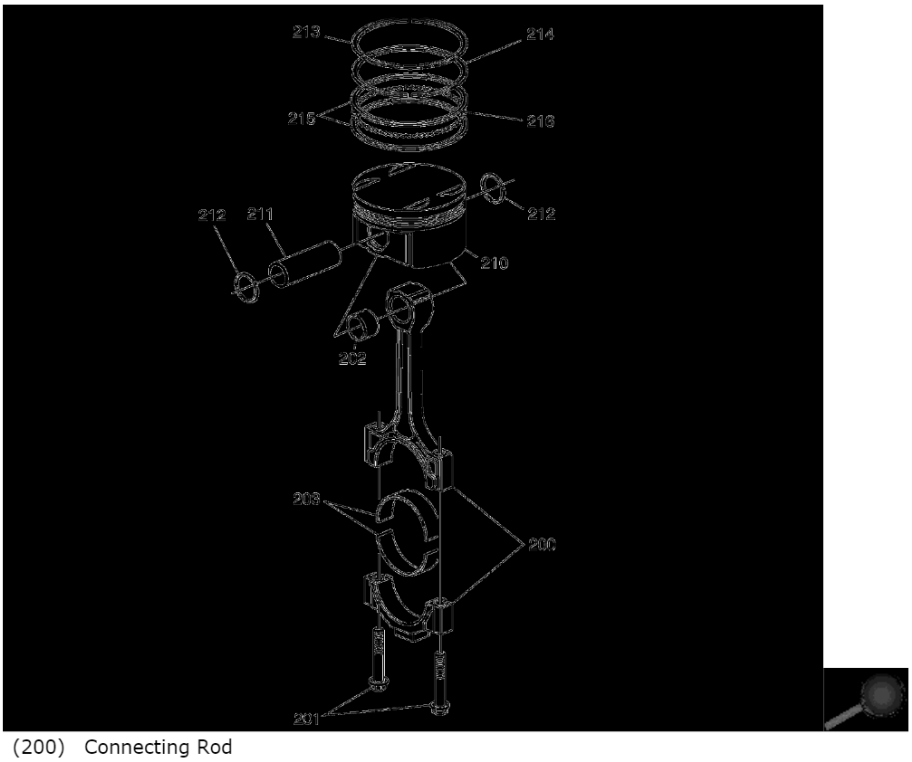
© 2014 General Motors. All rights reserved.

cardiagn.com

(19) Cylinder Head Locating Pin
(20) Engine Block
(21) Engine Block Oil Gallery Expansion Plug– 14 mm
(22) Engine Front Cover Stud
(23) Engine Block Oil Gallery Threaded Plug - 20 mm
(24) Engine Block Oil Gallery Expansion Plug - 10 mm
(25) Crankshaft Bearing Cap Side Bolt - Short
(26) Crankshaft Upper Thrust Bearing #3
(27) Crankshaft Upper Bearing

cardiagn.com

Piston, Rings, Bearing and Connecting Rod

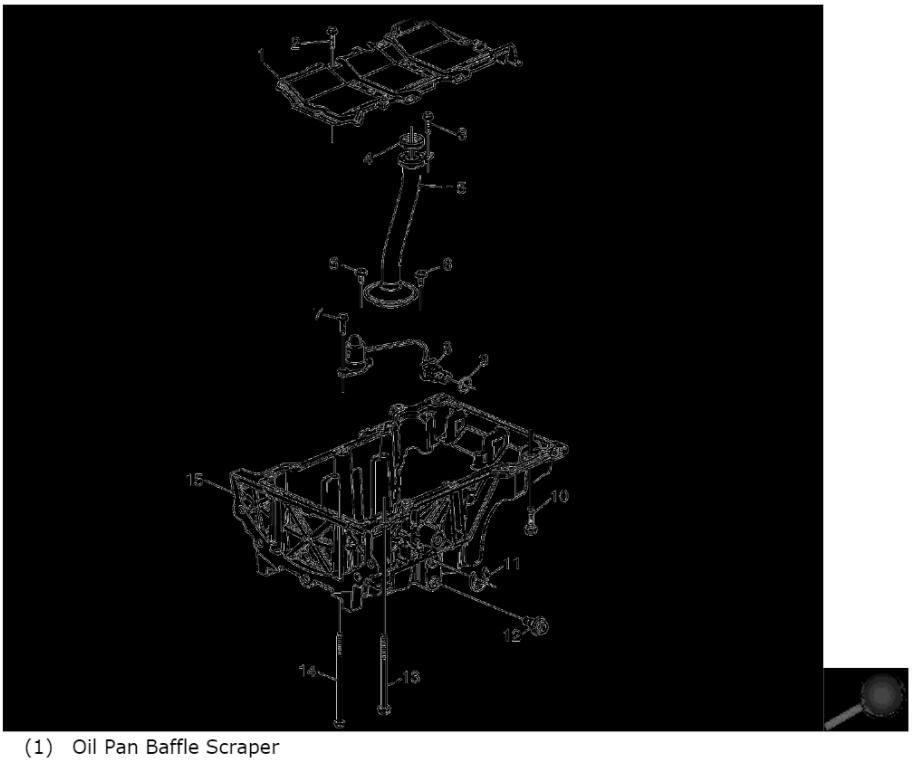


(200) Connecting Rod
(201) Connecting Rod Bolt
(202) Connecting Rod Bushing
(203) Connecting Rod Bearing
(210) Piston
(211) Piston Pin
(212) Piston Pin Retainer
(213) Piston Upper Compression Ring
(214) Piston Lower Compression Ring
(215) Piston Oil Control Rail Ring
(216) Piston Oil Control Ring Spacer

cardiagn.com

© 2014 General Motors. All rights reserved.

Oil Pan Assembly (RWD)

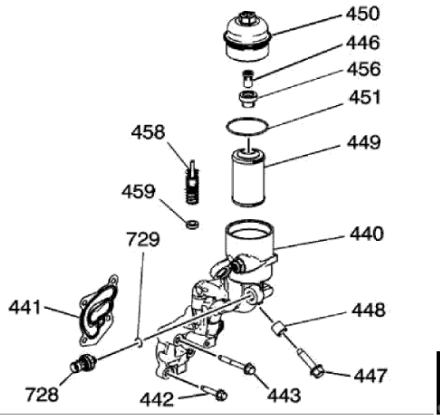


(1) Oil Pan Baffle Scraper
(2) Oil Pan Baffle Scraper Bolt
(3) Oil Pump Suction Pipe Bolt
(4) Oil Pump Suction Pipe Seal
(5) Oil Pump Suction Pipe
(6) Oil Pump Suction Pipe Retaining Bolt
(7) Engine Oil Level Switch Bolt
(8) Engine Oil Level Switch
(9) Engine Oil Level Switch Seal
(10) Oil Pan Bolt — Short
(11) Engine Oil Level Switch Clip
(12) Oil Pan Drain Plug
(13) Oil Pan Bolt
(14) Oil Pan Bolt - Long
(15) Oil Pan

cardiagn.com

© 2014 General Motors. All rights reserved.

Oil Filter Adapter

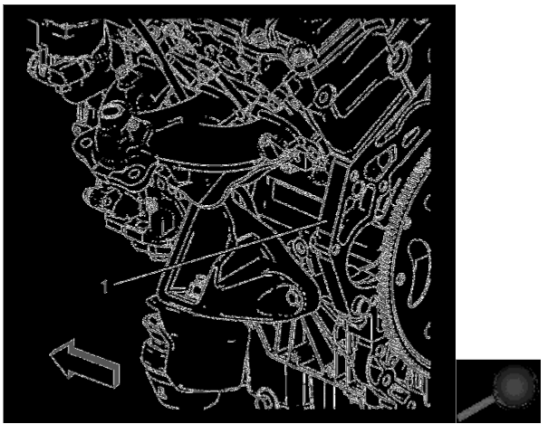


(440) Oil Filter Adapter
(441) Oil Filter Adapter Gasket
(442) Oil Filter Adapter Bolt
(443) Oil Filter Adapter Bolt – Long
(446) Oil Filter Bypass Valve
(447) Oil Filter Adapter Bolt – Large
(448) Oil Filter Adapter Bolt Sleeve
(449) Oil Filter
(450) Oil Filter Cap
(451) Oil Filter Cap O-ring
(456) Oil Filter Bypass Valve Body
(458) Drain Valve Assembly
(459) Drain Valve Assembly Seal
(728) Engine Oil Pressure Sensor
(729) Engine Oil Pressure Sensor O-ring

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Identification



The engine serial number is located on the left-hand side at the rear of the engine cylinder block (1) and is stamped or laser etched onto the block at the assembly plant. When reading the engine serial number the following information can be obtained:

Engine Serial Number LFX*141870560* is used as an example:

- The first three characters, LFX identifies the engine model by its Regular Production Option (RPO) code as an LFX engine.
- The next character, * is a number limiter and has no meaning.
- The next two characters, 14 identifies the year the engine was manufactured as 2014.
- The next three characters, 187 identifies the Julian date the engine was manufactured as day 187.
- The next four characters, 0560, identifies the assembly plant sequence number as 0560.
- The next digit, * is a number limiter and has no meaning.

cardiagn.com

© 2014 General Motors. All rights reserved.

Symptoms - Engine Mechanical

Strategy Based Diagnostics

1. Perform a Diagnostic System Check - Vehicle before using the symptom tables, if applicable.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to Disassembled Views, Engine Component Description, Drive Belt System Description and Lubrication Description.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system problem. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to Strategy Based Diagnosis.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to Checking Aftermarket Accessories.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Check for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Engine Compression Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis

© 2014 General Motors. All rights reserved.

cardiagn.com

Base Engine Misfire without Internal Engine Noises

Base Engine Misfire without Internal Engine Noises

Cause	Correction
Abnormalities, extreme cracking, bumps, or missing areas, in the accessory drive belt. Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement.
Worn, damaged, or mis-aligned accessory drive components or pulley runout above acceptable tolerances may lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components: Repair or replace as required.
Loose or incorrectly installed engine automatic transmission flex plate/engine flywheel or crankshaft balancer. A misfire code may be present without an actual misfire condition.	Repair or replace the engine automatic transmission flex plate/engine flywheel or balancer as required. Refer to Engine Flywheel Replacement or Engine Flywheel Replacement or Crankshaft Balancer Replacement.
Restricted exhaust system. An extreme restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace as required. Refer to engine exhaust for the required procedure.
Incorrectly installed or damaged vacuum hoses.	Repair or replace as required.
Incorrect sealing between the intake manifold and cylinder heads, intake manifold and throttle body and/or pressure relief valve and intake manifold.	Replace the intake manifold, plenum duct, cylinder heads, throttle body, pressure relief valve or gaskets as required.
Incorrectly installed or damaged EVAP purge solenoid and/or O-ring seal.	Repair or replace the EVAP purge solenoid as required.
Worn or loose Stationary Hydraulic Lash Adjusters (SHLAs), valve rocker arms. The stationary hydraulic lash adjusters (SHLAs), valve rocker arm, roller bearing should be intact and in the correct position	Replace the SHLAs, valve rocker arms, as required.
Sticking valves.	Repair or replace as required.

© 2014 General Motors. All rights reserved.

cardiagn.com

Cause	Correction
Carbon buildup on the valve stem can cause the valve not to close correctly.	
Timing chain or chains worn or mis-aligned above acceptable tolerances.	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes.	Replace the camshaft or camshafts and high Stationary Hydraulic Lash Adjusters (SHLAs), valve lifters.
Oil pressure above acceptable tolerances. A lubrication system with oil pressure above acceptable tolerances may lead to valve lifter pump-up above acceptable tolerances and loss of compression.	• Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. • Repair or replace the oil pump as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and cylinder block cooling system passages. Refer to Diagnostic System Check - Vehicle. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection. • Inspect the cylinder heads, cylinder block, and/or head gaskets. • Repair or replace as required.
Worn piston rings. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection. • Inspect the cylinders for a loss of compression. Refer to Engine Compression Test. • Perform cylinder leak down and compression testing to identify the cause. • Repair or replace as required.
A damaged crankshaft reluctor wheel. A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with EXTREME reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set.	Replace the crankshaft as required.

cardiagn.com

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Base Engine Misfire with Abnormal Internal Lower Engine Noises

Cause	Correction
Abnormalities, extreme cracking, bumps or missing areas, in the accessory drive belt. Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement.
Worn, damaged, or mis-aligned accessory drive components or pulley runout above acceptable tolerances. A misfire code may be present without an actual misfire condition.	Inspect the components, repair or replace as required.
Loose or incorrectly installed engine automatic transmission flex plate/engine flywheel or crankshaft balancer. A misfire code may be present without an actual misfire condition.	Repair or replace the engine automatic transmission flex plate/engine flywheel or balancer as required. Refer to Engine Flywheel Replacement or Automatic Transmission Flex Plate Replacement or Crankshaft Balancer Replacement.
Worn or broken piston rings Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection. • Inspect the cylinders for a loss of compression. Refer to Engine Compression Test. • Perform cylinder leak down and compression testing to determine the cause. • Repair or replace as required.
Worn crankshaft thrust bearings. Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Base Engine Misfire with Abnormal Valve Train Noise

Base Engine Misfire with Abnormal Valve Train Noise

Cause	Correction
Worn or loose followers, valve rocker arms The follower, valve rocker arm, roller bearing should be intact and in the proper position.	Replace the followers, valve rocker arms, as required.
Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly.	Repair or replace as required.
Excessively worn or mis-aligned timing chain or chains	Replace the timing chain or chains and sprockets as required.
Worn camshaft lobes	Replace the camshaft or camshafts and SHLAs (valve lifters).
Sticking SHLAs (lifters)	Replace the SHLAs as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Base Engine Misfire with Coolant Consumption

Base Engine Misfire with Coolant Consumption

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages. Refer to Diagnostic Starting Point - Vehicle. Coolant consumption may or may not cause the engine to overheat.	• Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection. • Perform a cylinder leak down test. • Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. • Repair or replace as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Base Engine Misfire with Excessive Oil Consumption

Base Engine Misfire with Excessive Oil Consumption

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection. 2. Repair or replace as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection. 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test. 3. Perform cylinder leak down and compression testing to determine the cause. 4. Repair or replace as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Engine Noise on Start-Up, but Only Lasting a Few Seconds

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	Drain the engine oil and replace with the correct viscosity oil.
High stationary hydraulic lash adjuster (SHLA), valve lifter, leak down rate	Replace the SHLAs, valve lifters, as required.
Worn crankshaft thrust bearing	• Inspect the thrust bearing and crankshaft. • Repair or replace as required.
Damaged or faulty oil filter by-pass valve	• Inspect the oil filter by-pass valve for proper operation. • Repair or replace as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Upper Engine Noise, Regardless of Engine Speed

Upper Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace as required.
Loose and/or worn follower, valve rocker arm	1. Inspect the follower, valve rocker arm. 2. Repair or replace as required.
Improper lubrication to the followers, valve rocker arms	Inspect the following components, and repair or replace as required: • The follower, valve rocker arm • The SHLA, valve lifter • The oil filter bypass valve • The oil pump and pump screen • The cylinder head oil galleries • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn or dirty stationary hydraulic lash adjusters (SHLAs), valve lifters	Replace the SHLAs, valve lifters.
Stretched or broken timing chain or chains and/or damaged sprocket teeth	Replace the timing chain or chains and sprockets.
Worn timing chain tensioner or tensioners	Replace the timing chain tensioner or tensioners as required.
Worn timing chain shoe or shoes	Replace the timing chain shoe or shoes as required.
Worn timing chain guide or guides	Replace the timing chain guide or guides as required.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft or camshafts and SHLAs, valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components, and repair as required:

© 2014 General Motors. All rights reserved.

cardiagn.com

Cause	Correction
	• The valves • The valve guides
• Stuck valves • Carbon on the valve stem or valve seat may cause the valve to stay open	Inspect the following components, and repair as required: • The valves • The valve guides

cardiagn.com

Lower Engine Noise, Regardless of Engine Speed

Lower Engine Noise, Regardless of Engine Speed

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace damaged components as required.
• Worn accessory drive components • Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer Symptoms - Engine Controls.
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair or replace as required.
Loose or damaged engine flywheel	Repair or replace the engine flywheel.
• Damaged oil pan, contacting the oil pump screen • An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace as required.
Oil pump screen loose, damaged or restricted	1. Inspect the oil pump screen. 2. Repair or replace as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair as required.

© 2014 General Motors. All rights reserved.

cardiagn.com

Cause	Correction
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and the connecting rod. 2. Repair or replace as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals
• Incorrect piston, piston pin and connecting rod installation • Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. 2. Repair as required.

cardiagn.com

Engine Noise Under Load

Engine Noise Under Load

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to Symptoms - Engine Controls.
Loose torque converter bolts	1. Inspect the torque converter bolts and engine flywheel. 2. Repair as required.
Cracked engine flywheel	1. Inspect the engine flywheel and bolts. 2. Repair as required.
Excessive connecting rod bearing clearance	Inspect the following components, and repair as required: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	Inspect the following components, and repair as required: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Will Not Crank - Crankshaft Will Not Rotate

Engine Will Not Crank - Crankshaft Will Not Rotate

Cause	Correction
Seized accessory drive system component	1. Remove the accessory drive belt or belts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and check for fluid. 2. Inspect for broken head gasket or gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace as required.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. 3. Repair or replace as required.
Material in cylinder • Broken valve • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and the connecting rod bearings. 2. Repair as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair as required.

© 2014 General Motors. All rights reserved.

cardiagn.com

Cause	Correction
Seized or broken camshaft	1. Inspect the camshaft or camshafts. 2. Inspect the cylinder head camshaft journals for damage. 3. Repair as required.
Seized or broken balance shaft	1. Inspect the balance shaft. 2. Inspect the block for damaged balance shaft bearings. 3. Repair as required.
Seized or broken camshaft timing components	1. Inspect the following sprockets: ◦ The crankshaft sprocket ◦ The exhaust sprockets ◦ The intake sprockets 2. Inspect the following chains: ◦ The primary camshaft drive chain ◦ The secondary camshaft drive chains 3. Inspect the following guides: ◦ The lower primary camshaft drive chain guide ◦ The upper primary camshaft drive chain guides 4. Inspect the secondary camshaft drive chain shoe. 5. Inspect the following tensioners: ◦ The primary camshaft drive chain tensioner ◦ The secondary camshaft drive chain tensioners 6. Repair as required.
Seized or broken valve train components	1. Inspect the followers, rocker arms. 2. Inspect the lifters. 3. Inspect the valves. 4. Inspect the valve springs. 5. Repair as required.

cardiagn.com

Coolant in Combustion Chamber

Coolant in Combustion Chamber

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. **Note:** While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in the cooling system. It is important to follow the kit instructions. This is not a substitute for the service information. Combustion leak tests are available from a wide variety of aftermarket suppliers. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a Cylinder Leakage Test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Coolant in Engine Oil

Coolant in Engine Oil

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed. 2. Inspect by performing a Cylinder Leakage Test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. 3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Compression Test (LFW)

Special Tools

J 39313 Spark Plug Port Adapter

For equivalent regional tools, refer to Special Tools.

A compression pressure test of the engine cylinders determines the condition of the rings, the valves and the head gasket.

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge.
2. Turn the engine OFF.
3. Remove the ignition coils. Refer to Camshaft Cover Replacement - Left Side or Camshaft Cover Replacement - Right Side.
4. Remove the fuel pump fuse from the rear fuse block.
5. Remove the spark plugs from all cylinders.
6. Remove the air duct from the throttle body.
7. Block the throttle plate in open position.
8. Measure the engine compression, using the following procedure:
   8.1. Thread the *J 39313* adapter into the spark plug hole.
   8.2. Thread the compression gauge into the *J 39313* adapter .
   8.3. Have an assistant crank the engine through, at least 4 compression strokes, in the testing cylinder.
   8.4. Check and record the readings on the gauge at each stroke.
   8.5. Remove the compression gauge from the *J 39313* adapter .
   8.6. Remove the *J 39313* adapter from the spark plug hole.
   8.7. Repeat the compression test for each cylinder.
9. Record the compression readings from all of the cylinders.
   - The lowest reading should not be less than 70 percent of the highest reading.
   - No cylinder reading should be less than 965 kPa (140 psi).
10. The following are examples of measurement problems:
    - When the compression measurement is normal, the compression builds up quickly and evenly to specified compression on each cylinder.
    - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil. Use approximately 3 squirts of oil from a plunger-type oiler.
    - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
    - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
11. Remove the block from the throttle plate.
12. Install the air duct to the throttle body.
13. Install the spark plugs.

© 2014 General Motors. All rights reserved.

cardiagn.com

14. Install the ignition coils. Refer to Camshaft Cover Replacement - Left Side or Camshaft Cover Replacement - Right Side.
15. Install the fuel pump fuse to the rear fuse block.

cardiagn.com

Engine Compression Test (LFX)

Special Tools

EN−39313 Spark Plug Port Adapter

For equivalent regional tools, refer to Special Tools.

A compression pressure test of the engine cylinders determines the condition of the piston rings, the valves and the head gaskets.

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge. You may wish to connect a battery charger for the duration of the test to maintain an adequate battery level.
2. Turn the engine OFF.
3. Remove the intake manifold cover.
4. Remove the ignition coils and spark plugs from all cylinders. Refer to Ignition Coil Replacement - Bank 1 and Ignition Coil Replacement - Bank 2.
5. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.
6. Measure the engine compression, using the following procedure:
   6.1. Thread the *EN−39313* adapter into the spark plug hole.
   6.2. Thread the compression gauge into the *EN−39313* adapter.
   6.3. Enable cranking via the GDS2 or remote start switch. Record the reading after the cranking cycle completes.
   6.4. When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
   6.5. Repeat the compression test for each cylinder.
7. Compare the compression readings from all of the cylinders.
   - The lowest reading should not be less than 70 percent of the highest reading.
   - No cylinder reading should be less than 690 kPa (100 psi).
8. The following are indicators of potential problems:
   - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
   - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition of oil.
   - Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders.
9. Disconnect GDS2 diagnostic tool or remote start switch.
10. Install the spark plugs. Refer to Spark Plug Replacement.
11. Install the ignition coils and spark plugs from all cylinders. Refer to Ignition Coil Replacement - Bank 1 and Ignition Coil Replacement - Bank 2.
12. Install the intake manifold cover.

© 2014 General Motors. All rights reserved.

cardiagn.com

Cylinder Leakage Test

Special Tools

- *EN 35667-A* Cylinder Head Leakdown Tester
- *EN 39313* Spark Plug Port Adapter

For equivalent regional tools, refer to Special Tools.

Note: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate one or more of the following:
- Worn or burnt valves
- Broken valve springs
- Stuck valve lifters
- Incorrect valve lash/adjustment
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

Warning: Refer to Battery Disconnect Warning.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement.

   Caution: Only turn the engine in a CLOCKWISE direction as viewed from the crankshaft balancer. Counterclockwise rotation may result in the timing chain jumping a tooth, causing poor running, DTCs, or severe engine damage.
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Thread the *EN 39313* adapter into the spark plug hole.
5. Install the *EN 35667-A* tester or equivalent.

   Note: It may be necessary to hold the crankshaft balancer bolt to prevent the engine from rotating.
6. Apply shop air pressure to the *EN 35667-A* tester and adjust according to the manufacturers instructions.
7. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring
   - Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring
   - Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.
8. Perform the leakage test on the remaining cylinders and record the values.

© 2014 General Motors. All rights reserved.

cardiagn.com

Engine Oil Level Sensor Diagnosis

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Engine Oil Level Sensor Signal	2	1	—	1
Engine Oil Level Sensor Ground	—	1	—	—
1. DIC message Engine Oil Level Low Always ON 2. DIC message Engine Oil Level Low Always OFF				

Typical Scan Tool Data

Engine Oil Level Switch

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON **Parameter Normal Range:** OK			
Engine Oil Level Sensor/Switch Signal	OK	Low	OK
Engine Oil Level Ground	—	Low	—

Circuit/System Description

The engine oil level sensor/switch is a normally-closed with proper engine oil level. The switch opens when the engine oil level drops below a calibrated level. The engine control module (ECM) monitors the engine oil level signal circuit when the ignition is ON, and the engine is OFF. With the switch in the closed position, the ECM detects a low voltage signal circuit. With the switch in the open position, the ECM detects a high voltage on the signal circuit. When high voltage is detected on the signal circuit, the ECM will send a serial data message to the instrument panel cluster and a message is displayed on the driver information center.

The following information determines the message sent form the ECM to the instrument cluster. The Engine Oil Level Low message is displayed only after the ECM detects a high voltage on the signal circuit for three consecutive ignition cycles, followed by an ignition OFF event from 15 min to greater than 50 min, depending on the engine oil temperature.

The Engine Oil Level Low message is turned OFF when the ECM detects a low voltage on the signal circuit after an ignition OFF event for greater than 90 s, then followed by the ignition ON for less than 1 s.

© 2014 General Motors. All rights reserved.

cardiagn.com

Reference Information

Schematic Reference

- Engine Mechanical Schematics
- Instrument Cluster Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

- Instrument Cluster Description and Operation
- Indicator/Warning Message Description and Operation

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Verify proper engine oil level.

⇒ **If not at proper level**

Add oil as necessary.

⇓ **If at proper level**

2. Ignition ON, verify the scan tool Engine Oil Level parameter reads OK.

⇒ **If not OK**

Refer to Circuit/System Testing.

⇓ **If OK**

3. All OK.

Circuit/System Testing

Note: Verify proper engine oil level before continuing with diagnosis.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B35 Engine Oil Level Switch. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. Test for less than 2 Ω in the ground circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

⇓ **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool Engine Oil Level Switch parameter reads Low.

⇒ **If the Engine Oil Level Switch parameter reads OK**

cardiagn.com

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

4.2. Test for infinite resistance between the signal circuit terminal 2 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇒ If infinite resistance, replace the K20 Engine Control Module.

⇓ **If the Engine Oil Level Switch parameter reads Low**

Note: If a short to voltage is found on the signal circuit, the fuse in the 3A jumper wire will open.

5. Install a 3A fused jumper wire between the signal circuit terminal 2 and the ground circuit terminal 1.

6. Verify the scan tool Engine Oil Level Switch parameter reads OK.

⇒ **If the Engine Oil Level Switch parameter reads Low**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

6.2. Test for less than 1 V between the signal circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V

6.3. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance on the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If the Engine Oil Level Switch parameter reads OK**

7. Test or replace the B35 Engine Oil Level Switch.

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Engine Oil Level Sensor and/or Switch Replacement
- Control Module References for the ECM replacement, programming, and setup

cardiagn.com

Oil Consumption Diagnosis

Oil Consumption Diagnosis

Checks	Causes
The causes of excessive oil consumption may include the following conditions:	
Preliminary	• External oil leaks — Refer to Oil Leak Diagnosis. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2–3 minutes) and check for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components • Worn valve guides and/or valve stems • Worn, missing or improperly installed valve stem oil seals • Piston rings broken, worn, not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary. • Piston and rings improperly installed or miss-fitted to the cylinder bore

cardiagn.com

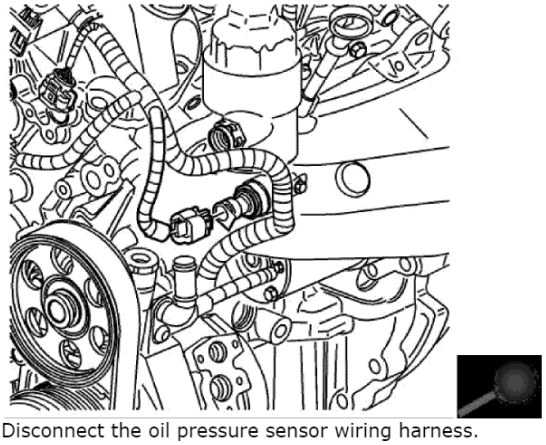
© 2014 General Motors. All rights reserved.

Oil Pressure Diagnosis and Testing

Special Tools

- *EN-50789* Oil Pressure Adapter Fitting
- *J 21867* Pressure Gauge

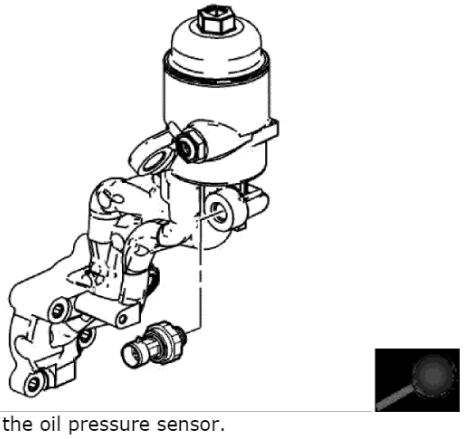
1. With the vehicle on a level surface, run the vehicle for a few minutes, allow adequate drain down time, 2–3 minutes, and measure for a low oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10–15 seconds, and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following:
    - Foamy oil
    - Slow idle speed
    - Plugged oil filter
    - Oil diluted by the following:
        - Water
        - Engine coolant
        - Unburned fuel mixtures
    - Malfunctioning oil filter bypass valve
    - Incorrect or faulty oil pressure gauge
    - Incorrect or faulty oil pressure gauge sensor
    - Improper engine oil viscosity for the expected temperature



6. Disconnect the oil pressure sensor wiring harness.

cardiagn.com

© 2014 General Motors. All rights reserved.



7. Remove the oil pressure sensor.
8. Install the *J 21867* pressure gauge with the *EN-50789* oil pressure adapter fitting.
9. Measure the engine oil pressure.
10. Compare the readings to the Engine Mechanical Specifications.
11. If the engine oil pressure is below specifications, inspect the engine for one or more of the following:
    - Loose oil filter adapter bolts
    - Missing or damaged oil filter adapter O-ring seal or seals
    - Worn or dirty oil pump
    - Loose oil pump-to-engine block bolts
    - Loose, plugged or damaged oil pump screen
    - Missing or damaged oil pump screen O-ring seal
    - Damage or leak in the oil pump screen suction tube
    - Malfunctioning oil pump pressure regulator valve
    - Missing or incorrectly installed oil gallery plugs
    - Loose camshaft intermediate drive shaft bolts
    - Excessive bearing clearance for the following:
      - Connecting rod or rods
      - Crankshaft
      - Camshaft or camshafts
      - Camshaft intermediate drive shaft sprocket
    - Cracked, porous or restricted oil galleries
    - Broken valve lifters
12. Repair or replace components as necessary.

cardiagn.com

Oil Leak Diagnosis

Oil Leak Diagnosis

Checks	Action
Caution: It is important to correctly identify the source of an oil leak. A power steering fluid leak or spillage can travel across the valley area of the engine and run out the weep hole, which is located at the back of the block. Failure to correctly identify the source of an oil leak can lead to the incorrect or unnecessary replacement of components. You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.	
Locating and identifying the leak	To determine if the leaking fluid is engine oil, transmission fluid, power steering fluid, brake fluid, or some other fluid, use the visual inspection method.
Visual Inspection Method	1. Bring the vehicle to normal operating temperature. 2. Park the vehicle over a large sheet of paper, or other clean surface. 3. Wait several minutes, then check for drippings. 4. Identify the type of fluid, and the approximate location of the leak. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. Check for leaks at sealing surfaces, fittings, or from cracked or damaged components. 7. If you cannot locate the leak, do the following: 7.1. Completely clean the entire engine and surrounding components. 7.2. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 7.3. Park the vehicle over a large sheet of paper, or other clean surface. 7.4. Wait several minutes, then check for drippings. 7.5. Identify the type of fluid, and the approximate location of the leak. 7.6. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 7.7. See possible causes for leaks. 8. If you still cannot locate the leak, use the powder method or the black light and dye method.
Powder Method	1. Completely clean the entire engine and surrounding components.

© 2014 General Motors. All rights reserved.

cardiagn.com

Checks	Action
	2. Apply an aerosol-type powder (baby powder, foot powder, etc.) to the suspected area. 3. Operate the vehicle for several miles at normal operation temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. 5. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 6. See possible causes for leaks.
Black Light and Dye Method	1. A dye and light kit is available for finding leaks. Use the *GE 28428-E* High-Intensity Black Light Kit or equivalent. Refer to the manufacturer's instructions when using the tool. 2. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 3. See possible causes for leaks.
Possible Causes for Leaks	Check for the following conditions: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces

cardiagn.com

Crankcase Ventilation System Inspection/Diagnosis

Crankcase Ventilation (CV) System Inspection

- Test for vacuum at the vacuum hose where it connects to the crankcase ventilation housing. There should be manifold vacuum present at the hose. If there is no vacuum, inspect for a plugged hose, leaking hose or a plugged vent adapter.
- Plug the end of the vacuum hose while the engine is running. Inspect the hose for any areas that collapse when the end of the hose is blocked. Replace the hose if it collapses when blocked.
- If oil has accumulated in the intake air duct, inspect for the following conditions:
  - Plugged vacuum orifice in the crankcase ventilation housing
  - Plugged or restricted crankcase ventilation housing
  - Excessive crankcase pressure or blow-by, refer to Oil Consumption Diagnosis.
- Additional items to inspect:
  - Plugged or leaking fresh air vent hose assembly or vent adapter
  - Plugged or restricted passages in the throttle body
  - Missing or damaged O-ring seals on the vent adapter
  - Inspect the cam covers, the oil pan gasket, and other sealing areas for leaks

Results of Incorrect Operation

A plugged crankcase ventilation housing or hose may contribute to the following conditions:

- A rough idle
- Stalling or a slow idle speed
- Oil leaks
- Oil accumulation in the intake air duct
- Sludge in the engine

A leaking housing or hose may contribute to the following conditions:

- A rough idle
- Stalling
- Unstable idle speed

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Chirping, Squeal, and Whine Diagnosis

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, worn, misaligned drive belt pulleys or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
15. This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
16. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
17. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.
19. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

© 2014 General Motors. All rights reserved.

cardiagn.com

Drive Belt Chirping, Squeal, and Whine Diagnosis

Step	Action	Yes	No
	Caution: Refer to Belt Dressing Caution. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30–40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys.	Go to Step 7	Go to Step 8

cardiagn.com

Step	Action	Yes	No
	Are any of the pulleys misaligned?		
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	**Caution:** Refer to Fastener Caution. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis. Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19
19	Replace the drive belt. Refer to Drive Belt Replacement. Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair.	System OK	Go to Step 3

cardiagn.com

Step	Action	Yes	No
	Did you correct the condition?		

cardiagn.com

Drive Belt Rumbling and Vibration Diagnosis

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.
5. Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.
9. Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.
11. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.
12. Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Drive Belt Rumbling and Vibration Diagnosis

Step	Action	Yes	No
Caution: Refer to Belt Dressing Caution. DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: – Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove			

© 2014 General Motors. All rights reserved.

cardiagn.com

Step	Action	Yes	No
	– The separation of the drive belt – A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	**Note:** If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 1. Remove the drive belt. 2. Operate the engine for no longer than 30–40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to Symptoms - Engine Mechanical or Vibration Analysis - Engine	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to Drive Belt Replacement or Air Conditioning Compressor Belt Replacement. Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to Drive Belt Replacement or Air Conditioning Compressor Belt Replacement. Did you complete the replacement?	Go to Step 8	Go to Step 9
8		System OK	Go to Step 9

cardiagn.com

Step	Action	Yes	No
	Operate the system in order to verify the repair. Did you correct the condition?		
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	**Caution:** Refer to Fastener Caution. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	Go to Step 11
11	Inspect for a bent water pump shaft. Refer to Water Pump Replacement. Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

cardiagn.com

Drive Belt Falls Off and Excessive Wear Diagnosis

Diagnostic Aids

Vibration from the engine operating may cause a body component or another part of the vehicle to make a rumbling noise.

The drive belt may have a condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belt is installed, there might be an inoperative accessory drive component. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify the drive belt is causing the rumbling noise. A rumbling noise may be confused with an internal engine noise due to the similarity in the description. When removing the drive belt the water pump will not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspecting the drive belt is to ensure that it is not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plies of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.
5. Small amounts of pilling is normal condition and acceptable. When the pilling is extreme the drive belt does not have a smooth surface for correct operation.

Drive Belt Falls Off and Excessive Wear Diagnosis

Step	Action	Yes	No
Caution: Refer to Belt Dressing Caution. DEFINITION: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: – Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove. – The separation of the drive belt. – A damaged drive belt.			
1	Did you review the Symptoms – Engine Mechanical diagnostic information, and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise. Does the engine make the rumbling noise?	Go to Step 3	Go to Diagnostic Aids

© 2014 General Motors. All rights reserved.

cardiagn.com

Step	Action	Yes	No
3	**Important:** When removing the drive belt the water pump will not be operating and the engine may overheat. 1. Remove the drive belt. Refer to Drive Belt Replacement. 2. Operate the engine for no longer than 30 to 40 seconds. Does the rumbling noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	Inspect the drive belt for damage, separation, or sections of missing ribs. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for extreme pilling of more than 1/3 of the drive belt pulley grooves. Did you find extreme pilling?	Go to Step 6	Go to Step 7
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belt. Refer to Drive Belt Replacement. Did you complete the repair?	Go to Step 8	–
7	Install a new drive belt. Refer to Drive Belt Replacement. Did you complete the replacement?	Go to Step 8	–
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Diagnostic Aids

cardiagn.com

Drive Belt Tensioner Diagnosis

Drive Belt Tensioner Diagnosis

Step	Action	Yes	No
1	Remove the drive belt. Refer to Drive Belt Replacement. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to Step 4	Go to Step 2
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to Step 3	Go to Step 4
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to Step 4
4	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement. Is the repair complete?	System OK	-

cardiagn.com

© 2014 General Motors. All rights reserved.

Fastener Tightening Specifications

Fastener Tightening Specifications

Application	Specification	
	Metric	English
A/C		
• Air Conditioning Compressor to Air Conditioning Compressor Bracket Retaining Bolt	22 N•m	16 lb ft
• Air Conditioning Compressor Bracket to Engine Block Retaining Bolt	58 N•m	43 lb ft
• Suction Discharge Pipe Pad to Air Conditioning Compressor Retaining Bolt	22 N•m	16 lb ft
• Battery Positive Cable to Generator Retaining Nut	13 N•m	115 lb in
Automatic Transmission Flex Plate Bolt		
• First Pass	30 N•m (1)	22 lb ft (1)
• Final Pass	45 Degrees	
Brake Caliper Anchor Plate to Knuckle Retaining Bolts		
• First Pass	60 N•m	44 lb ft
• Final Pass	120 Degrees	
Camshaft Position Actuator		
• Camshaft Position Actuator to Camshaft Retaining Bolt	58 N•m	43 lb ft
• Camshaft Position Actuator Solenoid Valve to Engine Front Cover Retaining Bolt	9 N•m	80 lb in

© 2014 General Motors. All rights reserved.

cardiagn.com

Application	Specification	
	Metric	English
Camshaft Bearing Cap to Cylinder Head Retaining Bolt	10 N•m	89 lb in
Camshaft Cover to Cylinder Head Retaining Bolt	10 N•m	89 lb in
Camshaft Intermediate Drive Chain Idler to Engine Block Retaining Bolt	58 N•m	43 lb ft
Camshaft Position Sensor to Engine Front Cover Retaining Bolt	10 N•m	89 lb in
Close Out Cover to Engine Block Retaining Bolt	10 N•m	89 lb in
Connecting Rod Bolt		
• First Pass	25 N•m (1)	18 lb ft (1)
• Final Pass	110 Degrees	
Coolant Drain Plug – M14	50 N•m	37 lb in
Coolant Drain Plug – M20	75 N•m	55 lb in
Crankshaft Balancer to Crankshaft Retaining Bolt		
• First Pass	100 N•m (1)	74 lb ft (1)
• Final Pass	150 Degrees	
Crankshaft Bearing Cap to Engine Block Retaining Bolt		
Inner		
• First Pass	20 N•m (1)	15 lb ft (1)
• Final Pass	80 Degrees	
Outer		
• First Pass	15 N•m (1)	10 lb ft (1)
	110 Degrees	

cardiagn.com

Application	Specification	
	Metric	English
• Final Pass		
Side		
• First Pass	30 N•m (1)	22 lb ft (1)
• Final Pass	60 Degrees	
Crankshaft Rear Oil Seal Housing to Engine Block Retaining Bolt	9 N•m	80 lb in
Cylinder Head to Engine Block Retaining Bolt - M8		
• First Pass	15 N•m (1)	11 lb ft (1)
• Final Pass	75 Degrees	
Cylinder Head to Engine Block Retaining Bolt - M11		
• First Pass	30 N•m (1)	22 lb ft (1)
• Final Pass	150 Degrees	
Cylinder Head Coolant Threaded Plug to Cylinder Head	45 N•m	33 lb ft
Cylinder Head Core Hole Plug	75 N•m	55 lb ft
Drive Belt Tensioner Bolt	25 N•m	18 lb ft
Engine Coolant Inlet Pipe to Alternator Mounting Bracket Retaining Nut	22 N•m	16 lb ft
Engine Coolant Inlet Pipe to Thermostat Housing Retaining Bolt	22 N•m	16 lb ft
Engine Coolant Outlet Housing to Intake Manifold Retaining Bolts	10 N•m	89 lb in
Engine Cover Mounting Bracket to Cylinder Head Retaining Bolt - M10 (Except LLT)	58 N•m	43 lb ft
Engine Cover Mounting Bracket to Cylinder Head Retaining Bolt - M8 (Except LLT)	22 N•m	16 lb ft

cardiagn.com

Application	Specification	
	Metric	English
Engine Driveplate to Crankshaft Retaining Bolt		
• First Pass	30 N•m	22 lb ft
• Final Pass	45 Degrees	
Engine Front Cover to Engine Retaining Bolt		
• First Pass	20 N•m	15 lb ft
• Final Pass	60 Degrees	
Engine Flywheel to Crankshaft Retaining Bolt		
• First Pass	30 N•m (1)	22 lb ft (1)
• Final Pass	75 Degrees	
Engine Ground Strap Nut to Cylinder Head Ground Strap Stud	25 N•m	18 lb ft
Engine Ground Strap Stud to Cylinder Head	50 N•m	37 lb ft
Engine Mount		
• Engine Mount Bracket to Engine Block Retaining Bolt	58 N•m	43 lb ft
• Engine Mount to Engine Mount Bracket Retaining Nut	80 N•m	59 lb ft
• Engine Mount to Front Subframe Retaining Nut	80 N•m	59 lb ft
Engine Wiring Harness Bracket		
• Engine Wiring Harness Bracket to Cylinder Head Rear Retaining Bolt	40 N•m	30 lb ft
	10 N•m	89 lb in

cardiagn.com

Application	Specification	
	Metric	English
• Engine Wiring Harness Bracket to Engine Block Retaining Bolt		
• Engine Wiring Harness Bracket to Right Bank Cylinder Head Retaining Bolt	10 N•m	89 lb in
Engine Wiring Harness Ground		
• Engine Wiring Harness Ground to Left Bank Cylinder Head Retaining Bolt	10 N•m	89 lb in
• Engine Wiring Harness Ground to Right Bank Cylinder Head Front Retaining Bolt	10 N•m	89 lb in
• Engine Wiring Harness Ground to Right Bank Cylinder Head Rear Retaining Bolt	10 N•m	89 lb in
Fuel Injector Harness Electrical Connector/EVAP Valve Mounting Bracket to Intake Manifold Retaining Bolt	9 N•m	80 lb in
Fuel Line Pressure Fuel Line Fitting Nuts	50 N•m	37 lb ft
Fuel Pump Bolts - High Pressure	15 N•m (1)	11 lb ft (1)
Fuel Rail to Lower Intake Manifold Retaining Bolt (LWR)	10 N•m	89 lb in
Fuel Rail to Cylinder Head Retaining Bolt (LLT, LF1, LFW, LFX)	25 N•m	18 lb ft
Generator		
• Generator Bracket Stud to Generator Bracket	18 N•m	13 lb ft
• Generator Retaining Nut to Generator Bracket Stud	58 N•m	43 lb ft
• Generator Bracket to Engine Block Retaining Bolt (M10X1.5X25)	58 N•m	43 lb ft
• Generator Bracket to Engine Block Retaining Bolt (M10X1.5X40)	58 N•m	43 lb ft

cardiagn.com

Application	Specification	
	Metric	English
• Generator Bracket to Engine Block Retaining Bolt (M8X1.25X40)	22 N•m	16 lb ft
Heater Pipe Assembly to Thermostat Housing Retaining Bolt	9 N•m	80 lb in
Heater Pipe Assembly to Cylinder Head Retaining Bolt	35 N•m	26 lb ft
Idler Pulley Bolt	58 N•m	43 lb ft
Ignition Coil to Camshaft Cover Retaining Bolt	10 N•m	89 lb in
Intake Manifold LY7		
• Engine Cover Ball Stud to Upper Intake Manifold	7 N•m	62 lb in
• Intake Manifold Runner Control Solenoid to Upper Intake Manifold Retaining Bolt	10 N•m	89 lb in
• Upper Intake Manifold-to-Cylinder Head Retaining Bolt - Long	23 N•m	17 lb ft
• Upper Intake Manifold-to-Cylinder Head Retaining Bolt - Short	23 N•m	17 lb ft
• Upper Intake Manifold to Lower Intake Manifold Retaining Bolt	23 N•m	17 lb ft
Intake Manifold		
• Engine Cover Ball Stud to Upper Intake Manifold	9 N•m	80 lb in
• Intake Manifold Brace to Intake Manifold Retaining Bolt	10 N•m	89 lb in
• Intake Manifold Cover to Intake Manifold Retaining Bolts	10 N•m	89 lb in

cardiagn.com

Application	Specification	
	Metric	English
• Intake Manifold to Cylinder Head Retaining Bolt - Long	25 N•m	18 lb ft
• Intake Manifold to Cylinder Head Retaining Bolt - Short	25 N•m	18 lb ft
Knock Sensor Bolt	25 N•m	18 lb ft
Manifold Absolute Pressure Sensor (MAP) Bolt	4 N•m	35 lb in
Oil Filter Adapter		
• Oil Filter Adapter to Engine Block Retaining Bolt– M10	58 N•m	43 lb ft
• Oil Filter Adapter to Engine Block Retaining Bolt– M8	23 N•m	17 lb ft
Oil Filter Cap to Oil Filter Adapter	25 N•m	18 lb ft
Oil Gallery Plug – M14	50 N•m	37 lb ft
Oil Gallery Plug – M20	75 N•m	55 lb ft
Oil Level Indicator Tube Bracket to Cylinder Head Retaining Bolt	9 N•m	80 lb in
Oil Level Sensor to Oil Pan Retaining Bolt	20 N•m	15 lb ft
Oil Pan		
• Front Engine Cover to Oil Pan Retaining Bolt	22 N•m	16 lb ft
• Oil Pan to Engine Block Retaining Bolt	22 N•m	16 lb ft
• Oil Pan to Crankshaft Rear Oil Seal Housing Retaining Bolt	9 N•m	80 lb in
• Transmission to Oil Pan Retaining Bolt	48 N•m	35 lb ft
• Oil Pan Baffle to Oil Pan Retaining Bolt	10 N•m	89 lb in

cardiagn.com

Application	Specification	
	Metric	English
• Oil Pan Scraper to Oil Pan Retaining Bolt	10 N•m	89 lb in
Oil Pan Drain Plug to Oil Pan	25 N•m	18 lb ft
Oil Pressure Sensor to Oil Filter Adapter	20 N•m	15 lb ft
Oil Pump Bolt	25 N•m	18 lb ft
Oil Suction Pipe to Oil Pan Retaining Bolt	10 N•m	89 lb in
Oil Jet to Engine Block Retaining Bolt	9 N•m	80 lb in
Oxygen Sensor Pump Converter Pipe	42 N•m	31 lb ft
Power Brake Booster Pump to Front Engine Cover Bolts (M6) (LF1, LFW, LLT)	10 N•m	89 lb in
Power Brake Booster Pump to Front Engine Cover Bolts (M10) (LF1, LFW, LLT)	70 N•m	52 lb ft
Power Steering Pump		
• Power Steering Bracket to Cylinder Head Retaining Bolt	58 N•m	43 lb ft
• Power Steering Bracket to Engine Front Cover Retaining Bolt	58 N•m	43 lb ft
• Power Steering Bracket to Engine Block Retaining Bolt	58 N•m	43 lb ft
• Power Steering Pump to Power Steering Pump Bracket Retaining Bolt	27 N•m	20 lb ft
• Power Steering Fluid Reservoir Bracket to Engine Front Cover Retaining Bolt	9 N•m	80 lb in
Pressure Plate to Flywheel Retaining Bolt		
• First Pass	15 N•m	11 lb ft
• Second Pass	30 N•m	22 lb ft

cardiagn.com

Application	Specification	
	Metric	English
Primary Camshaft Drive Chain		
• Primary Camshaft Drive Chain Lower Guide to Oil Pump Retaining Bolt	25 N•m	18 lb ft
• Primary Camshaft Drive Chain Tensioner to Engine Block Retaining Bolt	23 N•m	17 lb ft
• Primary Camshaft Drive Chain Upper Guide to Engine Block Retaining Bolt	23 N•m	17 lb ft
Secondary Camshaft Drive Chain		
• Secondary Camshaft Drive Chain Guide to Engine Block Retaining Bolt	23 N•m	17 lb ft
• Secondary Camshaft Drive Chain Shoe to Engine Block Retaining Bolt	23 N•m	17 lb ft
• Secondary Camshaft Drive Chain Tensioner to Engine Block Retaining Bolt		
• First Pass	5 N•m	44 lb in
• Final Pass	25 N•m	18 lb ft
Spark Plug	18 N•m	13 lb ft
Starter Motor		
• Starter Motor to Cylinder Block Retaining Bolt	58 N•m	43 lb ft
• Battery Positive Cable to Starter Motor Terminal Retaining Nut	10 N•m	89 lb in
Thermostat Housing to Engine Block Retaining Bolt	10 N•m	89 lb in
Throttle Body to Upper Intake Manifold Retaining Bolt	10 N•m	89 lb in
Transmission		

cardiagn.com

Application	Specification	
	Metric	English
Automatic Transmission Flex Plate to Crankshaft Retaining Bolts	30 N•m	22 lb ft
• Transmission Support to Body Retaining Bolt	58 N•m	43 lb ft
• Shift Control Linkage to Manual Shift Shaft Retaining Nut (6L50–E)	15 N•m	11 lb ft
• Shift Control Linkage to Manual Shift Shaft Retaining Nut (4L60–E)	23 N•m	17 lb ft
Water Pump Bolt		
• First Pass	10 N•m (1)	89 lb in (1)
• Second Pass	10 N•m	89 lb in
• Final Pass	45 Degrees	
Water Pump Pulley Bolt	10 N•m	89 lb in
1. Use NEW fastener.		

cardiagn.com

Engine Mechanical Specifications (LFX)

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.6 Liter	220 cu in
• RPO	LFX	
• VIN	3	
• Bore	94 mm	3.7008 in
• Stroke	85.6 mm	3.37 in
• Compression Ratio	11.5:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	0.95–1.10 mm	0.0375–0.0433 in
Block		
• Crankshaft Main Bearing Bore Diameter	72.867–72.881 mm	2.8688–2.8693 in
• Cylinder Bore Diameter	93.992–94.008 mm	3.7005–3.7011 in
• Cylinder Bore Out-of-Round – Production Max.	0.026 mm	0.001 in
• Cylinder Bore Taper	0.020 mm	0.0008 in

© 2014 General Motors. All rights reserved.

cardiagn.com

Application	Specification	
	Metric	English
Camshaft		
• Camshaft Bearing Inside Diameter – Front Number 1	35.000–35.020 mm	1.3779–1.3787 in
• Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4	27.000–27.020 mm	1.0630–1.0638 in
• Camshaft End Play	0.072–0.490 mm	0.0028–0.0190 in
• Camshaft Journal Diameter – Front Number 1	34.936–34.960 mm	1.3754–1.3764 in
• Camshaft Journal Diameter – Middle and Rear Number 2–4	26.936–26.960 mm	1.0605–1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040–0.084 mm	0.0016–0.0033 in
• Camshaft Lobe Lift – Exhaust	42.425–42.725 mm	1.6703–1.6821 in
• Camshaft Lobe Lift – Intake	42.385–42.685 mm	1.6687–1.6805 in
• Camshaft Runout – Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout – Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift – Exhaust	10.8 mm	0.4252 in
• Valve Lift – Intake	10.8 mm	0.4252 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010–0.070 mm	0.0004–0.0026 in

cardiagn.com

Application	Specification	
	Metric	English
• Connecting Rod Bore Diameter – Bearing End	59.620–59.636 mm	2.3472–2.3479 in
• Connecting Rod Bore Diameter – Pin End – Production	24.009–24.019 mm	0.9452–0.9456 in
• Connecting Rod Bore Diameter – Pin End – Service Maximum	24.021 mm	0.9457 in
• Connecting Rod Length – Center to Center	152.400 mm	6.0000 in
• Connecting Rod Side Clearance	0.095–0.355 mm	0.00037–0.0140 in
• Connecting Rod Width – Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
• Connecting Rod Width – Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	55.992–56.008 mm	2.2044–2.2050 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		

cardiagn.com

Application	Specification	
	Metric	English
• Production	22.000 mm	0.8661 in
• Service	21.920–22.080 mm	0.8630–0.8693 in
• Crankshaft End Play	0.100–0.330 mm	0.0039–0.0130 in
• Crankshaft Main Bearing Clearance	0.031–0.069 mm	0.0012–0.0027 in
• Crankshaft Main Journal Diameter	67.992–68.008 mm	2.6768–2.6775 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000–0.040 mm	0.0000–0.0016 in
• Square	0.000–0.010 mm	0.0000–0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	24.000 mm	0.9449 in
• Service	23.900–24.100 mm	0.9409–0.9488 in
• Crankshaft Main Journal Width, #3		
• Production	24.400 mm	0.9606 in
• Service	24.360–24.440 mm	0.9591–0.9622 in
• Crankshaft Pilot Bearing Bore Diameter		0.8254–0.8266 in

cardiagn.com

Application	Specification	
	Metric	English
	20.965–20.995 mm	
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout – Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076–0.305 mm	0.0030–0.0120 in
• Crankshaft Thrust Surface – Height Diameter	95.000 mm	3.7401 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore – Exhaust	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Bore – Intake	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Installed Height	14.050–14.550 mm	0.5531–0.5728 in
• Valve Lifter Bore Diameter	12.008–12.030 mm	0.4728–0.4736 in
Lubrication System		
• Oil Capacity – with Filter	5.7 Liters	6.0 Quarts
• Oil Capacity – without Filter	5.2 Liters	5.5 Quarts
• Oil Pressure – Minimum @ Idle	69 kPa	10 psi
• Oil Pressure – Minimum @ 2,000 RPM	207 kPa	30 psi

cardiagn.com

Application	Specification	
	Metric	English
• Piston Cooling Jet Valve Opening Pressure	2.7 bar	35 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring – Nominal	0.150–0.250 mm	0.0059–0.0098 in
• First Compression Ring – Maximum, Ring in Bore	0.290 mm	0.0114 in
• Second Compression Ring – Nominal	0.300–0.450 mm	0.0118–0.0177 in
• Second Compression Ring – Maximum, Ring in Bore	0.490 mm	0.0193 in
• Oil Control Ring	0.150–0.350 mm	0.0059–0.0138 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.030–0.075 mm	0.0012–0.0030 in
• Second Compression Ring	0.015–0.060 mm	0.0006–0.0024 in
• Oil Control Ring	0.030–0.170 mm	0.0012–0.0067 in
• Piston Ring Thickness		
• First Compression Ring	0.975–0.990 mm	0.0384–0.0390 in
• Second Compression Ring	1.170–1.195 mm	0.0461–0.0470 in
• Oil Control Ring	1.360–1.480 mm	0.0535–0.0583 in

cardiagn.com

Application	Specification	
	Metric	English
Pistons and Pins		
• Piston		
• Piston Diameter – Measured Over Skirt Coating	93.976–94.014 mm	3.6998–3.7013 in
• Piston Diameter – Service Limit Minimum w/more than 10K miles	93.926 mm	3.6979 in
• Piston Pin Bore Diameter	24.004–24.009 mm	0.9450–0.9452 in
• Piston Ring Groove Width – First Compression Ring	1.020–1.050 mm	0.0402–0.0413 in
• Piston Ring Groove Width – Second Compression Ring	1.210–1.230 mm	0.0476–0.0484 in
• Piston Ring Groove Width – Oil Control Ring	1.510–1.530 mm	0.0594–0.0602 in
• Piston to Bore Clearance – Production; Measured at Skirt Coating	0.022–0.032 mm	0.0009–0.0013 in
• Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore – Production	0.009–0.022 mm	0.0004–0.0009 in
• Piston Pin Clearance to Connecting Rod Bore – Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore – Production	0.004–0.012 mm	0.0002–0.0005 in
	0.015 mm	0.0006 in

cardiagn.com

Application	Specification	
	Metric	English
• Piston Pin Clearance to Piston Pin Bore – Service Maximum		
• Piston Pin Diameter	23.997–24.000 mm	0.9448–0.9449 in
• Piston Pin Length	52.600–53.100 mm	2.0709–2.0906 in
Valve System		
• Valves		
• Valve Face Angle	44.25 degrees	
• Valve Face Runout	0.0500 mm	0.0020 in
• Valve Face Width – Exhaust	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Face Width – Intake	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Head Diameter – Exhaust	30.470–30.730 mm	1.1996–1.2098 in
• Valve Head Diameter – Intake	38.170–38.430 mm	1.5028–1.5130 in
• Valve Installed Height	35.23–36.69 mm	1.3870–1.4445 in
• Valve Length – Exhaust	95.11 mm	3.74 in
• Valve Length – Intake	100.630 mm	3.9618 in
• Valve Seat Angle – Seating Surface	45 degrees	
• Valve Seat Angle – Relief Surface	30 degrees	
• Valve Seat Angle – Undercut Surface	60 degrees	

cardiagn.com

Application	Specification	
	Metric	English
• Valve Seat Roundness– Maximum	0.025 mm	0.0010 in
• Valve Seat Runout – Maximum	0.080 mm	0.0031 in
• Valve Seat Width – Exhaust Seating Surface	1.400–1.800 mm	0.0551–0.0709 in
• Valve Seat Width – Exhaust Relief Surface	0.700–0.900 mm	0.0276–0.0354 in
• Valve Seat Width – Intake Seating Surface	1.000–1.400 mm	0.0394–0.0551 in
• Valve Seat Width – Intake Relief Surface	0.500–0.700 mm	0.0197–0.0276 in
• Valve Stem Diameter – Exhaust	5.945–5.965 mm	0.2341–0.2348 in
• Valve Stem Diameter – Intake	5.945–5.965 mm	0.2341–0.2348 in
• Valve Stem-to-Guide Clearance – Exhaust	0.035–0.075 mm	0.0014–0.0030 in
• Valve Stem-to-Guide Clearance – Intake	0.035–0.075 mm	0.0014–0.0030 in
• Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)		
• Valve Lifter (SHLA) Diameter	11.989–12.000 mm	0.4720–0.4724 in
• Valve Lifter (SHLA)-to-Bore Clearance	0.008–0.041 mm	0.0003–0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.750–17.800 mm	0.6988–0.7008 in

cardiagn.com

Application	Specification	
	Metric	English
• Valve Springs		
• Valve Spring Coil Thickness	3.250 x 3.900 mm	0.1280 x 0.1535 in
• Valve Spring Diameter – Inside Top	12.200–12.700 mm	0.4803–0.5000 in
• Valve Spring Diameter – Outside Top	20.250 mm	0.7972 in
• Valve Spring Diameter – Inside Bottom	17.950–18.450 mm	0.7067–0.7264 in
• Valve Spring Diameter – Outside Bottom	26.000 mm	1.0236 in
• Valve Spring Free Length	42.500–45.500 mm	1.6732–1.7913 in
• Valve Spring Installed Height – Closed	35.000 mm	1.3779 in
• Valve Spring Installed Height – Open	24.000 mm	0.9449 in
• Valve Spring Load – Closed	247–273 N	56–61 lb
• Valve Spring Load – Open	598–662 N	134–149 lb

cardiagn.com

Engine Mechanical Specifications (LWR)

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.6 Liter	217 cu in
• RPO	LWR	
• VIN	4	
• Bore	94 mm	3.7008 in
• Stroke	85.6 mm	3.37 in
• Compression Ratio	12.2:1	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	0.7 mm	0.0276 in
Block		
• Crankshaft Main Bearing Bore Diameter	72.867–72.881 mm	2.8688–2.8693 in
• Cylinder Bore Diameter	93.992–94.008 mm	3.7005–3.7011 in
• Cylinder Bore Out-of-Round – Production Max.	0.026 mm	0.001 in
• Cylinder Bore Taper	0.020 mm	0.0008 in

© 2014 General Motors. All rights reserved.

cardiagn.com

Application	Specification	
	Metric	English
Camshaft		
• Camshaft Bearing Inside Diameter – Front Number 1	35.000–35.020 mm	1.3779–1.3787 in
• Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4	27.000–27.020 mm	1.0630–1.0638 in
• Camshaft End Play	0.045–0.215 mm	0.0018–0.0085 in
• Camshaft Journal Diameter – Front Number 1	34.936–34.960 mm	1.3754–1.3764 in
• Camshaft Journal Diameter – Middle and Rear Number 2–4	26.936–26.960 mm	1.0605–1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040–0.084 mm	0.0016–0.0033 in
• Camshaft Lobe Lift – Exhaust	42.425–42.725 mm	1.6703–1.6821 in
• Camshaft Lobe Lift – Intake	42.385–42.685 mm	1.6687–1.6805 in
• Camshaft Runout – Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout – Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift – Exhaust	10.8 mm	0.4252 in
• Valve Lift – Intake	10.8 mm	0.4252 in
Connecting Rod		
• Connecting Rod Bearing Clearance	0.010–0.070 mm	0.0004–0.0028 in

cardiagn.com

Application	Specification	
	Metric	English
• Connecting Rod Bore Diameter – Bearing End	59.620–59.636 mm	2.3472–2.3479 in
• Connecting Rod Bore Diameter – Pin End – Production	24.009–24.019 mm	0.9452–0.9456 in
• Connecting Rod Bore Diameter – Pin End – Service Maximum	24.021 mm	0.9457 in
• Connecting Rod Length – Center to Center	150.400 mm	5.9212 in
• Connecting Rod Side Clearance	0.095–0.355 mm	0.0374–0.0140 in
• Connecting Rod Width – Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
• Connecting Rod Width – Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	55.992–56.008 mm	2.2044–2.2050 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in
• Connecting Rod Journal Width		

cardiagn.com

Application	Specification	
	Metric	English
• Production	22.000 mm	0.8661 in
• Service	21.920–22.080 mm	0.8630–0.8693 in
• Crankshaft End Play	0.100–0.330 mm	0.0039–0.0130 in
• Crankshaft Main Bearing Clearance	0.031–0.069 mm	0.0012–0.0027 in
• Crankshaft Main Journal Diameter	67.992–68.008 mm	2.6768–2.6775 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000–0.040 mm	0.0000–0.0016 in
• Square	0.000–0.010 mm	0.0000–0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	24.000 mm	0.9449 in
• Service	23.900–24.100 mm	0.9409–0.9488 in
• Crankshaft Main Journal Width, #3		
• Production	24.400 mm	0.9606 in
• Service	24.360–24.440 mm	0.9591–0.9622 in
• Crankshaft Pilot Bearing Bore Diameter		0.8254–0.8266 in

cardiagn.com

Application	Specification	
	Metric	English
	20.965–20.995 mm	
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout – Maximum	1.500 mm	0.0591 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076–0.305 mm	0.0030–0.0120 in
• Crankshaft Thrust Surface – Height Diameter	95.000 mm	3.7401 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore – Exhaust	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Bore – Intake	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Installed Height	14.050–14.550 mm	0.5531–0.5728 in
• Valve Lifter Bore Diameter	12.008–12.030 mm	0.4728–0.4736 in
Lubrication System		
• Oil Capacity – with Filter	6.7 Liters	7.1 Quarts
• Oil Capacity – without Filter	6.3 Liters	6.7 Quarts
• Oil Pressure – Minimum @ Idle	69 kPa	10 psi
• Oil Pressure – Minimum @ 2,000 RPM	207 kPa	30 psi

cardiagn.com

Application	Specification	
	Metric	English
• Piston Cooling Jet Valve Opening Pressure	2.7 bar	35 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring – Nominal	0.150–0.300 mm	0.0059–0.0118 in
• First Compression Ring – Maximum, Ring in Bore	0.390 mm	0.1535 in
• Second Compression Ring – Nominal	0.280–0.480 mm	0.0110–0.0189 in
• Second Compression Ring – Maximum, Ring in Bore	0.560 mm	0.0220 in
• Oil Control Ring	0.150–0.600 mm	0.0059–0.0236 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.030–0.065 mm	0.0012–0.0026 in
• Second Compression Ring	0.015–0.060 mm	0.0006–0.0024 in
• Oil Control Ring	0.030–0.170 mm	0.0012–0.0067 in
• Piston Ring Thickness		
• First Compression Ring	1.175–1.190 mm	0.0463–0.0469 in
• Second Compression Ring	1.470–1.495 mm	0.0579–0.0589 in
• Oil Control Ring	2.360–2.480 mm	0.0929–0.0976 in

cardiagn.com

Application	Specification	
	Metric	English
Pistons and Pins		
• Piston		
• Piston Diameter – Measured Over Skirt Coating	93.976–94.014 mm	3.6998–3.7013 in
• Piston Diameter – Service Limit Minimum w/more than 10K miles	93.926 mm	3.6979 in
• Piston Pin Bore Diameter	24.004–24.009 mm	0.9450–0.9452 in
• Piston Ring Groove Width – First Compression Ring	1.020–1.050 mm	0.0402–0.0414 in
• Piston Ring Groove Width – Second Compression Ring	1.210–1.230 mm	0.0476–0.0484 in
• Piston Ring Groove Width – Oil Control Ring	1.510–1.530 mm	0.0594–0.0602 in
• Piston to Bore Clearance – Production; Measured at Skirt Coating	0.022–0.032 mm	0.0008–0.0013 in
• Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore – Production	0.007–0.024 mm	0.0003–0.0010 in
• Piston Pin Clearance to Connecting Rod Bore – Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore – Production	0.004–0.012 mm	0.0002–0.0005 in
	0.015 mm	0.0006 in

cardiagn.com

Application	Specification	
	Metric	English
• Piston Pin Clearance to Piston Pin Bore – Service Maximum		
• Piston Pin Diameter	23.997–24.000 mm	0.9448–0.9449 in
• Piston Pin Length	60.600–61.100 mm	2.3858–2.4055 in
Valve System		
• Valves		
• Valve Face Angle	44.25 degrees	
• Valve Face Runout	0.050 mm	0.0020 in
• Valve Face Width – Exhaust	2.750 mm	0.1083 in
• Valve Face Width – Intake	2.180 mm	0.0858 in
• Valve Head Diameter – Exhaust	30.470–30.730 mm	1.1996–1.2098 in
• Valve Head Diameter – Intake	36.830–37.090 mm	1.4500–1.4602 in
• Valve Installed Height	35.23–36.69 mm	1.3870–1.4445 in
• Valve Length – Exhaust	97.110 mm	3.8232 in
• Valve Length – Intake	101.230 mm	3.9854 in
• Valve Seat Angle – Seating Surface	45 degrees	
• Valve Seat Angle – Relief Surface	30 degrees	
• Valve Seat Angle – Undercut Surface	60 degrees	

cardiagn.com

Application	Specification	
	Metric	English
• Valve Seat Roundness– Maximum	0.025 mm	0.0010 in
• Valve Seat Runout – Maximum	0.080 mm	0.0032 in
• Valve Seat Width – Exhaust Seating Surface	1.400–1.800 mm	0.0551–0.0709 in
• Valve Seat Width – Exhaust Relief Surface	0.700–0.900 mm	0.0276–0.0354 in
• Valve Seat Width – Intake Seating Surface	1.000–1.400 mm	0.0394–0.0551 in
• Valve Seat Width – Intake Relief Surface	0.500–0.700 mm	0.0197–0.0276 in
• Valve Stem Diameter – Exhaust	5.945–5.965 mm	0.2341–0.2348 in
• Valve Stem Diameter – Intake	5.955–5.975 mm	0.2344–0.2352 in
• Valve Stem-to-Guide Clearance – Exhaust	0.035–0.075 mm	0.0014–0.0030 in
• Valve Stem-to-Guide Clearance – Intake	0.025–0.065 mm	0.0010–0.0026 in
• Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)		
• Valve Lifter (SHLA) Diameter	11.989–12.000 mm	0.4720–0.4724 in
• Valve Lifter (SHLA)-to-Bore Clearance	0.008–0.041 mm	0.0003–0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.750–17.800 mm	0.6988–0.7008 in

cardiagn.com

Application	Specification	
	Metric	English
• Valve Springs		
• Valve Spring Coil Thickness	3.250 x 3.900 mm	0.1280 x 0.1535 in
• Valve Spring Diameter – Inside Top	12.200–12.700 mm	0.4803–0.4999 in
• Valve Spring Diameter – Outside Top	20.250 mm	0.7972 in
• Valve Spring Diameter – Inside Bottom	17.950–18.450 mm	0.7067–0.7264 in
• Valve Spring Diameter – Outside Bottom	26.000 mm	1.0236 in
• Valve Spring Free Length	42.500–45.500 mm	1.6732–1.7913 in
• Valve Spring Installed Height – Closed	35.000 mm	1.3779 in
• Valve Spring Installed Height – Open	24.000 mm	0.9449 in
• Valve Spring Load – Closed	247–273 N	56–61 lb
• Valve Spring Load – Open	598–662 N	134–149 lb

cardiagn.com

Engine Mechanical Specifications (LFW)

Engine Mechanical Specifications

Application	Specification	
	Metric	English
General		
• Engine Type	V-6	
• Displacement	3.0 Liter	183 cu in
• RPO	LFW	
• VIN	5-cars/5-trucks	
• Bore	89 mm	3.5039 in
• Stroke	80.3 mm	3.1614 in
• Compression Ratio	11.7:1	
• Idle Speed RPM (AT)	600 A/C Off - 600 A/C On	
• Firing Order	1-2-3-4-5-6	
• Spark Plug Gap	1.1 mm	0.0433 in
Block		
• Crankshaft Main Bearing Bore Diameter	72.867–72.881 mm	2.8688–2.8693 in
• Cylinder Bore Diameter	88.992–89.008 mm	3.5036–3.5042 in
• Cylinder Bore Out-of-Round – Production Max.	0.026 mm	0.001 in

© 2014 General Motors. All rights reserved.

cardiagn.com

Application	Specification	
	Metric	English
• Cylinder Bore Taper	0.020 mm	0.0008 in
Camshaft		
• Camshaft Bearing Inside Diameter – Front Number 1	35.000–35.020 mm	1.3779–1.3787 in
• Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4	27.000–27.020 mm	1.0630–1.0638 in
• Camshaft End Play	0.045–0.215 mm	0.0018–0.0085 in
• Camshaft Journal Diameter – Front Number 1	34.936–34.960 mm	1.3754–1.3764 in
• Camshaft Journal Diameter – Middle and Rear Number 2–4	26.936–26.960 mm	1.0605–1.0614 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Journal to Bore Clearance	0.040–0.084 mm	0.0016–0.0033 in
• Camshaft Lobe Lift – Exhaust	42.456–42.756 mm	1.6715–1.6833 in
• Camshaft Lobe Lift – Intake	42.385–42.685 mm	1.6687–1.6805 in
• Camshaft Runout – Front and Rear Number 1 and 4	0.025 mm	0.0010 in
• Camshaft Runout – Middle 2 and 3	0.050 mm	0.0020 in
• Valve Lift – Exhaust	10.8 mm	0.4252 in
• Valve Lift – Intake	10.8 mm	0.4252 in
Connecting Rod		

cardiagn.com

Application	Specification	
	Metric	English
• Connecting Rod Bearing Clearance	0.010–0.070 mm	0.0004–0.0028 in
• Connecting Rod Bore Diameter – Bearing End	59.620–59.636 mm	2.3472–2.3479 in
• Connecting Rod Bore Diameter – Pin End – Production	24.009–24.019 mm	0.9452–0.9456 in
• Connecting Rod Bore Diameter – Pin End – Service Maximum	24.007 mm	0.9457 in
• Connecting Rod Length – Center to Center	156.05 mm	6.1437 in
• Connecting Rod Side Clearance	0.095–0.355 mm	0.0037–0.0140 in
• Connecting Rod Width – Bearing End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
• Connecting Rod Width – Pin End		
• Production	21.775 mm	0.8573 in
• Service	21.725–21.825 mm	0.8553–0.8593 in
Crankshaft		
• Connecting Rod Journal Diameter	55.992–56.008 mm	2.2044–2.2050 in
• Connecting Rod Journal Out-of-Round	0.005 mm	0.0002 in
• Connecting Rod Journal Taper	0.005 mm	0.0002 in

cardiagn.com

Application	Specification	
	Metric	English
• Connecting Rod Journal Width		
• Production	22.000 mm	0.8661 in
• Service	21.920–22.080 mm	0.8630–0.8693 in
• Crankshaft End Play	0.100–0.330 mm	0.0039–0.0130 in
• Crankshaft Main Bearing Clearance	0.031–0.069 mm	0.0012–0.0027 in
• Crankshaft Main Journal Diameter	68.000 mm	2.6772 in
• Crankshaft Main Journal Out-of-Round	0.005 mm	0.0002 in
• Crankshaft Main Journal Taper	0.005 mm	0.0002 in
• Crankshaft Main Journal Thrust Wall		
• Runout	0.000–0.040 mm	0.0000–0.0016 in
• Square	0.000–0.010 mm	0.0000–0.0004 in
• Crankshaft Main Journal Width, #2, 4		
• Production	24.000 mm	0.9449 in
• Service	23.900–24.100 mm	0.9409–0.9488 in
• Crankshaft Main Journal Width, #3		
• Production	24.400 mm	0.9606 in
• Service		0.9591–0.9622 in

cardiagn.com

Application	Specification	
	Metric	English
	24.360–24.440 mm	
• Crankshaft Pilot Bearing Bore Diameter	20.965–20.995 mm	0.8254–0.8266 in
• Crankshaft Rear Flange Runout	0.025 mm	0.0010 in
• Crankshaft Reluctor Ring Runout – Maximum	2.000 mm	0.0787 in
• Crankshaft Runout	0.030 mm	0.0012 in
• Crankshaft Thrust Bearing Clearance	0.076–0.305 mm	0.0030–0.0120 in
• Crankshaft Thrust Surface – Height Diameter	95.000 mm	3.7401 in
• Crankshaft Thrust Surface Runout	0.040 mm	0.0016 in
Cylinder Head		
• Valve Guide Bore – Exhaust	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Bore – Intake	6.000–6.020 mm	0.2362–0.2370 in
• Valve Guide Installed Height	14.050–14.550 mm	0.5531–0.5728 in
• Valve Lifter Bore Diameter	12.008–12.030 mm	0.4728–0.4736 in
Lubrication System		
• Oil Capacity – With or Without Oil Filter Change	5.7 Liters	6 Quarts
• Oil Pressure – Minimum @ Idle	69 kPa	10 psi
• Oil Pressure – Minimum @ 2,000 RPM	207 kPa	30 psi

cardiagn.com

Application	Specification	
	Metric	English
• Piston Cooling Jet Valve Opening Pressure	2.7 bar	35 psi
Piston Rings		
• Piston Ring End Gap		
• First Compression Ring – Nominal	0.150–0.300 mm	0.0059–0.0118 in
• First Compression Ring – Maximum, Ring in Bore	0.350 mm	0.1378 in
• Second Compression Ring – Nominal	0.280–0.480 mm	0.0110–0.0189 in
• Second Compression Ring – Maximum, Ring in Bore	0.450 mm	0.0177 in
• Oil Control Ring	0.150–0.600 mm	0.0059–0.0236 in
• Piston Ring to Groove Clearance		
• First Compression Ring	0.030–0.065 mm	0.0012–0.0026 in
• Second Compression Ring	0.015–0.060 mm	0.0006–0.0024 in
• Oil Control Ring	0.030–0.170 mm	0.0012–0.0669 in
• Piston Ring Thickness		
• First Compression Ring	1.175–1.190 mm	0.0463–0.0469 in
• Second Compression Ring	1.470–1.495 mm	0.0579–0.0589 in
• Oil Control Ring	2.360–2.480 mm	0.0929–0.0976 in

cardiagn.com

Application	Specification	
	Metric	English
Pistons and Pins		
• Piston		
• Piston Diameter – Measured Over Skirt Coating	88.976–89.014 mm	3.5029–3.5045 in
• Piston Diameter – Service Limit Minimum, w/more than 10k miles	88.926 mm	3.5010 in
• Piston Pin Bore Diameter	24.007–24.012 mm	0.9452–0.9454 in
• Piston Ring Groove Width – First Compression Ring	1.220–1.240 mm	0.0480–0.0488 in
• Piston Ring Groove Width – Second Compression Ring	1.510–1.530 mm	0.0595–0.0602 in
• Piston Ring Groove Width – Oil Control Ring	2.510–2.530 mm	0.0988–0.0996 in
• Piston to Bore Clearance – Production; Measured at Skirt Coating	0.022–0.032 mm	0.0008–0.0013 in
• Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles	0.050 mm	0.0020 in
• Pin		
• Piston Pin Clearance to Connecting Rod Bore – Production	0.007–0.024 mm	0.0003–0.0010 in
• Piston Pin Clearance to Connecting Rod Bore – Service Maximum	0.030 mm	0.0012 in
• Piston Pin Clearance to Piston Pin Bore – Production	0.007–0.015 mm	0.0003–0.0006 in
	0.015 mm	0.0006 in

cardiagn.com

Application	Specification	
	Metric	English
• Piston Pin Clearance to Piston Pin Bore – Service Maximum		
• Piston Pin Diameter	23.997–24.000 mm	0.9448–0.9449 in
• Piston Pin Length	60.60–61.10 mm	2.3858–2.4055 in
Valve System		
• Valves		
• Valve Face Angle	44.25 degrees	
• Valve Face Runout	0.050 mm	0.0020 in
• Valve Face Width – Exhaust	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Face Width – Intake	DO NOT GRIND, REPLACE VALVE	DO NOT GRIND, REPLACE VALVE
• Valve Head Diameter – Exhaust	30.470–30.730 mm	1.1996–1.2098 in
• Valve Head Diameter – Intake	35.03–35.29 mm	1.3791–1.3894 in
• Valve Installed Height	35.23–36.69 mm	1.3870–1.4445 in
• Valve Length – Exhaust	97.11 mm	3.8232 in
• Valve Length – Intake	101.23 mm	3.9854 in
• Valve Seat Angle – Seating Surface	45 degrees	
• Valve Seat Angle – Relief Surface	30 degrees	
• Valve Seat Angle – Undercut Surface	60 degrees	

cardiagn.com

Application	Specification	
	Metric	English
• Valve Seat Roundness– Maximum	0.025 mm	0.0010 in
• Valve Seat Runout – Maximum	0.080 mm	0.0032 in
• Valve Seat Width – Exhaust Seating Surface	1.400–1.800 mm	0.0551–0.0709 in
• Valve Seat Width – Exhaust Relief Surface	0.700–0.900 mm	0.0276–0.0354 in
• Valve Seat Width – Intake Seating Surface	1.000–1.400 mm	0.0394–0.0551 in
• Valve Seat Width – Intake Relief Surface	0.500–0.700 mm	0.0197–0.0276 in
• Valve Stem Diameter – Exhaust	5.945–5.965 mm	0.2341–0.2348 in
• Valve Stem Diameter – Intake	5.955–5.975 mm	0.2344–0.2352 in
• Valve Stem-to-Guide Clearance – Exhaust	0.035–0.075 mm	0.0014–0.0030 in
• Valve Stem-to-Guide Clearance – Intake	0.025–0.065 mm	0.0010–0.0026 in
• Valve Lifters – Stationary Hydraulic Lifter Assembly (SHLA)		
• Valve Lifter (SHLA) Diameter	11.989–12.000 mm	0.4720–0.4724 in
• Valve Lifter (SHLA)-to-Bore Clearance	0.037–0.041 mm	0.0015–0.0016 in
• Rocker Arms		
• Valve Rocker Arm Ratio	1.68 to 1	
• Valve Rocker Arm Roller Diameter	17.740–17.800 mm	0.6987–0.7008 in

cardiagn.com

Application	Specification	
	Metric	English
• Valve Springs		
• Valve Spring Coil Thickness	3.250 x 3.900 mm	0.1280 x 0.1535 in
• Valve Spring Diameter – Inside Top	12.090–12.590 mm	0.4760–0.4957 in
• Valve Spring Diameter – Outside Top	20.140 mm	0.7929 in
• Valve Spring Diameter – Inside Bottom	17.950–18.450 mm	0.7067–0.7264 in
• Valve Spring Diameter – Outside Bottom	26.000 mm	1.0236 in
• Valve Spring Free Length	42.050–44.850 mm	1.6555–1.7657 in
• Valve Spring Installed Height – Closed	35.000 mm	1.3779 in
• Valve Spring Installed Height – Open	24.000 mm	0.9449 in
• Valve Spring Load – Closed	247–273 N	56–61 lb
• Valve Spring Load – Open	598–662 N	134–149 lb

cardiagn.com

Adhesives, Fluids, Lubricants, and Sealers

Adhesives, Fluids, Lubricants, and Sealers

Application	Type of Material	GM Part Number	
		United States	Canada
Block Pan Rail	Sealant	12378521	88901148
Camshaft Prelube	Lubricant	88862586	88862827
Coolant Drain Threaded Plug	Sealant	12346004	10953480
Coolant Expansion Plugs	Threadlocker	12345382	10953489
Coolant and Oil Plug Threads	Sealant	12346004	10953480
Crankshaft Bearing Surfaces	5W-30	19293000	19286321
Crankshaft Connecting Rod Bearing Journal	5W-30	19293000	19286321
Crankshaft Prelube	5W-30	19293000	19286321
Crankshaft Rear Oil Seal Housing	Sealant	12378521	88901148
Engine Front Cover/Split Lines	Sealant	12378521	88901148
Engine Oil	5W-30	19293000	19386321
Fuel Injection Fuel Rail Fuel Pressure Sensor Sealing Cone/Threads	5W-30	19293000	19286321
Fuel Rail Sealing Cone/Threads	5W-30	19293000	19286321
Ignition Coils	Lubricant	19260901	19260902
Oil Gallery Threaded Plug	Sealant	12346004	10953480
Oil Pan, Engine Front Cover, Crankshaft Rear Oil Seal Housing	Sealant	12378521 (150g cartridge)	88901148
		88861417 (75 gram squeeze tube)	88861418
Piston Pin Bores	5W-30	19293000	19286321
Positive Crankcase Ventilation (PCV) Orifice	Sealant	12378521	88901148

© 2014 General Motors. All rights reserved.

cardiagn.com

Application	Type of Material	GM Part Number	
		United States	Canada
Stationary Hydraulic Lash Adjuster (SHLA)	5W-30	19293000	19286321
SHLA Bores in Cylinder Head	5W-30	19293000	19286321
SHLA Pivot Spheres	5W-30	19293000	19286321
Thread Repair	Cleaner	88862650	88901247
	Threadlocker	89021297	10953488
Thread Repair Cutting Oil	Lubricant	1052864	992881
Valve Stem/Guide ID	5W-30	19293000	19286321

cardiagn.com

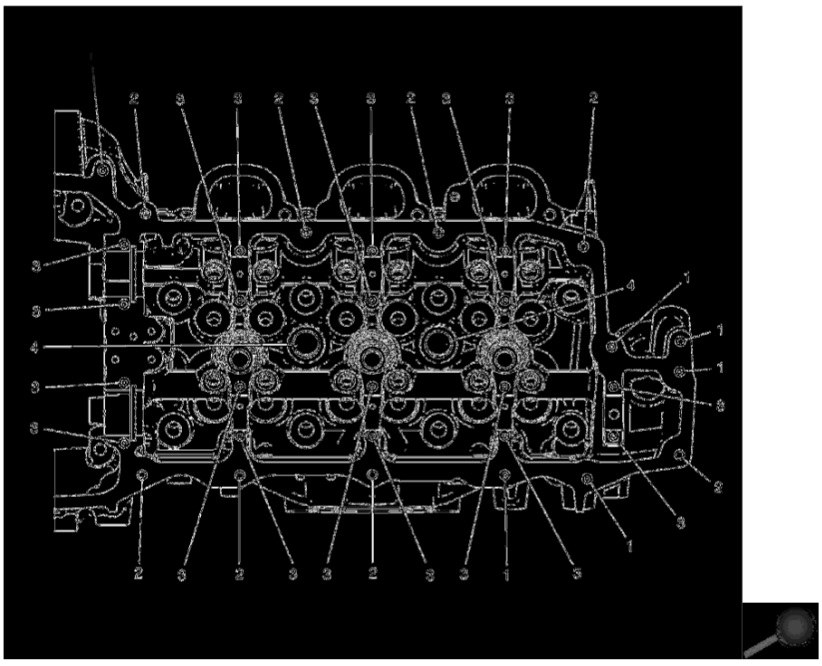
Thread Repair Specifications

Table 1: Left Cylinder Head Camshaft Cover Face
Table 2: Left Cylinder Head Front Face
Table 3: Left Cylinder Head Intake Face
Table 4: Left Cylinder Head Exhaust Face
Table 5: Left Cylinder Head Rear Face
Table 6: Right Cylinder Head Camshaft Cover Face
Table 7: Right Cylinder Head Front Face
Table 8: Right Cylinder Head Intake Face
Table 9: Right Cylinder Head Exhaust Face
Table 10: Right Cylinder Head Rear Face
Table 11: Engine Block Front
Table 12: Engine Block Left Side
Table 13: Engine Block Right Side
Table 14: Engine Block Rear
Table 15: Engine Block Bottom
Table 16: Engine Block Left Deck Face
Table 17: Engine Block Right Deck Face
Table 18: Engine Front Cover
Table 19: Upper Intake Manifold - Top
Table 20: Upper Intake Manifold - Front
Table 21: Upper Intake Manifold - Rear
Table 22: Lower Intake Manifold - Top
Table 23: Oil Pan Front
Table 24: Oil Pan Left Side
Table 25: Oil Pan Right Side
Table 26: Oil Pan Rear
Table 27: Oil Pan Top

Left Cylinder Head Camshaft Cover Face

cardiagn.com

© 2014 General Motors. All rights reserved.

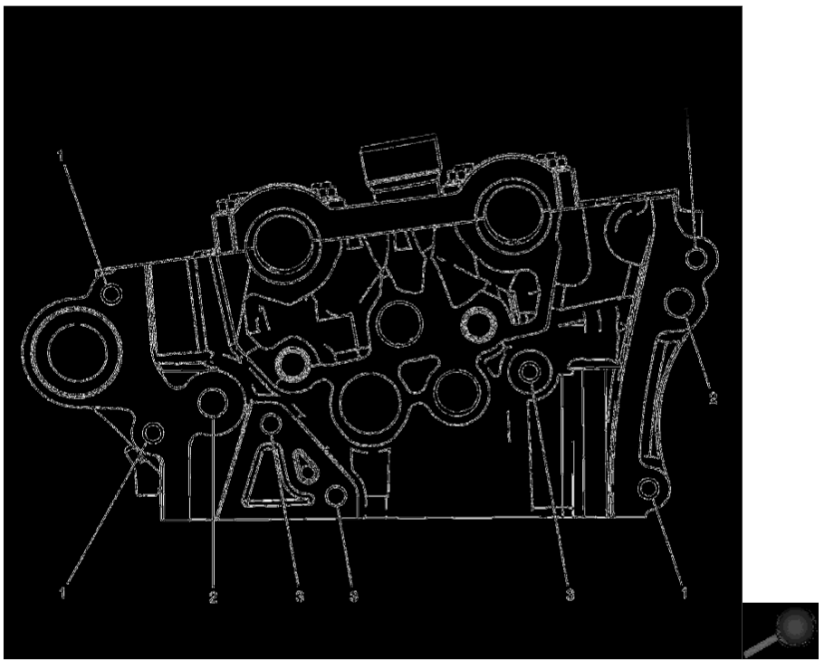


Left Cylinder Head Camshaft Cover Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
2	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
3	M6 x 1.0	701	N/A	N/A	203	204	205	28.5	1.1220	24.0	0.9449
4	M20 x 1.5	715	716	N/A	717	718	719	25.0	0.9842	17.0	0.6693

Left Cylinder Head Front Face

cardiagn.com

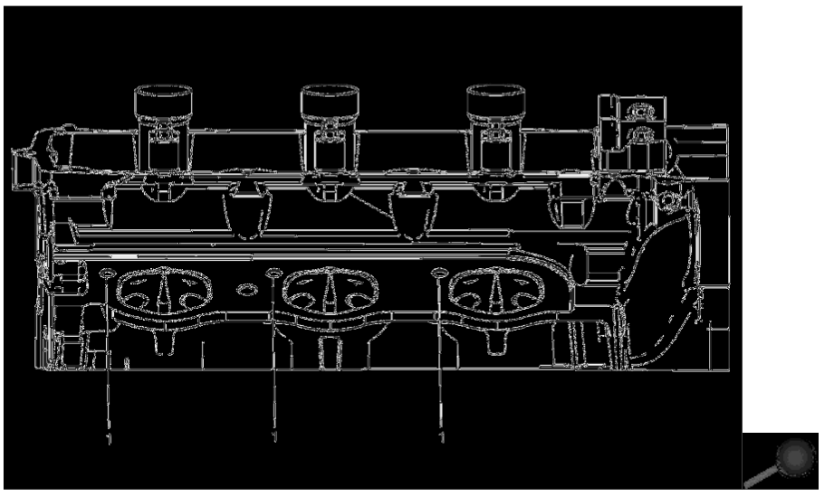


Left Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
2	M12 x 1.75	856	857	N/A	858	859	416	40.0	1.5748	32.5	1.2795
3	M8 x 1.25	206	207	N/A	208	209	210	18.0	0.7087	22.5	0.8858

Left Cylinder Head Intake Face

cardiagn.com

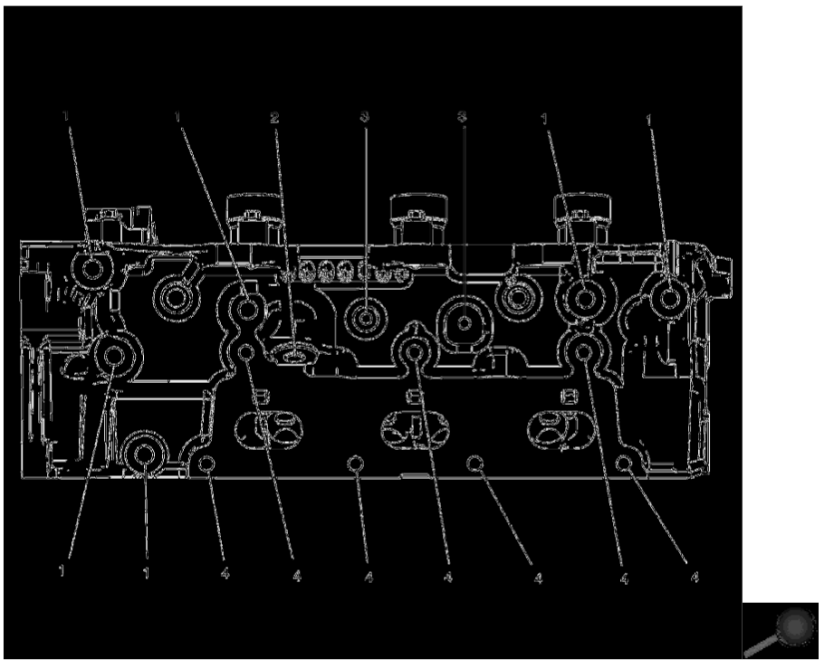


Left Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

Left Cylinder Head Exhaust Face

cardiagn.com

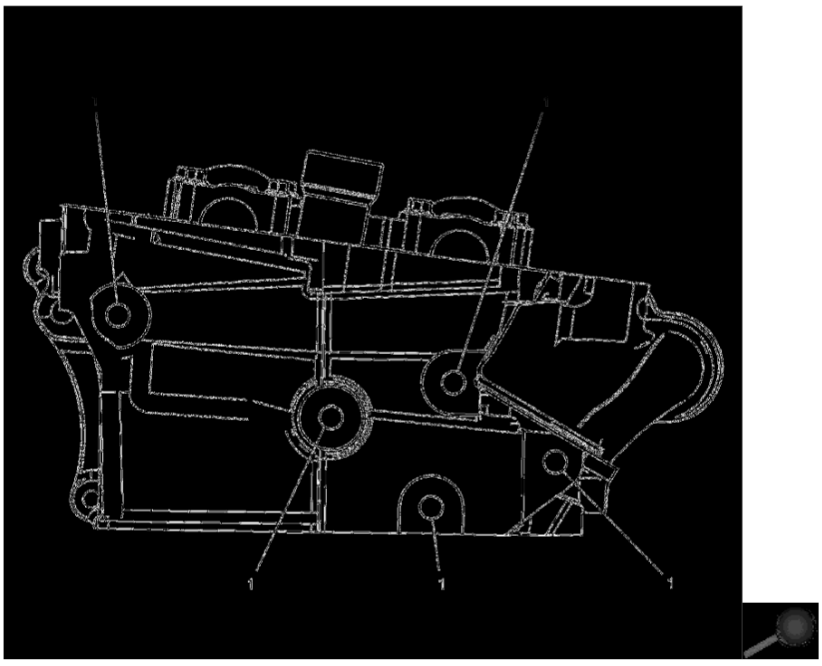


Left Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
2	M12 x 1.5	705	706	N/A	707	708	709	27.5	1.0827	13.0	0.5118
3	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.0000
4	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

Left Cylinder Head Rear Face

cardiagn.com

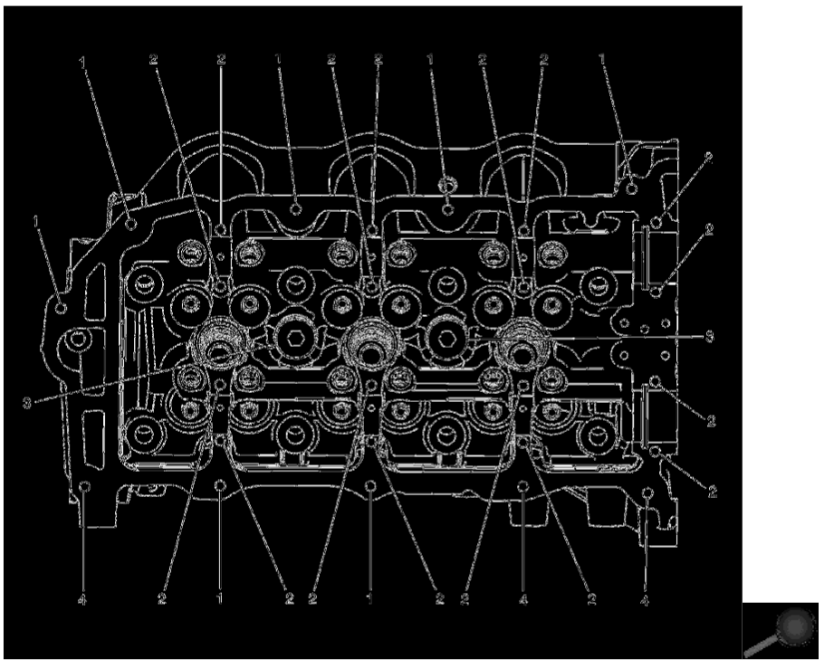


Left Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630

[Right Cylinder Head Camshaft Cover Face]

cardiagn.com

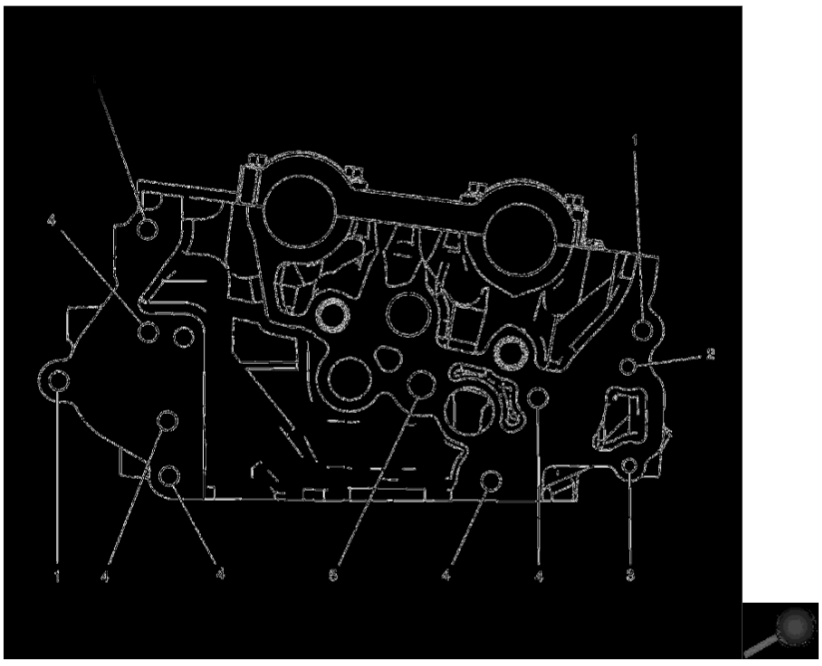


Right Cylinder Head Camshaft Cover Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M6 x 1.0	701	N/A	N/A	203	204	205	28.5	1.1220	24.0	0.9449
3	M20 x 1.5	715	716	N/A	717	718	719	25.0	0.9842	17.0	0.6693
4	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087

Right Cylinder Head Front Face

cardiagn.com

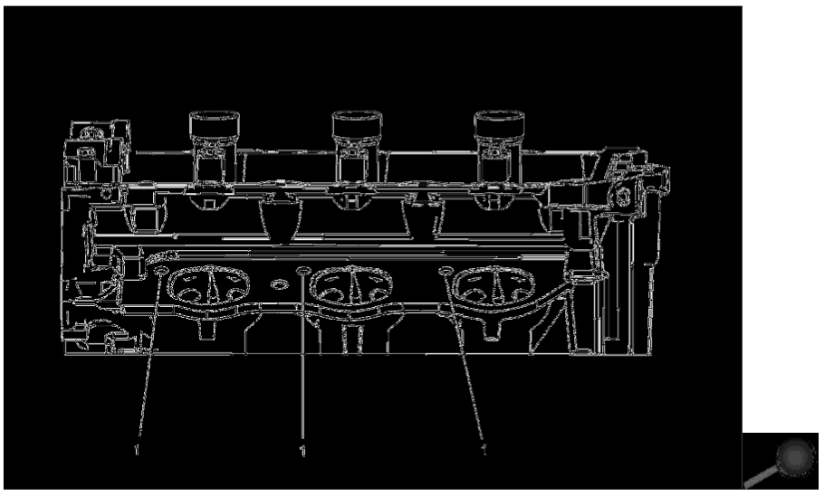


Right Cylinder Head Front Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
2	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8880	18.0	0.7087
3	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
4	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
5	M12 x 1.75	856	857	N/A	858	859	416	40.0	1.5748	32.5	1.2795

Right Cylinder Head Intake Face

cardiagn.com

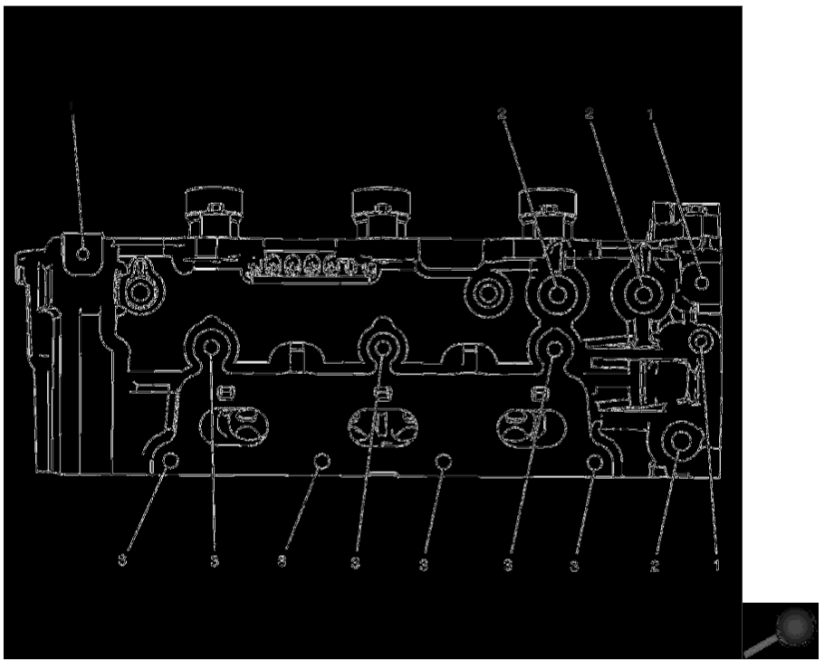


Right Cylinder Head Intake Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

[Right Cylinder Head Exhaust Face]

cardiagn.com

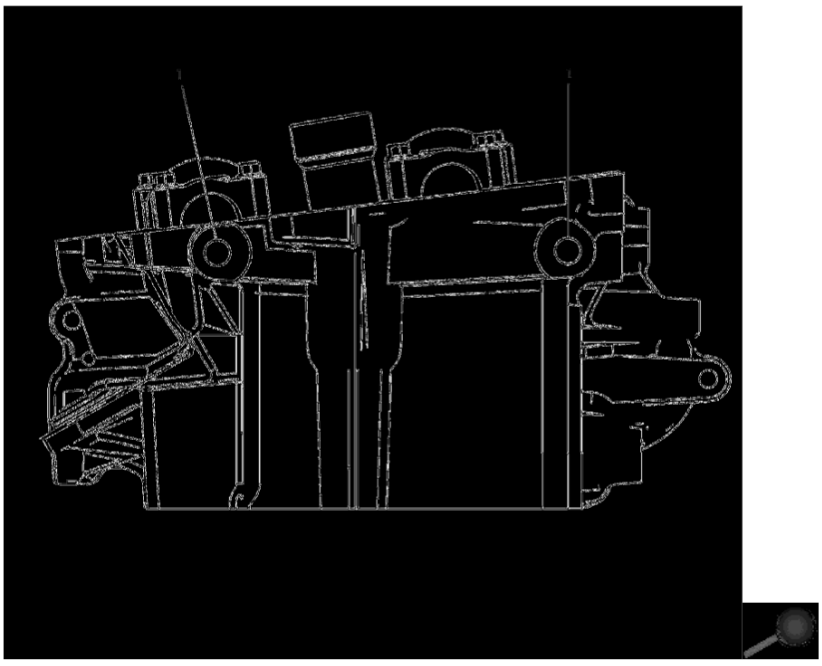


Right Cylinder Head Exhaust Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.0000
2	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
3	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

Right Cylinder Head Rear Face

cardiagn.com

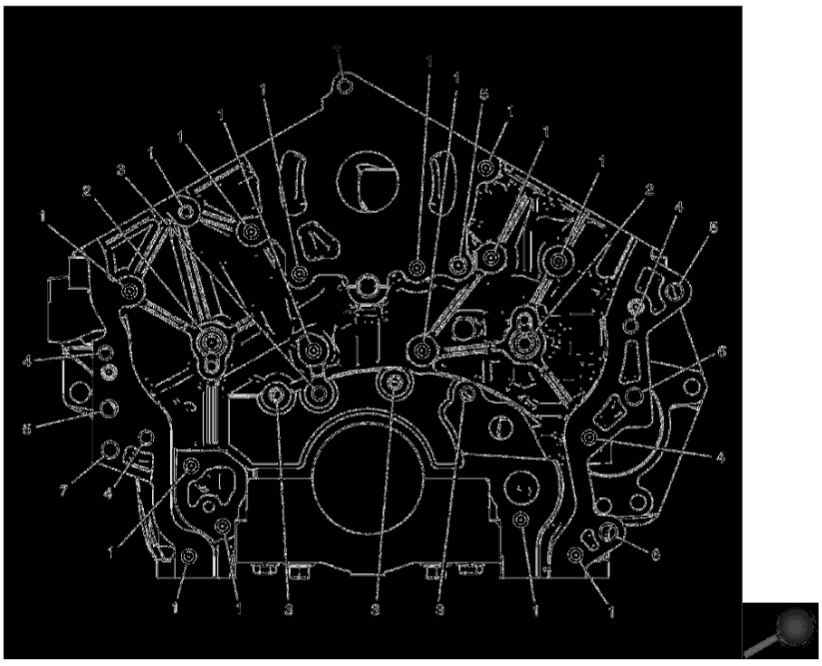


Right Cylinder Head Rear Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630

Engine Block Front

cardiagn.com

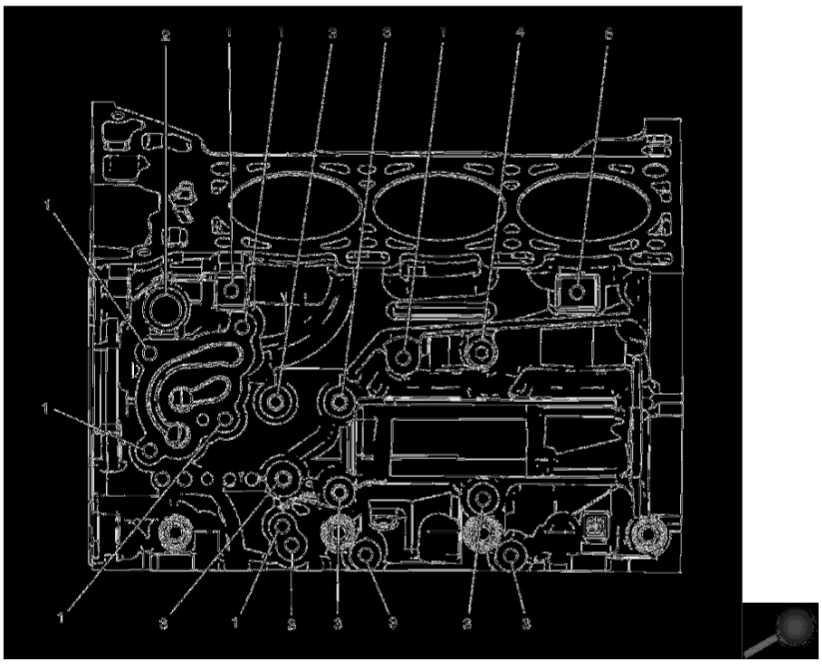


Engine Block Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3189	27.0	1.0630
3	M8 x 1.25	206	207	N/A	208	209	210	THRU		22.0	0.8661
4	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	
5	M10 x 1.5	211	212	N/A	213	214	215	28.0	1.1024	28.0	1.1024
6	M10 x 1.5	211	212	N/A	213	214	215	THRU		20.0	0.7874
7	M10 x 1.5	211	212	N/A	213	214	215	THRU		28.0	1.1024

Engine Block Left Side

cardiagn.com

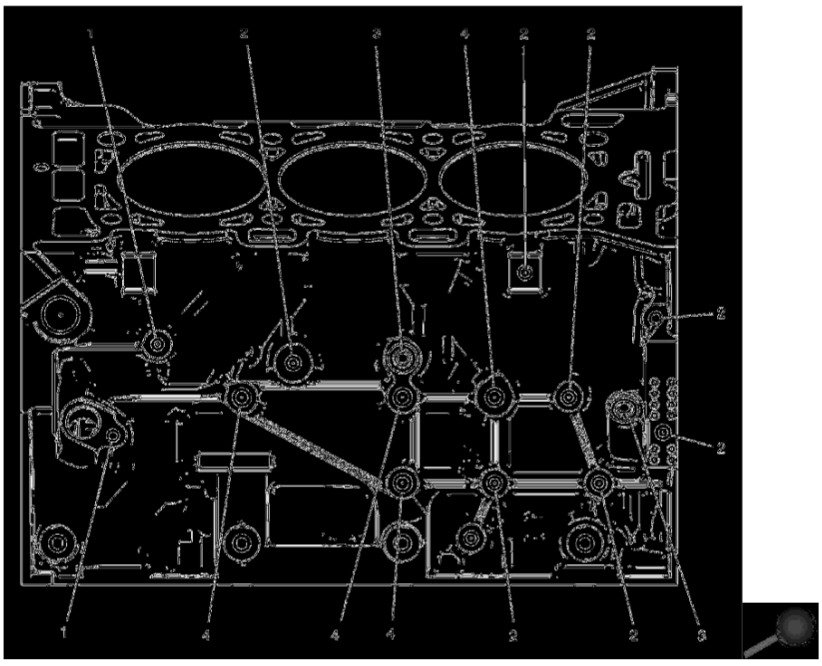


Engine Block Left Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M20 x 1.5	715	716	N/A	717	718	719	30.0	1.1810	20.0	0.7874
3	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3190	27.0	1.0630
4	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
5	M8 x 1.25	206	207	N/A	208	209	415	16.5	0.6496	11.0	0.4331

Engine Block Right Side

cardiagn.com

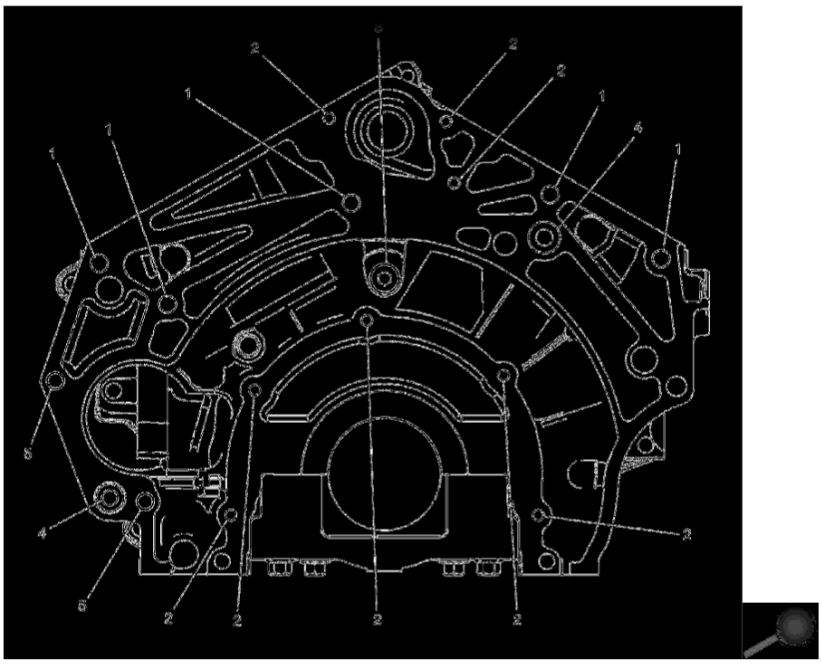


Engine Block Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
		J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
2	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
3	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
4	M10 x 1.5	211	212	N/A	213	214	215	33.5	1.3190	27.0	1.0630

Engine Block Rear

cardiagn.com

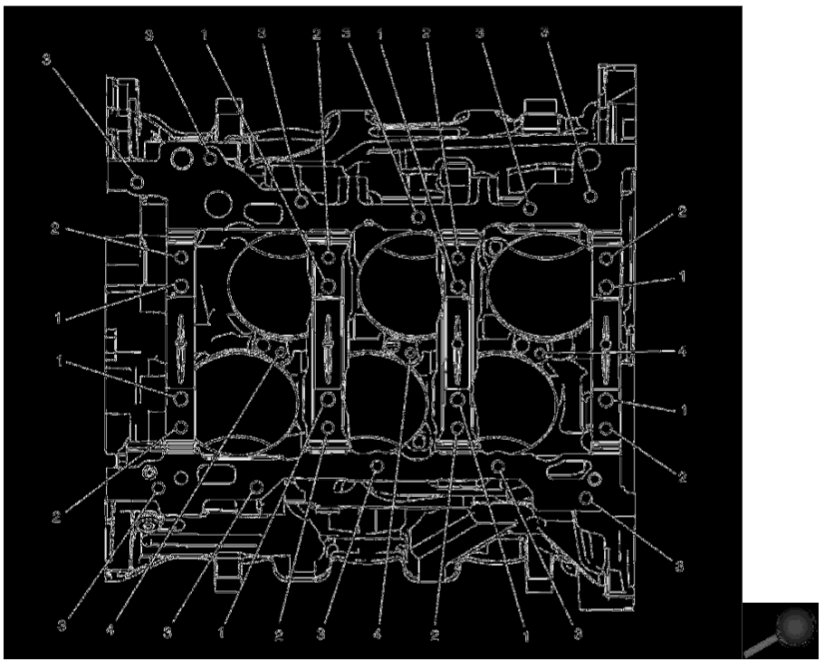


Engine Block Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3190	27.0	1.0630
2	M6 x 1.0	201	202	N/A	203	204	205	22.5	0.8858	18.0	0.7087
3	M14 x 1.5	409	410	N/A	411	412	735	THRU		15.0	0.5905
4	M10 x 1.5	211	212	N/A	213	214	216	39.5	1.5551	33.0	1.2992
5	M10 x 1.5	211	212	N/A	213	214	420	THRU		THRU	

Engine Block Bottom

cardiagn.com

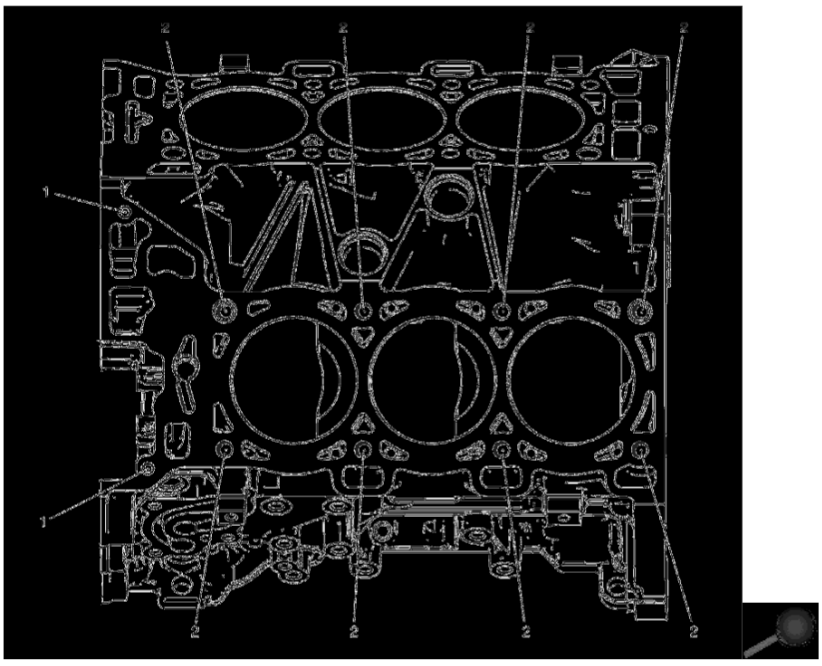


Engine Block Bottom

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M10 x 2.0	720	N/A	N/A	721	722	104	56.0	2.2047	49.0	1.9291
2	M8 x 1.25	702	N/A	N/A	703	704	620	46.0	1.8110	40.5	1.5945
3	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
4	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

Engine Block Left Deck Face

cardiagn.com

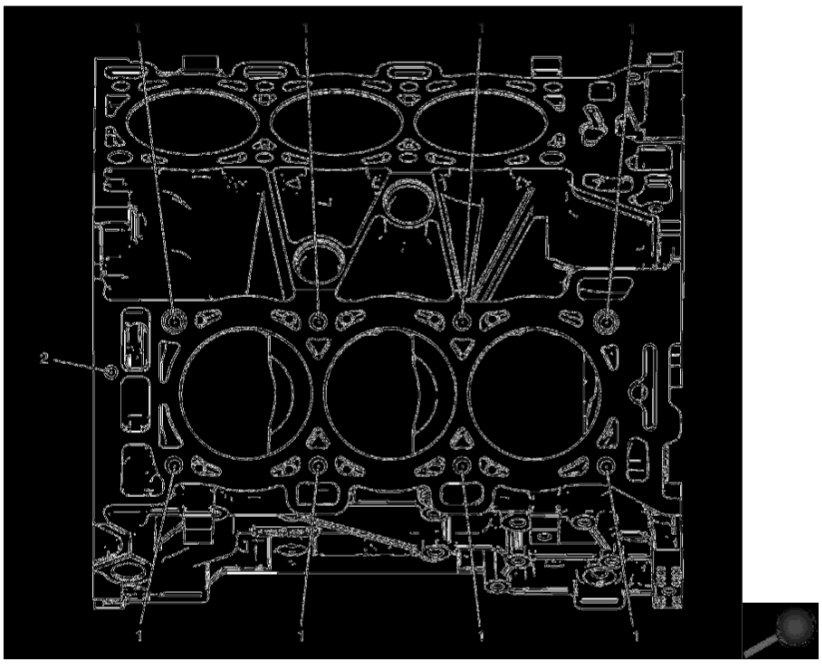


Engine Block Left Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
2	M11 x 2.0	723	N/A	N/A	724	725	108	102.5	4.0354	94.0	3.7008

Engine Block Right Deck Face

cardiagn.com

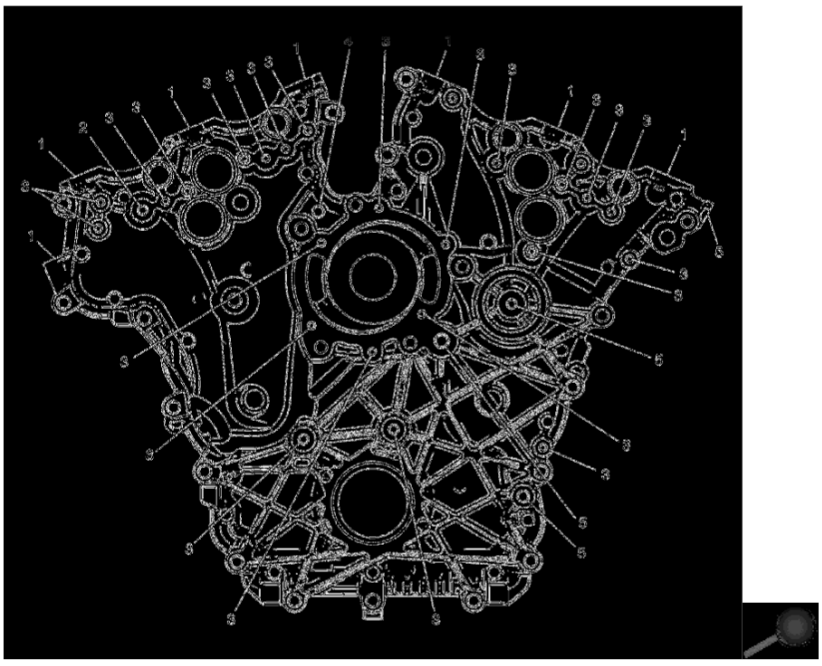


Engine Block Right Deck Face

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M11 x 2.0	723	N/A	N/A	724	725	108	102.5	4.0354	94.0	3.7008
2	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

cardiagn.com

Engine Front Cover

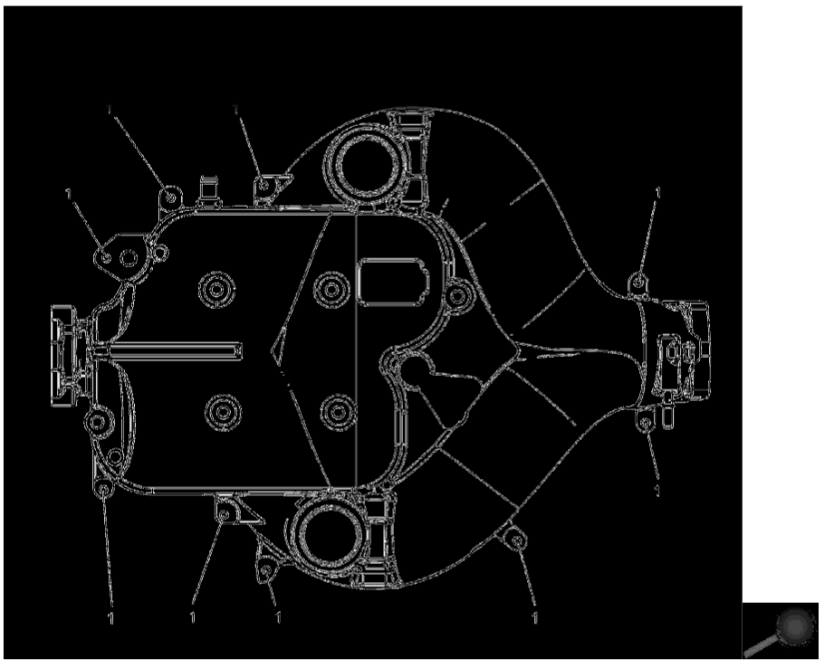


Engine Front Cover

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055
3	M6 x 1.0	201	202	N/A	203	204	205	21.5	0.8465	18.0	0.7087
4	M10 x 1.5	211	212	N/A	213	214	215	THRU		THRU	
5	M10 x 1.5	211	212	N/A	213	214	420	32.5	1.2795	27.0	1.0630

Upper Intake Manifold - Top

cardiagn.com

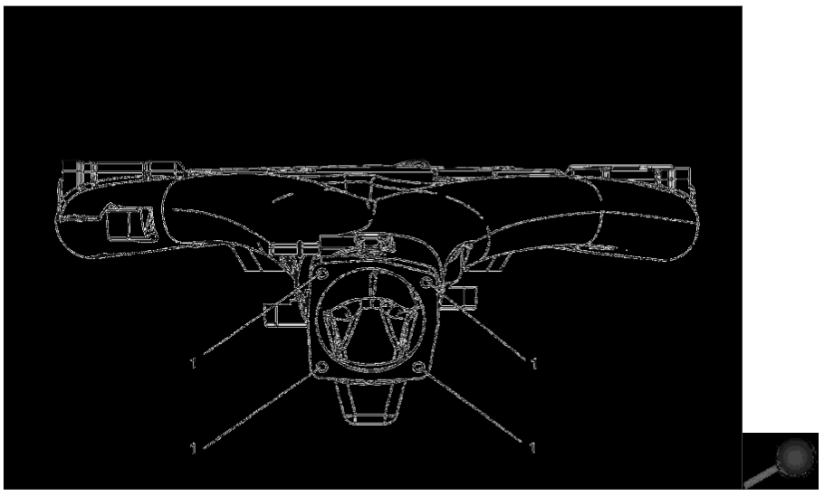


Upper Intake Manifold - Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J 42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

Upper Intake Manifold - Front

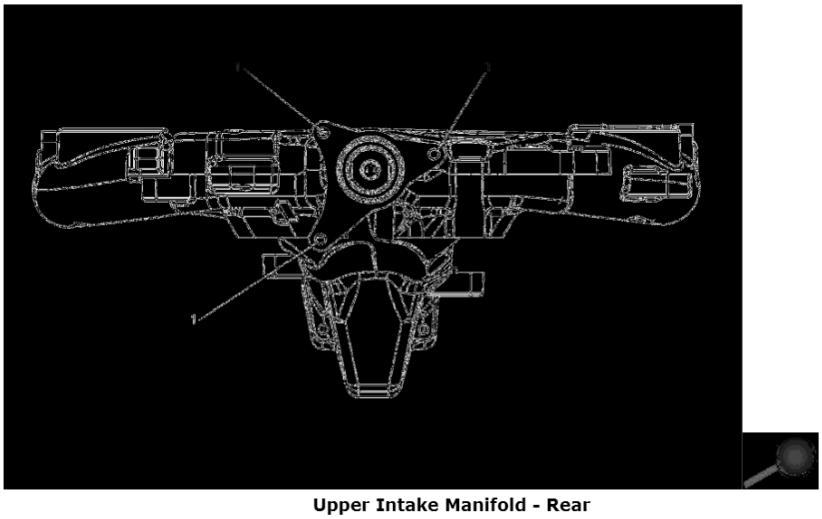
cardiagn.com



Upper Intake Manifold - Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J 42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

[Upper Intake Manifold - Rear]

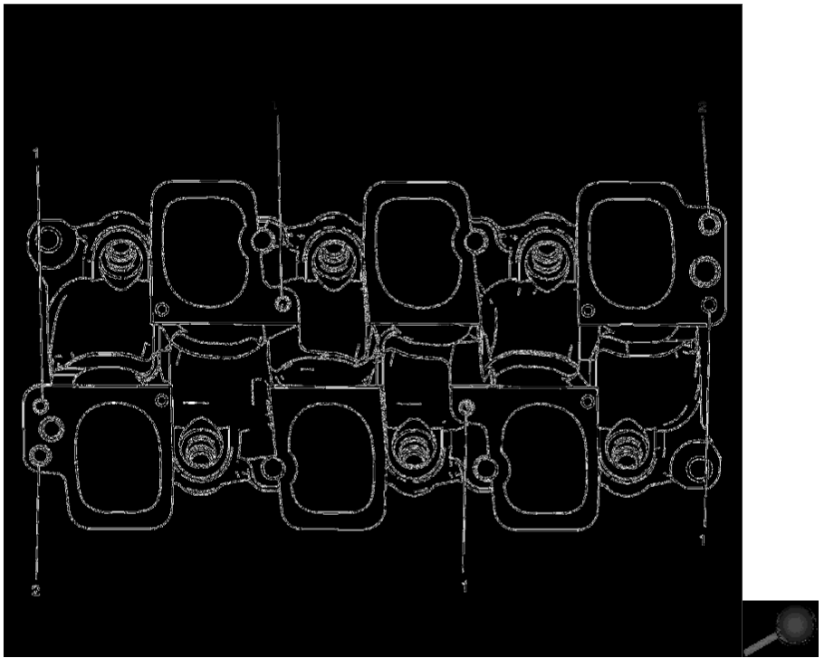


Upper Intake Manifold - Rear

cardiagn.com

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J 42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	

Lower Intake Manifold - Top

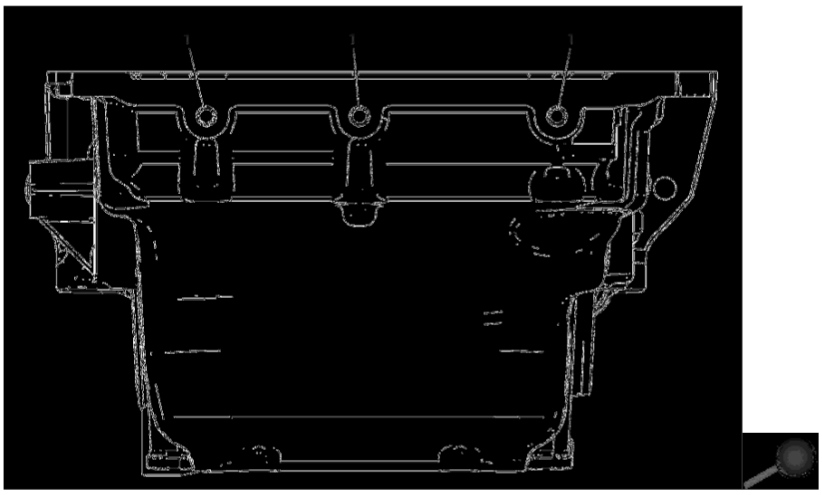


Lower Intake Manifold - Top

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J 42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	201	202	N/A	203	204	205	THRU		THRU	
2	M8 x 1.25	206	207	N/A	208	209	210	THRU		THRU	

Oil Pan Front

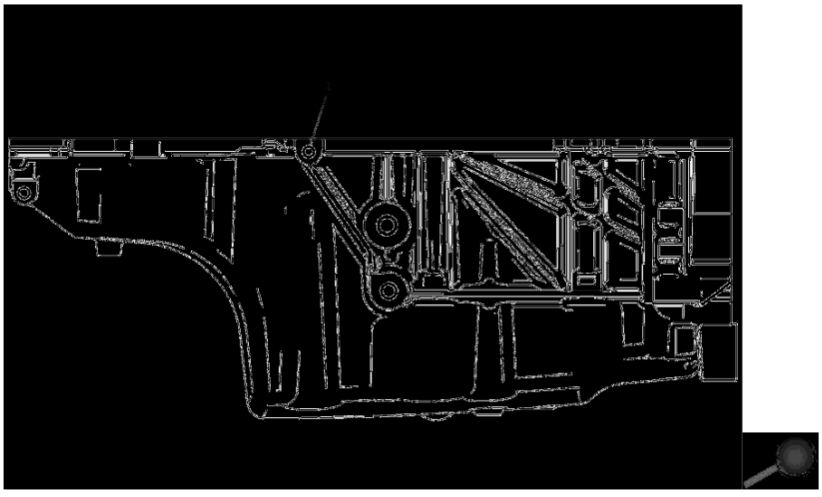
cardiagn.com



Oil Pan Front

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J42385–						MM	(IN)	MM	(IN)
1	M8 x 1.25	206	207	N/A	208	209	210	28.5	1.1220	23.0	0.9055

Oil Pan Left Side

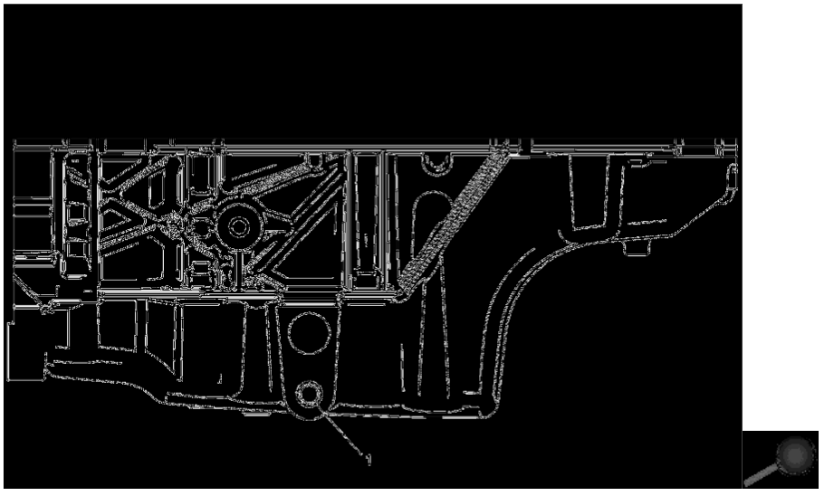


Oil Pan Left Side

cardiagn.com

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J 42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630

Oil Pan Right Side

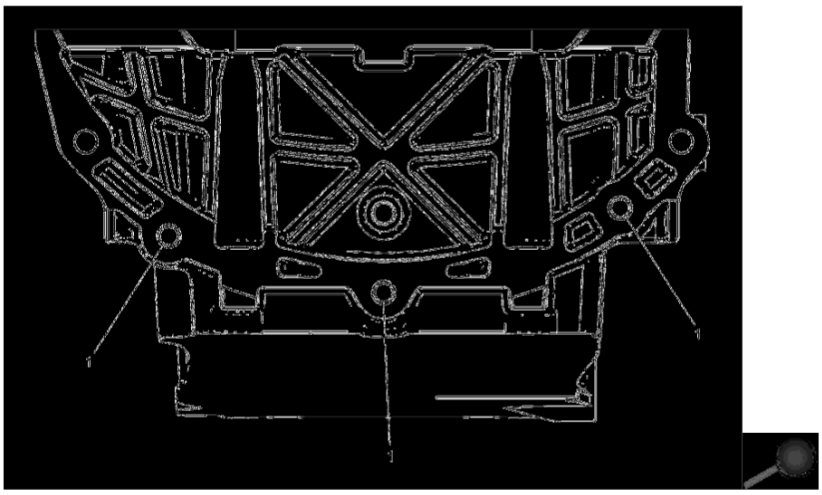


Oil Pan Right Side

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J 42385–						MM	(IN)	MM	(IN)
1	M12 x 1.75	856	857	N/A	858	859	855	39.5	1.5551	32.0	1.2598

Oil Pan Rear

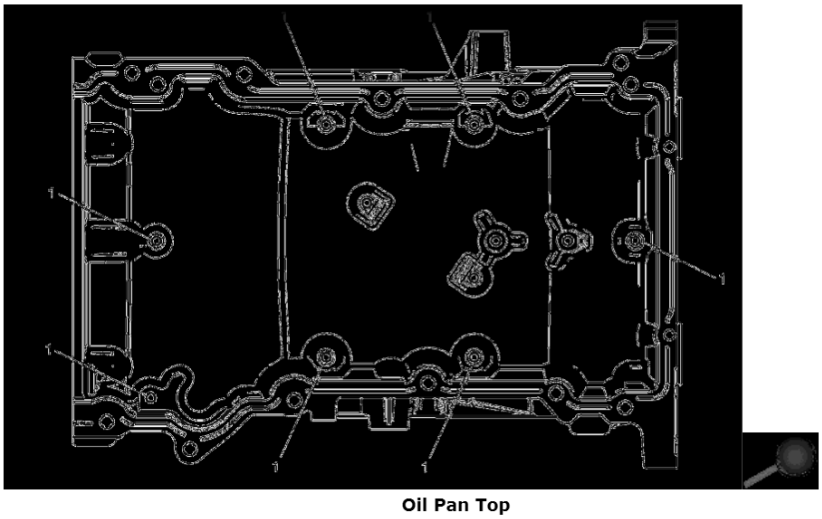
cardiagn.com



Oil Pan Rear

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
—	—	J42385–						MM	(IN)	MM	(IN)
1	M10 x 1.5	211	212	N/A	213	214	420	33.5	1.3189	27.0	1.0630

Oil Pan Top

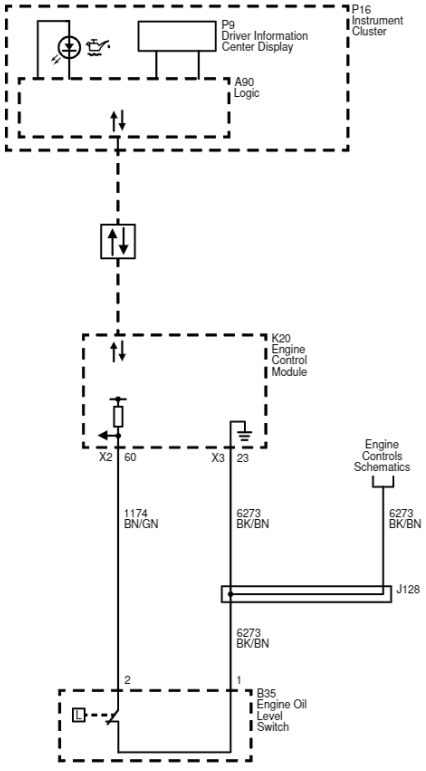


Oil Pan Top

cardiagn.com

Hole Location	Thread Size	Drill	Counter Bore Tool	Stop Collar	Tap	Driver	Insert	Drill Depth (Maximum)		Tap Depth (Minimum)	
–	–	J42385–						MM	(IN)	MM	(IN)
1	M6 x 1.0	701	N/A	N/A	203	204	205	28.0	1.1024	23.5	0.9252

cardiagn.com



cardiagn.com

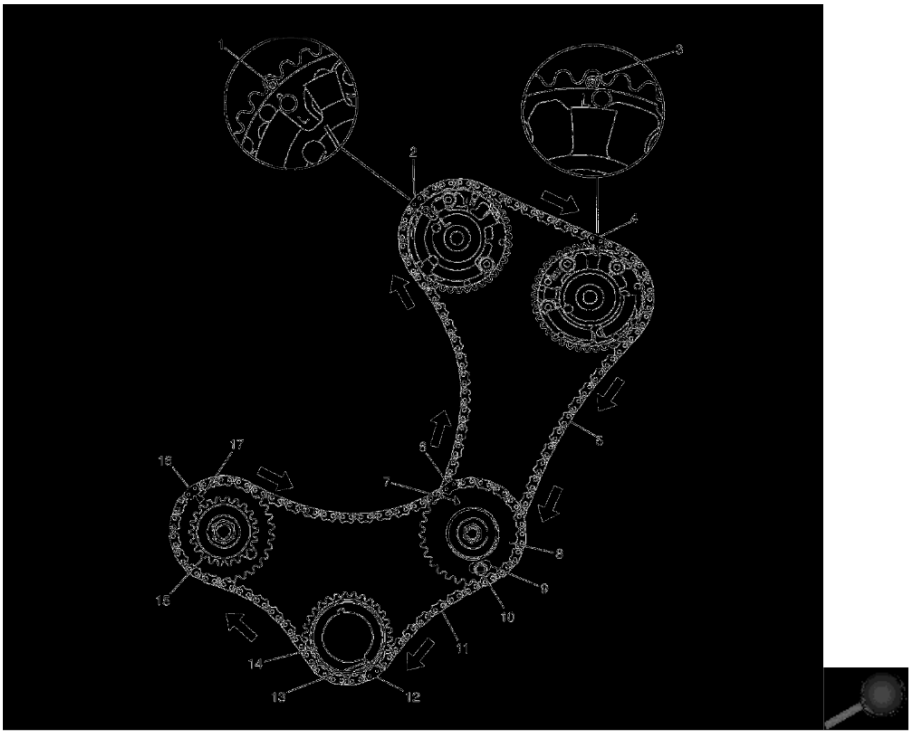
Timing Chain Alignment Diagram

Figure 1: Camshaft Timing Drive Chain Alignment Stage One
Figure 2: Camshaft Timing Drive Chain Alignment Stage Two

cardiagn.com

© 2014 General Motors. All rights reserved.

Stage One



(1) Left Intake Camshaft Position (CMP) Actuator Timing Mark
(2) Left Intake Secondary Camshaft Timing Drive Chain Timing Link
(3) Left Exhaust Camshaft Position (CMP) Actuator Timing Mark
(4) Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link
(5) Left Secondary Camshaft Timing Drive Chain
(6) Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
(7) Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
(8) Left Primary Camshaft Intermediate Drive Chain Sprocket
(9) Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
(10) Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window for the Left Secondary Camshaft Timing Drive Chain Timing Link
(11) Primary Camshaft Drive Chain
(12) Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
(13) Crankshaft Sprocket Timing Mark
(14) Crankshaft Sprocket

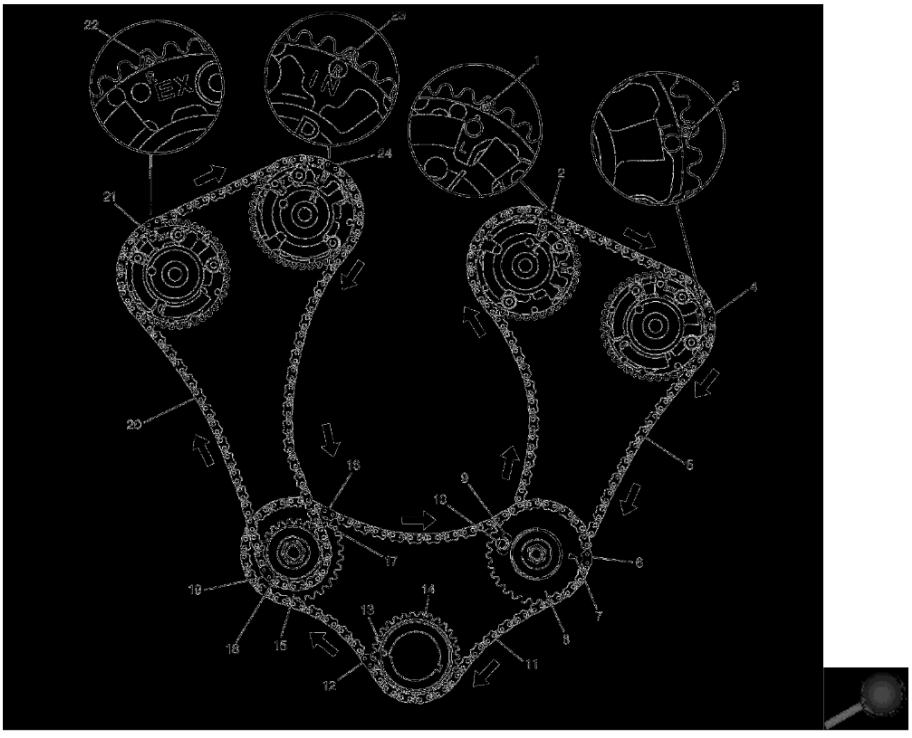
© 2014 General Motors. All rights reserved.

cardiagn.com

(15) Right Primary Camshaft Intermediate Drive Chain Sprocket
(16) Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket
(17) Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark

cardiagn.com

Stage Two



(1) Left Intake Camshaft Position (CMP) Actuator Timing Mark
(2) Left Intake Secondary Camshaft Timing Drive Chain Timing Link
(3) Left Exhaust Camshaft Position (CMP) Actuator Timing Mark
(4) Left Exhaust Secondary Camshaft Timing Drive Chain Timing Link
(5) Left Secondary Camshaft Timing Drive Chain
(6) Primary Camshaft Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
(7) Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain
(8) Left Primary Camshaft Intermediate Drive Chain Sprocket
(9) Left Secondary Camshaft Timing Drive Chain Timing Link for the Left Primary Camshaft Intermediate Drive Chain Sprocket
(10) Left Primary Camshaft Intermediate Drive Chain Sprocket Timing Window
(11) Primary Camshaft Drive Chain
(12) Primary Camshaft Drive Chain Timing Link for the Crankshaft Sprocket
(13) Crankshaft Sprocket Timing Mark
(14) Crankshaft Sprocket
(15) Right Primary Camshaft Intermediate Drive Chain Sprocket

© 2014 General Motors. All rights reserved.

cardiagn.com

(16) Primary Camshaft Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket

(17) Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark for the Primary Camshaft Drive Chain

(18) Right Primary Camshaft Intermediate Drive Chain Sprocket Timing Mark/Window for the Right Secondary Camshaft Timing Drive Chain

(19) Right Secondary Camshaft Timing Drive Chain Timing Link for the Right Primary Camshaft Intermediate Drive Chain Sprocket

(20) Right Secondary Camshaft Timing Drive Chain

(21) Right Exhaust Secondary Camshaft Timing Drive Chain Timing Link

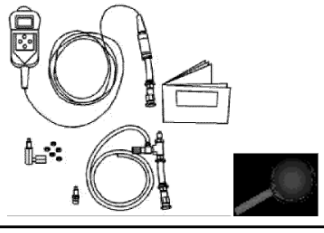
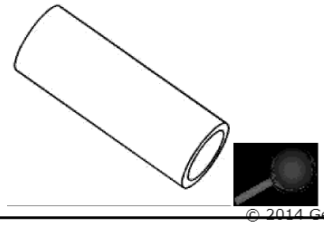
(22) Right Exhaust Camshaft Position (CMP) Actuator Timing Mark

(23) Right Intake Camshaft Position (CMP) Actuator Timing Mark

(24) Right Intake Secondary Camshaft Timing Drive Chain Timing Link

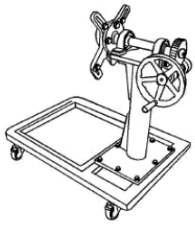
cardiagn.com

Special Tools

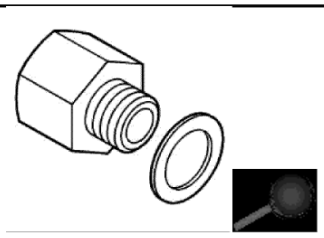
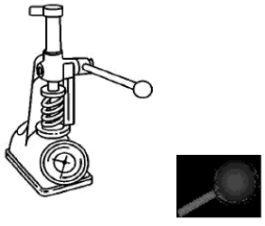
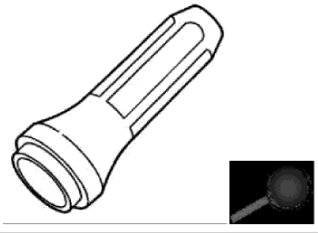
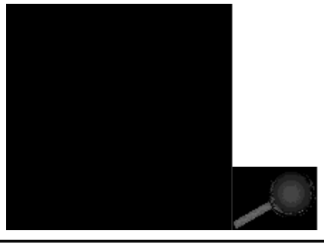
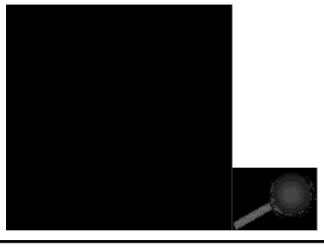
Illustration	Tool Number/Description
	CH 25033-C J 25033-C Pulley Installer
	CH 25034-C J 25034-C Pulley Remover
	CH 42640 J 42640 Steering Column Anti-Rotation Pin
	CH 48027 DW 100-010 EN 49495 J 21867 Digital Pressure Gauge
	DT 5590 J 5590 J 24254 Bearing and Seal Driver

© 2014 General Motors. All rights reserved.

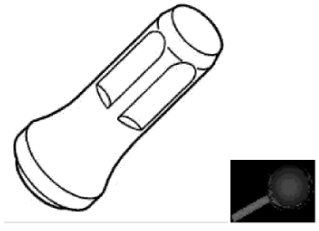
cardiagn.com

Illustration	Tool Number/Description
	DT 23129 J 23129 KM 586 Universal Seal Remover
	DW 110-030 Engine Overhaul Stand
	EN 8037 J 8037 Ring Compressor
	EN 8062 J 8062 Valve Spring Compressor - Head Off
	EN 8087 J 8087 Cylinder Bore Gauge
	EN 21867-6 J 21867-6 83 93 852 Oil Pressure Adapter Fitting

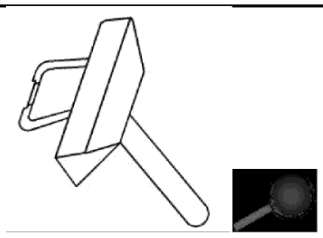
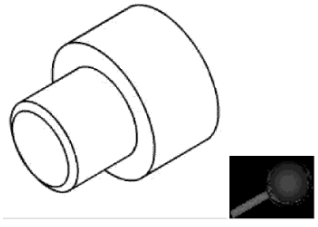
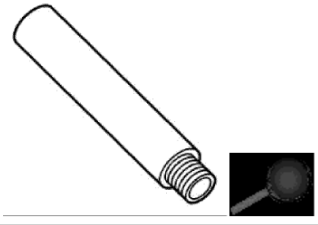
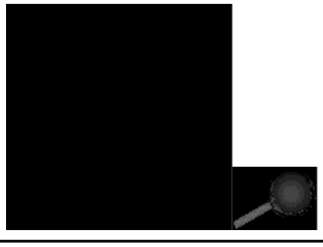
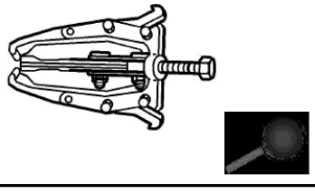
cardiagn.com

Illustration	Tool Number/Description
	
	EN 22738-B J 22738-B Valve Spring Tester
	EN 24254-A J 24254-A J 24254 Oil Seal Installer
	EN 28410 J 28410 Gasket Remover
	EN 28467-B DW 110-060 J 28467-B Universal Engine Support Fixture
	EN 28467-501 J 28467-501 Engine Support Fixture Adapters

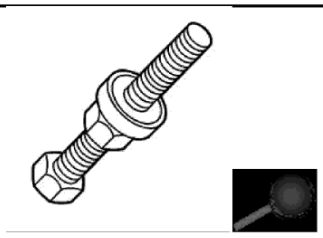
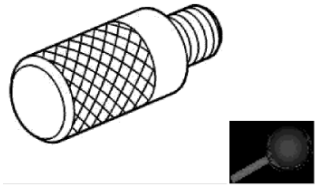
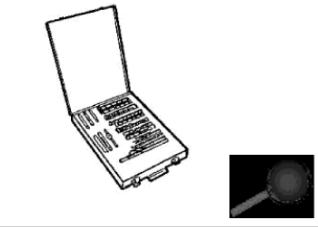
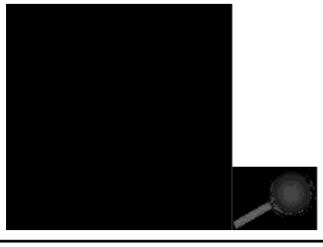
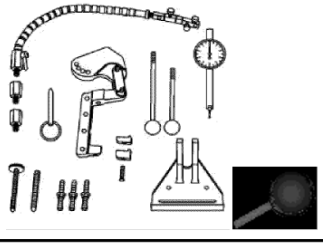
cardiagn.com

Illustration	Tool Number/Description
	EN 29184 EN 47635 & J 41998–B EN 47635 J 29184 Oil Seal Installer
	EN 35667-A J 35667-A Cylinder Head Leakdown Tester
	EN 36462-A J 36462-A Engine Support Adapter Leg
	EN 36857 J 36857 Engine Lift Bracket
	EN 37228 J 37228 KM J 37228 Seal Cutter

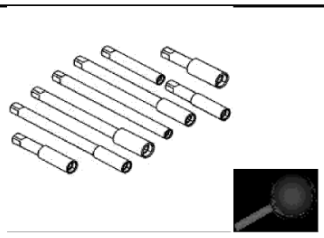
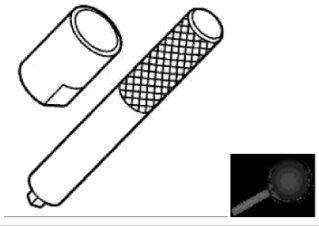
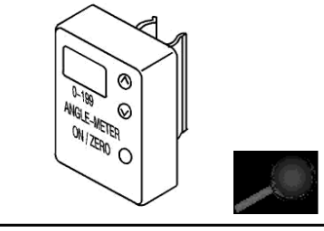
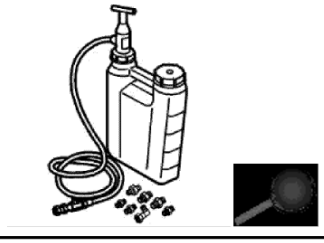
cardiagn.com

Illustration	Tool Number/Description
	
	EN 38416-2 J 38416-2 Crankshaft Button
	EN 39313 J 39313 Spark Plug Port Adapter
	EN 41712 J 41712 Oil Pressure Switch Socket
	EN 41816 J 41816 Crankshaft Balancer Remover
	EN 41998-B J 41998-B J 41998 Crankshaft Balancer Installer

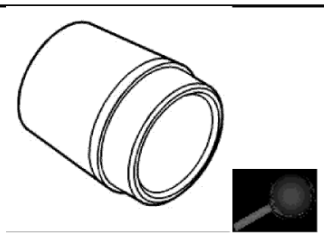
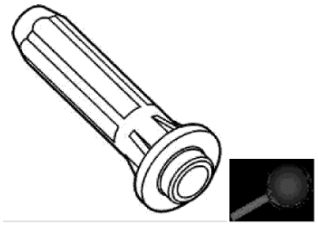
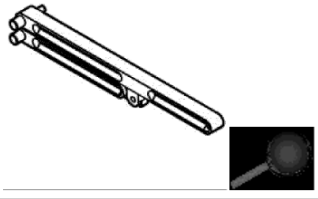
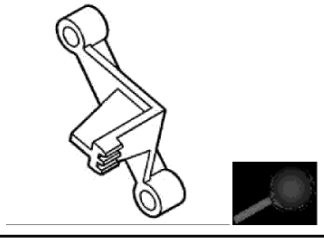
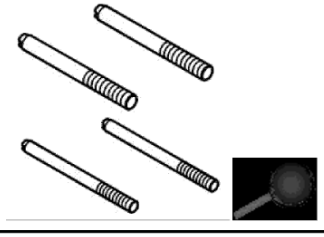
cardiagn.com

Illustration	Tool Number/Description
	
	EN 42183 J 42183 Driver Handle
	EN 42385-700 J 42385-700 High Feature Thread Repair Kit
	EN 42385-2000 J 42385-2000 Thread Insert Kit
	EN 43690-A J 43690-A Rod Bearing Clearance Checking Tool
	EN 43965 J 43965 Thread Repair Extension Kit

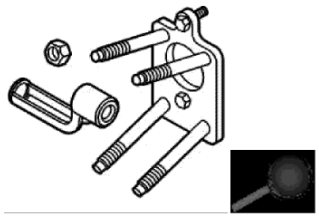
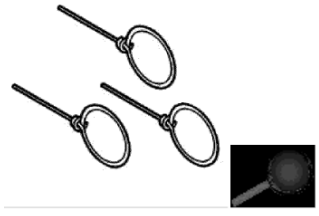
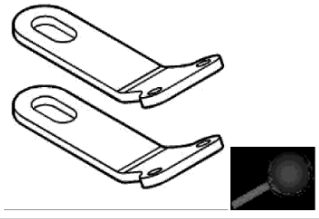
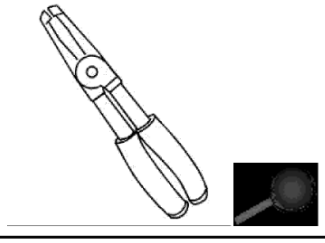
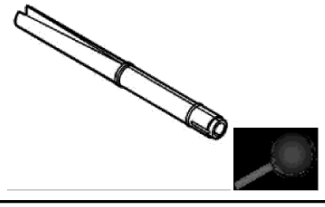
cardiagn.com

Illustration	Tool Number/Description
	
	EN 45000 J 45000 KM J 45000 87 91 360 Seal Remover
	EN 45027 J 45027 Tensioner Tool
	EN 45059 J 45059 KM 470-B Angle Meter
	EN 45299 J 45299 Engine Preluber
	EN 46101 J 46101 Spark Plug Tube Seal Guide

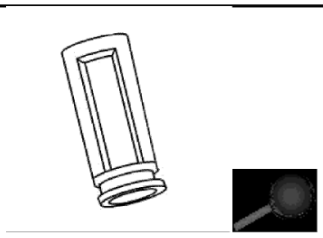
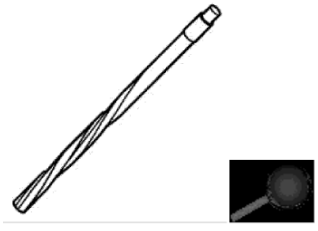
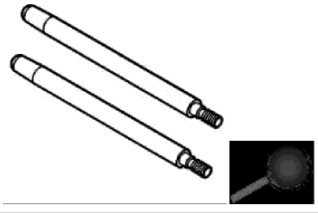
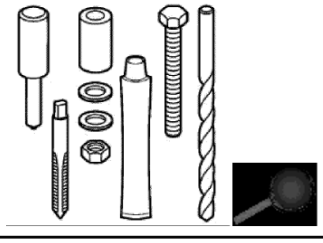
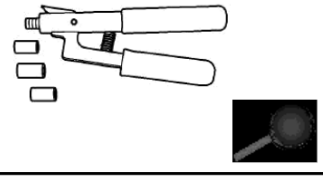
cardiagn.com

Illustration	Tool Number/Description
	
	EN 46103 J 46103 Camshaft Actuator Valve Seal Installer
	EN 46104 J 46104 Water Pump Pulley Holding Tool
	EN 46106 J 46106 KM 652 Flywheel Holding Tool
	EN 46109 J 46109 Guide Pins
	EN 46110 EN 46110-EU J 46110-EU On-Vehicle Valve Spring Compressor

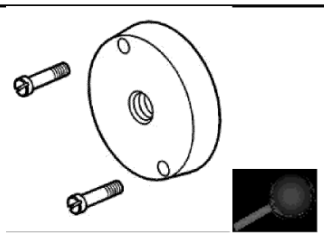
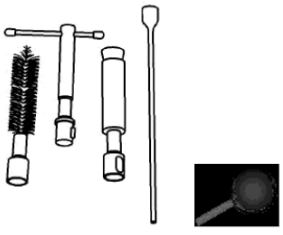
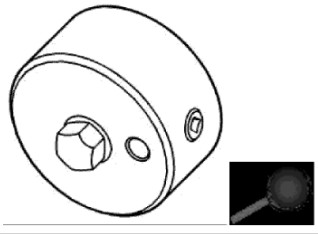
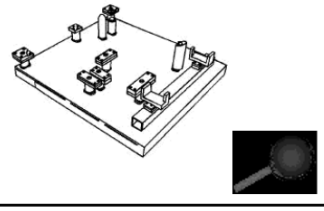
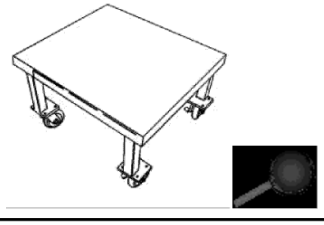
cardiagn.com

Illustration	Tool Number/Description
	
	EN 46112 Tensioner Retraction Pins
	EN 46114 Engine Lift Brackets
	EN 46116 KM 840 (Remover)/EN 47986 (Installer) 83 94 157 Valve Stem Seal Remover/Installer
	EN 46117 Valve Stem Key Remover/Installer
	EN 46119 Off-Vehicle Valve Spring Compressor Adapter

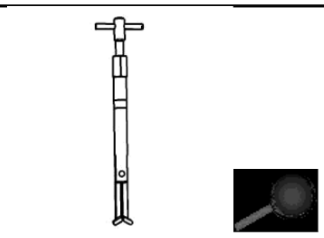
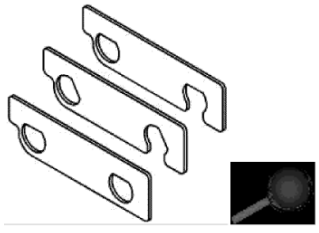
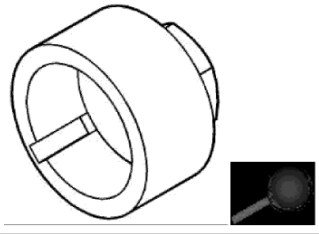
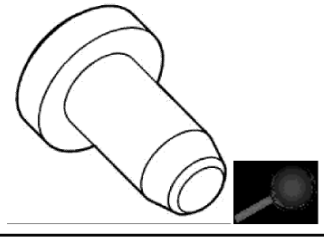
cardiagn.com

Illustration	Tool Number/Description
	
	EN 46120 Valve Guide Reamer
	EN 46121 Connecting Rod Guide Pin Set
	EN 46122 Camshaft Position Actuator Check-Ball Valve Remover/Installer
	EN 46745 J 43654 Piston Pin Clip Remover/Installer
	EN 47839 Crankshaft Rear Oil Seal Installation Tool

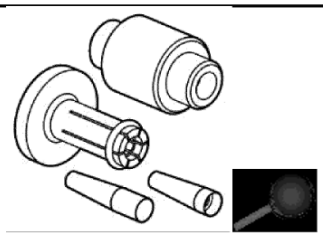
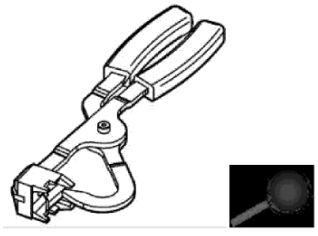
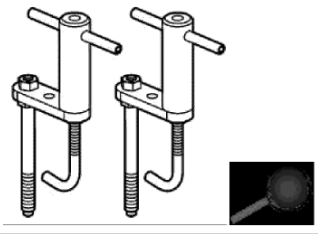
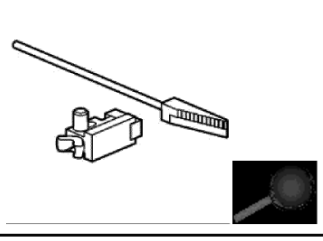
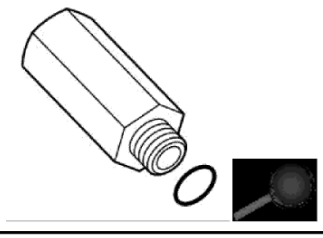
cardiagn.com

Illustration	Tool Number/Description
	
	EN 47909 Injector Bore and Sleeve Cleaning Kit
	EN 47971 Oil Pressure Gauge Adapter
	EN 48243 Engine Assembly Remove/Install Pallet
	EN 48244 Engine Assembly Remove/Install Pallet Supporter
	EN 48313 Timing Chain Retention Tool

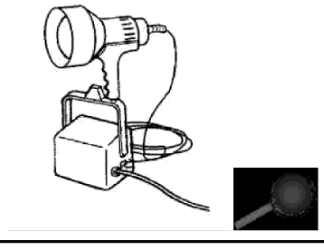
cardiagn.com

Illustration	Tool Number/Description
	
	EN 48383 Camshaft Retaining Tool
	EN 48589-A EN 48589 Crankshaft Rotation Socket
	EN 48896 HP Fuel Pump Installation Alignment Gauge
	EN 49102 J 41818 & EN 47985 Crankshaft Bearing Cap Remover
	EN 49245 Injector Seal Installer Kit

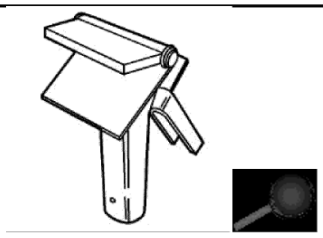
cardiagn.com

Illustration	Tool Number/Description
	
	EN 49247 Injector Retaining Clip Installer
	EN 49248 Injector Rail Assembly Remover
	EN 49982 Timing Chain Retainer
	EN 50789 Oil Pressure Adapter Fitting
	GE 6125-1B J 6125-1B KM J 7004 Slide Hammer Adapter

cardiagn.com

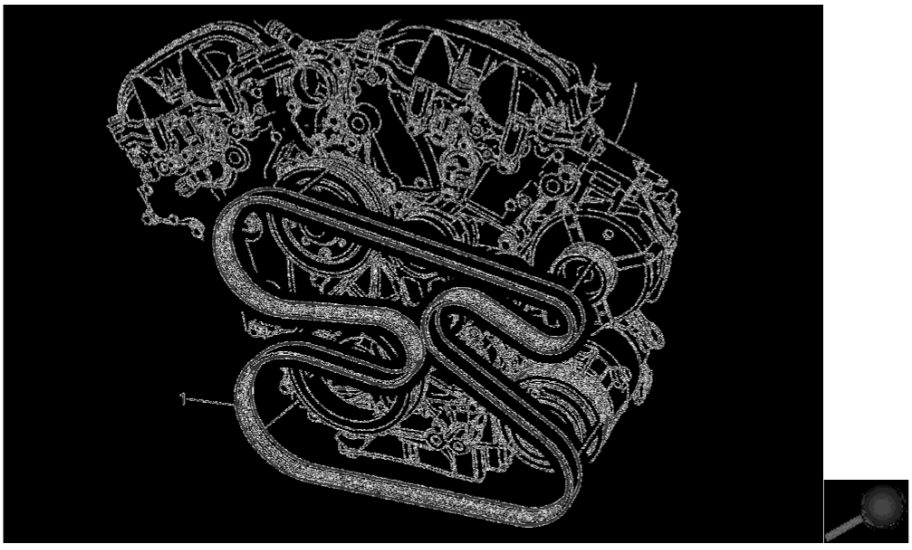
Illustration	Tool Number/Description
	GE 7872 J 7872 Magnetic Base Dial Indicator
	GE 8001 J 8001 Dial Indicator Set
	GE 8358 J 8358 Carbon Removal Brush
	GE 28428-E J 28428-E High Intensity Black Light Kit
	GE 48326 Sealant Dispenser

cardiagn.com

Illustration	Tool Number/Description
	

cardiagn.com

Drive Belt Replacement (LFX)



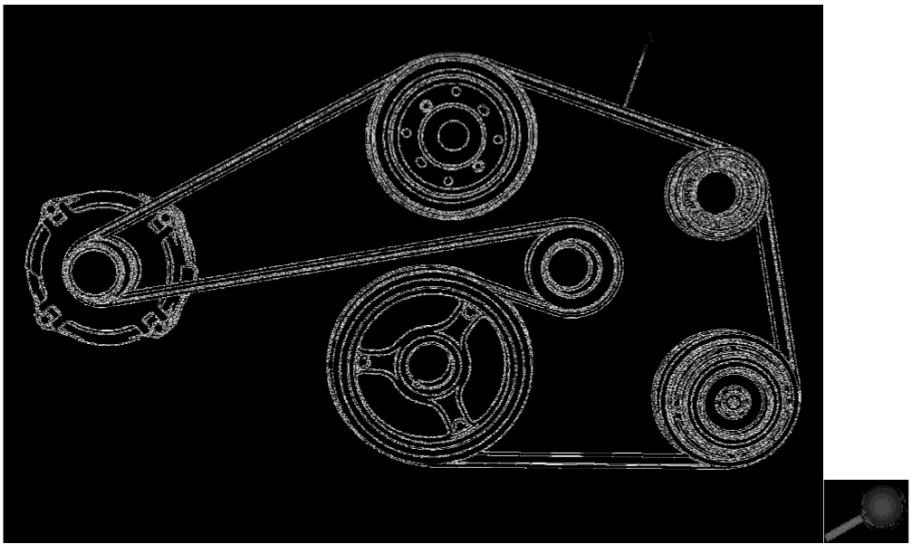
Drive Belt Replacement

Callout	Component Name
Preliminary Procedures Remove the engine mount bracket. Refer to Engine Mount Bracket Replacement - Right Side	
1	Drive Belt **Procedure** 1. Rotate the drive belt tensioner clockwise to release the drive belt tension. 2. Slide the drive belt off of the belt idler pulley. 3. Slowly release the drive belt tensioner.

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Replacement (LFW)



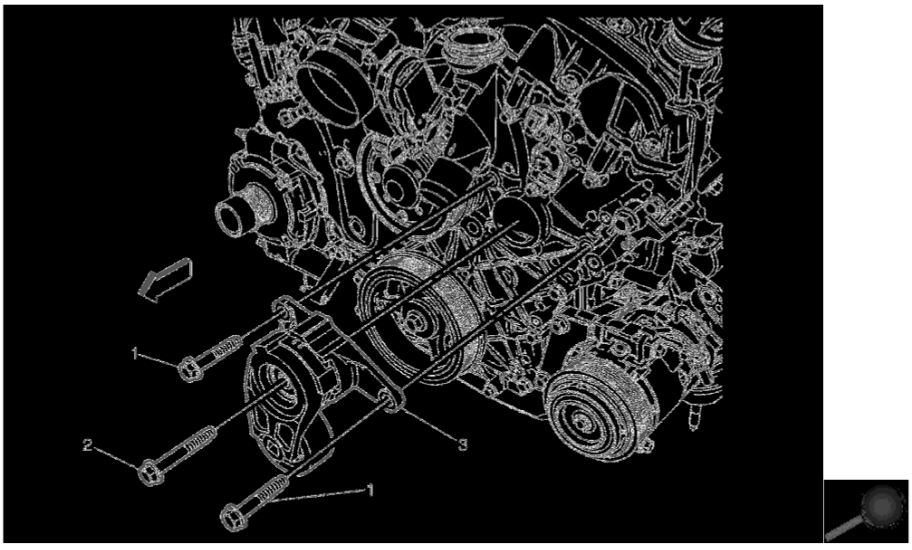
Drive Belt Replacement

Callout	Component Name
Preliminary Procedure Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.	
1	Drive Belt **Procedure** 1. Rotate the drive belt tensioner clockwise to release the drive belt tension. 2. Slide the drive belt off of the belt idler pulley. 3. Slowly release the drive belt tensioner.

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Tensioner Replacement



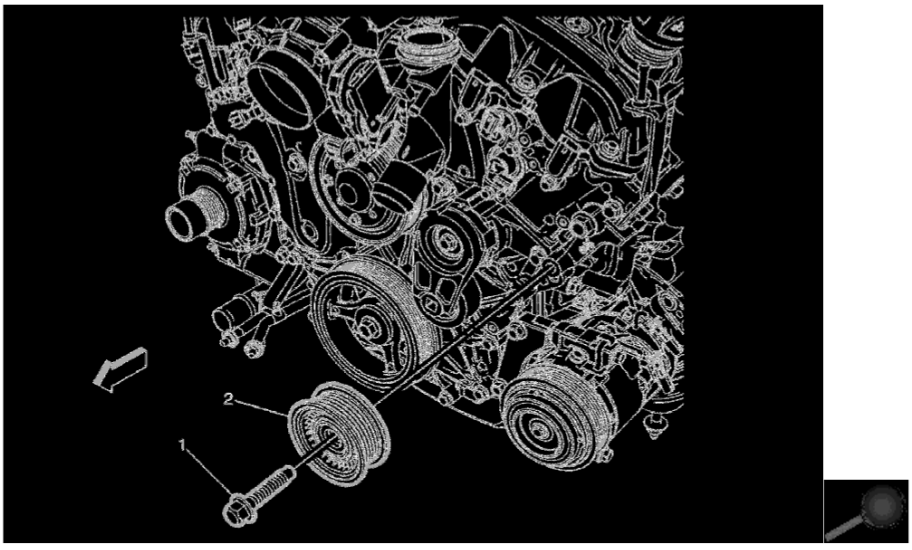
Drive Belt Tensioner Replacement

Callout	Component Name
Preliminary Procedures Remove the drive belt idler pulley. Refer to Drive Belt Idler Pulley Replacement.	
1	Drive Belt Tensioner Fastener (Qty;2) **Caution:** Refer to Fastener Caution. **Tighten** **20 N•m (15 lb ft)**
2	Drive Belt Tensioner Fastener **Tighten** **25 N•m (18 lb ft)**
3	Drive Belt Tensioner

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Idler Pulley Replacement (LFW)



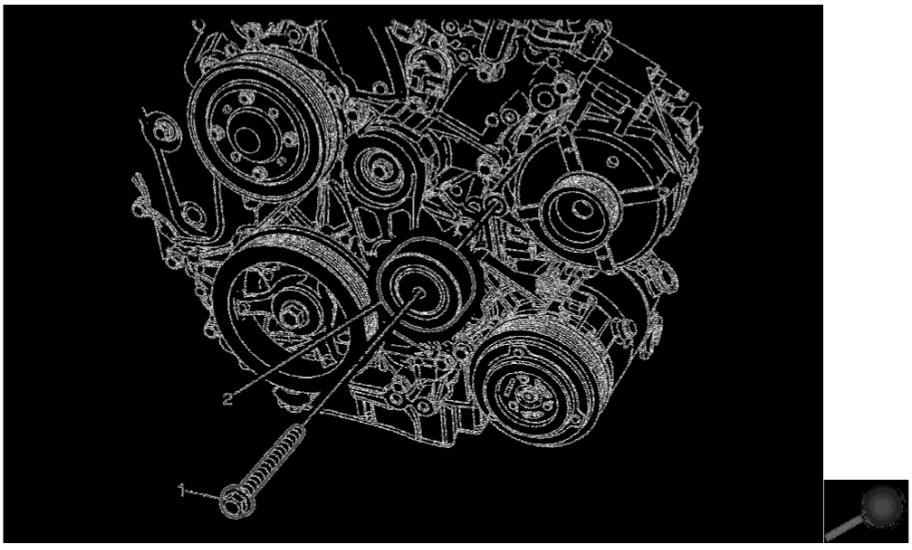
Drive Belt Idler Pulley Replacement

Callout	Component Name
Preliminary Procedures Remove the drive belt. Refer to Drive Belt Replacement.	
1	Drive Belt Idler Pulley Fastener **Caution:** Refer to Fastener Caution. **Tighten** **58 N•m (43 lb ft)**
2	Drive Belt Idler Pulley

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Idler Pulley Replacement (LFX)



Drive Belt Idler Pulley Replacement

Callout	Component Name
Preliminary Procedures Remove the drive belt. Refer to Drive Belt Replacement.	
1	Drive Belt Idler Pulley Fastener **Caution:** Refer to Fastener Caution. **Tighten** **58 N•m (43 lb ft)**
2	Drive Belt Idler Pulley

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Mount Inspection

Caution: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

Caution: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

Visual/Physical Inspection

1. Support the powertrain using the appropriate support method; refer to the powertrain mount replacement procedure. Raising the powertrain removes the weight from the engine mount and creates slight tension in the rubber.
2. Clean the mount and surrounding area to ensure good visibility of the mount condition.
3. Verify all attaching fasteners are present and at the correct torque. Refer to Engine Mount Replacement - Left Side and/or Engine Mount Replacement - Right Side for any torque sequencing and/or torque specifications.

   Note: Observe the engine mount while raising the engine. If the engine mount exhibits any of the following conditions the mount may require replacement. Refer to Engine Mount Replacement - Left Side and/or Engine Mount Replacement - Right Side.
4. Slightly raise the engine approximately 5-7 mm.
5. Inspect the mount for any of the following conditions:
   - Hard rubber surfaces - covered with extreme heat check cracks.
   - Rubber separation from the metal plate of the engine mount.
   - Rubber is split through the center of the engine mount.

     Note: Before replacing any engine mount due to suspected fluid loss, verify that the source of the fluid is from the engine mount , and not the engine or an external source.
   - If equipped with a hydraulic mount, inspect for GLYCOL™ fluid leaking from the engine mount.

cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Mount Replacement - Left Side (LFW)

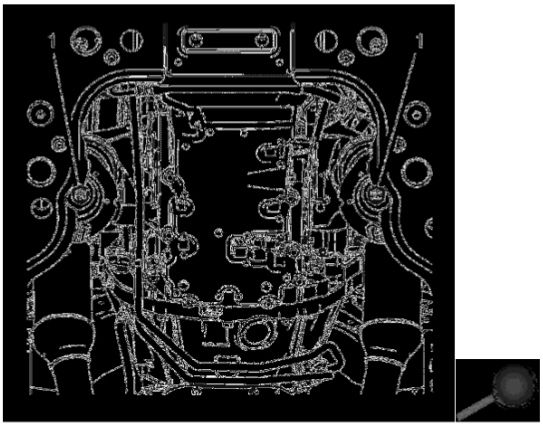
Special Tools

EN 46114 Engine Lift Brackets

For equivalent regional tools, refer to Special Tools.

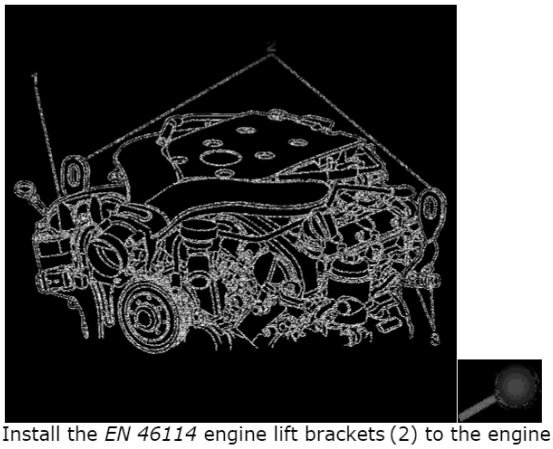
Removal Procedure

1. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
2. Remove the oil pan shield. Refer to Oil Pan Shield Replacement.



Note: Removal of both lower engine mount nuts (1) will prevent stretching of the mount that isn't being replaced when the engine if lifted

3. Remove the engine mount to front subframe retaining nuts (1).
4. Lower the vehicle.



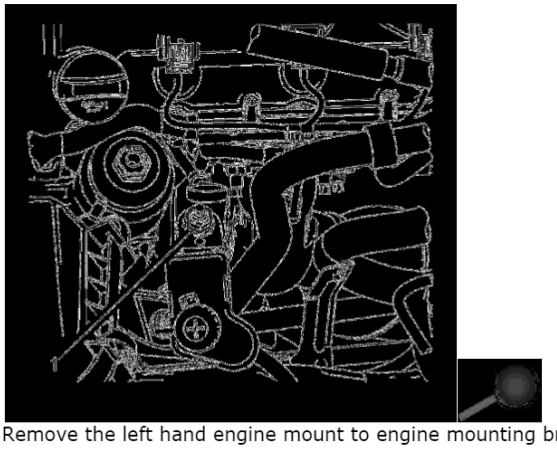
5. Install the *EN 46114* engine lift brackets (2) to the engine.

Note: While lifting the engine do not damage the surrounding areas and components.

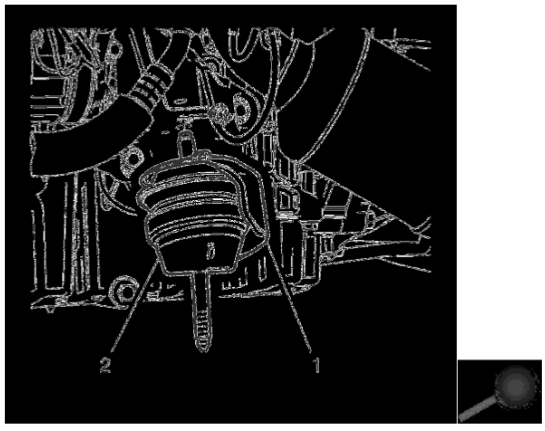
© 2014 General Motors. All rights reserved.

cardiagn.com

6. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the left hand engine mount.



7. Remove the left hand engine mount to engine mounting bracket retaining nut (1).



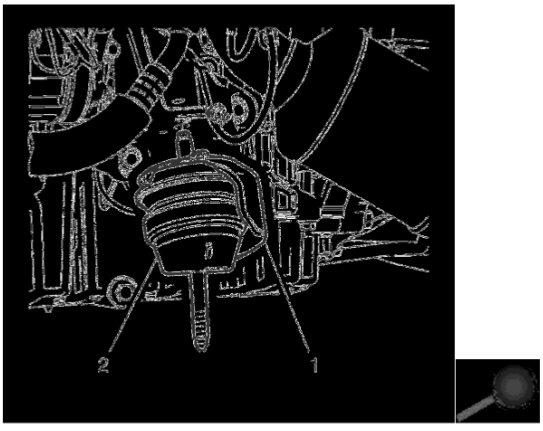
Note: If required raise the engine further to provide adequate clearance for mount removal.

Note: DO NOT distort or bend the left hand engine mount heat shield (1).

8. Remove the left hand engine mount (2) from the engine.

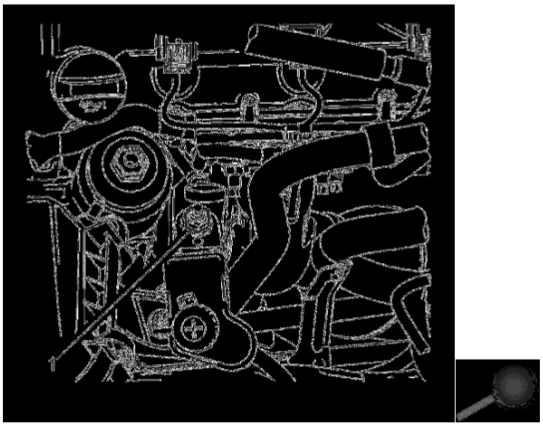
Installation Procedure

cardiagn.com



Note: DO NOT distort or bend the left hand engine mount heat shield (1).

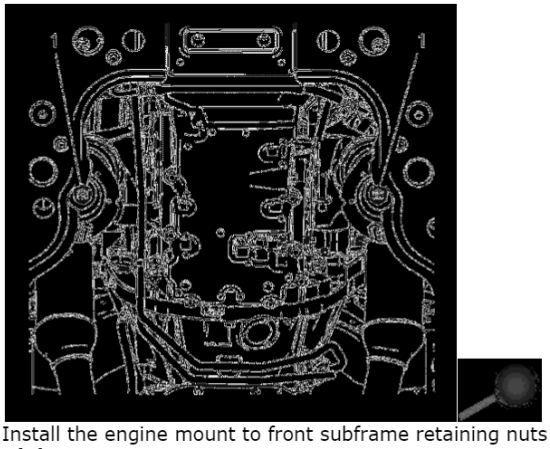
1. Install the left hand engine mount (2) to the engine and hand start the retaining nut.
2. Lower the engine until the weight is resting on the left hand engine mount.



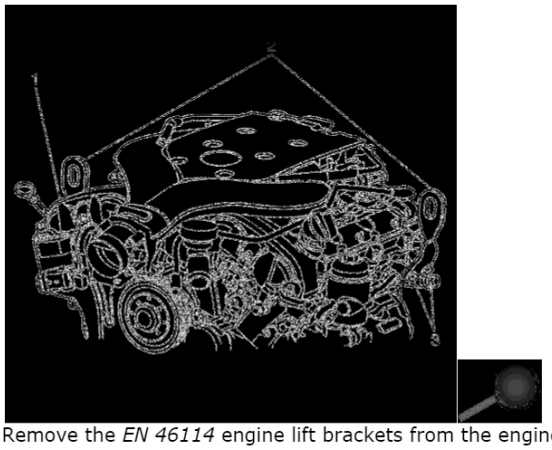
Caution: Refer to Fastener Caution.

3. Install the left hand engine mount to engine mounting bracket retaining nut (1).
   Tighten
   Tighten the nut to 80 N•m (59 lb ft).
4. Raise the vehicle.

cardiagn.com



5. Install the engine mount to front subframe retaining nuts (1).
   Tighten
   Tighten the nuts to 80 N•m (59 lb ft).
6. Install the oil pan shield. Refer to Oil Pan Shield Replacement.



7. Remove the *EN 46114* engine lift brackets from the engine.
8. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

cardiagn.com

Engine Mount Replacement - Right Side (LFW)

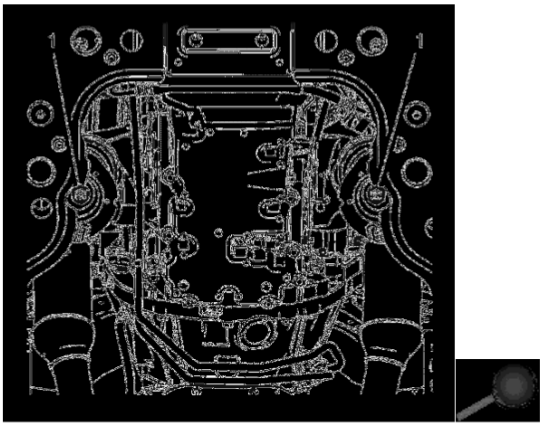
Special Tools

EN 46114 Engine Lift Brackets

For equivalent regional tools, refer to Special Tools.

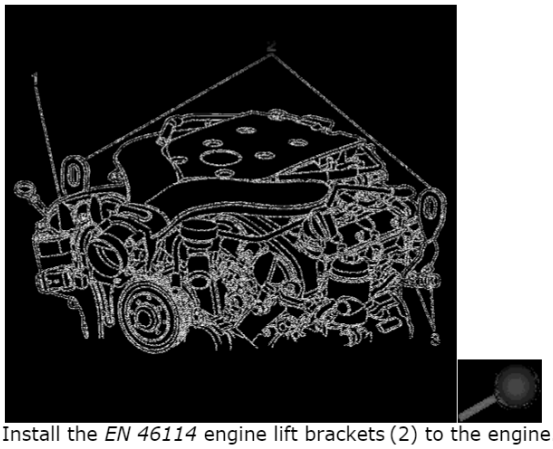
Removal Procedure

1. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
2. Remove the oil pan shield. Refer to Oil Pan Shield Replacement.



Note: Removal of both lower engine mount nuts (1) will prevent stretching of the mount that isn't being replaced when the engine is lifted.

3. Remove the engine mount to front subframe retaining nuts (1).
4. Lower the vehicle.



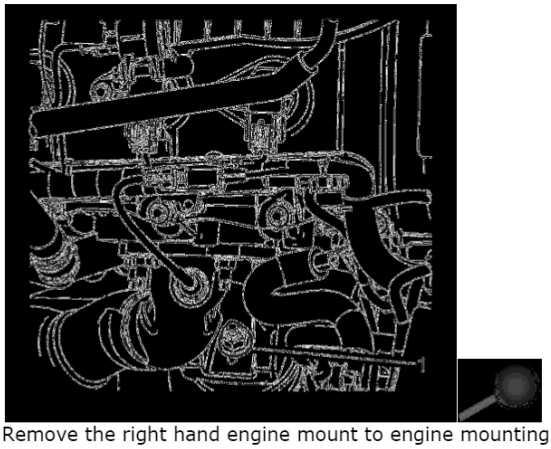
5. Install the *EN 46114* engine lift brackets (2) to the engine.

Note: While lifting the engine do not damage the surrounding areas and components.

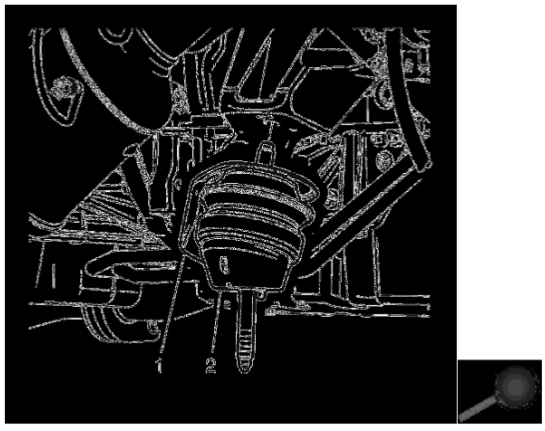
© 2014 General Motors. All rights reserved.

cardiagn.com

6. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the right hand engine mount.



7. Remove the right hand engine mount to engine mounting bracket retaining nut (1).



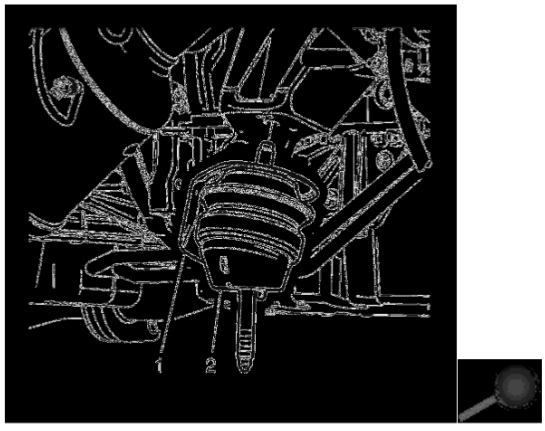
Note: If required raise the engine further to provide adequate clearance for mount removal.

Note: DO NOT distort or bend the right hand engine mount heat shield (1).

8. Remove the right hand engine mount (2) from the engine.

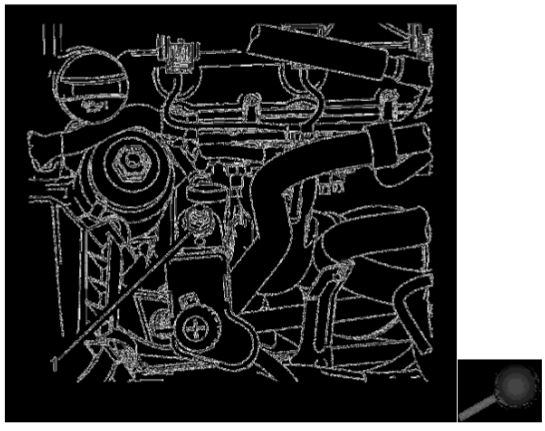
Installation Procedure

cardiagn.com



Note: DO NOT distort or bend the right hand engine mount heat shield (1).

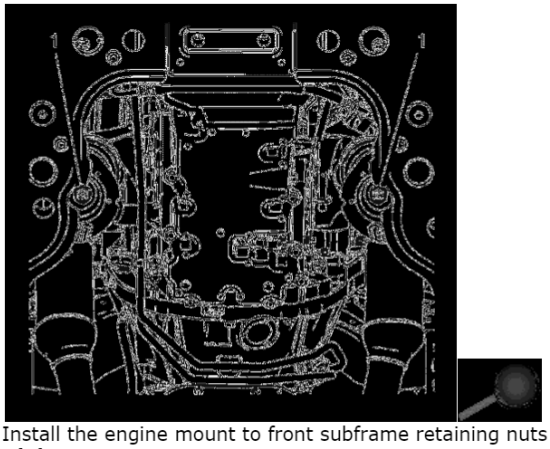
1. Install the right hand engine mount (2) to the engine and hand start the retaining nut.
2. Lower the engine until the weight is resting on the right hand engine mount.



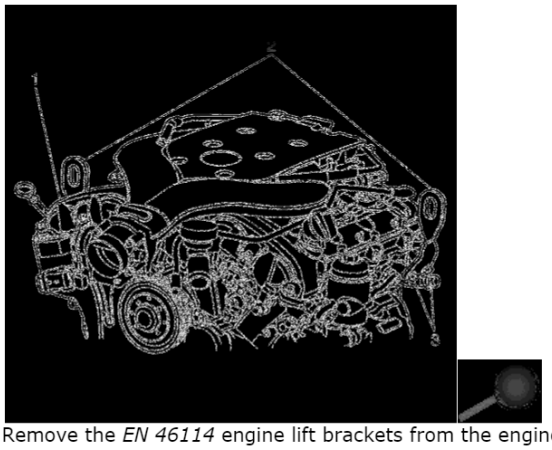
Caution: Refer to Fastener Caution.

3. Install the right hand engine mount to engine mounting bracket retaining nut (1).
   Tighten
   Tighten the nut to 80 N•m (59 lb ft).
4. Raise the vehicle.

cardiagn.com



5. Install the engine mount to front subframe retaining nuts (1).
   Tighten
   Tighten the nuts to 80 N•m (59 lb ft).
6. Install the oil pan shield. Refer to Oil Pan Shield Replacement.



7. Remove the *EN 46114* engine lift brackets from the engine.
8. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

cardiagn.com

Engine Mount Bracket Replacement - Left Side

Special Tools

EN 46114 Engine Lift Brackets

Removal Procedure

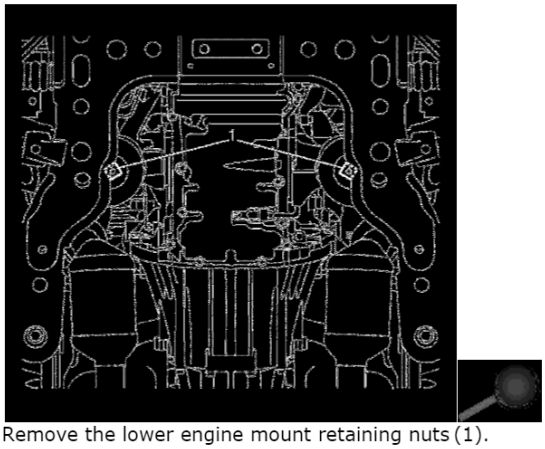
Warning: Refer to Battery Disconnect Warning

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection
2. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Refer to Safety Glasses Warning.

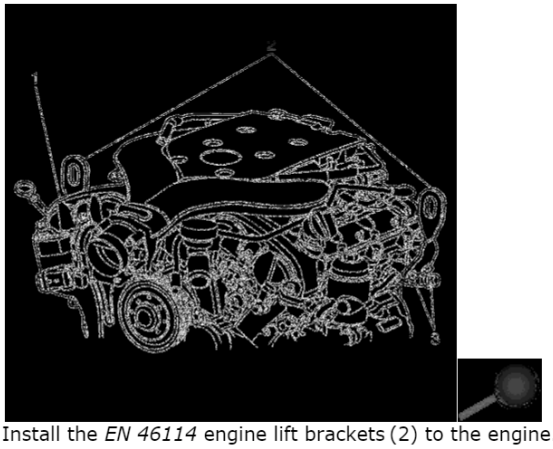
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the oil pan shield. Refer to Oil Pan Shield Replacement.



5. Remove the lower engine mount retaining nuts (1).
6. Lower the vehicle.

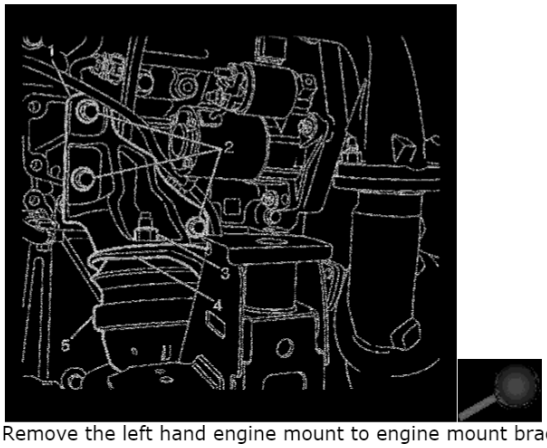
cardiagn.com

© 2014 General Motors. All rights reserved.



7. Install the *EN 46114* engine lift brackets (2) to the engine.

   Note: While lifting the engine do not damage the surrounding areas and components.
8. Use a suitable engine lifting tool to raise the engine until the weight of the engine is removed from the left hand engine mount.



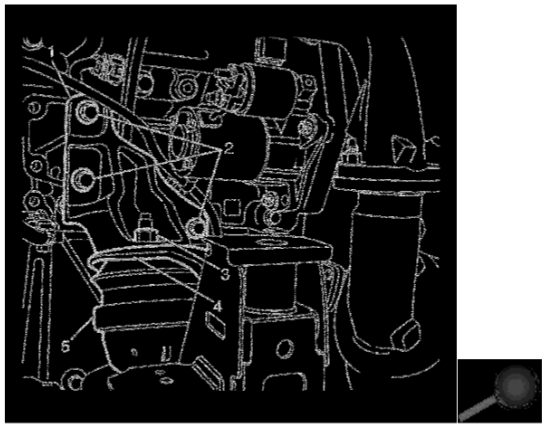
9. Remove the left hand engine mount to engine mount bracket retaining nut (3).

   Note: If required raise the engine further to provide adequate space.
10. Remove the left hand engine mount (5) from the left hand engine mount bracket (1).

    Note: DO NOT distort or bend the left hand engine mount heat shield (4).
11. Remove the left hand engine mount bracket to cylinder block retaining bolts (2).
12. Remove the left hand engine mount bracket (1) from the engine.

Installation Procedure

cardiagn.com



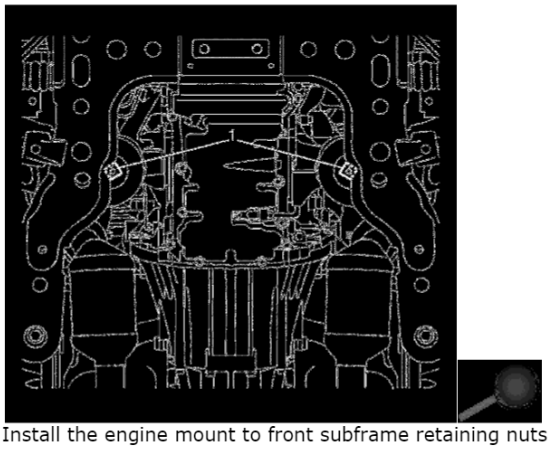
Note: DO NOT distort or bend the left hand engine mount heat shield (4).

1. Install the left hand engine mount bracket (1) to the engine.

   Caution: Refer to Fastener Caution.
2. Install the left hand engine mount bracket to engine block retaining bolts (2).
   Tighten
   60 N•m (44 lb ft)
3. Install the left hand engine mount (5) to the vehicle.
4. Install the left hand engine mount to engine mount bracket retaining nut (3).
   Tighten
   Tighten the nut to 80 N•m (59 lb ft).
5. Lower the engine until the weight is resting on the left hand engine mount.

   Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

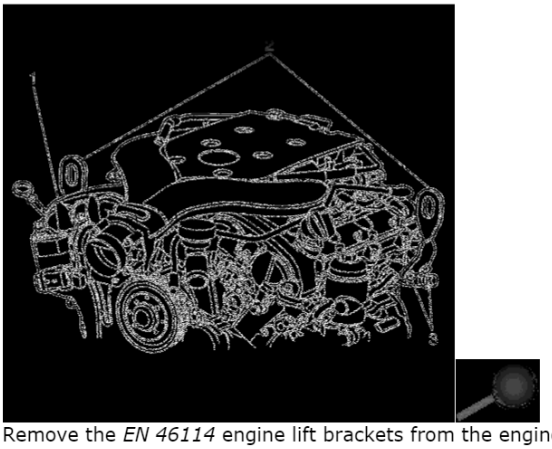
   Warning: Refer to Safety Glasses Warning.
6. Raise the vehicle.



7. Install the engine mount to front subframe retaining nuts (1).
   Tighten
   Tighten the nuts to 80 N•m (59 lb ft).
8. Install the oil pan shield. Refer to Oil Pan Shield Replacement.

cardiagn.com

9. Lower the vehicle to the ground.

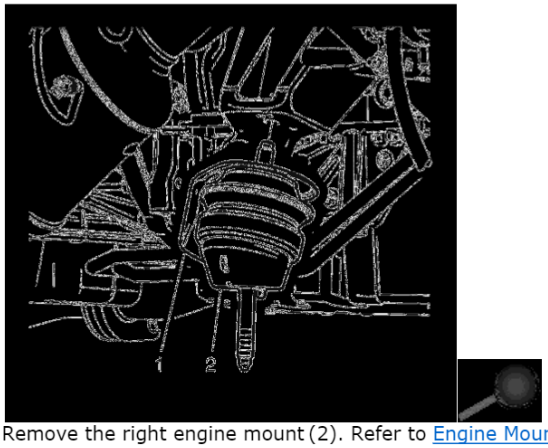


10. Remove the *EN 46114* engine lift brackets from the engine.
11. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
12. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

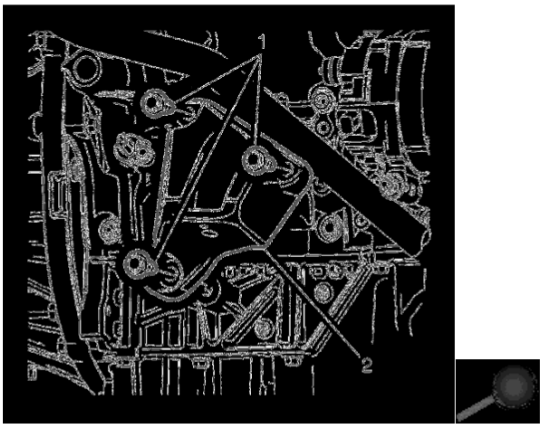
cardiagn.com

Engine Mount Bracket Replacement - Right Side

Removal Procedure



1. Remove the right engine mount (2). Refer to Engine Mount Replacement - Right Side.



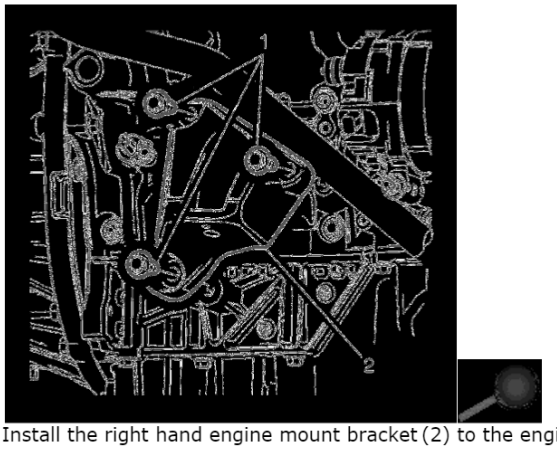
Note: Reposition the heat shield as necessary.

2. Remove the right hand engine mount bracket to cylinder block retaining bolts (1).
3. Remove the right hand engine mount bracket (2) from the engine.

Installation Procedure

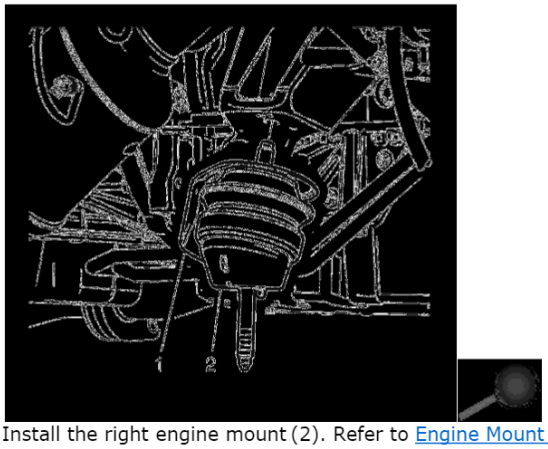
cardiagn.com

© 2014 General Motors. All rights reserved.



1. Install the right hand engine mount bracket (2) to the engine.

   Caution: Refer to Fastener Caution.
2. Install the left hand engine mount bracket to engine block retaining bolts (1).
   Tighten
   Tighten the bolts to 60 N•m (44 lb ft).



3. Install the right engine mount (2). Refer to Engine Mount Replacement - Right Side.

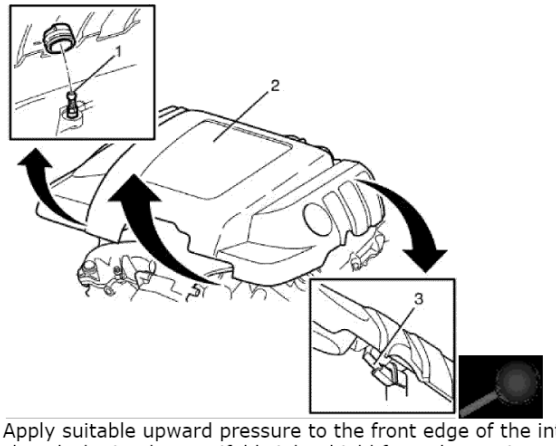
cardiagn.com

Intake Manifold Cover Replacement (LFX and LFW)

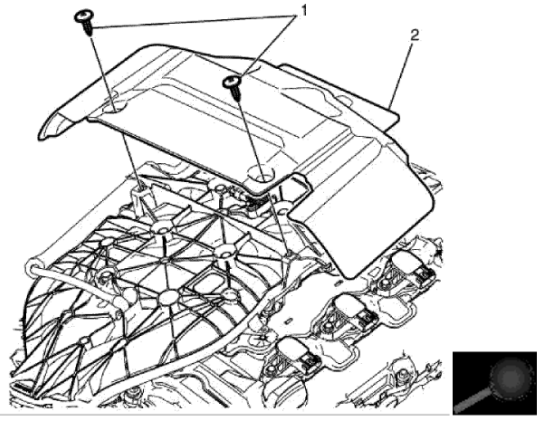
Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Ignition OFF
2. Raise and secure the engine compartment hood.



3. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the retainers (1).
4. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
5. Remove the intake manifold sight shield (2) from the engine.



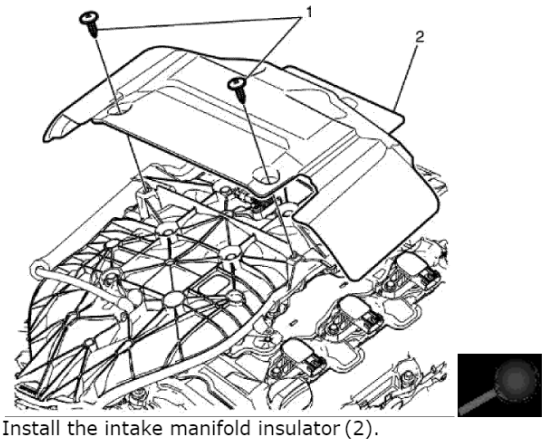
Note: Take care not to damage the intake manifold insulator (2).

6. Remove the intake manifold insulator retainers (1).
7. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.
8. Remove the intake manifold insulator (2).

© 2014 General Motors. All rights reserved.

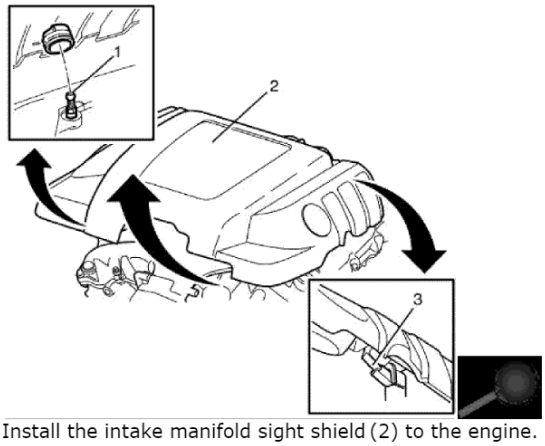
cardiagn.com

Installation Procedure



1. Install the intake manifold insulator (2).

   Note: Take care not to damage the intake manifold insulator (2).
2. Install the intake manifold insulator retainers (1).
3. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement.

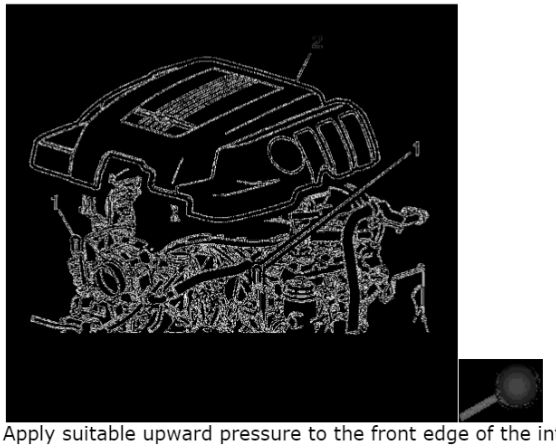


4. Install the intake manifold sight shield (2) to the engine.
5. Install the intake manifold sight shield (2) to the intake manifold sight shield retainers (3).
6. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).
7. Close the engine compartment hood.

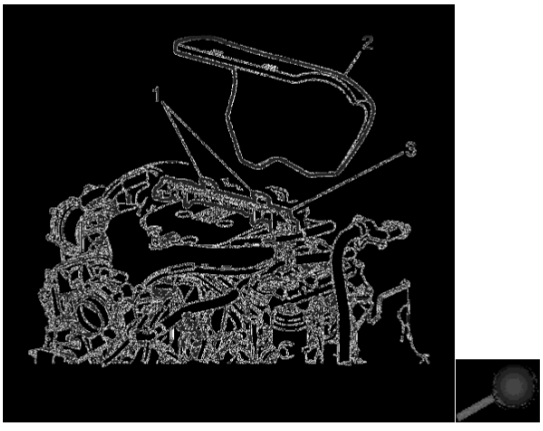
cardiagn.com

Intake Manifold Cover Replacement (LWR)

Removal Procedure



1. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the rear retainers.
2. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
3. Remove the intake manifold sight shield (2) from the engine.



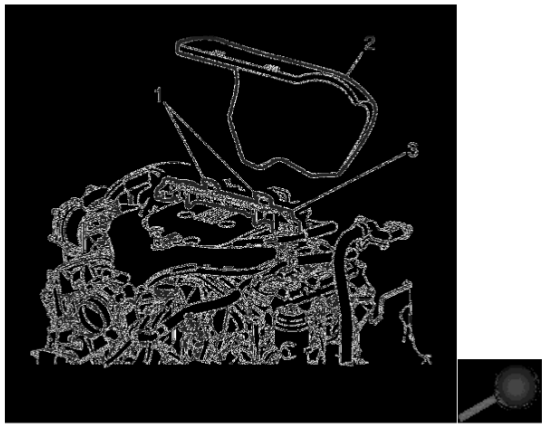
Note: Take care not to damage the intake manifold insulator (2).

4. Remove the intake manifold insulator (2) by carefully lifting and rotating the insulator off the retainers (1).

Installation Procedure

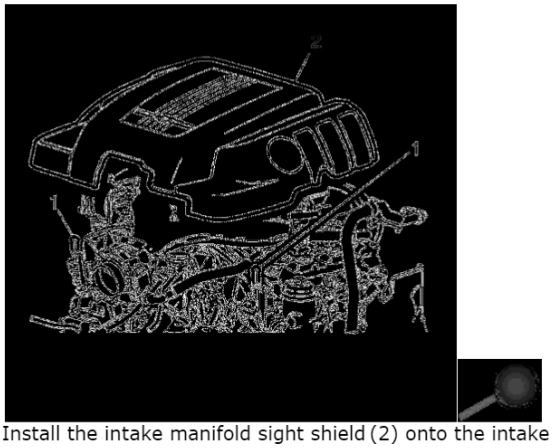
© 2014 General Motors. All rights reserved.

cardiagn.com



Note: Take care not to damage the intake manifold insulator (2).

1. Install the intake manifold insulator (2) by lowering and rotating the insulator onto the retainers (1).



2. Install the intake manifold sight shield (2) onto the intake manifold sight shield rear retainers.
3. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).

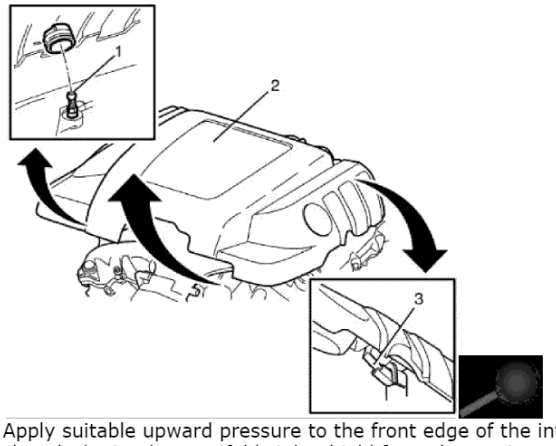
cardiagn.com

Intake Manifold Insulator Replacement (LFX and LFW)

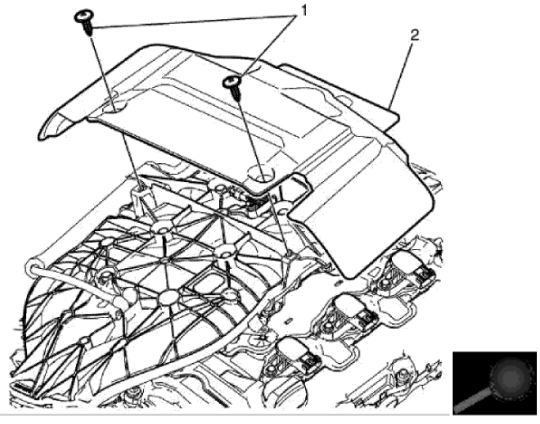
Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Ignition OFF
2. Raise and secure the engine compartment hood.



3. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the retainers (1).
4. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
5. Remove the intake manifold sight shield (2) from the engine.



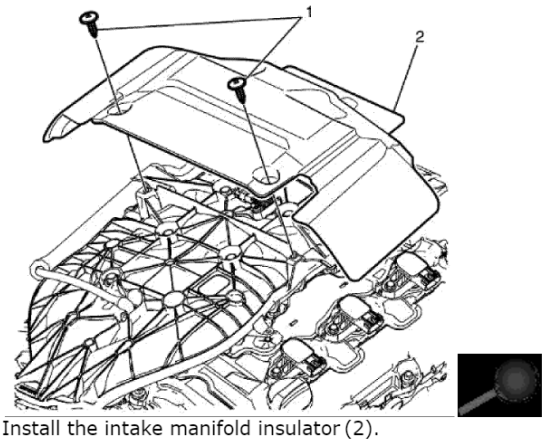
Note: Take care not to damage the intake manifold insulator (2).

6. Remove the intake manifold insulator retainers (1).
7. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.
8. Remove the intake manifold insulator (2).

© 2014 General Motors. All rights reserved.

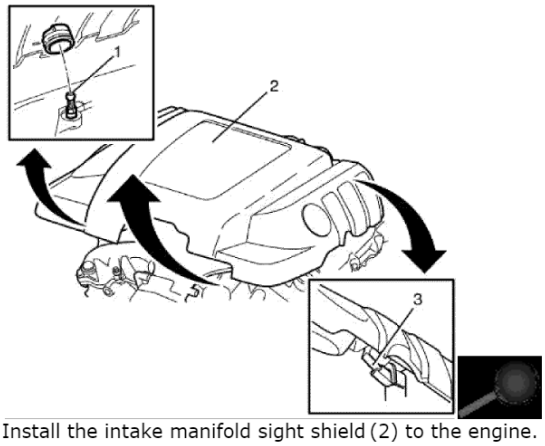
cardiagn.com

Installation Procedure



1. Install the intake manifold insulator (2).

   Note: Take care not to damage the intake manifold insulator (2).
2. Install the intake manifold insulator retainers (1).
3. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement.

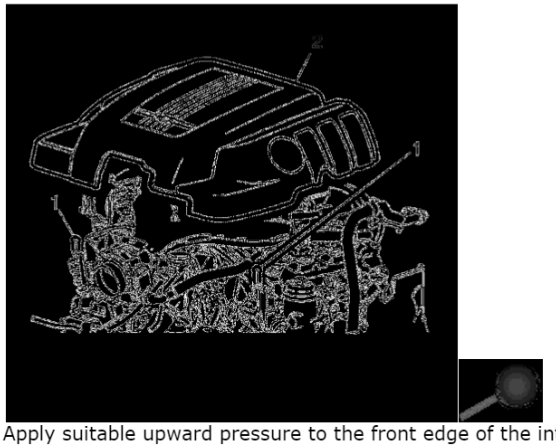


4. Install the intake manifold sight shield (2) to the engine.
5. Install the intake manifold sight shield (2) to the intake manifold sight shield retainers (3).
6. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).
7. Close the engine compartment hood.

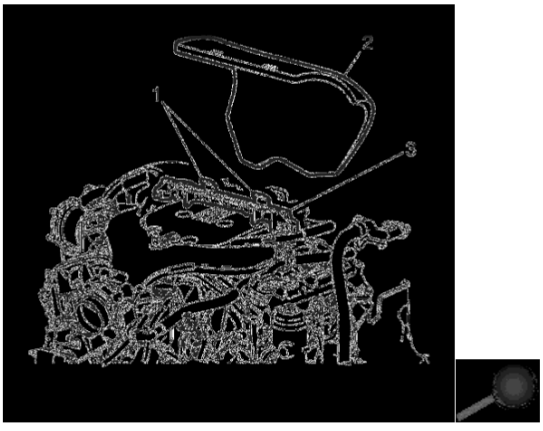
cardiagn.com

Intake Manifold Insulator Replacement (LWR)

Removal Procedure



1. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the rear retainers.
2. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
3. Remove the intake manifold sight shield (2) from the engine.



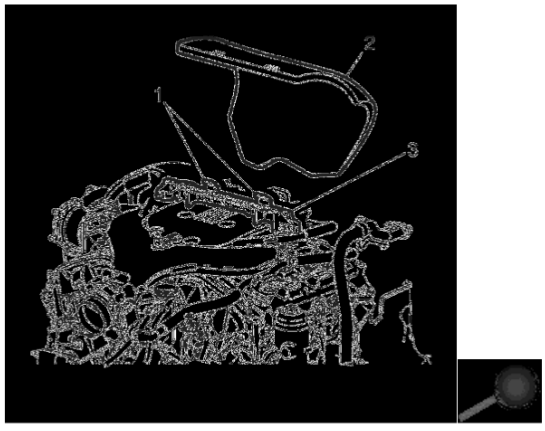
Note: Take care not to damage the intake manifold insulator (2).

4. Remove the intake manifold insulator (2) by carefully lifting and rotating the insulator off the retainers (1).

Installation Procedure

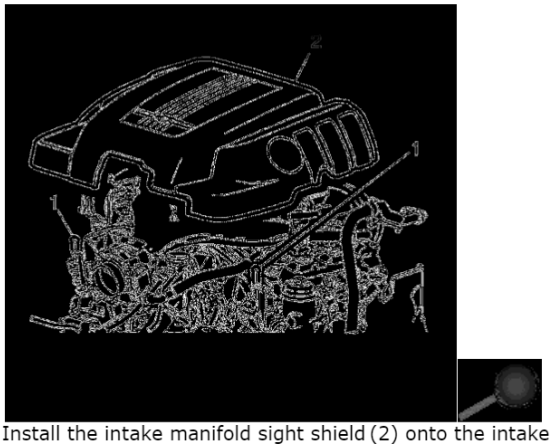
cardiagn.com

© 2014 General Motors. All rights reserved.



Note: Take care not to damage the intake manifold insulator (2).

1. Install the intake manifold insulator (2) by lowering and rotating the insulator onto the retainers (1).



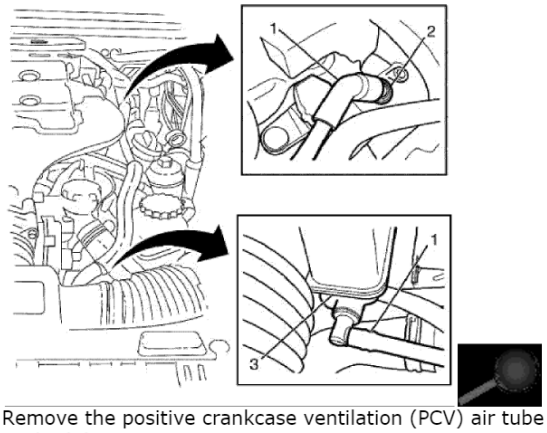
2. Install the intake manifold sight shield (2) onto the intake manifold sight shield rear retainers.
3. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).

cardiagn.com

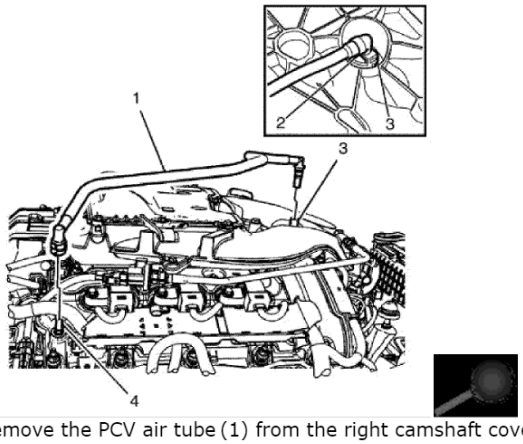
Positive Crankcase Ventilation Hose/Pipe/Tube Replacement

Removal Procedure

1. Ignition OFF.
2. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement.



3. Remove the positive crankcase ventilation (PCV) air tube (1) from the left camshaft cover outlet (2).
4. Remove the PCV air tube (1) from the air cleaner outlet duct (3).



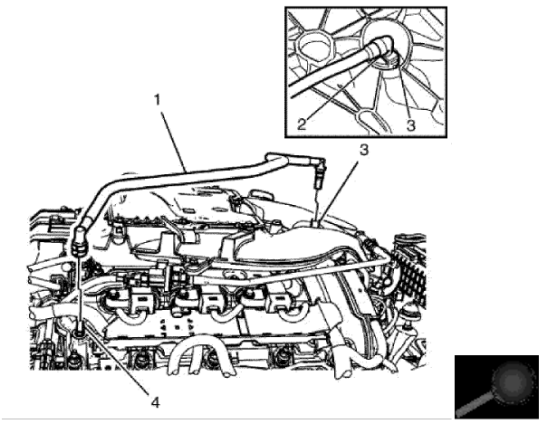
5. Remove the PCV air tube (1) from the right camshaft cover (4).

   Note: Turn the PCV air tube connector (2) 90 degrees to detach the connector from the intake manifold (3).
6. Remove the PCV air tube (1) from the intake manifold (3).

Installation Procedure

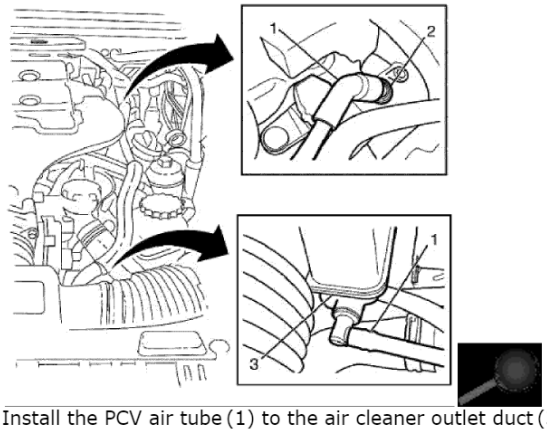
© 2014 General Motors. All rights reserved.

cardiagn.com



Note: Turn the PCV air tube connector (2) 90 degrees to attach the connector from the intake manifold (3).

1. Install the PCV air tube (1) to the intake manifold (3).
2. Install the PCV air tube (1) to the right camshaft cover (4).



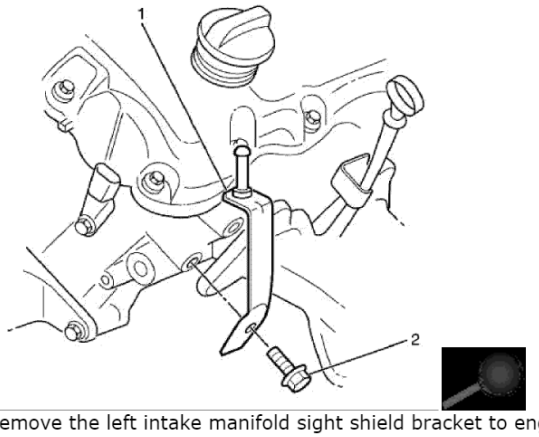
3. Install the PCV air tube (1) to the air cleaner outlet duct (3).
4. Install the PCV air tube (1) onto the left camshaft cover outlet (2).
5. Install the intake manifold cover. Refer to Intake Manifold Cover Replacement.

cardiagn.com

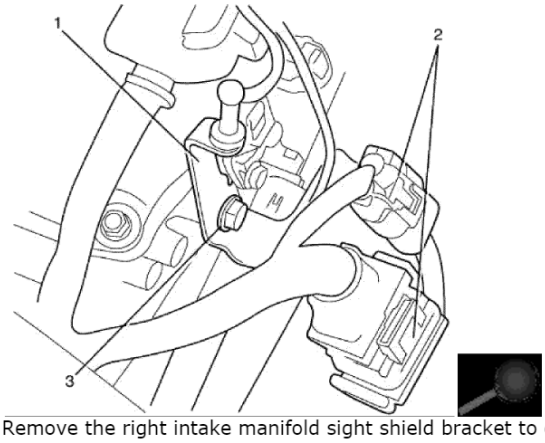
Intake Manifold Sight Shield Bracket Replacement

Removal Procedure

1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



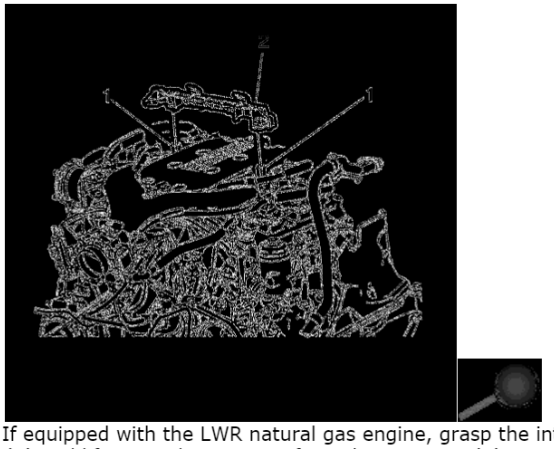
2. Remove the left intake manifold sight shield bracket to engine assembly bolt (2).
3. Remove the left intake manifold sight shield bracket (1) from the engine assembly.



4. Remove the right intake manifold sight shield bracket to engine assembly bolt (3).
5. Remove the right intake manifold sight shield bracket (1) from the engine assembly.

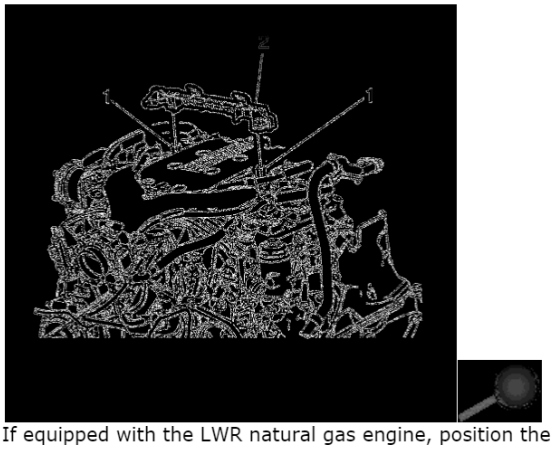
cardiagn.com

© 2014 General Motors. All rights reserved.

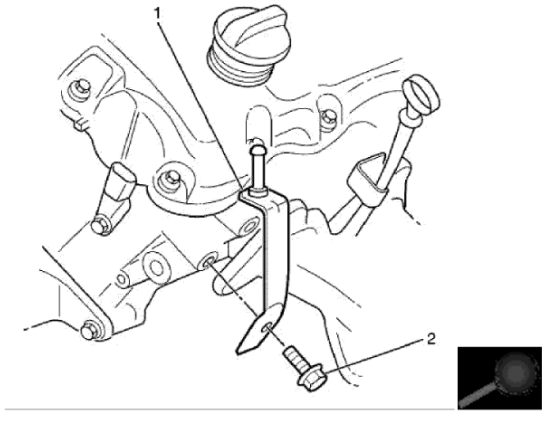


6. If equipped with the LWR natural gas engine, grasp the intake manifold insulator bracket (2) and lift upward to remove from the retainers (1).

Installation Procedure



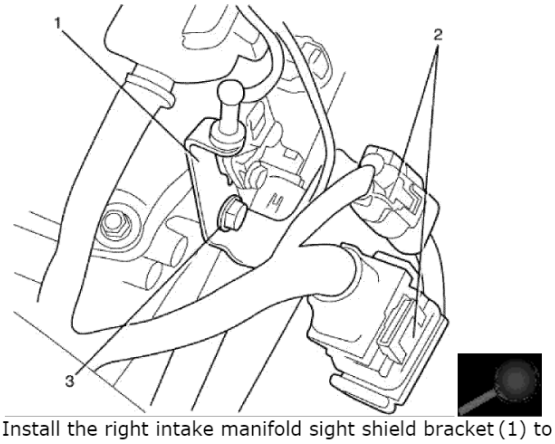
1. If equipped with the LWR natural gas engine, position the intake manifold insulator bracket (2) over the retainers (1) and push downward until seated.



cardiagn.com

2. Install the left intake manifold sight shield bracket (1) to the engine assembly.

   Caution: Refer to Fastener Caution.
3. Install the left intake manifold sight shield bracket to engine assembly bolt (2) and tighten to **35 N·m (26 lb in).**



4. Install the right intake manifold sight shield bracket (1) to engine assembly.
5. Install the right intake manifold sight shield bracket to engine assembly bolt (3) and tighten to **35 N·m (26 lb in).**
6. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

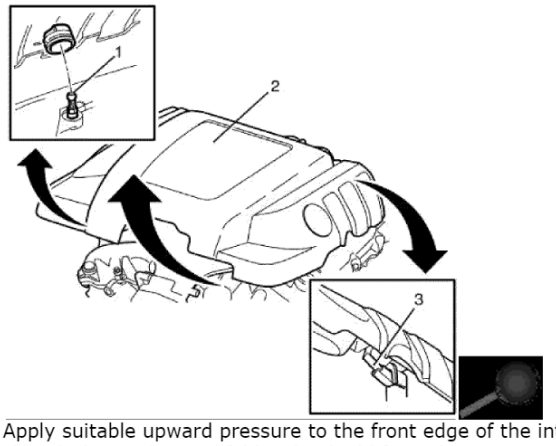
cardiagn.com

Intake Manifold Sight Shield Replacement (LFX and LFW)

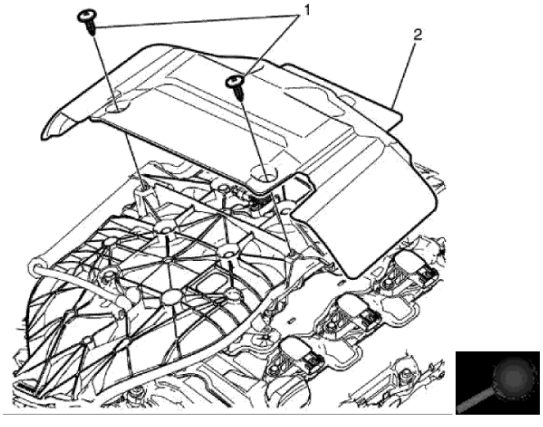
Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Ignition OFF
2. Raise and secure the engine compartment hood.



3. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the retainers (1).
4. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
5. Remove the intake manifold sight shield (2) from the engine.



Note: Take care not to damage the intake manifold insulator (2).

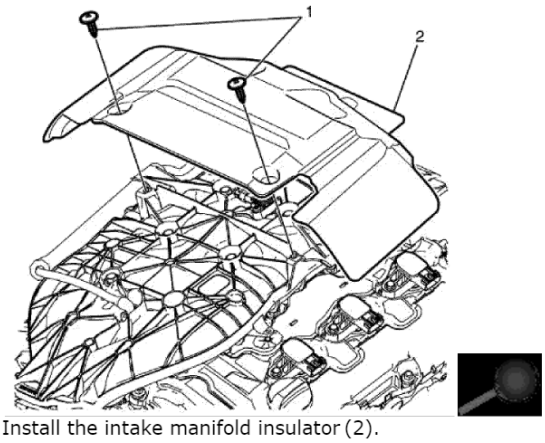
6. Remove the intake manifold insulator retainers (1).
7. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.

© 2014 General Motors. All rights reserved.

cardiagn.com

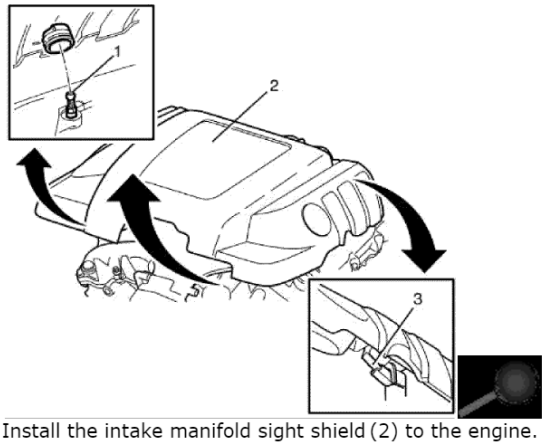
8. Remove the intake manifold insulator (2).

Installation Procedure



1. Install the intake manifold insulator (2).

   Note: Take care not to damage the intake manifold insulator (2).
2. Install the intake manifold insulator retainers (1).
3. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement.

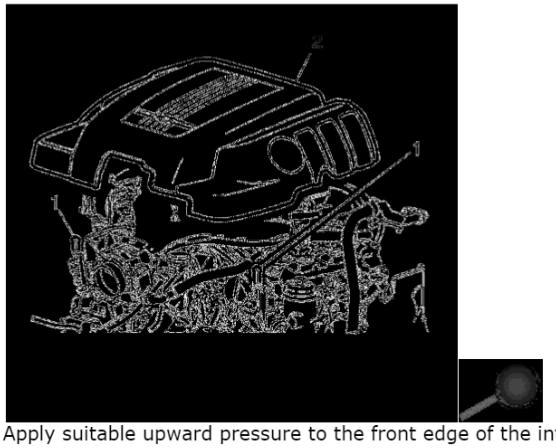


4. Install the intake manifold sight shield (2) to the engine.
5. Install the intake manifold sight shield (2) to the intake manifold sight shield retainers (3).
6. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).
7. Close the engine compartment hood.

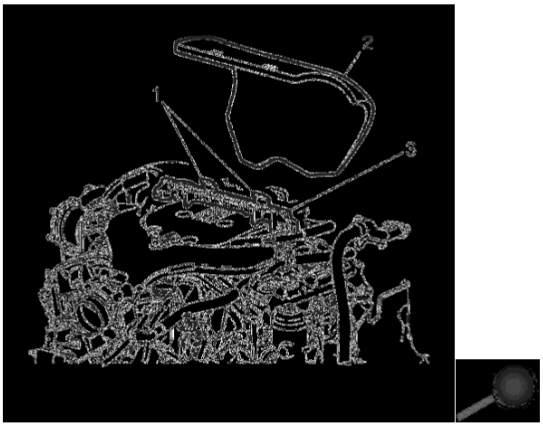
cardiagn.com

Intake Manifold Sight Shield Replacement (LWR)

Removal Procedure



1. Apply suitable upward pressure to the front edge of the intake manifold sight shield (2) to detach the intake manifold sight shield from the rear retainers.
2. Pull the intake manifold sight shield (2) forward to detach the intake manifold sight shield from the retainers (3).
3. Remove the intake manifold sight shield (2) from the engine.



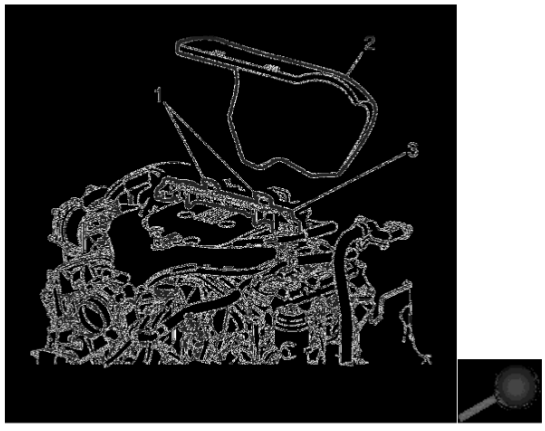
Note: Take care not to damage the intake manifold insulator (2).

4. Remove the intake manifold insulator (2) by carefully lifting and rotating the insulator off the retainers (1).

Installation Procedure

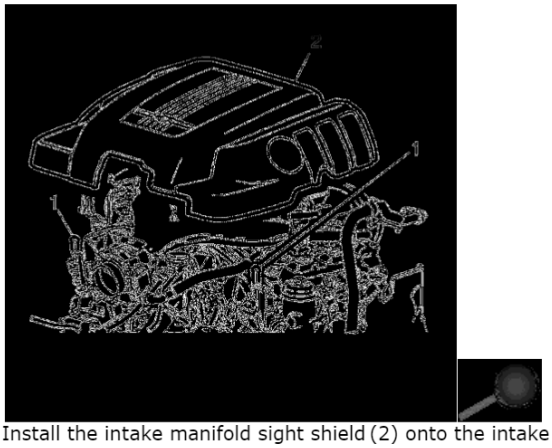
cardiagn.com

© 2014 General Motors. All rights reserved.



Note: Take care not to damage the intake manifold insulator (2).

1. Install the intake manifold insulator (2) by lowering and rotating the insulator onto the retainers (1).



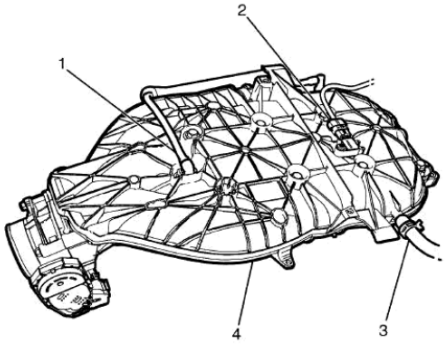
2. Install the intake manifold sight shield (2) onto the intake manifold sight shield rear retainers.
3. Apply suitable downward pressure to the front edge of the intake manifold sight shield (2) to engage the intake manifold sight shield to the retainers (1).

cardiagn.com

Intake Manifold Replacement (LFX and LFW)

Removal Procedure

1. Ignition OFF
2. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.
4. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement
5. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.
6. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.

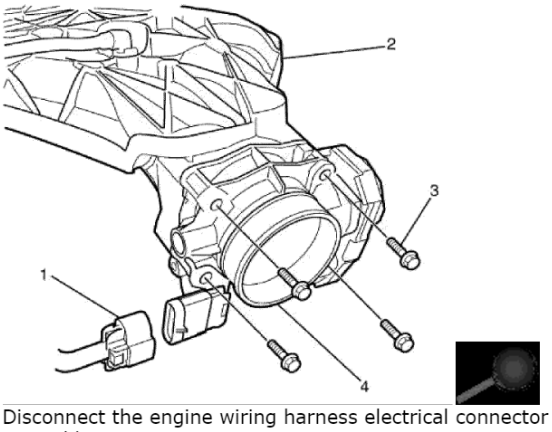


7. Detach the brake booster vacuum hose (3) from the intake manifold (4).
8. Disconnect the engine wiring harness electrical connector from the manifold absolute pressure sensor (2).

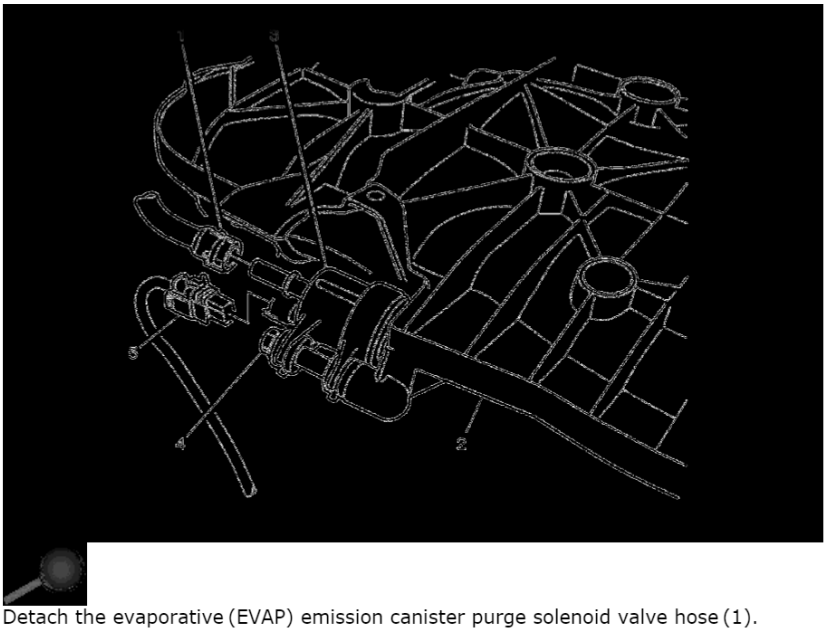
   Note: Turn the positive crankcase ventilation (PVC) tube connector 90 degrees to release the connector.
9. Detach the PCV tube (1) from the intake manifold (4).

cardiagn.com

© 2014 General Motors. All rights reserved.

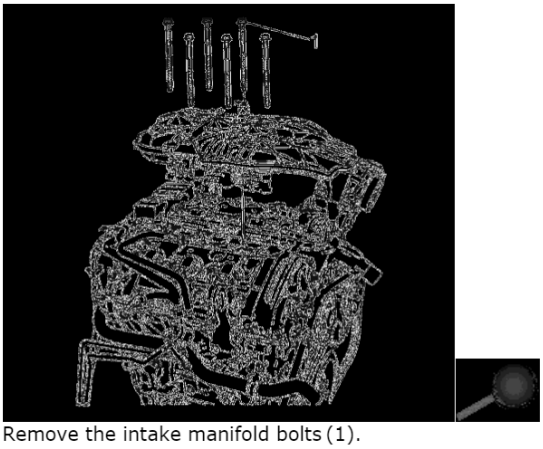


10. Disconnect the engine wiring harness electrical connector (1) from the throttle body assembly.

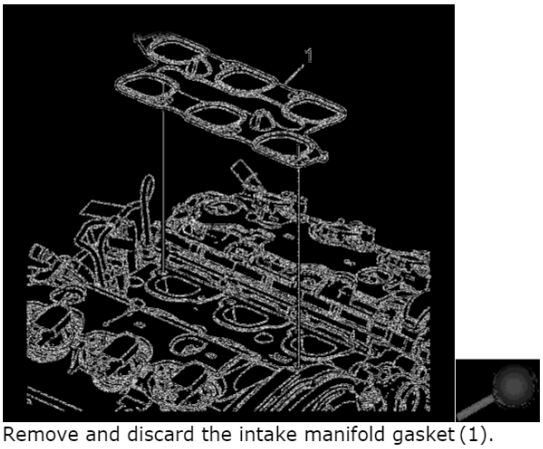


11. Detach the evaporative (EVAP) emission canister purge solenoid valve hose (1).
12. Disconnect the engine wiring harness connector (5) from the EVAP emission canister purge solenoid valve.

cardiagn.com



13. Remove the intake manifold bolts (1).
14. Remove the intake manifold from the engine.

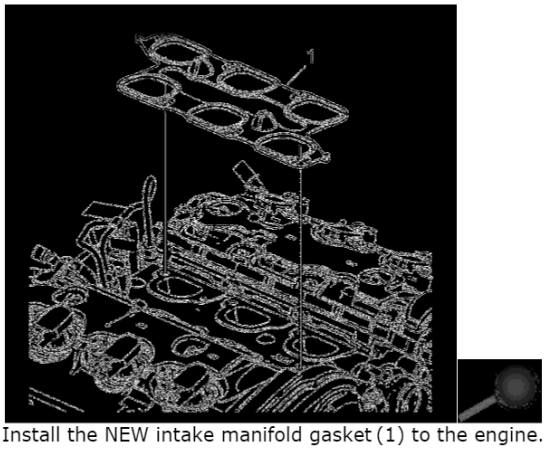


15. Remove and discard the intake manifold gasket (1).
16. If replacing the intake manifold, disassemble the intake manifold. Refer to Intake Manifold Disassemble.

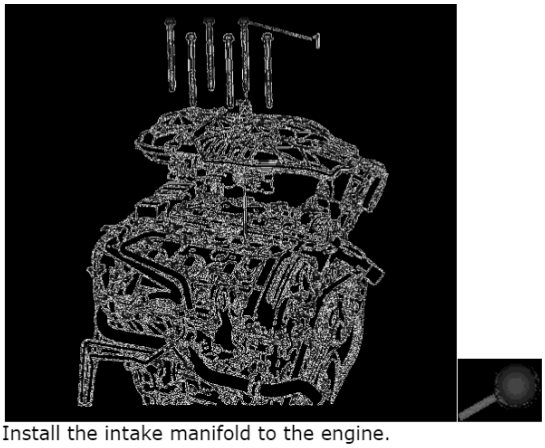
Installation Procedure

1. If installing a new intake manifold, assemble the intake manifold. Refer to Intake Manifold Assemble.

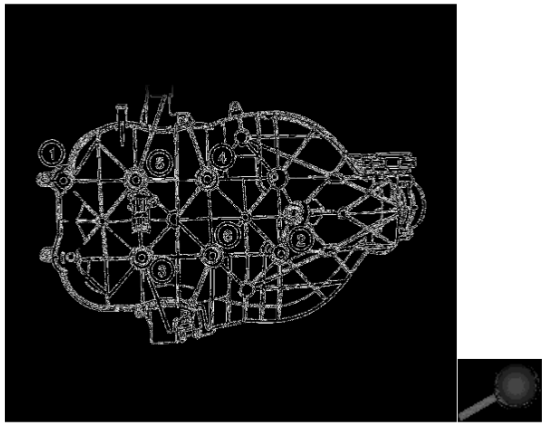
cardiagn.com



2. Install the NEW intake manifold gasket (1) to the engine.



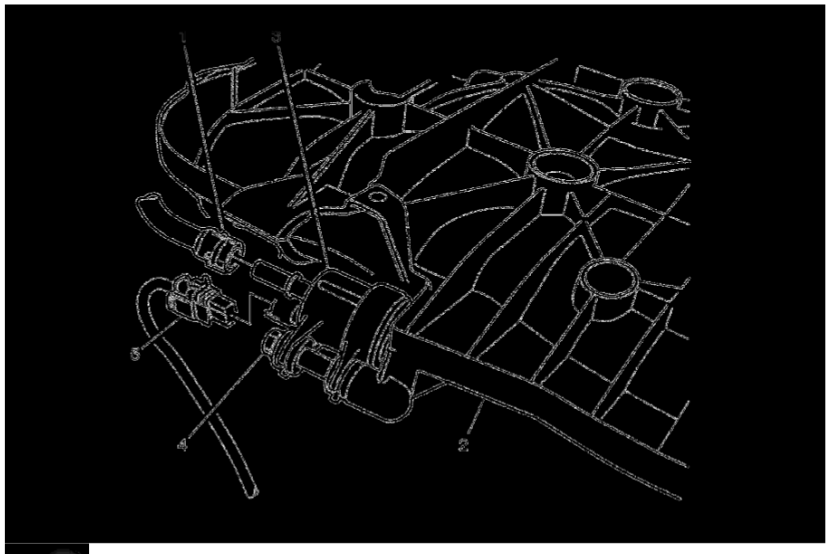
3. Install the intake manifold to the engine.
4. Install the intake manifold bolts (1).



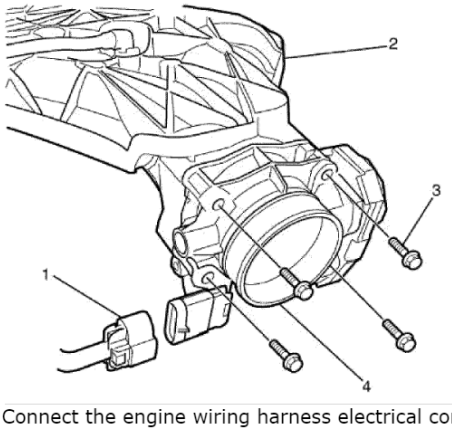
Caution: Refer to Fastener Caution.

5. Tighten the intake manifold bolts to **23N•m (17 lb ft)** in the sequence shown.

cardiagn.com

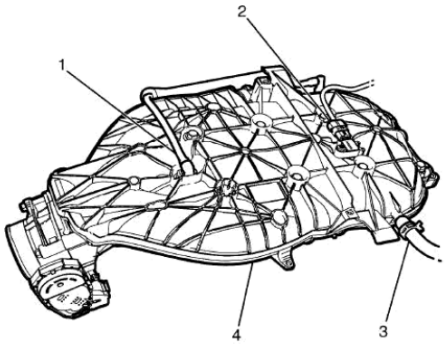


6. Install the EVAP emission canister purge solenoid valve hose (1) to the EVAP emission canister purge solenoid valve.
7. Connect the engine wiring harness connector (5) to the EVAP emission canister purge solenoid valve.



8. Connect the engine wiring harness electrical connector (1) to the throttle body assembly.

cardiagn.com



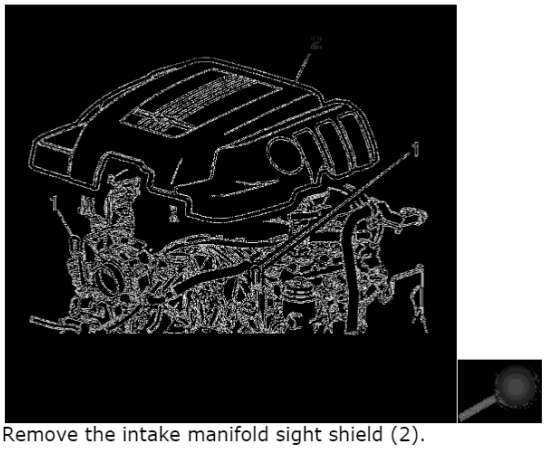
9. Attach the brake booster vacuum hose (3) to the intake manifold (4).
10. Connect the engine wiring harness electrical connector to the manifold absolute pressure sensor (2).
11. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
12. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
13. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement
14. Install the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.
15. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

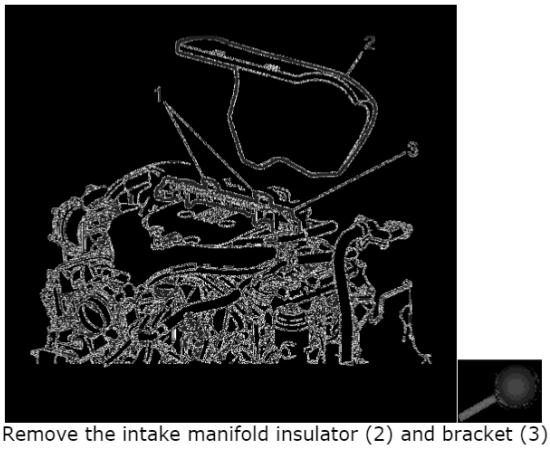
Upper Intake Manifold Replacement (LWR)

Removal Procedure

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.



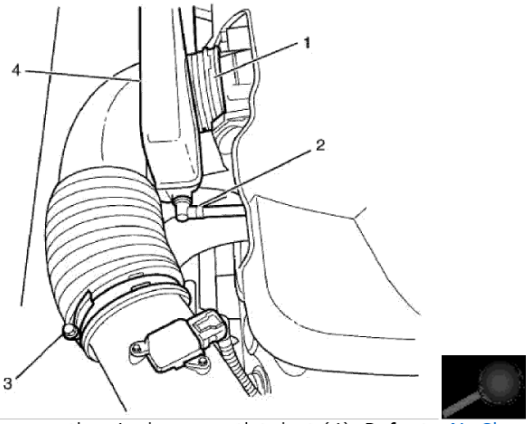
3. Remove the intake manifold sight shield (2).



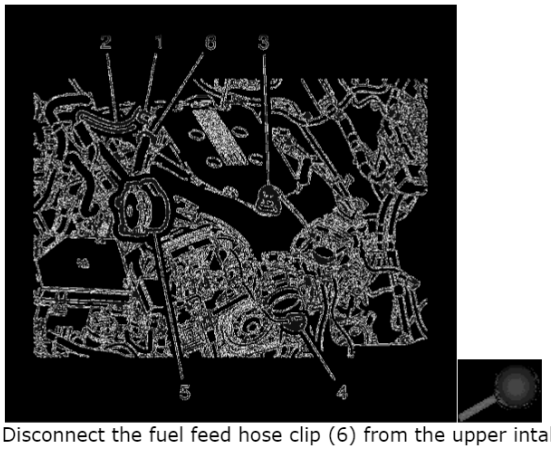
4. Remove the intake manifold insulator (2) and bracket (3). Refer to Intake Manifold Sight Shield Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.



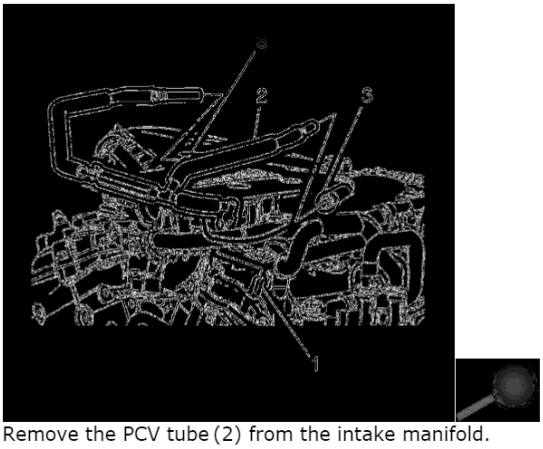
5. Remove the air cleaner outlet duct (4). Refer to Air Cleaner Outlet Duct Replacement.



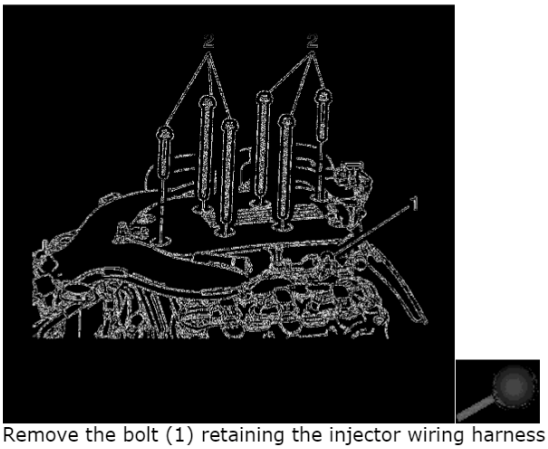
6. Disconnect the fuel feed hose clip (6) from the upper intake manifold.

   Note: It is not necessary to disconnect the fuel lines from the filter housing. Leave the fuel lines connected, remove the bracket bolts and position the filter and bracket assembly out of the way.
7. Remove the LPG fuel filter and bracket assembly (5) from the intake manifold. Refer to Fuel Filter Bracket Replacement.
8. Disconnect the brake booster vacuum hose from the intake manifold fitting (1).
9. Disconnect the fuel pressure regulator vacuum reference hose (2) from the intake manifold fitting.
10. Disconnect the engine wiring harness electrical connector from the manifold absolute pressure sensor (3).
11. Disconnect the engine wiring harness electrical connector (4) from the throttle body assembly.

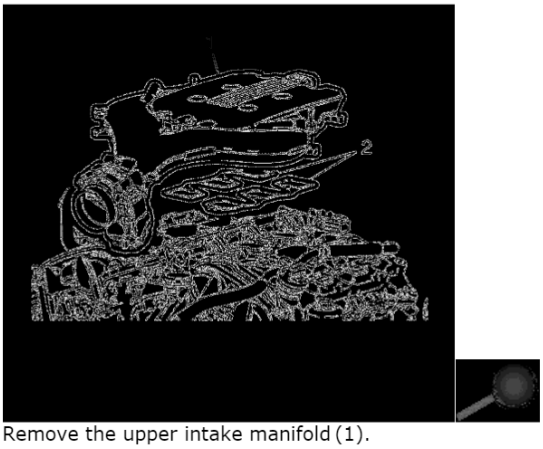
cardiagn.com



12. Remove the PCV tube (2) from the intake manifold.



13. Remove the bolt (1) retaining the injector wiring harness to the upper intake manifold.
14. Remove the upper intake manifold bolts (2).



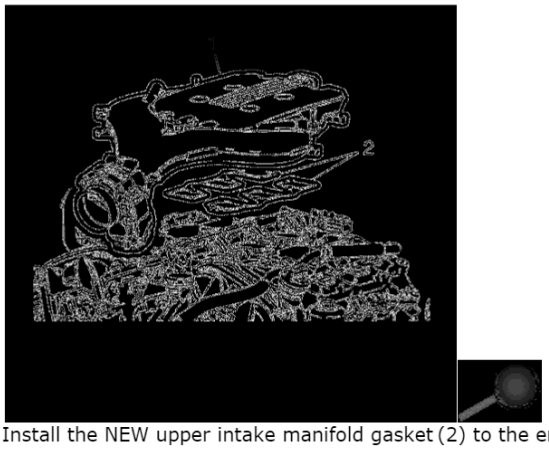
15. Remove the upper intake manifold (1).
16. Remove and discard the intake manifold gasket (2).

cardiagn.com

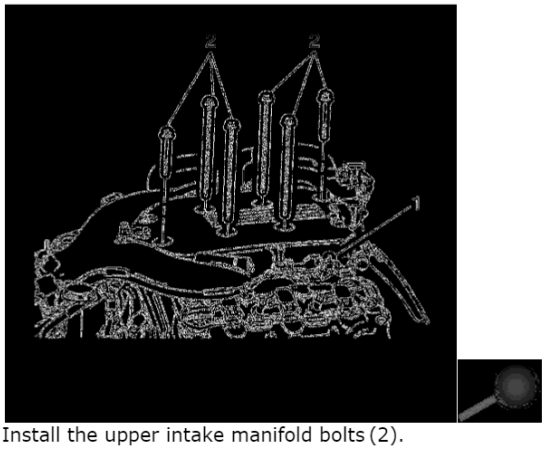
17. If replacing the intake manifold, disassemble the intake manifold. Refer to Intake Manifold Disassemble.

Installation Procedure

1. If installing a new intake manifold, assemble the intake manifold. Refer to Intake Manifold Assemble.



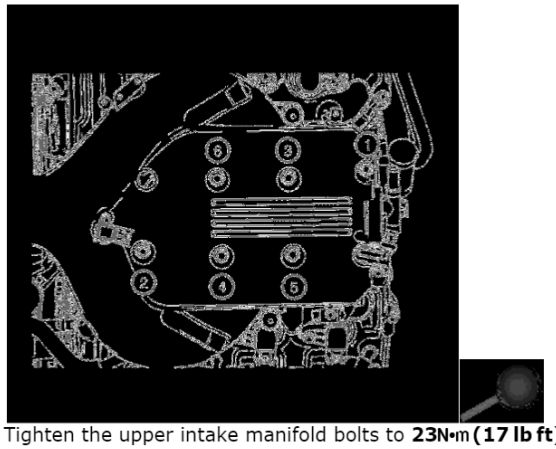
2. Install the NEW upper intake manifold gasket (2) to the engine.
3. Install the upper intake manifold to the engine.



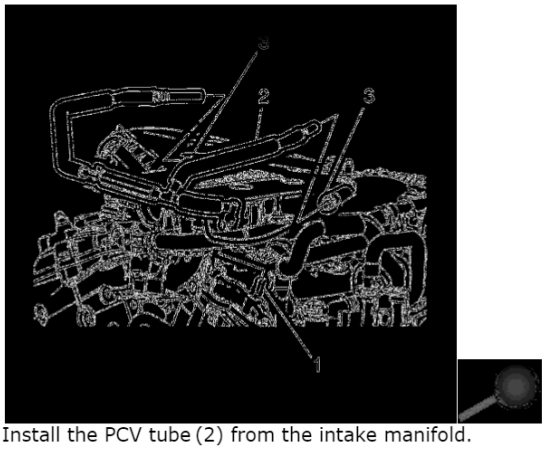
4. Install the upper intake manifold bolts (2).

   Caution: Refer to Fastener Caution.
5. Install the bolt (1) retaining the injector wiring harness to the intake manifold. Tighten the wire harness bolt to **10N•m (89 lb in)**

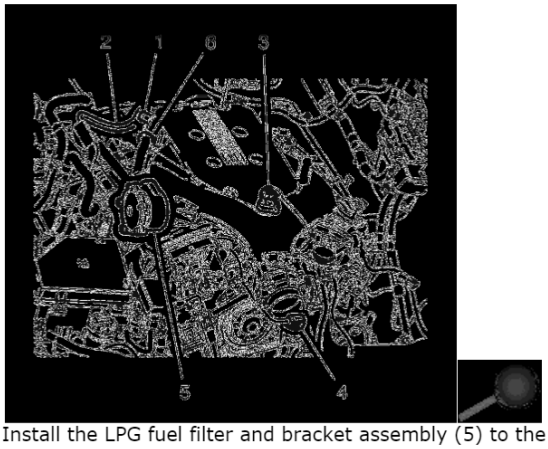
cardiagn.com



6. Tighten the upper intake manifold bolts to **23N•m (17 lb ft)** in the sequence shown.



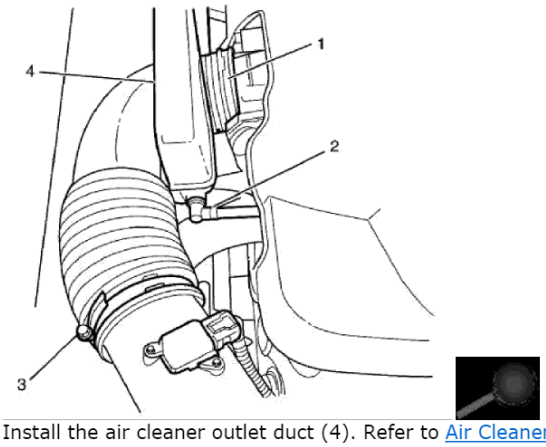
7. Install the PCV tube (2) from the intake manifold.



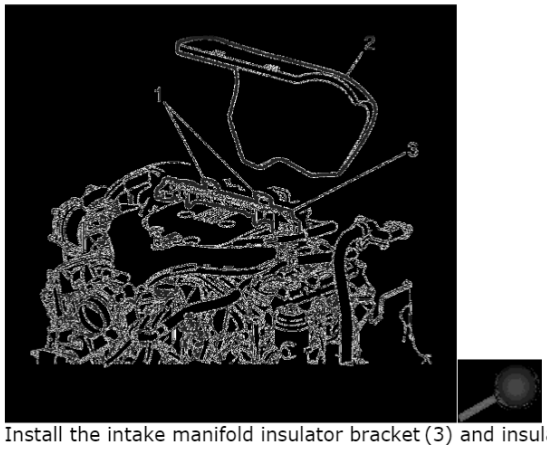
8. Install the LPG fuel filter and bracket assembly (5) to the intake manifold. Refer to Fuel Filter Bracket Replacement.
9. Connect the fuel feed hose clip (6) to the upper intake manifold.

cardiagn.com

10. Connect the engine wiring harness electrical connector (4) from the throttle body assembly.
11. Connect the brake booster vacuum hose from the intake manifold fitting (1).
12. Connect the fuel pressure regulator vacuum reference hose (2) from the intake manifold fitting.
13. Connect the engine wiring harness electrical connector from the manifold absolute pressure sensor (3).

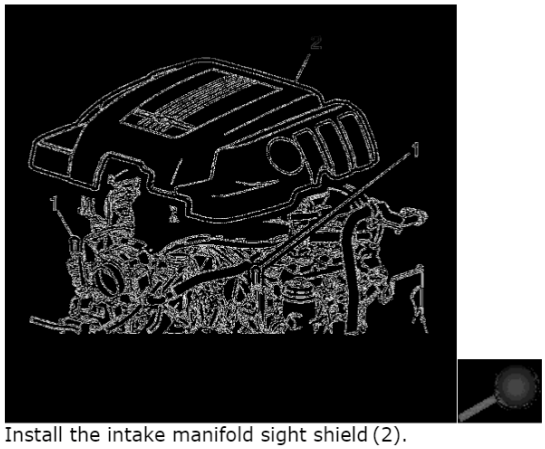


14. Install the air cleaner outlet duct (4). Refer to Air Cleaner Outlet Duct Replacement.



15. Install the intake manifold insulator bracket (3) and insulator (3). Refer to Intake Manifold Sight Shield Replacement.

cardiagn.com



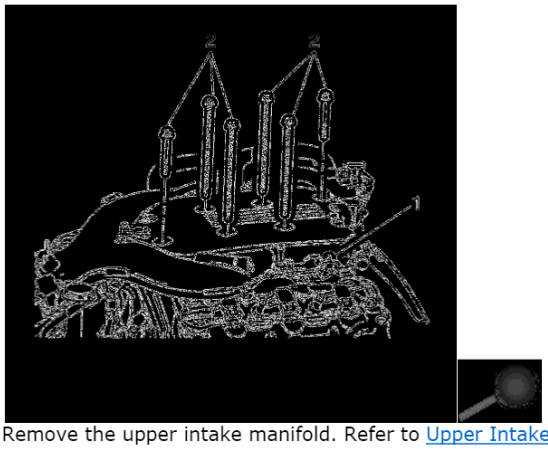
16. Install the intake manifold sight shield (2).
17. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement
18. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

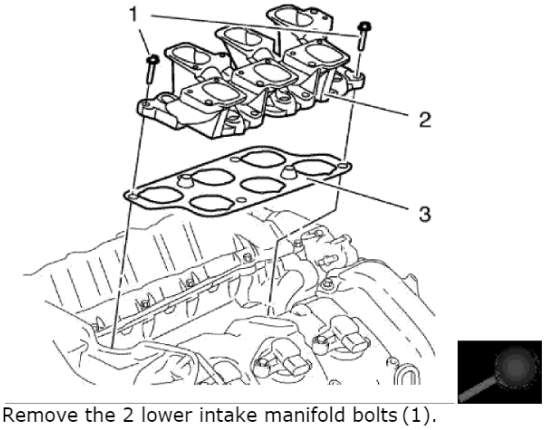
Lower Intake Manifold Replacement (LWR)

Removal Procedure

1. Drain the cooling system. Refer to Cooling System Draining and Filling.



2. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.
3. Remove the fuel injectors and fuel rail. Refer to Fuel Injector and Fuel Rail Replacement.

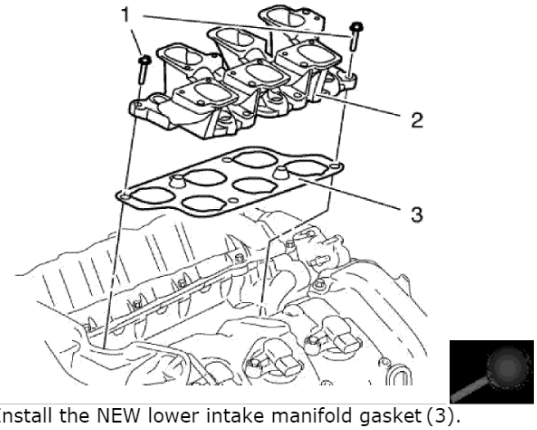


4. Remove the 2 lower intake manifold bolts (1).
5. Remove the lower intake manifold (2).
6. Remove the lower Intake manifold gasket (3).
7. Clean and inspect lower intake manifold. Refer to Intake Manifold Cleaning and Inspection.

Installation Procedure

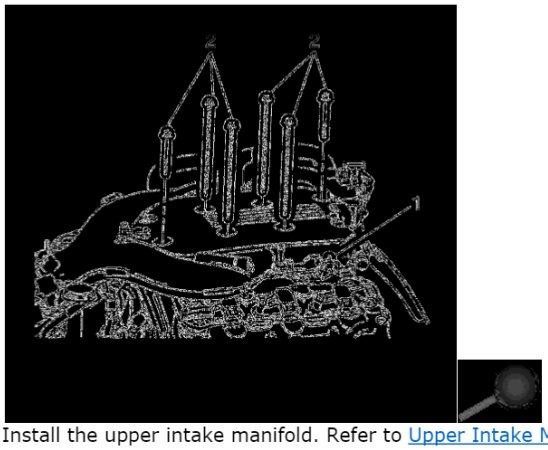
© 2014 General Motors. All rights reserved.

cardiagn.com



1. Install the NEW lower intake manifold gasket (3).
2. Install the lower intake manifold (2).

   Caution: Refer to Fastener Caution.
3. Install the 2 lower intake manifold bolts (1) and tighten to **23 N•m (17 lb ft)**.
4. Install the fuel injectors and fuel rail. Refer to Fuel Injector and Fuel Rail Replacement.



5. Install the upper intake manifold. Refer to Upper Intake Manifold Replacement.
6. Fill the cooling system. Refer to Cooling System Draining and Filling.

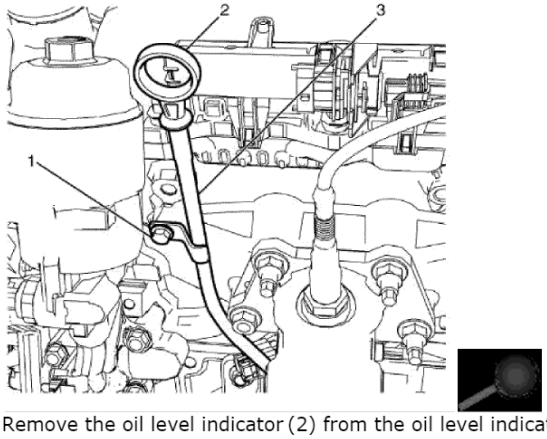
cardiagn.com

Oil Level Indicator Tube Replacement (LFX and LFW)

Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

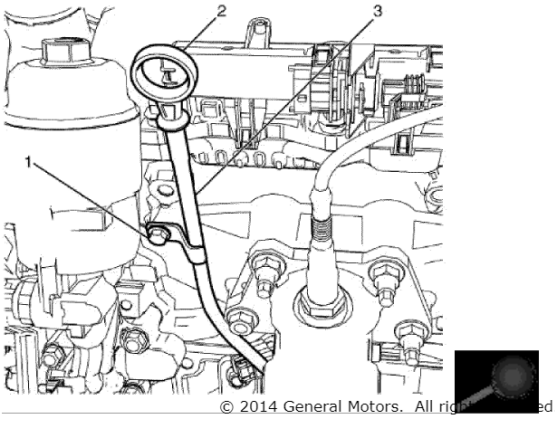


2. Remove the oil level indicator (2) from the oil level indicator tube (3).
3. Remove the oil level indicator tube to cylinder head retaining bolt (1).

Note:
- Apply suitable upward pressure to remove the oil level indicator tube from the engine.
- The oil level indicator tube seal is a single use item.

4. Remove the oil level indicator tube (3) from the engine.

Installation Procedure



© 2014 General Motors. All rights reserved.

cardiagn.com

1. Install a NEW oil level indicator tube seal to the oil level indicator tube (3).

   Note: Apply suitable downward pressure to install the oil level indicator tube to the engine.
2. Install the oil level indicator tube (3) to the engine.

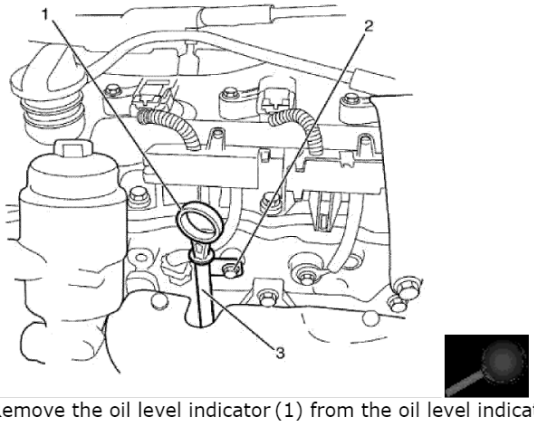
   Caution: Refer to Fastener Caution.
3. Install the oil level indicator tube to cylinder head retaining bolt (1) and tighten to **9 N•m (80 lb in).**
4. Install the oil level indicator (2) to the oil level indicator tube (3).
5. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

cardiagn.com

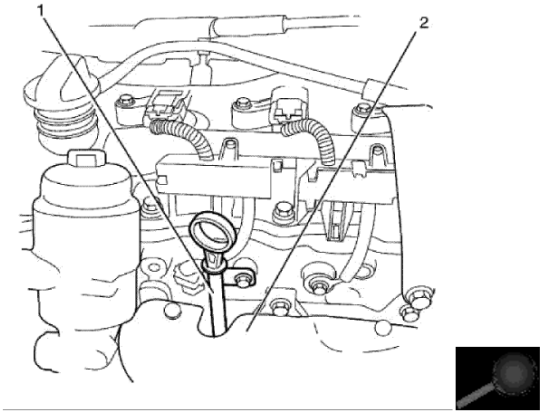
Oil Level Indicator Tube Replacement (LWR)

Removal Procedure

Warning: Refer to Safety Glasses Warning.



1. Remove the oil level indicator (1) from the oil level indicator tube (3).
2. Remove the oil level indicator tube to cylinder head retaining bolt (2).

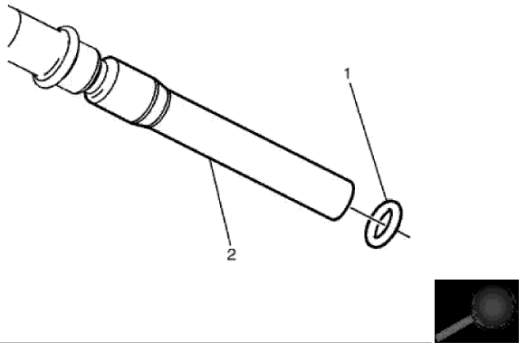


Note:
- Apply suitable upward pressure to remove the oil level indicator tube from the engine.
- The oil level indicator tube seal is a single use item.

3. Remove the oil level indicator tube (1) from the engine up through the exhaust manifold (2)..

cardiagn.com

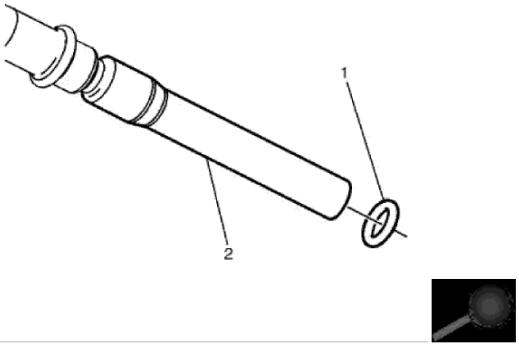
© 2014 General Motors. All rights reserved.



Note: The oil level indicator tube O-ring is a single use component

4. Remove the O-ring (1) from the oil level indicator tube (2) and discard.

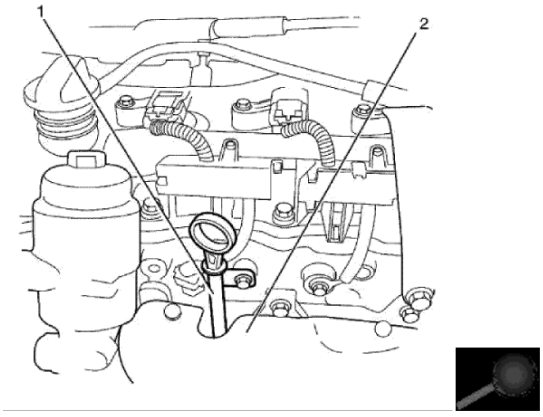
Installation Procedure



Note: The oil level indicator tube O-ring is a single use component

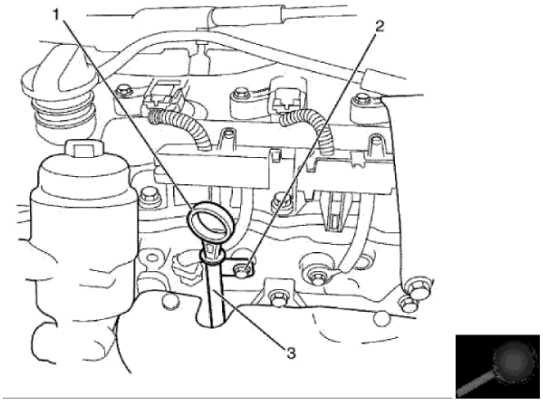
1. Install the O-ring (1) on the oil level indicator tube (2) and discard.

cardiagn.com



Note: Apply suitable downward pressure to install the oil level indicator tube to the engine.

2. Install the oil level indicator tube (1) to the engine.



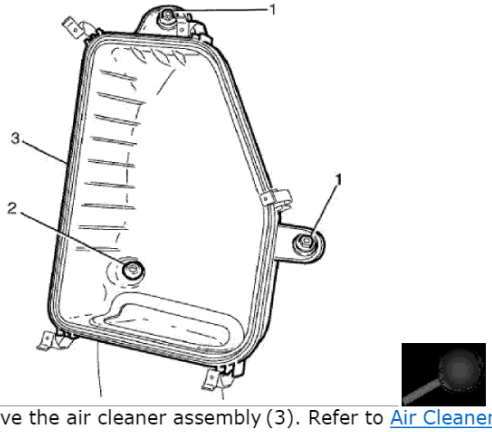
Caution: Refer to Fastener Caution.

3. Install the oil level indicator tube bracket to cylinder head retaining bolt (2). and tighten to **9 N•m (80 lb in).**
4. Install the oil level indicator (1) to the oil level indicator tube.

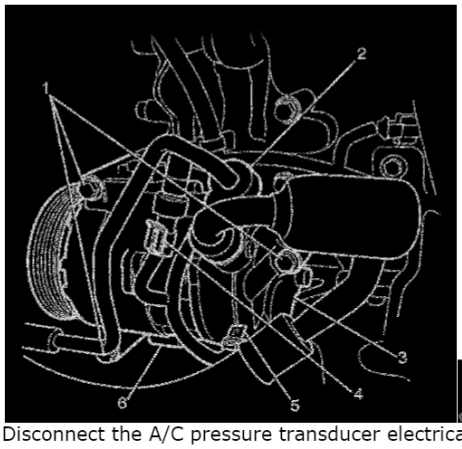
cardiagn.com

Oil Filter Adapter Replacement

Removal Procedure



1. Remove the air cleaner assembly (3). Refer to Air Cleaner Assembly Replacement.
2. Remove the oil filter. Refer to Engine Oil and Oil Filter Replacement.
3. Remove the drive belt. Refer to Drive Belt Replacement.

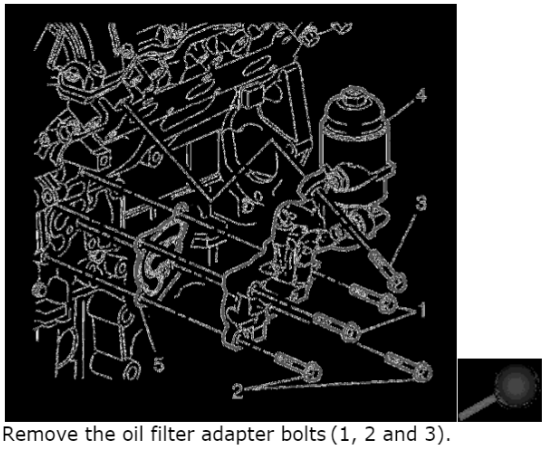


4. Disconnect the A/C pressure transducer electrical connector (4).
5. Disconnect the A/C compressor electrical connector (5).

   Important: DO NOT disconnect the A/C pipes (2) from the A/C compressor (6).
6. Remove the A/C compressor to A/C compressor mounting bracket retaining bolts (1).
7. Secure and reposition the A/C compressor (6) away from the A/C compressor mounting bracket (3) in order to gain access to the oil filter adapter to cylinder block retaining bolts.

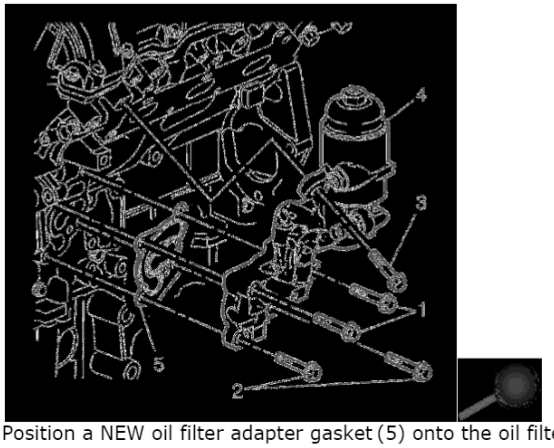
cardiagn.com

© 2014 General Motors. All rights reserved.



8. Remove the oil filter adapter bolts (1, 2 and 3).
9. Remove the oil filter adapter (4).
10. Remove and discard the gasket (5).

Installation Procedure



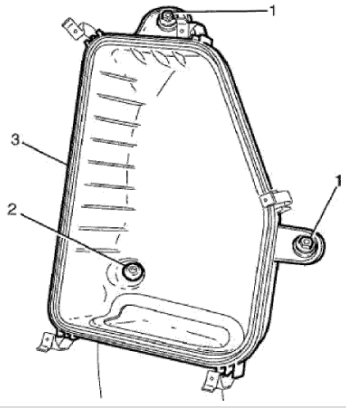
1. Position a NEW oil filter adapter gasket (5) onto the oil filter adapter.
2. Install the oil filter adapter bolts (1, 2) into the oil filter adapter.
3. Loosely tighten the oil filter adapter bolts (1, 2).
4. Install and loosely tighten the oil filter adapter bolt (3) into the oil filter adapter.

   Caution: Refer to Fastener Caution.
5. Tighten the oil filter adapter bolts (1, 2) to **25 N•m (18 lb ft)**.
6. Tighten the oil filter adapter bolt (3) to **58 N•m (43 lb ft)**.

   Important: Make sure the A/C pipes (2) are not twisted or kinked upon compressor installation.
7. Install the A/C compressor (6) with the A/C pipes (2) to the A/C compressor mounting bracket (3).
8. Install the A/C compressor to A/C compressor mounting bracket retaining bolts (1).
9. Connect the A/C pressure transducer electrical connector (4).
10. Connect the A/C compressor electrical connector (5).
11. Install the drive belt. Refer to Drive Belt Replacement.

cardiagn.com

12. Install the oil filter. Refer to Engine Oil and Oil Filter Replacement.



13. Install the air cleaner assembly (3). Refer to Air Cleaner Assembly Replacement.

cardiagn.com

Crankshaft Balancer Replacement

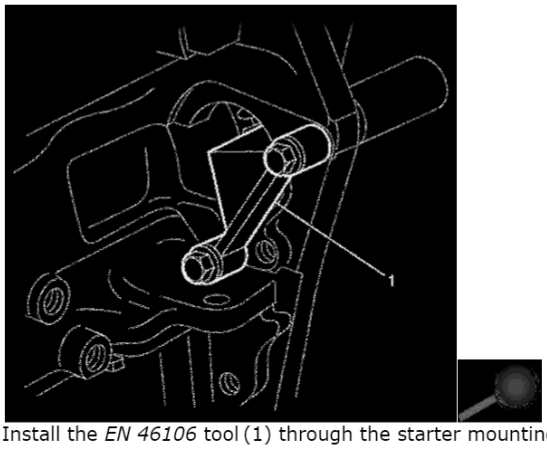
Special Tools

- *EN 38416-2* Crankshaft Button
- *EN 41816* Crankshaft Balancer Remover
- *EN 46106* Flywheel Holding Tool
- *EN 41998-B* Crankshaft Balancer Installer

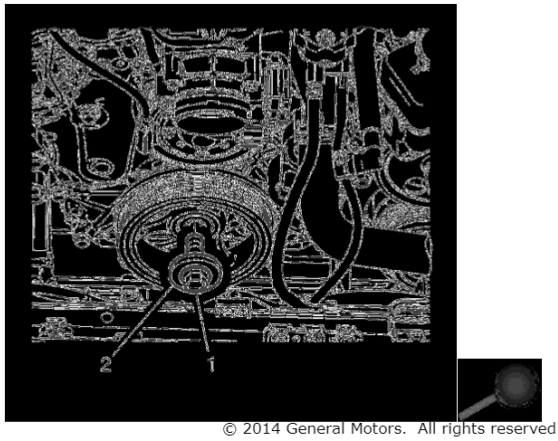
For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Remove the drive belt. Refer to Drive Belt Replacement.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove the starter motor. Refer to Starter Removal.



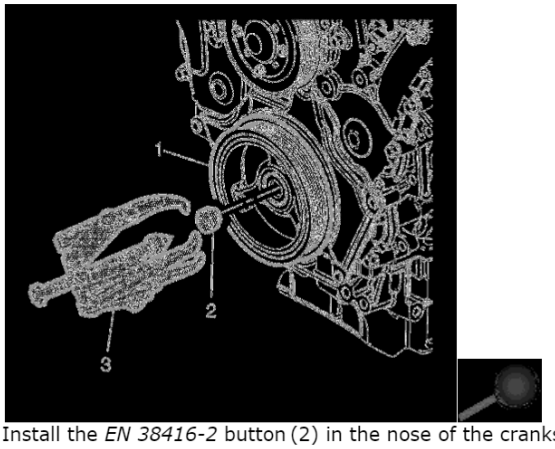
4. Install the *EN 46106* tool (1) through the starter mounting hole.
5. Lower the vehicle.



© 2014 General Motors. All rights reserved.

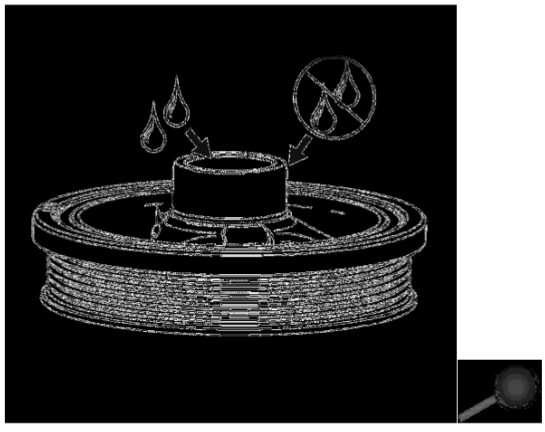
cardiagn.com

6. Remove and discard the crankshaft balancer to crankshaft retaining bolt (1) and washer (2).



7. Install the *EN 38416-2* button (2) in the nose of the crankshaft.
8. Install the *EN 41816* remover (3) in order to remove the crankshaft balancer (1).
9. Tighten the center bolt of the *EN 41816* remover in order to pull the crankshaft balancer off of the crankshaft.
10. Remove the *EN 41816* remover from the crankshaft balancer.

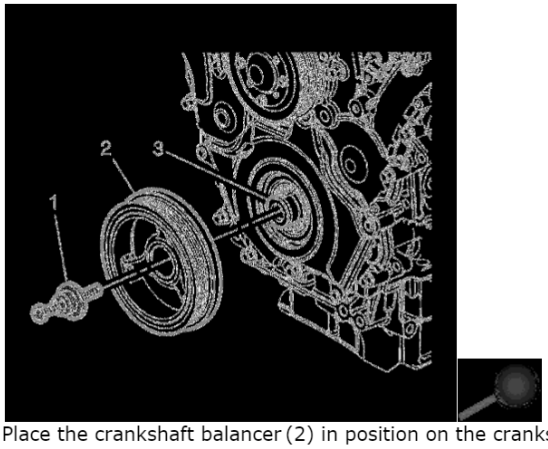
Installation Procedure



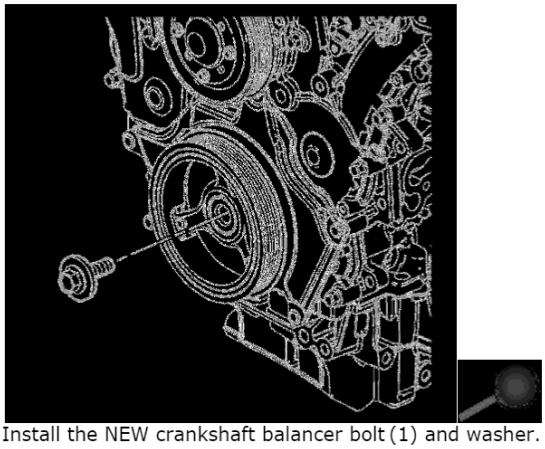
Note: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

1. Apply lubricant to the inside of the crankshaft balancer hub bore.

cardiagn.com



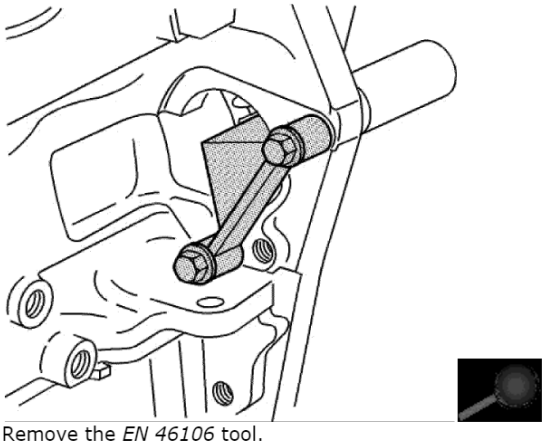
2. Place the crankshaft balancer (2) in position on the crankshaft (3).
3. Thread the *EN 41998-B* installer (1) in the crankshaft. Ensure you engage at least 10 threads of the *EN 41998-B* installer before pressing the crankshaft balancer in place.
4. Push the crankshaft balancer into position by tightening the nut on the *J 41998-B* installer until the large washer bottoms out on the crankshaft end.
5. Remove the *EN 41998-B* installer.



6. Install the NEW crankshaft balancer bolt (1) and washer.

   Caution: Refer to Fastener Caution.
7. Tighten the crankshaft balancer bolt.
   7.1. Tighten the crankshaft balancer bolt to **100 N·m (74 lb ft)**.
   7.2. Tighten the crankshaft balancer bolt an additional **150 degrees** using the *EN 45059* meter.
8. Raise the vehicle.

cardiagn.com



9. Remove the *EN 46106* tool.
10. Install the starter motor. Refer to Starter Installation.
11. Lower the vehicle.
12. Install the drive belt. Refer to Drive Belt Replacement.

cardiagn.com

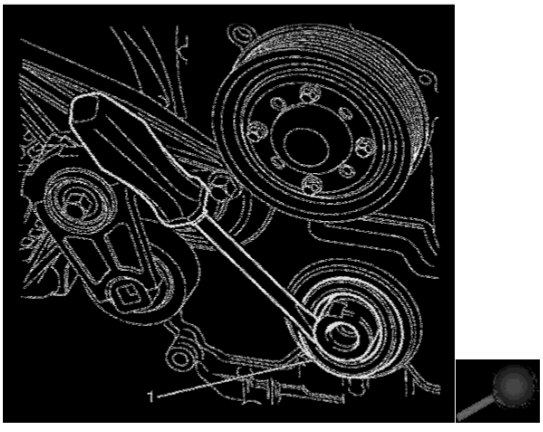
Crankshaft Front Oil Seal Replacement

Tools Required

J 29184 Oil Seal Installer

Removal Procedure

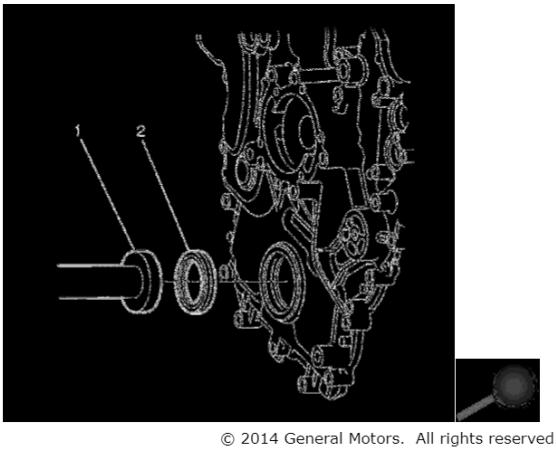
1. Remove the drive belt. Refer to Drive Belt Replacement.
2. Remove the crankshaft balancer. Refer to Crankshaft Balancer Replacement.



Important: DO NOT damage the sealing surfaces of the front cover or the crankshaft when prying the crankshaft front oil seal for removal. Damaging the sealing surface may cause leakage or require replacement of the damaged component.

3. Use a flat-bladed tool in order to remove the crankshaft oil seal (1).

Installation Procedure



© 2014 General Motors. All rights reserved.

cardiagn.com

Important: DO NOT lubricate the crankshaft front oil seal or the crankshaft balancer sealing surfaces.

1. Use the *J 29184* oil seal installer (1) or equivalent to install the crankshaft front oil seal (2).
2. Install the crankshaft balancer. Refer to Crankshaft Balancer Installation.
3. Install the drive belt. Refer to Drive Belt Replacement.

cardiagn.com

Camshaft Cover Replacement - Left Side (LFX and LFW)

Special Tools

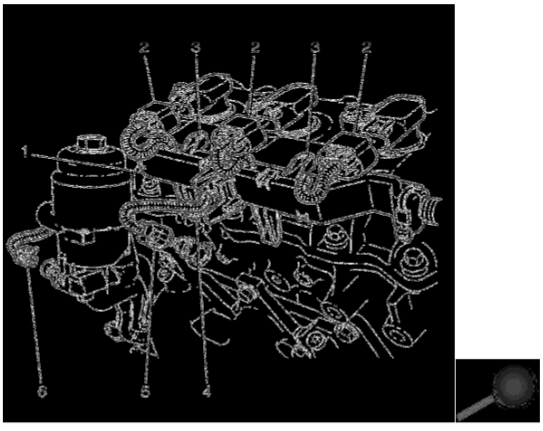
EN 46101 Spark Plug Tube Seal Guide

Removal Procedure

Warning: Refer to Safety Glasses Warning.

1. Ignition off.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery ground cable from the battery. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
4. Remove the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
5. Remove the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
6. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
7. Remove the intake manifold. Refer to Intake Manifold Removal.



Warning: Refer to Exhaust Service Warning.

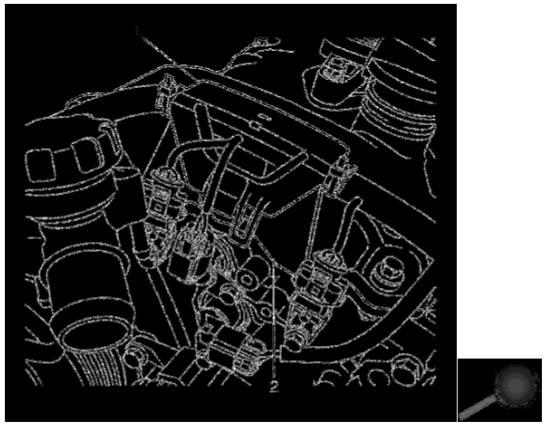
Note:
- Unlock the ignition coil electrical connectors before disconnecting from the ignition coils.
- Do not damage the ignition coil electrical connectors.

8. Disconnect the ignition coil electrical connectors (2) from the ignition coils.

   Note: Use a suitable tool to detach the wiring harness (1) from the camshaft cover retainers (4) and lift the wiring harness (1) upward to detach the wiring harness from the camshaft cover lugs (3).
9. Detach the engine wiring harness (1) from the left bank camshaft cover.
10. Reposition and secure the wiring harness (1) away from the camshaft cover in order to provide clearance for removal of the camshaft cover.

© 2014 General Motors. All rights reserved.

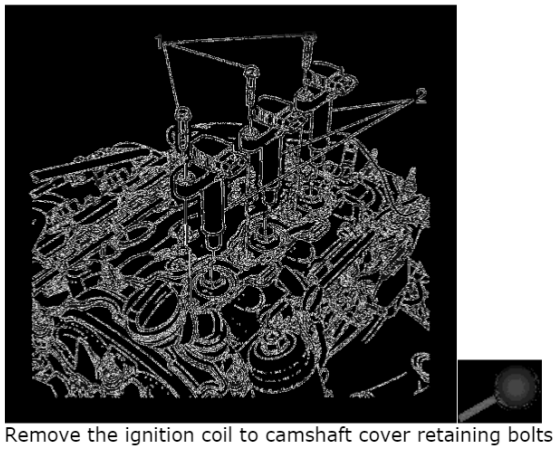
cardiagn.com



Note:

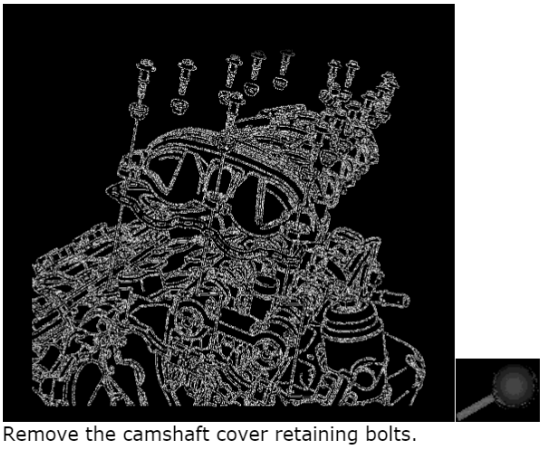
- Do not disconnect the engine front cover electrical connectors.
- Use a suitable tool to detach the wiring harness (1) from the camshaft cover (2) and lift the wiring harness (1) upwards to detach the wiring harness from the camshaft cover (2).

11. Remove the wiring harness (1) from the front of the camshaft cover (2).
12. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).

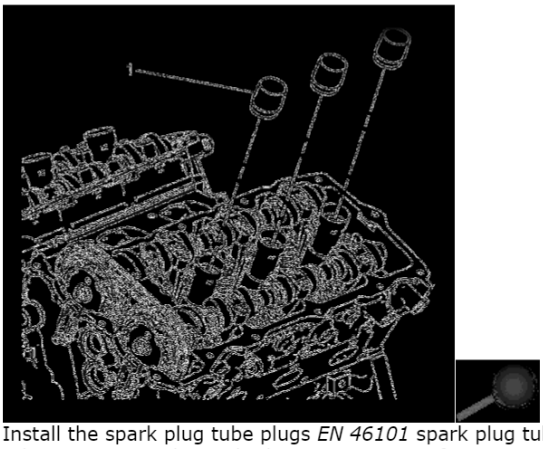


13. Remove the ignition coil to camshaft cover retaining bolts (1).
14. Remove the ignition coils (2) from the camshaft cover (3).

cardiagn.com



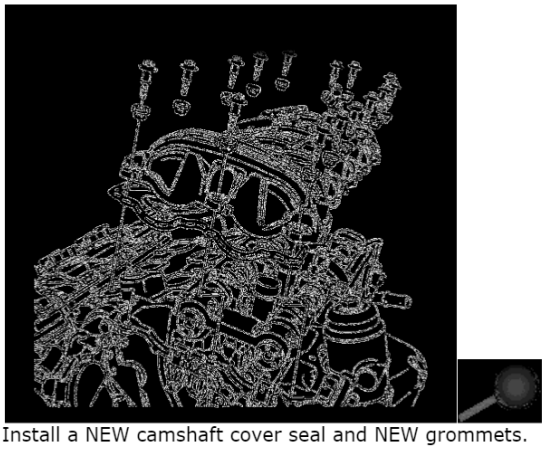
15. Remove the camshaft cover retaining bolts.
16. Remove the camshaft cover from the engine
17. Remove and discard the camshaft cover seal and grommets.



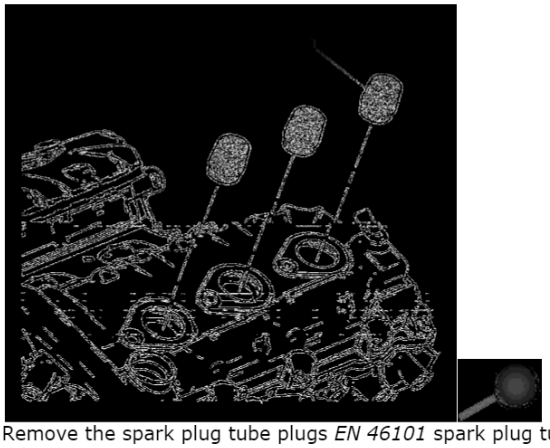
18. Install the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) to the spark plug tubes to prevent dirt and other contaminants from entering into the cylinders.

cardiagn.com

Installation Procedure

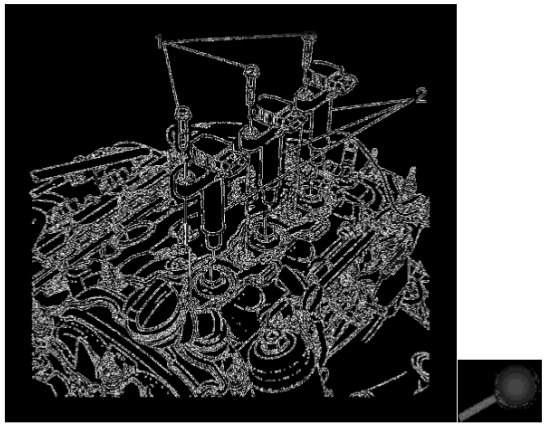


1. Install a NEW camshaft cover seal and NEW grommets.
2. Install the camshaft cover. Refer to Camshaft Cover Installation - Left Side.



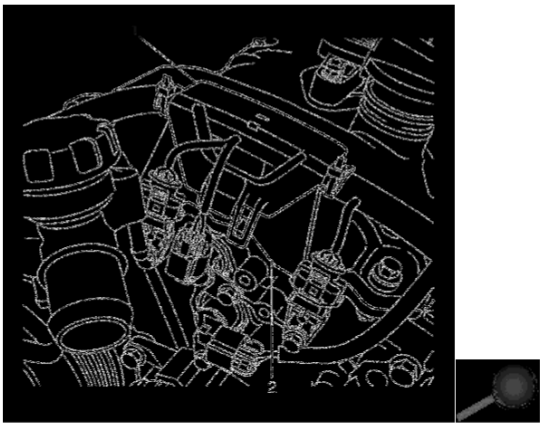
cardiagn.com

3. Remove the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) from the spark plug tubes of the left cylinder head.



Caution: Refer to Fastener Caution.

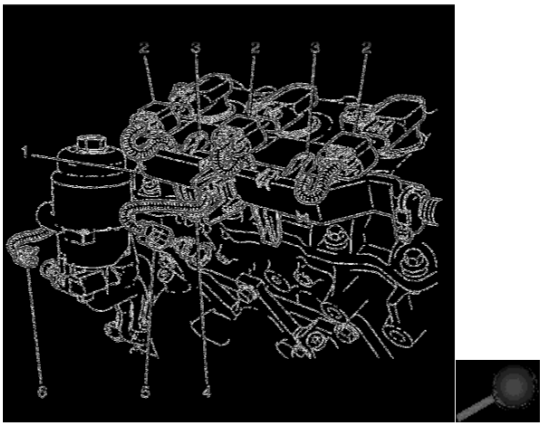
4. Install the ignition coils (2) to the camshaft cover.
5. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in)**.



Note:

- Make sure the wiring harness (1) is located on the locating lugs of the camshaft cover (2).
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover (2).

6. Install the wiring harness (1) to the front of the camshaft cover (2).



Note:

- Make sure the wiring harness (1) is located on the locating lugs of the camshaft cover.
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover.

7. Install the engine wiring harness (1) to the left bank camshaft cover.

Note: After connecting the ignition coil connectors make sure that the ignition coil electrical connectors are locked to the ignition coils.

8. Connect the ignition coil electrical connectors (2) to the ignition coils.
9. Install the intake manifold. Refer to Intake Manifold Replacement.

cardiagn.com

10. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
11. Install the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
12. Install the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
13. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
14. Connect the battery ground cable to the battery. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Camshaft Cover Replacement - Left Side (LWR)

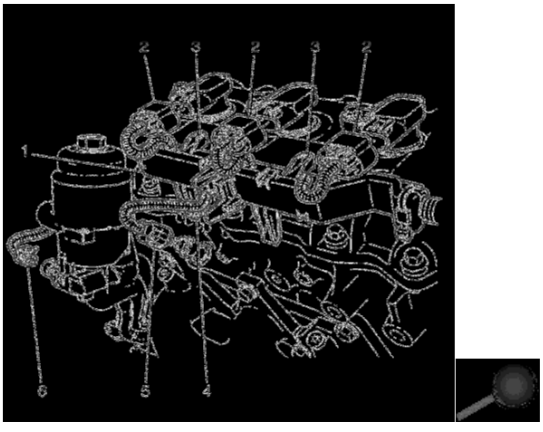
Special Tools

EN 46101 Spark Plug Tube Seal Guide

Removal Procedure

Warning: Refer to Battery Disconnect Warning.

1. Disconnect the battery ground cable from the battery. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
3. Remove the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
4. Remove the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
5. Remove the upper intake manifold. Refer to Engine Oil Pressure Sensor and/or Switch Replacement.



Note:
- Unlock the ignition coil electrical connectors before disconnecting from the ignition coils.
- Do not damage the ignition coil electrical connectors.

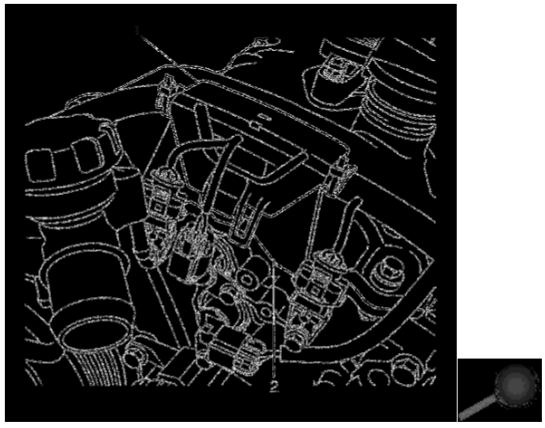
6. Disconnect the ignition coil electrical connectors (2) from the ignition coils.

Note: Use a suitable tool to detach the wiring harness (1) from the camshaft cover retainers (4) and lift the wiring harness (1) upward to detach the wiring harness from the camshaft cover lugs (3).

7. Detach the engine wiring harness (1) from the left bank camshaft cover.
8. Reposition and secure the wiring harness (1) away from the camshaft cover in order to provide clearance for removal of the camshaft cover.

cardiagn.com

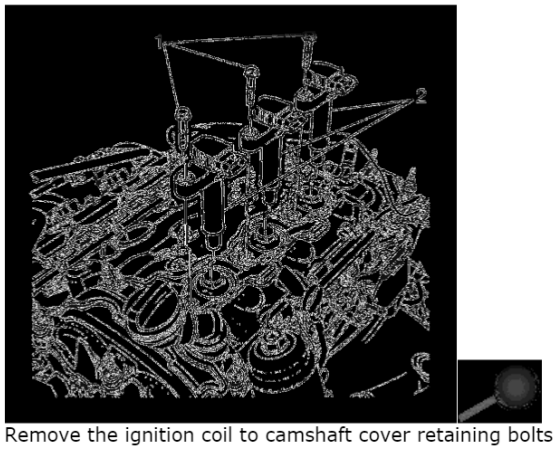
© 2014 General Motors. All rights reserved.



Note:

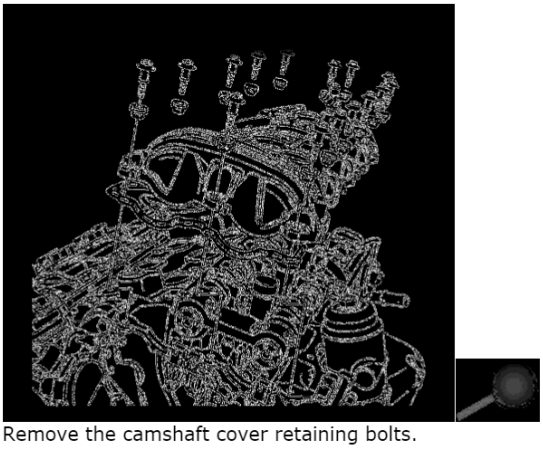
- Do not disconnect the engine front cover electrical connectors.
- Use a suitable tool to detach the wiring harness (1) from the camshaft cover (2) and lift the wiring harness (1) upwards to detach the wiring harness from the camshaft cover (2).

9. Remove the wiring harness (1) from the front of the camshaft cover (2).
10. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).

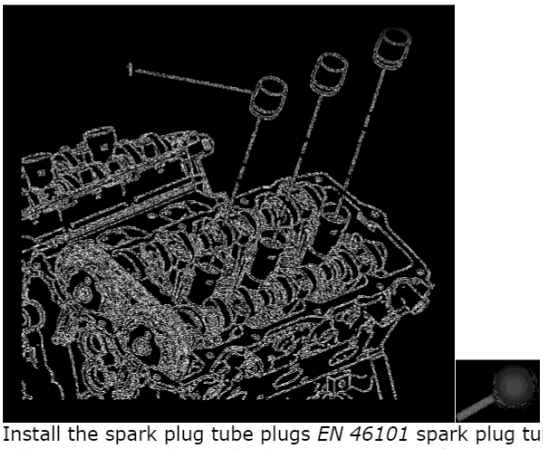


11. Remove the ignition coil to camshaft cover retaining bolts (1).
12. Remove the ignition coils (2) from the camshaft cover (3).

cardiagn.com



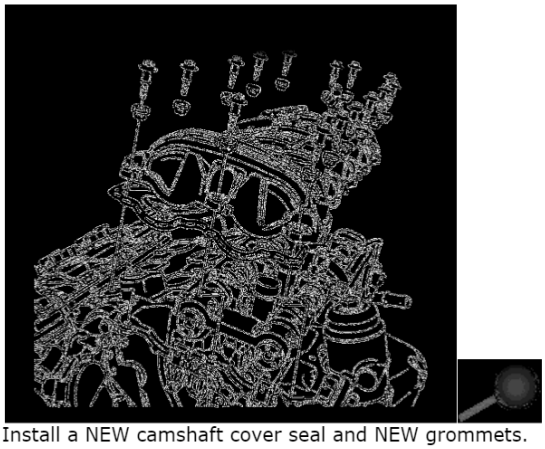
13. Remove the camshaft cover retaining bolts.
14. Remove the camshaft cover from the engine
15. Remove and discard the camshaft cover seal and grommets.



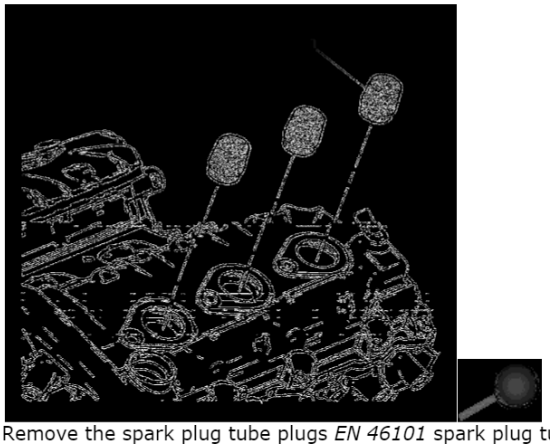
16. Install the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) to the spark plug tubes to prevent dirt and other contaminants from entering into the cylinders.

cardiagn.com

Installation Procedure

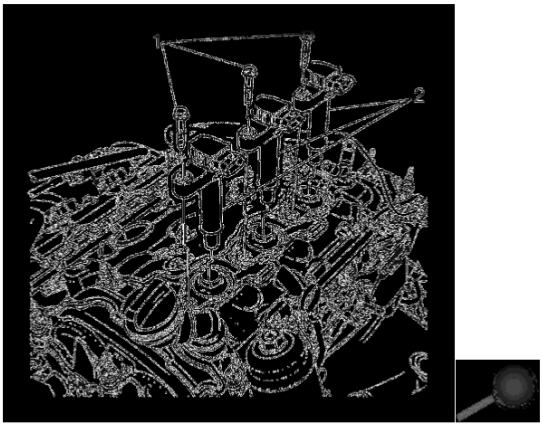


1. Install a NEW camshaft cover seal and NEW grommets.
2. Install the camshaft cover. Refer to Camshaft Cover Installation - Left Side.



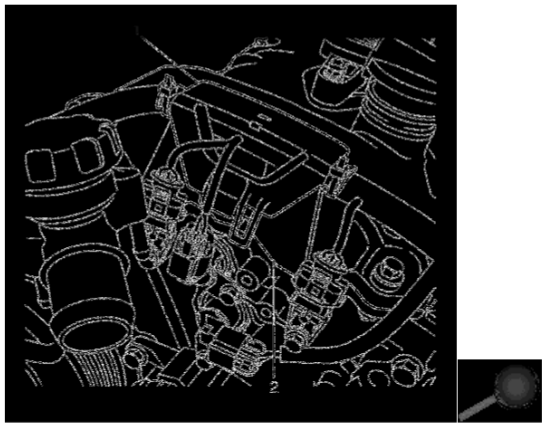
cardiagn.com

3. Remove the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) from the spark plug tubes of the left cylinder head.



Caution: Refer to Fastener Caution.

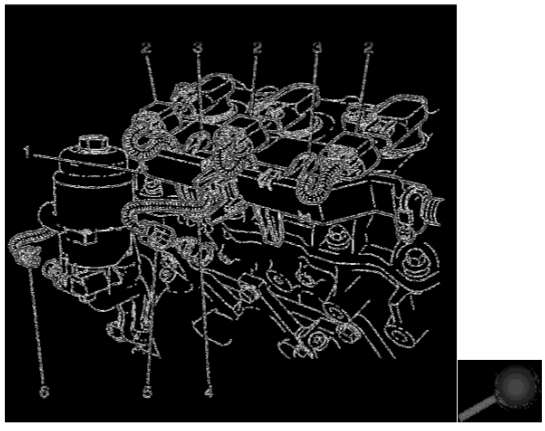
4. Install the ignition coils (2) to the camshaft cover.
5. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in)**.



Note:

- Make sure the wiring harness (1) is aligned on the locating lugs of the camshaft cover (2).
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover (2).

6. Install the wiring harness (1) to the front of the camshaft cover (2).



Note:

- Make sure the wiring harness (1) is located on the locating lugs of the camshaft cover.
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover.

7. Install the engine wiring harness (1) to the left bank camshaft cover.

Note: After connecting the ignition coil connectors make sure that the ignition coil electrical connectors are locked to the ignition coils.

8. Connect the ignition coil electrical connectors (2) to the ignition coils.
9. Install the upper intake manifold. Refer to Engine Oil Pressure Sensor and/or Switch Replacement.

cardiagn.com

10. Install the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
11. Install the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
12. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
13. Connect the battery ground cable to the battery. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Camshaft Cover Replacement - Right Side (LFX and LFW)

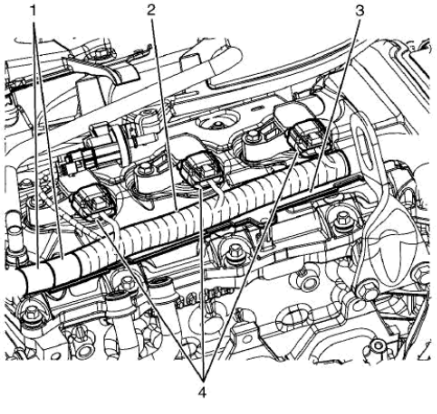
Special Tools

EN 46101 Spark Plug Tube Seal Guide

Removal Procedure

1. Ignition off.

   Warning: Refer to Battery Disconnect Warning.
2. Disconnect the battery ground cable from the battery. Refer to Battery Negative Cable Disconnection and Connection.
3. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
4. Remove the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
5. Remove the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
6. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
7. Remove the intake manifold. Refer to Intake Manifold Removal.



Warning: Refer to Exhaust Service Warning.

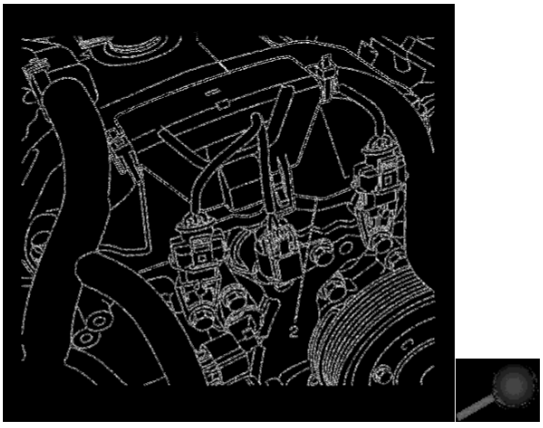
Note:
- Unlock the ignition coil electrical connectors before disconnecting from the ignition coils.
- Do not damage the ignition coil electrical connectors.

8. Disconnect the ignition coil electrical connectors (4) from the ignition coils.

   Note: Use a suitable tool to detach the wiring harness retainers from the camshaft cover.
9. Detach the wiring harness (2) from the camshaft cover.
10. Reposition and secure the wiring harness (2) away from the camshaft cover in order to provide clearance for removal of the camshaft cover.

cardiagn.com

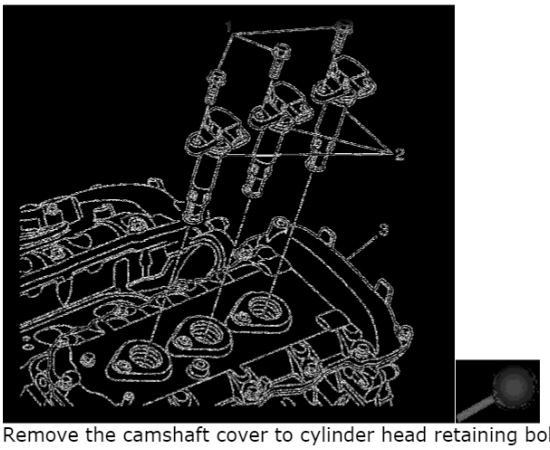
© 2014 General Motors. All rights reserved.



Note:

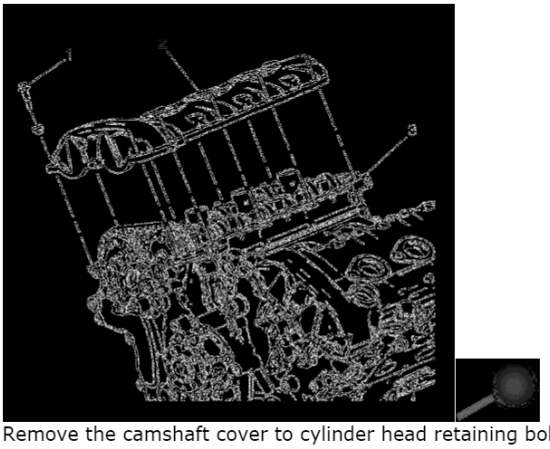
- Do not disconnect the engine front cover electrical connectors.
- Use a suitable tool to detach the wiring harness (1) from the camshaft cover (2) and lift the wiring harness (1) upwards to detach the wiring harness from the camshaft cover (2).

11. Remove the wiring harness (1) from the front of the camshaft cover (2).
12. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).

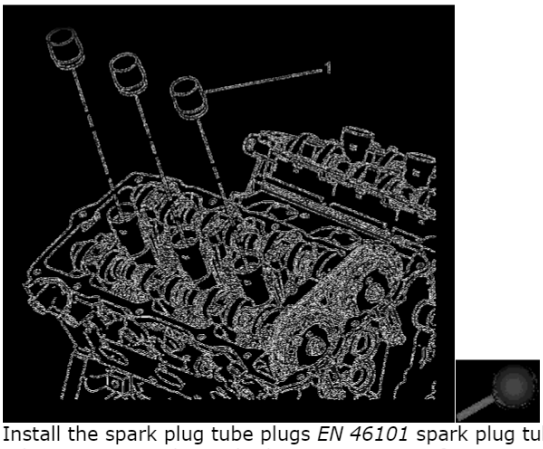


13. Remove the camshaft cover to cylinder head retaining bolts (1).
14. Remove the camshaft cover (2) from the cylinder head (3).

cardiagn.com



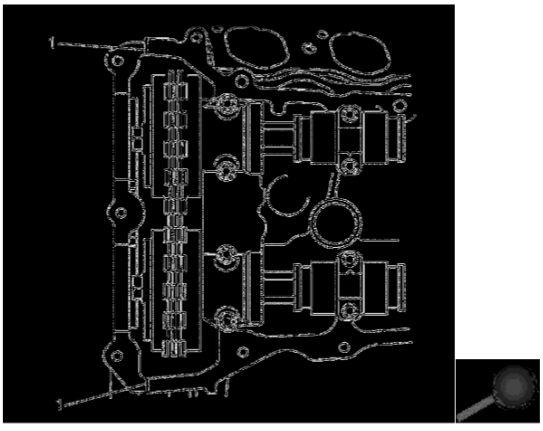
15. Remove the camshaft cover to cylinder head retaining bolts (1).
16. Remove the camshaft cover (2) from the cylinder head (3).
17. Remove and discard the camshaft cover seal and grommets.



18. Install the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) to the spark plug tubes to prevent dirt and other contaminants from entering the cylinders.

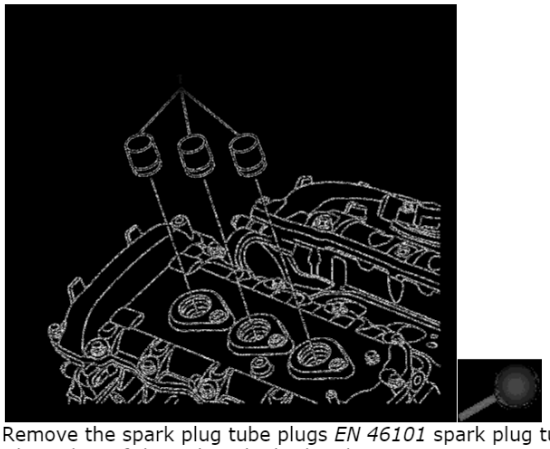
Installation Procedure

cardiagn.com



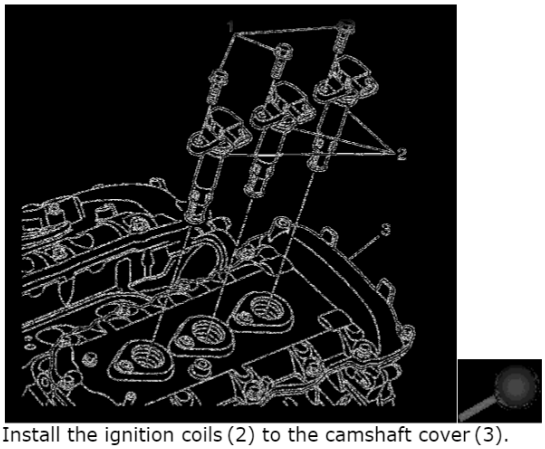
Note: Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.

1. Place a 3 mm bead of GM approved sealant (1) on the join line between the engine front cover and the cylinder head.
2. Install a NEW camshaft cover seal and NEW grommets.
3. Install the camshaft cover. Refer to Camshaft Cover Installation - Right Side.
4. Install a NEW camshaft cover seal and NEW grommets.
5. Install the camshaft cover. Refer to Camshaft Cover Installation - Right Side.



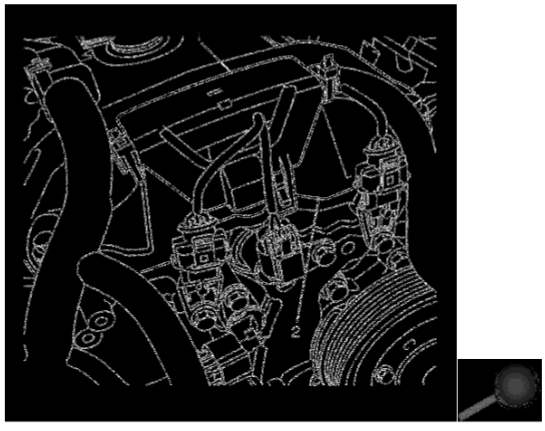
6. Remove the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) from the spark plug tubes of the right cylinder head.

cardiagn.com



7. Install the ignition coils (2) to the camshaft cover (3).

   Caution: Refer to Fastener Caution.
8. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in)**.

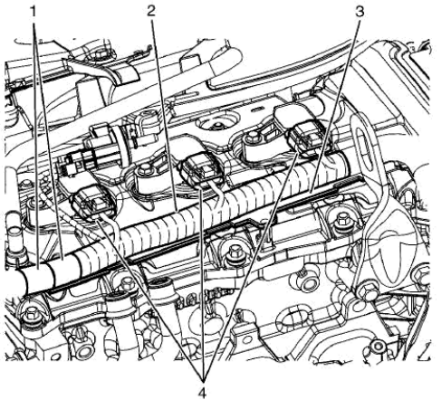


Note:

- Make sure the wiring harness (1) is located on the locating lugs of the camshaft cover (2).
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover (2).

9. Install the wiring harness (1) to the front of the camshaft cover (2).

cardiagn.com



10. Install the engine wiring harness (2) to the camshaft cover.

Note:

- After connecting the ignition coil connectors make sure that the ignition coil electrical connectors are locked to the ignition coils.
- Do not damage the ignition coil electrical connectors.

11. Connect the ignition coil electrical connectors (4) to the ignition coils.
12. Install the intake manifold. Refer to Intake Manifold Replacement.
13. Install the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.
14. Install the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
15. Install the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
16. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
17. Connect the battery ground cable to the battery. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Camshaft Cover Replacement - Right Side (LWR)

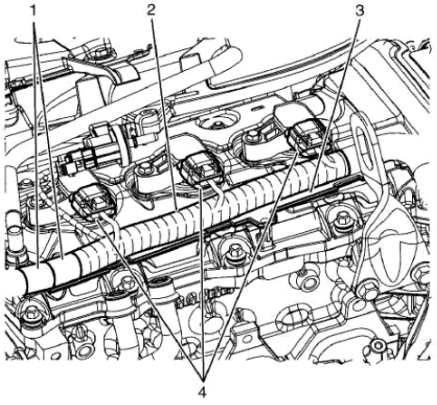
Special Tools

EN 46101 Spark Plug Tube Seal Guide

Removal Procedure

Warning: Refer to Battery Disconnect Warning.

1. Disconnect the battery ground cable from the battery. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
3. Remove the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
4. Remove the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
5. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.



Note:
- Unlock the ignition coil electrical connectors before disconnecting from the ignition coils.
- Do not damage the ignition coil electrical connectors.

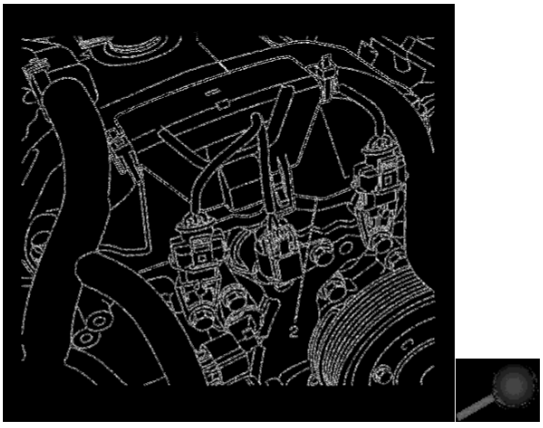
6. Disconnect the ignition coil electrical connectors (4) from the ignition coils.

Note: Use a suitable tool to detach the wiring harness retainers from the camshaft cover.

7. Detach the wiring harness (2) from the camshaft cover.
8. Reposition and secure the wiring harness (2) away from the camshaft cover in order to provide clearance for removal of the camshaft cover.

cardiagn.com

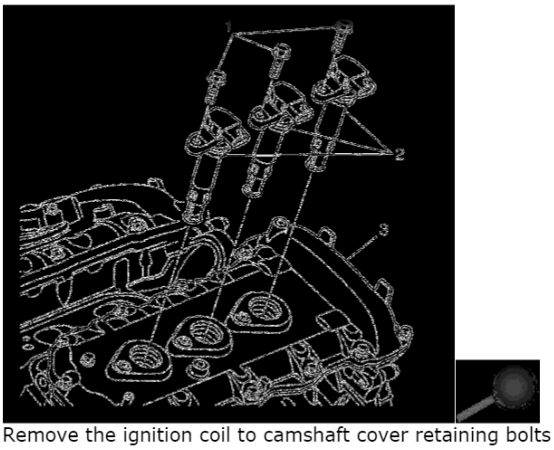
© 2014 General Motors. All rights reserved.



Note:

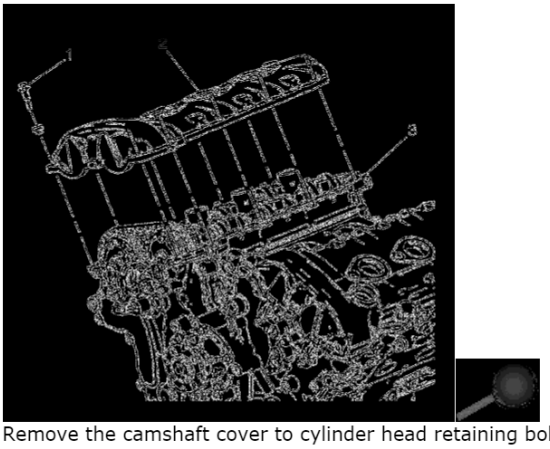
- Do not disconnect the engine front cover electrical connectors.
- Use a suitable tool to detach the wiring harness (1) from the camshaft cover (2) and lift the wiring harness (1) upwards to detach the wiring harness from the camshaft cover (2).

9. Remove the wiring harness (1) from the front of the camshaft cover (2).
10. Reposition and secure the wiring harness (1) away from the camshaft cover (2) in order to provide clearance for removal of the camshaft cover (2).

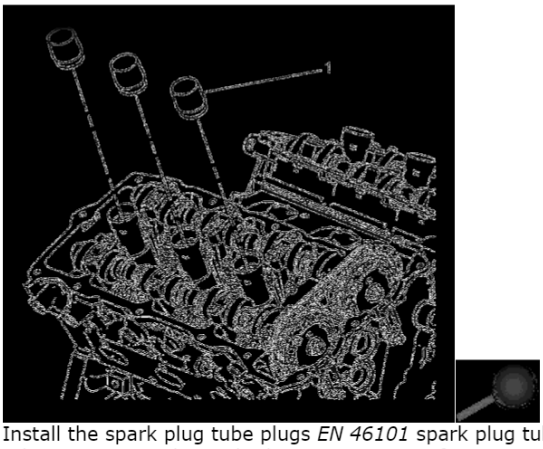


11. Remove the ignition coil to camshaft cover retaining bolts (1).
12. Remove the ignition coils (2) from the camshaft cover (3).

cardiagn.com



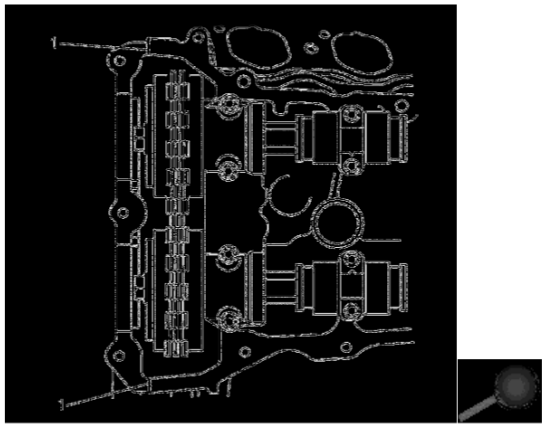
13. Remove the camshaft cover to cylinder head retaining bolts (1).
14. Remove the camshaft cover (2) from the cylinder head (3).
15. Remove and discard the camshaft cover seal and grommets.



16. Install the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) to the spark plug tubes to prevent dirt and other contaminants from entering the cylinders.

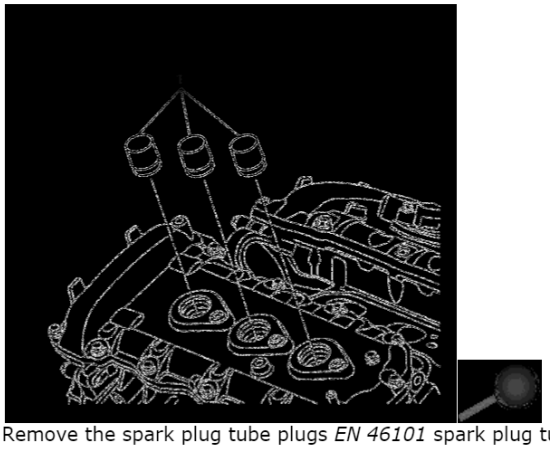
Installation Procedure

cardiagn.com



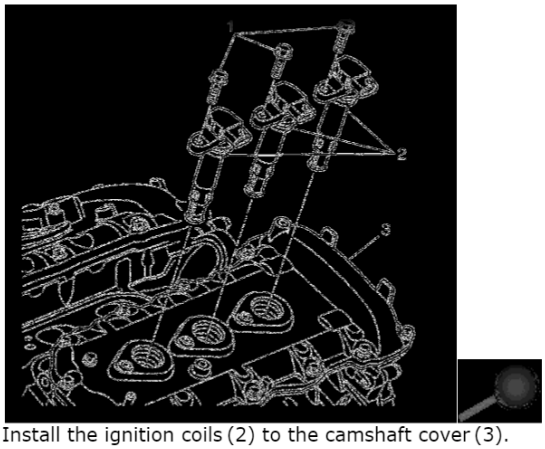
Note: Make sure the sealing surfaces of the cylinder head and camshaft cover are clean.

1. Place a 3 mm bead of GM approved sealant (1) on the join line between the engine front cover and the cylinder head.
2. Install a NEW camshaft cover seal and NEW grommets.
3. Install the camshaft cover. Refer to Camshaft Cover Installation - Right Side.



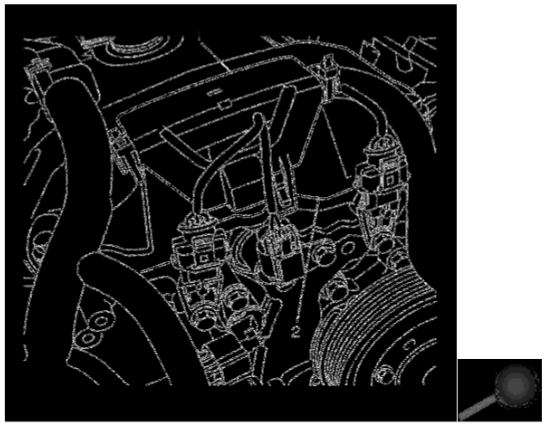
4. Remove the spark plug tube plugs *EN 46101* spark plug tube seal guide (1) from the spark plug tubes of the right cylinder head.

cardiagn.com



5. Install the ignition coils (2) to the camshaft cover (3).

   Caution: Refer to Fastener Caution.
6. Install the ignition coil to camshaft cover retaining bolts (1) and tighten to **10 N•m (89 lb in)**.

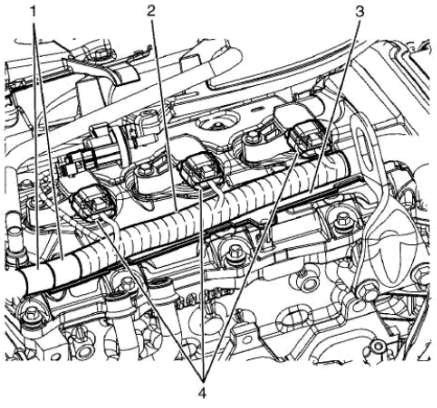


Note:

- Make sure the wiring harness (1) is aligned on the locating lugs of the camshaft cover (2).
- Listen for an audible click to confirm the correct installation of the wiring harness (1) to the camshaft cover (2).

7. Install the wiring harness (1) to the front of the camshaft cover (2).

cardiagn.com



8. Install the engine wiring harness (2) to the camshaft cover.

Note:

- After connecting the ignition coil connectors make sure that the ignition coil electrical connectors are locked to the ignition coils.
- Do not damage the ignition coil electrical connectors.

9. Connect the ignition coil electrical connectors (4) to the ignition coils.
10. Install the upper intake manifold. Refer to Upper Intake Manifold Replacement.
11. Install the positive crankcase ventilation tubes. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement.
12. Install the intake manifold sight shield. Intake Manifold Sight Shield Replacement.
13. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
14. Connect the battery ground cable to the battery. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Engine Front Cover Replacement (LFX)

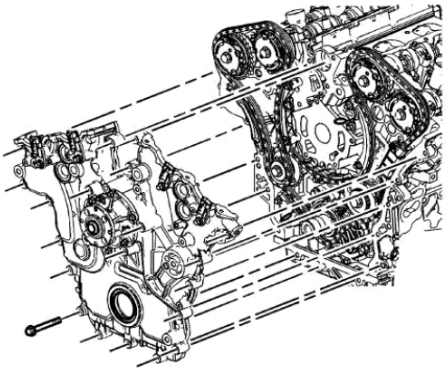
Special Tools

EN-46109 Engine Front Cover Installation Guide Pins

For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Remove the intake manifold. Refer to Intake Manifold Replacement.
2. Remove the camshaft covers. Refer to Camshaft Cover Replacement - Left Side and Camshaft Cover Replacement - Right Side.
3. Drain the engine coolant. Refer to Cooling System Draining and Filling.
4. Remove the water outlet with the radiator hose and reposition aside. Refer to Water Outlet Replacement.
5. Remove the generator. Refer to Generator Replacement.
6. Remove the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
7. Remove the camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust, Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake, Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust, and Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake.
8. Remove the belt tensioner. Refer to Drive Belt Tensioner Replacement.
9. Remove the camshaft position actuator solenoid valves from the front cover. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake, Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust, Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake, and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust.



10. Remove the engine front cover with the water pump. Refer to Engine Front Cover Removal.
11. Disassemble the engine front cover. Refer to Engine Front Cover Disassemble.

Note: Do NOT use sharp and/or metal gasket scrapers in order to clean the sealing surfaces.

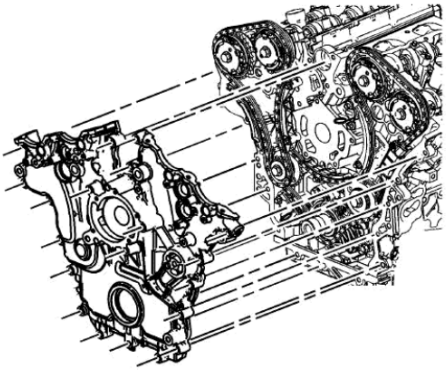
© 2014 General Motors. All rights reserved.

cardiagn.com

12. Carefully clean the engine front cover sealing surfaces. Refer to Engine Front Cover Cleaning and Inspection.
13. Use compressed air in order to remove any engine coolant from the engine cooling passages and from the top of the oil pan scraper (windage tray).

Installation Procedure

1. Assemble the engine front cover. Refer to Engine Front Cover Assemble.



2. Use the *EN-46109* pins in order to install the engine front cover. Refer to Engine Front Cover Installation.
3. Install the camshaft position actuator solenoid valves to the front cover. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake, Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust, Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake, and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust.
4. Install the camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust, Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake, Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust and Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake.
5. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
6. Install the generator bracket with the generator and the belt tensioner. Refer to Generator Replacement.
7. Install the water outlet. Refer to Water Outlet Replacement.
8. Install the purge vent hose to the water outlet. Refer to Engine Coolant Air Bleed Pipe Replacement.
9. Fill the cooling system. Refer to Cooling System Draining and Filling.
10. Install the camshaft covers. Refer to Camshaft Cover Replacement - Left Side and Camshaft Cover Replacement - Right Side.
11. Install the intake manifold. Refer to Intake Manifold Replacement.
12. Install the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.
13. Fill the cooling system. Refer to Cooling System Draining and Filling.

cardiagn.com

Secondary Camshaft Intermediate Drive Chain Replacement - Left Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the camshaft timing chain components. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the camshaft timing chain components. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Intermediate Drive Chain Replacement - Right Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the camshaft timing chain components. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the camshaft timing chain components. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Left Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the left bank secondary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection.

Installation Procedure

1. Install the left bank secondary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Intermediate Drive Chain Tensioner Replacement - Right Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the right side secondary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the right side secondary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Tensioner Shoe Replacement - Left Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the left side secondary camshaft drive chain tensioner, shoe, and guide. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the left side secondary camshaft drive chain shoe, guide, and tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Tensioner Shoe Replacement - Right Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the right side secondary camshaft drive chain tensioner, shoe, and guide. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the right side secondary camshaft drive chain shoe, guide, and tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Guide Replacement - Left Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the left side secondary camshaft drive chain tensioner, shoe, and guide. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the left side secondary camshaft drive chain shoe, guide, and tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Guide Replacement - Right Side

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the right side secondary camshaft drive chain tensioner, shoe, and guide. Refer to Camshaft Timing Chain Components Removal.
3. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection. Replace components as necessary.

Installation Procedure

1. Install the right side secondary camshaft drive chain shoe, guide, and tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Camshaft Drive Chain and Sprockets Replacement

Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the right side secondary camshaft drive chain components. Refer to Camshaft Timing Chain Components Removal.
3. Remove the primary camshaft drive chain components. Refer to Camshaft Timing Chain Components Removal.
4. Clean and inspect all of the camshaft timing drive components. Refer to Camshaft Timing Drive Components Cleaning and Inspection.

Installation Procedure

1. Install the primary camshaft drive chain components. Refer to Camshaft Timing Chain Components Installation.
2. Install the right side secondary camshaft drive chain components. Refer to Camshaft Timing Chain Components Installation.
3. Install the engine front cover. Refer to Engine Front Cover Replacement.

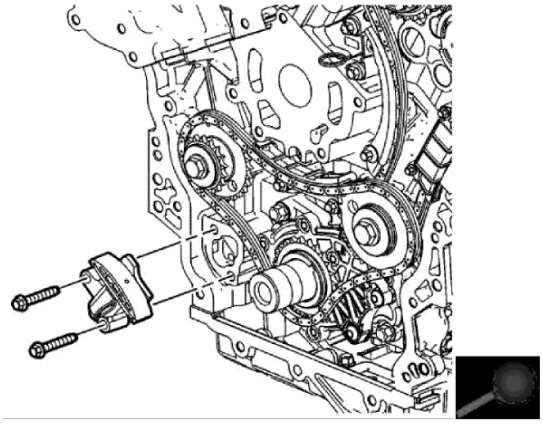
cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Camshaft Intermediate Drive Chain Tensioner Replacement

Removal Procedure

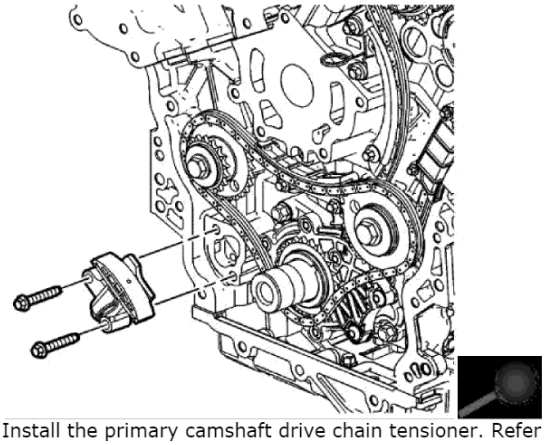
1. Remove the engine front cover. Refer to Engine Front Cover Replacement.



Note: If the entire camshaft timing system is not in Stage 2, Timing Chain Alignment Diagram, mark the timing chain and sprockets in order to ensure proper reassembly.

2. Remove the primary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Removal.

Installation Procedure



1. Install the primary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Installation.
2. Install the engine front cover. Refer to Engine Front Cover Replacement.

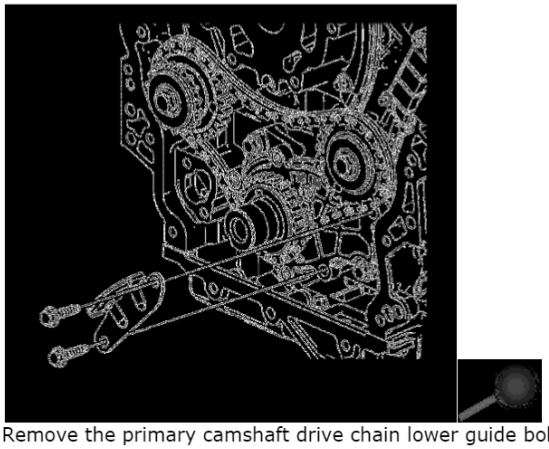
© 2014 General Motors. All rights reserved.

cardiagn.com

Primary Timing Chain Guide Replacement - Lower

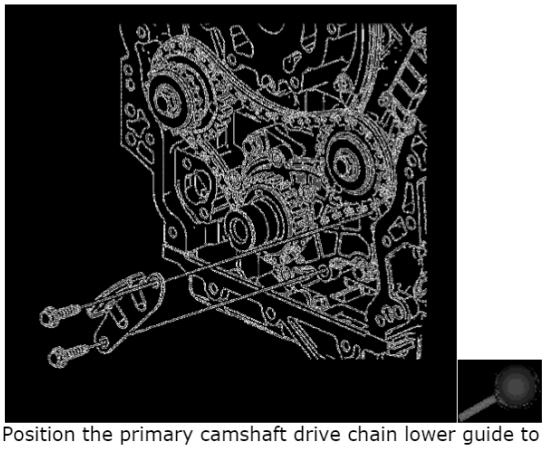
Removal Procedure

1. Remove the primary camshaft drive chain tensioner. Refer to Primary Camshaft Intermediate Drive Chain Tensioner Replacement.



2. Remove the primary camshaft drive chain lower guide bolts.
3. Remove the primary camshaft drive chain lower guide.

Installation Procedure



1. Position the primary camshaft drive chain lower guide to the oil pump.

   Caution: Refer to Fastener Caution.
2. Install the primary camshaft drive chain lower guide bolts and tighten to **25 N•m (18 lb ft)**.
3. Install the primary camshaft drive chain tensioner. Refer to Primary Camshaft Intermediate Drive Chain Tensioner Replacement.

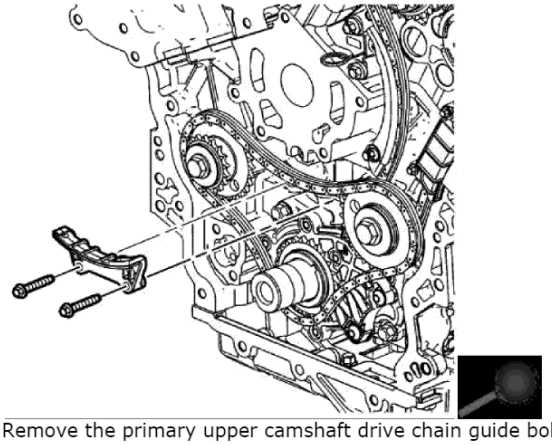
© 2014 General Motors. All rights reserved.

cardiagn.com

Primary Timing Chain Guide Replacement - Upper

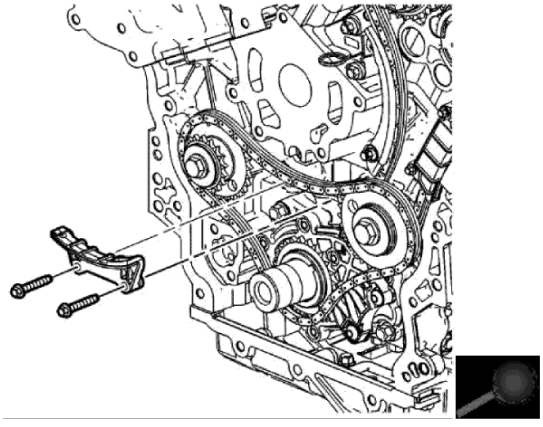
Removal Procedure

1. Remove the engine front cover. Refer to Engine Front Cover Replacement.
2. Remove the primary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Removal.



3. Remove the primary upper camshaft drive chain guide bolts and guide.

Installation Procedure



Caution: Refer to Fastener Caution.

1. Install the primary upper camshaft drive chain guide and bolts. tighten bolts to 25 N•m (18 lb ft)
2. Install the primary camshaft drive chain tensioner. Refer to Camshaft Timing Chain Components Installation.
3. Install the engine front cover. Refer to Engine Front Cover Replacement.

© 2014 General Motors. All rights reserved.

cardiagn.com

Camshaft Position Actuator Replacement - Bank 1

Special Tools

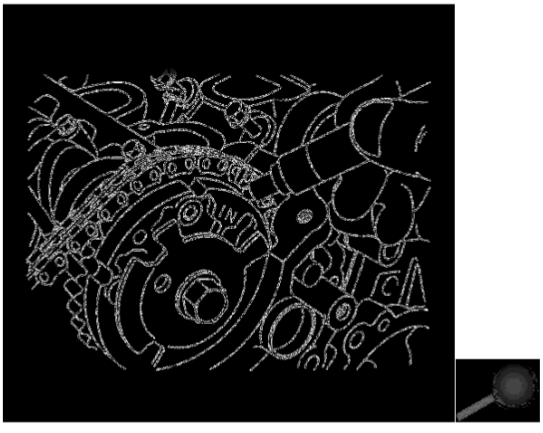
- *EN49982-1* Timing Chain Retainer
- *EN49982-2* Timing Chain Retainer

For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Remove the camshaft cover. Refer to Camshaft Cover Replacement - Right Side.
2. Remove the camshaft position actuator solenoid valve solenoid – intake. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake.
3. Remove the intake camshaft position sensor. Refer to Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake.
4. Remove the exhaust camshaft position sensor. Refer to Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust.
5. Remove the camshaft position actuator solenoid valve solenoid – exhaust. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust.
6. Rotate engine clockwise using crankshaft dampener retaining bolt until the flats at the rear ends of the camshafts are pointing up. This puts the camshafts on "base circle" and will reduce their tendency to rotate from valve spring pressure when the camshaft position actuators/drive chains are removed.

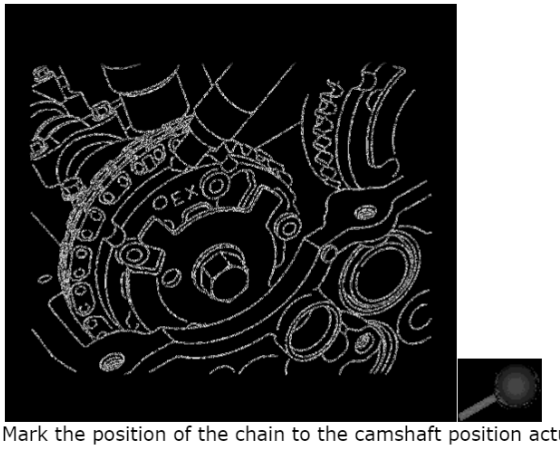
   Note: Do NOT remove or back out the camshaft position actuator bolt(s) significantly, simply break them loose from their fully-torqued position. The position actuators must stay firmly attached until the retaining tools are in place, but they should be broken loose while the chain is still tight and in position.
7. Loosen intake and/or exhaust camshaft position actuator retaining bolts, depending on which camshaft position actuator and/or camshaft you will be servicing. If servicing both camshaft position actuators and/or camshafts, loosen both bolts.



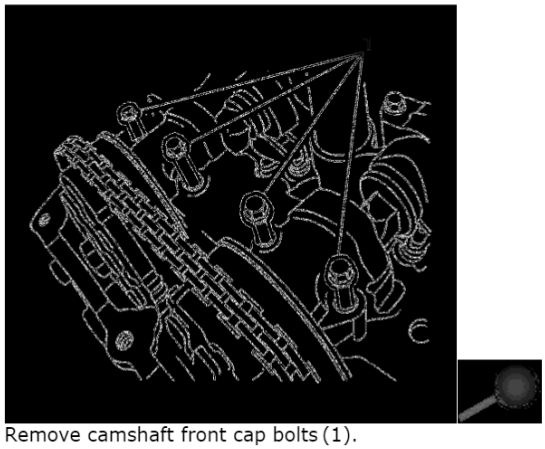
   Note: Be certain to clearly mark the position of the chain to the camshaft position actuator (s). Though the engine does not need to be set to a specific timing mark before starting the procedure, the relationship of the chain to the actuator(s) is critical and must be reestablished on assembly.
8. Mark the position of the chain to the camshaft position actuator – intake.

© 2014 General Motors. All rights reserved.

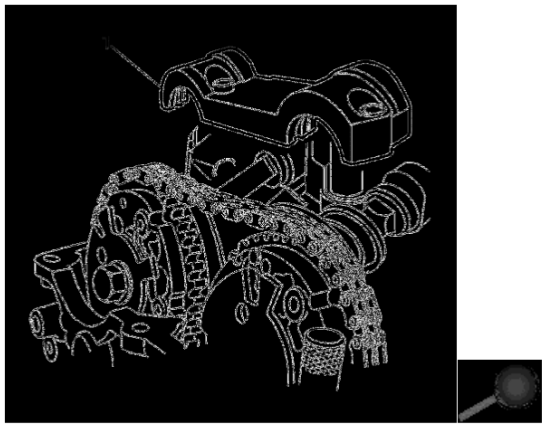
cardiagn.com



9. Mark the position of the chain to the camshaft position actuator – exhaust.



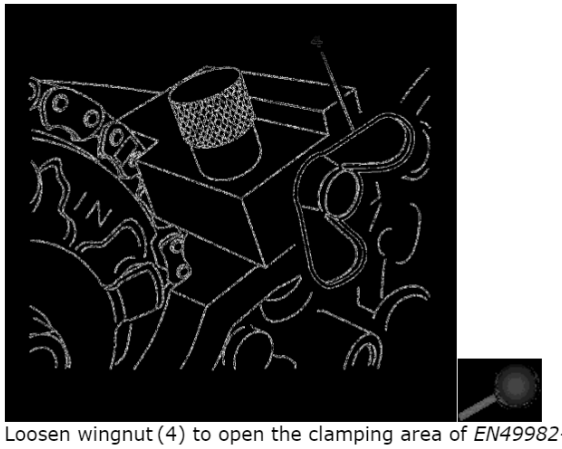
10. Remove camshaft front cap bolts (1).



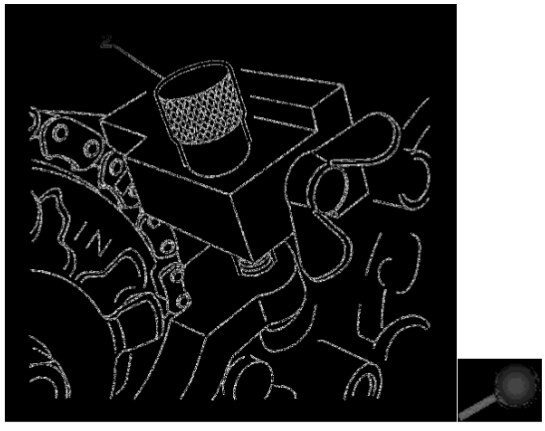
Note: Do NOT remove or loosen any other camshaft bearing caps at this time, even if you intend to eventually remove the camshaft.

11. Remove the camshaft front cap (1).

cardiagn.com



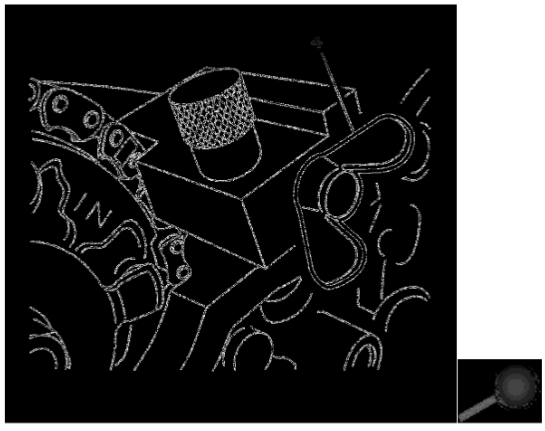
12. Loosen wingnut (4) to open the clamping area of *EN49982-1* retainer.



Note: Do NOT overtighten the thumbscrew. The *EN49982-1* retainer should be able to slide slightly via the slot the screw goes through. This fore/aft movement will allow easier removal and installation of the chain later.

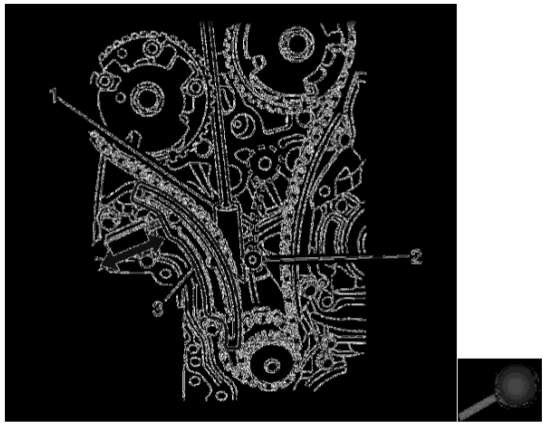
13. Install *EN49982-1* retainer intake side chain holder onto front cover by screwing in the thumbscrew (2) on the *EN49982-1* retainer finger-tight.

cardiagn.com



Note: Do NOT tighten the wingnut with a tool of any kind. Firm finger-tightening is sufficient.

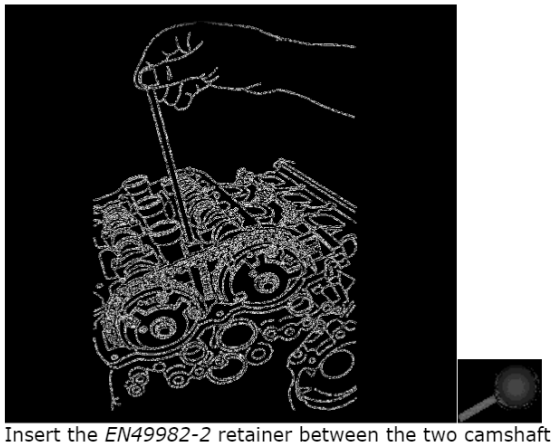
14. Tighten wingnut (4) so *EN49982-1* retainer closes over and firmly grasps timing chain.



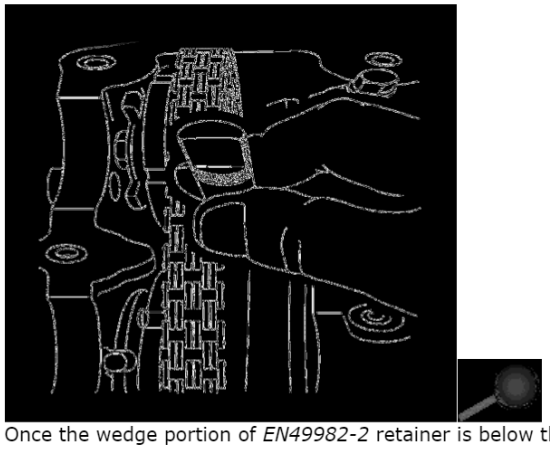
Note: The engine front cover is removed for clarity in the following graphics, but is NOT required to be removed to perform the procedure.

15. *EN49982-2* retainer (1) will be installed in the following steps such that it wedges between an internal rib (2) that is cast into the inside of the front cover (shown in dotted line above) and the timing chain and spring-loaded tensioner shoe (3), holding the chain in position. The wedge will be left in place during the cam position actuator and/or camshaft service.

cardiagn.com

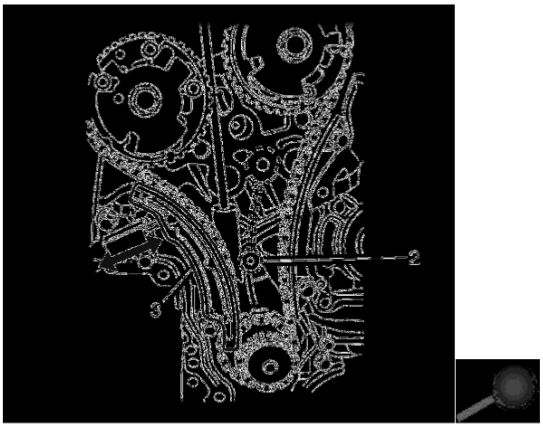


16. Insert the *EN49982-2* retainer between the two camshaft position actuators with the "teeth" on the *EN49982-2* retainer facing toward the front cover.



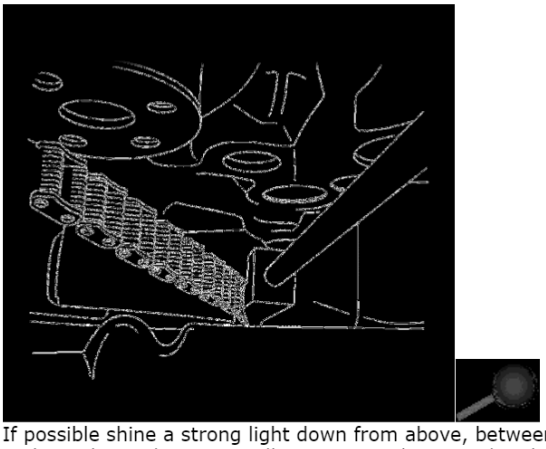
17. Once the wedge portion of *EN49982-2* retainer is below the camshaft position actuators, rotate the *EN49982-2* retainer until the flat in the handle faces toward the intake camshaft position actuator. This orients the "teeth" toward the chain.

cardiagn.com

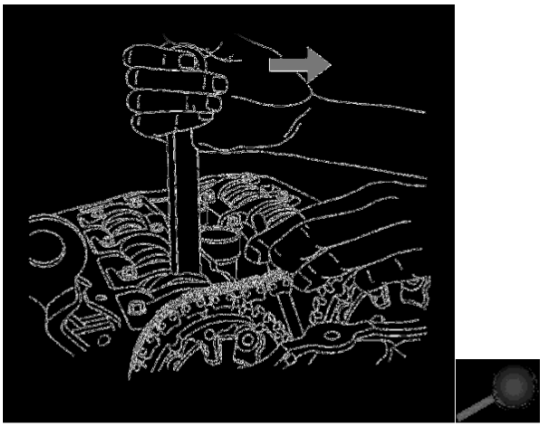


Note: Do not try to force the wedge into position, simply ensure it is loosely engaged in the timing chain and in the correct overall position.

18. Drop the wedge down until it begins to engage the timing chain and the belt casting (2).

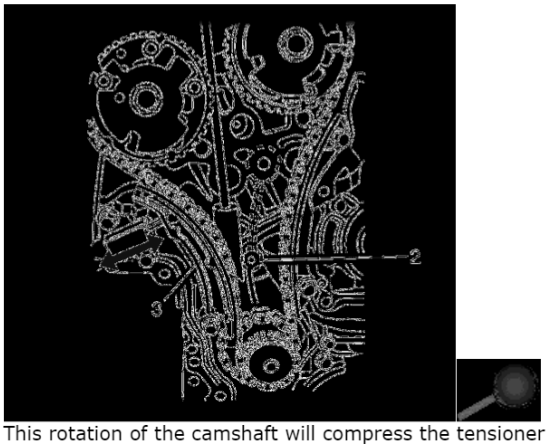


19. If possible shine a strong light down from above, between the camshaft position actuators, and see the wedge in overall position as shown in the above graphic.

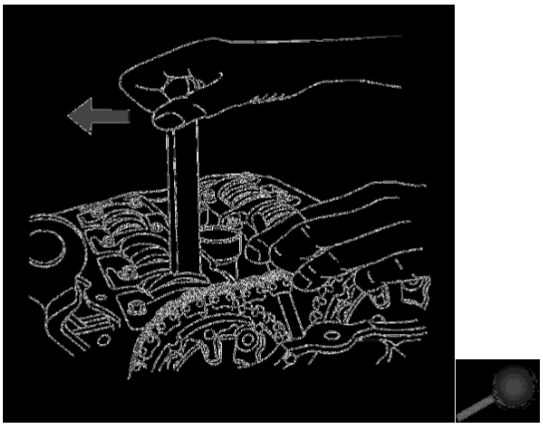


cardiagn.com

20. Using a 20 mm wrench on the cast hexagonal portion of the exhaust camshaft, rotate the camshaft toward the intake camshaft while pushing down on the handle of the *EN49982-2* retainer.



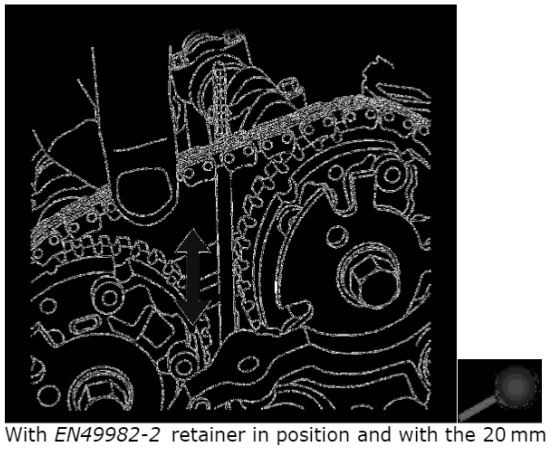
21. This rotation of the camshaft will compress the tensioner shoe (3) against the spring force of the tensioner, opening up a gap between the chain and the internal rib in the front cover. The wedge will then drop into this gap. You will feel a distinct click as the teeth engage the chain.



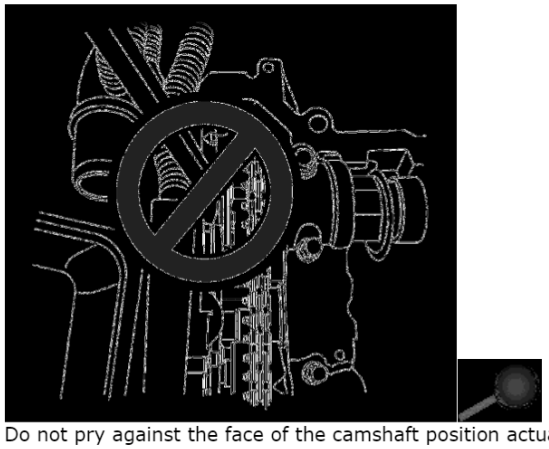
Caution: Be sure the EN49982-2 is captured firmly as described before continuing. This is critical to ensuring the camshaft drive chains stay properly timed.

22. Release the force on the wrench, allowing the spring tension to close the tensioner shoe against the wedge portion of *EN49982-2* retainer. You should be able to lightly tug on the *EN49982-2* retainer and it should stay in position. Repeat Steps 20 and 21 if necessary to re-insert the *EN49982-2* retainer until you are certain it is in position and will stay in position.

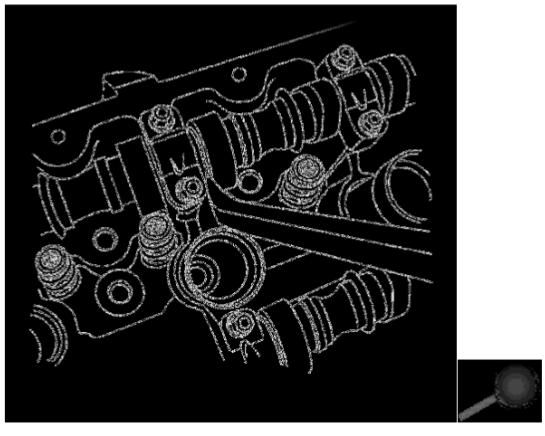
cardiagn.com



23. With *EN49982-2* retainer in position and with the 20 mm wrench removed, there should now be some slack in the timing drive chain as indicated in the graphics shown.



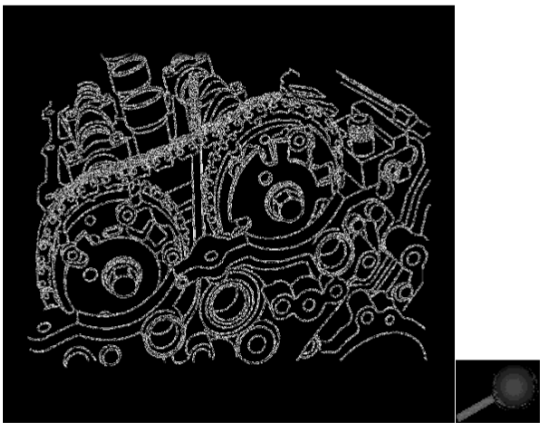
24. Do not pry against the face of the camshaft position actuators or the position actuator retaining bolt.



cardiagn.com

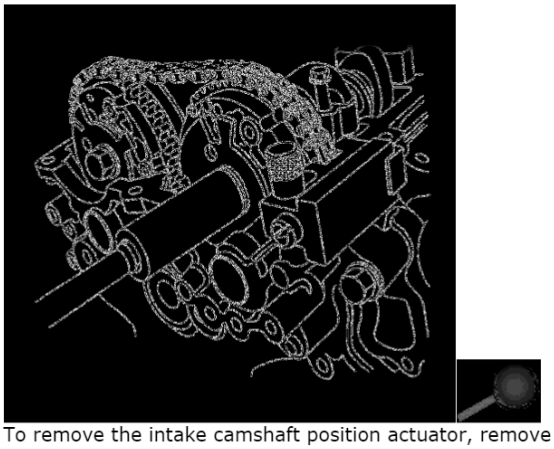
Caution: Do not pry against the face of the camshaft position actuators or the position actuator retaining bolts as the position actuators will be damaged.

25. Position a screwdriver or small pry bar between a camshaft cap and camshaft lobe. Carefully move/pry the camshafts as far as possible toward the rear/flywheel end of the engine.



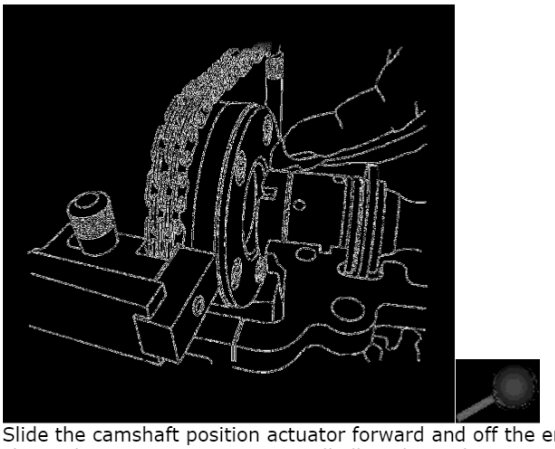
Note: Do not move or disturb the *EN49982* retainer components after their installation or the timing chains may be lost inside the front cover.

26. The *EN49982-1* retainer and *EN49982-2* retainer should be in position as shown, they must be left in position during the servicing of the camshaft position actuator(s) and/or camshaft(s).

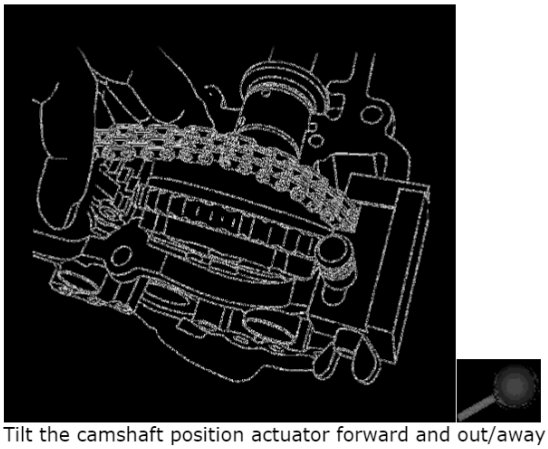


27. To remove the intake camshaft position actuator, remove the loosened retaining bolt. To remove only the exhaust camshaft position actuator, skip the steps for removing the intake camshaft position actuator. However, the *EN49982-1* retainer MUST be installed as discussed even if the intake side will not be serviced or the timing of the camshaft chains will be lost.

cardiagn.com



28. Slide the camshaft position actuator forward and off the end of the intake camshaft. The slot in the *EN49982-1* retainer will allow the tool to move forward enough to disengage the camshaft position actuator from the front of the camshaft. Remove the plastic thrust washer when removing the camshaft position actuator from the end of the camshaft.



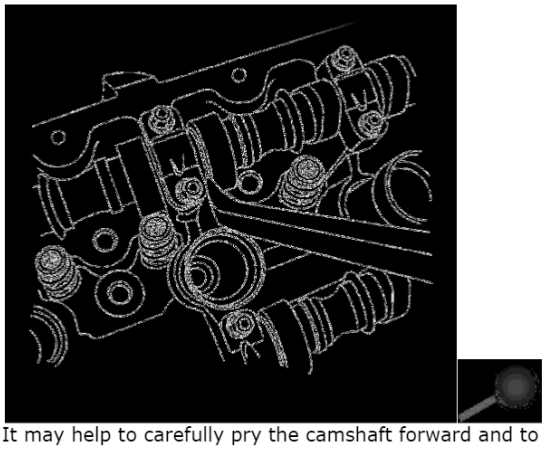
29. Tilt the camshaft position actuator forward and out/away from the engine.

    Note: DO NOT remove the *EN49982* retainers. They are holding the cam chains to maintain their properly-timed positions.

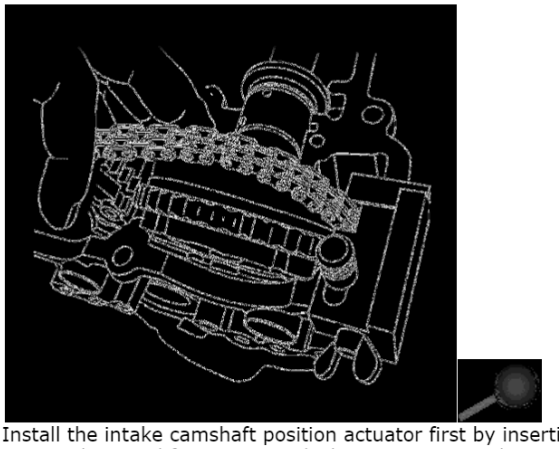
30. Allow the chain to rest on the *EN49982-1* retainer and *EN49982-2* retainer in position during service.

Installation Procedure

cardiagn.com

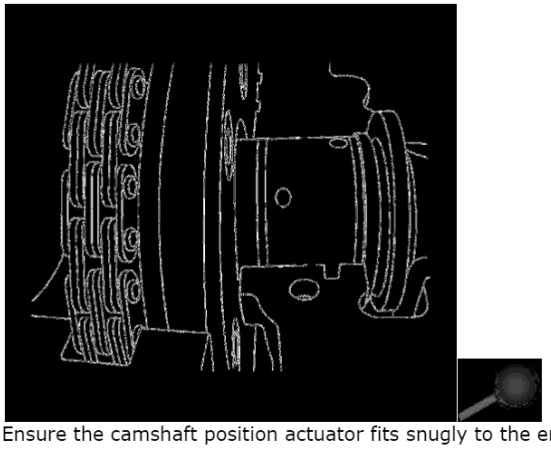


1. It may help to carefully pry the camshaft forward and to move the *EN49982-1* retainer backward via the slot to reengage the position actuator to the camshaft. The dowel pin on the camshaft position actuator must be aligned with the slot in the camshaft nose for reassembly.



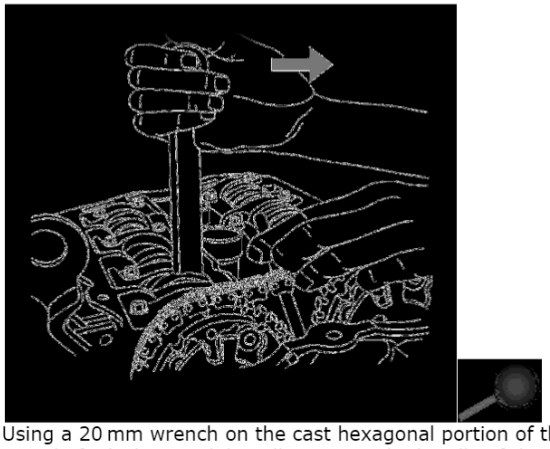
2. Install the intake camshaft position actuator first by inserting the actuator between the timing chain and front cover. Tilt the actuator in and engage the chain while aligning the marks you made on the chain and position actuator.

cardiagn.com



3. Ensure the camshaft position actuator fits snugly to the end of the camshaft.

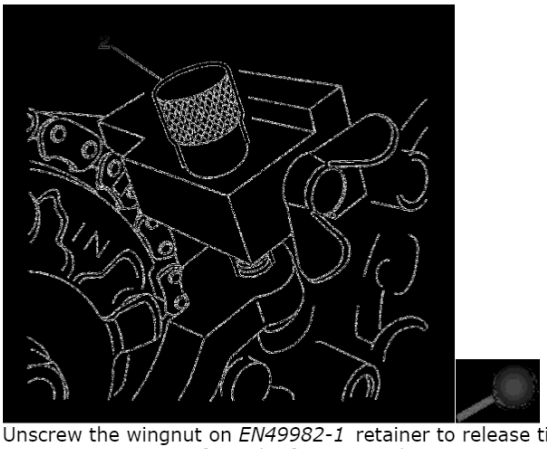
   Caution: Refer to Fastener Caution.
4. Install the intake camshaft position actuator retaining bolt, and lightly tighten the bolt to hold the camshaft actuator in place. DO NOT torque at this time.
5. Install the exhaust camshaft position actuator retaining bolt, and lightly tighten the bolt to hold the camshaft actuator in place. DO NOT torque at this time.
6. Double-check that the marks on both the intake and exhaust camshaft position actuators to ensure that they are aligned with their respective paint marks on the chain.



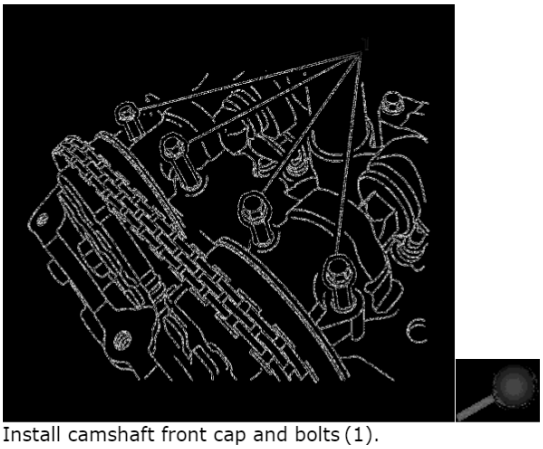
7. Using a 20 mm wrench on the cast hexagonal portion of the exhaust camshaft, rotate the camshaft clockwise while pulling up on the handle of the *EN49982-2* retainer.
8. Remove EN49982-2 retainer.
9. Release the pressure on the wrench. The timing chain should now be tight and should lose the slack the wedge was providing.

   Note: Double-check the marks on the camshaft position actuators and chains to ensure they are correct.
10. Torque one or both camshaft position actuator retaining bolts to **58 N•m (43 lb ft)**.

cardiagn.com



11. Unscrew the wingnut on *EN49982-1* retainer to release timing chain, and then remove *EN49982-1* retainer from the front cover by unscrewing the thumbscrew (2).



12. Install camshaft front cap and bolts (1).
13. Tighten the camshaft front cap outer bolts to **10 N•m (89 lb in)**.
14. Tighten the camshaft front cap inner bolts to **10 N•m (89 lb in)**.
15. Install the camshaft position actuator solenoid valve solenoid – exhaust. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust.
16. Install the camshaft position actuator solenoid valve solenoid-intake. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake.
17. Install the intake camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake.
18. Install the exhaust camshaft position sensor. Refer to Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust.
19. Install the camshaft cover. Refer to Camshaft Cover Replacement - Right Side.

cardiagn.com

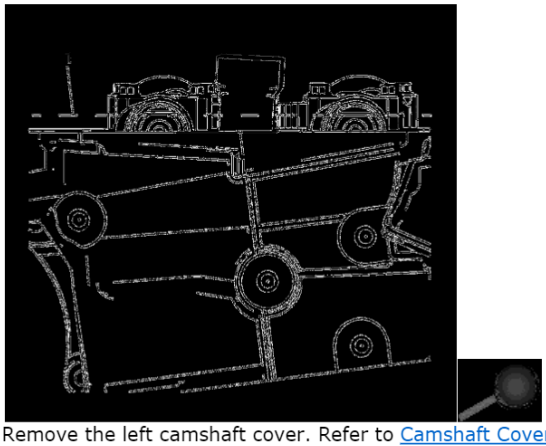
Camshaft Position Actuator Replacement - Bank 2

Special Tools

EN-48313 Timing Chain Retention Tool

For equivalent regional tools, refer to Special Tools.

Removal Procedure

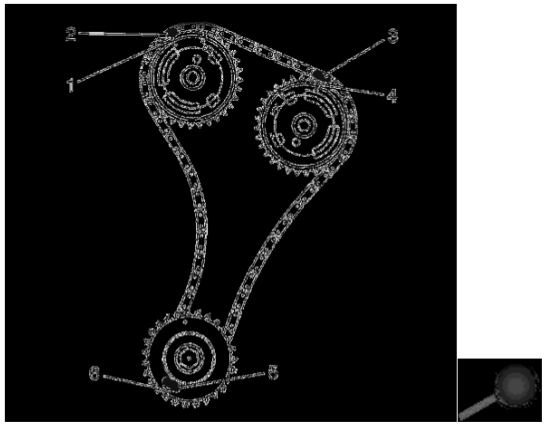


1. Remove the left camshaft cover. Refer to Camshaft Cover Replacement - Left Side.
2. Remove the left intake and exhaust camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake and Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust.
3. Remove the left intake and exhaust camshaft position actuator solenoids. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust.

   Note: Rotate the crankshaft balancer bolt in a clockwise direction ONLY.
4. Rotate the crankshaft balancer using the balancer bolt until the camshafts are in a neutral (low tension) position. The camshafts will be parallel with the camshaft cover rail (1).

cardiagn.com

© 2014 General Motors. All rights reserved.

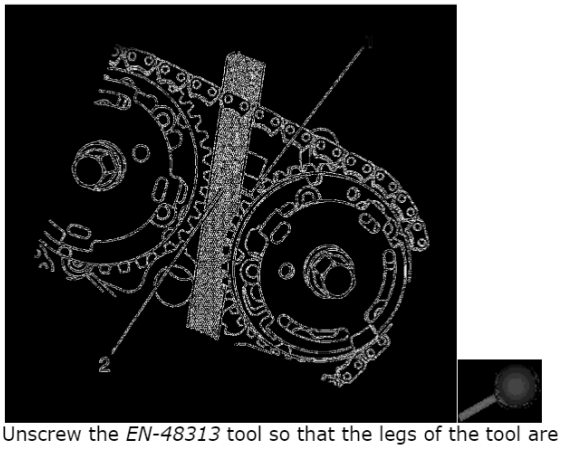


Note: Ensure that the camshaft timing chain and the camshaft position actuators are marked for proper assembly.

5. Use a paint stick to create an alignment mark on one of the timing chain links (2) and the adjacent tooth on the exhaust camshaft position actuator (1).
6. Use a paint stick to create an alignment mark on one of the timing chain links (3) and the adjacent tooth on the intake camshaft position actuator (4).

Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

7. Use an open end wrench on the hex cast into the left intake and exhaust camshafts and rotate the camshafts toward each other in order to create slack in the chain between the actuators.

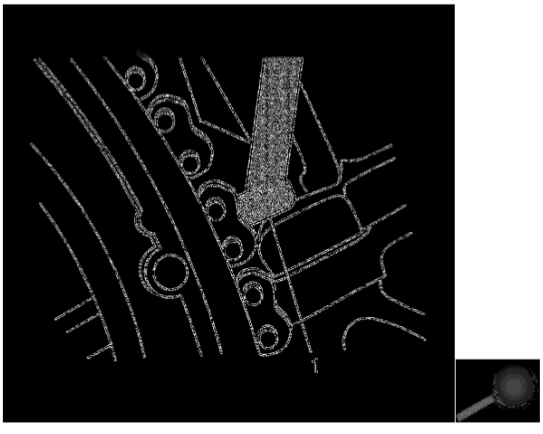


8. Unscrew the *EN-48313* tool so that the legs of the tool are retracted.
9. Insert the *EN-48313* tool between the camshaft actuators, rearward of the timing chain until the bottom line that is scribed in the body of the tool (2) is adjacent to the top surface of the cylinder head (1). This is the approximate installed position.

cardiagn.com

Note: The engine front cover is removed for clarity in the following graphics, but NOT required to perform the procedure.

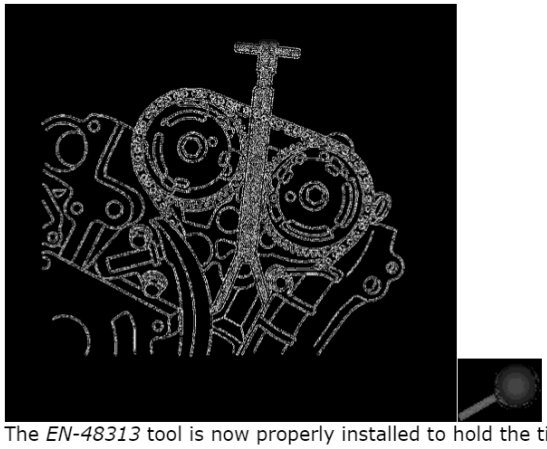
10. Ensure that the feet (4) on the legs of the tool are facing the front of the engine.
11. Partially expand the legs (1, 3) of the *EN-48313* tool by turning the T-shaped handle clockwise.
12. Insert the leg of the tool (1) behind the timing chain guide (2).
13. Continue expanding the *EN-48313* tool until the legs (1, 3) contact the timing chain. Do not tighten at this time.



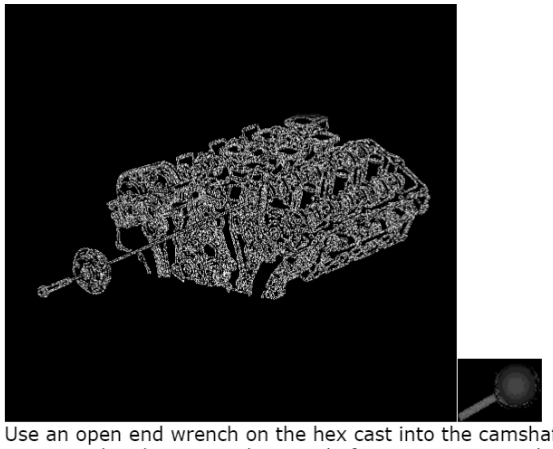
Note: Ensure that the foot (1) of the *EN-48313* tool is engaged into one of the link pockets to prevent tool slippage during tightening of the *EN-48313* tool.

14. Hand tighten the *EN-48313* tool.
15. Use an open end wrench on the hex cast into the left intake and exhaust camshafts and rotate the camshafts toward each other in order to create slack in the chain between the actuators.

cardiagn.com



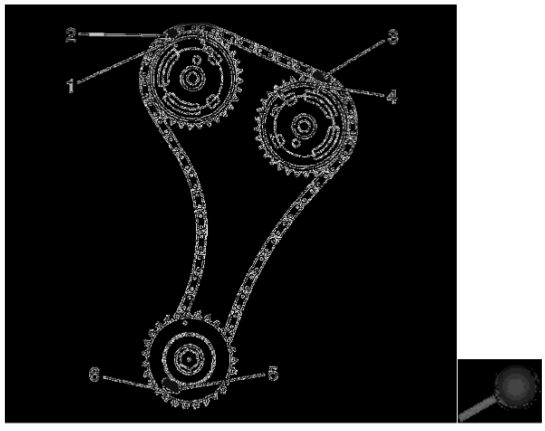
16. The *EN-48313* tool is now properly installed to hold the timing chain in position.



17. Use an open end wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
18. If replacing the exhaust camshaft position actuator, then remove the bolt and the actuator.
19. If replacing the intake camshaft position actuator, then remove the bolt and the actuator.
20. If removing both the exhaust and intake camshaft actuators, the timing chain can be draped over the *EN-48313* tool once the actuators have been removed.
21. Rotate the actuator in order to align the opening in the actuator reluctor wheel with the cam sensor boss in the front cover, to allow actuator removal.
22. Remove the camshaft thrust washer.

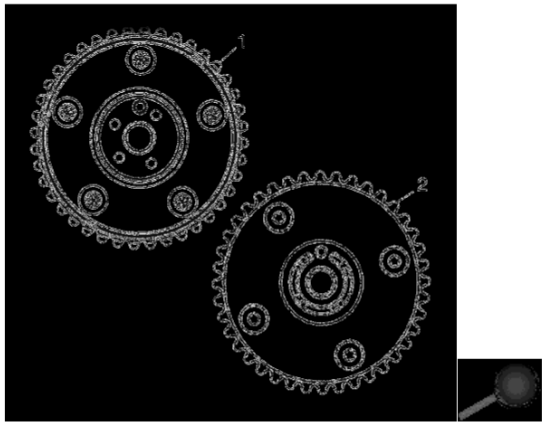
Installation Procedure

cardiagn.com



Note: Ensure that the camshaft timing chain and the camshaft position actuators are marked for proper assembly.

1. Align the exhaust camshaft actuator alignment mark (1) to the timing chain alignment mark (2) made during disassembly.
2. Ensure that the intake camshaft actuator alignment mark (4) and the timing chain alignment mark (3) are also aligned.
3. Position the exhaust camshaft actuator to the camshaft and install the actuator bolt hand tight.
4. Remove the *EN-48313* tool.

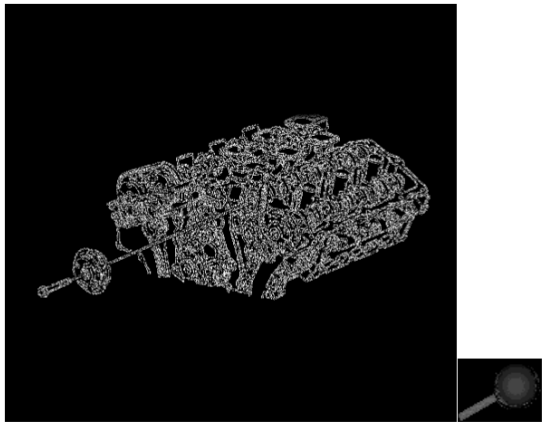


Note:

- The camshaft position actuator will vary depending on application.
- Camshaft thrust washers must only be installed on applications that had thrust washers present during removal of the camshaft position actuators. Do not install washers on applications if they are not already present.

5. If equipped, ensure the proper camshaft thrust washer is used. Use a 1.6 mm (0.063 in) thrust washer on applications that have 5 attaching screws on the back side of the camshaft position actuator (1). Use a 1.1 mm (0.043 in) thick thrust washer with yellow speckles on applications that have 4 attaching screws on the back side of the camshaft position actuator (2).
6. Install the thrust washer, if applicable.

cardiagn.com



Caution: Refer to Fastener Caution.

7. If the exhaust camshaft position actuator has been replaced, then tighten the bolt to **58 N•m (43 lb ft)**.
8. If the intake camshaft position actuator has been replaced, then tighten the bolt to **58 N•m (43 lb ft)**.
9. If both the exhaust and intake has been replaced, then tighten bolt to **58 N•m (43 lb ft)**.
10. Install the left intake and exhaust camshaft position actuator solenoids. Refer to Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake and Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust.
11. Install the left intake and exhaust camshaft position sensors. Refer to Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake and Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust.
12. Install the left camshaft cover. Refer to Camshaft Cover Replacement - Left Side.
13. Install the intake manifold. Refer to Intake Manifold Replacement.

cardiagn.com

Setting Camshaft Timing

Important: Setting the camshaft timing is necessary whenever the camshaft drive system has been disturbed such that the relationship between any chain and sprocket has been lost. Even when only one sprocket is involved, multiple crankshaft rotations will not produce conditions where correct timing can be confirmed.

If necessary, follow the left bank secondary camshaft drive chain replacement procedures to reset the camshaft timing. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.

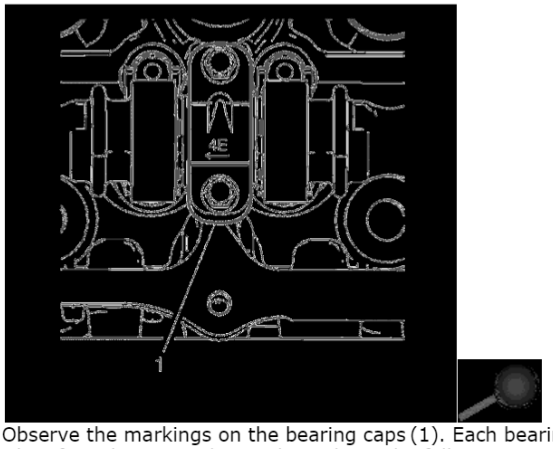
cardiagn.com

© 2014 General Motors. All rights reserved.

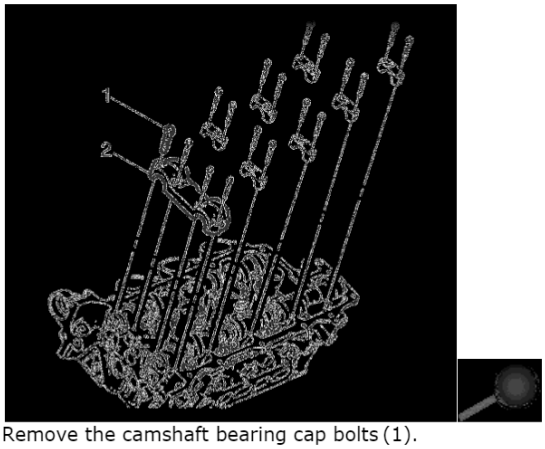
Camshaft Replacement - Left Side

Removal Procedure

1. Remove the camshaft position actuators. Refer to Camshaft Position Actuator Replacement - Bank 2.



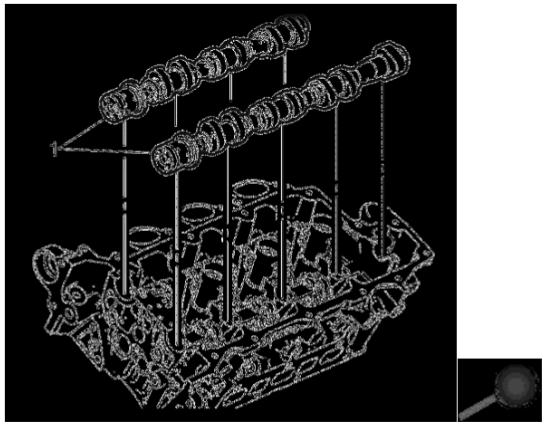
2. Observe the markings on the bearing caps (1). Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the engine.



3. Remove the camshaft bearing cap bolts (1).
4. Remove the camshaft bearing caps (2).

© 2014 General Motors. All rights reserved.

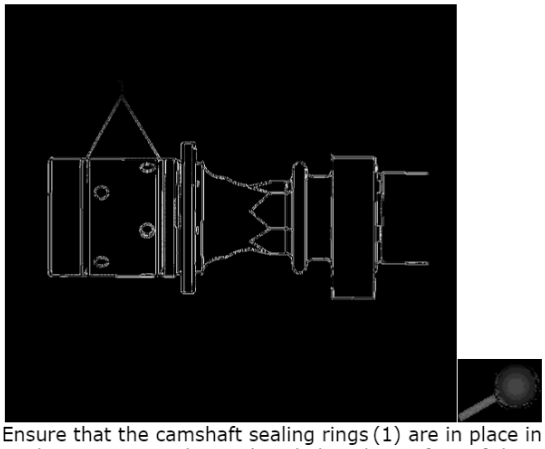
cardiagn.com



Note: Mark the camshafts upon removal to ensure installation is in the correct position.

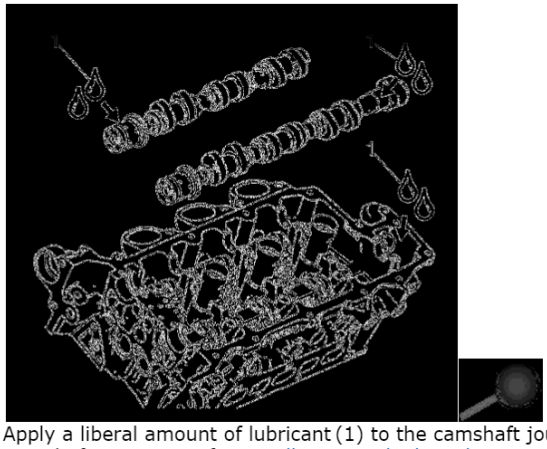
5. Remove the camshafts (1).

Installation Procedure

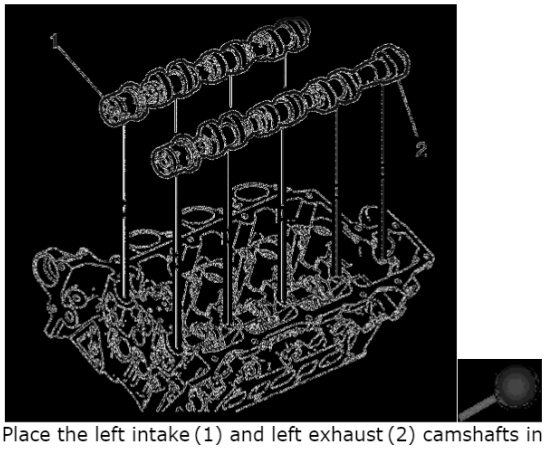


1. Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

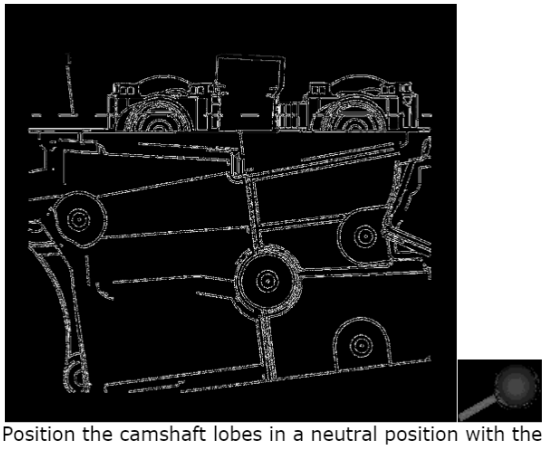
cardiagn.com



2. Apply a liberal amount of lubricant (1) to the camshaft journals and the left cylinder head camshaft carriers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

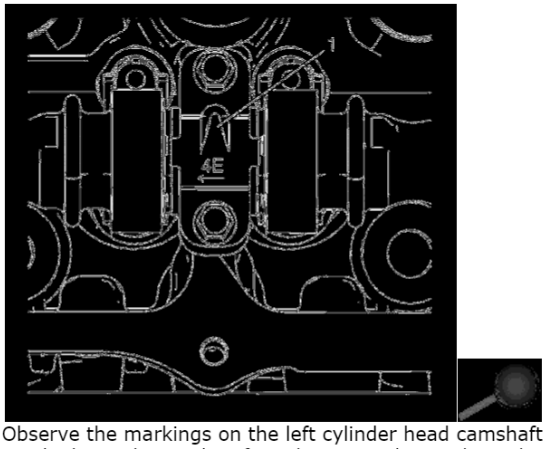


3. Place the left intake (1) and left exhaust (2) camshafts in position in the left cylinder head.

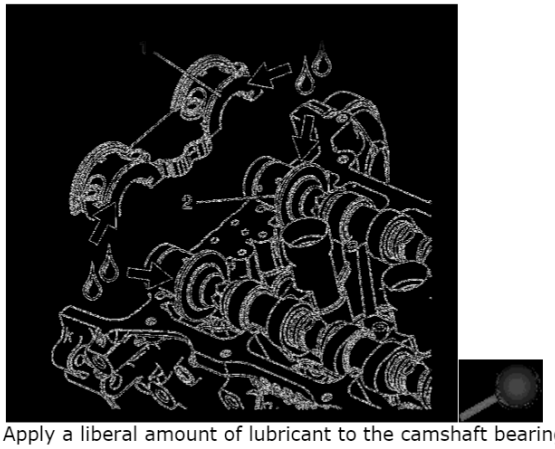


4. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the left cylinder head camshaft cover rail.

cardiagn.com

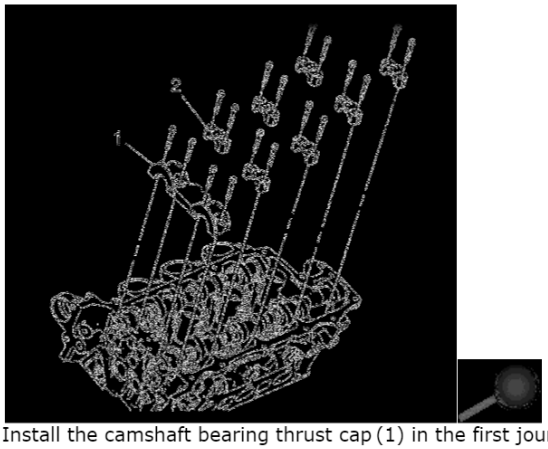


5. Observe the markings on the left cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature (1) must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 2, 4, 6 indicates the cylinder position from the front of the engine.
6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

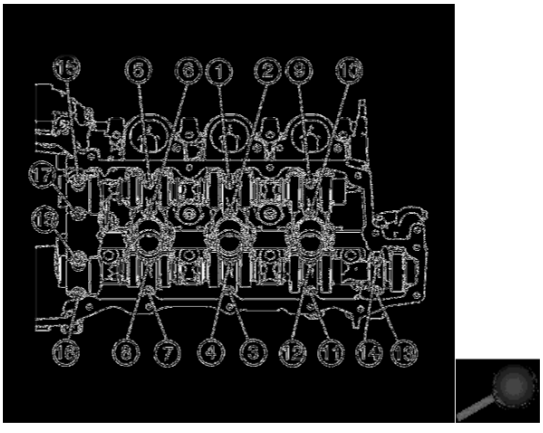


7. Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

cardiagn.com



8. Install the camshaft bearing thrust cap (1) in the first journal of the left cylinder head.
9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.



Caution: Refer to Fastener Caution.

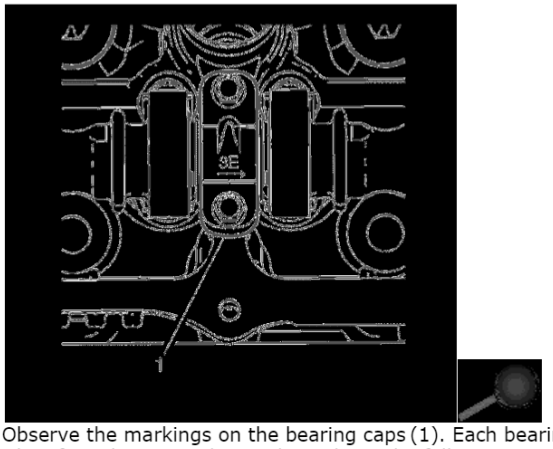
11. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to **10 N•m (89 lb in)**.
12. Loosen the center intake camshaft bearing cap bolts 1, 2 and the center exhaust camshaft bearing cap bolts 3, 4.
13. Retighten the center camshaft bearing cap bolts 1, 2, 3, 4 and retighten the camshaft bearing cap bolts to **10 N•m (89 lb in)**.
14. Install the camshaft position actuators. Refer to Camshaft Position Actuator Replacement - Bank 2.

cardiagn.com

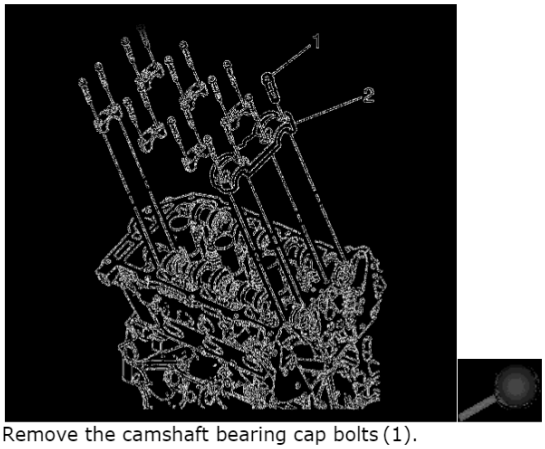
Camshaft Replacement - Right Side

Removal Procedure

1. Remove the camshaft position actuators. Refer to Camshaft Position Actuator Replacement - Bank 1.



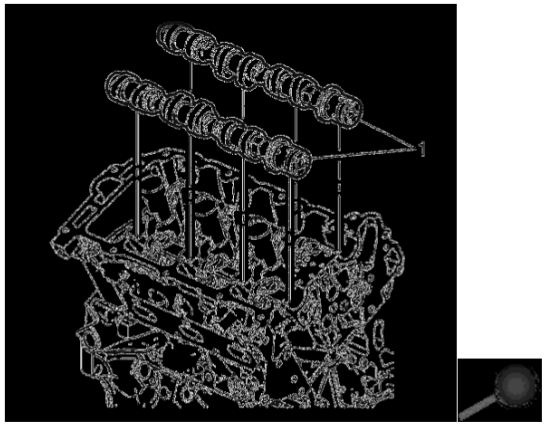
2. Observe the markings on the bearing caps (1). Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the engine.



3. Remove the camshaft bearing cap bolts (1).
4. Remove the camshaft bearing caps (2).

© 2014 General Motors. All rights reserved.

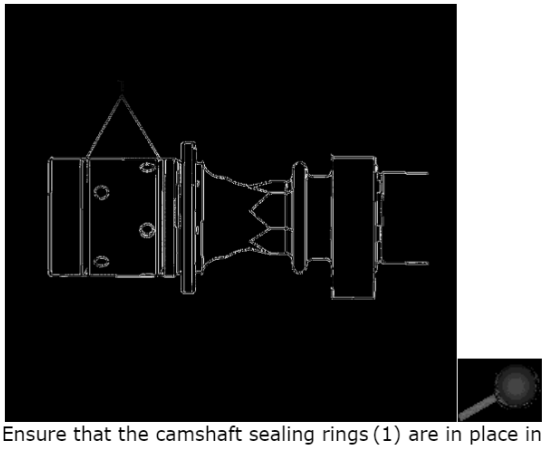
cardiagn.com



Important: Mark the camshafts upon removal to ensure installation is in the correct position.

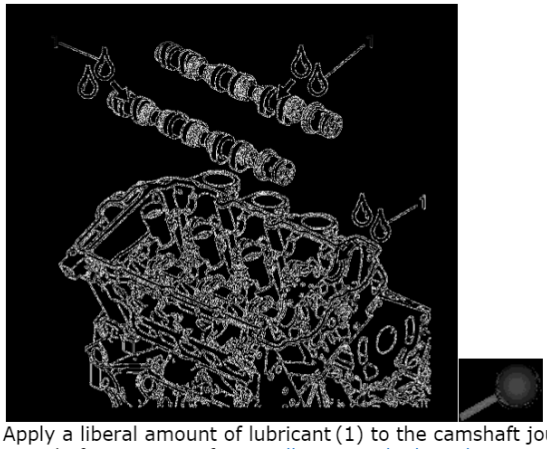
5. Remove the camshafts (1).

Installation Procedure

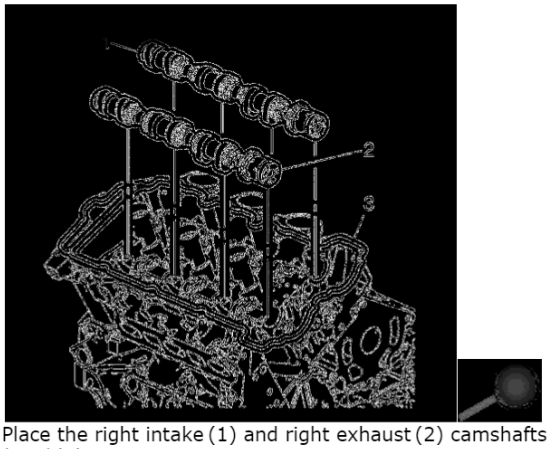


1. Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.

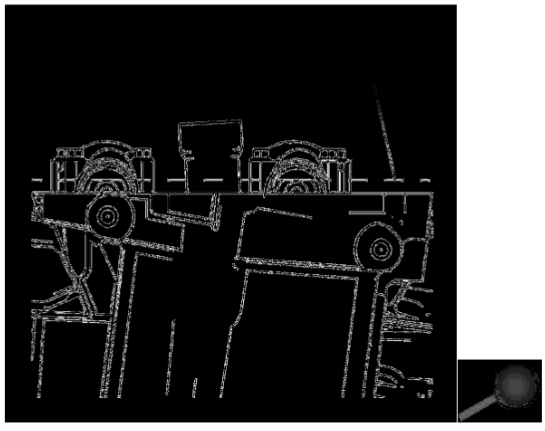
cardiagn.com



2. Apply a liberal amount of lubricant (1) to the camshaft journals and the right cylinder head camshaft carriers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

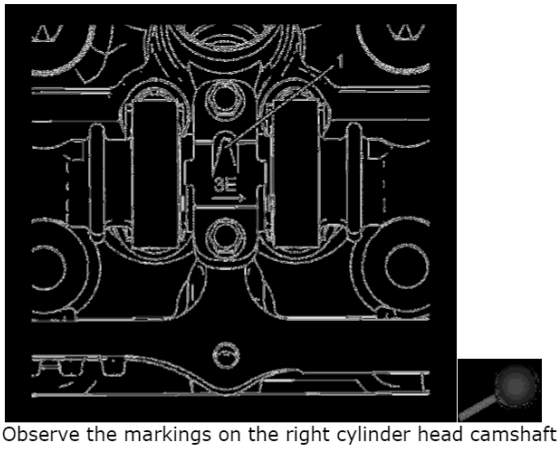


3. Place the right intake (1) and right exhaust (2) camshafts in position in the right cylinder head (3).

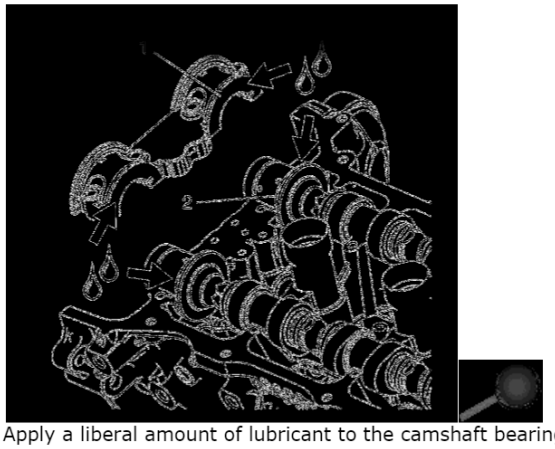


cardiagn.com

4. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the right cylinder head camshaft cover rail.

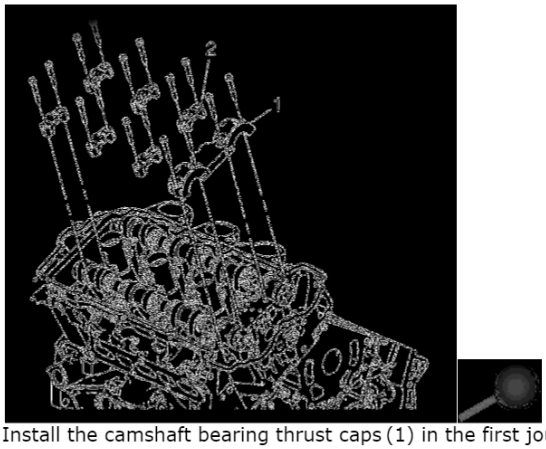


5. Observe the markings on the right cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature (1) must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 1, 3, 5 indicates the cylinder position from the front of the engine.
6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

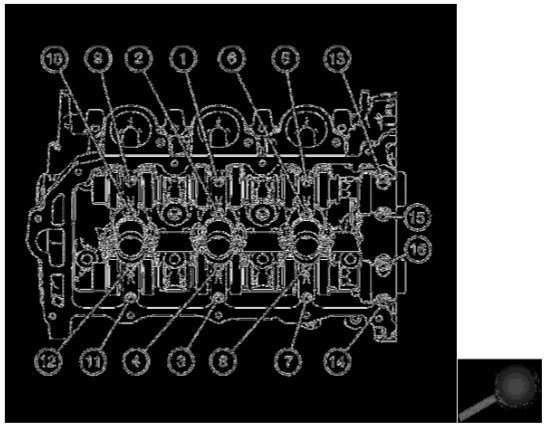


7. Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

cardiagn.com



8. Install the camshaft bearing thrust caps (1) in the first journal of the right cylinder head.
9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.



Caution: Refer to Fastener Caution.

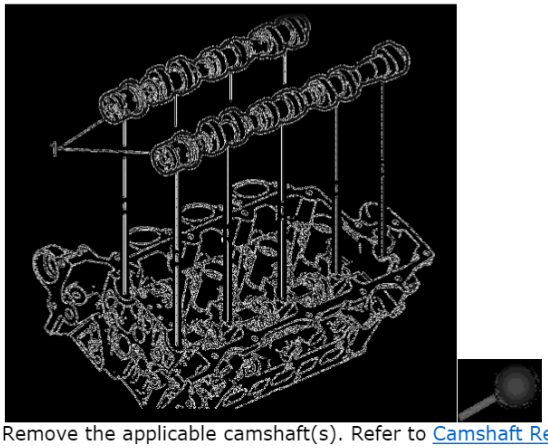
Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

11. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to **10 N·m (89 lb in)**.
12. Loosen the center intake camshaft bearing cap bolts (1, 2) and the center exhaust camshaft bearing cap bolts (3, 4).
13. Retighten the center camshaft bearing cap bolts (1, 2, 3, 4) and retighten the camshaft bearing cap bolts to **10 N·m (89 lb in)**.
14. Install the camshaft position actuators. Refer to Camshaft Position Actuator Replacement - Bank 1.

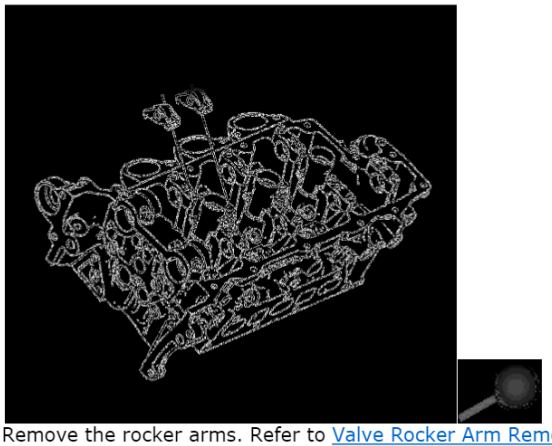
cardiagn.com

Valve Rocker Arm Replacement - Left Side

Removal Procedure



1. Remove the applicable camshaft(s). Refer to Camshaft Replacement - Left Side.

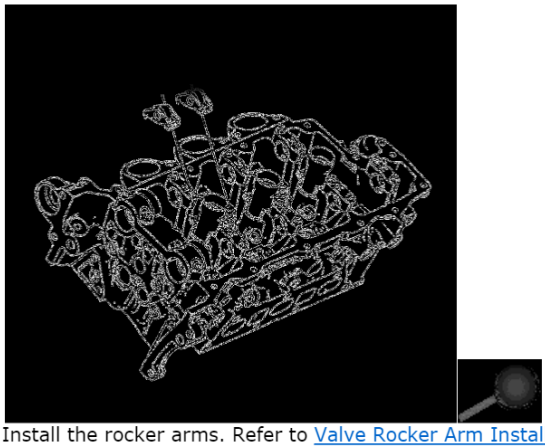


2. Remove the rocker arms. Refer to Valve Rocker Arm Removal - Left Side.
3. Clean and inspect the camshaft(s) and the rocker arm(s). Repair or replace as necessary. Refer to Camshaft Cleaning and Inspection and Valve Lifter Cleaning and Inspection.

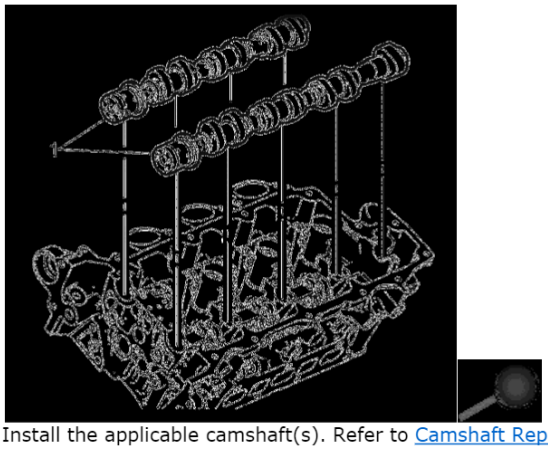
Installation Procedure

cardiagn.com

© 2014 General Motors. All rights reserved.



1. Install the rocker arms. Refer to Valve Rocker Arm Installation - Left Side.

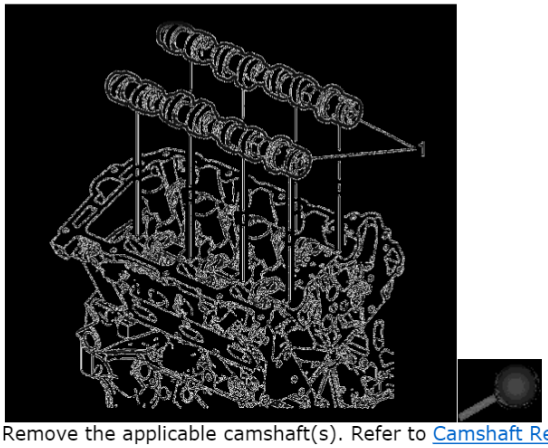


2. Install the applicable camshaft(s). Refer to Camshaft Replacement - Left Side.

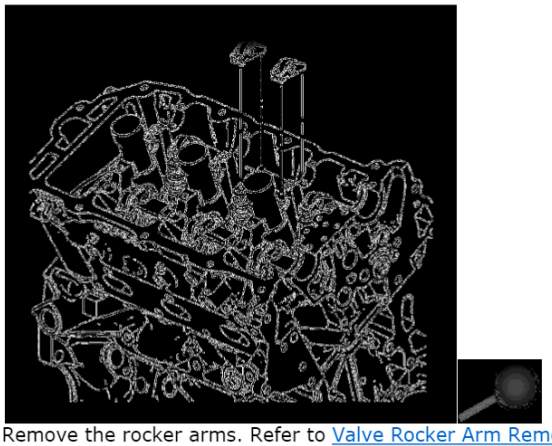
cardiagn.com

Valve Rocker Arm Replacement - Right Side

Removal Procedure



1. Remove the applicable camshaft(s). Refer to Camshaft Replacement - Right Side.

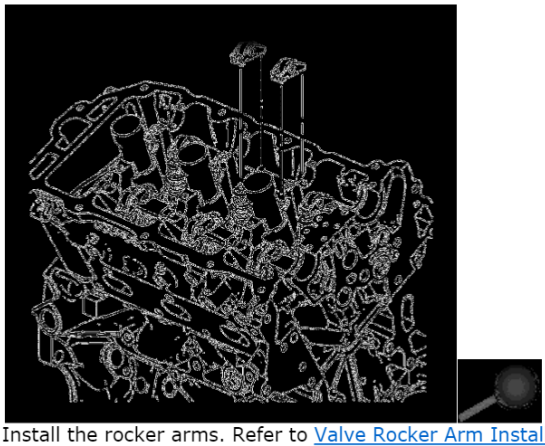


2. Remove the rocker arms. Refer to Valve Rocker Arm Removal - Right Side.
3. Clean and inspect the camshaft(s) and the rocker arm(s). Repair or replace as necessary. Refer to Camshaft Cleaning and Inspection and Valve Lifter Cleaning and Inspection.

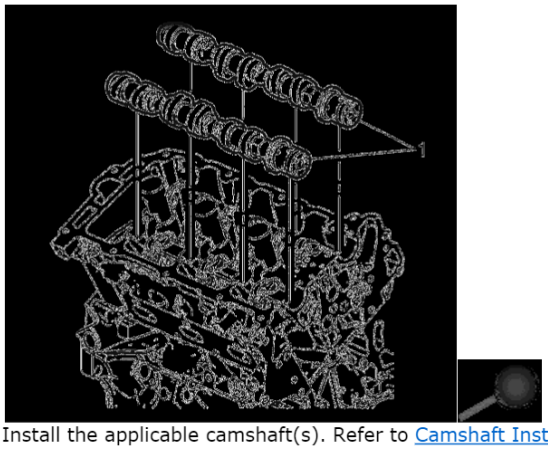
Installation Procedure

cardiagn.com

© 2014 General Motors. All rights reserved.



1. Install the rocker arms. Refer to Valve Rocker Arm Installation - Right Side.



2. Install the applicable camshaft(s). Refer to Camshaft Installation - Right Side.

cardiagn.com

Valve Lifter Replacement - Left Side

Removal Procedure

1. Remove the applicable camshaft(s). Camshaft Replacement - Left Side.
2. Remove the rocker arms. Refer to Valve Rocker Arm Removal - Left Side.

3. Remove the lifters. Refer to Valve Lifter Removal - Left Side.
4. Clean and inspect the camshaft(s), rocker arm(s) and lifter(s). Repair or replace as necessary. Refer to Camshaft Cleaning and Inspection and Valve Rocker Arm Cleaning and Inspection and Valve Lifter Cleaning and Inspection.

Installation Procedure

1. Install the lifters. Refer to Valve Lifter Installation - Left Side.
2. Install the rocker arms. Refer to Valve Rocker Arm Installation - Left Side.
3. Install the applicable camshaft(s). Refer to Camshaft Replacement - Left Side.

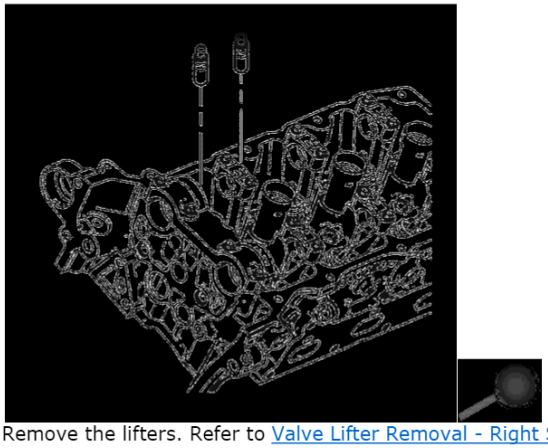
© 2014 General Motors. All rights reserved.

cardiagn.com

Valve Lifter Replacement - Right Side

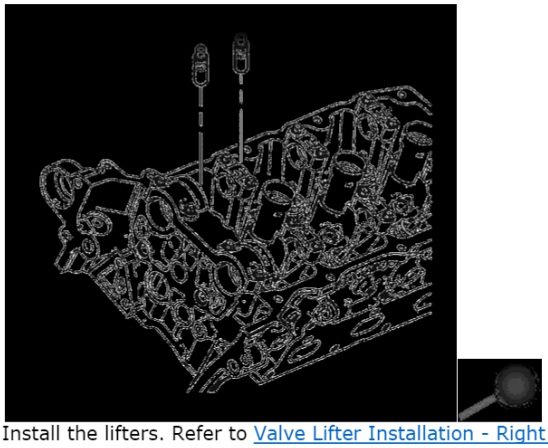
Removal Procedure

1. Remove the applicable camshaft(s). Refer to Camshaft Replacement - Right Side.
2. Remove the rocker arms. Refer to Valve Rocker Arm Removal - Right Side.



3. Remove the lifters. Refer to Valve Lifter Removal - Right Side.
4. Clean and inspect the camshaft(s), rocker arm(s) and lifter(s). Repair or replace as necessary. Refer to Camshaft Cleaning and Inspection and Valve Rocker Arm Cleaning and Inspection and Valve Lifter Cleaning and Inspection.

Installation Procedure



1. Install the lifters. Refer to Valve Lifter Installation - Right Side.
2. Install the rocker arms. Refer to Valve Rocker Arm Installation - Right Side.
3. Install the applicable camshaft(s). Refer to Camshaft Installation - Right Side.

© 2014 General Motors. All rights reserved.

cardiagn.com

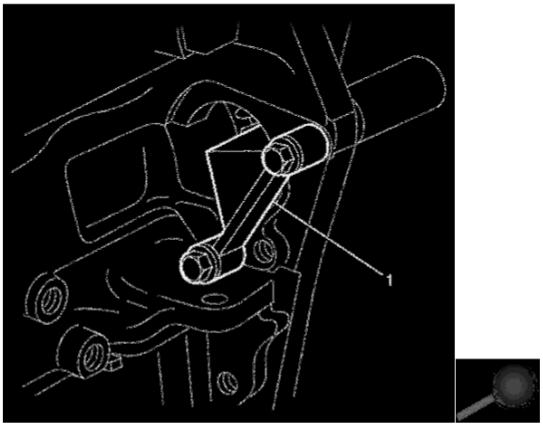
Valve Stem Oil Seal and Valve Spring Replacement - Left Side

Tools Required

- *EN 46106* Flywheel Holding Tool
- *EN 46110* On-Vehicle Valve Spring Compressor
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Collet Remover/Installer
- *J 39313* Spark Plug Port Adapter

Removal Procedure

1. Remove the starter motor. Refer to Starter Replacement.

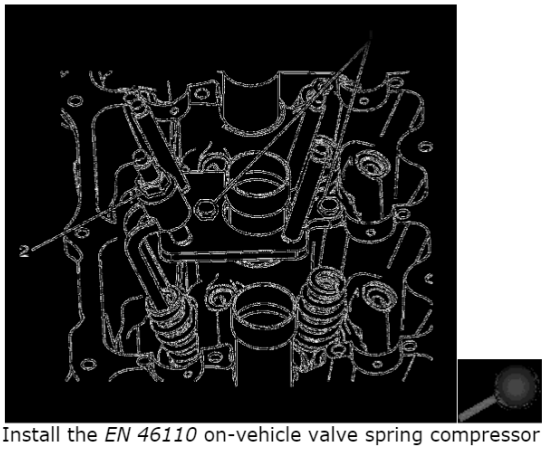


Important: If the *EN 46106* flywheel holding tool (1) is not installed, the crankshaft may rotate. If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.

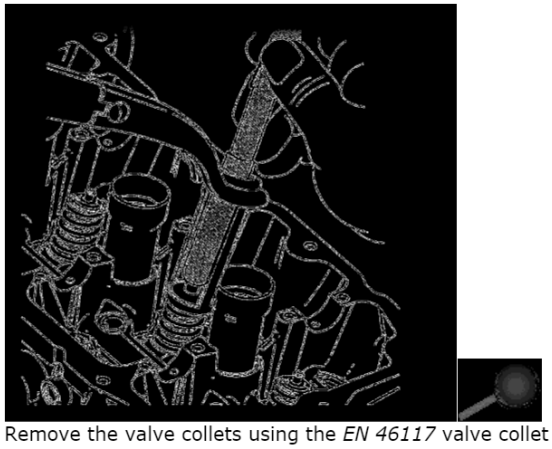
2. Install the *EN 46106* flywheel holding tool (1) in order to prevent crankshaft rotation.
3. Remove the camshafts and rocker arms. Refer to Camshaft Replacement - Left Side.
4. Remove the spark plug from the applicable cylinder. Refer to Spark Plug Replacement.
5. Install the *J 39313* spark plug port adapter to the applicable cylinder.
6. Connect the *J 39313* spark plug port adapter to a compressed air source.
7. Install the *EN 46110* on-vehicle valve spring compressor above the applicable cylinder.

cardiagn.com

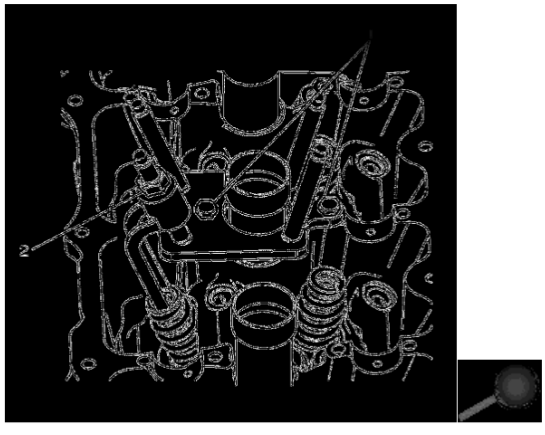
© 2014 General Motors. All rights reserved.



8. Install the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
9. Tighten the *EN 46110* on-vehicle valve spring compressor nut (2).

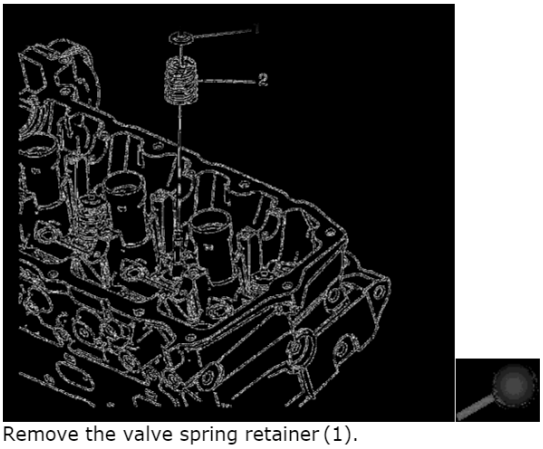


10. Remove the valve collets using the *EN 46117* valve collet remover/installer.

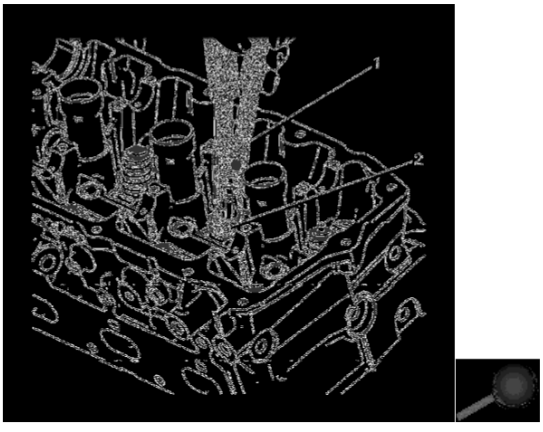


cardiagn.com

11. Loosen the *EN 46110* on-vehicle valve spring compressor nut (2).
12. Remove the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
13. Remove the *EN 46110* on-vehicle valve spring compressor.



14. Remove the valve spring retainer (1).
15. Remove the valve spring (2).

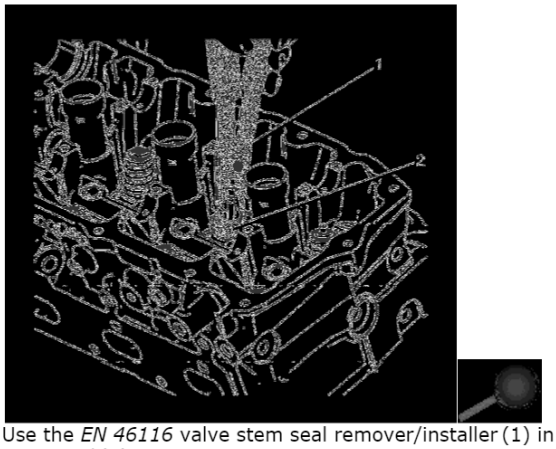


Important: NEVER reuse a valve stem oil seal.

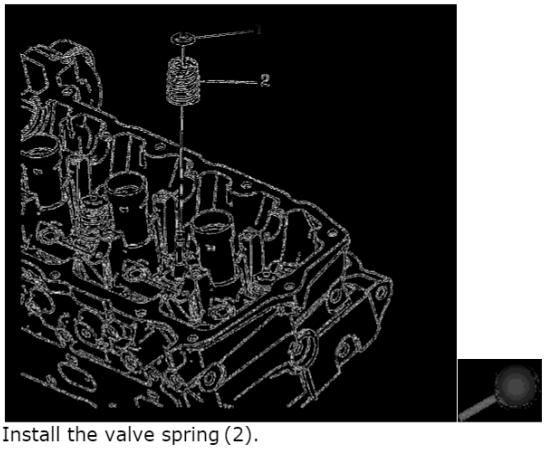
16. Remove the valve stem oil seal (2) using the *EN 46116* valve stem seal remover/installer (1).
    Discard the valve stem oil seals.
17. Repeat these procedures for the remaining valves.

Installation Procedure

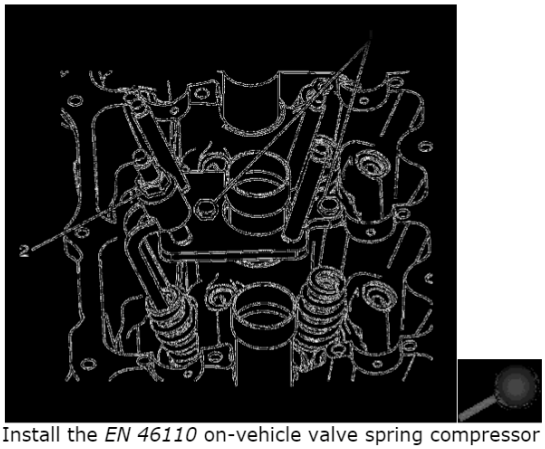
cardiagn.com



1. Use the *EN 46116* valve stem seal remover/installer (1) in order to install the NEW valve stem seal (2).



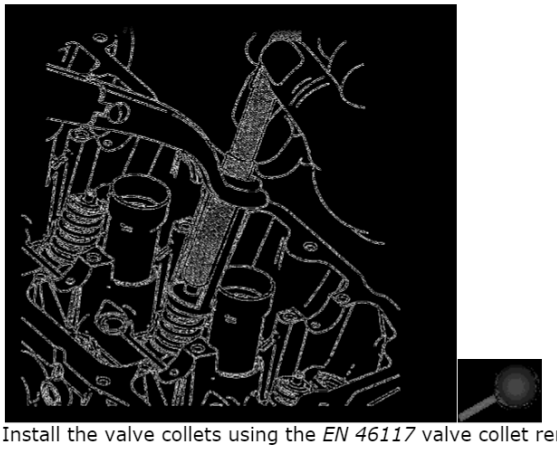
2. Install the valve spring (2).
3. Install the valve spring retainer (1).



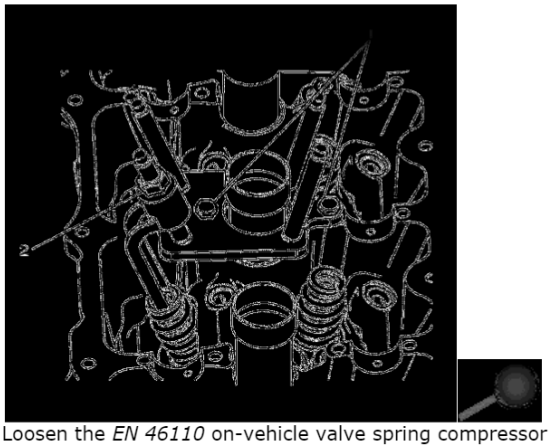
4. Install the *EN 46110* on-vehicle valve spring compressor above the applicable valve spring.

cardiagn.com

5. Install the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
6. Tighten the *EN 46110* on-vehicle valve spring compressor nut (2).

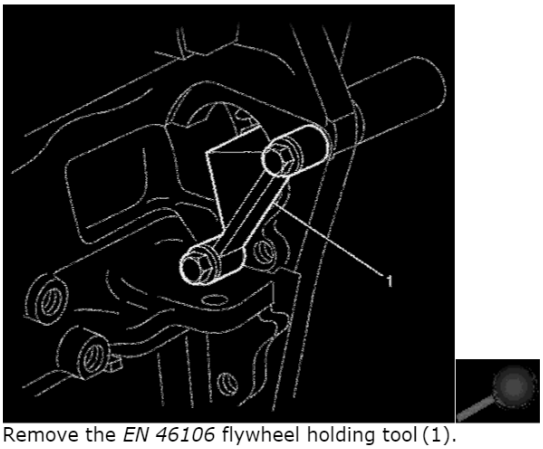


7. Install the valve collets using the *EN 46117* valve collet remover/installer (1).



8. Loosen the *EN 46110* on-vehicle valve spring compressor nut (2).
9. Remove the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
10. Remove the *EN 46110* on-vehicle valve spring compressor .
11. Disconnect the *J 39313* spark plug port adapter from the compressed air source.
12. Remove the *J 39313* spark plug port adapter.
13. Install the spark plugs. Refer to Spark Plug Replacement.
14. Install the rocker arms and camshafts. Refer to Camshaft Replacement - Left Side.

cardiagn.com



15. Remove the *EN 46106* flywheel holding tool (1).
16. Install the starter motor. Refer to Starter Replacement.

cardiagn.com

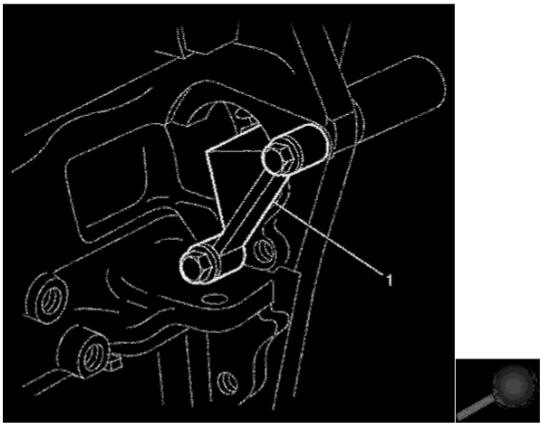
Valve Stem Oil Seal and Valve Spring Replacement - Right Side

Tools Required

- *EN 46106* Flywheel Holding Tool
- *EN 46110* On-Vehicle Valve Spring Compressor
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Collet Remover/Installer
- *J 39313* Spark Plug Port Adapter

Removal Procedure

1. Remove the starter motor. Refer to Starter Replacement.

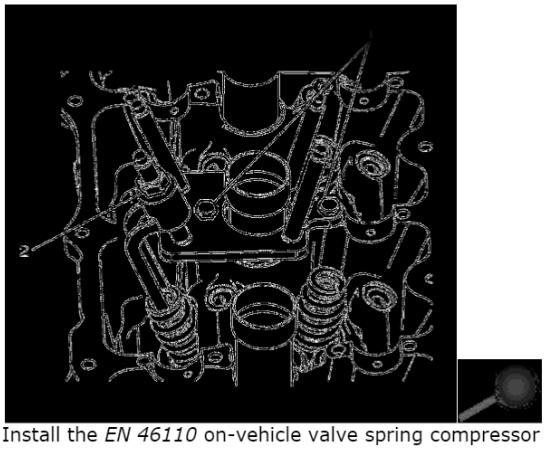


Important: If the *EN 46106* flywheel holding tool is not installed, the crankshaft may rotate. If the crankshaft rotates, disassembly and reassembly of the entire camshaft timing system may be required.

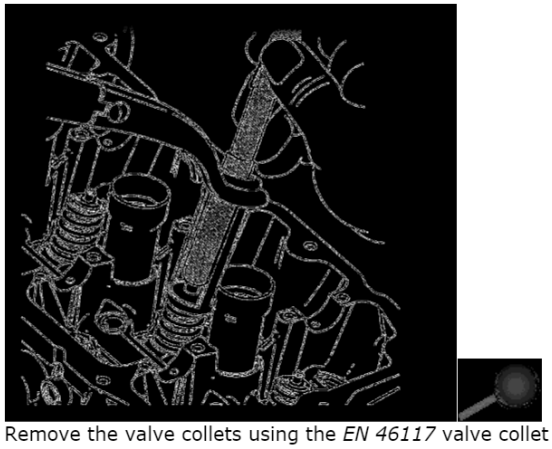
2. Install the *EN 46106* flywheel holding tool (1).
3. Remove the camshafts and rocker arms. Refer to Camshaft Replacement - Left Side.
4. Remove the spark plug from the applicable cylinder. Refer to Spark Plug Replacement.
5. Install the *J 39313* spark plug port adapter to the applicable cylinder.
6. Connect the *J 39313* spark plug port adapter to a compressed air source.
7. Install the *EN 46110* on-vehicle valve spring compressor above the applicable cylinder.

cardiagn.com

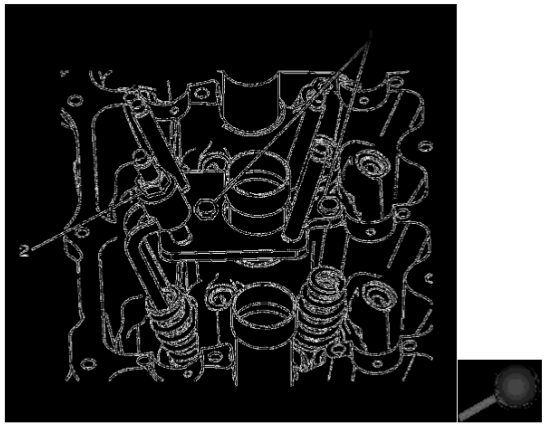
© 2014 General Motors. All rights reserved.



8. Install the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
9. Tighten the *EN 46110* on-vehicle valve spring compressor nut (2).

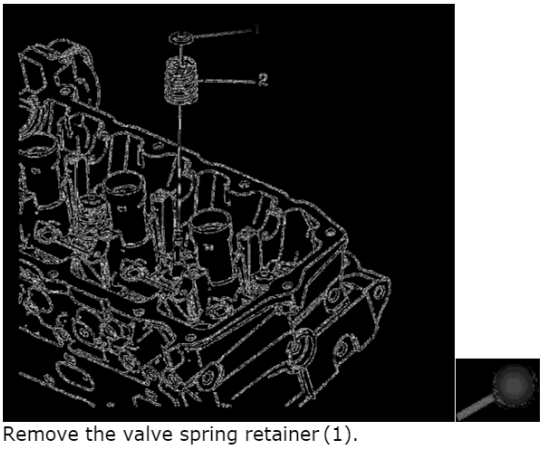


10. Remove the valve collets using the *EN 46117* valve collet remover/installer.

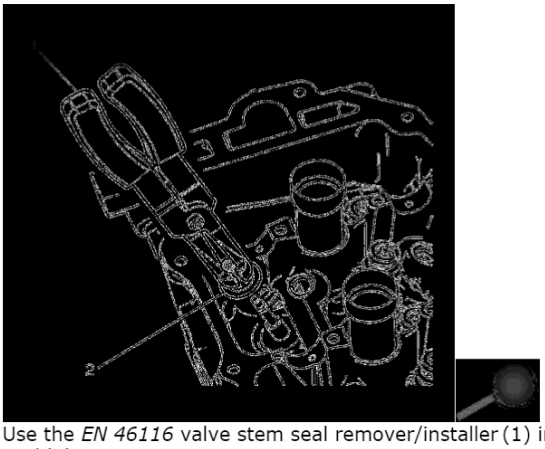


cardiagn.com

11. Loosen the *EN 46110* on-vehicle valve spring compressor nut (2).
12. Remove the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
13. Remove the *EN 46110* on-vehicle valve spring compressor.



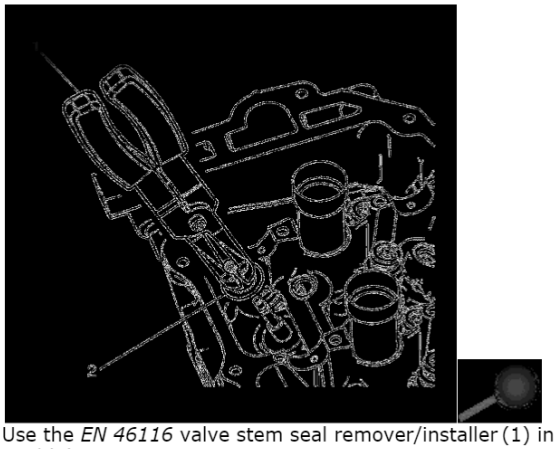
14. Remove the valve spring retainer (1).
15. Remove the valve spring (2).



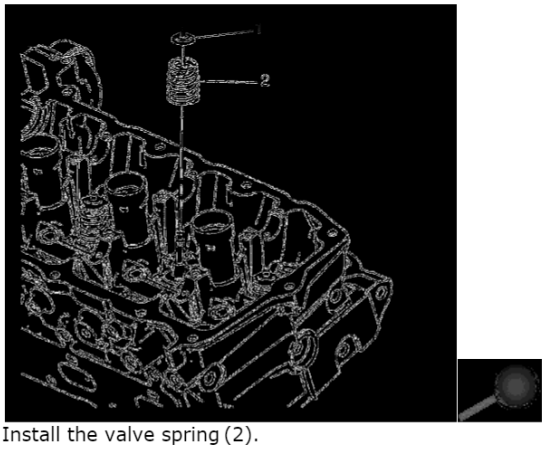
16. Use the *EN 46116* valve stem seal remover/installer (1) in order to remove the valve stem seal (2).

Installation Procedure

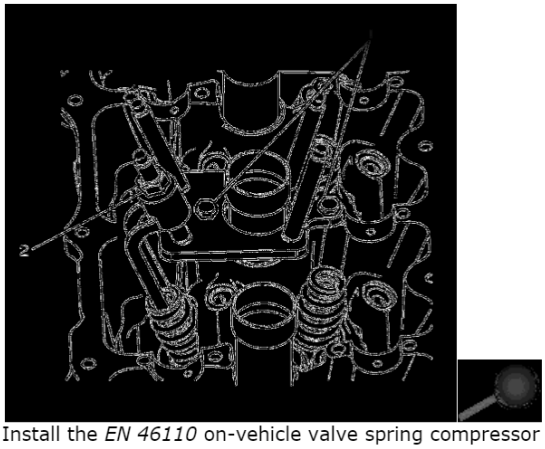
cardiagn.com



1. Use the *EN 46116* valve stem seal remover/installer (1) in order to install the valve stem seal (2).



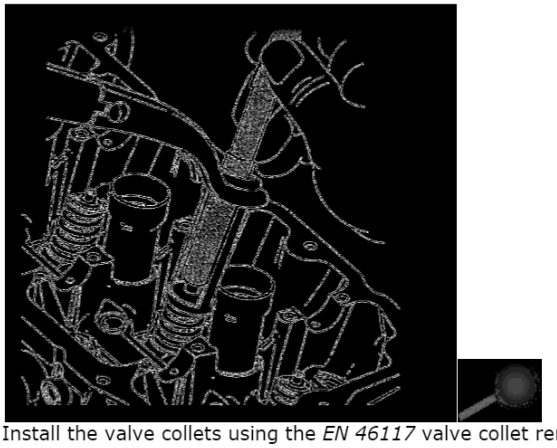
2. Install the valve spring (2).



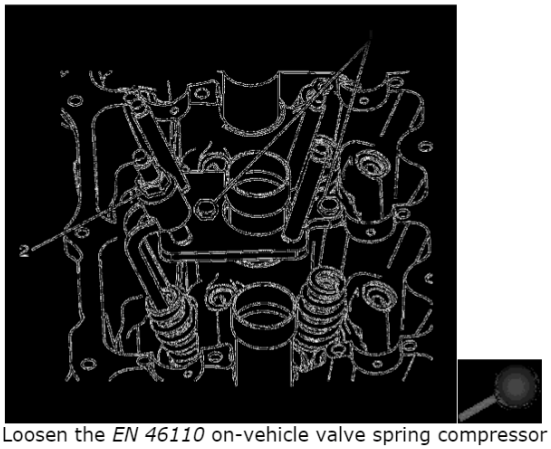
3. Install the *EN 46110* on-vehicle valve spring compressor above the applicable valve spring.

cardiagn.com

4. Install the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
5. Tighten the *EN 46110* on-vehicle valve spring compressor nut (2).
6. Install the valve spring retainer (1).

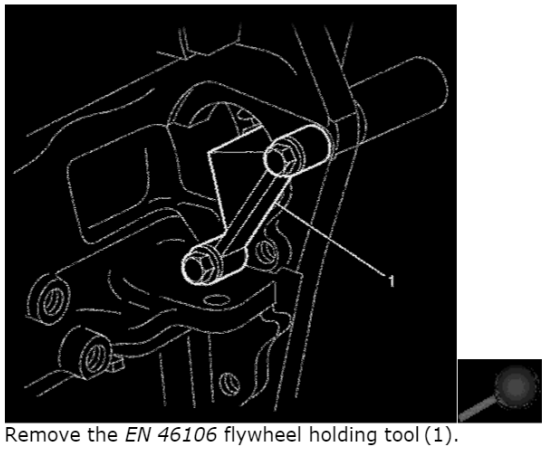


7. Install the valve collets using the *EN 46117* valve collet remover/installer.



8. Loosen the *EN 46110* on-vehicle valve spring compressor nut (2).
9. Remove the *EN 46110* on-vehicle valve spring compressor to cylinder head retaining bolts (1).
10. Remove the *EN 46110* on-vehicle valve spring compressor.
11. Disconnect the *J 39313* spark plug port adapter from the compressed air source.
12. Remove the *J 39313* spark plug port adapter.
13. Install the spark plugs. Refer to Spark Plug Replacement.
14. Install the rocker arms and camshafts. Refer to Camshaft Replacement - Left Side.

cardiagn.com



15. Remove the *EN 46106* flywheel holding tool (1).
16. Install the starter motor. Refer to Starter Replacement.

cardiagn.com

Cylinder Head Replacement - Left Side (LWR)

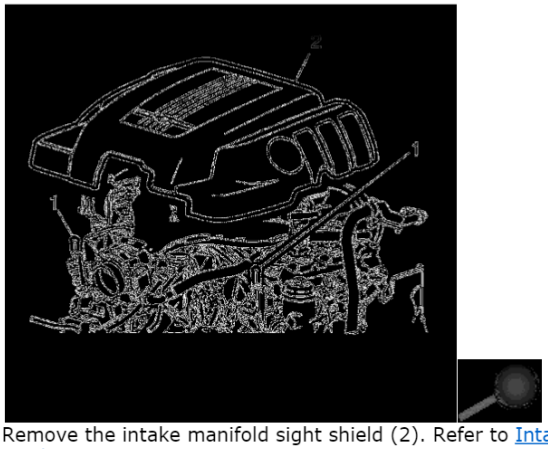
Special Tools

J 45059 Angle Meter

Removal Procedure

Warning: Refer to Battery Disconnect Warning.

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Drain the cooling system. Refer to Cooling System Draining and Filling.
3. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

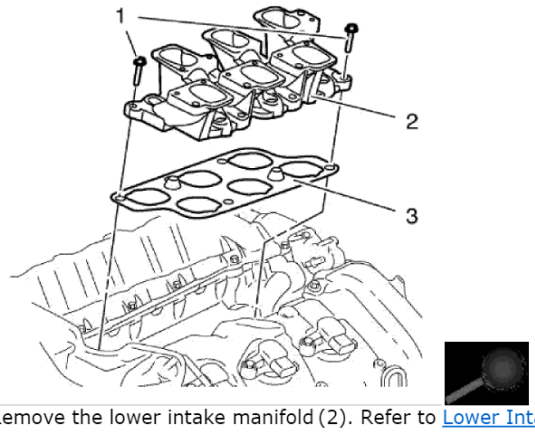


4. Remove the intake manifold sight shield (2). Refer to Intake Manifold Sight Shield Replacement.
5. Remove the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.

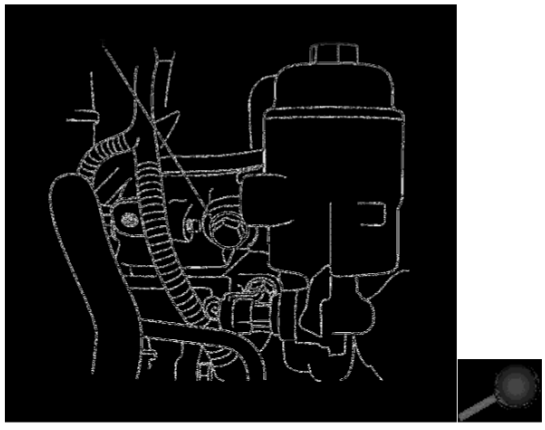
© 2014 General Motors. All rights reserved.

cardiagn.com

6. Remove the upper intake manifold. Refer to Upper Intake Manifold Replacement.

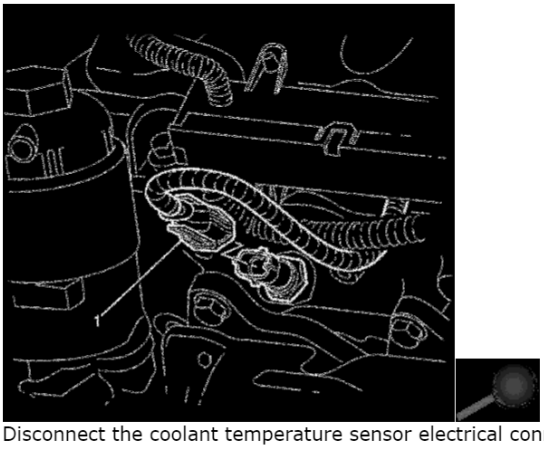


7. Remove the lower intake manifold (2). Refer to Lower Intake Manifold Replacement.
8. Remove the left and right camshaft covers. Refer to Camshaft Cover Replacement - Left Side and Camshaft Cover Replacement - Right Side.

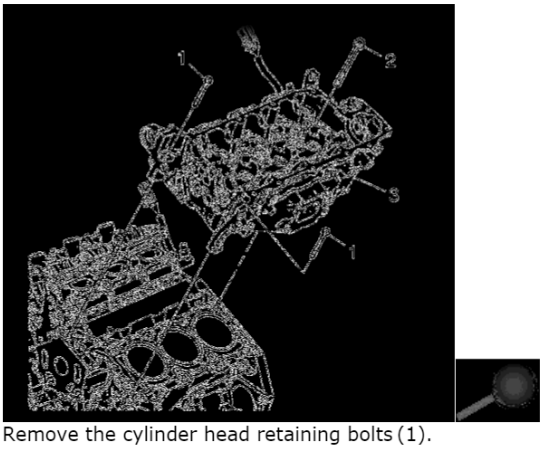


Note: DO NOT remove the oil filter adapter.
9. Remove the oil filter adapter upper retaining bolt (1).

cardiagn.com

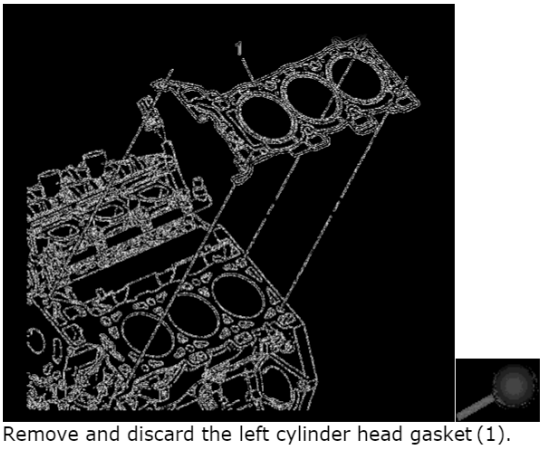


10. Disconnect the coolant temperature sensor electrical connector (1).
11. Remove the oil level indicator. Refer to Oil Level Indicator Tube Replacement.
12. Remove engine front cover. Refer to Engine Front Cover Replacement.
13. Remove the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.
14. Remove the left exhaust manifold. Refer to Exhaust Manifold Replacement - Left Side.



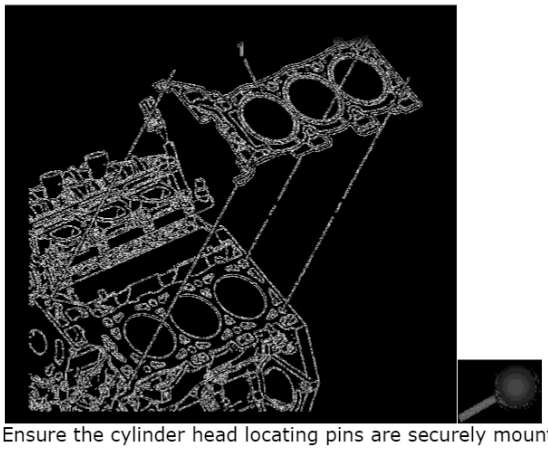
15. Remove the cylinder head retaining bolts (1).
16. Remove the left cylinder head retaining bolts (2).
17. Remove the left cylinder head (3) from the engine.

cardiagn.com



18. Remove and discard the left cylinder head gasket (1).
19. Clean and inspect the cylinder head and the engine block sealing surfaces. Refer to:
    - Cylinder Head Cleaning and Inspection
    - Engine Block Cleaning and Inspection

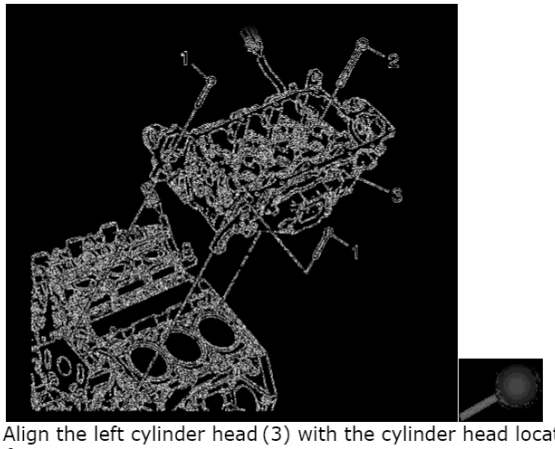
Installation Procedure



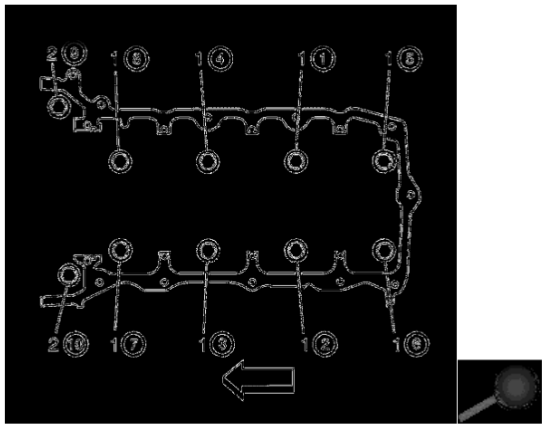
1. Ensure the cylinder head locating pins are securely mounted on the cylinder block face.

   Note: Use the cylinder head locating pins on the cylinder block face to retain the cylinder head gasket.
2. Install a NEW left cylinder head gasket (1).

cardiagn.com



3. Align the left cylinder head (3) with the cylinder head locating pins on the cylinder block face.
4. Position the left cylinder head to the cylinder block face.



Caution: Refer to Fastener Caution.

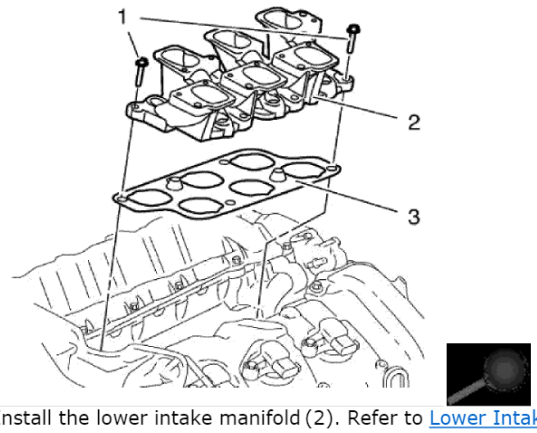
Note:

- Ensure the cylinder head bolts and cylinder head bolt holes are dry before installing the cylinder head bolts to the cylinder head.
- Tighten the cylinder head bolts in the sequence shown.

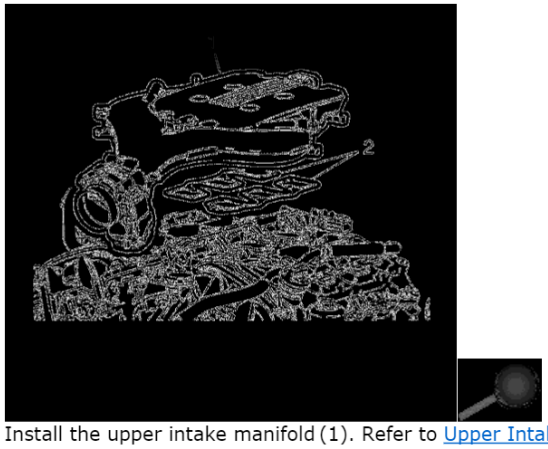
5. Install NEW left cylinder head bolts (1).
   5.1. Tighten the cylinder head bolts (1) at first pass to **30 N•m (22 lb ft)**.
   5.2. Tighten the cylinder head bolts (1) a second pass **150 degrees** using the *J 45059* angle meter.
6. Install NEW left cylinder head bolts (2).
   6.1. Tighten the cylinder head bolts (2) at first pass to **15 N•m (11 lb ft)**.
   6.2. Tighten the cylinder head bolts (2) a second pass **75 degrees** using the *J 45059* angle meter.
7. Install the left exhaust manifold. Refer to Exhaust Manifold Replacement - Left Side.
8. Install the oil level indicator. Refer to Oil Level Indicator Tube Replacement.
9. Install the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.

cardiagn.com

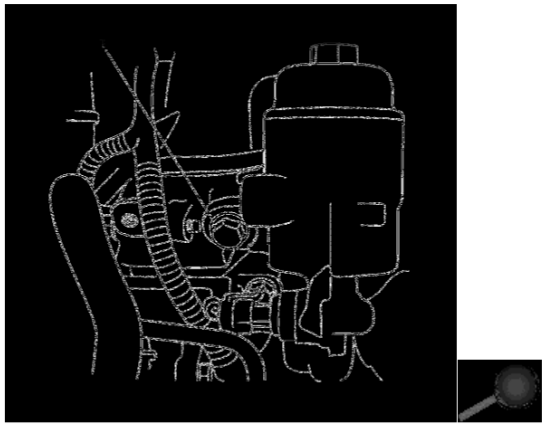
10. Install the left and right camshaft covers. Refer to Camshaft Cover Replacement - Left Side and Camshaft Cover Replacement - Right Side.



11. Install the lower intake manifold (2). Refer to Lower Intake Manifold Replacement.

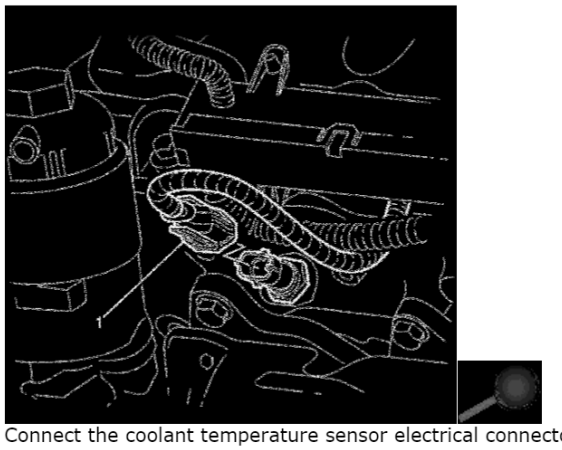


12. Install the upper intake manifold (1). Refer to Upper Intake Manifold Replacement.

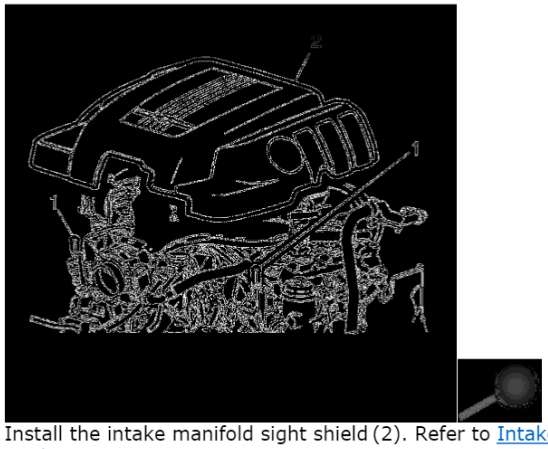


cardiagn.com

13. Install the oil filter adapter upper retaining bolt (1) and tighten to **65 N•m (48 lb in)**.



14. Connect the coolant temperature sensor electrical connector (1).
15. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
16. Refill the cooling system. Refer to Cooling System Draining and Filling.
17. Install the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.



18. Install the intake manifold sight shield (2). Refer to Intake Manifold Sight Shield Replacement.
19. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Cylinder Head Replacement - Left Side (LFW)

Special Tools

J 45059 Angle Meter

Removal Procedure

Warning: Refer to Safety Glasses Warning.

Warning: Refer to Gasoline/Gasoline Vapors Warning.

Warning: Refer to Relieving Fuel Pressure Warning.

1. Relieve the high side fuel pressure. Refer to Fuel Pressure Relief.
2. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.

Warning: Refer to Safety Glasses Warning.

3. Ignition OFF.

Warning: Refer to Battery Disconnect Warning.

4. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
5. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
6. Remove the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.
7. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Under some conditions, the ethylene glycol engine coolant is combustible. In order to help avoid being burned, do not spill the antifreeze or the coolant on the exhaust system or the hot engine parts.

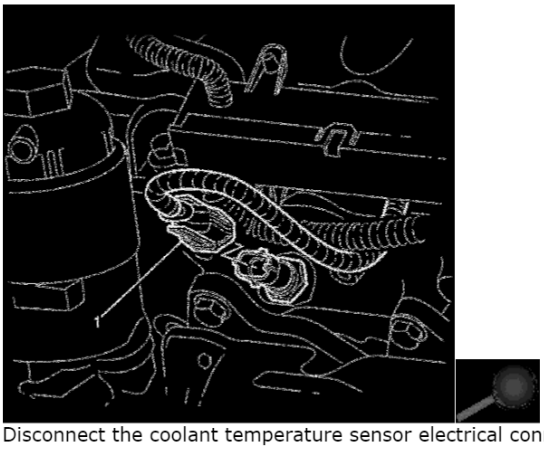
Warning: Dispose of the used engine coolant properly. Store the used coolant in a used coolant Holding Tank awaiting proper disposal or recycling. Do not pour used coolant down the drain. Ethylene glycol antifreeze is a very toxic chemical. Disposal into the sewer system or into the ground water is both environmentally irresponsible and illegal

Warning: Refer to Radiator Cap Removal Warning.

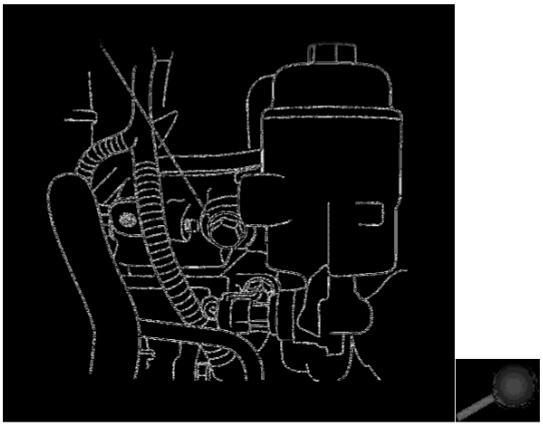
8. Drain the cooling system. Refer to Cooling System Draining and Filling.
9. Remove the intake manifold. Refer to Intake Manifold Removal.
10. Remove the intermediate fuel feed pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
11. Remove the fuel pump. Refer to Fuel Pump Replacement.
12. Remove the left camshaft cover. Refer to Camshaft Cover Replacement - Left Side.
13. Remove the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.
14. Remove the oil level indicator. Refer to Oil Level Indicator Tube Replacement.

cardiagn.com

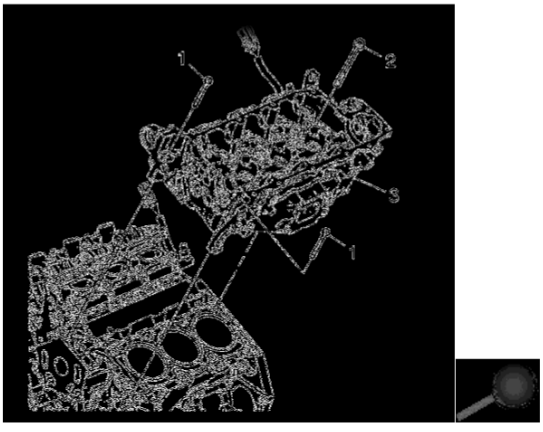
© 2014 General Motors. All rights reserved.



15. Disconnect the coolant temperature sensor electrical connector (1).
16. Remove the catalytic converter. Refer to Catalytic Converter Replacement - Left Side.

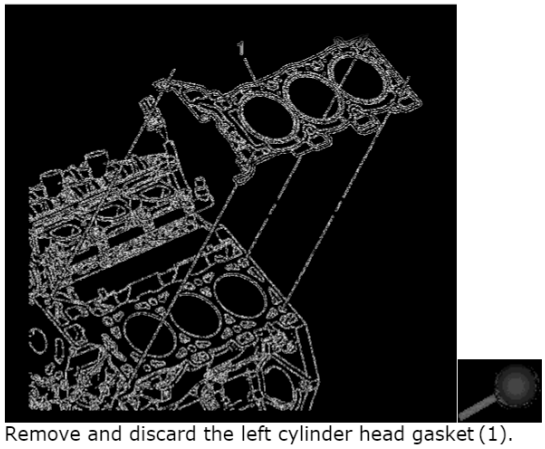


Note: DO NOT remove the oil filter adapter.
17. Remove the oil filter adapter upper retaining bolt (1).



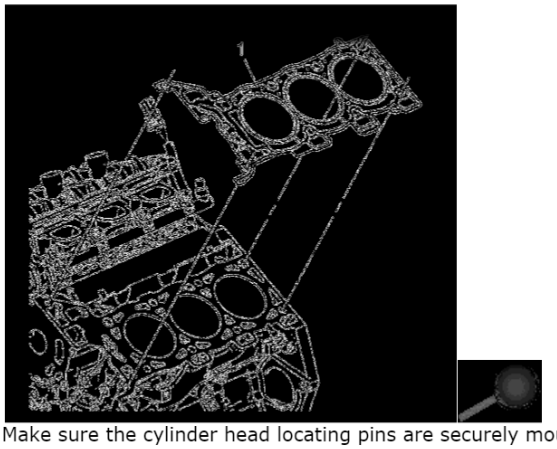
cardiagn.com

18. Remove the cylinder head retaining bolts (1).
19. Remove the left cylinder head retaining bolts (2).
20. Remove the left cylinder head (3) from the engine.



21. Remove and discard the left cylinder head gasket (1).
22. Clean and inspect the cylinder head and the engine block sealing surfaces. Refer to:
    - Cylinder Head Cleaning and Inspection
    - Engine Block Cleaning and Inspection

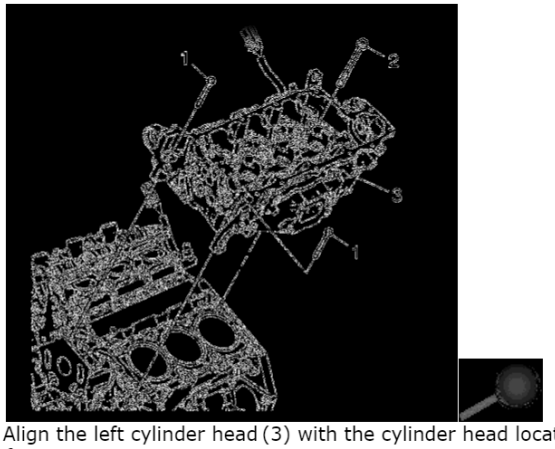
Installation Procedure



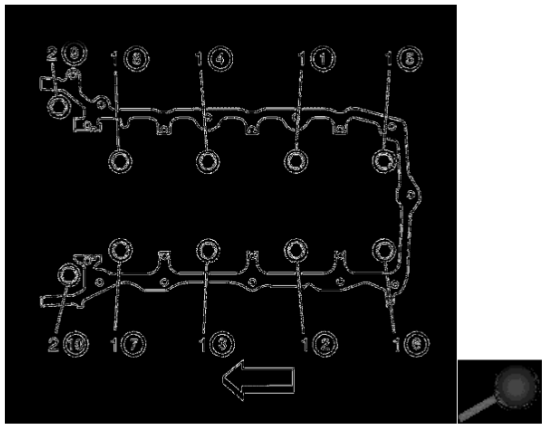
1. Make sure the cylinder head locating pins are securely mounted on the cylinder block face.

   Note: Use the cylinder head locating pins on the cylinder block face to retain the cylinder head gasket.
2. Install a NEW left cylinder head gasket (1).

cardiagn.com



3. Align the left cylinder head (3) with the cylinder head locating pins on the cylinder block face.
4. Position the left cylinder head to the cylinder block face.



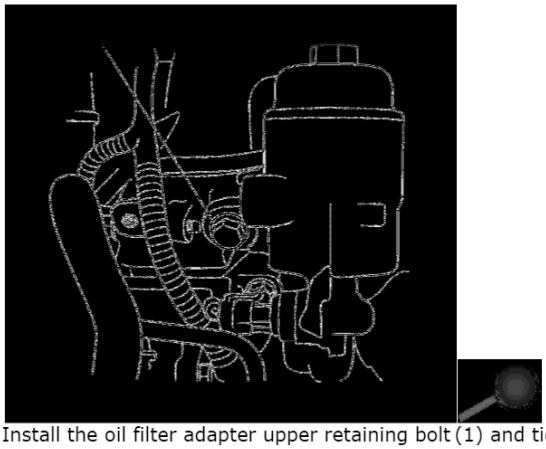
cardiagn.com

Caution: Refer to Fastener Caution.

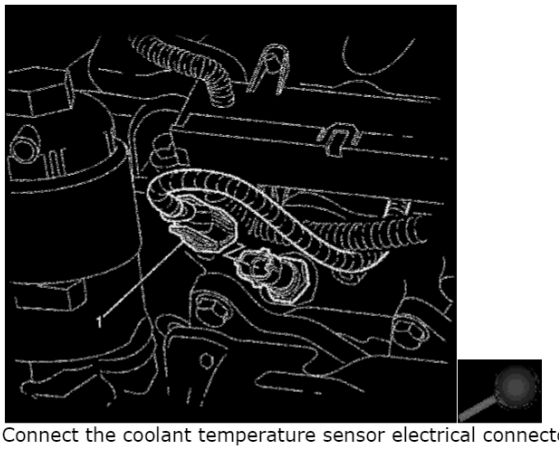
Note:

- Make sure the cylinder head bolts and cylinder head bolt holes are dry before installing the cylinder head bolts to the cylinder head.
- Tighten the cylinder head bolts in the sequence shown.

5. Install NEW left cylinder head bolts (1).
   5.1. Tighten the cylinder head bolts (1) at first pass to **30 N•m (22 lb ft)**.
   5.2. Tighten the cylinder head bolts (1) a second pass **150 degrees** using the *J 45059* angle meter.
6. Install NEW left cylinder head bolts (2).
   6.1. Tighten the cylinder head bolts (2) at first pass to **15 N•m (11 lb ft)**.
   6.2. Tighten the cylinder head bolts (2) a second pass **75 degrees** using the *J 45059* angle meter.



7. Install the oil filter adapter upper retaining bolt (1) and tighten to **65 N•m (48 lb in)**.
8. Install the left catalytic converter to the cylinder head. Refer to Catalytic Converter Replacement - Left Side.



9. Connect the coolant temperature sensor electrical connector (1).
10. Install the oil level indicator. Refer to Oil Level Indicator Tube Replacement.
11. Install the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.
12. Install the camshaft cover. Refer to Camshaft Cover Replacement - Left Side.
13. Install the intermediate fuel feed pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
14. Install the fuel pump. Refer to Fuel Pump Replacement.
15. Install the intake manifold. Refer to Intake Manifold Removal.
16. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
17. Refill the cooling system. Refer to Cooling System Draining and Filling.
18. Install the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.
19. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
20. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Cylinder Head Replacement - Right Side (LWR)

Special Tools

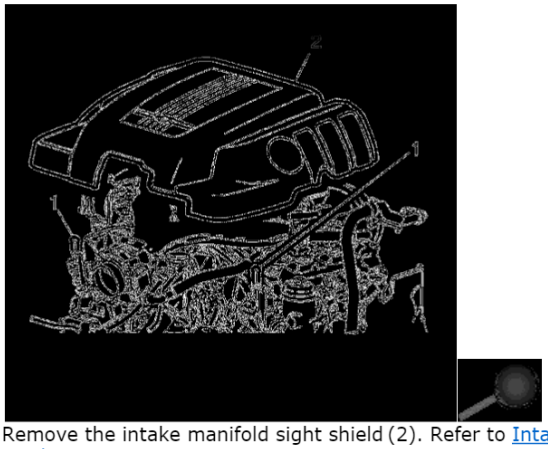
J 45059 Angle Meter

For equivalent regional tools, refer to Special Tools.

Removal Procedure

Warning: Refer to Battery Disconnect Warning.

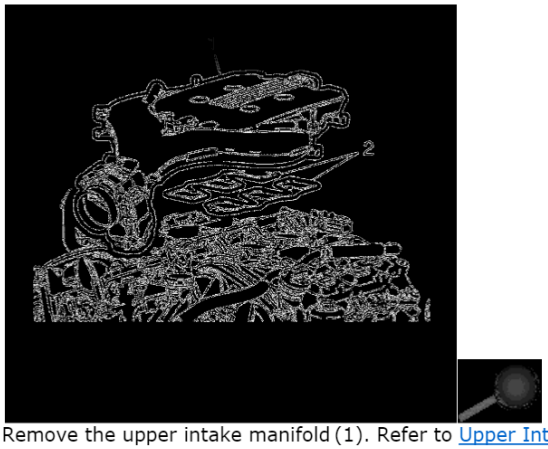
1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Drain the cooling system. Refer to Cooling System Draining and Filling.
3. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.



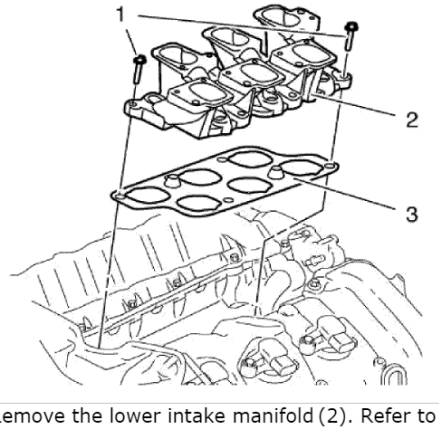
4. Remove the intake manifold sight shield (2). Refer to Intake Manifold Sight Shield Replacement.
5. Remove the intake manifold sight shield brackets (1). Refer to Intake Manifold Sight Shield Bracket Replacement.

cardiagn.com

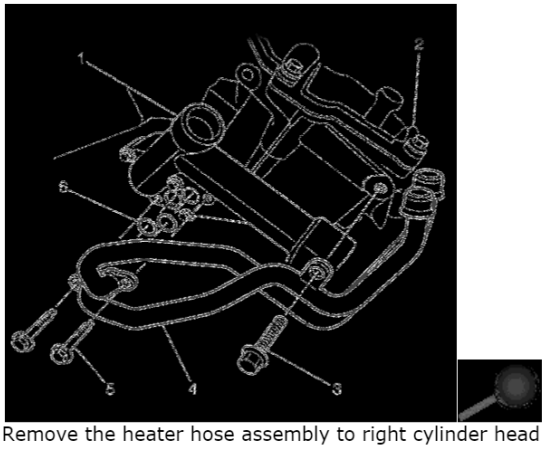
© 2014 General Motors. All rights reserved.



6. Remove the upper intake manifold (1). Refer to Upper Intake Manifold Replacement.

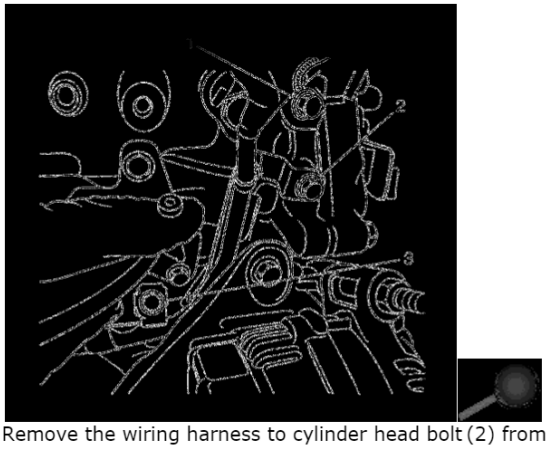


7. Remove the lower intake manifold (2). Refer to Lower Intake Manifold Replacement.

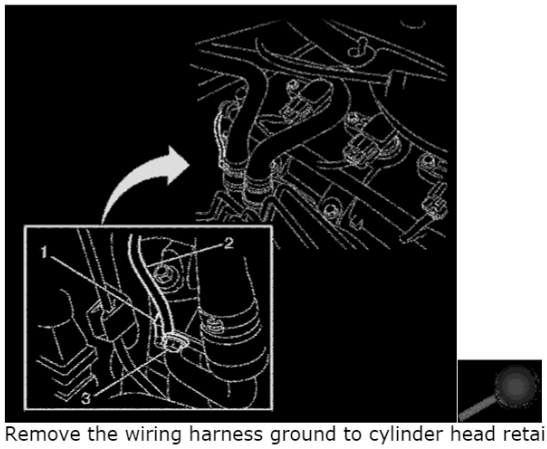


8. Remove the heater hose assembly to right cylinder head retaining bolt (3).

cardiagn.com

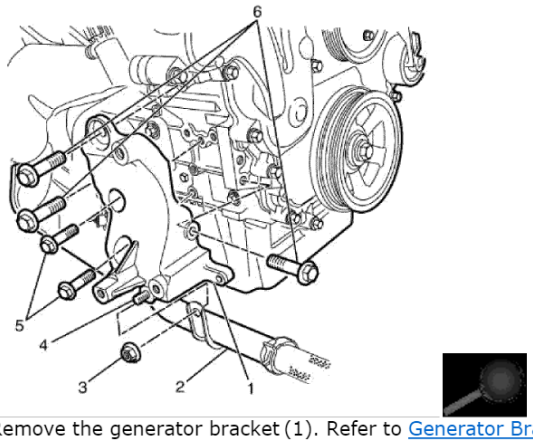


9. Remove the wiring harness to cylinder head bolt (2) from the cylinder head.
10. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
11. Reposition the wiring harness away from the right cylinder head.

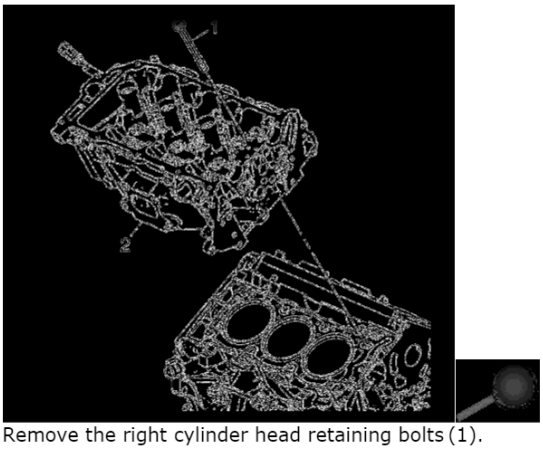


12. Remove the wiring harness ground to cylinder head retaining bolts (3).
13. Reposition the wiring harness (2) away from the right cylinder head (1).
14. Remove the left and right camshaft covers. Refer to Camshaft Cover Replacement - Right Side and Camshaft Cover Replacement - Left Side.
15. Remove the engine front cover. Refer to Engine Front Cover Replacement.
16. Remove the right bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Right Side.
17. Remove the right exhaust manifold. Refer to Exhaust Manifold Replacement - Left Side.

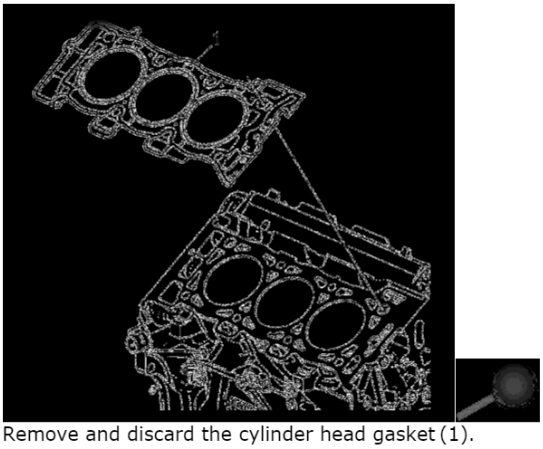
cardiagn.com



18. Remove the generator bracket (1). Refer to Generator Bracket Replacement.



19. Remove the right cylinder head retaining bolts (1).
20. Remove the right cylinder head (2) from the engine.

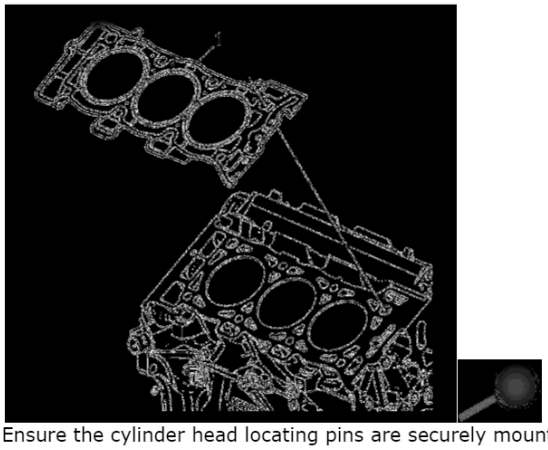


21. Remove and discard the cylinder head gasket (1).

cardiagn.com

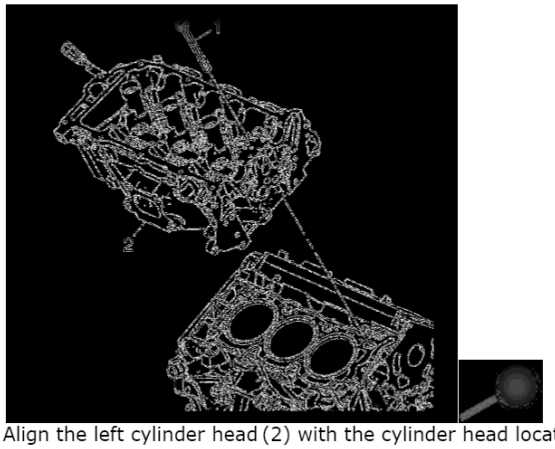
22. Clean and inspect the:
    - Cylinder head—Refer to Cylinder Head Cleaning and Inspection.
    - Cylinder block sealing surfaces—Refer to Engine Block Cleaning and Inspection.
    - Engine front cover sealing surface—Refer to Engine Front Cover Cleaning and Inspection.
23. Disassemble the cylinder head if required . Refer to Cylinder Head Disassemble.

Installation Procedure



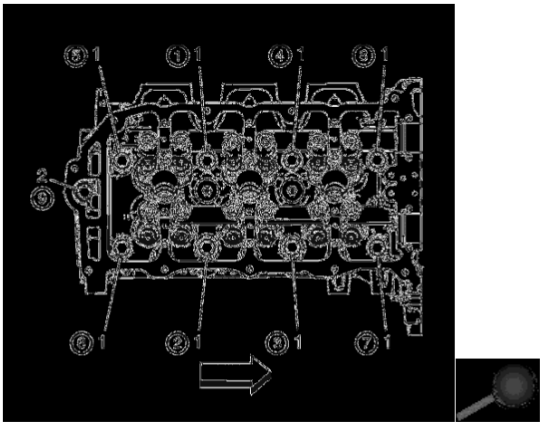
1. Ensure the cylinder head locating pins are securely mounted on the cylinder block face.

   Note: Use the cylinder head locating pins on the cylinder block face to retain the cylinder head gasket.
2. Install a NEW right cylinder head gasket (1).



3. Align the left cylinder head (2) with the cylinder head locating pins on the cylinder block face.
4. Position the left cylinder head to the cylinder block face.

cardiagn.com

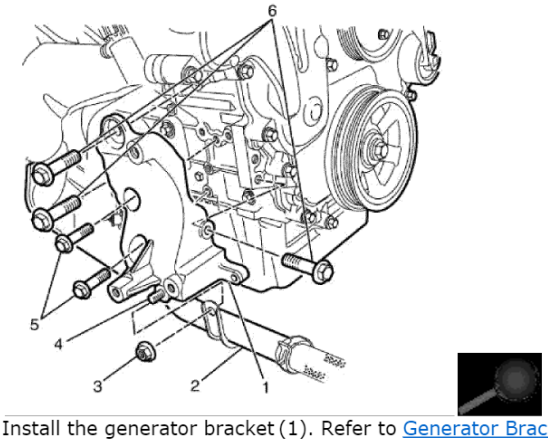


Caution: Refer to Fastener Caution.

Note:

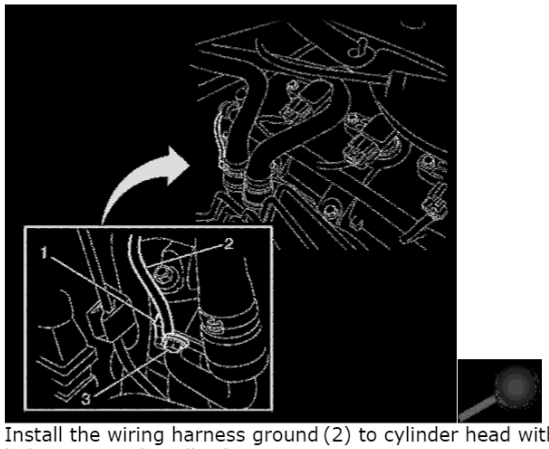
- Ensure the cylinder head bolts and cylinder head bolt holes are dry before installing the cylinder head bolts to the cylinder head.
- Tighten the cylinder head bolts in the sequence shown.

5. Install the NEW cylinder head bolts (1).
   5.1. Tighten the cylinder head bolts (1) at first pass to **30 N•m (22 lb ft)**.
   5.2. Tighten the cylinder head bolts (1) a final pass **150 degrees** using the *J 45059* angle meter.
6. Install a NEW cylinder head bolt (2).
   6.1. Tighten the cylinder head bolt (2) at first pass to **15 N•m (11 lb ft)**.
   6.2. Tighten the cylinder head bolt (2) a final pass **75 degrees** using the *J 45059* angle meter.
7. Install the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.

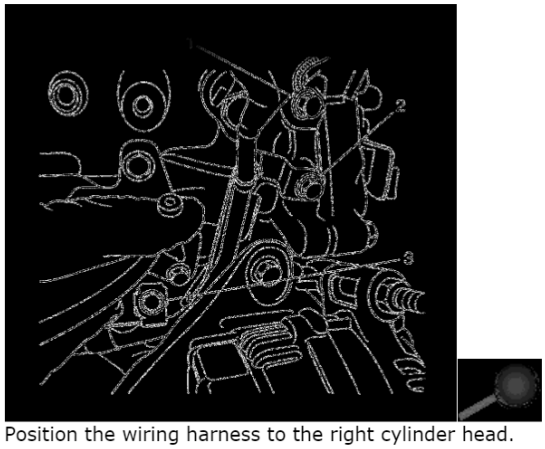


8. Install the generator bracket (1). Refer to Generator Bracket Replacement.
9. Install the engine front cover. Refer to Engine Front Cover Replacement.
10. Install the right and left camshaft covers. Refer to Camshaft Cover Replacement - Left Side and Camshaft Cover Replacement - Right Side.

cardiagn.com

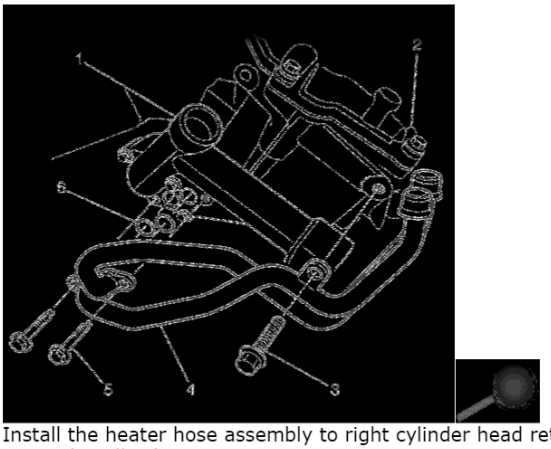


11. Install the wiring harness ground (2) to cylinder head with the retaining bolt (3). Tighten bolt to 12 N•m (106 lb in).

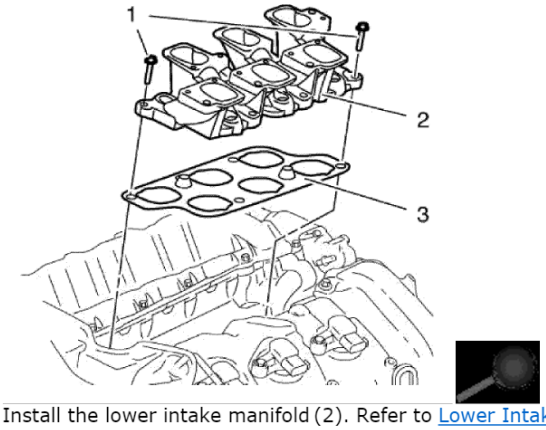


12. Position the wiring harness to the right cylinder head.
13. Install the wiring harness to cylinder head bolt (2) to the cylinder head. Tighten bolt to 12 N•m (106 lb in).
14. Install the engine wiring harness ground to right bank cylinder head retaining bolt (1). Tighten bolt to 12 N•m (106 lb in).

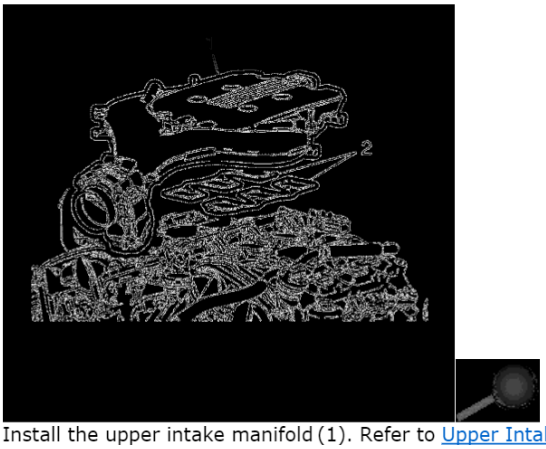
cardiagn.com



15. Install the heater hose assembly to right cylinder head retaining bolt (3). Tighten bolt to 12 N•m (106 lb in).



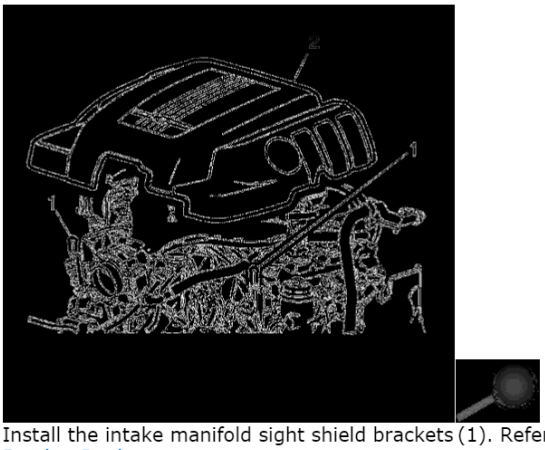
16. Install the lower intake manifold (2). Refer to Lower Intake Manifold Replacement.



17. Install the upper intake manifold (1). Refer to Upper Intake Manifold Replacement.

cardiagn.com

18. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
19. Refill the cooling system. Refer to Cooling System Draining and Filling.



20. Install the intake manifold sight shield brackets (1). Refer to Intake Manifold Sight Shield Bracket Replacement.
21. Install the intake manifold sight shield (2). Refer to Intake Manifold Sight Shield Replacement.
22. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Cylinder Head Replacement - Right Side (LFW)

Special Tools

J 45059 Angle Meter

Removal Procedure

Warning: Refer to Safety Glasses Warning.

Warning: Refer to Gasoline/Gasoline Vapors Warning.

Warning: Refer to Relieving Fuel Pressure Warning.

1. Relieve the high side fuel pressure. Refer to Fuel Pressure Relief.
2. Relieve the low side fuel pressure. Refer to Fuel Pressure Relief.

Warning: Refer to Safety Glasses Warning.

3. Ignition OFF.

Warning: Refer to Battery Disconnect Warning.

4. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
5. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
6. Remove the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.
7. Remove the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.

Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Under some conditions, the ethylene glycol engine coolant is combustible. In order to help avoid being burned, do not spill the antifreeze or the coolant on the exhaust system or the hot engine parts.

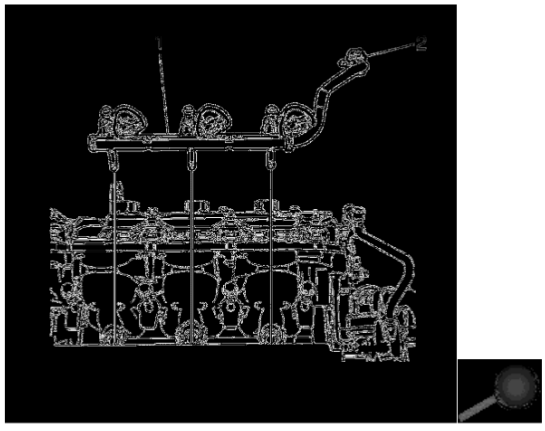
Warning: Dispose of the used engine coolant properly. Store the used coolant in a used coolant Holding Tank awaiting proper disposal or recycling. Do not pour used coolant down the drain. Ethylene glycol antifreeze is a very toxic chemical. Disposal into the sewer system or into the ground water is both environmentally irresponsible and illegal

Warning: Refer to Radiator Cap Removal Warning.

8. Drain the cooling system. Refer to Cooling System Draining and Filling.
9. Remove the intake manifold. Refer to Intake Manifold Removal.
10. Remove the intermediate fuel feed pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
11. Remove the fuel pump. Refer to Fuel Pump Replacement.
12. Remove the fuel feed pipe. Refer to Fuel Feed Pipe Replacement.

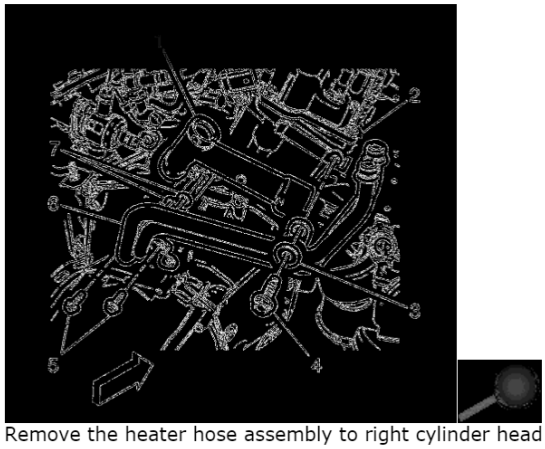
cardiagn.com

© 2014 General Motors. All rights reserved.



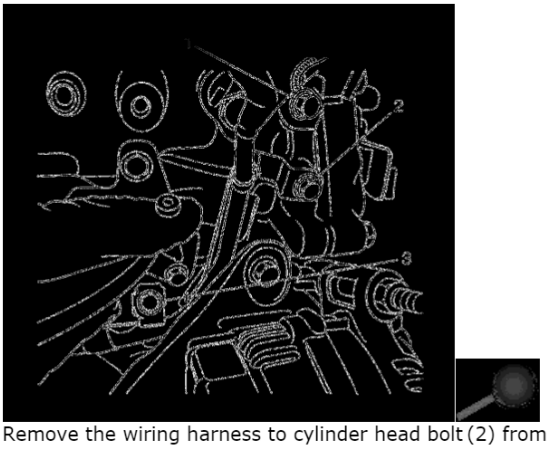
Note: Do not remove the right bank fuel injector harness (1) from the fuel injectors.

13. Disconnect the right bank fuel injector harness connector (2) from the engine harness.
14. Remove the right camshaft cover. Refer to Camshaft Cover Replacement - Right Side.
15. Remove the right bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Right Side.

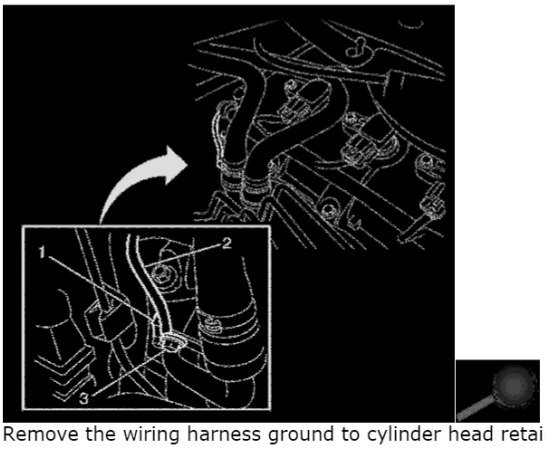


16. Remove the heater hose assembly to right cylinder head retaining bolt (4) and washer (3).

cardiagn.com

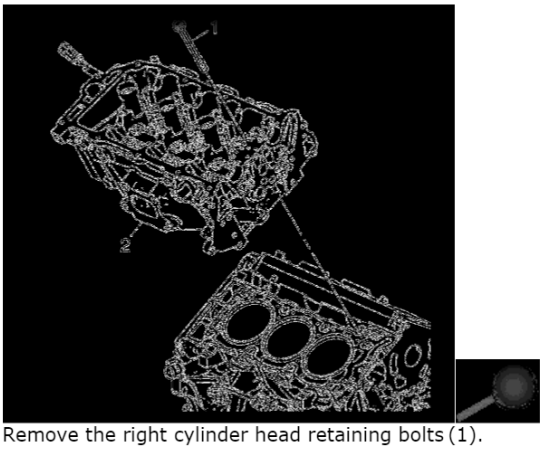


17. Remove the wiring harness to cylinder head bolt (2) from the cylinder head.
18. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
19. Reposition the wiring harness away from the right cylinder head.

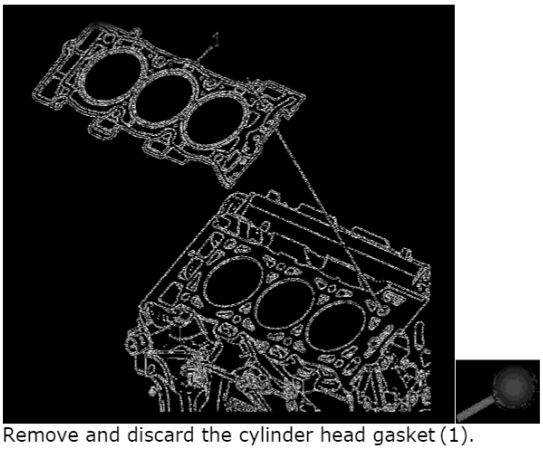


20. Remove the wiring harness ground to cylinder head retaining bolts (3).
21. Remove the catalytic converter. Refer to Catalytic Converter Replacement - Left Side.
22. Remove the generator bracket. Refer to Generator Bracket Replacement.

cardiagn.com



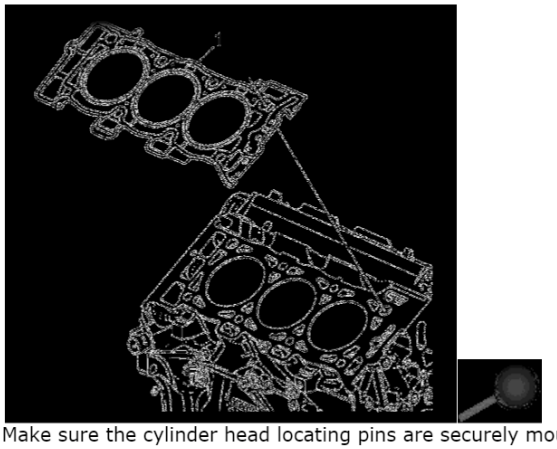
23. Remove the right cylinder head retaining bolts (1).
24. Remove the right cylinder head (2) from the engine.



25. Remove and discard the cylinder head gasket (1).
26. Clean and inspect the:
    - Cylinder head—Refer to Cylinder Head Cleaning and Inspection.
    - Cylinder block sealing surfaces—Refer to Engine Block Cleaning and Inspection.
    - Engine front cover sealing surface—Refer to Engine Front Cover Cleaning and Inspection.
27. Disassemble the cylinder head if required . Refer to Cylinder Head Disassemble.

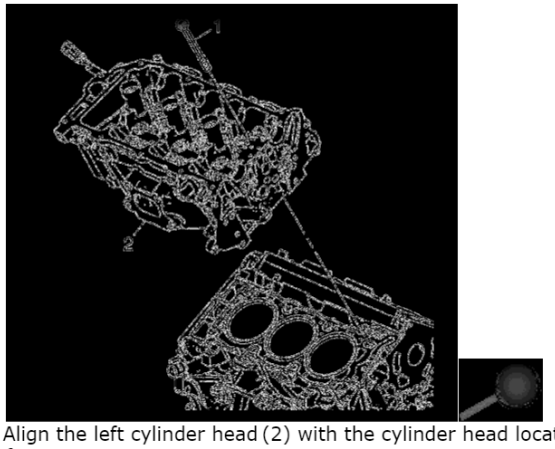
Installation Procedure

cardiagn.com



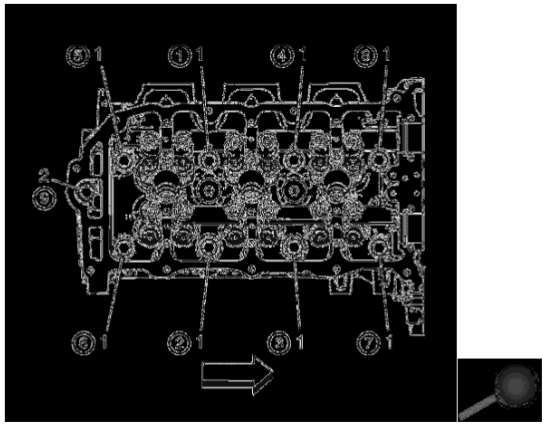
1. Make sure the cylinder head locating pins are securely mounted on the cylinder block face.

   Note: Use the cylinder head locating pins on the cylinder block face to retain the cylinder head gasket.
2. Install a NEW right cylinder head gasket (1).



3. Align the left cylinder head (2) with the cylinder head locating pins on the cylinder block face.
4. Position the left cylinder head to the cylinder block face.

cardiagn.com

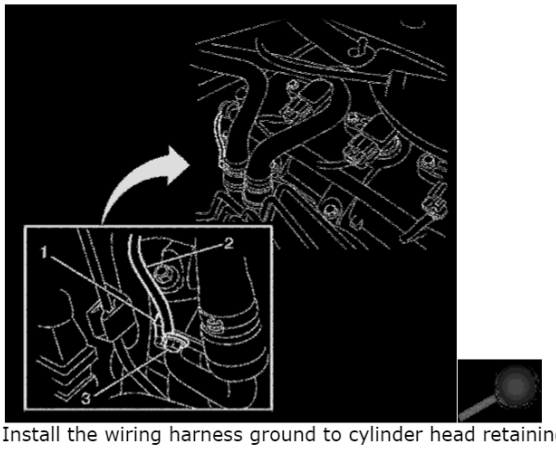


Caution: Refer to Fastener Caution.

Note:

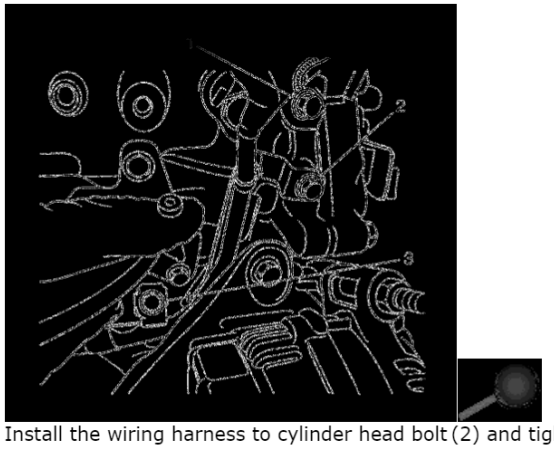
- Make sure the cylinder head bolts and cylinder head bolt holes are dry before installing the cylinder head bolts to the cylinder head.
- Tighten the cylinder head bolts in the sequence shown.

5. Install the NEW cylinder head bolts (1).
   5.1. Tighten the cylinder head bolts (1) at first pass to **30 N•m (22 lb ft)**.
   5.2. Tighten the cylinder head bolts (1) a second pass **150 degrees** using the *J 45059* angle meter.
6. Install a NEW cylinder head bolt (2).
   6.1. Tighten the cylinder head bolt (2) at first pass to **15 N•m (11 lb ft)**.
   6.2. Tighten the cylinder head bolt (2) a second pass **75 degrees** using the *J 45059* angle meter.
7. Install the generator bracket. Refer to Generator Bracket Replacement.
8. Install the catalytic converter. Refer to Catalytic Converter Replacement - Left Side.

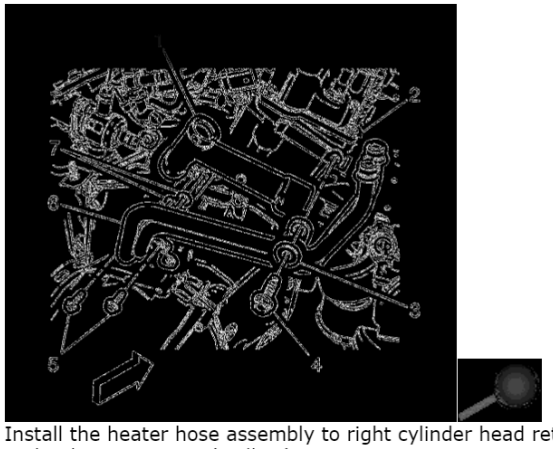


9. Install the wiring harness ground to cylinder head retaining bolts (3).
10. Position the wiring harness on the right cylinder head.

cardiagn.com

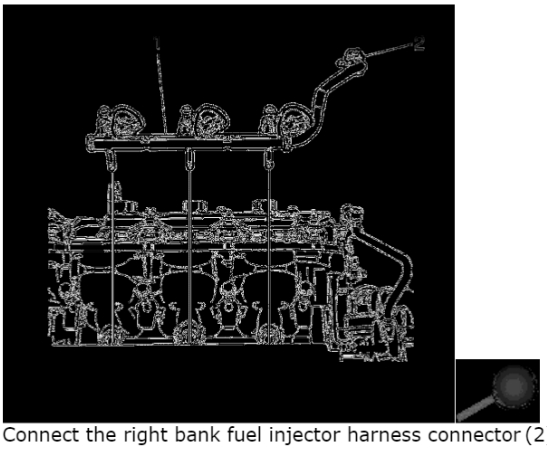


11. Install the wiring harness to cylinder head bolt (2) and tighten to 10 N•m (89 lb in).



12. Install the heater hose assembly to right cylinder head retaining bolt (4) and washer (3) and tighten to 10 N•m (89 lb in).
13. Install the left bank secondary timing chain. Refer to Secondary Camshaft Intermediate Drive Chain Replacement - Left Side.
14. Install the camshaft cover. Refer to Camshaft Cover Replacement - Left Side.
15. Install the intermediate fuel feed pipe. Refer to Fuel Feed Intermediate Pipe Replacement.
16. Install the fuel pump. Refer to Fuel Pump Replacement.
17. Install the fuel feed pipe. Refer to Fuel Feed Pipe Replacement.

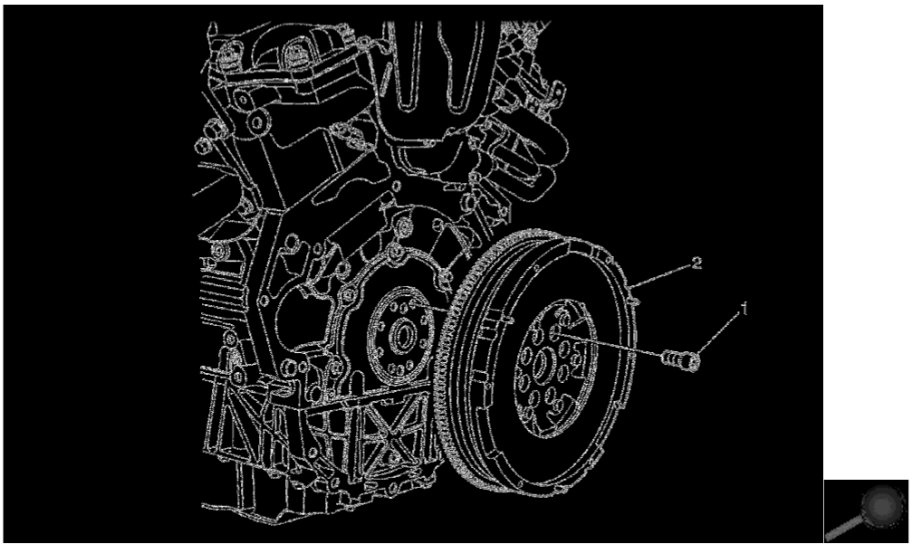
cardiagn.com



18. Connect the right bank fuel injector harness connector (2) to the engine harness.
19. Install the intake manifold. Refer to Intake Manifold Removal.
20. Install the air inlet grille panel. Refer to Air Inlet Grille Panel Replacement.
21. Refill the cooling system. Refer to Cooling System Draining and Filling.
22. Install the intake manifold sight shield brackets. Refer to Intake Manifold Sight Shield Bracket Replacement.
23. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
24. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Engine Flywheel Replacement



Engine Flywheel Replacement

Callout	Component Name
Preliminary Procedure Remove the clutch assembly. Refer to Clutch Assembly Replacement.	
1	Flywheel Fastener (Qty: 8) **Caution:** Refer to Fastener Caution. **Procedure** New bolts must be used whenever removing the flywheel. **Tighten** 67 N•m (49 lb ft)
2	Flywheel **Procedure** Transfer parts as needed.

cardiagn.com

© 2014 General Motors. All rights reserved.

Automatic Transmission Flex Plate Replacement

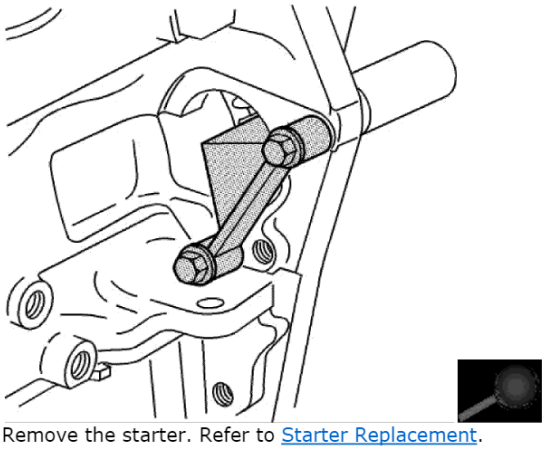
Special Tools

EN-46106 Flywheel Holding Tool

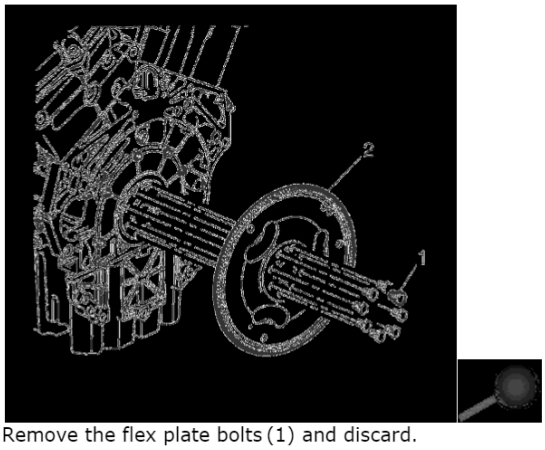
For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Remove the transmission. Refer to Transmission Replacement.



2. Remove the starter. Refer to Starter Replacement.
3. Install the *EN 46106* Holding Tool through the starter mounting hole.

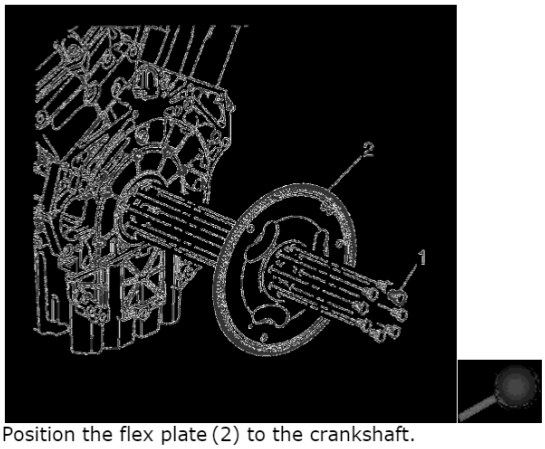


4. Remove the flex plate bolts (1) and discard.
5. Remove the flex plate (2).
6. Clean and inspect the flex plate. Refer to Engine Flywheel Cleaning and Inspection. If the flex plate teeth are damaged, inspect the starter for proper operation. Replace the starter if you find excessive wear or damage to the starter drive. Refer to Starter Replacement.

© 2014 General Motors. All rights reserved.

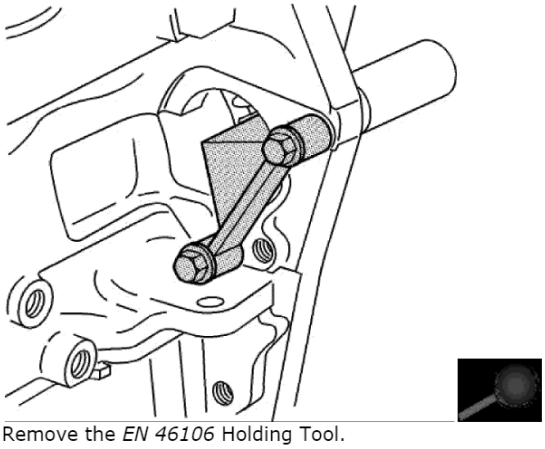
cardiagn.com

Installation Procedure



1. Position the flex plate (2) to the crankshaft.

   Caution: Refer to Fastener Caution.
2. Install NEW flex plate bolts (1) and tighten to **30 N•m (22 lb ft)** plus and additional 45 degrees.



3. Remove the *EN 46106* Holding Tool.
4. Install the starter. Refer to Starter Replacement.
5. Install the transmission. Refer to Transmission Replacement.

cardiagn.com

Crankshaft Rear Oil Seal and Housing Replacement

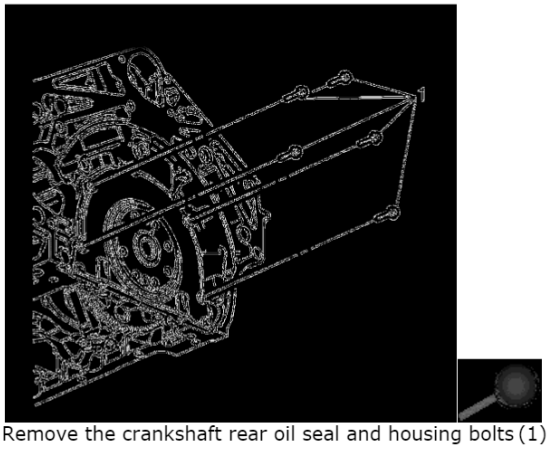
Special Tools

- *EN-42183* Handle
- *EN-46109* Guide Pin Set
- *EN-47839* Crankshaft Rear Oil Seal Installation Tool

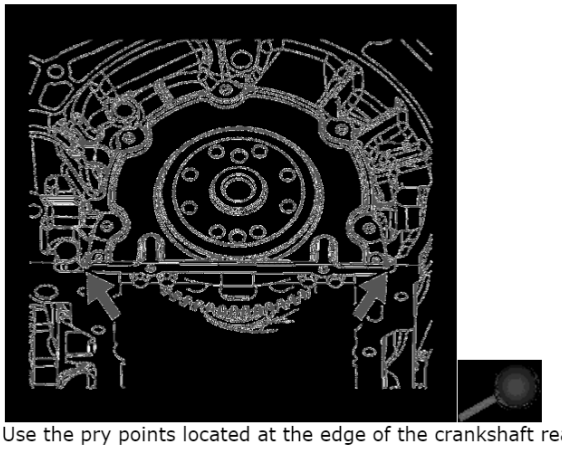
For equivalent regional tools, refer to Special Tools.

Removal Procedure

1. Remove the flex plate. Refer to Automatic Transmission Flex Plate Replacement.
2. Remove the oil pan. Refer to Oil Pan Replacement.



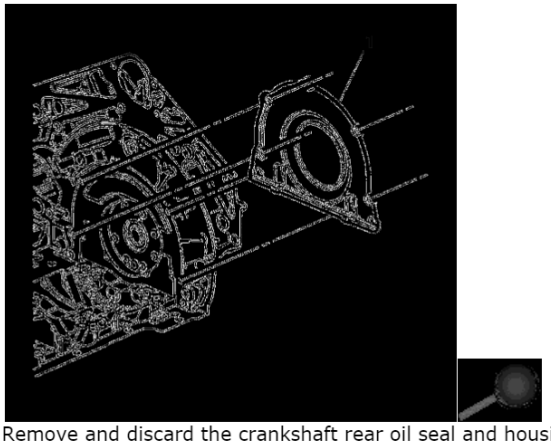
3. Remove the crankshaft rear oil seal and housing bolts (1).



4. Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant.

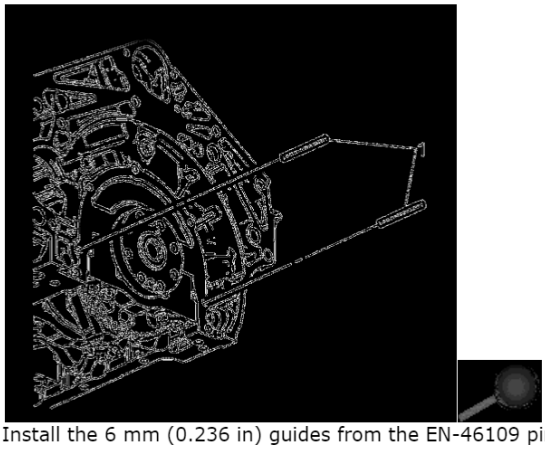
cardiagn.com

© 2014 General Motors. All rights reserved.

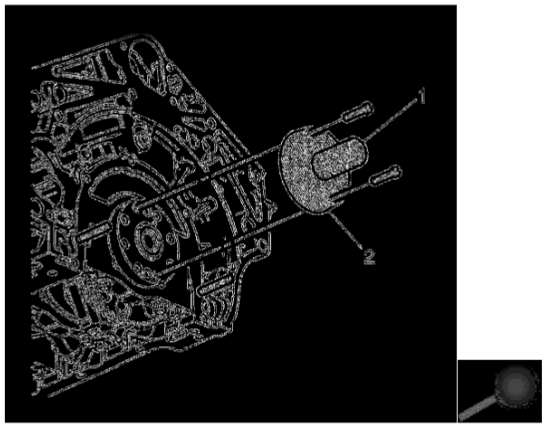


5. Remove and discard the crankshaft rear oil seal and housing (1). Refer to Crankshaft Rear Oil Seal and Housing Removal.

Installation Procedure

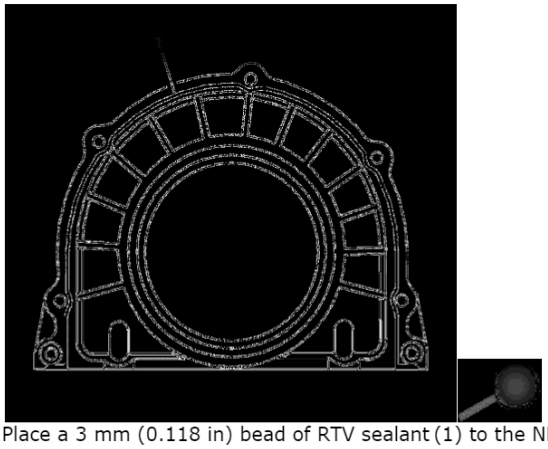


1. Install the 6 mm (0.236 in) guides from the EN-46109 pin set into the 2 crankshaft rear oil seal housing corner bolt holes of the engine block.

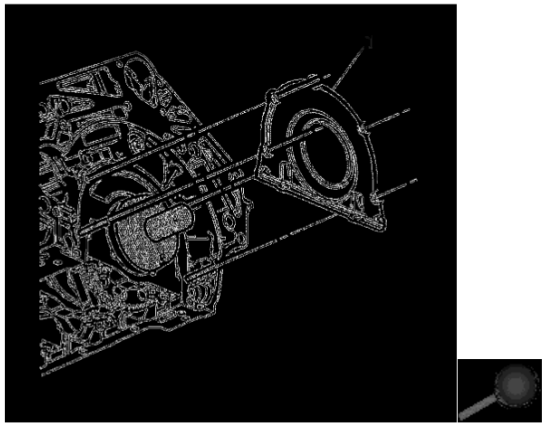


cardiagn.com

2. Install the EN-47839 tool with the EN-42183 handle (1, 2) onto the rear of the crankshaft flange.



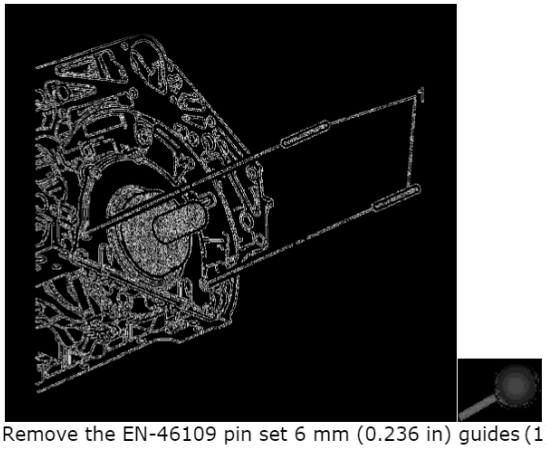
3. Place a 3 mm (0.118 in) bead of RTV sealant (1) to the NEW crankshaft rear oil seal housing as shown (1). Refer to Adhesives, Fluids, Lubricants, and Sealers, for recommended sealant.



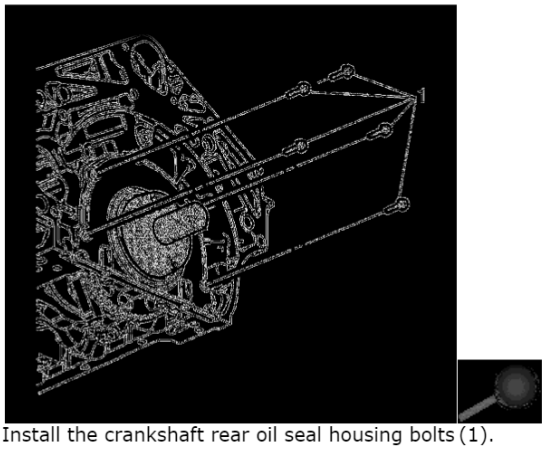
Note: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

4. Install the crankshaft rear oil seal housing (1) to the engine block.

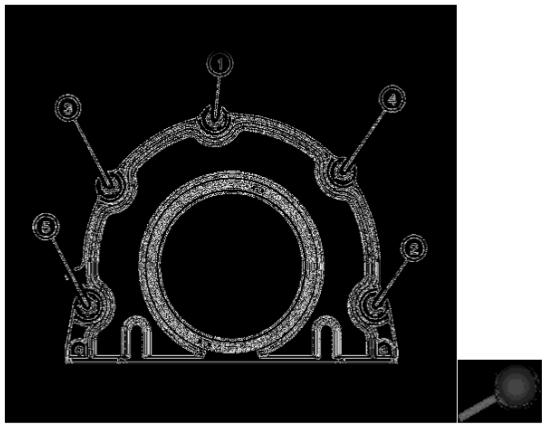
cardiagn.com



5. Remove the EN-46109 pin set 6 mm (0.236 in) guides (1) from the engine block.



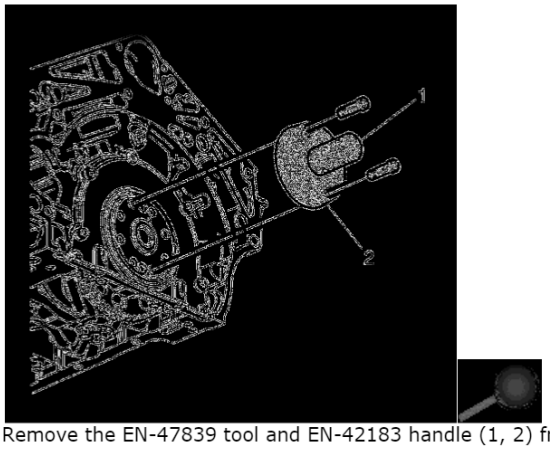
6. Install the crankshaft rear oil seal housing bolts (1).



Caution: Refer to Fastener Caution.

7. Tighten the crankshaft rear oil seal housing bolts in sequence and tighten to **10 N·m (89 lb in)**.

cardiagn.com



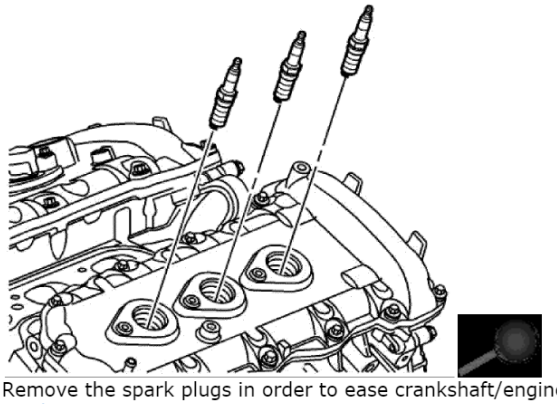
8. Remove the EN-47839 tool and EN-42183 handle (1, 2) from the crankshaft flange.
9. Install the oil pan. Refer to Oil Pan Replacement.
10. Install the flex plate. Refer to Automatic Transmission Flex Plate Replacement.

cardiagn.com

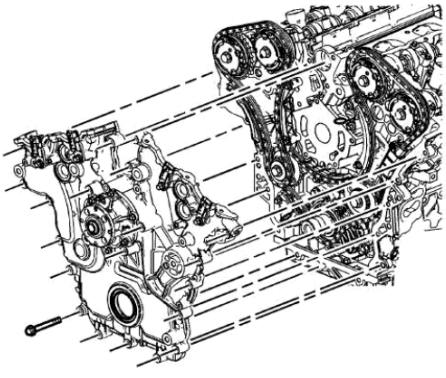
Oil Pump Replacement

Removal Procedure

1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



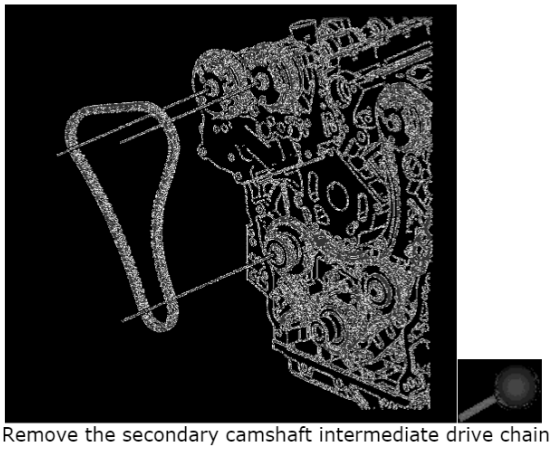
2. Remove the spark plugs in order to ease crankshaft/engine rotation. Refer to Spark Plug Replacement.



3. Remove the engine front cover. Refer to Engine Front Cover Replacement.

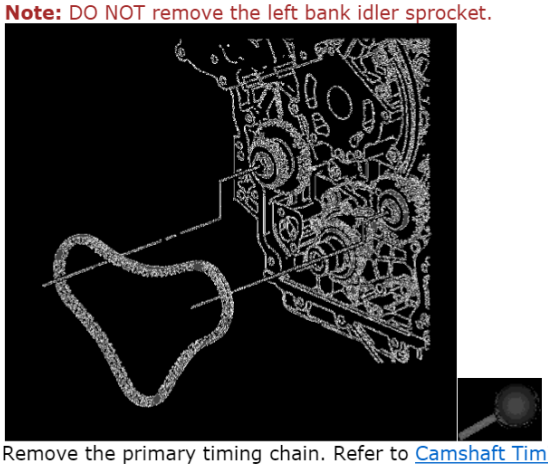
cardiagn.com

© 2014 General Motors. All rights reserved.

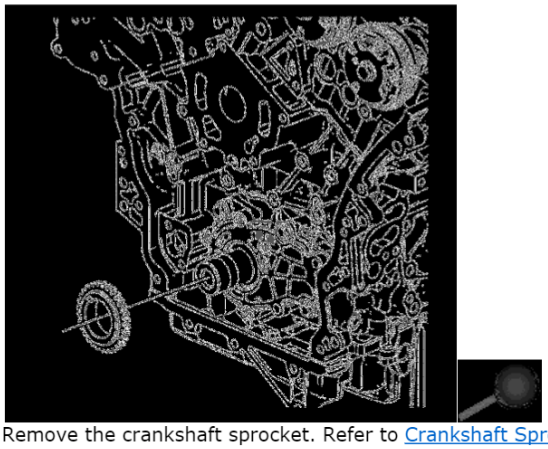


4. Remove the secondary camshaft intermediate drive chain removal - right side. Refer to Camshaft Timing Chain Components Removal.

   Note: DO NOT remove the left bank idler sprocket.



5. Remove the primary timing chain. Refer to Camshaft Timing Chain Components Removal.



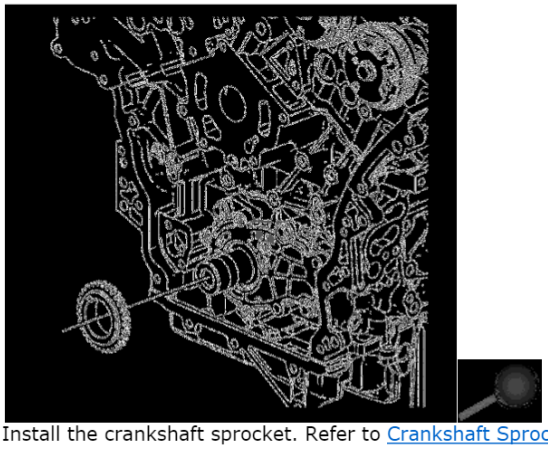
6. Remove the crankshaft sprocket. Refer to Crankshaft Sprocket Removal.

cardiagn.com

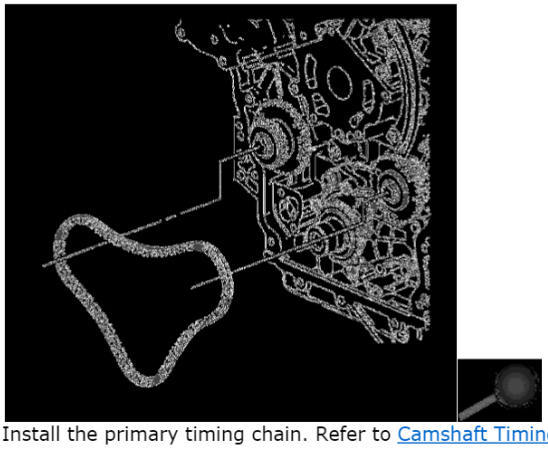
7. Remove the oil pump bolts and the oil pump. Refer to Oil Pump Removal.
8. Perform the following steps as necessary:
   - Disassemble the oil pump. Refer to Oil Pump Disassemble.
   - Clean and inspect the oil pump. Refer to Oil Pump Disassemble.

Installation Procedure

1. Assemble the oil pump as necessary. Refer to Oil Pump Assemble.
2. Install the oil pump. Refer to Oil Pump Installation.

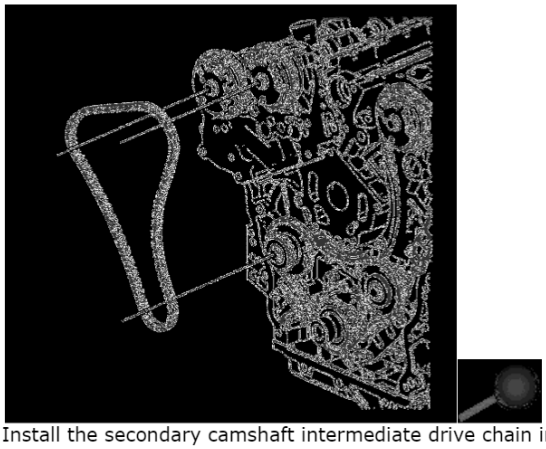


3. Install the crankshaft sprocket. Refer to Crankshaft Sprocket Installation.

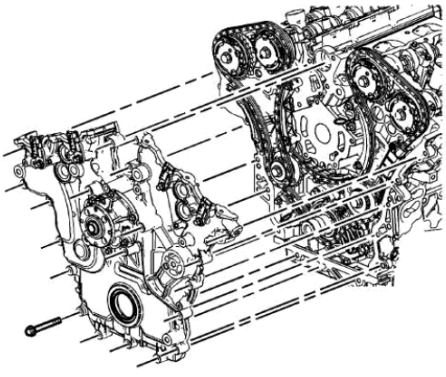


4. Install the primary timing chain. Refer to Camshaft Timing Chain Components Installation.

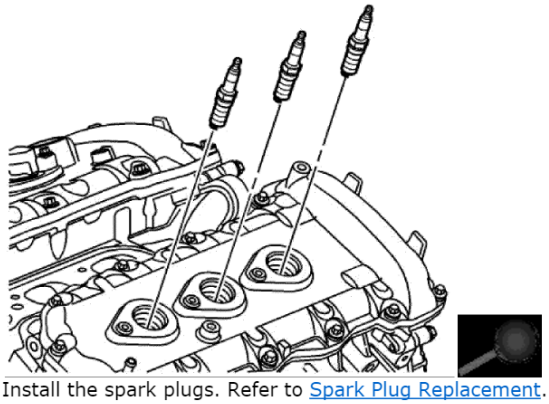
cardiagn.com



5. Install the secondary camshaft intermediate drive chain installation - right side. Refer to Camshaft Timing Chain Components Installation.



6. Install the engine front cover. Refer to Engine Front Cover Replacement.



7. Install the spark plugs. Refer to Spark Plug Replacement.

cardiagn.com

8. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

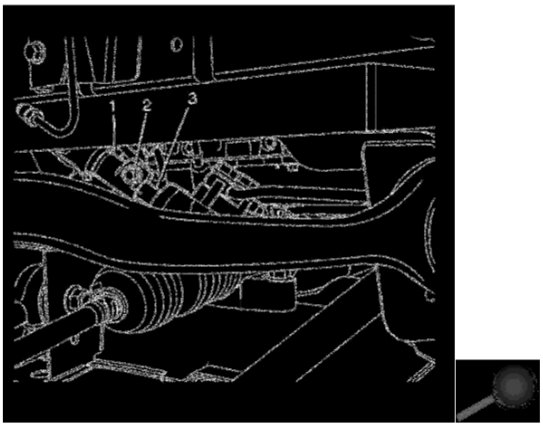
cardiagn.com

Oil Pan Replacement

Removal Procedure

Warning: Refer to Battery Disconnect Warning.

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the oil level indicator. Refer to Engine Mount Replacement - Left Side.
3. Remove the left side engine mount. Refer to Engine Mount Replacement - Left Side.
4. Remove the crankshaft balancer. Refer to Crankshaft Balancer Replacement.
5. Drain the engine oil. Refer to Engine Oil and Oil Filter Replacement.

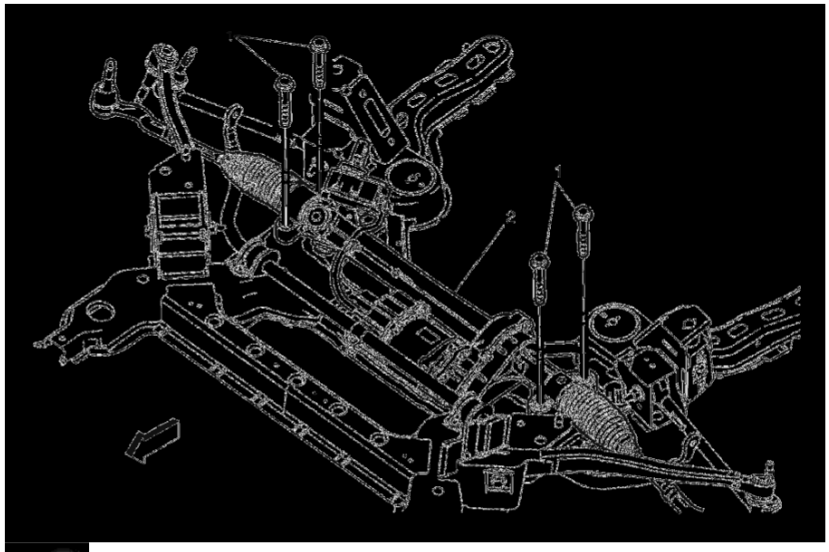


Note: Observing the orientation of the intermediate steering shaft (1) with reference to the pinion shaft (3) will minimize the potential of incorrect steering column assembly alignment.

6. Mark the intermediate steering shaft (1) in relation to the pinion shaft (3).
7. Remove the intermediate steering shaft to pinion shaft retaining bolt (2).
8. Remove the intermediate steering shaft (1) from the pinion shaft (3).

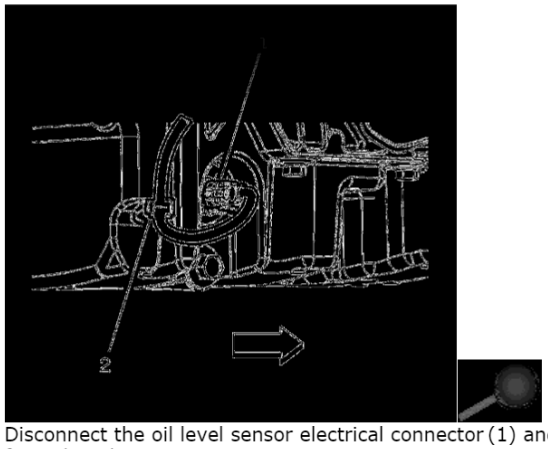
cardiagn.com

© 2014 General Motors. All rights reserved.



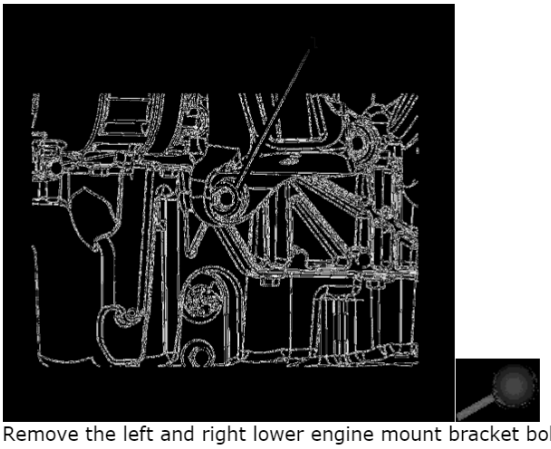
Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

9. Remove the steering gear to subframe retaining bolts (1). Discard the bolts.
10. Reposition the steering gear away from the engine oil pan.

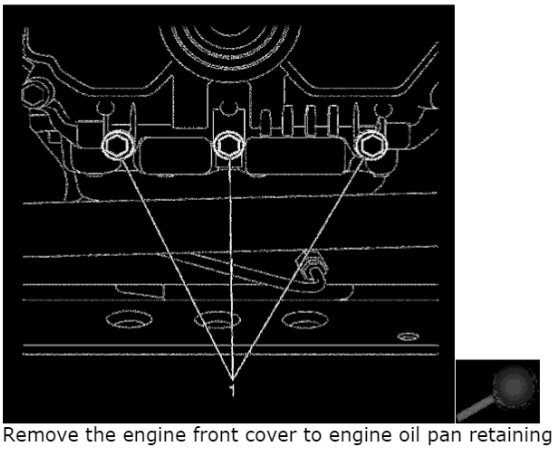


11. Disconnect the oil level sensor electrical connector (1) and detach harness retainer (2) from the oil pan.

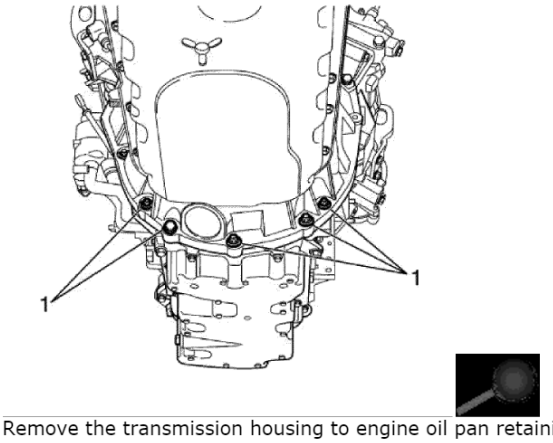
cardiagn.com



12. Remove the left and right lower engine mount bracket bolts (1).

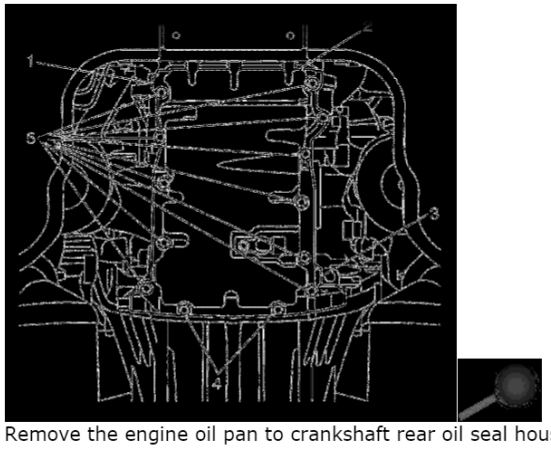


13. Remove the engine front cover to engine oil pan retaining bolts (1).



14. Remove the transmission housing to engine oil pan retaining bolts (1).

cardiagn.com

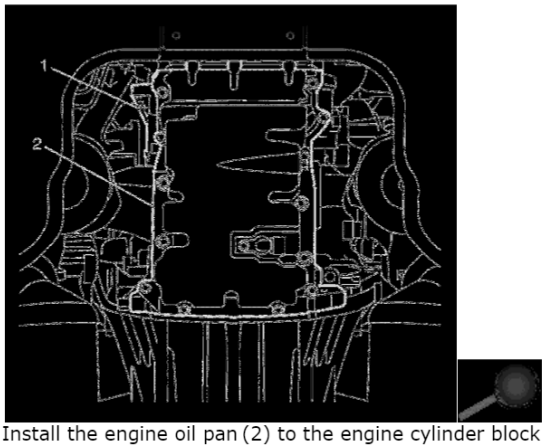


15. Remove the engine oil pan to crankshaft rear oil seal housing retaining bolts (4).
16. Remove the engine oil pan to cylinder block retaining bolts (5).

    Note: Use the pry points (1 and 3) to pry the engine oil pan from the cylinder block.
17. Remove the engine oil pan (2) from the cylinder block.
18. Perform the following steps as necessary.
    - Disassemble the engine oil pan. Refer to Oil Pan Disassemble.
    - Clean and inspect the engine oil pan. Refer to Oil Pan Cleaning and Inspection.

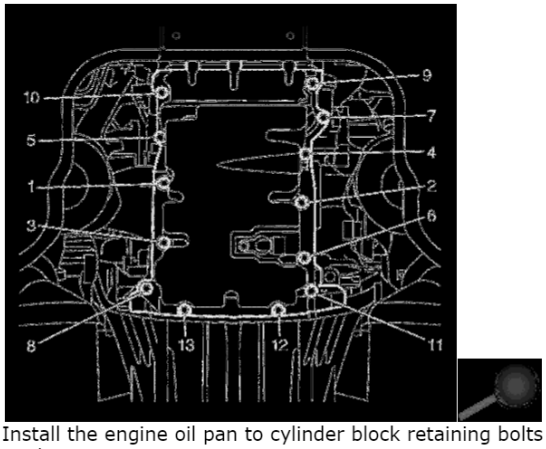
Installation Procedure

1. Assemble the engine oil pan as necessary. Refer to Oil Pan Assemble.
2. Place a 3 mm (0.118 in) bead of GM approved sealant (1) on the oil pan to cylinder block and oil pan to front cover mating surface..



3. Install the engine oil pan (2) to the engine cylinder block (1).

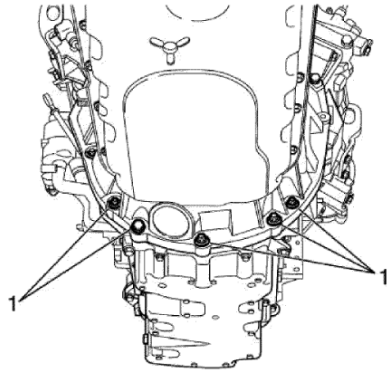
cardiagn.com



4. Install the engine oil pan to cylinder block retaining bolts (1 to 11). Do not tighten the bolts at this stage.

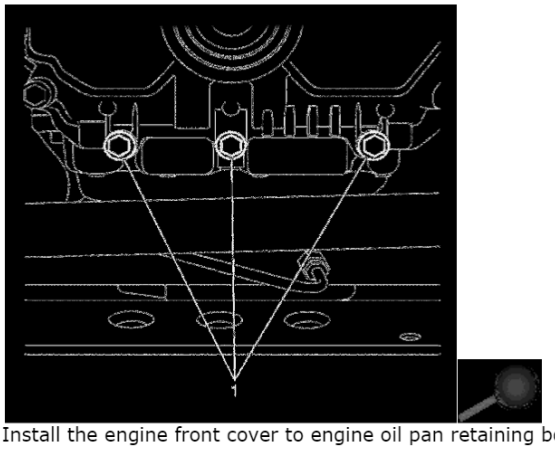
   Note: Tighten the bolts in the sequence shown.

   Caution: Refer to Fastener Caution.
5. Install the engine oil pan retaining bolts (1 to 11) and tighten to 22 N•m (16 lb ft).
6. Install the engine oil pan to crankshaft rear oil seal housing retaining bolts (12 and 13) and tighten to 9 N•m (80 lb in).

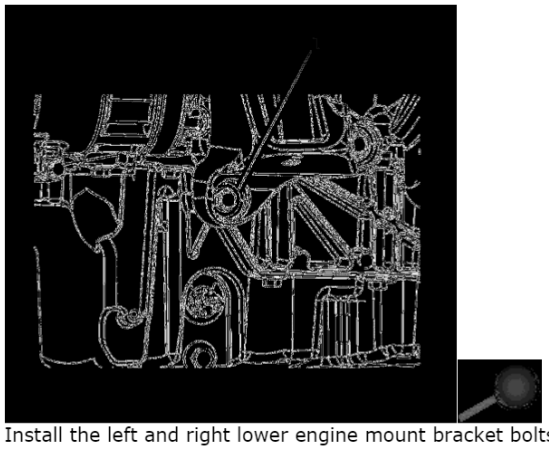


7. Install the transmission housing to engine oil pan retaining bolts (1) and tighten to 48 N•m (35 lb ft).

cardiagn.com

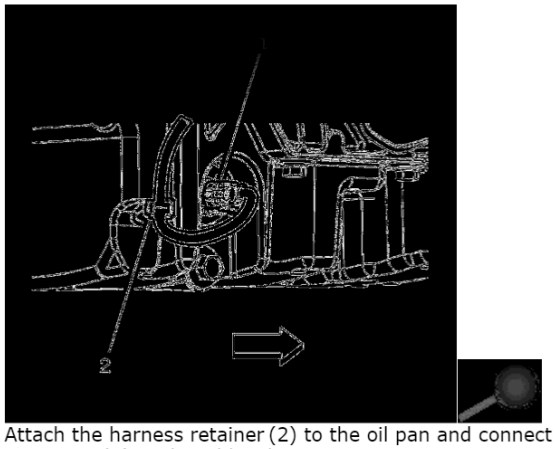


8. Install the engine front cover to engine oil pan retaining bolts (1) and tighten to 20 N•m (15 lb ft) + 60 degrees.
9. Install the crankshaft balancer. Refer to Crankshaft Balancer Replacement.

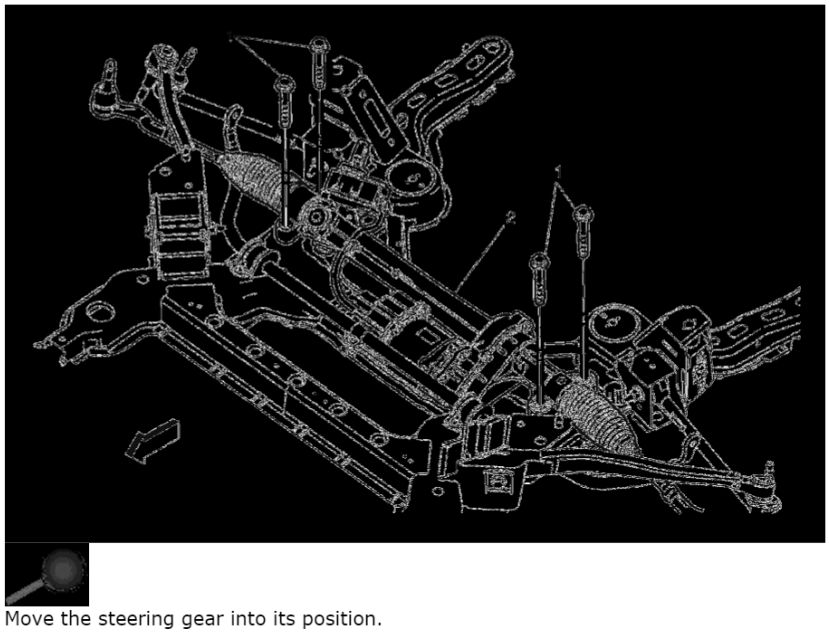


10. Install the left and right lower engine mount bracket bolts (1) and tighten to 58 N•m (43 lb ft).

cardiagn.com

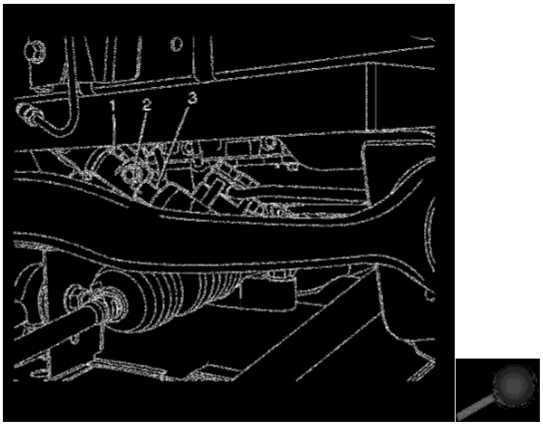


11. Attach the harness retainer (2) to the oil pan and connect the oil level sensor electrical connector (1) to the oil level sensor.



12. Move the steering gear into its position.
13. Install the NEW steering gear to subframe retaining bolts (1).
    13.1. First pass tighten to 50 N•m (37 lb ft).
    13.2. Final pass tighten an additional 120 degrees

cardiagn.com

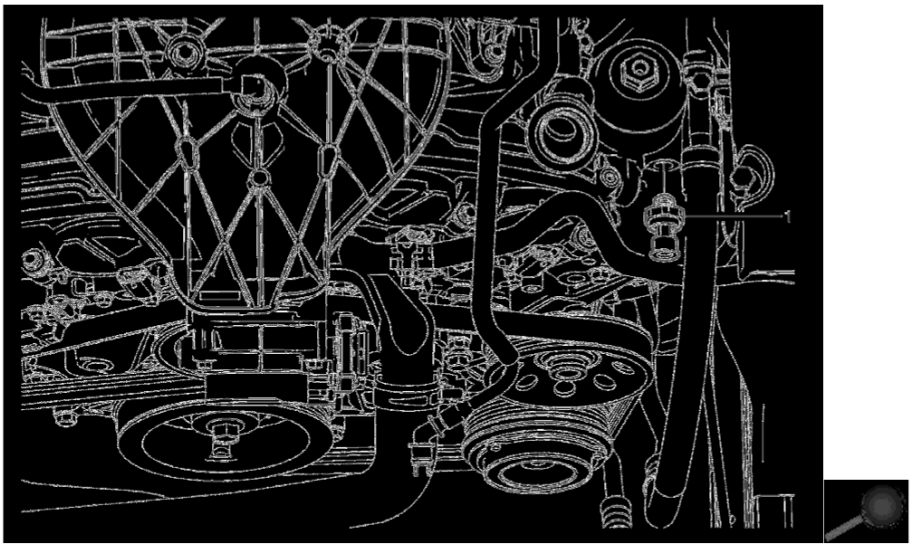


Note: Make sure that the intermediate steering shaft and pinion shaft are installed in the same position as it was before it was removed.

14. Align the mark made during the removal procedure and install the intermediate steering shaft (1) to the pinion shaft (3).
15. Install the NEW intermediate steering shaft to pinion shaft retaining bolt (2) and tighten to 25 N•m (18 lb ft).
16. Install the oil pan shield. Refer to Oil Pan Shield Replacement.
17. Install the front bumper fascia extension. Refer to Front Bumper Fascia Extension Replacement.
18. Lower the vehicle to the ground
19. Fill the engine with engine oil. Refer to Engine Oil and Oil Filter Replacement.
20. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

cardiagn.com

Engine Oil Pressure Sensor and/or Switch Replacement



Engine Oil Pressure Sensor and/or Switch Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement	
1	Engine Oil pressure Sensor and / or Switch **Caution:** Refer to Component Fastener Tightening Caution. **Procedure** Disconnect electrical connector. **Tighten** 20 N•m (15 lb ft)

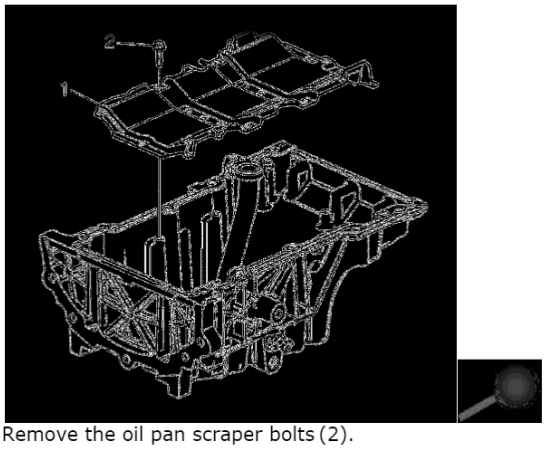
cardiagn.com

© 2014 General Motors. All rights reserved.

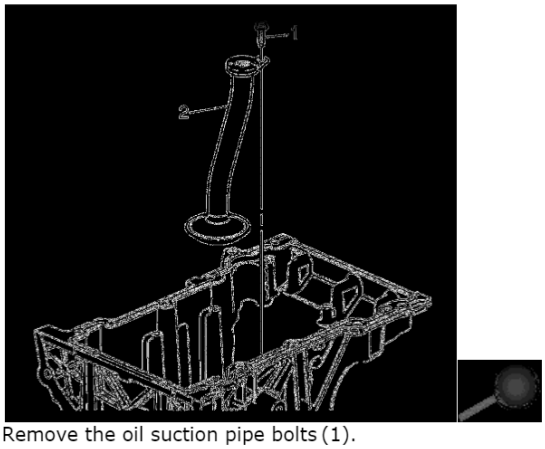
Engine Oil Level Sensor and/or Switch Replacement

Removal Procedure

1. Remove the oil pan. Refer to Oil Pan Replacement.



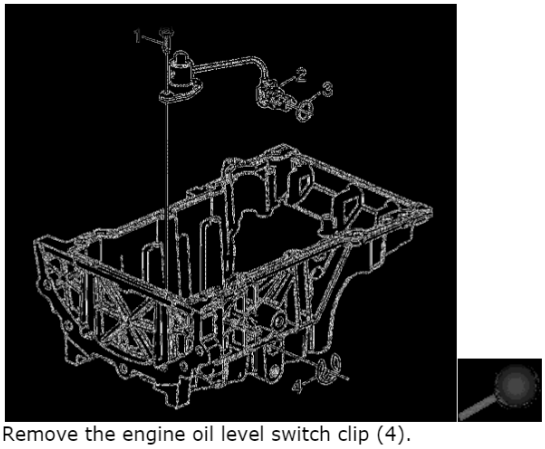
2. Remove the oil pan scraper bolts (2).
3. Remove the oil pan scraper (1).



4. Remove the oil suction pipe bolts (1).
5. Remove the oil suction pipe (2).

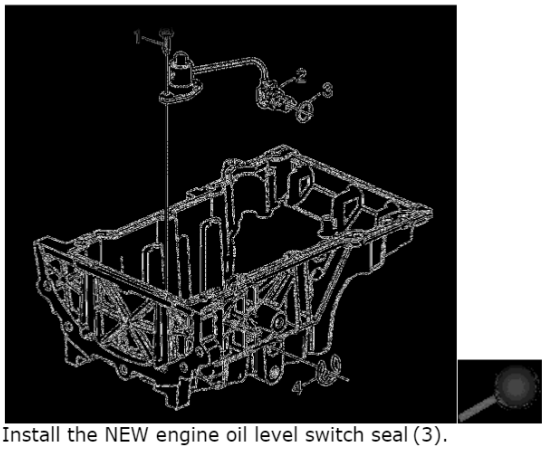
cardiagn.com

© 2014 General Motors. All rights reserved.



6. Remove the engine oil level switch clip (4).
7. Remove the engine oil level switch bolts (1).
8. Remove the engine oil level switch (2).
9. Remove and discard the engine oil level switch seal (3).

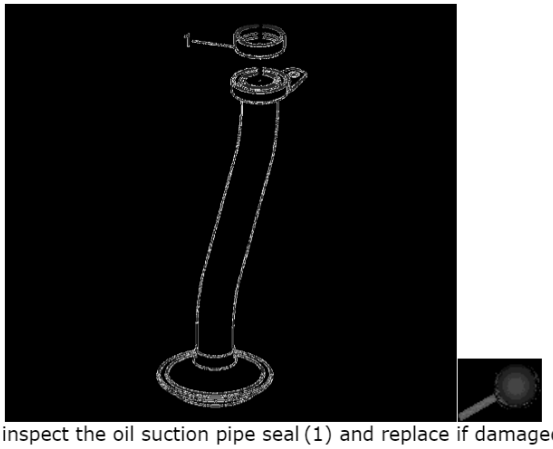
Installation Procedure



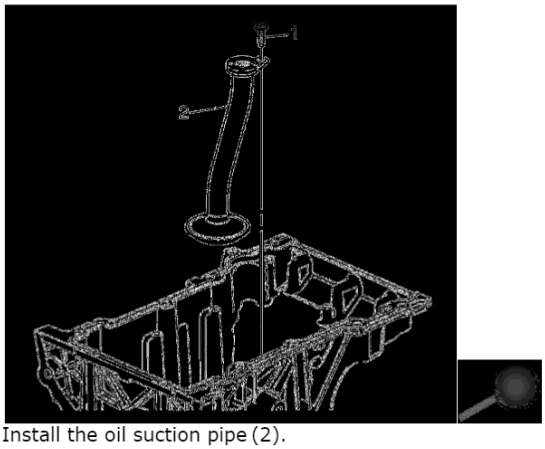
1. Install the NEW engine oil level switch seal (3).
2. Install the engine oil level switch (2).

   Caution: Refer to Fastener Caution.
3. Install the engine oil level switch bolts (1) and tighten to **10 N·m (89 lb in)**.
4. Install NEW engine oil level switch clip (4).

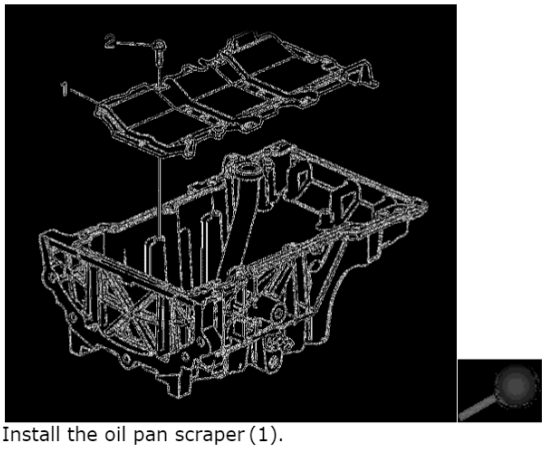
cardiagn.com



5. inspect the oil suction pipe seal (1) and replace if damaged.



6. Install the oil suction pipe (2).
7. Install the oil suction pipe bolts (1) and tighten to **10 N•m (89 lb in)**.



8. Install the oil pan scraper (1).
9. Install the oil pan scraper bolts (2) and tighten to **10 N•m (89 lb in)**.

cardiagn.com

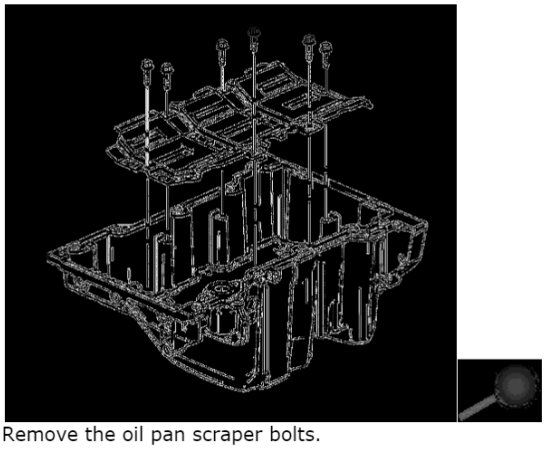
10. Install the oil pan. Refer to Oil Pan Replacement.

cardiagn.com

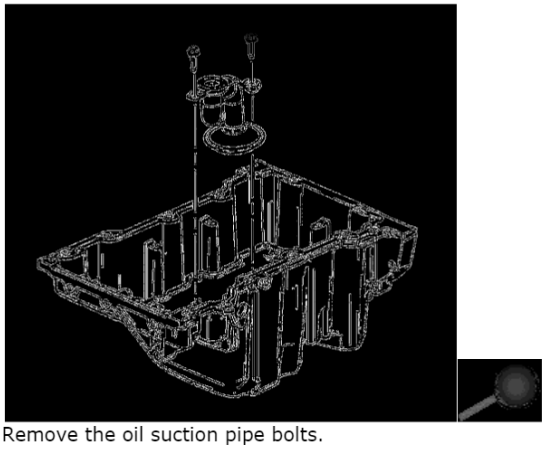
Oil Pump Suction Pipe and Screen Assembly Replacement

Removal Procedure

1. Remove the oil pan. Refer to Oil Pan Replacement.



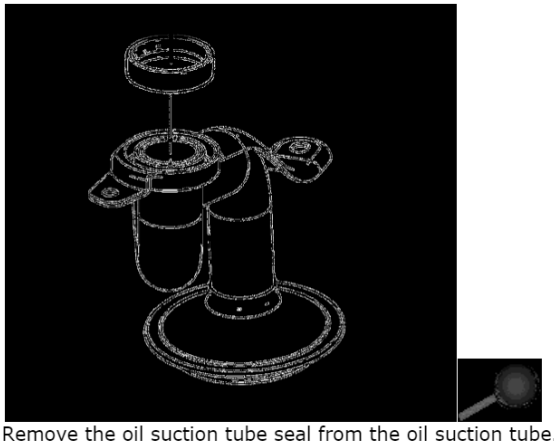
2. Remove the oil pan scraper bolts.
3. Remove the oil pan scraper.



4. Remove the oil suction pipe bolts.
5. Remove the oil suction pipe.

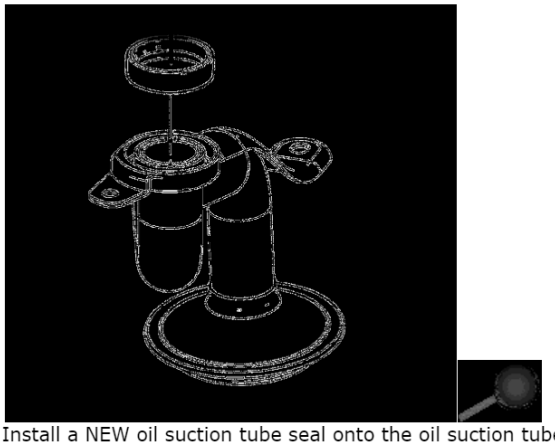
cardiagn.com

© 2014 General Motors. All rights reserved.

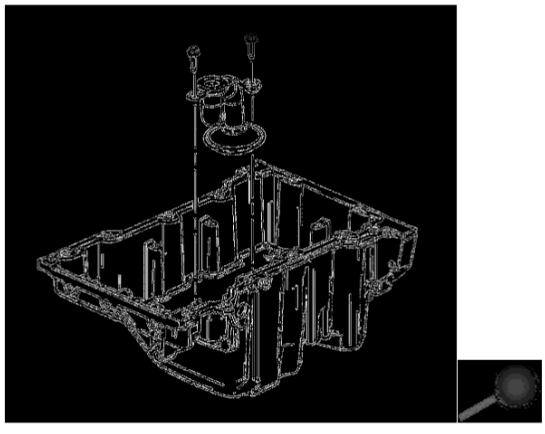


6. Remove the oil suction tube seal from the oil suction tube. Discard the oil suction tube seal.

Installation Procedure



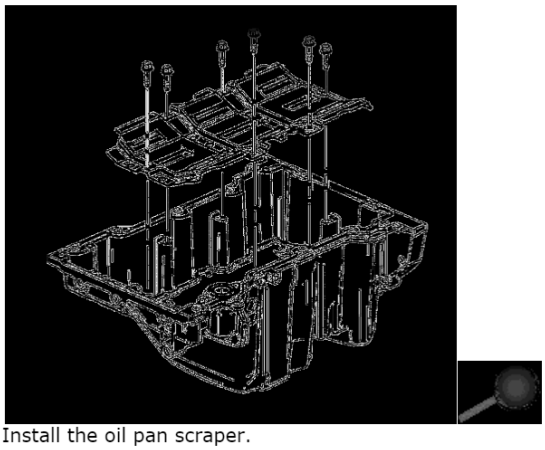
1. Install a NEW oil suction tube seal onto the oil suction tube. DO NOT reuse the old oil suction tube seal.



cardiagn.com

2. Install the oil suction pipe.

   Caution: Refer to Fastener Caution.
3. Install the oil suction pipe bolts and tighten to **10 N•m (89 lb in)**.



4. Install the oil pan scraper.
5. Install the oil pan scraper bolts and tighten to **10 N•m (89 lb in)**.
6. Install the oil pan. Refer to Oil Pan Replacement.

cardiagn.com

Engine Replacement

Special Tools

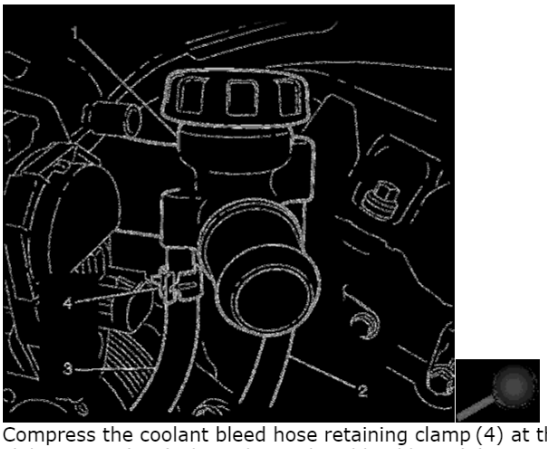
- *EN 46114* Engine Lift Brackets
- *J 39400-A* Halogen Leak Detector
- *J 41623-B* Cooler Quick Connect Tool

Removal Procedure

Note: The front wheels of the vehicle must be maintained in the straight ahead position and the steering column must be in the LOCK position before disconnecting the steering column or intermediate shaft. Failure to follow these procedures will cause incorrect alignment of some components during installation and result in damage to the SIR coil assembly.

1. Relieve the fuel pressure. Refer to Fuel Pressure Relief.
2. Remove the ignition key and lock the steering.

   Warning: Refer to Battery Disconnect Warning.
3. Disconnect the battery ground cable. Refer to Battery Negative Cable Disconnection and Connection.
4. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
5. Remove the air inlet grille. Refer to Air Inlet Grille Panel Replacement.
6. Recover the air conditioning (A/C) refrigerant. Refer to Refrigerant Recovery and Recharging.
7. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.
8. Drain the cooling system. Refer to Cooling System Draining and Filling.
9. Remove the radiator outlet hose. Refer to Radiator Outlet Hose Replacement.



10. Compress the coolant bleed hose retaining clamp (4) at the outlet housing (1) end and slide 50 mm (2 in) along the coolant bleed hose (3).
11. Remove the coolant bleed hose (3) from the outlet housing (1).

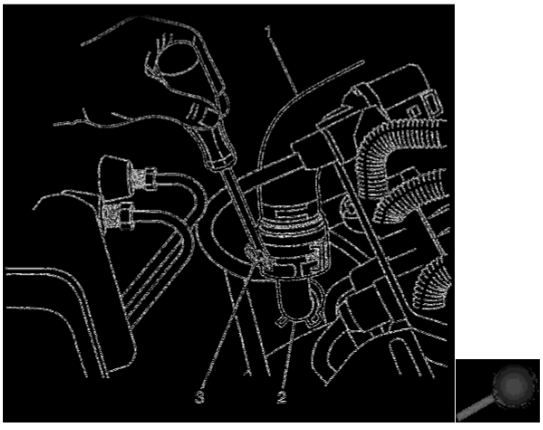
    Note: Twist and pull the coolant recovery hose (2) to remove from the outlet housing (1).
12. Disconnect the coolant recovery hose (2) from the outlet housing (1).

    Note: Plugging or capping pipes and hoses prevents leaks or contamination.

© 2014 General Motors. All rights reserved.

cardiagn.com

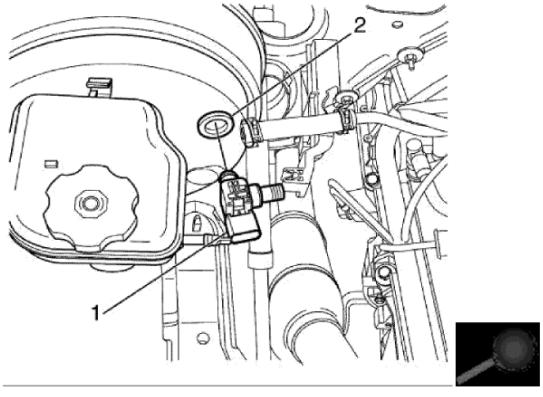
13. Plug or cap the cooling system hoses and coolant outlets.



Warning: Refer to Safety Glasses Warning

Note: The inlet and outlet heater hoses (1) are retained to the heater pipes (2) by quick connect fittings. Disconnect the heater hoses (1) quick connect fittings by releasing the retaining clips (3) with a suitable tool.

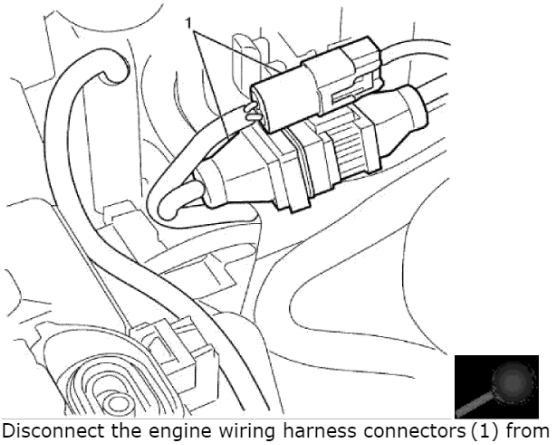
14. Disconnect the heater hoses (1) from the heater pipe (2).



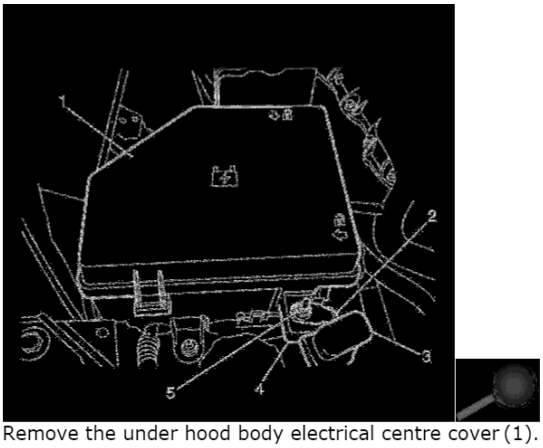
Note: Apply the brakes several times until the brake pedal becomes firm to deplete the vacuum reserve of the brake booster .

15. Deplete the brake booster vacuum reserve.
16. Disconnect the engine wiring harness from the brake booster vacuum pressure sensor/check valve (1) .
17. Remove the brake booster vacuum pressure sensor/check valve (1) from the vacuum brake booster.
18. Disconnect the engine control module connectors. Refer to Engine Control Module Replacement.

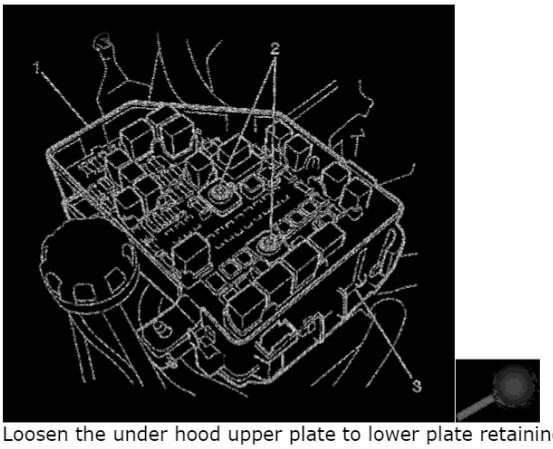
cardiagn.com



19. Disconnect the engine wiring harness connectors (1) from the main engine wiring harness.



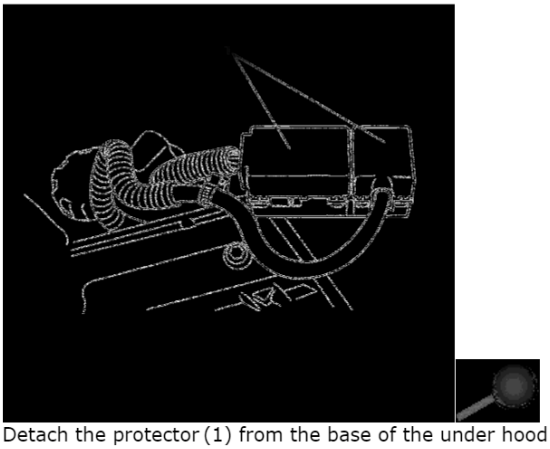
20. Remove the under hood body electrical centre cover (1).
21. Remove the positive cable to under hood plate retaining bolt (5).
22. Disconnect the positive cable (2) from the upper under hood plate (4).



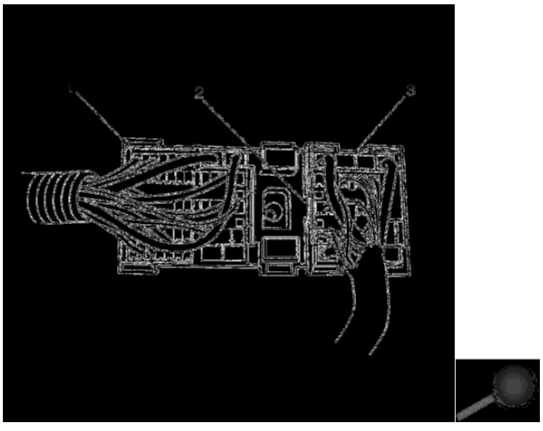
23. Loosen the under hood upper plate to lower plate retaining bolts (2).

cardiagn.com

24. Raise the upper under hood plate (1) from the lower under hood plate (3).



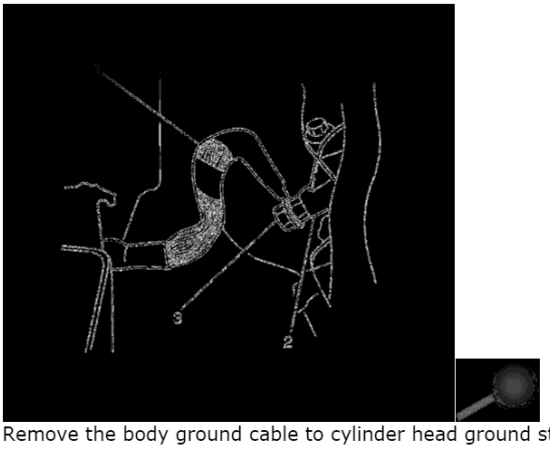
25. Detach the protector (1) from the base of the under hood connector.



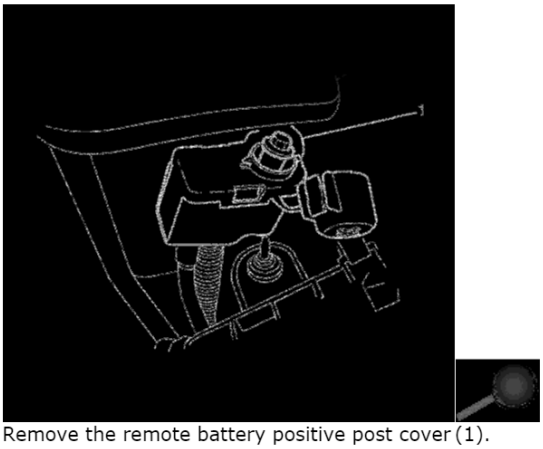
Note: Use a suitable tool to depress the connector locking tang (2), then pull the body harness connector (1) upward and the engine connector (3) downward to separate the body harness connector (1) from the engine connector (3).

26. Separate the body harness connector (1) from the engine connector (3).
27. Reposition and secure the engine wiring harness and connector (3) on the engine.

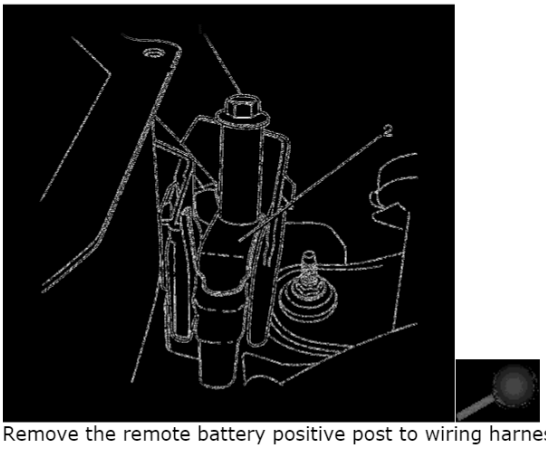
cardiagn.com



28. Remove the body ground cable to cylinder head ground stud retaining nut (3).
29. Detach the body ground cable (1) from the cylinder head ground stud (2).



30. Remove the remote battery positive post cover (1).



31. Remove the remote battery positive post to wiring harness retaining nut (1).
32. Remove the wiring harness (2).

cardiagn.com

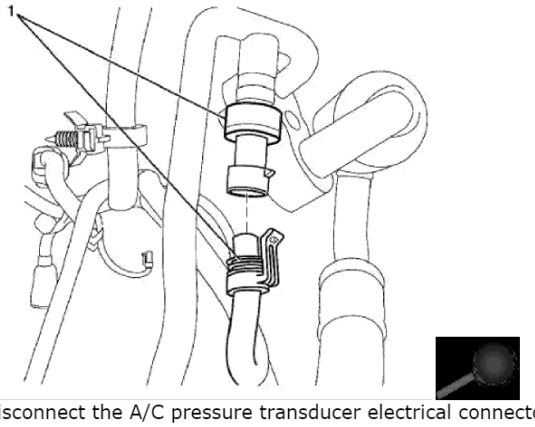
Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Refer to Safety Glasses Warning.

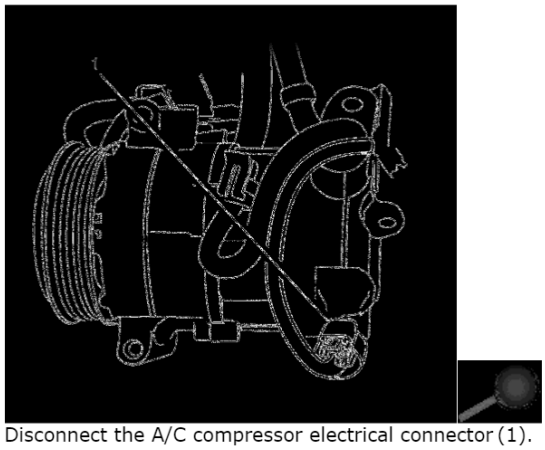
33. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
34. Remove the underbody front air deflector. Refer to Underbody Front Air Deflector Replacement.
35. Remove the oil pan shield. Refer to Oil Pan Shield Replacement.
36. Disconnect the radiator inlet hose. Refer to Radiator Inlet Hose Replacement.

Note: Plugging or capping pipes and hoses prevents leaks or contamination.

37. Plug or cap the radiator water inlet and the radiator outlet hose.

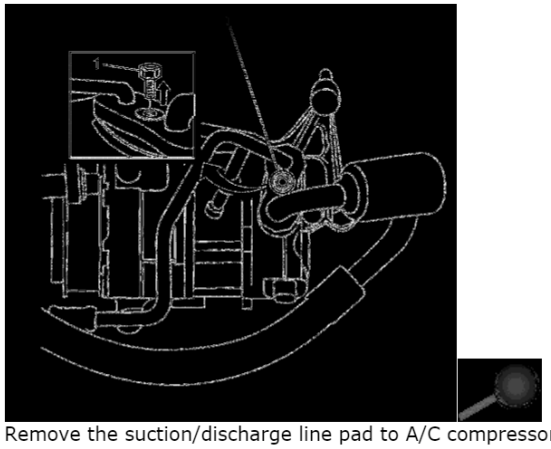


38. Disconnect the A/C pressure transducer electrical connector (1).

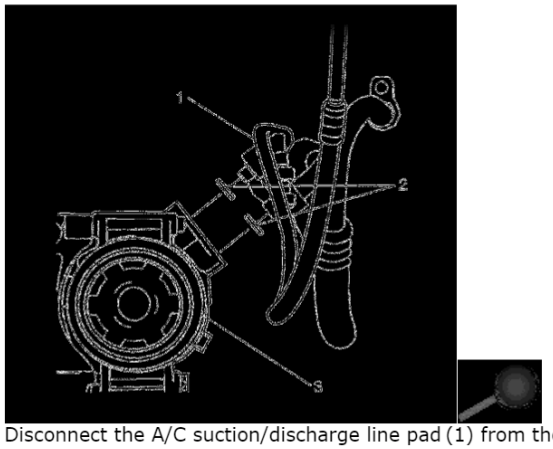


39. Disconnect the A/C compressor electrical connector (1).

cardiagn.com



40. Remove the suction/discharge line pad to A/C compressor retaining nut (1).



41. Disconnect the A/C suction/discharge line pad (1) from the A/C compressor (3).

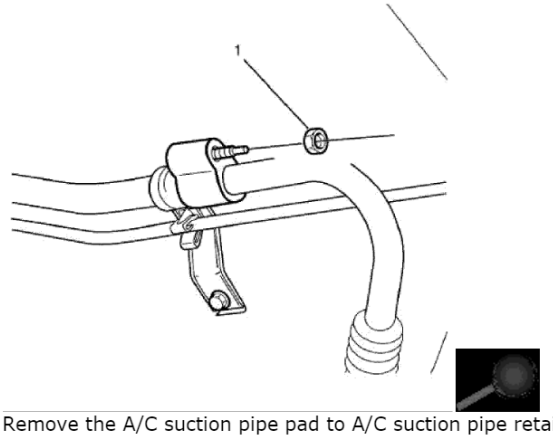
Note: Plug the A/C suction/discharge pipe ends and the compressor ports immediately to prevent contamination and absorption of moisture from the atmosphere.

42. Plug or cap the A/C suction/discharge pipe (1) ends and the compressor (3) ports.

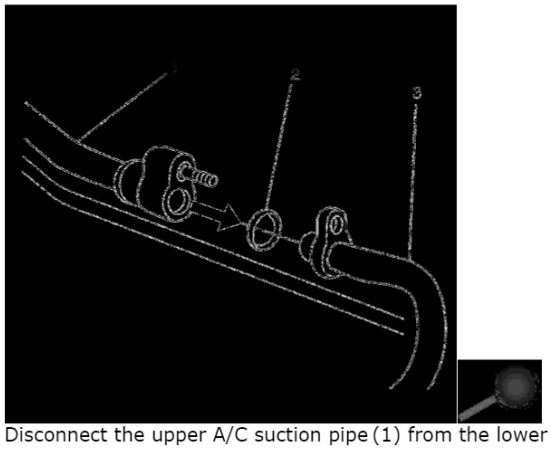
Note: The A/C sealing O-rings (2) are a single use components. Install NEW A/C sealing O-rings (2) whenever the A/C suction/discharge line pad (1) is removed from the A/C compressor (3).

43. Remove the A/C suction/discharge pipe sealing O-rings (2).
Discard the O-rings (2).

cardiagn.com



44. Remove the A/C suction pipe pad to A/C suction pipe retaining nut (1).



45. Disconnect the upper A/C suction pipe (1) from the lower A/C suction tube (3).

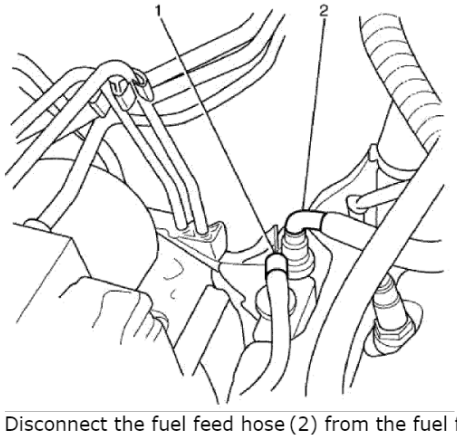
Note: Plug or cap the A/C suction pipe ends (1 and 3) immediately to prevent contamination and absorption of moisture from the atmosphere.

46. Plug the A/C suction pipe ends.

Note: The A/C suction pipe sealing O-ring (2) is a single use component. Install a NEW A/C suction pipe sealing O-ring (2) whenever the upper A/C suction pipe (1) is removed from the lower A/C suction pipe (3).

47. Remove the A/C suction pipe sealing O-ring (2).
    Discard the O-ring (2).
48. Reposition and secure the A/C suction/discharge pipes away from the engine.

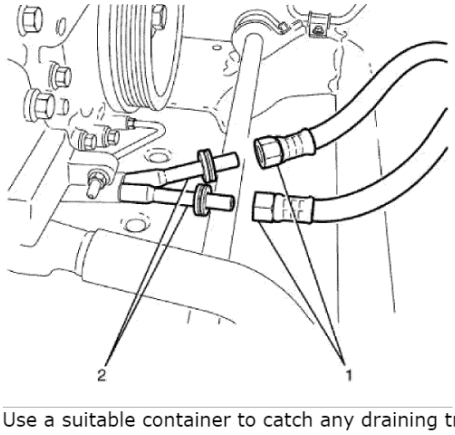
cardiagn.com



49. Disconnect the fuel feed hose (2) from the fuel feed pipe. Refer to Metal Collar Quick Connect Fitting Service.

    Note: Plugging or capping pipes and hoses prevents leaks or contamination.
50. Plug or cap the ends of the fuel feed pipe (2) and fuel feed hose (1).
51. Disconnect the EVAP emission hose (1) from the EVAP emission pipe. Refer to Plastic Collar Quick Connect Fitting Service.

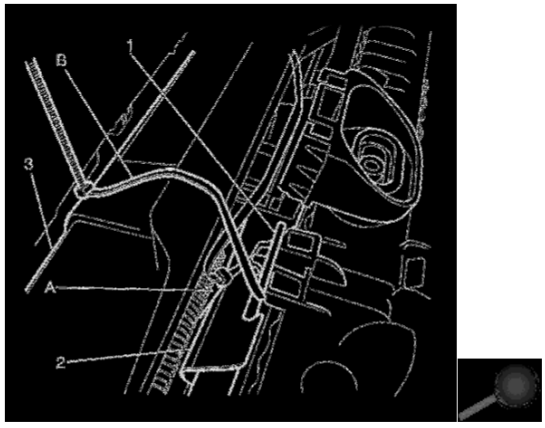
    Note: Plugging or capping pipes and hoses prevents leaks or contamination.
52. Plug or cap the ends of the EVAP purge hose and the EVAP purge pipe.



53. Use a suitable container to catch any draining transmission fluid.

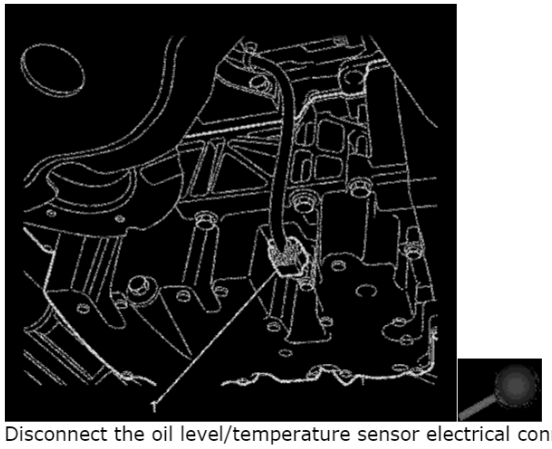
    Note: Plugging or capping pipes and hoses prevents leaks or contamination.
54. Disconnect the flexible hoses (1) from the transmission cooler lines (2) using the *J 41623-B* cooler quick connect tool. Refer to Metal Collar Quick Connect Fitting Service.
55. Reposition the flexible hoses (1) away from the engine and subframe.

cardiagn.com



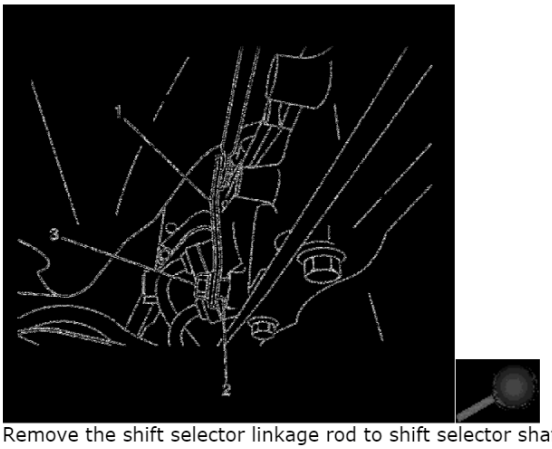
Note: The radiator and condenser assembly is supported by the subframe. To support the radiator and condenser assembly after the subframe is removed, suitably secure the radiator and condenser assembly to the front end assembly.

56. Secure radiator and condenser assembly (2) to the front end assembly (3) with large zip ties (B) or an equivalent.

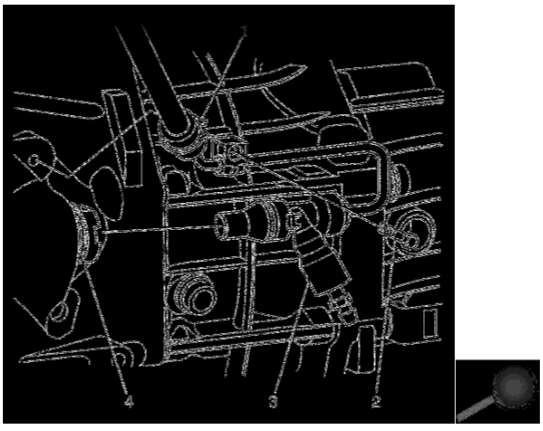


57. Disconnect the oil level/temperature sensor electrical connector (1).
58. Remove the exhaust system for access. Refer to Exhaust System Replacement.
59. Remove the center exhaust heat shield. Refer to Exhaust Heat Shield Replacement - Center.
60. Remove the propeller shaft. Refer to Propeller Shaft Replacement.

cardiagn.com



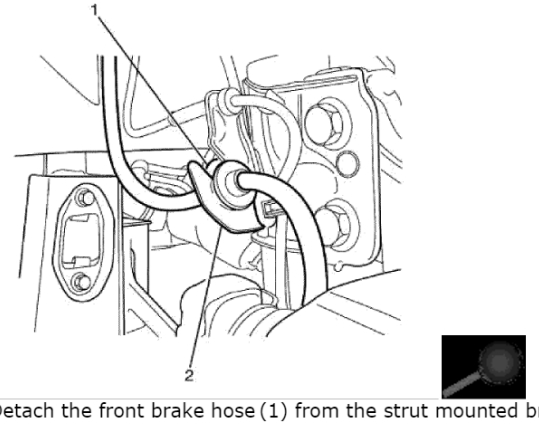
61. Remove the shift selector linkage rod to shift selector shaft retaining nut (3).
62. Remove the shift selector linkage rod (1) from the shift selector shaft (2).



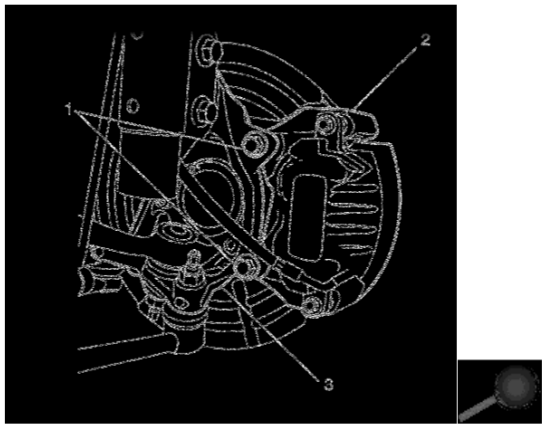
Note: Steps 65–72 are for vehicles fitted with a manual transmission.

63. Remove the gearshift lever boot. Refer to Control Lever and/or Boot Replacement.
64. Detach the flexible hose securing clip (1).
65. Remove the concentric actuator cylinder feed pipe bracket to transmission retaining bolt (2).
66. Release the bleeder assembly securing clip (4), by using a suitable tool and releasing it from the bleeder adapter.
67. Remove the bleeder assembly (3) from the bleeder adapter.
68. Reposition the bleeder assembly (3) away from the transmission with heavy mechanics wire or an equivalent.
69. Remove the starter motor. Refer to Starter Replacement.
70. Partially lower the vehicle.
71. Remove the front wheels. Refer to Tire and Wheel Removal and Installation.

cardiagn.com



72. Detach the front brake hose (1) from the strut mounted brake hose retaining bracket (2).
73. Repeat for the opposite side.

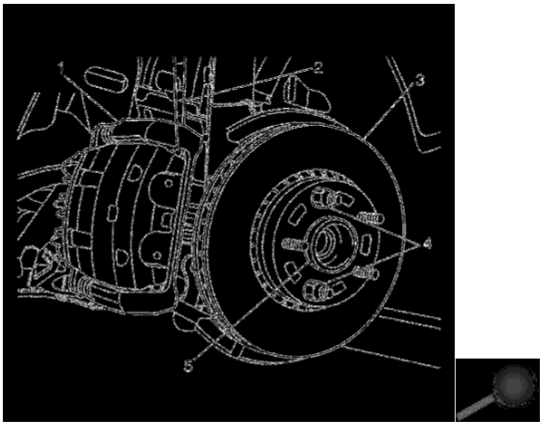


Note:
- Bolts with micro-encapsulated thread sealant must be discarded after removal.
- Make sure all the bolt threaded holes are thoroughly cleaned and all micro-encapsulated thread sealant is removed.

74. Remove the front brake caliper anchor plate to knuckle retaining bolts (1).
    - Discard the bolts.
    - Clean the bolt threaded holes.

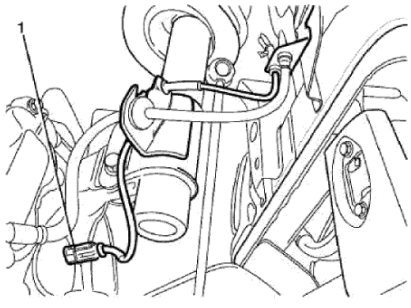
    Note: DO NOT disconnect the hydraulic brake flexible hose from the brake caliper. If the hydraulic brake flexible hose is disconnected from the brake caliper complete bleeding of the braking system will be required.
75. Remove the front brake caliper (2) from the front steering knuckle (3).
76. Repeat for the opposite side.

cardiagn.com



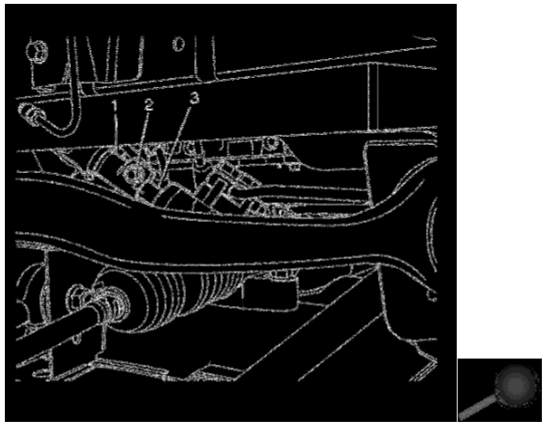
Caution: Support the brake caliper with heavy mechanic wire, or equivalent, whenever it is separated from its mount and the hydraulic flexible brake hose is still connected. Failure to support the caliper in this manner will cause the flexible brake hose to bear the weight of the caliper, which may cause damage to the brake hose and in turn may cause a brake fluid leak.

77. Support the front brake caliper (1) with heavy mechanic's wire, or equivalent (2).
78. Install two wheel nuts (4) to retain the front brake disc (3) to the hub (5).
79. Repeat for the opposite side.



80. Disconnect the front wheel speed sensor electrical harness connector (1) and position away from the subframe and suspension components.
81. Repeat for the opposite side.

cardiagn.com



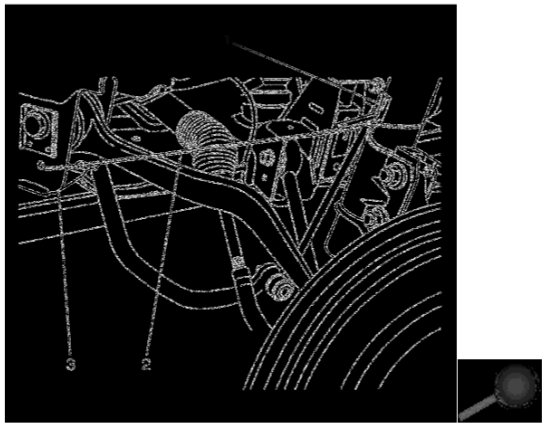
Note: Observing the orientation of the intermediate steering shaft (1) with reference to the pinion shaft (3) will minimize the potential of incorrect steering column assembly alignment.

82. Mark the intermediate steering shaft (1) with reference to the pinion shaft (3).

Note:

- Bolts with micro-encapsulated thread sealant must be discarded after removal.
- Make sure the bolt threaded hole is thoroughly cleaned and all micro-encapsulated thread sealant is removed.

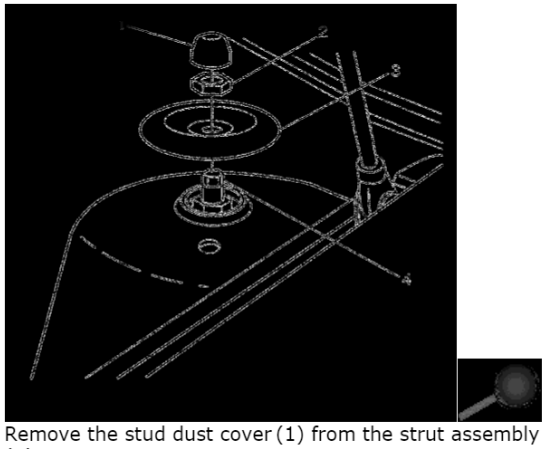
83. Remove the intermediate steering shaft to pinion shaft retaining bolt (2).
84. Remove the intermediate shaft (1) from the pinion shaft (3).
    - Discard the bolt.
    - Clean the bolt threaded hole.
85. Lower the vehicle.



Note: The strut assembly (1) must be secured to the subframe (3) to prevent damage to the front wheelhouse liner, fenders and suspension components.

86. Secure the strut assembly (1) to the subframe (3) using heavy mechanics wire or equivalent (2).
87. Repeat for the opposite side.

cardiagn.com

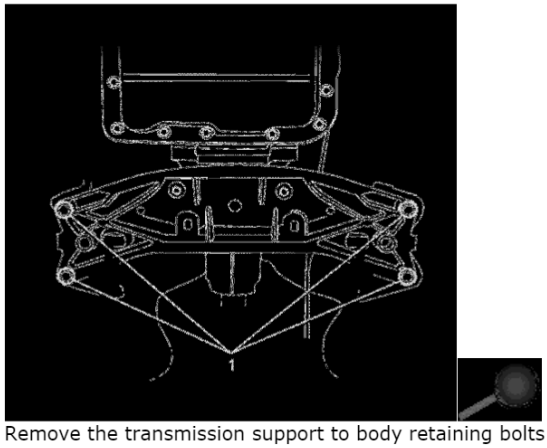


88. Remove the stud dust cover (1) from the strut assembly to front wheelhouse retaining nut (2).

Note:

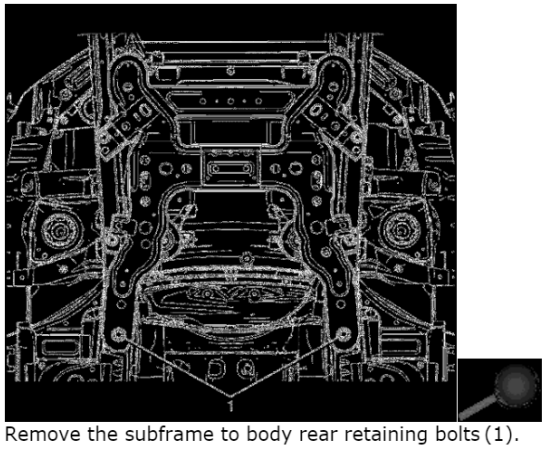
- Support the strut assembly (4) before removing the front wheelhouse retaining nut (2).
- Hold the strut piston shaft (4) with a suitable tool when removing the front wheelhouse retaining nut.

89. Remove the strut assembly to front wheelhouse retaining nut (2).
    Discard the nut.
90. Remove the strut assembly to front wheelhouse retaining plate (3).
91. Repeat for the opposite side.
92. Support the powertrain with a suitable lift table.

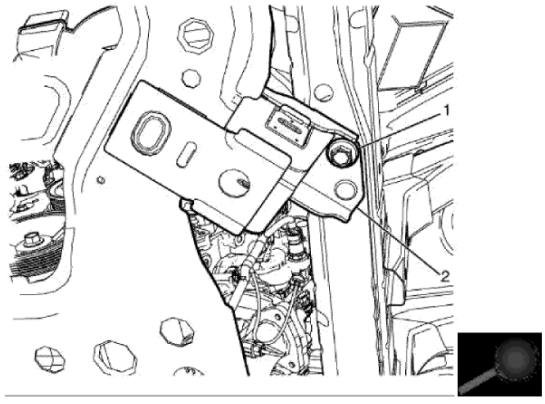


93. Remove the transmission support to body retaining bolts (1).

cardiagn.com

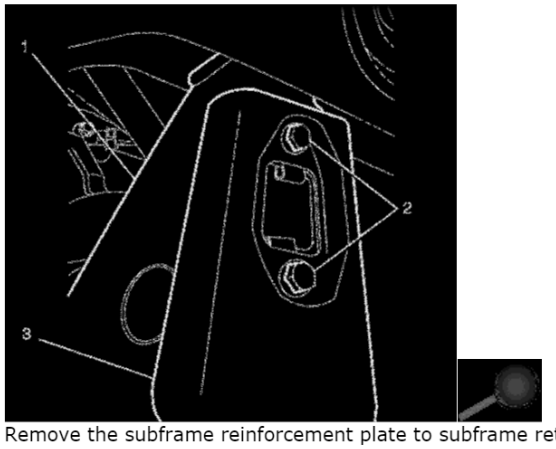


94. Remove the subframe to body rear retaining bolts (1).



Note: For graphical illustration the left side is shown. The right side is similar.

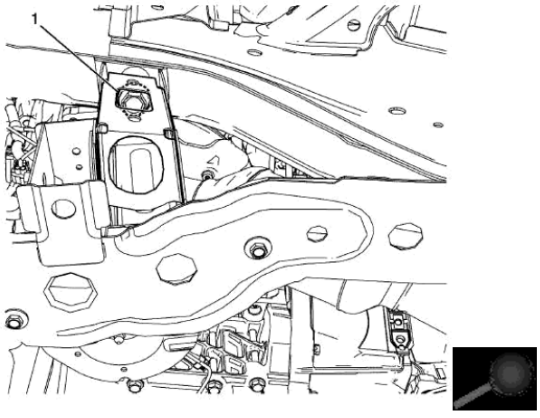
95. Remove the subframe to body front retaining bolt (1).
96. Repeat for the opposite side.



97. Remove the subframe reinforcement plate to subframe retaining bolts (2).
98. Remove the subframe reinforcement plate (3) from the subframe (1).

cardiagn.com

99. Repeat for the opposite side.

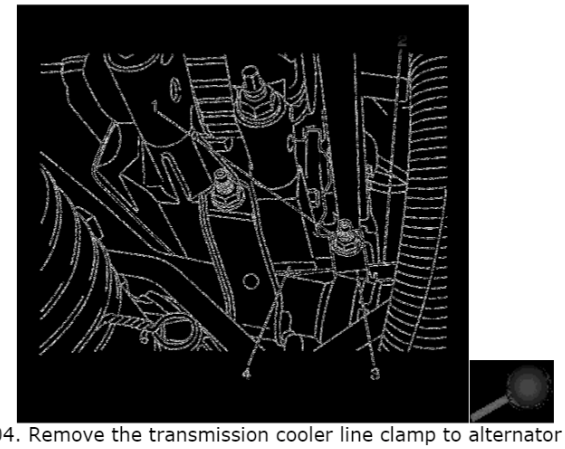


Note: For graphical illustration the left side is shown. The right side is similar.

100. Remove the subframe to body retaining bolt (1).
101. Repeat for the opposite side.

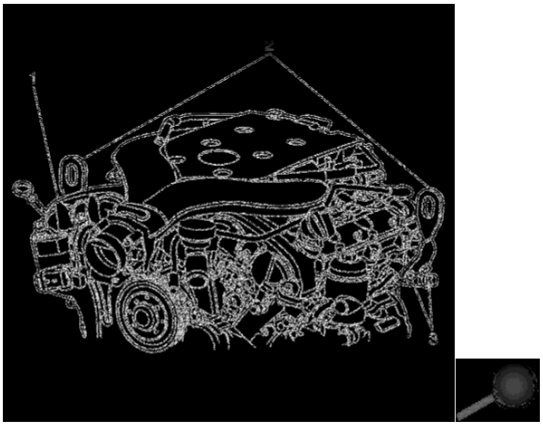
Note: Make sure that all the hoses, harnesses, pipes and front struts are not damaged during the powertrain removal process.

102. With the aid of an assistant, lower the table or raise the vehicle to remove the powertrain with the subframe assembly from the vehicle.
103. Remove the engine and transmission wiring harness and related components. Refer to Engine Wiring Harness Assembly Removal.



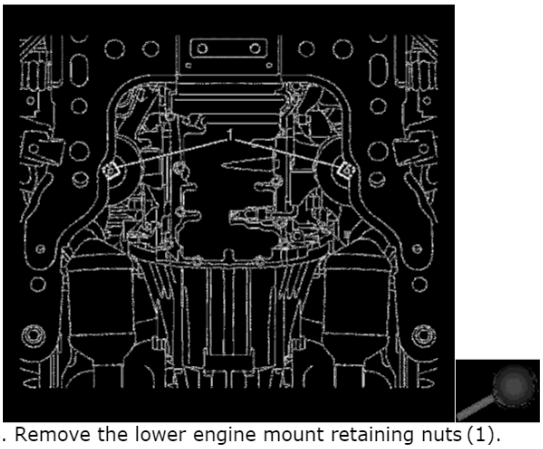
104. Remove the transmission cooler line clamp to alternator mounting bracket retaining nut (1).
105. Remove the transmission cooler line clamp (3) and transmission cooler lines (2) from the alternator mounting bracket (4).

cardiagn.com



Caution: Refer to Fastener Caution.

106. Install the engine lift brackets *EN 46114* engine lift brackets to the cylinder heads. Tighten the engine lift bracket bolts to **50 N·m (36 lb ft)**.
107. Install a suitable lifting crane to the engine lift brackets (2) and raise the lifting crane to support the engine.
108. Position a second powertrain lift table below the transmission.
109. Remove the transmission from the engine.
110. Rest the transmission on the second lift table after it has been removed.
111. Remove the engine flywheel. Refer to Engine Flywheel Removal.
112. Remove the catalytic converters. Refer to:
    - Catalytic Converter Replacement - Right Side
    - Catalytic Converter Replacement - Left Side
113. Remove the drive belt. Refer to Drive Belt Replacement.
114. Remove the A/C compressor. Refer to Air Conditioning Compressor Replacement.
115. Remove the A/C compressor mounting bracket. Refer to Air Conditioning Compressor Bracket Replacement.
116. Remove the alternator. Refer to Generator Replacement.
117. Remove the alternator mounting bracket. Refer to Generator Bracket Replacement.



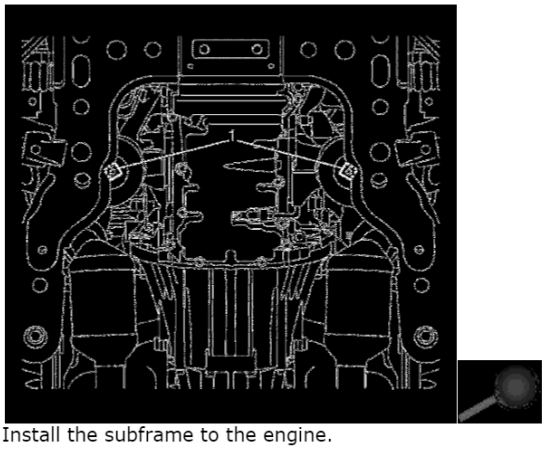
118. Remove the lower engine mount retaining nuts (1).

cardiagn.com

119. Using a suitable lifting crane, raise the engine until it is free from the engine mount stud.
120. Remove the engine mount brackets with the engine mounts. Refer to:
    - Engine Mount Bracket Replacement - Left Side
    - Engine Mount Bracket Replacement - Right Side
121. Remove the engine from the subframe.
    If required mount the engine on a suitable engine stand.

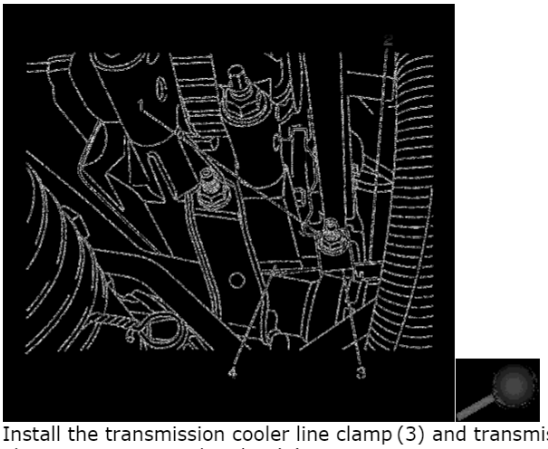
Installation Procedure

1. Install the engine mount brackets with the engine mounts to the engine. Refer to:
    - Engine Mount Bracket Replacement - Left Side
    - Engine Mount Bracket Replacement - Right Side
2. Use the lift crane to install the engine to the subframe.
3. Raise the engine with the lift crane to partially support the engine.



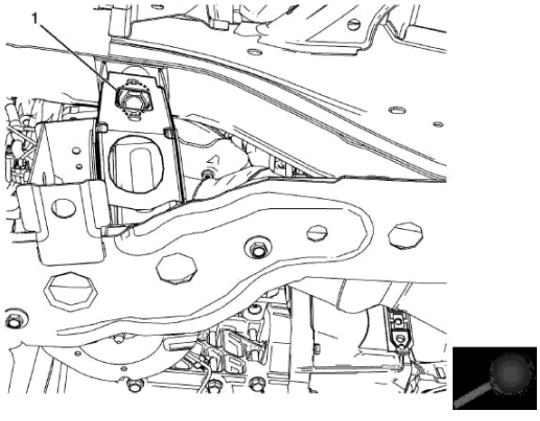
4. Install the subframe to the engine.
5. Install the lower engine mount retaining nuts (1). Tighten the bolts to **80 N•m (59 lb ft)**.
6. Install the alternator bracket. Refer to Generator Bracket Replacement.
7. Install the alternator. Refer to Generator Replacement.
8. Install the A/C compressor mounting bracket. Refer to Air Conditioning Compressor Bracket Replacement.
9. Install the A/C compressor. Refer to Air Conditioning Compressor Replacement.
10. Install the drive belt. Refer to Drive Belt Replacement.
11. Install the catalytic converters. Refer to Catalytic Converter Replacement - Left Side and Catalytic Converter Replacement - Right Side.
12. Install the flywheel. Refer to Engine Flywheel Removal.
13. Install the transmission to the engine.

cardiagn.com



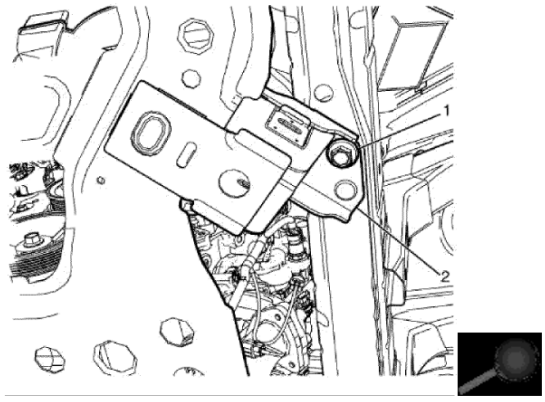
14. Install the transmission cooler line clamp (3) and transmission cooler lines (2) to the alternator mounting bracket (4).
15. Install the transmission cooler line clamp to alternator mounting bracket retaining nut (1) and tighten to **22 N•m (16 lb ft)**.
16. Install the engine and transmission wiring harness and related components. Refer to Engine Wiring Harness Assembly Removal.
17. Lower the engine, transmission, front suspension and subframe assembly onto the lift table.

    Note: Make sure that all the hoses, harnesses, pipes and front struts are not damaged during the powertrain installation process.
18. With the aid of an assistant, raise the table or lower the vehicle to install the engine, transmission, front suspension and subframe assembly to the vehicle.



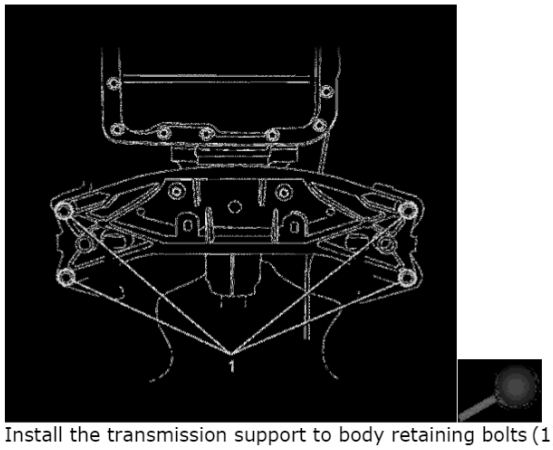
    Note: For graphical illustration the left side is shown. The right side is similar.
19. Install the subframe to body retaining bolts (1) and tighten to **160 N•m (118 lb ft)**.
20. Repeat for the opposite side.

cardiagn.com

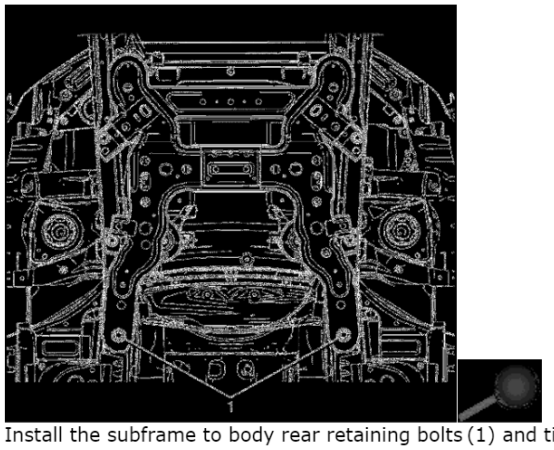


Note: For graphical illustration the left side is shown. The right side is similar.

21. Install the subframe to body front retaining bolts (1) and tighten to **160 N•m (118 lb ft)**.
22. Repeat for the opposite side.

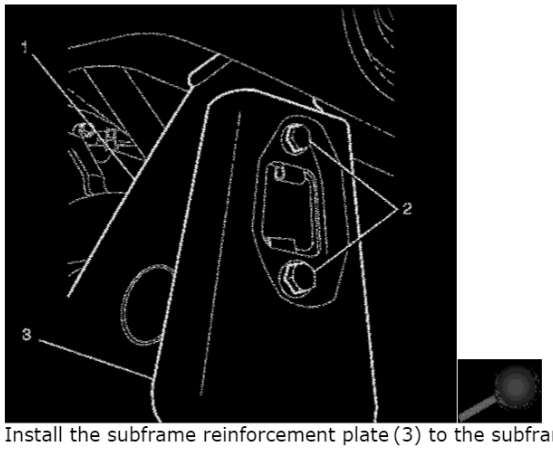


23. Install the transmission support to body retaining bolts (1) and tighten to **58 N•m (43 lb ft)**.

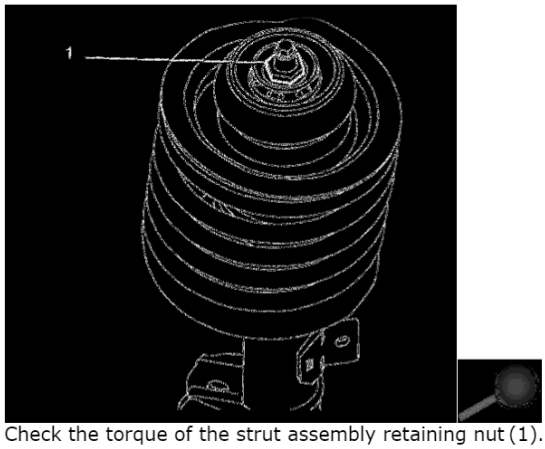


24. Install the subframe to body rear retaining bolts (1) and tighten to **240 N•m (177 lb ft)**.

cardiagn.com

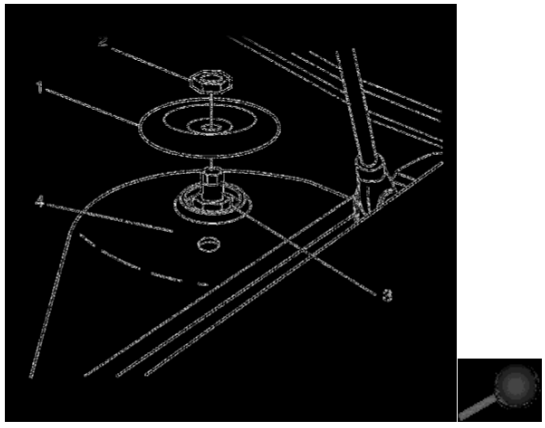


25. Install the subframe reinforcement plate (3) to the subframe (1).
26. Install the subframe reinforcement plate to subframe retaining bolts (2) and tighten to **17 N•m (13 lb ft)**.
27. Repeat for the opposite side.
28. Remove the lift table from the vehicle.
29. Partially lower the vehicle.



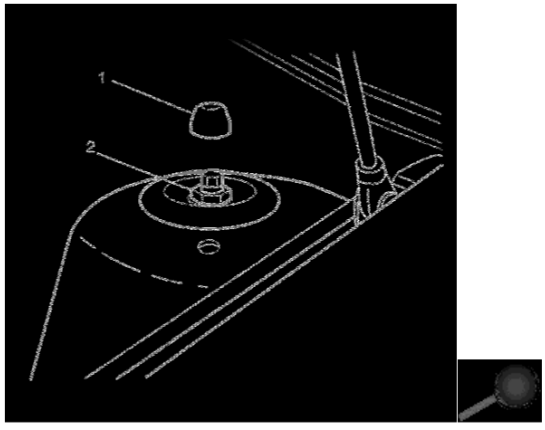
30. Check the torque of the strut assembly retaining nut (1). Tighten the nut to **75 N•m (55 lb ft)**.
31. Repeat for the opposite side.

cardiagn.com



Note: For graphical illustration the left side is shown. The right side is similar.

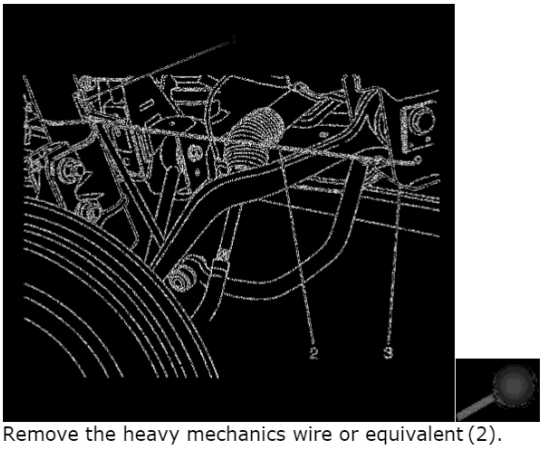
32. Install the strut assembly (3) to the vehicle (4).
33. Install strut assembly to body retaining plate (1).
34. Install the NEW strut assembly to body retaining nut (2) and tighten to **55 N•m (41 lb ft)**.
35. Repeat for the opposite side.



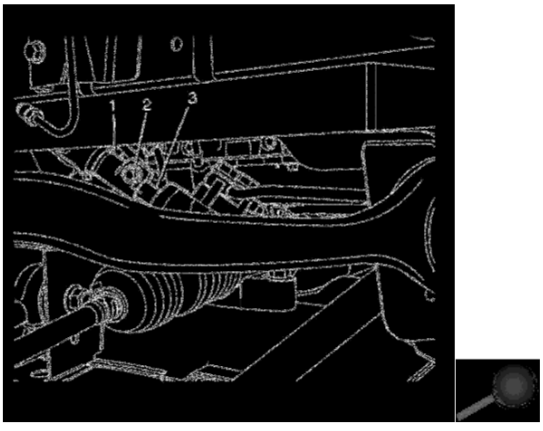
Note: For graphical illustration the left side is shown. The right side is similar.

36. Install the dust cover (1) to the strut assembly to body retaining nut (2).
37. Repeat for the opposite side.
38. Partially raise the vehicle.

cardiagn.com



39. Remove the heavy mechanics wire or equivalent (2).
40. Repeat for the opposite side.

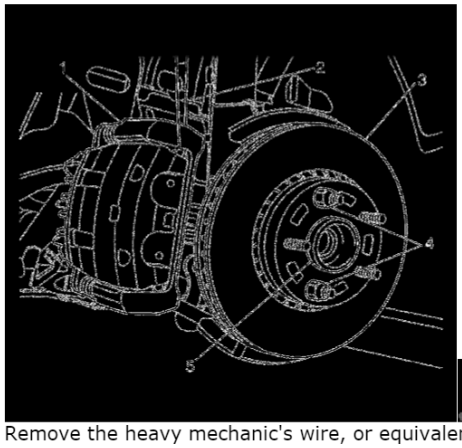


Note: The intermediate steering shaft and pinion shaft must be installed in the same position as it was before it was removed.

41. Align the mark previously made and install the intermediate steering shaft (1) to the pinion shaft (3).
42. Install a NEW intermediate steering shaft to pinion shaft retaining bolt (2) and tighten to **25 N•m (18 lb ft)**.

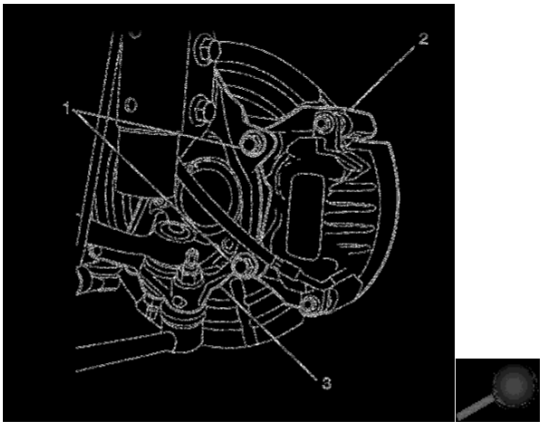
cardiagn.com

43. Connect the wheel speed sensor electrical harness connector (1) to the wheel speed sensor.
44. Repeat for the opposite side.



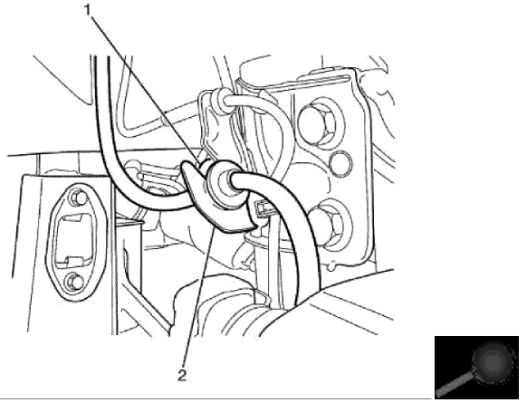
45. Remove the heavy mechanic's wire, or equivalent support (2) from the brake caliper (1).
46. Remove the wheel nuts (4) retaining the brake disc (3) to the hub (5).
47. Repeat for the opposite side.

cardiagn.com



Caution: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

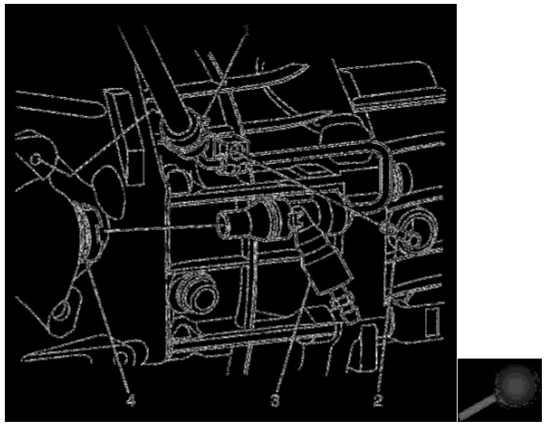
48. Install the brake caliper assembly (2) to the steering knuckle (3).
49. Install the NEW brake caliper anchor plate to knuckle retaining bolts (1) and tighten to **60 N•m (44 lb ft) plus 120 degrees**.
50. Repeat for the opposite side.



Caution: Make sure the brake hose is not twisted or kinked after installation. Damage to the hose could result.

51. Install the brake hose (1) to the strut mounted brake hose retaining bracket (2).
52. Install the front wheels. Refer to Tire and Wheel Removal and Installation.
53. Repeat for the opposite side.

cardiagn.com

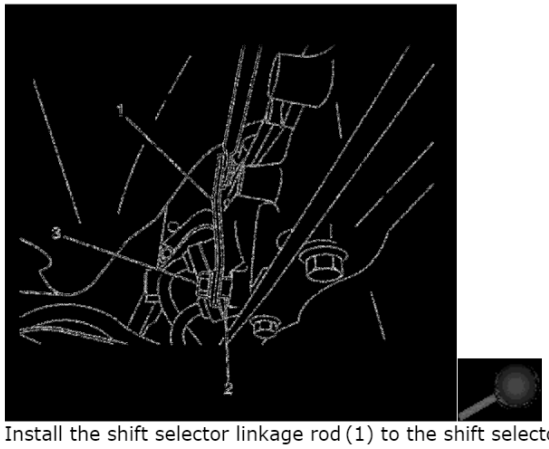


Note: Steps 58–62 are for vehicles fitted with a manual transmission.

54. Install the starter motor. Refer to Starter Replacement.
55. Install the bleeder assembly (3).
56. Install the bleeder assembly securing clip (4).
57. Install the concentric actuator cylinder feed pipe bracket to transmission retaining bolt (2). Tighten the nut to **7 N•m (62 lb ft)**.

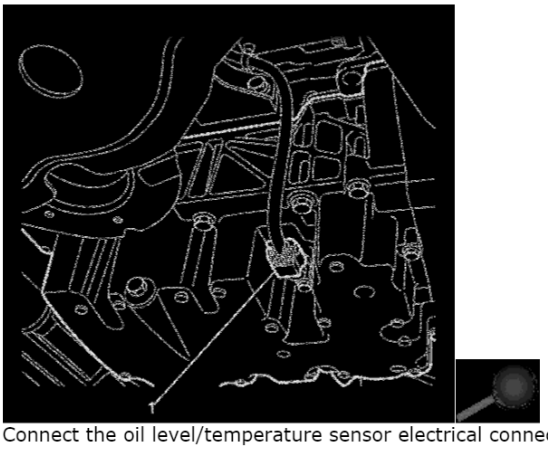
Note: Listen for an audible click to confirm correct fitting of the flexible hose securing clip.

58. Install the flexible hose securing clip.
59. Install the gearshift lever boot. Refer to Control Lever and/or Boot Replacement.

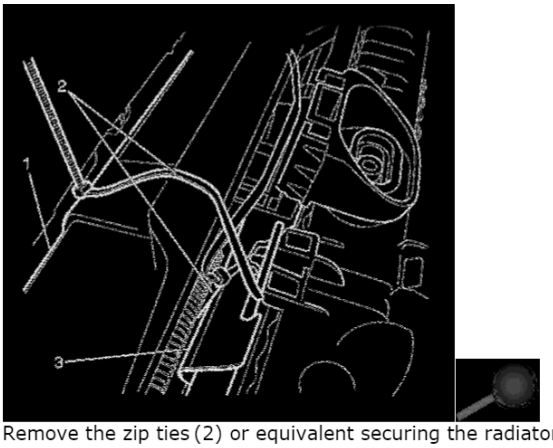


60. Install the shift selector linkage rod (1) to the shift selector shaft (2).
61. Install the shift selector linkage rod to shift selector shaft retaining nut (3) and tighten to **15 N•m (11 lb ft)**.
62. Install the propeller shaft. Refer to Propeller Shaft Replacement.
63. Install the centre exhaust heat shield. Refer to Exhaust Heat Shield Replacement - Center.
64. Install the exhaust system. Refer to Exhaust System Replacement.

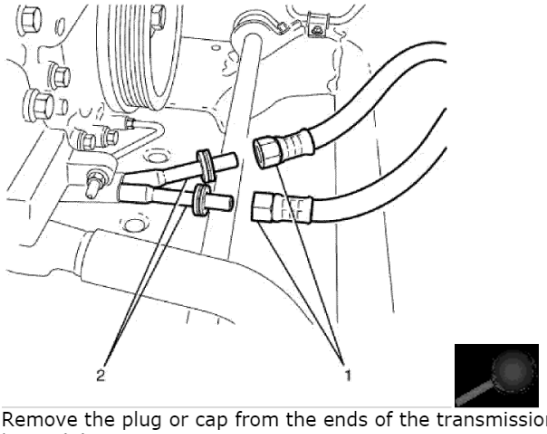
cardiagn.com



65. Connect the oil level/temperature sensor electrical connector (1).



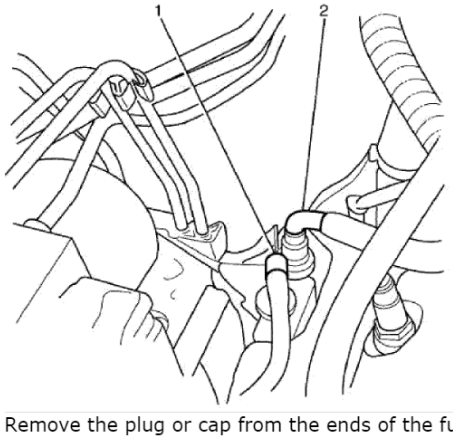
66. Remove the zip ties (2) or equivalent securing the radiator and condenser assembly (3) to the front end assembly (1).



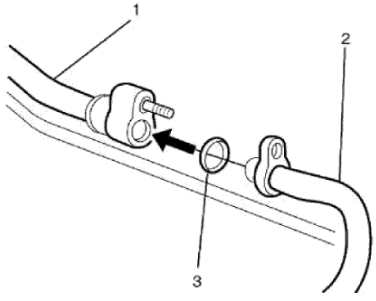
67. Remove the plug or cap from the ends of the transmission cooler lines (2) and the flexible hoses (1).

cardiagn.com

68. Install the flexible hoses (1) to the transmission fluid lines (2). Refer to Metal Collar Quick Connect Fitting Service.



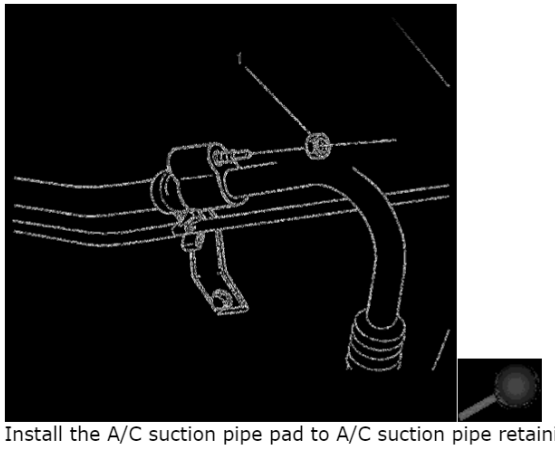
69. Remove the plug or cap from the ends of the fuel feed hose and fuel feed pipe.
70. Connect the fuel feed hose (2) to the fuel feed pipe. Refer to Metal Collar Quick Connect Fitting Service.
71. Remove the plug or cap from the ends of the EVAP purge hose and EVAP purge pipe.
72. Connect the EVAP purge hose (1) to the EVAP purge pipe. Refer to Plastic Collar Quick Connect Fitting Service.



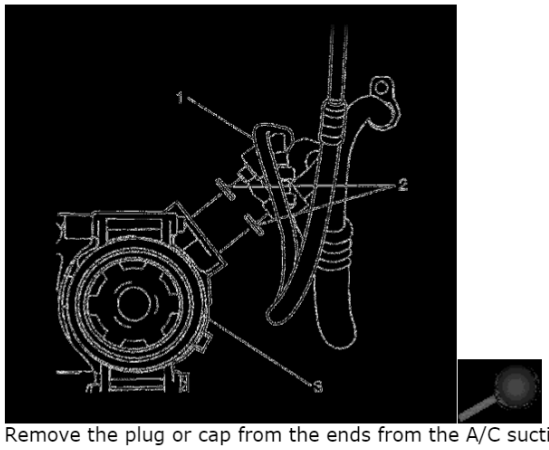
Note: DO NOT coat the new sealing washer with oil. It must be fitted dry.

73. Remove the plug or cap from the ends from the upper suction pipe (1) and the lower suction pipe (2)
74. Install a NEW seal (3) to suction pipe (2).
75. Install the upper suction pipe (1) to the lower suction pipe (2).

cardiagn.com



76. Install the A/C suction pipe pad to A/C suction pipe retaining nut (1) and tighten to **22 N•m (16 lb ft)**.

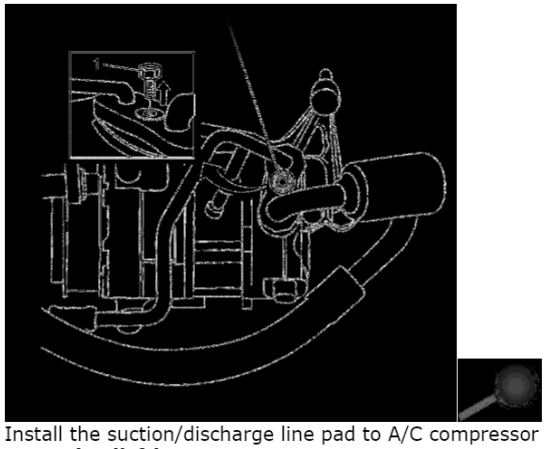


77. Remove the plug or cap from the ends from the A/C suction/discharge pipe (1) and the compressor ports.

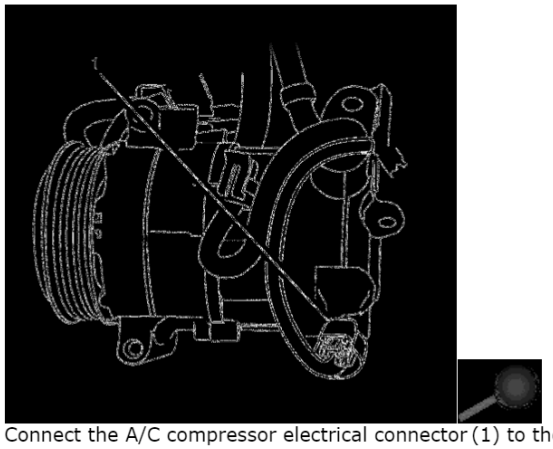
Note: DO NOT lubricate the A/C suction/discharge pipe seals. It must be fitted dry.

78. Fit the NEW A/C suction/discharge pipe seals (2) to the suction/discharge pipe.
79. Connect the A/C suction/discharge line pad (1) to the A/C compressor (3).

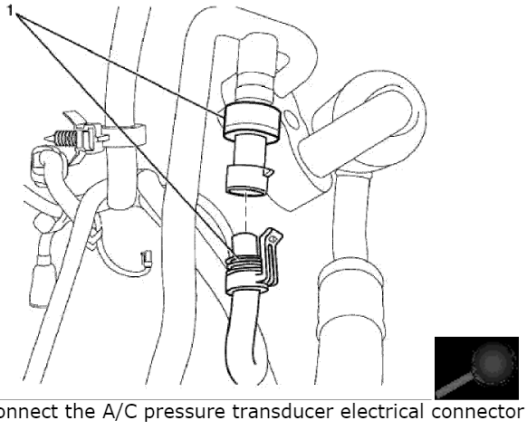
cardiagn.com



80. Install the suction/discharge line pad to A/C compressor retaining nut (1) and tighten to **22 N•m (16 lb ft)**.



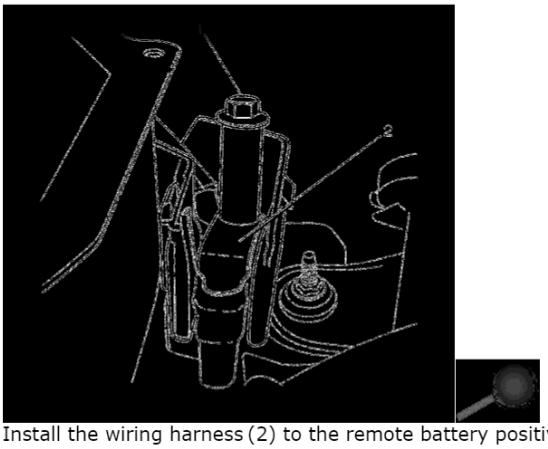
81. Connect the A/C compressor electrical connector (1) to the A/C compressor.



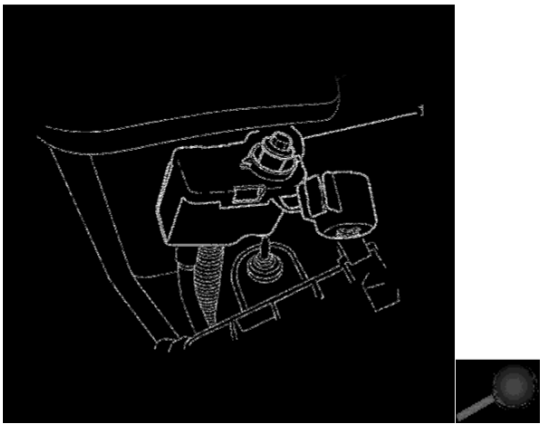
82. Connect the A/C pressure transducer electrical connector (1) to the A/C pressure transducer.
83. Remove the plug or cap from the ends of the cooling system hoses and inlets.

cardiagn.com

84. Connect the radiator inlet hose. Refer to Radiator Inlet Hose Replacement.
85. Install the oil pan shield. Refer to Oil Pan Shield Replacement.
86. Install the underbody front air deflector. Refer to Underbody Front Air Deflector Replacement.
87. Lower the vehicle.



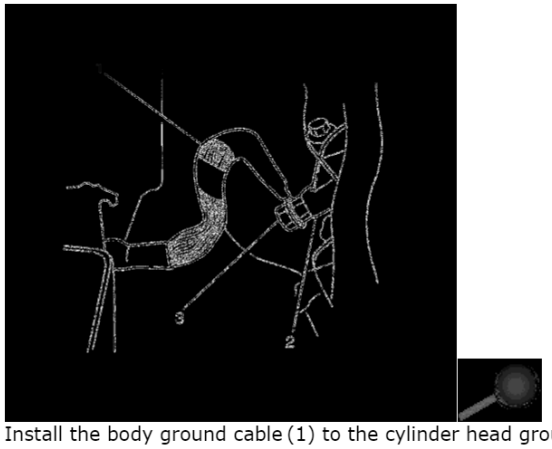
88. Install the wiring harness (2) to the remote battery positive post (1).
89. Install the remote battery positive post to wiring harness retaining nut (1). Tighten the bolt to **15 N•m (11 lb ft)**.



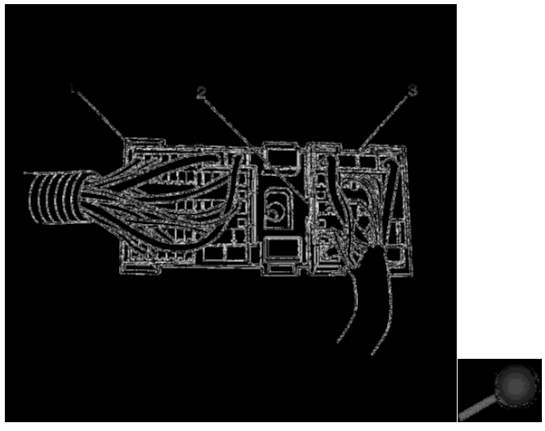
Note: Make sure the clips on the remote battery positive post cover (1) are engaged to avoid an induced rattle condition.

90. Install the remote battery positive post cover (1).

cardiagn.com

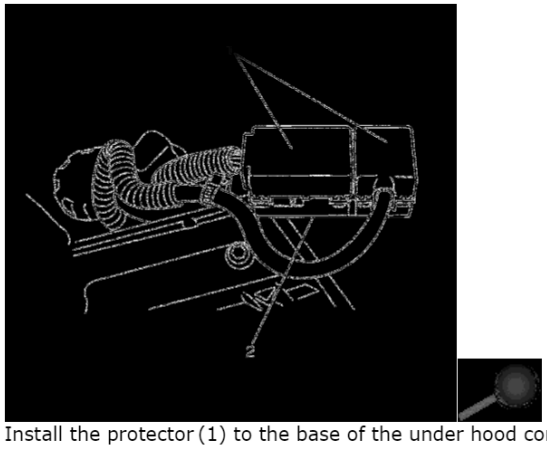


91. Install the body ground cable (1) to the cylinder head ground stud (2).
92. Install the body ground cable to the cylinder head ground stud retaining nut (3) and tighten to **30 N·m (22 lb ft)**.

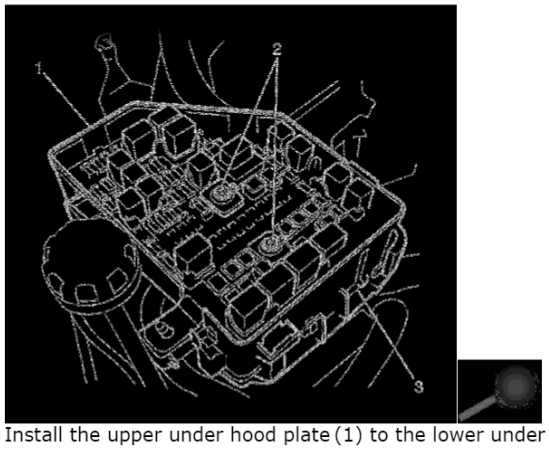


Note: Listen for a audible click to confirm the correct installation of the engine connector (3).
93. Install the engine connector (3) into the body harness connector (1).

cardiagn.com



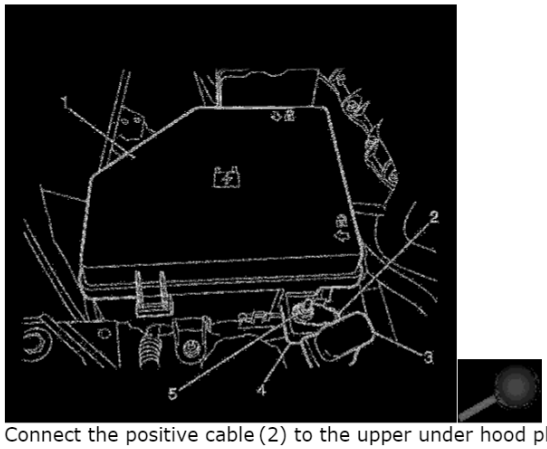
94. Install the protector (1) to the base of the under hood connector (2).



95. Install the upper under hood plate (1) to the lower under hood plate (3).

Note: The under hood upper plate to lower plate retaining bolts (2) DO NOT have a torque specification. Listen for an audible clicking sound whilst tightening the under hood upper plate to lower plate retaining bolts (2) to confirm correct fitting.

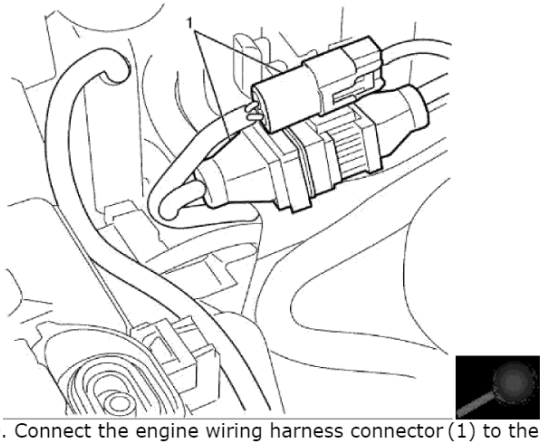
96. Install the under hood upper plate to lower plate retaining bolts (2).



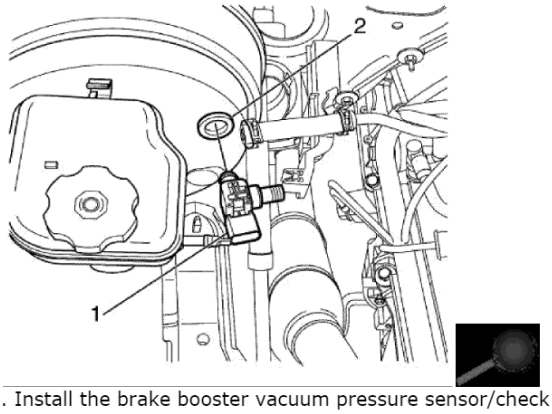
97. Connect the positive cable (2) to the upper under hood plate (4).

cardiagn.com

98. Install the positive cable to under hood plate retaining nut (5) and tighten to **10 N•m (89 lb in)**.
99. Install the under hood body electrical centre lid (1).



100. Connect the engine wiring harness connector (1) to the main engine wiring harness.
101. Connect the engine control module connectors. Refer to Engine Control Module Replacement.

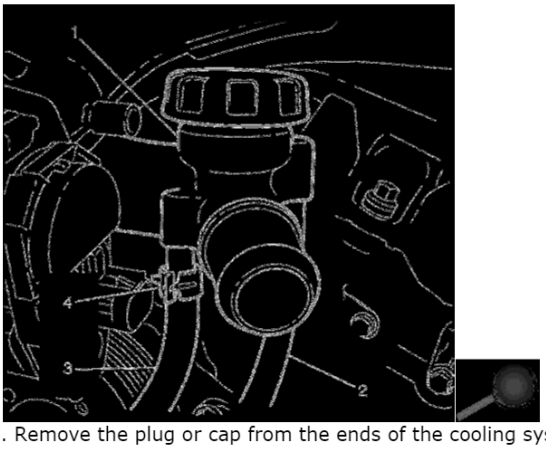


102. Install the brake booster vacuum pressure sensor/check valve (1) to the break booster.
103. Connect the engine wiring harness to the brake booster vacuum pressure sensor/check valve (1) .

cardiagn.com

Note: Listen for a audible click to confirm correct fitting of the heater hoses.

104. Install the heater hoses (1) to the heater pipe (2).



105. Remove the plug or cap from the ends of the cooling system hoses (3) and (2).
106. Install the coolant bleed hose (3) to the outlet housing (1).
107. Compress the coolant bleed hose retaining clamp (4) and position the coolant bleed hose retaining clamp (4) to its original position on the coolant bleed hose (3).
108. Install the coolant recovery hose (2) to the outlet housing (1).
109. Install the radiator outlet hose. Refer to Radiator Outlet Hose Replacement.
110. Connect the battery ground cable. Refer to Battery Negative Cable Disconnection and Connection.
111. Fill the cooling system. Refer to Cooling System Draining and Filling.

Note: Prelube is necessary if the engine is replaced or overhauled.

112. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to Engine Prelubing.
113. If prelubing has not been performed, fill the engine oil and install the oil filter. Refer to Engine Oil and Oil Filter Replacement.
114. Install the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement.

Note: The A/C receiver and dehydrator are single use components.

115. Replace the A/C receiver and dehydrator. Refer to Receiver and Dehydrator Replacement.
116. Evacuate and recharge the A/C system. Refer to Refrigerant Recovery and Recharging.
117. Install the air inlet grille. Refer to Air Inlet Grille Panel Replacement.

cardiagn.com

118. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.
119. Disable the ignition system with the scan tool.
120. Crank the engine several times and listen for any unusual noises.
121. Enable the ignition system.
122. Start the engine and listen for unusual noises.
123. Check the engine oil pressure and confirm that the engine oil pressure is acceptable.
124. Run the engine at about 1,000 RPM until the engine has reached normal operating temperature.
125. Listen for sticking stationary hydraulic lash adjuster, (SHLAs) (valve lifters) and other unusual noises.

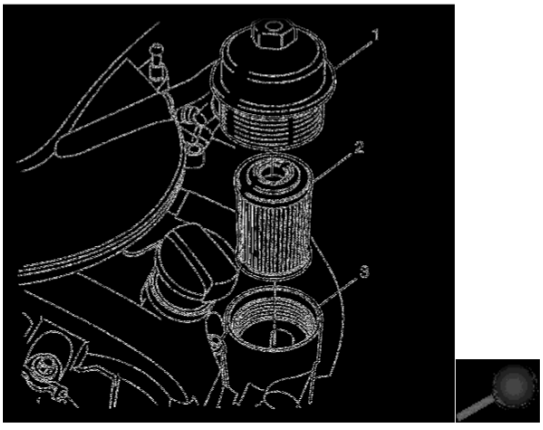
    Note: When adding or changing transmission fluid use only recommend automatic transmission fluid.
126. Check the transmission fluid level and top up if required.
127. Inspect for fuel, oil, and/or other coolant leaks while the engine is running.
128. Leak test the A/C system using the *J 39400-A* halogen leak detector.

cardiagn.com

Engine Oil and Oil Filter Replacement (LFW)

Removal Procedure

1. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



Note: Use a six-point socket to remove the oil filter adaptor cap (1).

2. Remove the oil filter adapter cap (1) with the oil filter cartridge (2) from the engine oil filter adapter (3).

Note: The oil filter cartridge (2) must be replaced at every service interval.

3. Remove the oil filter cartridge (2) from the oil filter adaptor cap (1).

Discard the oil filter cartridge (2) .

Discard the oil filter adaptor cap O-ring.

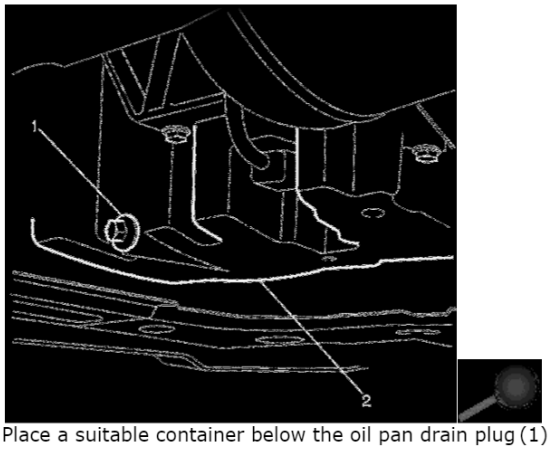
Danger: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

Warning: Refer to Safety Glasses Warning.

4. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
5. Remove the oil pan shield. Refer to Oil Pan Shield Replacement.

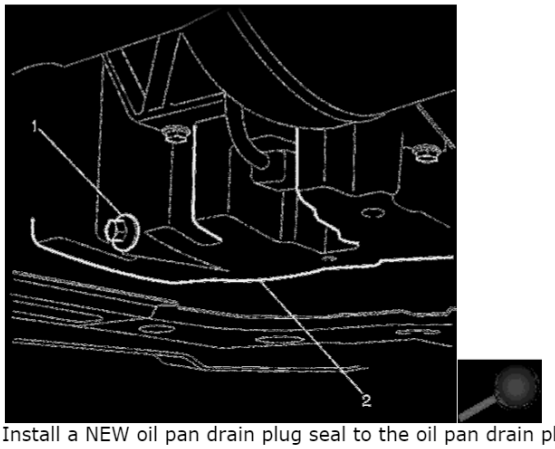
cardiagn.com

© 2014 General Motors. All rights reserved.



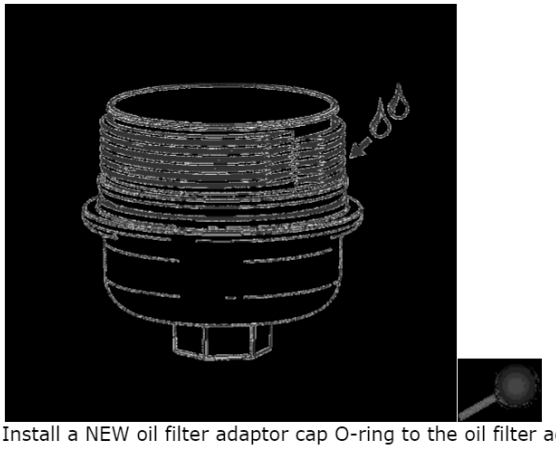
6. Place a suitable container below the oil pan drain plug (1).
7. Remove the oil pan drain plug (1) from the oil pan (2).
8. Allow all the oil to drain.
9. Remove and discard the oil pan drain plug seal.

Installation Procedure

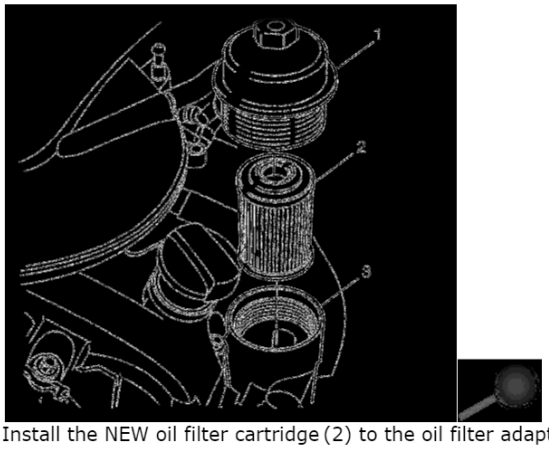


1. Install a NEW oil pan drain plug seal to the oil pan drain plug (1).
   Caution: Refer to Fastener Caution.
2. Install the oil pan drain plug (1) to the oil pan (2) and tighten to **25 N•m (18 lb ft)**.
3. Install the oil pan shield. Refer to Oil Pan Shield Replacement.
4. Lower the vehicle.

cardiagn.com



5. Install a NEW oil filter adaptor cap O-ring to the oil filter adaptor cap.
6. Lubricate the oil filter cap O-ring and threads with clean engine oil.



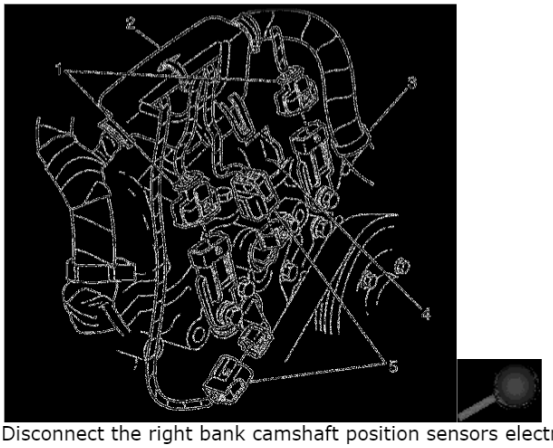
7. Install the NEW oil filter cartridge (2) to the oil filter adaptor cap (1).

   Note: Use a six-point socket to install the oil filter adaptor cap.
8. Install the oil filter adaptor cap (1) with the oil filter cartridge (2) to the engine oil filter adapter (3) and tighten to **30 N•m (22 lb ft)**.
9. Fill the engine with the correct quantity of oil. Refer to Approximate Fluid Capacities
10. Fill the engine with the correct oil type. Refer to Fluid and Lubricant Recommendations.
11. Install the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.

cardiagn.com

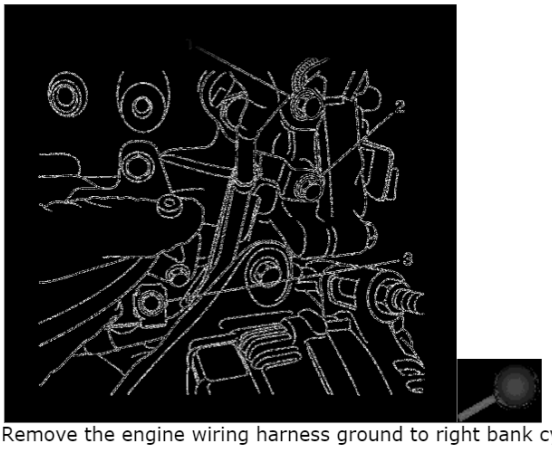
Engine Wiring Harness Assembly Removal (LWR)

Warning: Refer to Safety Glasses Warning.



1. Disconnect the right bank camshaft position sensors electrical connectors (1).
2. Disconnect the right bank intake and exhaust camshaft position actuator valve electrical connectors (5).
3. Detach the engine wiring harness to cylinder head retaining lug (3).

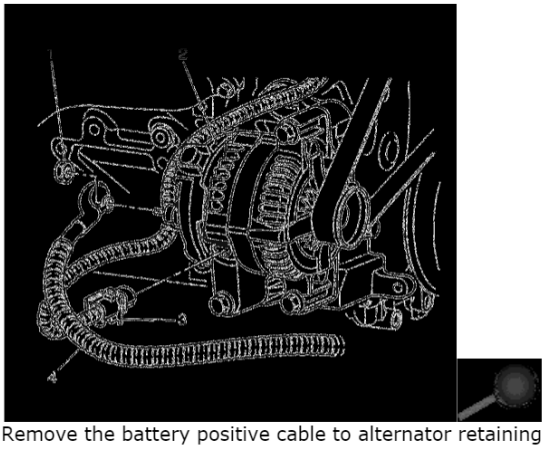
   Note: Use a suitable tool to detach the engine wiring harness bracket (2) from the retainer (4) on the right bank camshaft cover. Slide the engine wiring harness bracket (2) upward to detach it from the right bank camshaft cover (4).
4. Detach the engine wiring harness bracket (2) from the right bank camshaft cover (4).



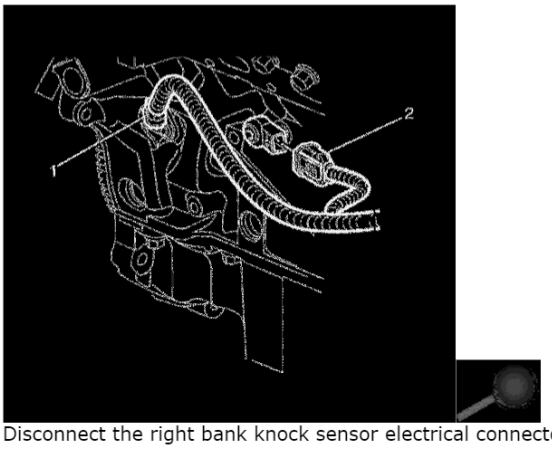
5. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
6. Remove the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
7. Remove the engine wiring harness bracket to cylinder block retaining bolt (3).

cardiagn.com

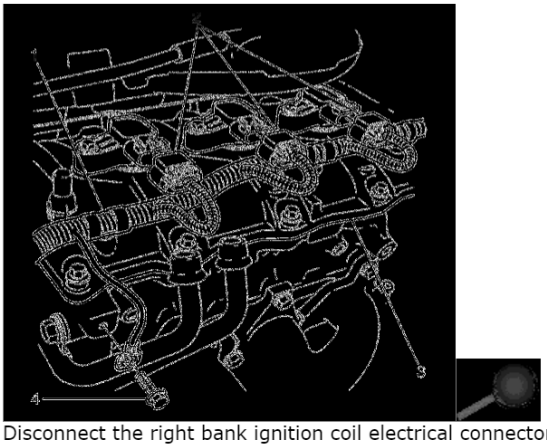
© 2014 General Motors. All rights reserved.



8. Remove the battery positive cable to alternator retaining nut (1).
9. Disconnect the battery positive cable (4) from the alternator (2).
10. Disconnect the engine harness connector (3) from the alternator (2).



11. Disconnect the right bank knock sensor electrical connector (2).
12. Disconnect the crankshaft position sensor electrical connector (1).



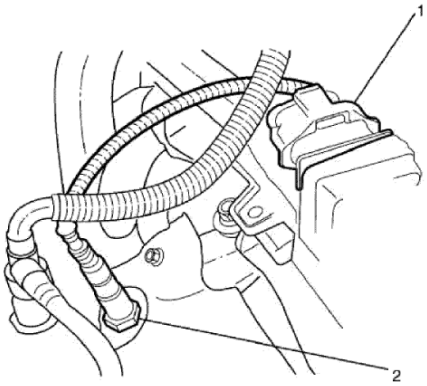
13. Disconnect the right bank ignition coil electrical connectors (2).

cardiagn.com

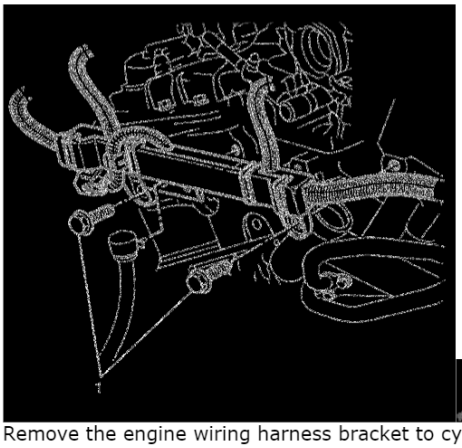
14. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (4).

    Note: Use a suitable tool to detach the engine wiring harness clips (1) from the right bank camshaft cover (3).

15. Detach the engine wiring harness (1) from the right bank camshaft cover (3).

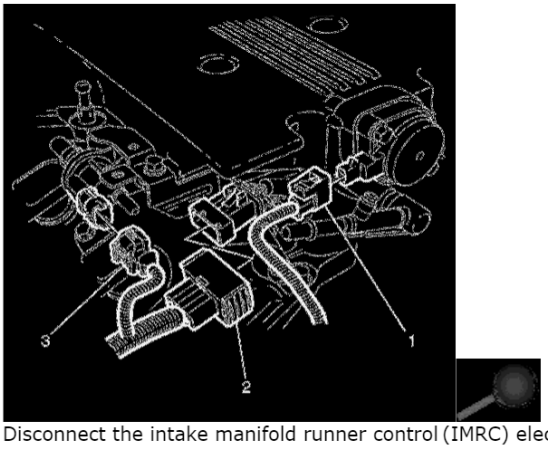


16. Disconnect the right bank heated oxygen sensor (HO2S) electrical connector (1) from the engine wiring harness connector.

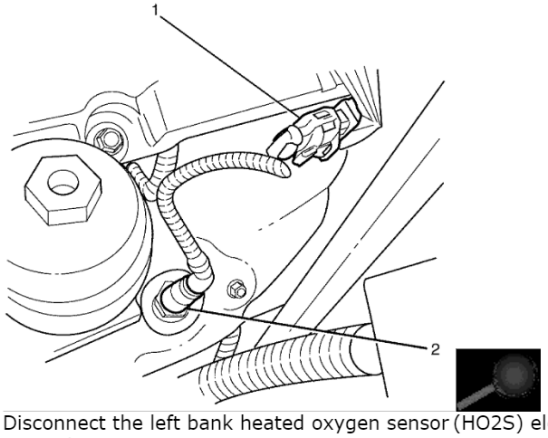


17. Remove the engine wiring harness bracket to cylinder head retaining bolts (1).

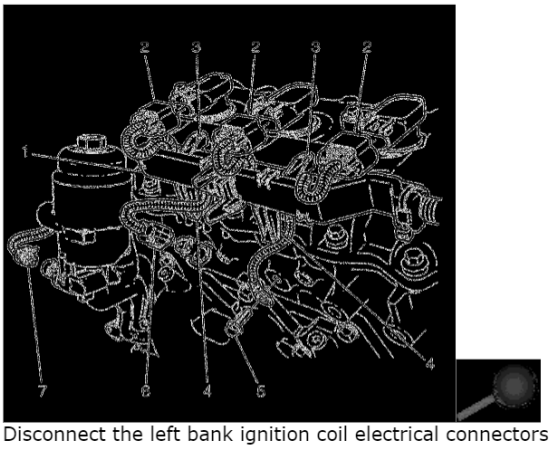
cardiagn.com



18. Disconnect the intake manifold runner control (IMRC) electrical connector (1).
19. Disconnect the injector harness electrical connector (2).
20. Disconnect the purge solenoid valve electrical connector (3).



21. Disconnect the left bank heated oxygen sensor (HO2S) electrical connector (1) from the engine wiring harness.



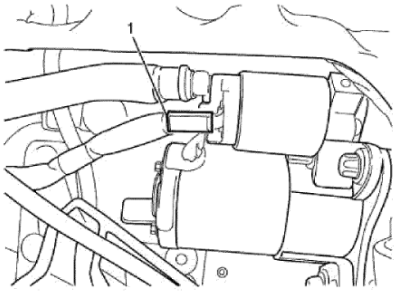
22. Disconnect the left bank ignition coil electrical connectors (2).

cardiagn.com

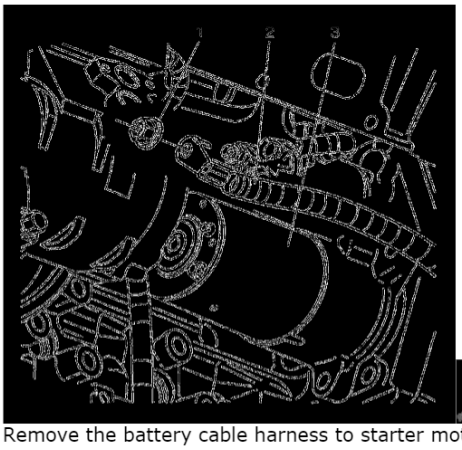
23. Remove the engine wiring harness ground to left bank cylinder head retaining bolt (5).
24. Disconnect the coolant temperature sensor electrical connector (6).
25. Disconnect the oil pressure sensor electrical connector (7).

Note: Use a suitable tool to detach the engine wiring harness (1) from the right bank camshaft cover retainers (4) and lift upward to detach the engine wiring harness (1) from the right bank camshaft cover lugs (3).

26. Detach the engine wiring harness bracket (1) from the left bank camshaft cover lugs (3).

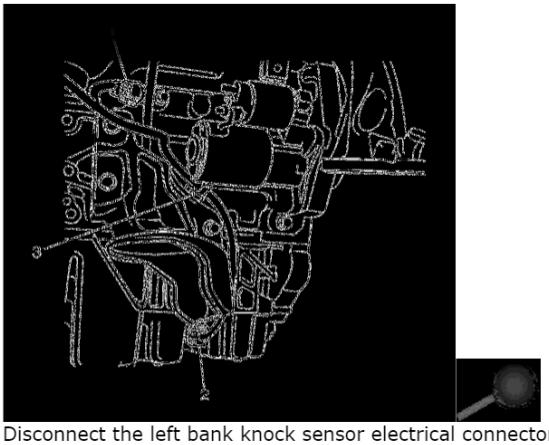


27. Disconnect the starter motor electrical connector (1).

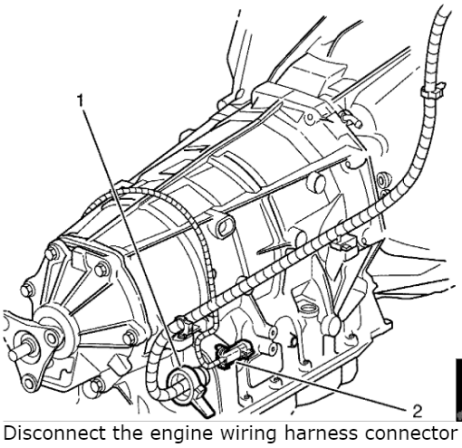


28. Remove the battery cable harness to starter motor retaining nut (1).
29. Disconnect the battery cable (2) from the starter motor (3).

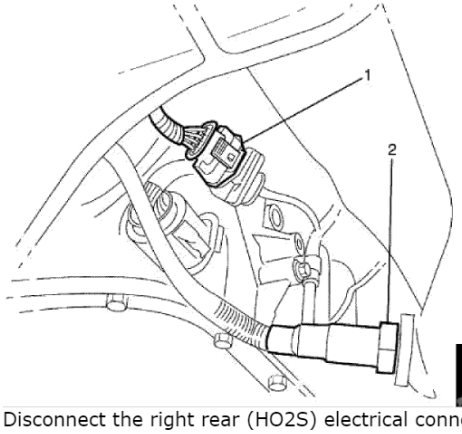
cardiagn.com



30. Disconnect the left bank knock sensor electrical connector (1).
31. Disconnect the oil level sensor electrical connector (2).
32. Detach the engine wiring harness to cylinder block retaining lug (3).

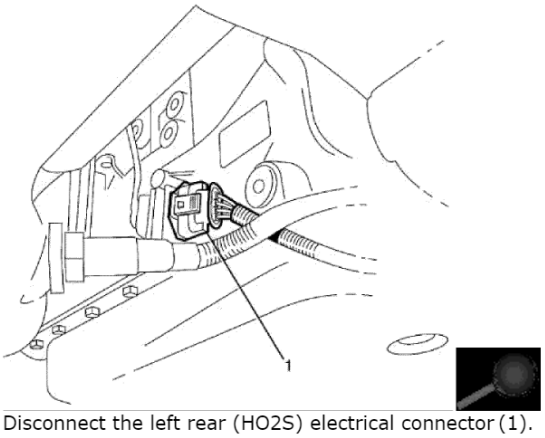


33. Disconnect the engine wiring harness connector (1) from the transmission.

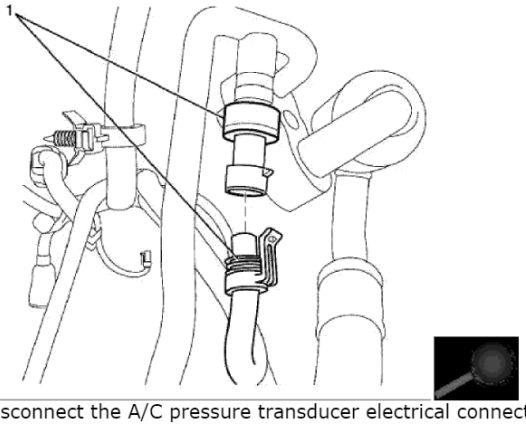


34. Disconnect the right rear (HO2S) electrical connector (1).

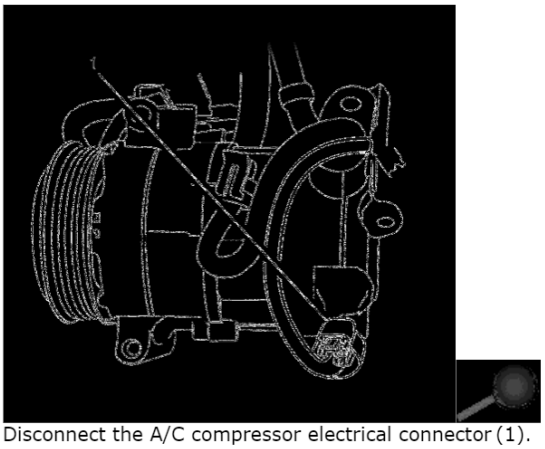
cardiagn.com



35. Disconnect the left rear (HO2S) electrical connector (1).

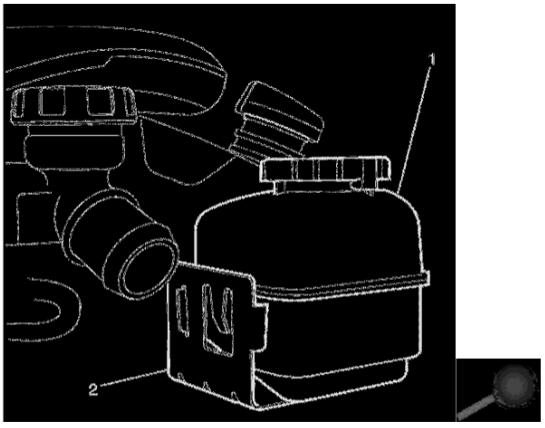


36. Disconnect the A/C pressure transducer electrical connector (1).



37. Disconnect the A/C compressor electrical connector (1).

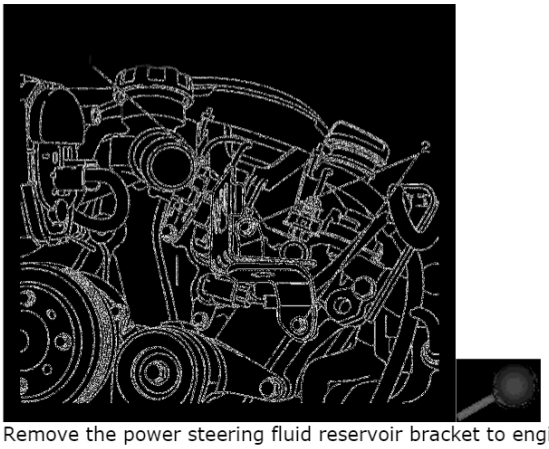
cardiagn.com



Note: DO NOT disconnect the power steering pipes or drain the power steering fluid.

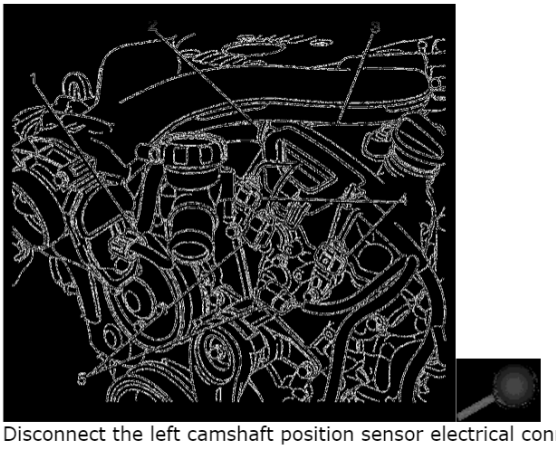
Note: The locking tang on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1).

38. Release the locking tang on the power steering reservoir bracket (2) with a suitable tool.
39. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).
40. Reposition the power steering fluid reservoir away from the power steering fluid reservoir bracket (2).



41. Remove the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
42. Remove the power steering fluid reservoir bracket (1).

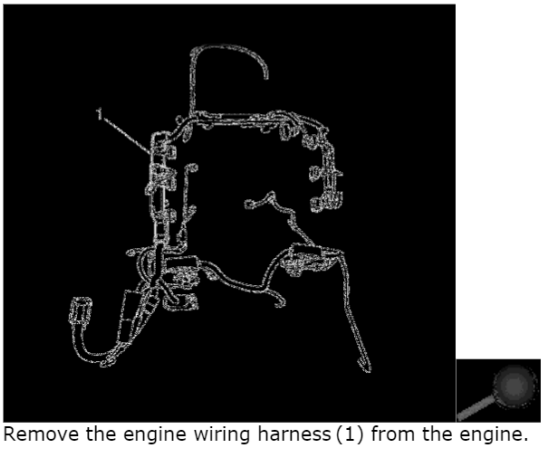
cardiagn.com



43. Disconnect the left camshaft position sensor electrical connectors (4).
44. Disconnect the left bank intake and exhaust camshaft position actuator valve electrical connectors (5).
45. Disconnect the throttle position sensor electrical connector (1).

Note: Use a suitable tool to detach the engine wiring harness bracket (2) from the left bank camshaft cover (3). Slide the engine wiring harness bracket (2) upward to detach it from the left bank camshaft cover (4).

46. Detach the engine wiring harness bracket (2) from the left bank camshaft cover (3).

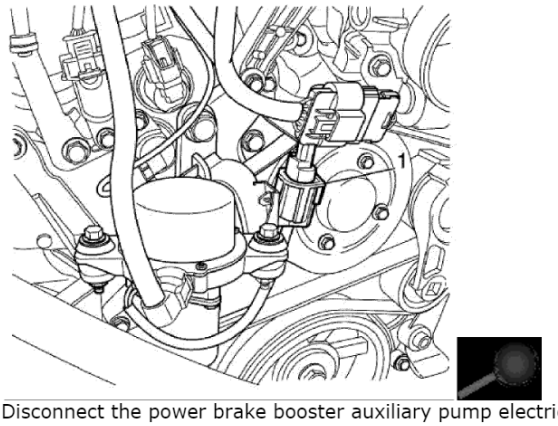


47. Remove the engine wiring harness (1) from the engine.

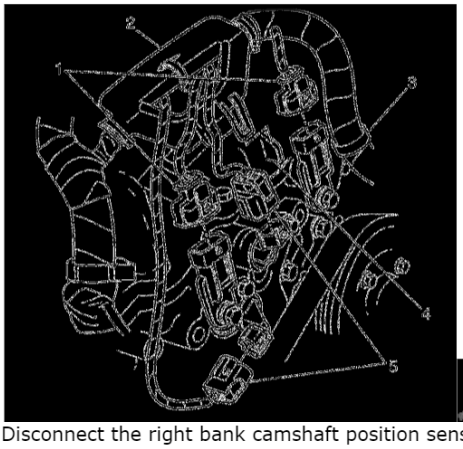
cardiagn.com

Engine Wiring Harness Assembly Removal (LFW or LFX)

Warning: Refer to Safety Glasses Warning.



1. Disconnect the power brake booster auxiliary pump electrical connector (1).

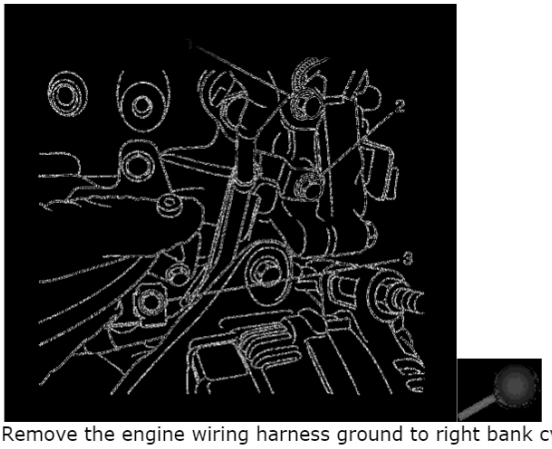


2. Disconnect the right bank camshaft position sensor electrical connectors (1).
3. Disconnect the right bank intake and exhaust camshaft position actuator solenoid valve electrical connectors (5).
4. Detach the engine wiring harness to cylinder head retaining lug (3).

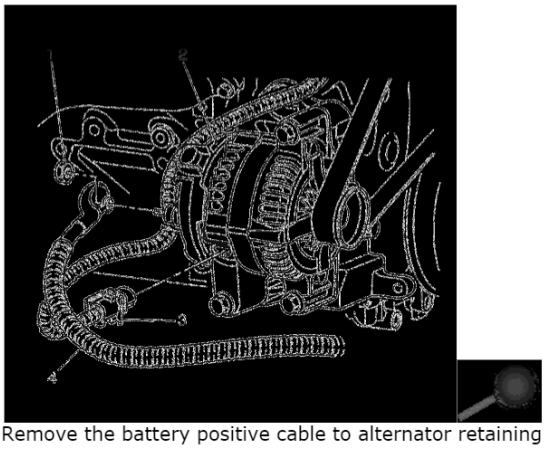
   Note: Use a suitable tool to detach the engine wiring harness bracket (2) from the retainer (4) on the right bank camshaft cover. Slide the engine wiring harness bracket (2) upward to detach it from the right bank camshaft cover (4).
5. Detach the engine wiring harness bracket (2) from the right bank camshaft cover (4).

cardiagn.com

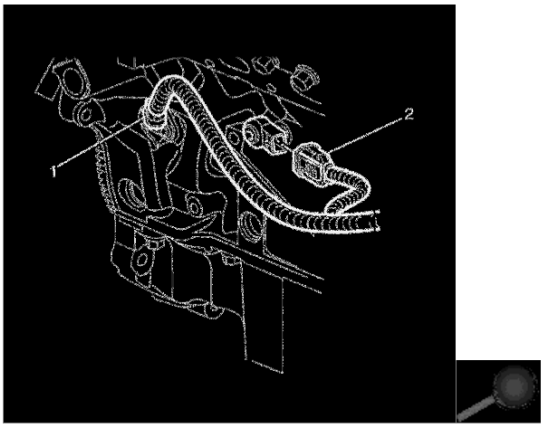
© 2014 General Motors. All rights reserved.



6. Remove the engine wiring harness ground to right bank cylinder head retaining bolt (1).
7. Remove the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
8. Remove the engine wiring harness bracket to cylinder block retaining bolt (3).

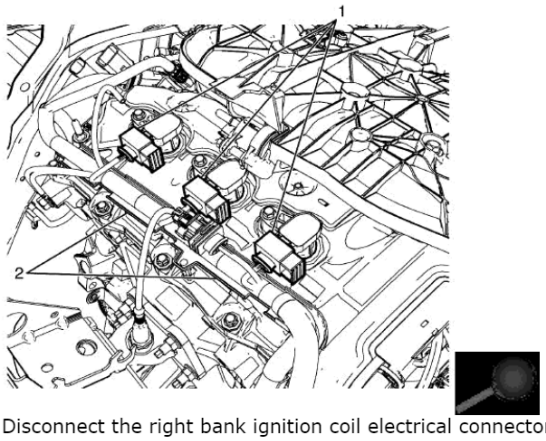


9. Remove the battery positive cable to alternator retaining nut (1).
10. Disconnect the battery positive cable (4) from the alternator (2).
11. Disconnect the engine harness connector (3) from the alternator (2).



cardiagn.com

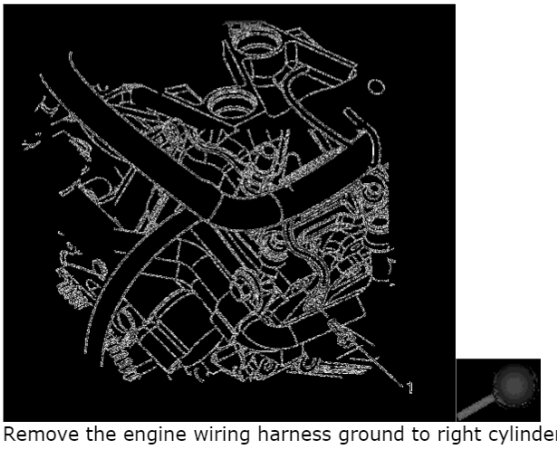
12. Disconnect the right bank knock sensor electrical connector (2).
13. Disconnect the crankshaft position sensor electrical connector (1).



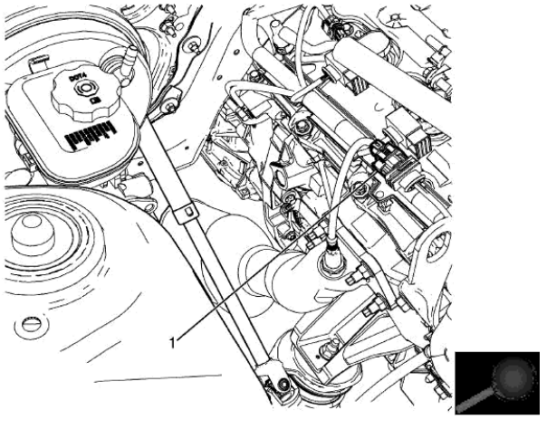
14. Disconnect the right bank ignition coil electrical connectors (1).

Note: Use a suitable tool to detach the engine wiring harness from the camshaft cover.

15. Detach the engine wiring harness (2) from the right bank camshaft cover.

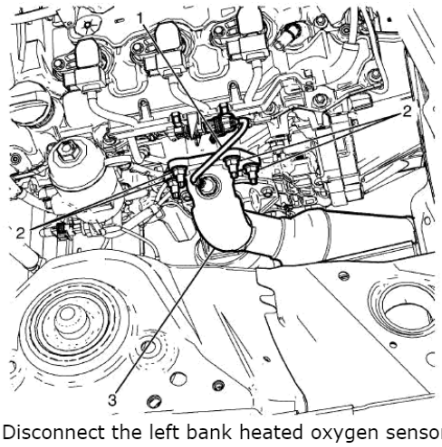


16. Remove the engine wiring harness ground to right cylinder head retaining bolt (1).

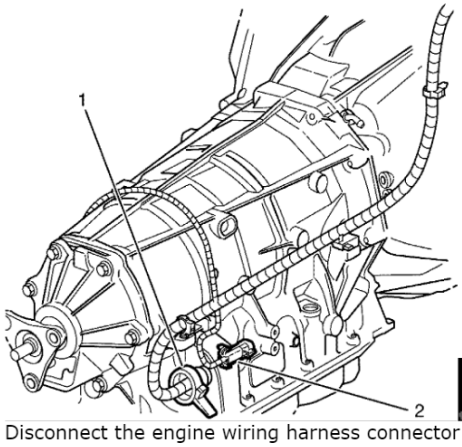


cardiagn.com

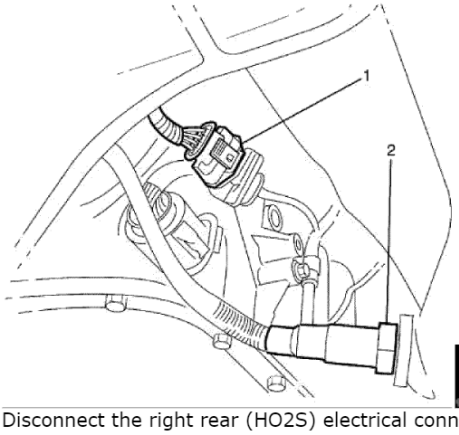
17. Disconnect the right bank heated oxygen sensor (HO2S) electrical connector (1) from the engine wiring harness connector.



18. Disconnect the left bank heated oxygen sensor (HO2S) electrical (1) from the engine wiring harness.

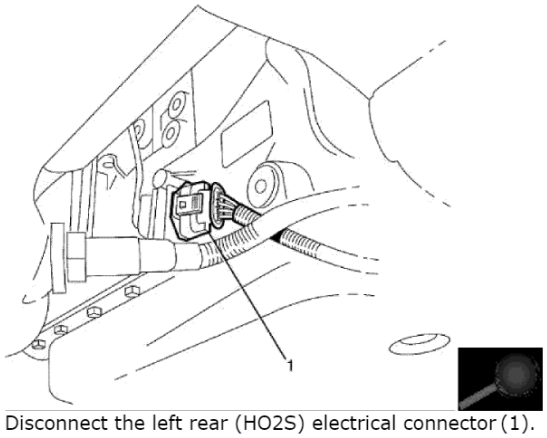


19. Disconnect the engine wiring harness connector (1) from the transmission.

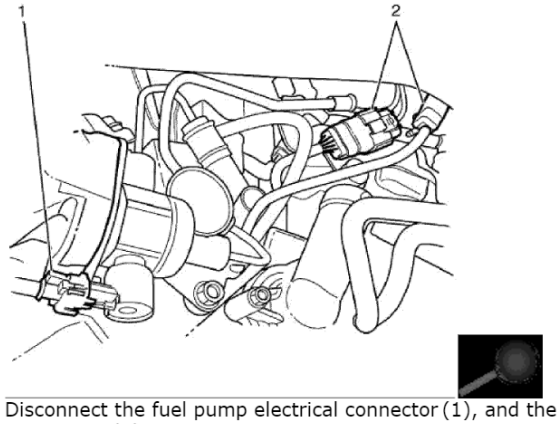


20. Disconnect the right rear (HO2S) electrical connector (1).

cardiagn.com

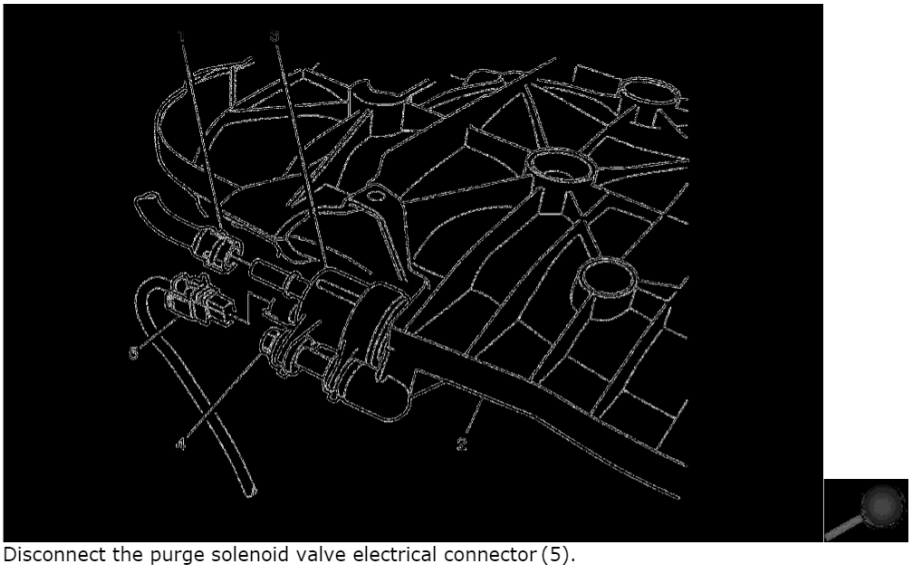


21. Disconnect the left rear (HO2S) electrical connector (1).

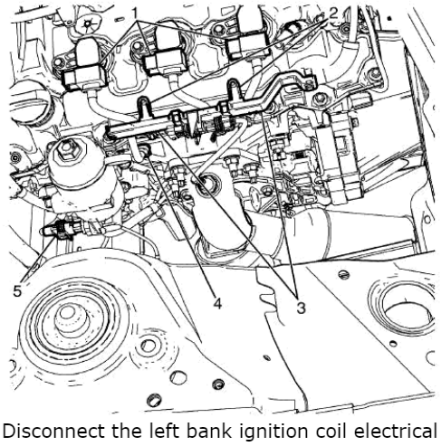


22. Disconnect the fuel pump electrical connector (1), and the fuel injector electrical harness connectors (2).

cardiagn.com



23. Disconnect the purge solenoid valve electrical connector (5).

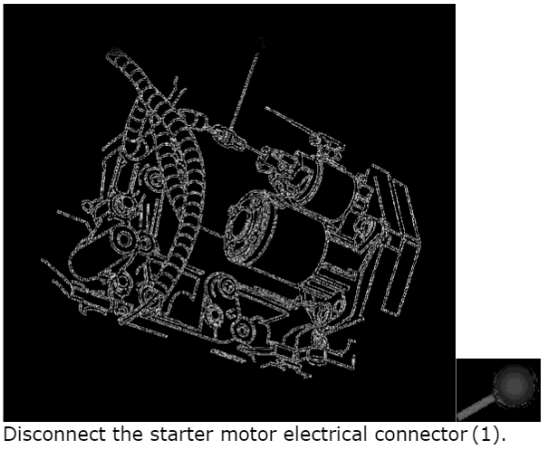


24. Disconnect the left bank ignition coil electrical connectors (1).
25. Disconnect the coolant temperature sensor electrical connector (4).
26. Disconnect the oil pressure sensor electrical connector (5).

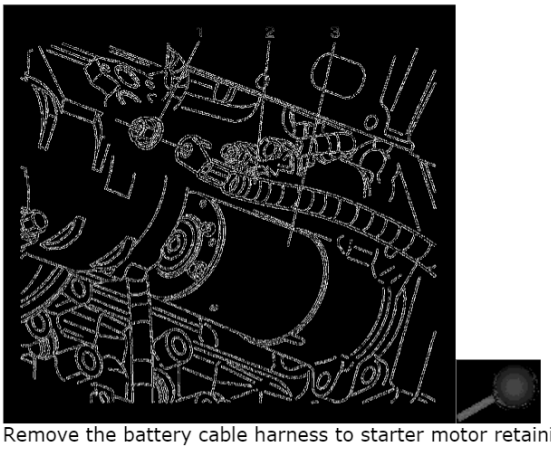
Note: Use a suitable tool to detach the engine wiring harness (3) from the right bank camshaft cover retainers (2) and lift upward to detach the engine wiring harness (3) from the right bank camshaft cover retainers (2).

27. Detach the engine wiring harness (3) from the right bank camshaft cover retainers (2).

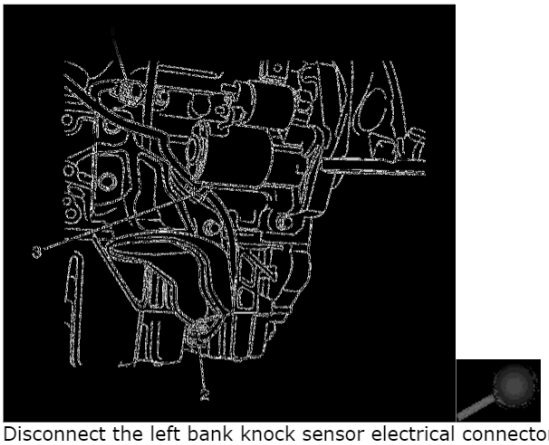
cardiagn.com



28. Disconnect the starter motor electrical connector (1).

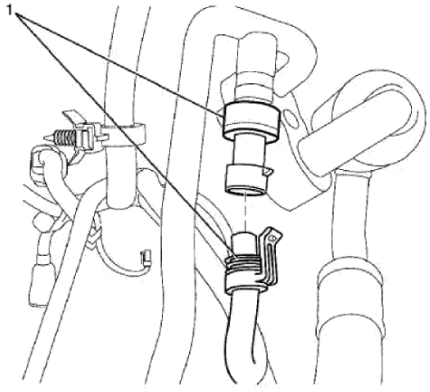


29. Remove the battery cable harness to starter motor retaining nut (1).
30. Disconnect the battery cable harness (2) from the starter motor (3).

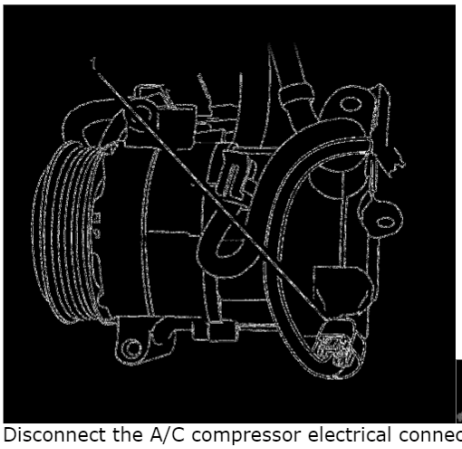


31. Disconnect the left bank knock sensor electrical connector (1).
32. Disconnect the oil level sensor electrical connector (2).
33. Detach the engine wiring harness to cylinder block retaining lug (3).

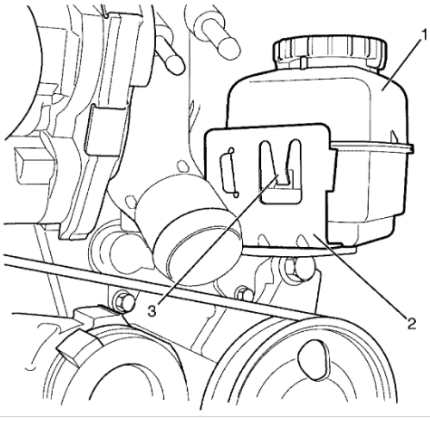
cardiagn.com



34. Disconnect the A/C pressure transducer electrical connector (1).



35. Disconnect the A/C compressor electrical connector (1).



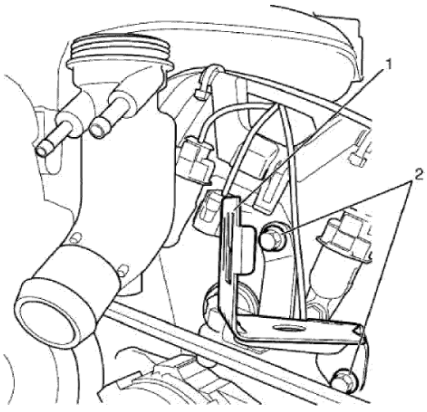
Note: DO NOT disconnect the power steering pipes or drain the power steering fluid.

Note: The locator tang (3) on the power steering reservoir bracket (2) must be released before removing the power steering reservoir (1).

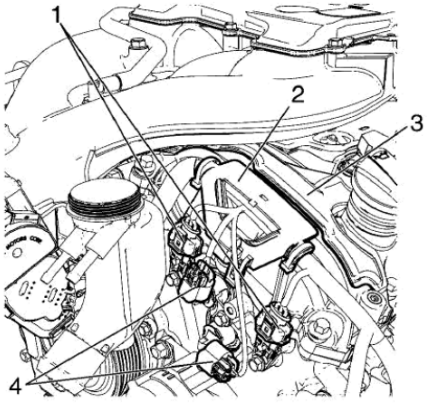
36. Release the locator tang (3) on the power steering reservoir bracket (2) with a suitable tool.

cardiagn.com

37. Separate power steering fluid reservoir (1) from the power steering fluid reservoir bracket (2).
38. Reposition the power steering fluid reservoir away from the power steering fluid reservoir bracket (2).

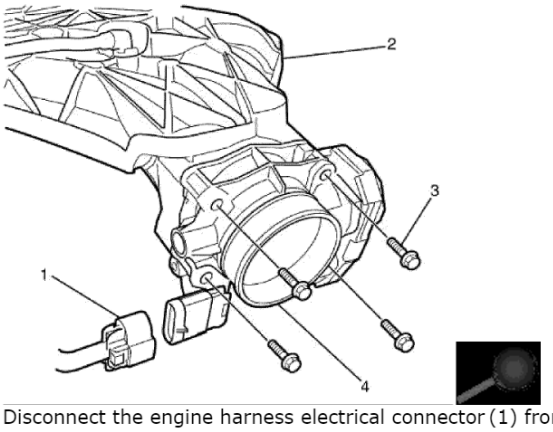


39. Remove the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
40. Remove the power steering fluid reservoir bracket (1).

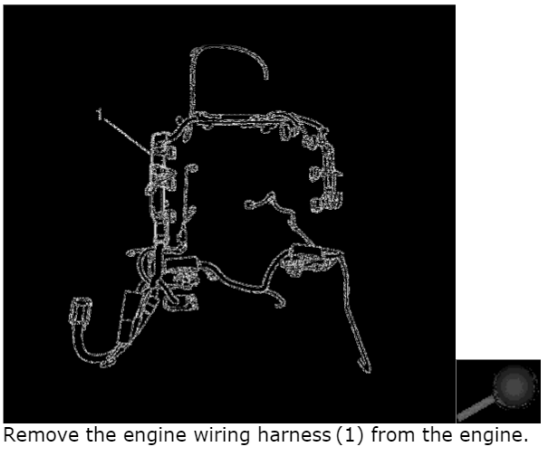


41. Disconnect the left camshaft position sensors electrical connectors (1).
42. Disconnect the left bank intake and exhaust camshaft position actuator valve electrical connectors (4).
43. Detach the engine wiring harness bracket (2) from the left bank camshaft cover (3).

cardiagn.com



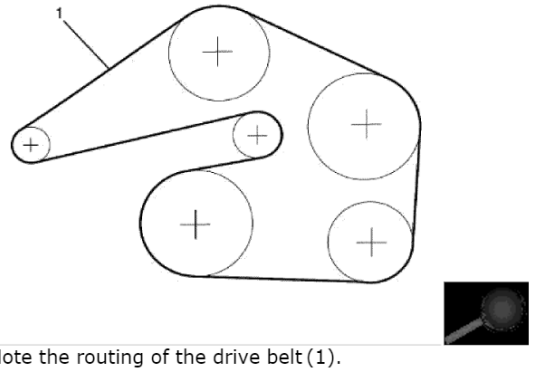
44. Disconnect the engine harness electrical connector (1) from the throttle body.



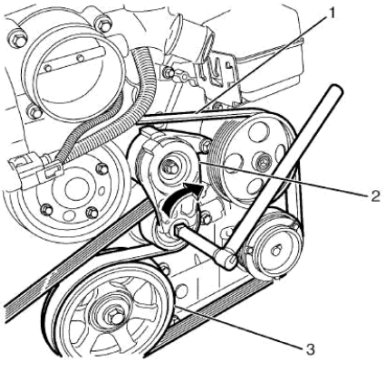
45. Remove the engine wiring harness (1) from the engine.

cardiagn.com

Drive Belt Removal



1. Note the routing of the drive belt (1).



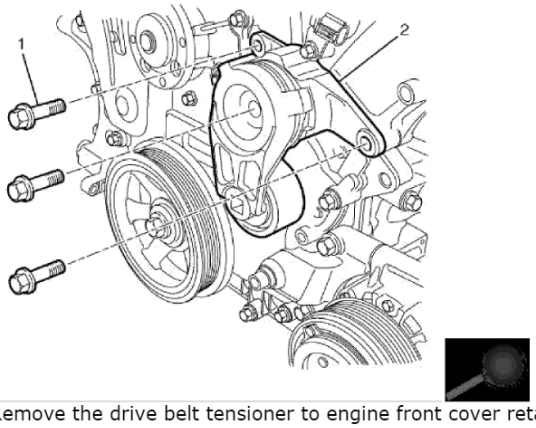
2. Using a suitable tool rotate the drive belt tensioner (2) clockwise to release the tension on the drive belt (1).
3. Remove the drive belt from the crankshaft pulley (3).
4. Slowly release the drive belt tensioner (2).
5. Remove the drive belt (1) from the engine.

cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Tensioner Removal

1. Remove the drive belt. Refer to Drive Belt Replacement.

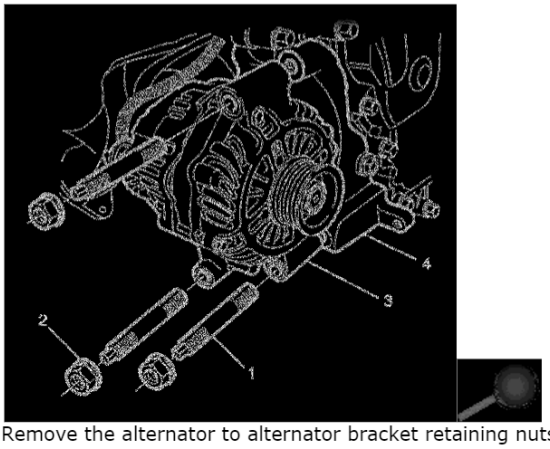


2. Remove the drive belt tensioner to engine front cover retaining bolts (1).
3. Remove the drive belt tensioner (2) from the engine front cover.

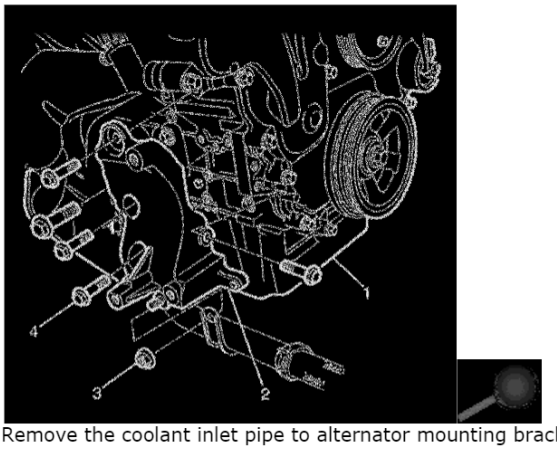
cardiagn.com

© 2014 General Motors. All rights reserved.

Generator Removal



1. Remove the alternator to alternator bracket retaining nuts (2).
2. Remove the alternator to alternator bracket retaining studs (1).
3. Remove the alternator (3) from the alternator bracket (4).

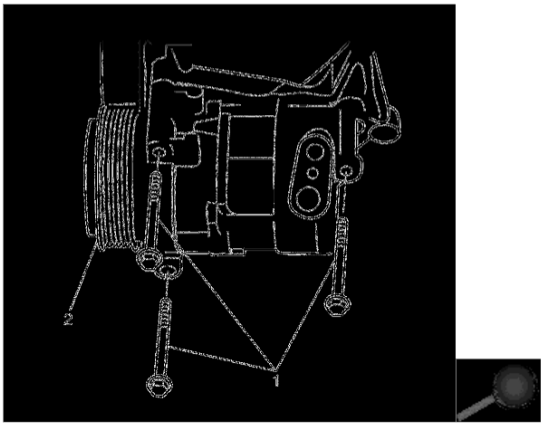


4. Remove the coolant inlet pipe to alternator mounting bracket retaining nut (3)
5. Remove the alternator mounting bracket to cylinder block retaining bolts (4).
6. Remove the alternator mounting bracket (2) from the cylinder block (1).

cardiagn.com

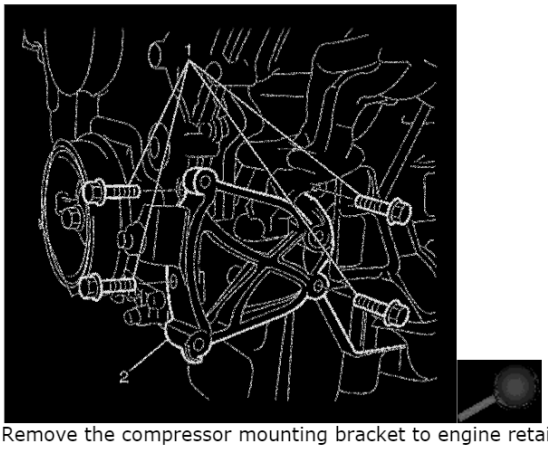
© 2014 General Motors. All rights reserved.

Air Conditioning (A/C) Compressor Removal



Important: The compressor must be supported before removing the compressor to compressor mounting bracket retaining bolts (1).

1. Remove the compressor to compressor mounting bracket retaining bolts (1).
2. Remove the compressor (2) by sliding forwards and upwards.

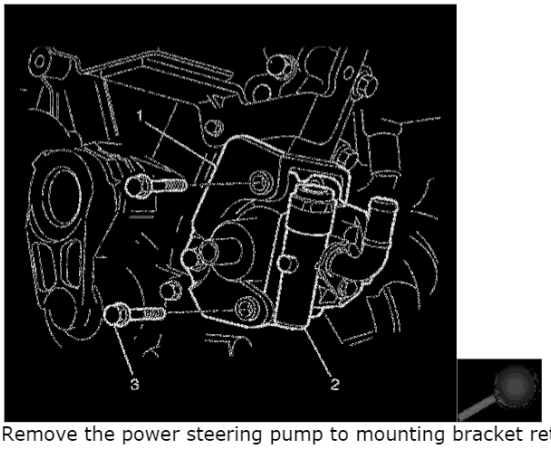


3. Remove the compressor mounting bracket to engine retaining bolts (1).
4. Remove the compressor mounting bracket (2).

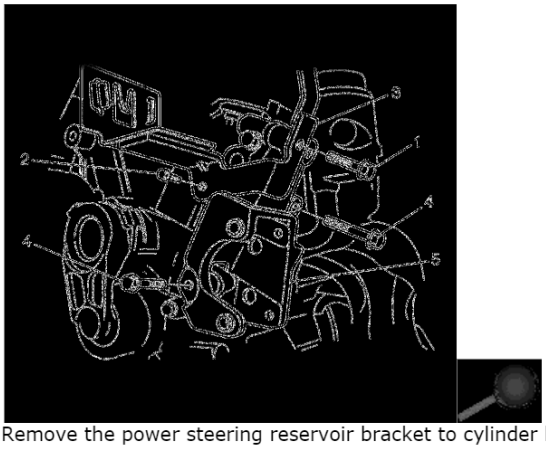
cardiagn.com

© 2014 General Motors. All rights reserved.

Power Steering Pump Removal



1. Remove the power steering pump to mounting bracket retaining bolts (3).
2. Remove the power steering pump (2) from the power steering pump mounting bracket (1).

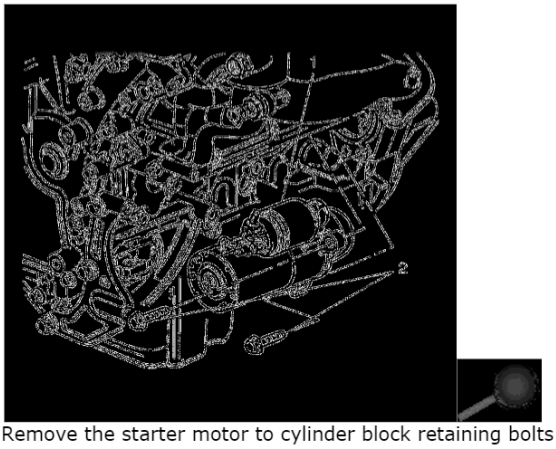


3. Remove the power steering reservoir bracket to cylinder head retaining bolt (1).
4. Remove the power steering reservoir bracket to engine front cover retaining bolt (2).
5. Remove the power steering reservoir bracket (3).
6. Remove the power steering pump bracket to cylinder head retaining bolts (4).
7. Remove the power steering pump bracket (5).

cardiagn.com

© 2014 General Motors. All rights reserved.

Starter Removal

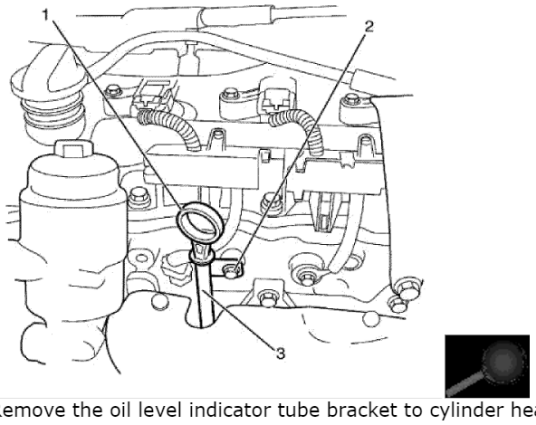


1. Remove the starter motor to cylinder block retaining bolts (2).
2. Remove the starter motor (1).

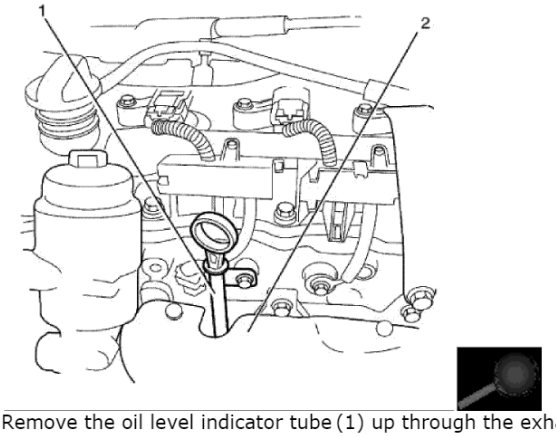
cardiagn.com

© 2014 General Motors. All rights reserved.

Oil Level Indicator and Tube Removal (LWR)



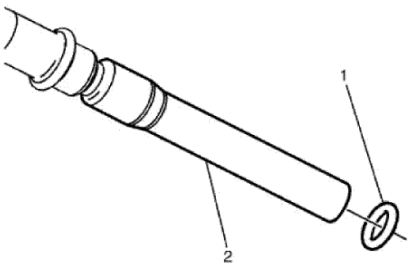
1. Remove the oil level indicator tube bracket to cylinder head retaining bolt (2).
2. Remove the oil level indicator (1) from the oil level indicator tube (3).



3. Remove the oil level indicator tube (1) up through the exhaust manifold (2).

cardiagn.com

© 2014 General Motors. All rights reserved.

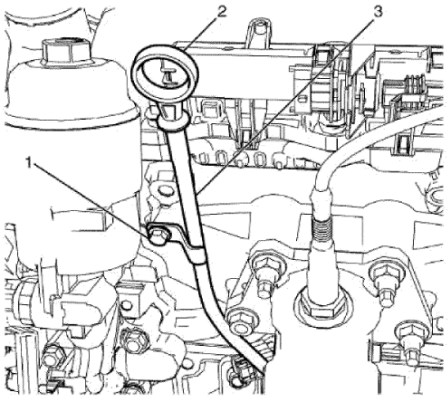


Note: The oil level indicator tube O-ring is a single use component.

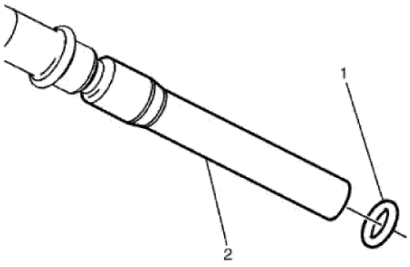
4. Remove the O-ring (1) from the oil level indicator tube (2) and discard.

cardiagn.com

Oil Level Indicator and Tube Removal (LFW or LFX)



1. Remove the oil level indicator (2) from the oil level indicator tube (3).
2. Remove the oil level indicator tube bracket to cylinder head retaining bolt (1).
3. Remove the oil level indicator tube by pulling upward on the oil level indicator tube.



Note: The oil level indicator tube O-ring is a single use component.

4. Remove the O-ring (1) from the oil level indicator tube (2) and discard.

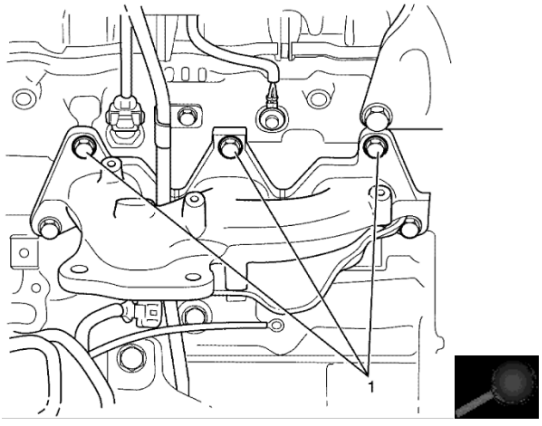
cardiagn.com

© 2014 General Motors. All rights reserved.

Exhaust Manifold Removal - Left Side (LWR)

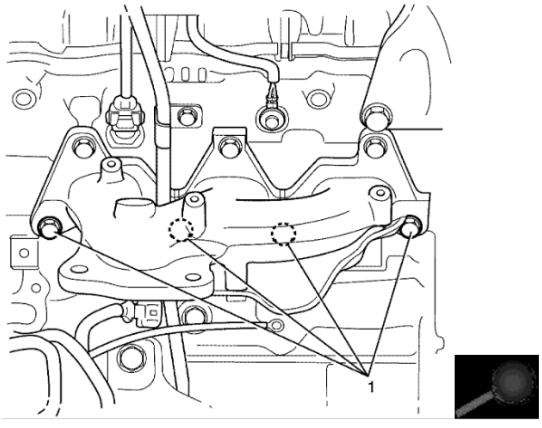
Removal Procedure

1. Remove the left bank heated oxygen sensor. Refer to Heated Oxygen Sensor Replacement - Bank 2 Sensor 1.
2. Remove the exhaust manifold heat shield. Refer to Exhaust Manifold Heat Shield Replacement - Left Side.



Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

3. Loosen the exhaust manifold to cylinder head retaining bolts (1) starting from the outside and working towards the centre.
4. Remove the exhaust manifold to cylinder head retaining bolts (1).
   Discard the bolts.



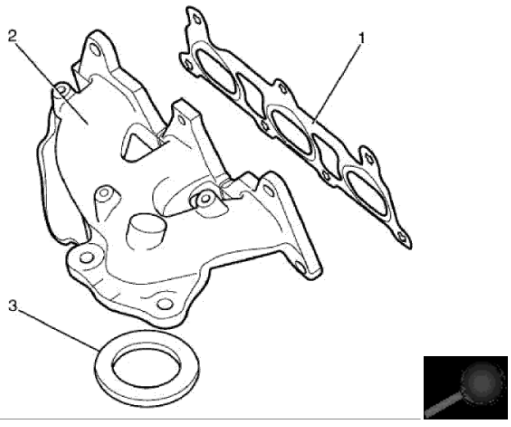
Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

5. Loosen the exhaust manifold to cylinder head retaining bolts (1) starting from the outside and working towards the centre.
6. Remove the exhaust manifold to cylinder head retaining bolts (1).

© 2014 General Motors. All rights reserved.

cardiagn.com

Discard the bolts.



Note: Make sure that the surrounding wiring harness and electrical connectors are not damaged when removing the exhaust manifold (2).

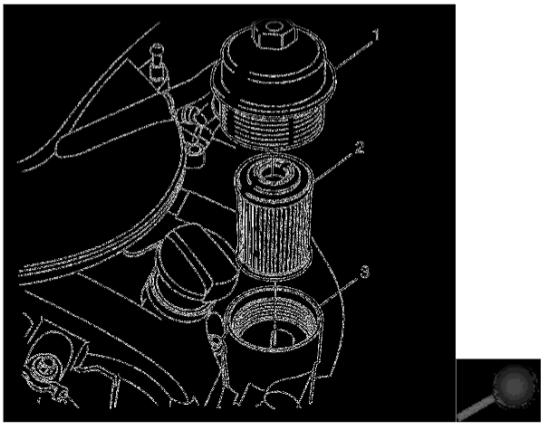
7. Remove the exhaust manifold (2) from the engine assembly.

Note: The exhaust manifold gasket (1) and sealing ring (3) are single use components.

8. Separate the exhaust manifold (2) from the exhaust manifold gasket (1) and sealing ring (3).
9. Discard the exhaust manifold gasket (1) and sealing ring (3).

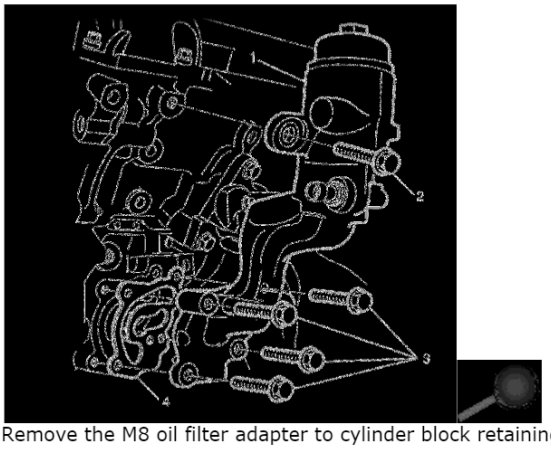
cardiagn.com

Oil Filter Adapter Removal



Important: Use a six-point socket to remove the oil filter cap (1).

1. Remove the oil filter adapter cap (1) from the engine oil filter adapter (3).
2. Remove the oil filter cartridge (2).
   Discard the oil filter cartridge (2).
3. Re-install the oil filter cap.



4. Remove the M8 oil filter adapter to cylinder block retaining bolts (3).
5. Remove the M10 oil filter adapter to cylinder head retaining bolt (2).
6. Remove the oil filter adapter (1).
7. Remove and discard the oil filter adapter gasket (4).

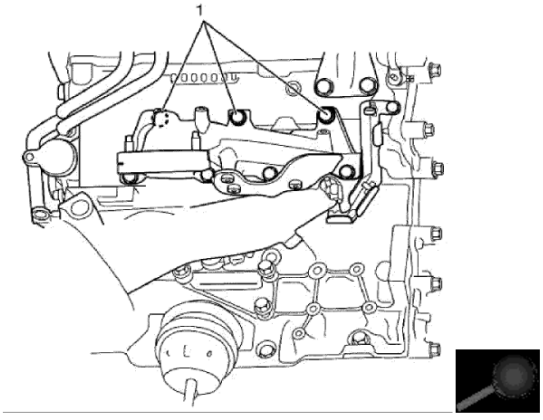
cardiagn.com

© 2014 General Motors. All rights reserved.

Exhaust Manifold Removal - Right Side (LWR)

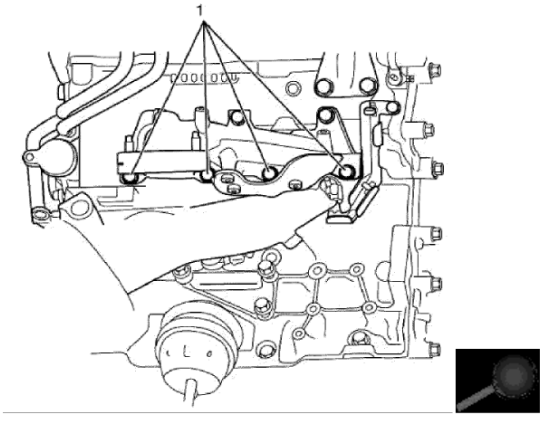
Removal Procedure

1. Remove the right bank heated oxygen sensor. Refer to Heated Oxygen Sensor Replacement - Bank 1 Sensor 1.
2. Remove the right side exhaust manifold heat shield. Refer to Exhaust Manifold Heat Shield Replacement - Right Side.



Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

3. Loosen the exhaust manifold to cylinder head retaining bolts (1) starting from the outside and working towards the centre.
4. Remove the exhaust manifold to cylinder head retaining bolts (1).
   Discard the bolts.



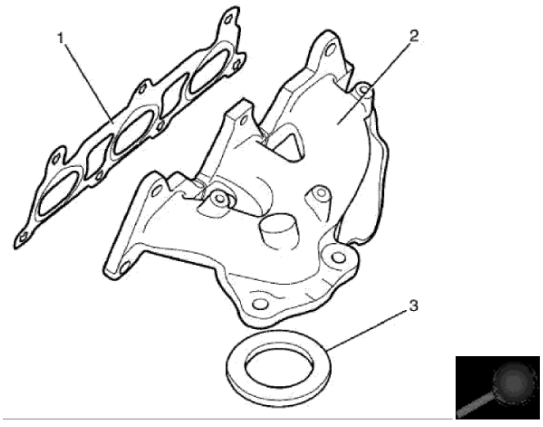
Note: Bolts with micro-encapsulated thread sealant must be discarded after removal.

5. Loosen the exhaust manifold to cylinder head retaining bolts (1) starting from the outside and working towards the centre.
6. Remove the exhaust manifold to cylinder head retaining bolts (1).

© 2014 General Motors. All rights reserved.

cardiagn.com

Discard the bolts.



Note: Make sure that the surrounding wiring harness and electrical connectors are not damaged when removing the exhaust manifold (2).

7. Remove the exhaust manifold (2) from the engine assembly.
8. Separate the exhaust manifold (2) from the exhaust manifold gasket (1) and sealing ring (3).

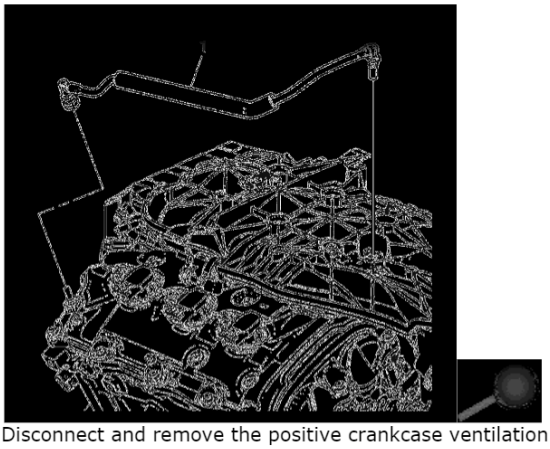
Note: The exhaust manifold gasket (1) and sealing ring (3) are single use components.

9. Discard the exhaust manifold gasket (1) and sealing ring (3).

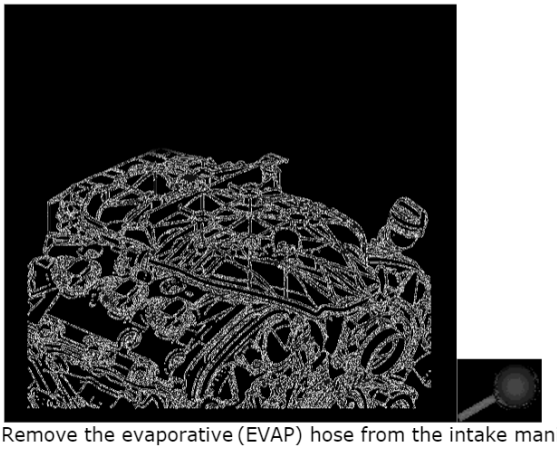
cardiagn.com

Intake Manifold Removal (LFW or LFX)

1. Remove the fuel pipe shield. Refer to Fuel Pipe Shield Replacement.



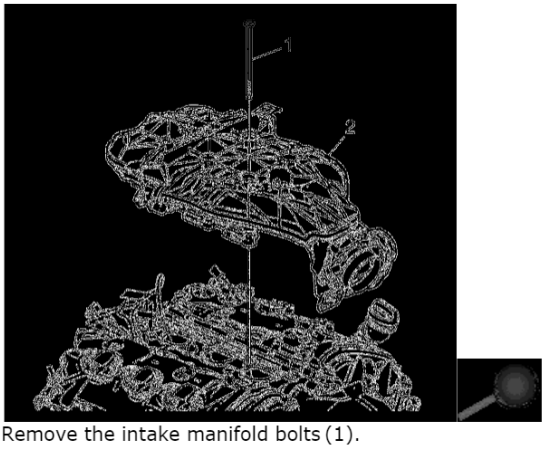
2. Disconnect and remove the positive crankcase ventilation (PCV) tube (1) from the intake manifold and right camshaft cover.



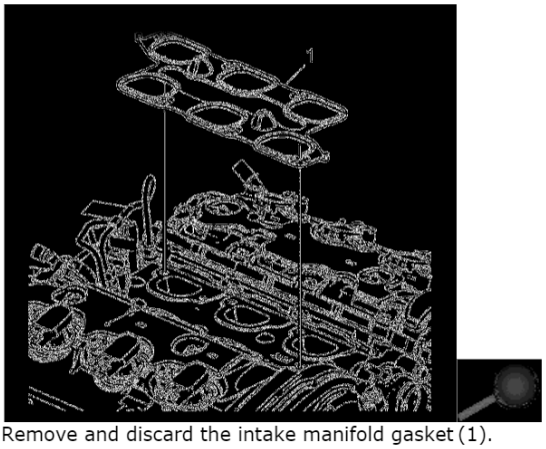
3. Remove the evaporative (EVAP) hose from the intake manifold and EVAP solenoid.

cardiagn.com

© 2014 General Motors. All rights reserved.



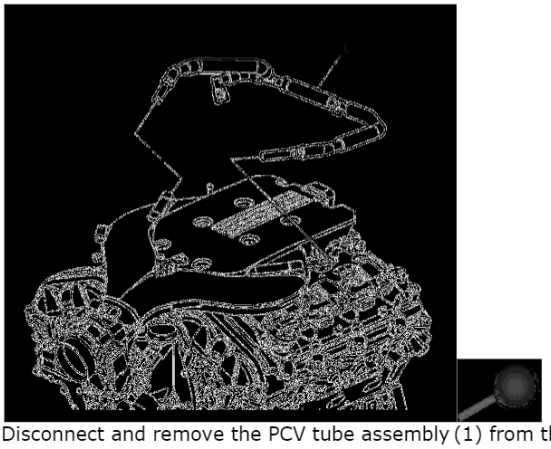
4. Remove the intake manifold bolts (1).
5. Remove the intake manifold assembly (2).



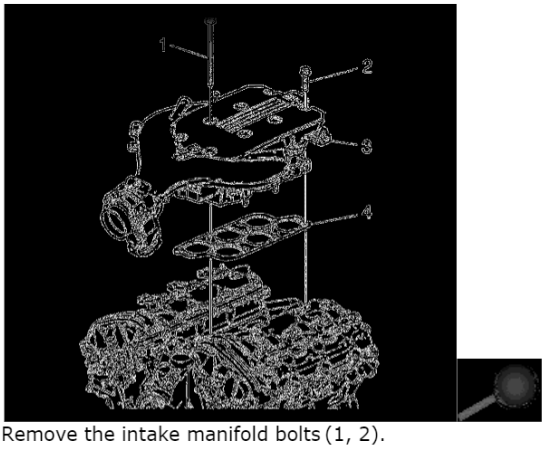
6. Remove and discard the intake manifold gasket (1).

cardiagn.com

Intake Manifold Removal (LWR)



1. Disconnect and remove the PCV tube assembly (1) from the upper intake manifold and right camshaft cover.

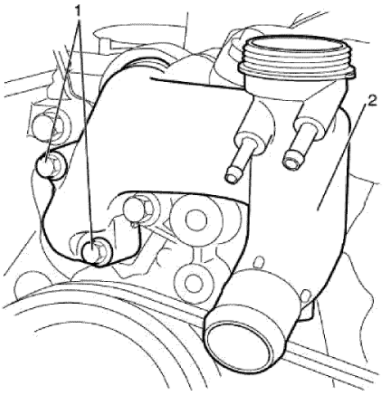


2. Remove the intake manifold bolts (1, 2).
3. Remove the intake manifold assembly (3).
4. Remove the lower intake manifold gasket (4).

cardiagn.com

© 2014 General Motors. All rights reserved.

Water Outlet Removal



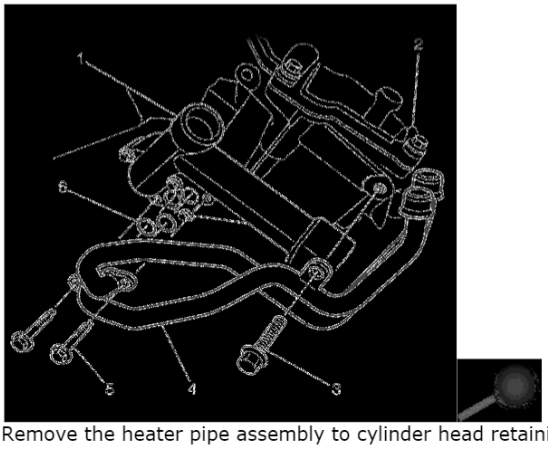
1. Remove the water outlet housing to cylinder head retaining bolts (1).

   Note: Use of a soft hammer will aid in the removal of the coolant outlet housing.
2. Remove the coolant outlet housing (2) from the engine.
3. Remove the rubber O-ring and seal.

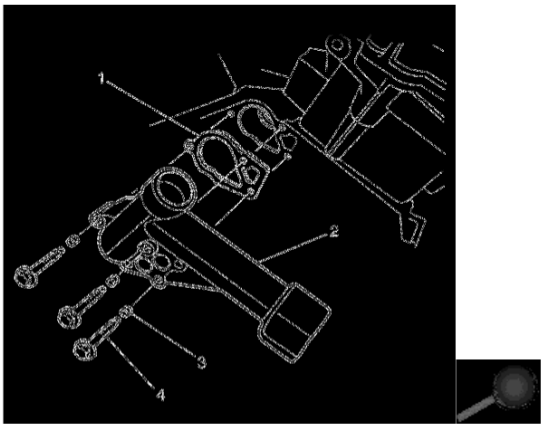
cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Coolant Thermostat Housing Removal



1. Remove the heater pipe assembly to cylinder head retaining bolt (3).
2. Remove the heater pipe assembly to engine coolant thermostat housing retaining bolts (5).
3. Remove the heater pipe assembly (4) from the cylinder head (2) and engine coolant thermostat housing (1).
4. Remove the heater pipe assembly to engine coolant thermostat housing O-ring seals (6).



Important: The engine coolant thermostat housing has one longer bolt which is located in the upper left of the housing.

5. Remove engine coolant thermostat housing to cylinder head retaining bolts (4) and plastic retainers (3).
6. Remove engine coolant thermostat housing (2).

Important: Always replace the engine coolant thermostat housing to cylinder head gasket (1).

7. Remove engine coolant thermostat housing gasket (1).

cardiagn.com

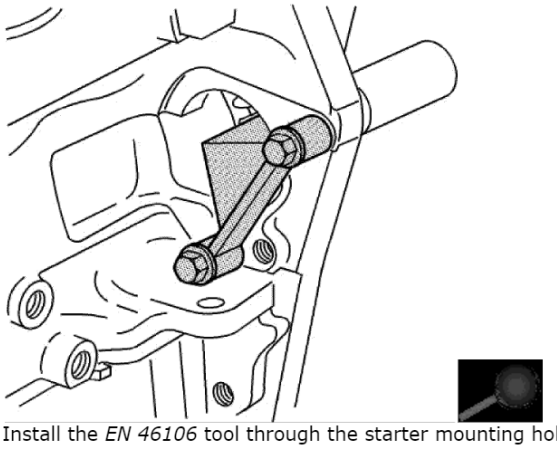
© 2014 General Motors. All rights reserved.

Crankshaft Balancer Removal

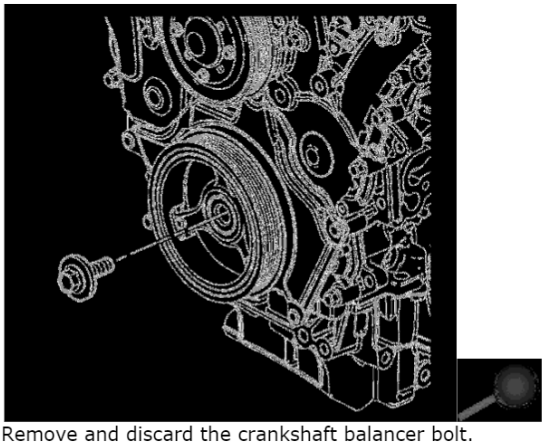
Special Tools

- *EN 38416-2* Crankshaft Button
- *EN 41816* Crankshaft Balancer Remover
- *EN 46106* Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools.



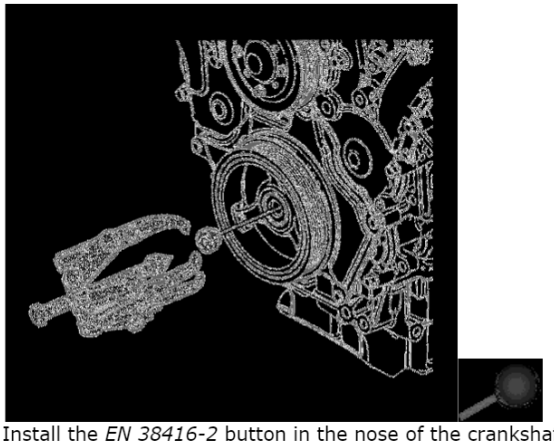
1. Install the *EN 46106* tool through the starter mounting hole.



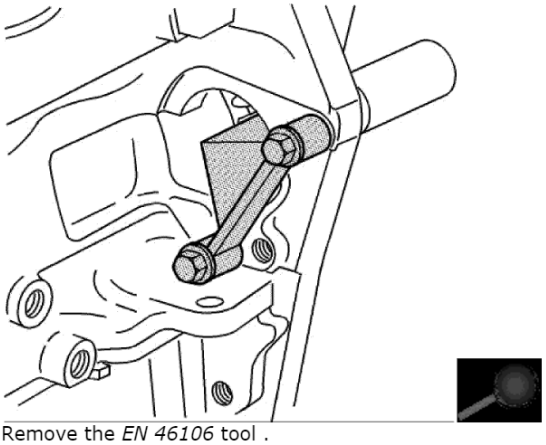
2. Remove and discard the crankshaft balancer bolt.

cardiagn.com

© 2014 General Motors. All rights reserved.



3. Install the *EN 38416-2* button in the nose of the crankshaft.
4. Install the *EN 41816* remover in order to remove the crankshaft balancer.
5. Tighten the center bolt of the *EN 41816* remover in order to pull the crankshaft balancer off of the crankshaft.
6. Remove the *EN 41816* remover from the crankshaft balancer.



7. Remove the *EN 46106* tool .

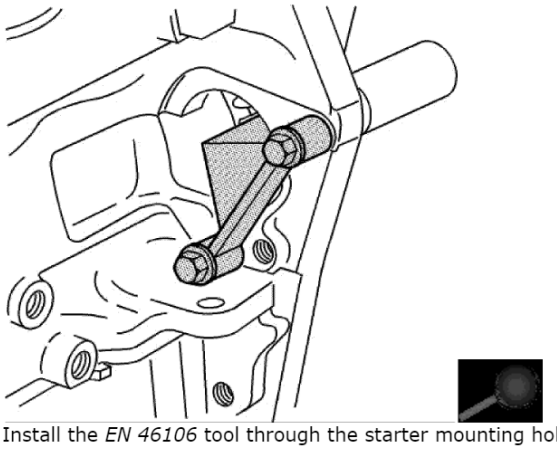
cardiagn.com

Engine Flywheel Removal

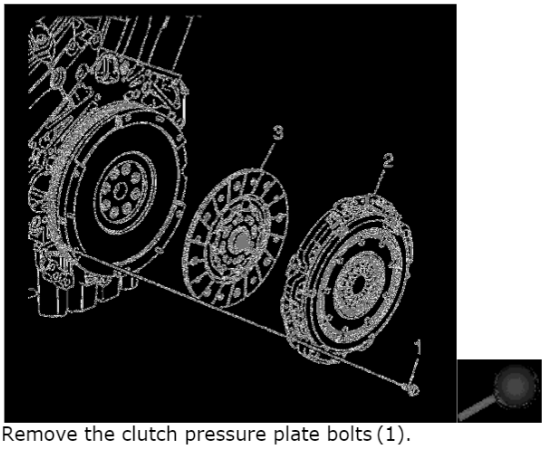
Special Tools

EN 46106 Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools.



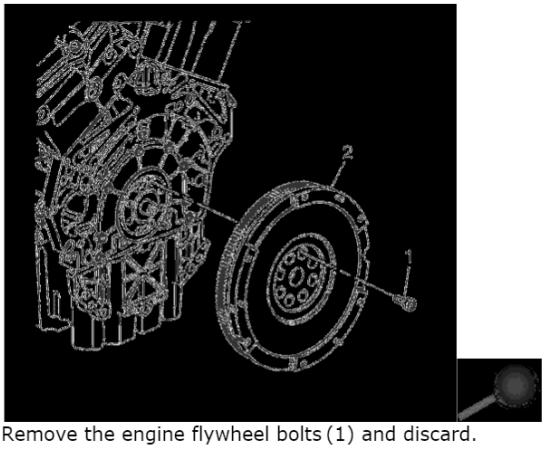
1. Install the *EN 46106* tool through the starter mounting hole.



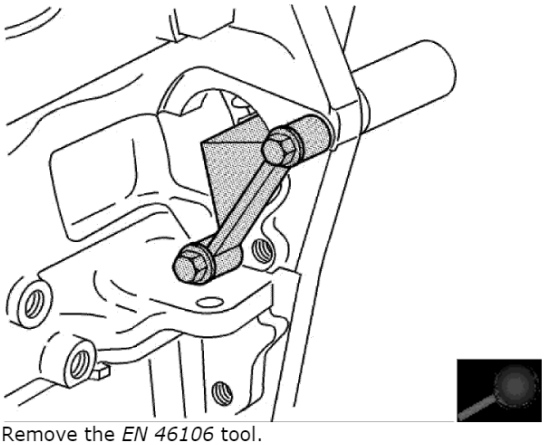
2. Remove the clutch pressure plate bolts (1).
3. Remove the clutch pressure plate (2) and the clutch driven plate disc (3).

cardiagn.com

© 2014 General Motors. All rights reserved.



4. Remove the engine flywheel bolts (1) and discard.
5. Remove the engine flywheel (2) from the crankshaft.



6. Remove the *EN 46106* tool.

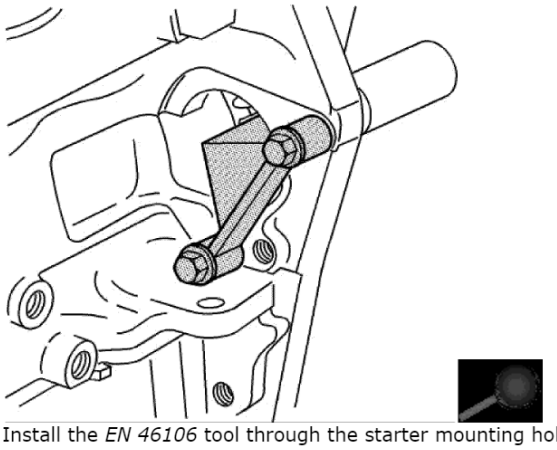
cardiagn.com

Automatic Transmission Flex Plate Removal

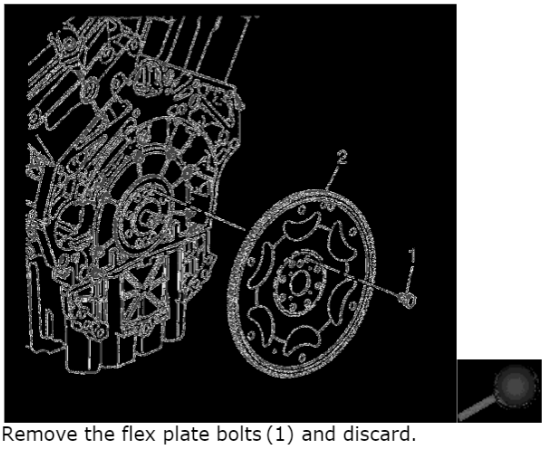
Special Tools

EN 46106 Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools.



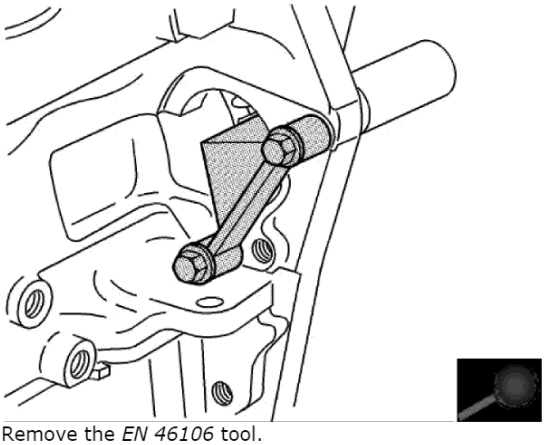
1. Install the *EN 46106* tool through the starter mounting hole.



2. Remove the flex plate bolts (1) and discard.
3. Remove the flex plate (2) from the crankshaft.

cardiagn.com

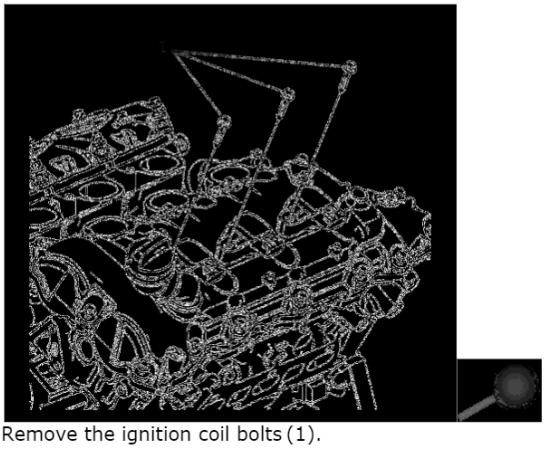
© 2014 General Motors. All rights reserved.



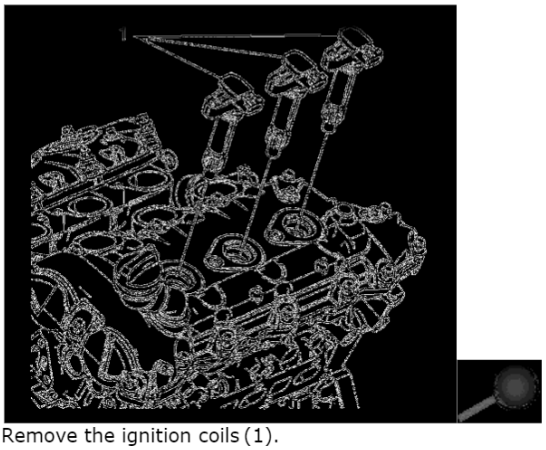
4. Remove the *EN 46106* tool.

cardiagn.com

Camshaft Cover Removal - Left Side



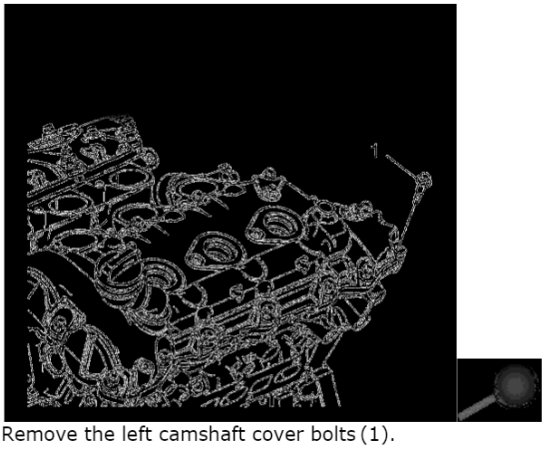
1. Remove the ignition coil bolts (1).



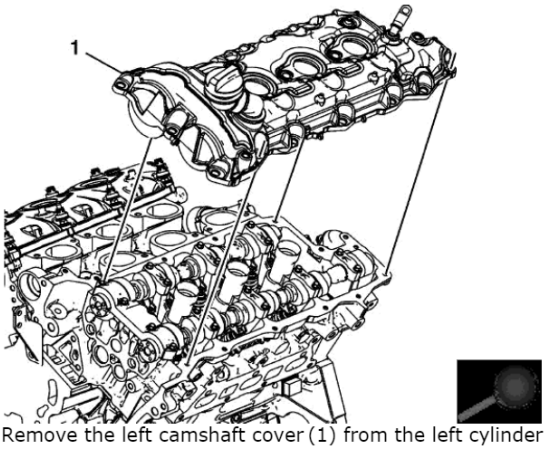
2. Remove the ignition coils (1).

cardiagn.com

© 2014 General Motors. All rights reserved.



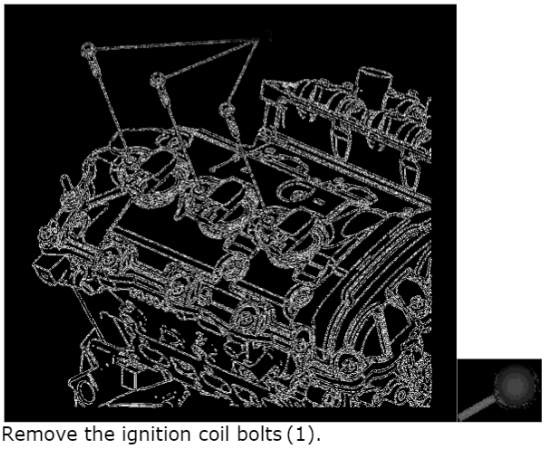
3. Remove the left camshaft cover bolts (1).
4. Remove and discard the camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.



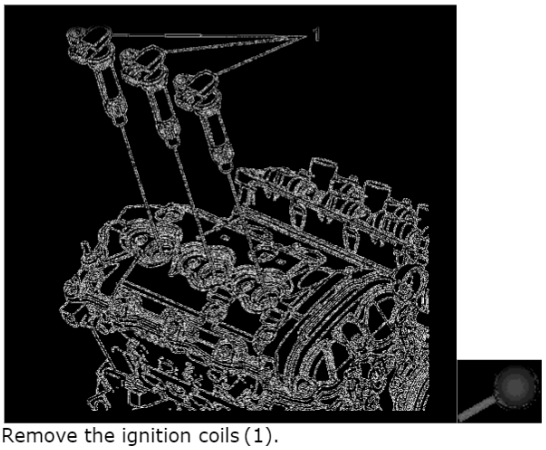
5. Remove the left camshaft cover (1) from the left cylinder head.

cardiagn.com

Camshaft Cover Removal - Right Side



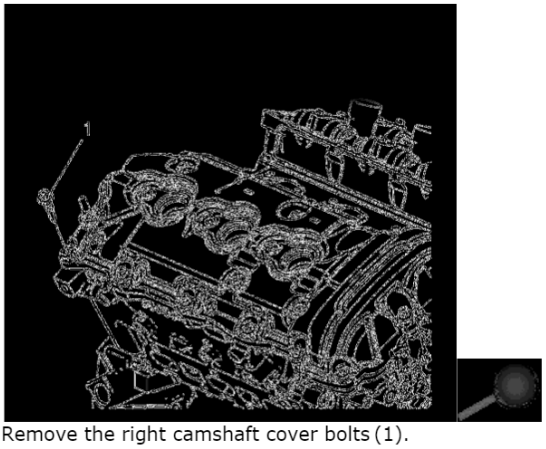
1. Remove the ignition coil bolts (1).



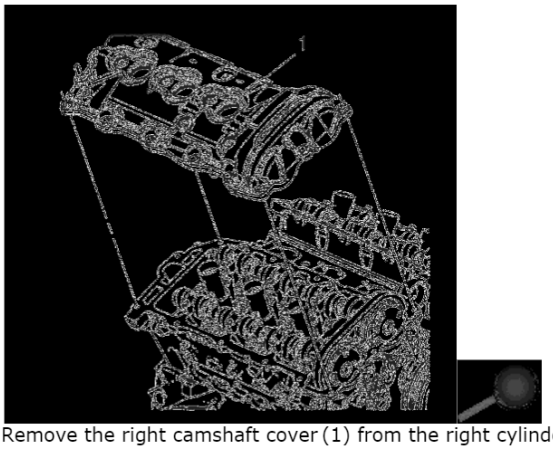
2. Remove the ignition coils (1).

cardiagn.com

© 2014 General Motors. All rights reserved.



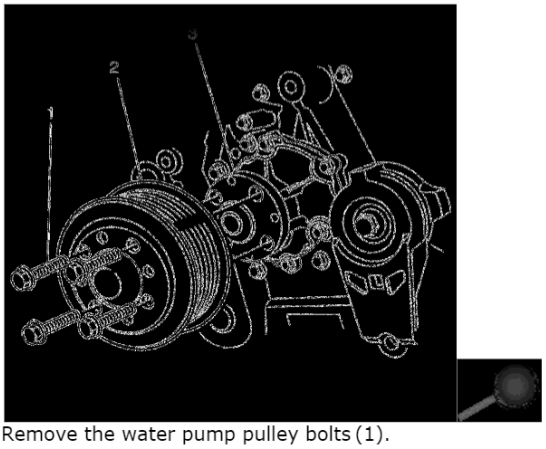
3. Remove the right camshaft cover bolts (1).
4. Remove and discard the camshaft cover grommets and camshaft cover bolts if they are serviced with the grommet.



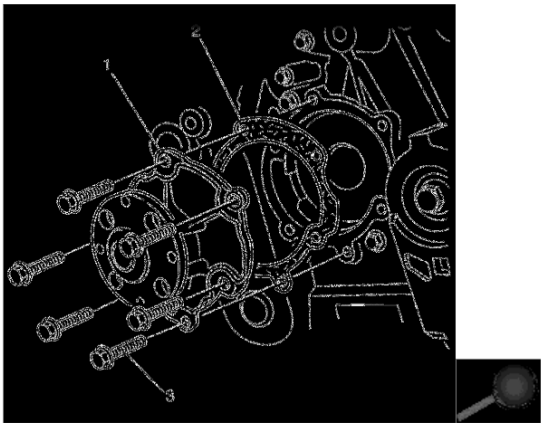
5. Remove the right camshaft cover (1) from the right cylinder head.

cardiagn.com

Water Pump Removal



1. Remove the water pump pulley bolts (1).
2. Remove the water pump pulley (2) from the water pump (3).



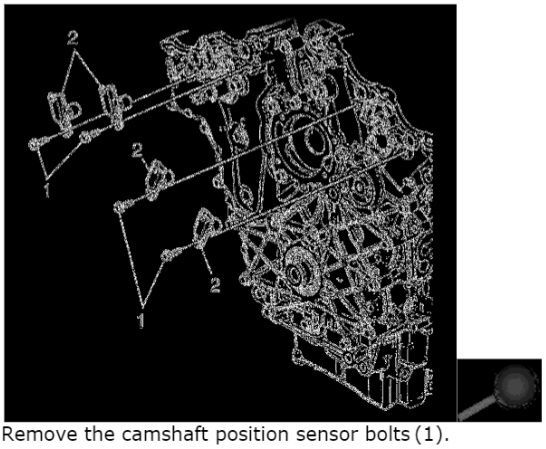
Note: Use a soft hammer to separate the water pump from the engine cover.

3. Remove and DISCARD the water pump to engine front cover retaining bolts (3).
4. Remove the water pump (1).
5. Remove and DISCARD the water pump gasket (2).

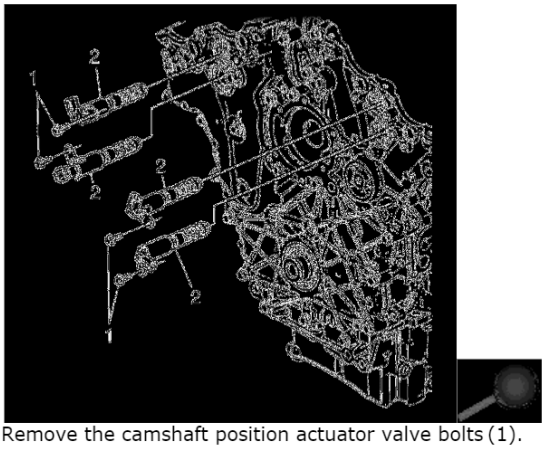
cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Front Cover Removal



1. Remove the camshaft position sensor bolts (1).
2. Remove the camshaft position sensors (2).



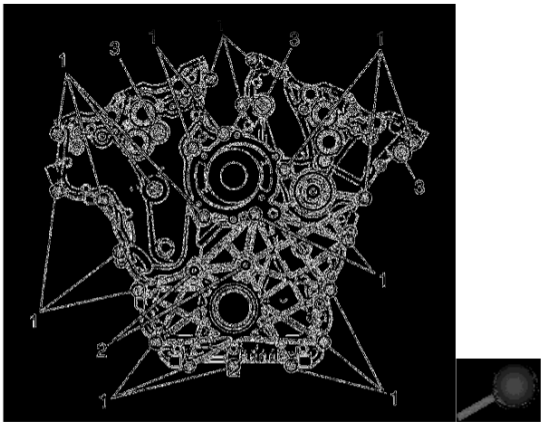
3. Remove the camshaft position actuator valve bolts (1).

Caution: The camshaft position actuator valves must be removed from the front cover prior to front cover removal or damage to the valves may occur.

4. Remove the camshaft position actuator valves (2) from the front cover.

cardiagn.com

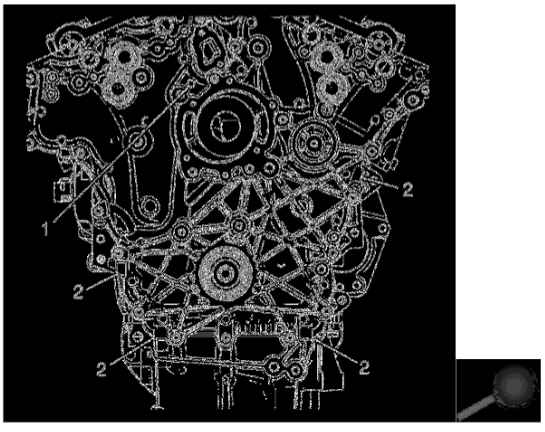
© 2014 General Motors. All rights reserved.



Note: Engine front cover bolts in the number (3) location are model dependent and may have already been removed.

Note: There are a total of 23 M8 bolts (1) and 2 M6 bolts (2) that must be removed, and 3 optional M12 bolts (3) that may need to be removed before the front cover will separate from the engine block.

5. Remove the engine front cover bolts (1–3).

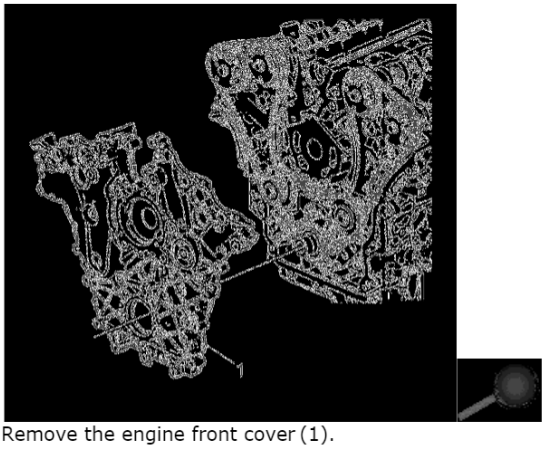


Caution: Do not use the jackscrew hole without first removing all engine front cover bolts. Failure to remove all engine front cover bolts before using the jackscrew hole could result in damage to components.

Caution: Do not pry between the engine front cover and the camshaft position sensors or the camshaft position actuators in order to separate the RTV. Use the pry points and a bolt in the jackscrew hole in order to remove the engine front cover. Damage to the camshaft position sensors or the camshaft position actuators may occur if the camshaft position sensors or the camshaft position actuators are used to pry against in order to remove the engine front cover.

6. Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1).
7. Using the pry points (2) located at the edge of the front cover and the jackscrew, separate the room temperature vulcanizing (RTV) sealant.

cardiagn.com



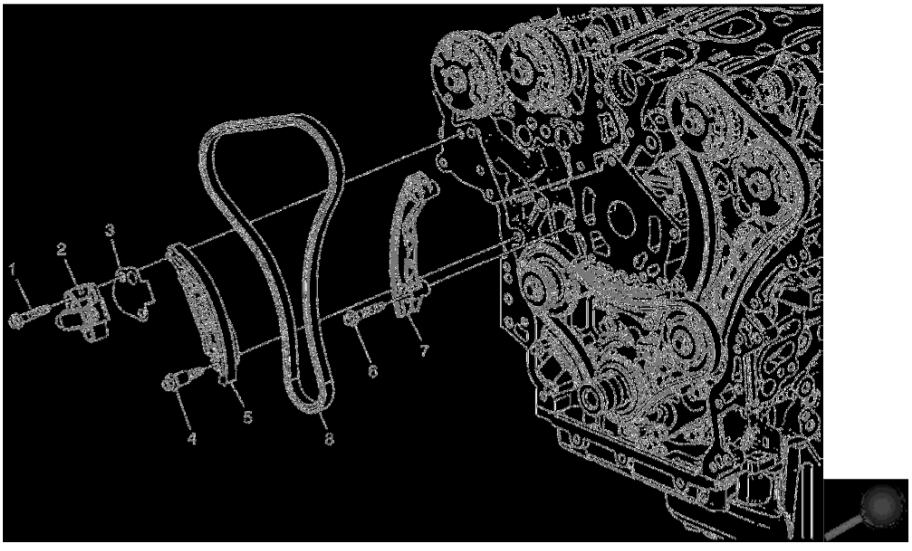
8. Remove the engine front cover (1).

cardiagn.com

Camshaft Timing Chain Components Removal

Table 1: Secondary Camshaft Drive Chain Components Removal - Right Side
Table 2: Primary Camshaft Drive Chain Components Removal
Table 3: Secondary Camshaft Drive Chain Components Removal - Left Side

Secondary Camshaft Drive Chain Components Removal - Right Side



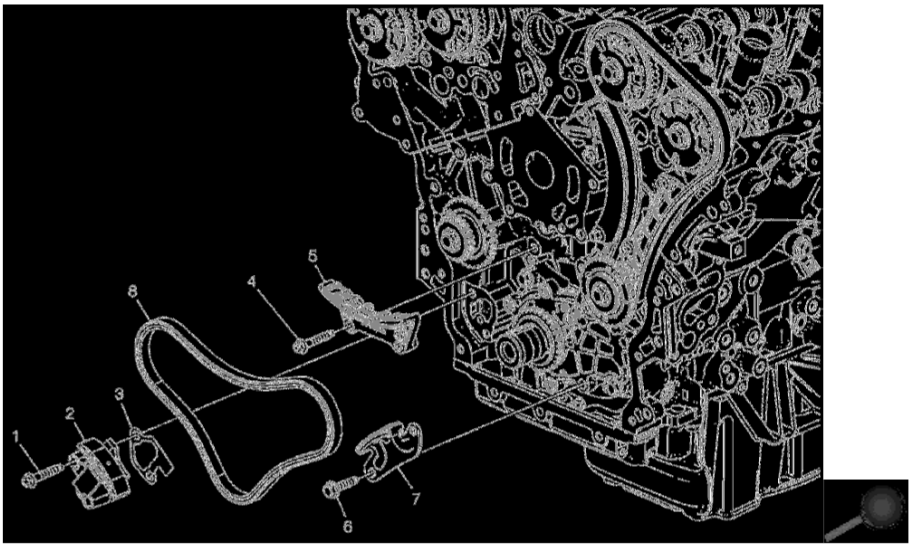
Secondary Camshaft Drive Chain Components Removal - Right Side

Callout	Component Name
1	Right Secondary Camshaft Drive Chain Tensioner Bolt
2	Right Secondary Camshaft Drive Chain Tensioner
3	Right Secondary Camshaft Drive Chain Tensioner Gasket **Note:** Discard the gasket.
4	Right Secondary Camshaft Drive Chain Shoe Bolt
5	Right Secondary Camshaft Drive Chain Shoe
6	Right Secondary Camshaft Drive Chain Guide Bolt
7	Right Secondary Camshaft Drive Chain Guide
8	Right Secondary Camshaft Drive Chain

Primary Camshaft Drive Chain Components Removal

© 2014 General Motors. All rights reserved.

cardiagn.com

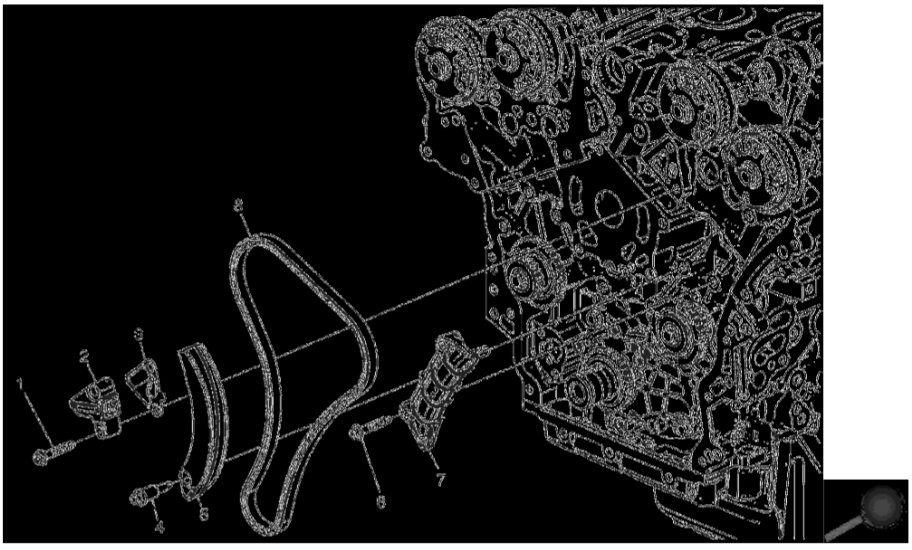


Primary Camshaft Drive Chain Components Removal

Callout	Component Name
1	Primary Camshaft Drive Chain Tensioner Bolt
2	Primary Camshaft Drive Chain Tensioner
3	Primary Camshaft Drive Chain Tensioner Gasket **Note:** Discard the gasket.
4	Primary Camshaft Drive Chain Upper Guide Bolt
5	Primary Camshaft Drive Chain Upper Guide
6	Primary Camshaft Drive Chain Lower Guide Bolt
7	Primary Camshaft Drive Chain Lower Guide
8	Primary Camshaft Drive Chain

cardiagn.com

Secondary Camshaft Drive Chain Components Removal - Left Side

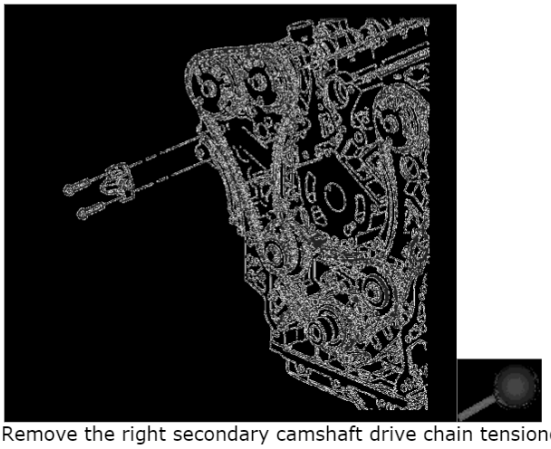


Secondary Camshaft Drive Chain Components Removal - Left Side

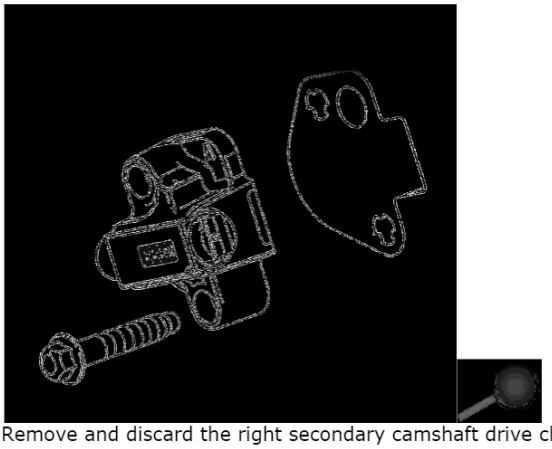
Callout	Component Name
1	Left Secondary Camshaft Drive Chain Tensioner Bolt
2	Left Secondary Camshaft Drive Chain Tensioner
3	Left Secondary Camshaft Drive Chain Tensioner Gasket **Note:** Discard the gasket.
4	Left Secondary Camshaft Drive Chain Shoe Bolt
5	Left Secondary Camshaft Drive Chain Shoe
6	Left Secondary Camshaft Drive Chain Guide Bolt
7	Left Secondary Camshaft Drive Chain Guide
8	Left Secondary Camshaft Drive Chain

cardiagn.com

Secondary Timing Chain Tensioner Removal - Right Side



1. Remove the right secondary camshaft drive chain tensioner bolts.
2. Remove the right secondary camshaft drive chain tensioner.

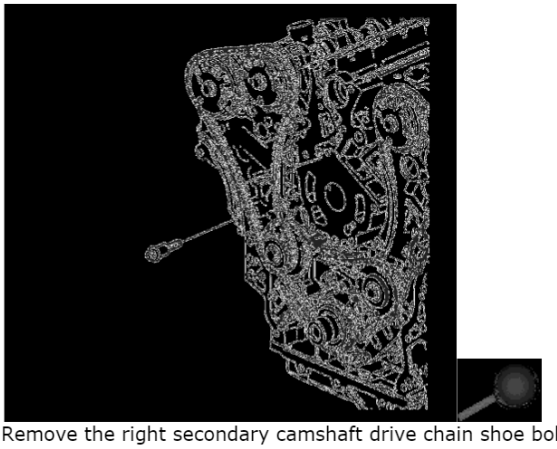


3. Remove and discard the right secondary camshaft drive chain tensioner gasket.
4. Inspect the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head for burrs or any defects that would degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.

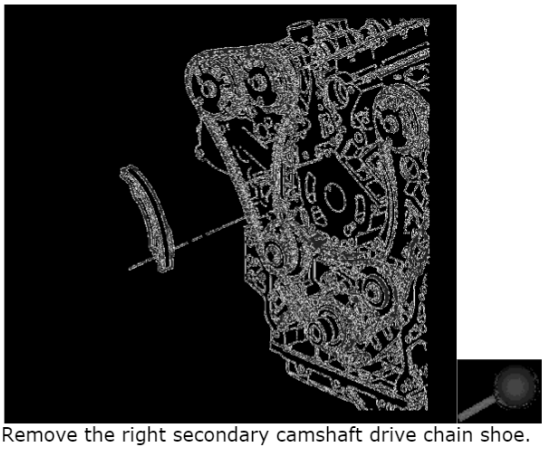
cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Drive Chain Shoe Removal - Right Side



1. Remove the right secondary camshaft drive chain shoe bolt.

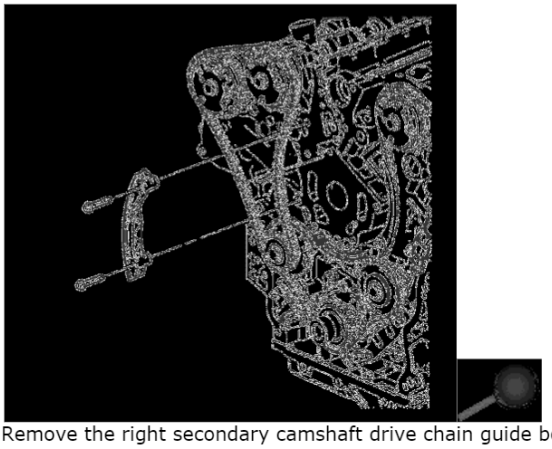


2. Remove the right secondary camshaft drive chain shoe.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Guide Removal - Right Side

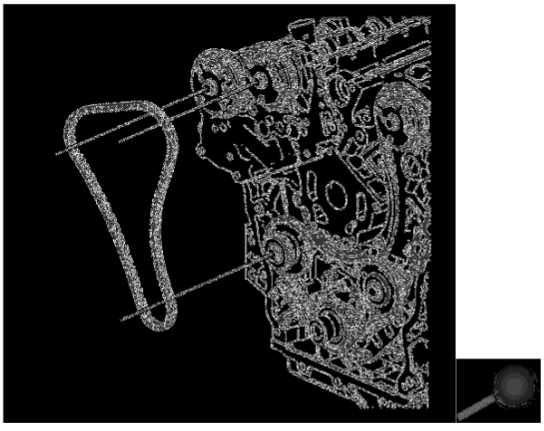


1. Remove the right secondary camshaft drive chain guide bolts.
2. Remove the right secondary camshaft drive chain guide.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Intermediate Drive Chain Removal - Right Side

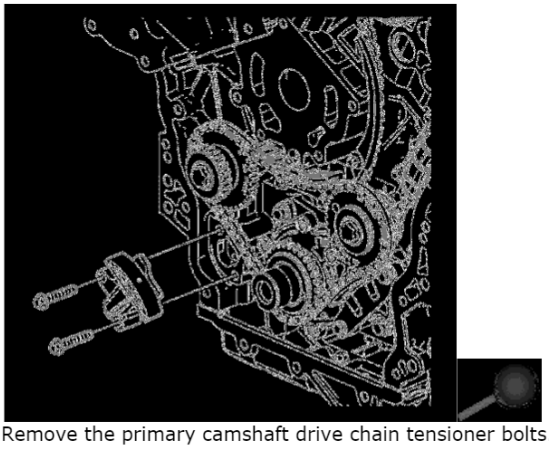


Remove the right secondary camshaft drive chain from the right camshaft position actuators and the right camshaft intermediate drive chain idler sprocket.

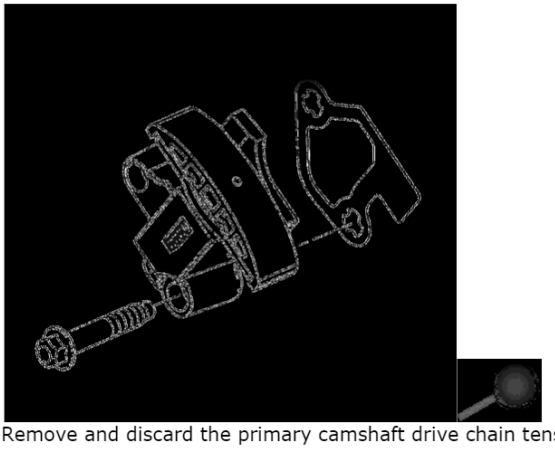
cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Camshaft Intermediate Drive Chain Tensioner Removal



1. Remove the primary camshaft drive chain tensioner bolts.
2. Remove the primary camshaft drive chain tensioner.

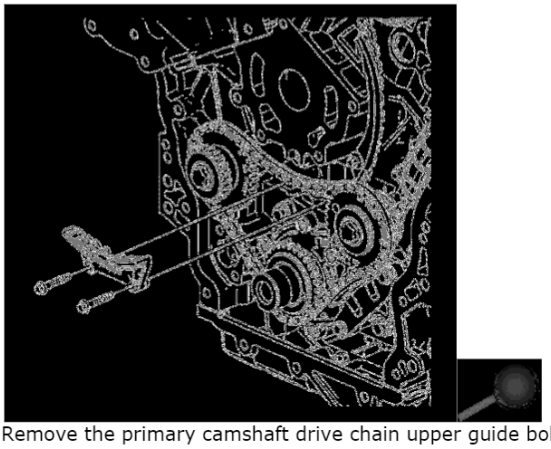


3. Remove and discard the primary camshaft drive chain tensioner gasket.
4. Inspect the primary camshaft drive chain tensioner mounting surface on the engine block for burrs or any defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.

cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Timing Chain Guide Removal - Upper

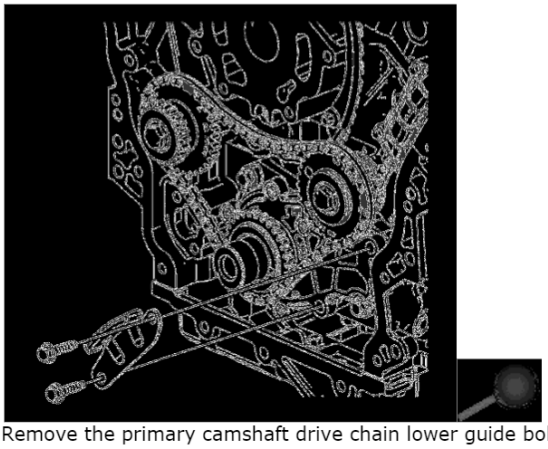


1. Remove the primary camshaft drive chain upper guide bolts.
2. Remove the primary camshaft drive chain upper guides.

cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Timing Chain Guide Removal - Lower

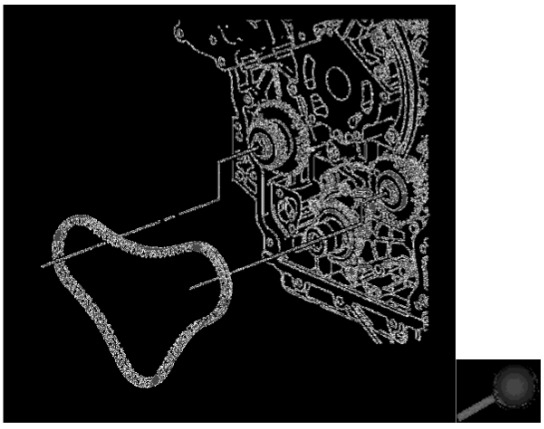


1. Remove the primary camshaft drive chain lower guide bolts.
2. Remove the primary camshaft drive chain lower guide.

cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Camshaft Intermediate Drive Chain Removal

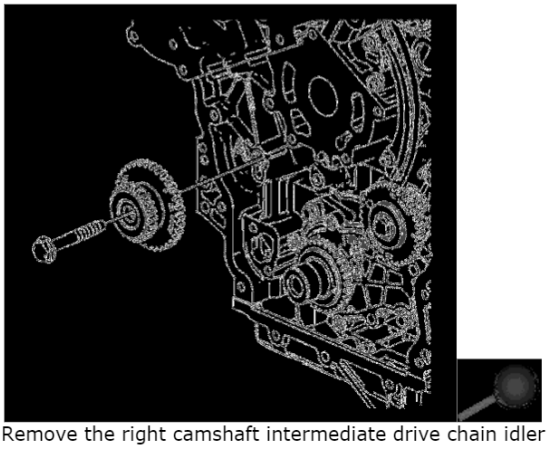


Remove the primary camshaft drive chain.

cardiagn.com

© 2014 General Motors. All rights reserved.

Timing Chain Idler Sprocket Removal - Right Side

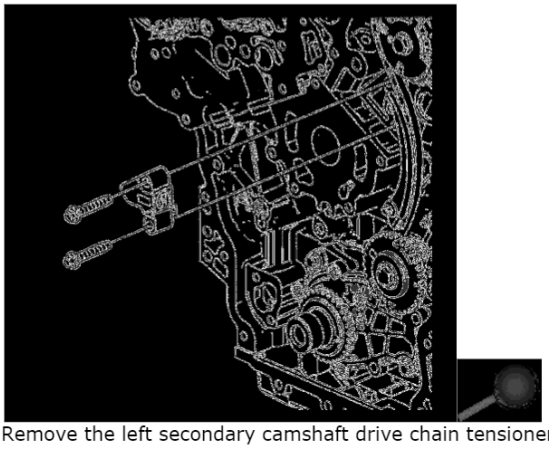


1. Remove the right camshaft intermediate drive chain idler bolt.
2. Remove the right camshaft intermediate drive chain idler.

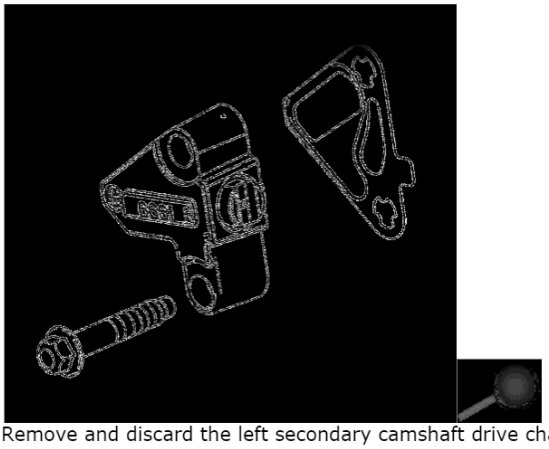
cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Tensioner Removal - Left Side



1. Remove the left secondary camshaft drive chain tensioner bolts.
2. Remove the left secondary camshaft drive chain tensioner.

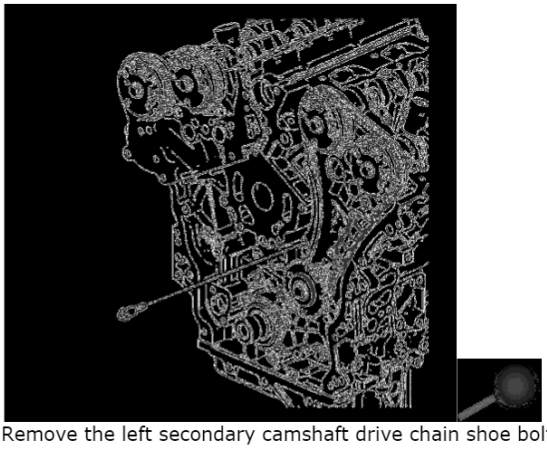


3. Remove and discard the left secondary camshaft drive chain tensioner gasket.
4. Inspect the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head for burrs or any defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.

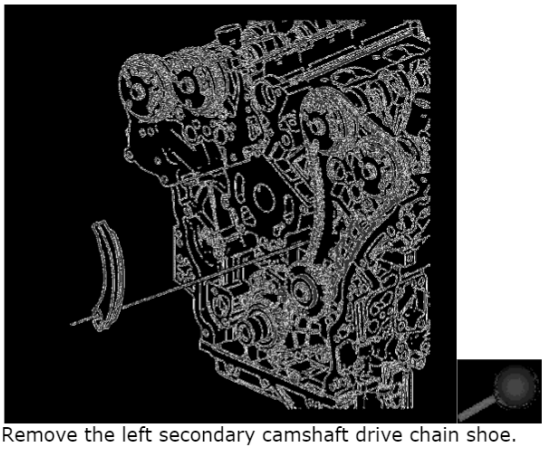
cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Drive Chain Shoe Removal - Left Side



1. Remove the left secondary camshaft drive chain shoe bolt.

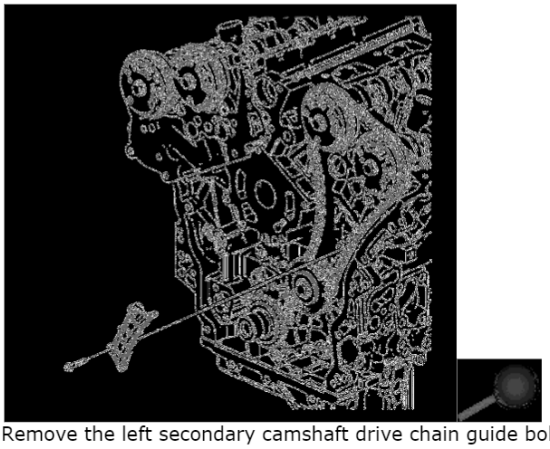


2. Remove the left secondary camshaft drive chain shoe.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Timing Chain Guide Removal - Left Side

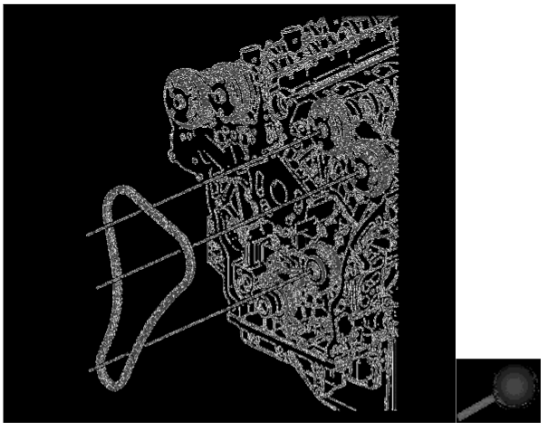


1. Remove the left secondary camshaft drive chain guide bolts.
2. Remove the left secondary camshaft drive chain guide.

cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Intermediate Drive Chain Removal - Left Side

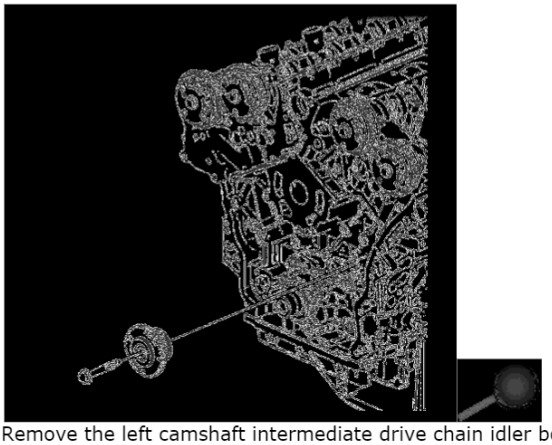


Remove the left secondary camshaft drive chain from the left camshaft position actuators and the left camshaft intermediate drive chain idler sprocket.

cardiagn.com

© 2014 General Motors. All rights reserved.

Timing Chain Idler Sprocket Removal - Left Side

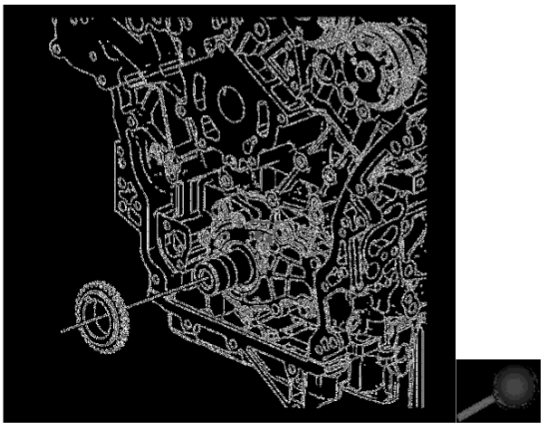


1. Remove the left camshaft intermediate drive chain idler bolt.
2. Remove the left camshaft intermediate drive chain idler.

cardiagn.com

© 2014 General Motors. All rights reserved.

Crankshaft Sprocket Removal

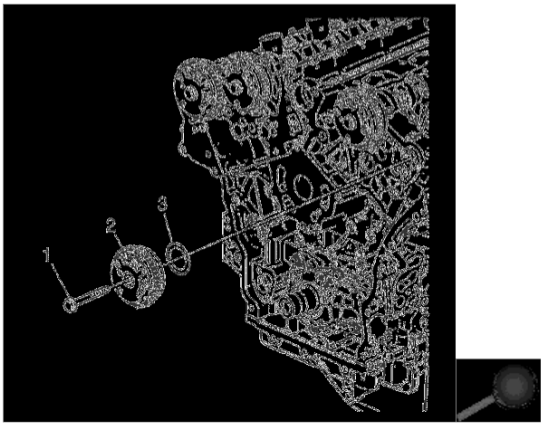


Remove the crankshaft sprocket from the nose of the crankshaft.

cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Position Actuator Removal - Left Side Exhaust



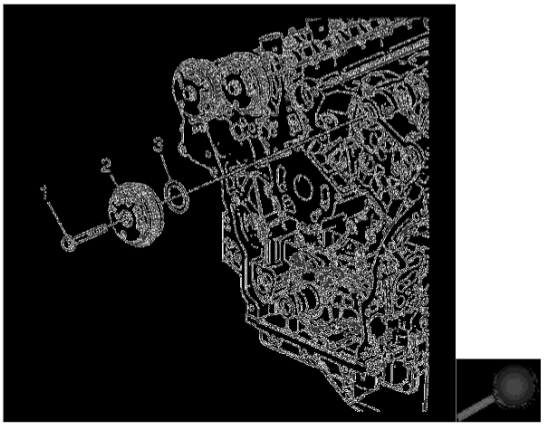
Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the left exhaust camshaft position actuator bolt (1).
3. Remove the left exhaust camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Position Actuator Removal - Left Side Intake



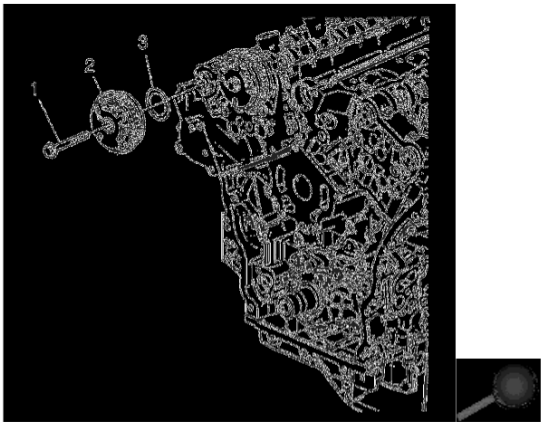
Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the left intake camshaft position actuator bolt (1).
3. Remove the left intake camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Position Actuator Removal - Right Side Exhaust



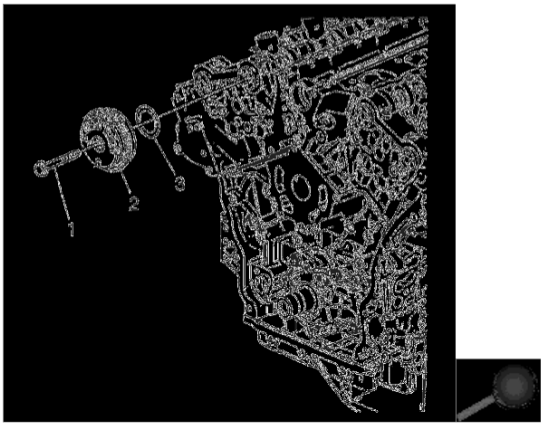
Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the right exhaust camshaft position actuator bolt (1).
3. Remove the right exhaust camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Position Actuator Removal - Right Side Intake



Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

1. Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt.
2. Remove the right intake camshaft position actuator bolt (1).
3. Remove the right intake camshaft position actuator (2).
4. Remove the camshaft thrust washer if applicable (3).

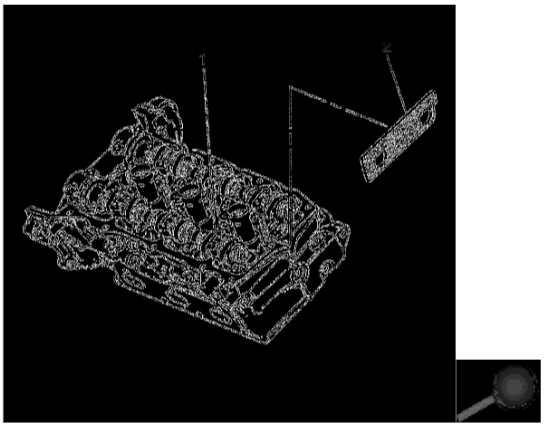
cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Removal - Left Side

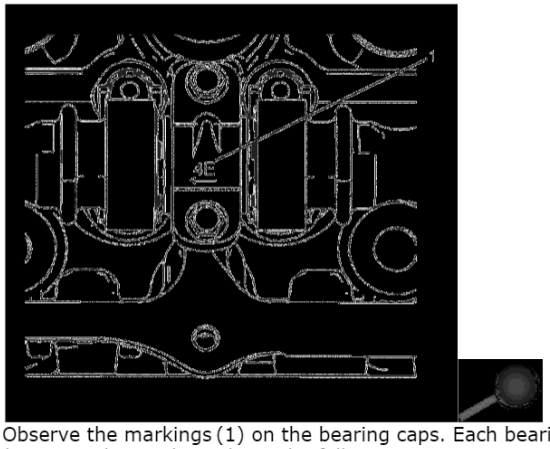
Special Tools

EN-48383 Camshaft Retaining Tools



Note: *EN-48383* camshaft retaining tool (2) was installed to the camshafts (1) as part of the left bank cylinder head camshaft position actuator removal procedure.

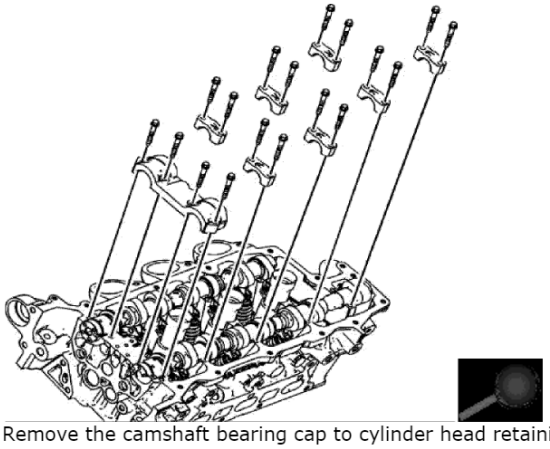
1. Remove the *EN-48383* camshaft retaining tool (2) from the left bank camshafts (1).
2. Position the camshaft lobes in a neutral position.



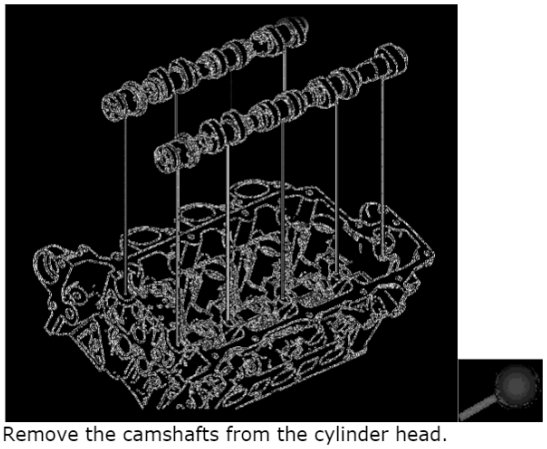
3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the cylinder block.

© 2014 General Motors. All rights reserved.

cardiagn.com



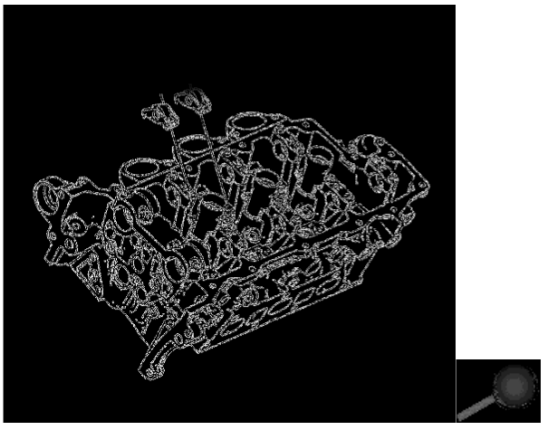
4. Remove the camshaft bearing cap to cylinder head retaining bolts.
5. Remove the camshaft bearing caps.



6. Remove the camshafts from the cylinder head.

cardiagn.com

Valve Rocker Arm Removal - Left Side

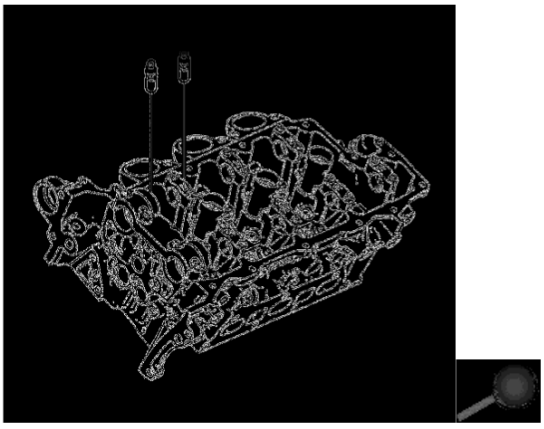


Remove the valve rocker arms from the cylinder head. If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

cardiagn.com

© 2014 General Motors. All rights reserved.

Valve Lifter Removal - Left Side



Note:

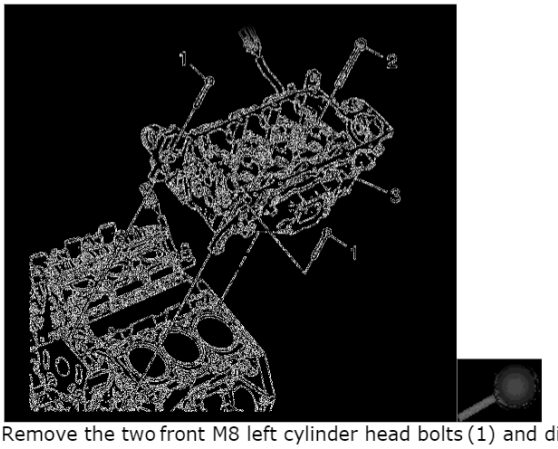
- Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

Remove the valve lifters (SHLAs) from the cylinder head. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

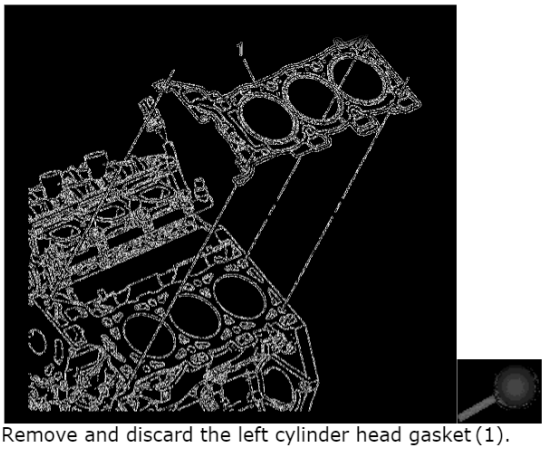
cardiagn.com

© 2014 General Motors. All rights reserved.

Cylinder Head Removal - Left Side (LFW or LFX)



1. Remove the two front M8 left cylinder head bolts (1) and discard.
2. Remove the left cylinder head bolts (2) and discard.
3. Remove the left cylinder head (3).

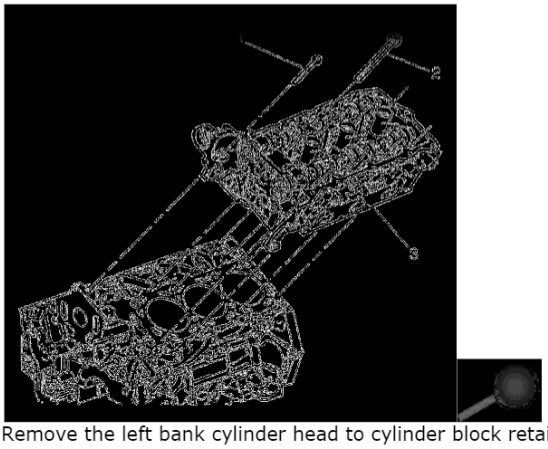


4. Remove and discard the left cylinder head gasket (1).

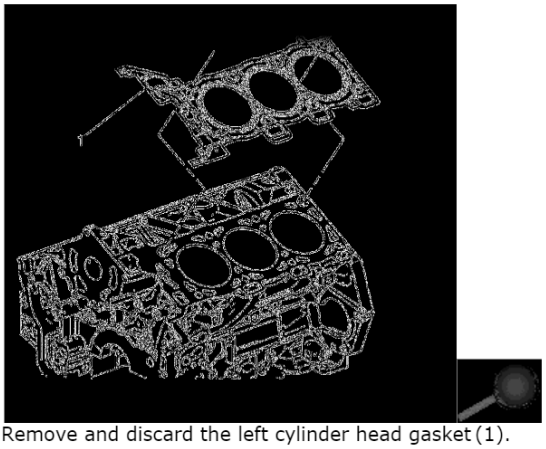
cardiagn.com

© 2014 General Motors. All rights reserved.

Cylinder Head Removal - Left Side (LWR)



1. Remove the left bank cylinder head to cylinder block retaining bolts (1 and 2).
2. Remove the left bank cylinder head (3).



3. Remove and discard the left cylinder head gasket (1).

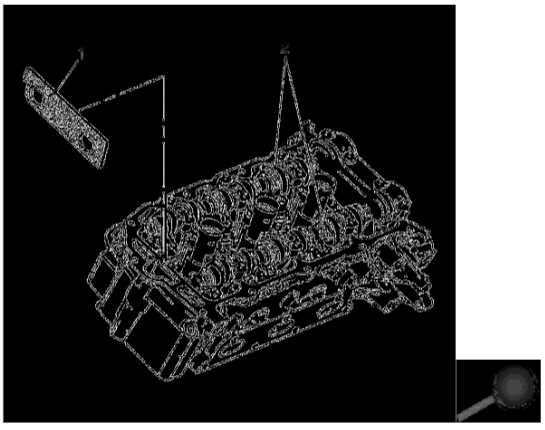
cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Removal - Right Side

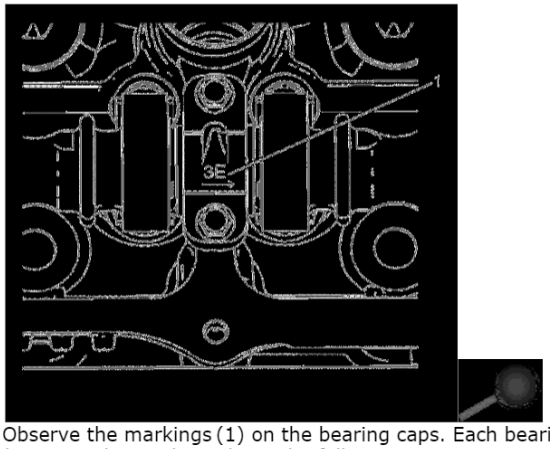
Special Tools

EN-48383 Camshaft Retaining Tools



Note: The *EN-48383* camshaft retaining tool (1) was installed to the camshafts (2) as part of the right bank cylinder head camshaft position actuator removal procedure.

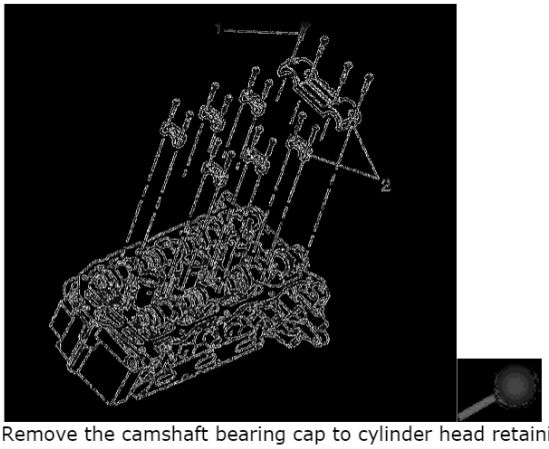
1. Remove the *EN-48383* camshaft retaining tool (1) from the right bank camshafts (2).
2. Position the camshaft lobes in a neutral position.



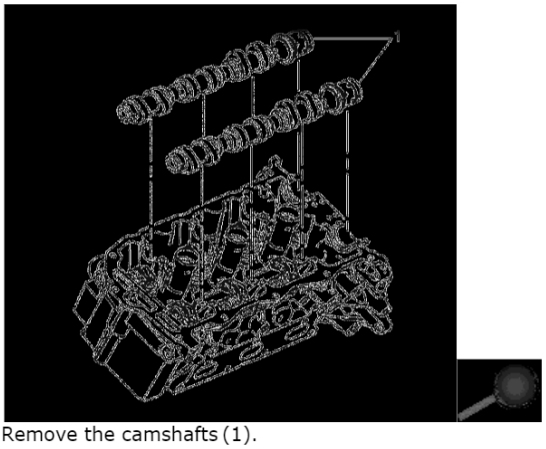
3. Observe the markings (1) on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number indicates the journal position from the front of the cylinder block.

© 2014 General Motors. All rights reserved.

cardiagn.com



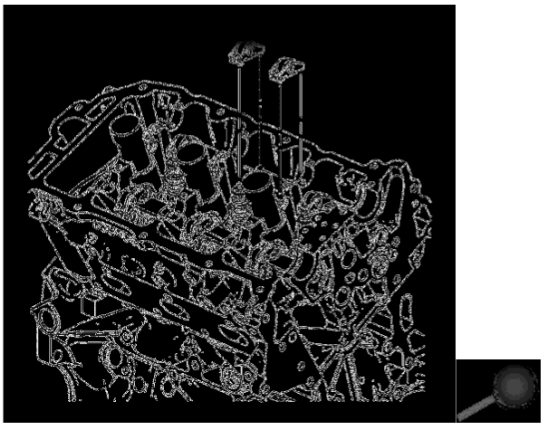
4. Remove the camshaft bearing cap to cylinder head retaining bolts (1).
5. Remove the camshaft bearing caps (2).



6. Remove the camshafts (1).

cardiagn.com

Valve Rocker Arm Removal - Right Side

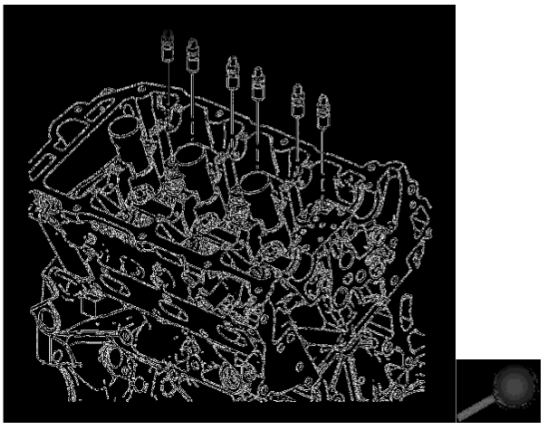


Remove the valve rocker arms from the cylinder head. If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

cardiagn.com

© 2014 General Motors. All rights reserved.

Valve Lifter Removal - Right Side



Important:

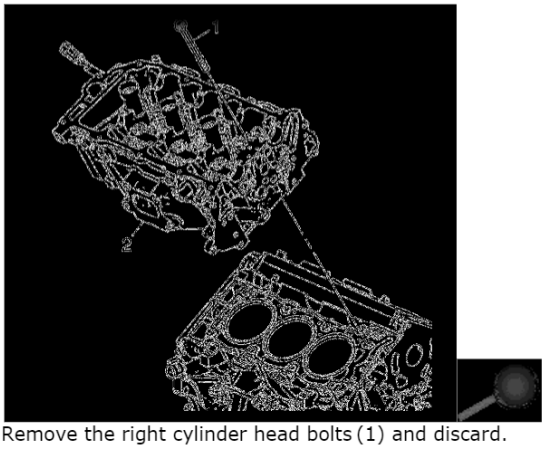
- Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.
- Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

Remove the valve lifters (SHLAs) from the cylinder head. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

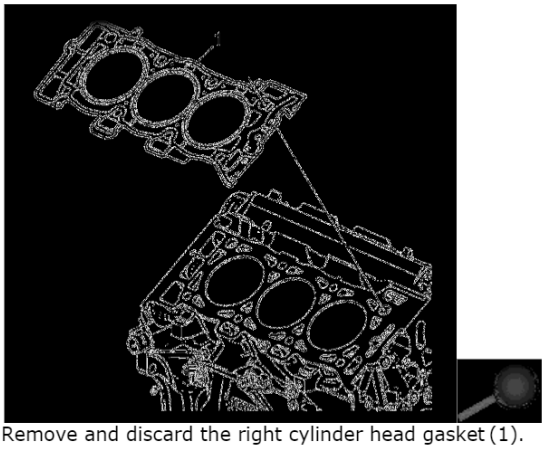
cardiagn.com

© 2014 General Motors. All rights reserved.

Cylinder Head Removal - Right Side (LFW or LFX)



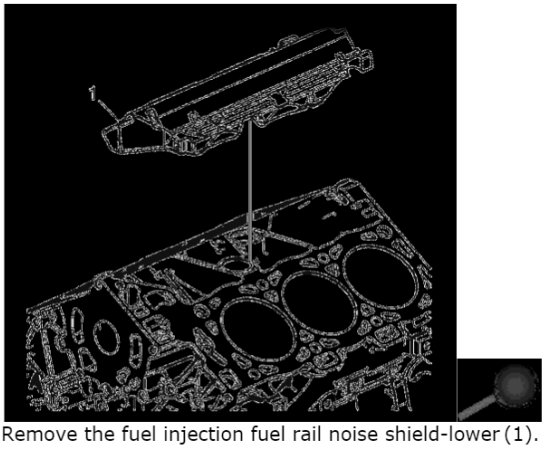
1. Remove the right cylinder head bolts (1) and discard.
2. Remove the right cylinder head (2).



3. Remove and discard the right cylinder head gasket (1).

cardiagn.com

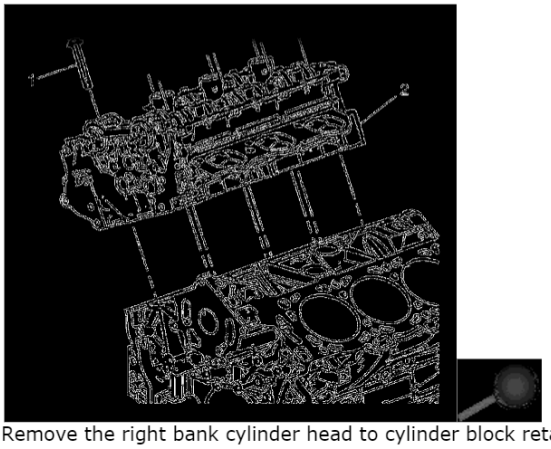
© 2014 General Motors. All rights reserved.



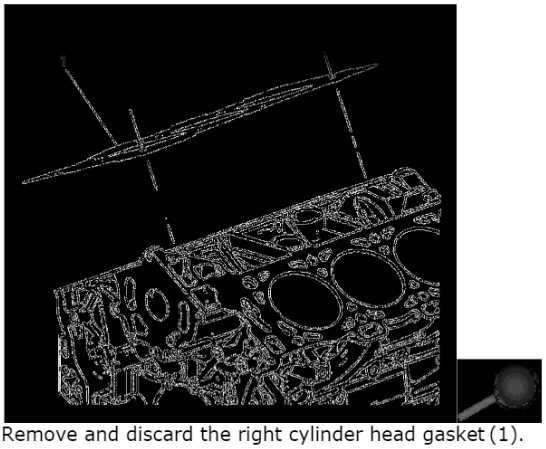
4. Remove the fuel injection fuel rail noise shield-lower (1).

cardiagn.com

Cylinder Head Removal - Right Side (LWR)



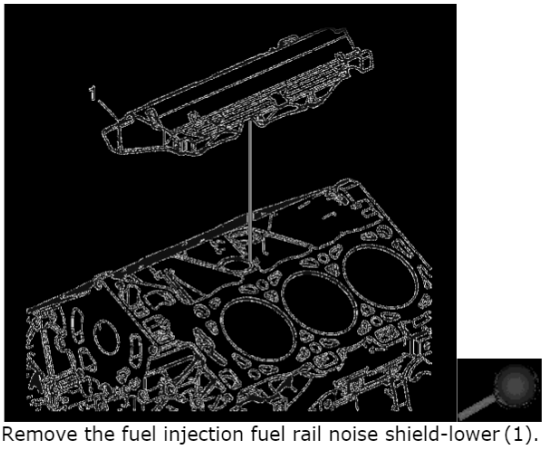
1. Remove the right bank cylinder head to cylinder block retaining bolts (1).
2. Remove the right bank cylinder head (2).



3. Remove and discard the right cylinder head gasket (1).

cardiagn.com

© 2014 General Motors. All rights reserved.

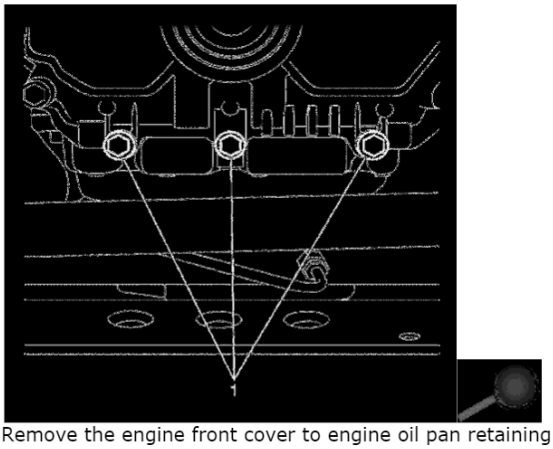


4. Remove the fuel injection fuel rail noise shield-lower (1).

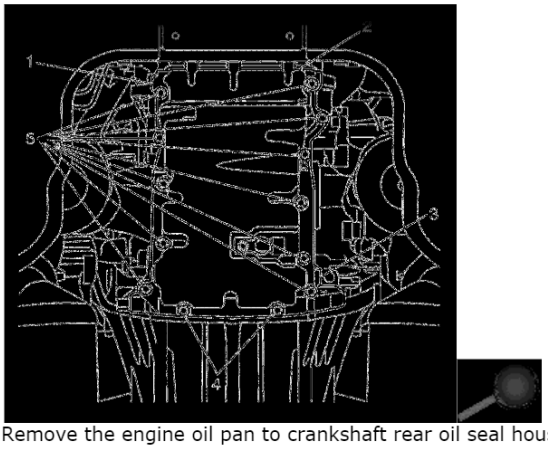
cardiagn.com

Oil Pan Removal

1. Remove the crankshaft balancer. Refer to Crankshaft Balancer Replacement.



2. Remove the engine front cover to engine oil pan retaining bolts (1)



3. Remove the engine oil pan to crankshaft rear oil seal housing retaining bolts (4).
4. Remove the engine oil pan to cylinder block retaining bolts (5).

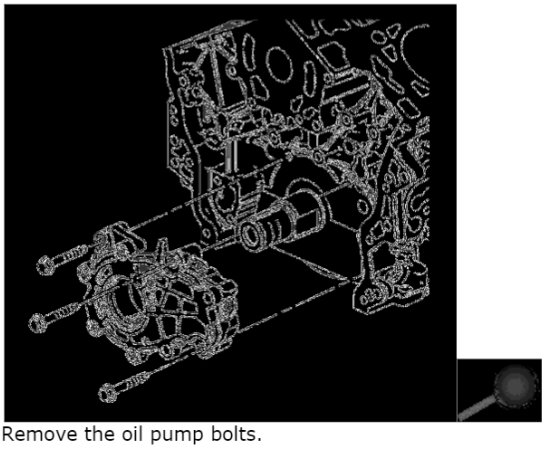
Note: Use the pry points (1 and 3) to pry the engine oil pan from the cylinder block.

5. Remove the engine oil pan (2) from the cylinder block.

cardiagn.com

© 2014 General Motors. All rights reserved.

Oil Pump Removal

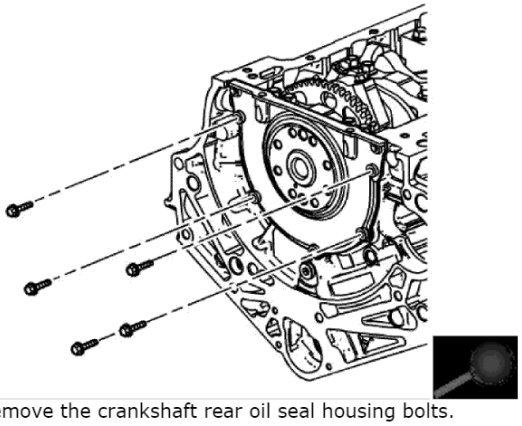


1. Remove the oil pump bolts.
2. Remove the oil pump.

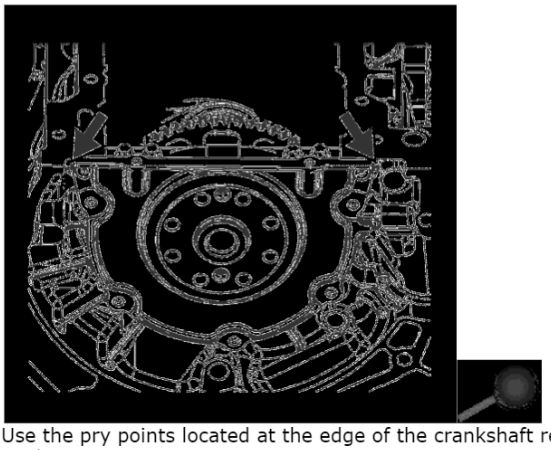
cardiagn.com

© 2014 General Motors. All rights reserved.

Crankshaft Rear Oil Seal and Housing Removal



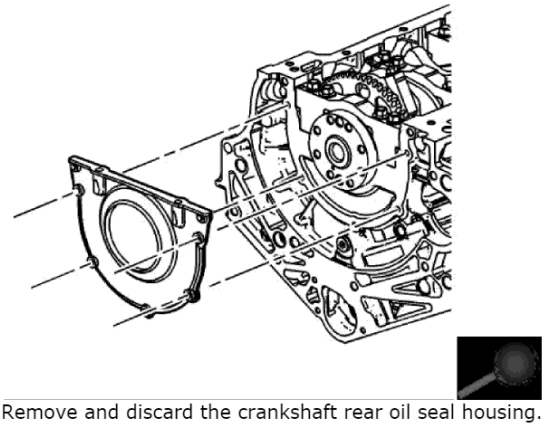
1. Remove the crankshaft rear oil seal housing bolts.



2. Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant.

cardiagn.com

© 2014 General Motors. All rights reserved.



3. Remove and discard the crankshaft rear oil seal housing.

cardiagn.com

Piston, Connecting Rod, and Bearing Removal

Special Tools

EN 46121 Connecting Rod Guide Pin Set

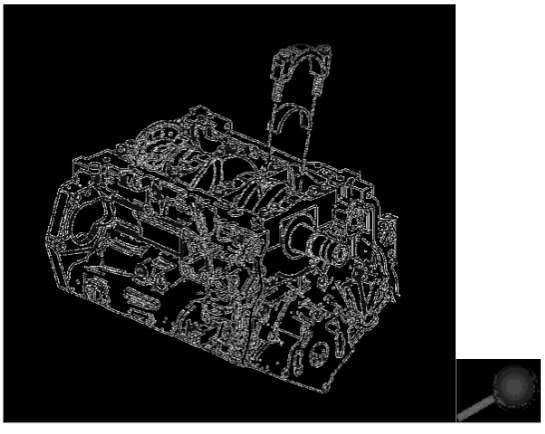
For equivalent regional tools, refer to Special Tools.

Note: An arrow/dot showing proper piston orientation is located on the top of the piston.

Note: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
   1.1. Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
   1.2. Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod.
   1.3. The connecting rod side clearance should not exceed specifications. Refer to Engine Mechanical Specifications.
   1.4. If the end play exceeds the specified limits, measure the width of the crankpin end of the connecting rod. Refer to Piston, Connecting Rod, and Bearing Cleaning and Inspection.
   1.5. If the connecting rod width is significantly smaller than specified and severe wear is present on the side of the connecting rod, replace the connecting rod.
   1.6. If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
2. Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.

   Caution: Do not use a stamp, punch or any other method that may distort or stress the connecting rod or connecting rod cap. Extensive engine damage may result from a connecting rod that is distorted or stressed.
3. Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.



Caution: Powdered metal connecting rods have rod bolts which yield when torqued. If the rod bolts are loosened or removed the rod bolts must be replaced. Rod bolts that are not

© 2014 General Motors. All rights reserved.

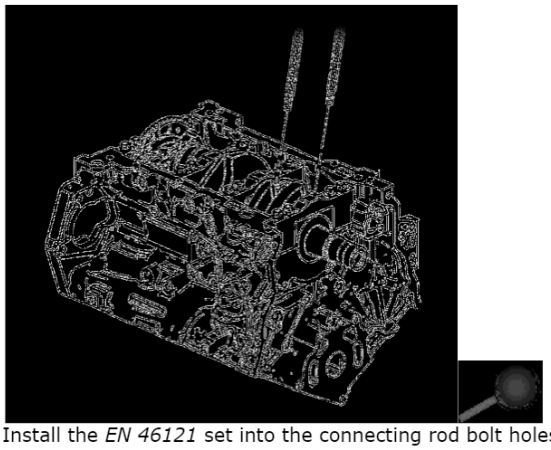
cardiagn.com

replaced will not torque to the correct clamp load and can lead to serious engine damage.

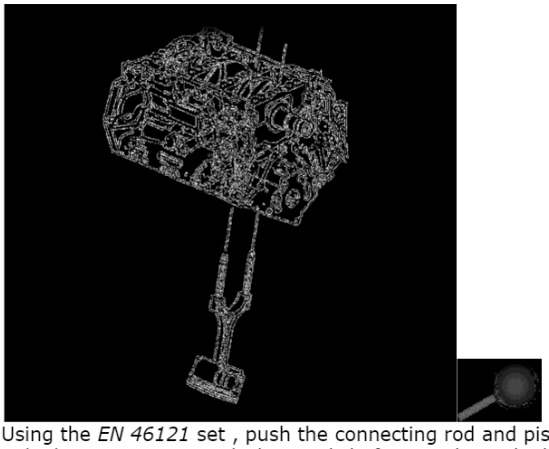
4. Remove the connecting rod bolts.

   Note: The connecting rod caps must remain with the original connecting rod.

5. Remove the connecting rod cap.

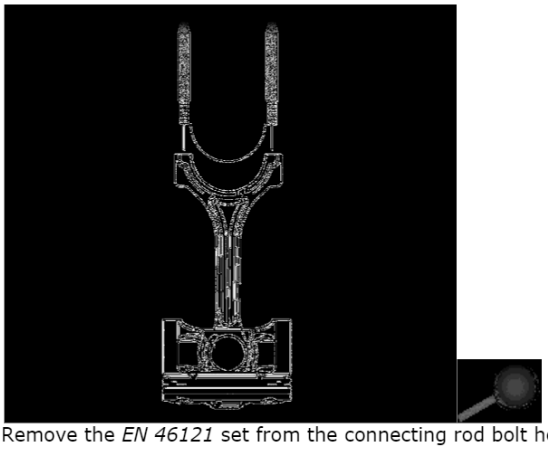


6. Install the *EN 46121* set into the connecting rod bolt holes.

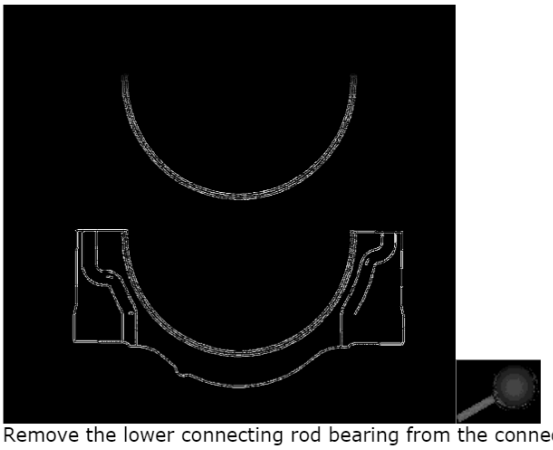


7. Using the *EN 46121* set , push the connecting rod and piston assembly through the top of the cylinder. DO NOT scratch the crankshaft journal or cylinder wall and DO NOT damage the oil jets when removing the connecting rod and piston assembly.

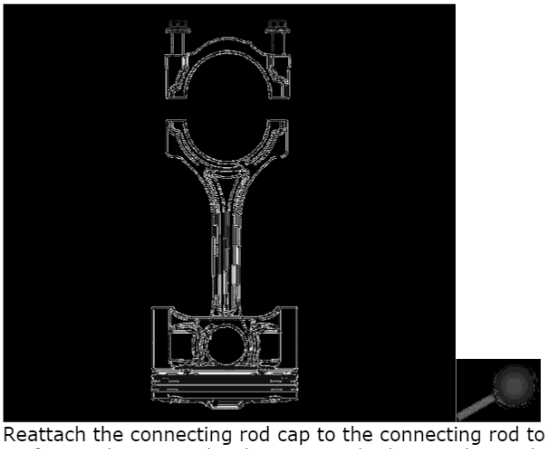
cardiagn.com



8. Remove the *EN 46121* set from the connecting rod bolt holes.
9. Remove the upper connecting rod bearing from the connecting rod.



10. Remove the lower connecting rod bearing from the connecting rod cap.



11. Reattach the connecting rod cap to the connecting rod to prevent damage to their mating surfaces. The cap and rod are a matched set and must be kept together.

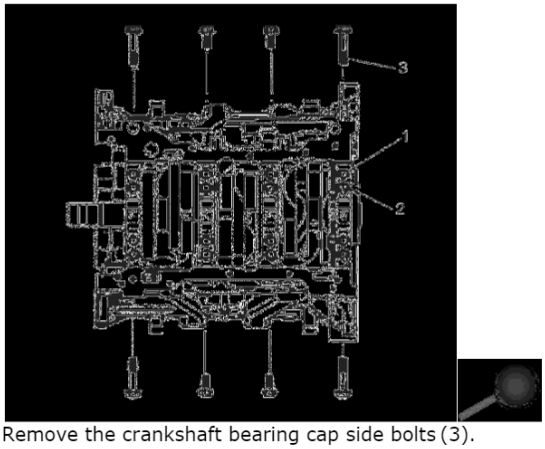
cardiagn.com

Crankshaft and Bearing Removal

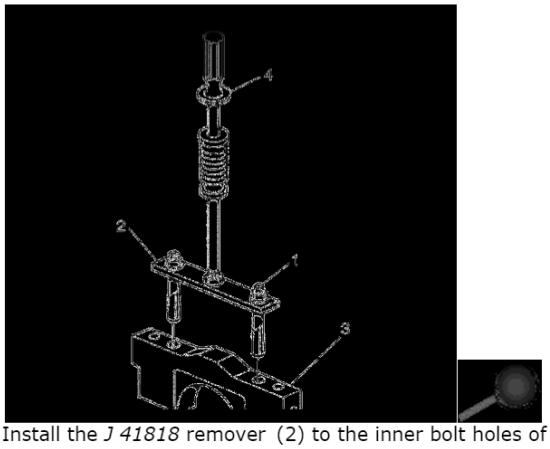
Special Tools

- *J 41818* Crankshaft Bearing Cap Remover
- *J 6125-1B* Slide Hammer with Adapter For equivalent regional tools, refer to Special Tools.

Crankshaft Removal



1. Remove the crankshaft bearing cap side bolts (3).
2. Remove the crankshaft bearing cap outer bolts (1).
3. Remove the crankshaft bearing cap inner bolts (2).

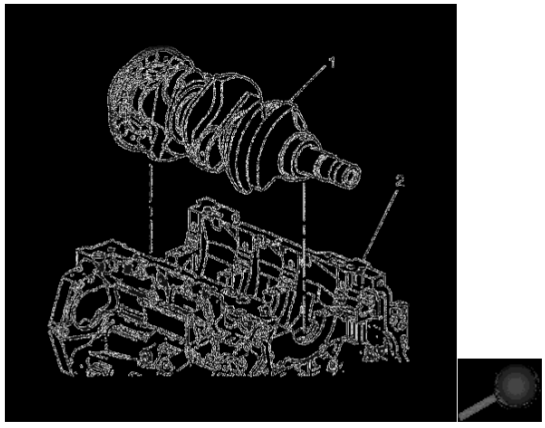


4. Install the *J 41818* remover (2) to the inner bolt holes of the crankshaft bearing cap (3).

   Caution: Refer to Fastener Caution.
5. Tighten the *J 41818* remover nuts (1) to **11 N•m (97 lb in)**.
6. Install the *J 6125-1B* adapter (4) onto the *J 41818* remover (2).
7. Remove the crankshaft bearing cap

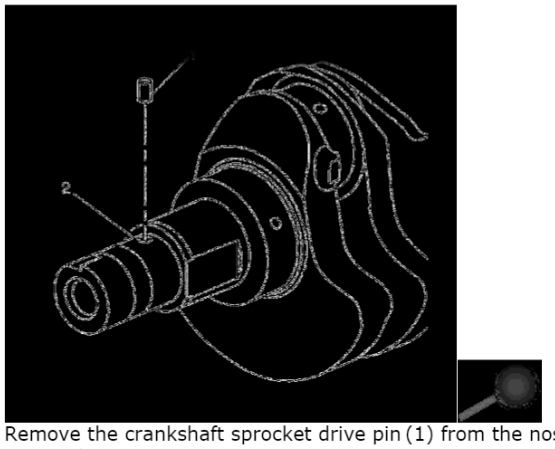
© 2014 General Motors. All rights reserved.

cardiagn.com



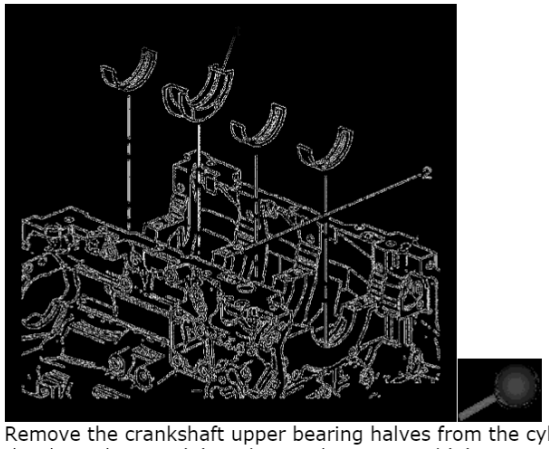
Note: Lift the crankshaft (1) straight up evenly to remove from the cylinder block (2).

8. Remove the crankshaft (1).
9. Place the crankshaft in a secure place.

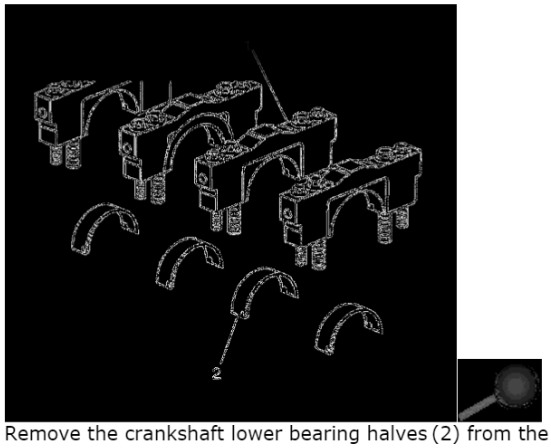


10. Remove the crankshaft sprocket drive pin (1) from the nose of the crankshaft (2), if required.
11. Prepare a piece of cardboard or equivalent, numbered 1–4 for bearing identification. Main bearing journals are numbered from the front of the cylinder block.

cardiagn.com



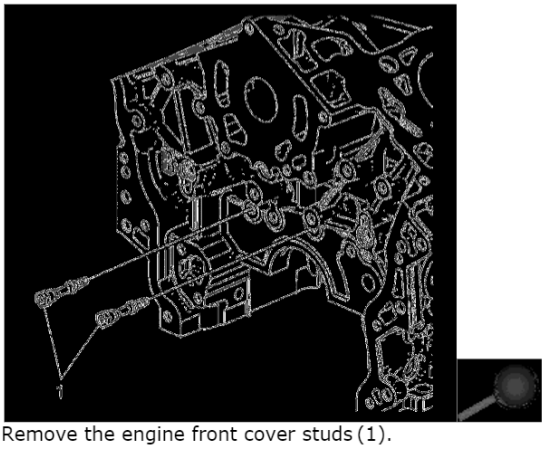
12. Remove the crankshaft upper bearing halves from the cylinder block. Note the position of the thrust bearing (1) at the number 3 journal (2).
13. Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.



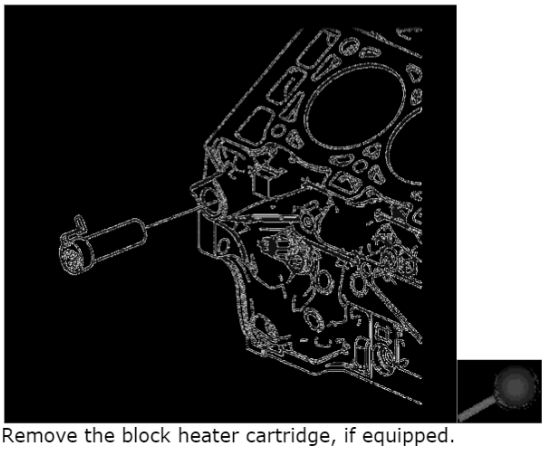
14. Remove the crankshaft lower bearing halves (2) from the crankshaft bearing caps (1).
15. Place the crankshaft lower bearing halves (2) in the correct positions on the cardboard.

cardiagn.com

Engine Block Disassemble



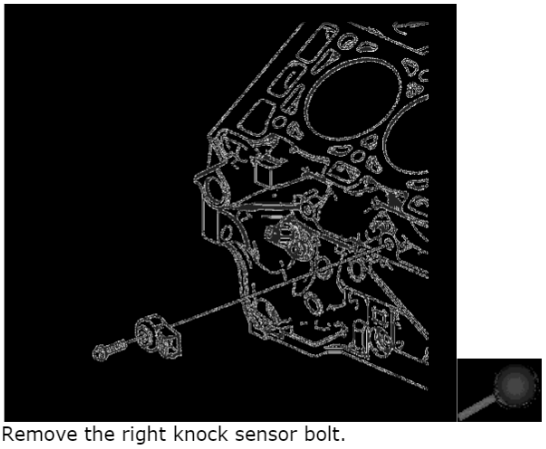
1. Remove the engine front cover studs (1).



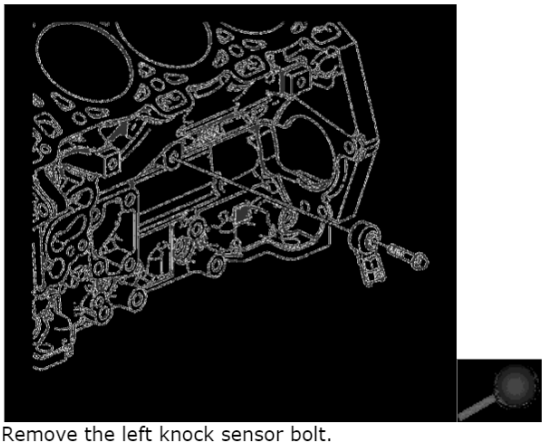
2. Remove the block heater cartridge, if equipped.

cardiagn.com

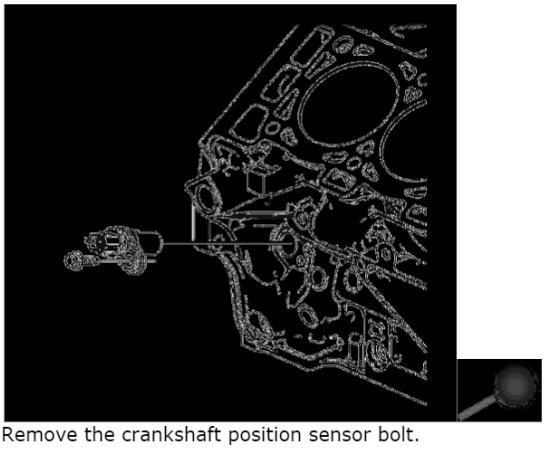
© 2014 General Motors. All rights reserved.



3. Remove the right knock sensor bolt.
4. Remove the right knock sensor.

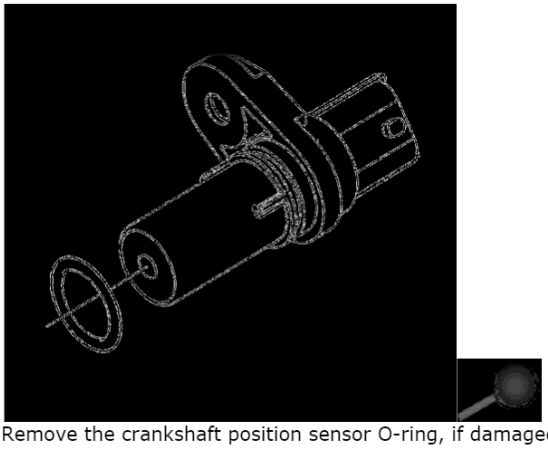


5. Remove the left knock sensor bolt.
6. Remove the left knock sensor.

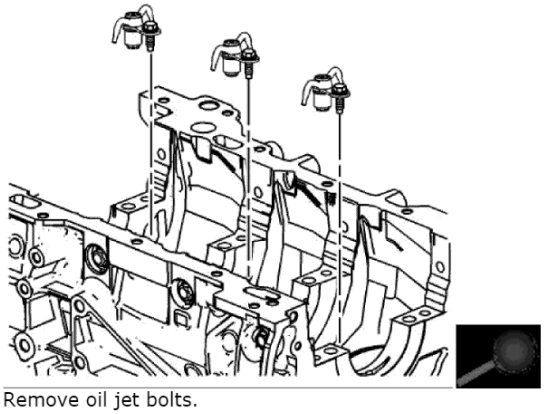


7. Remove the crankshaft position sensor bolt.
8. Remove the crankshaft position sensor.

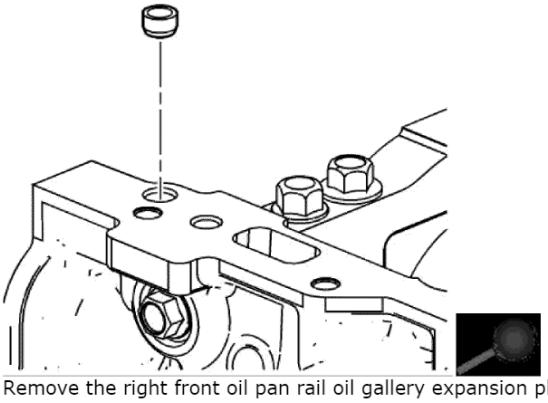
cardiagn.com



9. Remove the crankshaft position sensor O-ring, if damaged.

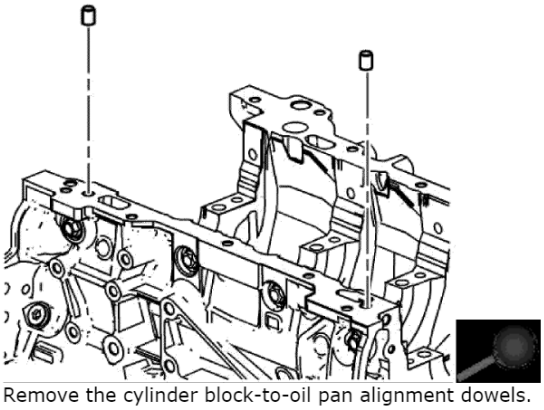


10. Remove oil jet bolts.
11. Remove oil jets.

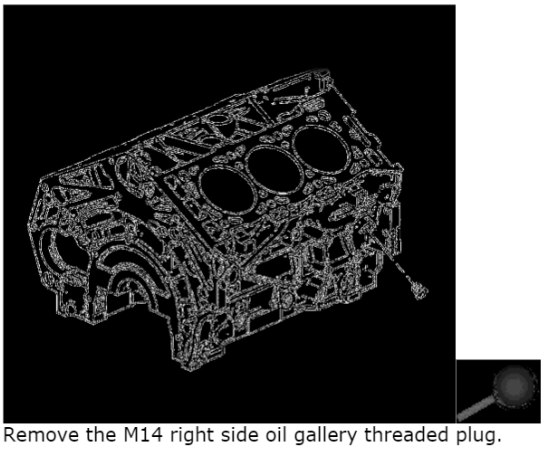


12. Remove the right front oil pan rail oil gallery expansion plug.

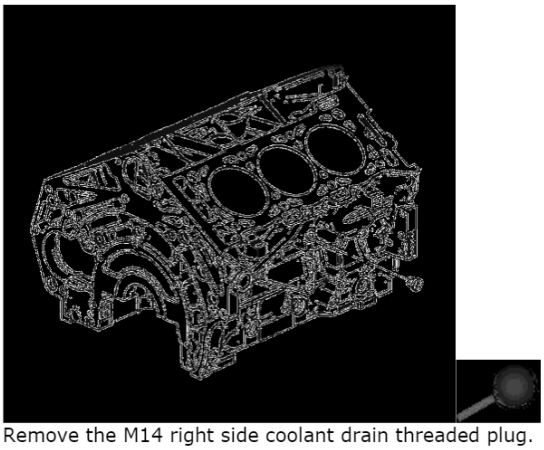
cardiagn.com



13. Remove the cylinder block-to-oil pan alignment dowels.

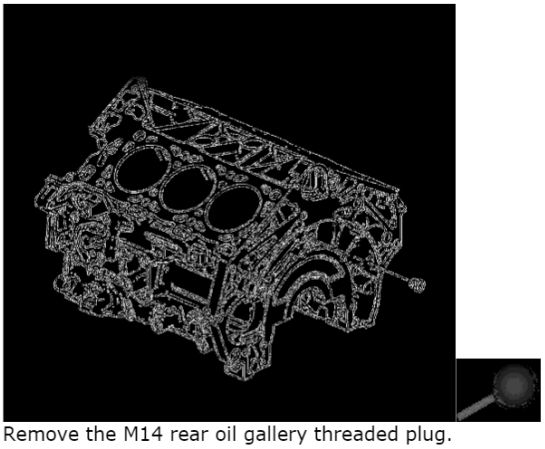


14. Remove the M14 right side oil gallery threaded plug.

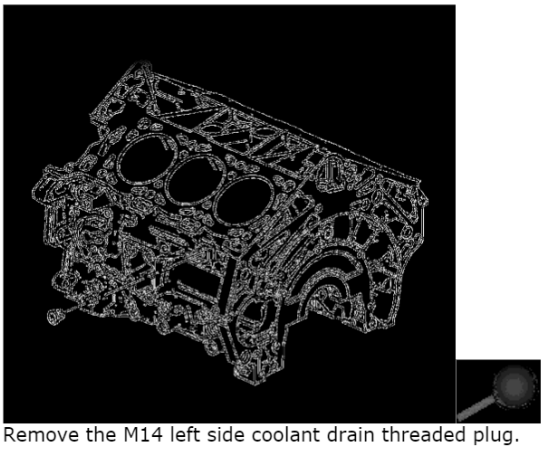


15. Remove the M14 right side coolant drain threaded plug.

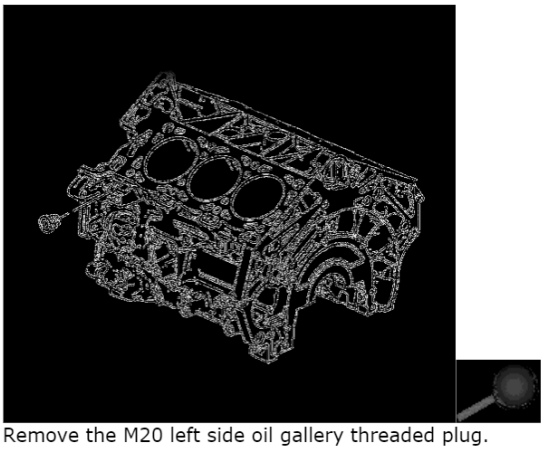
cardiagn.com



16. Remove the M14 rear oil gallery threaded plug.

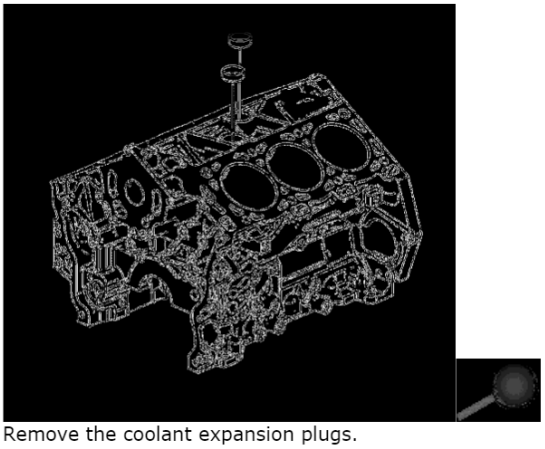


17. Remove the M14 left side coolant drain threaded plug.

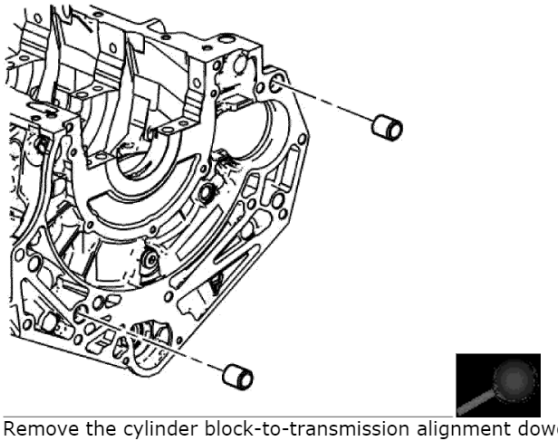


18. Remove the M20 left side oil gallery threaded plug.

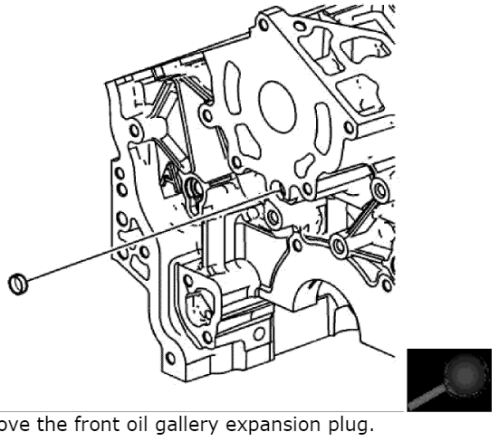
cardiagn.com



19. Remove the coolant expansion plugs.

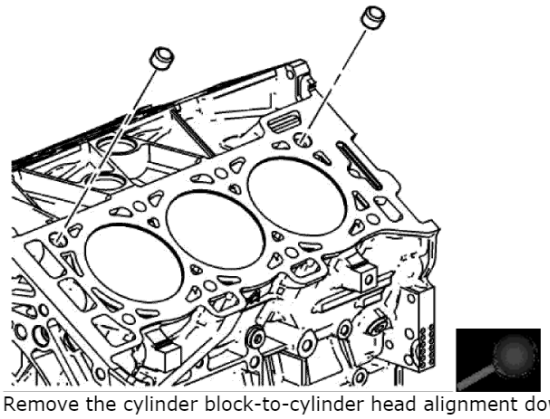


20. Remove the cylinder block-to-transmission alignment dowels.



21. Remove the front oil gallery expansion plug.

cardiagn.com



22. Remove the cylinder block-to-cylinder head alignment dowels.

cardiagn.com

Engine Block Cleaning and Inspection

Special Tools

- *J 8087* Cylinder Bore Gauge
- *J 28410* Gasket Remover

For equivalent regional tools, refer to Special Tools.

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *J 28410* remover .
2. Clean all the following areas with solvent:
   - Sealing surfaces
   - Cooling passages
   - Oil passages
   - Bearing journals
3. Clean all threaded and through holes with solvent.

   Warning: Refer to Safety Glasses Warning.
4. Dry the cylinder block with compressed air.

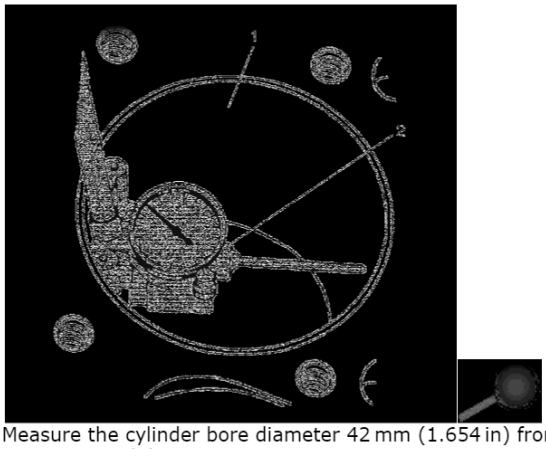
Visual Inspection

1. Inspect the crankshaft bearings journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the cylinder block assembly must be replaced.
2. Inspect the primary camshaft drive chain tensioner mounting surface on the cylinder block for burrs or any defects that may degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.
3. Inspect all sealing and mating surfaces for damage, repair or replace the cylinder block assembly if necessary.
4. Inspect all threaded and through holes for damage or debris above acceptable tolerances.
5. Inspect all bolts for damage, if damaged replace with NEW bolts only.
6. Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the cylinder block assembly must be replaced.
7. Inspect the cylinder block for cracks. DO NOT repair any cracks. If cracks are found, the cylinder block assembly must be replaced.
8. Repair any damaged threaded holes. Refer to Thread Repair Specifications and Thread Repair.

Measuring Cylinder Bore Diameter

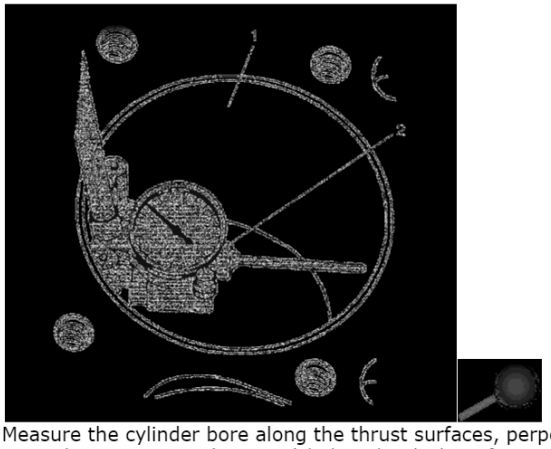
cardiagn.com

© 2014 General Motors. All rights reserved.



1. Measure the cylinder bore diameter 42 mm (1.654 in) from the deck face (1) using the *J 8087* gauge (2).
2. Record and compare your results with the Engine Mechanical Specifications. If the cylinder diameter exceeds the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.
   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

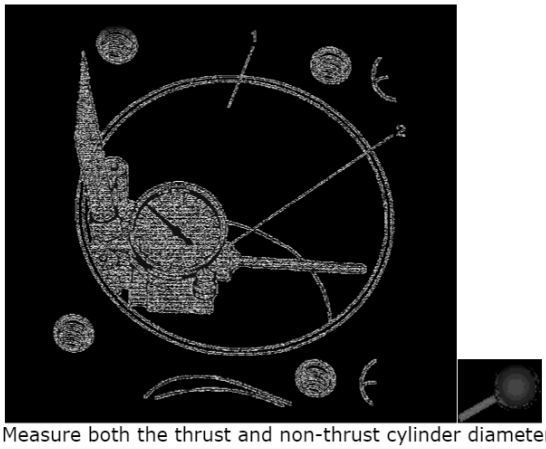
Measuring Cylinder Bore Taper



1. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 10 mm (0.397 in) below the deck surface and record your measurement.
2. Measure the cylinder bore along the thrust surfaces, perpendicular to the crankshaft centerline, at 100 mm (3.976 in) below the deck surface and record your measurement.
3. Calculate the difference between the 2 measurements. The result will be the cylinder taper.
4. Compare your results with the Engine Mechanical Specifications. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.
   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

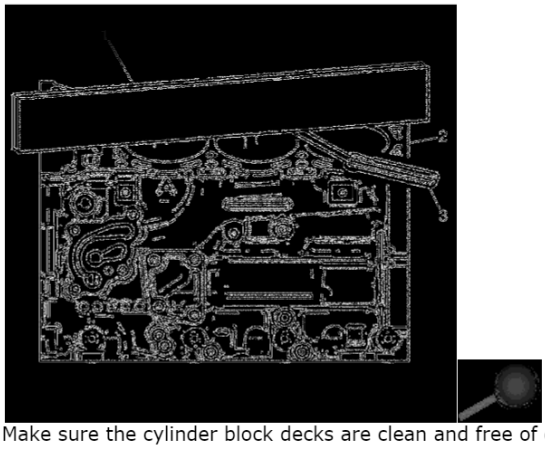
Measuring Cylinder Bore Out-of-Round

cardiagn.com



1. Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
2. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
3. Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
4. Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
5. Compare your results with the Engine Mechanical Specifications. If the cylinders exceed the specifications, the cylinder block may be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.
   If the cylinder bore exceeds specification by more than 0.25 mm (0.010 in) the cylinder block must be replaced.

Deck Flatness Inspection



1. Make sure the cylinder block decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that may inhibit correct cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder block deck face surface.
4. Measure the clearance between the straight-edge and the cylinder block deck face using a feeler gauge at 4 points along the straight-edge.

cardiagn.com

5. If the warpage is less than 0.05 mm (0.002 in), the cylinder block deck surface does not require resurfacing.
6. If the warpage is between 0.05–0.20 mm (0.002–0.008 in) or any imperfections or scratches that may inhibit correct cylinder head gasket sealing are present, the cylinder block deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

cardiagn.com

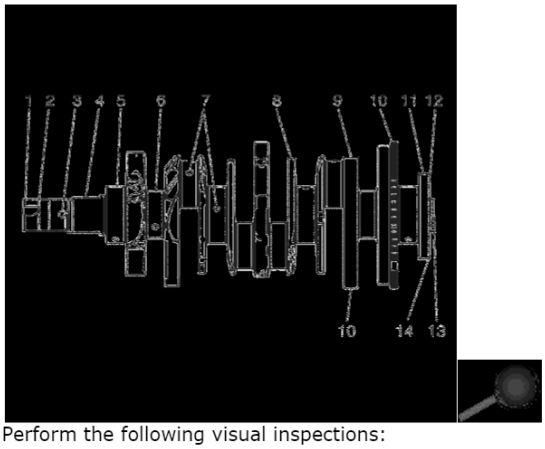
Crankshaft and Bearing Cleaning and Inspection

Cleaning Procedure

1. Clean the following components in solvent:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

   Warning: Refer to Safety Glasses Warning.
2. Dry the following components with compressed air:
   - Crankshaft bearings
   - Connecting rod bearings
   - Crankshaft journals
   - Crankpin journals
   - Crankshaft oil passages
   - Crankshaft threaded holes

Visual Inspection



1. Perform the following visual inspections:
   - Inspect the crankshaft balancer bolt hole (1) for thread damage.
   - Inspect the crankshaft balancer mounting area (2) for damage.
   - Inspect the crankshaft sprocket pin hole (3) for damage.
   - Inspect the oil pump drive flats (4) for damage.
   - Inspect the crankshaft main journals (5) for damage.
   - Inspect the crankshaft connecting rod journals (6) for damage.
   - Inspect the crankshaft oil passages (7) for obstructions.

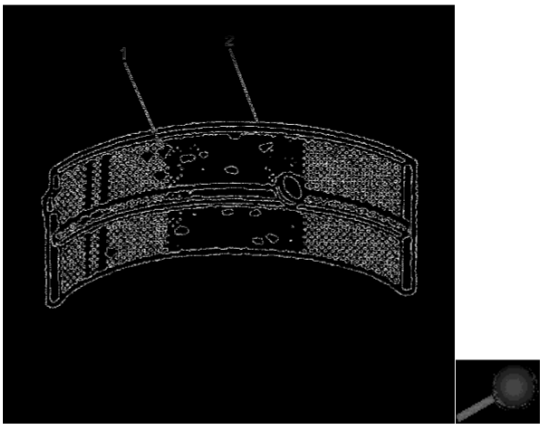
© 2014 General Motors. All rights reserved.

cardiagn.com

- Inspect the crankshaft main bearing thrust wall surfaces (8) for damage.
- Inspect the crankshaft counterweights (9) for damage.
- Inspect the crankshaft reluctor ring teeth (10) for damage.
- Inspect the crankshaft rear main oil seal surface (11) for damage.
- Inspect the crankshaft engine flywheel mounting surface (12) for damage.
- Inspect the crankshaft pilot hole (13) for damage.
- Inspect the crankshaft engine flywheel bolt holes (14) for thread damage.

2. Repair or replace the crankshaft as necessary.

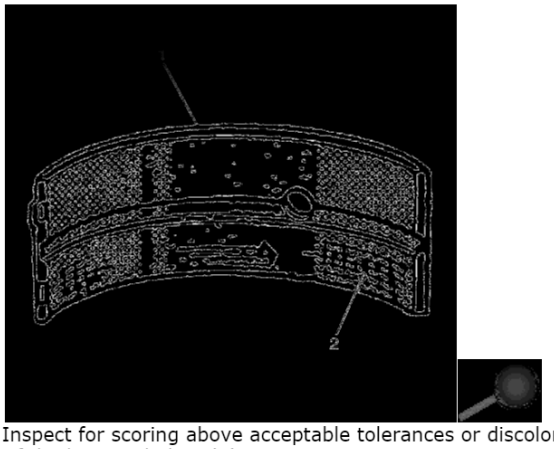
Crankshaft Bearing Inspection



Note:

- All connecting rod and main journal bearings that have been used in a running engine must be replaced. Never re-use the crankshaft or connecting rod bearings.
- The following bearing wear conditions should be used to diagnose engine operating conditions or root cause of a condition.

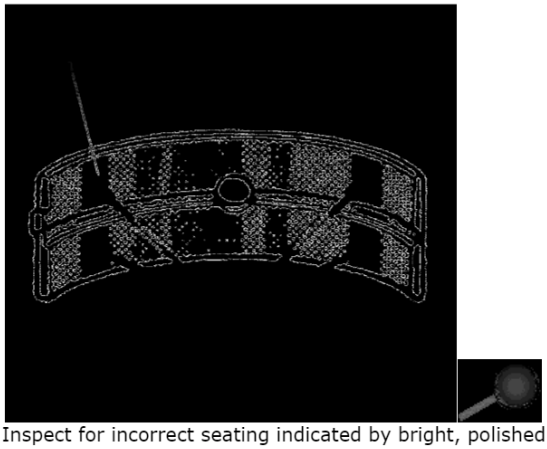
1. Inspect for fatigue indicated by craters or pockets (1). Flattened sections on the bearing halves (2) also indicate fatigue.



2. Inspect for scoring above acceptable tolerances or discoloration (2) on both front and back of the bearing halves (1).

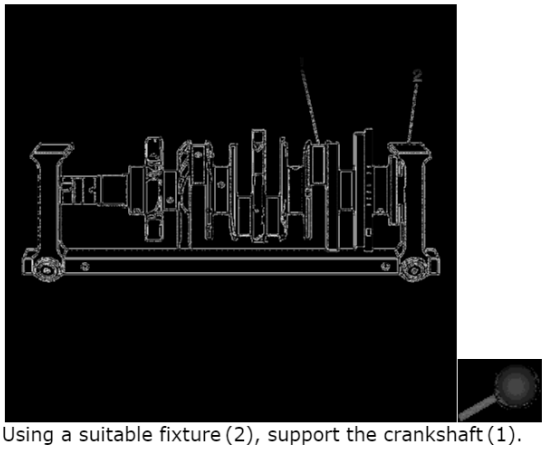
cardiagn.com

3. Inspect the main bearings for dirt embedded into the bearing material.

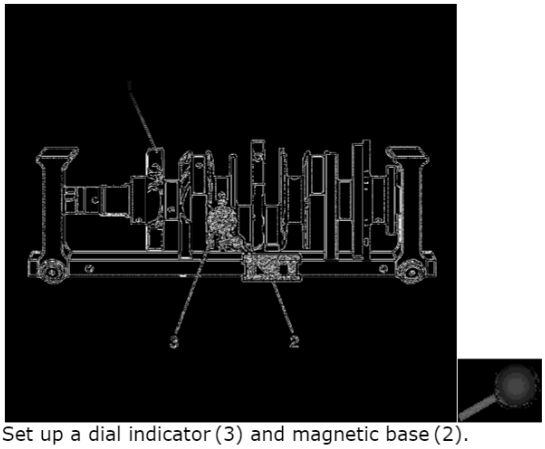


4. Inspect for incorrect seating indicated by bright, polished sections (1).

Crankshaft Measurement



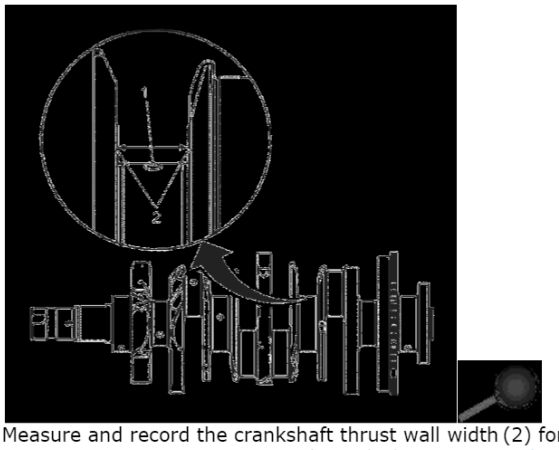
1. Using a suitable fixture (2), support the crankshaft (1).



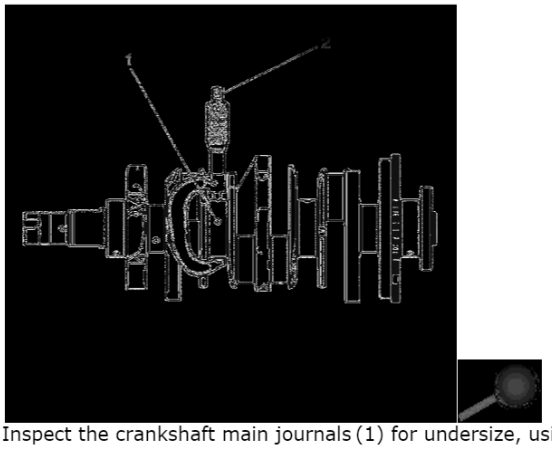
2. Set up a dial indicator (3) and magnetic base (2).

cardiagn.com

3. Rotate the crankshaft (1) to measure and record the crankshaft runout. Compare your results with the Engine Mechanical Specifications.

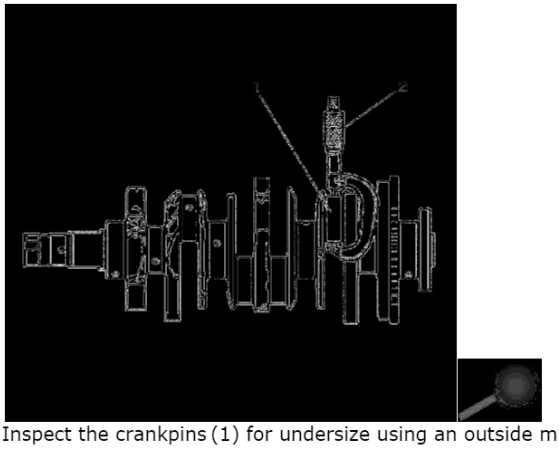


4. Measure and record the crankshaft thrust wall width (2) for wear using an inside micrometer. Compare your results with the Engine Mechanical Specifications.
5. Measure and record the crankshaft thrust wall surface (1) for runout using the dial indicator. Compare your results with the Engine Mechanical Specifications.
6. If the crankshaft journals are damaged or worn beyond specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized main bearings available for service.

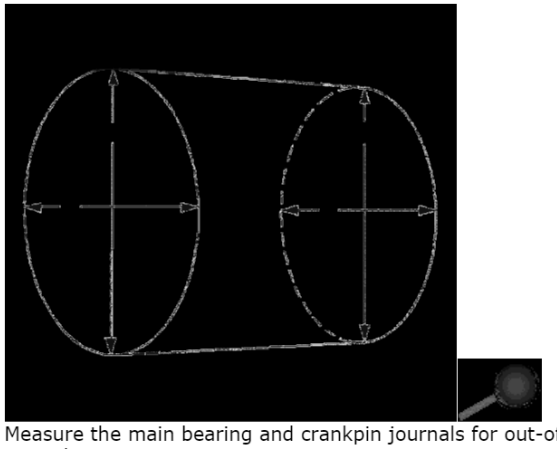


7. Inspect the crankshaft main journals (1) for undersize, using an outside micrometer (2).

cardiagn.com



8. Inspect the crankpins (1) for undersize using an outside micrometer (2).
9. Compare your results with the Engine Mechanical Specifications. If the crankpin journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized connecting rod bearings available for service.



10. Measure the main bearing and crankpin journals for out-of-round using the following procedure:
    10.1. Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
    10.2. Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
    10.3. Subtract A from C and B from D. The differences will indicate journal out-of-round.
    10.4. The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
    10.5. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.
11. Measure the main bearing and crankpin journals for taper using the following procedure:
    11.1. Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
    11.2. Subtract the smallest from the largest measurement. The result will be the journal taper.

cardiagn.com

11.3. If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.

11.4. If the journals are worn beyond the specifications, the crankshaft may be ground 0.25 mm (0.010 in). There is only 1 size of oversized crankshaft and connecting rod bearings available for service.

cardiagn.com

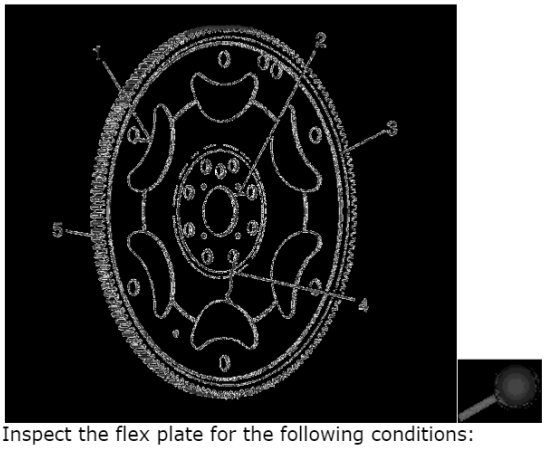
Automatic Transmission Flex Plate Cleaning and Inspection

Cleaning Procedure

1. Clean the flex plate in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the flex plate with compressed air.

Inspection Procedure



1. Inspect the flex plate for the following conditions:
   - Stress cracks around the flex plate-to-torque converter mounting bolt hole locations (1) and/or flex plate-to-crankshaft (2, 4)

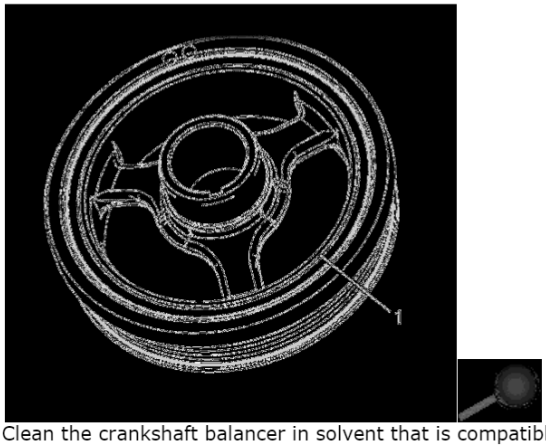
     Note: Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a NEW flex plate.
   - Cracks at welded areas that retain the ring gear onto the flex plate (3)
   - Damaged or missing ring gear teeth (5)
2. Replace the flex plate as necessary.

cardiagn.com

© 2014 General Motors. All rights reserved.

Crankshaft Balancer Cleaning and Inspection

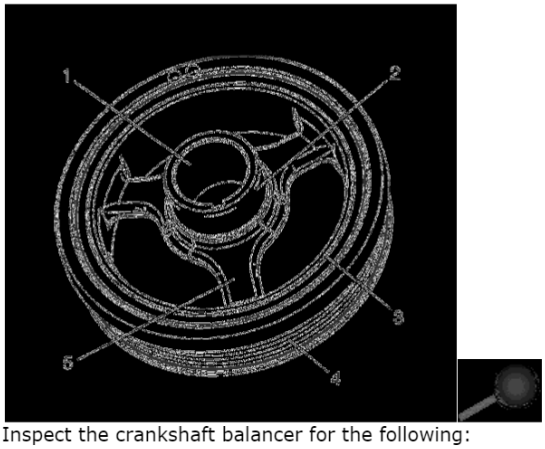
Cleaning Procedure



1. Clean the crankshaft balancer in solvent that is compatible with the rubber (1).

   Warning: Refer to Safety Glasses Warning.
2. Dry the crankshaft balancer with compressed air.

Inspection Procedure



1. Inspect the crankshaft balancer for the following:
   - Worn or damaged hub-to-crankshaft surface (1)
   - Worn, grooved or damaged hub seal surface (2)

     A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.
   - Worn, chunking or deteriorated rubber between the hub and pulley (3)
   - Damaged drive belt ribs (4)

© 2014 General Motors. All rights reserved.

cardiagn.com

- Damaged webs (5)

2. Repair or replace the crankshaft balancer as necessary.

cardiagn.com

Engine Flywheel Cleaning and Inspection

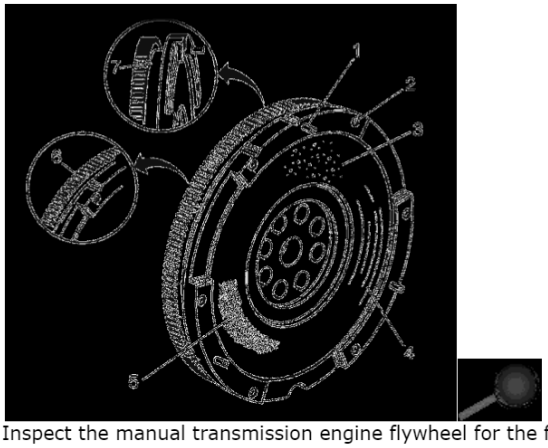
Cleaning Procedure

Note: In order to maintain the proper component balance, contact surface taper and heat transfer, manual transmission flywheels are NOT to be machined.

1. Clean the engine flywheel in solvent.

   Caution: Refer to Safety Glasses Caution.
2. Dry the engine flywheel with compressed air.

Inspection Procedure



1. Inspect the manual transmission engine flywheel for the following conditions:
   - Missing and/or damaged alignment pins (1)
   - Damaged threaded holes (2)
   - Pitted surface (3)
   - Scoring or grooves (4)
   - Rust or other surface damaged (5)
   - Damaged ring gear teeth (6)
   - Loose or improperly positioned ring gear

     The ring gear has an interference fit onto the engine flywheel and should be positioned completely against the flange of the engine flywheel (7).
2. Replace the engine flywheel as necessary.

cardiagn.com

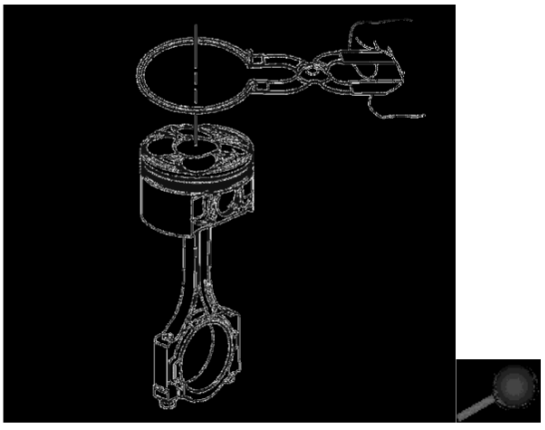
© 2014 General Motors. All rights reserved.

Piston and Connecting Rod Disassemble

Special Tools

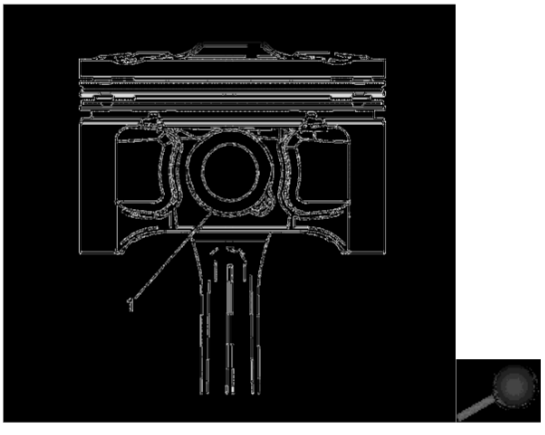
EN-46745 Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to Special Tools.



Caution: You must use a piston ring expander to remove and install the piston rings. Only expand the rings far enough to fit over the piston lands. If the rings are overexpanded, the top ring will shatter and the others will distort.

1. Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage.



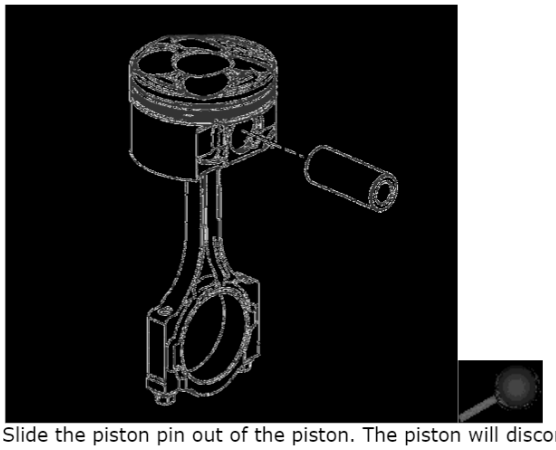
Note:

- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.
- DO NOT reuse the piston pin retainers.

© 2014 General Motors. All rights reserved.

cardiagn.com

2. Using the *EN-46745* remover/installer , remove the piston pin retainers by using the removal access notch (1) in the side of the piston. Discard the piston pin retainers.



3. Slide the piston pin out of the piston. The piston will disconnect from the connecting rod.

cardiagn.com

Piston, Connecting Rod, and Bearing Cleaning and Inspection

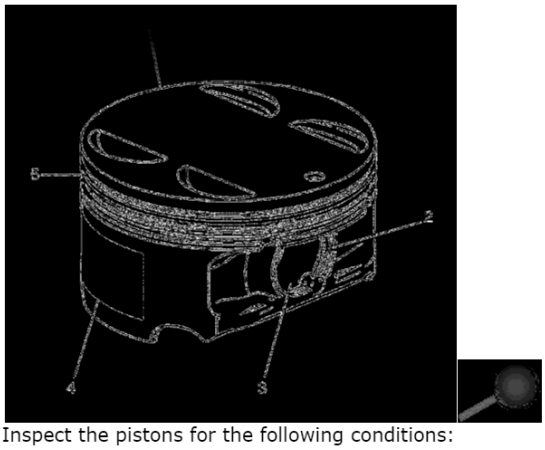
Cleaning Procedure

Note: DO NOT wire brush any part of the piston.

1. Clean the piston skirts and the pins with a cleaning solvent.
2. Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.

   Warning: Refer to Safety Glasses Warning.
3. Dry the piston with compressed air.

Piston Inspection Procedure

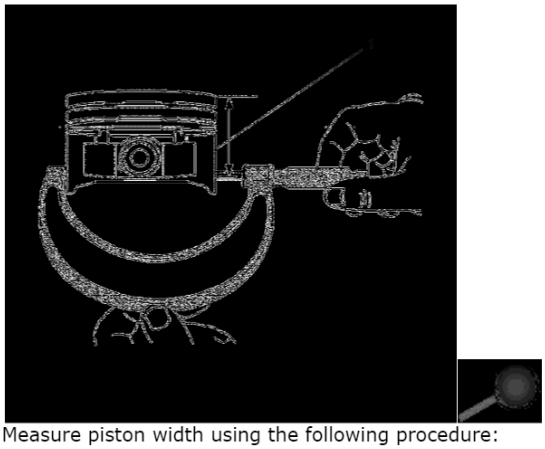


1. Inspect the pistons for the following conditions:
   - Cracked ring lands, skirts or pin bosses
   - Ring grooves for nicks, burrs that may cause binding (5)
   - Warped or worn ring lands (5)
   - Piston pin retainer grooves for burrs (2)
   - Eroded areas at the top of the piston (1)
   - Scuffed or damaged skirt coating (4)
   - Worn piston pin bores or worn piston pins (3)
2. Replace pistons that show any signs of damage or wear above acceptable tolerances.

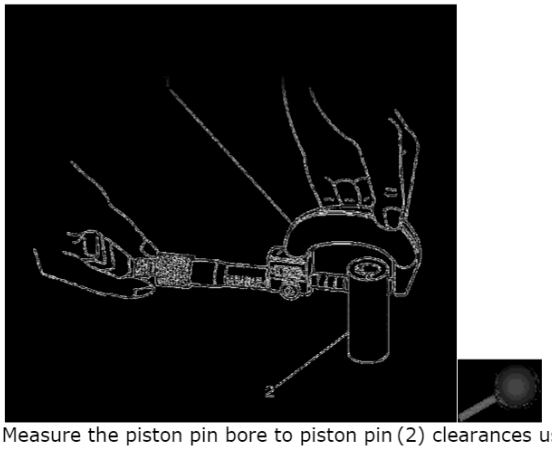
Piston Measurement Procedure

cardiagn.com

© 2014 General Motors. All rights reserved.

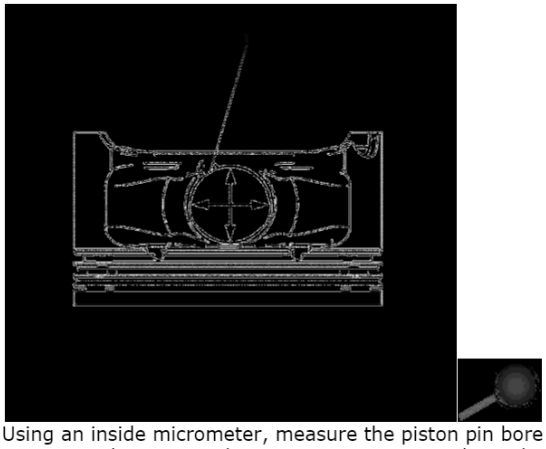


1. Measure piston width using the following procedure:
   1.1. Using an outside micrometer, measure the width of the piston at 30 mm (1.181 in) below the crown, top (1), at the thrust surfaces of the piston, perpendicular to the piston pin centerline.
   1.2. Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
   1.3. Compare your results with the Engine Mechanical Specifications.
   1.4. If the clearance obtained through measurement is greater than the provided specifications and the cylinder bores are within specification, replace the piston.



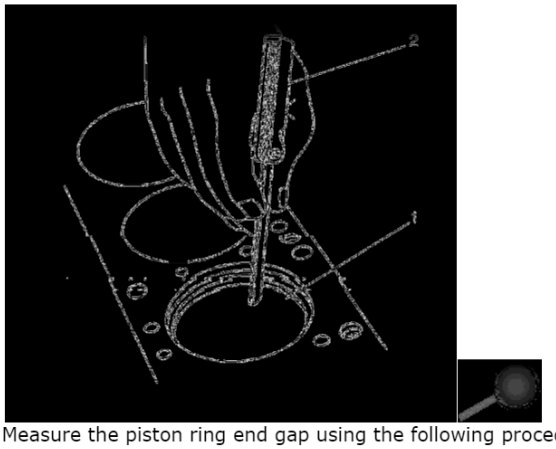
2. Measure the piston pin bore to piston pin (2) clearances using the following procedure:
   2.1. Piston pin bores and pins must be free of varnish or scuffing.
   2.2. Use an outside micrometer (1) to measure the piston pin in the piston contact areas.

cardiagn.com



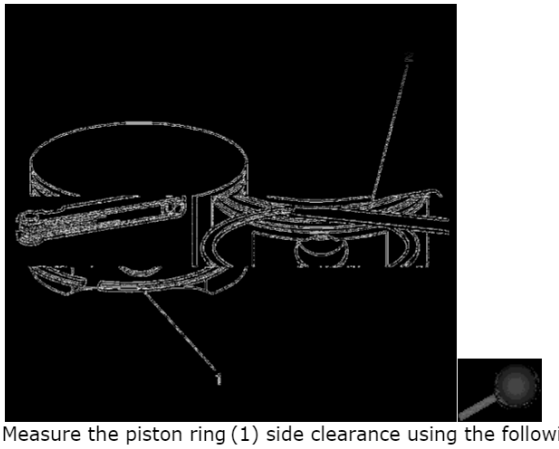
3. Using an inside micrometer, measure the piston pin bore (1). Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the Engine Mechanical Specifications.
4. If the clearance is above acceptable tolerances, determine which piece is out of specification and replace as necessary.
5. You must replace the piston if any of its dimensions are out of specification.
6. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Piston Ring Measurement Procedure

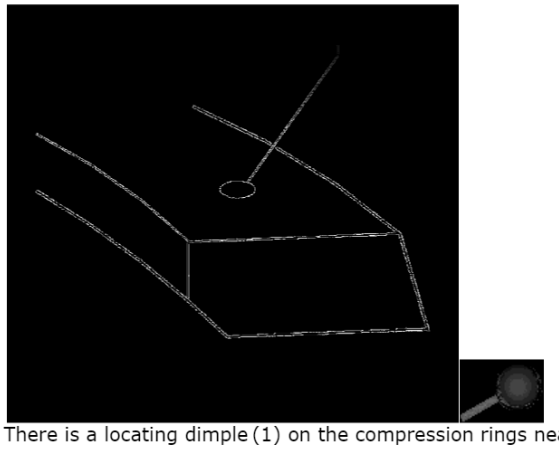


1. Measure the piston ring end gap using the following procedure:
   1.1. Place the piston ring (1) in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Make sure that the piston ring (1) is square with the cylinder bore by positioning the piston ring (1) with the piston head.
   1.2. Measure the end gap of the piston ring (1) with feeler gauges (2). Refer to Engine Mechanical Specifications.
   1.3. If the clearance exceeds the provided specifications, the piston rings (1) must be replaced.
   1.4. Repeat the procedure for all the piston rings (1).

cardiagn.com



2. Measure the piston ring (1) side clearance using the following procedure:
   2.1. Roll the piston ring (1) entirely around the piston ring groove. If any binding is caused by the ring groove, dress the groove with a fine file. If any binding is caused by a distorted piston ring (1), replace the piston ring (1).
   2.2. With the piston ring (1) on the piston, use feeler gauges (2) to check clearance at multiple locations.
   2.3. Compare the measurements with piston ring side clearance listed in the Engine Mechanical Specifications.
   2.4. If the clearance is greater than specifications, replace the piston ring (1).



3. There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up.
4. If the new ring does not reduce the clearance to the correct specification, install a new piston.
5. If the new piston does not meet clearance specifications, the cylinder block may need to be oversized to 0.25 mm (0.010 in). There is only one size of oversized pistons and rings available for service.

Connecting Rod Cleaning Procedure

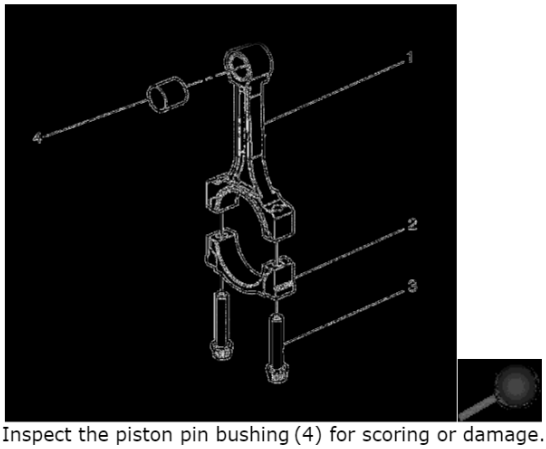
1. Clean the connecting rods in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the connecting rod using compressed air.
3. Remove the connecting rod cap and clean the threads.

cardiagn.com

4. Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure

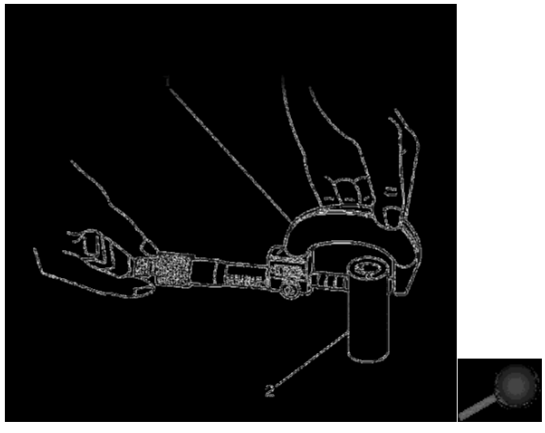


1. Inspect the piston pin bushing (4) for scoring or damage.
2. Inspect the connecting rod beam (1) for twisting or bending.
3. Inspect the rod cap (2) for any nicks or damage caused by possible interference.
4. Inspect for scratches or abrasion on the rod bearing seating surface.

   Note: DO NOT scrape the rod or rod cap.
5. If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.
6. Inspect the connecting rod bolts (3) for damage or stretching.

Connecting Rod Measurement Procedure

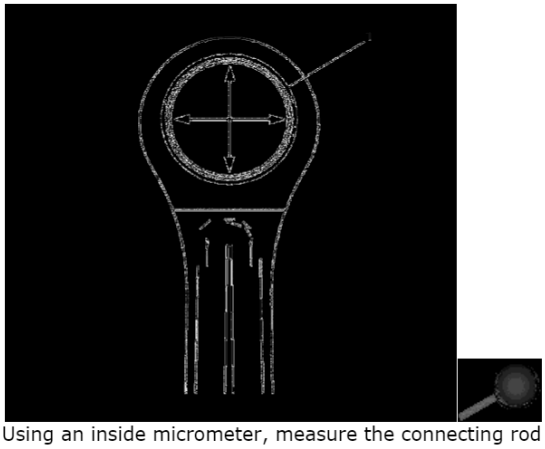
Piston Pin End



Note: Measurements of all components should be taken with the components at normal room temperature.

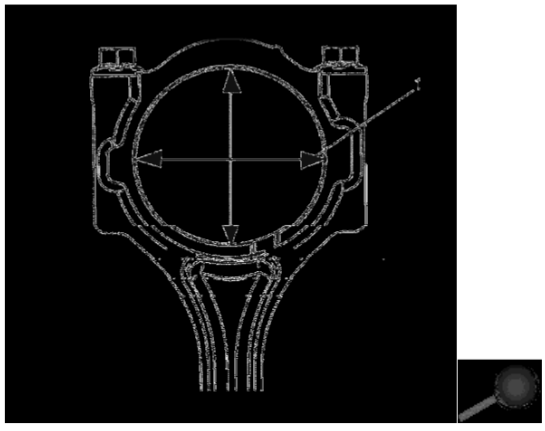
1. Using an outside micrometer (1), take 2 measurements of the piston pin (2) in the area of the connecting rod contact.

cardiagn.com



2. Using an inside micrometer, measure the connecting rod piston pin bore (1).
3. Subtract the piston pin diameter from the piston pin bore (1).
4. Compare the clearance measurements with the Engine Mechanical Specifications.
5. If the clearance is above acceptable tolerances, replace the piston pin. If a new pin does not resolve the clearance condition, replace the connecting rod.

Connecting Rod Crankshaft Bearing End



Note: Measurements of all components should be taken with the components at normal room temperature.

1. Using an inside micrometer, measure the connecting rod crankshaft bearing bore (1).
2. Compare the bore measurements with the Engine Mechanical Specifications.
3. Replace the connecting rod if the connecting rod crankshaft bearing bore (1) is out of specifications. DO NOT recondition the connecting rod.

cardiagn.com

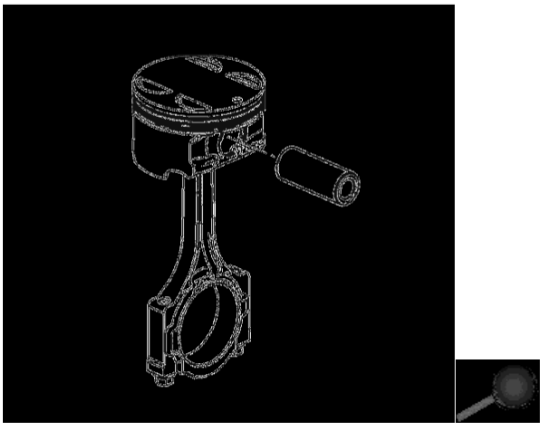
Piston and Connecting Rod Assemble

Special Tools

- *EN-46121* Connecting Rod Guide Pin Set
- *EN-46745* Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to Special Tools

Piston and Piston Pin Installation Procedure



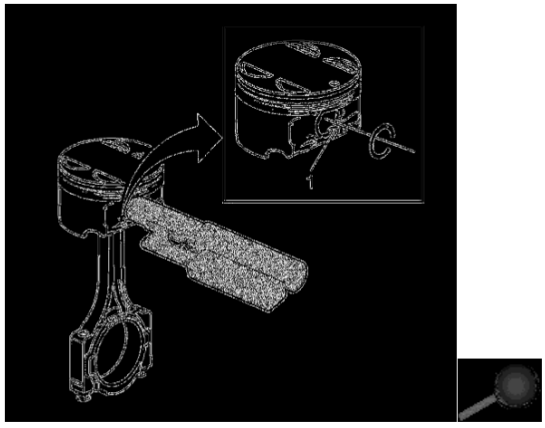
Note:

- The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.
- The piston is model dependent and may not appear exactly as shown.

1. Lubricate the piston pin bores in the piston and the connecting rod with GM prelube lubricant. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
2. Assemble the piston and piston pin to the connecting rod. Properly orient the piston when reusing a marked connecting rod.
3. Align the piston pin bore with the connecting rod pin bore.
4. Slide the piston pin into the piston and the connecting rod.

cardiagn.com

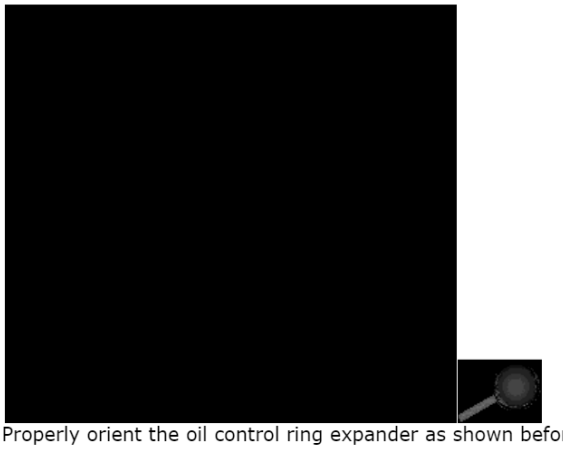
© 2014 General Motors. All rights reserved.



Note: New piston pin retainers must be used. Never reuse the piston pin retainers.

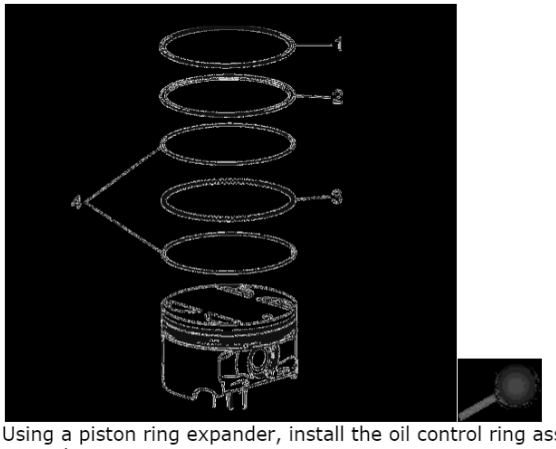
5. Install NEW piston pin retainers using the *EN-46745* remover/installer. Align the *EN-46745* remover/installer to the notch (1) in the piston.
6. Ensure that the piston pin retainers are fully seated in their grooves.
7. Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure



1. Properly orient the oil control ring expander as shown before installation. The ends of the expander must be facing toward the top of the piston.

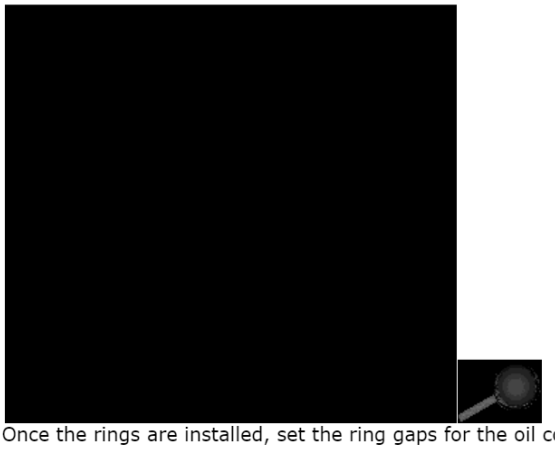
cardiagn.com



2. Using a piston ring expander, install the oil control ring assembly using the following procedure:
   2.1. Install the expander ring (3).
   2.2. Install the 2 oil scraper rings (4). Expand the rings only enough to clear the piston diameter. Overexpanding the piston rings will distort or crack the rings.

   Note: The lower compression piston ring (2) is thicker and will not fit in the upper compression rings (1) position.
3. Install the lower compression piston ring (2) onto the piston with the mark facing the top of the piston.

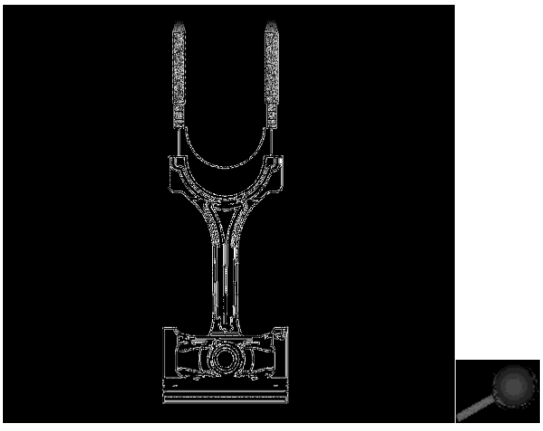
   Note: For the LY7, the upper compression ring is symmetrical and may be installed either side up. For all other RPO's, the mark on the piston ring should face the top of the piston.
4. Install the upper compression piston ring (1) onto the piston with the mark facing the top of the piston, if required.



5. Once the rings are installed, set the ring gaps for the oil control, second and top ring as follows. Use the piston location arrow for reference.
   5.1. Lower oil control ring – position 1
   5.2. Upper oil control ring – position 2
   5.3. Top Ring – position 3
   5.4. Oil control ring expander – position 4
   5.5. Second ring – position 5

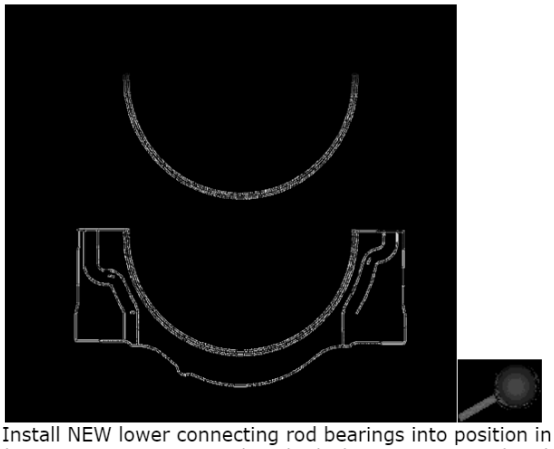
cardiagn.com

Connecting Rod Bearing Installation Procedure



Note: If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.

1. Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.
2. Clean all the oil from behind the connecting rod bearing halves.
3. Install NEW upper connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
4. Install the *EN-46121* set into the connecting rod bolt holes.



5. Install NEW lower connecting rod bearings into position in the connecting rod cap. Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap.

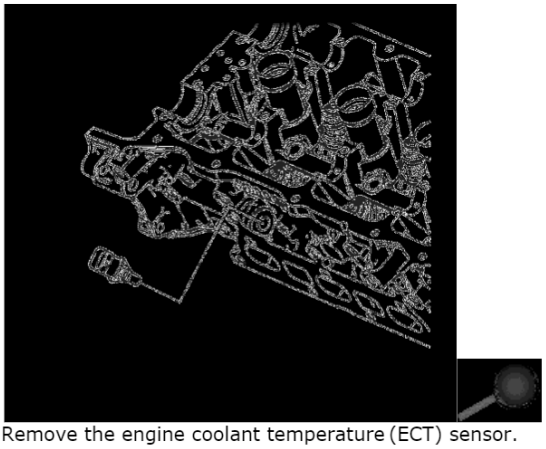
cardiagn.com

Cylinder Head Disassemble (LWR)

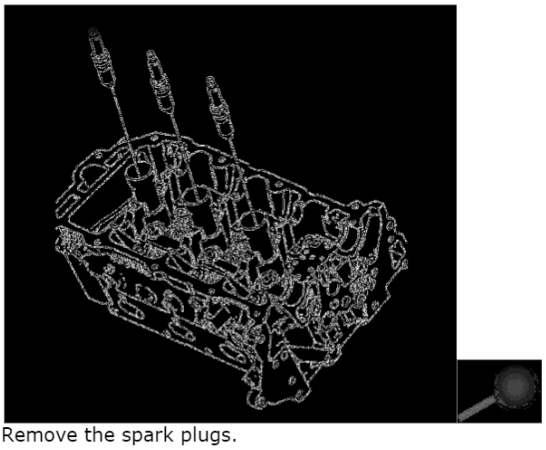
Special Tools

- *EN 8062* Valve Spring Compressor - Head Off
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN 46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer

For equivalent regional tools, refer to Special Tools.



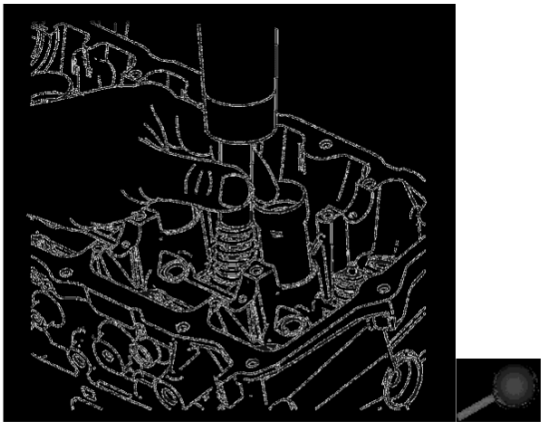
1. Remove the engine coolant temperature (ECT) sensor.



2. Remove the spark plugs.

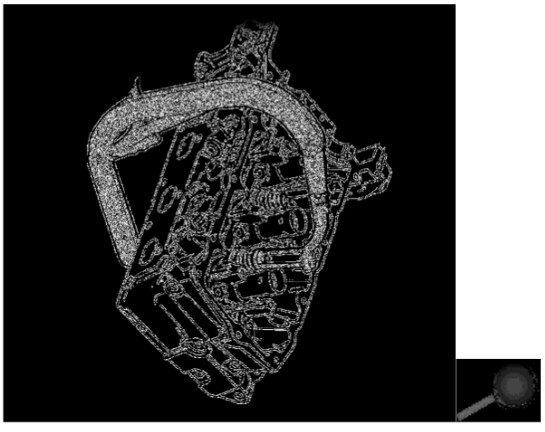
cardiagn.com

© 2014 General Motors. All rights reserved.



Note: Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

3. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

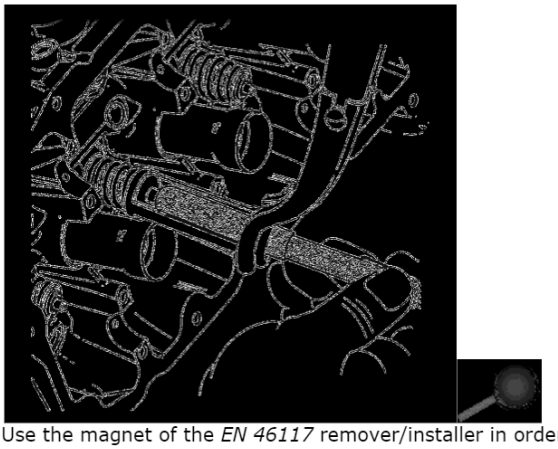


Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

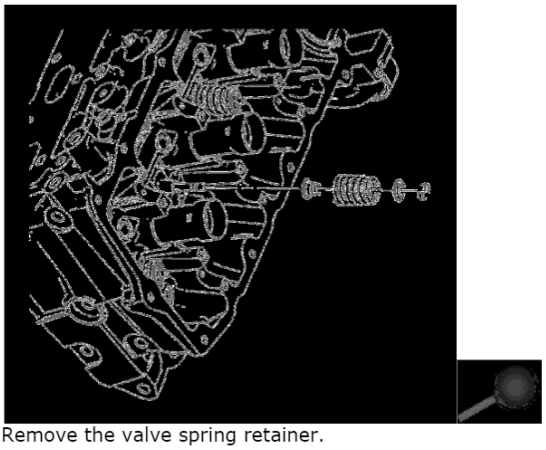
Caution: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

4. Compress the valve spring using the *EN 8062* compressor and the *EN 46119* adapter .

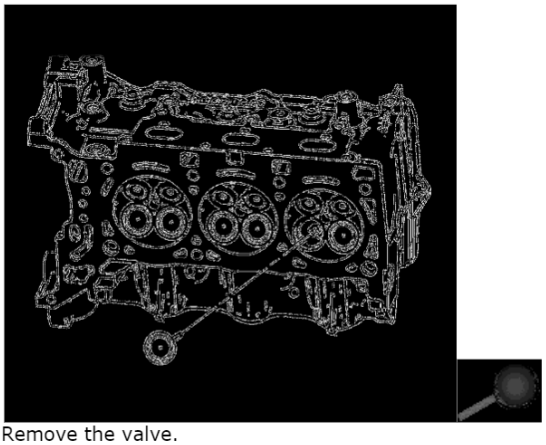
cardiagn.com



5. Use the magnet of the *EN 46117* remover/installer in order to remove the valve keepers.
6. Remove the valve spring compressor and the adapter.

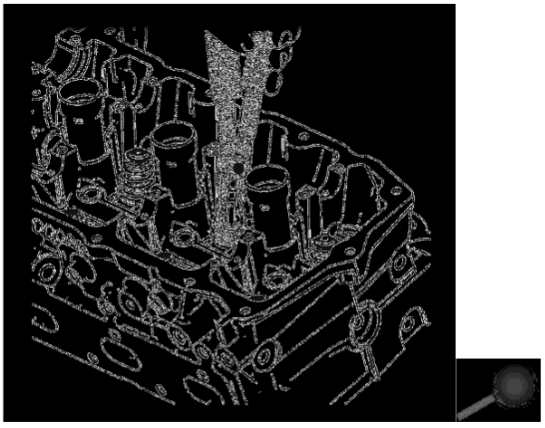


7. Remove the valve spring retainer.
8. Remove the valve spring.



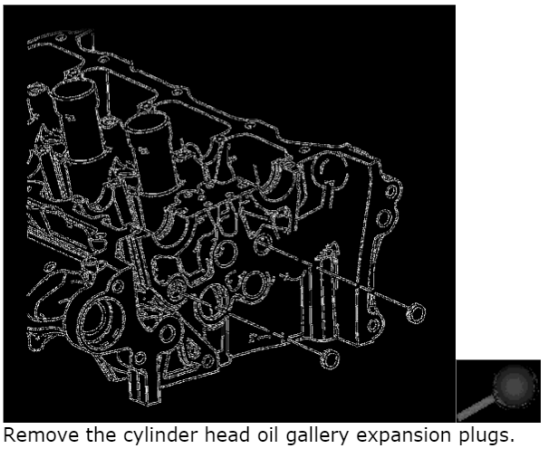
9. Remove the valve.

cardiagn.com

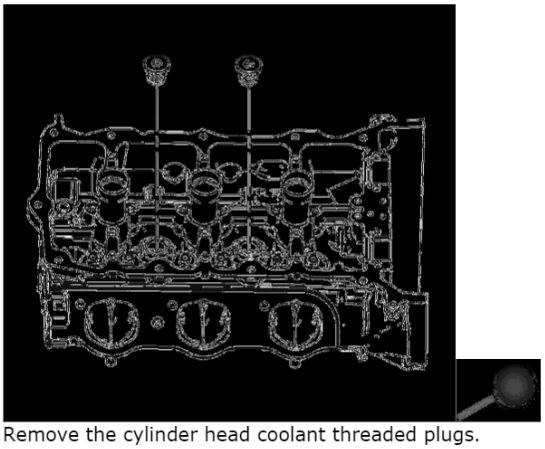


Note: NEVER reuse a valve stem oil seal.

10. Remove the valve stem oil seal using the *EN 46116* remover/installer and discard.
11. Repeat these procedures for the remaining valves.

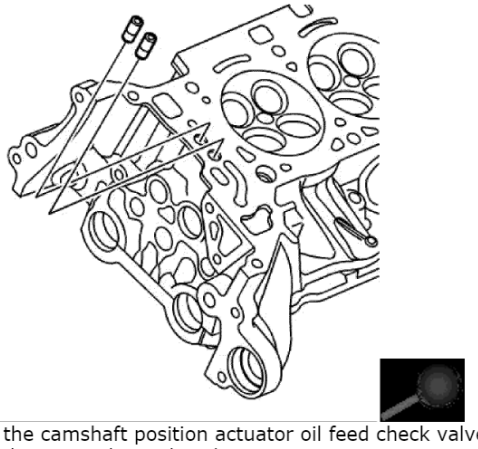


12. Remove the cylinder head oil gallery expansion plugs.

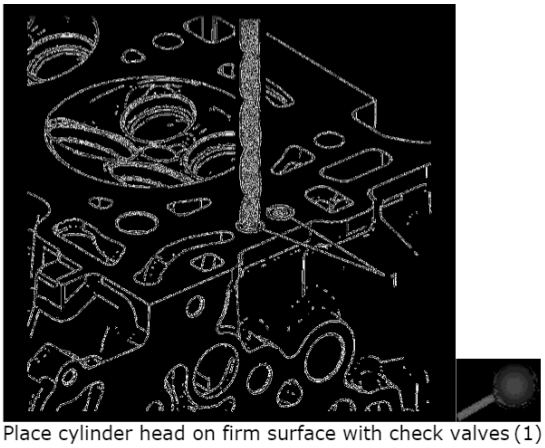


13. Remove the cylinder head coolant threaded plugs.

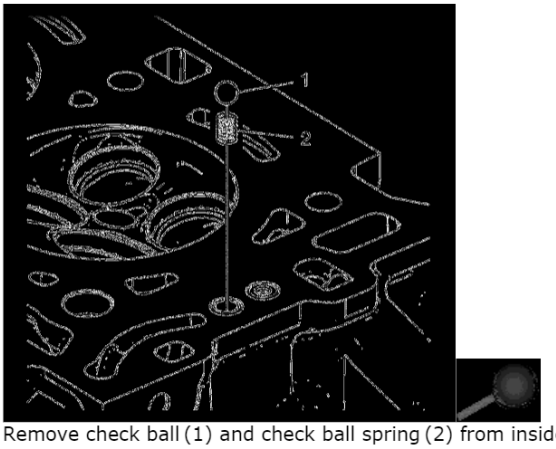
cardiagn.com



14. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced.

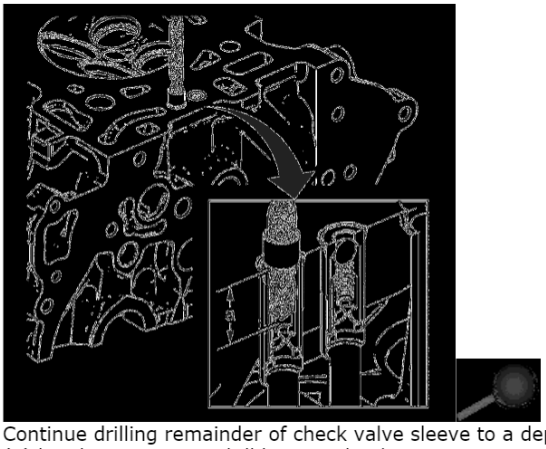


15. Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces.
16. Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.

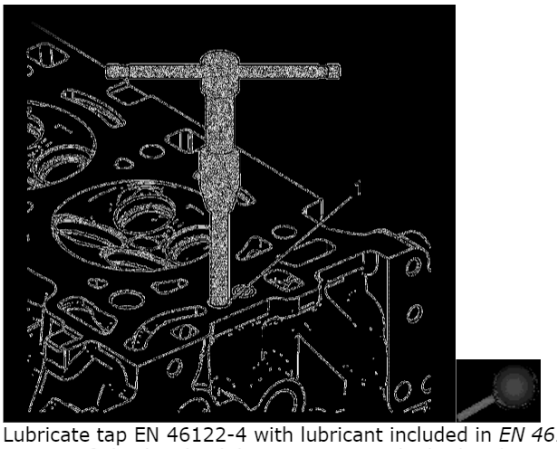


17. Remove check ball (1) and check ball spring (2) from inside of check valve.

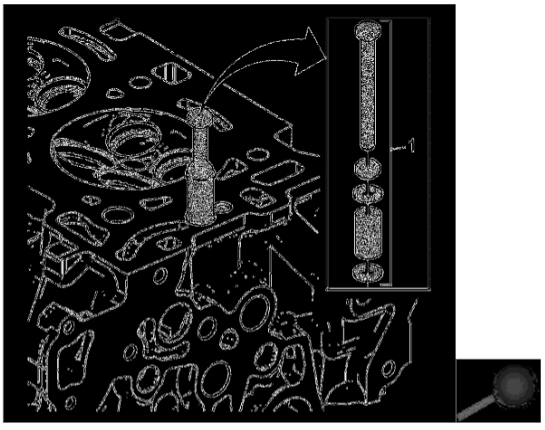
cardiagn.com



18. Continue drilling remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) (a) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve.

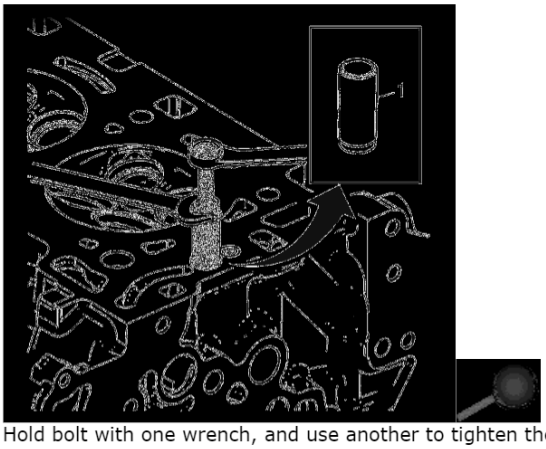


19. Lubricate tap EN 46122-4 with lubricant included in *EN 46122* remover/installer . Tap drilled out portion of check valve (1) remaining in cylinder head. Tap to full depth possible until tap bottoms out in head.



cardiagn.com

20. Assemble bolt, nut, washers, and collar EN 46122-2 (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head.
21. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.



22. Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head.
23. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

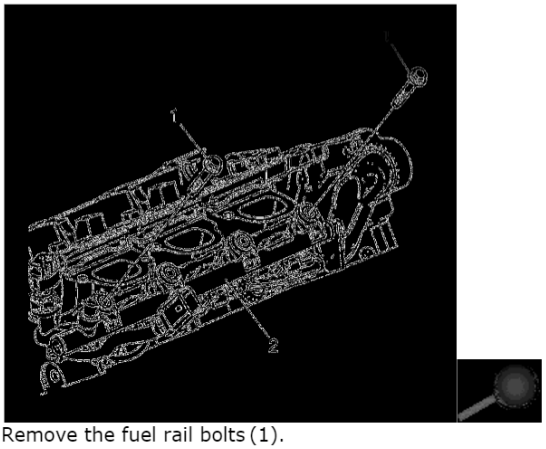
cardiagn.com

Cylinder Head Disassemble (LFW or LFX)

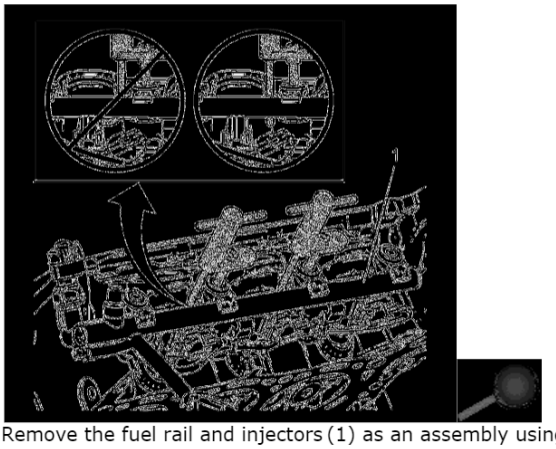
Special Tools

- *EN 8062* Valve Spring Compressor - Head Off
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN 46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer
- *EN 49248* Injector Rail Assembly Remover

For equivalent regional tools, refer to Special Tools.



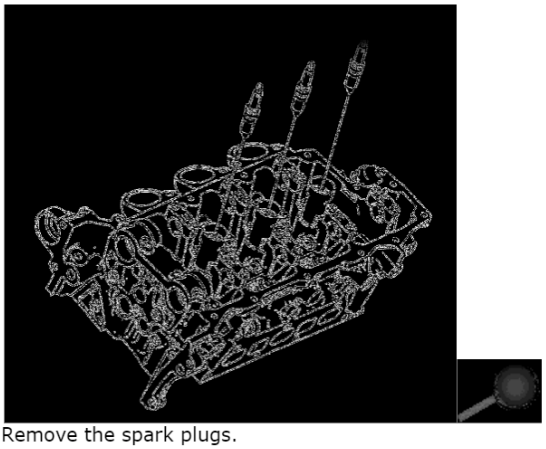
1. Remove the fuel rail bolts (1).



2. Remove the fuel rail and injectors (1) as an assembly using the *EN 49248* remover .

cardiagn.com

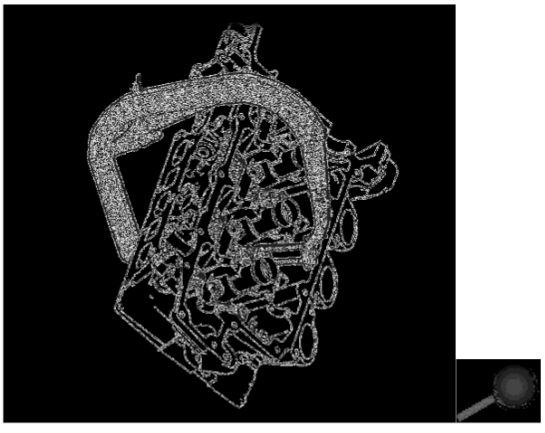
© 2014 General Motors. All rights reserved.



3. Remove the spark plugs.

Note: Ensure valve heads will not contact anything during the following step in order to avoid bending or damage.

4. Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers.

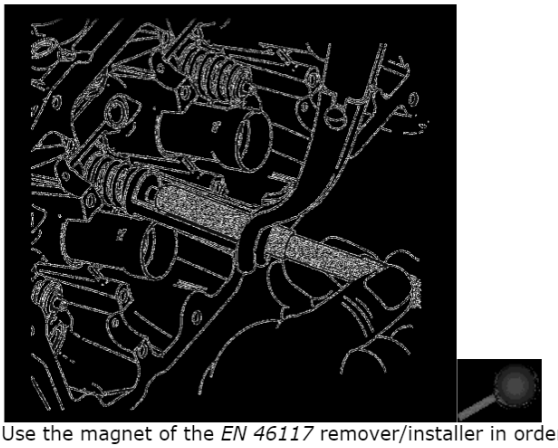


cardiagn.com

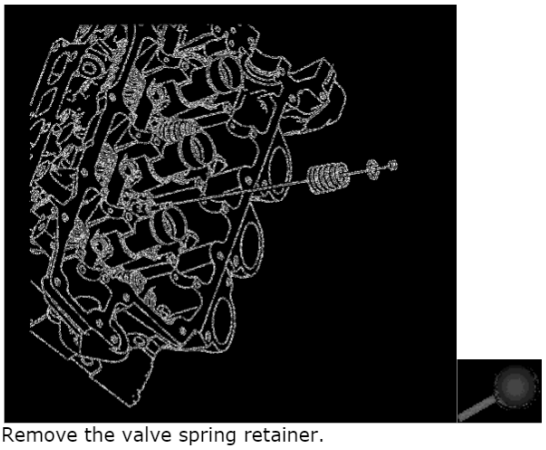
Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

Caution: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

5. Compress the valve spring using the *EN 8062* compressor and the *EN 46119* adapter .

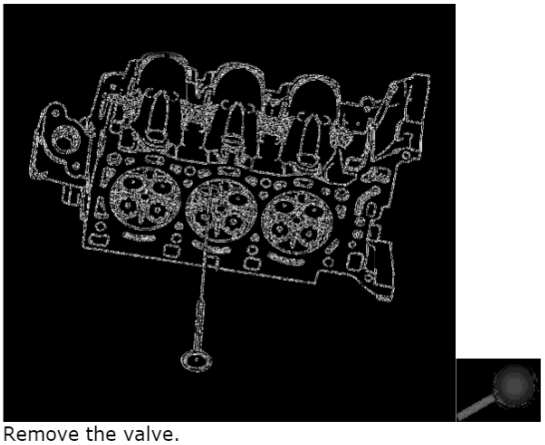


6. Use the magnet of the *EN 46117* remover/installer in order to remove the valve keepers.
7. Remove the valve spring compressor and the adapter.

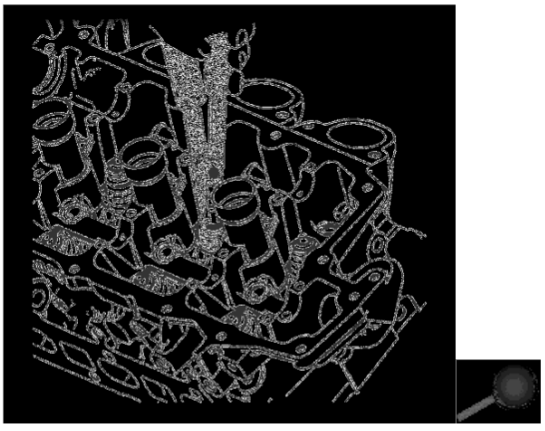


8. Remove the valve spring retainer.
9. Remove the valve spring.

cardiagn.com

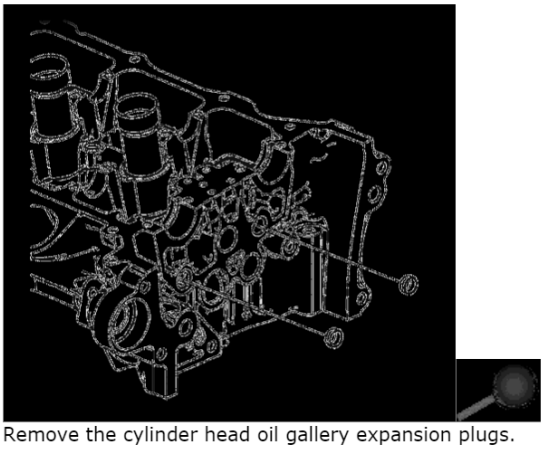


10. Remove the valve.



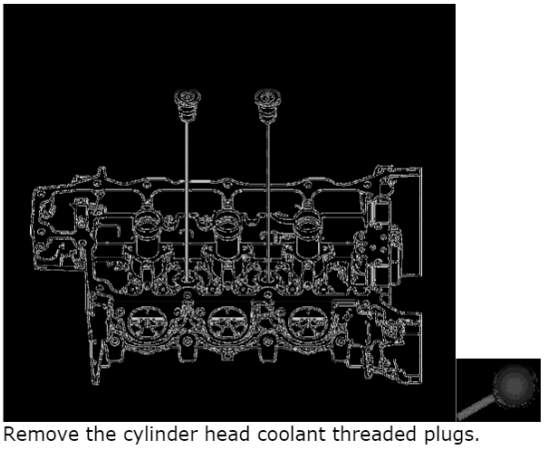
Note: NEVER reuse a valve stem oil seal.

11. Remove the valve stem oil seal using the *EN 46116* remover/installer and discard.
12. Repeat these procedures for the remaining valves.

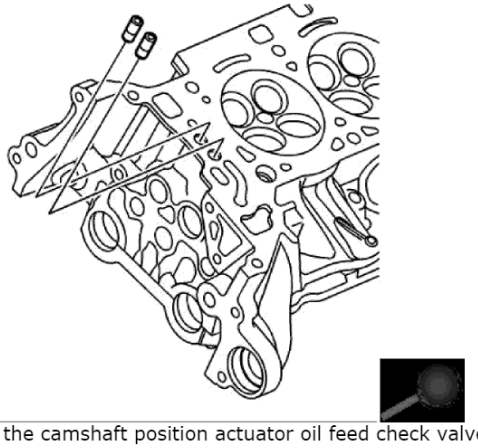


13. Remove the cylinder head oil gallery expansion plugs.

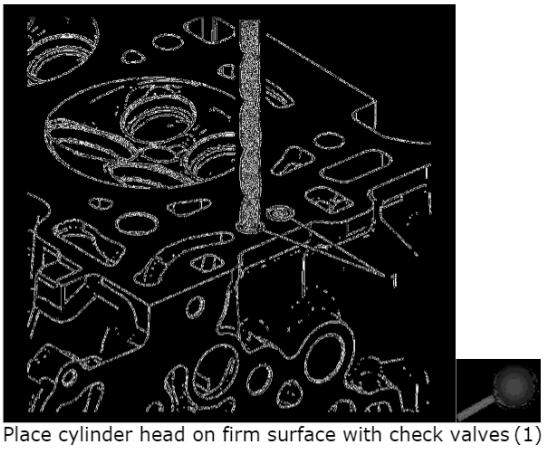
cardiagn.com



14. Remove the cylinder head coolant threaded plugs.

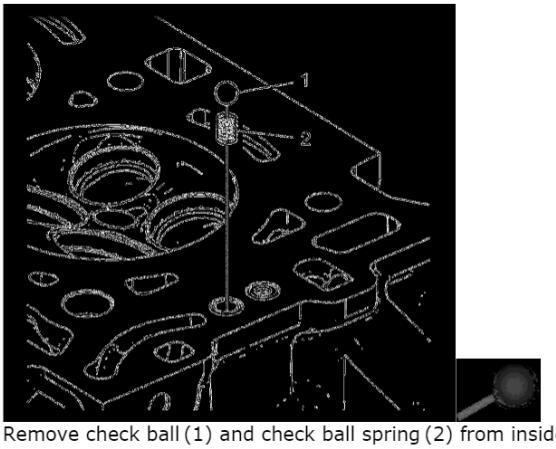


15. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. If check valves are OK, disregard remaining steps which detail replacing the check valves.

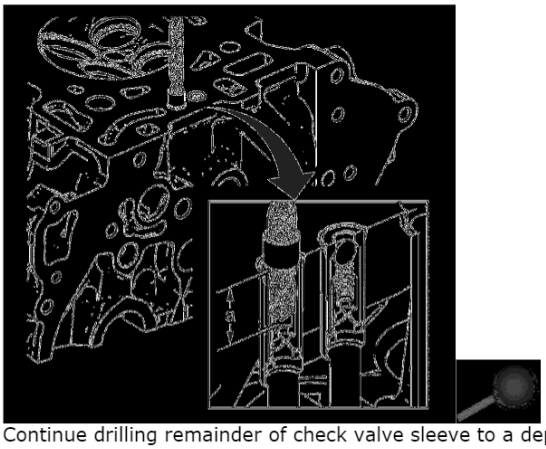


16. Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces.
17. Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.

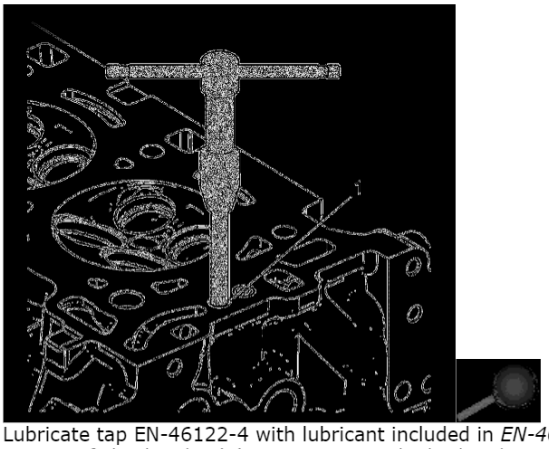
cardiagn.com



18. Remove check ball (1) and check ball spring (2) from inside of check valve.

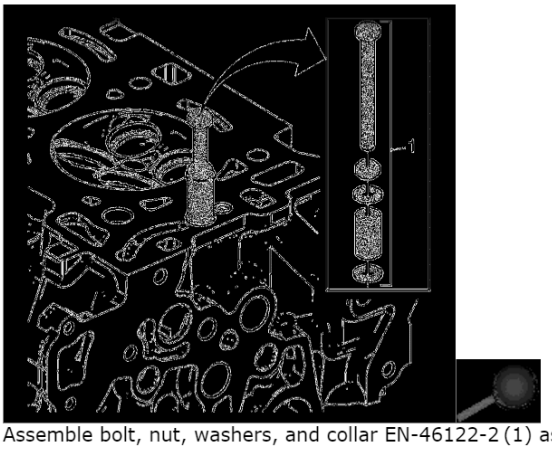


19. Continue drilling remainder of check valve sleeve to a depth of approximately 19 mm (0.75 in) (a) by placing tape on drill bit as a depth gauge. It is not necessary or desirable to drill completely through the bottom of the check valve.

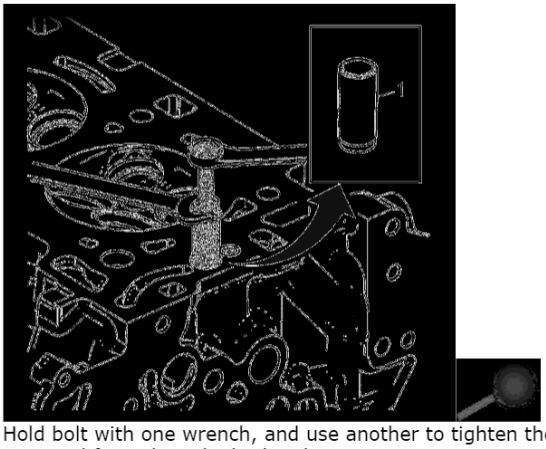


20. Lubricate tap EN-46122-4 with lubricant included in *EN-46122* remover/installer . Tap drilled out portion of check valve (1) remaining in cylinder head. Tap to full depth possible until tap bottoms out in head.

cardiagn.com



21. Assemble bolt, nut, washers, and collar EN-46122-2 (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head.
22. Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.



23. Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head.
24. Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

cardiagn.com

Cylinder Head Cleaning and Inspection

Special Tools

- *GE 8001* Dial Indicator Set
- *GE 8358* Carbon Removal Brush
- *EN 28410* Gasket Remover
- *EN 42096* Valve Guide Reamer
- *EN 47909* Injector Bore and Sleeve Cleaning Kit

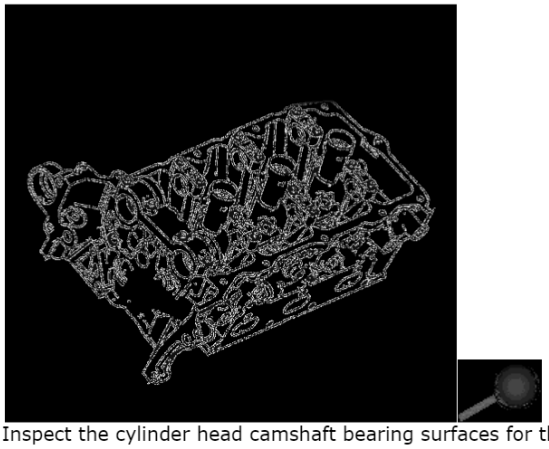
For equivalent regional tools, refer to Special Tools.

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *EN 28410* remover .
2. Clean all cylinder head surfaces with non-corrosive solvent.

   Warning: Refer to Safety Glasses Warning.
3. Blow out all the oil galleries using compressed air.
4. Remove any carbon deposits from the combustion chambers using the *GE 8358* brush .
5. Clean any debris or build-up from the lifter pockets.

Visual Inspection



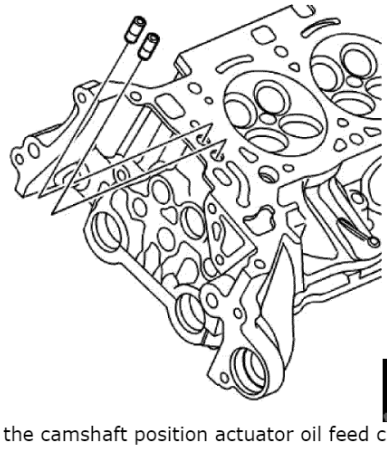
1. Inspect the cylinder head camshaft bearing surfaces for the following conditions:
   - Excessive scoring or pitting
   - Discoloration from overheating
   - Deformation from excessive wear
   - If the camshaft bearing journals appear to be scored or damaged, you must replace the cylinder head. DO NOT machine the camshaft bearing journals.
2. If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
3. Inspect the cylinder head for the following:
   - Cracks, damage or pitting in the combustion chambers

© 2014 General Motors. All rights reserved.

cardiagn.com

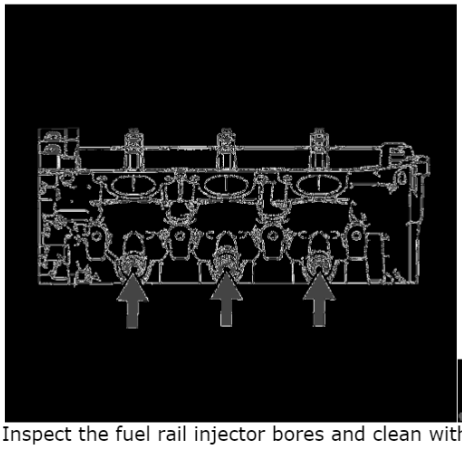
- Debris in the oil galleries — Continue to clean the galleries until all debris is removed.
- Coolant leaks or damage to the deck face sealing surface — If coolant leaks are present, measure the surface warpage as described under Cylinder Head Measurement – Deck Flatness Inspection.
- Burrs or any defects that would degrade the sealing of the NEW secondary camshaft drive chain tensioner gasket
- Damage to any gasket surfaces
- Damage to any threaded bolt holes
- Burnt or eroded areas in the combustion chamber
- Cracks in the exhaust ports and combustion chambers
- External cracks in the water passages
- Restrictions in the intake or exhaust passages
- Restrictions in the cooling system passages
- Rusted, damaged or leaking core plugs

4. If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.



cardiagn.com

5. Inspect the camshaft position actuator oil feed check valves. Damaged, restricted or clogged check valves must be replaced. Refer to Cylinder Head Disassemble.



6. Inspect the fuel rail injector bores and clean with *EN-47909* kit , if required.

Cylinder Head Measurement

Camshaft Journal Clearance

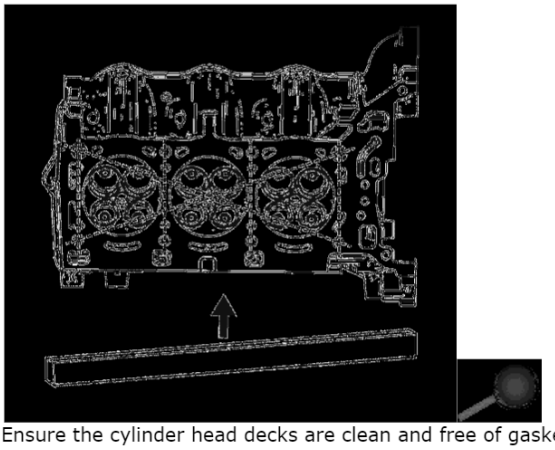
1. Install the camshaft bearing cap in the cylinder head without the camshaft.

   Caution: Refer to Fastener Caution.
2. Install the camshaft cap bolts and tighten to **10 N•m (89 lb in)**.
3. Measure the camshaft bearings using an inside micrometer.
4. Subtract the camshaft journal diameter from the camshaft bearing diameter. This will provide the running clearance. If the running clearance exceeds specifications and the camshaft journals are within specification, replace the cylinder head.

Camshaft Journal Alignment

1. Ensure the camshafts are serviceable.
2. Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
3. Install the camshafts in the cylinder head.
4. Install the camshaft bearing caps.
5. Install the camshaft cap bolts and tighten to **10 N•m (89 lb in)**.
6. Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

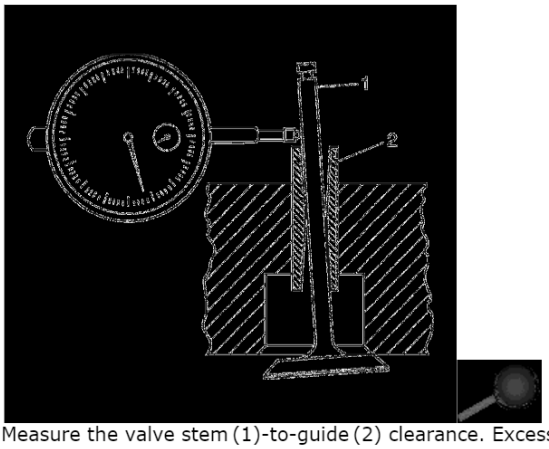
Deck Flatness Inspection



1. Ensure the cylinder head decks are clean and free of gasket material.
2. Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
3. Place a straight-edge diagonally across the cylinder head deck face surface.
4. Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gauge at 4 points along the straight-edge.
5. If the warpage is less than 0.05 mm (0.002 in), the cylinder head deck surface does not require resurfacing.
6. If the warpage is between 0.05–0.20 mm (0.002–0.008 in) or any imperfections or scratches that could inhibit proper cylinder head gasket sealing are present, the cylinder head deck surface requires resurfacing.
7. If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in).
8. If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the head must be replaced.

cardiagn.com

Valve Guide Measurement



1. Measure the valve stem (1)-to-guide (2) clearance. Excessive valve stem-to-guide clearance may cause an excessive oil consumption and may also cause a valve to break. Insufficient clearance will result in noisy and sticky functioning of the valve and will disturb the engine assembly smoothness.
2. Clamp the *GE 8001* set to the cylinder head at the camshaft cover rail.
3. Locate the dial indicator so that the movement of the valve stem from side to side, crossways to the cylinder head, will cause a direct movement of the indicator stem. The dial indicator stem must contact the side of the valve stem just above the valve guide.
4. Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
5. Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading. Refer to Engine Mechanical Specifications for proper clearance.
    - If the clearance for the valve is greater than specifications and a new standard diameter valve stem will not bring the clearance within specifications, the valve guide may be oversized by 0.075 mm (0.003 in) using the *EN 42096* reamer . There is 1 size of oversized valve stem available for service.
    - Valve guide wear at the bottom 10 mm (0.390 in) of the valve guide is not significant to normal operation.
    - If oversizing the guide does not bring the clearance within specifications, replace the cylinder head.

cardiagn.com

Valve Spring Inspection and Measurement

Special Tools

J 22738-B Valve Spring Tester

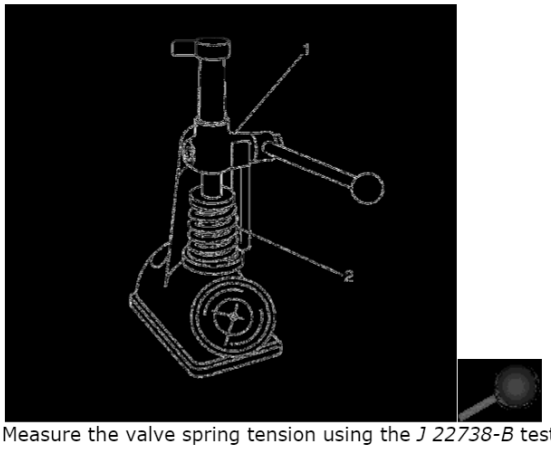
For equivalent regional tools, refer to Special Tools.

Inspection Procedure

1. Clean the valve springs in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the valve springs with compressed air.
3. Inspect the valve springs for broken coils or coil ends.

Measurement Procedure



1. Measure the valve spring tension using the *J 22738-B* tester . Refer to Engine Mechanical Specifications.
2. If low valve spring load is found, replace the valve springs. DO NOT use shims to increase spring load. The use of shims can cause the valve spring to bottom out before the camshaft lobe is at peak lift.

cardiagn.com

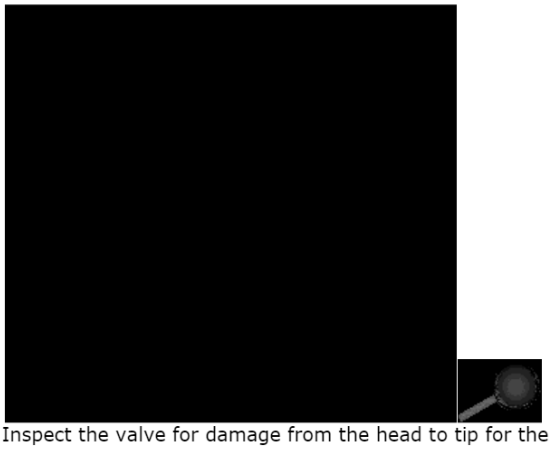
© 2014 General Motors. All rights reserved.

Valve and Seat Grinding

Valve Cleaning Procedure

1. Use soft bristle wire brush to clean any carbon build-up from the valve head. DO NOT use a wire brush on any part of the valve stem. The valve stem is chrome plated to provide enhanced wear characteristics. Wire brushing the stem could remove the chrome plating.
2. Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure



1. Inspect the valve for damage from the head to tip for the following conditions:
   - Pitting in the valve seat area (1)
   - Lack of valve margin (2)
   - Bending in the valve stem (3)
   - Pitting or excessive wear in the stem (4)
   - Worn valve key grooves (5)
   - Worn valve tip (6)
2. Replace the valve if any of these conditions exist.

Valve Measurement Overview

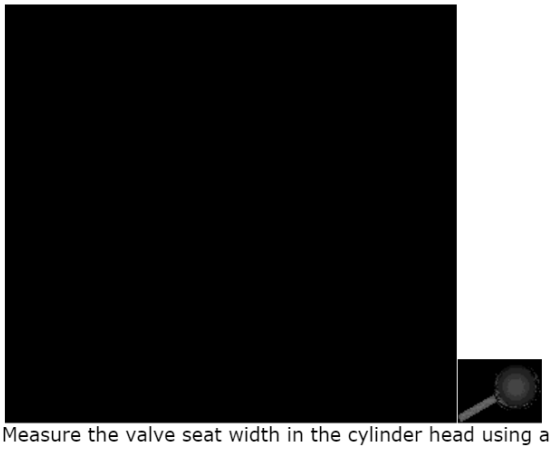
Note: The following measurement and reconditioning procedures must be followed to ensure proper engine performance.

1. Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
2. If the measurement procedures reveal that the valve seat must be reconditioned, it is critical to perform the measurement procedures after reconditioning. Valves for E85-compatible engines CANNOT be reconditioned. Any grinding, lapping, wire-brushing or other similar procedure will damage or destroy the coating that gives the valve the E-85 compatible features. If an E85-compatible valve is out of specification in any area, replace it.

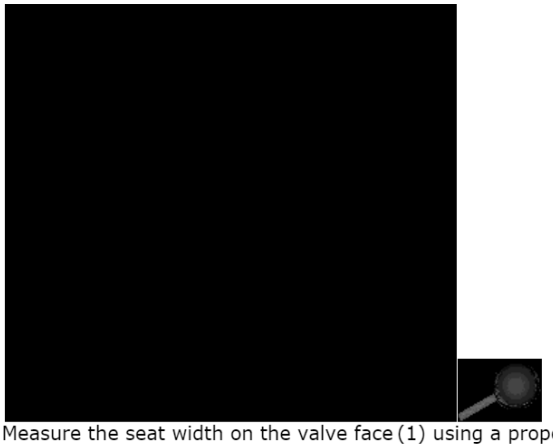
Valve Seat Width Measurement Procedure

© 2014 General Motors. All rights reserved.

cardiagn.com



1. Measure the valve seat width in the cylinder head using a proper scale.



2. Measure the seat width on the valve face (1) using a proper scale.

   Note: The seat contact area must be at least 0.5 mm (0.020 in) from the outer diameter (margin) of the valve. If the contact area is too close to the margins, the valve must be replaced.
3. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
4. If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
5. If the seat width is not acceptable, you must replace the valve. Proper valve seat width is critical to providing the correct amount of valve heat dissipation.

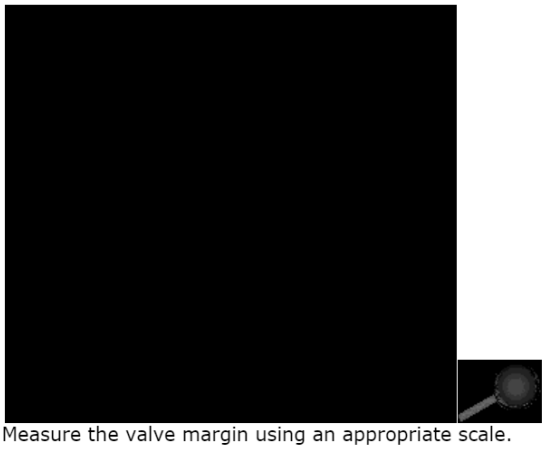
Valve Seat Roundness Measurement Procedure

1. Measure the valve seat roundness using a dial indicator attached to a tapered pilot installed in the guide. The pilot should have a slight bind when installed in the guide.

   Caution: The correct size pilot must be used. Do not use adjustable diameter pilots. Adjustable pilots may damage the valve guides.
2. Compare your measurements with the specifications listed in Engine Mechanical Specifications.
3. If the valve seat exceeds the roundness specification, you must replace the valve.
4. If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

cardiagn.com

Valve Margin Measurement Procedure

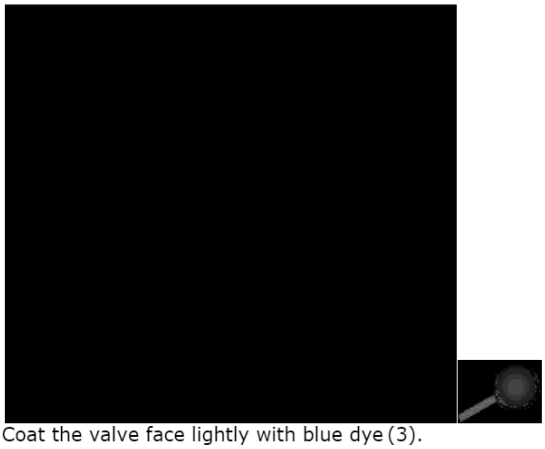


1. Measure the valve margin using an appropriate scale.
2. Reference the specifications in this section for minimum valve margin and compare them to your measurements.
3. If the valve margins are beyond specification, replace the valves.
4. If the valve margins are within specification, test the valve for seat concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve-to-Seat Concentricity Measurement Procedure

Note:

- Checking the valve-to-seat concentricity determines whether the valve and seat are sealing properly.
- You must measure the valve face and the valve seat to ensure proper valve sealing.



1. Coat the valve face lightly with blue dye (3).
2. Install the valve in the cylinder head.
3. Turn the valve against the seat with enough pressure to wear off the dye.
4. Remove the valve from the cylinder head.
5. Inspect the valve face.

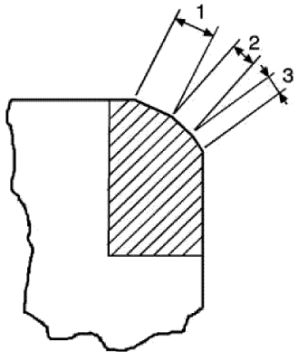
cardiagn.com

- If the valve face is concentric, providing a proper seal-with the valve stem, a continuous mark will be made around the entire face (1).

  Note: The wear mark MUST be at least 0.5 mm (0.020 in) from the outer diameter, the margin, of the valve. If the wear mark is too close to the margin, the seat must be reconditioned to move the contact area away from the margin.

- If the face is not concentric with the stem, the mark will NOT be continuous around the valve face. The valve should be replaced and the seat must be reconditioned using the Valve and Seat Reconditioning Procedure.

Valve and Seat Reconditioning Procedure



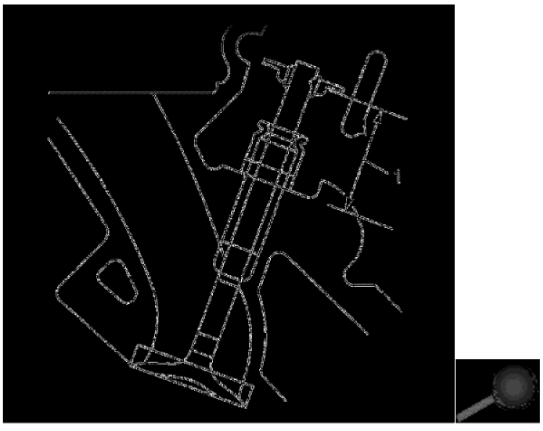
Note:

- If the valve seat width, roundness or concentricity is beyond specifications, you must grind the seats in order to ensure proper heat dissipation and prevent the buildup of carbon on the seats.
- A NEW valve must be used with any reconditioned seat.

1. Grind the valve seats (2) to the proper angle specification listed in Engine Mechanical Specifications.
2. Using the proper angle specification listed in Engine Mechanical Specifications, grind, relieve, the valve seats (1) to correctly position the valve seating surface (2) to the valve.
3. Using the proper angle specification listed in Engine Mechanical Specifications, grind, undercut, the valve seats (3) to narrow the valve seat widths to the specifications listed in Engine Mechanical Specifications.
4. When grinding the seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
5. Install the valve in the cylinder head. Do not lap the valves under any condition, whether the valves are new or used.
6. After obtaining the proper valve seat width in the cylinder head, you must re-measure the valve stem height using the Valve Stem Height Measurement Procedure.
7. If the valve stem height is acceptable, test the seats for concentricity using the Valve-to-Seat Concentricity Measurement Procedure.

Valve Stem Height Measurement Procedure

cardiagn.com



Note: To determine the valve stem height measurement, measure from the valve spring seat to the valve spring retainer.

1. Install the valve into the valve guide.
2. Ensure the valve is seated to the cylinder head valve seat.
3. Install the valve stem oil seal.
4. Install the valve spring retainer and valve stem locks.
5. Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to Engine Mechanical Specifications.
6. If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.

   Caution: DO NOT grind the valve stem tip. The tip of the valve is hardened and grinding the tip will eliminate the hardened surface causing premature wear and possible engine damage.

   Caution: DO NOT use shims in order to adjust valve stem height. The use of shims will cause the valve spring to bottom out before the camshaft lobe is at peak lift and engine damage could result.
7. If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

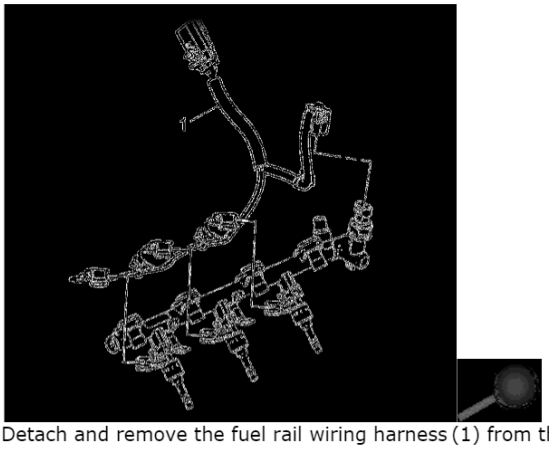
cardiagn.com

Fuel Rail and Injectors Cleaning and Inspection (LFW or LFX)

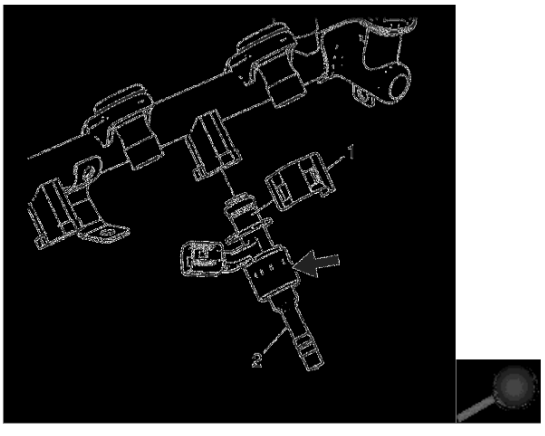
Special Tools

- *EN-47909* Injector Bore and Sleeve Cleaning Kit
- *EN-49245* Fuel Injector Seal Install/Sizer
- *EN-49247* Injector Retaining Clip Installer

1. Remove the fuel injection fuel rail assembly. Refer to:
   - Fuel Injection Fuel Rail Assembly Replacement - Bank 1
   - Fuel Injection Fuel Rail Assembly Replacement - Bank 2



2. Detach and remove the fuel rail wiring harness (1) from the fuel injector rail.



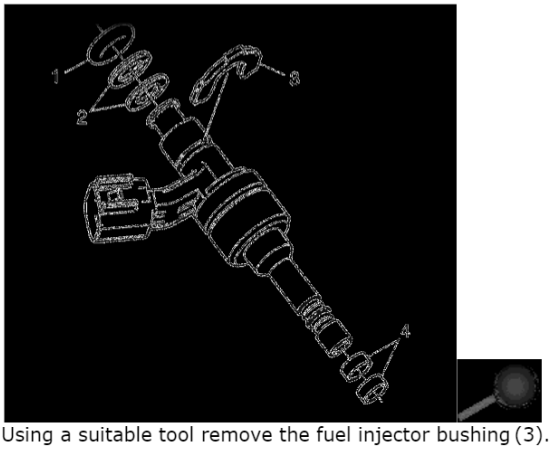
Note: Do not damage the injector spray tip or the electrical connector.

3. Using a suitable tool remove the fuel injector to rail retainer (1) from the fuel injector rail by spreading both sides of the fuel injector to rail retainer at the same time.
4. Discard the fuel injector to rail retainer (1).

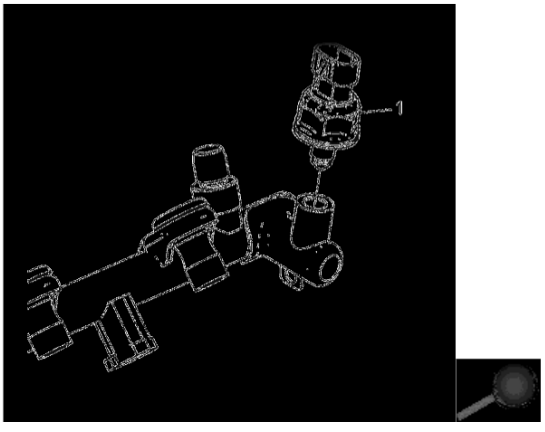
© 2014 General Motors. All rights reserved.

cardiagn.com

5. Carefully twist the fuel injector to remove the fuel injector (2) from the fuel injector rail.



6. Using a suitable tool remove the fuel injector bushing (3).
7. Discard fuel injector bushing.
8. Remove and discard the following components:
   - Fuel injector O-ring (1).
   - Plastic spacers (2).
   - Fuel injector seals (4).



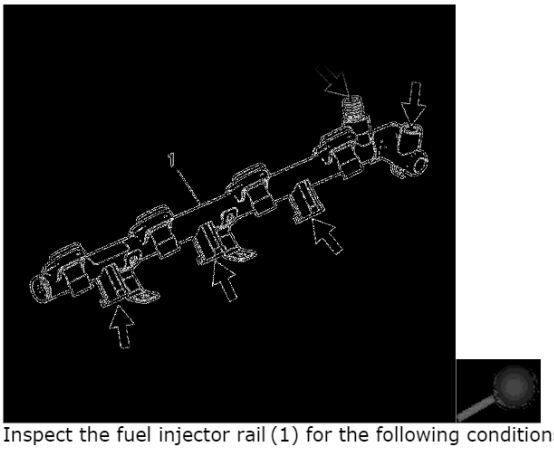
Note: Do not apply force to the plastic housing of the fuel pressure sensor. Failure to comply will destroy the sensor.

9. Remove the fuel pressure sensor (1) from the fuel injector rail.

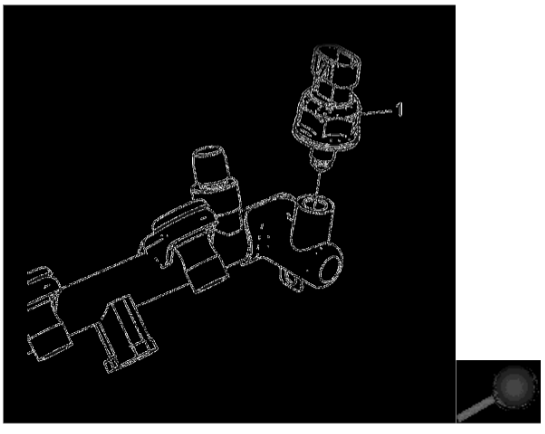
Note: Do not submerge the fuel injector rail or fuel injectors in solvent.

10. Clean the exterior of the fuel injector rail and fuel injectors with solvent using the injector bore and sleeve cleaning kit *EN-47909* injector bore and sleeve cleaning kit.

cardiagn.com



11. Inspect the fuel injector rail (1) for the following conditions:
    - Damage, debris or restrictions to the fuel injector rail
    - Damage, debris or restrictions to the fuel ports in the fuel injector rail
    - Damage to the mounting area for the fuel injector rail
    - Damage to the fuel injector rail mounting bolts or mounting bolt grommets/isolators
    - Damage to the threads on the fuel injector rail feed fitting
    - Damage to the threads in the fuel pressure sensor bore
    - Damage to the fuel pressure sensor connector, threads, or sealing face
12. If any of the above conditions are found, replace the fuel injector rails. Do not attempt to repair the fuel injector rails.



Note: Do not apply force to the plastic housing of the fuel pressure sensor. Failure to comply will destroy the sensor.

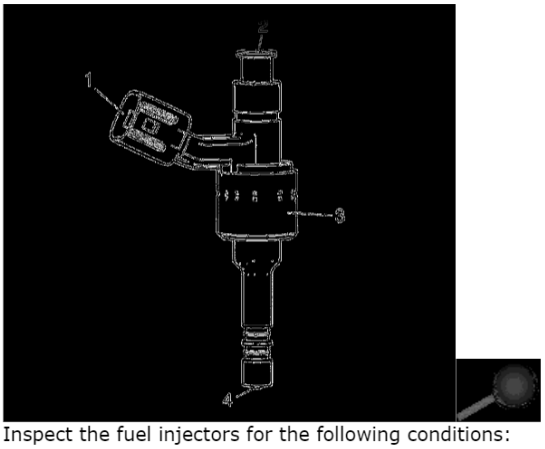
13. Install the fuel pressure sensor (1) to the fuel injector rail.

    Note: Make sure that the fuel pressure sensor threads and the fuel injector rail threads are dry.
    - Lubricate the fuel injector rail threads and sealing area with GM approved silicon free engine oil.
    - Lubricate the fuel pressure sensor threads and sealing area with GM approved silicon free engine oil.
    - Install the fuel pressure sensor to the fuel injector rail and hand tighten.

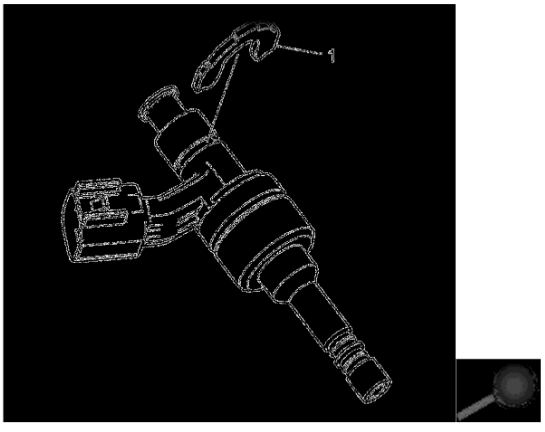
cardiagn.com

- Remove the fuel pressure sensor from the fuel injector rail and re-lubricate.

  Caution: Refer to Fastener Caution.
- Install the fuel pressure sensor to the fuel injector rail and tighten to **33 N·m (25 lb ft)**.



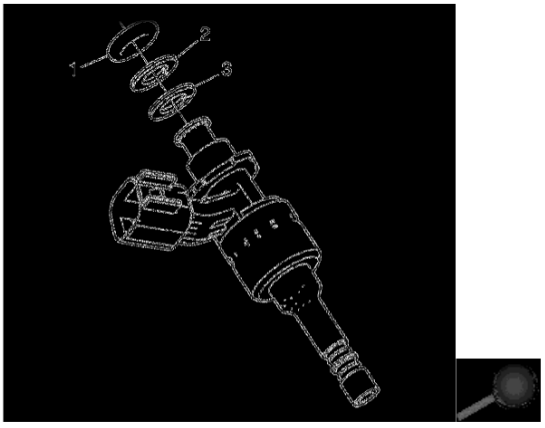
14. Inspect the fuel injectors for the following conditions:
    - Damage to the fuel injector connector (1)
    - Damage to the fuel inlet cone (2)
    - Damage to the fuel injector body (3)
    - Damage to the fuel injector spray tip (4)
15. Replace the fuel injector if any of the above conditions are found. Do not attempt to repair the fuel injectors.



Note: Listen for an audible click to confirm correct installation of the fuel injector bushing

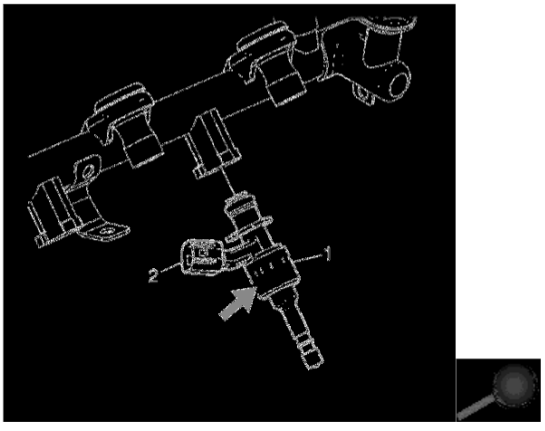
16. Install a NEW fuel injector bushing (1) to the fuel injector.

cardiagn.com



Note: When installing the plastic spacers (2), install the white plastic spacer first and the brown plastic spacer second.

17. Install the NEW plastic spacers (2) to the fuel injector.
18. Lubricate the NEW O-ring (1) with 5W30 engine oil.
19. Install the NEW O-ring (1) to the injector.

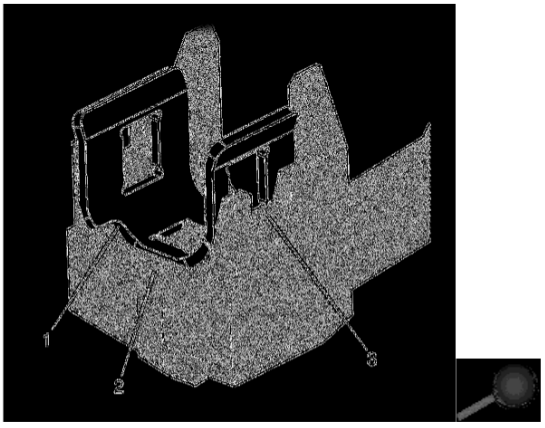


Note: Do NOT install the teflon injector tip/bore seals until AFTER the fuel injectors are installed on the fuel injector rail.

Note: Make sure that the fuel injector connectors are placed in the correct position.

20. Install the fuel injectors to the fuel injector rail.

cardiagn.com



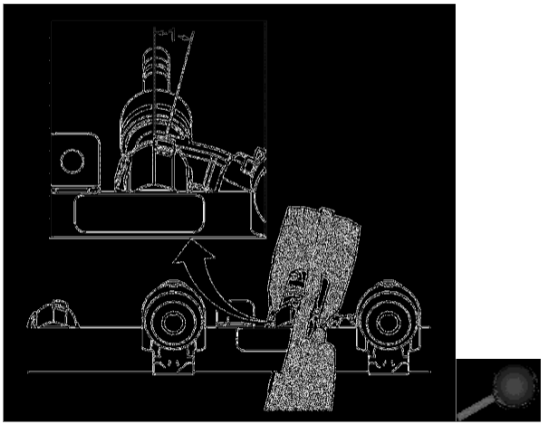
Note: USE SOFT JAWS to clamp the fuel injector fuel rail.

21. Support the fuel injector fuel rail in a vise.

    Note: Make sure the fuel injector to fuel rail retainer (1) is correctly installed to *EN-49247* injector retaining clip installer.

    - The notch (1) should always face forward
    - The fuel injector to fuel rail retainer should be behind the plate (2)
    - The tool windows (3) allow for visual alignment

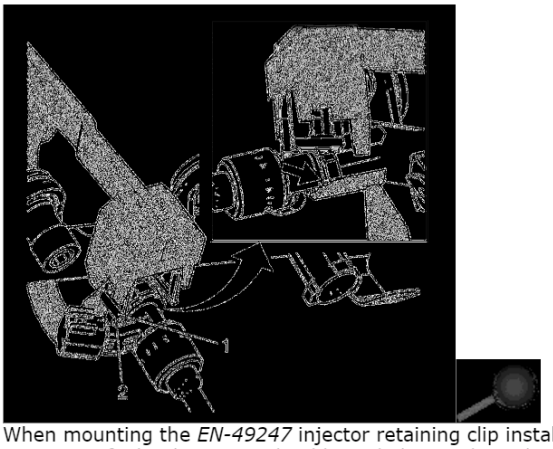
22. Install the fuel injector to fuel rail retainer to the *EN-49247* injector retaining clip installer.



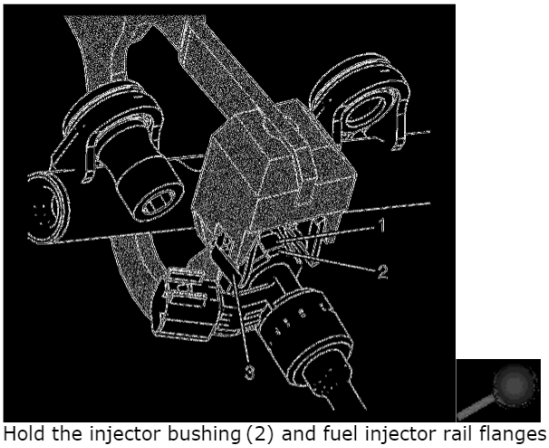
Note: Observe the following steps before installing the fuel injector to fuel rail retainer.

23. There is a 15-degree angle of rotation (1) with the fuel injector rail flanges relative to the fuel injector rail. Hold the *EN-49247* injector retaining clip installer at a similar angle to aid the correct installation of the fuel injector to fuel rail retainer.

cardiagn.com

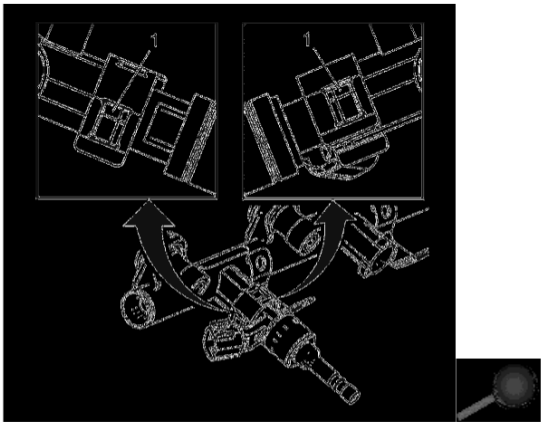


24. When mounting the *EN-49247* injector retaining clip installer to the fuel injector rail, the fuel injector to fuel rail retainer should nearly be touching the electrical connector (2).
25. The base of the *EN-49247* injector retaining clip installer should be positioned as shown before squeezing the tool to complete the installation.



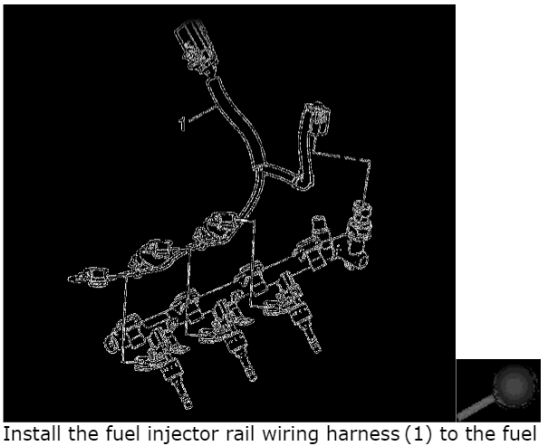
26. Hold the injector bushing (2) and fuel injector rail flanges (1) in alignment.
27. Hold the injector assembly firmly against the fuel injector rail to prevent a gap forming between the fuel injector and the fuel injector rail.
28. Install the fuel injector to fuel rail retainer (3).

cardiagn.com



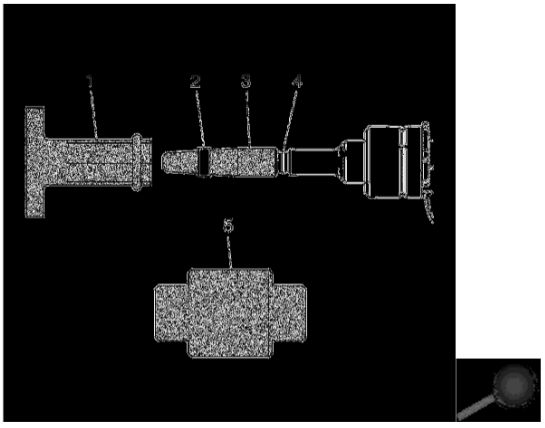
Caution: Ensure the fuel injector retainer is properly installed. Failure to completely install the retainers may degrade fuel injection system performance or cause system malfunction.

29. Make sure that the fuel injector to fuel rail retainer is correctly seated to the fuel injector rail assembly.
30. Repeat the above steps for the remaining fuel injectors until all the fuel injectors are installed and retained in the fuel injector rail.



31. Install the fuel injector rail wiring harness (1) to the fuel injector rail.

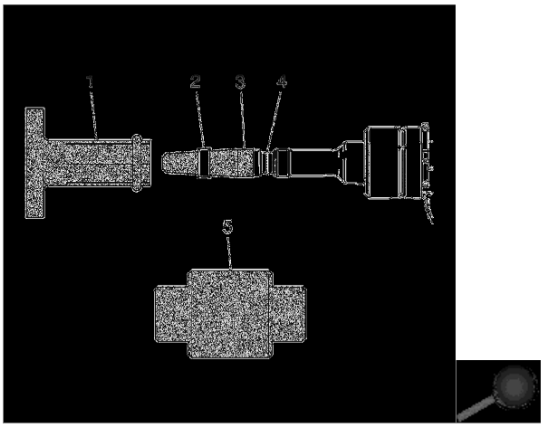
cardiagn.com



Note: Do not use any lubricant when installing the NEW seals (2) to the fuel injector spray tip.

32. Install the long protector (3) of the *EN-49245* fuel injector seal install/sizer to the fuel injector spray tip covering the first recessed area closest to the tip.
33. Place a NEW seal (2) onto long protector (3) of the *EN-49245* fuel injector seal install/sizer.
34. Using the pusher (1) of the *EN-49245* fuel injector seal install/sizer, push the seal (2) into the second recessed area (4) of the fuel injector.

    Note: The sizer (5) of the *EN-49245* fuel injector seal install/sizer is two sided, and either direction will size the seal correctly.
35. Compress the seal (2) with your fingers.
36. Resize the seal (2) using the sizer (5) of the *EN-49245* fuel injector seal install/sizer.



Note: Do not use any lubricant when installing the NEW seals (2) on the fuel injector spray tip.

37. Install the short protector (3) of the *EN-49245* fuel injector seal install/sizer to the fuel injector tip.
38. Place a NEW seal (2) onto the short protector (3) of *EN-49245* fuel injector seal install/sizer.
39. Using the pusher (1) of the *EN-49245* fuel injector seal install/sizer, push the seal (2) into the first recessed area (4) of the fuel injector.

    Note: The sizer (5) of the *EN-49245* fuel injector seal install/sizer is two sided, and either direction will size the seal correctly.
40. Compress the seal (2) with your fingers.
41. Resize the seal (2) using the sizer (5) of the *EN-49245* fuel injector seal install/sizer.

cardiagn.com

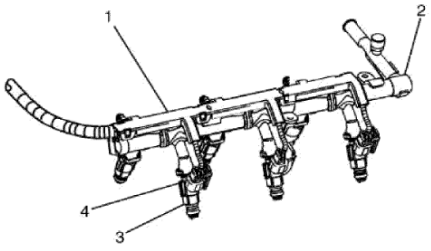
Fuel Rail and Injectors Cleaning and Inspection (LWR)

Special Tools

EN-47909 Injector Bore and Sleeve Cleaning Kit

Removal

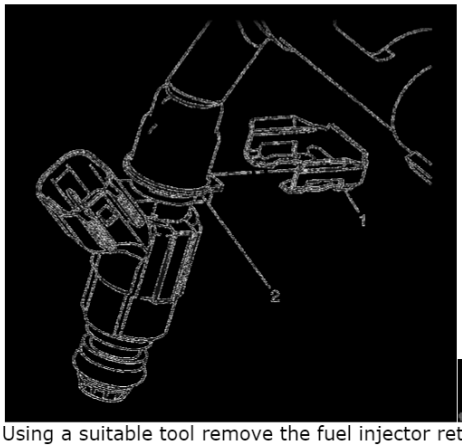
1. Remove the fuel rail and injectors as an assembly. Refer to Fuel Injector and Fuel Rail Replacement.



2. Disconnect the fuel injector electrical connectors (4) from the fuel injectors (3).
3. Remove the fuel injector harness (1) from the fuel rail (2).

Note: Do not submerge the fuel injector rail or fuel injectors in solvent.

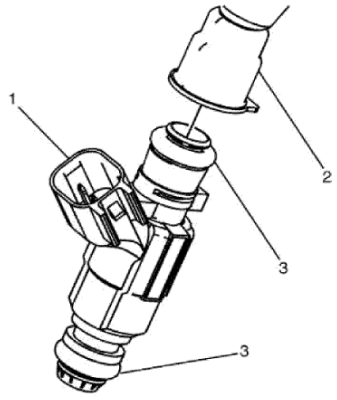
4. Clean the exterior of the fuel injector rail and fuel injectors with solvent using the injector bore and sleeve cleaning kit *EN-47909* injector bore and sleeve cleaning kit.



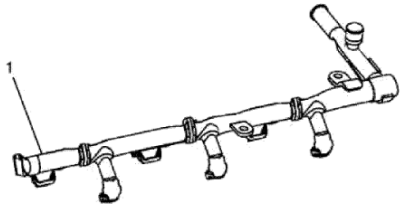
5. Using a suitable tool remove the fuel injector retainer clip (1) from the fuel rail (2).

© 2014 General Motors. All rights reserved.

cardiagn.com



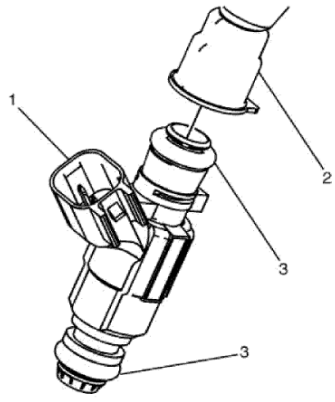
6. Remove the fuel injector (1) from the fuel rail (2).
7. Remove the fuel injector seals (3) from the fuel injector (1).
8. Discard the fuel injector seals.
9. Inspect the fuel injectors for the following conditions:
   - Damage to the fuel injector electrical connector
   - Damage to the fuel injector inlet cone
   - Damage to the fuel injector body
   - Damage to the fuel injector spray tip
10. Replace the fuel injector if any of the above conditions are found. Do not attempt to repair the fuel injectors.



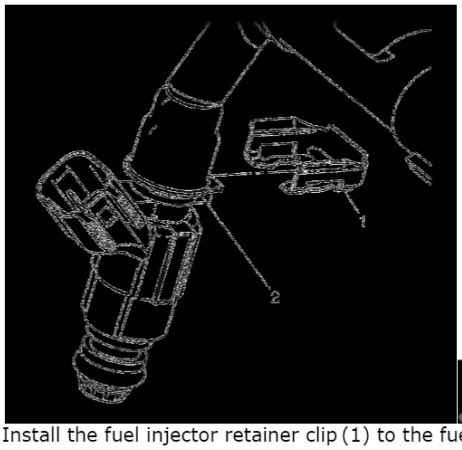
11. Inspect the fuel injector rail (1) for the following conditions:
    - Damage to the fuel injector rail
    - Damage to the fuel ports of the fuel injector rail
    - Damage to the mounting area for the fuel injector rail
    - Damage to the fuel injector rail mounting bolts or mounting bolt grommets/isolators
    - Damage to the fuel rail service port
12. If any of the above conditions are found, replace the fuel injector rails. Do not attempt to repair the fuel injector rails.

Installation

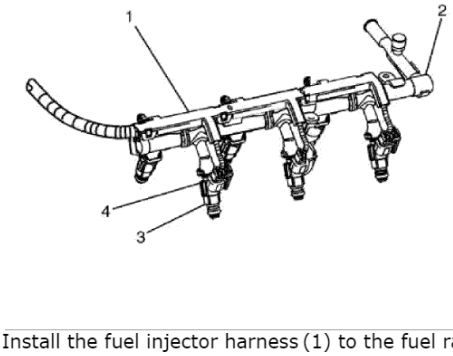
cardiagn.com



1. Install NEW fuel injector seals (3) to the fuel injector (1).
2. Install the fuel injector (1) to the fuel rail (2).



3. Install the fuel injector retainer clip (1) to the fuel rail (2).



4. Install the fuel injector harness (1) to the fuel rail (2).
5. Connect the fuel injector electrical connectors (4) to the fuel injectors (3).

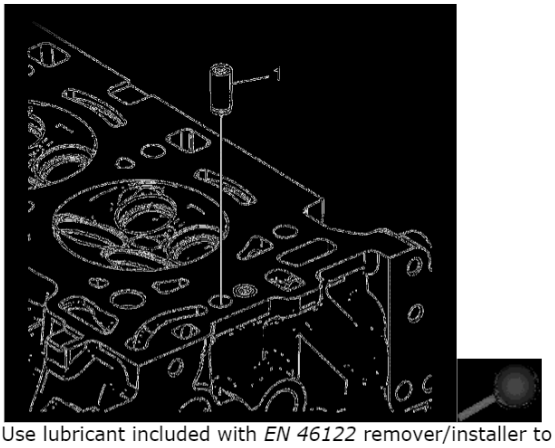
cardiagn.com

Cylinder Head Assemble (LWR)

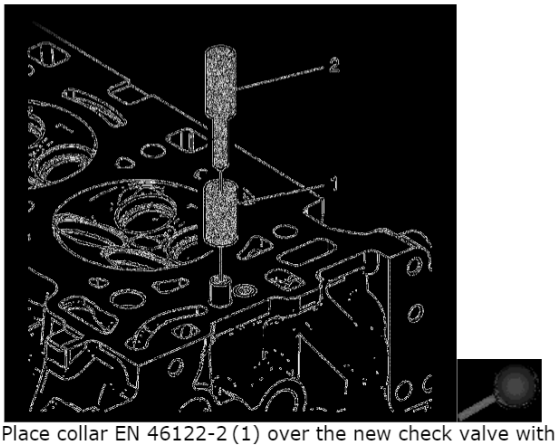
Special Tools

- *EN 8062* Valve Spring Compressor – Head Off
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN 46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer

For equivalent regional tools, refer to Special Tools.



1. Use lubricant included with *EN 46122* remover/installer to lubricate outside of new check valve (1).
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.

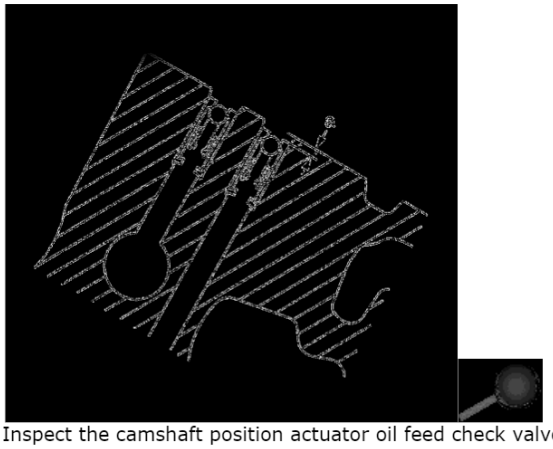


3. Place collar EN 46122-2 (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.

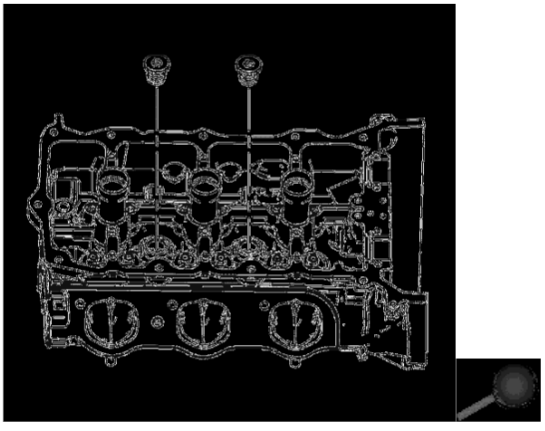
© 2014 General Motors. All rights reserved.

cardiagn.com

4. Using the driver EN 46122-1 (2), lightly tap the new check valve into place until the driver stops against the top of the collar.



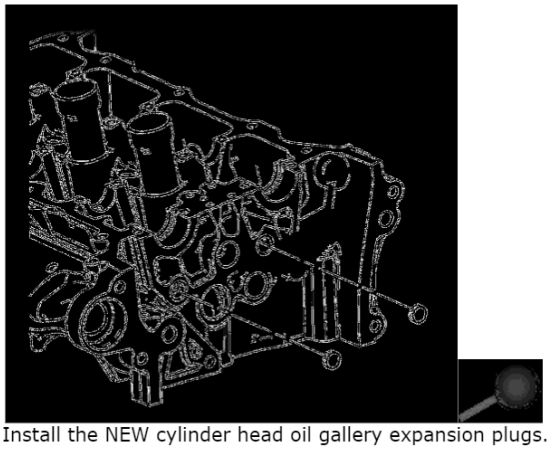
5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).



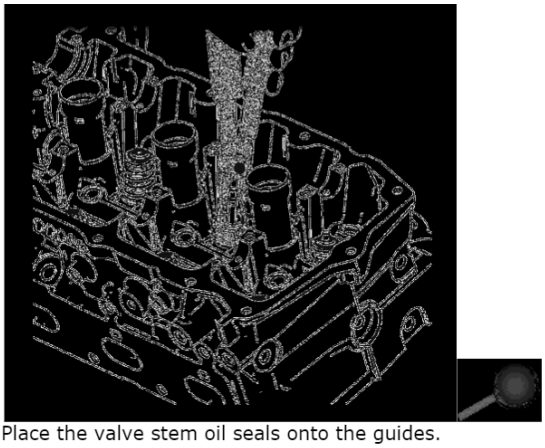
Caution: Refer to Fastener Caution.

6. Install the cylinder head coolant threaded plugs and tighten to **31 N•m (23 lb ft)**.

cardiagn.com



7. Install the NEW cylinder head oil gallery expansion plugs.



8. Place the valve stem oil seals onto the guides.

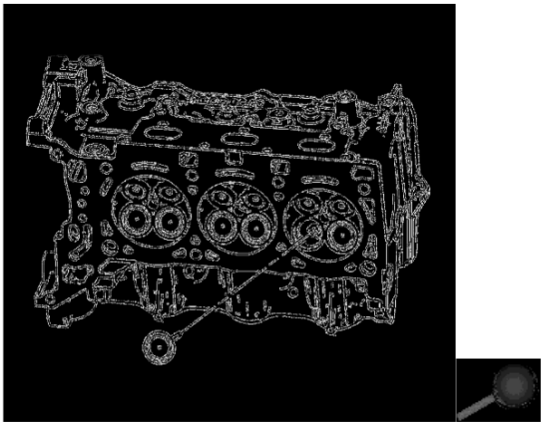
   Note: NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.

9. Mount a new valve stem oil seal using the *EN 46116* remover/installer .

   Note: Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.

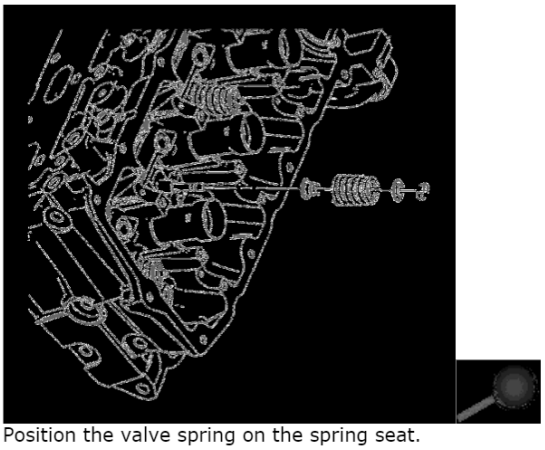
10. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the *EN 46116* remover/installer .
11. Lubricate the valve stem and valve guide ID with clean engine oil GM P/N 12345501 (Canadian P/N 992704) or equivalent.

cardiagn.com

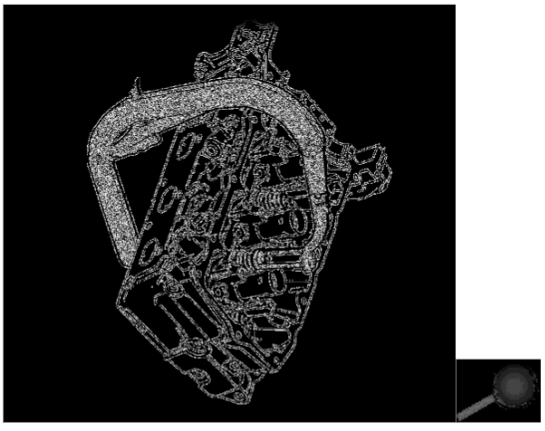


Note: The valve stem oil seal must not come loose from the valve guide when the valve is installed.

12. Insert the valve into the valve guide until it bottoms on the valve seat.



13. Position the valve spring on the spring seat.
14. Place the valve spring retainer onto the valve spring.

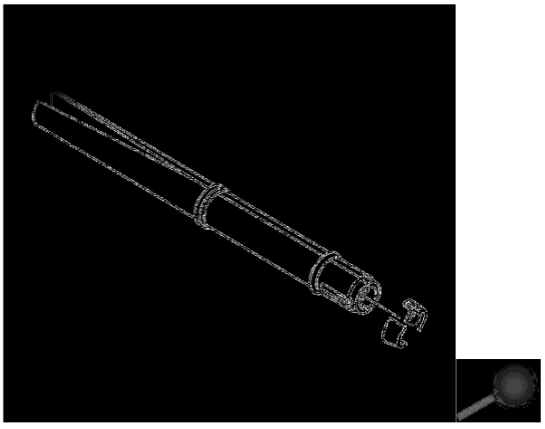


cardiagn.com

Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

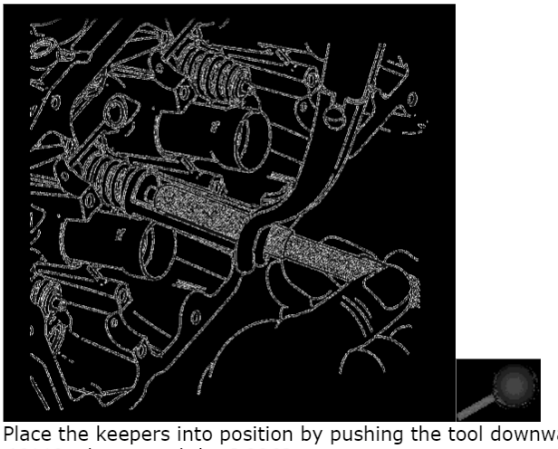
Caution: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

15. Compress the valve spring using the *EN 8062* compressor and the *EN 46119* adapter .



Note: Ensure proper directional placement of valve keepers in the *EN 46117* remover/installer . The valve keepers must be installed with the tapered end towards the valve stem seal.

16. With the spring compressed, install the valve keepers into the *EN 46117* remover/installer .



17. Place the keepers into position by pushing the tool downward and releasing tension on the *EN 46119* adapter and the *J 8062* compressor .
18. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer. The valve keepers and the spring should remain in place.

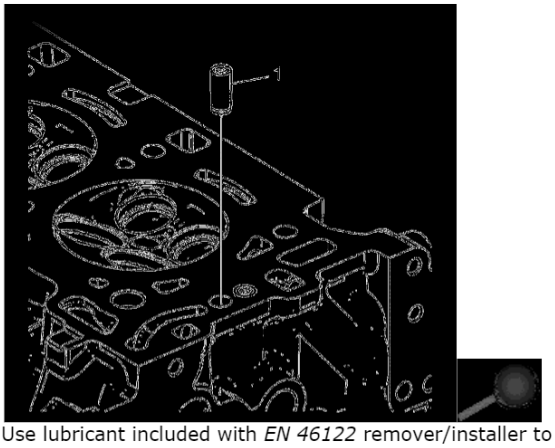
cardiagn.com

Cylinder Head Assemble (LFW or LFX)

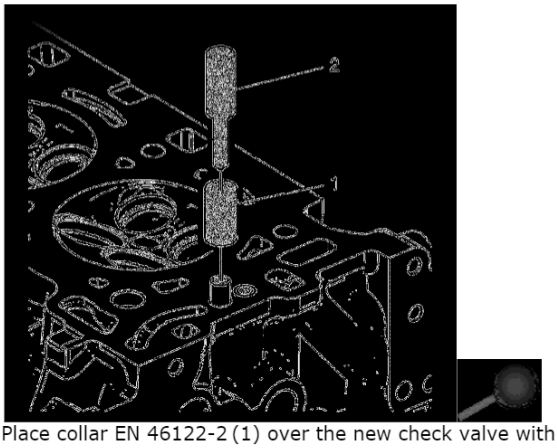
Special Tools

- *EN 8062* Valve Spring Compressor – Head Off
- *EN 46116* Valve Stem Seal Remover/Installer
- *EN 46117* Valve Stem Key Remover/Installer
- *EN 46119* Off-Vehicle Valve Spring Compressor Adapter
- *EN 46122* Camshaft Position Actuator Check-Ball Valve Remover/Installer

For equivalent regional tools, refer to Special Tools.



1. Use lubricant included with *EN 46122* remover/installer to lubricate outside of new check valve (1).
2. With the check ball end of the check valve facing UP, away from the head, insert the NEW check valve into the check valve bore in the cylinder head.

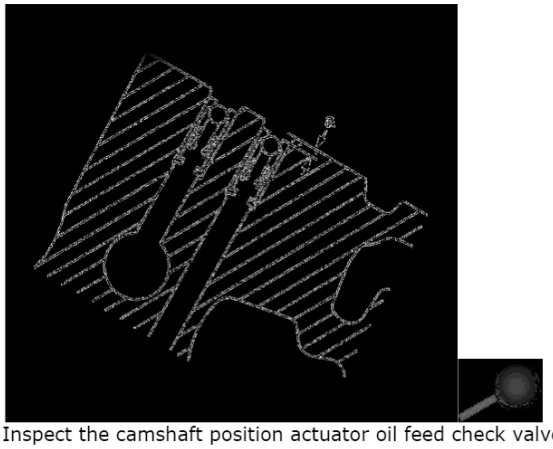


3. Place collar EN 46122-2 (1) over the new check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head.

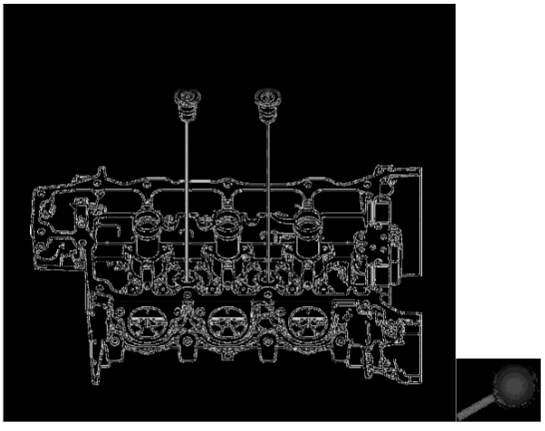
© 2014 General Motors. All rights reserved.

cardiagn.com

4. Using the driver EN 46122-1 (2), lightly tap the new check valve into place until the driver stops against the top of the collar.



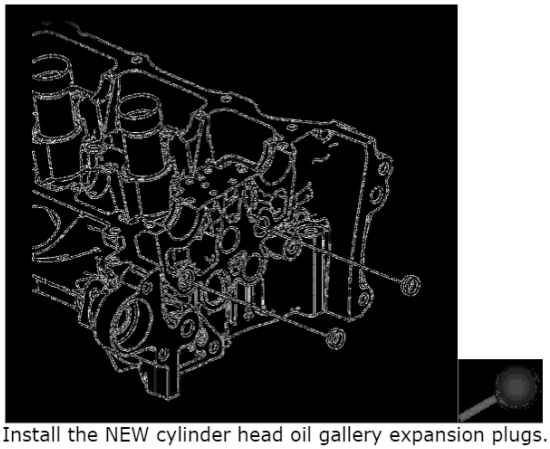
5. Inspect the camshaft position actuator oil feed check valves in order to ensure they are properly installed in the cylinder head. The camshaft position actuator oil feed check valve should be flush to 2 mm (0.0787 in) below the cylinder head deck surface (a).



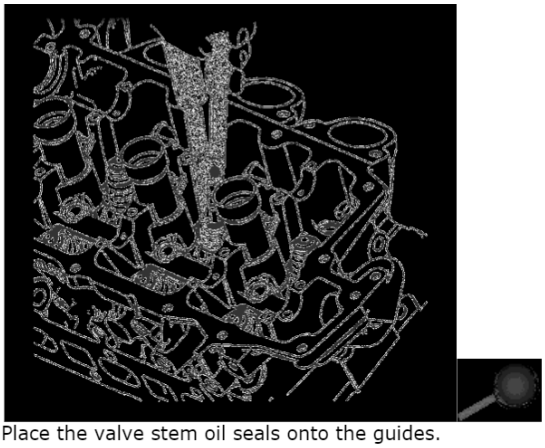
Caution: Refer to Fastener Caution.

6. Install the cylinder head coolant threaded plugs and tighten to **75 N•m (55 lb ft)**.

cardiagn.com



7. Install the NEW cylinder head oil gallery expansion plugs.



8. Place the valve stem oil seals onto the guides.

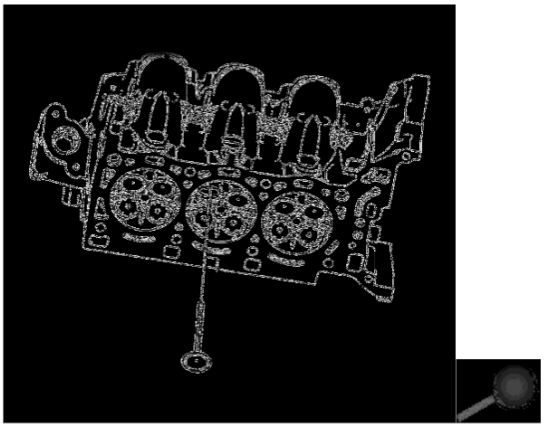
   Note: NEVER reuse a valve stem oil seal. Always use new seals when assembling the cylinder head.

9. Mount a new valve stem oil seal using the *EN 46116* remover/installer.

   Note: Force should only be applied to the valve spring contact area of the new valve stem oil seal during installation.

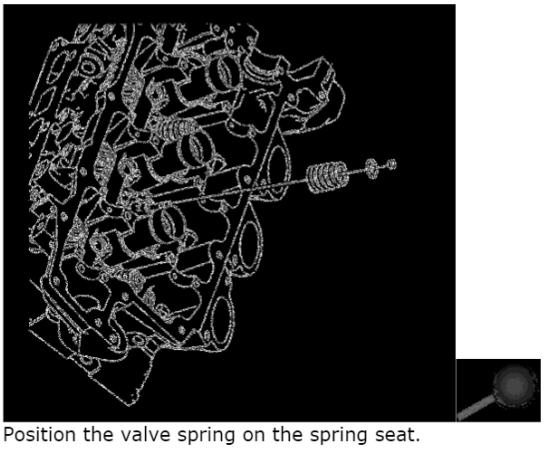
10. Push and twist the valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the *EN 46116* remover/installer.
11. Lubricate the valve stem and valve guide ID with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

cardiagn.com

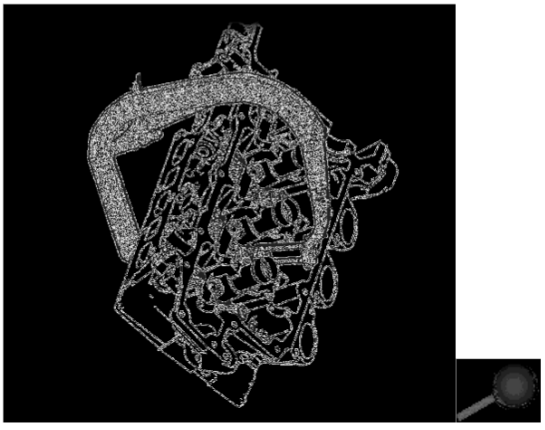


Note: The valve stem oil seal must not come loose from the valve guide when the valve is installed.

12. Insert the valve into the valve guide until it bottoms on the valve seat.



13. Position the valve spring on the spring seat.
14. Place the valve spring retainer onto the valve spring.

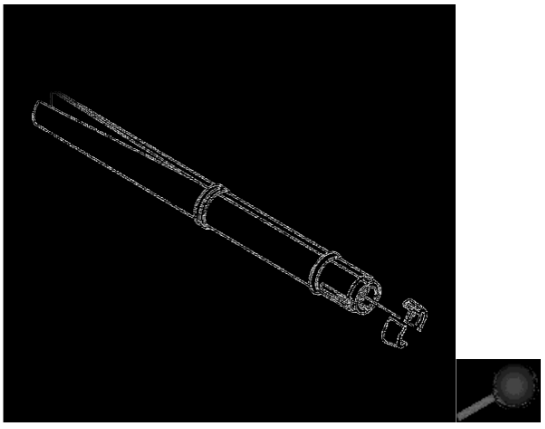


cardiagn.com

Warning: Compressed valve springs have high tension against the valve spring compressor. Valve springs that are not properly compressed by or released from the valve spring compressor can be ejected from the valve spring compressor with intense force. Use care when compressing or releasing the valve spring with the valve spring compressor and when removing or installing the valve stem keys. Failing to use care may cause personal injury.

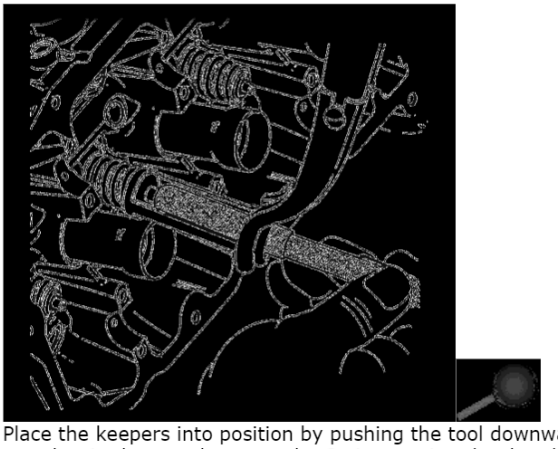
Caution: Do not compress the valve springs to less than 24.0 mm (0.943 in). Contact between the valve spring retainer and the valve stem oil seal can cause potential valve stem oil seal damage.

15. Compress the valve spring using the *EN 8062* compressor and the *EN 46119* adapter.



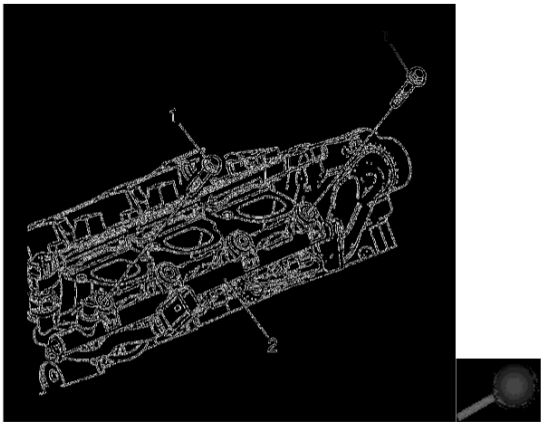
Note: Ensure proper directional placement of valve keepers in the *EN 46117* remover/installer. The valve keepers must be installed with the tapered end towards the valve stem seal.

16. With the spring compressed, install the valve keepers into the *EN 46117* remover/installer.



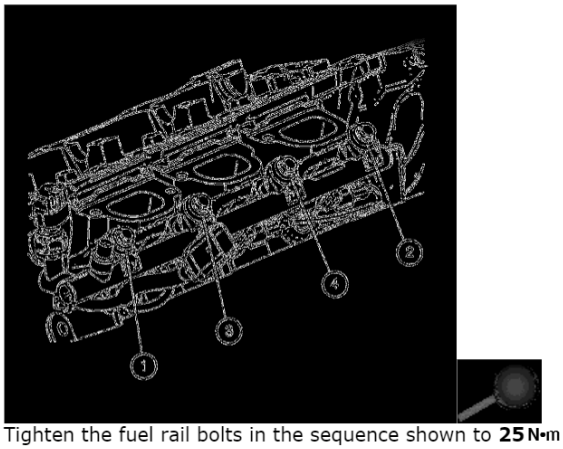
17. Place the keepers into position by pushing the tool downward. While holding the tool lightly together in the area between the O-rings, using the thumb and forefinger, release tension on the *EN-46119* adapter and the *EN 8062* compressor. This will slowly push the *EN-46117* remover/installer off the valve stem, leaving the keepers in place.
18. Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer.

cardiagn.com



Note: If the fuel rail was removed from the cylinder head, the fuel injector tip seals must be replaced. Refer to Fuel Rail and Injectors Cleaning and Inspection.

19. Install the fuel rail with injectors (2) into the cylinder head evenly.
20. Install and hand tighten the two outer fuel rail bolts (1) to seat the injectors in the injector bores.
21. Install and hand tighten the two inner fuel rail bolts.



22. Tighten the fuel rail bolts in the sequence shown to **25 N·m (18 lb ft)**.

cardiagn.com

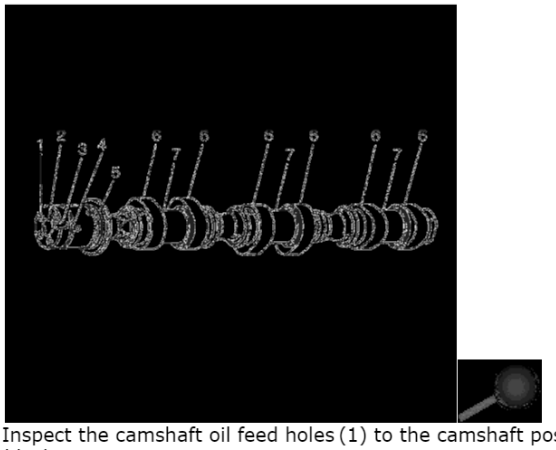
Camshaft Cleaning and Inspection

Cleaning Procedure

1. Clean the camshaft in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the camshaft with compressed air.

Visual Inspection

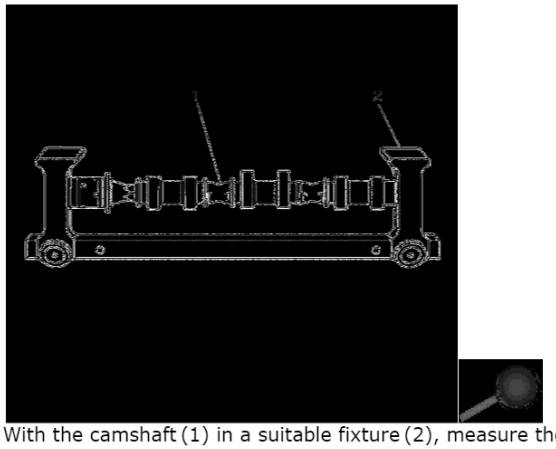


1. Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage.
2. Inspect the threaded hole (2) for damage.
3. Inspect the camshaft position actuator locating notch (3) for damage or wear.
4. Inspect the camshaft sealing grooves (4) for damage.
5. Inspect the camshaft thrust surface (5) for damage.
6. Inspect the camshaft lobes (6) and journals (7) for the following conditions:
   - Scoring or pitting above acceptable tolerances
   - Discoloration from overheating
   - Deformation from wear above acceptable tolerances, especially the camshaft lobes
7. If any of the above conditions exist on the camshaft, replace the camshaft.

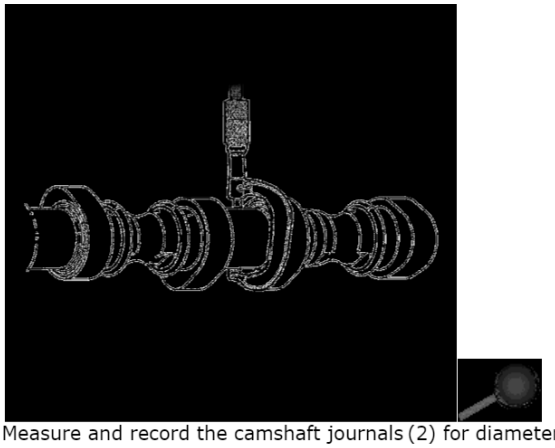
Camshaft Measurement

cardiagn.com

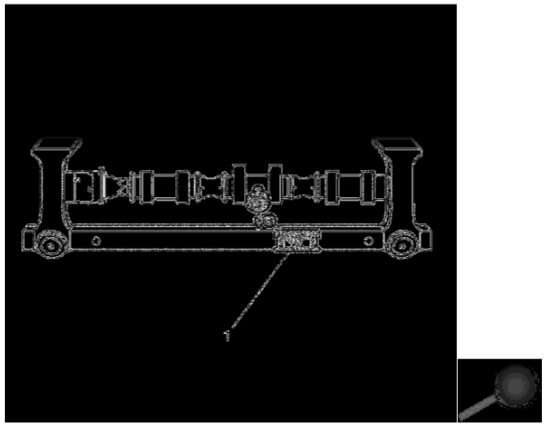
© 2014 General Motors. All rights reserved.



1. With the camshaft (1) in a suitable fixture (2), measure the camshaft (1) for wear.

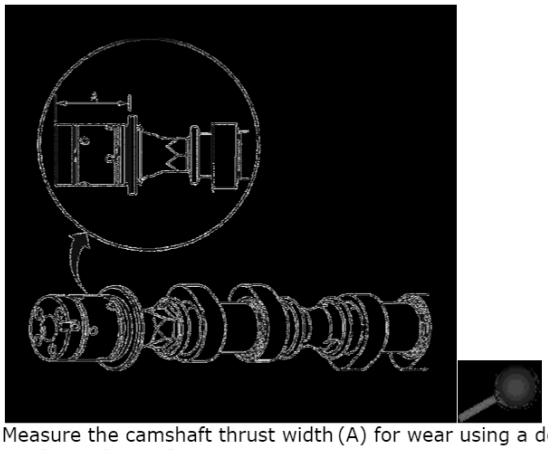


2. Measure and record the camshaft journals (2) for diameter and out-of-round using an outside micrometer (1). Refer to Engine Mechanical Specifications.
   - If the diameter is smaller than specifications, replace the camshaft.
   - If the out-of-round exceeds specifications, replace the camshaft.

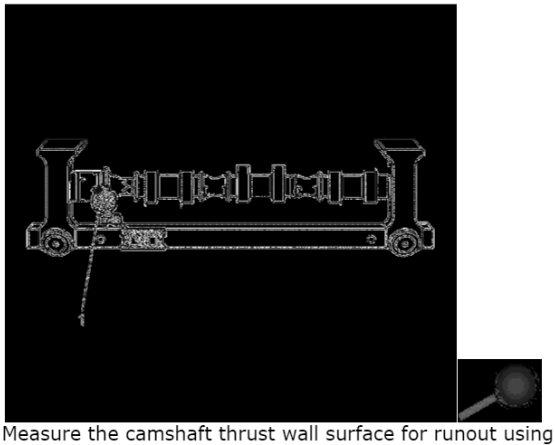


cardiagn.com

3. Measure and record the camshaft runout using a dial indicator (1). Refer to Engine Mechanical Specifications.

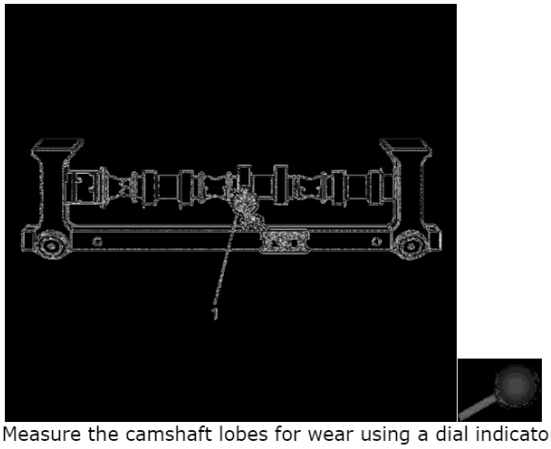


4. Measure the camshaft thrust width (A) for wear using a depth micrometer. Refer to Engine Mechanical Specifications.

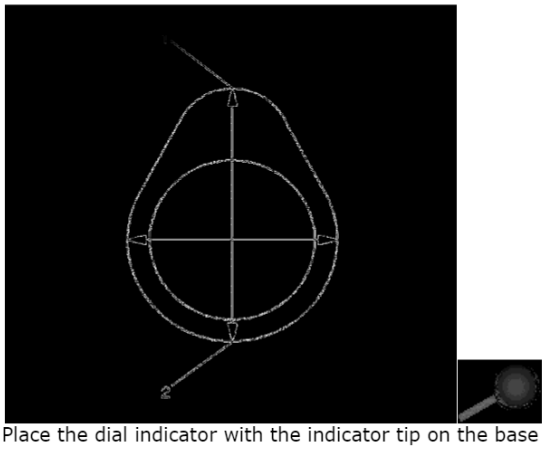


5. Measure the camshaft thrust wall surface for runout using a dial indicator (1). Refer to Engine Mechanical Specifications.
6. If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.

cardiagn.com



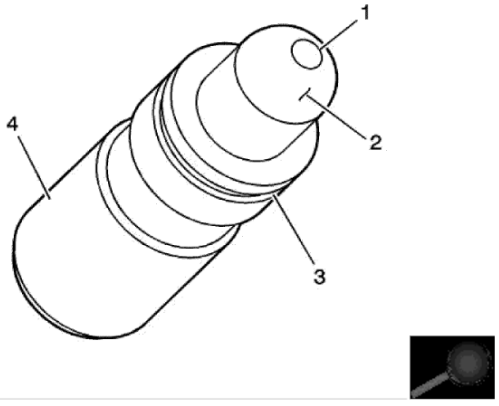
7. Measure the camshaft lobes for wear using a dial indicator (1).



8. Place the dial indicator with the indicator tip on the base circle (2) of the camshaft lobe.
   8.1. Place the dial indicator at zero.
   8.2. Rotate the camshaft until the indicator tip is at the highest point (1) on the lobe. This reading is the lift of the camshaft lobe. Refer to Engine Mechanical Specifications.
   8.3. If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

cardiagn.com

Valve Lifter Cleaning and Inspection



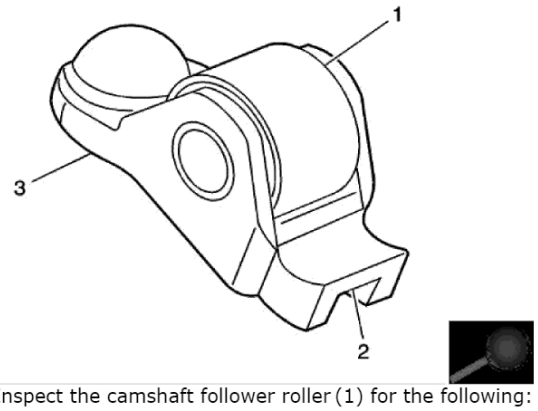
Caution: Refer to Valve Lifter Priming Caution.

1. Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas:
   - A plugged oil passage (1)
   - A scored or worn camshaft follower pivot area (2)
   - A damaged or broken retainer (3), some applications
   - A severely scuffed or worn SHLA body (4)
2. Replace the SHLA or SHLAs as necessary.

cardiagn.com

© 2014 General Motors. All rights reserved.

Valve Rocker Arm Cleaning and Inspection



1. Inspect the camshaft follower roller (1) for the following:
   - Flat spots
   - Excessive scoring and pitting
   - Ensure the roller spins freely
2. Inspect the camshaft follower valve tip area (2).
3. Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
4. Replace the camshaft follower or followers as necessary.

cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Timing Drive Components Cleaning and Inspection

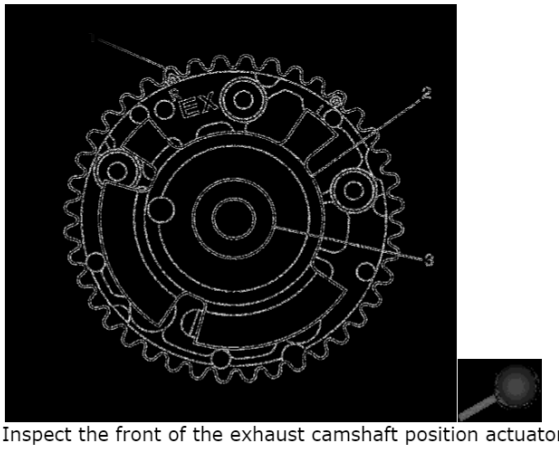
Cleaning Procedure

1. Clean all the following components with solvent:
   - Crankshaft sprocket.
   - Primary timing drive chain.
   - Primary timing drive chain shoe.
   - Primary timing drive chain guides.
   - Primary timing drive chain tensioner.
   - Secondary timing drive chains.
   - Secondary timing drive chain shoes.
   - Secondary timing drive chain guides.
   - Secondary timing drive chain tensioners.
   - Timing component fastening bolts.
2. Clean each camshaft position actuator's exterior with solvent.

   Warning: Refer to Safety Glasses Warning.
3. Dry the timing components with compressed air.

Visual Inspection

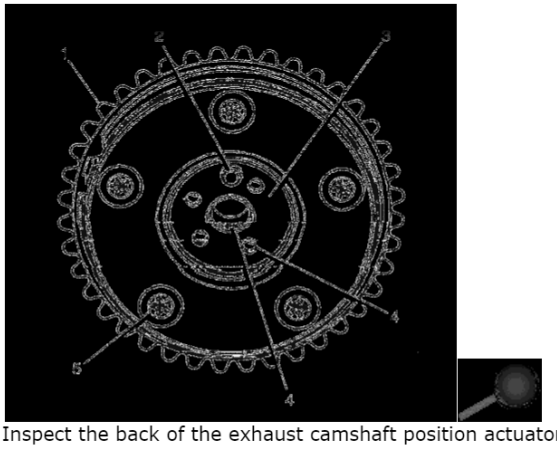
Camshaft Position Actuators



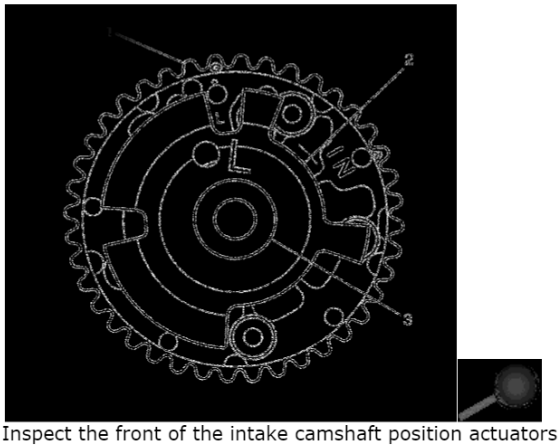
1. Inspect the front of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1).
   - Reluctor/sensor wheel damage (2).
   - Camshaft position actuator to camshaft retaining bolt seating/sealing inner hub flange damage (3).

cardiagn.com

© 2014 General Motors. All rights reserved.

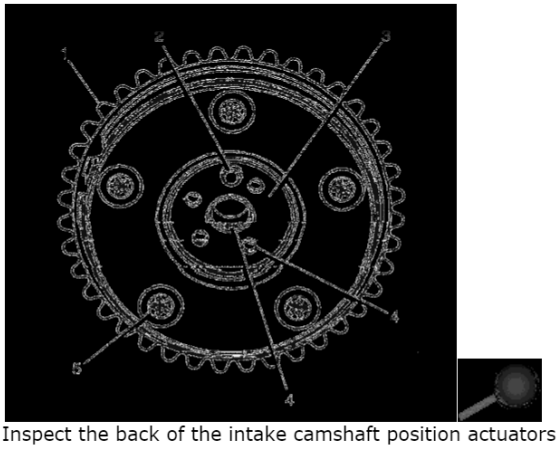


2. Inspect the back of the exhaust camshaft position actuators for the following:
   - Sprocket damage (1).
   - Camshaft locating pin damage (2).
   - Camshaft seating/sealing inner hub flange damage (3).
   - Blockage to the oil passages (4).
   - Loose or missing housing bolts (5).



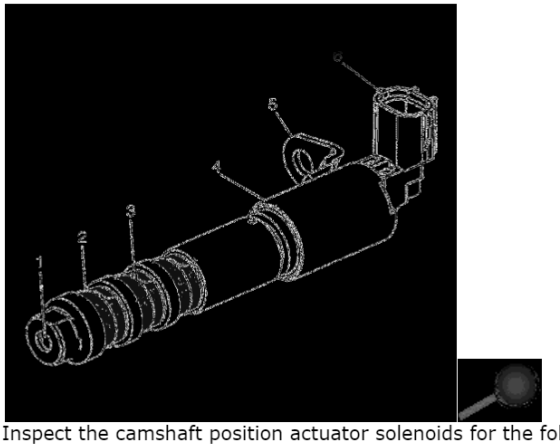
3. Inspect the front of the intake camshaft position actuators for the following:
   - Sprocket damage (1).
   - Reluctor/sensor wheel damage (2).
   - Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3).

cardiagn.com



4. Inspect the back of the intake camshaft position actuators for the following:
    - Sprocket damage (1).
    - Camshaft locating pin damage (2).
    - Camshaft seating/sealing inner hub flange damage (3).
    - Blockage to the oil passages (4).
    - Loose or missing housing bolts (5).
5. Replace a damaged camshaft position actuator.

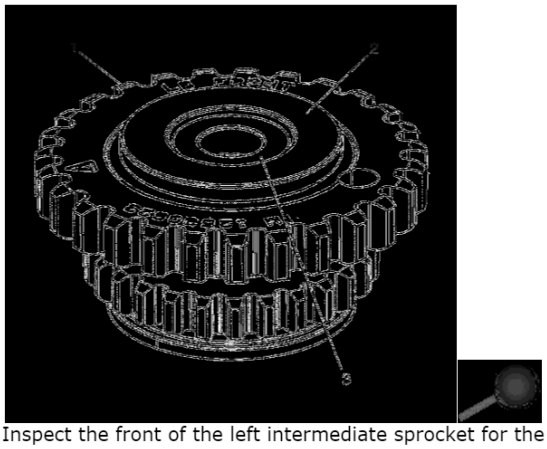
Camshaft Position Actuator Solenoids



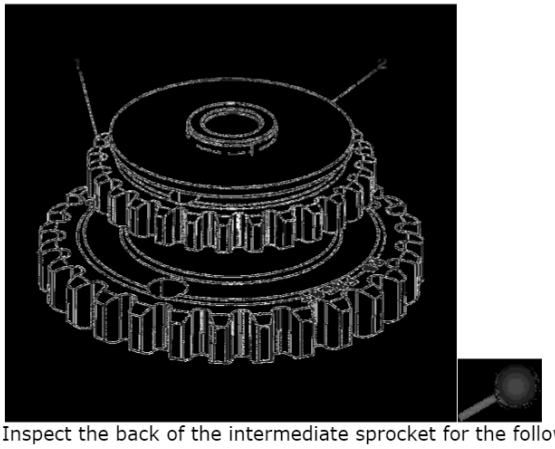
1. Inspect the camshaft position actuator solenoids for the following:
    - Blockage to the oil passage (1).
    - Missing or damaged oil screen clip (2).
    - Blockage or damage to the oil screen (3).
    - Damage to the sealing surface for the camshaft position actuator solenoid oil seal (4).
    - Damage to the bracket (5).
    - Damage to the wiring harness connection and/or terminals (6).
2. Replace a damaged camshaft position actuator solenoid.

cardiagn.com

Left Intermediate Sprocket



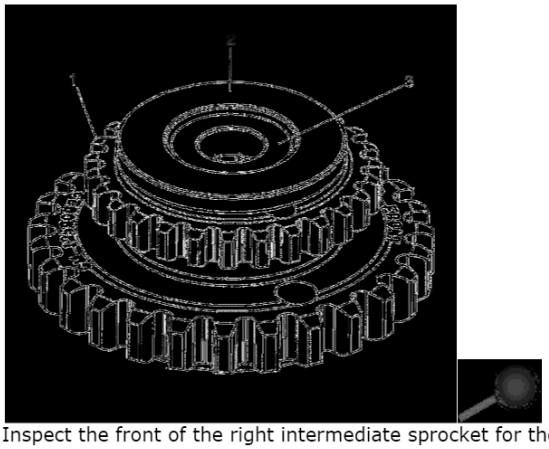
1. Inspect the front of the left intermediate sprocket for the following:
    - Damage to the primary camshaft drive chain sprocket (1).
    - Damage to the hub bearing (2) — Make surethe hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
    - Damage to the bolt flange seating/sealing surface (3).



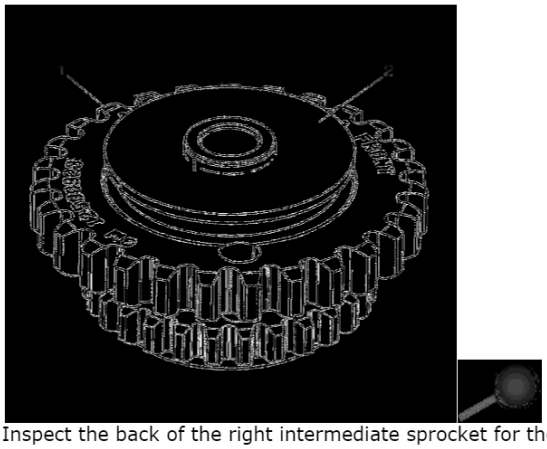
2. Inspect the back of the intermediate sprocket for the following:
    - Damage to the left secondary camshaft drive chain sprocket (1).
    - Damage to the bearing hub-to-engine block sealing surface (2).
3. Replace a damaged left intermediate sprocket.

Right Intermediate Sprocket

cardiagn.com



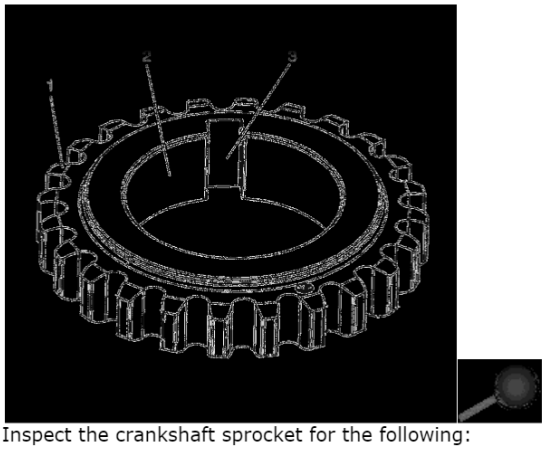
1. Inspect the front of the right intermediate sprocket for the following:
    - Damage to the right secondary camshaft drive chain sprocket (1)
    - Damage to the bearing hub bearing (2) — make sure the hub bearing spins freely. If the hub bearing wobbles, is noisy or feels rough when rotated replace the intermediate sprocket.
    - Damage to the bolt flange seating/sealing surface (3)



2. Inspect the back of the right intermediate sprocket for the following:
    - Damage to the primary camshaft drive chain sprocket (1)
    - Damage to the bearing hub-to-engine block sealing surface (2)
3. Replace a damaged right intermediate sprocket.

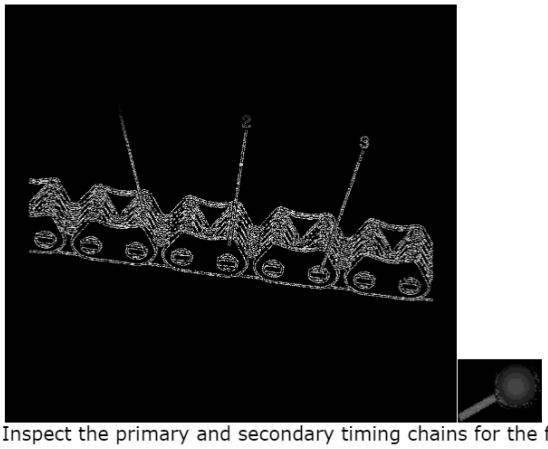
Crankshaft Sprocket

cardiagn.com



1. Inspect the crankshaft sprocket for the following:
    - Sprocket damage (1)
    - Bore damage (2)
    - Keyway damage (3)
2. Replace a damaged crankshaft sprocket.

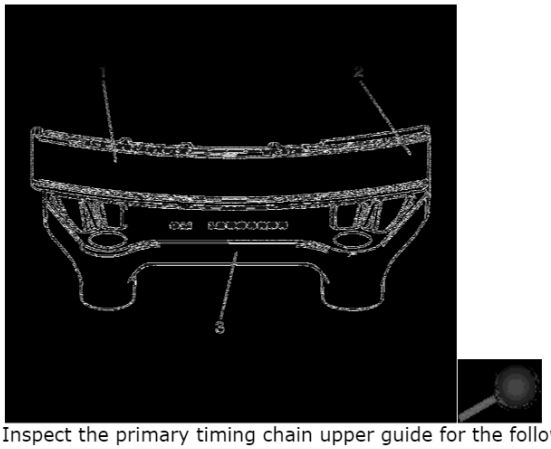
Primary and Secondary Timing Chains



1. Inspect the primary and secondary timing chains for the following:
    - Binding or worn links (1)
    - Loose links (2)
    - Loose pins (3)
2. Replace a damaged primary timing chain.

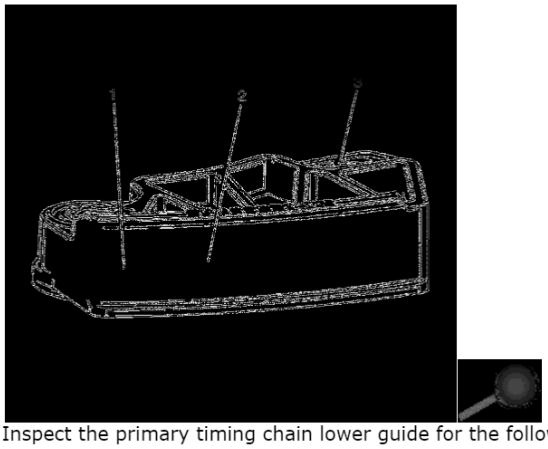
Primary Timing Chain Upper Guide

cardiagn.com



1. Inspect the primary timing chain upper guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)
2. Replace a damaged primary timing chain upper guide.

Primary Timing Chain Lower Guide

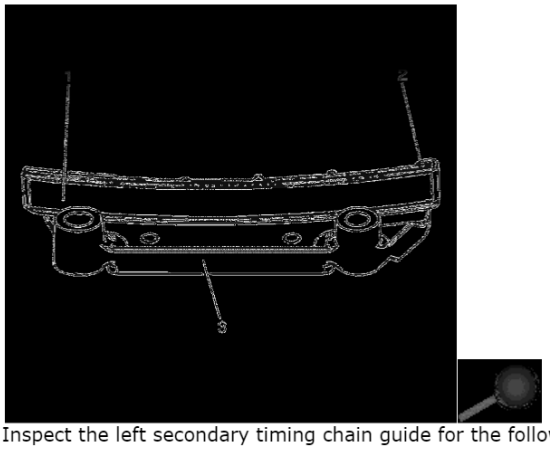


1. Inspect the primary timing chain lower guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)

   Note: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.
2. Replace a damaged primary timing chain lower guide by replacing the oil pump.

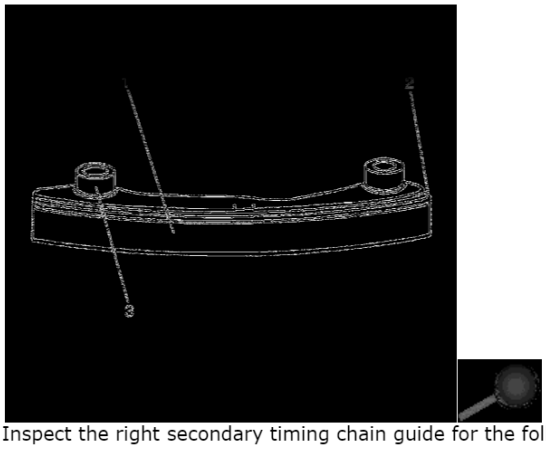
Left Secondary Timing Chain Guide

cardiagn.com



1. Inspect the left secondary timing chain guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)
2. Replace a damaged left secondary timing chain guide.

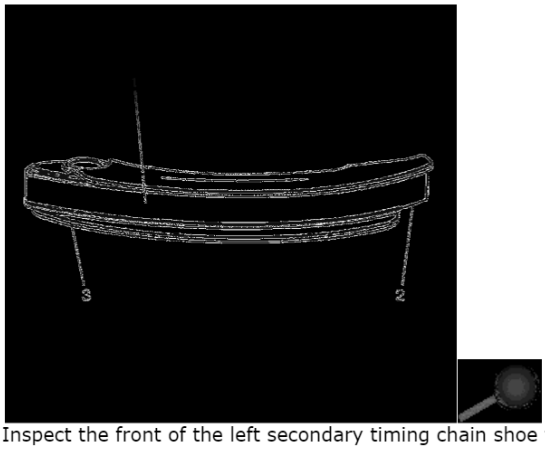
Right Secondary Timing Chain Guide



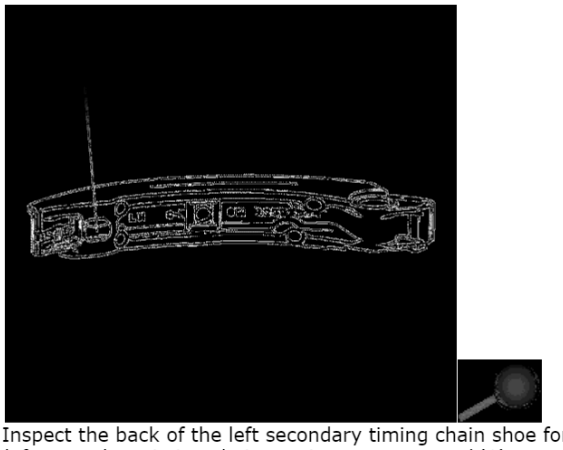
1. Inspect the right secondary timing chain guide for the following:
   - Worn guide surface (1)
   - Cracked or broken guide surface (2)
   - Cracked or damaged guide base (3)
2. Replace a damaged right secondary timing chain guide.

Left Secondary Timing Chain Shoe

cardiagn.com



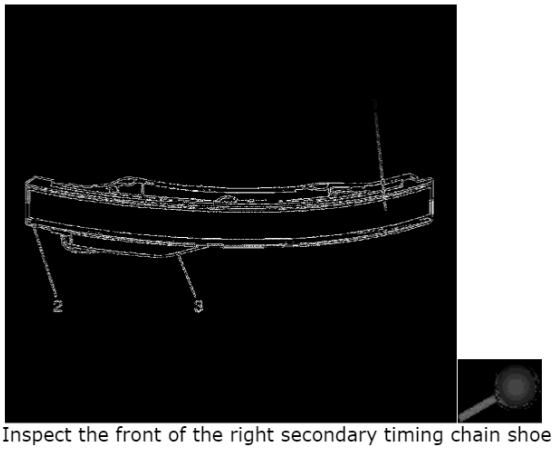
1. Inspect the front of the left secondary timing chain shoe for the following:
   - Worn shoe surface (1)
   - Cracked or broken shoe surface (2)
   - Cracked or damaged shoe (3)



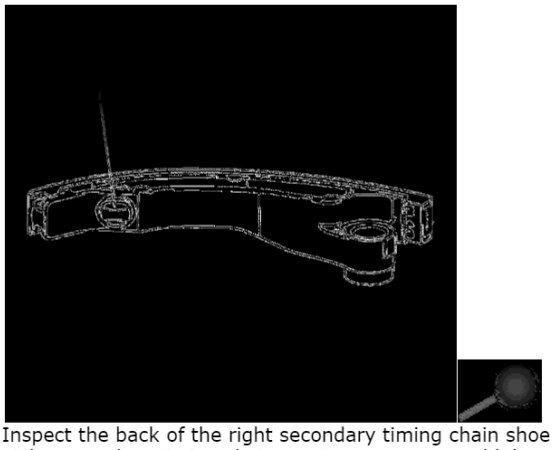
2. Inspect the back of the left secondary timing chain shoe for a damaged, worn or missing left secondary timing chain tensioner contact pad (1).
3. Replace a damaged left secondary timing chain shoe.

Right Secondary Timing Chain Shoe

cardiagn.com



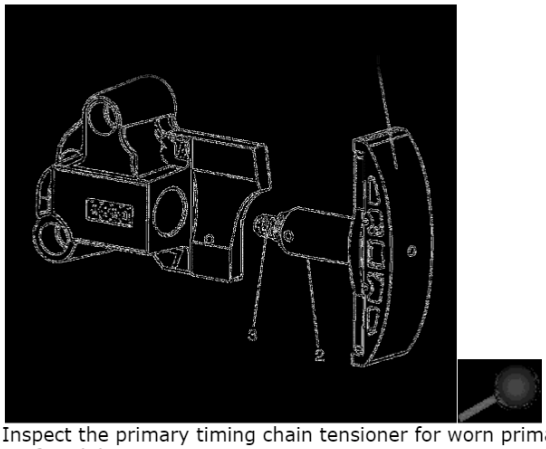
1. Inspect the front of the right secondary timing chain shoe for the following:
   - Worn shoe surface (1)
   - Cracked or broken shoe surface (2)
   - Cracked or damaged shoe (3)



2. Inspect the back of the right secondary timing chain shoe for a damaged, worn or missing right secondary timing chain tensioner contact pad (1).
3. Replace a damaged right secondary timing chain shoe.

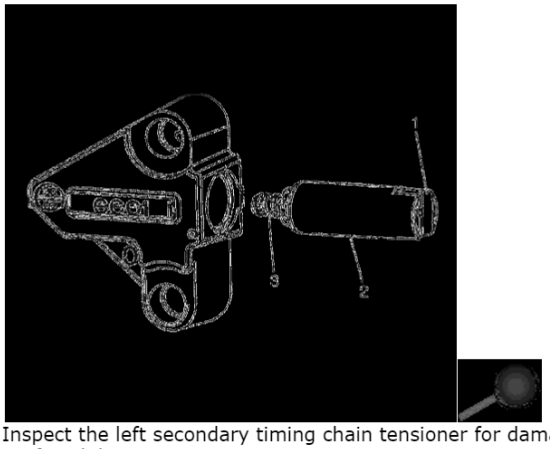
Primary Timing Chain Tensioner

cardiagn.com



1. Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1).
2. Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger (2) moves freely in and out of the body of the tensioner. Refer to Camshaft Timing Chain Components Installation.
3. Replace a damaged primary timing chain tensioner.

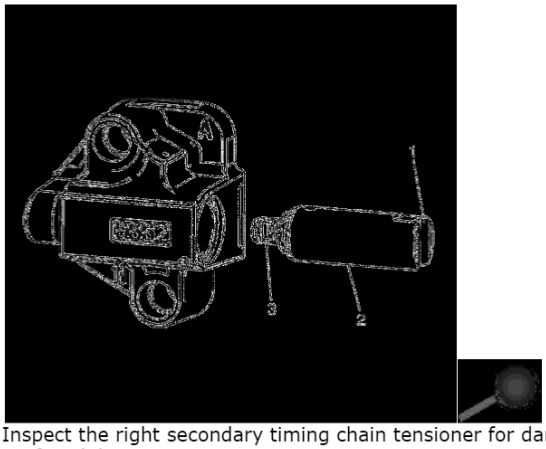
Left Secondary Timing Chain Tensioner



1. Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger (2) moves freely in and out of the body of the tensioner. Refer to Camshaft Timing Chain Components Installation.
3. Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner

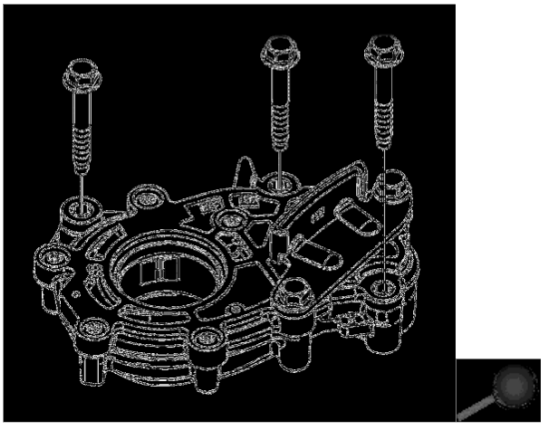
cardiagn.com



1. Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1).
2. Inspect the right secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger (2) moves freely in and out of the body of the tensioner. Refer to Camshaft Timing Chain Components Installation.
3. Replace a damaged right secondary timing chain tensioner.

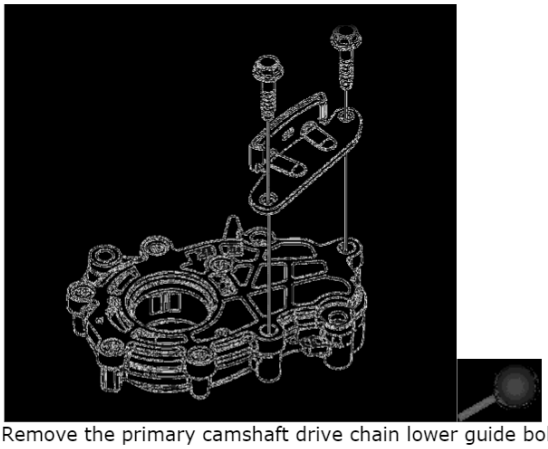
cardiagn.com

Oil Pump Disassemble



Important: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

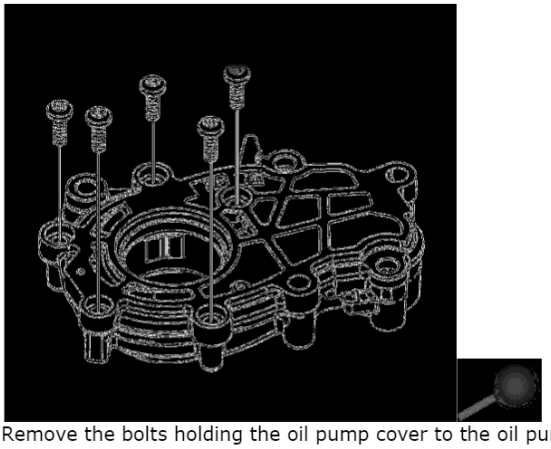
1. Remove the oil pump mounting bolts.



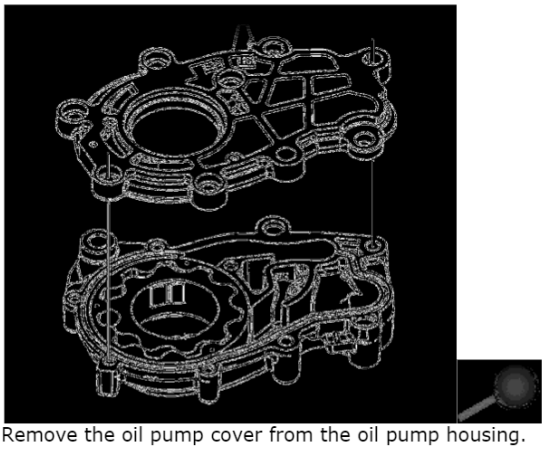
2. Remove the primary camshaft drive chain lower guide bolts.
3. Remove the primary camshaft drive chain lower guide.

cardiagn.com

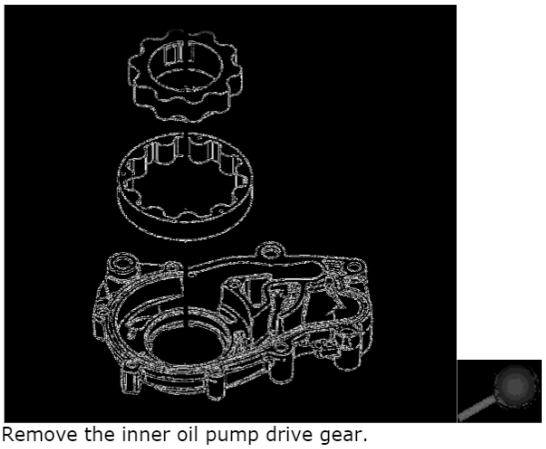
© 2014 General Motors. All rights reserved.



4. Remove the bolts holding the oil pump cover to the oil pump housing.

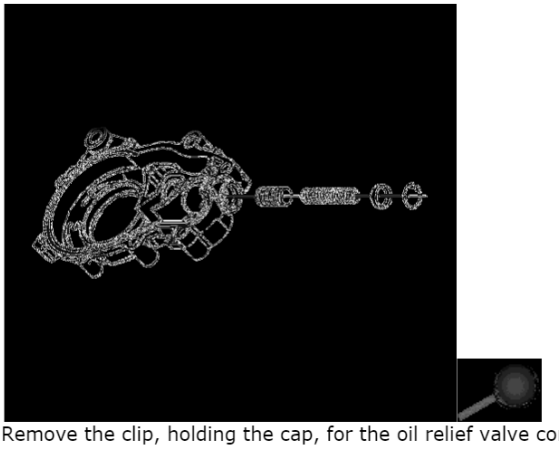


5. Remove the oil pump cover from the oil pump housing.



6. Remove the inner oil pump drive gear.
7. Remove the outer oil pump driven gear.

cardiagn.com



8. Remove the clip, holding the cap, for the oil relief valve components.
9. Remove the cap, spring, and plunger from the oil pump housing.

cardiagn.com

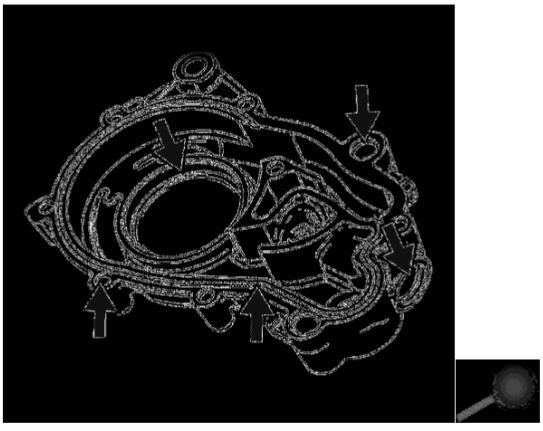
Oil Pump Cleaning and Inspection

Cleaning Procedure

1. Clean the oil pump components with non-corrosive solvent.

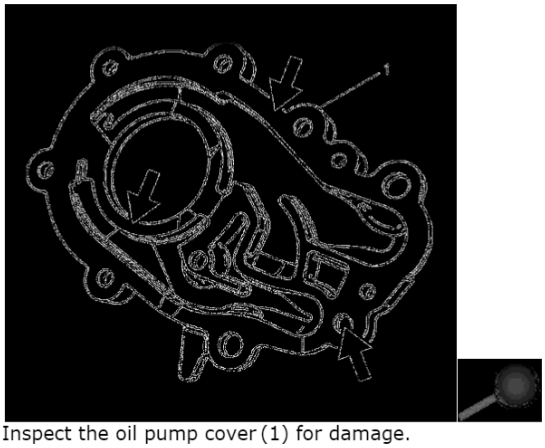
   Warning: Refer to Safety Glasses Warning.
2. Dry the oil pump components with compressed air.

Inspection Procedure



Note: There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must not be reused. A disassembled oil pump must be replaced.

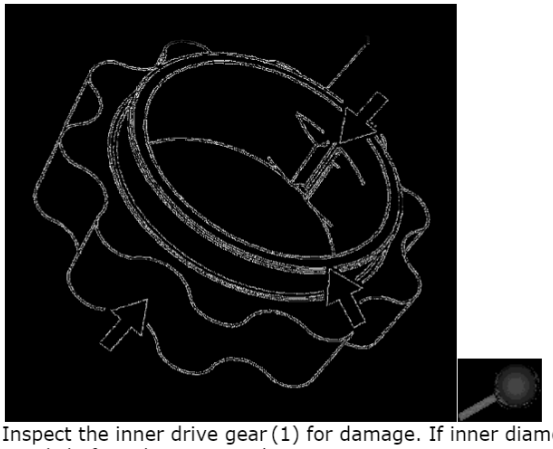
1. Inspect the oil pump housing for damage.



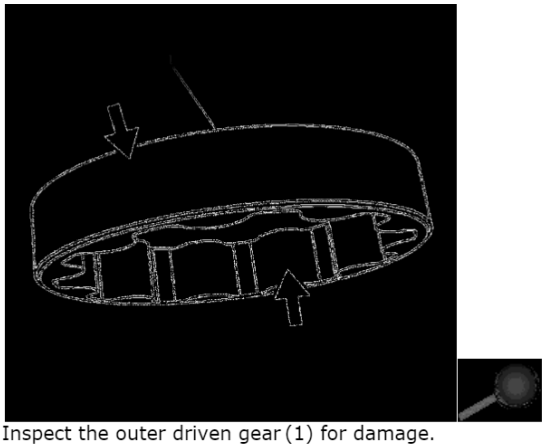
2. Inspect the oil pump cover (1) for damage.

cardiagn.com

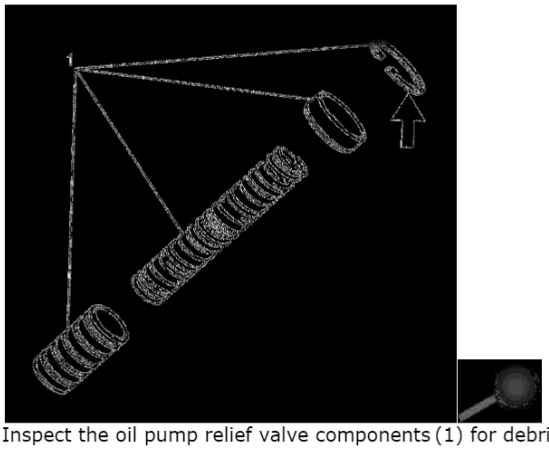
© 2014 General Motors. All rights reserved.



3. Inspect the inner drive gear (1) for damage. If inner diameter damage is found, ensure the crankshaft is also inspected.

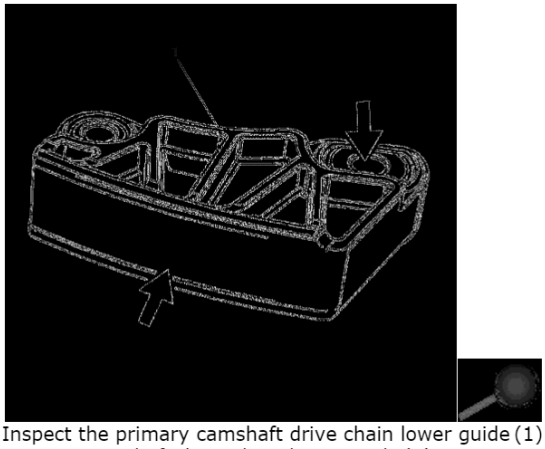


4. Inspect the outer driven gear (1) for damage.



5. Inspect the oil pump relief valve components (1) for debris or damage.

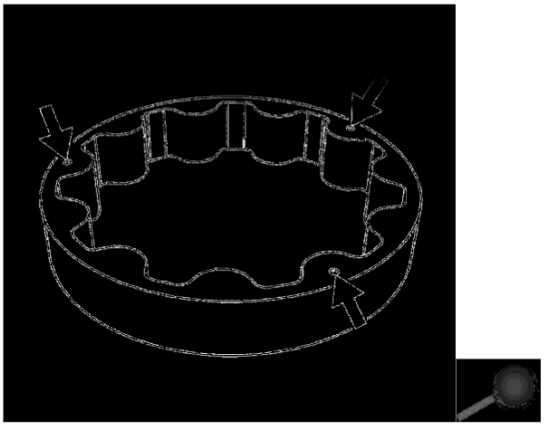
cardiagn.com



6. Inspect the primary camshaft drive chain lower guide (1) for damage. If replacement of the primary camshaft drive chain lower guide (1) is necessary, replace the entire oil pump assembly. The primary camshaft drive chain lower guide (1) is not serviceable separately.
7. If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

cardiagn.com

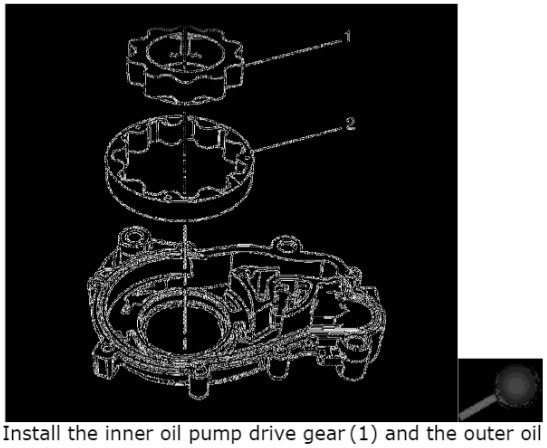
Oil Pump Assemble



Note:

- There are no serviceable components within the oil pump. Disassemble the pump only to diagnose an oiling concern. A disassembled oil pump must be replaced. DO NOT reuse a disassembled oil pump or a serviceable oil pump with a primary camshaft drive chain lower guide that needs to be replaced.
- The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.

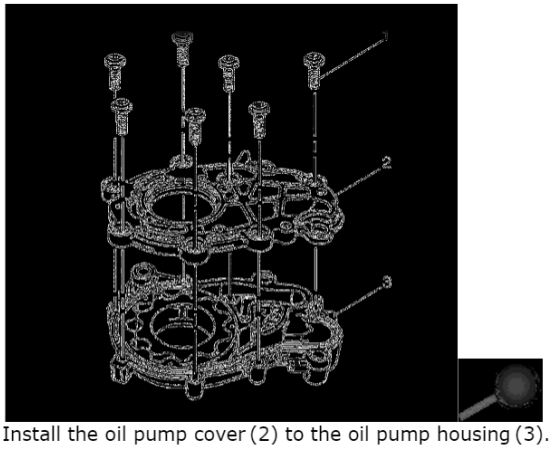
1. The dimpled surface must be face-up in the pump body.



2. Install the inner oil pump drive gear (1) and the outer oil pump driven gear (2) in the pump cover in the same orientation as removed.

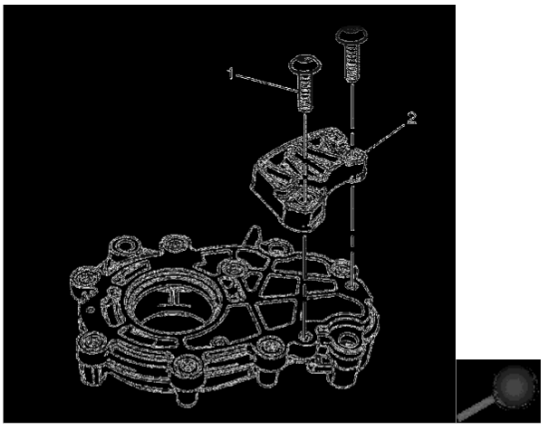
cardiagn.com

© 2014 General Motors. All rights reserved.



3. Install the oil pump cover (2) to the oil pump housing (3).

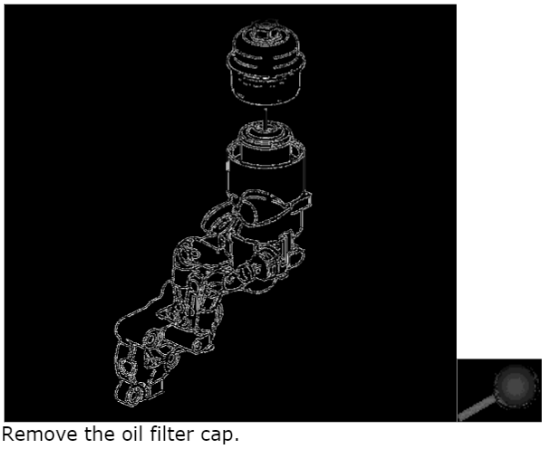
   Caution: Refer to Fastener Caution.
4. Install the oil pump cover to oil pump housing retaining bolts (1) and tighten to **10 N•m (89 lb in)**.



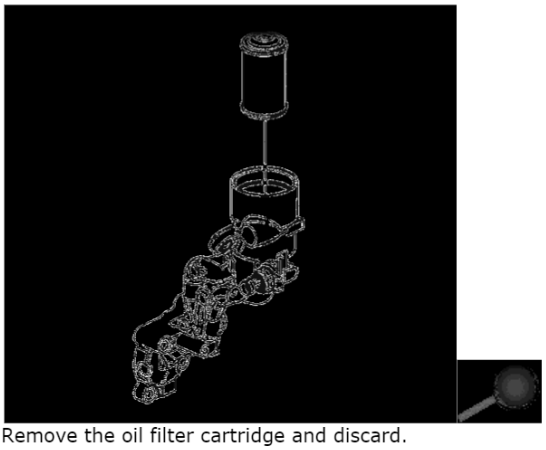
   Note: The primary camshaft drive chain lower guide is not a serviceable component. If the primary camshaft drive chain lower guide is to be reused, the primary camshaft drive chain lower guide is not to be removed from the oil pump cover. If the primary camshaft drive chain lower guide must be replaced, the oil pump must be replaced.
5. Install the primary camshaft drive chain lower guide (2).
6. Install the primary camshaft drive chain lower guide to oil pump retaining bolts (1) and tighten to **13 N•m (115 lb in)**.

cardiagn.com

Oil Filter Adapter Disassemble



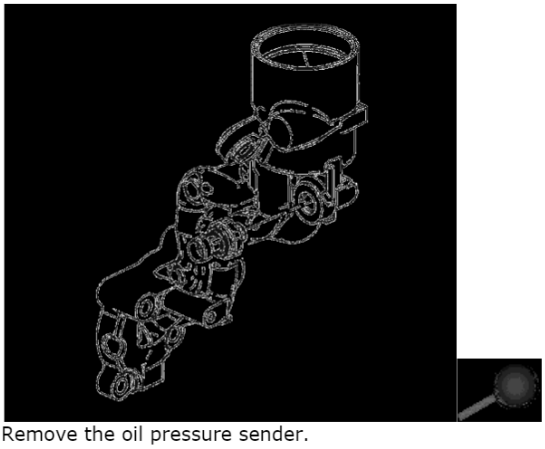
1. Remove the oil filter cap.



2. Remove the oil filter cartridge and discard.

cardiagn.com

© 2014 General Motors. All rights reserved.



3. Remove the oil pressure sender.

cardiagn.com

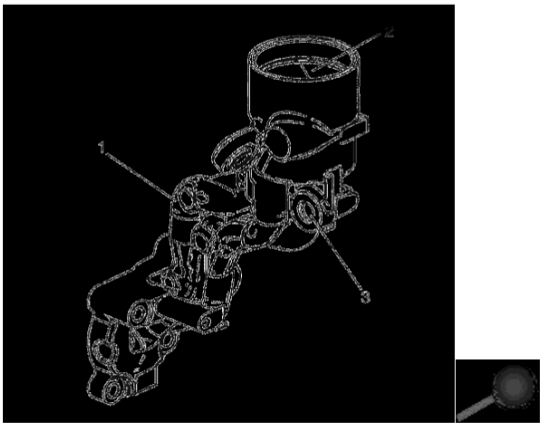
Oil Filter Adapter Cleaning and Inspection

Cleaning Procedure

1. Clean the oil filter adapter components with non-corrosive solvent.

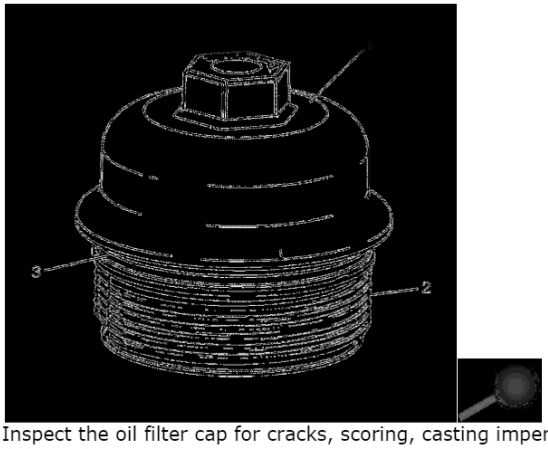
   Warning: Refer to Safety Glasses Warning.
2. Dry the oil filter adapter components with compressed air.

Inspection Procedure



Note: The internal parts of the oil filter adapter are not serviced separately. If wear or damage is noted, replace the entire oil filter adapter assembly.

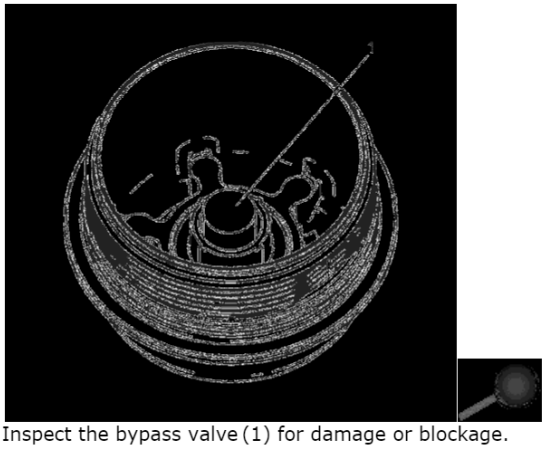
1. Inspect the oil filter housing for cracks, scoring, casting imperfections (1) and damaged threads (3).
2. Inspect the drain back valve (2) for damage or blockage.



3. Inspect the oil filter cap for cracks, scoring, casting imperfections (1) and damaged threads (2). Replace as necessary.
4. Inspect the oil filter cap O-ring (3) for damage. Replace as necessary.

© 2014 General Motors. All rights reserved.

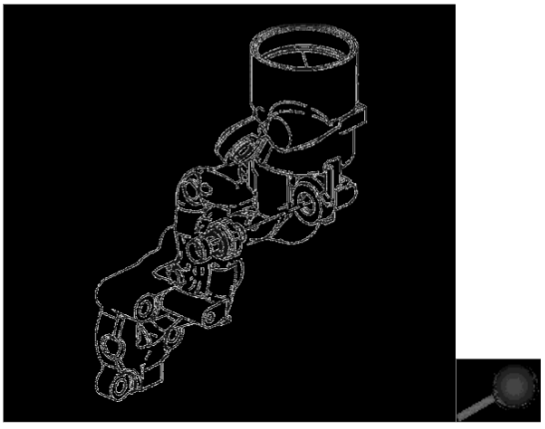
cardiagn.com



5. Inspect the bypass valve (1) for damage or blockage.

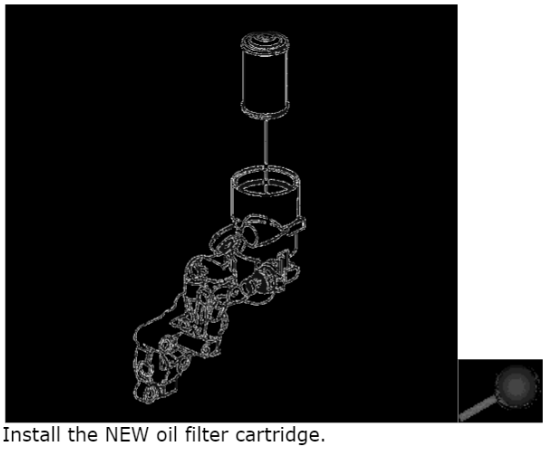
cardiagn.com

Oil Filter Adapter Assemble



Caution: Refer to Fastener Caution.

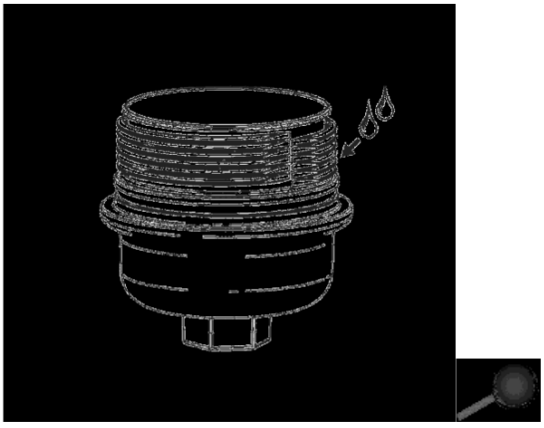
1. Install the oil pressure sender and tighten to **20 N•m (15 lb ft)**.



2. Install the NEW oil filter cartridge.
3. If the oil filter cap O-ring is removed, install a NEW O-ring on the oil filter cap.
   3.1. Ensure the O-ring groove is not damaged. Replace the oil filter cap if the O-ring groove is damaged.
   3.2. Protect the O-ring from damage during installation by covering the threads of the oil filter cap with tape or plastic wrap.
   3.3. DO NOT stretch the O-ring during installation.
   3.4. Roll the O-ring into position over the covered threads.
   3.5. Remove the tape or plastic wrap from the oil filter cap threads.
   3.6. Ensure the oil filter cap threads are clean.

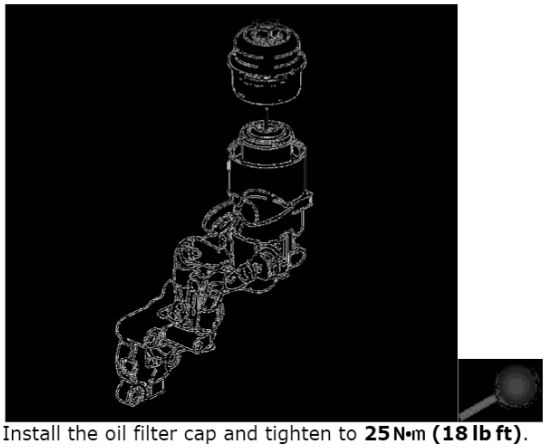
© 2014 General Motors. All rights reserved.

cardiagn.com



Caution: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

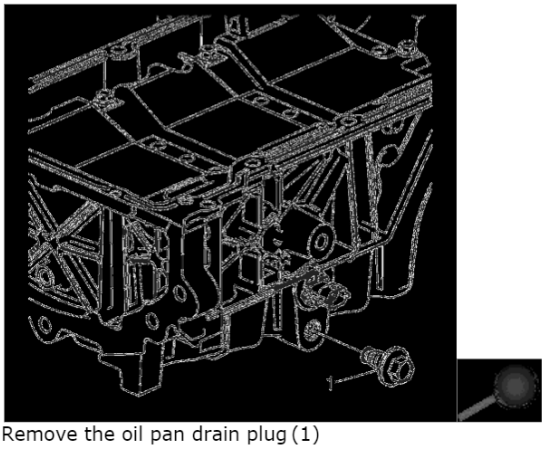
4. Lubricate the oil filter cap threads and O-ring with clean engine oil.



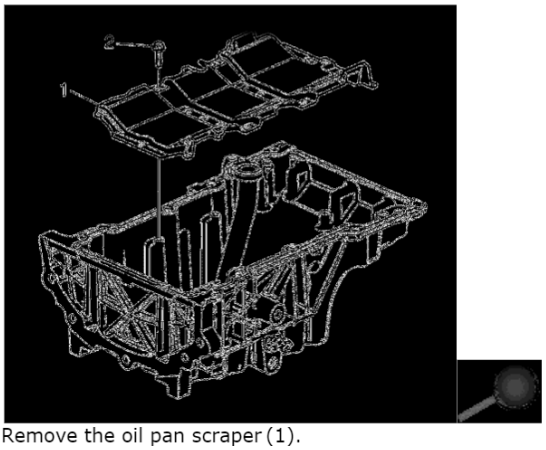
5. Install the oil filter cap and tighten to **25 N•m (18 lb ft)**.

cardiagn.com

Oil Pan Disassemble



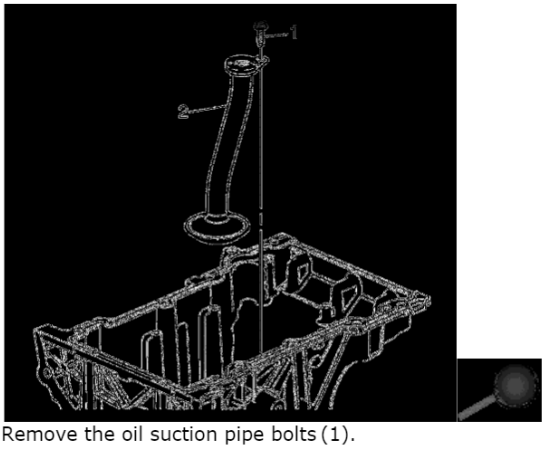
1. Remove the oil pan drain plug (1)



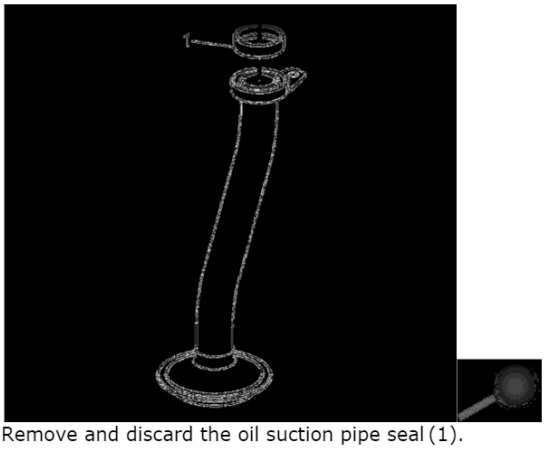
2. Remove the oil pan scraper (1).
3. Remove the oil pan scraper bolts (2).

cardiagn.com

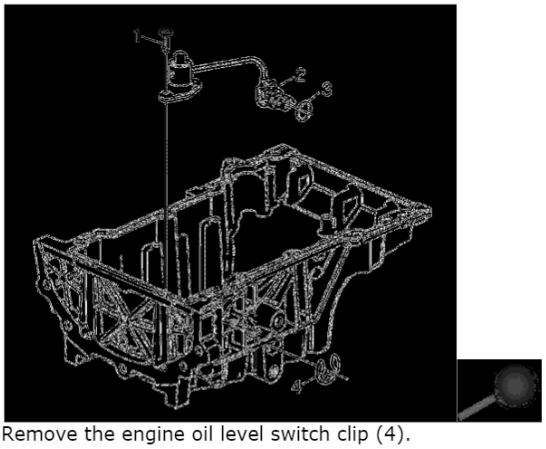
© 2014 General Motors. All rights reserved.



4. Remove the oil suction pipe bolts (1).
5. Remove the oil suction pipe (2).



6. Remove and discard the oil suction pipe seal (1).



7. Remove the engine oil level switch clip (4).
8. Remove the engine oil level switch bolts (1).
9. Remove the engine oil level switch (2).

cardiagn.com

10. Remove and discard the engine oil level switch seal (3).

cardiagn.com

Oil Pan Cleaning and Inspection

Special Tools

J 28410 Gasket Remover

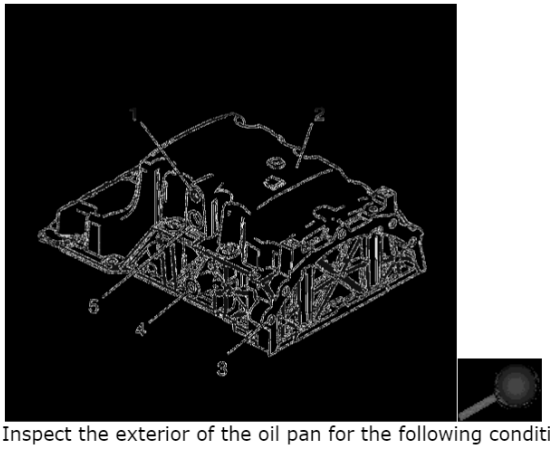
For equivalent regional tools, refer to Special Tools.

Cleaning Procedure

1. Remove any old thread sealant, gasket material or sealant using *J 28410* remover.
2. Clean the oil pan and oil pan components in solvent.
3. Clean out debris from the bolt holes.

   Warning: Refer to Safety Glasses Warning.
4. Dry the oil pan and oil pan components with compressed air.

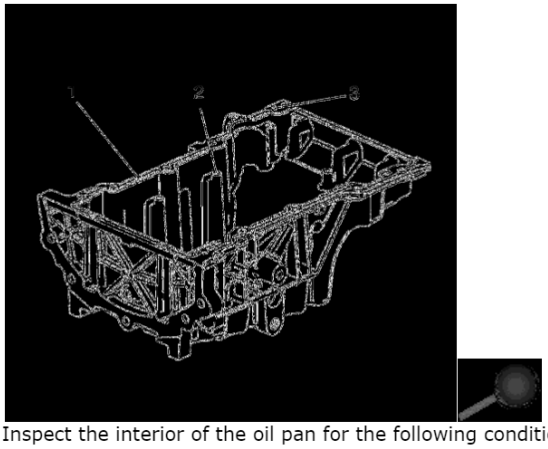
Inspection Procedure



1. Inspect the exterior of the oil pan for the following conditions:
   - Dents or damage to the exterior (2)
   - Damage to the drain plug or drain plug hole (1)
   - Damage to the brace mounting bosses (4)
   - Damage to the mounting bosses (3)
   - Damage to the engine oil level switch hole (5)

cardiagn.com

© 2014 General Motors. All rights reserved.



2. Inspect the interior of the oil pan for the following conditions:
    - Gouges or damage to the oil pan sealing surfaces (1)
    - Damage to the oil pan scraper mounting holes (2)
    - Damage to the bolt holes (3)
3. Repair or replace the oil pan and/or oil pan components as necessary.

cardiagn.com

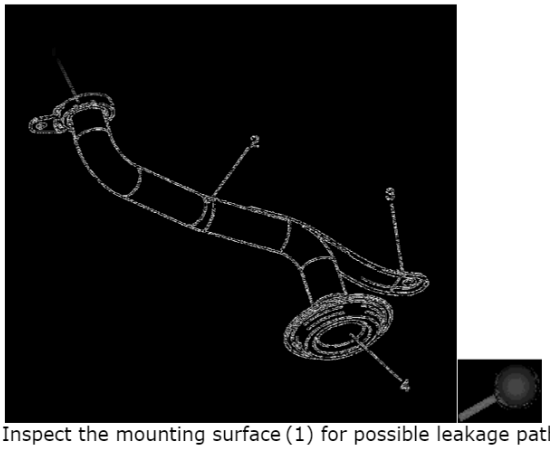
Oil Pump Suction Pipe and Screen Cleaning and Inspection

Cleaning Procedure

1. Clean the oil pump pipe and screen with solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the oil pump pipe and screen with compressed air.

Inspection Procedure

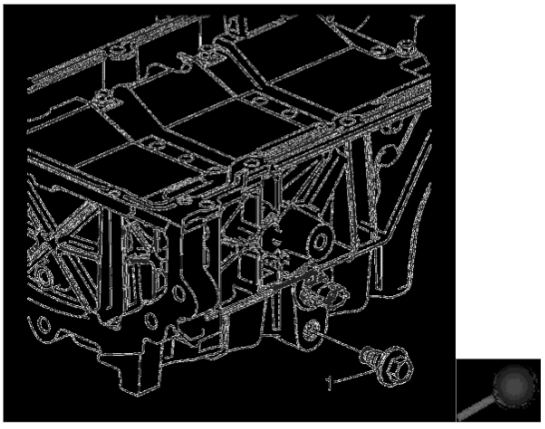


1. Inspect the mounting surface (1) for possible leakage paths.
2. Inspect the oil pump pipe tube (2) for cracks, imperfections and/or damage.
3. Inspect the oil pump pipe support bracket (3) for cracks or damage.
4. Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

cardiagn.com

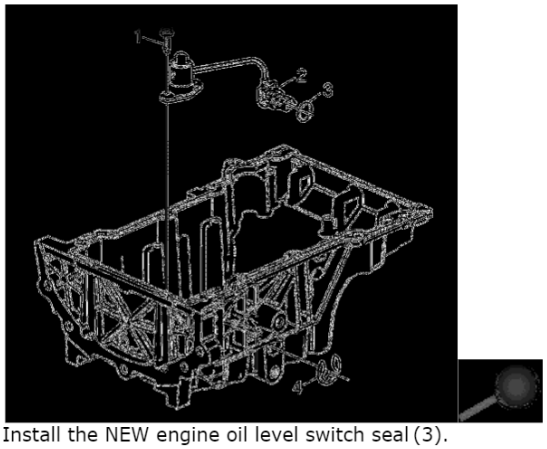
© 2014 General Motors. All rights reserved.

Oil Pan Assemble



Caution: Refer to Fastener Caution.

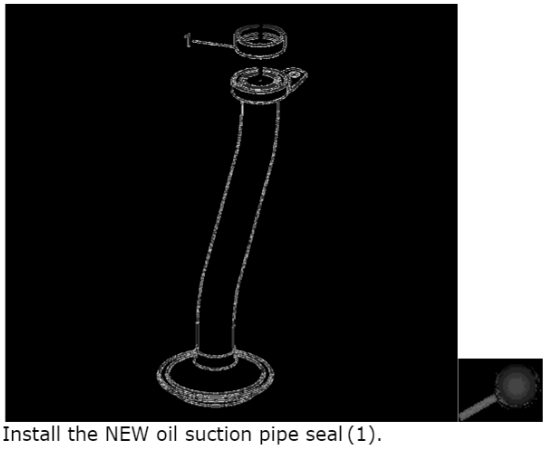
1. Install the oil pan drain plug (1) and tighten the oil pan drain plug to **25 N•m (18 lb ft)**.



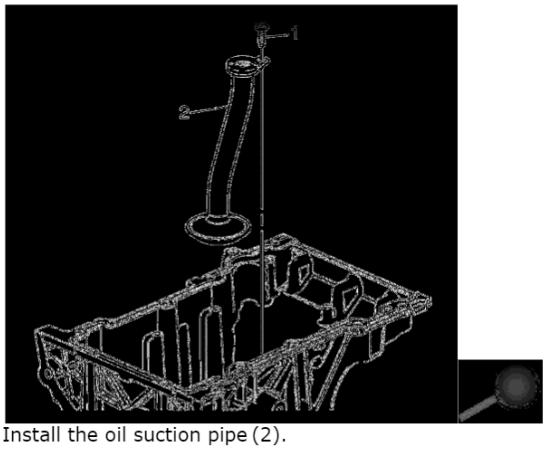
2. Install the NEW engine oil level switch seal (3).
3. Install the engine oil level switch (2).
4. Install the engine oil level switch bolts (1) and tighten to **10 N•m (89 lb in)**.
5. Install NEW engine oil level switch clip (4).

cardiagn.com

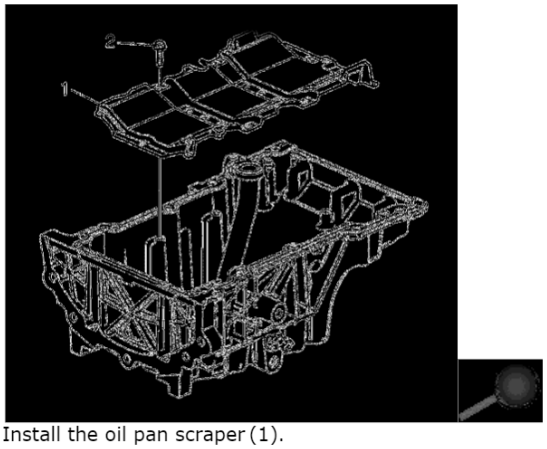
© 2014 General Motors. All rights reserved.



6. Install the NEW oil suction pipe seal (1).



7. Install the oil suction pipe (2).
8. Install the oil suction pipe bolts (1) and tighten to **10 N•m (89 lb in)**.



9. Install the oil pan scraper (1).
10. Install the oil pan scraper bolts (2) and tighten to **10 N•m (89 lb in)**.

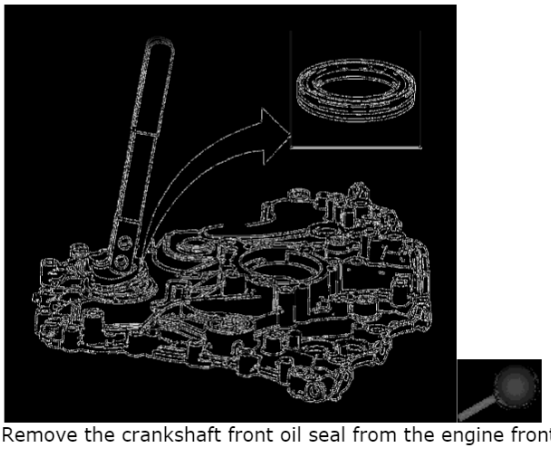
cardiagn.com

Engine Front Cover Disassemble

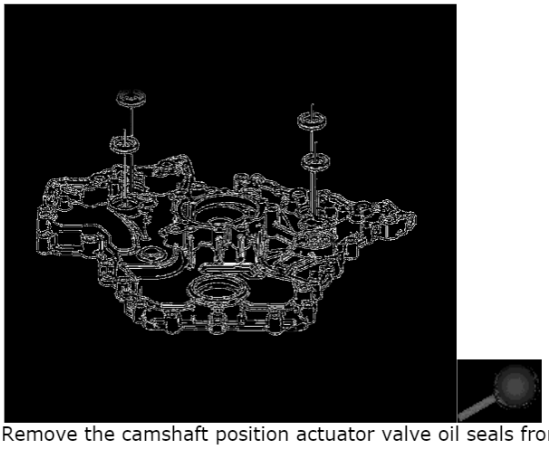
Special Tools

EN 45000 Seal Remover

For equivalent regional tools, refer to Special Tools



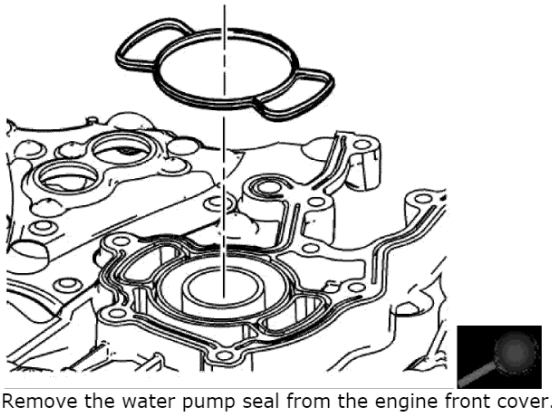
1. Remove the crankshaft front oil seal from the engine front cover using the *EN 45000* remover .



2. Remove the camshaft position actuator valve oil seals from the engine front cover.

cardiagn.com

© 2014 General Motors. All rights reserved.



3. Remove the water pump seal from the engine front cover.
4. Discard the water pump seal.

cardiagn.com

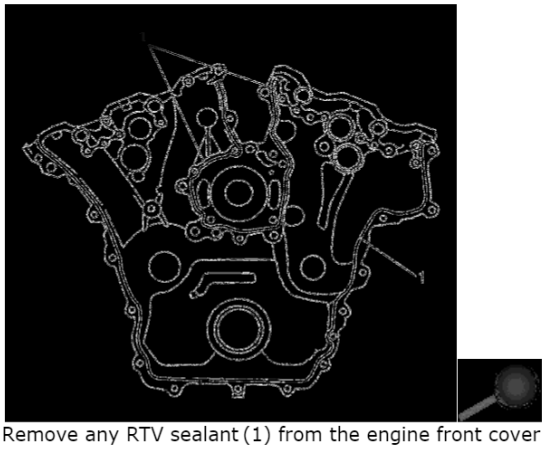
Engine Front Cover Cleaning and Inspection

Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to Special Tools.

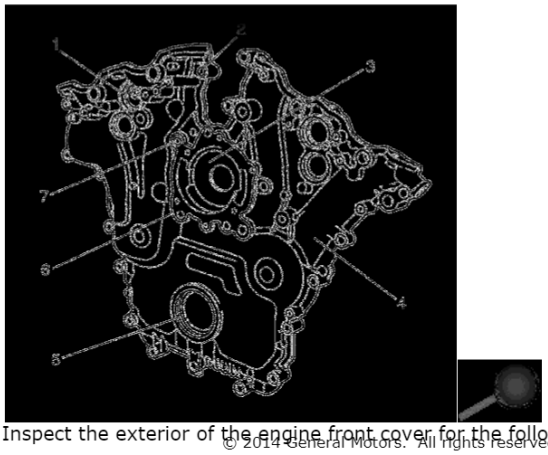
Cleaning Procedure



1. Remove any RTV sealant (1) from the engine front cover using *J 28410* remover .
2. Clean out debris from the bolt holes.
3. Clean the engine front cover (1) in solvent.

   Warning: Refer to Safety Glasses Warning.
4. Dry the engine front cover (1) with compressed air.

Inspection Procedure

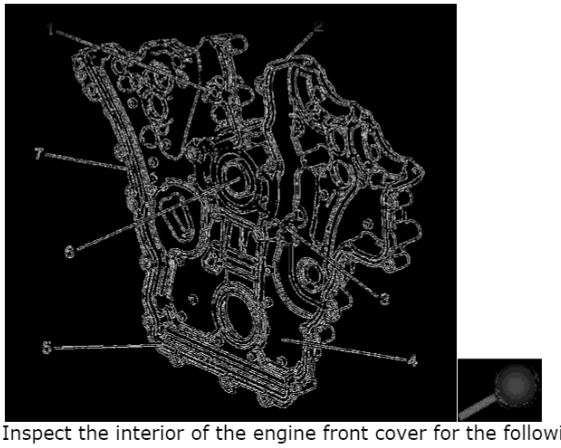


1. Inspect the exterior of the engine front cover for the following conditions:

© 2014 General Motors. All rights reserved.

cardiagn.com

- Damage to the water pump bolt hole threads (7).
- Gouges or damage to the water pump sealing surfaces (6).
- Damage to the crankshaft front oil seal bore (5).
- Damage to the camshaft position actuator solenoid seal bores (1).
- Damage to the engine front cover bolt holes (2).
- Damage and/or corrosion to the engine coolant passage (3).
- Dents or damage to the exterior (4).



2. Inspect the interior of the engine front cover for the following conditions:
   - Gouges or damage to the engine front cover sealing surfaces to the cylinder block (7), oil pan (5), and/or camshaft covers (2).
   - Damage and/or corrosion to the engine coolant passage .(6)
   - Damage to the crankshaft front oil seal bore.
   - Gouges or damage to the O-ring sealing areas.
   - Gouges or damage to the water pump seal area (3).
   - Loose or damaged deadener plates (4).
   - Damage to the engine front cover bolt holes (1).
3. Repair or replace the engine front cover as necessary.

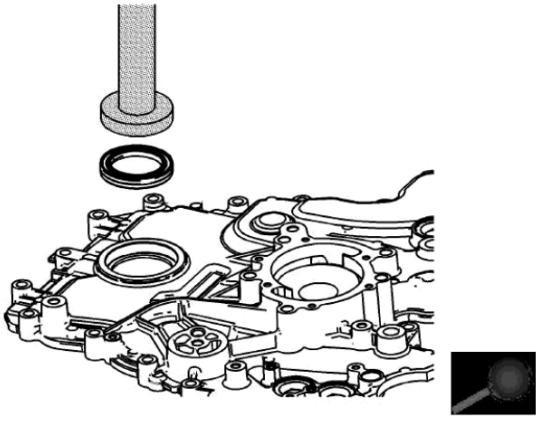
cardiagn.com

Engine Front Cover Assemble

Special Tools

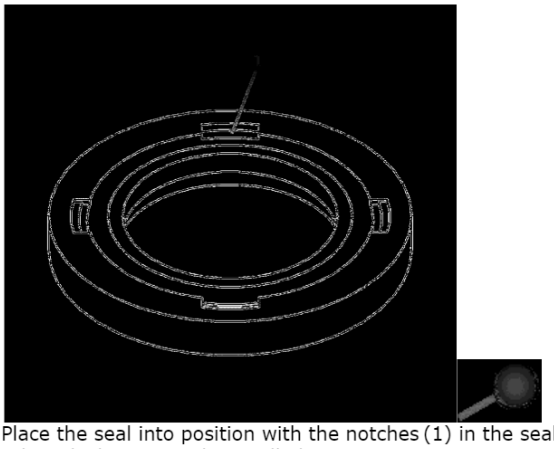
- *EN 29184* Oil Seal Installer
- *EN 46103* Camshaft Actuator Valve Seal Installer

For equivalent regional tools, refer to Special Tools.



Important: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

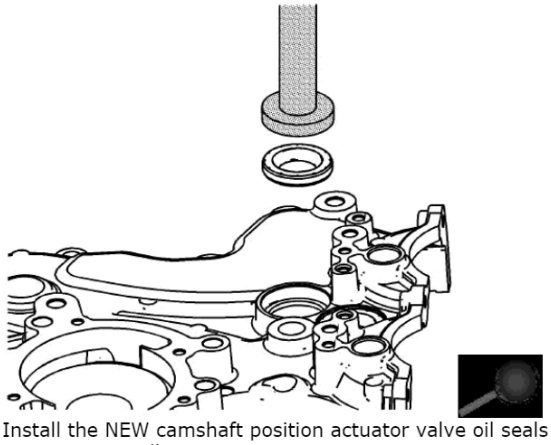
1. Install the NEW crankshaft front oil seal into the engine front cover using the *EN 29184* installer .



2. Place the seal into position with the notches (1) in the seal down. The notches (1) will face inboard when properly installed.

cardiagn.com

© 2014 General Motors. All rights reserved.



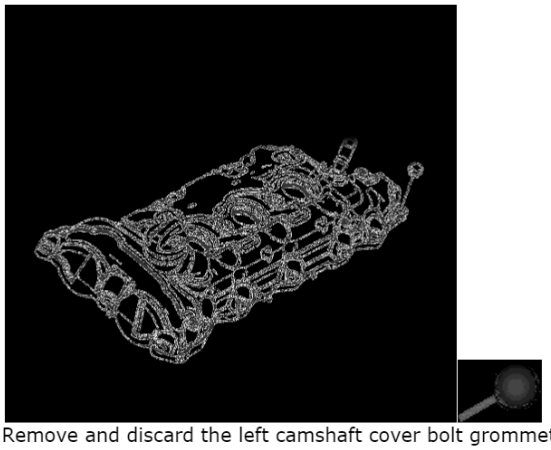
3. Install the NEW camshaft position actuator valve oil seals into the engine front cover using the *EN 46103* installer .

cardiagn.com

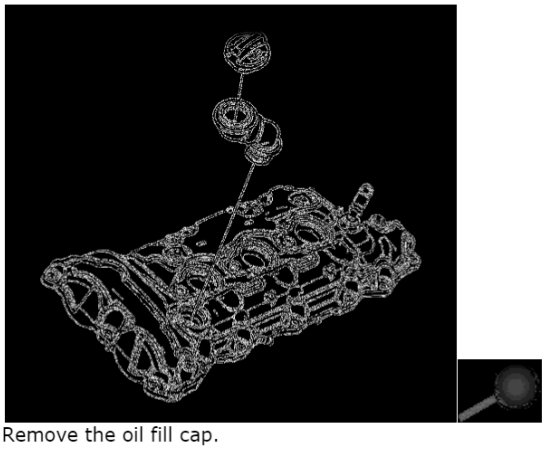
Camshaft Cover Disassemble

Left Camshaft Cover

Warning: Refer to Safety Glasses Warning.



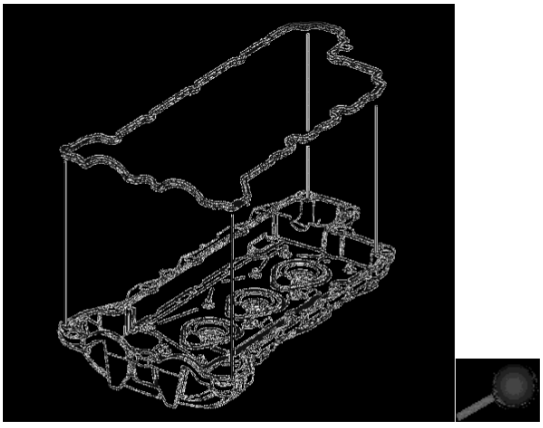
1. Remove and discard the left camshaft cover bolt grommets.



2. Remove the oil fill cap.

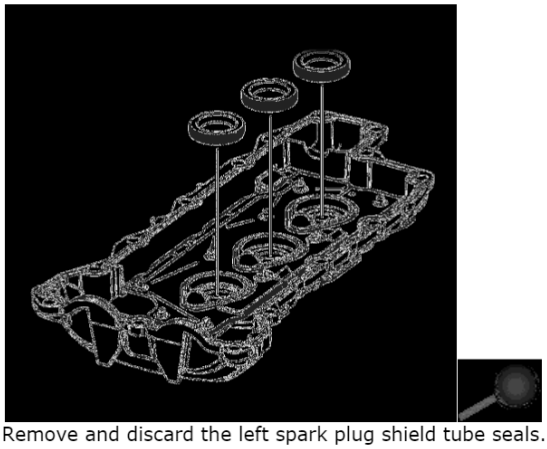
cardiagn.com

© 2014 General Motors. All rights reserved.



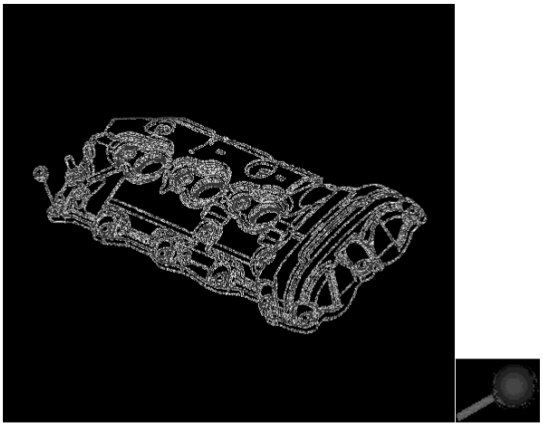
Note: Do not reuse the camshaft cover gasket and spark plug shield tube seals.

3. Remove and discard the left camshaft cover gasket.



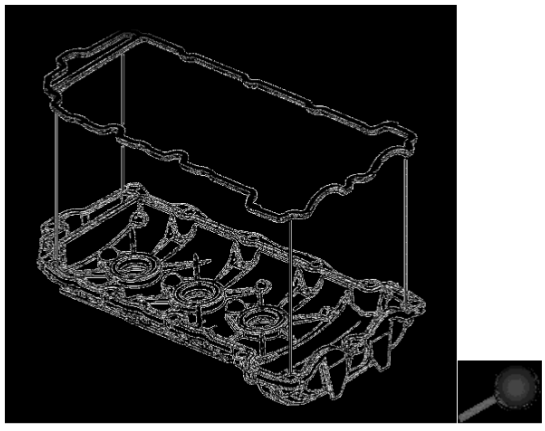
4. Remove and discard the left spark plug shield tube seals.

Right Camshaft Cover



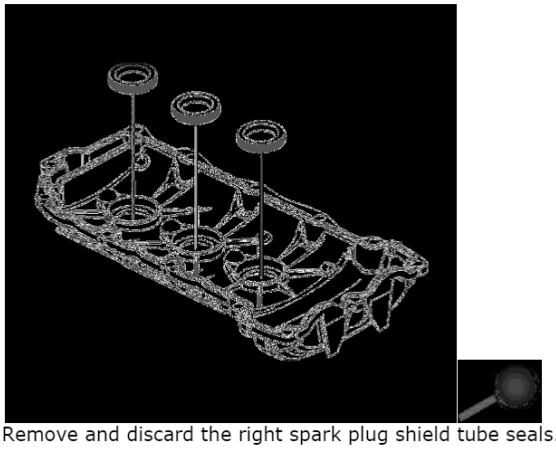
cardiagn.com

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the intake manifold sight shield. Refer to Intake Manifold Sight Shield Replacement.



Note: Do not reuse the camshaft cover gasket and spark plug shield tube seals.

3. Remove and discard the right camshaft cover gasket.



4. Remove and discard the right spark plug shield tube seals.

cardiagn.com

Camshaft Cover Cleaning and Inspection

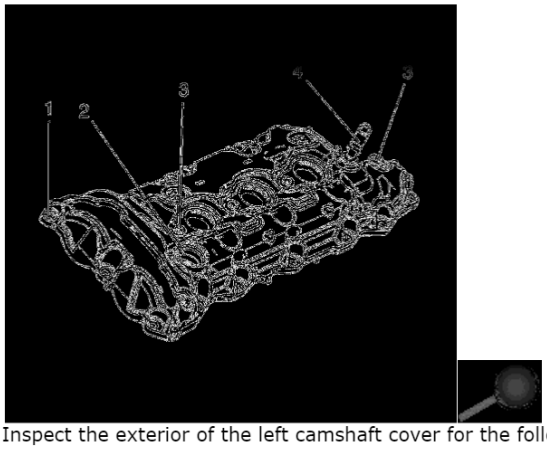
Cleaning Procedure

1. Clean the camshaft covers in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the camshaft covers with compressed air.

Inspection Procedure

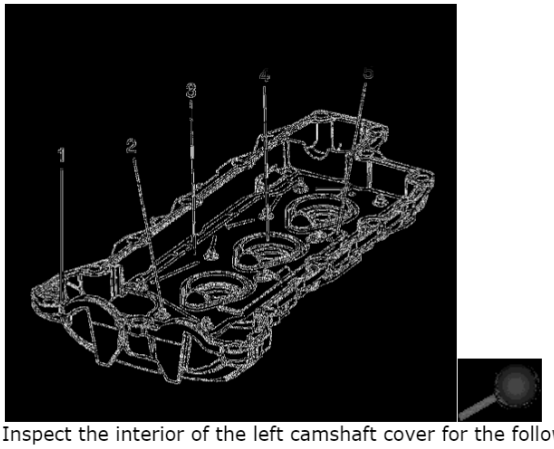
1. Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:
   - Leak engine oil
   - Affect crankcase ventilation
   - Interfere with the camshafts
   - Interfere with the ignition coil sealing
   - Allow water or condensation to enter the engine



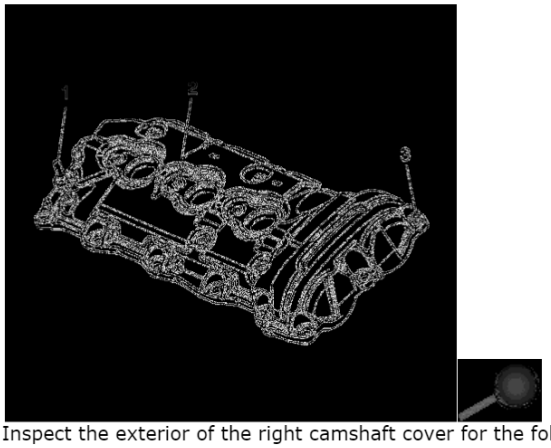
2. Inspect the exterior of the left camshaft cover for the following conditions:
   - Damage to the camshaft cover bolt holes (1)
   - Damage to the oil fill hole (2)
   - Damage to the mounting holes (3) for the ignition coil assembly and fuel injector sight shield ballstud.
   - Damage to the positive crankcase ventilation (PCV) hose connector (4)—A damaged PCV hose connector is replaceable.

cardiagn.com

© 2014 General Motors. All rights reserved.

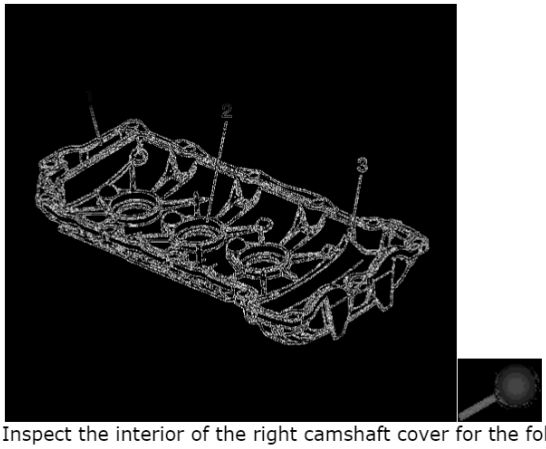


3. Inspect the interior of the left camshaft cover for the following conditions:
   - Gouges or damage to the camshaft cover sealing groove (1)
   - Damaged, loose or missing baffle fasteners (2)
   - Damaged, loose or missing baffle (3)
   - Gouges or damage to the spark plug shield seal bore (4)
   - Restrictions to the ventilation system (5)



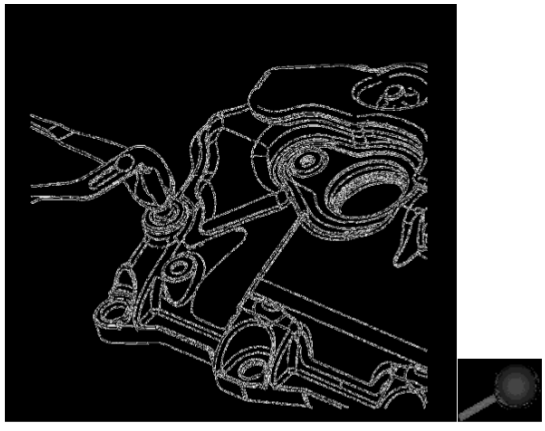
4. Inspect the exterior of the right camshaft cover for the following conditions:
   - Damage to the PCV orifice (1)—A damaged PCV orifice can be replaced. Refer to PCV Orifice Replacement.
   - Damage to the mounting holes (2) for the ignition coil assembly
   - Damage to the camshaft cover bolt holes (3)

cardiagn.com



5. Inspect the interior of the right camshaft cover for the following conditions:
   - Restrictions to the ventilation system (1)
   - Gouges or damage to the spark plug shield seal bore (2)
   - Gouges or damage to the camshaft cover sealing groove (3)
6. Repair or replace the camshaft cover or covers as necessary.

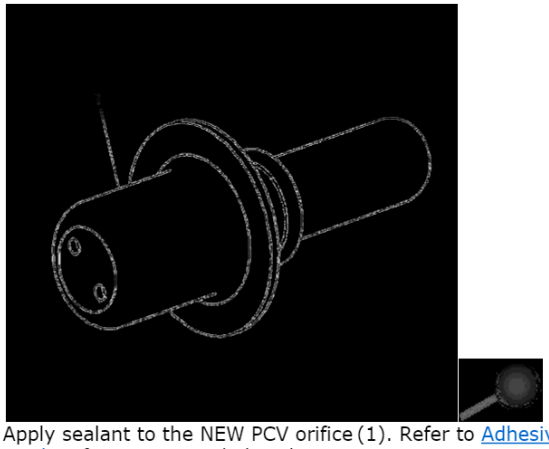
PCV Orifice Replacement



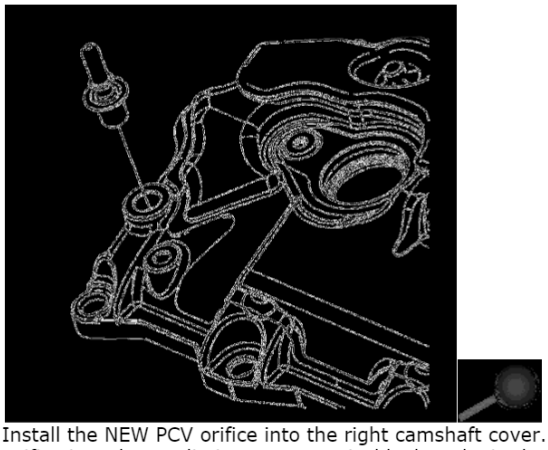
Note: If the PCV orifice is damaged or plugged and cannot be cleaned out, the PCV orifice can be replaced.

1. Remove the old PCV orifice by gripping the neck of the orifice with pliers and twisting and pulling out of the right camshaft cover.

cardiagn.com



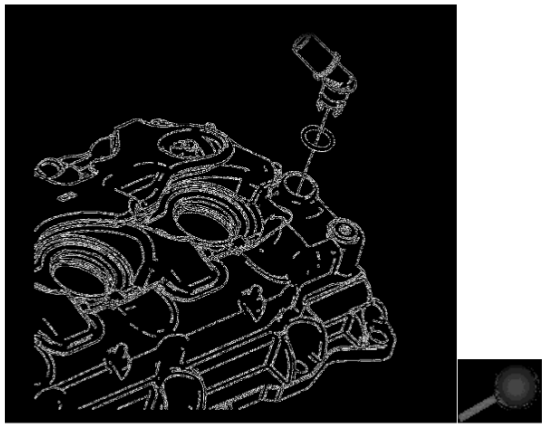
2. Apply sealant to the NEW PCV orifice (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.



3. Install the NEW PCV orifice into the right camshaft cover. After insertion, twist the PCV orifice in order to eliminate any vertical leak paths in the sealant.

PCV Fitting Replacement

cardiagn.com



Note: If the PCV fitting is damaged or plugged and cannot be cleaned out, the PCV fitting can be replaced.

1. Remove the old PCV fitting.
2. Install the new PCV fitting with a NEW O-ring.

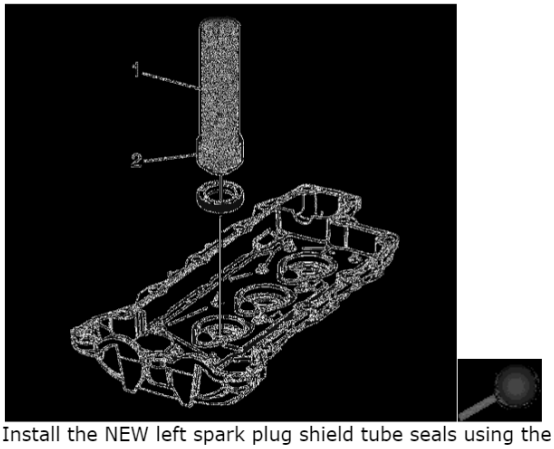
cardiagn.com

Camshaft Cover Assemble

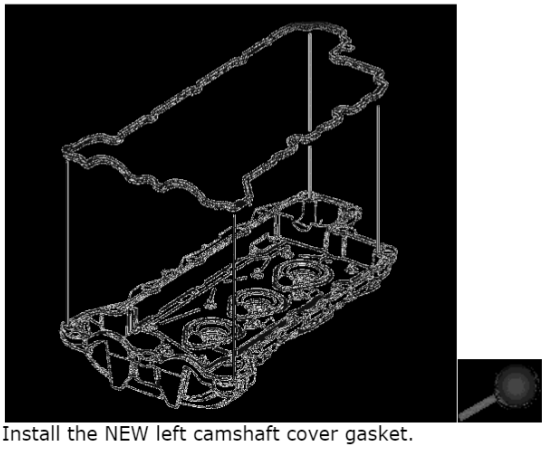
Special Tools

- *J 5590* Bearing and Seal Driver
- *J-24254-A* Oil Seal Installer

Left Camshaft Cover



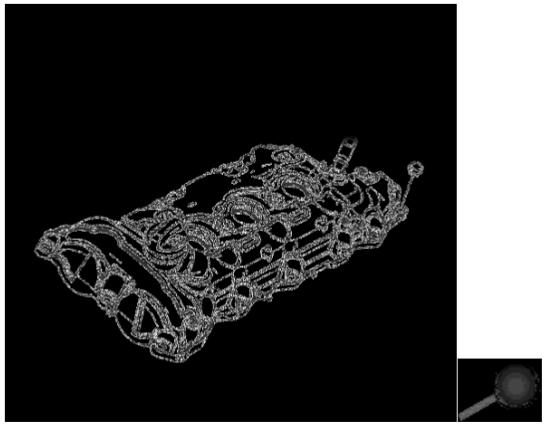
1. Install the NEW left spark plug shield tube seals using the:
    - *J 5590* bearing and seal driver (1)
    - *J-24254-A* oil seal installer (2)



2. Install the NEW left camshaft cover gasket.

cardiagn.com

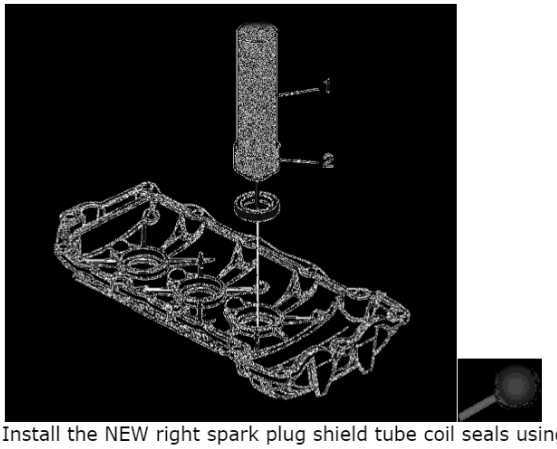
© 2014 General Motors. All rights reserved.



Note: The camshaft cover bolt grommet must be installed into the camshaft cover bolt hole before installing the camshaft cover bolt.

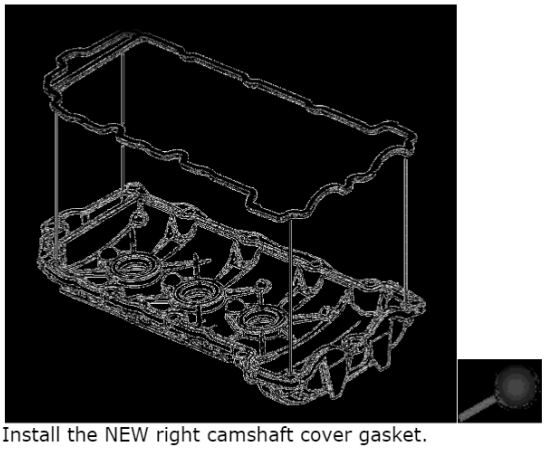
3. Install the NEW left camshaft cover bolt grommets.

Right Camshaft Cover

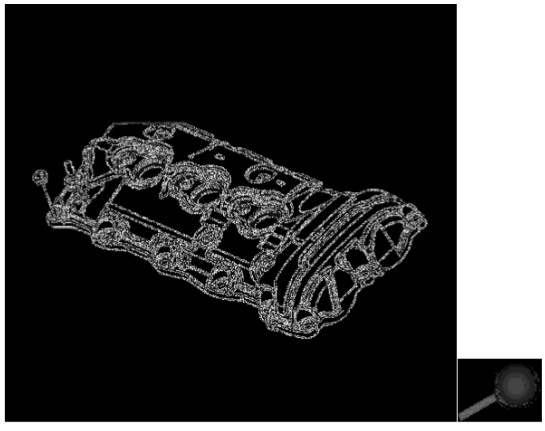


1. Install the NEW right spark plug shield tube coil seals using the:
   - *J 5590* bearing and seal driver (1)
   - *J-24254-A* oil seal installer (2)

cardiagn.com



2. Install the NEW right camshaft cover gasket.

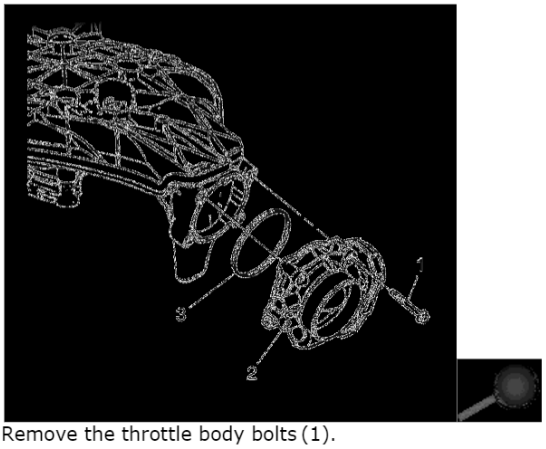


Note: The camshaft cover bolt grommet must be installed into the camshaft cover bolt hole before installing the camshaft cover bolt.

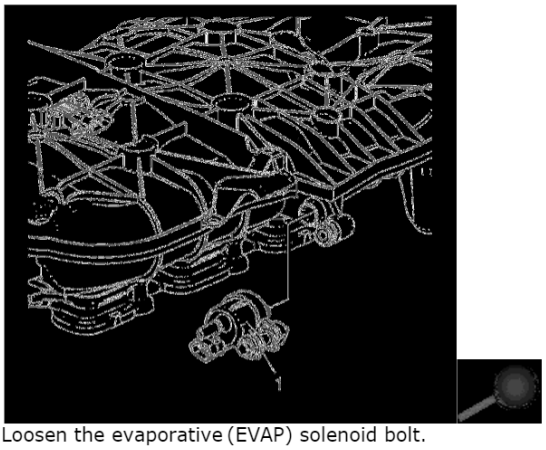
3. Install the NEW right camshaft cover bolt grommets.

cardiagn.com

Intake Manifold Disassemble (LFW or LFX)



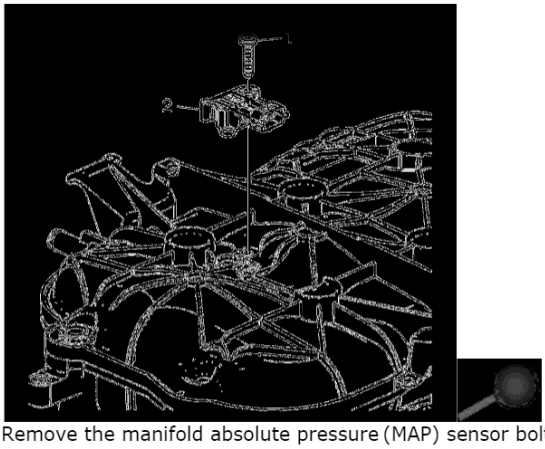
1. Remove the throttle body bolts (1).
2. Remove the throttle body (2).
3. Remove and discard the throttle body seal (3).



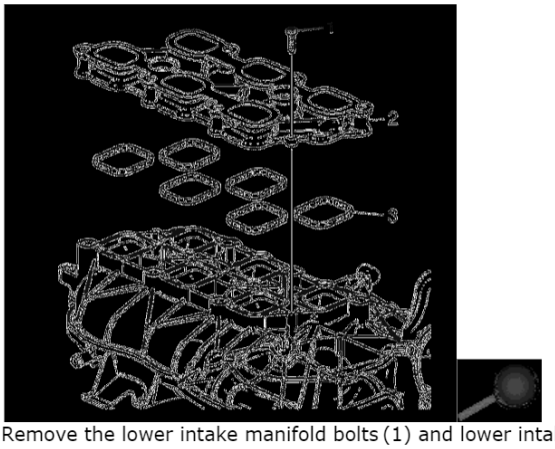
4. Loosen the evaporative (EVAP) solenoid bolt.
5. Remove the EVAP solenoid (1).

cardiagn.com

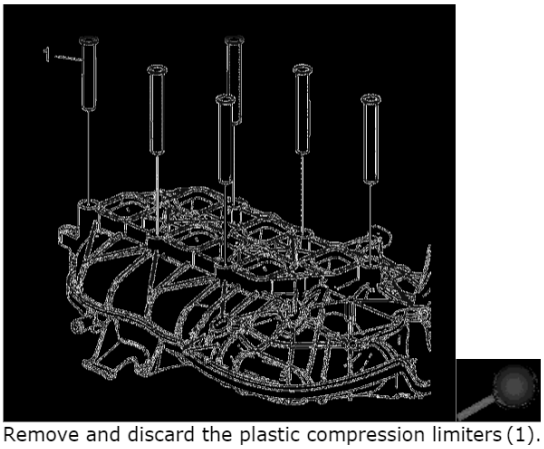
© 2014 General Motors. All rights reserved.



6. Remove the manifold absolute pressure (MAP) sensor bolt (1).
7. Remove the MAP sensor (2).



8. Remove the lower intake manifold bolts (1) and lower intake manifold (2).
9. Remove and discard the lower intake manifold gaskets (3).

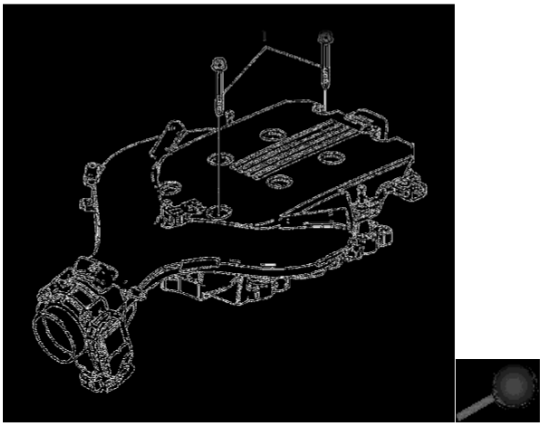


10. Remove and discard the plastic compression limiters (1).

cardiagn.com

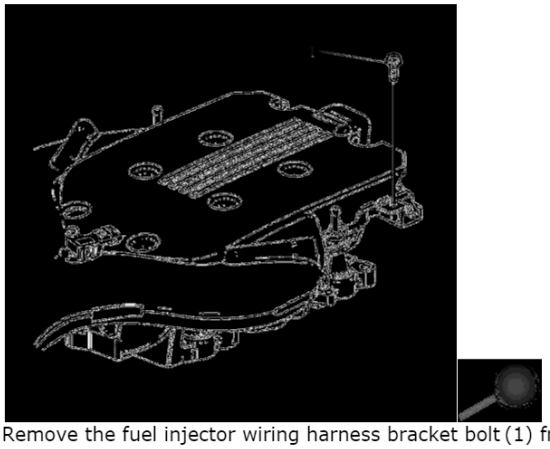
Intake Manifold Disassemble (LWR)

Upper to Lower Intake Manifold Disassemble Procedure



Note: Do not reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

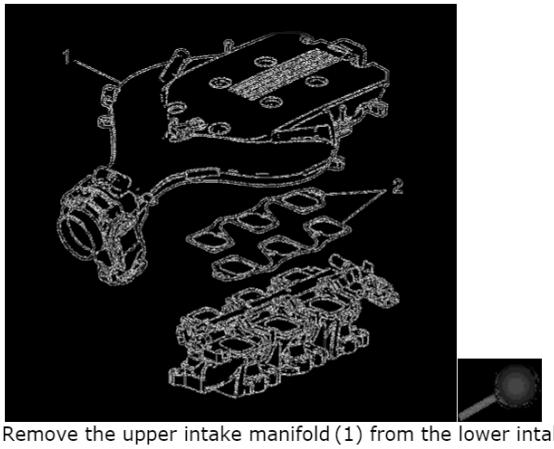
1. Remove the upper-to-lower intake manifold bolts (1).



2. Remove the fuel injector wiring harness bracket bolt (1) from the upper intake manifold.

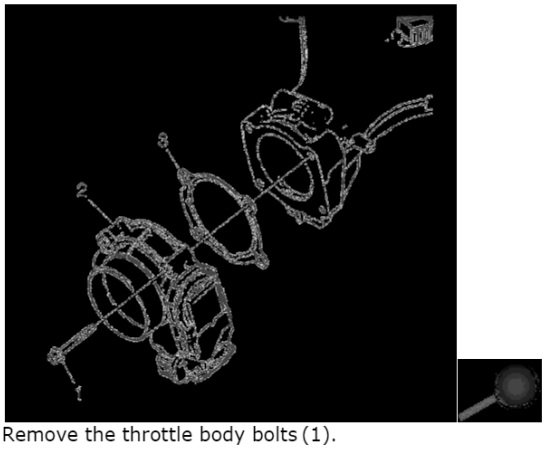
cardiagn.com

© 2014 General Motors. All rights reserved.



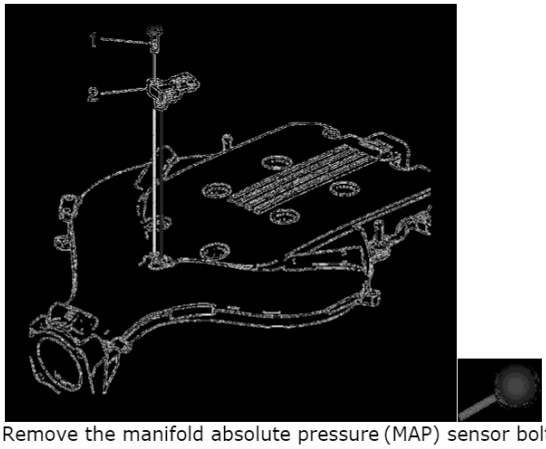
3. Remove the upper intake manifold (1) from the lower intake manifold.
4. Remove and discard the upper-to-lower intake manifold gaskets (2).

Upper Intake Manifold Disassemble Procedure

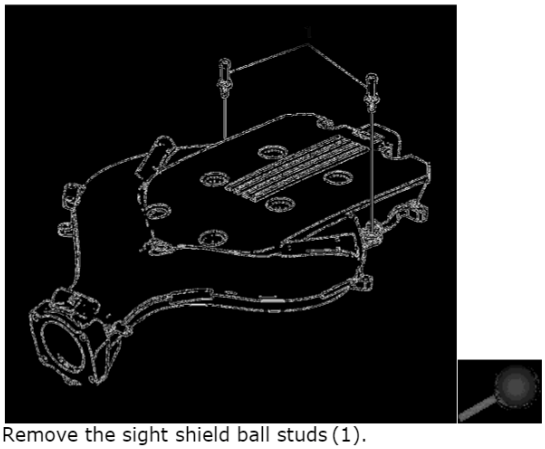


1. Remove the throttle body bolts (1).
2. Remove the throttle body (2).
3. Remove and discard the throttle body gasket (3).

cardiagn.com

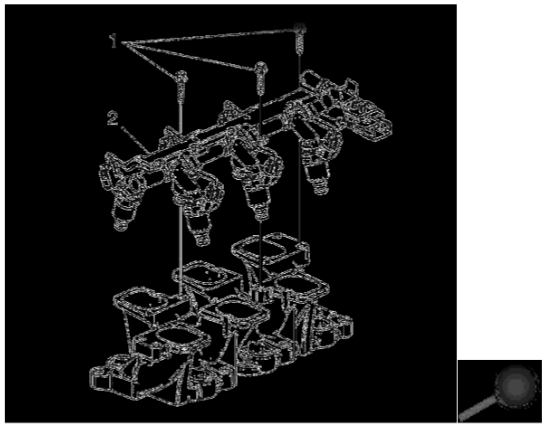


4. Remove the manifold absolute pressure (MAP) sensor bolt (1) and MAP sensor (2).



5. Remove the sight shield ball studs (1).

Lower Intake Manifold Disassemble Procedure



Note: Remove the fuel injector rail and wiring harness together as an assembly.

1. Remove the fuel injector rail bolts (1).

cardiagn.com

2. Remove the fuel injector rail with wiring harness (2).

cardiagn.com

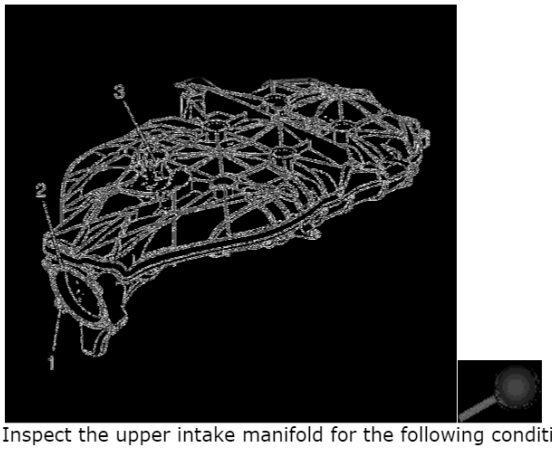
Intake Manifold Cleaning and Inspection (LFW or LFX)

Upper Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Throttle body
   - Intake manifold
2. Clean the following intake manifold areas in solvent.
   - Intake manifold gasket sealing areas
   - Intake manifold passages
   - Brake booster hose passage
   - Evaporative emission (EVAP) solenoid passage
   - Positive crankcase ventilation (PCV) vacuum hose passages

   Warning: Refer to Safety Glasses Warning.
3. Dry the upper intake manifold and throttle body with compressed air.

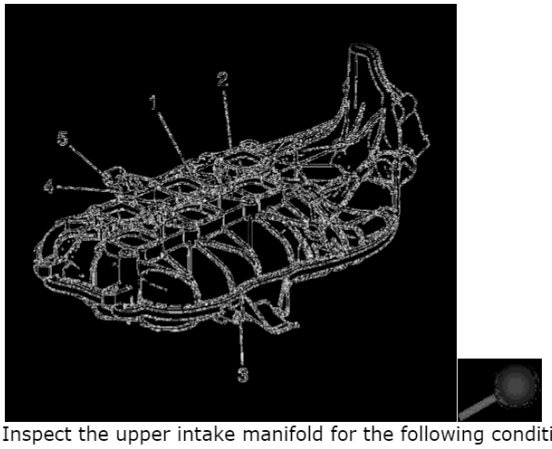
Inspection Procedure



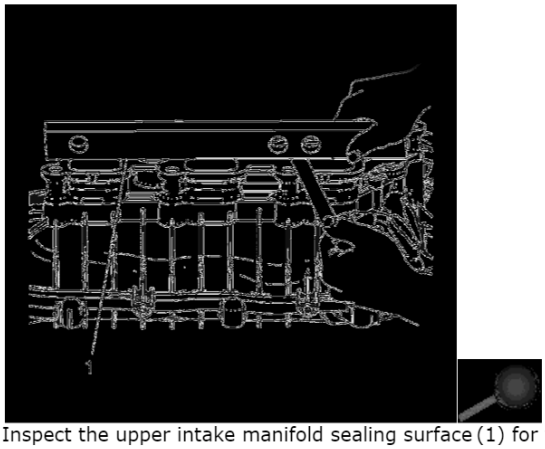
1. Inspect the upper intake manifold for the following conditions:
   - Damage to the throttle body bolt holes (1)
   - Damage, debris or restrictions to the PCV system hose ports (3)
   - Damage to the gasket sealing surface for the throttle body (2)

cardiagn.com

© 2014 General Motors. All rights reserved.



2. Inspect the upper intake manifold for the following conditions:
   - Damage, debris or restrictions to the brake vacuum booster hose port (3)
   - Damage to the intake manifold bolt bosses (1)
   - Damage to the EVAP purge solenoid mounting boss (5)
   - Damage, debris or restrictions to the EVAP purge solenoid port (4)
   - Gouges or damage to the intake manifold sealing surfaces (2)



3. Inspect the upper intake manifold sealing surface (1) for warpage.
   3.1. Locate a straight edge across the intake manifold sealing surface.
   3.2. Insert a feeler gauge between the upper intake manifold and the straight edge. An intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
4. Repair or replace the upper intake manifold as necessary.

cardiagn.com

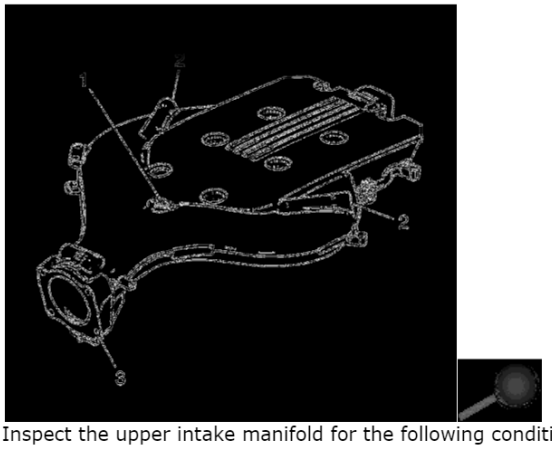
Intake Manifold Cleaning and Inspection (LWR)

Upper Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Throttle body
   - Intake manifold
2. Clean the following intake manifold areas in solvent.
   - Intake manifold gasket sealing areas
   - Intake manifold passages
   - Positive crankcase ventilation (PCV) vacuum hose passages
   - Manifold Absolute Pressure (MAP) sensor passage

   Warning: Refer to Safety Glasses Warning.
3. Dry the upper intake manifold and throttle body with compressed air.

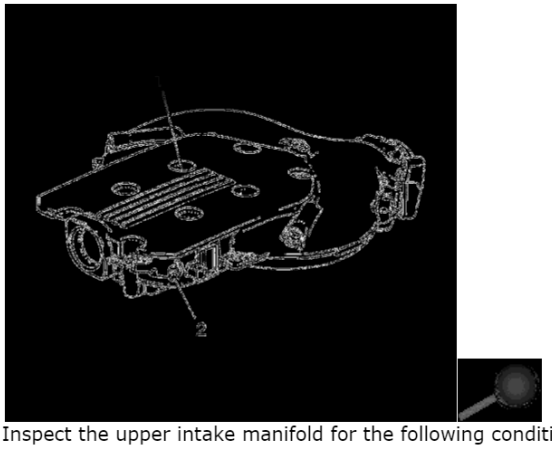
Inspection Procedure



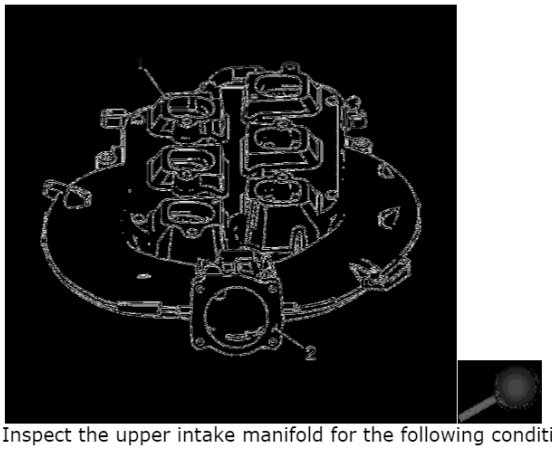
1. Inspect the upper intake manifold for the following conditions:
   - Damage, debris or restrictions to the MAP sensor mounting port (1).
   - Damage to the throttle body bolt holes (3).
   - Damage, debris or restrictions to the PCV system hose ports (2).

cardiagn.com

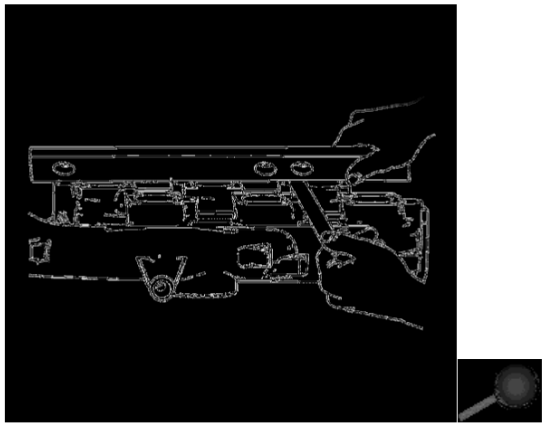
© 2014 General Motors. All rights reserved.



2. Inspect the upper intake manifold for the following conditions:
   - Damage to the intake manifold bolt bosses (1).
   - Damage, debris or restrictions in the vacuum passage (2).



3. Inspect the upper intake manifold for the following conditions:
   - Gouges or damage to the upper intake manifold sealing surfaces (1).
   - Damage to the gasket sealing surface for the throttle body (2).



cardiagn.com

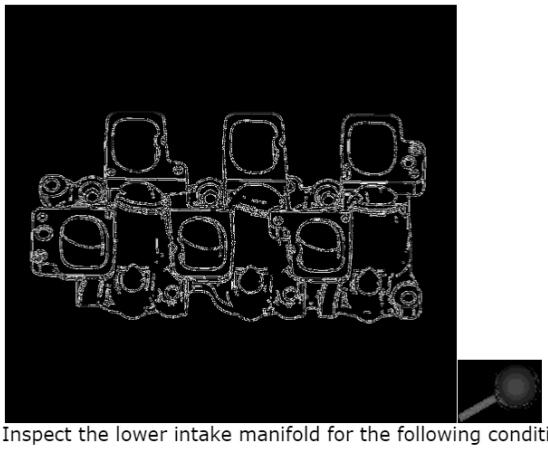
4. Inspect the upper intake manifold sealing surface for warpage.
   4.1. Locate a straight edge across the upper-to-lower intake manifold sealing surface.
   4.2. Insert a feeler gauge between the upper intake manifold and the straight edge. An upper intake manifold with warpage in excess of 0.50 mm (0.020 in) must be replaced.
5. Repair or replace the upper intake manifold as necessary.

Lower Intake Manifold Cleaning Procedure

1. Remove any remaining gasket and/or gasket material from the following:
   - Upper-to-lower intake manifold sealing surface
   - Cylinder head-to-lower intake manifold sealing surface
2. Clean the following intake manifold areas in solvent.
   - Intake manifold gasket sealing surfaces
   - Intake manifold passages

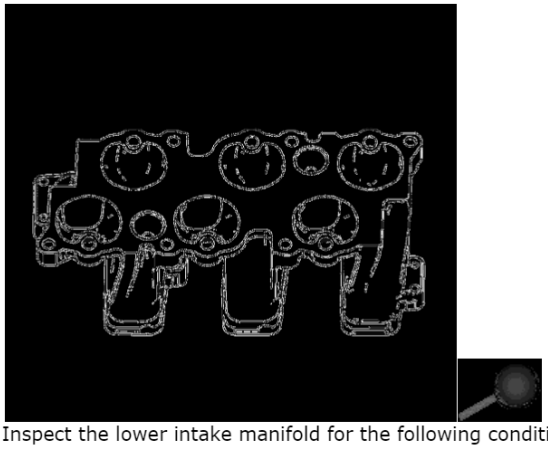
   Warning: Refer to Safety Glasses Warning.
3. Dry the intake manifold with compressed air.

Inspection Procedure

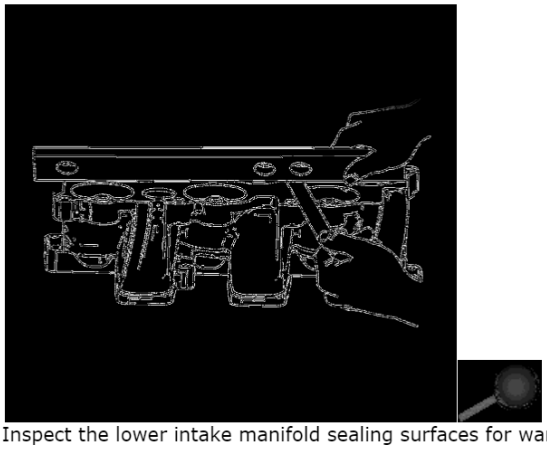


1. Inspect the lower intake manifold for the following conditions:
   - Damage, debris or restrictions to the lower intake manifold ports
   - Damage to the fuel rail mounting bolt holes
   - Damage to the fuel rail

cardiagn.com



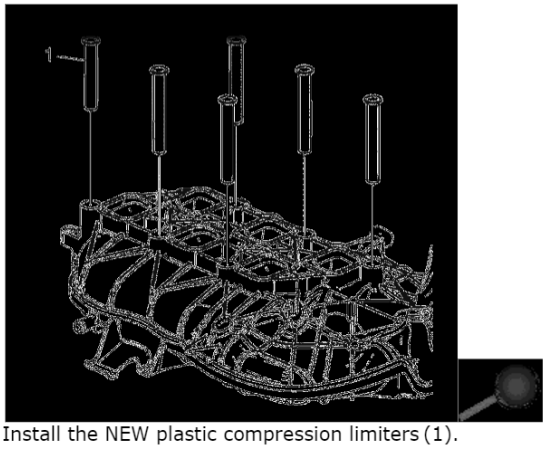
2. Inspect the lower intake manifold for the following conditions:
   - Gouges or damage to the intake manifold sealing surfaces
   - Damage to the lower intake manifold bolt bosses
   - Damage to the fuel injector ports



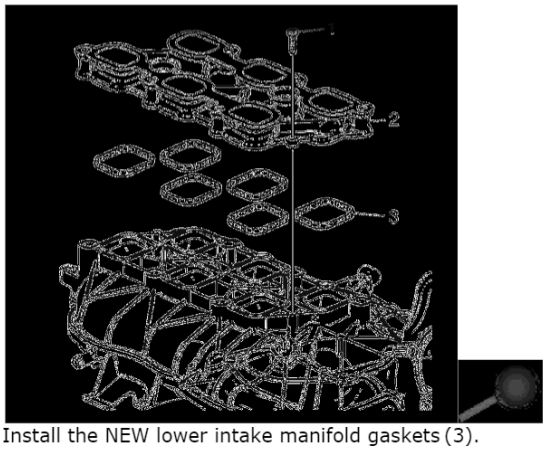
3. Inspect the lower intake manifold sealing surfaces for warpage.
   3.1. Locate a straight edge across the lower intake manifold sealing surfaces.
   3.2. Insert a feeler gauge between the lower intake manifold and the straight edge. A lower intake manifold with warpage in excess of 0.5 mm (0.020 in) must be replaced.
4. Repair or replace the lower intake manifold as necessary.

cardiagn.com

Intake Manifold Assemble (LFW or LFX)



1. Install the NEW plastic compression limiters (1).

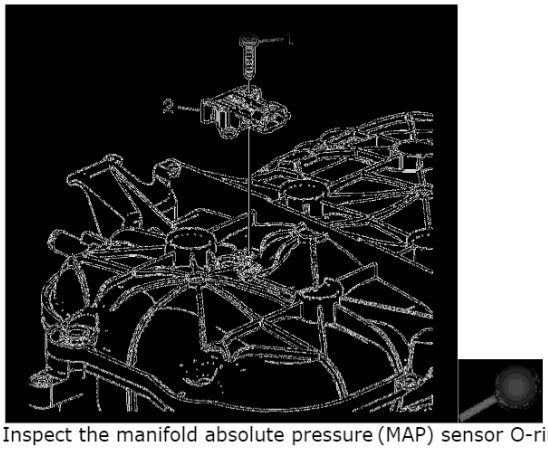


2. Install the NEW lower intake manifold gaskets (3).
3. Install the lower intake manifold (2) and bolts (1).

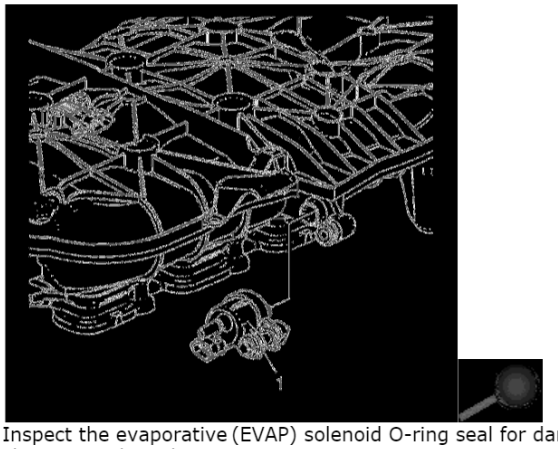
   Caution: Refer to Fastener Caution.
4. Tighten the lower intake manifold bolts (1) to **7 N·m (62 lb in)**.

cardiagn.com

© 2014 General Motors. All rights reserved.

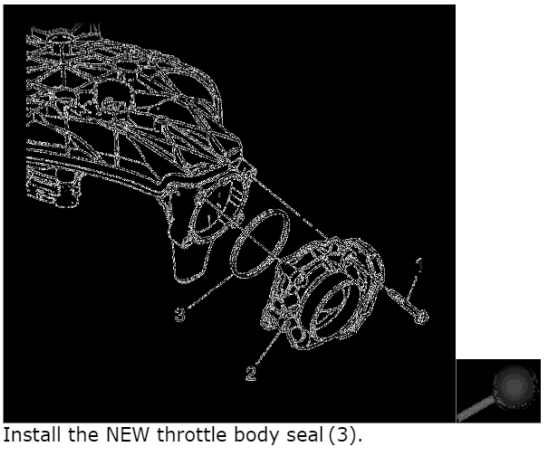


5. Inspect the manifold absolute pressure (MAP) sensor O-ring seal for damage. If the seal is damaged replace the MAP sensor.
6. Install the MAP sensor (2).
7. Install the MAP sensor bolt (1) and tighten to **4 N•m (35 lb in)**.



8. Inspect the evaporative (EVAP) solenoid O-ring seal for damage. If the seal is damaged replace the EVAP solenoid.
9. Install the EVAP solenoid (1).
10. Tighten the EVAP solenoid bolt to **10 N•m (89 lb in)**.

cardiagn.com

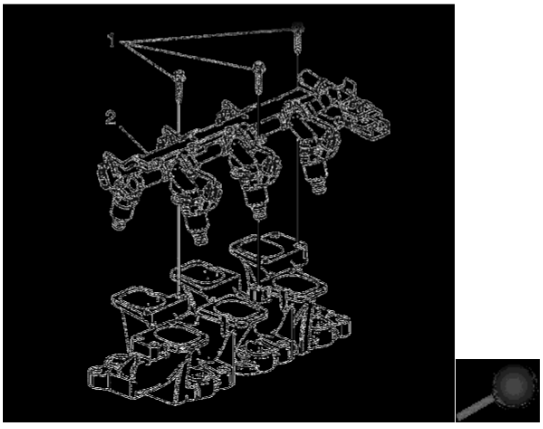


11. Install the NEW throttle body seal (3).
12. Install the throttle body (2).
13. Install the throttle body bolts (1) and tighten to **10 N•m (89 lb in)**.

cardiagn.com

Intake Manifold Assemble (LWR)

Lower Intake Manifold Assemble Procedure

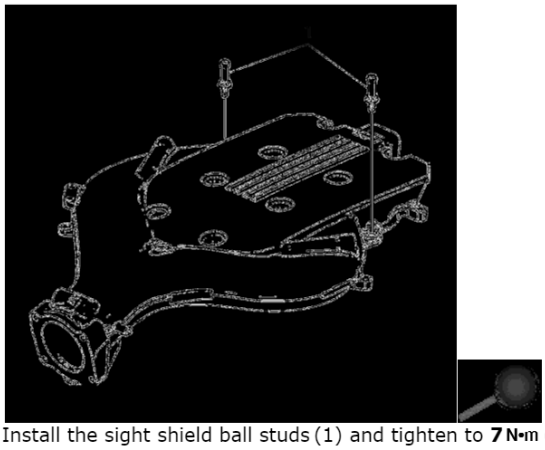


Note: Install the fuel injector rail and wiring harness together as an assembly.

1. Install the fuel injector rail with wiring harness (2).

   Caution: Refer to Fastener Caution.
2. Install the fuel injector rail bolts (1) and tighten to **10 N•m (89 lb in)**.

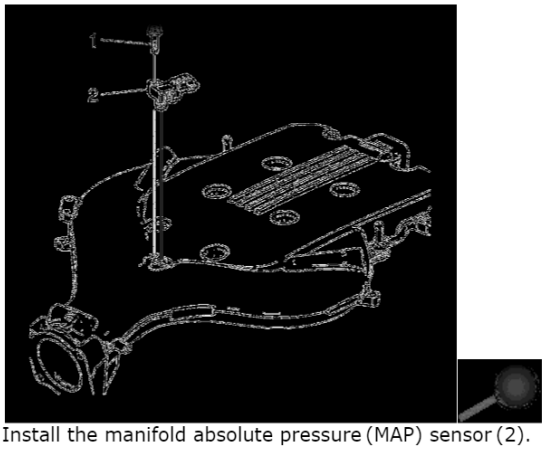
Upper Intake Manifold Assemble Procedure



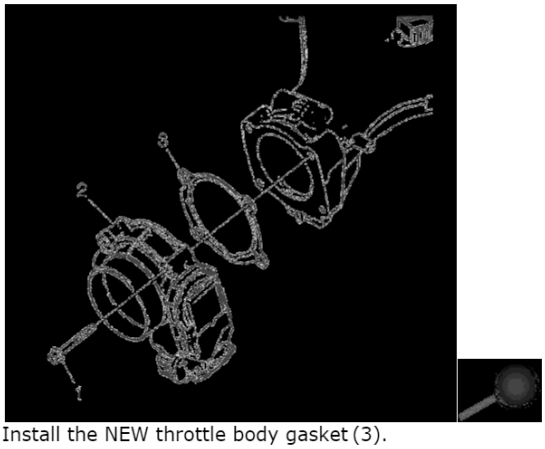
1. Install the sight shield ball studs (1) and tighten to **7 N•m (62 lb in)**.

cardiagn.com

© 2014 General Motors. All rights reserved.



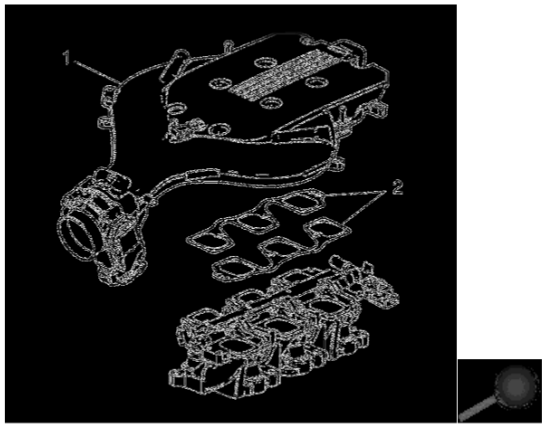
2. Install the manifold absolute pressure (MAP) sensor (2).
3. Install the MAP sensor bolt (1) and tighten to **10 N•m (89 lb in)**.



4. Install the NEW throttle body gasket (3).
5. Install the throttle body (2).
6. Install the throttle body bolts (1) and tighten to **10 N•m (89 lb in)**.

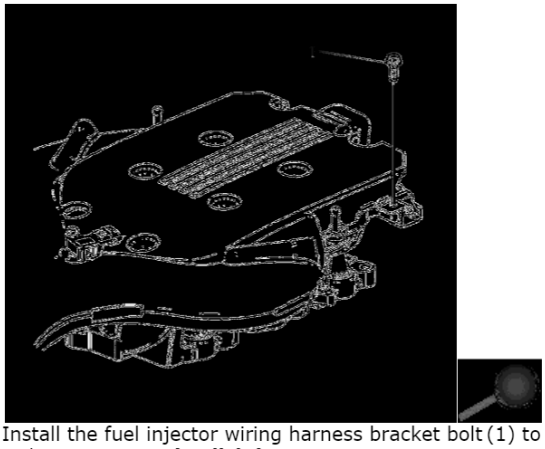
Upper to Lower Intake Manifold Assemble Procedure

cardiagn.com



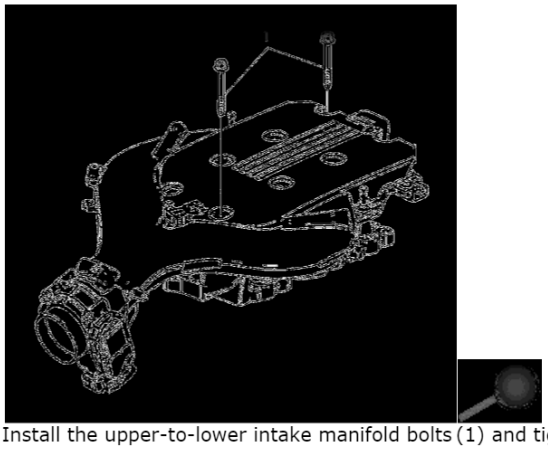
Note: Do not reuse the upper-to-lower intake manifold gasket and the intake manifold-to-cylinder head sealing gaskets.

1. Install the NEW upper-to-lower intake manifold gaskets (2).
2. Install the upper intake manifold (1) to the lower intake manifold.



3. Install the fuel injector wiring harness bracket bolt (1) to the upper intake manifold and tighten to **10 N•m (89 lb in)**.

cardiagn.com



4. Install the upper-to-lower intake manifold bolts (1) and tighten to **23 N•m (17 lb ft)**.

cardiagn.com

Exhaust Manifold Cleaning and Inspection - Left Side (LWR)

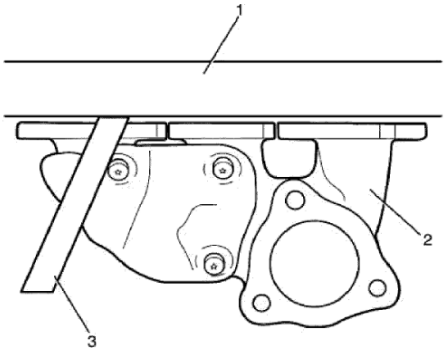
Cleaning Procedure

1. Clean the exhaust manifold in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the exhaust manifold with compressed air.

Inspection Procedure

1. Inspect the left exhaust manifold for the following:
   - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
   - Damage to the exhaust manifold mounting holes.
   - Damage to the threaded holes for the heat shield.
   - Damage to the exhaust manifold flange bolt holes.
   - Damage to the gasket sealing surfaces.
   - Damage or restrictions within the exhaust passages.
2. Repair or replace the left exhaust manifold and/or components as necessary.



3. Measure the surface flatness of the exhaust manifold (2), using a straight edge (1) and a feeler gauge (3). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the exhaust manifold surface flatness exceeds the specification, the exhaust manifold (3) must be replaced.

cardiagn.com

© 2014 General Motors. All rights reserved.

Exhaust Manifold Cleaning and Inspection - Right Side (LWR)

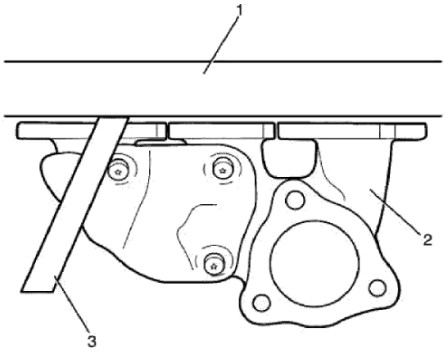
Cleaning Procedure

1. Clean the exhaust manifold in solvent.

   Warning: Refer to Safety Glasses Warning.
2. Dry the exhaust manifold with compressed air.

Inspection Procedure

1. Inspect the right exhaust manifold for the following:
   - Damage or corrosion above acceptable tolerances to the exhaust manifold exterior.
   - Damage to the exhaust manifold mounting holes.
   - Damage to the threaded holes for the heat shield.
   - Damage to the exhaust manifold flange bolt holes.
   - Damage to the gasket sealing surfaces.
   - Damage or restrictions within the exhaust passages.
2. Repair or replace the right exhaust manifold and/or components as necessary.



3. Measure the surface flatness of the exhaust manifold (2) using a straight edge (1) and a feeler gauge (3). Exhaust manifold surface flatness must not exceed 0.254 mm (0.010 in).
4. If the surface flatness exceed the specification, the exhaust manifold (2) must be replaced.

cardiagn.com

© 2014 General Motors. All rights reserved.

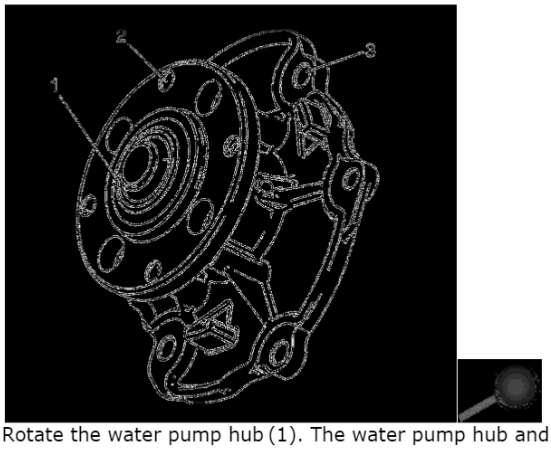
Water Pump Cleaning and Inspection

Cleaning Procedure

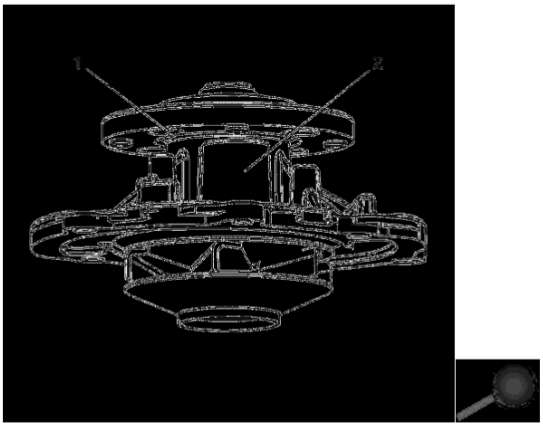
Caution: Do not immerse the water pump in solvent. The solvent may enter the water pump's permanently lubricated bearings and cause premature bearing failure.

1. Remove the old gasket material from the water pump sealing surfaces.
2. Clean all excess dirt and debris from the water pump housing.

Inspection Procedure



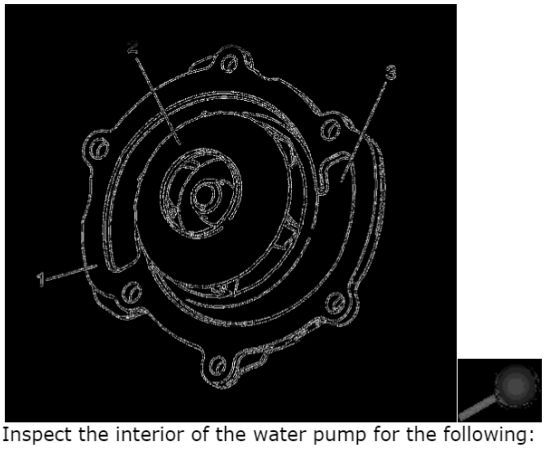
1. Rotate the water pump hub (1). The water pump hub and impeller should turn straight and smoothly. If the hub wobbles, is noisy, or feels rough when rotated, replace the water pump.
2. Inspect the exterior of the water pump for the following:
   - Damage to the water pump hub bolt threads (2) for the water pump pulley
   - Damage to the water pump bolt holes (3)



cardiagn.com

© 2014 General Motors. All rights reserved.

3. Examine the water pump shaft (1) and the weep hole reservoir (2) in the water pump body for signs of leakage. If coolant leakage is evident, replace the water pump.



4. Inspect the interior of the water pump for the following:
   - Damage to the water pump gasket sealing surface (1)
   - Damage, corrosion or restrictions to the water pump impeller (2)
   - Damage, corrosion or restrictions to the coolant passages (3)
5. Repair or replace the water pump as necessary.

cardiagn.com

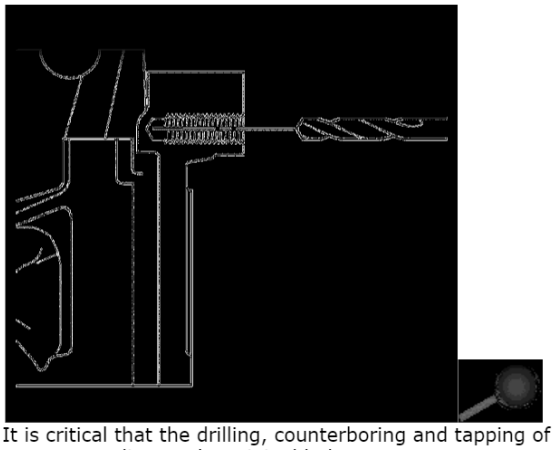
Thread Repair

Special Tools

- *J 42385-700* High Feature Thread Repair Kit
- *J 42385-2000* Thread Insert Kit
- *J 43965* Thread Repair Extension Kit

For equivalent regional tools, refer to Special Tools.

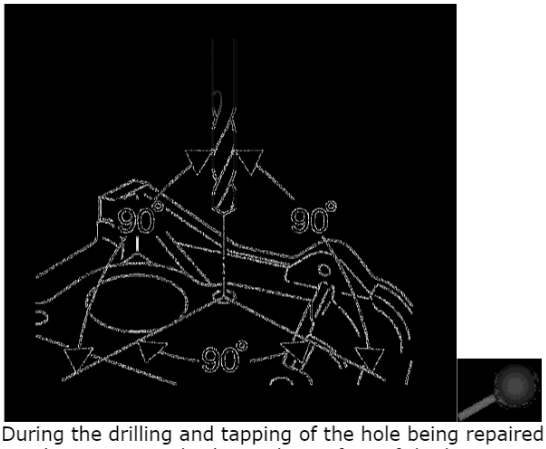
- The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert. During the insert installation process, the installation driver tool cold-rolls the bottom internal threads and expands the bottom external threads of the insert into the base material. This action mechanically locks the insert into place.
- The drill bit and counter bore tool from the tool kit *J 42385-700* kit and *J 42385-2000* thread insert kit is designed for use with either a suitable tap wrench or drill motor. Limited access and larger hole repair may process better using a tap wrench. An extension from kit *J 43965* extension kit may also be necessary to drive the thread repair tooling dependent on access to the hole being repaired. Use only a tap wrench when tapping the hole and during installation of the insert.



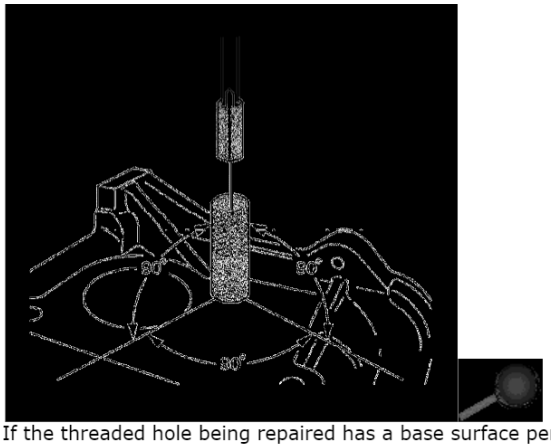
1. It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

cardiagn.com

© 2014 General Motors. All rights reserved.



2. During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

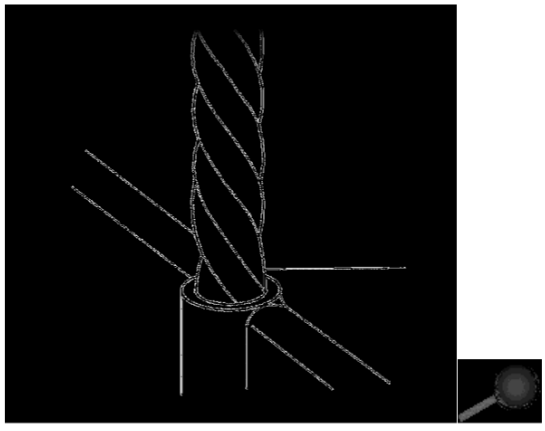


3. If the threaded hole being repaired has a base surface perpendicular to the hole centerline, tapping guides are available to aid in tapping the hole.

Tap Size	Tap Guide	Tape Size	Tape Guide	Tap Size	Tape Guide
—	J 42385-	—	J 42385-	—	J 42385-
6 x 1.0	729	10 x 1.5	731	14 x 1.5	736
8 x 1.25	730	12 x 1.5	732	20 x 1.5	737

Standard Thread Repair - Flush Hole

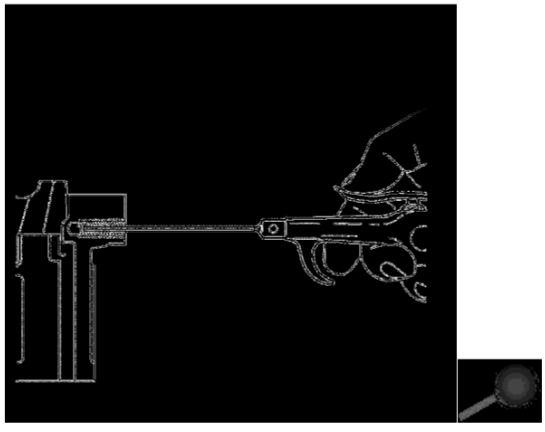
cardiagn.com



Note:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- DO NOT drill any further than the original hole depth.

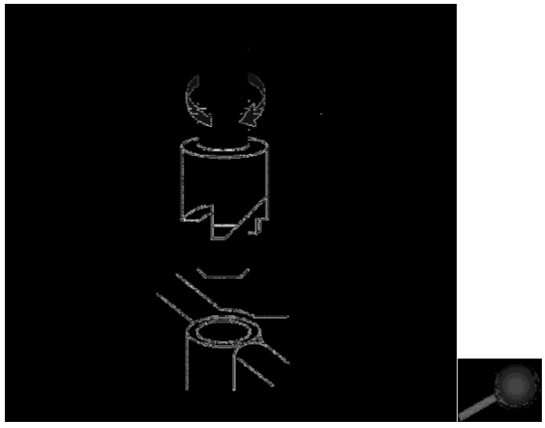
1. Drill out the threads of the damaged hole.
   Specifications
   - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
   - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
   - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).



Note: All chips must be removed from the drilled hole prior to tapping.

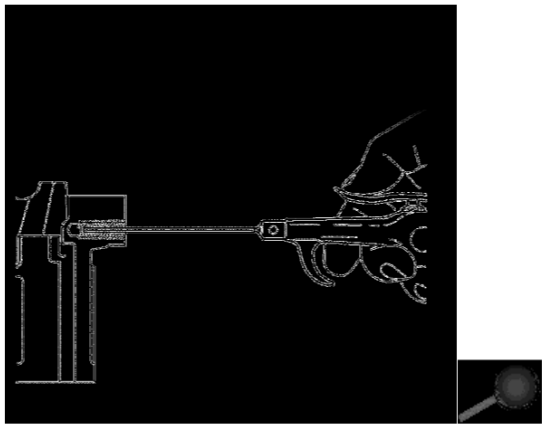
2. Using compressed air, clean out any chips.

cardiagn.com



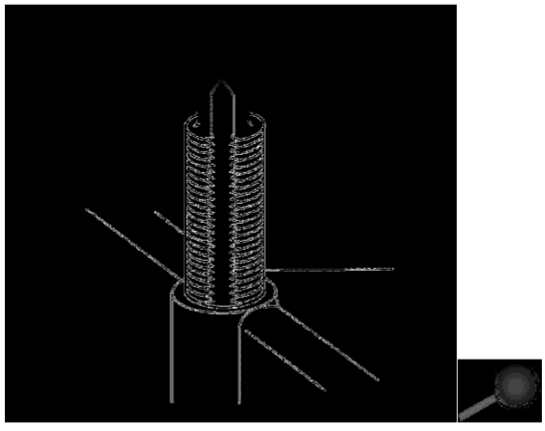
Note: A correctly counterbored hole will show a slight burnishing on the surface of the base material for 360 degrees around the drilled hole.

3. Counterbore the drilled hole to the full depth permitted by the tool.



Note: All chips must be removed from the drilled hole prior to tapping.

4. Using compressed air, clean out any chips.

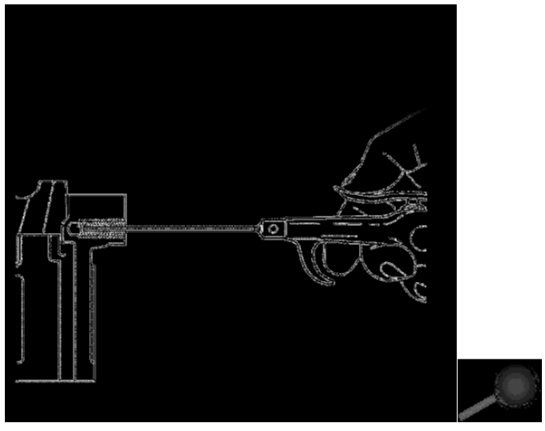


Note:

cardiagn.com

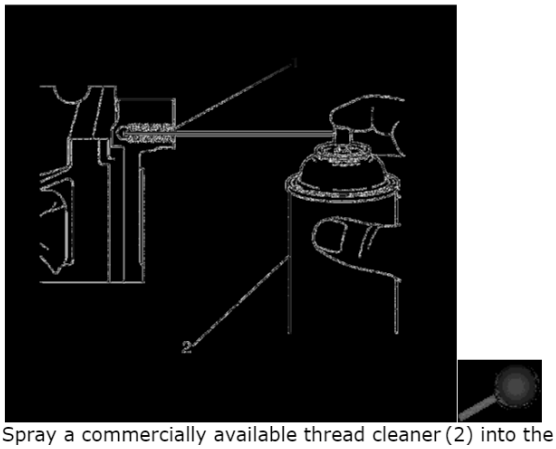
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

5. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.
   Specifications
   - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
   - M8 inserts require a minimum tap depth of 20 mm (0.79 in).
   - M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).



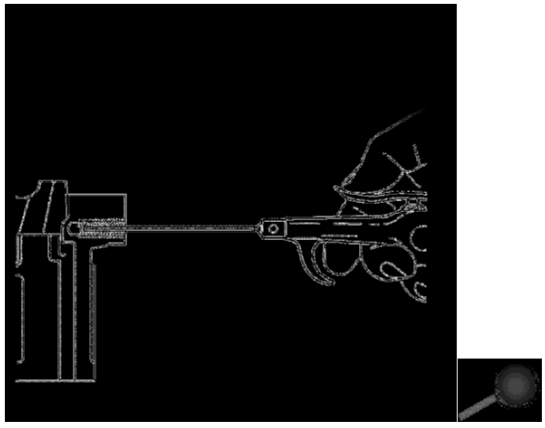
Note: All chips must be removed from the tapped hole prior to insert installation.

6. Using compressed air, clean out any chips.



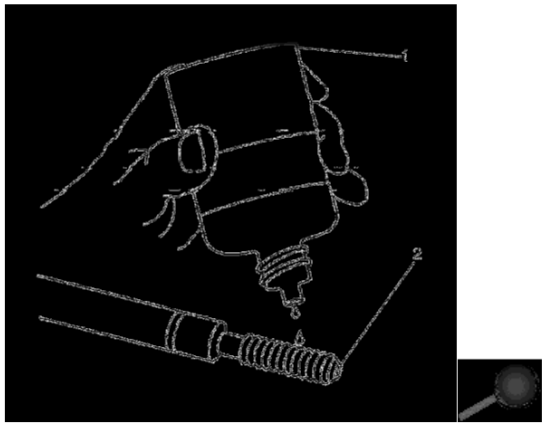
7. Spray a commercially available thread cleaner (2) into the tapped hole (1).

cardiagn.com



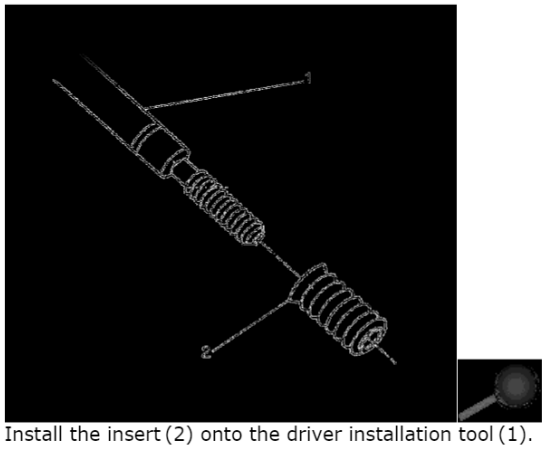
Note: All chips must be removed from the tapped hole prior to insert installation.

8. Using compressed air, clean out any chips.



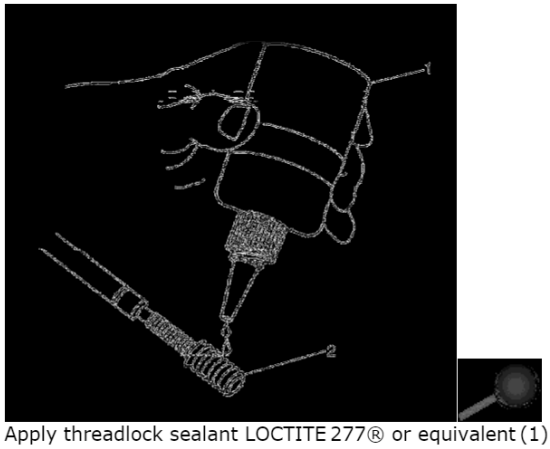
Note: DO NOT allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

9. Lubricate the threads of the driver installation tool (2) with the driver oil (1).

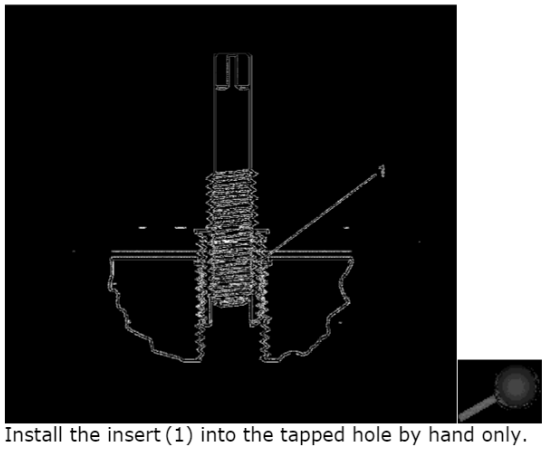


10. Install the insert (2) onto the driver installation tool (1).

cardiagn.com



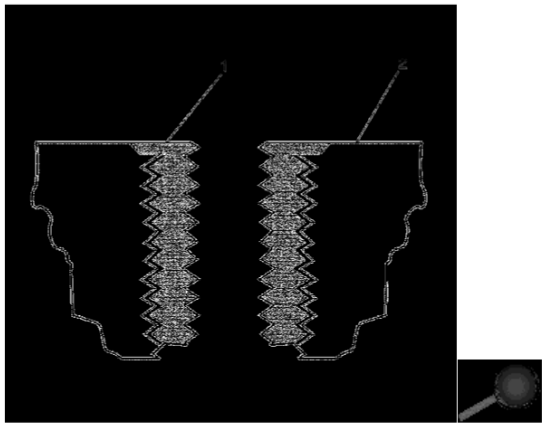
11. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).



12. Install the insert (1) into the tapped hole by hand only.

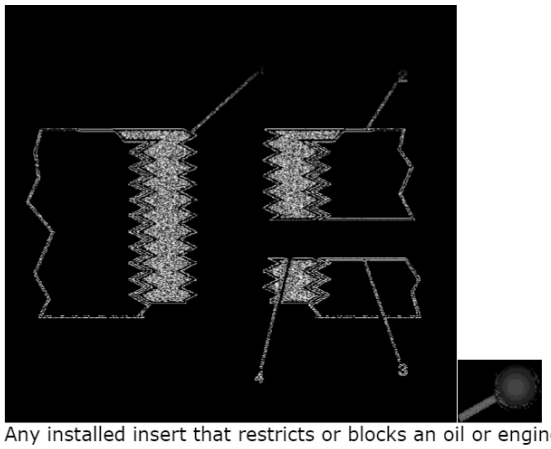
    Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

    The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.



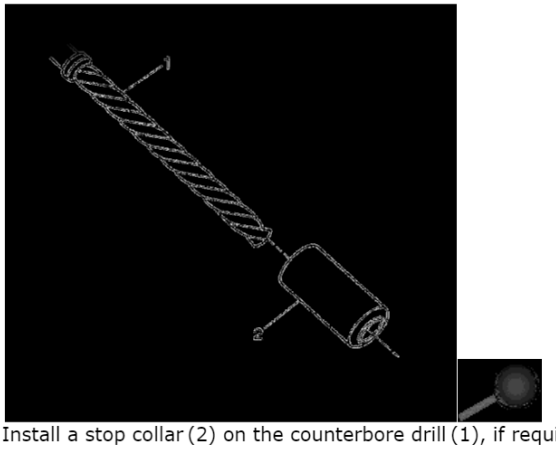
cardiagn.com

13. Inspect the insert for correct installation into the hole.
    A correctly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).



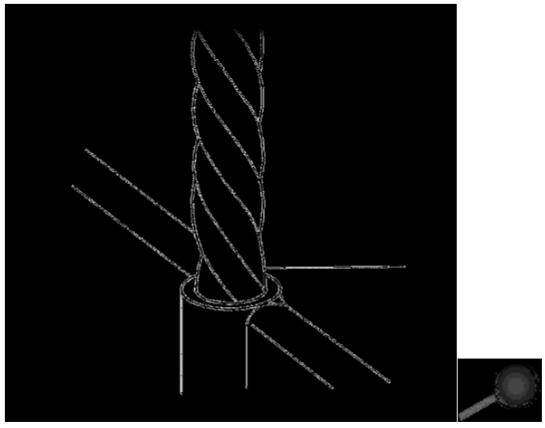
14. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Recessed Thread Repair



1. Install a stop collar (2) on the counterbore drill (1), if required.

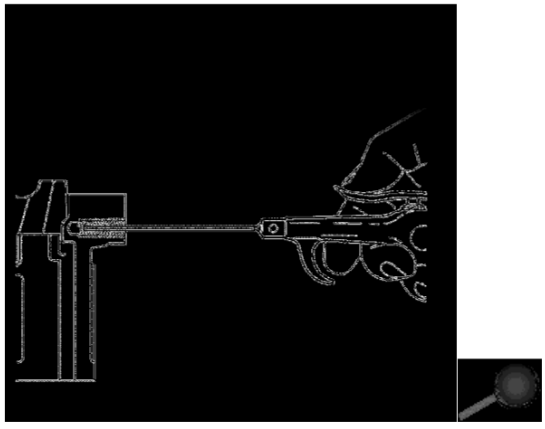
cardiagn.com



Note:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

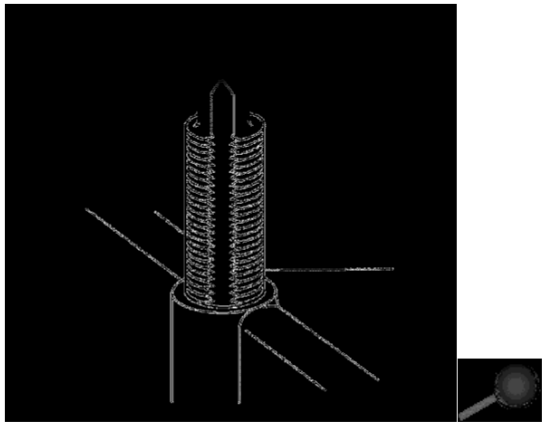
2. Drill out the threads of the damaged hole.



Note: All chips must be removed from the drilled hole prior to tapping.

3. Using compressed air, clean out any chips.

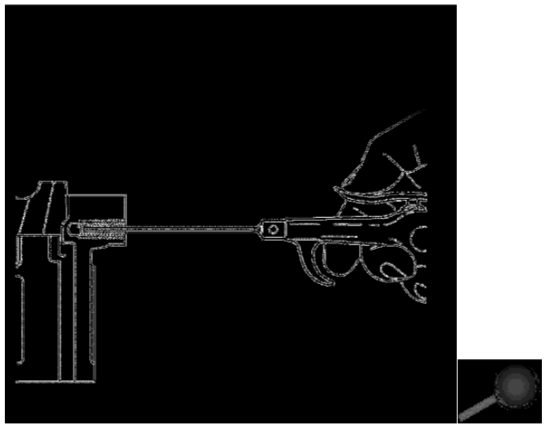
cardiagn.com



Note:

- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

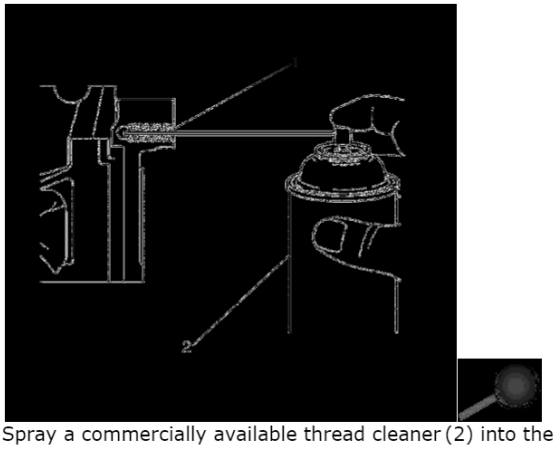
4. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.



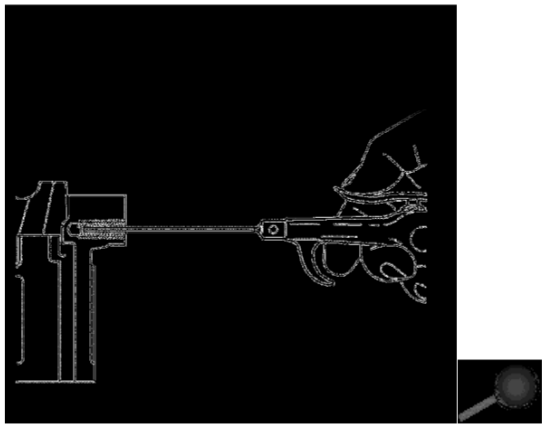
Note: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.

cardiagn.com

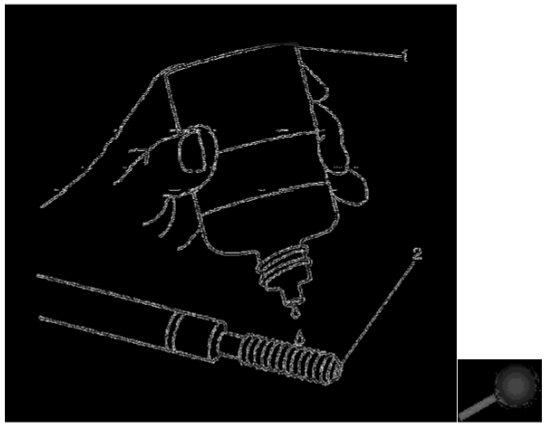


6. Spray a commercially available thread cleaner (2) into the tapped hole (1).



Note: All chips must be removed from the tapped hole prior to insert installation.

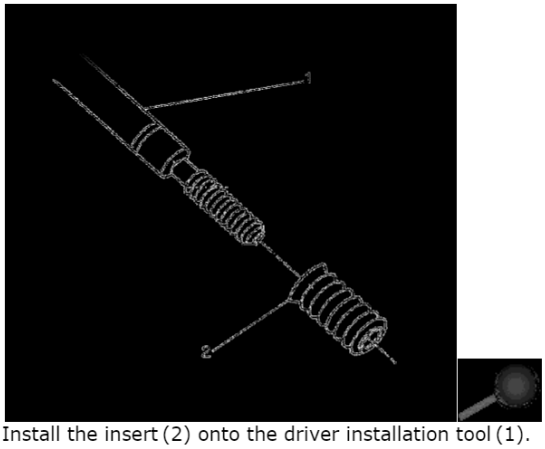
7. Using compressed air, clean out any chips.



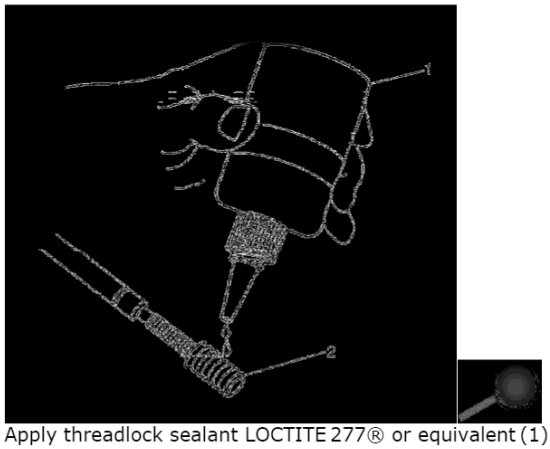
Note: DO NOT allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1).

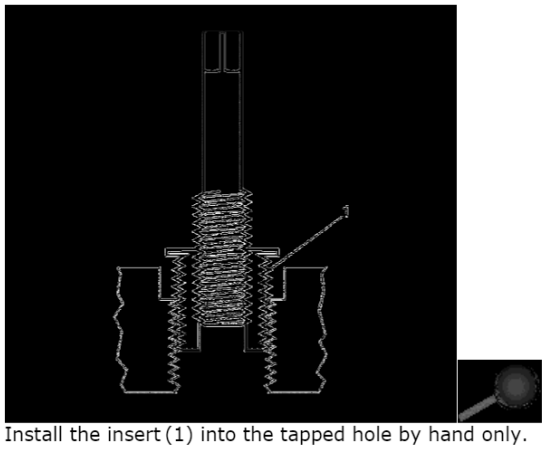
cardiagn.com



9. Install the insert (2) onto the driver installation tool (1).

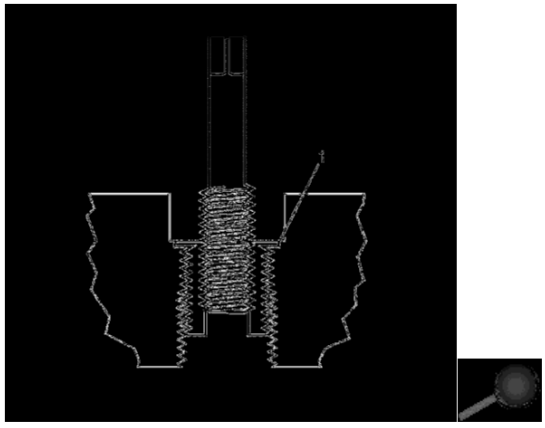


10. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).



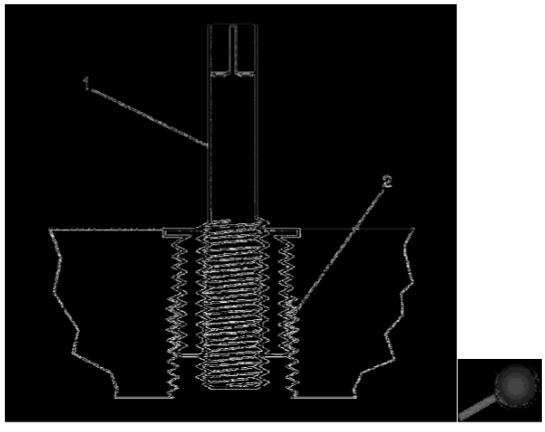
11. Install the insert (1) into the tapped hole by hand only.

cardiagn.com



Note: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

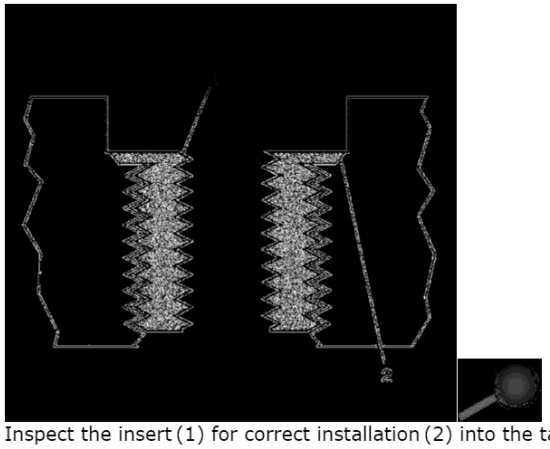
12. Install the insert until the flange (1) of the insert contacts the counterbored surface.



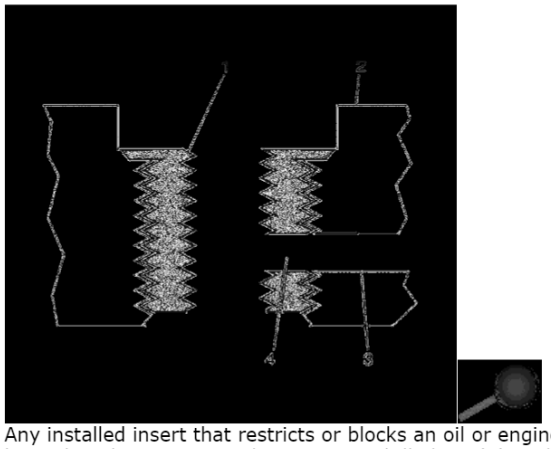
Note: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) through the insert (2).

cardiagn.com



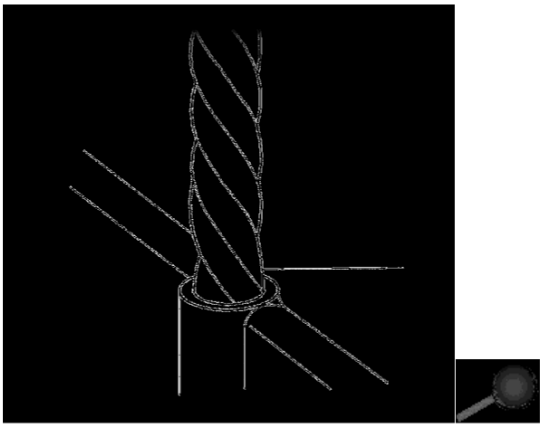
14. Inspect the insert (1) for correct installation (2) into the tapped hole.



15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

Tapered Pipe Thread Repair

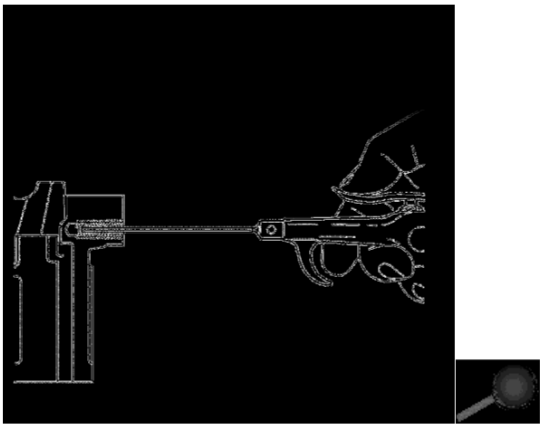
cardiagn.com



Note:

- The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.
- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the surface of the base material.

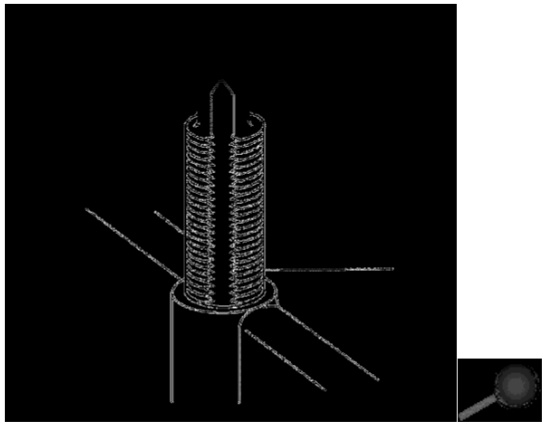
1. Drill out the threads of the damaged hole.



Note: All chips must be removed from the drilled hole prior to tapping.

2. Using compressed air, clean out any chips.

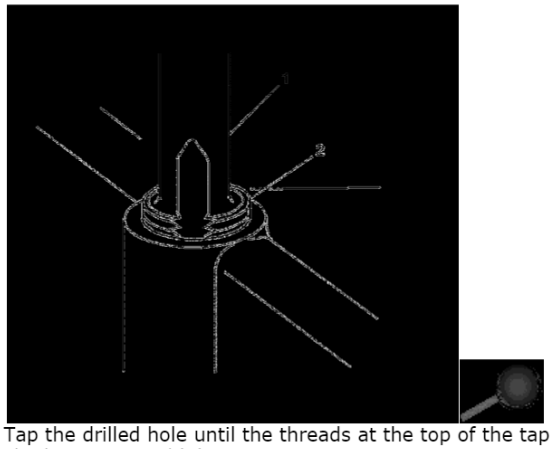
cardiagn.com



Note:

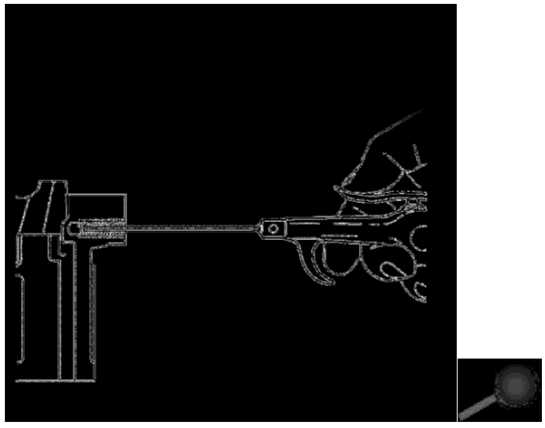
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

3. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.



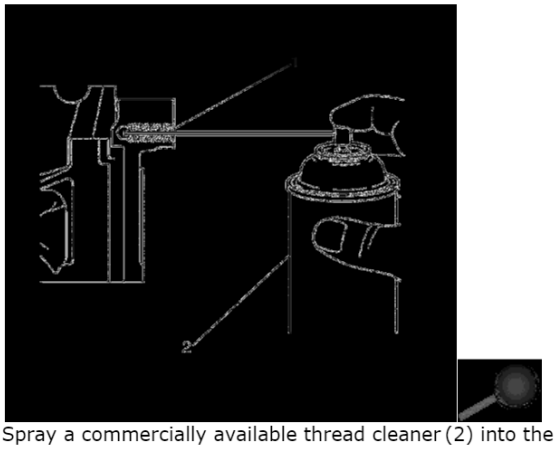
4. Tap the drilled hole until the threads at the top of the tap (1) are down to the surface of the base material (2).

cardiagn.com

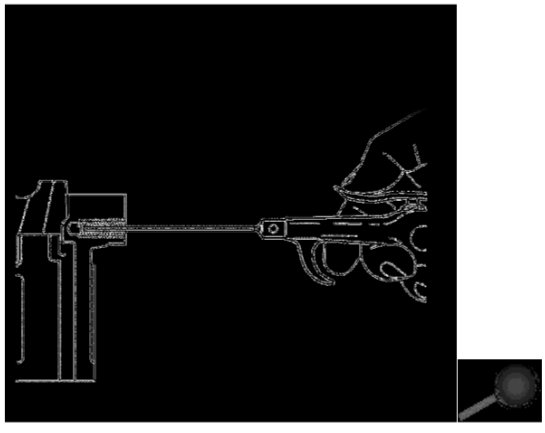


Note: All chips must be removed from the tapped hole prior to insert installation.

5. Using compressed air, clean out any chips.



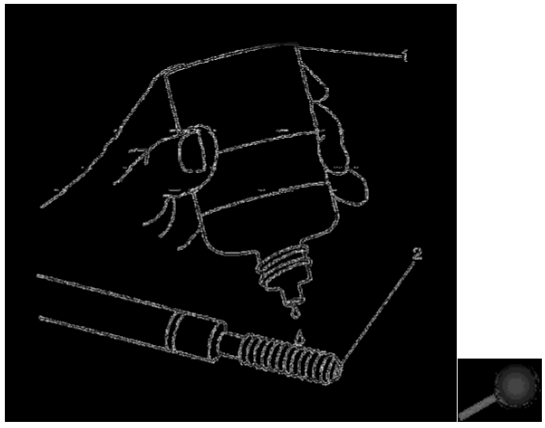
6. Spray a commercially available thread cleaner (2) into the tapped hole (1).



Note: All chips must be removed from the tapped hole prior to insert installation.

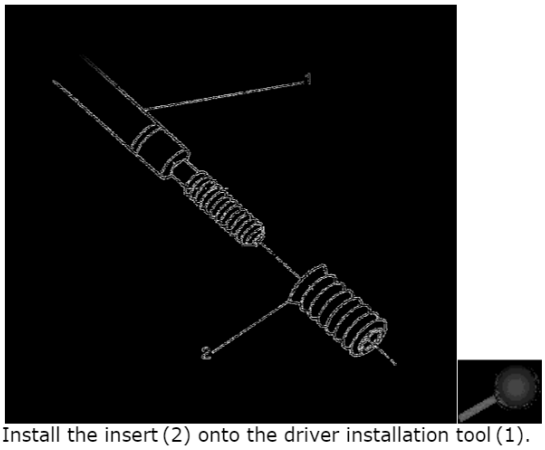
7. Using compressed air, clean out any chips.

cardiagn.com

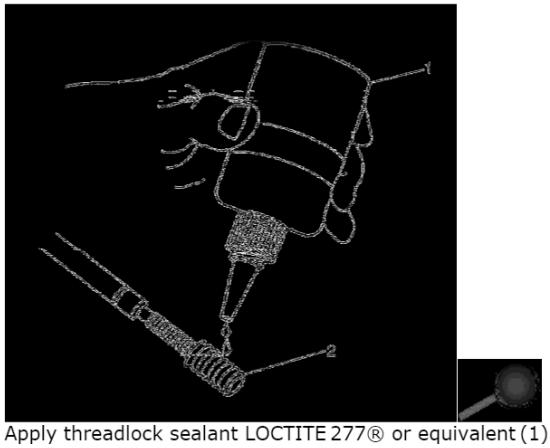


Note: DO NOT allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

8. Lubricate the threads of the driver installation tool (2) with the driver oil (1).

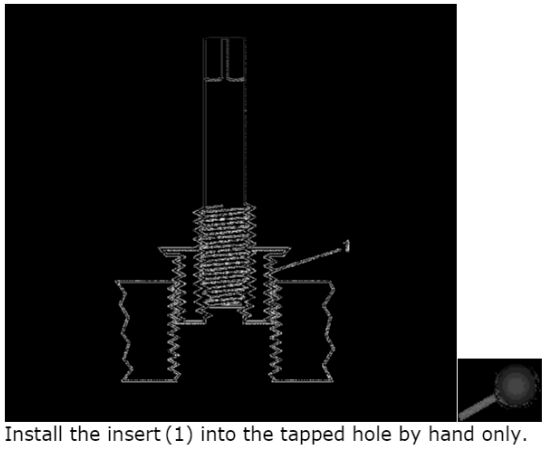


9. Install the insert (2) onto the driver installation tool (1).

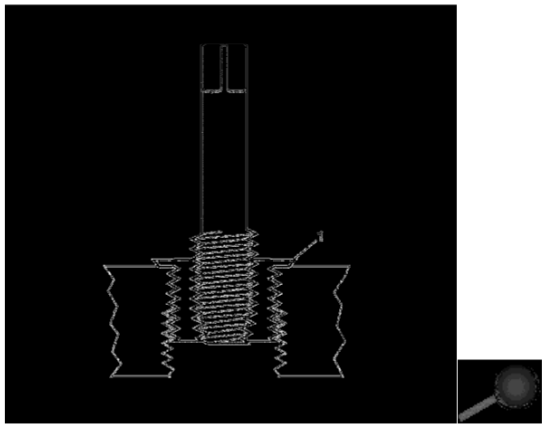


10. Apply threadlock sealant LOCTITE 277® or equivalent (1) to the insert OD threads (2).

cardiagn.com

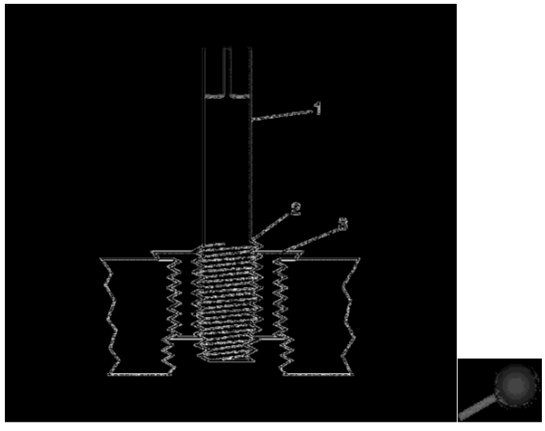


11. Install the insert (1) into the tapped hole by hand only.



Note: If the insert will not thread down until the flange contacts the surface of the base material remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

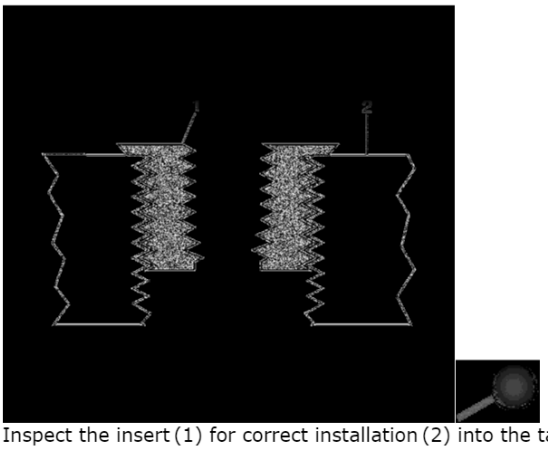
12. Install the insert until the flange (1) of the insert contacts the surface of the base material.



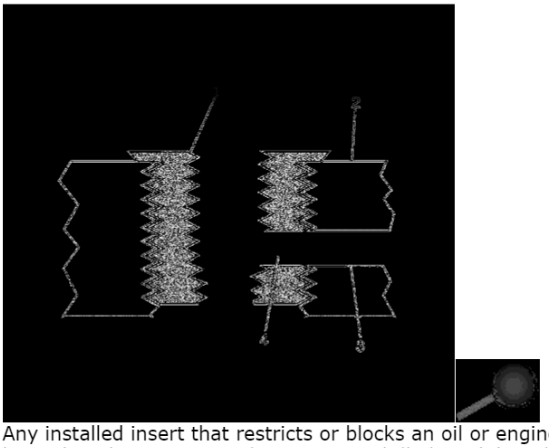
cardiagn.com

Note: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

13. Continue to rotate the driver installation tool (1) until the top of the threaded section (2) is level with the top of the insert (3).



14. Inspect the insert (1) for correct installation (2) into the tapped hole.



15. Any installed insert that restricts or blocks an oil or engine coolant passage (3) will need to have the oil or engine coolant passage drilled out (4) to the original size of the oil or engine coolant passage. After drilling the restriction or blockage, clean out any chips and thread the installation driver tool through the insert again to remove any burrs caused by the drilling of the oil or engine coolant passage.

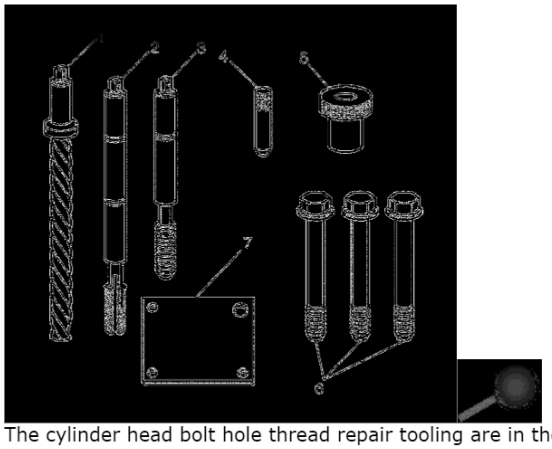
Cylinder Head Bolt Hole Thread Repair

Special Tools

- *J 42385-700* High Feature Thread Repair Kit
- *J 42385-2000* Thread Insert Kit

For equivalent regional tools, refer to Special Tools.

cardiagn.com



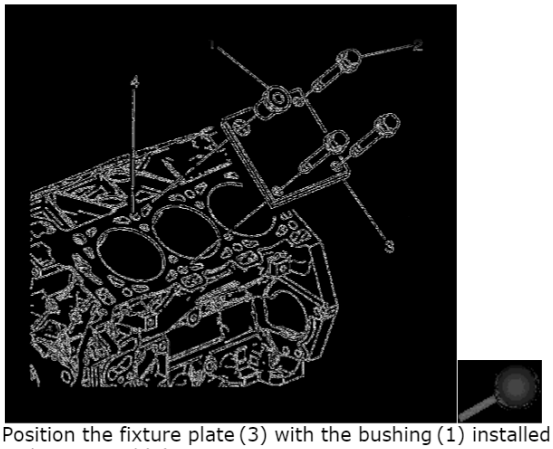
- The cylinder head bolt hole thread repair tooling are in the kits *J 42385-2000* thread insert kit and *J 42385-700* kit . The cylinder head bolt hole thread repair components consist of the following:
- J 42385-723 Drill (1)
- J 42385-724 Tap (2)
- J 42385-725 Installation driver (3)
- J 42385-303 Alignment pin (4)
- J 42385-302 Bushing (5)
- J 42385-733 Bolts (6)
- J 42385-401 Fixture plate (7)

Warning: Refer to Safety Glasses Warning.

Note:

- Remove the fixture plate prior to installing the insert with the installer tool.
- The use of a cutting type fluid such as WD 40®; or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

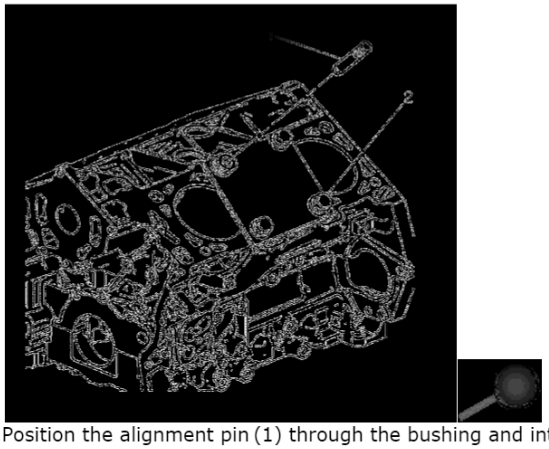
- When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.



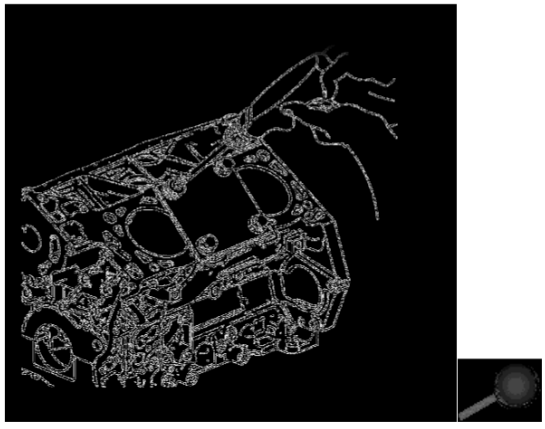
1. Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4).

cardiagn.com

2. Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.



3. Position the alignment pin (1) through the bushing and into the cylinder head bolt hole.
4. With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the cylinder head bolt hole.

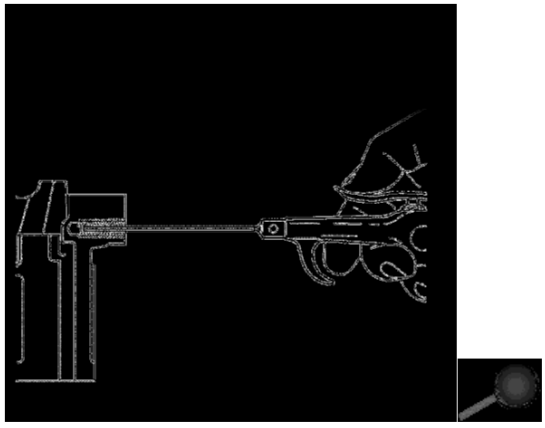


Note:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the hole until the stop collar contacts the top of the drill bushing.

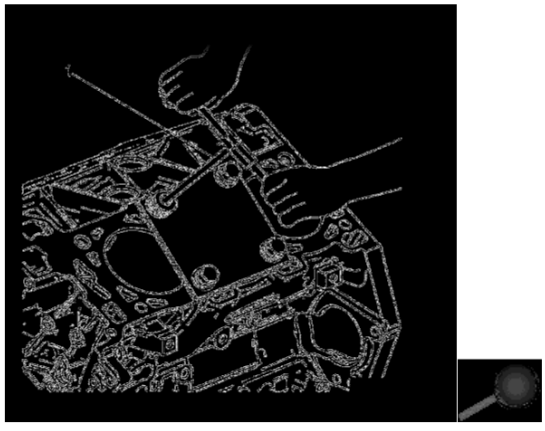
6. Drill out the threads of the damaged hole.

cardiagn.com



Note: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

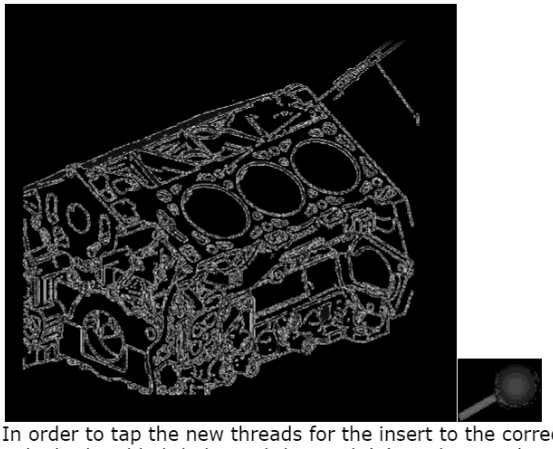


Note:

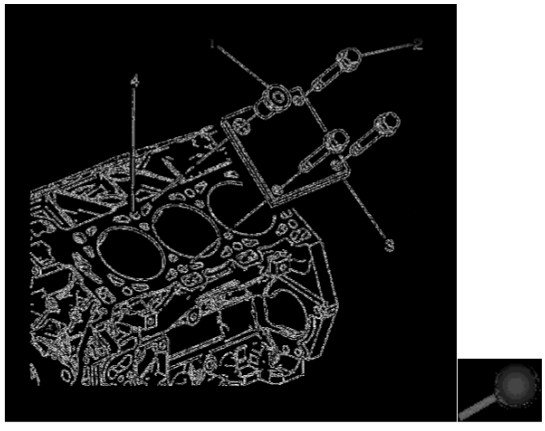
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench (1), tap the threads of the drilled hole by hand only.

cardiagn.com

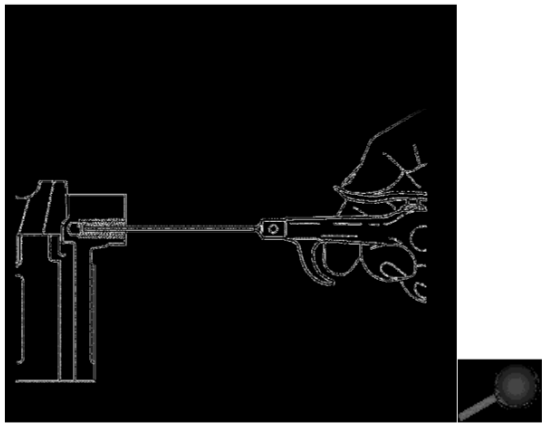


9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the cylinder head bolt hole until the mark (1) on the tap aligns with the top of the drill bushing.



Note: Remove the fixture plate prior to installing the insert with the installer tool.

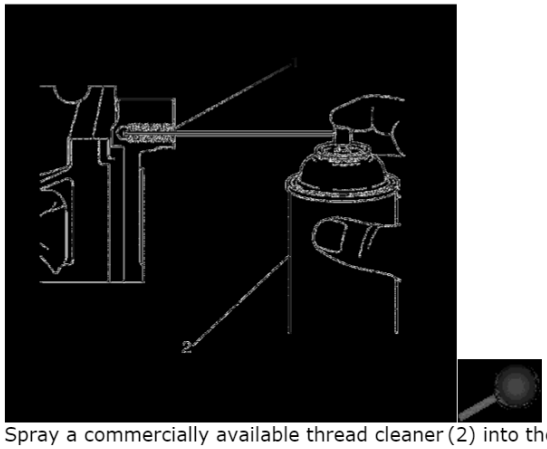
10. Remove the fixture plate bolts (2).
11. Remove the fixture plate (3) and bushing (1).



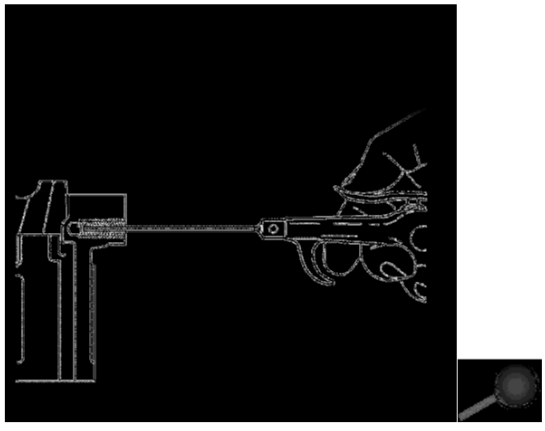
Note: All chips must be removed from the tapped hole prior to insert installation.

cardiagn.com

12. Using compressed air, clean out any chips.

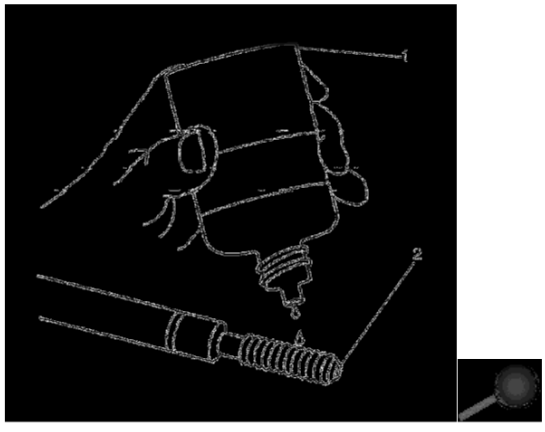


13. Spray a commercially available thread cleaner (2) into the tapped hole (1).



Note: All chips must be removed from the tapped hole prior to insert installation.

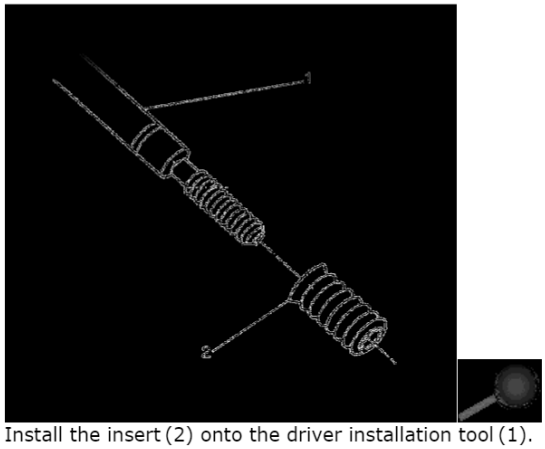
14. Using compressed air, clean out any chips.



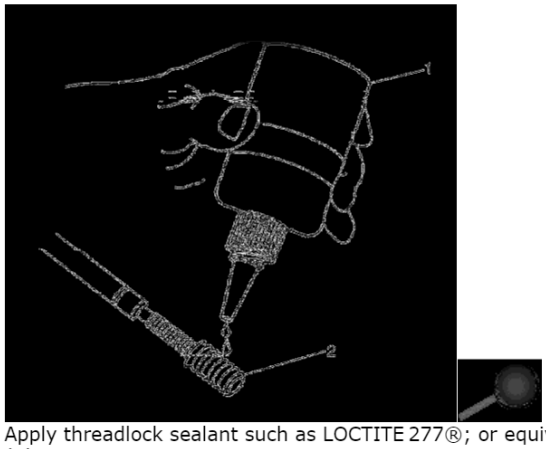
Note: DO NOT allow oil or other foreign material to contact the outside diameter (OD) of the insert.

cardiagn.com

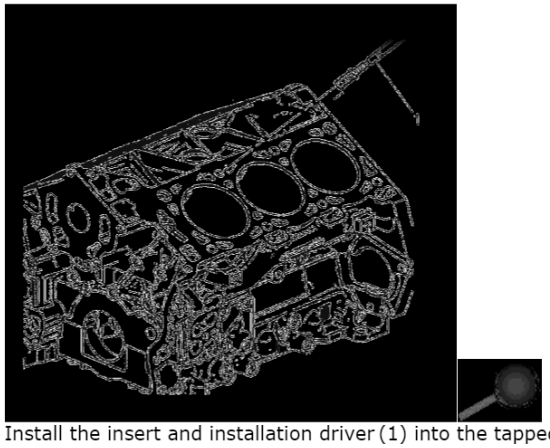
15. Lubricate the threads of the driver installation tool (2) with the driver oil (1).



16. Install the insert (2) onto the driver installation tool (1).



17. Apply threadlock sealant such as LOCTITE 277®; or equivalent (1) to the insert OD threads (2).



18. Install the insert and installation driver (1) into the tapped hole by hand only.
19. Start the insert into the threaded hole.

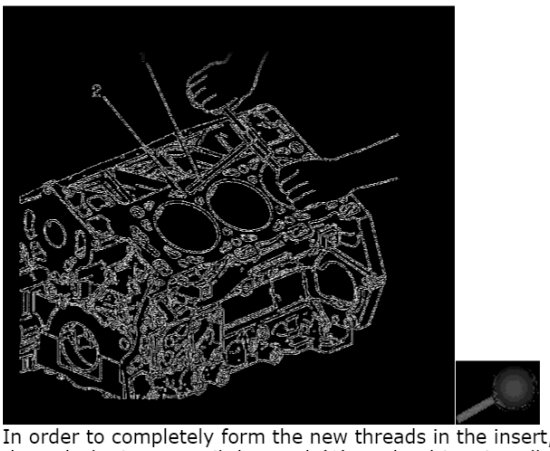
cardiagn.com

Note: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

20. Install the insert until the flange of the insert contacts the counterbored surface.

    Note: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

21. Continue to rotate the driver installation tool through the insert.



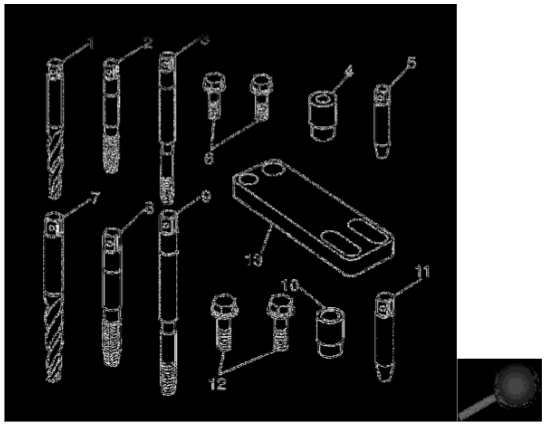
22. In order to completely form the new threads in the insert, rotate the driver installation tool through the insert until the mark (1) on the driver installation tool aligns with the surface of the cylinder block deck (2).
23. Inspect the insert for correct installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair

Special Tools

- *J 42385-700* High Feature Thread Repair Kit
- *J 42385-2000* Thread Insert Kit

  For equivalent regional tools, refer to Special Tools.



Note:

- In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.

cardiagn.com

- DO NOT remove the fixture plate prior to installing the insert with the installation driver. The fixture plate remains in position throughout the thread repair process.

- The crankshaft main bearing bolt hole thread repair tooling are in the kits *J 42385-2000* thread insert kit and *J 42385-700* kit . The crankshaft main bearing bolt hole thread repair components consist of the following:
- J 42385-702 Drill (1) for outboard holes
- J 42385-703 Tap (2) for outboard holes
- J 42385-704 Installation driver (3) for outboard holes
- J 42385-726 Bushing (4) for outboard holes
- J 42385-727 Alignment pin (5) for outboard holes
- J 42385-728 Bolts (6) for outboard holes
- J 42385-720 Drill (7) for inboard holes
- J 42385-721 Tap (8) for inboard holes
- J 42385-722 Installation driver (9) for inboard holes
- J 42385-713 Bushing (10)
- J 42385-308 Alignment pin (11)
- J 42385-734 Bolts (12)
- J 42385-712 Fixture plate (13)

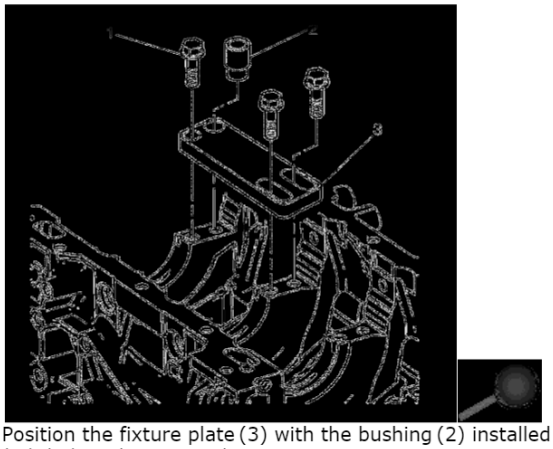
Outboard Bolt Holes

Warning: Refer to Safety Glasses Warning.

Note:

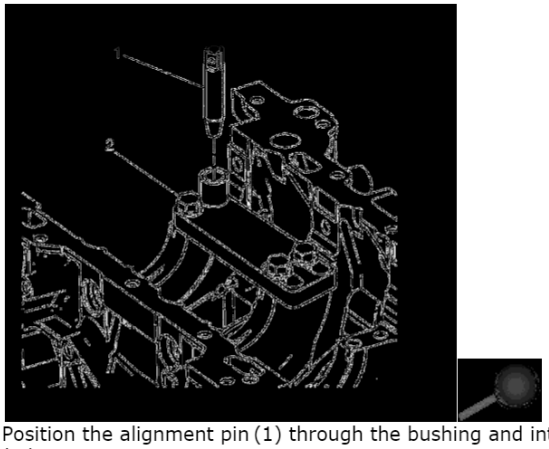
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid such as WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

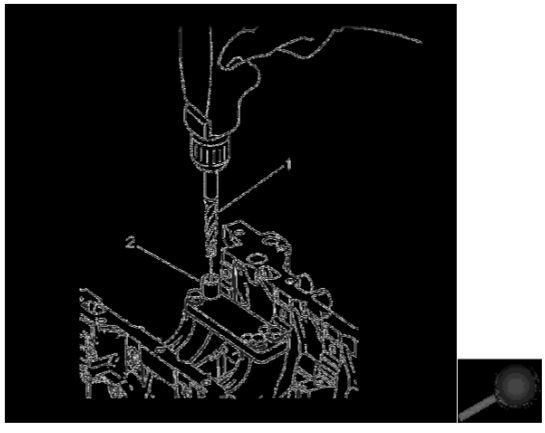


1. Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.

cardiagn.com



3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.
4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

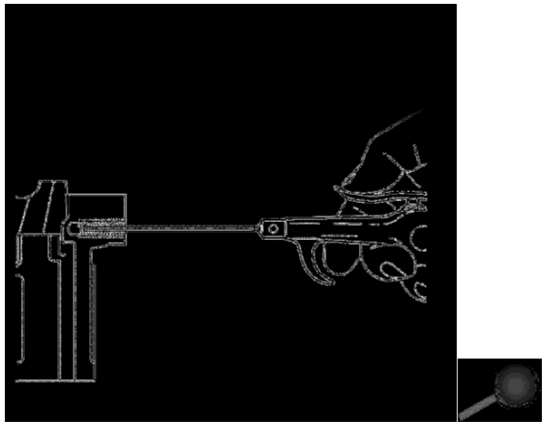


Note:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

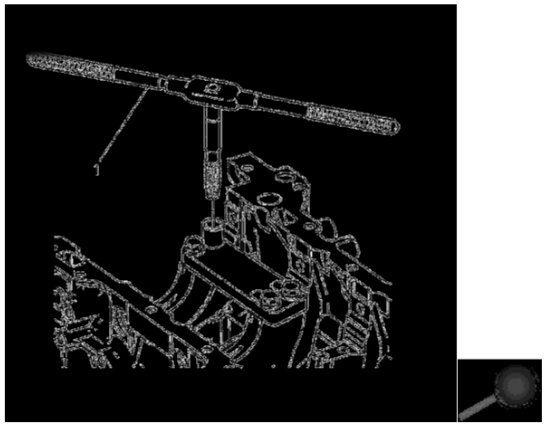
6. Drill out the threads of the damaged hole.

cardiagn.com



Note: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

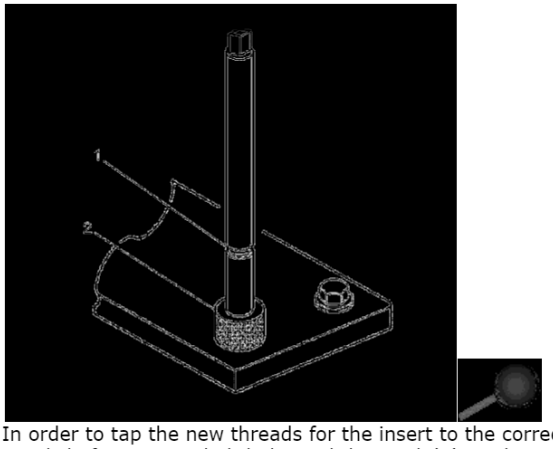


cardiagn.com

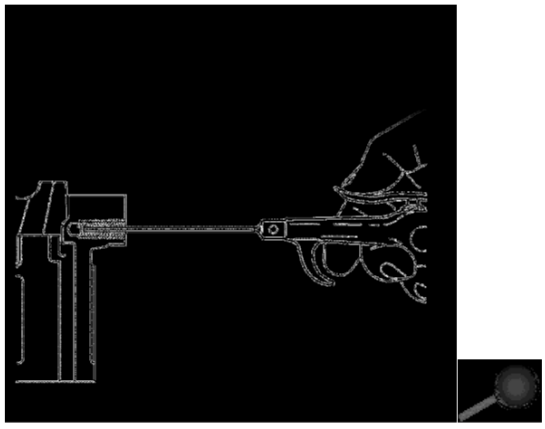
Note:

- DO NOT remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench (1), tap the threads of the drilled hole by hand only.

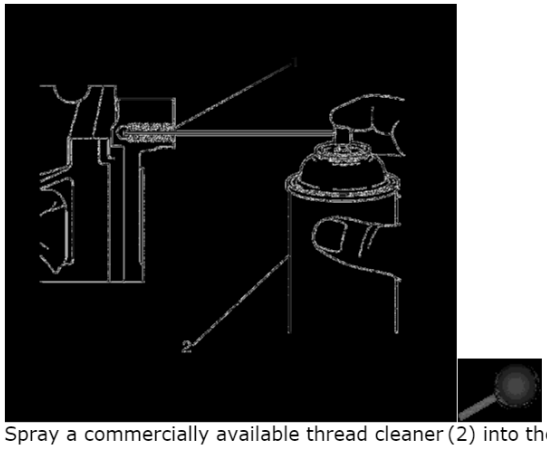


9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the crankshaft main cap bolt hole until the mark (1) on the tap aligns with the top of the drill bushing (2).



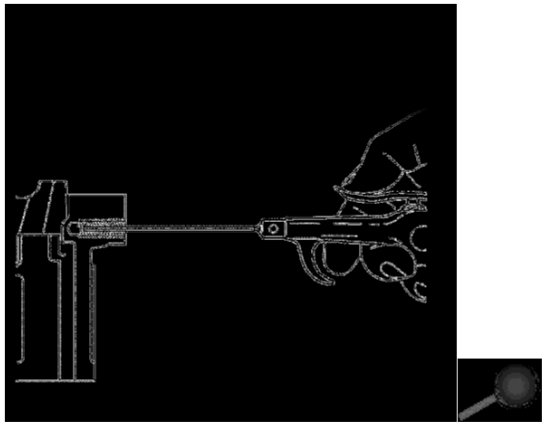
Note: All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.



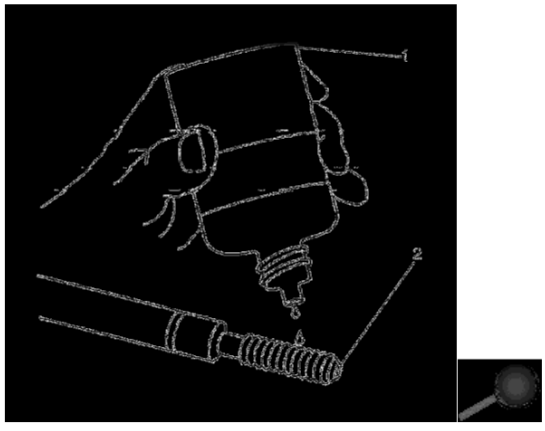
11. Spray a commercially available thread cleaner (2) into the tapped hole (1).

cardiagn.com



Note: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

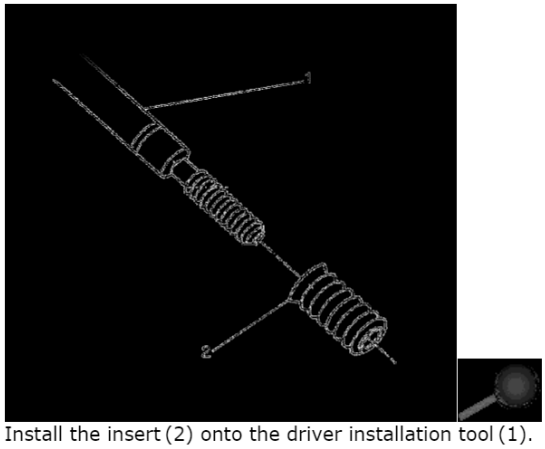


Note:

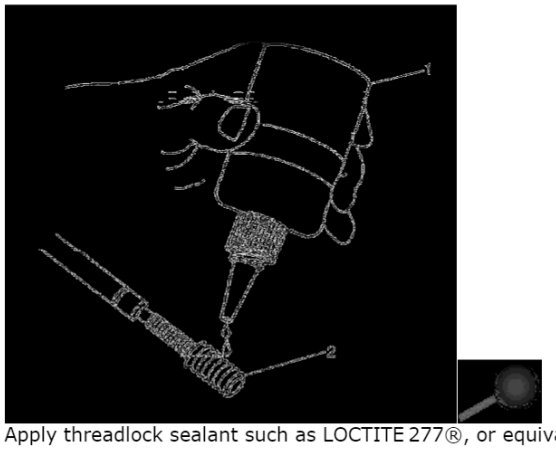
- DO NOT remove the fixture plate, make sure the fixture plate is installed during the installation process of the insert.
- DO NOT allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

13. Lubricate the threads of the driver installation tool (2) with the driver oil (1).

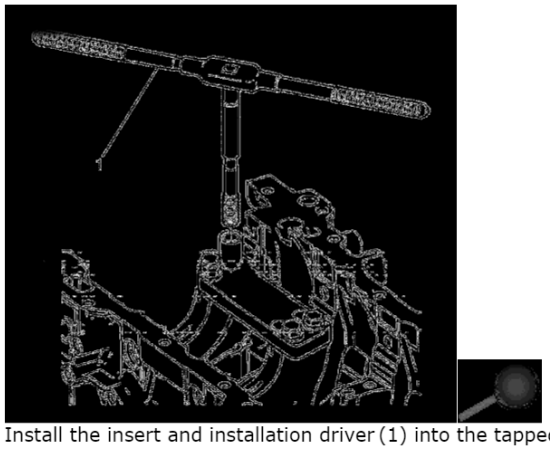
cardiagn.com



14. Install the insert (2) onto the driver installation tool (1).



15. Apply threadlock sealant such as LOCTITE 277®, or equivalent (1) to the insert OD threads (2).



16. Install the insert and installation driver (1) into the tapped hole by hand only.
17. Start the insert into the threaded hole.

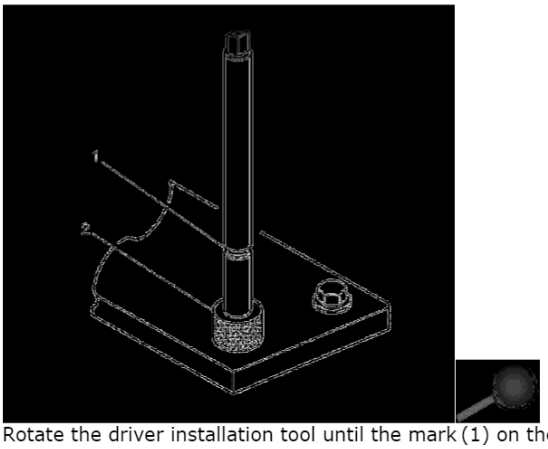
cardiagn.com

Note: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.

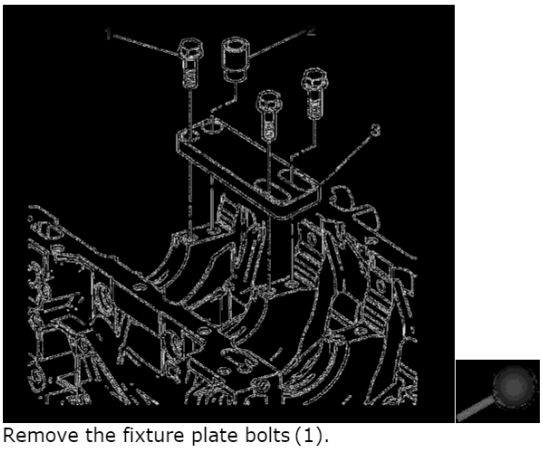
18. Install the insert until the flange of the insert contacts the counterbored surface.

    Note: The driver installation tool (1) will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.

19. Continue to rotate the driver installation tool (1) through the insert.



20. Rotate the driver installation tool until the mark (1) on the driver installation tool aligns with the top of the drill bushing (2).
21. Inspect the insert for correct installation into the tapped hole.



22. Remove the fixture plate bolts (1).
23. Remove the fixture plate (3) and bushing (2).

Inboard Bolt Holes

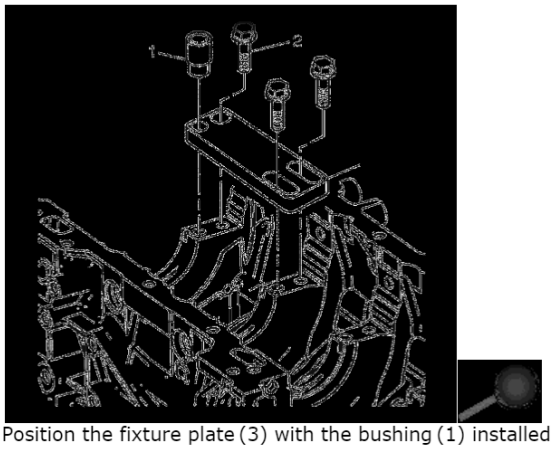
Warning: Refer to Safety Glasses Warning.

Note:

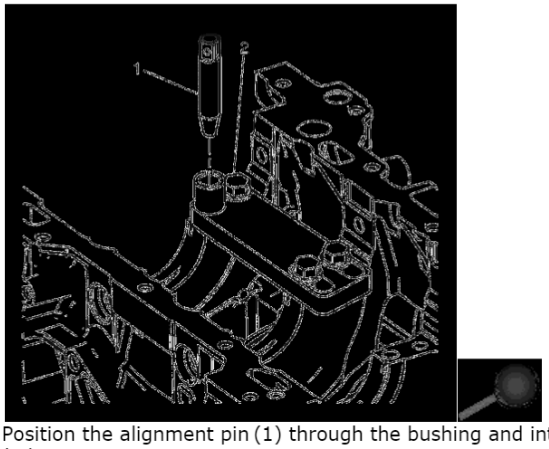
- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- The use of a cutting type fluid such as WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures.

cardiagn.com

- When installed to the correct depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

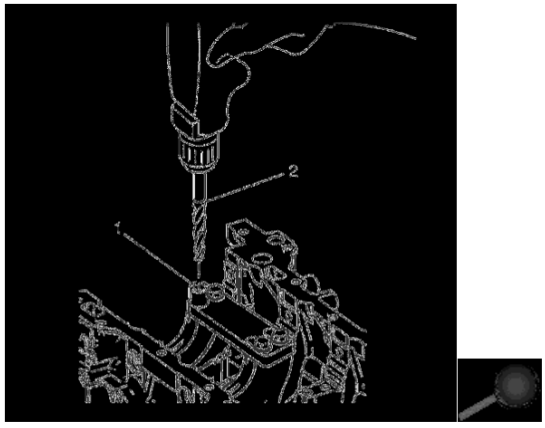


1. Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired.
2. Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.



3. Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole.
4. With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin (1) from the crankshaft main cap bolt hole.

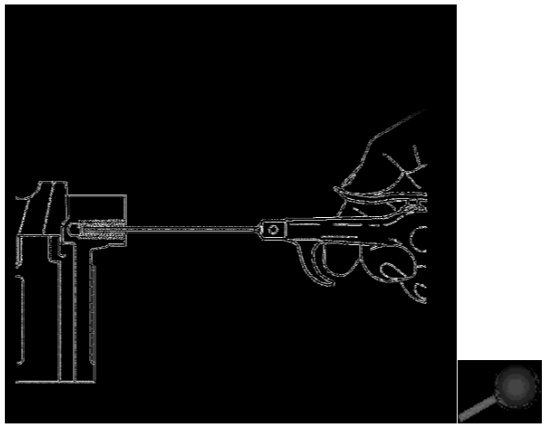
cardiagn.com



Note:

- During the drilling process, it is necessary to repeatedly remove the drill and clean chips from the hole and the flutes of the drill.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).

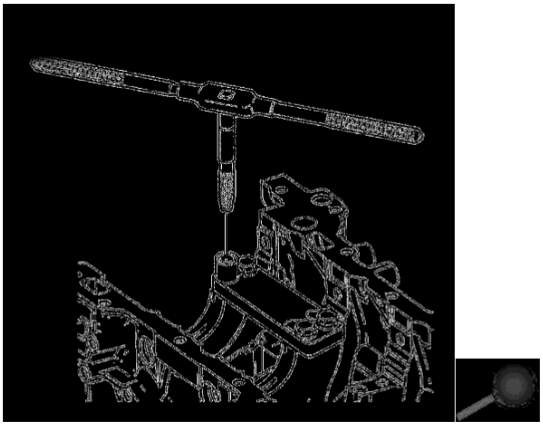
6. Drill out the threads of the damaged hole.



Note: All chips must be removed from the drilled hole prior to tapping.

7. Using compressed air, clean out any chips.

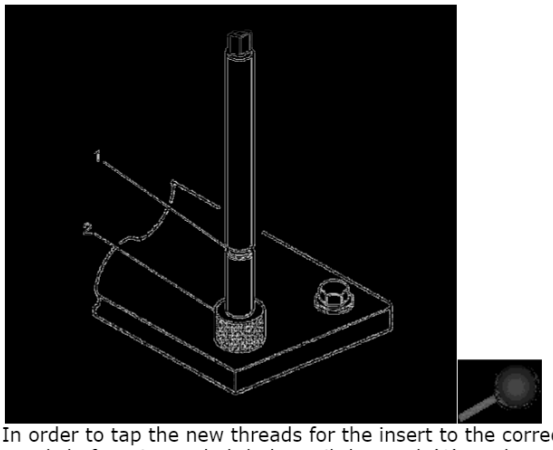
cardiagn.com



Note:

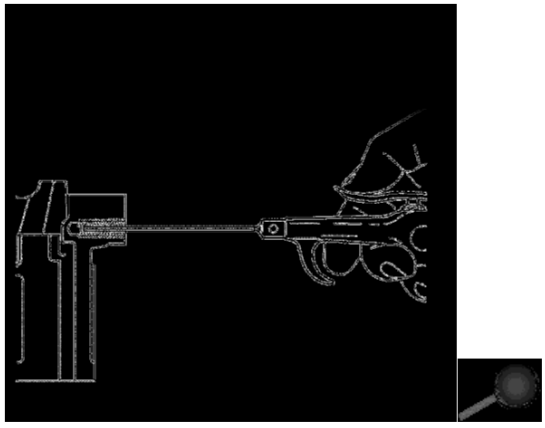
- DO NOT remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Make sure the tap has created full threads at least to the depth equal to the insert length.

8. Using a suitable tapping wrench, tap the threads of the drilled hole by hand only.



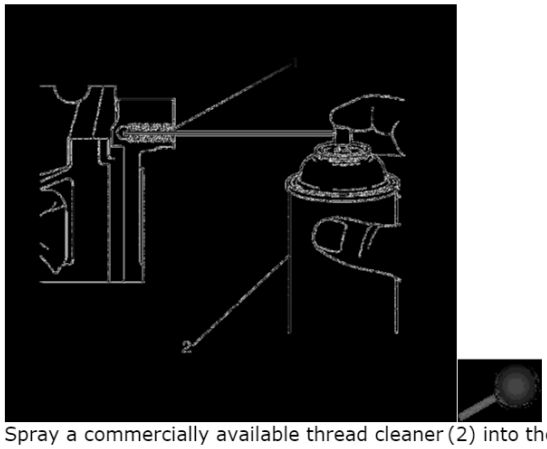
9. In order to tap the new threads for the insert to the correct depth, rotate the tap into the crankshaft main cap bolt hole until the mark (1) on the tap aligns with the top of the drill bushing (2).

cardiagn.com

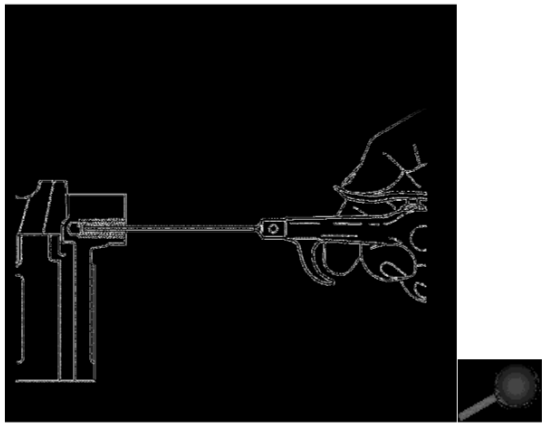


Note: All chips must be removed from the tapped hole prior to insert installation.

10. Using compressed air, clean out any chips.



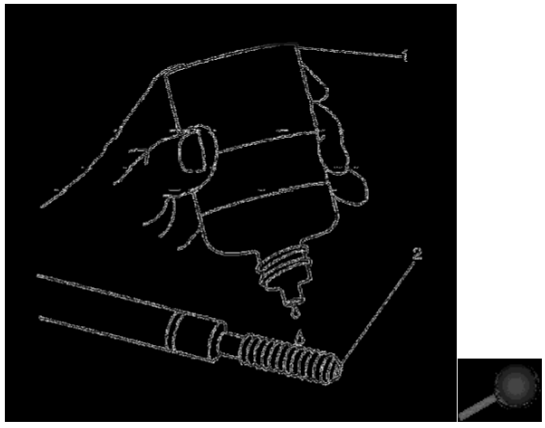
11. Spray a commercially available thread cleaner (2) into the tapped hole (1).



Note: All chips must be removed from the tapped hole prior to insert installation.

12. Using compressed air, clean out any chips.

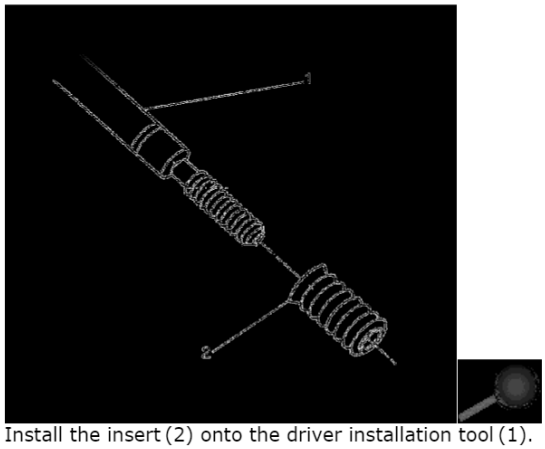
cardiagn.com



Note:

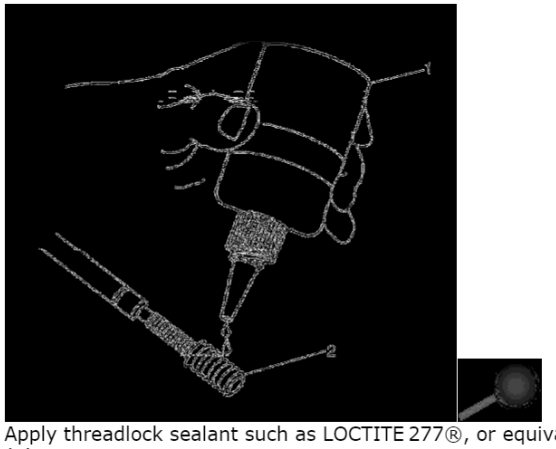
- DO NOT remove the fixture plate, make sure the fixture plate is installed during the installation process of the insert.
- DO NOT allow oil or other foreign material to contact the Outside Diameter (OD) of the insert.

13. Lubricate the threads of the driver installation tool (2) with the driver oil (1).

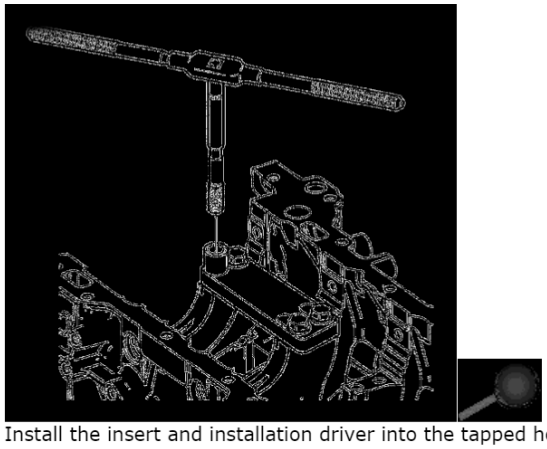


14. Install the insert (2) onto the driver installation tool (1).

cardiagn.com



15. Apply threadlock sealant such as LOCTITE 277®, or equivalent (1) to the insert OD threads (2).

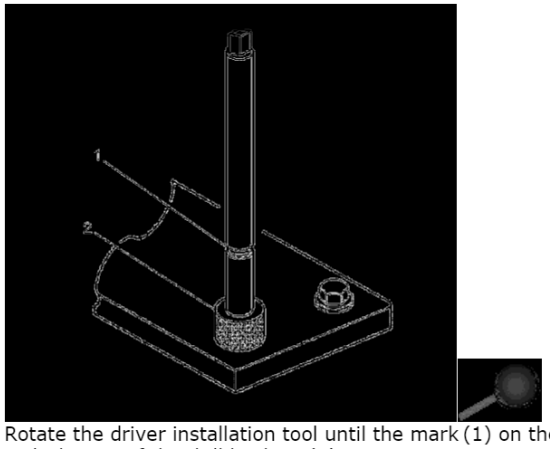


16. Install the insert and installation driver into the tapped hole by hand only.
17. Start the insert into the threaded hole.

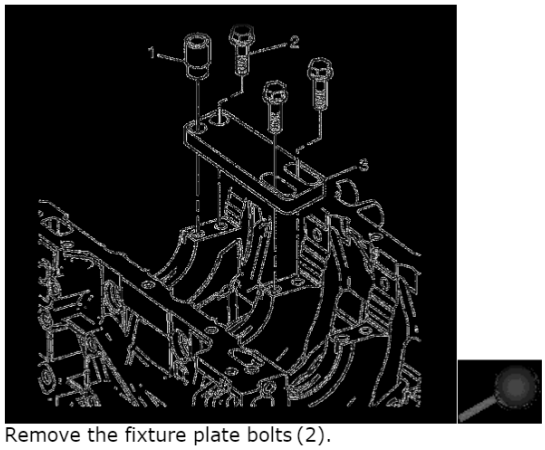
    Note: If the insert will not thread down until the flange contacts the counterbored surface remove the insert immediately with a screw extracting tool and inspect the tapped hole for any remaining chips and/or incorrect tapping.
18. Install the insert until the flange of the insert contacts the counterbored surface.

    Note: The driver installation tool will tighten up before screwing completely through the insert. This is acceptable. The threads at the bottom of the insert are being formed and the insert is mechanically locking the insert into the base material threads.
19. Continue to rotate the driver installation tool through the insert.

cardiagn.com



20. Rotate the driver installation tool until the mark (1) on the driver installation tool aligns with the top of the drill bushing (2).
21. Inspect the insert for correct installation into the tapped hole.



22. Remove the fixture plate bolts (2).
23. Remove the fixture plate (3) and bushing (1).

cardiagn.com

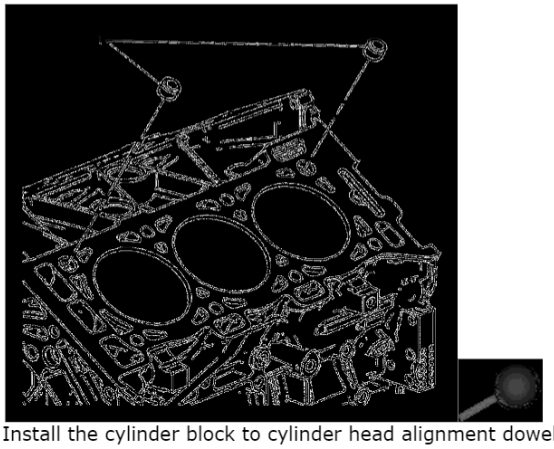
Service Prior to Assembly

- Dirt will cause premature wear of the rebuilt engine. Clean all the components.
- Use the proper tools to measure the components when checking for excessive wear. Components not within the manufacturer's specification must be repaired or replaced.
- When the components are reinstalled into an engine, return the components to their original location, position, and direction.
- During assembly, lubricate all the moving parts with clean engine oil (unless otherwise specified). This will provide initial lubrication when the engine is first started.

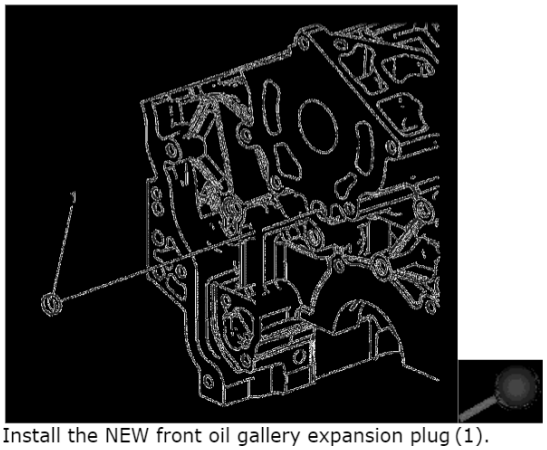
cardiagn.com

© 2014 General Motors. All rights reserved.

Engine Block Assemble



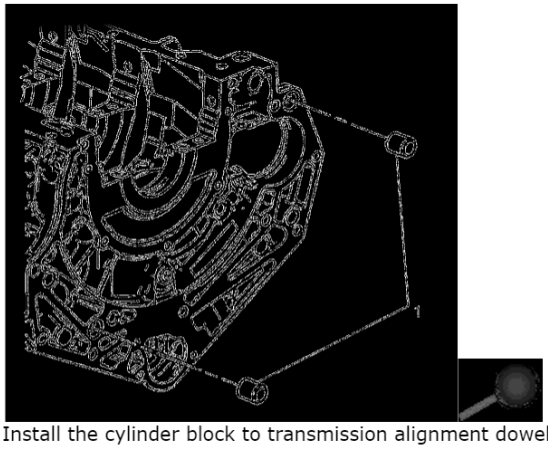
1. Install the cylinder block to cylinder head alignment dowels (1).



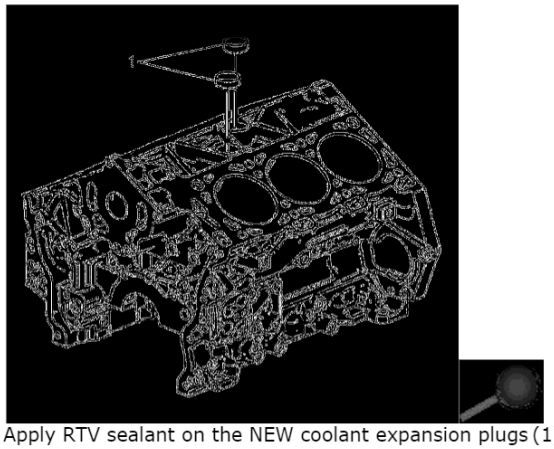
2. Install the NEW front oil gallery expansion plug (1).
3. Make sure the NEW front oil gallery expansion plug (1) is installed to the correct depth.

cardiagn.com

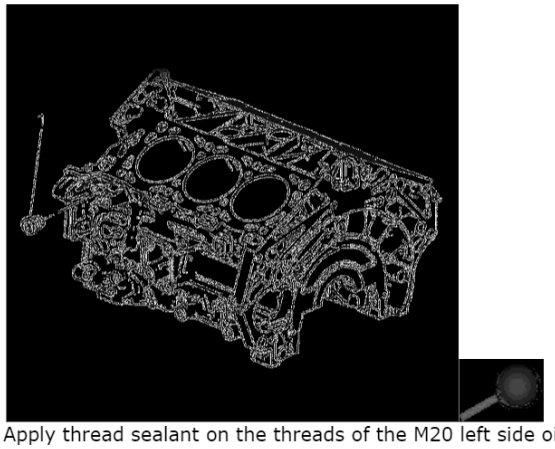
© 2014 General Motors. All rights reserved.



4. Install the cylinder block to transmission alignment dowels (1).



5. Apply RTV sealant on the NEW coolant expansion plugs (1).
6. Install the NEW coolant expansion plugs (1).
7. Make sure the NEW coolant expansion plugs (1) are installed to the correct depth.

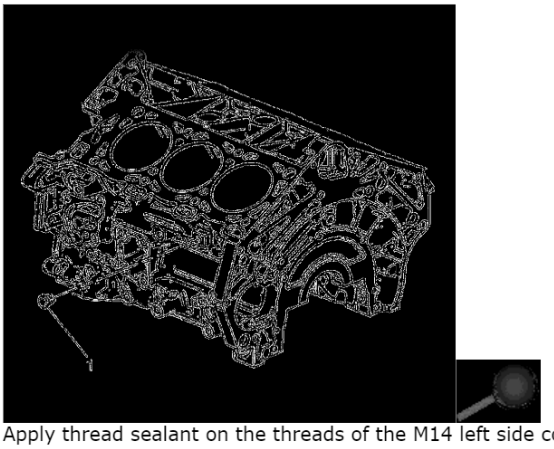


8. Apply thread sealant on the threads of the M20 left side oil gallery threaded plug (1).

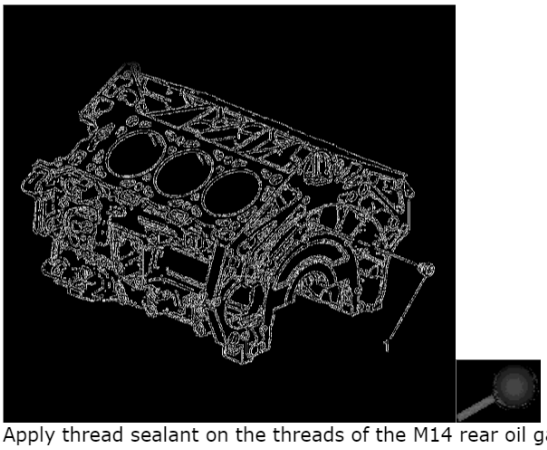
Caution: Refer to Fastener Caution.

cardiagn.com

9. Install the M20 left side oil gallery threaded plug (1) and tighten to **31 N•m (23 lb ft)**.

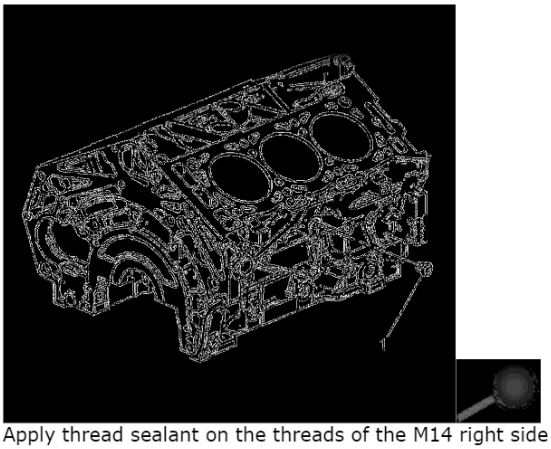


10. Apply thread sealant on the threads of the M14 left side coolant drain threaded plug (1).
11. Install the M14 left side coolant drain threaded plug (1) and tighten to **31 N•m (23 lb ft)**.

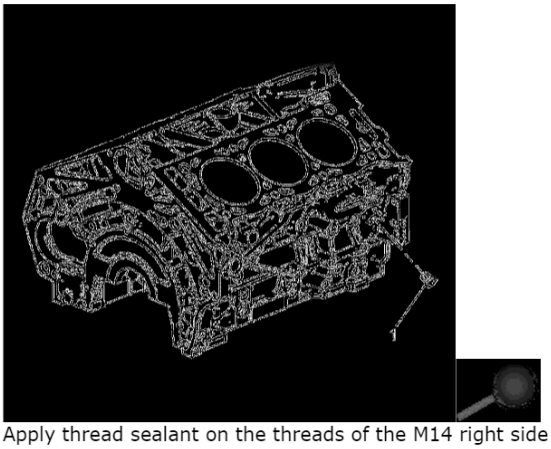


12. Apply thread sealant on the threads of the M14 rear oil gallery threaded plug (1).
13. Install the M14 rear oil gallery threaded plug (1) and tighten to **31 N•m (23 lb ft)**.

cardiagn.com

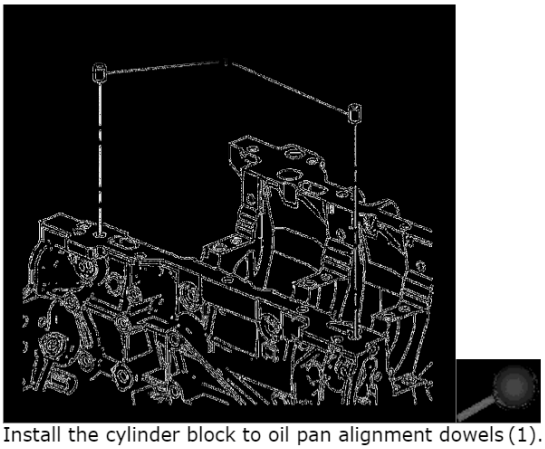


14. Apply thread sealant on the threads of the M14 right side coolant drain threaded plug (1).
15. Install the M14 right side coolant drain threaded plug (1) and tighten to **31 N•m (23 lb ft)**.

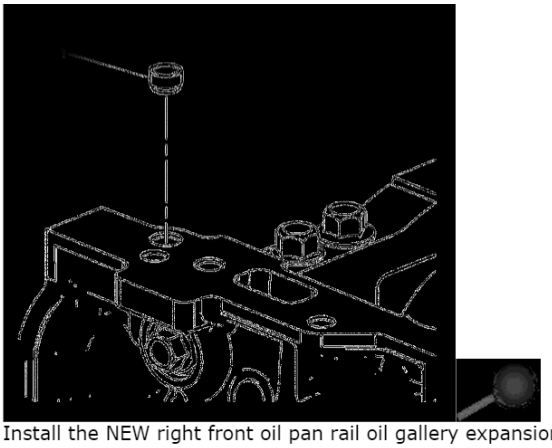


16. Apply thread sealant on the threads of the M14 right side oil gallery threaded plug (1).
17. Install the M14 right side oil gallery threaded plug (1) and tighten to **31 N•m (23 lb ft)**.

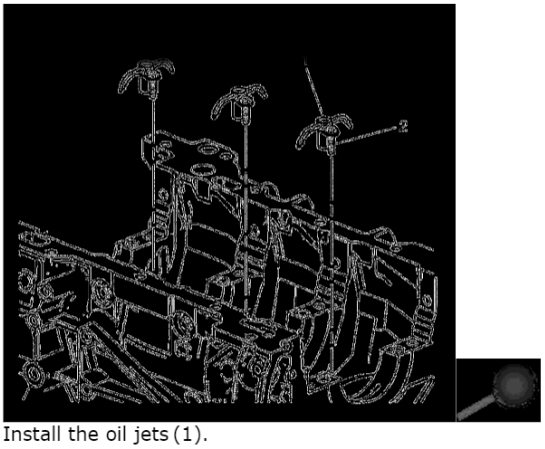
cardiagn.com



18. Install the cylinder block to oil pan alignment dowels (1).



19. Install the NEW right front oil pan rail oil gallery expansion plug (1).
20. Make sure the NEW right front oil pan rail oil gallery expansion plug (1) is installed to the correct depth.



21. Install the oil jets (1).

cardiagn.com

22. Install the oil jet to cylinder block retaining bolts (2) and tighten to **9 N•m (80 lb in)**.

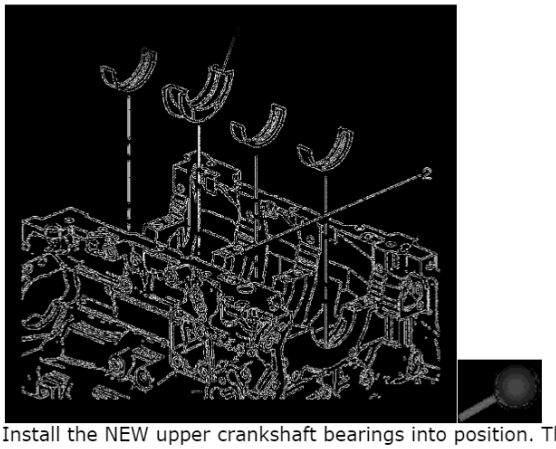
cardiagn.com

Crankshaft and Bearing Installation

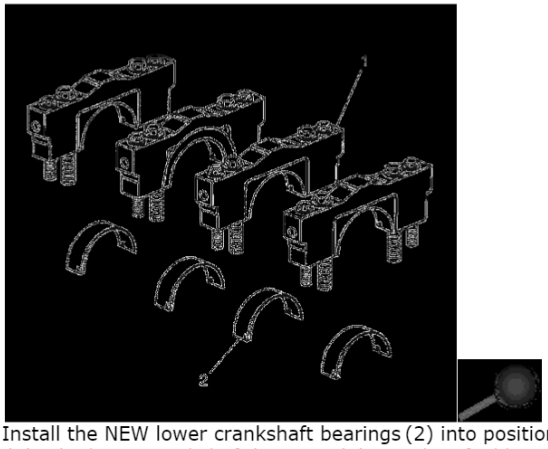
Crankshaft Bearing Installation Procedure

Note: If the crankshaft bearings have been used in a running engine, you must replace them with NEW crankshaft bearings for reassembly.

1. Clean the crankcase crank bore with a lint-free cloth.
2. Clean all the oil from the backside of new bearing halves.



3. Install the NEW upper crankshaft bearings into position. The thrust bearing (1) belongs in the number 3 journal (2). Make sure that the upper bearing insert contains the oil transfer hole and groove. Roll the bearing into position so that the lock tang engages the crank slot. The bearing must fit flush with the upper crankcase.

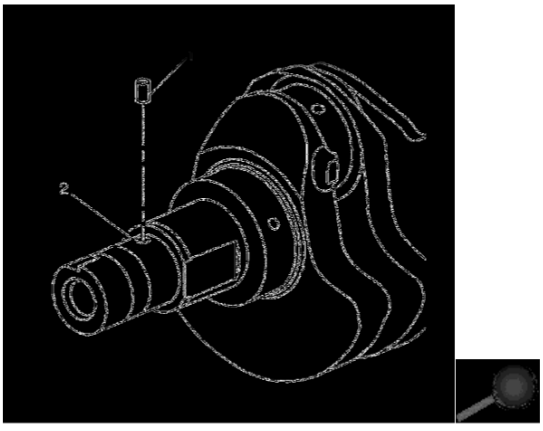


4. Install the NEW lower crankshaft bearings (2) into position in the crankshaft bearing caps (1). The lower crankshaft bearings (2) are identified by NO grooves or holes. The lower crankshaft bearings (2) must fit flush with the crankshaft bearing caps (1).

Crankshaft Installation Procedure

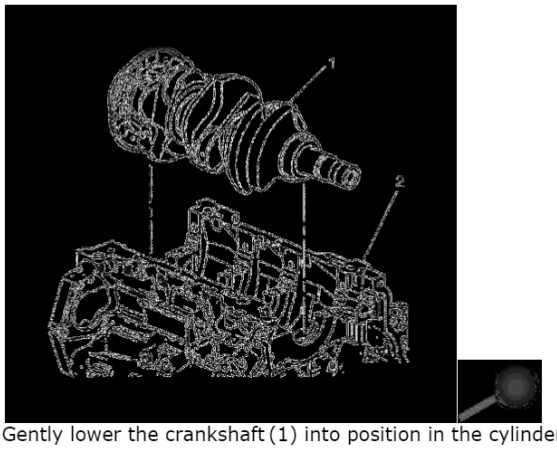
© 2014 General Motors. All rights reserved.

cardiagn.com



Caution: The crankshaft sprocket drive pin must be set to the proper depth. Installing the crankshaft sprocket drive pin too deep can lead to damage to the crankshaft sprocket and extensive engine damage.

1. If removed, install the crankshaft sprocket drive pin (1). Lightly tap the crankshaft sprocket drive pin (1) in place with a small soft face, bronze/plastic, hammer until it bottoms in the hole of the crankshaft (2).



2. Gently lower the crankshaft (1) into position in the cylinder block (2).

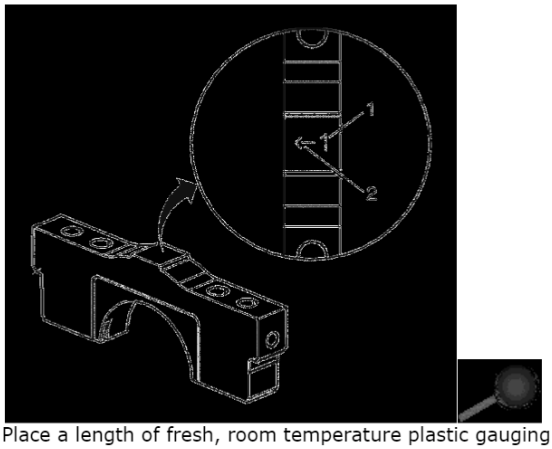
Crankshaft Bearing Clearance Measurement Procedure

Special Tools

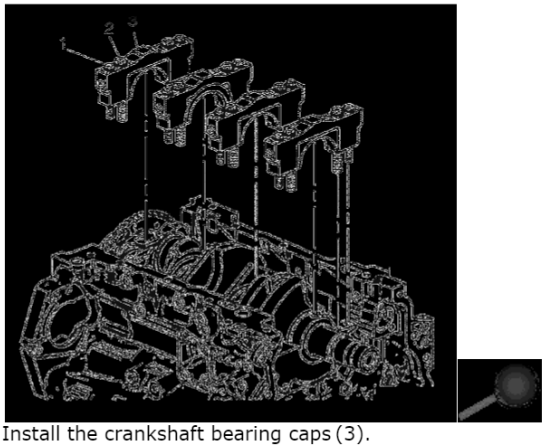
- *J 6125-1B* Slide Hammer with Adapter
- *J 41818* Crankshaft Bearing Cap Remover
- *J 45059* Angle Meter

For equivalent regional tools, refer to Special Tools.

cardiagn.com

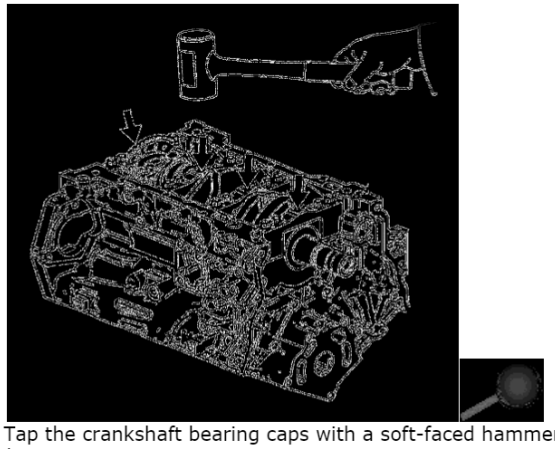


1. Place a length of fresh, room temperature plastic gauging material all the way across all the crankshaft bearing journals.
2. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.

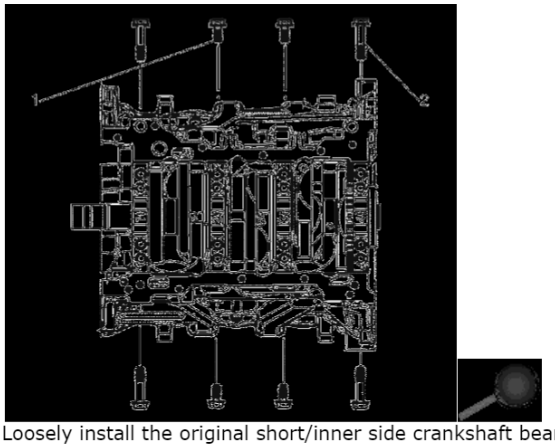


3. Install the crankshaft bearing caps (3).
4. Loosely install the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
5. Loosely install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).

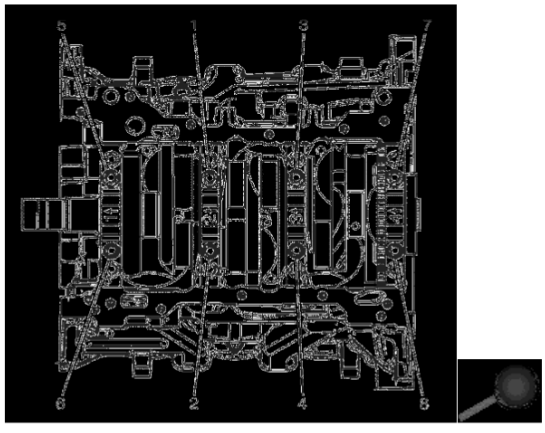
cardiagn.com



6. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.



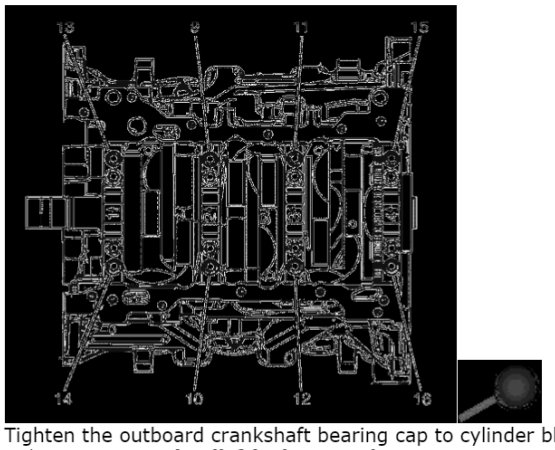
7. Loosely install the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
8. Loosely install the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).



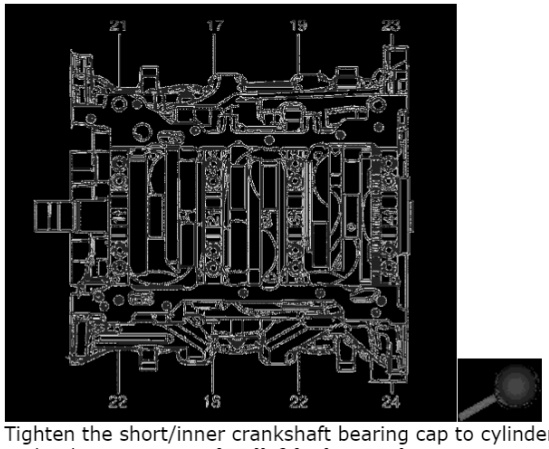
cardiagn.com

Caution: Refer to Fastener Caution.

9. Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1–8) and tighten to **20 N•m (15 lb ft) plus 80 degrees**.



10. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9–16) and tighten to **15 N•m (11 lb ft) plus 110 degrees**.

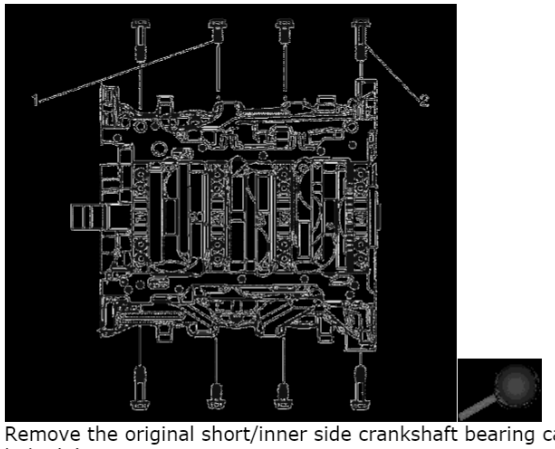


11. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17–20) and tighten to **30 N•m (22 lb ft) plus 60 degrees**.
12. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21–24) and tighten to **30 N•m (22 lb ft) plus 60 degrees**.

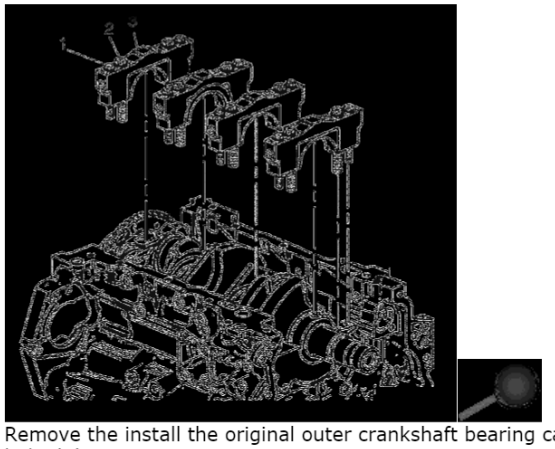
Note: DO NOT rotate the crankshaft.

13. After reaching final torque, allow the assembly to sit for 2 minutes.

cardiagn.com

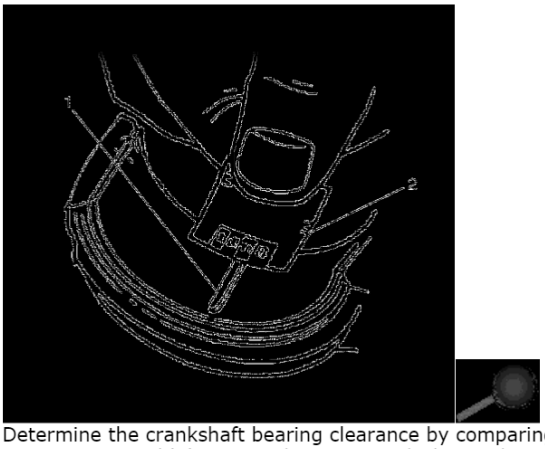


14. Remove the original short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
15. Remove the original long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).



16. Remove the install the original outer crankshaft bearing cap to cylinder block retaining bolts (2).
17. Remove the original inner crankshaft bearing cap to cylinder block retaining bolts (1).
18. Remove the crankshaft bearing caps (3) using the *J 6125-1B* Slide Hammer with Adapterand *J 41818* remover

cardiagn.com



19. Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).

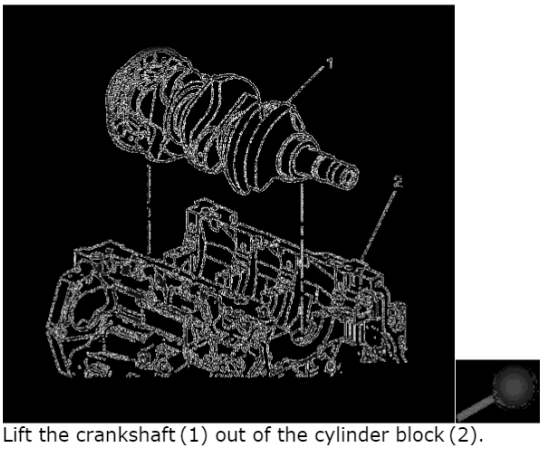
    Note: The crankshaft bearings CAN be reused after checking the clearance if the bearings have never been used in a running engine.

20. Compare your measurements with the engine mechanical specifications. Refer to Engine Mechanical Specifications. If the new bearings DO NOT provide the proper crankshaft to bearing clearance, inspect the following:

    20.1. Re-measure the crankshaft journals for the correct specified size and ensure the proper new bearings are being installed. If the crankshaft journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.

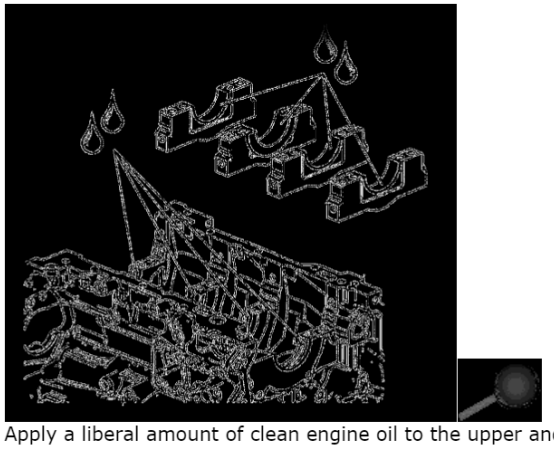
    20.2. Re-measure the cylinder block crankshaft bearing bore diameter to ensure proper size. The cylinder block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.

21. Clean the plastic gauging material from the crankshaft bearing journals with a soft, lint-free cloth.

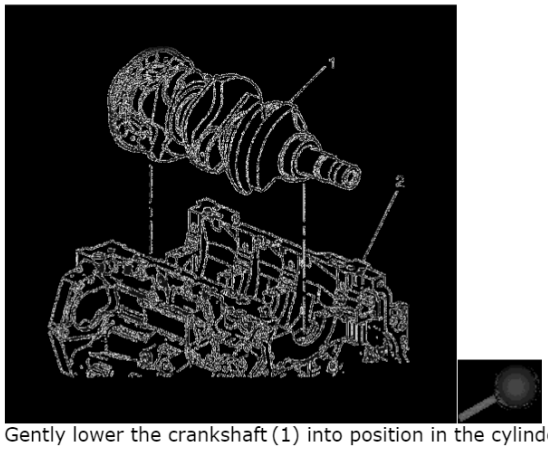


22. Lift the crankshaft (1) out of the cylinder block (2).

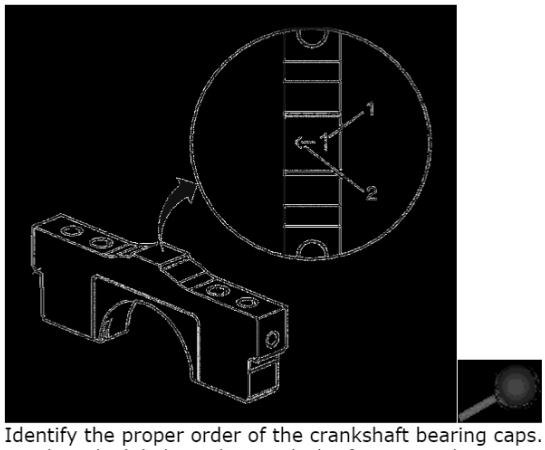
cardiagn.com



23. Apply a liberal amount of clean engine oil to the upper and lower bearing surfaces.

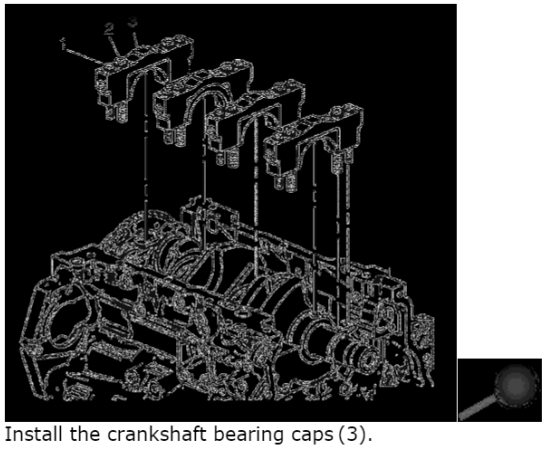


24. Gently lower the crankshaft (1) into position in the cylinder block (2).

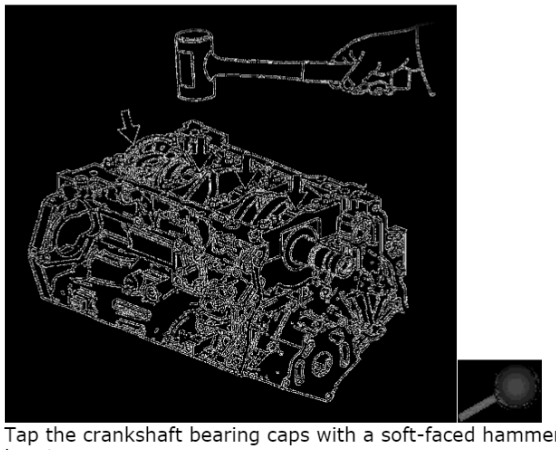


25. Identify the proper order of the crankshaft bearing caps. The crankshaft bearing caps are numbered 1 (1) through 4, with the front main bearing cap marked with the number 1. The arrow (2) is to be oriented to the front of the cylinder block.

cardiagn.com

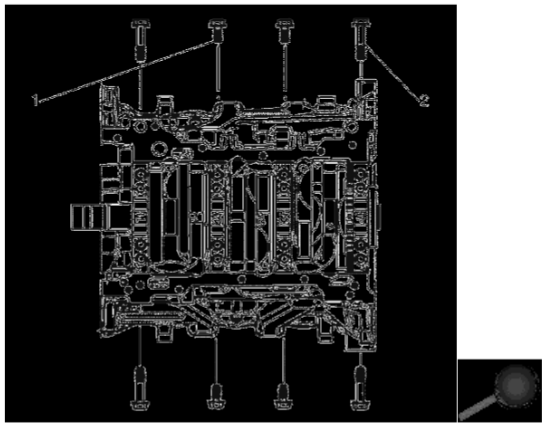


26. Install the crankshaft bearing caps (3).
27. Loosely install the NEW inner crankshaft bearing cap to cylinder block retaining bolts (1).
28. Loosely install the NEW outer crankshaft bearing cap to cylinder block retaining bolts (2).



cardiagn.com

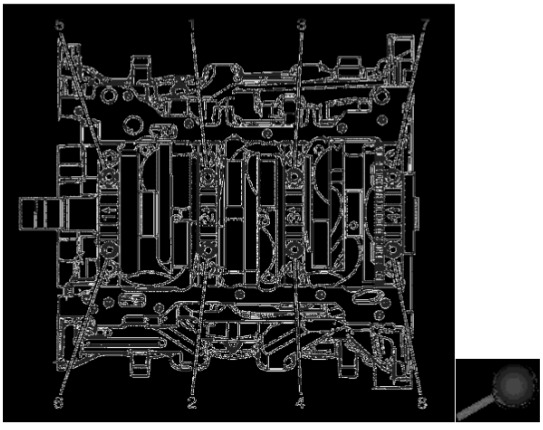
29. Tap the crankshaft bearing caps with a soft-faced hammer to help seat the crankshaft bearing caps.



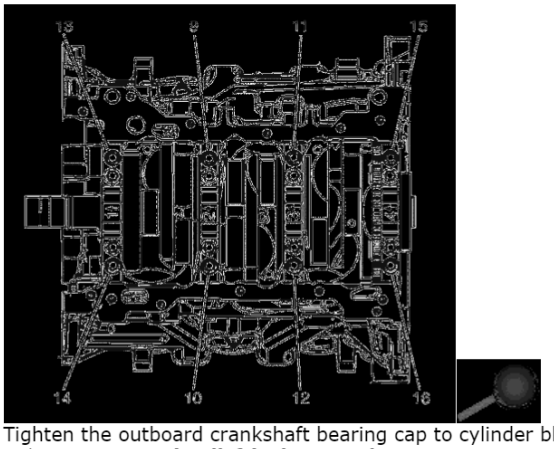
Note: The side main cap bolts originally have a sealant on the flange of the bolt head. NEW bolts must be used. If NEW bolts are not used, oil can leak from the crankcase past the bolts.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

30. Loosely install the NEW short/inner side crankshaft bearing cap to cylinder block retaining bolts (1).
31. Loosely install the NEW long/outer side crankshaft bearing cap to cylinder block retaining bolts (2).
32. Tighten the crankshaft bearing cap to cylinder block retaining bolts using the *J 45059* meterin the following sequence:

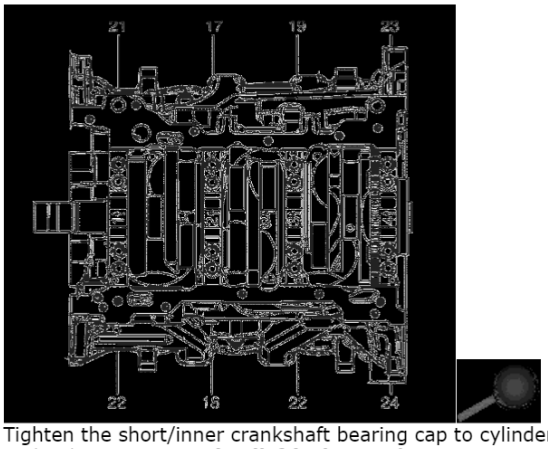


Tighten the inboard crankshaft bearing cap to cylinder block retaining bolts (1–8) and tighten to **20 N•m (15 lb ft) plus 80 degrees**.



33. Tighten the outboard crankshaft bearing cap to cylinder block retaining bolts (9–16) and tighten to **15 N•m (11 lb ft) plus 110 degrees**.

cardiagn.com



34. Tighten the short/inner crankshaft bearing cap to cylinder block retaining bolts (17–20) and tighten to **30 N•m (22 lb ft) plus 60 degrees**.
35. Tighten the long/outer crankshaft bearing cap to cylinder block retaining bolts (21–24) and tighten to **30 N•m (22 lb ft) plus 60 degrees**.
36. Make sure that the crankshaft turns without binding or noise.
37. After the crankshaft has been replaced, you must perform the crankshaft position learn procedure once the engine is installed in the vehicle. Refer to Crankshaft Position System Variation Learn.

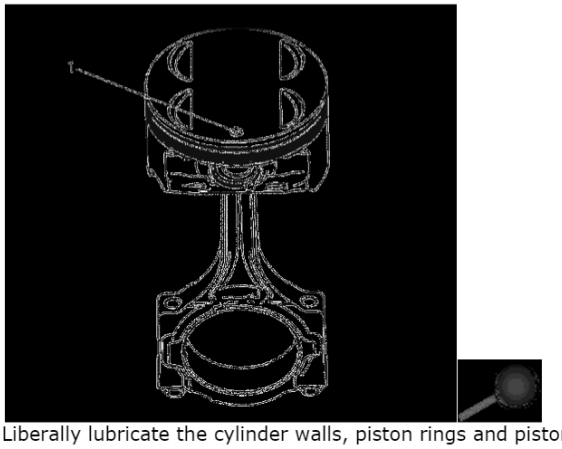
cardiagn.com

Piston, Connecting Rod, and Bearing Installation

Special Tools

- *EN-46111* Crankshaft Rotation Socket
- *EN-46121* Connecting Rod Guide Pin Set
- *J-45059* Angle Meter

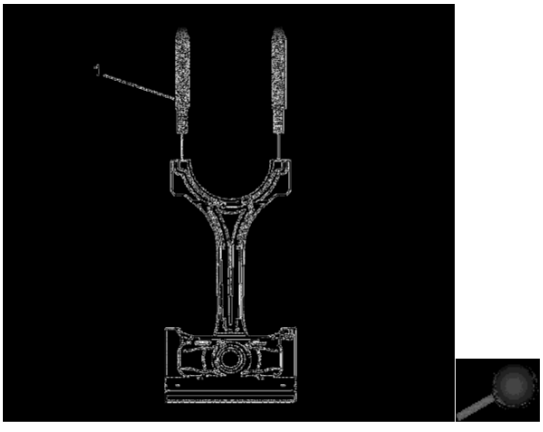
Piston and Connecting Rod Assembly Procedure



1. Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil.

   Note:
   - The piston is directional and must be installed in the engine block in the proper direction. The dot on the top of the piston must face the front of the engine.
   - Ensure the Bowl of the piston faces the intake.

2. Select the correctly numbered piston/connecting rod assembly for the cylinder. A dot (1) showing proper piston orientation is located on the top of the piston.

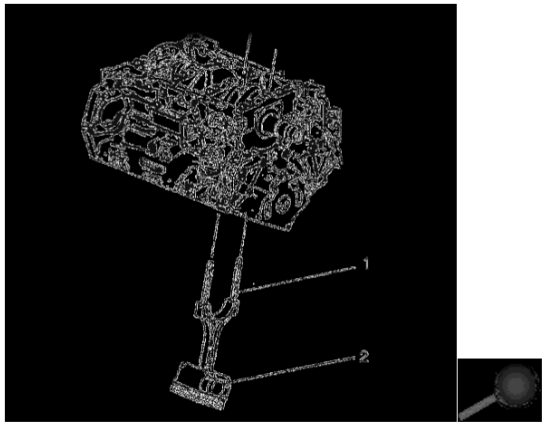


© 2014 General Motors. All rights reserved.

cardiagn.com

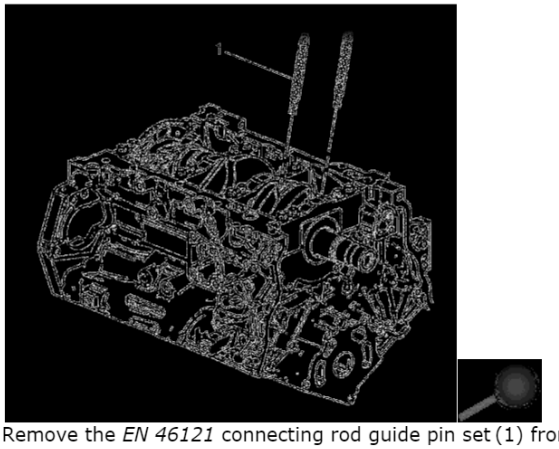
Note: Upon connecting rod disassembly, if the connecting rod bearings have been used in a running engine then the connecting rods bearings must be replaced.

3. Install the connecting rod bearing into the connecting rod.
4. Install the *EN 46121* connecting rod guide pin set (1) into the connecting rod bolt holes.
5. Compress the piston rings using a commercially available ring compressor.



Note: Extreme care must be used when installing the piston (2) and connecting rod in order to be sure the rod does not scrape or nick the cylinder bore, the oil jets, or the crankshaft surfaces.

6. Using both hands, slowly guide the piston (2) and connecting rod assembly into the cylinder from the top and bottom of the cylinder. DO NOT allow the connecting rod to contact the cylinder wall.
7. When the ring compressor contacts the deck surface, gently tap the piston (2) into the cylinder using the handle end of a dead-blow hammer. Guide the connecting rod onto the crankshaft bearing journal using the *EN 46121* connecting rod guide pin set (1) while gently tapping the piston (2) into the cylinder with a soft-blow hammer.



8. Remove the *EN 46121* connecting rod guide pin set (1) from the connecting rod bolt holes.

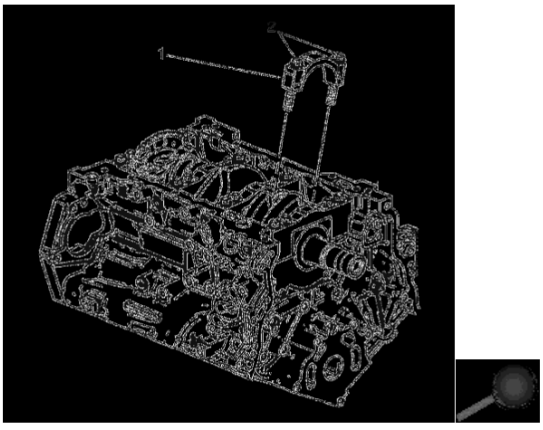
Connecting Rod Bearing Clearance Measurement Procedure – Using Plastic Gaging

Note: Connecting rod bearings that have been run in an engine should NEVER be reused.

Note: Prior to final assembly it is the clearance of the new connecting rod bearings must be checked.

cardiagn.com

1. Place a length of fresh, room temperature plastic gauging material all the way across the connecting rod bearing journal.
2. Install the connecting rod bearing into the connecting rod cap.



Note: The connecting rod is non-directional therefore the connecting rod bearing lock tangs can face inboard or outboard.

3. Install the connecting rod end cap (1) on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the connecting rod.

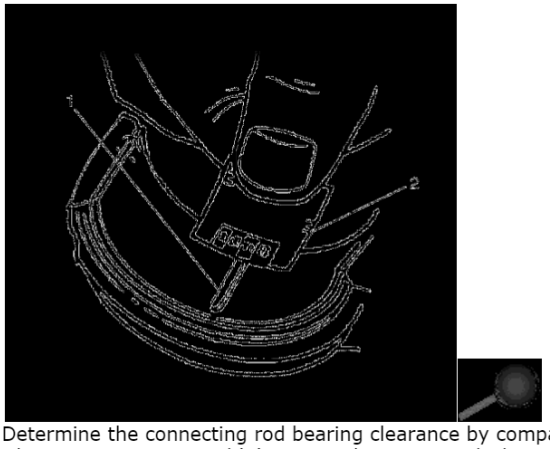
Caution: Refer to Fastener Caution.

Caution: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

Note: Reuse the old connecting rod bolts (2) ONLY for measuring the connecting rod bearing clearance.

4. Install the connecting rod bolts (2) into the connecting rod cap (1).
5. Tighten the connecting rod bolts (2).
   5.1. First Pass
   Tighten
   Tighten the bolts to 25 N•m (18 lb ft).
   5.2. Final Pass
   Tighten
   Tighten the bolts an additional 110 degrees using the *J 45059* angle meter.
6. Allow the assembly to sit for at least 2 minutes.
7. Remove the connecting rod cap bolts (2).
8. Remove the connecting rod cap (1).

cardiagn.com

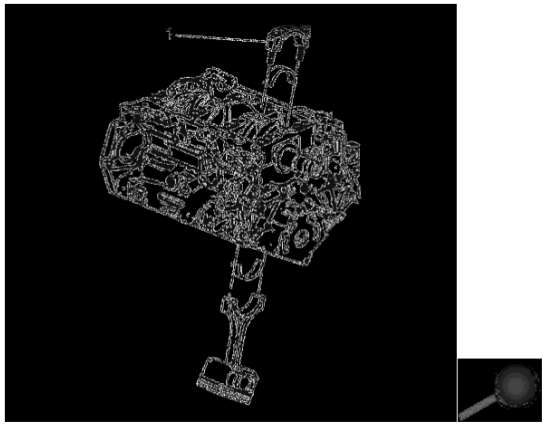


9. Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gauging material (1) at its widest point with the graduation on the gauging material container (2).
10. Compare your measurements with the engine mechanical specifications. Refer to Engine Mechanical Specifications. If the new bearings DO NOT provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
    10.1. Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the correct new bearings are being installed. If the crankshaft connecting rod journals are incorrectly sized, replace or regrind the crankshaft. Crankshaft machining is permitted and undersized bearings are available.
    10.2. Re-measure the connecting rod bearing bore diameter to ensure proper size. The connecting rod is not machinable and the connecting rod must be replaced if out of specification.
11. Clean the plastic gaging material from the connecting rod bearing journals using a soft lint -free cloth.

Connecting Rod Final Assembly Procedure

1. Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
2. Apply a liberal amount of clean engine oil to the crankshaft connecting rod bearing journal.
3. Guide the connecting rod to the crankshaft connecting rod journal.
4. Install the connecting rod end cap on its original connecting rod and ensure the bearing lock tangs are aligned on the same side of the rod.

cardiagn.com



Caution: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will effect the clamp load when the connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

5. Install the NEW connecting rod bolts into the connecting rod cap (1).
6. Tighten the connecting rod bolts.
   6.1. First Pass
   Tighten
   Tighten the bolts to 25 N•m (18 lb ft).
   6.2. Final Pass
   Tighten
   Tighten the bolts an additional 110 degrees using the *J 45059* angle meter.
7. During and after installation, ensure each piston is positioned properly in the correct cylinder. The locating arrow on the top of each piston must be pointing toward the front of the cylinder block.
8. Repeat these procedures for the remaining piston/connecting rod assemblies using the *EN 46111* crankshaft rotation socket in order to rotate the crankshaft.

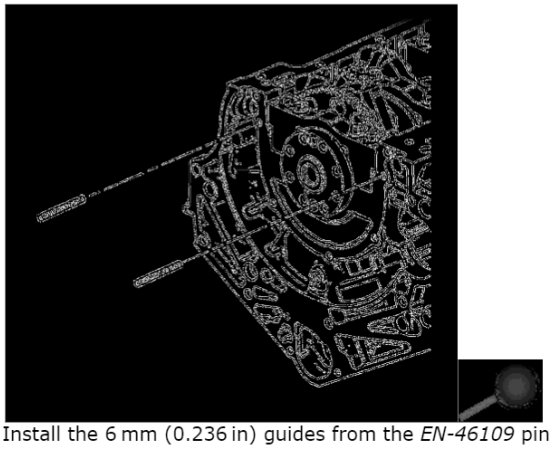
cardiagn.com

Crankshaft Rear Oil Seal and Housing Installation

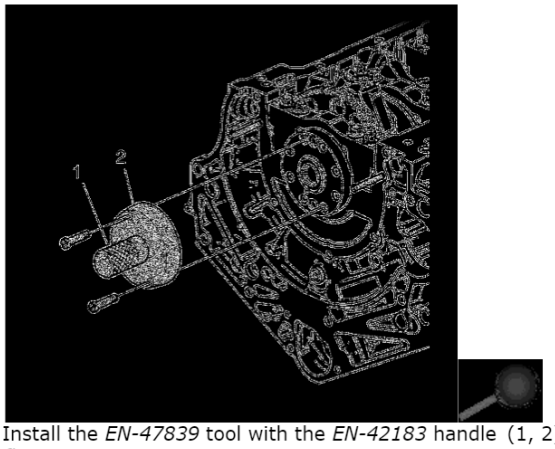
Special Tools

- *EN-42183* Handle
- *EN-46109* Guide Pin Set
- *EN-47839* Crankshaft Rear Oil Seal Installation Tool

For equivalent regional tools, refer to Special Tools.



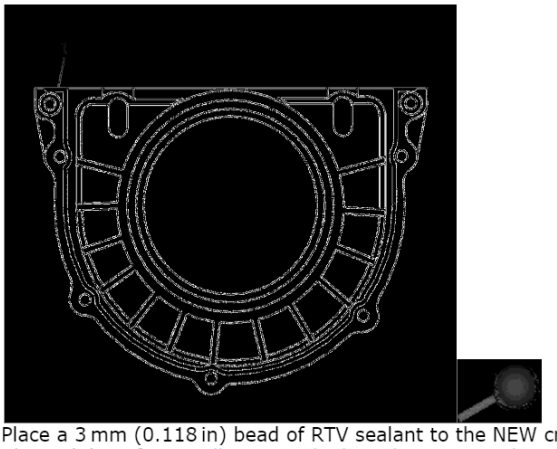
1. Install the 6 mm (0.236 in) guides from the *EN-46109* pin set into the 2 crankshaft rear oil seal housing corner bolt holes of the engine block.



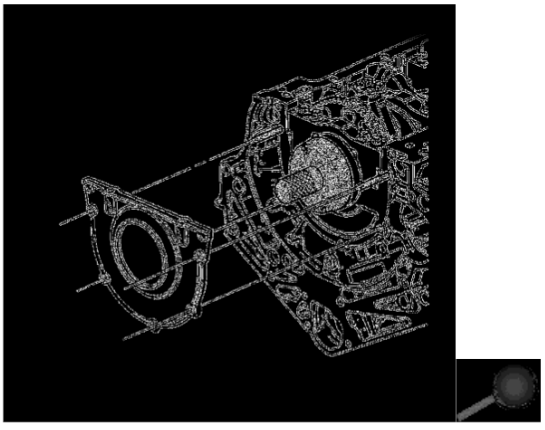
2. Install the *EN-47839* tool with the *EN-42183* handle (1, 2) onto the rear of the crankshaft flange.

cardiagn.com

© 2014 General Motors. All rights reserved.

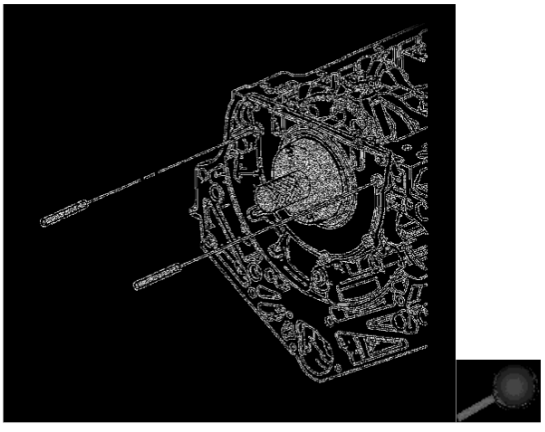


3. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.



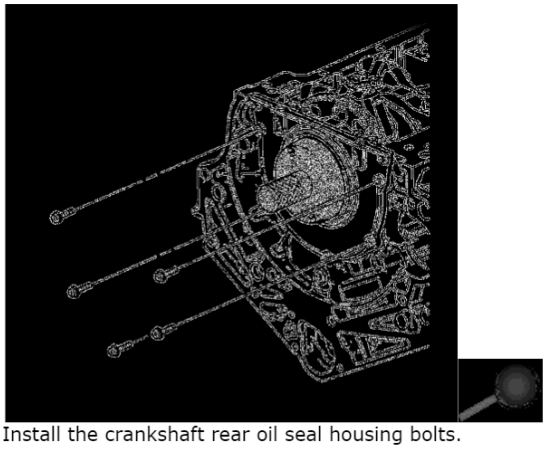
Note: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

4. Install the crankshaft rear oil seal housing to the engine block.

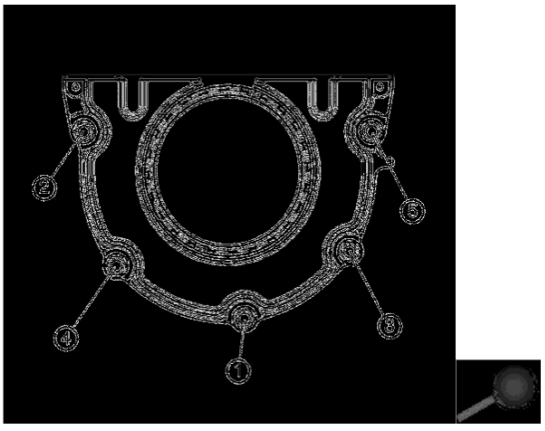


cardiagn.com

5. Remove the *EN-46109* pin set 6 mm (0.236 in) guides from the engine block.

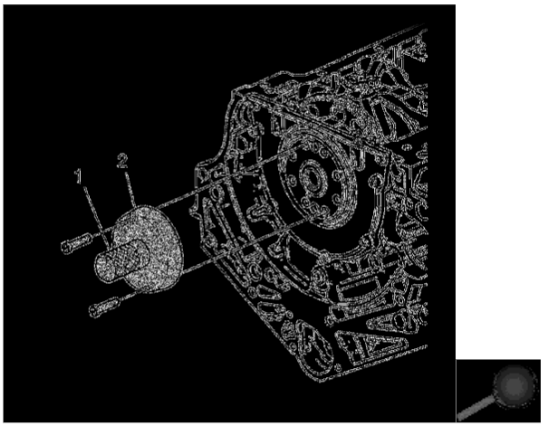


6. Install the crankshaft rear oil seal housing bolts.



Caution: Refer to Fastener Caution.

7. Tighten the crankshaft rear oil seal housing bolts in sequence and tighten to **10 N·m (89 lb in)**.

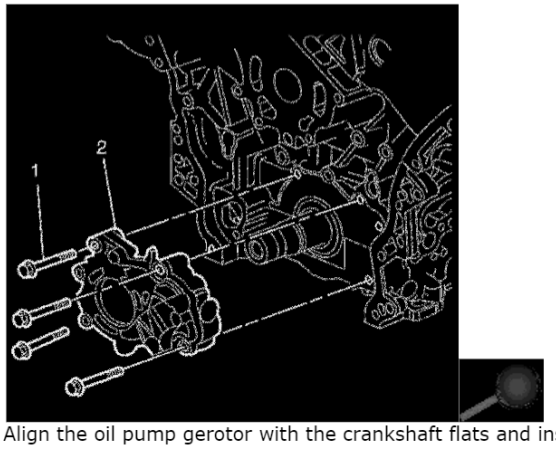


cardiagn.com

8. Remove the *EN-47839* tool and *EN-42183* handle (1, 2) from the crankshaft flange.

cardiagn.com

Oil Pump Installation



1. Align the oil pump gerotor with the crankshaft flats and install the oil pump (2).
2. Align the oil pump (2) body mounting holes.

   Caution: Refer to Fastener Caution.
3. Install the oil pump to cylinder block retaining bolts (1) and tighten to 23 N•m (17 lb ft).

cardiagn.com

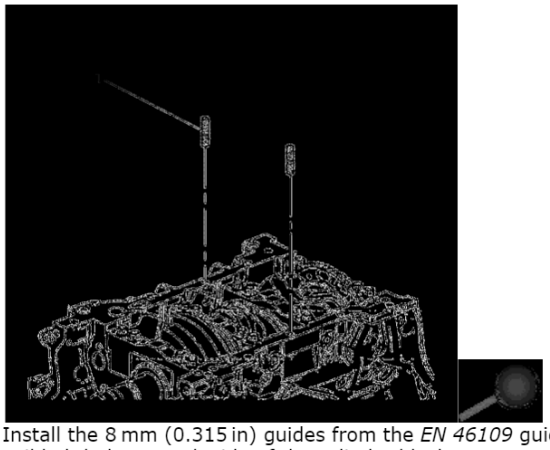
© 2014 General Motors. All rights reserved.

Oil Pan Installation

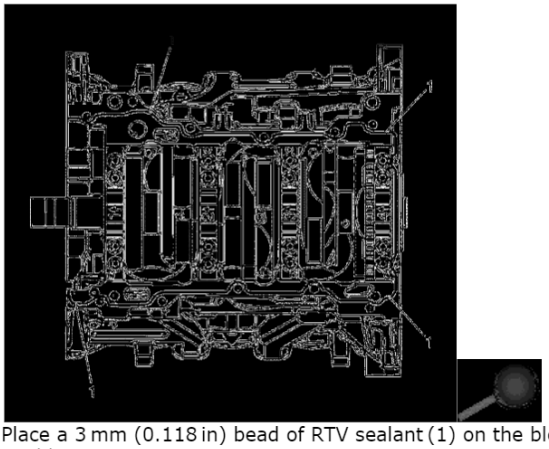
Special Tools

EN 46109 Guide Pin Set

For equivalent regional tools, refer to Special Tools.



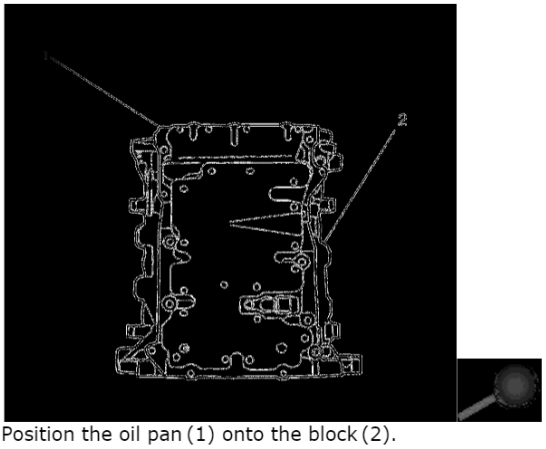
1. Install the 8 mm (0.315 in) guides from the *EN 46109* guide pin set (1) into the center oil pan rail bolt hole on each side of the cylinder block.



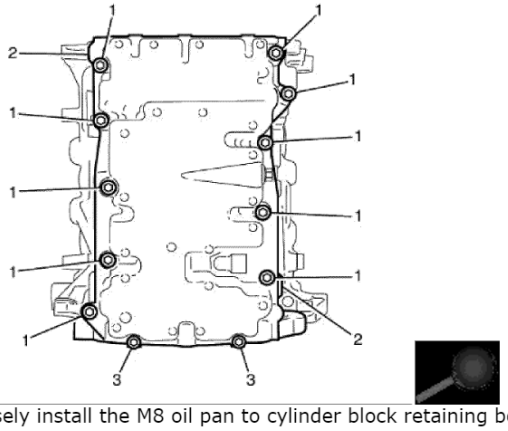
2. Place a 3 mm (0.118 in) bead of RTV sealant (1) on the block pan rail and the crankshaft rear oil seal housing.

cardiagn.com

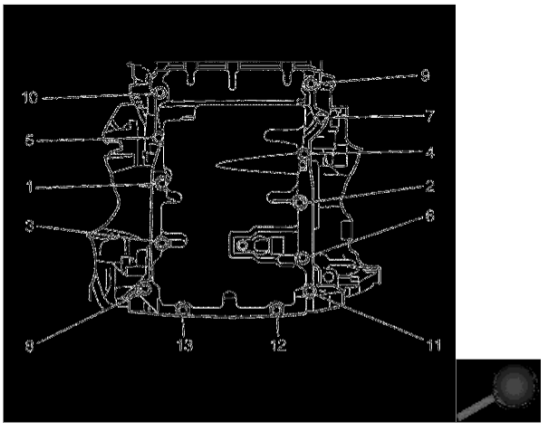
© 2014 General Motors. All rights reserved.



3. Position the oil pan (1) onto the block (2).
4. Remove the *EN 46109* guide pin set 8 mm (0.315 in) guides from the cylinder block.



5. Loosely install the M8 oil pan to cylinder block retaining bolts (1).
6. Loosely install the M6 oil pan to crankshaft rear oil seal housing retaining bolts (3).



Caution: Refer to Fastener Caution.

cardiagn.com

7. Install and tighten the M8 oil pan to cylinder block retaining bolts (1–11) and the M6 oil pan to crankshaft rear oil seal housing retaining bolts (12, 13) in the sequence shown.
   - Tighten the M8 bolts (1–11) to **22 N•m (16 lb ft)**.
   - Tighten the M6 bolts (12, 13) to **9 N•m (80 lb in)**.

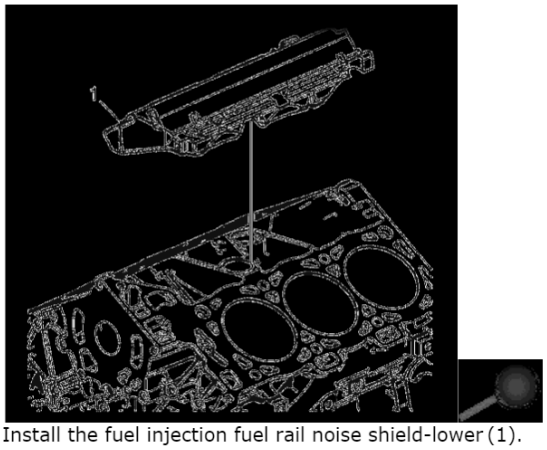
cardiagn.com

Cylinder Head Installation - Right Side (LFW or LFX)

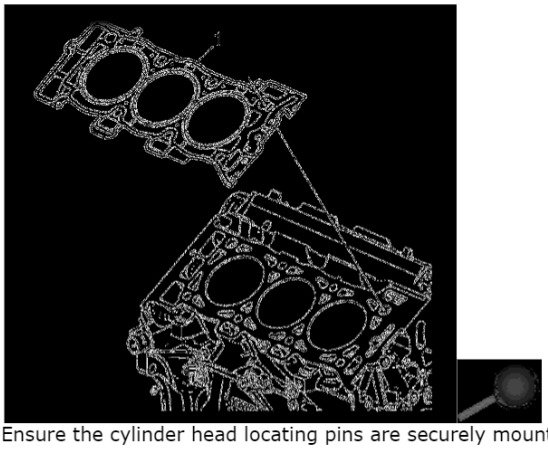
Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to Special Tools.



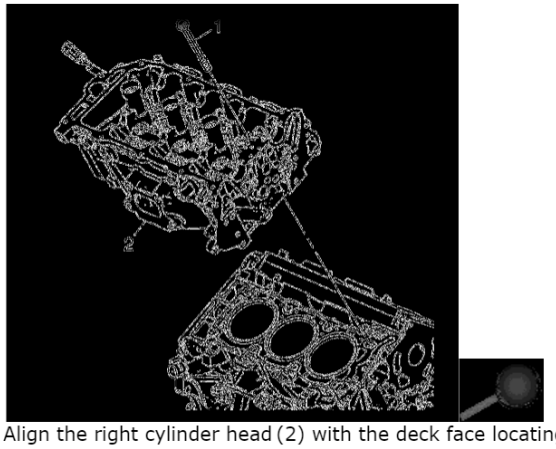
1. Install the fuel injection fuel rail noise shield-lower (1).



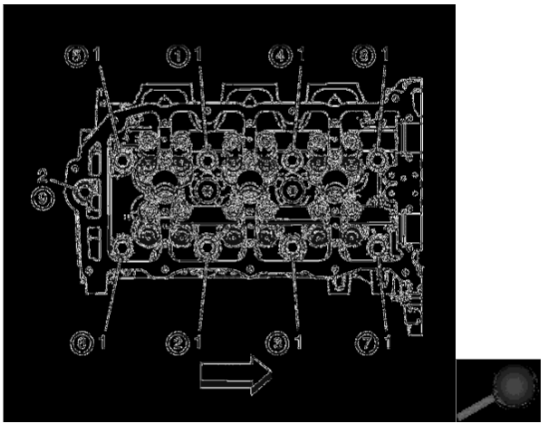
2. Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.
3. Install a NEW right cylinder head gasket (1) using the deck face locating pins for retention.

cardiagn.com

© 2014 General Motors. All rights reserved.



4. Align the right cylinder head (2) with the deck face locating pins.
5. Place the right cylinder head in position on the deck face.



Caution: Refer to Fastener Caution.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

Note: DO NOT allow oil on the cylinder head bolt bosses.

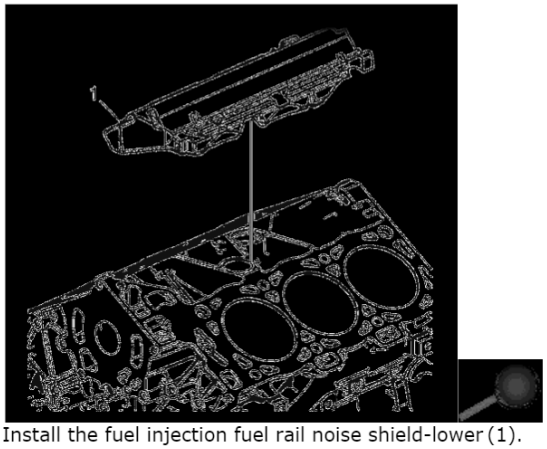
6. Install the NEW M11 cylinder head bolts (1).
   6.1. Tighten the M11 cylinder head bolts a first pass in sequence to **30 N•m (22 lb ft)**.
   6.2. Tighten the M11 cylinder head bolts a second pass in sequence an additional **150 degrees** using the *EN 45059* meter.
7. Install the NEW M8 cylinder head bolt (2).
   7.1. Tighten the M8 cylinder head bolt a first pass to **15 N•m (11 lb ft).**
   7.2. Tighten the M8 cylinder head bolt a second pass an additional **75 degrees** using the *EN 45059* meter.

cardiagn.com

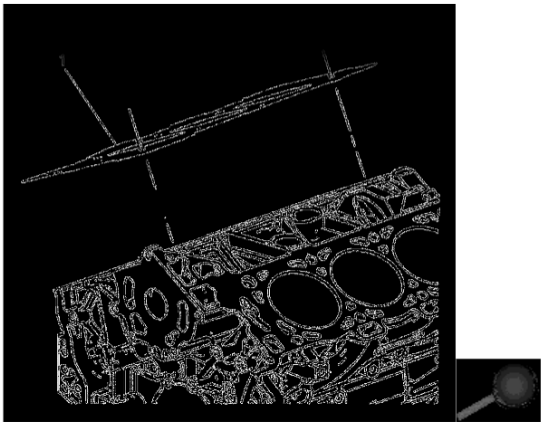
Cylinder Head Installation - Right Side (LWR)

Special Tools

- *EN-46111* Crankshaft Rotation Socket
- *J-45059* Angle Meter



1. Install the fuel injection fuel rail noise shield-lower (1).
2. Rotate the crankshaft using the *EN-46111* crankshaft rotation socket to the timing drive assembly position.
3. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.

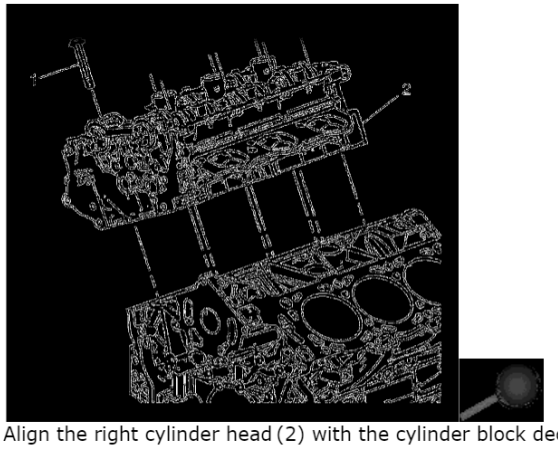


Note: Use the cylinder block deck face locating pins to retain the gasket to the deck face.

4. Install a NEW right cylinder head gasket (1) to the cylinder block deck face.

cardiagn.com

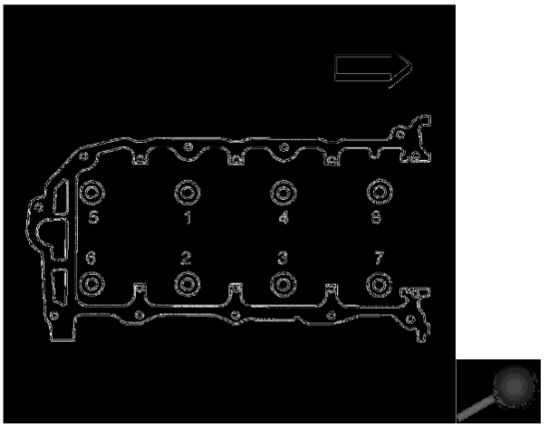
© 2014 General Motors. All rights reserved.



5. Align the right cylinder head (2) with the cylinder block deck face locating pins.
6. Place the right cylinder head (2) in position on the deck face.

   Note: Make sure the cylinder head bolts are dry before installation.

   Note: The cylinder head bolts are single use items and must be discarded after the cylinder head has been removed.
7. Install the NEW cylinder head to cylinder block retaining bolts (1).



   Caution: Refer to Fastener Caution.
8. Tighten the M11 cylinder head to cylinder block retaining bolts in the sequence shown above using the following method:
   - **First Pass**
     Tighten the M11 bolts 30 N•m (22 lb ft).
   - **Final Pass**
     Tighten the M11 bolts an additional 150 degrees using *J-45059* angle meter.

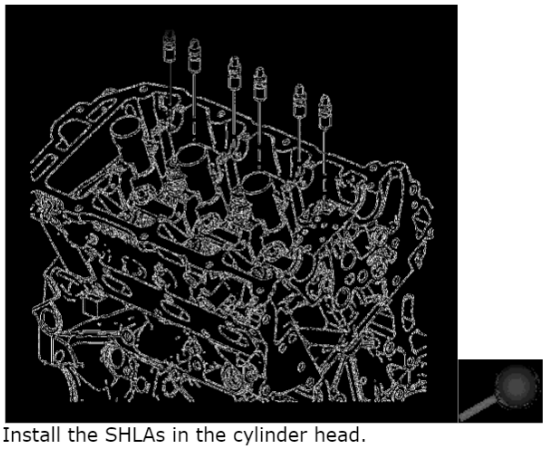
cardiagn.com

Valve Lifter Installation - Right Side

Note: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

Note: Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended engine oil. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended engine oil.

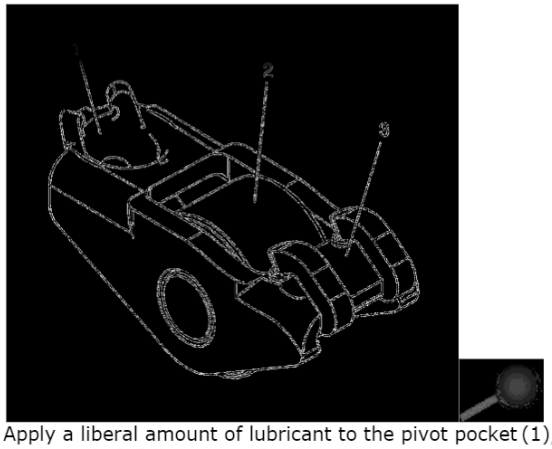


3. Install the SHLAs in the cylinder head.
4. Apply a liberal amount of lubricant to the SHLA pivot spheres. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

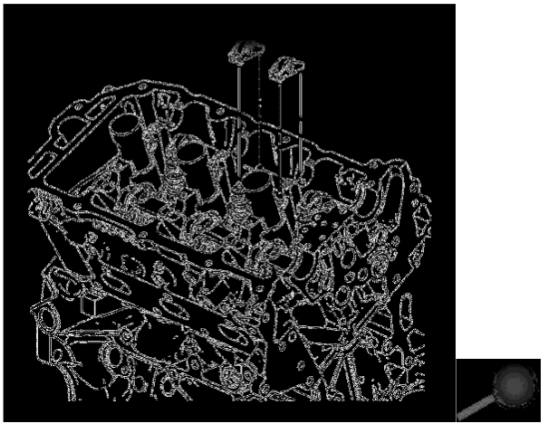
© 2014 General Motors. All rights reserved.

cardiagn.com

Valve Rocker Arm Installation - Right Side



1. Apply a liberal amount of lubricant to the pivot pocket (1), roller (2) and valve slot (3) areas of the camshaft followers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.



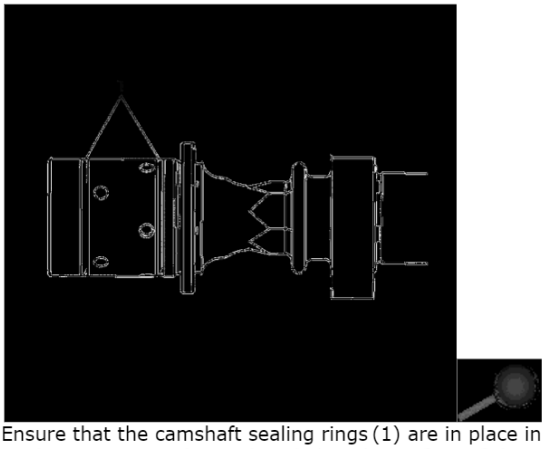
Note: The follower must be positioned squarely on the valve tip so that the full width of the roller will completely contact the camshaft lobe. If the followers are being reused you must put them back in their original location.

2. Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA).
3. The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip.
4. Clean the camshaft journals and carriers with a clean, lint-free cloth.

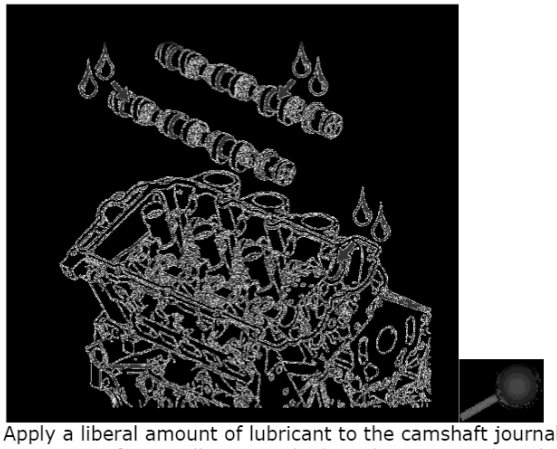
cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Installation - Right Side



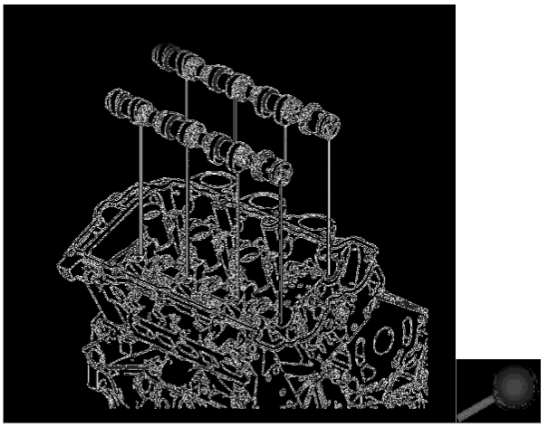
1. Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.



2. Apply a liberal amount of lubricant to the camshaft journals and the right cylinder head camshaft carriers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

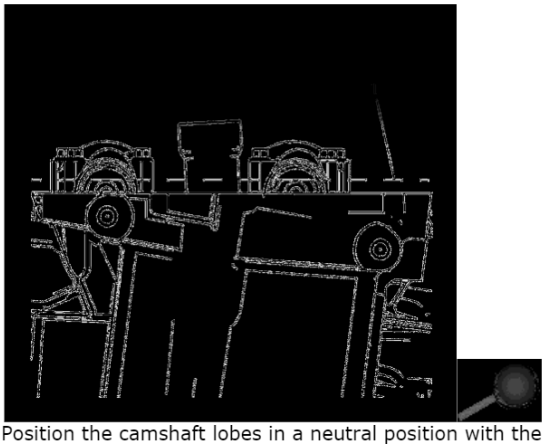
cardiagn.com

© 2014 General Motors. All rights reserved.

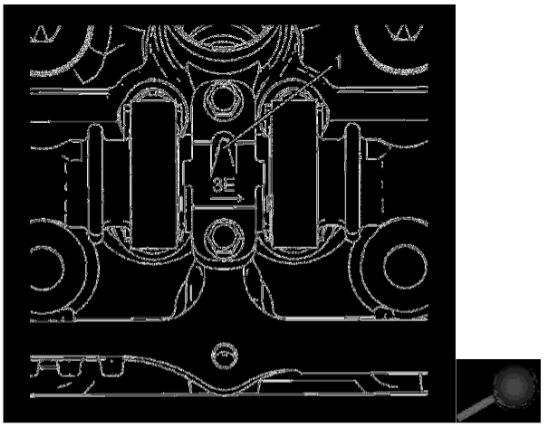


Note: The right intake camshaft has a laser inscription marking on the rear of the shaft to identify it as right bank intake (RI).

3. Place the right intake and right exhaust camshafts in position in the right cylinder head.

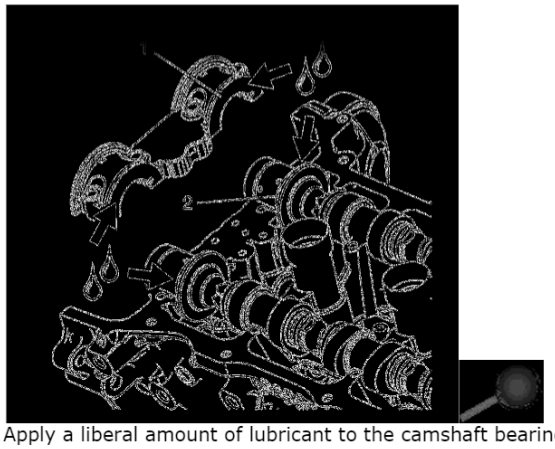


4. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the right cylinder head camshaft cover rail.

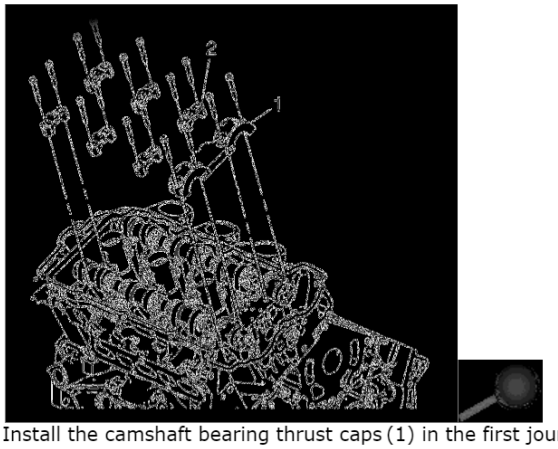


cardiagn.com

5. Observe the markings on the right cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature (1) must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 1, 3, 5 indicates the cylinder position from the front of the engine.
6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

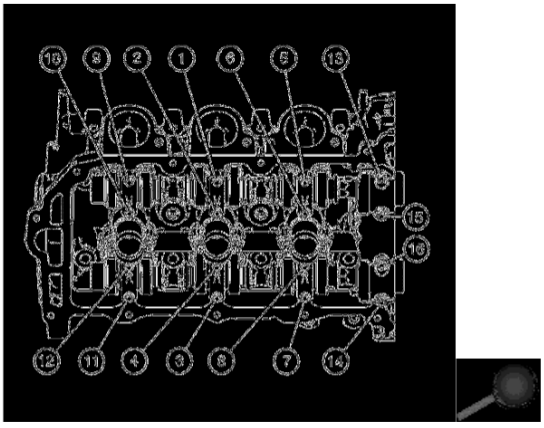


7. Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.



8. Install the camshaft bearing thrust caps (1) in the first journal of the right cylinder head.
9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.

cardiagn.com



Caution: Refer to Fastener Caution.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

11. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to **10 N•m (89 lb in)**.
12. Loosen the center intake camshaft bearing cap bolts (1, 2) and the center exhaust camshaft bearing cap bolts (3, 4).
13. Retighten the center camshaft bearing cap bolts (1, 2, 3, 4) and retighten the camshaft bearing cap bolts to **10 N•m (89 lb in)**.

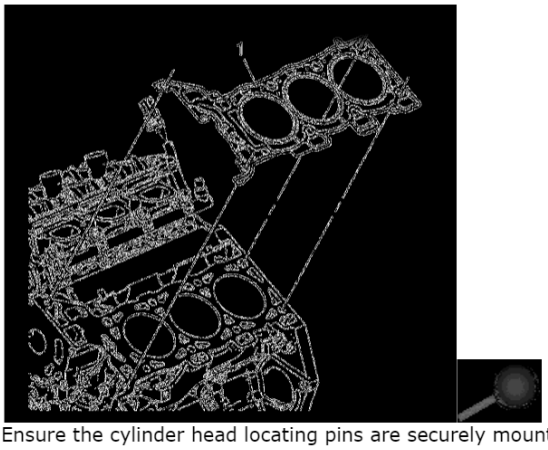
cardiagn.com

Cylinder Head Installation - Left Side (LFW or LFX)

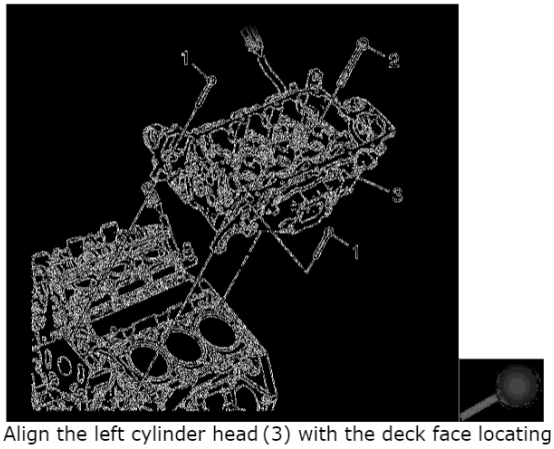
Special Tools

EN 45059 Angle Meter

For equivalent regional tools, refer to Special Tools.



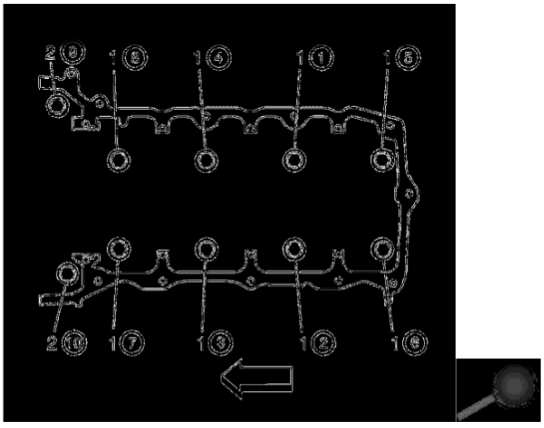
1. Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face.
2. Install a NEW left cylinder head gasket (1) using the deck face locating pins for retention.



3. Align the left cylinder head (3) with the deck face locating pins.
4. Place the left cylinder head in position on the deck face.

cardiagn.com

© 2014 General Motors. All rights reserved.



Caution: Refer to Fastener Caution.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

Note: DO NOT allow oil on the cylinder head bolt bosses.

5. Install the NEW M11 cylinder head bolts (1).
   5.1. Tighten the M11 cylinder head bolts a first pass in sequence to **30 N•m (22 lb ft)**.
   5.2. Tighten the M11 cylinder head bolts a second pass in sequence an additional **150 degrees** using the *EN 45059* meter.
6. Install the 2 NEW front M8 left cylinder head bolts (2).
   6.1. Tighten the M8 cylinder head bolts a first pass to **15 N•m (11 lb ft)**.
   6.2. Tighten the M8 cylinder head bolts a second pass in sequence an additional **75 degrees** using the *EN 45059* meter.

cardiagn.com

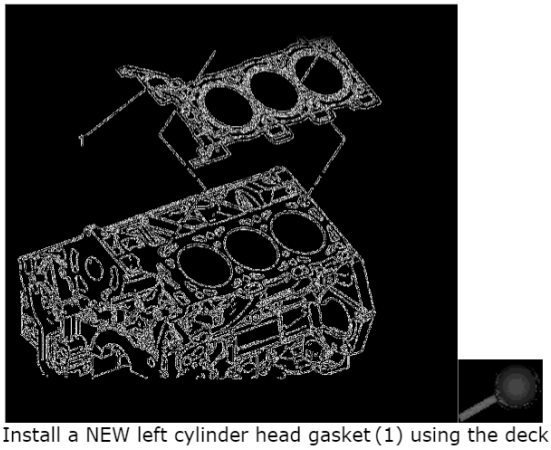
Cylinder Head Installation - Left Side (LWR)

Special Tools

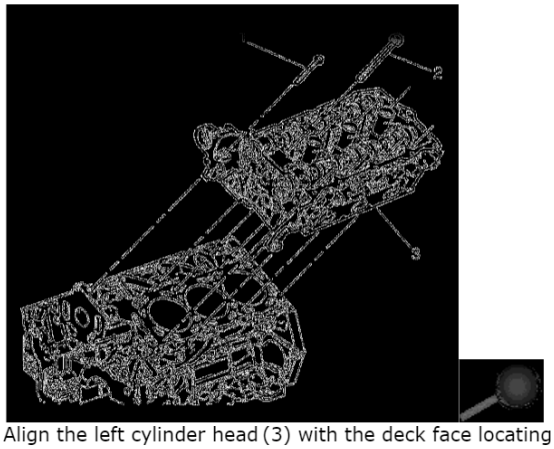
- *EN-46111* Crankshaft Rotation Socket
- *J-45059* Angle Meter

Note: Make sure that the crankshaft is in the timing drive assembly position using the crankshaft rotation socket *EN-46111* crankshaft rotation socket.

1. Make sure the cylinder head locating pins are securely mounted in the cylinder block deck face.



2. Install a NEW left cylinder head gasket (1) using the deck face locating pins for retention.



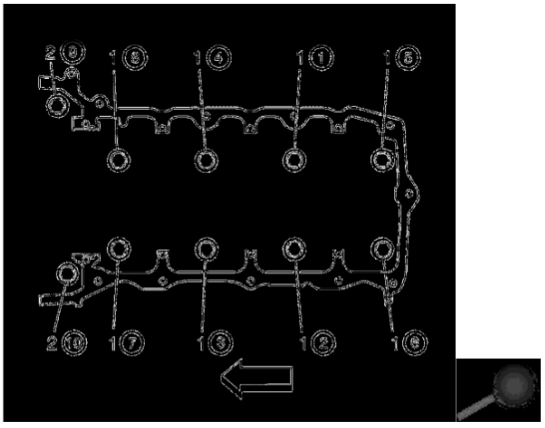
3. Align the left cylinder head (3) with the deck face locating pins.
4. Place the left cylinder head (3) in position on the deck face.

   Note: DO NOT allow oil on the cylinder head bolt bosses.

   Note: DO NOT reuse the old M11 cylinder head bolts.
5. Install the NEW M11 cylinder head to cylinder block retaining bolts (2).
6. Install the NEW M8 front cylinder head to cylinder block retaining bolts (1).

cardiagn.com

© 2014 General Motors. All rights reserved.



Caution: Refer to Fastener Caution

7. Tighten the cylinder head to cylinder block retaining bolts (1 and 2) in the sequence shown.
   Tighten
   Tighten the M11 cylinder head to cylinder block retaining bolts (1) a first pass in sequence to 30 N•m (22 lb ft).
   Tighten the M11 cylinder head to cylinder block retaining bolts (1) a final pass in sequence an additional 150 degrees using the *J–45059* angle meter.
8. Install the front M8 left cylinder head to cylinder block retaining bolts (2).
   Tighten
   Tighten the M8 cylinder head to cylinder block retaining bolts (2) a first pass to 15 N•m (11 lb ft).
   Tighten the M8 cylinder head to cylinder block retaining bolts (2) a final pass in sequence an additional 75 degrees using the *J–45059* angle meter.

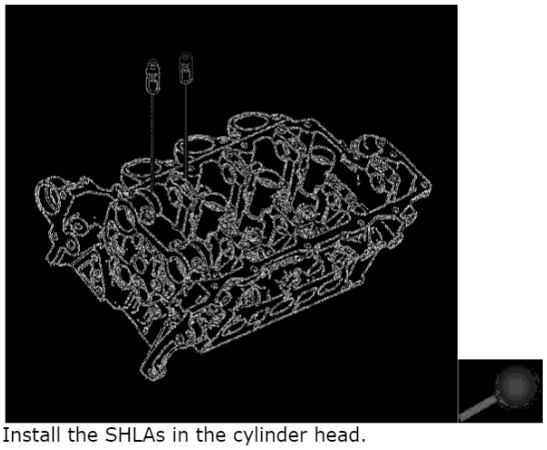
cardiagn.com

Valve Lifter Installation - Left Side

Note: Do not stroke/cycle the stationary hydraulic lash adjuster plunger without oil in the lower pressure chamber.

Note: Do not allow the stationary hydraulic lash adjuster to tip over, plunger down, after the oil fill.

1. Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant. Take precautions to prevent scratching the pivot sphere area (1) of the SHLA.
2. Lubricate the SHLA bores in the cylinder head with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

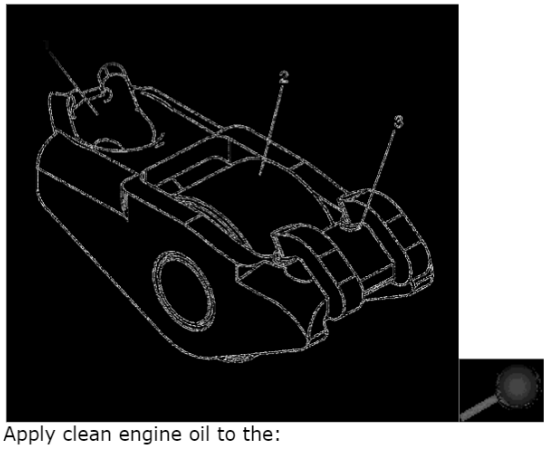


3. Install the SHLAs in the cylinder head.
4. Apply a liberal amount of lubricant to the SHLA pivot spheres. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

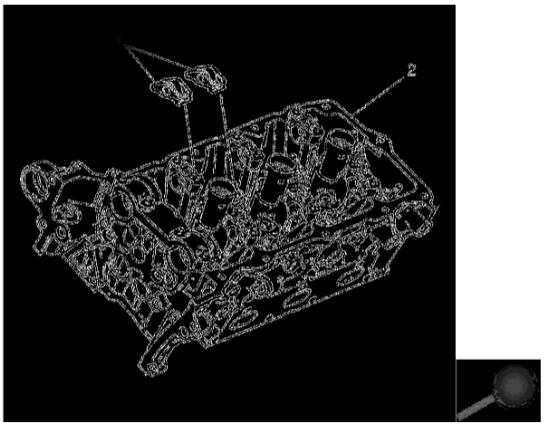
cardiagn.com

© 2014 General Motors. All rights reserved.

Valve Rocker Arm Installation - Left Side



1. Apply clean engine oil to the:
   - pivot pocket (1)
   - roller (2)
   - valve slot (3)



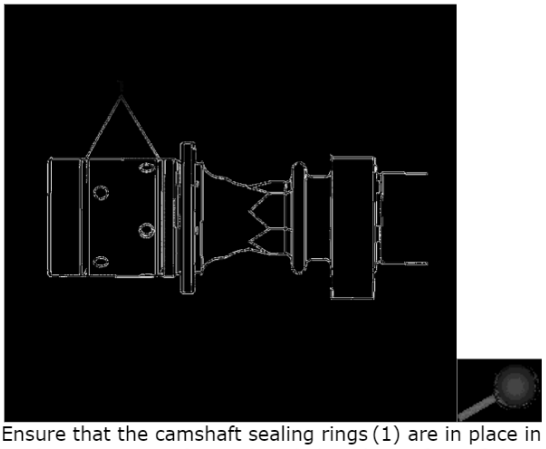
Note: If the valve rocker arms (1) are being reused it must be replaced in its original positions.

2. Place the valve rocker arms (1) in position on the valve stem and stationary hydraulic lash adjuster (SHLA).
3. Clean the camshaft journals and carriers with a clean, lint-free cloth.

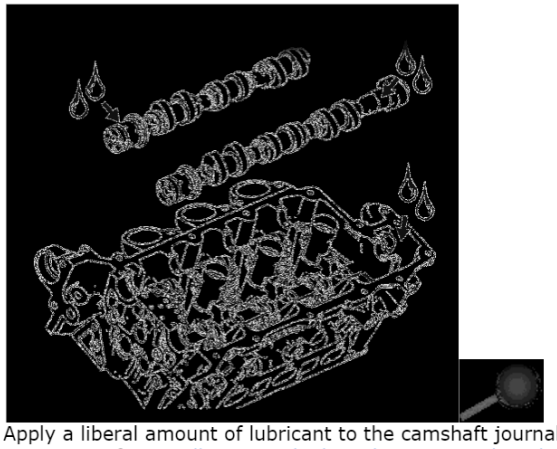
cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Installation - Left Side



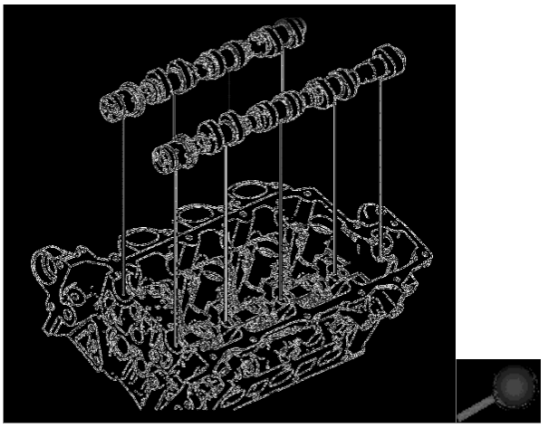
1. Ensure that the camshaft sealing rings (1) are in place in the camshaft grooves. Camshaft sealing rings must be in place below the surface of the camshaft journal in order to avoid being pinched between the cylinder head and the camshaft caps.



2. Apply a liberal amount of lubricant to the camshaft journals and the left cylinder head camshaft carriers. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

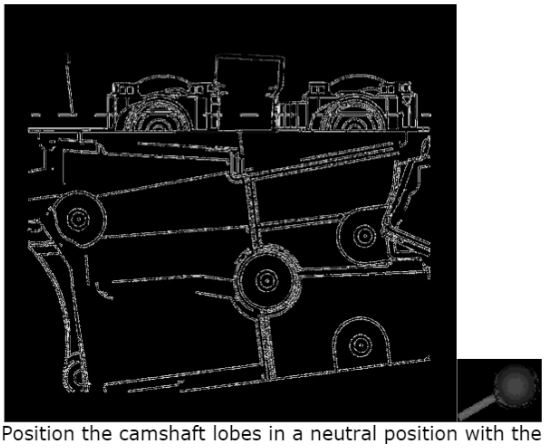
cardiagn.com

© 2014 General Motors. All rights reserved.



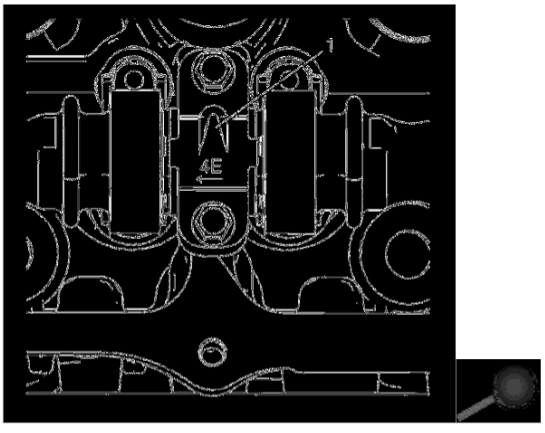
Note: The left intake camshaft has a laser inscription marking on the rear of the shaft to identify it as left bank intake (LI).

3. Place the left intake and left exhaust camshafts in position in the left cylinder head.

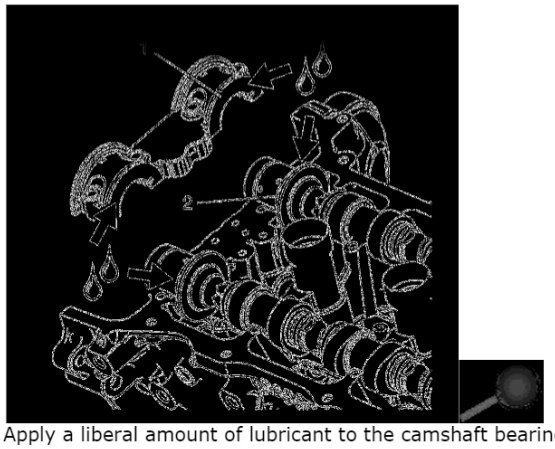


cardiagn.com

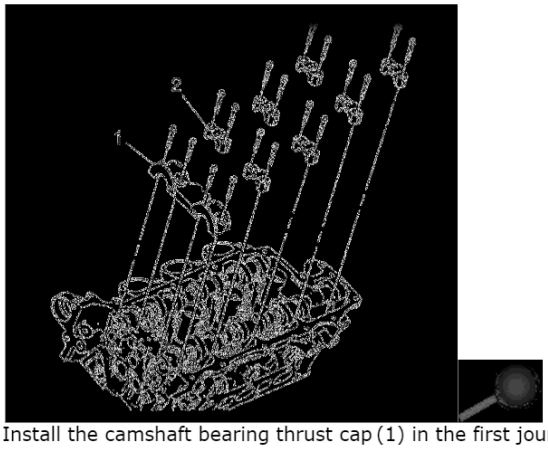
4. Position the camshaft lobes in a neutral position with the flats on the back of the camshafts up and parallel (1) with the left cylinder head camshaft cover rail.



5. Observe the markings on the left cylinder head camshaft bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings:
   - The raised feature (1) must always be oriented toward the center of the cylinder head.
   - The I indicates the intake camshaft.
   - The E indicates the exhaust camshaft.
   - The number 2, 4, 6 indicates the cylinder position from the front of the engine.
6. Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

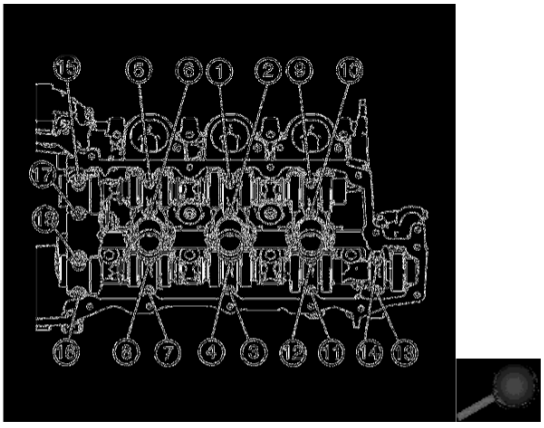


7. Apply a liberal amount of lubricant to the camshaft bearing cap (1) and camshaft thrust surface (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.



8. Install the camshaft bearing thrust cap (1) in the first journal of the left cylinder head.
9. Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
10. Hand start all the camshaft bearing cap bolts.

cardiagn.com

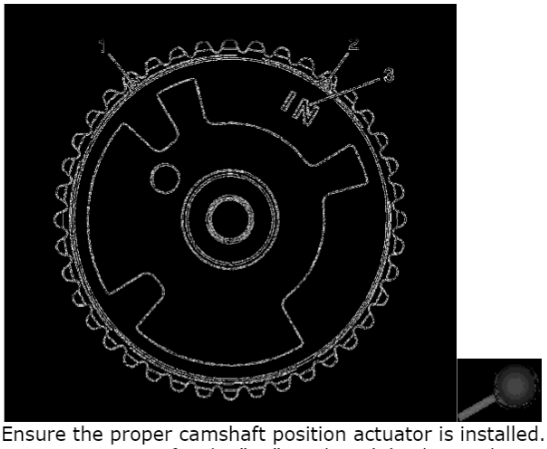


Caution: Refer to Fastener Caution.

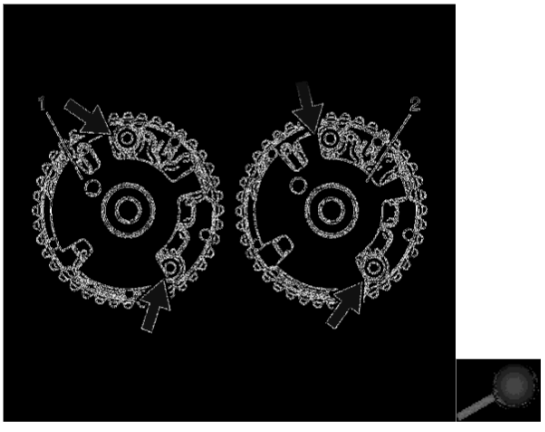
11. Tighten the camshaft bearing cap bolts in the sequence shown and tighten to **10 N·m (89 lb in)**.
12. Loosen the center intake camshaft bearing cap bolts 1, 2 and the center exhaust camshaft bearing cap bolts 3, 4.
13. Retighten the center camshaft bearing cap bolts 1, 2, 3, 4 and retighten the camshaft bearing cap bolts to **10 N·m (89 lb in)**.

cardiagn.com

Camshaft Position Actuator Installation - Right Side Intake



1. Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (3). The marking is for an intake camshaft position actuator.

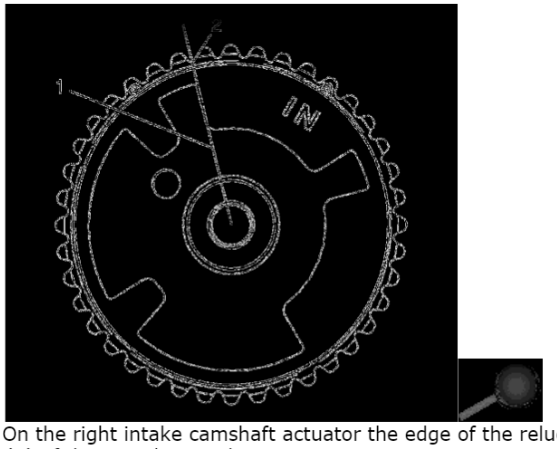


Caution: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

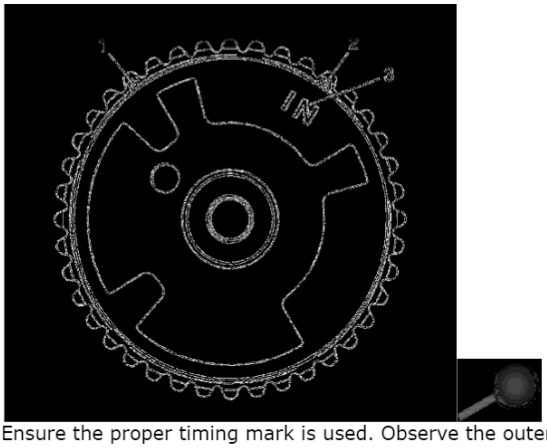
2. Ensure the proper camshaft position actuator is being installed. The reluctor wheel on the right intake camshaft position actuator (1) is indexed in a different position compared to the left intake camshaft position actuator (2).

cardiagn.com

© 2014 General Motors. All rights reserved.



3. On the right intake camshaft actuator the edge of the reluctor wheel (1) lines up with the valley (2) of the sprocket tooth.

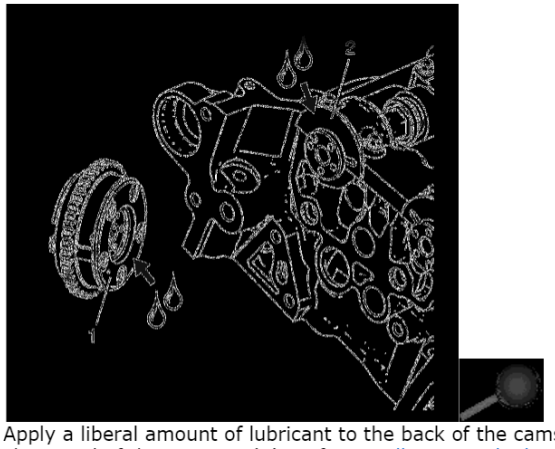


4. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the triangle marking (2). The triangle marking is for alignment to the highlighted timing chain link on the right side of the engine.

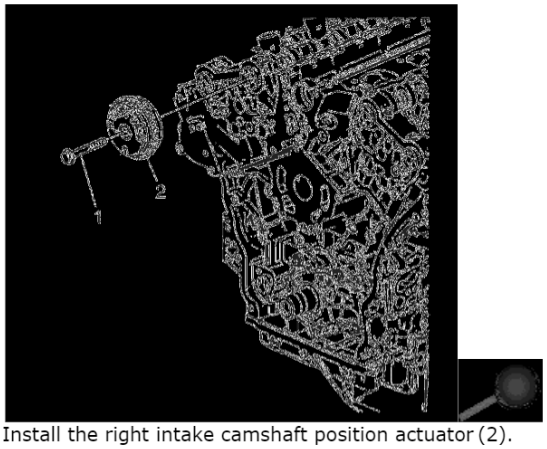
   Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

5. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.

cardiagn.com



6. Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

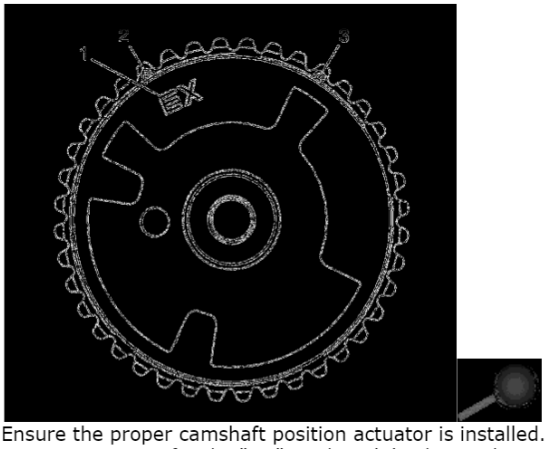


7. Install the right intake camshaft position actuator (2).

   Caution: Refer to Fastener Caution.
8. Install the camshaft position actuator bolt (1) and tighten to **58 N·m (43 lb ft)**.

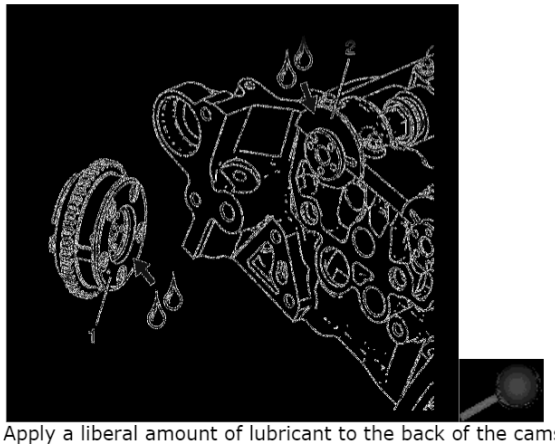
cardiagn.com

Camshaft Position Actuator Installation - Right Side Exhaust



1. Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.
2. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the triangle marking (2). The marking is for alignment to the highlighted timing chain link on the right side of the engine.

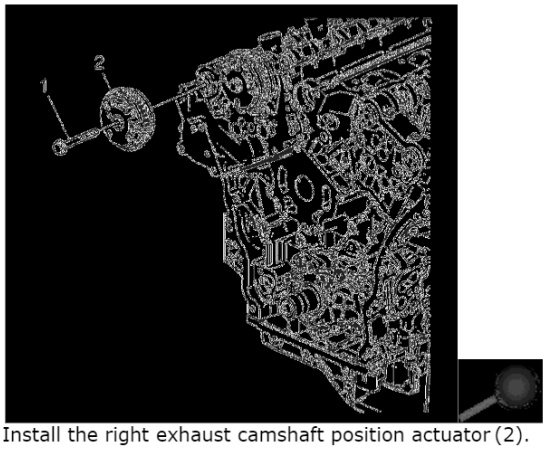
   Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.
3. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.



4. Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

cardiagn.com

© 2014 General Motors. All rights reserved.

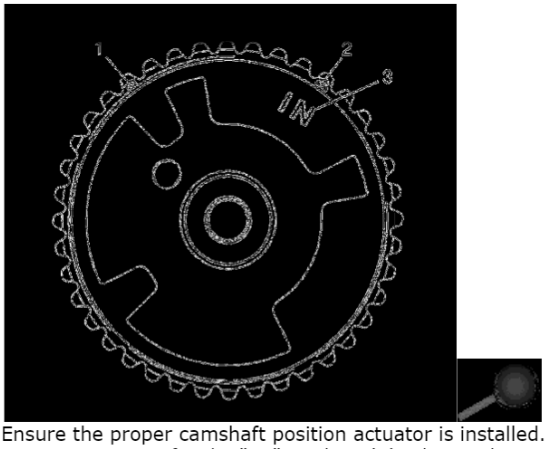


5. Install the right exhaust camshaft position actuator (2).

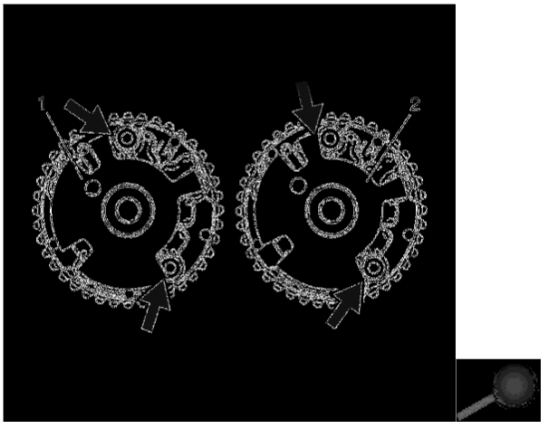
   Caution: Refer to Fastener Caution.
6. Install the camshaft position actuator bolt (1) and tighten to **58 N•m (43 lb ft)**.

cardiagn.com

Camshaft Position Actuator Installation - Left Side Intake



1. Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "IN" marking (3). The marking is for an intake camshaft position actuator.

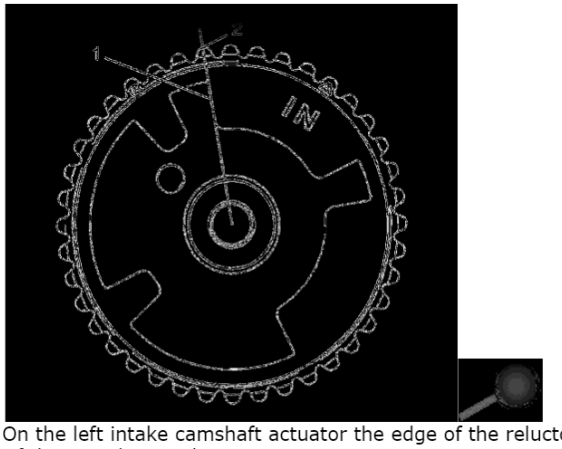


Caution: Ensure the proper camshaft position actuator is installed in the correct position. Failure to install the proper camshaft position actuator can effect engine performance and set an engine code.

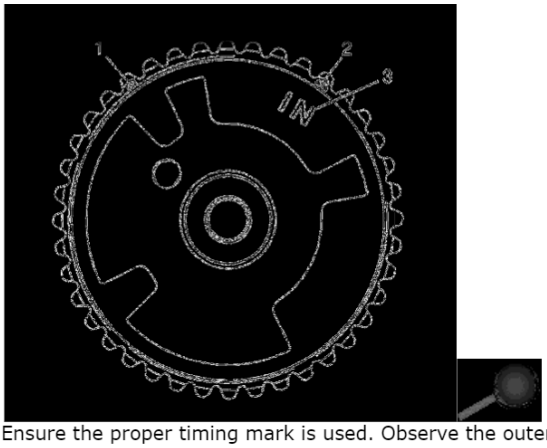
2. Ensure the proper camshaft position actuator is being installed. The reluctor wheel on the right intake camshaft position actuator (1) is indexed in a different position compared to the left intake camshaft position actuator (2).

cardiagn.com

© 2014 General Motors. All rights reserved.



3. On the left intake camshaft actuator the edge of the reluctor wheel (1) lines up with the peak (2) of the sprocket tooth.

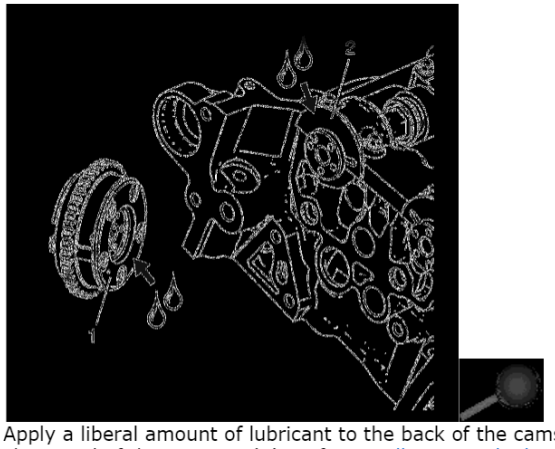


4. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the circle marking (1). The circle marking is for alignment to the highlighted timing chain link on the left side of the engine.

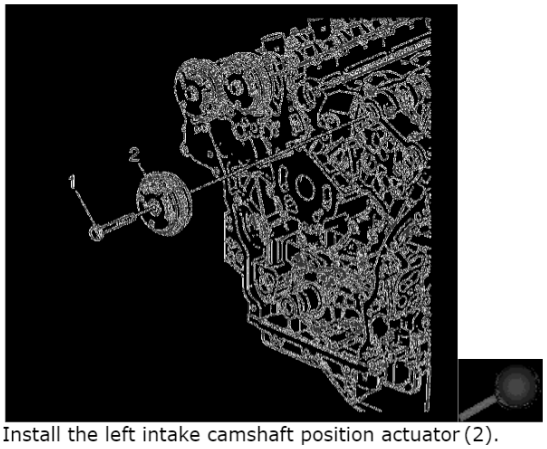
   Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.

5. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.

cardiagn.com



6. Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

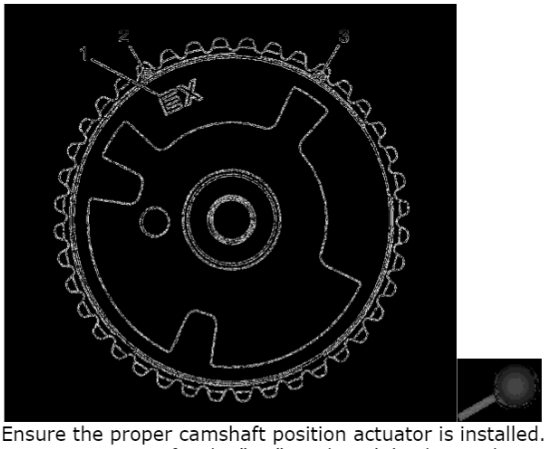


7. Install the left intake camshaft position actuator (2).

   Caution: Refer to Fastener Caution.
8. Install the camshaft position actuator bolt (1) and tighten to **58 N·m (43 lb ft)**.

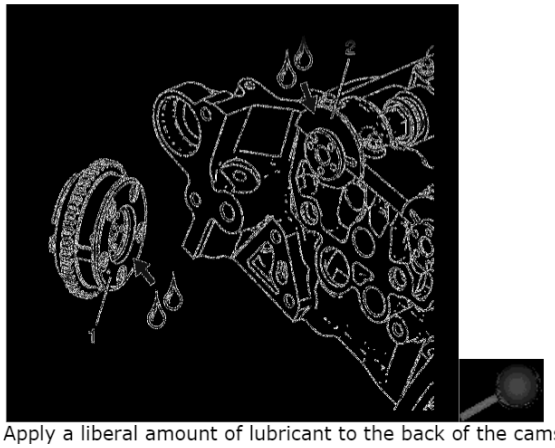
cardiagn.com

Camshaft Position Actuator Installation - Left Side Exhaust



1. Ensure the proper camshaft position actuator is installed. Observe the body of the camshaft position actuator for the "EX" marking (1). The marking is for an exhaust camshaft position actuator.
2. Ensure the proper timing mark is used. Observe the outer ring of the camshaft position actuator for the circle marking (3). The marking is for alignment to the highlighted timing chain link on the left side of the engine.

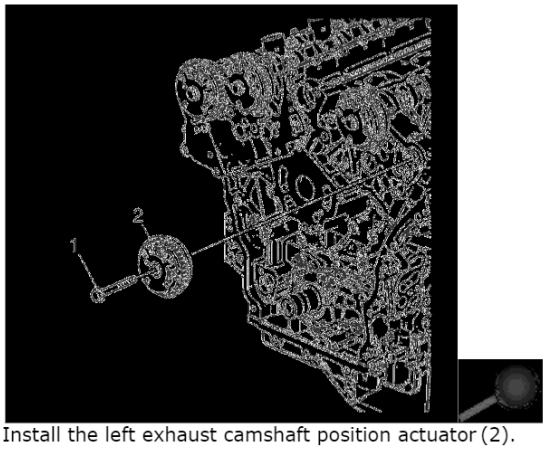
   Caution: Refer to Torque Reaction Against Timing Drive Chain Caution.
3. Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.



4. Apply a liberal amount of lubricant to the back of the camshaft position actuator (1) and front of the camshaft bearing cap (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

cardiagn.com

© 2014 General Motors. All rights reserved.



5. Install the left exhaust camshaft position actuator (2).

   Caution: Refer to Fastener Caution.
6. Install the camshaft position actuator bolt (1) and tighten to **58 N•m (43 lb ft)**.

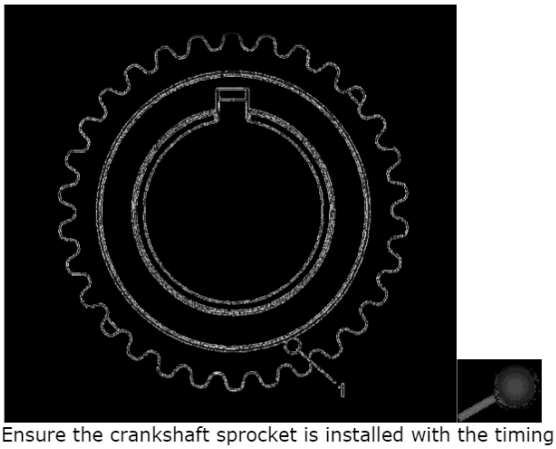
cardiagn.com

Crankshaft Sprocket Installation

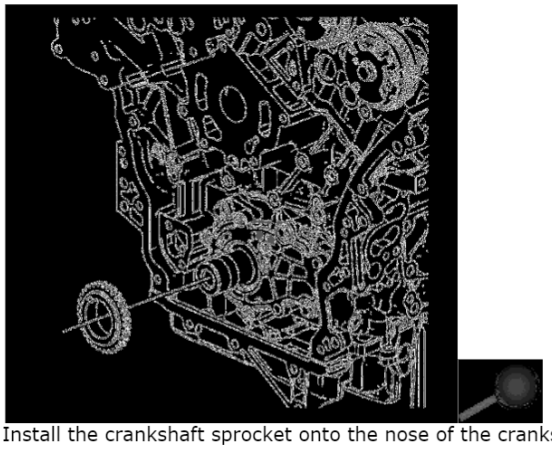
Special Tools

EN-48589 Crankshaft Rotation Socket

For equivalent regional tools, refer to Special Tools.



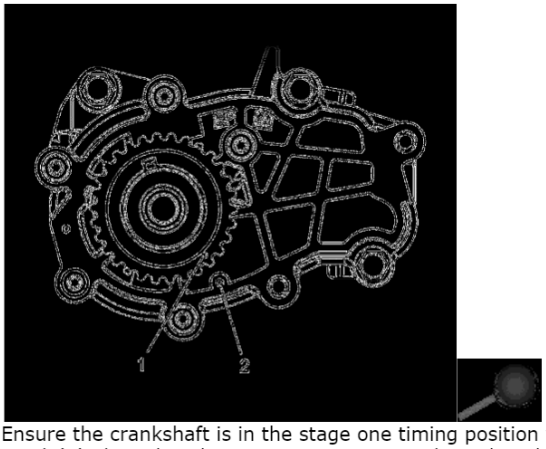
1. Ensure the crankshaft sprocket is installed with the timing mark (1) visible.



2. Install the crankshaft sprocket onto the nose of the crankshaft.
3. Align the notch in the crankshaft sprocket with the pin in the crankshaft.
4. Slide the crankshaft sprocket on the crankshaft nose until the crankshaft sprocket contacts the step in the crankshaft.

cardiagn.com

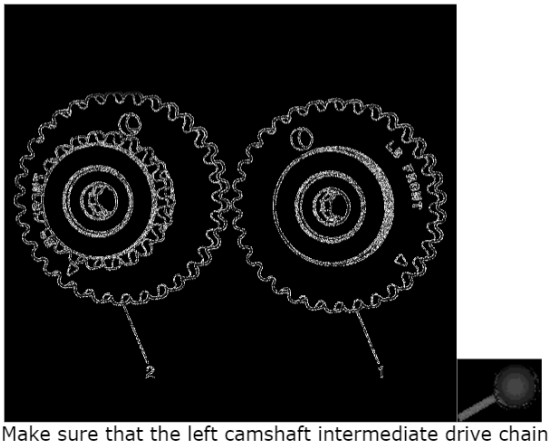
© 2014 General Motors. All rights reserved.



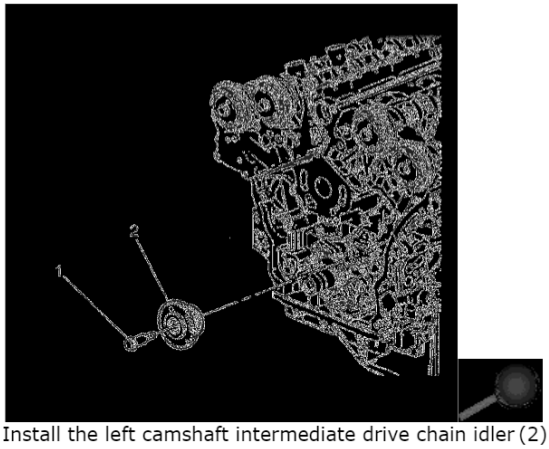
5. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (1) aligned to the stage one timing mark on the oil pump cover (2) using the *EN-48589* socket . Refer to Timing Chain Alignment Diagram.

cardiagn.com

Timing Chain Idler Sprocket Installation - Left Side



1. Make sure that the left camshaft intermediate drive chain idler (1) is being installed. The recessed hub (2) and the larger sprocket of the left camshaft intermediate drive chain idler is installed outward. The raised hub and the smaller sprocket of the left camshaft intermediate drive chain idler is installed towards the cylinder block.



2. Install the left camshaft intermediate drive chain idler (2).

   Caution: Refer to Fastener Caution.
3. Install the camshaft intermediate drive chain idler to cylinder block retaining bolt (1) and tighten to **58 N•m (43 lb ft)**.

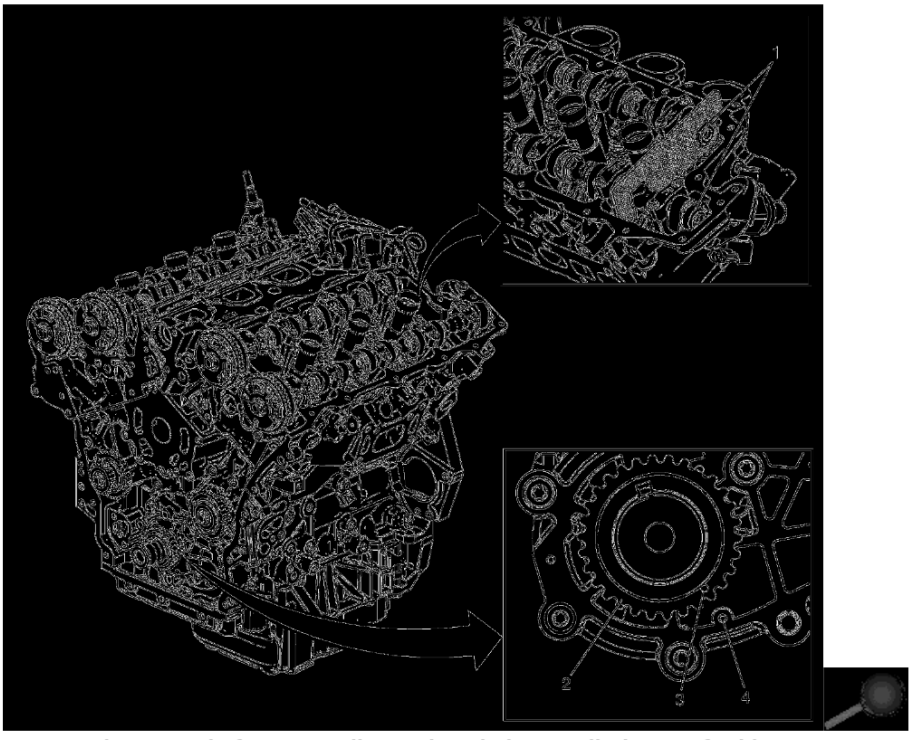
cardiagn.com

© 2014 General Motors. All rights reserved.

Camshaft Timing Chain Components Installation

Table 1: Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 1
Table 2: Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2
Table 3: Secondary Camshaft Drive Chain Guide and Shoe Installation - Left
Table 4: Secondary Camshaft Drive Chain Tensioner Installation - Left Side
Table 5: Primary Camshaft Intermediate Drive Chain Installation
Table 6: Primary Timing Chain Guide Installation - Lower and Upper
Table 7: Primary Camshaft Intermediate Drive Chain Tensioner Installation
Table 8: Stage 1 Alignment Position to the Stage 2 Alignment Position
Table 9: Secondary Camshaft Intermediate Drive Chain Installation - Right Side
Table 10: Secondary Camshaft Drive Chain Guide and Shoe Installation - Right Side
Table 11: Secondary Camshaft Drive Chain Tensioner Installation - Right Side

Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 1



Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 1

Callout	Component Name

Note: If you are performing this procedure for the first time, it is recommended that you view video 56510.12V from the common training website before beginning (U.S.

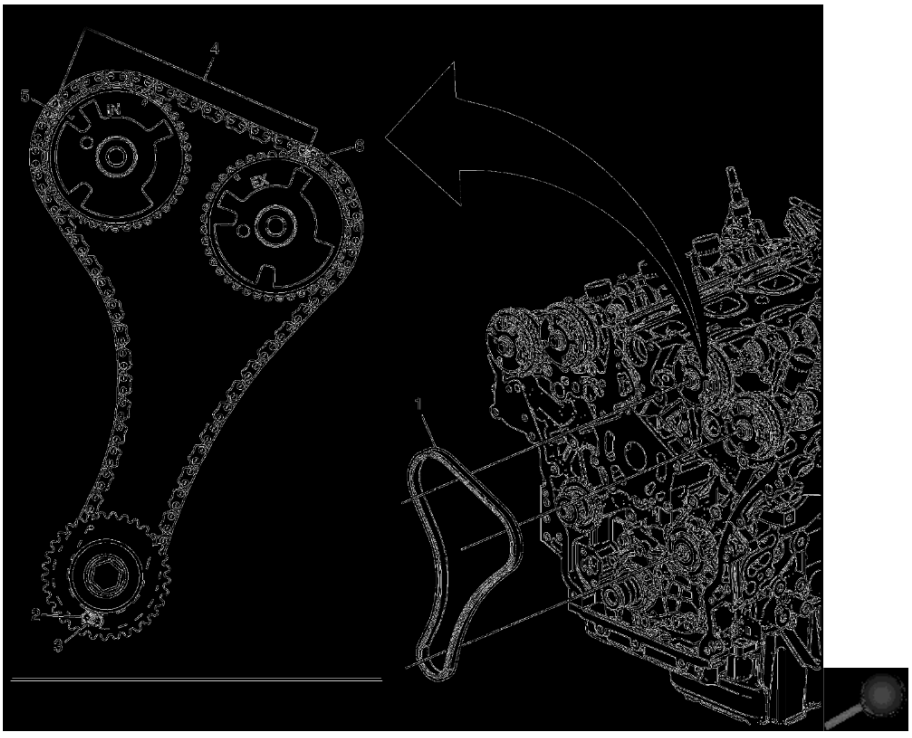
© 2014 General Motors. All rights reserved.

cardiagn.com

Callout	Component Name
	Dealers Only). To search for the video number, click on the catalog icon on the home page. Canadian dealers should view Tech Assist video 16038.01W on the LMS website and a related video on GM Global Connect (Library-Service>Technician Review>TAC Talk Video Help). See https://www.centerlearning.com/HomePage/Portal.asp for more information.
1	Left Intake and Exhaust Camshaft **Procedure** **Note:** ◦ There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the *EN-48383* retaining tools . ◦ All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the *EN-48383–1* retaining tool onto the rear of the left camshafts. 2. Ensure the *EN-48383–1* retaining tool is fully seated onto the camshafts. **Special Tools** *EN-48383* Camshaft Retaining Tools For equivalent regional tools, refer to Special Tools.
2	Crankshaft Sprocket **Note:** Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark (3) aligned to the stage one timing mark on the oil pump cover (4) using the *EN-48589* socket. Refer to Timing Chain Alignment Diagram. **Special Tools** *EN-48589* Crankshaft Rotation Socket For equivalent regional tools, refer to Special Tools.
3	Crankshaft Sprocket Timing Mark
4	Stage One Timing Mark On The Oil Pump Cover

cardiagn.com

Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2



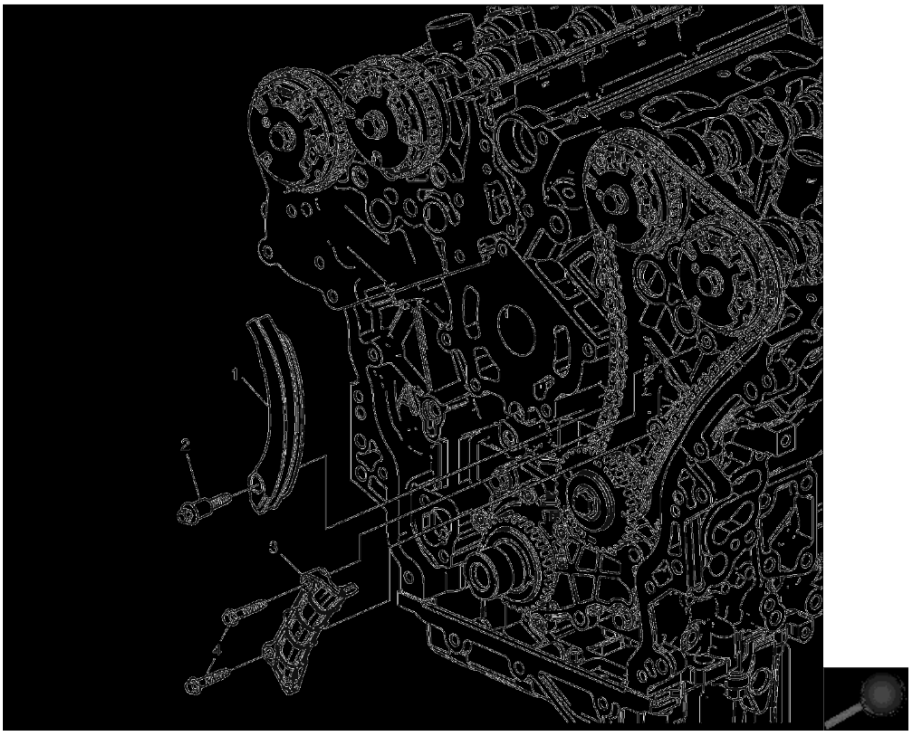
Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2

Callout	Component Name
Note: Ensure that the left (L) camshaft position actuator sprocket alignment circle marks are used during this step.	
1	Left Secondary Camshaft Drive Chain **Procedure** **Note:** Once the lower timing link is aligned, it may be helpful to hold the drive chain in position using a small flat blade screwdriver through the idler sprocket alignment access hole. 1. Place the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler with the camshaft drive chain timing link (2) aligned to the alignment access hole (3) in the left camshaft intermediate drive chain idler outer sprocket. 2. Wrap the secondary camshaft drive chain around both left (L) actuator drive sprockets. 3. Align the left (L) intake camshaft position actuator sprocket alignment circle mark (5) with the camshaft drive chain timing link. 4. Align the left (L) exhaust camshaft position actuator sprocket alignment circle mark (6) with the camshaft drive chain timing link. 5. Once aligned, ensure there are 10 chain links (4) between timing marks for the left (L) camshaft position actuator sprockets.

cardiagn.com

Callout	Component Name
2	Timing Camshaft Drive Chain
3	Alignment Access Hole
4	10 Chain Links Between Timing Marks for the Left (L) Camshaft Position Actuator Sprockets
5	Left (L) Intake Camshaft Position Actuator Sprocket Alignment Circle Mark
6	Left (L) Exhaust Camshaft Position Actuator Sprocket Alignment Circle Mark

Secondary Camshaft Drive Chain Guide and Shoe Installation - Left



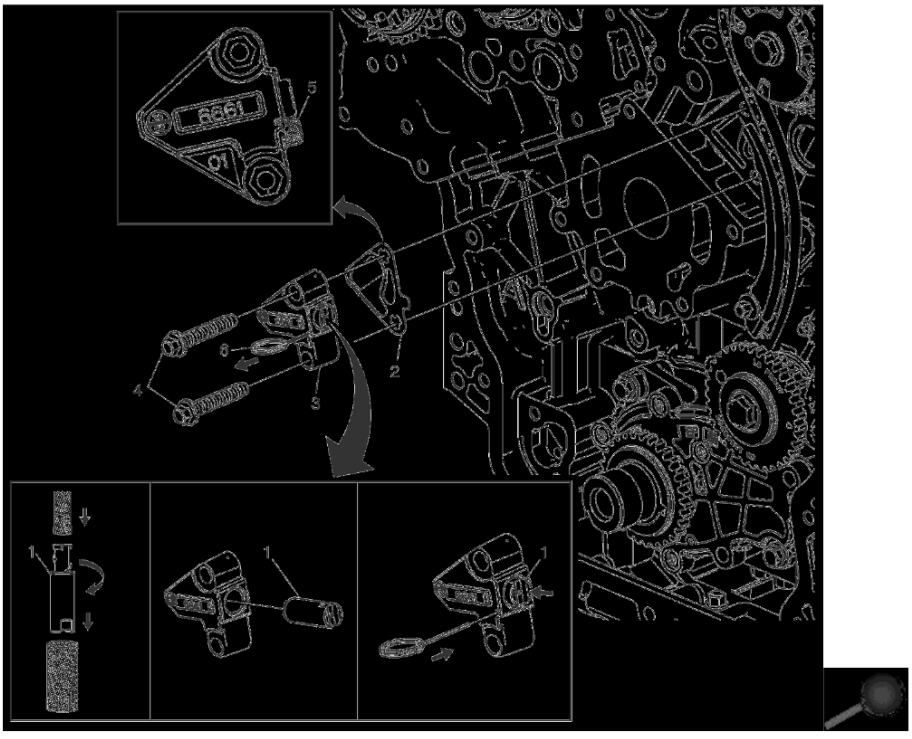
Secondary Camshaft Drive Chain Guide and Shoe Installation - Left

Callout	Component Name
1	Left Secondary Camshaft Drive Chain Shoe
2	Left Secondary Camshaft Drive Chain Shoe Bolt **Caution:** Refer to Fastener Caution. **Tighten** 25 N•m (18 lb ft)

cardiagn.com

Callout	Component Name
3	Left Secondary Camshaft Drive Chain Guide
4	Left Secondary Camshaft Drive Chain Guide Bolt **Tighten** 25 N•m (18 lb ft)

Secondary Camshaft Drive Chain Tensioner Installation - Left Side



Secondary Camshaft Drive Chain Tensioner Installation - Left Side

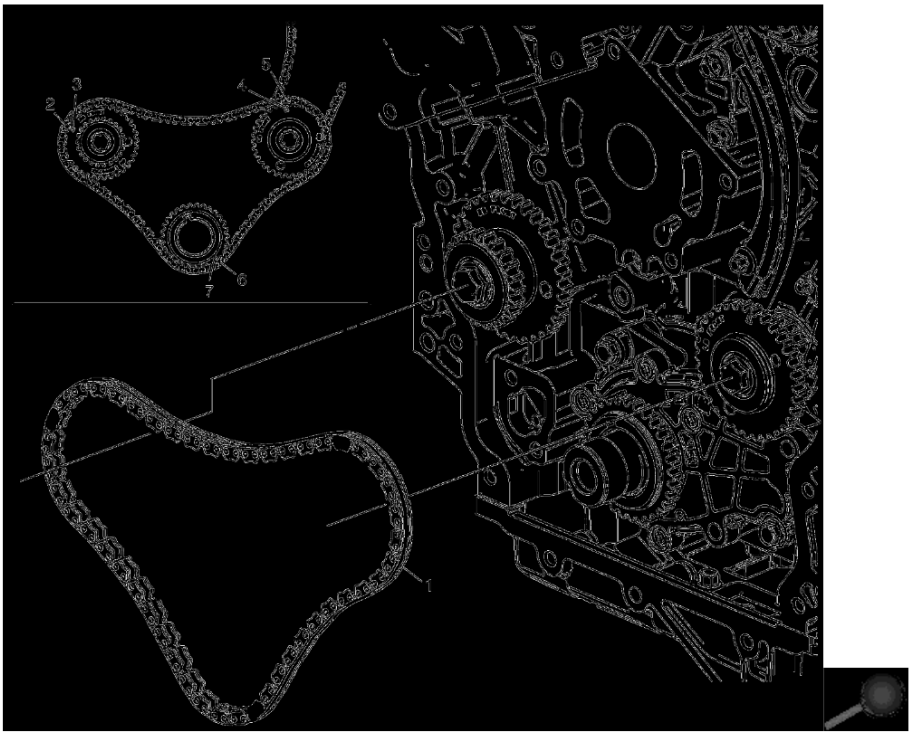
Callout	Component Name
1	Left Secondary Camshaft Drive Chain Tensioner Plunger. **Procedure** 1. Reset the left secondary camshaft drive chain tensioner plunger using *EN-45027* tensioner tool. 2. Install left secondary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the *EN-46112* tensioner retraction pins into the access hole in the side of the left secondary camshaft drive chain tensioner body. 4. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.

cardiagn.com

Callout	Component Name
	Special Tools • *EN-45027* Tensioner Tool • *EN-46112* Tensioner Retraction Pins For equivalent regional tools, refer to Special Tools.
2	Left Secondary Camshaft Drive Chain Tensioner Gasket **Note:** Ensure the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.
3	Left Secondary Camshaft Drive Chain Tensioner
4	Left Secondary Camshaft Drive Chain Tensioner Bolt **Procedure** 1. Place the chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the drive chain tensioner by pulling out the *EN–46112* tensioner retraction pins pin (6) and unlocking the tensioner plunger. 6. Verify the left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. **Tighten** • First Pass 5 N•m (44 lb in) • Second Pass 25 N•m (18 lb ft)
5	Drive Chain Tensioner Gasket Tab
6	*EN–46112* Pin

Primary Camshaft Intermediate Drive Chain Installation

cardiagn.com



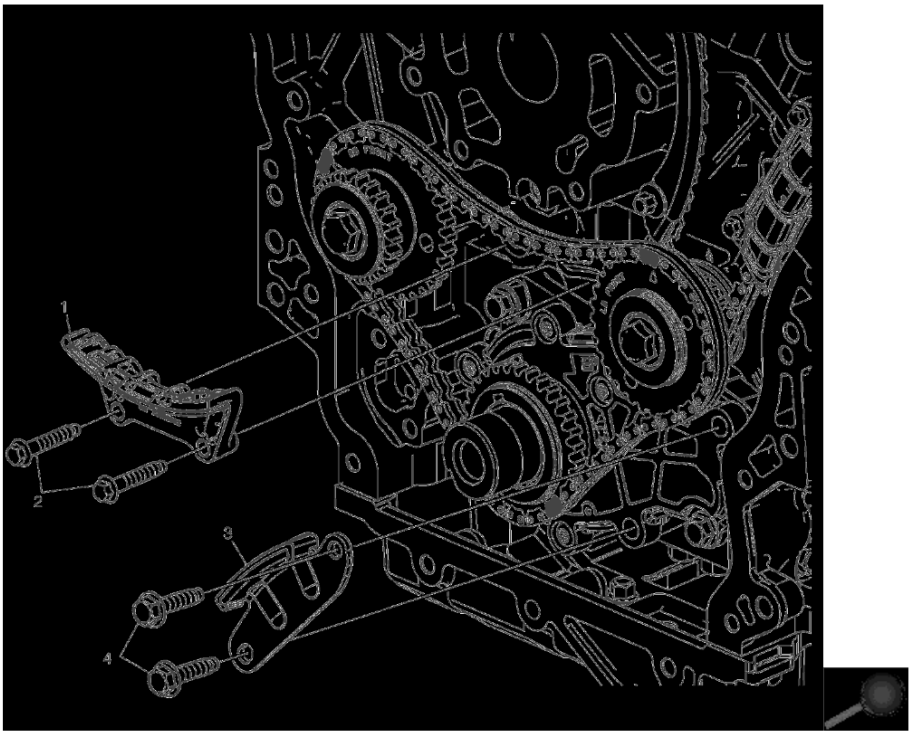
Primary Camshaft Intermediate Drive Chain Installation

Callout	Component Name
1	Primary Camshaft Drive Chain **Procedure** 1. Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket. 2. The left camshaft intermediate drive chain idler timing mark (2) will align with camshaft drive chain timing link (3). 3. The right camshaft intermediate drive chain idler timing mark (4) will align with camshaft drive chain timing link (5). 4. The crankshaft sprocket timing mark (7) will align with camshaft drive chain timing link (6).
2	Left Camshaft Intermediate Drive Chain Idler Timing Mark
3	Camshaft Drive Chain Timing Link
4	Right Camshaft Intermediate Drive Chain Idler Timing Mark
5	Camshaft Drive Chain Timing Link
6	Camshaft Drive Chain Timing Link

cardiagn.com

Callout	Component Name
7	Crankshaft Sprocket Timing Mark

Primary Timing Chain Guide Installation - Lower and Upper

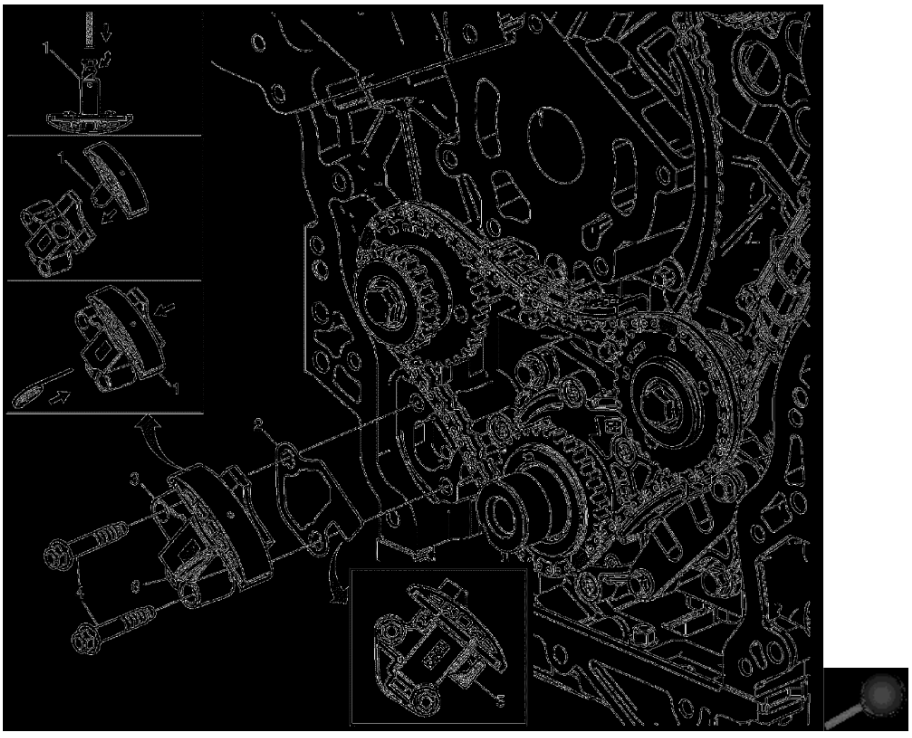


Primary Timing Chain Guide Installation - Lower and Upper

Callout	Component Name
1	Primary Camshaft Drive Chain Lower Guide
2	Primary Camshaft Drive Chain Lower Guide Bolt **Tighten** 25 N•m (18 lb ft)
3	Upper Primary Camshaft Drive Chain Guide.
4	Upper Primary Camshaft Drive Chain Guide Bolt **Tighten** 25 N•m (18 lb ft)

Primary Camshaft Intermediate Drive Chain Tensioner Installation

cardiagn.com



Primary Camshaft Intermediate Drive Chain Tensioner Installation

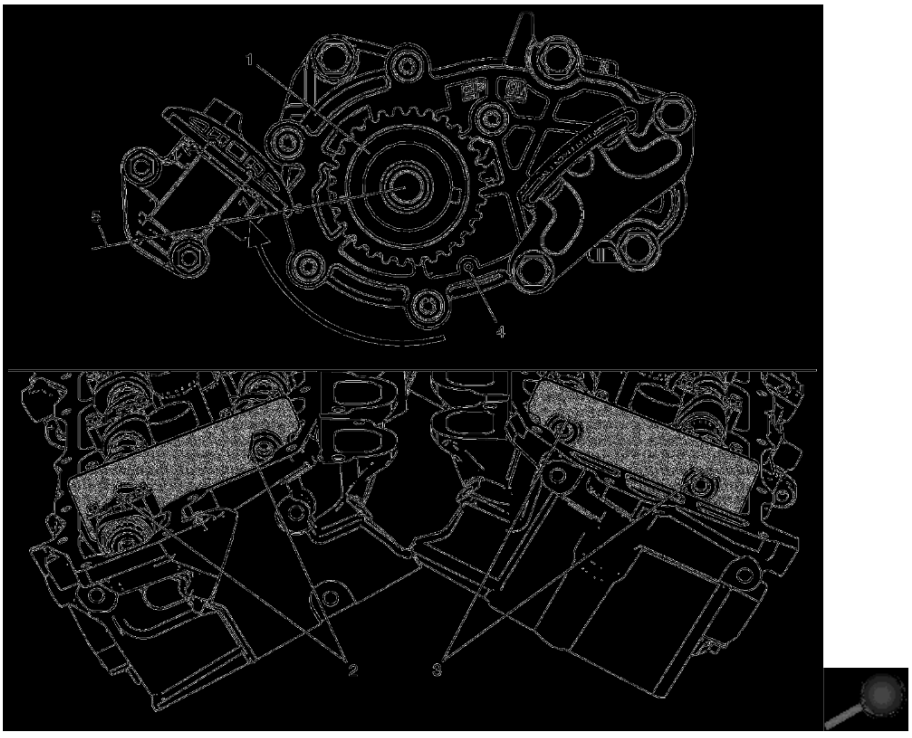
Callout	Component Name
1	Primary Camshaft Drive Chain Tensioner Plunger. **Procedure** 1. Reset the primary camshaft drive chain tensioner plunger using *EN–45027* tensioner tool. 2. Install primary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the primary camshaft drive chain tensioner by inserting the *EN-46112* tensioner retraction pins into the access hole in the side of the primary camshaft drive chain tensioner body. 4. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed. **Special Tools** • *EN-45027* Tensioner Tool • *EN–46112* Tensioner Retraction Pins For equivalent regional tools, refer to Special Tools.
2	Primary Camshaft Drive Chain Tensioner Gasket **Note:** Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.

cardiagn.com

Callout	Component Name
3	Primary Camshaft Drive Chain Tensioner
4	Primary Camshaft Drive Chain Tensioner Bolt **Procedure** 1. Place the drive chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the drive chain tensioner by pulling out the *EN–46112*pin (6) and unlocking the tensioner plunger. 6. Verify the primary and left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. **Tighten** • First Pass 5 N•m (44 lb in) • Second Pass 25 N•m (18 lb ft)
5	Drive Chain Tensioner Gasket Tab
6	*EN–46112* Pin

Stage 1 Alignment Position to the Stage 2 Alignment Position

cardiagn.com



Stage 1 Alignment Position to the Stage 2 Alignment Position

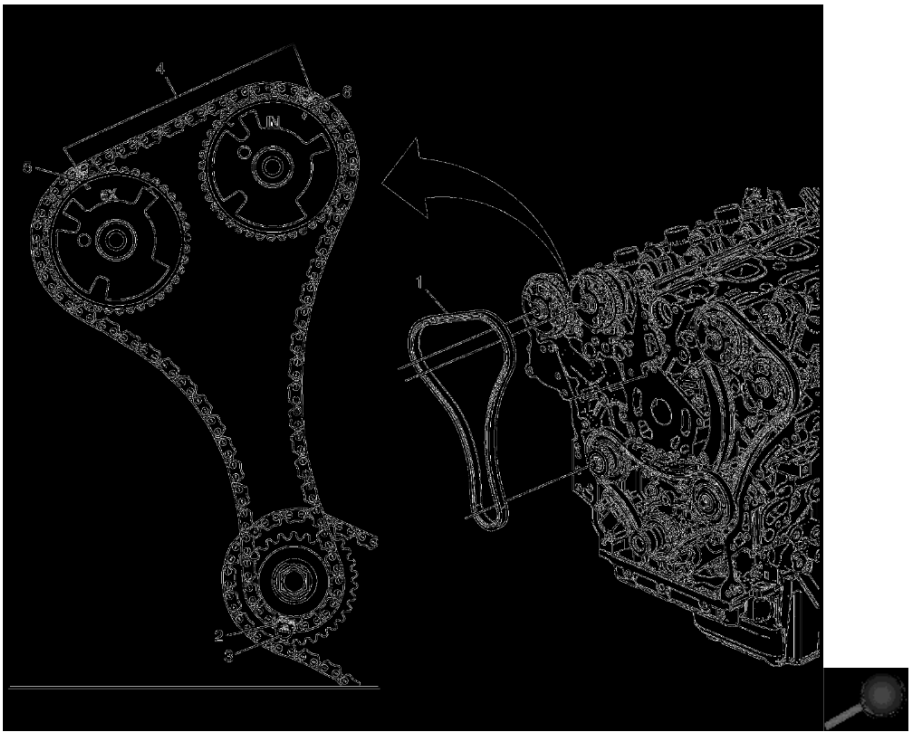
Callout	Component Name
Preliminary Procedure Remove the EN 48383-1 from the rear of the left camshafts.	
1	Crankshaft Sprocket **Procedure** Using the *EN–48589* crankshaft rotation socket, rotate the crankshaft and crankshaft sprocket from the stage one alignment position (4) to the stage two alignment position (5), 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components. **Special Tools** *EN-48589* Crankshaft Rotation Socket For equivalent regional tools, refer to Special Tools.
2	Left Intake and Exhaust Camshaft **Procedure** **Note:** ◦ There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the *EN-48383-2* retainer . ◦ All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the *EN-48383-2* retainer onto the rear of the left camshafts.

cardiagn.com

Callout	Component Name
	2. Ensure the *EN-48383-2* retainer is fully seated onto the camshafts. **Special Tools** *EN-48383* Crankshaft Rotation Tools For equivalent regional tools, refer to Special Tools.
3	Right Intake and Exhaust Camshaft **Procedure** **Note:** ◦ There should be no need to rotate the camshaft more than 10 degrees. Using the hex cast into the camshaft rotate the camshaft in order to install the *EN-48383-3* retainer . ◦ All camshafts must be locked in place before installation of any camshaft drive chains. 1. Install the *EN-48383-3* retainer onto the rear of the right camshafts. 2. Ensure the *EN-48383-3* retainer is fully seated onto the camshafts. **Special Tools** *EN–48383* Crankshaft Rotation Tools For equivalent regional tools, refer to Special Tools.
4	Stage One Alignment Position
5	Stage Two Alignment Position

Secondary Camshaft Intermediate Drive Chain Installation - Right Side

cardiagn.com



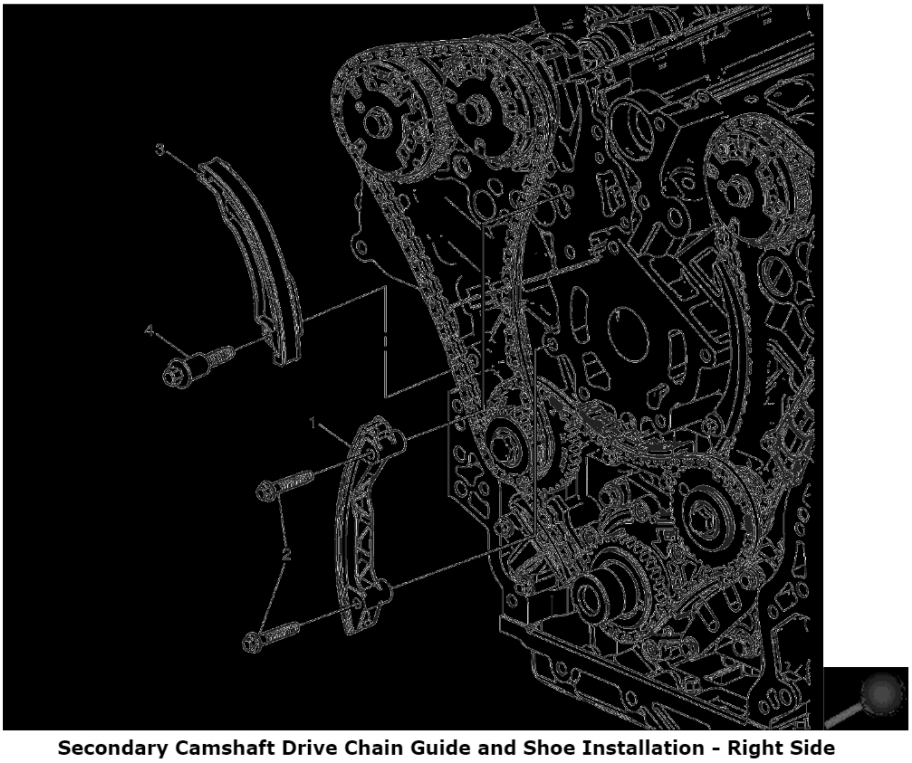
Secondary Camshaft Intermediate Drive Chain Installation - Right Side

Callout	Component Name
Note: Ensure that the right (R) camshaft position actuator sprocket alignment triangle marks are used during this step.	
1	Right Secondary Camshaft Intermediate Drive Chain **Note:** Ensure that the crankshaft is in the stage 2 timing drive assembly position. **Procedure** 1. Place the secondary camshaft intermediate drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the camshaft drive chain timing link (2) with the alignment access hole (3) in the right camshaft intermediate drive chain idler inner sprocket. 2. Wrap the secondary camshaft intermediate drive chain around both right (R) actuator drive sprockets. 3. Align the right (R) intake camshaft position actuator sprocket alignment triangle mark (5) with the camshaft drive chain timing link. 4. Align the right (R) exhaust camshaft position actuator sprocket alignment triangle mark (6) with the camshaft drive chain timing link. 5. Once aligned, ensure there are 10 chain links (4) between timing marks for the right (R) camshaft position actuator sprockets. 6. There will be 22 links between the right camshaft intermediate drive chain idler timing camshaft drive chain link and each right camshaft position actuator sprocket timing camshaft drive chain link.

cardiagn.com

Callout	Component Name
2	Camshaft Drive Chain Timing Link
3	Alignment Access Hole
4	10 Chain Links Between Timing Marks for the Right (R) Camshaft Position Actuator Sprockets
5	Right (R) Intake Camshaft Position Actuator Sprocket Alignment Triangle Mark
6	Right (R) Exhaust Camshaft Position Actuator Sprocket Alignment Triangle Mark

Secondary Camshaft Drive Chain Guide and Shoe Installation - Right Side



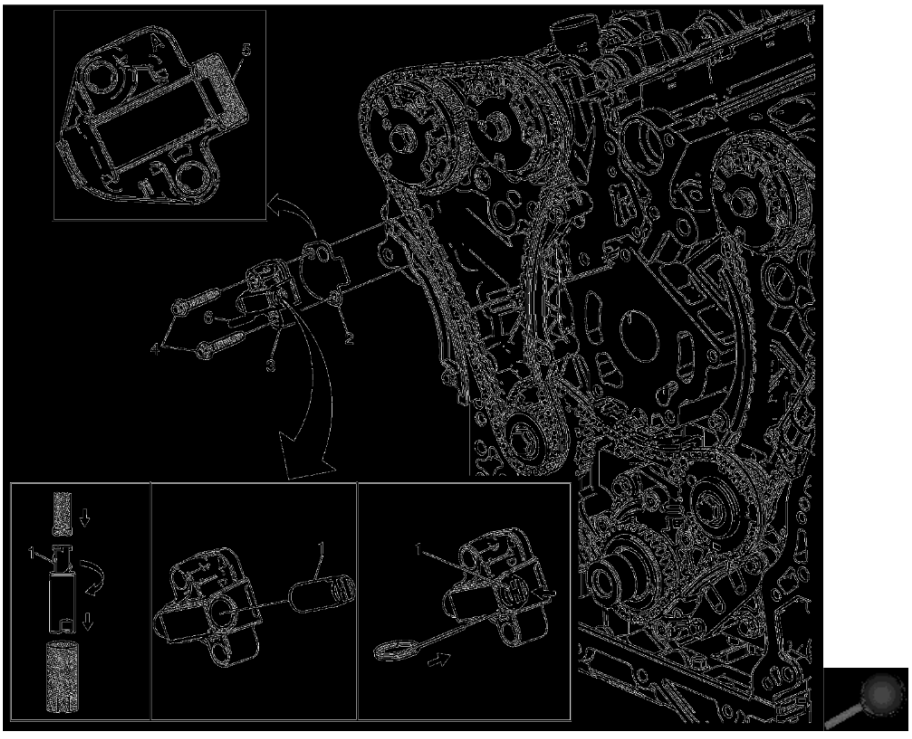
cardiagn.com

Secondary Camshaft Drive Chain Guide and Shoe Installation - Right Side

Callout	Component Name
1	Right Secondary Camshaft Drive Chain Guide
2	Right Secondary Camshaft Drive Chain Guide Bolt **Tighten** 25 N•m (18 lb ft)

Callout	Component Name
3	Right Secondary Camshaft Drive Chain Shoe
4	Right Secondary Camshaft Drive Chain Shoe Bolt **Tighten** 25 N•m (18 lb ft)

Secondary Camshaft Drive Chain Tensioner Installation - Right Side



Secondary Camshaft Drive Chain Tensioner Installation - Right Side

Callout	Component Name
1	Right Secondary Camshaft Drive Chain Tensioner Plunger **Procedure** 1. Reset the right secondary camshaft drive chain tensioner plunger using *EN –45027* tensioner tool. 2. Install right secondary camshaft drive chain tensioner plunger into body. 3. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner by inserting the *EN–46112* tensioner retraction pins into the access hole in the side of the right secondary camshaft drive chain tensioner body. 4. Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed.

cardiagn.com

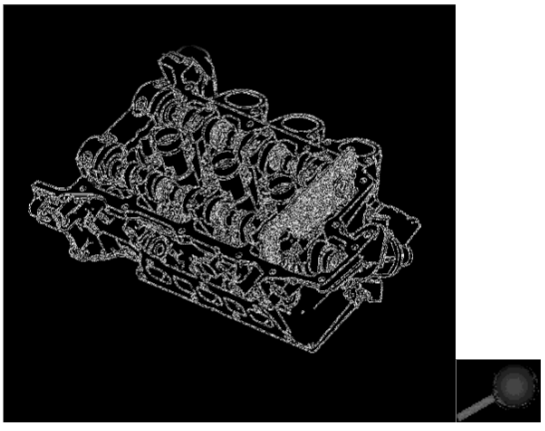
Callout	Component Name
	Special Tools • *EN-45027* Tensioner Tool • *EN–46112* Tensioner Retraction Pins For equivalent regional tools, refer to Special Tools.
2	Right Secondary Camshaft Drive Chain Tensioner Gasket **Note:** Ensure the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head does not have any burrs or defects that would degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.
3	Right Secondary Camshaft Drive Chain Tensioner
4	Right Secondary Camshaft Drive Chain Tensioner Bolt **Procedure** 1. Place the right secondary drive chain tensioner into position and loosely install the bolts to the block. 2. Verify the proper placement of the right secondary drive chain tensioner gasket tab (5). 3. Tighten the drive chain tensioner bolts in two passes. 4. Verify the timing marks are in the correct position before releasing the drive chain tensioner. 5. Release the right secondary drive chain tensioner by pulling out the *EN–46112* pin (6) and unlocking the tensioner plunger. 6. Verify all primary and secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. **Tighten** • First Pass 5 N•m (44 lb in) • Second Pass 25 N•m (18 lb ft)
5	Right Secondary Drive Chain Tensioner Gasket Tab
6	*EN-46112* Pin

cardiagn.com

Secondary Camshaft Intermediate Drive Chain Installation - Left Side

Special Tools

- *EN 46111* Crankshaft Rotation Socket
- *EN-48383* Camshaft Retaining Tools
- *EN-50086* Cam Chain Lock Tool

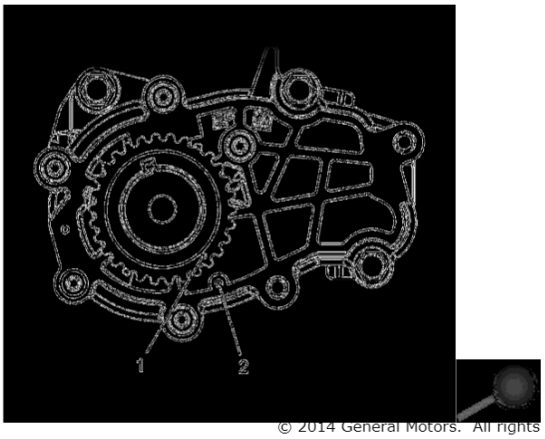


Note: Do not rotate the camshafts more than 10 degrees. Use the hex cast on the camshafts to adjust the camshafts while installing the *EN-48383* camshaft retaining tool.

Note: Once the *EN-48383* camshaft retaining tool is fitted, do not turn the camshafts as this can damage the tool.

1. Install the *EN-48383* camshaft retaining tool to the rear of the left camshafts.

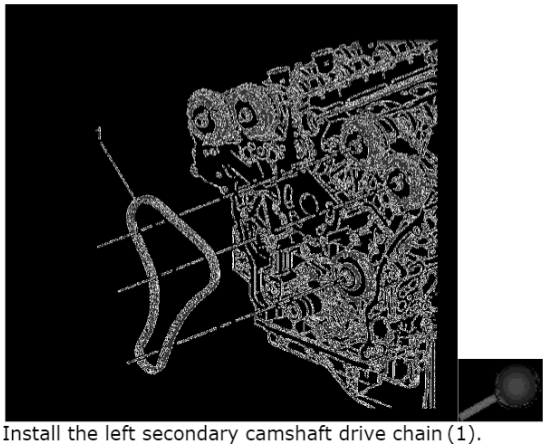
   Note: Both camshafts must be locked with the *EN-48383* camshaft retaining tool before installation of any camshaft drive chains.
2. Make sure that the *EN-48383* camshaft retaining tool is fully seated on the camshafts.



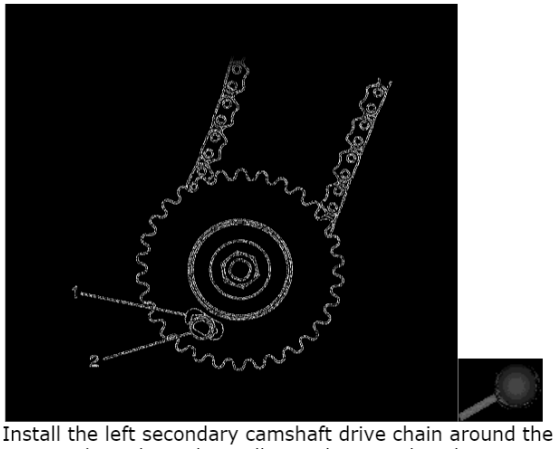
cardiagn.com

© 2014 General Motors. All rights reserved.

3. Use the crankshaft rotation socket *EN 46111* crankshaft rotation socket to turn the crankshaft while aligning the crankshaft sprocket timing mark (1) with the timing mark on the oil pump cover (2). Refer to Timing Chain Alignment Diagram stage one.

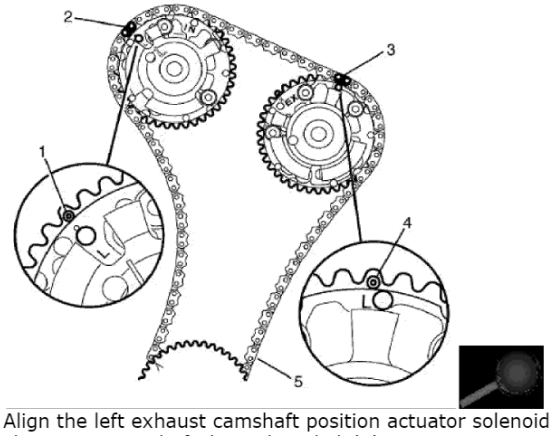


4. Install the left secondary camshaft drive chain (1).

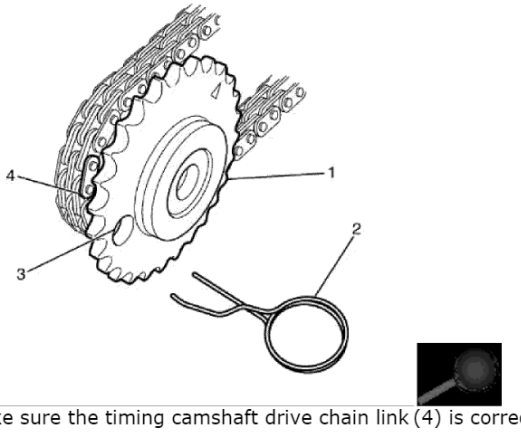


5. Install the left secondary camshaft drive chain around the inner sprocket of the left camshaft intermediate drive chain idler. Make sure that the timing camshaft drive chain link (1) aligns with the alignment access hole (2) of the left camshaft intermediate drive chain idler outer sprocket.
6. Wrap the secondary camshaft drive chain around both left actuator drive sprockets.
7. Make sure there are 10 chain links between the sprocket alignment circle marks of the actuator solenoid sprockets.

cardiagn.com

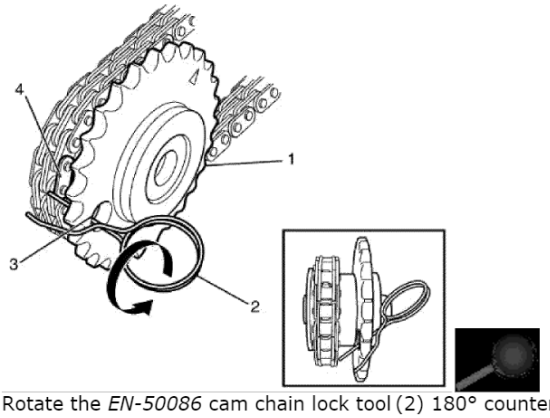


8. Align the left exhaust camshaft position actuator solenoid sprocket alignment circle mark (4) with the timing camshaft drive chain link (3).
9. Align the left intake camshaft position actuator solenoid sprocket alignment circle mark (1) with the timing camshaft drive chain link (2).

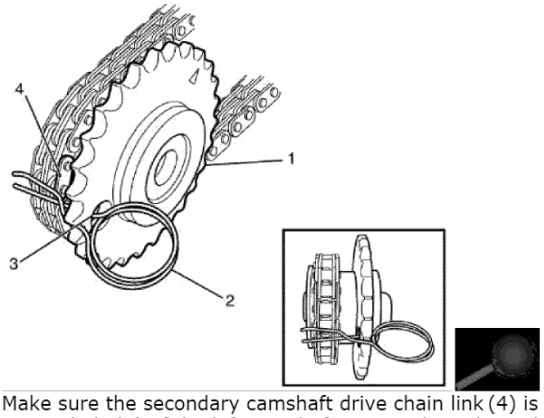


10. Make sure the timing camshaft drive chain link (4) is correctly aligned with the alignment access hole (3) of the left camshaft intermediate drive chain idler outer sprocket (1).
11. Install the *EN-50086* cam chain lock tool (2) through the alignment access hole (3).

cardiagn.com



12. Rotate the *EN-50086* cam chain lock tool (2) 180° counterclockwise until the *EN-50086* cam chain lock tool locks the left camshaft intermediate drive chain to the sprocket.



13. Make sure the secondary camshaft drive chain link (4) is correctly aligned with the alignment access hole (3) of the left camshaft intermediate drive chain idler outer sprocket (1) and is held in position by the *EN-50086* cam chain lock tool (2).
14. There will be 22 links between the left camshaft intermediate drive chain idler timing camshaft drive chain link and the left intake camshaft position actuator solenoid sprocket timing camshaft drive chain link.
15. Install the secondary timing chain guide – left side. Refer to Secondary Timing Chain Guide Installation - Left Side.
16. Install the secondary camshaft drive chain shoe – left side. Refer to Secondary Camshaft Drive Chain Shoe Installation - Left Side.
17. Install the secondary timing chain tensioner – left side. Refer to Secondary Timing Chain Tensioner Installation - Left Side.
18. Install the primary camshaft intermediate drive chain. Refer to Primary Camshaft Intermediate Drive Chain Installation.
19. Install the primary timing chain guide – upper. Refer to Primary Timing Chain Guide Installation - Upper.
20. Install the primary camshaft intermediate drive chain tensioner. Refer to Primary Camshaft Intermediate Drive Chain Tensioner Installation.
21. Remove the *EN-50086* cam chain lock tool.

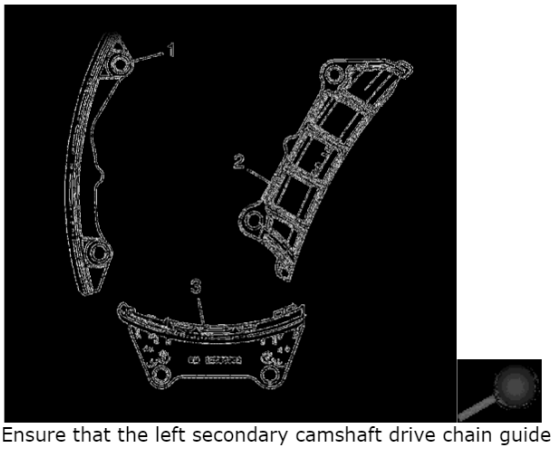
cardiagn.com

Secondary Timing Chain Guide Installation - Left Side

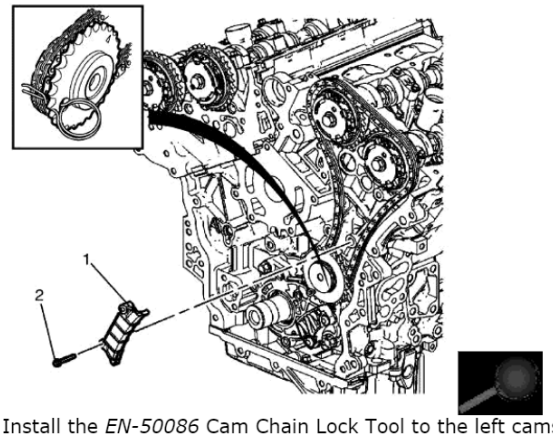
Special Tools

EN-50086 Cam Chain Lock Tool

For equivalent regional tools, refer to Special Tools.



1. Ensure that the left secondary camshaft drive chain guide (2) is being installed.



2. Install the *EN-50086* Cam Chain Lock Tool to the left camshaft intermediate drive chain idler.
3. Position the left secondary camshaft drive chain guide.

   Caution: Refer to Fastener Caution.
4. Install the secondary camshaft drive chain guide bolts (1, 2) and tighten to **25 N·m (18 lb ft)**.
5. Remove the *EN-50086* Cam Chain Lock Tool from the left camshaft intermediate drive chain idler.

cardiagn.com

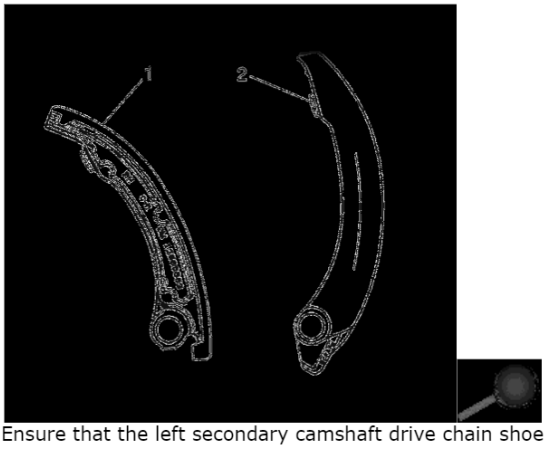
© 2014 General Motors. All rights reserved.

Secondary Camshaft Drive Chain Shoe Installation - Left Side

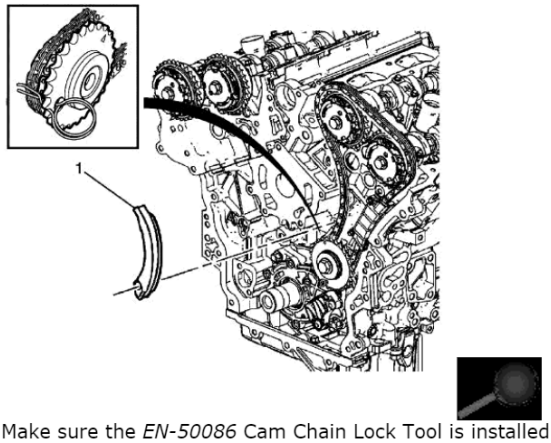
Special Tools

EN-50086 Cam Chain Lock Tool

For equivalent regional tools, refer to Special Tools.



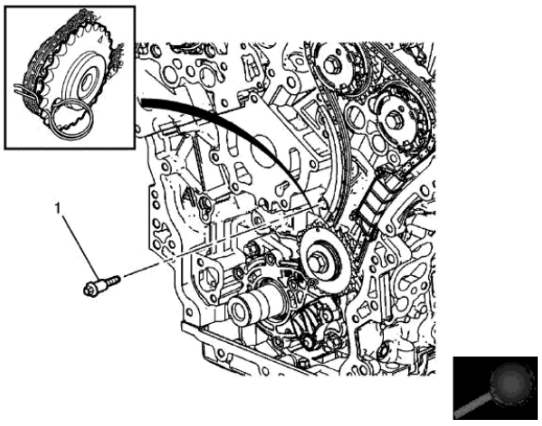
1. Ensure that the left secondary camshaft drive chain shoe (2) is being installed.



2. Make sure the *EN-50086* Cam Chain Lock Tool is installed to the left camshaft intermediate drive chain idler.
3. Position the left secondary camshaft drive chain shoe (1).

cardiagn.com

© 2014 General Motors. All rights reserved.



Caution: Refer to Fastener Caution.

4. Install the secondary camshaft drive chain shoe bolt (1) and tighten to **25 N•m (18 lb ft)**.
5. Remove the *EN-50086* Cam Chain Lock Tool from the left camshaft intermediate drive chain idler.

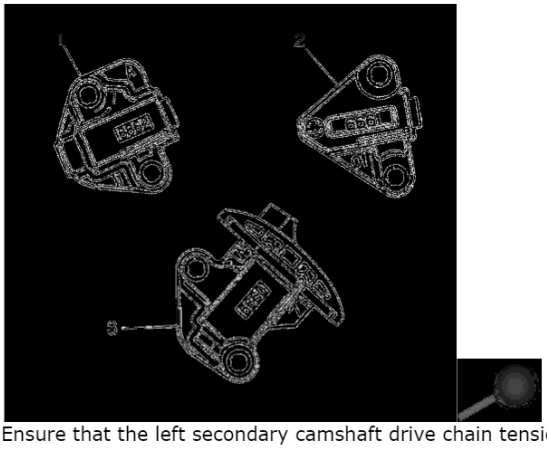
cardiagn.com

Secondary Timing Chain Tensioner Installation - Left Side

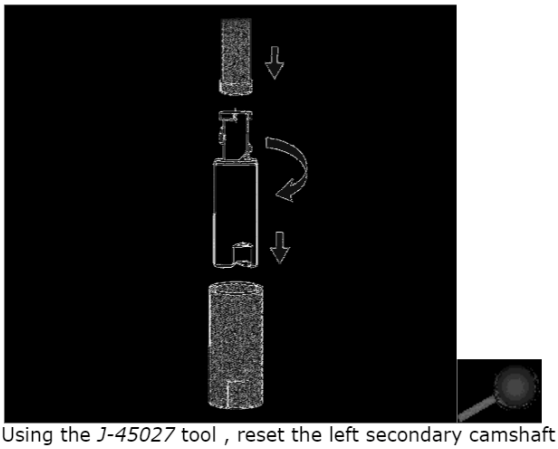
Special Tools

- *EN46112* Tensioner Retraction Pins
- *J 45027* Tensioner Tool
- *EN-50086* Cam Chain Lock Tool

For equivalent regional tools, refer to Special Tools.



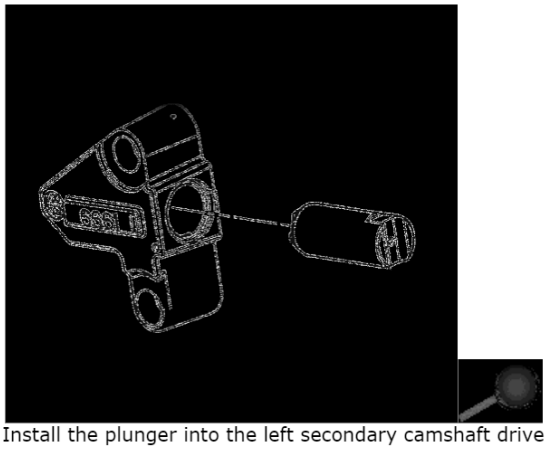
1. Ensure that the left secondary camshaft drive chain tensioner (2) is being installed.



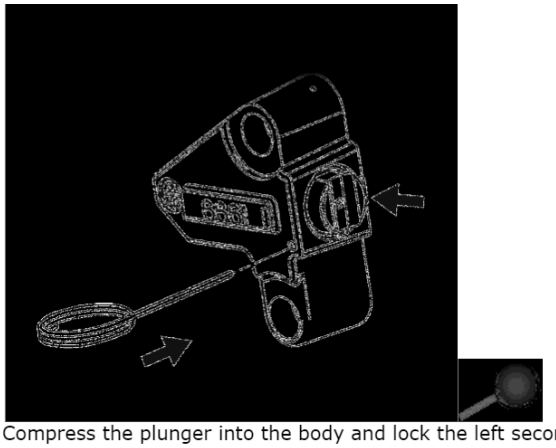
2. Using the *J-45027* tool , reset the left secondary camshaft drive chain tensioner plunger.

cardiagn.com

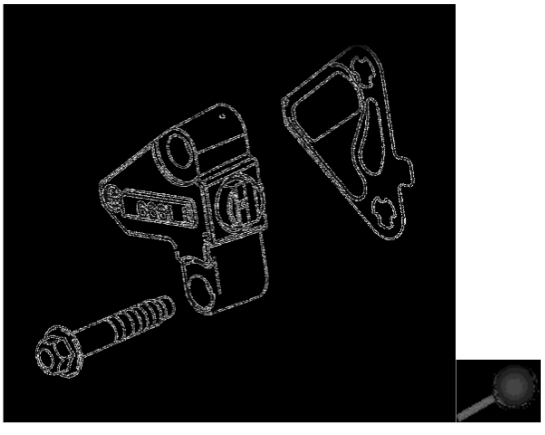
© 2014 General Motors. All rights reserved.



3. Install the plunger into the left secondary camshaft drive chain tensioner body.

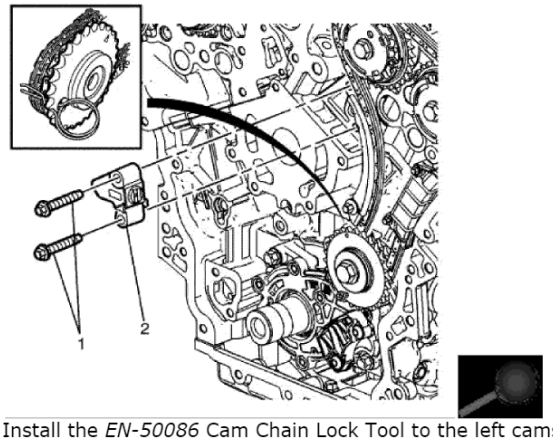


4. Compress the plunger into the body and lock the left secondary camshaft drive chain tensioner by inserting the *EN-46112* pins into the access hole in the side of the left secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.

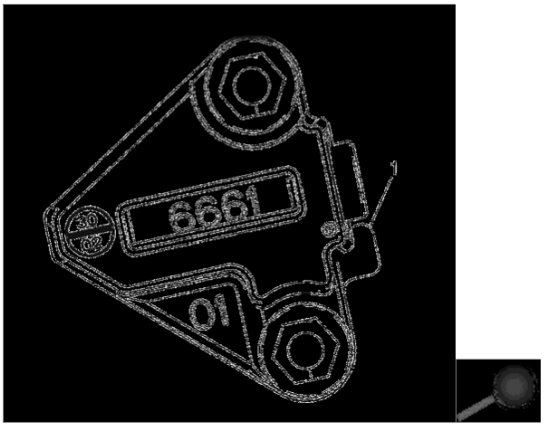


cardiagn.com

6. Install a NEW left secondary camshaft drive chain tensioner gasket to the left secondary camshaft drive chain tensioner.
7. Install the left secondary camshaft drive chain tensioner bolts through the left secondary camshaft drive chain tensioner and gasket.
8. Ensure the left secondary camshaft drive chain tensioner mounting surface on the left cylinder head does not have any burrs or defects that would degrade the sealing of the NEW left secondary camshaft drive chain tensioner gasket.



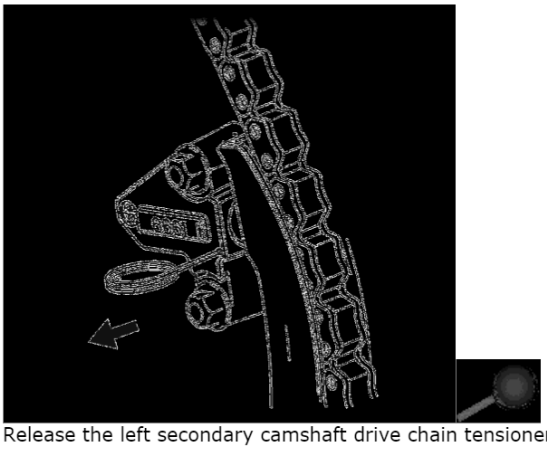
9. Install the *EN-50086* Cam Chain Lock Tool to the left camshaft intermediate drive chain idler.
10. Place the left secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.



Caution: Refer to Fastener Caution.

11. Verify the proper placement of the left secondary camshaft drive chain tensioner gasket tab (1).
    11.1. First Pass
    Tighten the left secondary camshaft drive chain tensioner bolts to **5 N•m (44 lb in)**.
    11.2. Final Pass
    Tighten the left secondary camshaft drive chain tensioner bolts to **25 N•m (18 lb ft)**.

cardiagn.com



12. Release the left secondary camshaft drive chain tensioner by pulling out the *EN-46112* pins and unlocking the tensioner plunger.
13. Verify the left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram – Stage One.

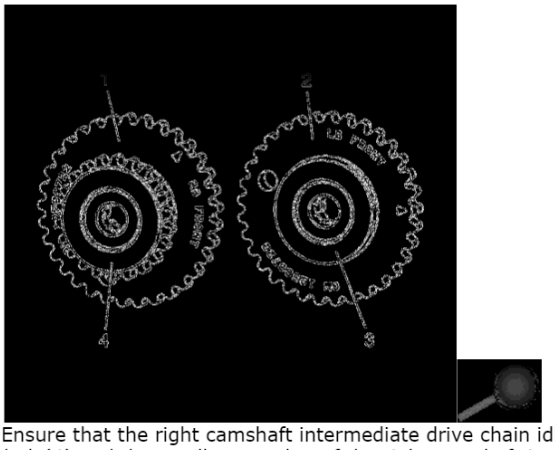
cardiagn.com

Timing Chain Idler Sprocket Installation - Right Side

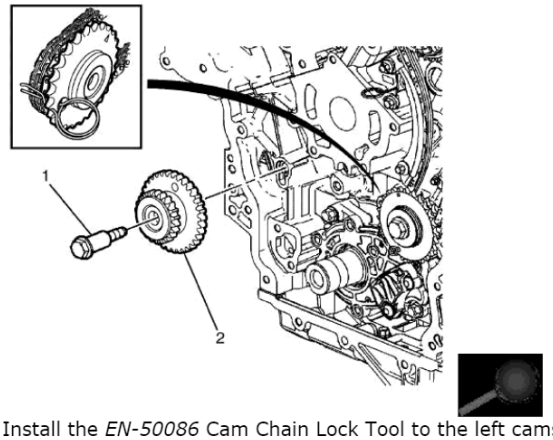
Special Tools

EN-50086 Cam Chain Lock Tool

For equivalent regional tools, refer to Special Tools.



1. Ensure that the right camshaft intermediate drive chain idler (1) is being installed. The recessed hub (4) and the smaller sprocket of the right camshaft intermediate drive chain idler is installed outward. The raised hub and the larger sprocket of the right camshaft intermediate drive chain idler is installed towards the block.



2. Install the *EN-50086* Cam Chain Lock Tool to the left camshaft intermediate drive chain idler.
3. Install the right camshaft intermediate drive chain idler (2).

   Caution: Refer to Fastener Caution.
4. Install the camshaft intermediate drive chain idler bolt and tighten to **58 N·m (43 lb ft)**.
5. Remove the *EN-50086* Cam Chain Lock Tool from the left camshaft intermediate drive chain idler.

© 2014 General Motors. All rights reserved.

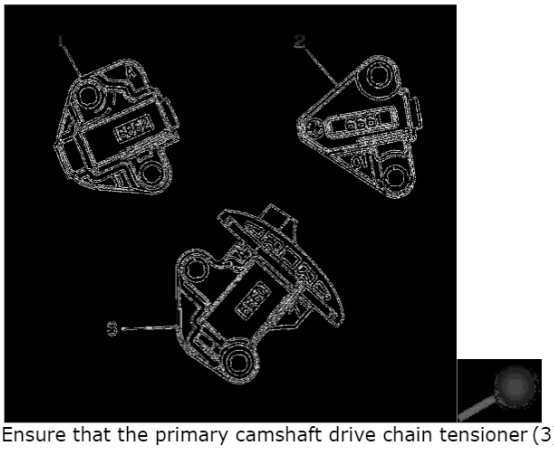
cardiagn.com

Primary Camshaft Intermediate Drive Chain Installation

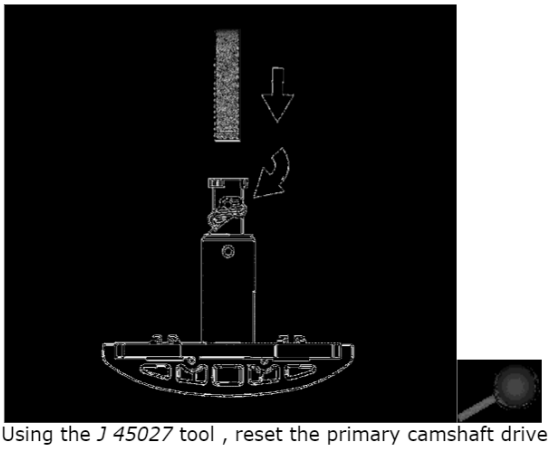
Special Tools

- *EN 46112* Tensioner Retraction Pins
- *EN-48383* Camshaft Retaining Tools
- *EN-46111* Crankshaft Rotation Socket
- *J 45027* Tensioner Tool

For equivalent regional tools, refer to Special Tools.



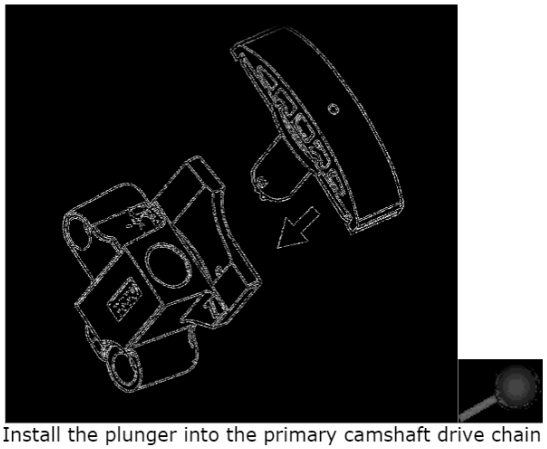
1. Ensure that the primary camshaft drive chain tensioner (3) is being installed.



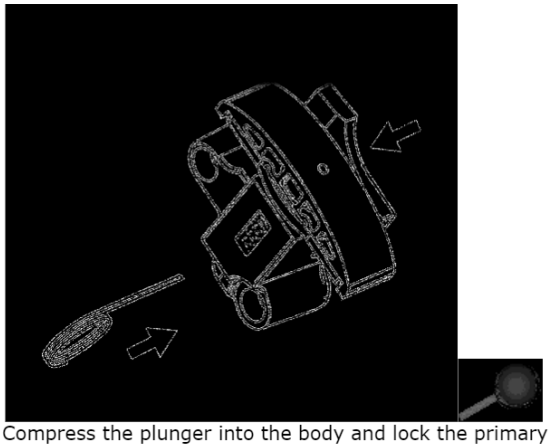
2. Using the *J 45027* tool , reset the primary camshaft drive chain tensioner plunger.

cardiagn.com

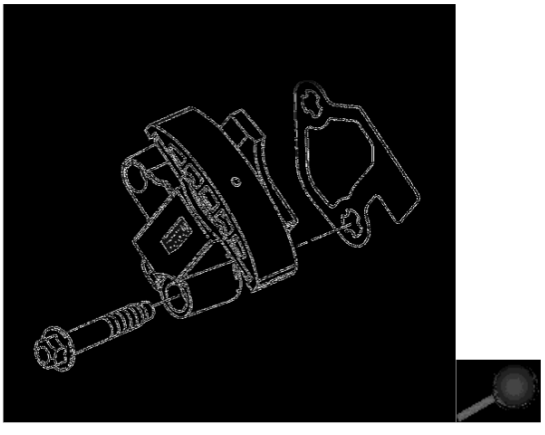
© 2014 General Motors. All rights reserved.



3. Install the plunger into the primary camshaft drive chain tensioner body.

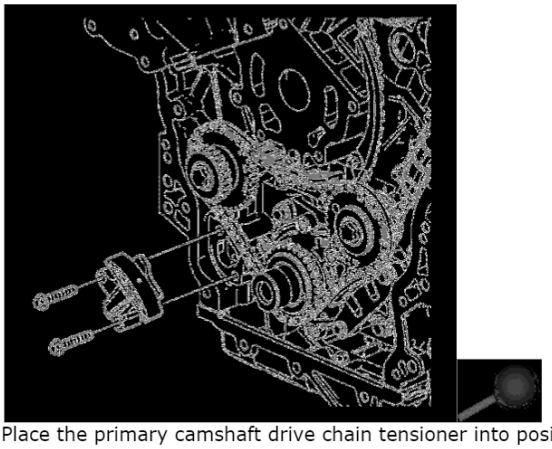


4. Compress the plunger into the body and lock the primary camshaft drive chain tensioner by inserting the *EN 46111* pins into the access hole in the side of the primary camshaft drive chain tensioner body.
5. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.

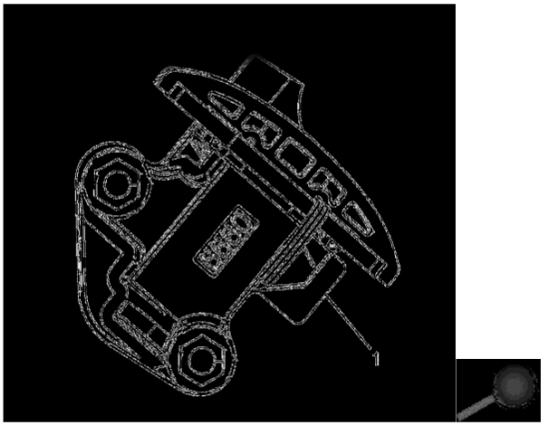


cardiagn.com

6. Install a NEW primary camshaft drive chain tensioner gasket to the primary camshaft drive chain tensioner.
7. Install the primary camshaft drive chain tensioner bolts through the primary camshaft drive chain tensioner and gasket.
8. Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.



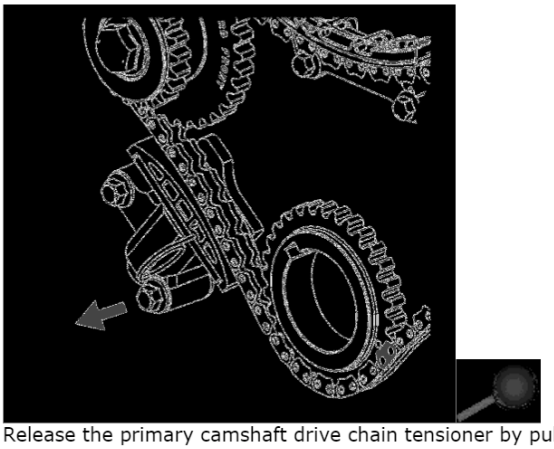
9. Place the primary camshaft drive chain tensioner into position and loosely install the bolts to the block.



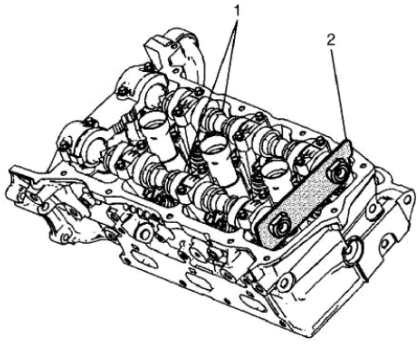
Caution: Refer to Fastener Caution.

10. Verify the proper placement of the primary camshaft drive chain tensioner gasket tab (1).
    10.1. First Pass
    Tighten the primary camshaft drive chain tensioner bolts to **5 N•m (44 lb in).**
    10.2. Final Pass
    Tighten the primary camshaft drive chain tensioner bolts to **25 N•m (18 lb ft).**

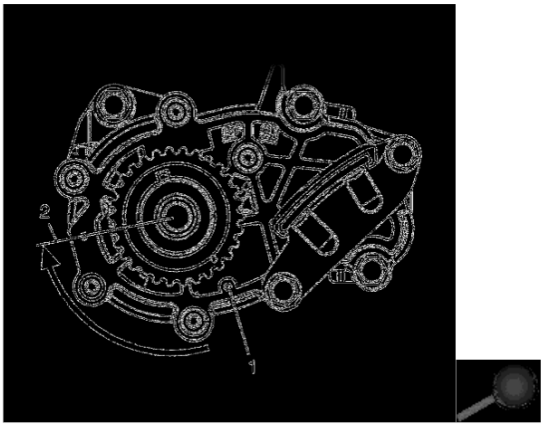
cardiagn.com



11. Release the primary camshaft drive chain tensioner by pulling out the *EN 46112* pins and unlocking the tensioner plunger.
12. Verify the primary and left secondary camshaft drive chain timing mark alignments. Refer to Timing Chain Alignment Diagram.

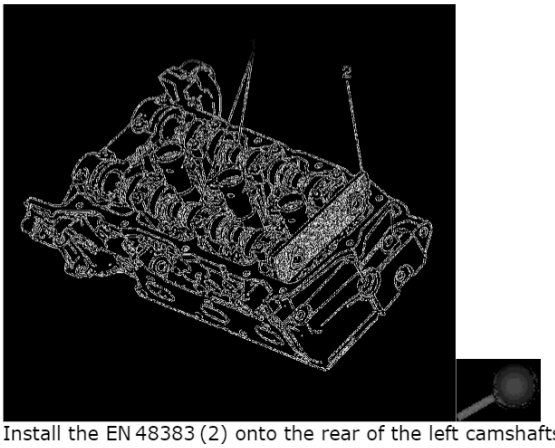


13. Remove the EN 48383 (2) from the rear of the left camshafts (1).

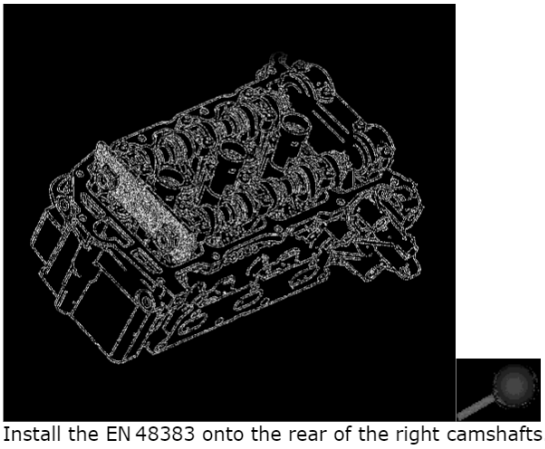


cardiagn.com

14. Using the *EN-48589* socket , rotate the crankshaft and crankshaft sprocket from the stage 1 alignment position (1) to the stage 2 alignment position (2), 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components.



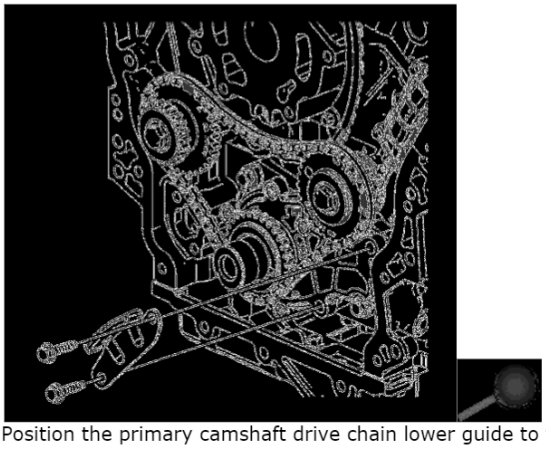
15. Install the EN 48383 (2) onto the rear of the left camshafts (1).



16. Install the EN 48383 onto the rear of the right camshafts.

cardiagn.com

Primary Timing Chain Guide Installation - Lower



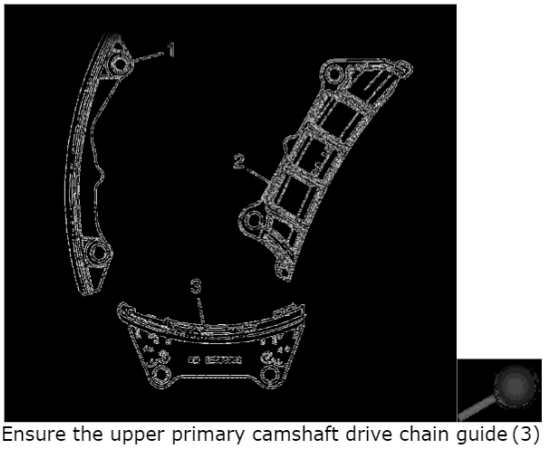
1. Position the primary camshaft drive chain lower guide to the oil pump.

   Caution: Refer to Fastener Caution.
2. Install the primary camshaft drive chain lower guide bolts and tighten to **25 N•m (18 lb ft)**.

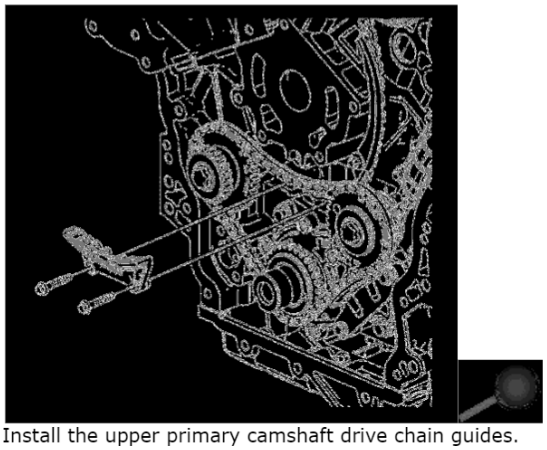
cardiagn.com

© 2014 General Motors. All rights reserved.

Primary Timing Chain Guide Installation - Upper



1. Ensure the upper primary camshaft drive chain guide (3) is being installed.



2. Install the upper primary camshaft drive chain guides.

   Caution: Refer to Fastener Caution.
3. Install the upper primary camshaft drive chain guide bolts and tighten to **25 N•m (18 lb ft)**.

cardiagn.com

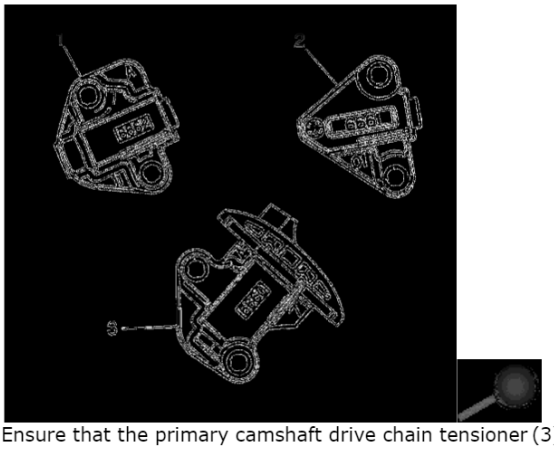
© 2014 General Motors. All rights reserved.

Primary Camshaft Intermediate Drive Chain Tensioner Installation

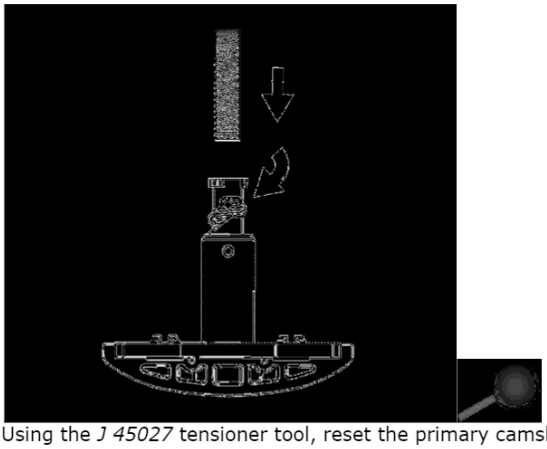
Special Tools

- *EN 46112* Tensioner Retraction Pins
- *EN-48383* Camshaft Retaining Tools
- *EN-48589* Crankshaft Rotation Socket
- *J 45027* Tensioner Tool

Warning: Refer to Safety Glasses Warning.



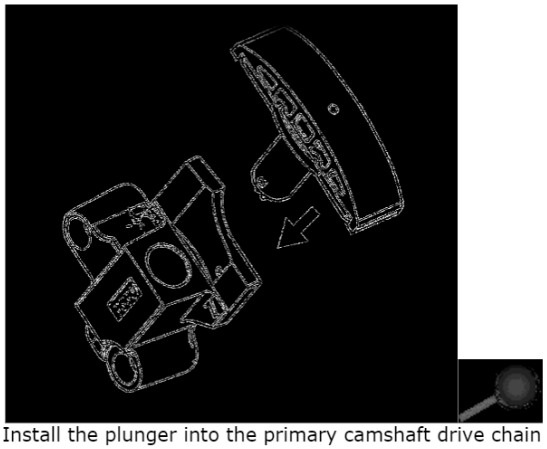
1. Ensure that the primary camshaft drive chain tensioner (3) is being installed.



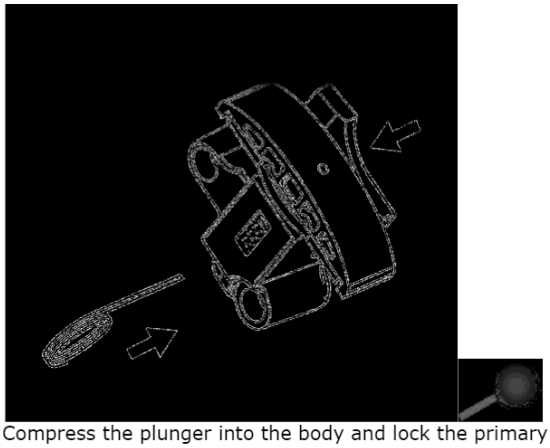
2. Using the *J 45027* tensioner tool, reset the primary camshaft drive chain tensioner plunger.

cardiagn.com

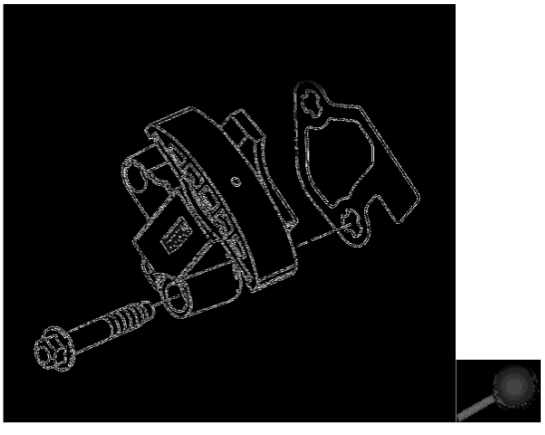
© 2014 General Motors. All rights reserved.



3. Install the plunger into the primary camshaft drive chain tensioner body.

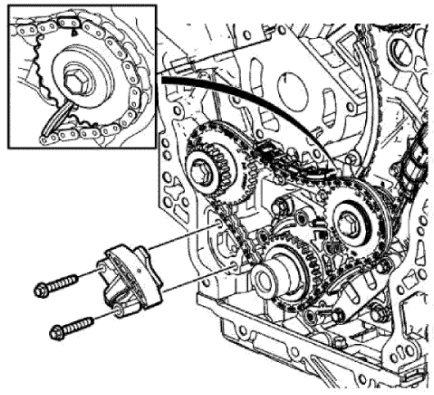


4. Compress the plunger into the body and lock the primary camshaft drive chain tensioner by inserting the *EN 46112* tensioner retraction pins into the access hole in the side of the primary camshaft drive chain tensioner body.
5. Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.

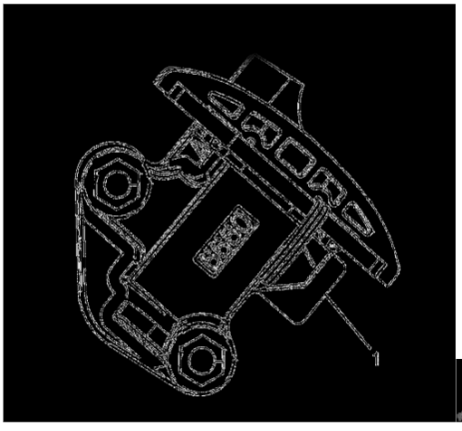


cardiagn.com

6. Install a NEW primary camshaft drive chain tensioner gasket to the primary camshaft drive chain tensioner.
7. Install the primary camshaft drive chain tensioner bolts through the primary camshaft drive chain tensioner and gasket.
8. Ensure the primary camshaft drive chain tensioner mounting surface on the engine block does not have any burrs or defects that would degrade the sealing of the NEW primary camshaft drive chain tensioner gasket.



9. Place the primary camshaft drive chain tensioner into position and loosely install the bolts to the block.



Caution: Refer to Fastener Caution.

10. Verify the proper placement of the primary camshaft drive chain tensioner gasket tab (1).

10.1. First Pass

Tighten

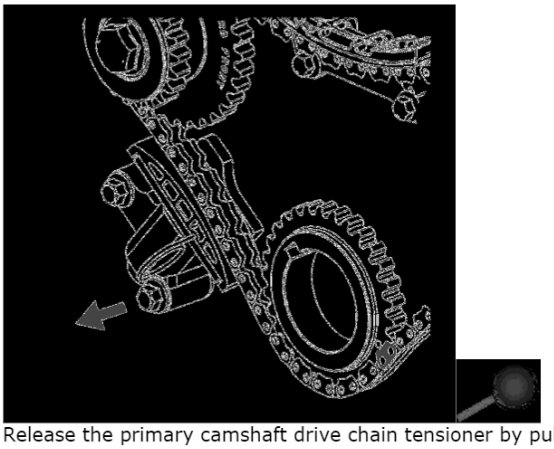
Tighten the primary camshaft drive chain tensioner bolts to 5 N•m (44 lb in).

10.2. Final Pass

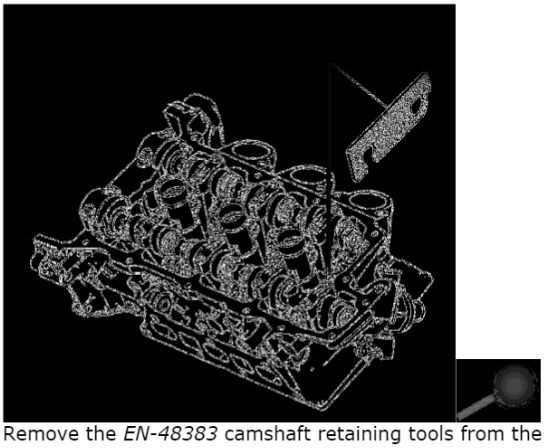
Tighten

Tighten the primary camshaft drive chain tensioner bolts to 23 N•m (17 lb ft).

cardiagn.com

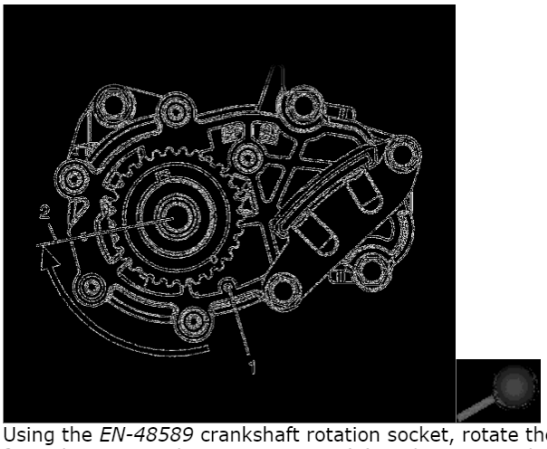


11. Release the primary camshaft drive chain tensioner by pulling out the *EN 46112* tensioner retraction pins and unlocking the tensioner plunger.
12. Verify the primary and left secondary camshaft drive chain timing mark alignments. Refer to Timing Chain Alignment Diagram.

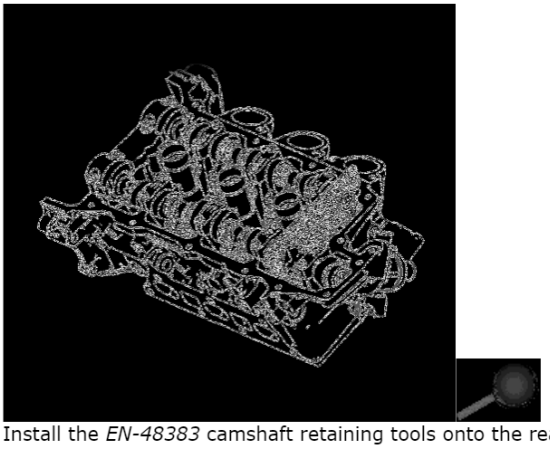


13. Remove the *EN-48383* camshaft retaining tools from the rear of the left camshafts.

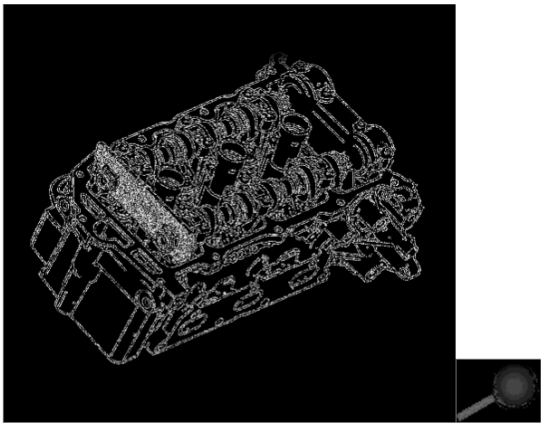
cardiagn.com



14. Using the *EN-48589* crankshaft rotation socket, rotate the crankshaft and crankshaft sprocket from the stage 1 alignment position (1) to the stage 2 alignment position (2), 115 crankshaft degrees, in order to install the right secondary camshaft drive chain components.



15. Install the *EN-48383* camshaft retaining tools onto the rear of the left camshafts.

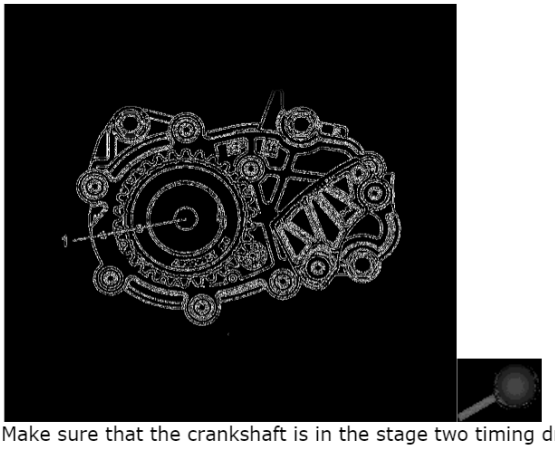


cardiagn.com

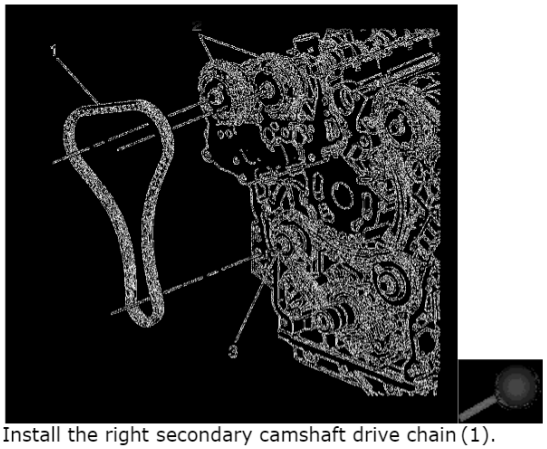
16. Install the *EN-48383* camshaft retaining tools onto the rear of the right camshafts.

cardiagn.com

Secondary Camshaft Intermediate Drive Chain Installation - Right Side



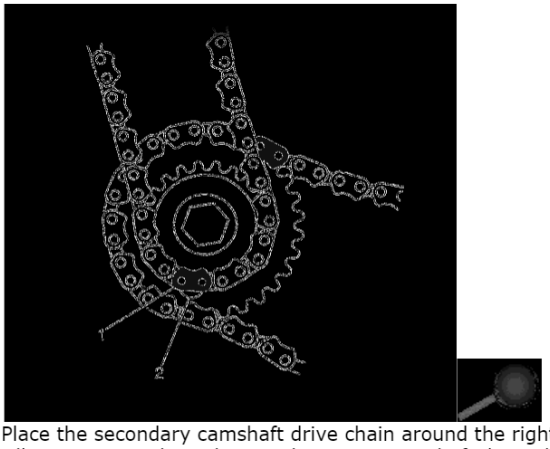
1. Make sure that the crankshaft is in the stage two timing drive assembly position (1).



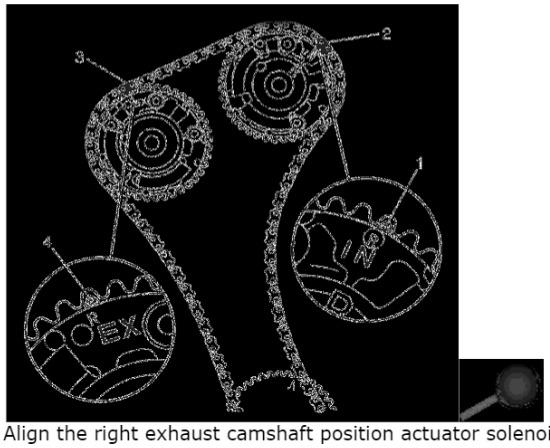
2. Install the right secondary camshaft drive chain (1).

cardiagn.com

© 2014 General Motors. All rights reserved.



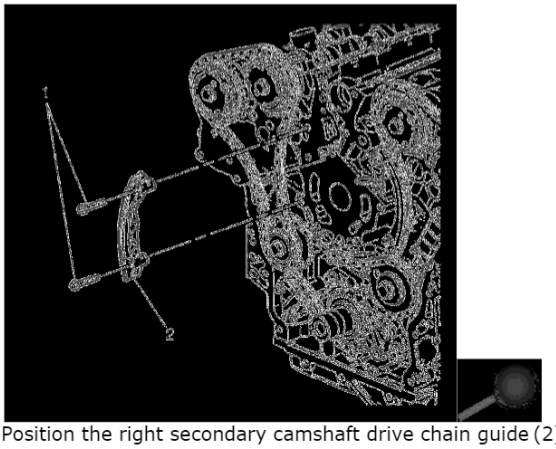
3. Place the secondary camshaft drive chain around the right camshaft intermediate drive chain idler outer sprocket, aligning the timing camshaft drive chain link (1) with the alignment access hole (2) made in the right camshaft intermediate drive chain idler inner sprocket.
4. Wrap the secondary camshaft drive chain around both right actuator drive sprockets.



5. Align the right exhaust camshaft position actuator solenoid sprocket alignment triangle mark (1) with the timing camshaft drive chain link (2).
6. Align the right intake camshaft position actuator solenoid sprocket alignment triangle mark (4) with the timing camshaft drive chain link (3).

cardiagn.com

Secondary Timing Chain Guide Installation - Right Side



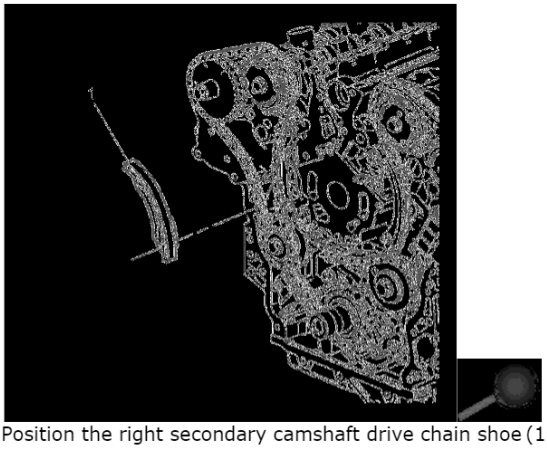
1. Position the right secondary camshaft drive chain guide (2).

   Caution: Refer to Fastener Caution.
2. Install the secondary camshaft drive chain guide to cylinder block retaining bolts (1) and tighten to **23 N•m (17 lb ft)**.

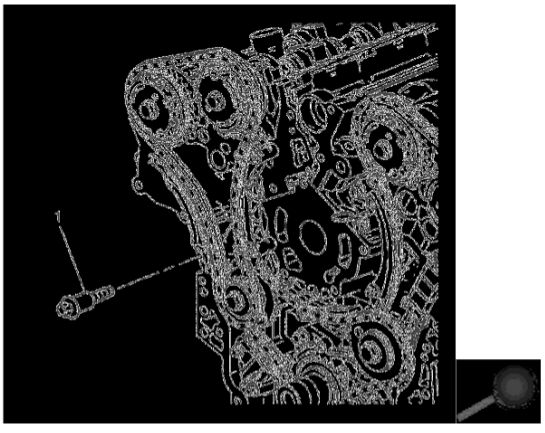
cardiagn.com

© 2014 General Motors. All rights reserved.

Secondary Camshaft Drive Chain Shoe Installation - Right Side



1. Position the right secondary camshaft drive chain shoe (1).



Caution: Refer to Fastener Caution.

2. Install the right secondary camshaft drive chain shoe to cylinder block retaining bolt (1) and tighten to **23 N•m (17 lb ft)**.

cardiagn.com

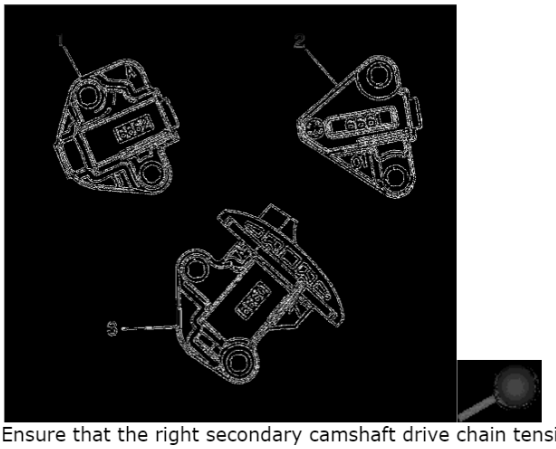
© 2014 General Motors. All rights reserved.

Secondary Timing Chain Tensioner Installation - Right Side

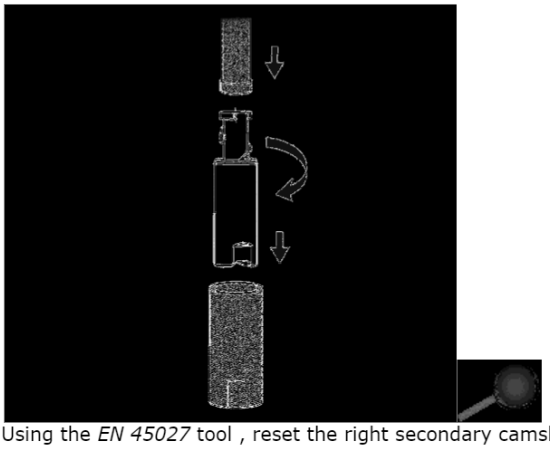
Special Tools

- *EN 45027* Tensioner Tool
- *EN 46112* Tensioner Retraction Pins

For equivalent regional tools, refer to Special Tools.



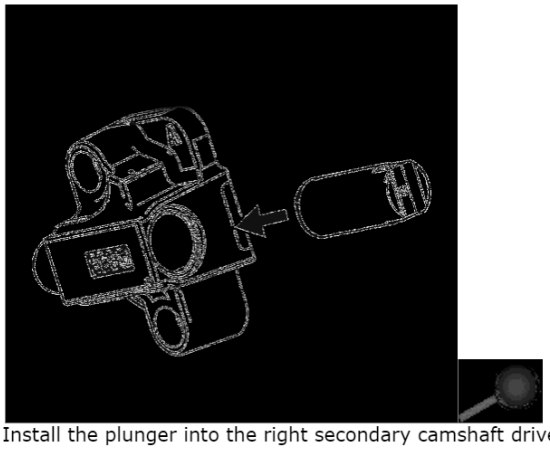
1. Ensure that the right secondary camshaft drive chain tensioner (1) is being installed.



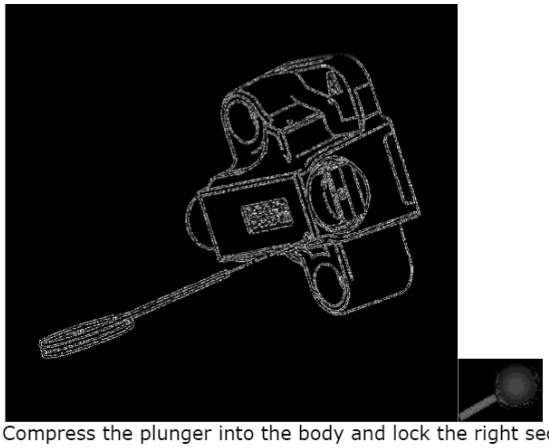
2. Using the *EN 45027* tool , reset the right secondary camshaft drive chain tensioner plunger.

cardiagn.com

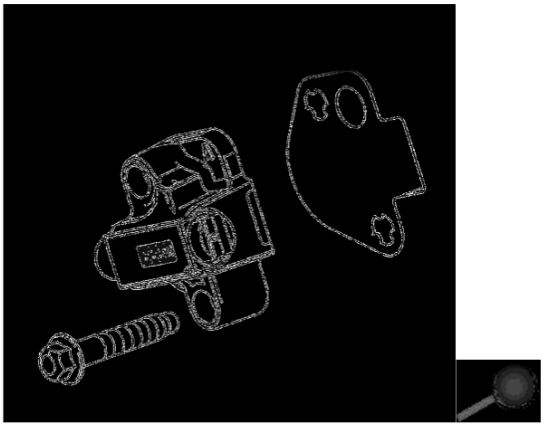
© 2014 General Motors. All rights reserved.



3. Install the plunger into the right secondary camshaft drive chain tensioner body.

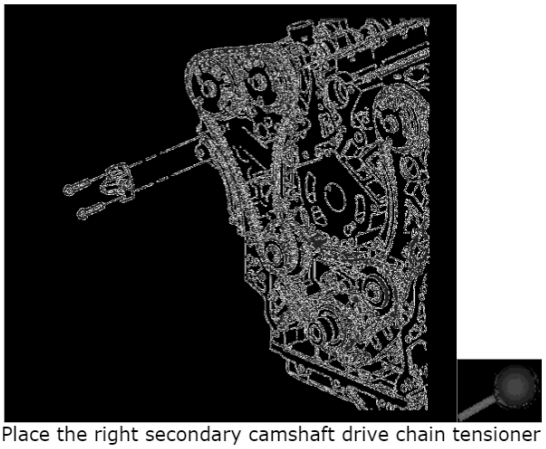


4. Compress the plunger into the body and lock the right secondary camshaft drive chain tensioner by inserting the *EN 46112* pins into the access hole in the side of the right secondary camshaft drive chain tensioner body.
5. Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed.

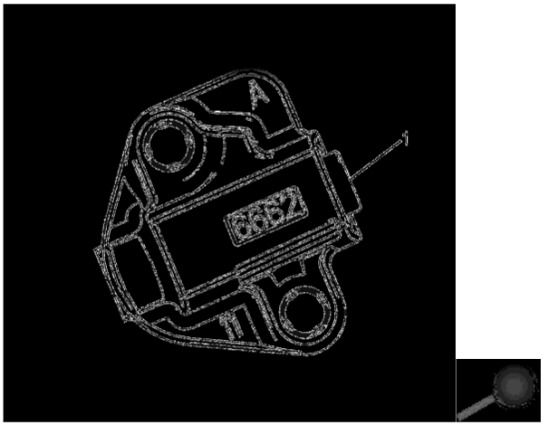


cardiagn.com

6. Install a NEW right secondary camshaft drive chain tensioner gasket to the right secondary camshaft drive chain tensioner.
7. Install the right secondary camshaft drive chain tensioner bolts through the right secondary camshaft drive chain tensioner and gasket.
8. Ensure the right secondary camshaft drive chain tensioner mounting surface on the right cylinder head does not have any burrs or defects that would degrade the sealing of the NEW right secondary camshaft drive chain tensioner gasket.



9. Place the right secondary camshaft drive chain tensioner into position and loosely install the bolts to the block.



Caution: Refer to Fastener Caution.

10. Verify the proper placement of the right secondary camshaft drive chain tensioner gasket tab (1).

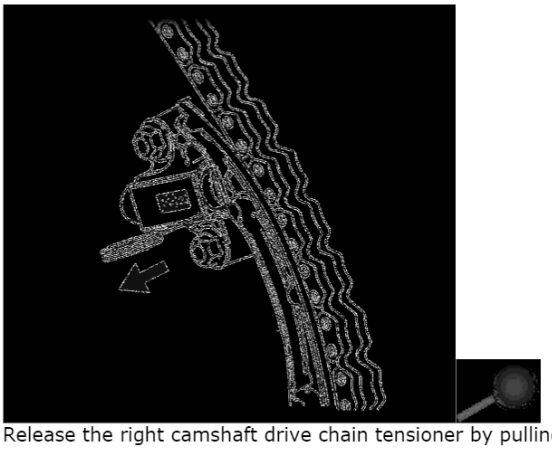
10.1. First Pass

Tighten the right secondary camshaft drive chain tensioner bolts to **5 N•m (44 lb in)**.

10.2. Final Pass

Tighten the right secondary camshaft drive chain tensioner bolts to **25 N•m (18 lb ft)**.

cardiagn.com



11. Release the right camshaft drive chain tensioner by pulling out the *EN 46112* pins and unlocking the tensioner plunger.

    Caution: Ensure that all timing chain tensioners are completely released. A timing chain tensioner that is not properly released can lead to serious engine damage.
12. Verify all primary and secondary camshaft drive chain timing mark alignments. Refer to Timing Chain Alignment Diagram – Stage Two.

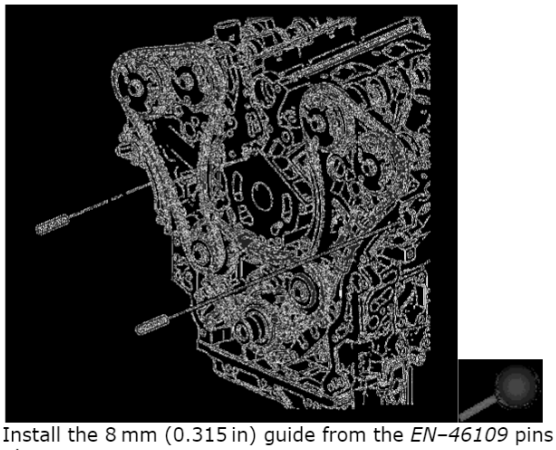
cardiagn.com

Engine Front Cover Installation

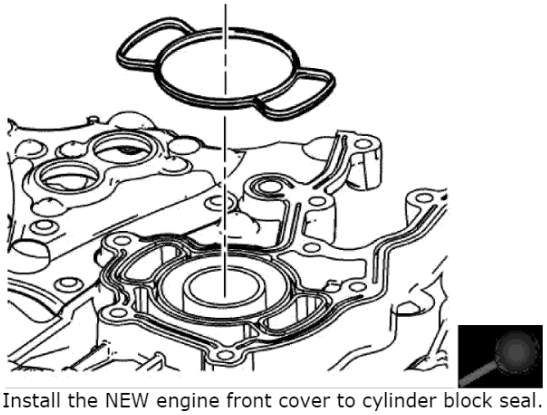
Special Tools

EN–46109 Guide Pins

For equivalent regional tools, refer to Special Tools.



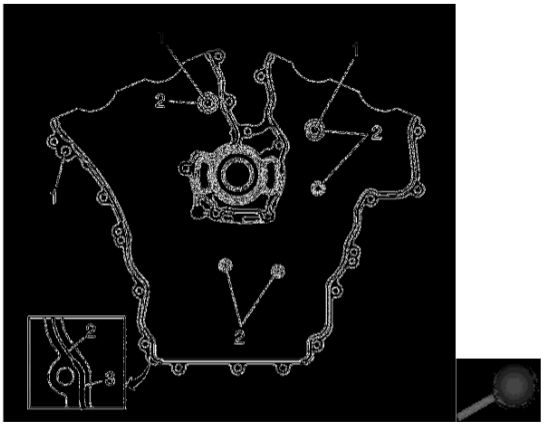
1. Install the 8 mm (0.315 in) guide from the *EN–46109* pins into the cylinder block positions as shown.



2. Install the NEW engine front cover to cylinder block seal.

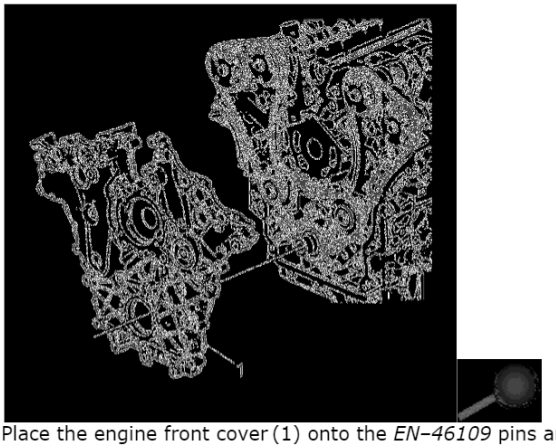
cardiagn.com

© 2014 General Motors. All rights reserved.



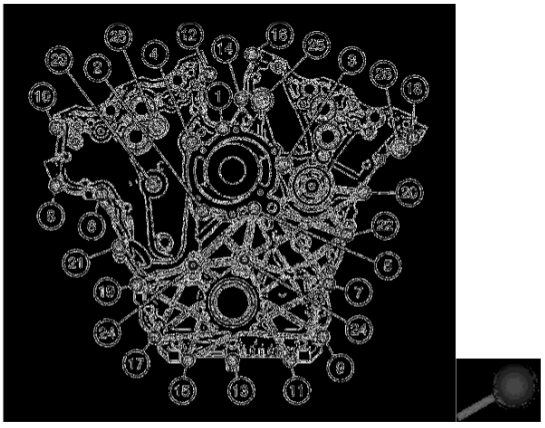
Note: No RTV sealant should be visible in the M12 bolt holes (1) upon final assembly of front cover to engine.

3. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (2). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (3). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.



4. Place the engine front cover (1) onto the *EN–46109* pins and slide into position.
5. Remove the *EN–46109* pins from the cylinder block.
6. Hand start all the engine front cover bolts.

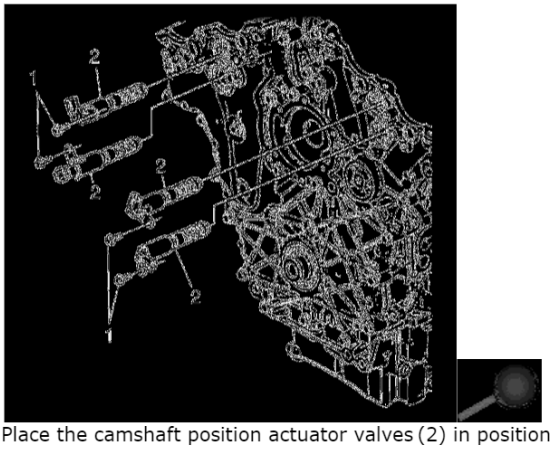
cardiagn.com



Caution: Refer to Fastener Caution.

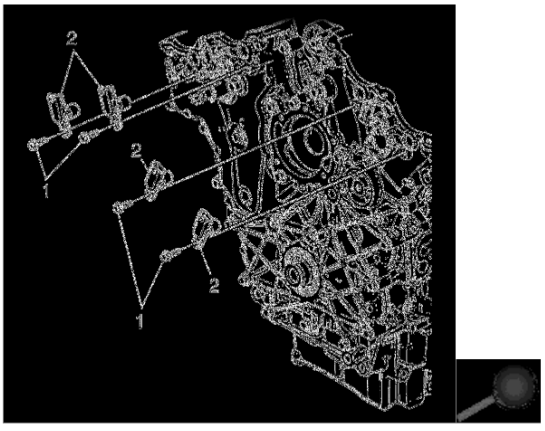
Note: Engine front cover bolts in the number (25) location are model dependent and may not apply.

7. Tighten the engine front cover bolts (1–23) in the sequence shown to **20 N•m (15 lb ft)**.
   7.1. Tighten the engine front cover bolts (1–23) a second pass in sequence to **20 N•m (15 lb ft)**.
   7.2. Tighten the engine front cover bolts (1–23) a third pass in sequence an additional **60 degrees**.
   7.3. Tighten the engine front cover bolts (24) to **15 N•m (11 lb ft)**.
   7.4. Tighten the engine front cover bolts (25) to **65 N•m (48 lb ft)**.



8. Place the camshaft position actuator valves (2) in position on the front cover.
9. Install the camshaft position actuator valve bolts (1) and tighten to **10 N•m (89 lb in)**.

cardiagn.com



Note: Inspect the camshaft position sensor O-ring seals. If the seals are damaged, the entire camshaft position sensor must be replaced.

10. Place the camshaft position sensors (2) in position on the front cover.
11. Install the camshaft position sensor bolts (1) and tighten to **10 N•m (89 lb in)**.

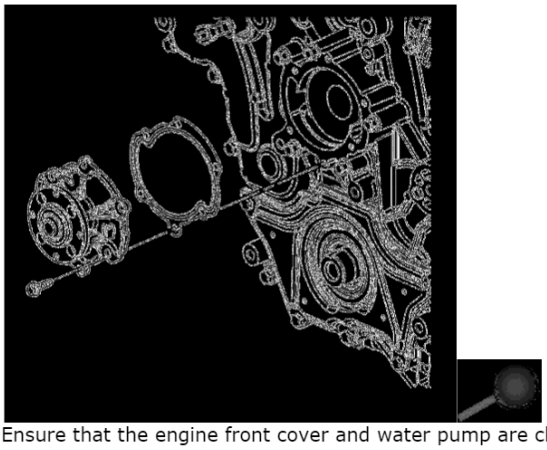
cardiagn.com

Water Pump Installation

Special Tools

EN-46104 Water Pump Pulley Holding Tool

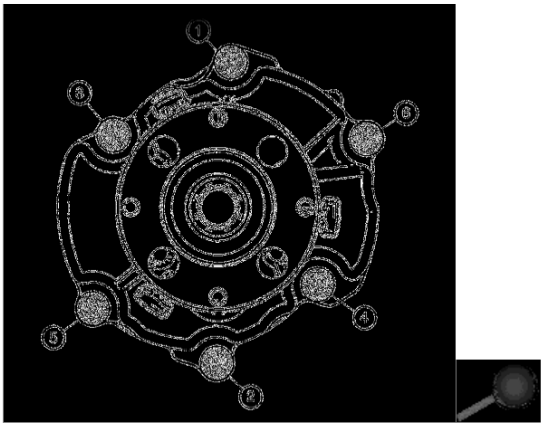
For equivalent regional tools, refer to Special Tools.



1. Ensure that the engine front cover and water pump are clear of old gasket material.
2. Ensure that the water pump mounting bolt holes in the front cover are completely clean and dry.
3. Place a NEW water pump gasket on the water pump.
4. Place the water pump in position on the front cover.

Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

5. Install the NEW water pump bolts finger tight.

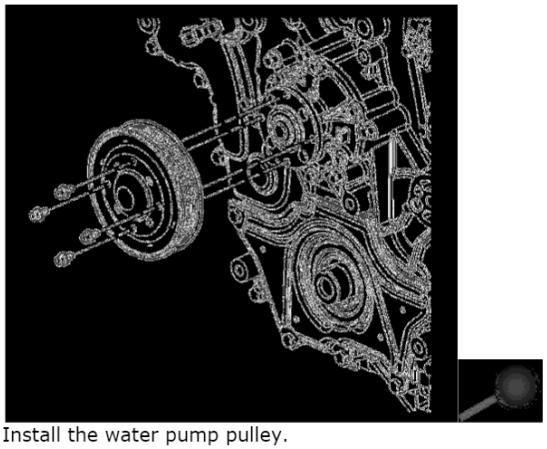


Caution: Refer to Fastener Caution.

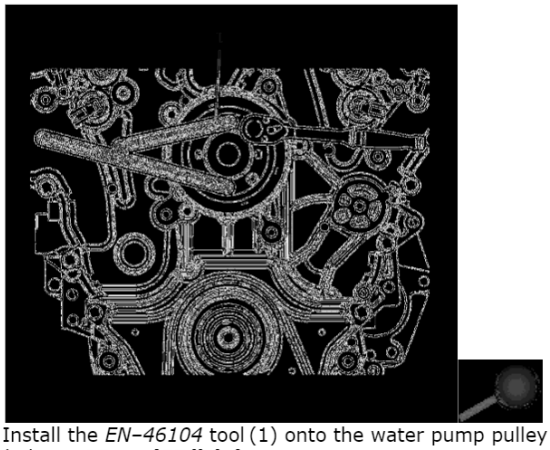
© 2014 General Motors. All rights reserved.

cardiagn.com

6. Tighten the NEW water pump bolts.
   6.1. Tighten the bolts a first pass in the sequence shown to **10 N•m (89 lb in)**.
   6.2. Tighten the bolts a second pass in the sequence shown to **10 N•m (89 lb in)**.
   6.3. Tighten the bolts a final pass in the sequence shown an additional **45 degrees**.



7. Install the water pump pulley.
8. Loosely install the water pump pulley bolts.



9. Install the *EN–46104* tool (1) onto the water pump pulley and tighten the water pump pulley bolts to **10 N•m (89 lb in)**.

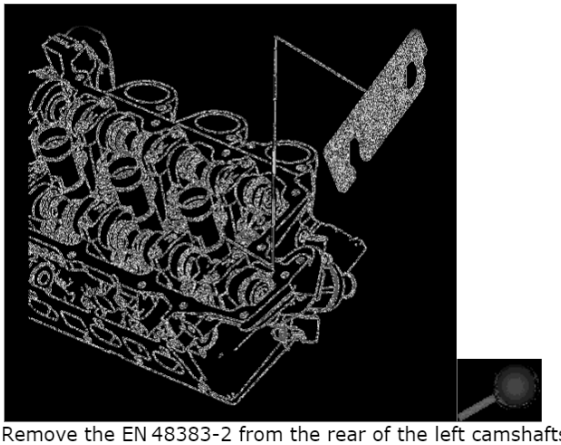
cardiagn.com

Camshaft Cover Installation - Left Side

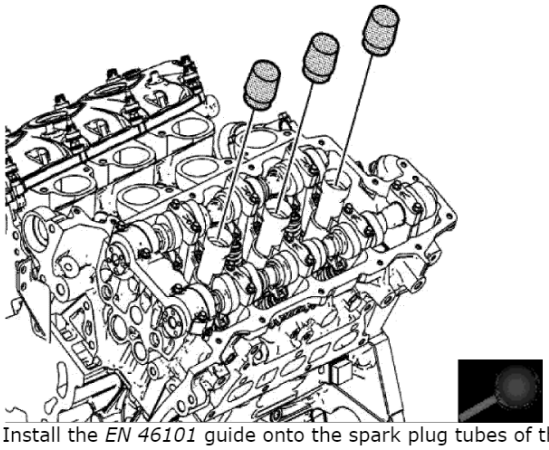
Special Tools

- *EN 46101* Spark Plug Tube Seal Guide
- *EN-48383* Camshaft Retaining Tools

For equivalent regional tools, refer to Special Tools.



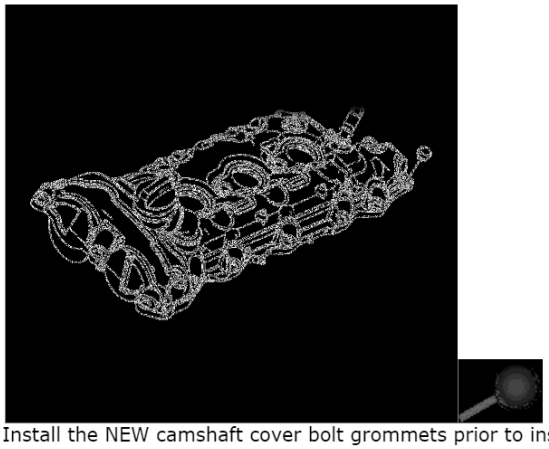
1. Remove the EN 48383-2 from the rear of the left camshafts.



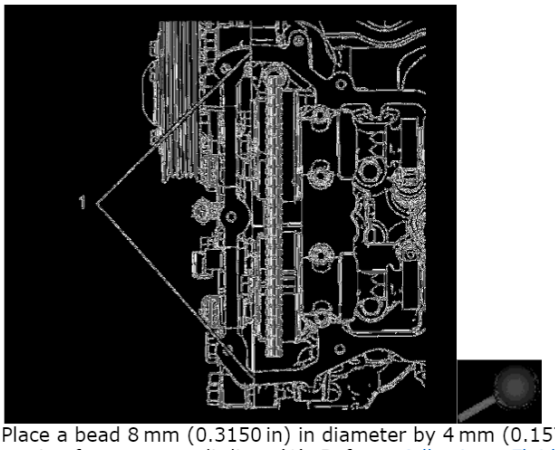
2. Install the *EN 46101* guide onto the spark plug tubes of the left cylinder head.

cardiagn.com

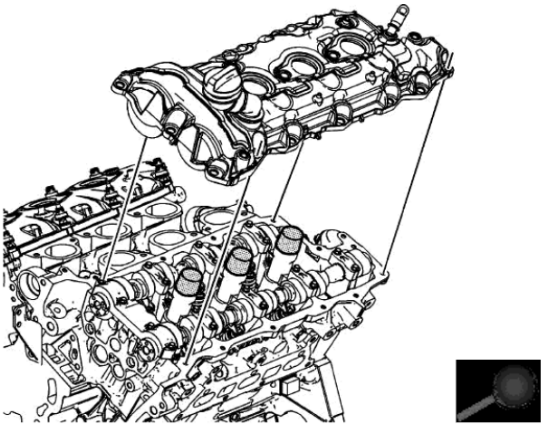
© 2014 General Motors. All rights reserved.



3. Install the NEW camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.

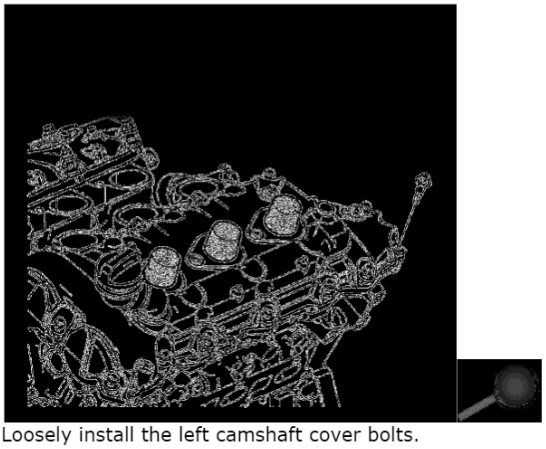


5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines (1). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant.

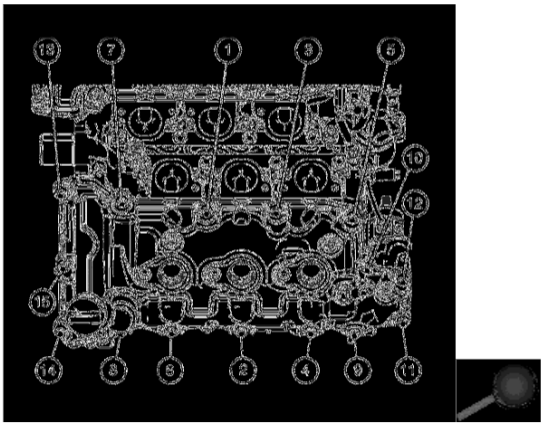


cardiagn.com

6. Place the left camshaft cover into position onto the left cylinder head.



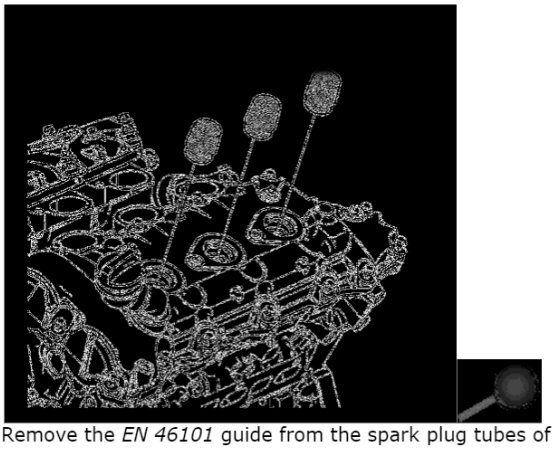
7. Loosely install the left camshaft cover bolts.



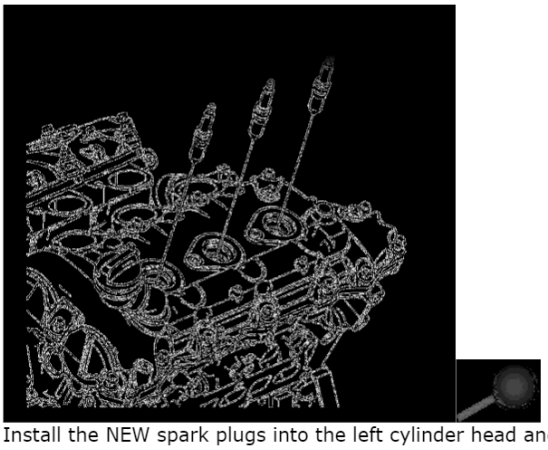
Caution: Refer to Fastener Caution.

8. Tighten the left camshaft cover bolts in the sequence shown.
   8.1. Tighten the left camshaft cover bolts in the sequence to **10 N•m (89 lb in).**
   8.2. Tighten the left camshaft cover bolts a second pass in the sequence to **10 N•m (89 lb in)**.

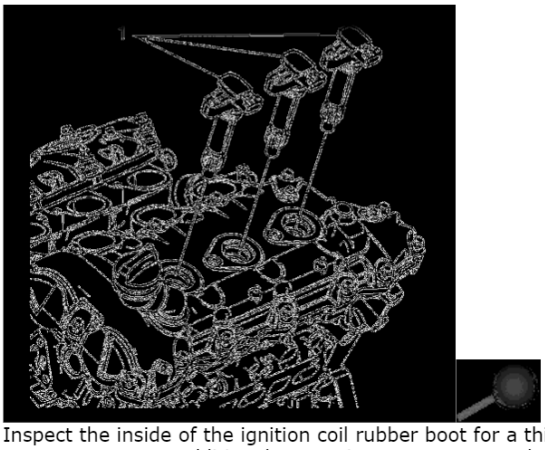
cardiagn.com



9. Remove the *EN 46101* guide from the spark plug tubes of the left cylinder head.



10. Install the NEW spark plugs into the left cylinder head and tighten to **18 N•m (13 lb ft)**.



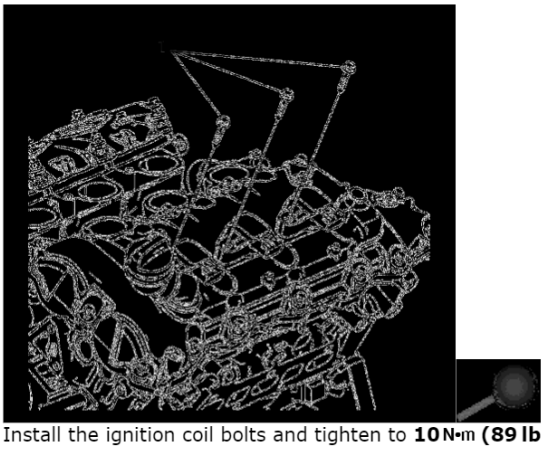
11. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:

cardiagn.com

11.1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers.

11.2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

12. Install the ignition coils.



13. Install the ignition coil bolts and tighten to **10 N·m (89 lb in)**.

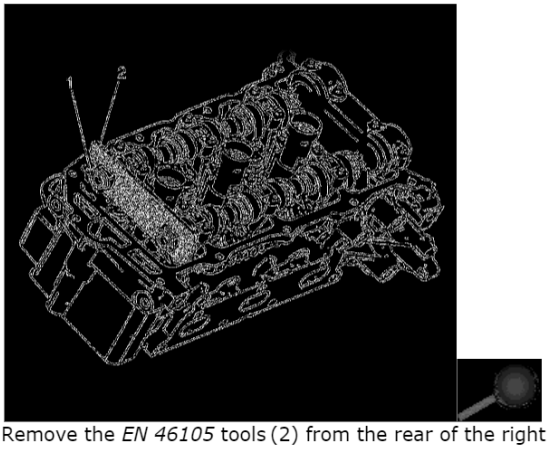
cardiagn.com

Camshaft Cover Installation - Right Side

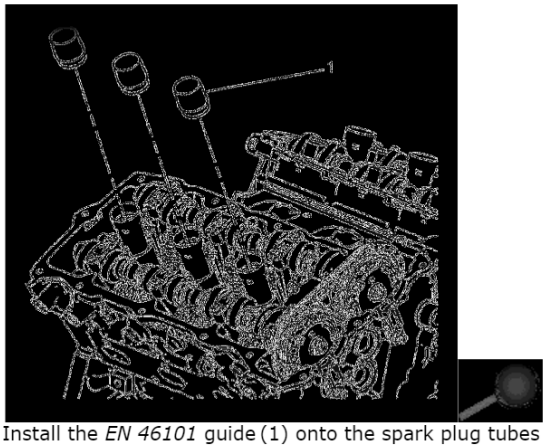
Special Tools

- *EN 46101* Spark Plug Tube Seal Guide
- *EN 46105* Camshaft Locking Tools

For equivalent regional tools, refer to Special Tools.



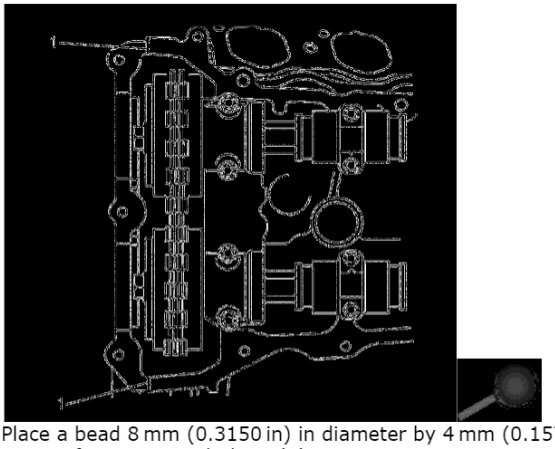
1. Remove the *EN 46105* tools (2) from the rear of the right camshafts (1).



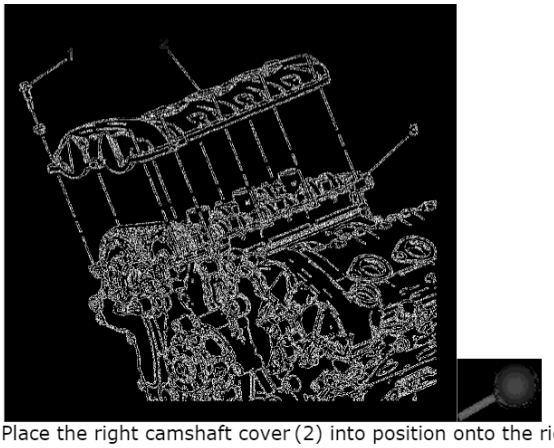
2. Install the *EN 46101* guide (1) onto the spark plug tubes of the right cylinder head.
3. Install the camshaft cover bolt grommets prior to installing the camshaft cover bolts.
4. Wipe the camshaft cover sealing surface on the right cylinder head with a clean, lint-free cloth.

cardiagn.com

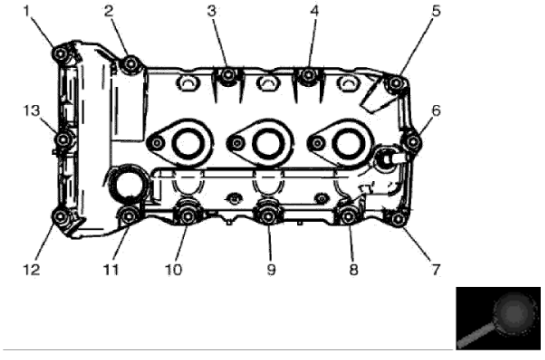
© 2014 General Motors. All rights reserved.



5. Place a bead 8 mm (0.3150 in) in diameter by 4 mm (0.1575 in) in height of RTV sealant on the engine front cover split lines (1).



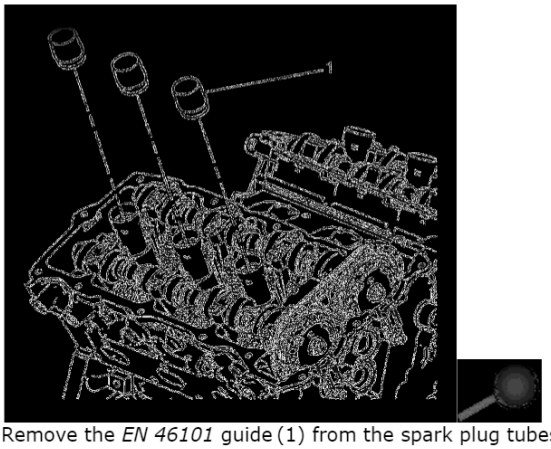
6. Place the right camshaft cover (2) into position onto the right cylinder head (3).
7. Loosely install the right camshaft cover bolts (1).



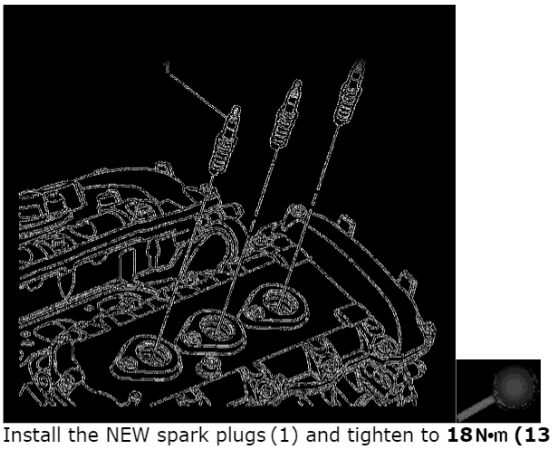
Caution: Refer to Fastener Caution.

cardiagn.com

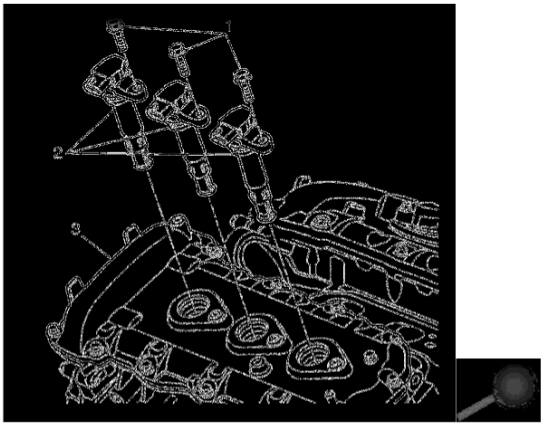
8. Tighten the left camshaft cover to cylinder head retaining bolts in the sequence shown and tighten in sequence to **10 N•m (89 lb in)**.



9. Remove the *EN 46101* guide (1) from the spark plug tubes of the right cylinder head.



10. Install the NEW spark plugs (1) and tighten to **18 N•m (13 lb ft)**.



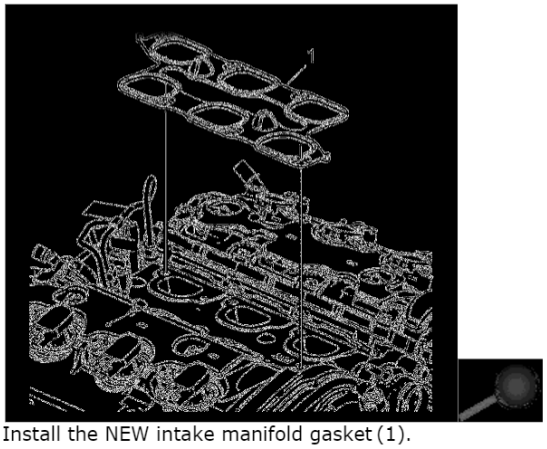
cardiagn.com

Note: DO NOT damage the spark plug and/or the seal in the left camshaft cover or an engine misfire condition may result.

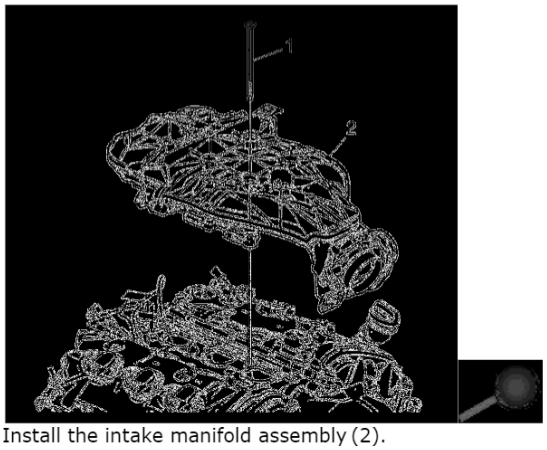
11. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure:
    11.1. Apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers.
    11.2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
12. Install the ignition coils (2).
13. Install each ignition coil to camshaft cover retaining bolt (1) and tighten to **10 N•m (89 lb in)**.

cardiagn.com

Intake Manifold Installation (LFW or LFX)



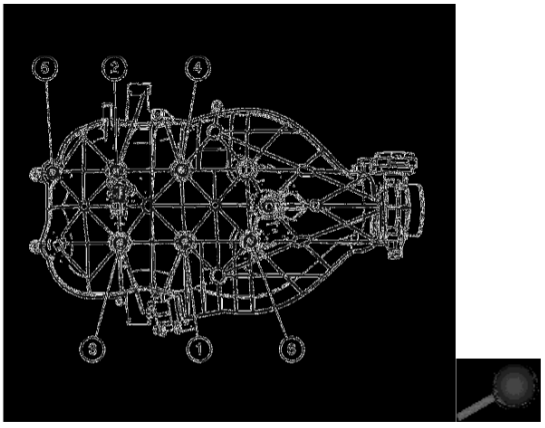
1. Install the NEW intake manifold gasket (1).



2. Install the intake manifold assembly (2).
3. Install the intake manifold bolts (1).

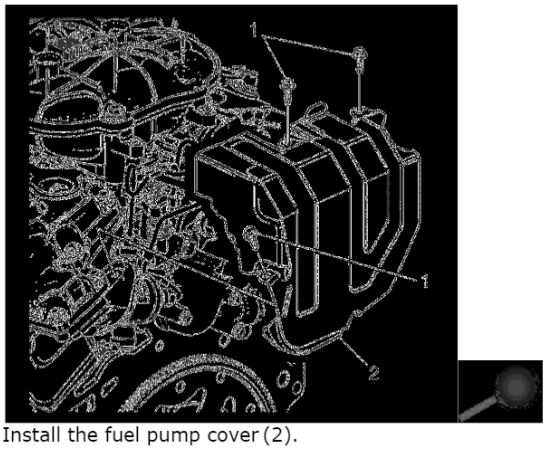
cardiagn.com

© 2014 General Motors. All rights reserved.



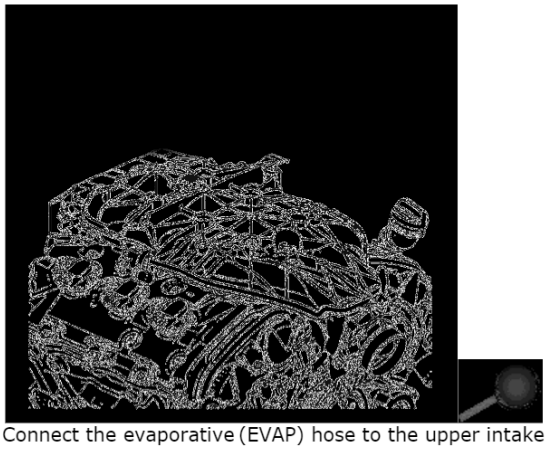
Caution: Refer to Fastener Caution.

4. Tighten the intake manifold bolts in the sequence shown.
5. Tighten the intake manifold bolts in sequence to **25 N•m (18 lb ft)**.
6. Tighten the intake manifold bolts a second pass in sequence to **25 N•m (18 lb ft)**.

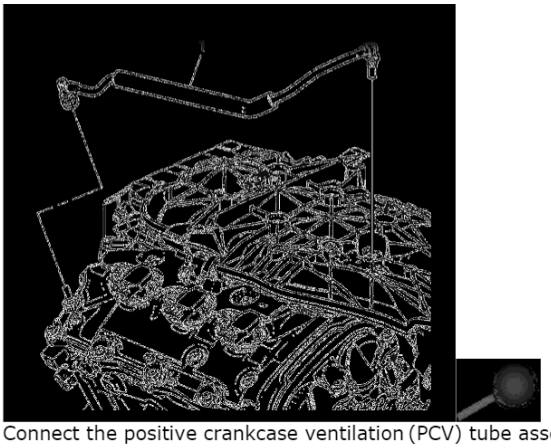


7. Install the fuel pump cover (2).
8. Install the fuel pump cover bolt (1) and tighten to **10 N•m (89 lb in)**.

cardiagn.com



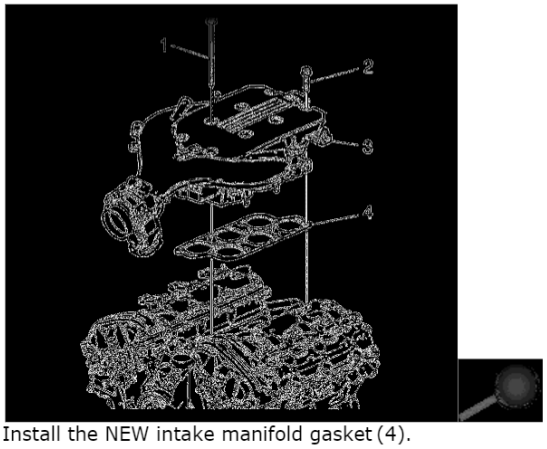
9. Connect the evaporative (EVAP) hose to the upper intake manifold and EVAP solenoid.



10. Connect the positive crankcase ventilation (PCV) tube assembly (1) to the upper intake manifold and the right camshaft cover.

cardiagn.com

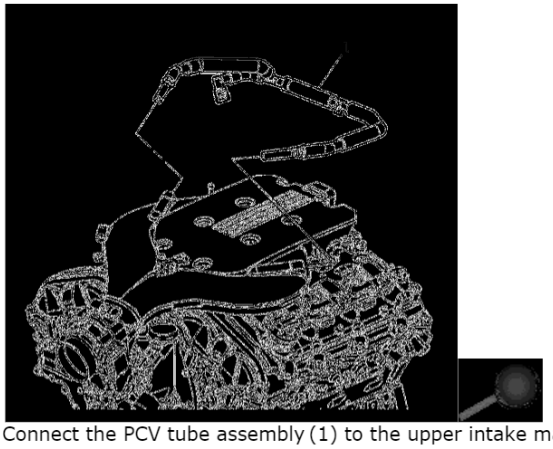
Intake Manifold Installation (LWR)



1. Install the NEW intake manifold gasket (4).
2. Install the intake manifold assembly (3).

   Caution: Refer to Fastener Caution.

   Note: Tighten the intake manifold bolts in an X pattern starting with the inside bolts and moving outward.
3. Install the intake manifold bolts (1, 2) and tighten to **23 N•m (17 lb ft)**.



4. Connect the PCV tube assembly (1) to the upper intake manifold and the right camshaft cover.

cardiagn.com

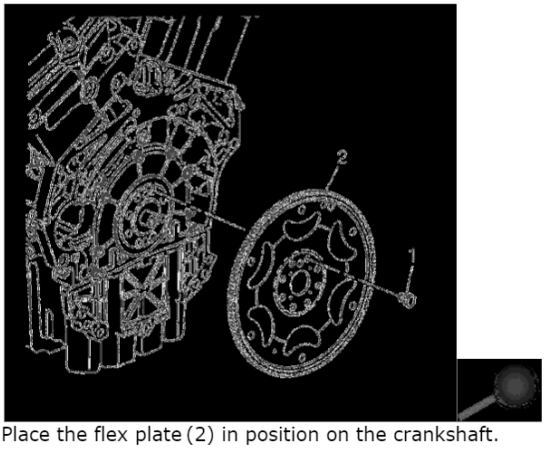
© 2014 General Motors. All rights reserved.

Automatic Transmission Flex Plate Installation

Special Tools

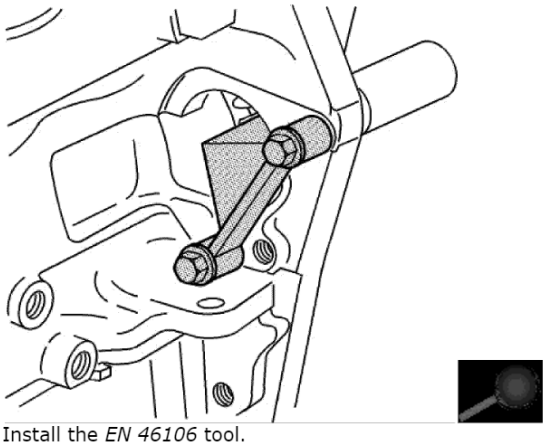
- *EN 45059* Angle Meter
- *EN 46106* Engine Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools.



1. Place the flex plate (2) in position on the crankshaft.

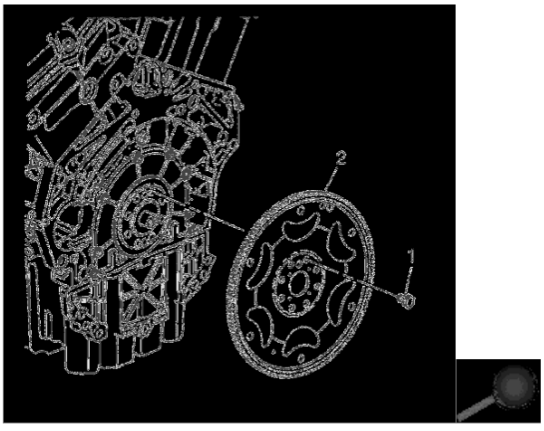
   Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.
2. Install 2 NEW bolts (1) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position.



3. Install the *EN 46106* tool.

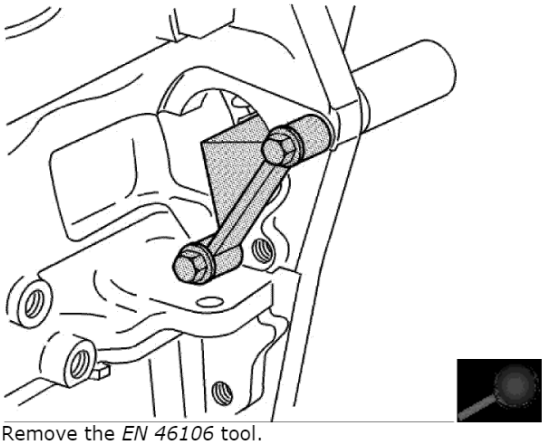
cardiagn.com

© 2014 General Motors. All rights reserved.



Caution: Refer to Fastener Caution.

4. Install the remaining NEW flex plate bolts (1).
   4.1. Tighten the NEW flex plate bolts (1) to **30 N•m (22 lb ft)**.
   4.2. Tighten the NEW flex plate bolts (1) an additional **75 degrees** using the *EN 45059* meter.



5. Remove the *EN 46106* tool.

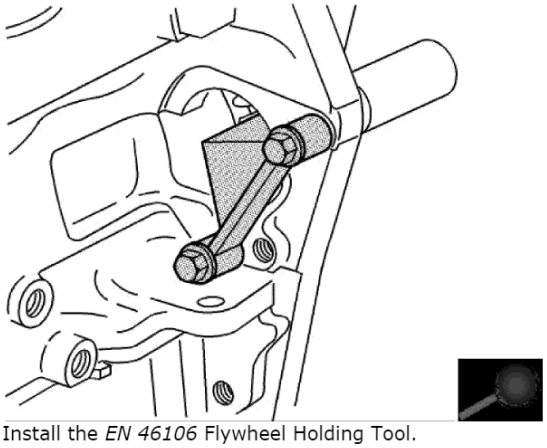
cardiagn.com

Engine Flywheel Installation

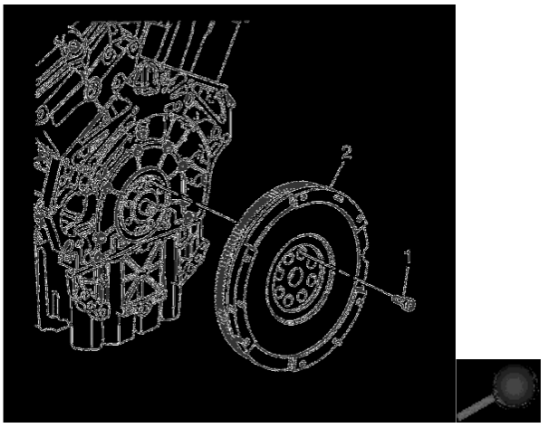
Special Tools

- *EN 46106* Flywheel Holding Tool
- *J 33169* Clutch Alignment Arbor
- *J 45059* Angle Meter

1. Place the engine flywheel in position on the crankshaft.
2. Install 2 NEW bolts in location at the top and bottom of the engine flywheel bolt pattern allowing the engine flywheel to hang in position.



3. Install the *EN 46106* Flywheel Holding Tool.



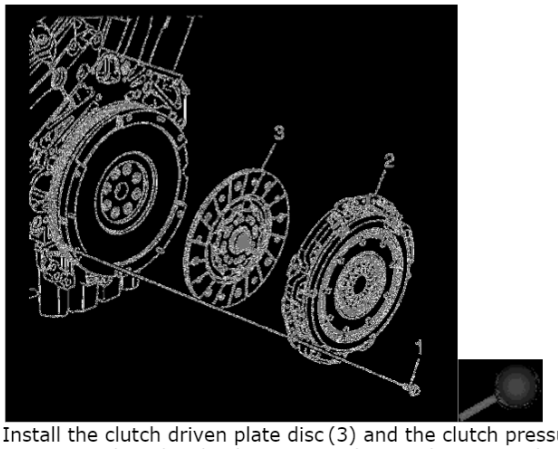
Caution: Refer to Fastener Notice.

4. Install the engine flywheel (2).
5. Install the NEW engine flywheel bolts (1).
   Tighten
   Tighten the NEW engine flywheel bolts (1) to 30 N•m (22 lb ft).

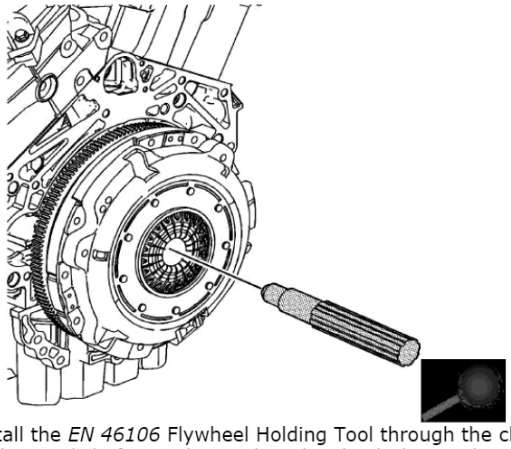
© 2014 General Motors. All rights reserved.

cardiagn.com

Tighten the NEW engine flywheel bolts (1) an additional 75 degrees using the *J 45059* Angle Meter.

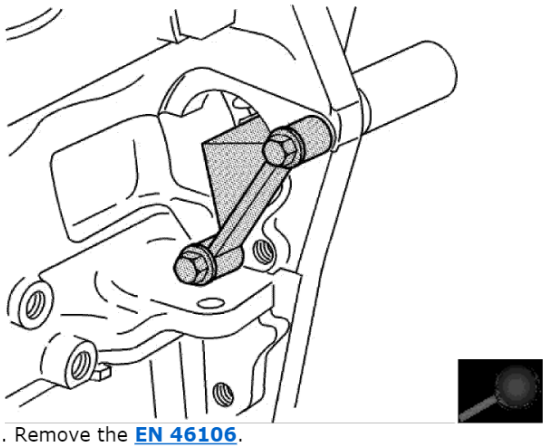


6. Install the clutch driven plate disc (3) and the clutch pressure plate (2) to the engine flywheel. Ensure to align the clutch pressure plate to the pins in the engine flywheel.
7. Loosely install the clutch pressure plate bolts (1).



8. Install the *EN 46106* Flywheel Holding Tool through the clutch driven plate disc and into the end of the crankshaft in order to align the clutch driven plate disc.
9. Tighten the clutch pressure plate bolts.
   Tighten
   Tighten the clutch pressure plate bolts to 23 N•m (17 lb ft).
10. Remove the *J 33169* Clutch Alignment Arbor.

cardiagn.com



11. Remove the **EN 46106**.

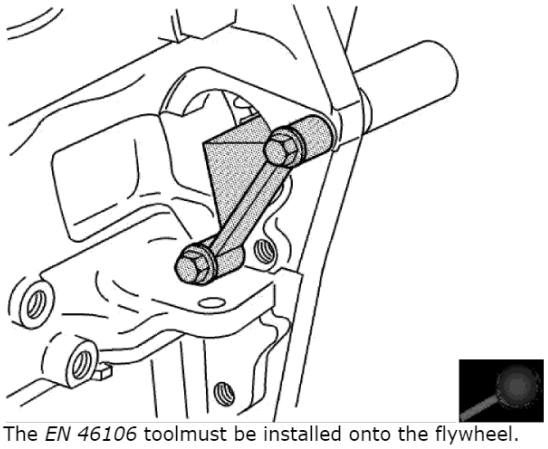
cardiagn.com

Crankshaft Balancer Installation

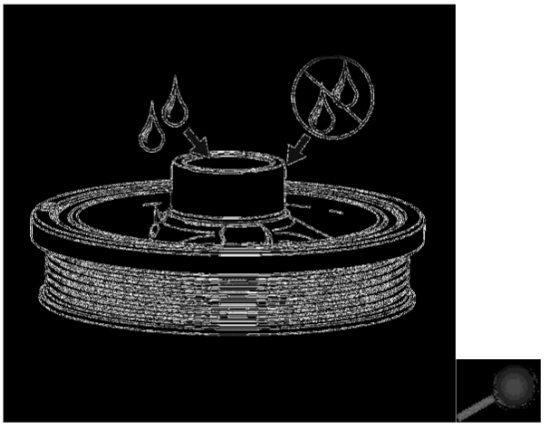
Special Tools

- *EN 41998-B* Crankshaft Balancer Installer
- *EN 45059* Angle Meter
- *EN 46106* Engine Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools.



1. The *EN 46106* toolmust be installed onto the flywheel.
2. Use the *EN 41998-B* installer, nut, bearing and washer to install the crankshaft balancer.

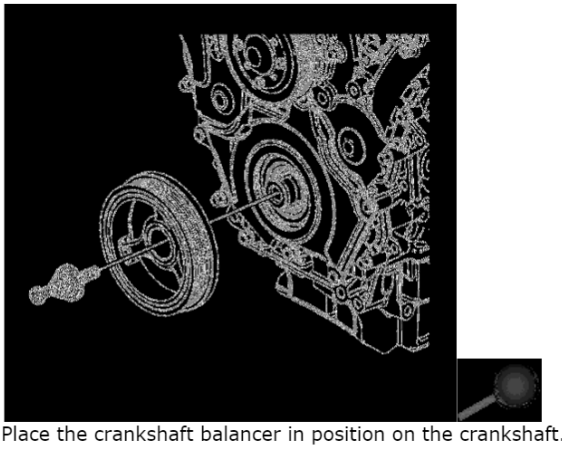


Note: Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal.

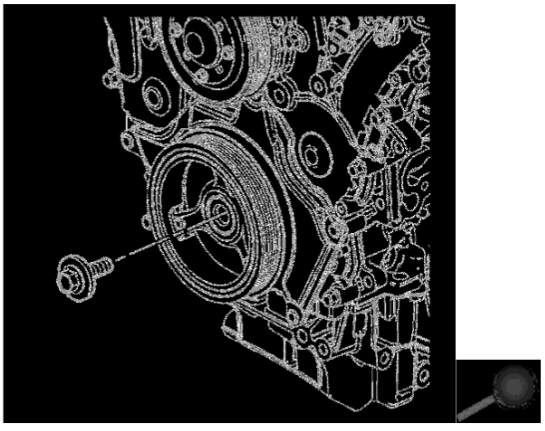
3. Apply lubricant to the inside of the crankshaft balancer hub bore.

cardiagn.com

© 2014 General Motors. All rights reserved.



4. Place the crankshaft balancer in position on the crankshaft.
5. Thread the *EN 41998-B* installerin the crankshaft. Ensure you engage at least 10 threads of the *EN 41998-B* installerbefore pressing the crankshaft balancer in place.
6. Push the crankshaft balancer into position by tightening the nut on the *J 41998-B* installeruntil the large washer bottoms out on the crankshaft end.
7. Remove the *EN 41998-B* installer.



Caution: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

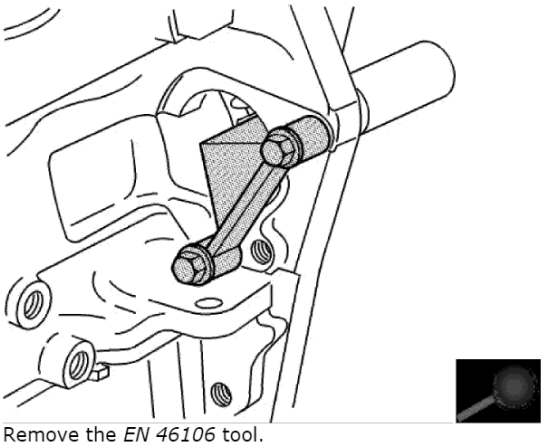
8. Install the NEW crankshaft balancer bolt.

   Caution: Refer to Fastener Caution.
9. Tighten the crankshaft balancer bolt.

   9.1. Tighten the crankshaft balancer bolt to **100 N•m (74 lb ft)**.

   9.2. Tighten the crankshaft balancer bolt an additional **150 degrees**using the *EN 45059* meter.

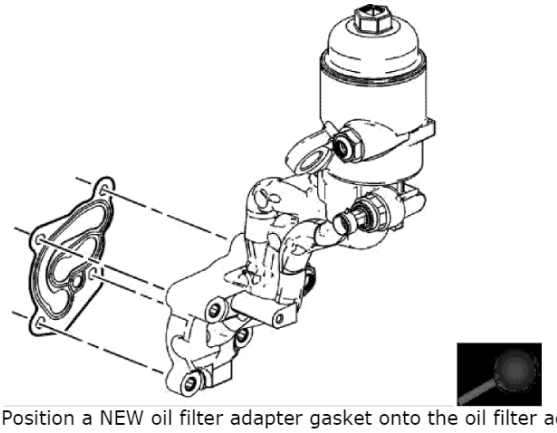
cardiagn.com



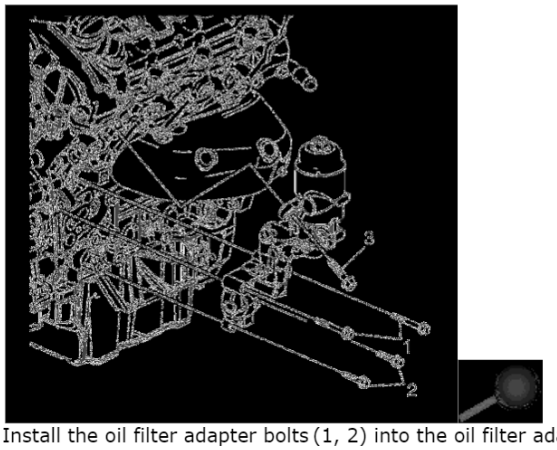
10. Remove the *EN 46106* tool.

cardiagn.com

Oil Filter Adapter Installation



1. Position a NEW oil filter adapter gasket onto the oil filter adapter.

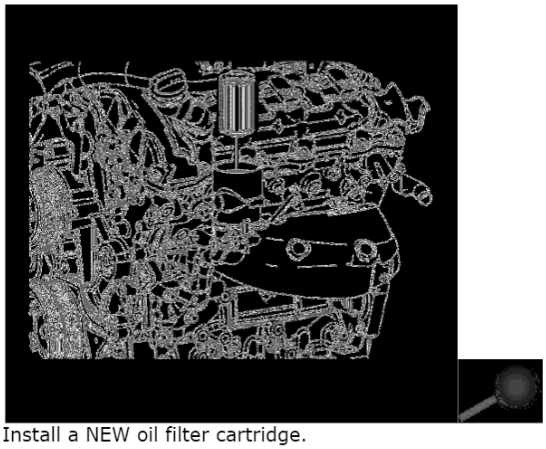


2. Install the oil filter adapter bolts (1, 2) into the oil filter adapter.
3. Loosely tighten the oil filter adapter bolts (1, 2).
4. Install and loosely tighten the oil filter adapter bolt (3) into the oil filter adapter.

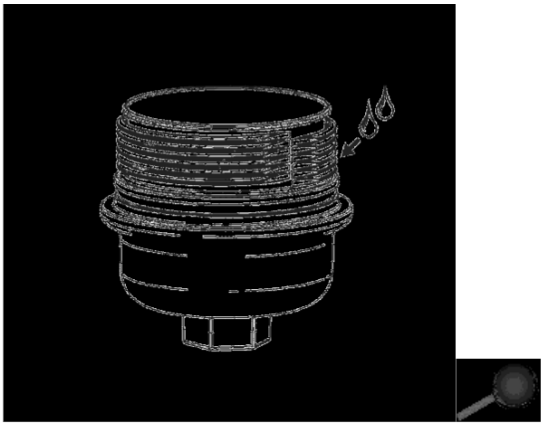
   Caution: Refer to Fastener Caution.
5. Tighten the oil filter adapter bolts (1, 2) to **25 N•m (18 lb ft)**.
6. Tighten the oil filter adapter bolt (3) to **58 N•m (43 lb ft)**.

cardiagn.com

© 2014 General Motors. All rights reserved.



7. Install a NEW oil filter cartridge.



Caution: Lubrication must be applied to the threads of the oil filter cap prior to installation. Failure to lubricate the oil filter cap threads can hinder later removal and cause possible oil filter cap damage.

8. Lubricate the oil filter cap threads with clean engine oil.

cardiagn.com

Caution: Proper oil filter cap tightening is mandatory. Failure to tighten the oil filter cap to the proper specification can hinder later removal and cause possible oil filter cap damage.

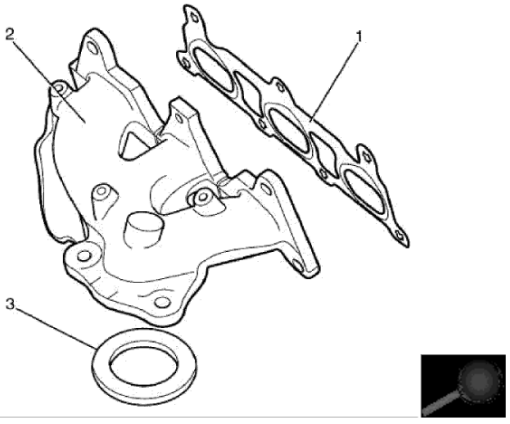
9. Install the oil filter cap and tighten to **25 N•m (18 lb ft)**.

cardiagn.com

Exhaust Manifold Installation - Left Side (LWR)

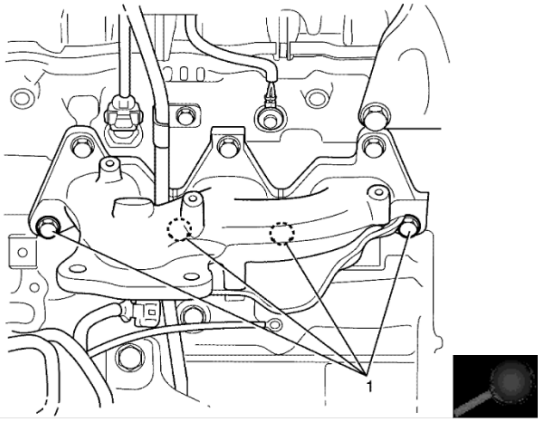
Caution: Refer to Exhaust System Inspection Caution.

1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Left Side.



Note: Make sure the sealing ring is seated correctly.

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.



Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

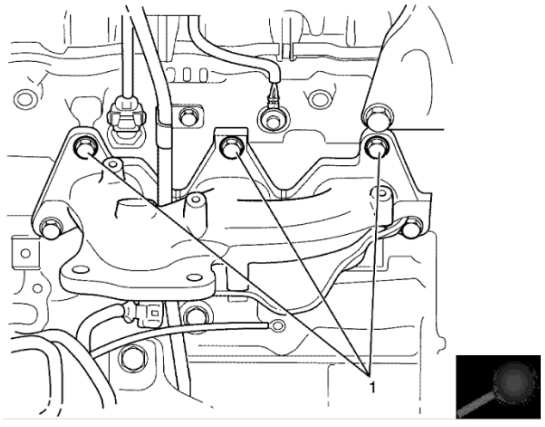
4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution.

5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N·m (15 lb ft)**.

© 2014 General Motors. All rights reserved.

cardiagn.com

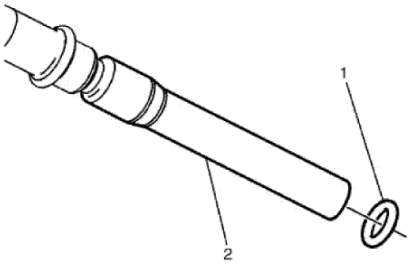


Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

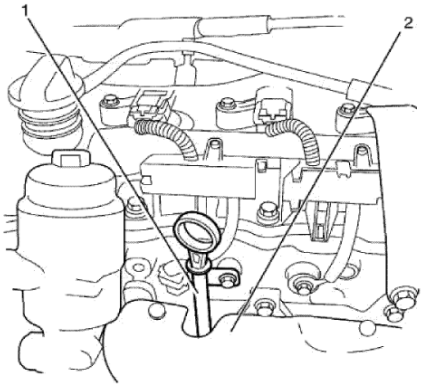
6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N•m (15 lb ft)**.

cardiagn.com

Oil Level Indicator and Tube Installation (LWR)



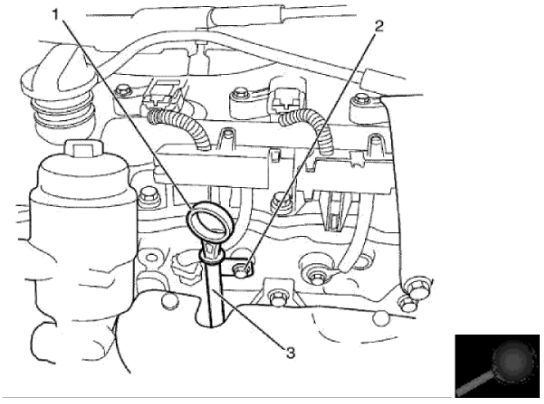
1. Install a NEW O-ring (1) to the oil level indicator tube (2).



2. Install the oil level indicator and tube (1) to the engine by sliding the oil level indicator and tube through the exhaust manifold opening .

cardiagn.com

© 2014 General Motors. All rights reserved.

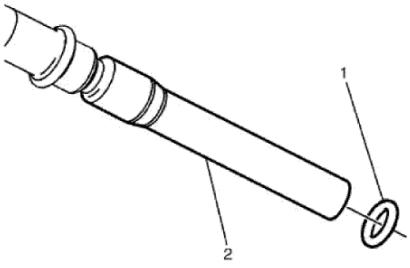


Caution: Refer to Fastener Caution

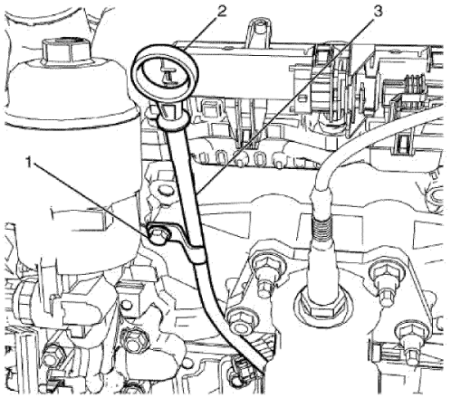
3. Install the oil level indicator tube bracket to cylinder head retaining bolt (2).
   Tighten
   Tighten the bolt to 9 N•m (80 lb in).

cardiagn.com

Oil Level Indicator and Tube Installation (LFW or LFX)



1. Install a NEW O-ring (1) on the oil level indicator tube (2).



2. Install the oil level indicator tube (3) by sliding the oil level indicator tube behind the exhaust and into the cylinder block.

   Caution: Refer to Fastener Caution
3. Install the oil level indicator tube bracket to cylinder head retaining bolt (1).
   Tighten
   Tighten the bolt to 9 N•m (80 lb in).
4. Install the oil level indicator (2) to the oil level indicator tube (3)

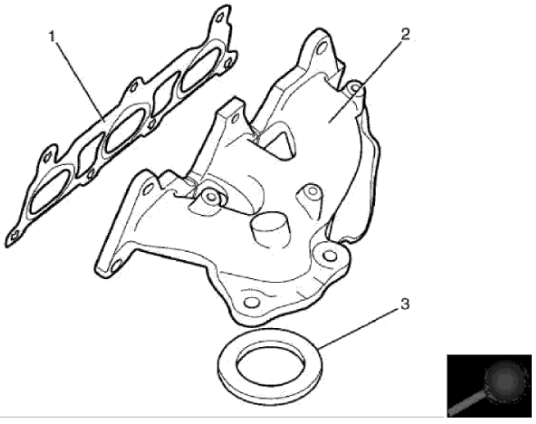
cardiagn.com

© 2014 General Motors. All rights reserved.

Exhaust Manifold Installation - Right Side (LWR)

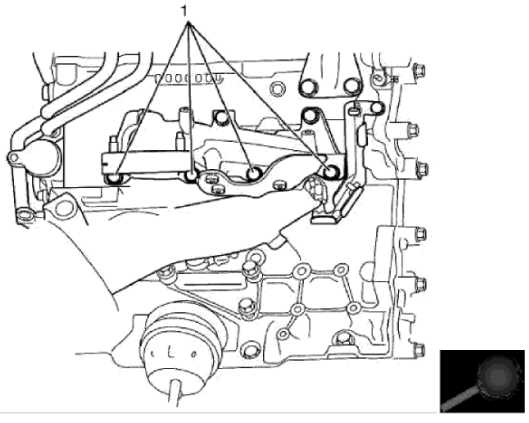
Caution: Refer to Exhaust System Inspection Caution.

1. Inspect the exhaust manifold before installation. Refer to Exhaust Manifold Cleaning and Inspection - Right Side.



Note: Make sure the sealing ring is seated correctly.

2. Install a NEW exhaust manifold gasket (1) and NEW sealing ring (3) to the exhaust manifold (2).
3. Install the exhaust manifold assembly (2) to the engine.



Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

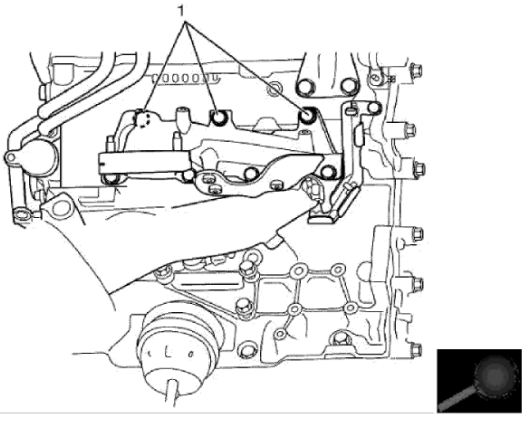
4. Install NEW exhaust manifold to cylinder head retaining bolts (1).

Caution: Refer to Fastener Caution.

5. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N•m (15 lb ft)**.

© 2014 General Motors. All rights reserved.

cardiagn.com

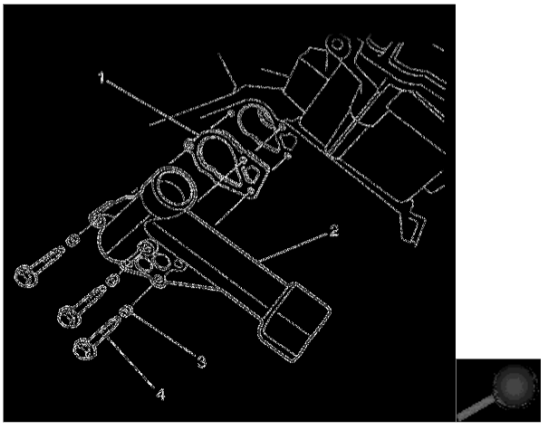


Note: Do not fully tighten the exhaust manifold to cylinder head retaining bolts (1) at this stage.

6. Install NEW exhaust manifold to cylinder head retaining bolts (1).
7. Tighten the exhaust manifold to cylinder head retaining bolts (1) working from the centre to the outside to **20 N•m (15 lb ft)**.

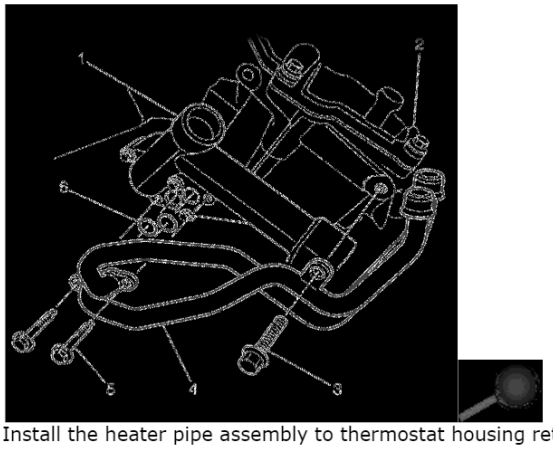
cardiagn.com

Engine Coolant Thermostat Housing Installation



Caution: Refer to Fastener Caution.

1. Install thermostat housing to cylinder block retaining bolts (4) ensuring a new block gasket (1) and rubber grommets (3) has been fitted and tighten bolts to **10 N•m (89 lb in)**.

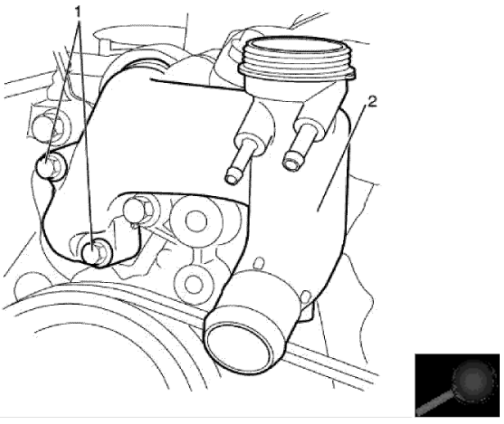


2. Install the heater pipe assembly to thermostat housing retaining bolts (5) ensuring new O-ring seals (6) have been fitted and tighten bolts to **10 N•m (89 lb in)**.
3. Install the heater pipe assembly (4) to cylinder head (2) retaining bolt (3) and tighten to **35 N•m (26 lb ft)**.

cardiagn.com

© 2014 General Motors. All rights reserved.

Water Outlet Installation



Note: Make sure a new rubber O-ring and seal is used when installing the water outlet housing.

1. Install the water outlet housing (2) to the cylinder head.

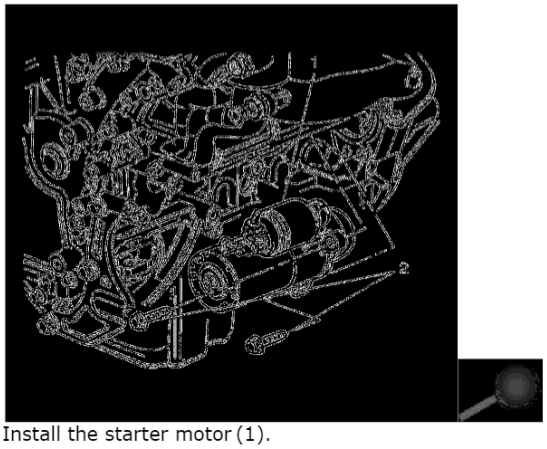
   Caution: Refer to Fastener Caution.

2. Install the water outlet housing to cylinder head retaining bolts (1).
   Tighten
   Tighten the bolts (1) to 10 N•m (89 lb in).

cardiagn.com

© 2014 General Motors. All rights reserved.

Starter Installation



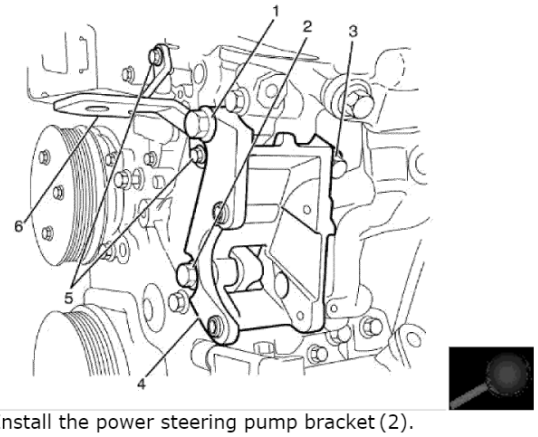
1. Install the starter motor (1).

   Caution: Refer to Fastener Caution.
2. Install the starter motor to cylinder block retaining bolts (2) and tighten to **58 N•m (42 lb ft)**.

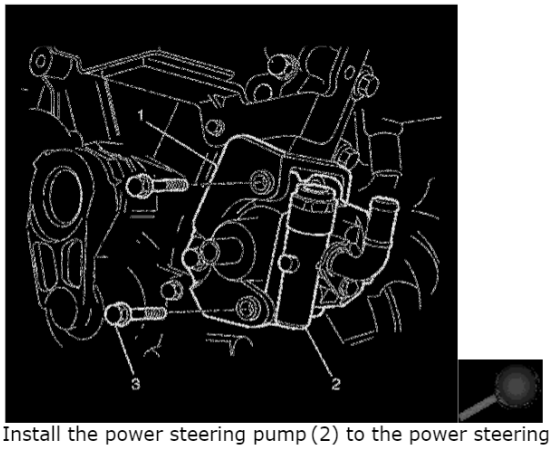
cardiagn.com

© 2014 General Motors. All rights reserved.

Power Steering Pump Installation



1. Install the power steering pump bracket (2).
2. Install the NEW power steering bracket to cylinder head retaining bolts (1).
   Tighten
   Tighten the bolts to 58 N•m (43 lb ft).
3. Install the power steering fluid reservoir bracket (4).
4. Install the NEW power steering fluid reservoir bracket to engine front cover retaining bolts (3).
   Tighten
   Tighten the bolts to 9 N•m (80 lb ft).



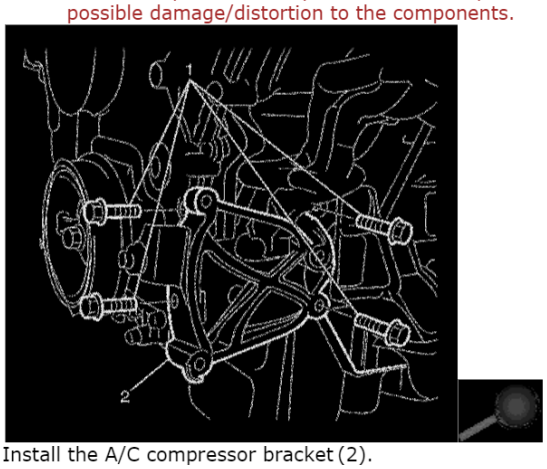
5. Install the power steering pump (2) to the power steering pump mounting bracket (3).
6. Install the power steering pump to mounting bracket retaining bolts (1).

cardiagn.com

© 2014 General Motors. All rights reserved.

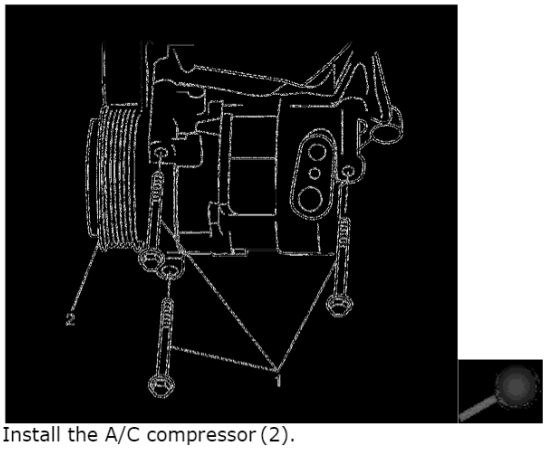
Air Conditioning (A/C) Compressor Installation

Note: Follow the procedure sequence in order to prevent drive belt mis-alignment and/or possible damage/distortion to the components.



1. Install the A/C compressor bracket (2).

   Caution: Refer to Fastener Caution.
2. Install the A/C compressor bracket to cylinder block retaining bolts (1) and tighten to **58 N•m (42 lb ft)**.
3. If you are replacing the compressor, balance the compressor oil. Refer to Air Conditioning Compressor Oil Balancing.

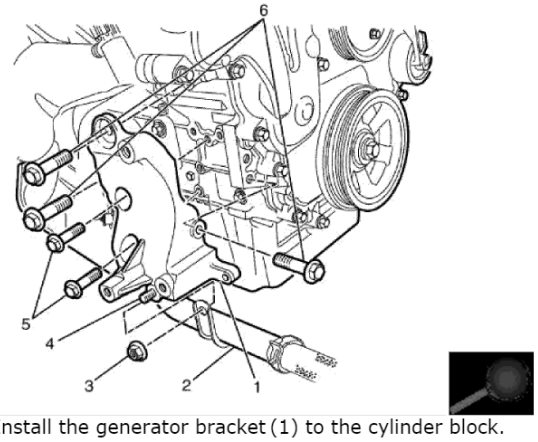


4. Install the A/C compressor (2).
5. Install the A/C compressor to A/C compressor bracket retaining bolts (1) and tighten to **22 N•m (16 lb ft)**.

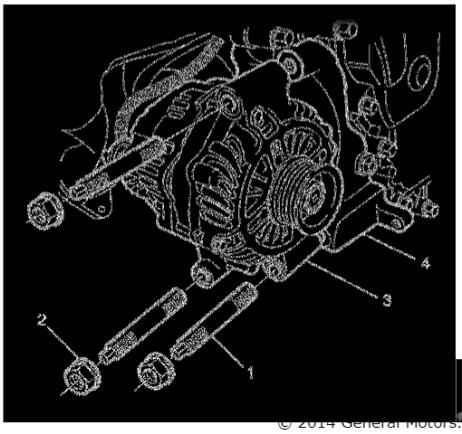
© 2014 General Motors. All rights reserved.

cardiagn.com

Generator Installation



1. Install the generator bracket (1) to the cylinder block.
   Caution: Refer to Fastener Caution
   Note: DO NOT fully tighten at this stage.
2. Install the generator bracket to engine block retaining bolts (5).
3. Install the generator bracket to engine block retaining bolts (6).
   Tighten
   Tighten the bolts to 58 N•m (43 lb ft).
4. Tighten the generator bracket to engine block retaining bolts (5).
   Tighten
   Tighten the bolts to 22 N•m (16 lb ft).
5. Attach the coolant inlet pipe (2) to the generator bracket stud (4).
6. Install the coolant inlet pipe to generator bracket retaining nut (3).
   Tighten
   Tighten the nut to 22 N•m (16 lb ft).



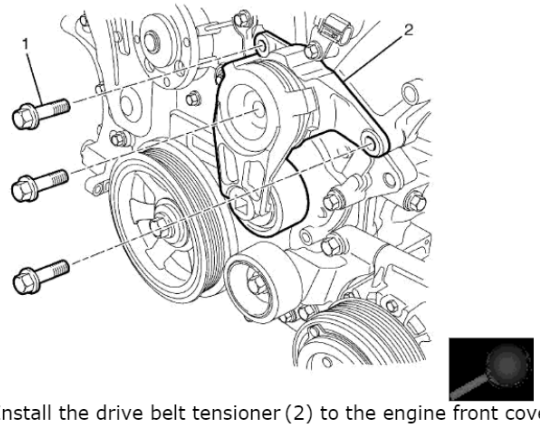
© 2014 General Motors. All rights reserved.

cardiagn.com

7. Install the generator (3) to the generator bracket (4).
8. Install the generator bracket studs (1) to the generator bracket (4).
   Tighten
   Tighten the studs to 18 N•m (13 lb ft).
9. Install the generator to generator bracket stud retaining nuts (2).
   Tighten
   Tighten the nuts to 58 N•m (43 lb ft).

cardiagn.com

Drive Belt Tensioner Installation

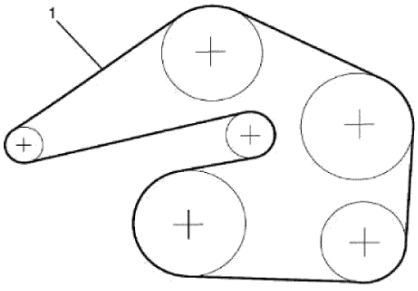


1. Install the drive belt tensioner (2) to the engine front cover.
   Caution: Refer to Fastener Caution.
2. Install the drive belt tensioner to engine front cover retaining bolts (1).
   Tighten
   Tighten the bolts to 25 N•m (18 lb ft).

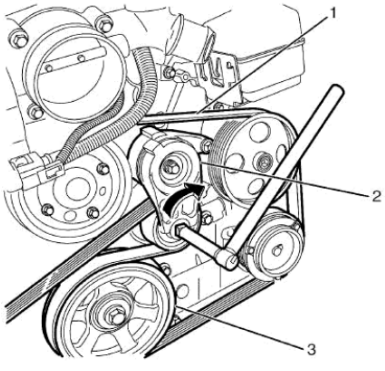
cardiagn.com

© 2014 General Motors. All rights reserved.

Drive Belt Installation



1. Install and correctly route the drive belt (1) around the following:
   - Water pump pulley
   - Generator
   - Drive belt tensioner
   - Crankshaft balancer
   - Air conditioning compressor
   - Power steering pump



2. Using a suitable tool rotate the drive belt tensioner (2) clockwise.

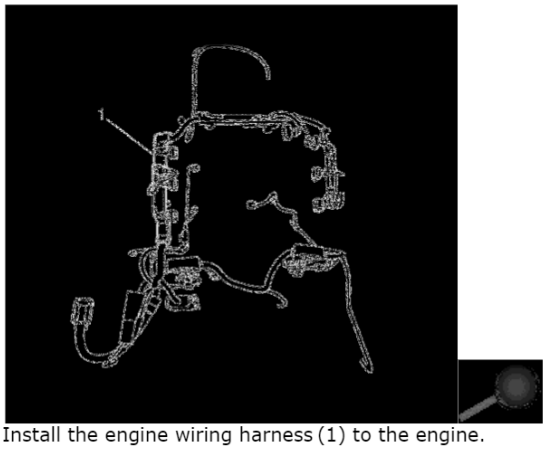
   Note: Make sure the drive belt (1) is correctly aligned and seated into the grooves of the accessory drive pulleys.
3. Install the drive belt (1) to the crankshaft pulley (3).
4. Slowly release the drive belt tensioner (2).
5. Remove the suitable tool from the drive belt tensioner (2).

© 2014 General Motors. All rights reserved.

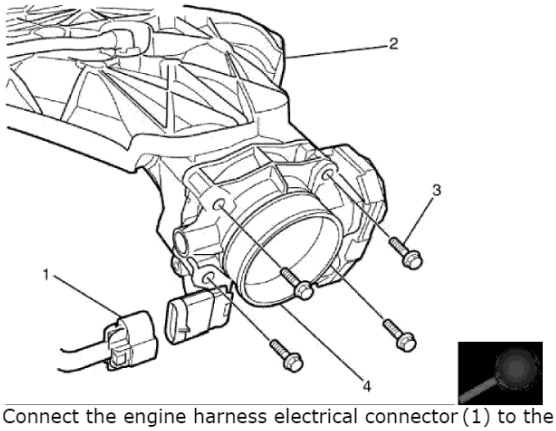
cardiagn.com

Engine Wiring Harness Assembly Installation (LFW or LFX)

Warning: Refer to Safety Glasses Warning.



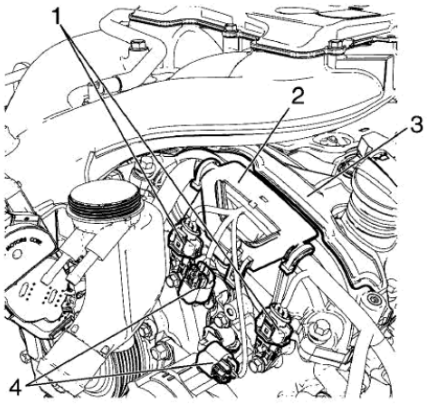
1. Install the engine wiring harness (1) to the engine.



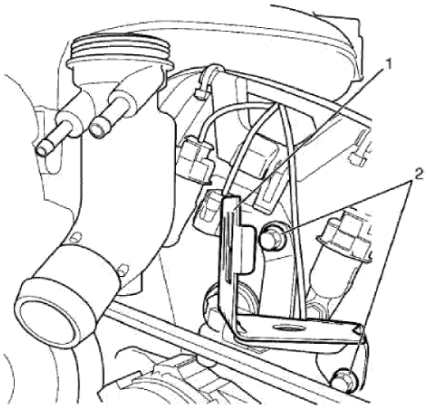
2. Connect the engine harness electrical connector (1) to the throttle body.

cardiagn.com

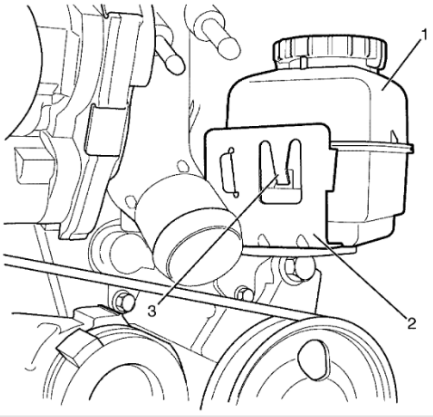
© 2014 General Motors. All rights reserved.



3. Connect the left camshaft position sensors electrical connectors (1).
4. Connect the left bank intake and exhaust camshaft position actuator valve electrical connectors (4).
5. Attach the engine wiring harness bracket (2) to the left bank camshaft cover (3).



6. Install the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
7. Install the power steering fluid reservoir bracket (1).

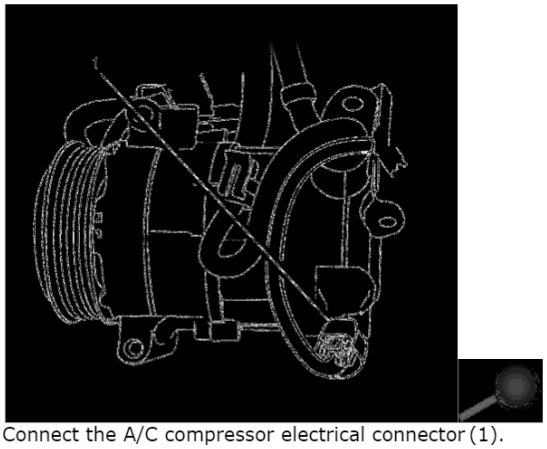


cardiagn.com

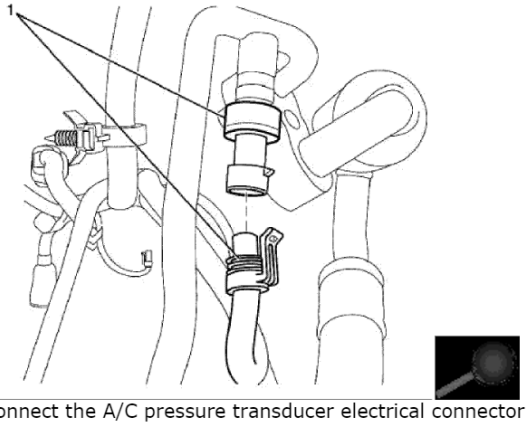
Note: DO NOT disconnect the power steering pipes or drain the power steering fluid.

Note: The locator tang (3) on the power steering reservoir bracket (2) must be aligned correctly (1).

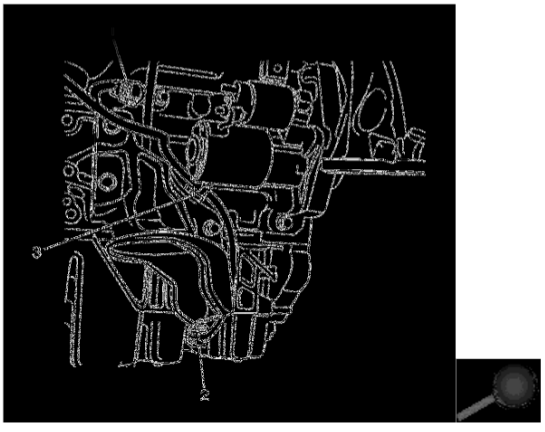
8. Fit the power steering fluid reservoir (1) to the power steering fluid reservoir bracket (2).



9. Connect the A/C compressor electrical connector (1).

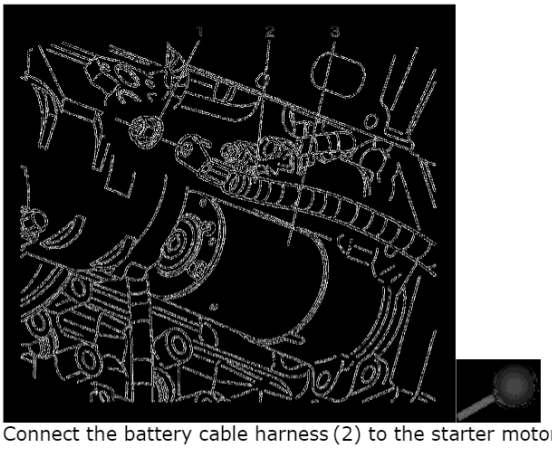


10. Connect the A/C pressure transducer electrical connector (1).

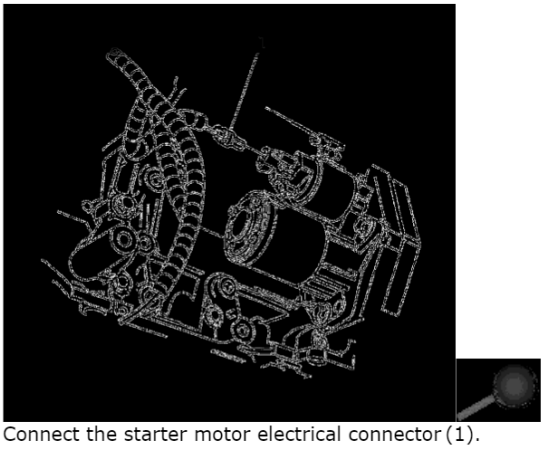


cardiagn.com

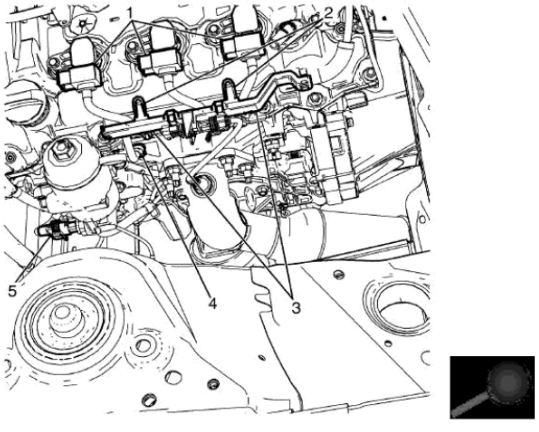
11. Connect the left bank knock sensor electrical connector (1).
12. Connect the oil level sensor electrical connector (2).
13. Attach the engine wiring harness to cylinder block retaining lug (3).



14. Connect the battery cable harness (2) to the starter motor (3).
15. Install the battery cable harness to starter motor retaining nut (1).



16. Connect the starter motor electrical connector (1).

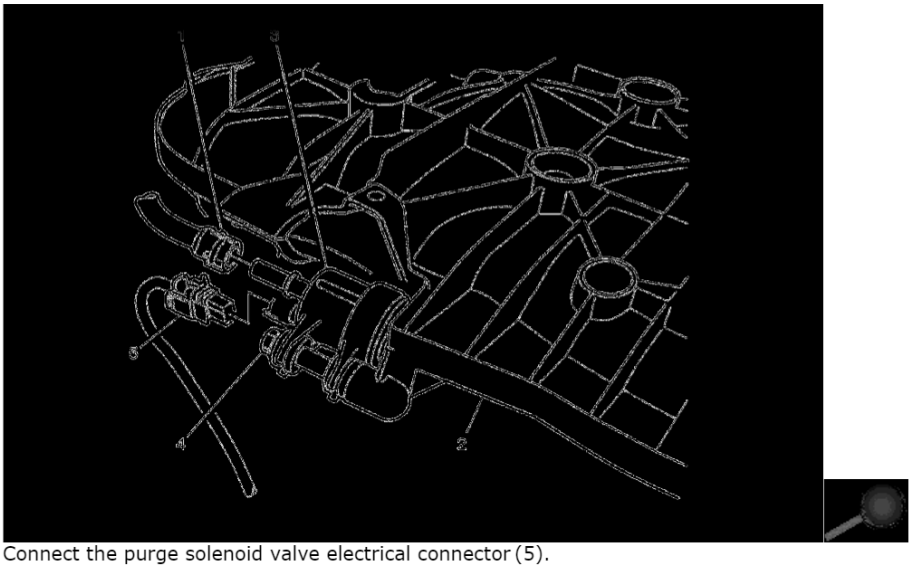


cardiagn.com

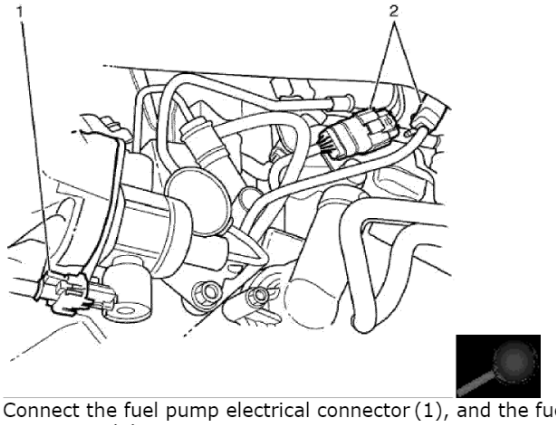
17. Connect the left bank ignition coil electrical connectors (1).
18. Connect the coolant temperature sensor electrical connector (4).
19. Connect the oil pressure sensor electrical connector (5).

Note: Use a suitable tool to attach the engine wiring harness (3) to the right bank camshaft cover retainers (2). Push downward to attach the engine wiring harness (3) to the right bank camshaft cover retainers (2).

20. Attach the engine wiring harness (3) to the right bank camshaft cover retainers (2).

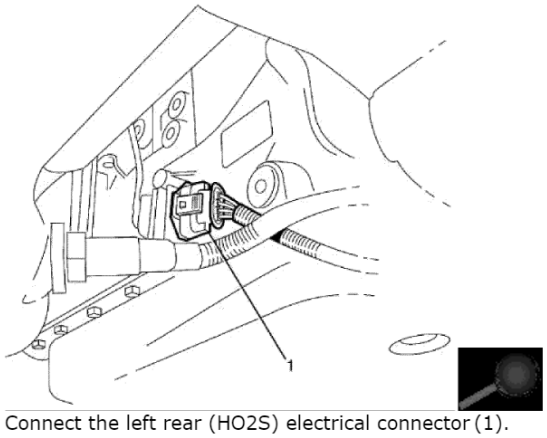


21. Connect the purge solenoid valve electrical connector (5).

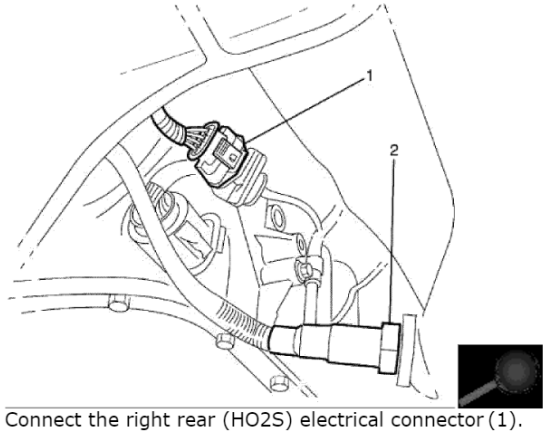


22. Connect the fuel pump electrical connector (1), and the fuel injector electrical harness connectors (2).

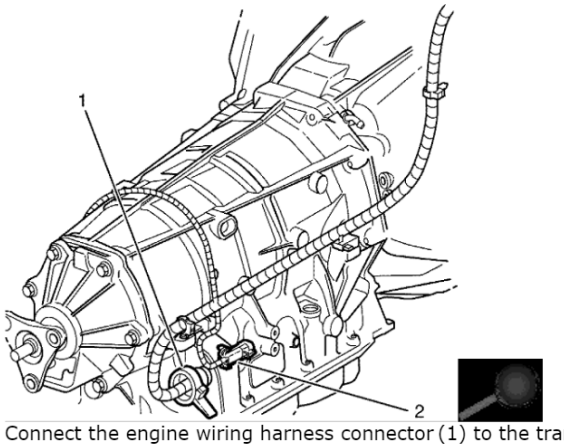
cardiagn.com



23. Connect the left rear (HO2S) electrical connector (1).

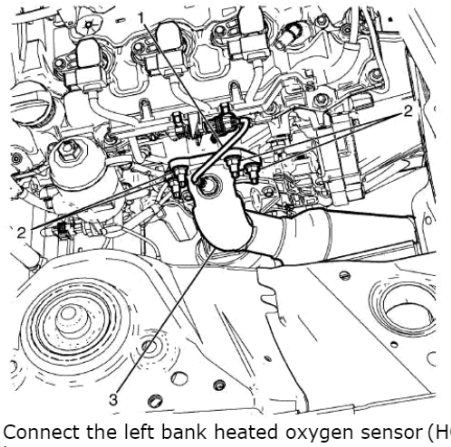


24. Connect the right rear (HO2S) electrical connector (1).

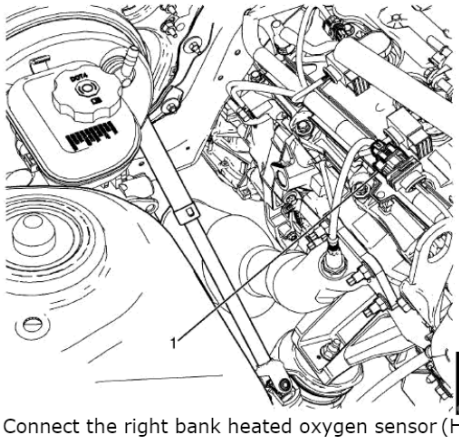


25. Connect the engine wiring harness connector (1) to the transmission.

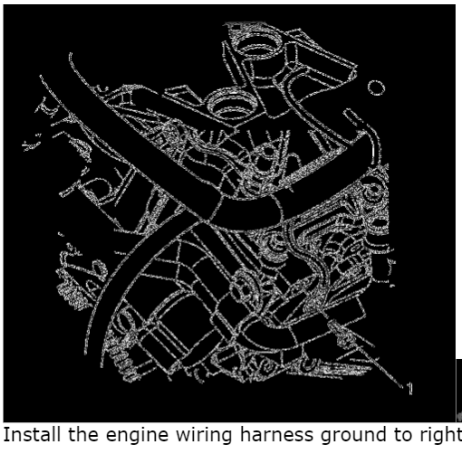
cardiagn.com



26. Connect the left bank heated oxygen sensor (HO2S) electrical connector (1) to the engine wiring harness.

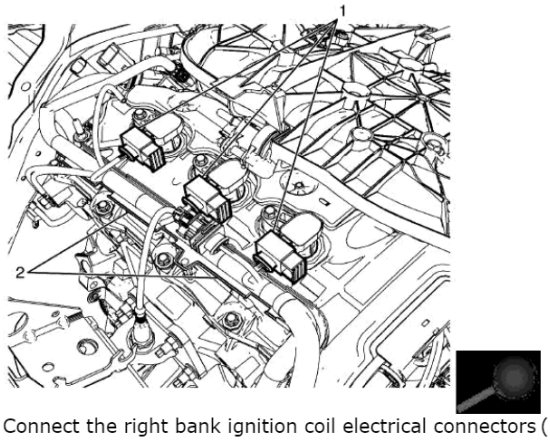


27. Connect the right bank heated oxygen sensor (HO2S) electrical connector (1) to the engine wiring harness connector.



28. Install the engine wiring harness ground to right cylinder head retaining bolt (1).

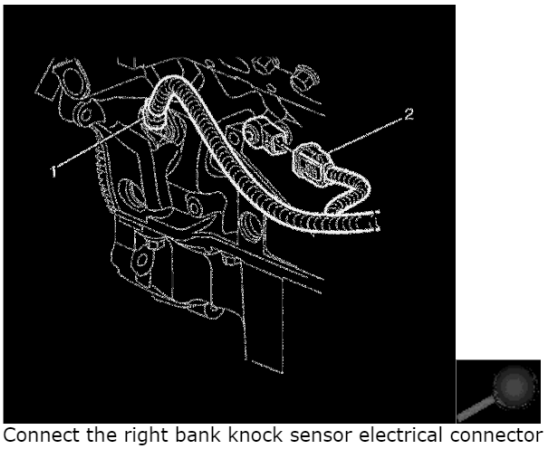
cardiagn.com



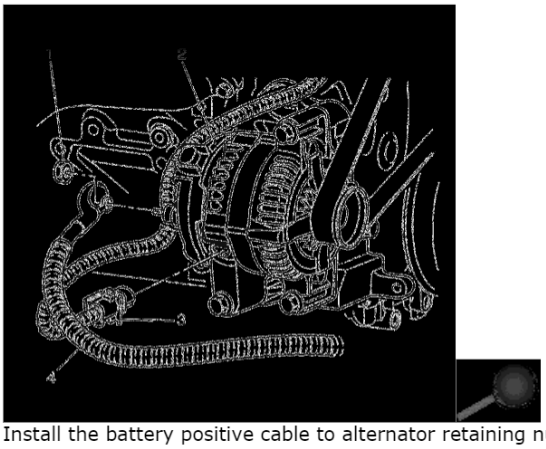
29. Connect the right bank ignition coil electrical connectors (1).

Note: Use a suitable tool to attach the engine wiring harness to the camshaft cover.

30. Attach the engine wiring harness (2) to the right bank camshaft cover.



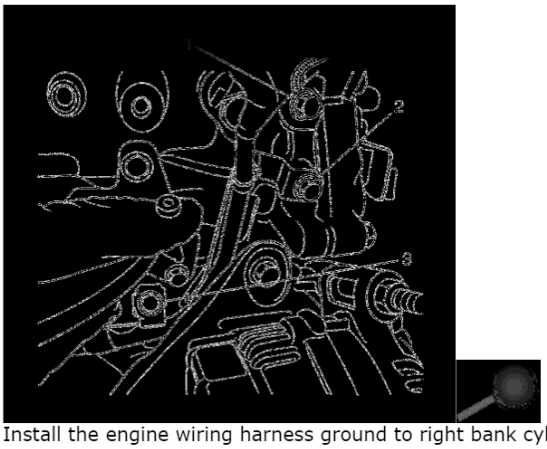
31. Connect the right bank knock sensor electrical connector (2).
32. Connect the crankshaft position sensor electrical connector (1).



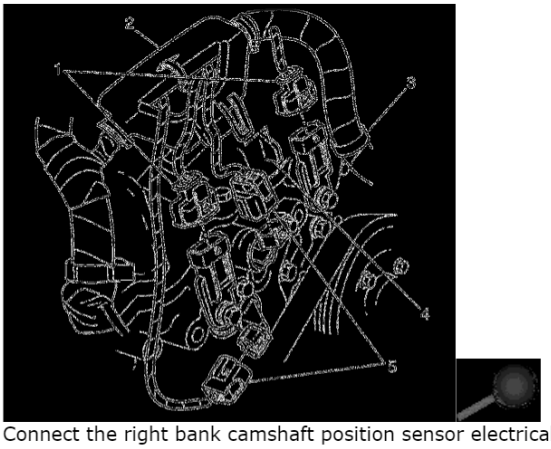
33. Install the battery positive cable to alternator retaining nut (1).

cardiagn.com

34. Connect the battery positive cable (4) to the alternator (2).
35. Connect the engine harness connector (3) to the alternator (2).



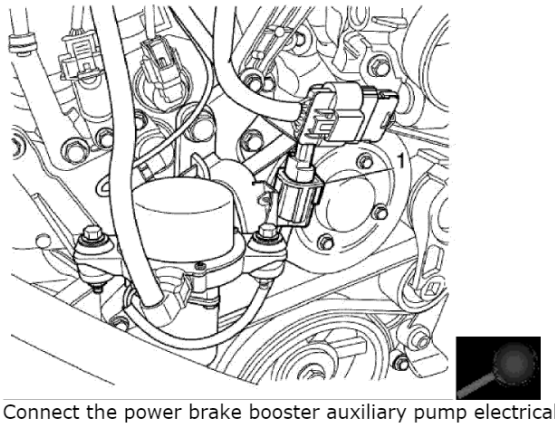
36. Install the engine wiring harness ground to right bank cylinder head retaining bolt (1).
37. Install the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
38. Install the engine wiring harness bracket to cylinder block retaining bolt (3).



39. Connect the right bank camshaft position sensor electrical connectors (1).
40. Connect the right bank intake and exhaust camshaft position actuator solenoid valve electrical connectors (5).
41. Attach the engine wiring harness to cylinder head retaining lug (3).

    Note: Use a suitable tool to attach the engine wiring harness bracket (2) to the retainer (4) on the right bank camshaft cover. Slide the engine wiring harness bracket (2) downward to attach it to the right bank camshaft cover (4).
42. Attach the engine wiring harness bracket (2) to the right bank camshaft cover (4).

cardiagn.com

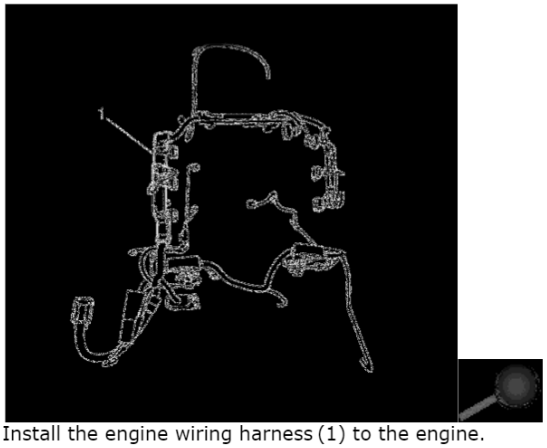


43. Connect the power brake booster auxiliary pump electrical connector (1).

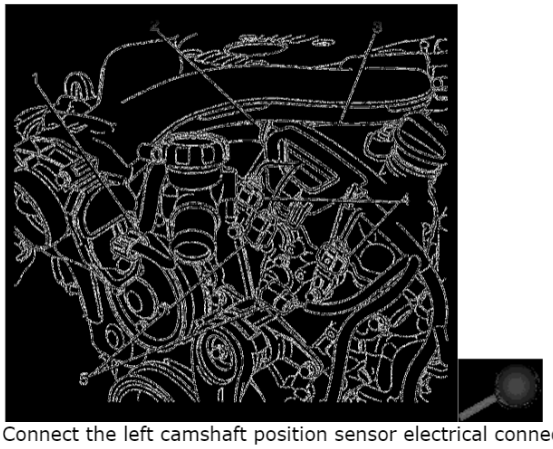
cardiagn.com

Engine Wiring Harness Assembly Installation (LWR)

Warning: Refer to Safety Glasses Warning.



1. Install the engine wiring harness (1) to the engine.

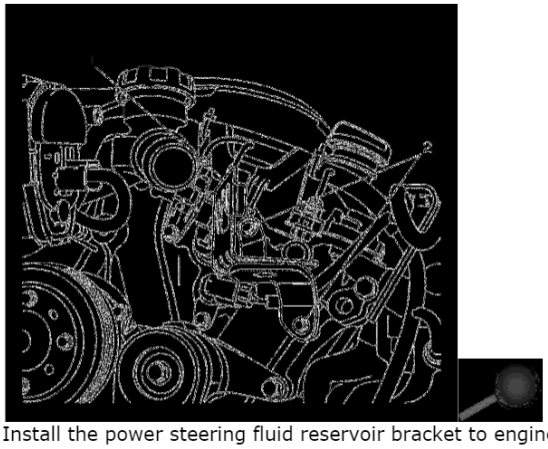


2. Connect the left camshaft position sensor electrical connectors (4).
3. Connect the left bank intake and exhaust camshaft position actuator valve electrical connectors (5).
4. Connect the throttle position sensor electrical connector (1).

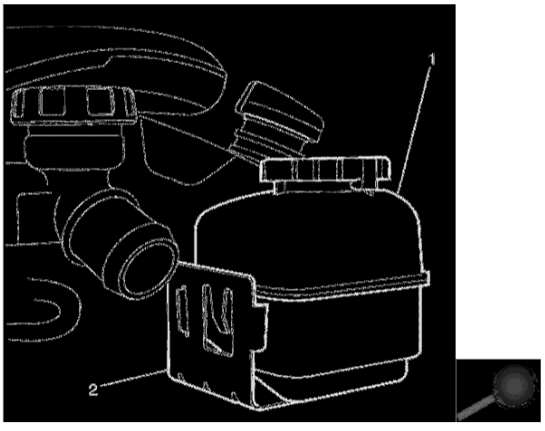
   Note: Use a suitable tool to attach the engine wiring harness bracket (2) to the left bank camshaft cover (3). Slide the engine wiring harness bracket (2) downward to attach it to the left bank camshaft cover (4).
5. Attach the engine wiring harness bracket (2) to the left bank camshaft cover (3).

cardiagn.com

© 2014 General Motors. All rights reserved.



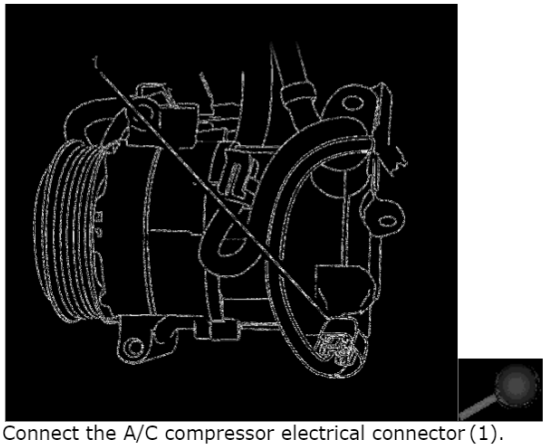
6. Install the power steering fluid reservoir bracket to engine front cover retaining bolts (2).
7. Install the power steering fluid reservoir bracket (1).



Note: DO NOT disconnect the power steering pipes or drain the power steering fluid.

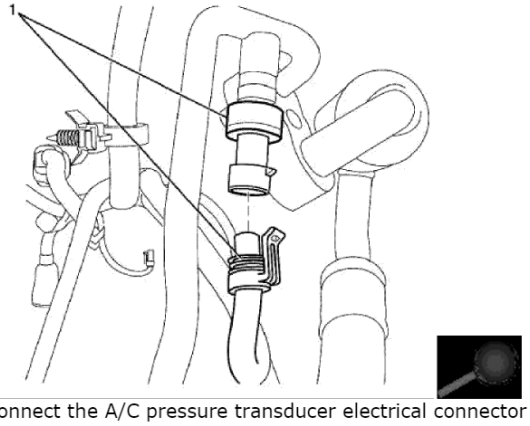
Note: The locking tang on the power steering reservoir bracket (2) must be aligned correctly (1).

8. Fit the power steering fluid reservoir (1) to the power steering fluid reservoir bracket (2).

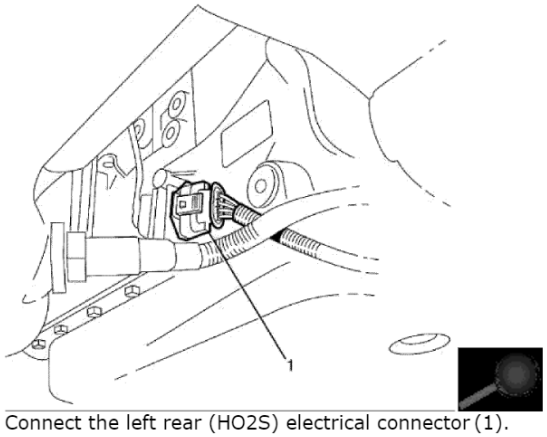


9. Connect the A/C compressor electrical connector (1).

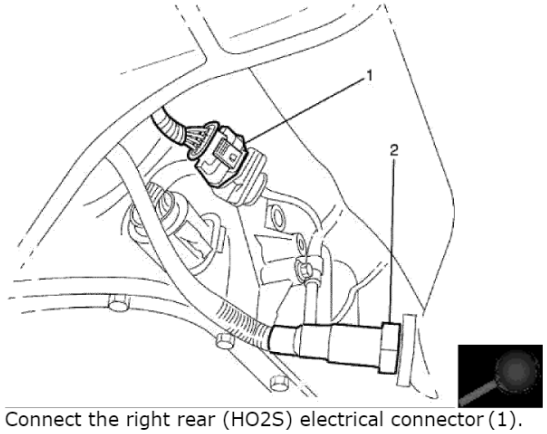
cardiagn.com



10. Connect the A/C pressure transducer electrical connector (1).

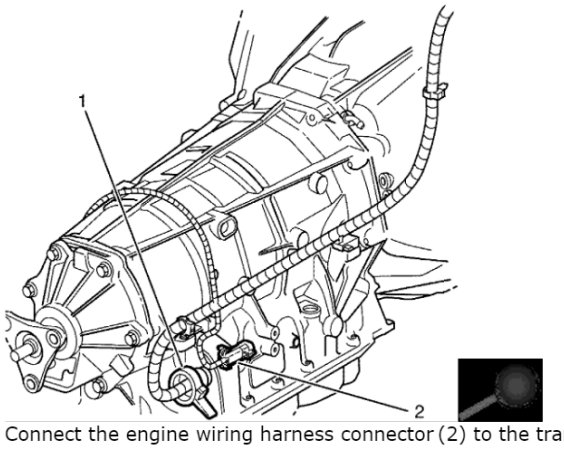


11. Connect the left rear (HO2S) electrical connector (1).

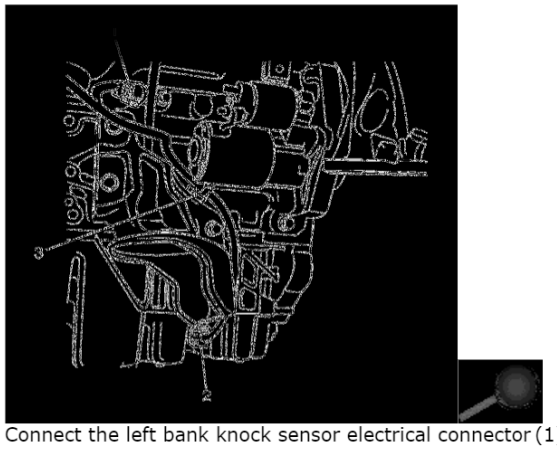


12. Connect the right rear (HO2S) electrical connector (1).

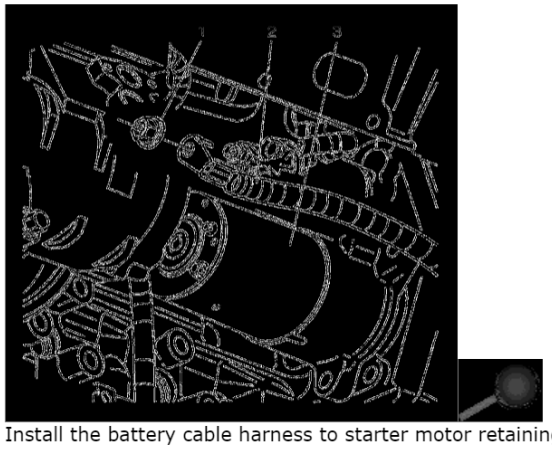
cardiagn.com



13. Connect the engine wiring harness connector (2) to the transmission.

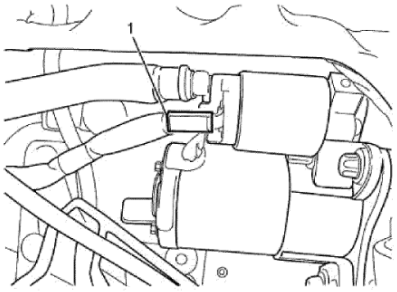


14. Connect the left bank knock sensor electrical connector (1).
15. Connect the oil level sensor electrical connector (2).
16. Attach the engine wiring harness to cylinder block retaining lug (3).

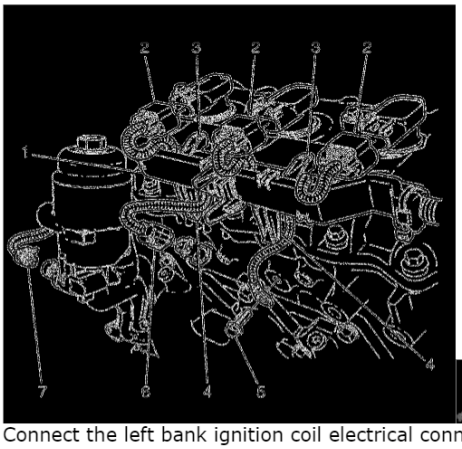


17. Install the battery cable harness to starter motor retaining nut (1).
18. Connect the battery cable (2) to the starter motor (3).

cardiagn.com



19. Connect the starter motor electrical connector (1).

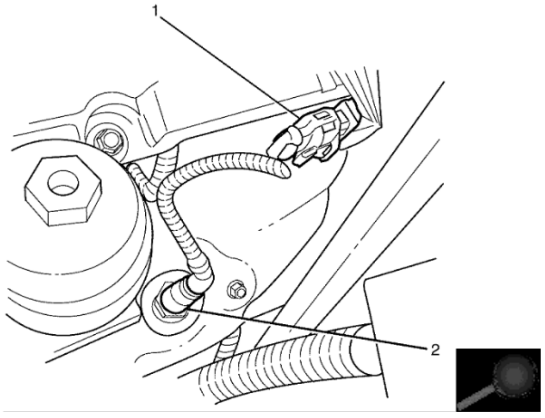


20. Connect the left bank ignition coil electrical connectors (2).
21. Install the engine wiring harness ground to left bank cylinder head retaining bolt (5).
22. Connect the coolant temperature sensor electrical connector (6).
23. Connect the oil pressure sensor electrical connector (7).

Note: Use a suitable tool to attach the engine wiring harness (1) to the right bank camshaft cover retainers (4). Push downward to attach the engine wiring harness (1) to the right bank camshaft cover lugs (3).

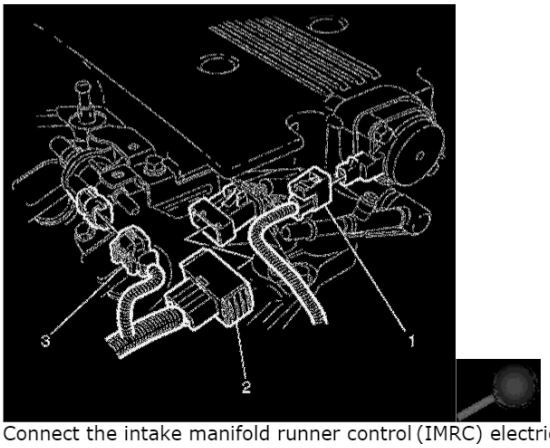
24. Attach the engine wiring harness bracket (1) to the left bank camshaft cover lugs (3).

cardiagn.com



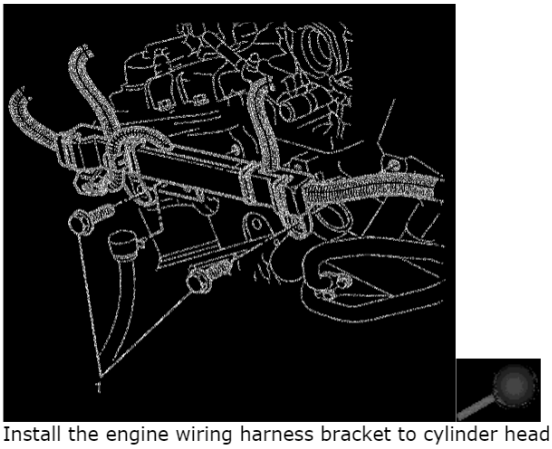
Note: The LY7 engine is shown. For the LY7 with KL7 variant, the upstream heated oxygen sensors are below the exhaust manifold.

25. Connect the left bank heated oxygen sensor (HO2S) electrical connector (1) to the engine wiring harness.

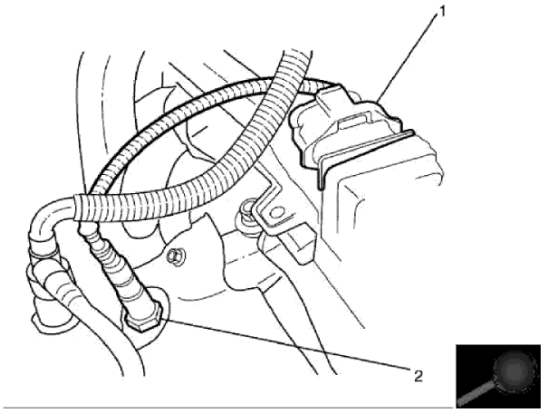


26. Connect the intake manifold runner control (IMRC) electrical connector (1).
27. Connect the injector harness electrical connector (2).
28. Connect the purge solenoid valve electrical connector (3).

cardiagn.com

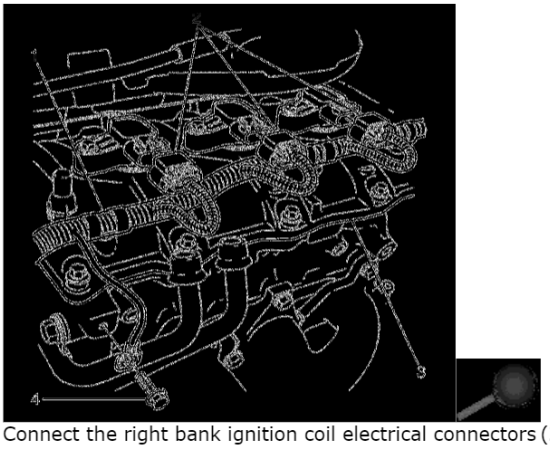


29. Install the engine wiring harness bracket to cylinder head retaining bolts (1).



Note: The LY7 engine is shown. For the LY7 with KL7 variant, the upstream heated oxygen sensors are below the exhaust manifold.

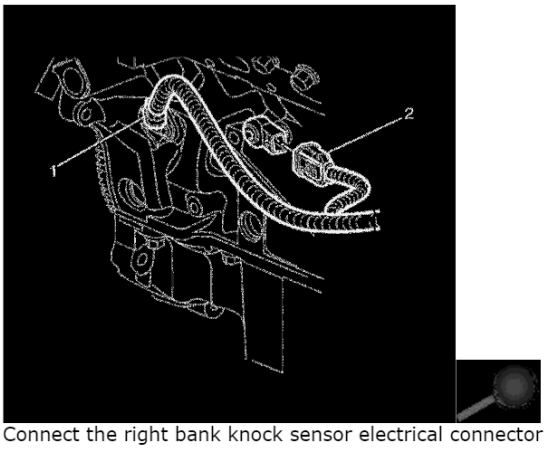
30. Connect the right bank heated oxygen sensor (HO2S) electrical connector (1) to the engine wiring harness connector.



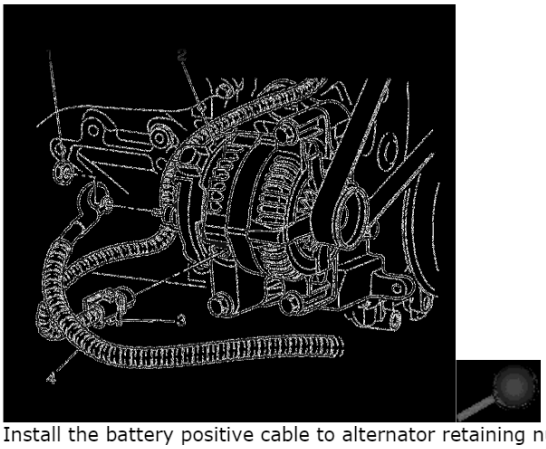
31. Connect the right bank ignition coil electrical connectors (2).

cardiagn.com

32. Install the engine wiring harness ground to right bank cylinder head retaining bolt (4).
33. Attach the engine wiring harness (1) to the right bank camshaft cover (3).

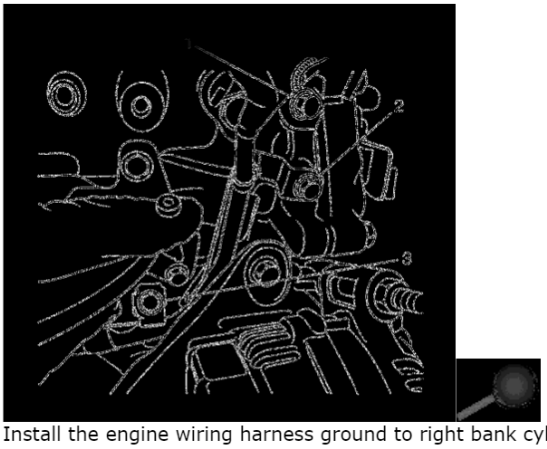


34. Connect the right bank knock sensor electrical connector (2).
35. Connect the crankshaft position sensor electrical connector (1).

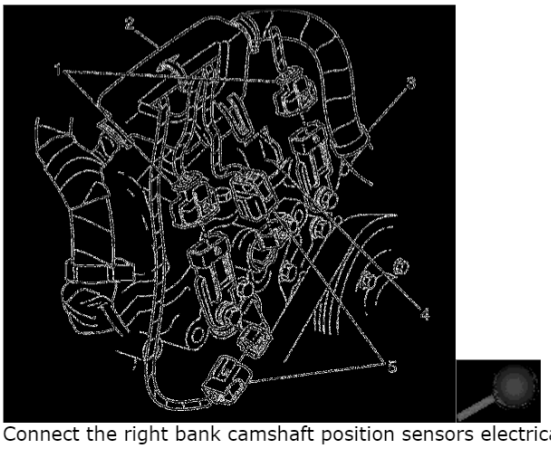


36. Install the battery positive cable to alternator retaining nut (1).
37. Connect the battery positive cable (4) to the alternator (2).
38. Connect the engine harness connector (3) to the alternator (2).

cardiagn.com



39. Install the engine wiring harness ground to right bank cylinder head retaining bolt (1).
40. Install the engine wiring harness bracket to right bank cylinder head retaining bolt (2).
41. Install the engine wiring harness bracket to cylinder block retaining bolt (3).



42. Connect the right bank camshaft position sensors electrical connectors (1).
43. Connect the right bank intake and exhaust camshaft position actuator valve electrical connectors (5).
44. Attach the engine wiring harness to cylinder head retaining lug (3).
45. Attach the engine wiring harness bracket (2) to the right bank camshaft cover (4).

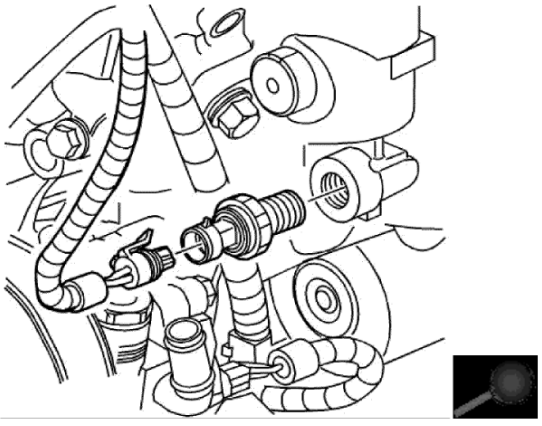
cardiagn.com

Engine Prelubing

Special Tools

EN 45299 Engine Preluber

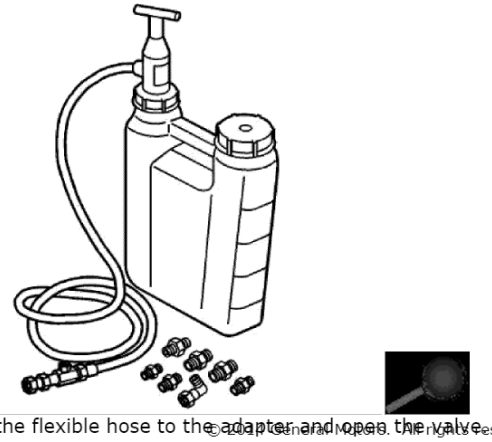
For equivalent regional tools, refer to Special Tools.



Note: A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Be sure to use an approved engine oil as specified in the owners manual.

1. Remove the oil filter cap.
2. Install the NEW oil filter cartridge.
3. Lubricate the threads of the oil filter cap with clean engine oil.

   Caution: Refer to Fastener Caution.
4. Install the oil filter cap and tighten to **25 N•m (18 lb ft)**.
5. Remove the oil pressure sending unit from the oil filter adapter.
6. Install the 14 x 1.5 mm adapter P/N 219433.



7. Install the flexible hose to the adapter and open the valve.

© 2013 General Motors. All rights reserved.

cardiagn.com

8. Pump the handle on the *EN 45299* preluber in order to flow a minimum of 1–1.9 liters (1–2 quarts) of engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.
9. Close the valve and remove the flexible hose and adapter from the engine.
10. Install the oil pressure sending unit and tighten to **20 N•m (15 lb ft)**.
11. Top-off the engine oil to the proper level.

cardiagn.com