

Component Procedures: Engine

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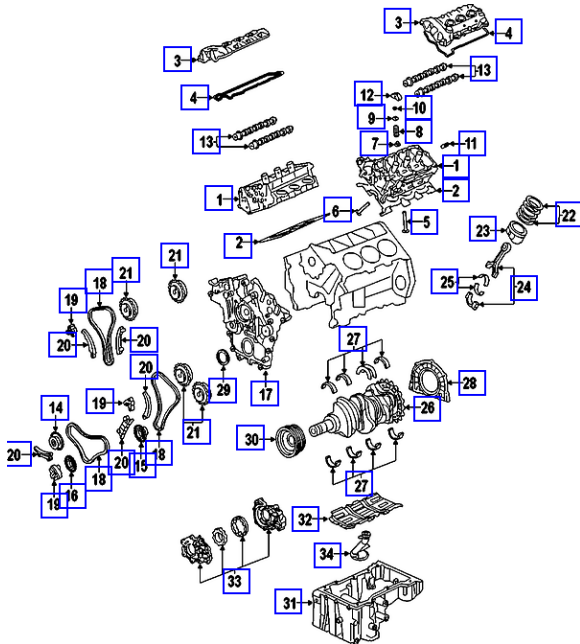
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Component Procedures: Engine

Exploded Parts Diagram (itype_83)



Parts and Labor (itype_189)

Parts

Qualifier	Part #	Name	Price	Note
Engine Assembly	12652805	Engine	4391.11	

Labor

Operation	Qualifier Path	Skill	Std Hrs	Wty Hrs
Remove & Install	Engine > Engine, R&I > Auto Trans	B	8.7	0.0
Remove & Install	Engine > Engine, R&I > Manual Trans	B	8.1	0.0
Remove & Replace	Engine > Engine, R&R > Auto Trans	B	11.2	7.6
Remove & Replace	Engine > Engine, R&R > Manual Trans	B	11.8	8.1
Remove & Replace	Engine > Long Block, R&R > Auto Trans	B	15.7	0.0
Remove & Replace	Engine > Long Block, R&R > Manual Trans	B	16.3	0.0
Remove & Replace	Engine > Short Block, R&R > Auto Trans	A	18.7	0.0
Remove & Replace	Engine > Short Block, R&R > Manual Trans	A	19.3	0.0
Overhaul	Engine > Engine, Overhaul > Auto Trans	A	28.7	0.0
Overhaul	Engine > Engine, Overhaul > Manual Trans	A	29.3	0.0

Specifications Quick Reference (itype_439)

Quick Specifications

- item

Engine Identification (Article 12009)

Vehicle Identification Number

The Vehicle Identification Number (VIN) Derivative is located in two places on the engine and is a nine digit number stamped or laser etched onto the block at the vehicle assembly plant. If reading the identification number the following information can be obtained:

- The first digit identifies the vehicle division.
- The second digit is the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last six digits of the Vehicle Identification Number (VIN).

The engine block is marked with the VIN on a pad area on the left rear side (1).

The engine block is marked with the VIN on a pad area on the center lower right side (1).

Engine Traceability Label

The engine traceability label is located in two places on the engine and consists of the broadcast code, bar code and sequence number. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

One engine traceability label (1) is located on the left rear side of the engine block. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Another engine traceability label (1) is located on the rear of the left cylinder head . This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Engine Verification Label

The engine verification label is located in two places on the engine and consists of the broadcast code and bar code. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

One engine verification label (1) is located on the left side of the engine front cover below the exhaust camshaft position sensor. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Another engine verification label (1) is located on the rear of the right cylinder head. This label is used in engine and vehicle assembly plants and is not intended to be permanent. If it is missing refer back to the engine block VIN pad for the permanent ID.

Engine Component Description (LFX) (Article 12013)

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 head s. This engine incorporates 2 intake and 2 exhaust valves per cylinder, and uses a dual overhead cam design with individual intake and exhaust camshaft s. 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 Rod s 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.

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 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 Side (RS) and Left Side (LS) designation through the engine mechanical section are viewed from the rear, flywheel side, of the engine or from inside the vehicle. These banks are also referred to as Bank 1 (RS) and Bank 2 (LS).

Engine Mechanical Schematics (Article 12215)

Figure 1: Engine Oil Level

Disassembled Views (Article 12008)

Figure 1: Engine Covers and Component Assemblies (1 of 2)

Figure 2: Engine Covers and Components Assemblies (2 of 2)

Figure 3: Camshaft Cover Assembly

Figure 4: Camshaft Timing Components

Figure 5: Intake Manifold

Figure 6: Fuel Rail

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 (RWD)

Figure 13: Oil filter Adapter

Drive Belt Tensioner Removal (Article 12087)

- Remove the drive belt tensioner to engine front cover retaining bolts (1). Click for full-size image
- Remove the drive belt tensioner (2).

Oil Level Indicator and Tube Removal (Article 12118)

- Remove the left exhaust manifold upper insulator from the oil level indicator tube . Click for full-size image
- Remove the left exhaust manifold heat shield bolts. Click for full-size image
- Remove the left exhaust manifold heat shield.
- Remove the left exhaust manifold lower insulator from the oil level indicator tube. Click for full-size image
- Remove the oil level indicator tube bracket bolt. Click for full-size image
- Remove the oil level indicator and tube by sliding the tube out from the lower crankcase hole.
- Remove and discard the O-ring from the oil level indicator tube if damaged. Click for full-size image

Oil Filter Adapter Removal (Article 12116)

- Remove the oil filter cap. Click for full-size image
- Remove and properly dispose of the oil filter cartridge . Click for full-size image
- Re-install the oil filter cap.
- Remove the oil filter adapter bolts (1–3) from the engine block . Click for full-size image
- Remove the oil filter adapter.
- Remove and discard the oil filter adapter gasket. Click for full-size image

Intake Manifold Removal (LF1, LFW or LFX) (Article 12111)

- Disconnect and remove the positive crankcase ventilation (PCV) tube (1) from the intake manifold and right camshaft cover . Click for full-size image
- Remove the evaporative (EVAP) hose from the intake manifold and EVAP solenoid. Click for full-size image
- Remove the fuel injection fuel rail shield bolt (1). Click for full-size image
- Remove the fuel injection fuel rail shield (2).
- Remove the engine rear noise shield (3).
- Remove the intake manifold bolts (1). Click for full-size image
- Remove the intake manifold assembly (2).
- Remove and discard the intake manifold gasket (1). Click for full-size image

Water Outlet Removal (Article 12153)

- Remove the water outlet bolts (4). Click for full-size image
- Remove the water outlet (1).
- Remove and discard the water outlet gasket (3).
- Remove and discard the water outlet O-ring seal (2).

Engine Coolant Thermostat Housing Removal (Article 12092)

- Remove the heater inlet and outlet pipe assembly bolt (1). Click for full-size image
- Remove the heater inlet and outlet pipe assembly bolts (2).
- Remove the heater inlet and outlet pipe assembly (3).
- Remove and discard the heater inlet and outlet pipe assembly O-ring (2) and gasket (1). Click for full-size image
- Remove the thermostat housing assembly bolts. Click for full-size image
- Remove the thermostat housing assembly.
- Remove and discard the thermostat housing assembly O-ring and gasket. Click for full-size image

Crankshaft Balancer Removal (Article 12074)

Special Tools

- EN 46106 - Flywheel Holding Tool
- J 38416-B - Harmonic Balancer Remover
- J 38416-2 - Crankshaft Button

For equivalent regional tools, refer to Special Tools .

- Install the EN 46106 - tool through the starter mounting hole. Click for full-size image
- Remove and discard the crankshaft balancer bolt (1). Click for full-size image
- Install the J 38416-2 - button (2) in the nose of the crankshaft. Click for full-size image
- Install the J 38416-B - remover (1) in order to remove the crankshaft balancer.
- Pull the crankshaft balancer (1) off by tightening the center bolt on the J 38416-B - remover until the crankshaft balancer pulls off of the crankshaft end. Click for full-size image
- Remove the J 38416-B - remover and J 38416-2 - button from the crankshaft balancer.
- Remove the EN 46106 - tool from the starter mounting hole. Click for full-size image

Flywheel Removal (Article 12101)

Special Tools

EN 46106 - Flywheel Holding Tool

For equivalent regional tools, refer to Special Tools .

- Install the EN 46106 - tool through the starter mounting hole. Click for full-size image
- Remove the clutch pressure plate bolts (1). Click for full-size image
- Remove the clutch pressure plate (2) and the clutch driven plate disc (3).
- Remove the engine flywheel bolts (1) and discard. Click for full-size image
- Remove the engine flywheel (2) from the crankshaft .
- Remove the EN 46106 - tool . Click for full-size image

Automatic Transmission Flex Plate Removal (Article 12045)

Single Use Fasteners and Components

Automatic Transmission Flex Plate Bolt [8x]

Callout Component Name

1 Automatic Transmission Flex Plate Bolt [8x] 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. Procedure Install the EN-46106 - Flywheel Holding Tool through the starter mounting hole. Remove the flex plate bolts (1) and DISCARD. Remove the flex plate (2) from the crankshaft . Remove the EN-46106 - Flywheel Holding Tool through the starter mounting hole. Special Tools EN-46106 - Flywheel Holding Tool Equivalent regional tools:

Special Tools

Procedure

- Install the EN-46106 - Flywheel Holding Tool through the starter mounting hole.
- Remove the flex plate bolts (1) and DISCARD.
- Remove the flex plate (2) from the crankshaft .
- Remove the EN-46106 - Flywheel Holding Tool through the starter mounting hole.

Special Tools

Camshaft Cover Removal - Left Side (Article 12052)

Single Use Fasteners and Components

Camshaft Cover Bolt Insulator [15x]

- Remove the ignition coil bolts (1). Click for full-size image
- Remove the ignition coils (1). Click for full-size image
- Remove the left camshaft cover bolts (1). Click for full-size image
- Remove and DISCARD the 15 camshaft cover insulators and camshaft cover bolts if they are serviced with the insulator.
- Remove the left camshaft cover (1) from the left cylinder head . Click for full-size image

Camshaft Cover Removal - Right Side (Article 12053)

Single Use Fasteners and Components

Camshaft Cover Bolt Insulator [13x]

- Remove the ignition coil bolts (1). Click for full-size image
- Remove the ignition coils (1). Click for full-size image
- Remove the right camshaft cover bolts (1). Click for full-size image
- Remove and DISCARD the camshaft cover insulators and camshaft cover bolts if they are serviced with the insulator.
- Remove the right camshaft cover (1) from the right cylinder head . Click for full-size image

Water Pump Removal (Article 12156)

Single Use Fasteners and Components

- Water Pump Bolt [6x]

- Water Pump Gasket

Callout Component Name

1 Water Pump Pulley Bolt [4x] Procedure Install the EN-46104 - Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. Remove the water pump pulley bolts. Remove the EN-46104 - Water Pump Pulley Holding Tool from the water pump pulley. Special Tools EN-46104 - Water Pump Pulley Holding Tool Equivalent regional tools: Special Tools

Procedure

- Install the EN-46104 - Water Pump Pulley Holding Tool onto the water pump pulley mounting holes.
- Remove the water pump pulley bolts.
- Remove the EN-46104 - Water Pump Pulley Holding Tool from the water pump pulley.

Special Tools

EN-46104 - Water Pump Pulley Holding Tool

2 Water Pump Pulley

3 Water Pump Bolt [6x] 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. Procedure Install NEW bolts. Do NOT reuse old bolts.

Install NEW bolts. Do NOT reuse old bolts.

4 Water Pump

5 Water Pump Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Install a NEW gasket. Do NOT reuse the old gasket.

Engine Front Cover Removal (Article 12097)

- Remove the camshaft position sensor bolts (1). Click for full-size image
- Remove the camshaft position sensors (2).
- Remove the camshaft position actuator valve bolts (1). Click for full-size image
- Remove the camshaft position actuator valves (2) from the front cover.
- Remove the engine front cover bolts (1-3). Click for full-size image
- Loosely install a 10 x 1.5 mm bolt in the jackscrew hole (1). Click for full-size image
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Using the pry points (2) located at the edge of the front cover and the jackscrew, separate the room temperature vulcanizing (RTV) sealant.

- Remove the engine front cover (1). Click for full-size image

Camshaft Timing Chain Components Removal (Article 12067)

Single Use Fasteners and Components

- Timing Chain Housing Gasket
- Timing Chain Housing Gasket - Left Side
- Timing Chain Housing Gasket - Right Side
- Secondary Camshaft Drive Chain Components Removal - Right Side

Callout Component Name

Preliminary Procedure 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. 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 for more information. Set the engine to stage 2 position. Timing Chain Alignment Diagram

Preliminary Procedure

Set the engine to stage 2 position. Timing Chain Alignment Diagram

- 1 Right Secondary Timing Chain Tensioner Bolt
- 2 Right Secondary Timing Chain Tensioner
- 3 Timing Chain Housing Gasket - Right Side Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Procedure

Install a NEW gasket. Do NOT reuse the old gasket.

- 4 Right Pivot Arm Timing Chain Guide Bolt
- 5 Right Pivot Arm Timing Chain Guide
- 6 Right Secondary Timing Chain Guide Bolt
- 7 Right Secondary Timing Chain Guide
- 8 Secondary Camshaft Intermediate Drive Chain

Primary Camshaft Drive Chain Components Removal

Preliminary Procedure Set the engine to stage 1 position. Timing Chain Alignment Diagram

Set the engine to stage 1 position. Timing Chain Alignment Diagram

- 1 Camshaft Intermediate Drive Chain Tensioner Bolt
- 2 Camshaft Intermediate Drive Chain Tensioner
- 3 Timing Chain Housing Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.
- 4 Upper Primary Timing Chain Guide Bolt
- 5 Upper Primary Timing Chain Guide
- 6 Lower Primary Timing Chain Guide Bolt
- 7 Lower Primary Timing Chain Guide
- 8 Primary Camshaft Drive Intermediate Chain

Secondary Camshaft Drive Chain Components Removal - Left Side

- 1 Left Secondary Timing Chain Tensioner Bolt
- 2 Left Secondary Timing Chain Tensioner
- 3 Timing Chain Housing Gasket - Left Side Procedure Install a NEW gasket. Do NOT reuse the old gasket.
- 4 Left Pivot Arm Timing Chain Guide Bolt
- 5 Left Pivot Arm Timing Chain Guide
- 6 Left Secondary Timing Chain Guide Bolt
- 7 Left Secondary Timing Chain Guide

Timing Chain Idler Sprocket Removal - Right Side (Article 12139)

Callout Component Name

- 1 Timing Chain Idler Sprocket Shaft Bolt
- 2 Right Side Timing Chain Idler Sprocket

Timing Chain Idler Sprocket Removal - Left Side (Article 12138)

Callout Component Name

- 1 Timing Chain Idler Sprocket Shaft Bolt
- 2 Left Side Timing Chain Idler Sprocket

Crankshaft Sprocket Removal (Article 12078)

Callout Component Name

- 1 Crankshaft Sprocket

Camshaft Position Actuator Removal - Left Side Exhaust (Article 12060)

- Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt. Click for full-size image
- Remove the left exhaust camshaft position actuator bolt (1).
- Remove the left exhaust camshaft position actuator (2).
- Remove the camshaft thrust washer if applicable (3).

Camshaft Position Actuator Removal - Left Side Intake (Article 12061)

- Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt. Click for full-size image
- Remove the left intake camshaft position actuator bolt (1).
- Remove the left intake camshaft position actuator (2).
- Remove the camshaft thrust washer if applicable (3).

Camshaft Position Actuator Removal - Right Side Exhaust (Article 12062)

- Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt. Click for full-size image
- Remove the right exhaust camshaft position actuator bolt (1).
- Remove the right exhaust camshaft position actuator (2).
- Remove the camshaft thrust washer if applicable (3).

Camshaft Position Actuator Removal - Right Side Intake (Article 12063)

- Use an open wrench on the hex cast into the camshaft in order to prevent engine rotation when loosening the camshaft position actuator bolt. Click for full-size image
- Remove the right intake camshaft position actuator bolt (1).
- Remove the right intake camshaft position actuator (2).
- Remove the camshaft thrust washer if applicable (3).

Fuel Pump Removal (LF1, LFW or LFX) (Article 12103)

Single Use Fasteners and Components

- Fuel Pump Bolt [2x]
- Fuel Pump Bracket Gasket
- Fuel Feed Intermediate Pipe
- Fuel Pump Housing Seal
- Fuel Feed Pipe

Callout Component Name

1 Fuel Injection Fuel Rail Noise Shield

2 Fuel Feed Pipe Bracket Bolt

3 Fuel Feed Pipe Procedure Install a new pipe. Do NOT reuse the old pipe.

Procedure

Install a new pipe. Do NOT reuse the old pipe.

4 Fuel Feed Intermediate Pipe Procedure Install a new pipe. Do NOT reuse the old pipe.

5 Fuel Pump Bolt [2x] Caution: Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage Procedure Install NEW bolts. Do NOT reuse old bolts.

Install NEW bolts. Do NOT reuse old bolts.

6 Fuel Pump

7 Fuel Pump Housing Seal Procedure Install a NEW seal. Do NOT reuse the old seal.

Install a NEW seal. Do NOT reuse the old seal.

8 Fuel Pump Bracket Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Install a NEW gasket. Do NOT reuse the old gasket.

9 Valve Lifter Follower

Camshaft Removal - Left Side (Article 12064)

- Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings: Click for full-size image
- 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.
- Remove the camshaft bearing cap bolts. [Click for full-size image](#)
- Remove the camshaft bearing caps.
- Remove the camshafts. [Click for full-size image](#)

Fuel Rail Removal (Article 12106)

Special Tools

EN-49248 - Injector Rail Assembly Remover

Equivalent regional tools: Special Tools

- Remove the fuel injection fuel rail noise shield (1). [Click for full-size image](#)
- Remove the fuel rail bolts (1) from the fuel rail (2). [Click for full-size image](#)
- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.
- Remove the fuel rail and injectors (1) as an assembly using the EN-49248 - Injector Rail Assembly Remover . [Click for full-size image](#)

Valve Rocker Arm Removal - Left Side (Article 12149)

Callout Component Name

1 Valve Rocker Arm Note: If the rocker arms are to be reused, keep in order so they can be reinstalled in the same position.

Valve Lifter Removal - Left Side (Article 12144)

Callout Component Name

1 Hydraulic Valve Lash Adjuster 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. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

- 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.
- If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

Cylinder Head Removal - Left Side (LF1, LFW or LFX) (Article 12084)

Single Use Fasteners and Components

- Cylinder Head Bolt - M8 [2x]
- Cylinder Head Bolt - M11 [8x]
- Cylinder Head Gasket
- Remove the 2 front M8 cylinder head bolts (1) and DISCARD. [Click for full-size image](#)
- Remove the 8 M11 cylinder head bolts (2) and DISCARD.
- Remove the cylinder head (3).
- Remove and DISCARD the cylinder head gasket (1). [Click for full-size image](#)

Camshaft Removal - Right Side (Article 12065)

- Observe the markings on the bearing caps. Each bearing cap is marked in order to identify its location. The markings have the following meanings: [Click for full-size image](#)
- 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.
- Remove the camshaft bearing cap bolts. [Click for full-size image](#)
- Remove the camshaft bearing caps.
- Remove the camshafts . [Click for full-size image](#)

Valve Rocker Arm Removal - Right Side (Article 12150)

Callout Component Name

1 Valve Rocker Arm Note: If the rocker arms are to be reused, keep in order so they can be reinstalled in the

same position.

Valve Lifter Removal - Right Side (Article 12145)

Callout Component Name

1 Hydraulic Valve Lash Adjuster 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. If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

- 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.
- If the lifters are to be reused, keep in order so they can be reinstalled in the same position.

Cylinder Head Removal - Right Side (LF1, LFW or LFX) (Article 12085)

Single Use Fasteners and Components

- Cylinder Head Bolt - M8
- Cylinder Head Bolt - M11 [8x]
- Cylinder Head Gasket
- Remove the 8 M11 cylinder head bolts (1) and DISCARD. Click for full-size image
- Remove the M8 cylinder head bolt (2) and DISCARD.
- Remove the cylinder head (3).
- Remove and DISCARD the cylinder head gasket (1). Click for full-size image
- Remove the fuel injection fuel rail noise shield-lower (1). Click for full-size image

Oil Pan Removal (Article 12123)

- Remove the oil pan bolts (1), (2) and (3). Click for full-size image
- Using the pry points located at the edge of the oil pan separate the RTV sealant.
- Remove the oil pan (1) from the block. Click for full-size image

Oil Pump Removal (Article 12127)

Callout Component Name

- 1 Oil Pump Bolt [3x]
- 2 Oil Pump

Crankshaft Rear Oil Seal and Housing Removal (Article 12076)

Single Use Fasteners and Components

Crankshaft Rear Oil Seal

Callout Component Name

- 1 Crankshaft Rear Oil Seal Housing Bolt

2 Crankshaft Rear Oil Seal Housing Procedure Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant. Remove and DISCARD the crankshaft rear oil seal housing.

Procedure

- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Use the pry points located at the edge of the crankshaft rear oil seal housing to separate the RTV sealant.
- Remove and DISCARD the crankshaft rear oil seal housing.

Piston, Connecting Rod, and Bearing Removal (Article 12133)

Special Tools

EN 46121 - Connecting Rod Guide Pin Set

For equivalent regional tools, refer to Special Tools .

- An arrow/dot showing proper piston orientation is located on the top of the piston.
- If the connecting rod bearings have been used in a running engine, you must replace them with NEW connecting rod bearings for reassembly.
- Before removing the connecting rods, check the connecting rod side clearance using the following procedure:
- Tap the connecting rod to one end of the crankshaft journal with a dead-blow or wooden hammer.
- Using feeler gauges, measure the clearance between the crankshaft counterweight and the connecting rod.

- The connecting rod side clearance should not exceed specifications. Refer to Engine Mechanical Specifications .
- 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 .
- 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.
- If the connecting rod width is within specification and excessive scoring is present on the crankshaft journals, replace the crankshaft.
- Using a marker, number each piston face. Draw an arrow along the centerline of the piston pointing toward the front of the engine.
- Mark the cylinder number on the connecting rod and the connecting rod cap with a scribe, paint stick or permanent marker.
- Remove the connecting rod bolts. [Click for full-size image](#)
- Remove the connecting rod cap.
- Install the EN 46121 - set into the connecting rod bolt holes. [Click for full-size image](#)
- 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. [Click for full-size image](#)
- Remove the EN 46121 - set from the connecting rod bolt holes. [Click for full-size image](#)
- Remove the upper connecting rod bearing from the connecting rod.
- Remove the lower connecting rod bearing from the connecting rod cap. [Click for full-size image](#)
- 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. [Click for full-size image](#)

Crankshaft and Bearing Removal (Article 12071)

Special Tools

- GE 6125-1B - Slide Hammer Adapter
- EN 49102 - Crankshaft Bearing Cap Remover

For equivalent regional tools, refer to Special Tools .

Crankshaft End Play Measurement

- Place a dial indicator at the crankshaft nose.
- Gently force the crankshaft to the extreme front and rear positions with a pry tool while monitoring the movement of the dial indicator.
- The crankshaft end play should not exceed specifications. Refer to Engine Mechanical Specifications .
- If the specifications are exceeded inspect the thrust bearing thrust OD and the crankshaft thrust wall for wear and/or excessive runout. Refer to Engine Mechanical Specifications .
- Replace the thrust bearing or crankshaft as necessary.

Crankshaft Removal

- Remove the crankshaft bearing cap side bolts. [Click for full-size image](#)
- Remove the crankshaft bearing cap outer bolts.
- Remove the crankshaft bearing cap inner bolts.
- Remove the crankshaft bearing caps using the GE 6125-1B - adapter (1) and EN 49102 - remover (2) . [Click for full-size image](#)
- Using two hands, lift the crankshaft straight up from the engine block . [Click for full-size image](#)
- Place the crankshaft in a secure place.
- Remove the crankshaft key from the nose of the crankshaft, if damaged. [Click for full-size image](#)

Crankshaft Bearing Removal

- Prepare a piece of cardboard or equivalent, numbered 1–4 for bearing identification. Main bearing journals are numbered from the front of the engine.
- Remove the crankshaft upper bearing halves from the cylinder block . Note the position of the thrust bearing (1) at the number 3 journal (2). [Click for full-size image](#)
- Place the crankshaft upper bearing halves on the cardboard in the correct positions. Note that the number 3 bearing is the thrust bearing.
- Remove the crankshaft lower bearing halves from the crankshaft bearing caps. [Click for full-size image](#)
- Place the crankshaft lower bearing halves in the correct positions on the cardboard.

Engine Block Disassemble (Article 12090)

Single Use Fasteners and Components

- Engine Block Core Hole Plug [2x]

- Engine Block Oil Gallery Plug - Front
- Engine Block Oil Gallery Plug - Right Side
- Remove the engine front cover studs (1). Click for full-size image
- Remove the block heater cartridge, if equipped. Click for full-size image
- Remove the right knock sensor bolt. Click for full-size image
- Remove the right knock sensor.
- Remove the left knock sensor bolt. Click for full-size image
- Remove the left knock sensor.
- Remove the crankshaft position sensor bolt. Click for full-size image
- Remove the crankshaft position sensor.
- Remove the crankshaft position sensor O-ring, if damaged. Click for full-size image
- Remove oil jet bolts. Click for full-size image
- Remove oil jets.
- Remove and DISCARD the right side engine block oil gallery plug. Click for full-size image
- Remove the cylinder block -to- oil pan alignment dowels. Click for full-size image
- Remove the M14 right side oil gallery threaded plug. Click for full-size image
- Remove the M14 right side coolant drain threaded plug. Click for full-size image
- Remove the M14 rear oil gallery threaded plug. Click for full-size image
- Remove the M14 left side coolant drain threaded plug. Click for full-size image
- Remove the M20 left side oil gallery threaded plug. Click for full-size image
- Remove and DISCARD the engine block core hole plugs. Click for full-size image
- Remove the cylinder block-to-transmission alignment dowels. Click for full-size image
- Remove and DISCARD the front engine block oil gallery plug. Click for full-size image
- Remove the cylinder block-to- cylinder head alignment dowels. Click for full-size image

Engine Block Cleaning and Inspection (Article 12089)

Special Tools

- EN-8087 - Cylinder Bore Gauge
- EN-28410 - Gasket Remover

Equivalent regional tools: Special Tools

Cleaning Procedure

- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Remove any old thread sealant, gasket material or sealant using EN-28410 - Gasket Remover .
- Clean all the following areas with solvent:
 - Sealing surfaces
 - Cooling passages
 - Oil passages
 - Bearing journals
- Clean all threaded and through holes with solvent.
- Dry the engine block with compressed air.

Visual Inspection

- Inspect the crankshaft bearing s journals for damage or spun bearings. The crankshaft bearing journals are not repairable, if the crankshaft bearing journals are damaged the engine block must be replaced. Click for full-size image
- 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.
- Inspect all sealing and mating surfaces for damage, repair or replace the engine block if necessary.
- Inspect all threaded and through holes for damage or excessive debris.
- Inspect all bolts for damage, if damaged replace with NEW bolts only.
- Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.
- Inspect the cylinder walls for cracks or damage. The cylinder sleeves are not serviced separately, if the cylinders are damaged the engine block must be replaced.
- Inspect the engine block for cracks. Do not repair any cracks. If cracks are found, the engine block must be replaced.
- Repair any damaged threaded holes. Thread Repair Specifications and Thread Repair

Measuring Cylinder Bore Diameter

Measure the cylinder bore diameter 37 mm (1.457 in) from the deck face using the EN-8087 - gauge .

Compare your results with the Engine Mechanical Specifications . If the cylinder diameter exceeds the specifications, the engine block may be oversized to 0.25 mm (0.010 in) . There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Taper

- 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.
- 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.
- Calculate the difference between the 2 measurements. The result will be the cylinder taper.
- Compare your results with the Engine Mechanical Specifications . If the cylinders exceed the specifications, the engine block may be oversized to 0.25 mm (0.010 in) . There is only one size of oversized pistons and rings available for service.

Measuring Cylinder Bore Out-of-Round

- Measure both the thrust and non-thrust cylinder diameter at 10 mm (0.397 in) below the deck. Record your measurements.
- Calculate the difference between the 2 measurements. The result will indicate out-of-round at the upper end of the cylinder.
- Measure both the thrust and non-thrust cylinder diameter at 100 mm (3.976 in) below the deck surface. Record your measurements.
- Calculate the difference between the 2 measurements. The result will indicate out-of-round at the lower end of the cylinder.
- Compare your results with the Engine Mechanical Specifications . If the cylinders exceed these specifications, the engine block may be oversized to 0.25 mm (0.010 in) . There is only one size of oversized pistons and rings available for service.

Deck Flatness Inspection

- Ensure the engine block decks are clean and free of gasket material. [Click for full-size image](#)
- Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
- Place a straight-edge diagonally across the engine block deck face surface.
- Measure the clearance between the straight-edge and the engine block deck face using a feeler gauge at 4 points along the straight-edge.
- If the warpage is less than 0.05 mm (0.002 in) , the engine block deck surface does not require resurfacing.
- 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 engine block deck surface requires resurfacing.
- If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in) .
- If the engine block deck surface requires more than 0.25 mm (0.010 in) material removal the block must be replaced.

Crankshaft and Bearing Cleaning and Inspection (Article 12069)

Cleaning Procedure

- Clean the following components in solvent:
 - Crankshaft bearing s
 - Connecting rod bearing s
 - Crankshaft journals
 - Crankpin journals
 - Crankshaft oil passages
 - Crankshaft threaded holes
- Dry the following components with compressed air:
 - Crankshaft bearings
 - Connecting rod bearings

Visual Inspection

- Perform the following visual inspections: [Click for full-size image](#)
- Inspect the crankshaft balancer bolt hole (1) for thread damage.
- Inspect the crankshaft balancer mounting area (2) for damage.
- Inspect the crankshaft keyway (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.
- 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.
- Repair or replace the crankshaft as necessary.

Crankshaft Bearing Inspection

- 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.
- Inspect for fatigue indicated by craters or pockets. Flattened sections on the bearing halves also indicate fatigue. [Click for full-size image](#)
- Inspect for excessive scoring or discoloration on both front and back of the bearing halves. [Click for full-size image](#)
- Inspect the main bearings for dirt embedded into the bearing material.
- Inspect for improper seating indicated by bright, polished sections. [Click for full-size image](#)

Crankshaft Measurement

Special Tools

GE 7872 - Magnetic Base Dial Indicator

For equivalent regional tools, refer to Special Tools

- Using a suitable fixture, support the crankshaft. [Click for full-size image](#)
- Install the GE 7872 - indicator . [Click for full-size image](#)
- Measure the crankshaft runout using the GE 7872 - indicator . Refer to Engine Mechanical Specifications .
- Measure the crankshaft thrust wall width (1) for wear using an inside micrometer. Refer to Engine Mechanical Specifications . [Click for full-size image](#)
- Measure the crankshaft thrust wall surface (2) for runout using the GE 7872 - indicator . Refer to Engine Mechanical Specifications .
- 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.
- Inspect the crankshaft main journals for undersize, using an outside micrometer. [Click for full-size image](#)
- Inspect the crankpins for undersize using an outside micrometer. [Click for full-size image](#)
- Compare your measurements with those listed in 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.
- Measure the main bearing and crankpin journals for out-of-round using the following procedure: [Click for full-size image](#)
- Using an outside micrometer, measure the journal at the extreme front and rear locations on the journal. Call these points A and B.
- Measure the journal in 2 new locations exactly 90 degrees from the first points. Call these points C and D.
- Subtract A from C and B from D. The differences will indicate journal out-of-round.
- The out-of-round should not exceed 0.004 mm (0.00016 in) maximum.
- 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.
- Measure the main bearing and crankpin journals for taper using the following procedure:
- Using an outside micrometer, measure the journal at the extreme front (A) and rear (B) of the journal parallel to the crankshaft centerline.
- Subtract the smallest from the largest measurement. The result will be the journal taper.
- If the main bearing journal taper exceeds 0.004 mm (0.00016 in), replace the crankshaft.

Automatic Transmission Flex Plate Cleaning and Inspection (Article 12043)

Cleaning Procedure

- Clean the flex plate in solvent.
- Dry the flex plate with compressed air.

Inspection Procedure

- Inspect the flex plate for the following conditions: [Click for full-size image](#)
- Stress cracks around the flex plate-to-torque converter mounting bolt hole locations (1) and/or flex plate-to-crankshaft (2, 4)
- Cracks at welded areas that retain the ring gear onto the flex plate (3)

- Damaged or missing ring gear teeth (5)
- Replace the flex plate as necessary.

Crankshaft Balancer Cleaning and Inspection (Article 12072)

Cleaning Procedure

- Clean the crankshaft balancer in solvent that is compatible with the rubber.
- Dry the crankshaft balancer with compressed air.

Inspection Procedure

- Inspect the crankshaft balancer for the following: [Click for full-size image](#)
- Worn or damaged hub-to-crankshaft surface (1)
- Worn, grooved or damaged hub seal surface (2).
- Worn, chunking or deteriorated rubber between the hub and pulley (3)
- Damaged drive belt ribs (4)
- Damaged threaded holes (5)
- Repair or replace the crankshaft balancer as required.

Flywheel Cleaning and Inspection (Article 12099)

Cleaning Procedure

- Clean the engine flywheel in solvent.
- Dry the engine flywheel with compressed air.

Inspection Procedure

- Inspect the manual transmission engine flywheel for the following conditions: [Click for full-size image](#)
- 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).
- Replace the engine flywheel as necessary.

Clearance Angle Inspection

The clearance inspection is to check if the secondary flywheel exhibits a normal amount of movement in relation to the primary flywheel, in both directions, as the internal flange contacts the ARC springs. If the flywheel cannot be moved in either direction or exhibits a binding condition, the flywheel is defective and must be replaced.

- Rotate secondary flywheel counter clockwise until the counterforce (spring force) is clearly noticeable
- Release secondary flywheel slowly until there is no spring force on the flywheel.
- Mark position with a vertical line on secondary flywheel (1) and on toothed ring (2). [Click for full-size image](#)
- Rotate secondary flywheel clockwise until the counterforce (spring force) is clearly noticeable. [Click for full-size image](#)
- Apply a new marking on secondary flywheel (1) on the height of the marking on the toothed ring for starter (3). [Click for full-size image](#)
- Count the number of teeth from marked tooth up to the height of the first marking on secondary flywheel (2).
- For the functional movement of the secondary flywheel, up to 6 teeth are allowed.
- If the movement exceeds 6 teeth, the flywheel must be replaced.

Piston and Connecting Rod Disassemble (Article 12130)

Special Tools

EN-46745 - Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to Special Tools .

- Remove the piston rings using a piston ring expander. Place each ring in a clean shop towel for storage. [Click for full-size image](#)
- The connecting rod is non-directional and may be assembled/reassembled to the piston in either direction.
- DO NOT reuse the piston pin retainers.
- 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. [Click for full-size image](#)
- Slide the piston pin out of the piston. The piston will disconnect from the connecting rod. [Click for full-](#)

size image

Piston, Connecting Rod, and Bearing Cleaning and Inspection (Article 12131)

Cleaning Procedure

- Clean the piston skirts and the pins with a cleaning solvent.
- Clean the piston ring grooves with a groove cleaner. Ensure that the oil ring holes and slots are clean.
- Dry the piston with compressed air.

Piston Inspection Procedure

- Inspect the pistons for the following conditions: [Click for full-size image](#)
- 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)
- Replace pistons that show any signs of damage or excessive wear.

Piston Measurement Procedure

- Measure piston width using the following procedure: [Click for full-size image](#)
- 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.
- Compare the measurement of the piston to its original cylinder by subtracting the piston width from the cylinder diameter.
- Check your measurements with the Engine Mechanical Specifications .
- If the clearance obtained through measurement is greater than the provided specifications and the cylinder bore s are within specification, replace the piston.
- Measure the piston pin bore to piston pin clearances using the following procedure: [Click for full-size image](#)
- Piston pin bores and pins must be free of varnish or scuffing.
- Use an outside micrometer to measure the piston pin in the piston contact areas.
- Using an inside micrometer, measure the piston pin bore. Compare your result with the piston pin diameter and piston pin to piston pin bore clearance listed in the Engine Mechanical Specifications . [Click for full-size image](#)
- If the clearance is excessive, determine which piece is out of specification and replace as necessary.
- You must replace the piston if any of its dimensions are out of specification.
- 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

- Measure the piston ring end gap using the following procedure: [Click for full-size image](#)
- Place the piston ring in the area of the bore where the piston ring will travel approximately 25 mm (1 in) down from the deck surface. Ensure that the ring is square with the cylinder bore by positioning the ring with the piston head.
- Measure the end gap of the piston ring with feeler gauges. Refer to Engine Mechanical Specifications .
- If the clearance exceeds the provided specifications, the piston rings must be replaced.
- Repeat the procedure for all the piston rings.
- Measure the piston ring side clearance using the following procedure: [Click for full-size image](#)
- Roll the piston ring 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, replace the ring.
- With the piston ring on the piston, use feeler gauges to check clearance at multiple locations.
- Compare the measurements with piston ring side clearance listed in the Engine Mechanical Specifications .
- If the clearance is greater than specifications, replace the piston rings.
- There is a locating dimple (1) on the compression rings near the end for identification. Install the compression rings with the dimple facing up. [Click for full-size image](#)
- If the new ring does not reduce the clearance to the proper specification, install a new piston.

Connecting Rod Cleaning Procedure

- Clean the connecting rods in solvent.
- Dry the connecting rod using compressed air.
- Remove the connecting rod cap and clean the threads.
- Remove the connecting rod bearing and discard. Never reuse a connecting rod bearing used in a running engine.

Connecting Rod Visual Inspection Procedure

- Inspect the piston pin bushing (4) for scoring or damage. Click for full-size image
- Inspect the connecting rod beam (1) for twisting or bending.
- Inspect the rod cap (2) for any nicks or damage caused by possible interference.
- Inspect for scratches or abrasion on the rod bearing seating surface.
- If the connecting rod bores contain minor scratches or abrasions, clean the bores in a circular direction with a light emery paper.

Connecting Rod Measurement Procedure

Piston Pin End

- Using an outside micrometer, take 2 measurements of the piston pin in the area of the connecting rod contact. Click for full-size image
- Using an inside micrometer, measure the connecting rod piston pin bore. Click for full-size image
- Subtract the piston pin diameter from the piston pin bore.
- Compare the clearance measurements with the Engine Mechanical Specifications .
- If the clearance is excessive, replace the piston pin. If a new pin does not resolve the clearance problem, replace the connecting rod.

Connecting Rod Crankshaft Bearing End

- Using an inside micrometer, measure the connecting rod crankshaft bearing bore. Click for full-size image
- Compare the bore measurements with the Engine Mechanical Specifications .
- Replace the connecting rod if the bore is out of specifications. DO NOT recondition the connecting rod.

Piston and Connecting Rod Assemble (Article 12129)

Single Use Fasteners and Components

- Connecting Rod Bearing
- Piston Pin Retainer [2x]

Special Tools

- EN-46121 - Connecting Rod Guide Pin Set
- EN-46745 - Piston Pin Clip Remover/Installer

Equivalent regional tools: Special Tools

Piston and Piston Pin Installation Procedure

- 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.
 - Lubricate the piston pin bores in the piston (1) and the connecting rod (2) with prelube lubricant.
- #### Adhesives, Fluids, Lubricants, and Sealers Click for full-size image
- Assemble the piston (3) and piston pin (2) to the connecting rod (4). Properly orient the piston when reusing a marked connecting rod. Click for full-size image
 - Align the piston pin bore with the connecting rod pin bore.
 - Slide the piston pin (2) into the piston (3) and the connecting rod (4).
 - Install NEW piston pin retainers (1) using the EN-46745 - Piston Pin Clip Remover/Installer . Align the EN-46745 - Piston Pin Clip Remover/Installer to the notch in the piston.
 - Ensure that the piston pin retainers (1) are fully seated in their grooves. Click for full-size image
 - Repeat these procedures for the remaining pistons.

Piston Ring Installation Procedure

- 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. Click for full-size image
 - Using a piston ring expander, install the oil control ring assembly using the following procedure: Click for full-size image
 - Install the expander ring (3).
 - 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.
- Install the lower compression piston ring (2) onto the piston with the mark facing the top of the piston.
 - Install the upper compression piston ring (1) onto the piston with the mark facing the top of the piston, if required.
 - 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. Click for full-size image
 - Lower oil control ring – position 1
 - Upper oil control ring – position 2
 - Top Ring – position 3
 - Oil control ring expander – position 4

- Second ring – position 5
- Connecting Rod Bearing Installation Procedure
- Clean the connecting rod (2) and the connecting rod cap bearing bore with a lint-free cloth. Click for full-size image
- Clean all the oil from behind the connecting rod bearing halves.
- Install NEW upper connecting rod bearing (1) 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.
- Install the EN-46121 - Connecting Rod Guide Pin Set into the connecting rod bolt holes.
- Install NEW lower connecting rod bearing (1) into position in the connecting rod cap (2). Roll the bearing into position so that the lock tang engages the alignment slot. The bearings must fit flush with the connecting rod cap. Click for full-size image

Cylinder Head Disassemble (LF1, LFW or LFX) (Article 12081)

Single Use Fasteners and Components

Valve Stem Oil Seal [12X]

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 .

- Remove the fuel rail bolts (1). Click for full-size image
- Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.
- Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.
- Remove the fuel rail and injectors (1) as an assembly using the EN-49248 - remover . Click for full-size image
- Remove the spark plugs . Click for full-size image
- Using an appropriately sized deep socket and a plastic hammer, lightly tap on the valve spring retainer to loosen the valve keepers. Click for full-size image
- Compress the valve spring using the EN-8062 - compressor and the EN-46119 - adapter . Click for full-size image
- Use the magnet of the EN-46117 - remover/installer in order to remove the valve keepers. Click for full-size image
- Remove the valve spring compressor and the adapter.
- Remove the valve spring retainer. Click for full-size image
- Remove the valve spring.
- Remove the valve. Click for full-size image
- Remove the 12 valve stem oil seal using the EN-46116 - remover/installer and DISCARD. Click for full-size image
- Repeat these procedures for the remaining valves.
- Remove the cylinder head oil gallery expansion plugs. Click for full-size image
- Remove the cylinder head coolant threaded plugs. Click for full-size image
- 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. Click for full-size image
- Place cylinder head on firm surface with check valves (1) facing up. Protect all cylinder head components and machined surfaces. Click for full-size image
- Using drill bit EN-46122-3, drill out top portion of check valve to expose internal check ball.
- Remove check ball (1) and check ball spring (2) from inside of check valve. Click for full-size image
- 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. Click for full-size image
- 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. Click for full-size image

- Assemble bolt, nut, washers, and collar EN-46122-2 (1) as shown. Position collar with slightly-larger inside diameter DOWN toward the cylinder head. Click for full-size image
- Screw bolt by hand fully down into threaded check valve sleeve, then lightly tighten nut against washer.
- Hold bolt with one wrench, and use another to tighten the nut until the check valve sleeve (1) is removed from the cylinder head. Click for full-size image
- Clean check valve bore and related passages thoroughly to remove any drilling chips or other debris.

Cylinder Head Cleaning and Inspection (Article 12080)

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

Equivalent regional tools: Special Tools

Cleaning Procedure

- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Remove any old thread sealant, gasket material or sealant using EN-28410 - Gasket Remover .
- Clean all cylinder head surfaces with non-corrosive solvent.
- Blow out all the oil galleries using compressed air.
- Remove any carbon deposits from the combustion chambers using the GE-8358 - Carbon Removal Brush .
- Clean any debris or build-up from the lifter pockets.

Visual Inspection

- Inspect the cylinder head camshaft bearing surfaces for the following conditions: Click for full-size image
- 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.
- If any of the above conditions exist on the camshaft bearing surfaces, replace the cylinder head.
- Inspect the cylinder head for the following:
- Cracks, damage or pitting in the combustion chambers
- 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 plug s
- If the cylinder head is cracked or damaged, it must be replaced. No welding or patching of the cylinder head is recommended.
- Inspect the fuel rail injector bores and clean with EN-47909 - Injector Bore and Sleeve Cleaning Kit , if required. Click for full-size image

Cylinder Head Measurement

Camshaft Journal Clearance

- Install the camshaft bearing cap in the cylinder head without the camshaft.
- Install the camshaft cap bolts and tighten to 10 Nm (89 lb in) .
- Measure the camshaft bearings using an inside micrometer.
- 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

- Ensure the camshafts are serviceable.

- Inspect the cylinder head camshaft bearing surfaces for any imperfections or scratches that could inhibit proper camshaft clearances. Repair minor imperfections or scratches.
- Install the camshafts in the cylinder head.
- Install the camshaft bearing caps.
- Ensure the camshafts spin freely in the cylinder head. If the camshaft does not run freely, replace the cylinder head.

Deck Flatness Inspection

- Ensure the cylinder head decks are clean and free of gasket material. [Click for full-size image](#)
- Inspect the surface for any imperfections or scratches that could inhibit proper cylinder head gasket sealing.
- Place a straight-edge diagonally across the cylinder head deck face surface.
- Measure the clearance between the straight-edge and the cylinder head deck face using a feeler gauge at 4 points along the straight-edge.
- If the warpage is less than 0.05 mm (0.002 in) , the cylinder head deck surface does not require resurfacing.
- 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.
- If resurfacing is required the maximum amount that can be removed is 0.25 mm (0.010 in) .
- If the cylinder head deck surface requires more than 0.25 mm (0.010 in) material removal the head must be replaced.

Valve Guide Measurement

- 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. [Click for full-size image](#)
- Clamp the GE–8001 - Dial Indicator Set to the cylinder head at the camshaft cover rail.
- 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.
- Drop the valve head about 0.064 mm (0.0025 in) off the valve seat.
- Use light pressure when moving the valve stem from side to side in order to obtain a clearance reading.

Engine Mechanical Specifications

- 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 - Valve Guide 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.

Valve Spring Inspection and Measurement (Article 12151)

Special Tools

EN-22738-B - Valve Spring Tester

Equivalent regional tools: Special Tools

Inspection Procedure

- Clean the valve springs in solvent.
- Dry the valve springs with compressed air.
- Inspect the valve springs for broken coils or coil ends.

Measurement Procedure

- Measure the valve spring tension using the EN-22738-B - Valve Spring Tester . [Engine Mechanical Specifications Click for full-size image](#)
- 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.

Valve and Seat Grinding (Article 12140)

Valve Cleaning Procedure

- 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.
- Thoroughly clean the valve with solvent and wipe dry.

Valve Visual Inspection Procedure

- Inspect the valve for damage from the head to tip for the following conditions: [Click for full-size image](#)

- 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)
- Replace the valve if any of these conditions exist.

Valve Measurement Overview

- Proper valve service is critical to engine performance. Therefore, all detailed measurement procedures must be followed to identify components that are out of specification.
- 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

- Measure the valve seat width in the cylinder head using a proper scale. [Click for full-size image](#)
- Measure the seat width on the valve face (1) using a proper scale. [Click for full-size image](#)
- Compare your measurements with the specifications listed in Engine Mechanical Specifications .
- If the seat widths are acceptable, check the valve seat roundness using the Valve Seat Roundness Measurement Procedure.
- 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

- 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.
- If the valve seat exceeds the roundness specification, you must replace the valve.
- If new valves are being used, the valve seat roundness must be within 0.05 mm (0.002 in).

Valve Margin Measurement Procedure

- Measure the valve margin using an appropriate scale. [Click for full-size image](#)
- Reference the specifications in this section for minimum valve margin and compare them to your measurements.
- If the valve margins are beyond specification, replace the valves.
- 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

- 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.
- Coat the valve face lightly with blue dye (3). [Click for full-size image](#)
- Install the valve in the cylinder head.
- Turn the valve against the seat with enough pressure to wear off the dye.
- Remove the valve from the cylinder head.
- Inspect the valve face.
- 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).
- 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

- 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.
- Grind the valve seats (2) to the proper angle specification listed in Engine Mechanical Specifications . [Click for full-size image](#)
- 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.
- 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 .
- When grinding the seats, grind off as little material as possible. Cutting valve seat results in lowering the valve spring pressure.
- Install the valve in the cylinder head. Do not lap the valves under any condition, whether the valves are new or used.

- 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.
 - 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
- Install the valve into the valve guide. [Click for full-size image](#)
 - Ensure the valve is seated to the cylinder head valve seat.
 - Install the valve stem oil seal .
 - Install the valve spring retainer and valve stem locks.
 - Measure the distance (1) between the cylinder head to the bottom of the valve spring retainer. Refer to Engine Mechanical Specifications .
 - If the maximum height specification is exceeded, a new valve should be installed and the valve stem height re-measured.
 - If the valve stem height still exceeds the maximum height specification, the cylinder head must be replaced.

Fuel Rail and Injectors Cleaning and Inspection (LF1, LFW or LFX) (Article 12104)

Single Use Fasteners and Components

- Fuel Injection Fuel Rail Seal
- Fuel Injector Bushing
- Fuel Injector Retainer
- Fuel Injector Seal
- Fuel Injector Seal Spacer -Brown
- Fuel Injector Seal Spacer -White

Special Tools

- EN-47909 - Injector Bore and Sleeve Cleaning Kit
- EN-49245 - Injector Seal Installer Kit
- EN-49247 - Injector Retaining Clip Installer

For equivalent regional tools, refer to Special Tools .

- Detach and remove the fuel rail wiring harness (1) from the fuel injector rail. [Click for full-size image](#)
- 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. [Click for full-size image](#)
- DISCARD the fuel injector retainer (1).
- Carefully twist the fuel injector to remove the fuel injector (2) from the fuel injector rail.
- Using a suitable tool remove the fuel injector bushing (3). [Click for full-size image](#)
- DISCARD fuel injector bushing.
- Remove and DISCARD the fuel injection fuel rail seal (1).
- Remove and DISCARD the fuel injector seal spacers (2).
- Remove and DISCARD the fuel injector seals (4).
- Remove the fuel pressure sensor (1) from the fuel injector rail. [Click for full-size image](#)
- 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 .
- Inspect the fuel injector rail (1) for the following conditions: [Click for full-size image](#)
- Damage, debris or restrictions to the fuel rail
- Damage, debris or restrictions to the fuel ports in the fuel rail
- Damage to the mounting area for the fuel rail
- Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
- Damage to the threads on the fuel rail feed fitting
- Damage to the threads in the fuel pressure sensor bore
- Damage to the fuel pressure sensor connector, threads, or sealing face
- If any of the above conditions are found, replace the fuel injector rails. Do not attempt to repair the fuel injector rails.
- Install the fuel pressure sensor (1) to the fuel injector rail. [Click for full-size image](#)
- Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
- Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
- Install the fuel pressure sensor to the fuel injector rail and hand tighten.
- Remove the fuel pressure sensor from the fuel injector rail and re-lubricate.
- Install the fuel pressure sensor to the fuel injector rail and tighten to 33 Nm (25 lb ft) .
- Inspect the fuel injectors for the following conditions: [Click for full-size image](#)

- 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 tip (4)
- Replace the fuel injector if any of the above conditions are found. Do not attempt to repair the fuel injectors.
- The fuel injector bushing (1) is to be installed BEFORE seal or spacers are installed.
- Listen for an audible click to confirm correct installation of the fuel injector bushing
- Install NEW fuel injector bushing (1) onto injector body. Bushing should seat with a distinct “snap” sound and feel. Ensure bushing is fully seated. [Click for full-size image](#)
- Install the NEW white plastic spacer (3) on the fuel injector first. [Click for full-size image](#)
- Install the brown plastic spacer (2) second.
- Lubricate the NEW fuel injection fuel rail seal (1) with one drop of clean engine oil.
- The right side (bank 1) fuel injector wiring harness connectors (1) should point to the rear of the engine. The left side (bank 2) fuel injector wiring harness connectors (2) should point to the front of the engine. [Click for full-size image](#)
- Do NOT install the Teflon injector tip/bore seals until AFTER the injectors are installed on the fuel rail.
- Make sure that the fuel injector connectors are placed in the correct position.
- Holding the largest diameter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2). [Click for full-size image](#)
- Clamp the fuel rail in a bench vise USING SOFT JAWS to aid in holding the rail during the installation of the retainer.
- 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
- Support the fuel injector fuel rail in a vise. [Click for full-size image](#)
- Install the fuel injector to fuel rail retainer to the EN-49247 - injector retaining clip installer .
- 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. [Click for full-size image](#)
- 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). [Click for full-size image](#)
- The base of the EN-49247 - injector retaining clip installer should be positioned as shown before squeezing the tool to complete the installation.
- Hold the injector bushing (2) and fuel injector rail flanges (1) in alignment. [Click for full-size image](#)
- Hold the injector assembly firmly against the fuel injector rail to prevent a gap forming between the fuel injector and the fuel injector rail.
- Install the fuel injector to fuel rail retainer (3).
- Ensure all 3 fuel injector bushing tabs and fuel rail flanges (1) are properly and completely captured by the fuel injector retainer. [Click for full-size image](#)
- Repeat the above steps for the remaining fuel injectors until all the fuel injectors are installed and retained in the fuel injector rail.
- Install the fuel injector rail wiring harness (1) to the fuel injector rail. [Click for full-size image](#)
- Install the long protector (3) of the EN-49245-1 - fuel injector seal install/sizer to the fuel injector spray tip covering the first recessed area closest to the tip. [Click for full-size image](#)
- Place a NEW seal (2) onto long protector (3) of the EN-49245-1 - fuel injector seal install/sizer .
- Using the pusher (1) of the EN-49245-3 - fuel injector seal install/sizer , push the seal (2) into the second recessed area (4) of the fuel injector.
- Compress the seal (2) with your fingers.
- Resize the seal (2) using the sizer (5) of the EN-49245-4 - fuel injector seal install/sizer .
- Install the short protector (3) of the EN-49245-2 - fuel injector seal install/sizer to the fuel injector tip. [Click for full-size image](#)
- Place a NEW seal (2) onto the short protector (3) of EN-49245-2 - fuel injector seal install/sizer .
- Using the pusher (1) of the EN-49245-3 - fuel injector seal install/sizer , push the seal (2) into the first recessed area (4) of the fuel injector.

Cylinder Head Assemble (LF1, LFW or LFX) (Article 12079)

Single Use Fasteners and Components

- Engine Block Oil Gallery Plug [2x]

- Engine Oil Manifold Check Valve
- Valve Stem Oil Seal [12x]

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 .

- Use lubricant included with EN 46122 - remover/installer to lubricate outside of NEW engine oil manifold check valve (1). Click for full-size image
- With the check ball end of the engine oil manifold check valve facing UP, away from the head, insert the NEW engine oil manifold check valve into the check valve bore in the cylinder head .
- Place collar EN 46122-2 (1) over the NEW engine oil manifold check valve with the slightly-larger inside diameter of the collar DOWN toward the cylinder head. Click for full-size image
- Using the driver EN-46122-1 (2), lightly tap the NEW engine oil manifold check valve into place until the driver stops against the top of the collar.
- 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). Click for full-size image
- Install the cylinder head coolant threaded plugs and tighten to 75 Nm (55 lb ft) . Click for full-size image
- Install the 2 NEW engine block oil gallery plugs. Click for full-size image
- Place the 12 NEW valve stem oil seals onto the guides. Click for full-size image
- Install the 12 NEW valve stem oil seals using the EN 46116 - remover/installer .
- Push and twist the NEW valve stem oil seal into position on the valve guide until the seal positively locks on the guide using the EN 46116 - remover/installer .
- Lubricate the valve stem and valve guide ID with clean engine oil. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
- Insert the valve into the valve guide until it bottoms on the valve seat. Click for full-size image
- Position the valve spring on the spring seat. Click for full-size image
- Place the valve spring retainer onto the valve spring.
- Compress the valve spring using the EN 8062 - compressor and the EN 46119 - adapter . Click for full-size image
- With the spring compressed, install the valve keepers into the EN 46117 - remover/installer . Click for full-size image
- 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. Click for full-size image
- Verify that the valve keepers are installed by placing a rag over the valve tip and tapping with a dead-blow hammer.
- Install the fuel rail with injectors (2) into the cylinder head evenly. Click for full-size image
- Install and hand tighten the two outer fuel rail bolts (1) to seat the injectors in the injector bores.
- Install and hand tighten the two inner fuel rail bolts.
- Tighten the fuel rail bolts in the sequence shown to 25 Nm (18 lb ft) . Click for full-size image

Camshaft Cleaning and Inspection (Article 12046)

Special Tools

GE-7872 - Magnetic Base Dial Indicator

Equivalent regional tools: Special Tools

Cleaning Procedure

- Clean the camshaft in solvent.
- Dry the camshaft with compressed air.

Visual Inspection

- Inspect the camshaft oil feed holes (1) to the camshaft position actuator for dirt, debris or blockage. Click for full-size image
- Inspect the threaded hole (2) for damage.
- Inspect the camshaft position actuator locating notch (3) for damage or wear.
- Inspect the camshaft sealing grooves (4) for damage.
- Inspect the camshaft thrust surface (5) for damage.

- Inspect the camshaft lobes (6) and journals (7) for the following conditions:

- Excessive scoring or pitting
- Discoloration from overheating
- Deformation from excessive wear, especially the camshaft lobes
- If any of the above conditions exist on the camshaft, replace the camshaft.

Camshaft Measurement

- With the camshaft in a suitable fixture, measure the camshaft for wear. Click for full-size image
- Measure the camshaft journals for diameter and out-of-round using an outside micrometer. Engine Mechanical Specifications Click for full-size image
- If the diameter is smaller than specifications, replace the camshaft.
- If the out-of-round exceeds specifications, replace the camshaft.
- Measure the camshaft runout using the GE-7872 - indicator . Engine Mechanical Specifications Click for full-size image
- Measure the camshaft thrust width for wear using a depth micrometer. Engine Mechanical Specifications Click for full-size image
- Measure the camshaft thrust wall surface for runout using GE-7872 - indicator . Engine Mechanical Specifications Click for full-size image
- If the camshaft is damaged or worn beyond specifications, replace the camshaft. No machining of the camshaft is allowed.
- Measure the camshaft lobes for wear using the GE-7872 - indicator . Click for full-size image
- Place the GE-7872 - indicator with the indicator tip on the base circle (1) of the camshaft lobe. Click for full-size image
- Place the GE-7872 - indicator at zero.
- Rotate the camshaft until the indicator tip is at the highest point (3) on the lobe. This reading is the lift of the camshaft lobe. Engine Mechanical Specifications
- If the indicated measurement is significantly lower than these specifications, replace the camshaft or engine performance will be reduced.

Valve Lifter Cleaning and Inspection (Article 12141)

- Inspect the stationary hydraulic lash adjuster (SHLA) in the following areas: Click for full-size image
- 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)
- Replace the SHLA or SHLAs as necessary.

Valve Rocker Arm Cleaning and Inspection (Article 12146)

- Inspect the camshaft follower roller (1) for the following: Click for full-size image
- Flat spots
- Excessive scoring and pitting
- Ensure the roller spins freely
- Inspect the camshaft follower valve tip area (2).
- Inspect the camshaft follower stationary hydraulic lash adjuster (SHLA) pivot area (3).
- Replace the camshaft follower or followers as necessary.

Camshaft Timing Drive Components Cleaning and Inspection (Article 12068)

Cleaning Procedure

- 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 tensioner s
- Timing component fastening bolts
- Clean each camshaft position actuator's exterior with solvent.

- Dry the timing components with compressed air.

Visual Inspection

Camshaft Thrust Washers (If Equipped)

- Inspect the camshaft thrust washers for deep scoring or uneven wear (1). [Click for full-size image](#)

- Replace as necessary.

Camshaft Position Actuators

- Inspect the front of the exhaust camshaft position actuators for the following: [Click for full-size image](#)

- Sprocket damage (1)

- Reluctor/sensor wheel damage (2)

- Camshaft position actuator bolt seating/sealing inner hub flange damage (3)

- Inspect the back of the exhaust camshaft position actuators for the following: [Click for full-size image](#)

- 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)

- Inspect the front of the left intake camshaft position actuators for the following: [Click for full-size image](#)

- Camshaft position actuator oil control valve bolt seating/sealing inner hub flange damage (3)

- Inspect the back of the left intake camshaft position actuators for the following: [Click for full-size image](#)

- Inspect the front of the right intake camshaft position actuators for the following: [Click for full-size image](#)

- Inspect the back of the right intake camshaft position actuators for the following: [Click for full-size image](#)

- Replace a damaged camshaft position actuator.

Camshaft Position Actuator Oil Control Valves

- Inspect the camshaft position actuator oil control valves for the following: [Click for full-size image](#)

- 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 oil control valve solenoid oil seal (4)

- Damage to the bracket (5)

- Damage to the wiring harness connection and/or terminals (6)

- Replace a damaged camshaft position actuator oil control valve.

Left Intermediate Sprocket with Primary and Secondary Inverted Tooth (IT) Chain

- Inspect the front of the left intermediate sprocket for the following: [Click for full-size image](#)

- Damage to the primary camshaft drive chain sprocket (1)

- Damage to the hub bearing (2)—Ensure 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)

- Inspect the back of the left intermediate sprocket for the following: [Click for full-size image](#)

- Damage to the left secondary camshaft drive chain sprocket (1)

- Damage to the bearing hub-to-engine block sealing surface (2)

- Replace a damaged left intermediate sprocket.

Right Intermediate Sprocket with Primary and Secondary Inverted Tooth (IT) Chain

- Inspect the front of the right intermediate sprocket for the following: [Click for full-size image](#)

- Damage to the right secondary camshaft drive chain sprocket (1)

- Inspect the back of the right intermediate sprocket for the following: [Click for full-size image](#)

- Damage to the bearing hub-to-engine block sealing surface (2)

- Replace a damaged right intermediate sprocket.

Crankshaft Sprocket with Primary Inverted Tooth (IT) Chain

- Inspect the crankshaft sprocket for the following: [Click for full-size image](#)

- Bore damage (2)

- Keyway damage (3)

- Replace a damaged crankshaft sprocket.

Secondary Timing Chains with Inverted Tooth (IT) Chain

- Inspect the secondary timing chain for the following: [Click for full-size image](#)

- Binding or worn links (1)

- Loose links (2)

- Loose pins (3)

- Replace a damaged secondary timing chain.

Primary Timing Chain with Inverted Tooth (IT) Chain

- Inspect the primary timing chain for the following: [Click for full-size image](#)
- Replace a damaged primary timing chain.

Primary Timing Chain Upper Guide

- Inspect the primary timing chain upper guide for the following: [Click for full-size image](#)
- Worn guide surface (1)
- Cracked or broken guide surface (2)
- Cracked or damaged guide base (3)
- Replace a damaged primary timing chain upper guide.

Primary Timing Chain Lower Guide

- Inspect the primary timing chain lower guide for the following: [Click for full-size image](#)
- Replace a damaged primary timing chain lower guide.

Left Secondary Timing Chain Guide

- Inspect the left secondary timing chain guides for the following: [Click for full-size image](#)
- Replace a damaged left secondary timing chain guide.

Right Secondary Timing Chain Guide

- Inspect the right secondary timing chain guides for the following: [Click for full-size image](#)
- Replace a damaged right secondary timing chain guide.

Left Secondary Timing Chain Shoe

- Inspect the front of the left secondary timing chain shoe for the following: [Click for full-size image](#)
- Worn shoe surface (1)
- Cracked or broken shoe surface (2)
- Cracked or damaged shoe (3)

- Inspect the back of the left secondary timing chain shoe for a damaged, worn, or missing left secondary timing chain tensioner contact pad (1). [Click for full-size image](#)

- Replace a damaged left secondary timing chain shoe.

Right Secondary Timing Chain Shoe

- Inspect the front of the right secondary timing chain shoe for the following: [Click for full-size image](#)
- Inspect the back of the right secondary timing chain shoe for a damaged, worn, or missing right secondary timing chain tensioner contact pad (1). [Click for full-size image](#)
- Replace a damaged right secondary timing chain shoe.

Primary Timing Chain Tensioner

- Inspect the primary timing chain tensioner for worn primary timing chain tensioner shoe surface (1). [Click for full-size image](#)
- Inspect the primary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#) .
- Replace a damaged primary timing chain tensioner.

Left Secondary Timing Chain Tensioner

- Inspect the left secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1). [Click for full-size image](#)
- Inspect the left secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#) .
- Replace a damaged left secondary timing chain tensioner.

Right Secondary Timing Chain Tensioner

- Inspect the right secondary timing chain tensioner for damaged plunger-to-shoe contact surface (1). [Click for full-size image](#)
- Inspect the right secondary timing chain tensioner for locked or binding timing chain tensioner. Reset the plunger (3) and ensure the plunger moves freely (2) in and out of the body of the tensioner. Refer to [Camshaft Timing Chain Components Installation](#) .
- Replace a damaged right secondary timing chain tensioner.

Oil Pump Disassemble (Article 12125)

- Remove the oil pump mounting bolts. [Click for full-size image](#)
- Remove the primary camshaft drive chain lower guide bolts. [Click for full-size image](#)
- Remove the primary camshaft drive chain lower guide.
- Remove the bolts holding the oil pump cover to the oil pump housing. [Click for full-size image](#)
- Remove the oil pump cover from the oil pump housing. [Click for full-size image](#)
- Remove the inner oil pump drive gear. [Click for full-size image](#)

- Remove the outer oil pump driven gear.
- Remove the clip, holding the cap, for the oil relief valve components. Click for full-size image
- Remove the cap, spring, and plunger from the oil pump housing.

Oil Pump Cleaning and Inspection (Article 12124)

Cleaning Procedure

- Clean the oil pump components with non-corrosive solvent.
- Dry the oil pump components with compressed air.

Inspection Procedure

- Inspect the oil pump housing for the following: Click for full-size image
- Damage, scoring, or debris on the housing surface for the driven gear (1)
- Damage to the oil pump mounting bosses (2)
- Damage, scoring, or debris on the housing surface for the drive gear (3)
- Damage, scoring, or debris in the oil pump relief valve port (4)
- Damage, scoring, or debris in the oil pump intake port (5)
- Damage, scoring, or debris in the oil pump relief valve bore (6)
- Damage, scoring, or debris in the oil pump output port (7)
- Damage to the threads in the oil pump housing for the oil pump cover bolts (8)
- Inspect the oil pump cover for the following conditions: Click for full-size image
- Damage to the oil pump cover mounting bosses (1)
- Damage, scoring, or debris in the oil pump cover oil passages (2)
- Damage to the sealing surface between the oil pump cover and the oil pump housing (3)
- Inspect the inner drive gear for damage. If inner diameter damage is found, ensure the crankshaft is also inspected. Click for full-size image
- Inspect the outer driven gear for damage. Click for full-size image
- Inspect the oil pump relief valve components for debris or damage. Click for full-size image
- Inspect the primary camshaft drive chain lower guide for damage (1–3). Click for full-size image
- If debris or damage is present within the oil pump, further inspection of all of the engine components is necessary.

Oil Filter Adapter Disassemble (Article 12114)

- Remove the oil filter cap. Click for full-size image
- Remove the oil filter cartridge and discard. Click for full-size image
- Remove the oil pressure sender . Click for full-size image

Oil Filter Adapter Cleaning and Inspection (Article 12113)

Cleaning Procedure

- Clean the oil filter adapter components with non-corrosive solvent.
- Dry the oil filter adapter components with compressed air.

Inspection Procedure

- Inspect the oil filter housing for cracks, scoring, casting imperfections (1) and damaged threads (3). Click for full-size image
- Inspect the drain back valve (2) for damage or blockage.
- Inspect the oil filter cap for cracks, scoring, casting imperfections (1) and damaged threads (2). Replace as necessary. Click for full-size image
- Inspect the oil filter cap O-ring (3) for damage. Replace as necessary.
- If the O-ring is damaged, carefully remove the O-ring using a tool that will not damage the oil filter cap O-ring groove. If the oil filter cap O-ring groove is damaged the oil filter cap must be replaced.
- Inspect the bypass valve (1) for damage or blockage. Click for full-size image

Oil Filter Adapter Assemble (Article 12112)

- Install the oil pressure sender and tighten to 20 Nm (15 lb ft) . Click for full-size image
- Install the NEW oil filter cartridge . Click for full-size image
- If the oil filter cap O-ring is removed, install a NEW O-ring on the oil filter cap.
- Ensure the O-ring groove is not damaged. Replace the oil filter cap if the O-ring groove is damaged.
- Protect the O-ring from damage during installation by covering the threads of the oil filter cap with tape or plastic wrap.
- DO NOT stretch the O-ring during installation.
- Roll the O-ring into position over the covered threads.

- Remove the tape or plastic wrap from the oil filter cap threads.
- Ensure the oil filter cap threads are clean.
- Lubricate the oil filter cap threads and O-ring with clean engine oil. [Click for full-size image](#)
- Install the oil filter cap and tighten to 25 Nm (18 lb ft) . [Click for full-size image](#)

Oil Pan Disassemble (Article 12121)

- Remove the oil pan drain plug (1) [Click for full-size image](#)
- Remove the oil pan scraper (1). [Click for full-size image](#)
- Remove the oil pan scraper bolts (2).
- Remove the oil suction pipe bolts (1). [Click for full-size image](#)
- Remove the oil suction pipe (2).
- Remove and discard the oil suction pipe seal (1). [Click for full-size image](#)
- Remove the engine oil level switch clip (4). [Click for full-size image](#)
- Remove the engine oil level switch bolts (1).
- Remove the engine oil level switch (2).
- Remove and discard the engine oil level switch seal (3).

Oil Pan Cleaning and Inspection (Article 12120)

Special Tools

EN-28410 - Gasket Remover

For equivalent regional tools, refer to Special Tools .

Cleaning Procedure

- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Remove any old thread sealant, gasket material or sealant using EN-28410 - remover .
- Clean the oil pan and oil pan components in solvent.
- Clean out debris from the bolt holes.
- Dry the oil pan and oil pan components with compressed air.

Inspection Procedure

- Inspect the exterior of the oil pan for the following conditions: [Click for full-size image](#)
- 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)
- Inspect the interior of the oil pan for the following conditions: [Click for full-size image](#)
- 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)
- Repair or replace the oil pan and/or oil pan components as necessary.

Oil Pump Suction Pipe and Screen Cleaning and Inspection (Article 12128)

Cleaning Procedure

- Clean the oil pump pipe and screen with solvent.
- Dry the oil pump pipe and screen with compressed air.

Inspection Procedure

- Inspect the mounting surface (1) for possible leakage paths. [Click for full-size image](#)
- Inspect the oil pump pipe tube (3) for cracks, imperfections and/or damage.
- Inspect the oil pump pipe support bracket (2) for cracks or damage.
- Inspect the oil pump screen (4) for blockage, foreign material, tears, cracks and/or damage.

Oil Pan Assemble (Article 12119)

- Install the oil pan drain plug (1) and tighten the oil pan drain plug to 25 Nm (18 lb ft) . [Click for full-size image](#)
- Install the NEW engine oil level switch seal (3). [Click for full-size image](#)
- Install the engine oil level switch (2).
- Install the engine oil level switch bolts (1) and tighten to 10 Nm (89 lb in) .
- Install NEW engine oil level switch clip (4).
- Install the NEW oil suction pipe seal (1). [Click for full-size image](#)

- Install the oil suction pipe (2). Click for full-size image
- Install the oil suction pipe bolts (1) and tighten to 10 Nm (89 lb in) .
- Install the oil pan scraper (1). Click for full-size image
- Install the oil pan scraper bolts (2) and tighten to 10 Nm (89 lb in) .

Engine Front Cover Disassemble (Article 12095)

Single Use Fasteners and Components

- Camshaft Position Actuator Solenoid Valve Seal [4x]
- Engine Front Cover Gasket

Callout Component Name

1 Camshaft Position Actuator Solenoid Valve Seal [4x] Procedure Install NEW seals. Do NOT reuse old seals.

Procedure

Install NEW seals. Do NOT reuse old seals.

2 Crankshaft Front Oil Seal Procedure Remove » Crankshaft Front Oil Seal EN-45000 - Seal Remover Special Tools

EN-45000 - Seal Remover Equivalent regional tools: Special Tools

- Remove » Crankshaft Front Oil Seal EN-45000 - Seal Remover

Special Tools

EN-45000 - Seal Remover

3 Engine Front Cover Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Install a NEW gasket. Do NOT reuse the old gasket.

Engine Front Cover Cleaning and Inspection (Article 12094)

Special Tools

EN-28410 - Gasket Remover

For equivalent regional tools, refer to Special Tools .

Cleaning Procedure

- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant Remove any RTV sealant (1) from the engine front cover using EN-28410 - remover . Click for full-size image

- Clean out debris from the bolt holes.
- Clean the engine front cover in solvent.
- Dry the engine front cover with compressed air.

Inspection Procedure

- Inspect the exterior of the engine front cover for the following conditions: Click for full-size image

- 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 valve oil 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)

- Inspect the interior of the engine front cover for the following conditions: Click for full-size image

- Gouges or damage to the engine front cover sealing surfaces to the engine block (6), oil pan (4), and/or camshaft covers (2)
- Damage and/or corrosion to the engine coolant passage (5)
- 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)
- Damage to the engine front cover bolt holes (1)
- Repair or replace the engine front cover as necessary.

Engine Front Cover Assemble (Article 12093)

Single Use Fasteners and Components

- Camshaft Position Actuator Solenoid Valve Seal [4x]
- Engine Front Cover Gasket

Callout Component Name

1 Camshaft Position Actuator Solenoid Valve Seal [4x] Procedure Place the seal into position with the notches

in the seal down. The notches will face inboard when properly installed. Install » Camshaft Position Actuator

Solenoid Valve Seal EN-46103 - Camshaft Actuator Valve Seal Installer Note: Install NEW seals. Do NOT reuse

old seals. Special Tools EN-46103 - Camshaft Actuator Valve Seal Installer Equivalent regional tools: Special Tools

Procedure

- Place the seal into position with the notches in the seal down. The notches will face inboard when properly installed.

- Install » Camshaft Position Actuator Solenoid Valve Seal EN-46103 - Camshaft Actuator Valve Seal Installer Special Tools

EN-46103 - Camshaft Actuator Valve Seal Installer

2 Crankshaft Front Oil Seal Procedure Install » Crankshaft Front Oil Seal EN-29184 - Oil Seal Installer Note:

Do not lubricate the crankshaft front oil seal or crankshaft balancer sealing surfaces. The crankshaft balancer is installed into a dry seal. Special Tools EN-29184 - Oil Seal Installer Equivalent regional tools: Special Tools

- Install » Crankshaft Front Oil Seal EN-29184 - Oil Seal Installer

EN-29184 - Oil Seal Installer

3 Engine Front Cover Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Install a NEW gasket. Do NOT reuse the old gasket.

Camshaft Cover Disassemble (Article 12049)

Left Camshaft Cover

- Remove and discard the left camshaft cover bolt grommets. Click for full-size image

- Remove the fuel injector sight shield ballstud. Click for full-size image

- Remove the oil fill cap. Click for full-size image

- Remove and discard the left camshaft cover gasket. Click for full-size image

- Remove and discard the left spark plug shield tube seals. Click for full-size image

Right Camshaft Cover

- Remove and discard the right camshaft cover bolt grommets. Click for full-size image

- Remove and discard the right camshaft cover gasket. Click for full-size image

- Remove and discard the right spark plug shield tube seals. Click for full-size image

Camshaft Cover Cleaning and Inspection (Article 12048)

Cleaning Procedure

- Clean the camshaft cover s in solvent.

- Dry the camshaft covers with compressed air.

Inspection Procedure

- Inspect each camshaft cover for the dents or damage to the exterior. A dented or damaged camshaft cover may:

- Leak engine oil

- Effect crankcase ventilation

- Interfere with the camshafts

- Interfere with the ignition coil sealing

- Allow water or condensation to enter the engine

- Inspect the exterior of the left camshaft cover for the following conditions: Click for full-size image

- 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.

- Inspect the interior of the left camshaft cover for the following conditions: Click for full-size image

- 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)

- Inspect the exterior of the right camshaft cover for the following conditions: Click for full-size image

- 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)

- Inspect the interior of the right camshaft cover for the following conditions: Click for full-size image

- 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)
- Repair or replace the camshaft cover or covers as necessary.

PCV Orifice Replacement

- Remove the old PCV orifice by gripping the neck of the orifice with pliers and twisting and pulling out of the right camshaft cover. [Click for full-size image](#)
- Apply sealant to the NEW PCV orifice (1). [Adhesives, Fluids, Lubricants, and Sealers](#) [Click for full-size image](#)
- 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. [Click for full-size image](#)

PCV Fitting Replacement

- Remove the old PCV fitting. [Click for full-size image](#)
- Install the new PCV fitting with a NEW O-ring.

Camshaft Cover Assemble (Article 12047)

Special Tools

- J 5590 - Bearing and Seal Driver
- J 24254-A - Oil Seal Installer

For equivalent regional tools, refer to Special Tools .

Left Camshaft Cover

- Install the NEW left spark plug shield tube seals using the J 5590 - driver (1) and J 24254-A - installer (2) . [Click for full-size image](#)
- Install the NEW left camshaft cover gasket. [Click for full-size image](#)
- Install the oil fill cap. [Click for full-size image](#)
- Install the fuel injector sight shield cover ballstud and tighten to 10 Nm (89 lb in) . [Click for full-size image](#)
- Install the NEW left camshaft cover bolt grommets. [Click for full-size image](#)

Right Camshaft Cover

- Install the NEW right spark plug shield tube coil seals using the J 5590 - driver (1) and J 24254-A - installer (2) . [Click for full-size image](#)
- Install the NEW right camshaft cover gasket. [Click for full-size image](#)
- Install the NEW right camshaft cover bolt grommets. [Click for full-size image](#)

Intake Manifold Disassemble (LF1, LFW or LFX) (Article 12109)

- Remove the throttle body bolts (1). [Click for full-size image](#)
- Remove the throttle body (2).
- Remove and discard the throttle body seal (3).
- Loosen the evaporative (EVAP) solenoid bolt. [Click for full-size image](#)
- Remove the EVAP solenoid (1).
- Remove the manifold absolute pressure (MAP) sensor bolt (1). [Click for full-size image](#)
- Remove the MAP sensor (2).
- Remove the lower intake manifold bolts (1) and lower intake manifold (2). [Click for full-size image](#)
- Remove and discard the lower intake manifold gasket s (3).
- Remove and discard the plastic compression limiters (1). [Click for full-size image](#)

Intake Manifold Cleaning and Inspection (LF1, LFW or LFX) (Article 12108)

Upper Intake Manifold Cleaning Procedure

- Remove any remaining gasket and/or gasket material from the following:
 - Throttle body
 - Intake manifold
- 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
- Dry the upper intake manifold and throttle body with compressed air.

Inspection Procedure

- Inspect the upper intake manifold for the following conditions: [Click for full-size image](#)
- 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)
- 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)
- Inspect the upper intake manifold sealing surface (1) for warpage. Click for full-size image
- Locate a straight edge across the intake manifold sealing surface.
- 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.
- Repair or replace the upper intake manifold as necessary.

Intake Manifold Assemble (LF1, LFW or LFX) (Article 12107)

- Install the NEW plastic compression limiters (1). Click for full-size image
- Install the NEW lower intake manifold gaskets (3). Click for full-size image
- Install the lower intake manifold (2) and bolts (1).
- Tighten the lower intake manifold bolts (1) to 7 Nm (62 lb in) .
- Inspect the manifold absolute pressure (MAP) sensor O-ring seal for damage. If the seal is damaged replace the MAP sensor. Click for full-size image
- Install the MAP sensor (2).
- Install the MAP sensor bolt (1) and tighten to 4 Nm (35 lb in) .
- Inspect the evaporative (EVAP) solenoid O-ring seal for damage. If the seal is damaged replace the EVAP solenoid. Click for full-size image
- Install the EVAP solenoid (1).
- Tighten the EVAP solenoid bolt to 10 Nm (89 lb in) .
- Install the NEW throttle body seal (3). Click for full-size image
- Install the throttle body (2).
- Install the throttle body bolts (1) and tighten to 10 Nm (89 lb in) .

Water Pump Cleaning and Inspection (Article 12154)

Cleaning Procedure

- Remove the old gasket material from the water pump sealing surfaces.
- Clean all excess dirt and debris from the water pump housing.

Inspection Procedure

- 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. Click for full-size image
- 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)
- 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. Click for full-size image
- Inspect the interior of the water pump for the following: Click for full-size image
 - 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)
- Repair or replace the water pump as necessary.

Thread Repair (Article 12135)

Special Tools

- EN 42385-700 - High Feature Thread Repair Kit
- EN 42385-2000 - Thread Insert Kit
- EN 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 EN 42385-700 - kit and EN 42385-2000 - 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 EN 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.

It is critical that the drilling, counterboring and tapping of the hole to be repaired follows the same centerline as the original hole.

During the drilling and tapping of the hole being repaired ensure the tooling is consistently machining perpendicular to the surface of the base material.

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 Tap Size Tap Guide Tap Size Tap Guide

— EN 42385- — EN 42385- — EN 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

- 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.
- Drill out the threads of the damaged hole. Click for full-size image 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).
- 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).
- Using compressed air, clean out any chips. Click for full-size image
- Counterbore the drilled hole to the full depth permitted by the tool (1). Click for full-size image
- During the tapping process, it is necessary to repeatedly remove the tap and clean chips from the hole and the flutes of the tap.
- Ensure the tap has created full threads at least to the depth equal to the insert length.
- Using a suitable tapping wrench, tap the threads of the drilled hole by hand only. Click for full-size image 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).
- 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).
- Spray cleaner into the tapped hole. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cleaner. Click for full-size image
- Lubricate the threads of the driver installation tool (2) with the EN 42385-110 (1). Click for full-size image
- Install the insert (2) onto the driver installation tool (1). Click for full-size image
- Apply threadlock sealant, EN 42385-109, LOCTITE 277® or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the insert (2) into the tapped hole by hand only. Click for full-size image
- Install the insert until the flange (2) of the insert contacts the counterbored surface.
- Continue to rotate the driver installation tool (1) through the insert (2). Click for full-size image
- Inspect the insert for proper installation into the tapped hole. A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2). Click for full-size image
- 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. Click for full-size image

Recessed Thread Repair

- The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.

- Do NOT remove the original stop collar from a counterbore drill.

When installed to the proper depth, the flange of the insert (1) will be seated against the counterbore (2) of the drilled/tapped hole.

- Install a stop collar (2) on the counterbore drill (1), if required. Click for full-size image

- Drill the hole until the stop collar contacts the surface of the base material.
- Drill out the threads of the damaged hole. Click for full-size image
- Using a suitable tapping wrench, tap the threads of the drilled hole by hand only. Click for full-size image
- Install the insert until the flange (2) of the insert contacts the counterbored surface. Click for full-size image
- Inspect the insert (1) for proper installation (2) into the tapped hole. Click for full-size image

Tapered Pipe Thread Repair

The thread repair insert for tapered pipe threads is coated with a clear silver zinc coating.

When installed to the proper depth, the flange (1) of the insert will be seated against surface (2) of the base material of the drilled/tapped hole.

- Tap the drilled hole until the threads at the top of the tap (2) are down to the surface of the base material. Click for full-size image
- Install the insert until the flange of the insert (3) contacts the surface of the base material. Click for full-size image
- 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).

Cylinder Head Bolt Hole Thread Repair

The cylinder head bolt hole thread repair tooling are in the kits EN 42385-2000 - insert kit and EN 42385-700

- kit . The cylinder head bolt hole thread repair components consist of the following:

- EN 42385-723 Drill (1)
- EN 42385-724 Tap (2)
- EN 42385-725 Installation driver (3)
- EN 42385-303 Alignment pin (4)
- EN 42385-302 Bushing (5)
- EN 42385-733 Bolts (6)
- EN 42385-401 Fixture plate (7)

- Remove the fixture plate prior to installing the insert with the installer tool.

- The use of a cutting type fluid, WD 40®; or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid.

When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.

- Position the fixture plate (3) with the bushing (1) installed over the cylinder head bolt hole to be repaired (4). Click for full-size image
- Loosely install the fixture plate bolts (2) into the remaining cylinder head bolt holes.
- Position the alignment pin (1) through the bushing and into the cylinder head bolt hole. Click for full-size image
- With the alignment pin in the desired cylinder head bolt hole, tighten the fixture retaining bolts (2).
- Remove the alignment pin (1) from the cylinder head bolt hole.
- Drill the hole until the stop collar contacts the top of the drill bushing.
- In order to tap the new threads for the insert to the proper depth, rotate the tap into the cylinder head bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2). Click for full-size image
- Remove the fixture plate bolts (2). Click for full-size image
- Remove the fixture plate (3) and bushing (1).
- Apply threadlock sealant, EN 42385-109, LOCTITE 277®; or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the insert and installation driver (1) into the tapped hole by hand only. Click for full-size image
- Start the insert into the threaded hole.
- Install the insert until the flange of the insert contacts the counterbored surface.
- Continue to rotate the driver installation tool through the insert.
- 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 engine block deck (2). Click for full-size image
- Inspect the insert for proper installation into the tapped hole.

Crankshaft Main Bolt Hole Thread Repair

- In order to repair some crankshaft main bolt holes it will be necessary to mount the fixture plate upside down.

- 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 EN 42385-2000 - insert kit and EN 42385-700 - kit . The crankshaft main bearing bolt hole thread repair components consist of the following:

- EN 42385-702 Drill (1) for outboard holes
- EN 42385-703 Tap (2) for outboard holes
- EN 42385-704 Installation driver (3) for outboard holes
- EN 42385-726 Bushing (4) for outboard holes
- EN 42385-727 Alignment pin (5) for outboard holes
- EN 42385-728 Bolts (6) for outboard holes
- EN 42385-720 Drill (7) for inboard holes
- EN 42385-721 Tap (8) for inboard holes
- EN 42385-722 Installation driver (9) for inboard holes
- EN 42385-713 Bushing (10)
- EN 42385-308 Alignment pin (11)
- EN 42385-734 Bolts (12)
- EN 42385-712 Fixture plate (13)

Outboard Bolt Holes

- Ensure the fixture plate is installed during the machining and installation processes of the insert.
- Position the fixture plate (3) with the bushing (2) installed over the crankshaft main cap bolt hole to be repaired. Click for full-size image
- Loosely install the fixture plate bolts (1) into the remaining crankshaft main cap bolt holes.
- Position the alignment pin (1) through the bushing and into the crankshaft main cap bolt hole. Click for full-size image
- With the alignment pin in the desired crankshaft main cap bolt hole, tighten the fixture retaining bolts (2).
- Remove the alignment pin (1) from the crankshaft main cap bolt hole.
- Drill the crankshaft main bolt hole until the mark (1) on the drill aligns with the top of the drill bushing (2).
- Do not remove the fixture plate, ensure the fixture plate is installed during the machining and installation processes of the insert.
- In order to tap the new threads for the insert to the proper depth, rotate the tap into the crankshaft main cap bolt hole until the mark (3) on the tap aligns with the top of the drill bushing (2). Click for full-size image
- Do not remove the fixture plate, ensure 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.
- Apply threadlock sealant, EN 42385-109, LOCTITE 277®, or equivalent (1) to the insert OD threads (2). Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the insert and installation driver into the tapped hole by hand only. Click for full-size image
- Rotate the driver installation tool until the mark (3) on the driver installation tool aligns with the top of the drill bushing (2). Click for full-size image
- Remove the fixture plate bolts (1). Click for full-size image
- Remove the fixture plate (3) and bushing (2).

Inboard Bolt Holes

- The use of a cutting type fluid, WD 40® or equivalent is recommended when performing the drilling, counterboring and tapping procedures. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended cutting fluid. When installed to the proper depth, the flange of the insert will be seated against the counterbore of the drilled/tapped hole.
- Position the fixture plate (3) with the bushing (1) installed over the crankshaft main cap bolt hole to be repaired. Click for full-size image
- Loosely install the fixture plate bolts (2) into the remaining crankshaft main cap bolt holes.

Service Prior to Assembly (Article 12134)

- 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.

Engine Block Assemble (Article 12088)

Single Use Fasteners and Components

- Engine Block Core Hole Plug [2x]
- Engine Block Oil Gallery Plug - Front
- Engine Block Oil Gallery Plug - Right Side
- Install the cylinder block -to- cylinder head alignment dowels. Click for full-size image
- Install the NEW front engine block oil gallery plug. Click for full-size image
- Ensure the NEW front engine block oil gallery plug is installed to the proper depth.
- Install the cylinder block-to-transmission alignment dowels. Click for full-size image
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant Apply the RTV sealant on the NEW engine block core hole plugs. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the NEW engine block core hole plugs.
- Ensure the NEW engine block core hole plugs are installed to the proper depth.
- Apply thread sealant on the threads of the M20 left side oil gallery threaded plug. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the M20 left side oil gallery threaded plug and tighten to 75 Nm (55 lb ft) .
- Apply thread sealant on the threads of the M14 left side coolant drain threaded plug. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the M14 left side coolant drain threaded plug and tighten to 50 Nm (37 lb ft) .
- Apply thread sealant on the threads of the M14 rear oil gallery threaded plug. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the M14 rear oil gallery threaded plug and tighten to 50 Nm (37 lb ft) .
- Apply thread sealant on the threads of the M14 right side coolant drain threaded plug. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the M14 right side coolant drain threaded plug and tighten to 50 Nm (37 lb ft) .
- Apply thread sealant on the threads of the M14 right side oil gallery threaded plug. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended sealant. Click for full-size image
- Install the M14 right side oil gallery threaded plug and tighten to 50 Nm (37 lb ft) .
- Install the cylinder block-to- oil pan alignment dowels. Click for full-size image
- Install the NEW right side engine block oil gallery plug. Click for full-size image
- Ensure the NEW engine block oil gallery plug is installed to the proper depth.
- Install the oil jets. Click for full-size image
- Install the oil jet bolts and tighten to 10 Nm (89 lb in) .
- Install the NEW crankshaft position sensor O-ring, if damaged. Click for full-size image
- Install the crankshaft position sensor. Click for full-size image
- Install the crankshaft position sensor bolt and tighten to 10 Nm (89 lb in) .
- Install the left knock sensor to the cylinder block, as shown. Click for full-size image
- Install the left knock sensor bolt and tighten to 25 Nm (18 lb ft) .
- Ensure proper sensor orientation.
- Install the right knock sensor to the cylinder block, as shown. Click for full-size image
- Install the right knock sensor bolt and tighten to 25 Nm (18 lb ft) .
- Install the block heater cartridge, if equipped. Click for full-size image
- Install the engine front cover studs (1) and tighten to 15 Nm (11 lb ft) . Click for full-size image

Crankshaft and Bearing Installation (Article 12070)

Single Use Fasteners and Components

- Crankshaft Bearing - Lower [4x]
- Crankshaft Bearing - Upper [4x]
- Crankshaft Bearing Cap Bolt - Inner [8x]
- Crankshaft Bearing Cap Bolt - Outer [8x]
- Crankshaft Bearing Cap Bolt - Side [8x]

Special Tools

- GE-6125-1B - Slide Hammer Adapter
- EN-45059 - Angle Meter
- EN-49102 - Crankshaft Bearing Cap Remover

Equivalent regional tools: Special Tools

Crankshaft Bearing Installation Procedure

- Clean the crankcase crank bore with a lint-free cloth.

- Clean all the oil from the backside of new bearing halves.
- Install the NEW upper crankshaft bearings (1) into position. The thrust bearing belongs in the number 3 journal (2). Ensure 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. Click for full-size image
- Install the NEW lower crankshaft bearings (1) into position in the main bearing caps(2). The lower crankshaft bearings are identified by NO grooves or holes. The bearings (1) must fit flush with the crankshaft bearing caps (2). Click for full-size image
- Crankshaft Installation Procedure
- If removed, install the crankshaft key (1). Lightly tap the key in place with a small soft face, bronze/plastic, hammer until it bottoms in the keyway. Click for full-size image
- Gently lower the crankshaft (1) into position in the cylinder block . Click for full-size image
- Crankshaft Bearing Clearance Measurement Procedure
- Place a length of fresh, room temperature plastic gaging material all the way across all the crankshaft bearing journals. Click for full-size image
- Identify the proper order of the main bearing caps. The main 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 engine.
- Install the crankshaft main bearing caps. Click for full-size image
- Loosely install the original short/inner side main cap bolts (2). Click for full-size image
- Loosely install the original long/outer side main cap bolts (1).
- Loosely install the original inner main cap bolts (4).
- Loosely install the original outer main cap bolts (3).
- Tap the crankshaft main bearing caps with a soft-faced hammer.
- Tighten the main caps bolts using the EN-45059 - Angle Meter in the following sequence: Click for full-size image
- Tighten the inboard bolts (1–8) first, in two passes.
- Tighten the inboard bolts to 20 Nm (15 lb ft) on the first pass.
- Tighten the inboard bolts (1–8) an additional 80 degrees on the 2nd pass.
- Tighten the outboard bolts (9–16) second, in two passes. Click for full-size image
- Tighten the outboard bolts to 15 Nm (15 lb ft) on the first pass.
- Tighten the outboard bolts (9–16) an additional 110 degrees on the 2nd pass.
- Tighten the short/inner bolts (17–20) third, in two passes. Click for full-size image
- Tighten the short/inner bolts to 30 Nm (22 lb ft) on the first pass.
- Tighten the short/inner bolts (17–20) an additional 60 degrees on the 2nd pass.
- Tighten the long/outer bolts (21–24) fourth, in two passes.
- Tighten the long/outer bolts to 30 Nm (22 lb ft) on the first pass.
- Tighten the long/outer bolts (21–24) an additional 60 degrees on the 2nd pass.
- After reaching final torque, allow the assembly to sit for 2 minutes.
- Remove the crankshaft bearing cap side bolts (1 and 2). Click for full-size image
- Remove the crankshaft bearing cap outer bolts (3).
- Remove the crankshaft bearing cap inner bolts (4).
- Remove the crankshaft bearing caps (1) using the GE-6125-1B - Slide Hammer Adapter (2) and EN-49102 - Crankshaft Bearing Cap Remover (3). Click for full-size image
- Determine the crankshaft bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container. Click for full-size image
- Compare your measurements with the Engine Mechanical Specifications . If the new bearings do not provide the proper crankshaft to bearing clearance, inspect the following:
- 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.
- Re-measure the engine block crankshaft bearing bore diameter to ensure proper size. The engine block crankshaft bearing bore is not machinable and the block must be replaced if out of specification.
- Clean the plastic gaging material from the crankshaft bearing journals with a soft, lint-free cloth.
- Lift the crankshaft (1) out of the cylinder block. Click for full-size image
- Apply a liberal amount of crankshaft prelube or clean engine oil to the upper (1) and lower (2) bearing surfaces. Adhesives, Fluids, Lubricants, and Sealers Click for full-size image
- Gently lower the crankshaft (1) into position in the cylinder block. Click for full-size image
- Identify the proper order of the main bearing caps. The main 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

engine. [Click for full-size image](#)

- Install the crankshaft main bearing caps (1). [Click for full-size image](#)
- Loosely install the NEW inner main cap bolts (4).
- Loosely install the NEW outer main cap bolts (3).
- Tap the crankshaft main bearing caps with a soft-faced hammer. [Click for full-size image](#)
- Loosely install the NEW short/inner side main cap bolts (2). [Click for full-size image](#)
- Loosely install the NEW long/outer side main cap bolts (1).
- Tighten the main cap bolts using the EN-45059 - Angle Meter in the following sequence: [Click for full-size image](#)
- Tighten the outboard bolts to 15 Nm (11 lb ft) on the first pass.
- Ensure that the crankshaft turns without binding or noise.

Piston, Connecting Rod, and Bearing Installation (Article 12132)

Special Tools

- EN-43690-A - Rod Bearing Clearance Checking Tool
- EN-45059 - Angle Meter
- EN-46121 - Connecting Rod Guide Pin Set
- EN-48589 - Crankshaft Rotation Socket

For equivalent regional tools, refer to Special Tools .

Piston and Connecting Rod Assembly Procedure

- Liberally lubricate the cylinder walls, piston rings and piston skirts with engine oil. [Click for full-size image](#)
 - 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.
 - 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.
 - Install the connecting rod bearing into the connecting rod. [Click for full-size image](#)
 - Install the EN 46121 - pin set into the connecting rod bolt holes.
 - Hard anodized and Teflon coated for low friction and prolonged wear resistance.
 - Smooth radius that tapers down to the specific bore size.
 - Sleeve should compress the piston rings smoothly and evenly.
 - Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.
 - Compress the piston rings using the a ring compressor sleeve or equivalent.
 - Using both hands, slowly guide the piston 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. [Click for full-size image](#)
 - Tap the piston into its bore with a hammer handle. Guide the connecting rod to the connecting rod journal using the EN-46121 - set while gently tapping the piston into place. Hold the ring compressor sleeve or equivalent against the engine block until all the rings have entered the cylinder bore.
 - Remove the EN 46121 - pin set from the connecting rod bolt holes. [Click for full-size image](#)
- ### Connecting Rod Bearing Clearance Measurement Procedure – Using Plastic Gaging
- Place a length of fresh, room temperature plastic gaging material all the way across the connecting rod bearing journal.
 - Install the connecting rod bearing into the connecting rod cap.
 - 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.
 - Install the connecting rod bolts into the connecting rod cap. [Click for full-size image](#)
 - Tighten the connecting rod bolts.
 - First Pass Tighten the connecting rod bolts to 25 Nm (18 lb ft) .
 - Final Pass Tighten the connecting rod bolts an additional 110 degrees using the EN 45059 - meter .
 - Allow the assembly to sit for at least 2 minutes.
 - Remove the connecting rod cap bolt s.
 - Remove the connecting rod cap.
 - Determine the connecting rod bearing clearance by comparing the width of the flattened plastic gaging material at its widest point with the graduation on the gaging material container. [Click for full-size image](#)
 - Compare your measurements with the engine mechanical specifications. If the new bearings do not provide the proper crankshaft to connecting rod bearing clearance, inspect the following:
 - Re-measure the crankshaft connecting rod journals for the correct specified size and ensure the proper 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.

- 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.
- Clean the plastic gaging material from the connecting rod bearing journals using a soft lint-free cloth.

Connecting Rod Bearing Clearance Measurement Procedure – Using EN-43690-A

The EN-43690-A - checking tool has been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets as supplied by the tool manufacturer.

EN 43690-A - checking tool

- EN 43690-20 Swivel Base (1)
- EN 43690-19 Dial Indicator (2)
- EN 43690-2 Base (3)
- EN 43690-5, -6 Handle (4)
- EN 43690-10, -11 Foot (5)
- 280307 Screw (6)
- EN 43690-1 Pivot Arm Assembly (7)
- EN 43690-3, -7, -8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- EN 43690-17, -18 Adapter (11)
- 280310 Pin (12)

EN 43690-A - adapter kit

- EN 43690-104 Spacer (1)
- EN 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- EN 43690-106 Retainer Plate (5)
- EN 43690-107 Cap (6)
- EN 43690-102 Foot (7)
- EN 43690-101 Pivot Arm Assembly (8)
- EN 43690-103 Adapter (9)
- 505439 Adapter (10)

- Install the connecting rod bearing into the connecting rod cap. [Click for full-size image](#)
- Install the connecting rod bolts into the connecting rod cap.
- Rotate the crankshaft until the crankshaft journal and the connecting rod to be measured is in the 12 o'clock position.
- Remove the crankshaft main bolts required to install the retainer plate EN 43690-105.
- Install the EN 43690-105 and crankshaft main bolts.
- Loosen the connecting rod bolts until the torque reading is zero.
- Re-tighten the connecting rod bolts.

- 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 engine.

- Repeat these procedures for the remaining piston/connecting rod assemblies using the EN-48589 - socket in order to rotate the crankshaft.

Connecting Rod Final Assembly Procedure

- Guide the connecting rod away from the crankshaft connecting rod journal in order to lubricate the crankshaft connecting rod bearing journal.
- Apply a liberal amount of crankshaft prelube or clean engine oil to the crankshaft connecting rod bearing journal. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
- Guide the connecting rod to the crankshaft connecting rod journal.
- Install the NEW connecting rod bolts into the connecting rod cap. [Click for full-size image](#)
- Repeat these procedures for the remaining piston/connecting rod assemblies using the EN 45059 - meter in order to rotate the crankshaft.

Crankshaft Rear Oil Seal and Housing Installation (Article 12075)

Single Use Fasteners and Components

Crankshaft Rear Oil Seal

Callout Component Name

1 Crankshaft Rear Oil Seal Housing Procedure 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 . Install the EN-47839 - tool with the EN-42183 - handle onto the rear of the crankshaft flange. Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant Note: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed. Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown. Adhesives, Fluids, Lubricants, and Sealers Install a NEW crankshaft rear oil seal housing to the engine block. Remove the EN-46109 - pin set 6 mm (0.236 in) guides from the engine block. Install the crankshaft rear oil seal housing bolts and tighten in sequence. Remove the EN-47839 - tool and EN-42183 - handle from the crankshaft flange. Special Tools EN-42183 - Handle EN-46109 - Guide Pin Set EN-47839 - Crankshaft Rear Oil Seal Installation Tool Equivalent regional tools: Special Tools

Procedure

- 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 .
- Install the EN-47839 - tool with the EN-42183 - handle onto the rear of the crankshaft flange.
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Place a 3 mm (0.118 in) bead of RTV sealant to the NEW crankshaft rear oil seal housing as shown. Adhesives, Fluids, Lubricants, and Sealers
- Install a NEW crankshaft rear oil seal housing to the engine block.
- Remove the EN-46109 - pin set 6 mm (0.236 in) guides from the engine block.
- Install the crankshaft rear oil seal housing bolts and tighten in sequence.
- Remove the EN-47839 - tool and EN-42183 - handle from the crankshaft flange.

Special Tools

- EN-42183 - Handle
- EN-46109 - Guide Pin Set
- EN-47839 - Crankshaft Rear Oil Seal Installation Tool

2 Crankshaft Rear Oil Seal Housing Bolt Caution: Refer to Fastener Caution . Tighten in sequence 10 Nm (89 lb in)

10 Nm (89 lb in)

Oil Pump Installation (Article 12126)

Callout Component Name

1 Oil Pump Procedure Align the oil pump drive gear with the crankshaft flats and install the oil pump to the engine block . Align the pump body with the mounting holes in the cylinder block .

Procedure

- Align the oil pump drive gear with the crankshaft flats and install the oil pump to the engine block .
- Align the pump body with the mounting holes in the cylinder block .

2 Oil Pump Bolt [3x] Caution: Refer to Fastener Caution . Tighten 25 Nm (18 lb ft)

25 Nm (18 lb ft)

Oil Pan Installation (Article 12122)

Special Tools

EN-46109 - Guide Pin Set

For equivalent regional tools, refer to Special Tools

- Install the 8 mm (0.315 in) guides from the EN-46109 - set into the center oil pan rail bolt hole on each side of the engine block . [Click for full-size image](#)
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant [Click for full-size image](#)
- Place a 3 mm (0.118 in) bead of RTV sealant, on the block pan rail and the crankshaft rear oil seal housing (1). Refer to Adhesives, Fluids, Lubricants, and Sealers .
- Position the oil pan (1) onto the block. [Click for full-size image](#)
- Remove the EN 46109 - set 8 mm (0.315 in) guides from the engine block.
- Loosely install the oil pan bolts (1), (2) and (3). [Click for full-size image](#)
- Tighten the oil pan bolts in sequence shown. [Click for full-size image](#)
- Tighten the 8 mm bolts (1–11) to 23 Nm (17 lb ft) .
- Tighten the 6 mm bolts (12, 13) to 10 Nm (89 lb in) .

Cylinder Head Installation - Right Side (LF1, LFW or LFX) (Article 12083)

Single Use Fasteners and Components

- Cylinder Head Bolt - M8
- Cylinder Head Bolt - M11 [8x]
- Cylinder Head Gasket

Special Tools

EN-45059 - Angle Meter

For equivalent regional tools, refer to Special Tools .

- Install the fuel injection fuel rail noise shield-lower (1). Click for full-size image
- Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face. Click for full-size image
- Install a NEW cylinder head gasket (1) using the deck face locating pins for retention.
- Align the cylinder head (2) with the deck face locating pins. Click for full-size image
- Place the cylinder head in position on the deck face.
- Install the 8 NEW M11 cylinder head bolts (1). Click for full-size image
- Tighten the M11 cylinder head bolts a first pass in sequence to 30 Nm (22 lb ft) .
- Tighten the M11 cylinder head bolts a second pass in sequence an additional 150 degrees using the EN 45059 - meter .
- Install the NEW M8 cylinder head bolt (2).
- Tighten the M8 cylinder head bolt a first pass to 15 Nm (11 lb ft).
- Tighten the M8 cylinder head bolt a second pass an additional 75 degrees using the EN 45059 - meter .

Valve Lifter Installation - Right Side (Article 12143)

Callout Component Name

1 Hydraulic Valve Lash Adjuster 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. Procedure Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Adhesives, Fluids, Lubricants, and Sealers Take precautions to prevent scratching the pivot sphere area of the SHLA. Lubricate the SHLA bores in the cylinder head with clean engine oil. Install the SHLAs in the cylinder head. Apply a liberal amount of lubricant to the SHLA pivot spheres.

- 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.

Procedure

- Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Adhesives, Fluids, Lubricants, and Sealers Take precautions to prevent scratching the pivot sphere area of the SHLA.
- Lubricate the SHLA bores in the cylinder head with clean engine oil.
- Install the SHLAs in the cylinder head.
- Apply a liberal amount of lubricant to the SHLA pivot spheres.

Valve Rocker Arm Installation - Right Side (Article 12148)

Callout Component Name

1 Valve Rocker Arm Procedure 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. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Adhesives, Fluids, Lubricants, and Sealers Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA). The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip. Clean the camshaft journals and carriers with a clean, lint-free cloth.

Procedure

- Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Adhesives, Fluids, Lubricants, and Sealers
- Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA).
- The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip.
- Clean the camshaft journals and carriers with a clean, lint-free cloth.

Camshaft Installation - Right Side (Article 12055)

- 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. Click for full-size image
- 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. Click for full-size image
- Place the right intake and right exhaust camshafts in position in the right cylinder head. Click for full-size image
 - 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. Click for full-size image
 - 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: Click for full-size image
 - 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.
 - Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.
 - 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. Click for full-size image
 - Install the camshaft bearing thrust caps (1) in the first journal of the right cylinder head. Click for full-size image
 - Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.
 - Hand start all the camshaft bearing cap bolts.
 - Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 Nm (89 lb in) . Click for full-size image
 - Loosen the center intake camshaft bearing cap bolts (1, 2) and the center exhaust camshaft bearing cap bolts (3, 4).
 - Retighten the center camshaft bearing cap bolts (1, 2, 3, 4) and retighten the camshaft bearing cap bolts to 10 Nm (89 lb in) .

Fuel Rail Installation (Article 12105)

- Install the fuel rail with injectors (2) into the cylinder head evenly. Click for full-size image
- Install and hand tighten the three fuel rail bolts (1) to seat the injectors in the injector bores.
- Tighten the fuel injection fuel rail bolts in the sequence shown to 25 Nm (18 lb ft) . Click for full-size image
- Install fuel injection fuel rail noise shield (1). Click for full-size image

Cylinder Head Installation - Left Side (LF1, LFW or LFX) (Article 12082)

Single Use Fasteners and Components

- Cylinder Head Bolt - M8 [2x]
- Cylinder Head Bolt - M11 [8x]
- Cylinder Head Gasket

Special Tools

EN 45059 - Angle Meter

For equivalent regional tools, refer to Special Tools .

- Ensure the cylinder head locating pins are securely mounted in the cylinder block deck face. Click for full-size image
- Install a NEW cylinder head gasket (1) using the deck face locating pins for retention.
- Align the cylinder head (3) with the deck face locating pins. Click for full-size image
- Place the cylinder head in position on the deck face.
- Install the 8 NEW M11 cylinder head bolts (1). Click for full-size image
- Tighten the M11 cylinder head bolts a first pass in sequence to 30 Nm (22 lb ft) .
- Tighten the M11 cylinder head bolts a second pass in sequence an additional 150 degrees using the EN 45059 - meter .
- Install the 2 NEW front M8 cylinder head bolts (2).
- Tighten the M8 cylinder head bolts a first pass to 15 Nm (11 lb ft) .
- Tighten the M8 cylinder head bolts a second pass in sequence an additional 75 degrees using the EN 45059 - meter .

Valve Lifter Installation - Left Side (Article 12142)

Callout Component Name

1 Hydraulic Valve Lash Adjuster 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. Procedure Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Adhesives, Fluids, Lubricants, and Sealers Take precautions to prevent scratching the pivot sphere area of the SHLA. Lubricate the SHLA bores in the cylinder head with clean engine oil. Install the SHLAs in the cylinder head. Apply a liberal amount of lubricant to the SHLA pivot spheres.

- 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.

Procedure

- Fill the stationary hydraulic lash adjuster (SHLA) with clean engine oil. Adhesives, Fluids, Lubricants, and Sealers Take precautions to prevent scratching the pivot sphere area of the SHLA.

- Lubricate the SHLA bores in the cylinder head with clean engine oil.

- Install the SHLAs in the cylinder head.

- Apply a liberal amount of lubricant to the SHLA pivot spheres.

Valve Rocker Arm Installation - Left Side (Article 12147)

Callout Component Name

1 Valve Rocker Arm Procedure 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. Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Adhesives, Fluids, Lubricants, and Sealers Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA). The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip. Clean the camshaft journals and carriers with a clean, lint-free cloth.

Procedure

- Apply a liberal amount of lubricant to the pivot pocket, roller and valve slot areas of the camshaft followers. Adhesives, Fluids, Lubricants, and Sealers

- Place the camshaft followers in position on the valve tip and stationary hydraulic lash adjuster (SHLA).

- The rounded head end of the follower goes on the SHLA while the flat end goes on the valve tip.

- Clean the camshaft journals and carriers with a clean, lint-free cloth.

Camshaft Installation - Left Side (Article 12054)

- 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. [Click for full-size image](#)

- 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. [Click for full-size image](#)

- Place the left intake and left exhaust camshaft s in position in the left cylinder head. [Click for full-size image](#)

- 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. [Click for full-size image](#)

- 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: [Click for full-size image](#)

- 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.

- Apply a liberal amount of lubricant to the camshaft bearing caps. Refer to Adhesives, Fluids, Lubricants, and Sealers for recommended lubricant.

- 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. [Click for full-size image](#)

- Install the camshaft bearing thrust cap (1) in the first journal of the left cylinder head. [Click for full-size image](#)

- Install the remaining bearing caps (2) with their orientation mark toward the center of the cylinder head.

- Hand start all the camshaft bearing cap bolts.

- Tighten the camshaft bearing cap bolts in the sequence shown and tighten to 10 Nm (89 lb in) . [Click for full-size image](#)

- Loosen the center intake camshaft bearing cap bolts 1, 2 and the center exhaust camshaft bearing cap bolts 3, 4.

- Retighten the center camshaft bearing cap bolts 1, 2, 3, 4 and retighten the camshaft bearing cap bolts to

10 Nm (89 lb in) .

Fuel Pump Installation (LF1, LFW or LFX) (Article 12102)

Single Use Fasteners and Components

- Fuel Pump Bolt [2X]
- Fuel Pump Bracket Gasket
- Fuel Feed Intermediate Pipe
- Fuel Pump Housing Seal
- Fuel Feed Pipe

Special Tools

EN-48896 - HP Fuel Pump Installation Alignment Gauge

For equivalent regional tools, refer to Special Tools .

- Use the EN-48896 - alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the head (1). [Click for full-size image](#)
- Lubricate the fuel pump cylinder head bore with clean engine oil. [Click for full-size image](#)
- Lubricate the fuel pump roller lifter with clean engine oil and install into the cylinder head bore.
- Install a NEW fuel pump bracket gasket (4).
- Lubricate NEW fuel pump housing seal (5) with one drop of clean engine oil and install.
- Install the valve lifter follower (3).
- Install the fuel pump (2).
- Start and hand-tighten the NEW fuel pump bolts (1) evenly .
- Tighten the fuel pump bolts (1) a first pass in sequence to 15 Nm (11 lb ft) .
- Tighten the fuel pump bolts (1) a second pass in an additional 60 degrees .
- DO NOT reuse the fuel feed intermediate pipe.
- The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.
- Install the NEW fuel feed intermediate pipe by starting all pipe fitting nuts (1), (2) and (3) to finger-tight only. [Click for full-size image](#)
- Tighten the pipe fittings to 28 Nm (21 lb ft) in the following order: (1) left fuel rail, (2) right fuel rail, then (3) fuel pump.
- Install the NEW fuel feed pipe (2) by installing the fuel line nut to the fuel pump finger-tight. [Click for full-size image](#)
- Install the fuel feed pipe bolts finger tight (1 and 3).
- Tighten the fuel feed pipe bolts (1 and 3) to 50 Nm (37 lb ft) .
- Tighten the fuel feed pipe fitting nut to 28 Nm (21 lb ft) .
- Install the fuel rail wiring connectors to the fuel feed pipe bracket.
- Install the fuel rail noise shield (1). [Click for full-size image](#)

Camshaft Position Actuator Installation - Right Side Intake (Article 12059)

- 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. [Click for full-size image](#)
- 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). [Click for full-size image](#)
- On the right intake camshaft actuator the edge of the reluctor wheel (1) lines up with the valley (2) of the sprocket tooth. [Click for full-size image](#)
- 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. [Click for full-size image](#)
- Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.
- 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. [Click for full-size image](#)
- Install the right intake camshaft position actuator (2). [Click for full-size image](#)
- Install the camshaft position actuator bolt (1) and tighten to 58 Nm (43 lb ft) .

Camshaft Position Actuator Installation - Right Side Exhaust (Article 12058)

- 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. Click for full-size image
- 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.
- Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.
- 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. Click for full-size image
- Install the right exhaust camshaft position actuator (2). Click for full-size image
- Install the camshaft position actuator bolt (1) and tighten to 58 Nm (43 lb ft) .

Camshaft Position Actuator Installation - Left Side Intake (Article 12057)

- 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. Click for full-size image
- 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). Click for full-size image
- On the left intake camshaft actuator the edge of the reluctor wheel (1) lines up with the peak (2) of the sprocket tooth. Click for full-size image
- 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. Click for full-size image
- Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.
- 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. Click for full-size image
- Install the left intake camshaft position actuator (2). Click for full-size image
- Install the camshaft position actuator bolt (1) and tighten to 58 Nm (43 lb ft) .

Camshaft Position Actuator Installation - Left Side Exhaust (Article 12056)

- 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. Click for full-size image
- 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.
- Use an open wrench on the hex cast into the camshaft in order to prevent camshaft rotation when tightening the camshaft position actuator bolt.
- 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. Click for full-size image
- Install the left exhaust camshaft position actuator (2). Click for full-size image
- Install the camshaft position actuator bolt (1) and tighten to 58 Nm (43 lb ft) .

Crankshaft Sprocket Installation (Article 12077)

Callout Component Name

1 Crankshaft Sprocket Procedure Ensure the crankshaft sprocket is installed with the timing mark visible. Install the crankshaft sprocket onto the nose of the crankshaft. Align the notch in the crankshaft sprocket with the pin in the crankshaft. Slide the crankshaft sprocket on the crankshaft nose until the crankshaft sprocket contacts the step in the crankshaft. Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark aligned to the stage one timing mark on the oil pump cover using the EN-48589 - socket . Refer to: Timing Chain Alignment Diagram Special Tools EN-48589 - Crankshaft Rotation Socket Equivalent regional tools: Special Tools

Procedure

- Ensure the crankshaft sprocket is installed with the timing mark visible.
- Install the crankshaft sprocket onto the nose of the crankshaft.
- Align the notch in the crankshaft sprocket with the pin in the crankshaft.
- Slide the crankshaft sprocket on the crankshaft nose until the crankshaft sprocket contacts the step in the crankshaft.
- Ensure the crankshaft is in the stage one timing position with the crankshaft sprocket timing mark aligned to the stage one timing mark on the oil pump cover using the EN-48589 - socket . Refer to: Timing Chain Alignment Diagram

Special Tools

EN-48589 - Crankshaft Rotation Socket

Timing Chain Idler Sprocket Installation - Left Side (Article 12136)

Callout Component Name

1 Left Side Timing Chain Idler Sprocket Procedure Ensure that the left timing chain idler sprocket is being installed. The recessed hub and the larger sprocket of the left timing chain idler sprocket is installed outward. Place the left camshaft intermediate drive chain idler to the cylinder block .

Procedure

- Ensure that the left timing chain idler sprocket is being installed. The recessed hub and the larger sprocket of the left timing chain idler sprocket is installed outward.
 - Place the left camshaft intermediate drive chain idler to the cylinder block .
- 2 Timing Chain Idler Sprocket Shaft Bolt Caution: Refer to Fastener Caution . Tighten 58 Nm (43 lb ft) 58 Nm (43 lb ft)

Camshaft Timing Chain Components Installation (Article 12066)

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. 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 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 chain s. Install the EN-48383-1 - retaining tool onto the rear of the left camshafts. Ensure the EN-48383-1 - retaining tool is fully seated onto the camshafts. Special Tool EN-48383 - Camshaft Retaining Tools Equivalent regional tools: Special Tools .

Procedure

- 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 chain s.
- Install the EN-48383-1 - retaining tool onto the rear of the left camshafts.
- Ensure the EN-48383-1 - retaining tool is fully seated onto the camshafts.

Special Tool

EN-48383 - Camshaft Retaining 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 Tool EN-48589 - Crankshaft Rotation Socket Equivalent regional tools: Special Tools .

EN-48589 - Crankshaft Rotation Socket

3 Crankshaft Sprocket Timing Mark

4 Stage One Timing Mark On The Oil Pump Cover

Secondary Camshaft Intermediate Drive Chain Installation - Left Side - Step 2

Note: Ensure that the left (L) camshaft position actuator sprocket alignment circle marks are used during this step.

1 Secondary Camshaft Intermediate 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. 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. Wrap the secondary camshaft drive chain around both left (L) actuator drive sprockets. Align the left (L) intake camshaft position actuator sprocket alignment circle mark (5) with the camshaft drive chain timing link. Align the left (L) exhaust camshaft position actuator sprocket alignment circle mark (6) with the camshaft drive chain timing link. Once aligned, ensure there are 10 chain links (4) between timing marks for the left (L) camshaft position actuator sprockets.

- 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.

- Wrap the secondary camshaft drive chain around both left (L) actuator drive sprockets.

- Align the left (L) intake camshaft position actuator sprocket alignment circle mark (5) with the camshaft drive chain timing link.

- Align the left (L) exhaust camshaft position actuator sprocket alignment circle mark (6) with the camshaft drive chain timing link.

- Once aligned, ensure there are 10 chain links (4) between timing marks for the left (L) camshaft position actuator sprockets.

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

1 Left Pivot Arm Timing Chain Guide

2 Left Pivot Arm Timing Chain Guide Bolt Caution: Refer to Fastener Caution . Tighten 25 Nm (18 lb ft)

25 Nm (18 lb ft)

3 Left Secondary Timing Chain Guide

4 Left Secondary Timing Chain Guide Bolt Tighten 25 Nm (18 lb ft)

Secondary Camshaft Drive Chain Tensioner Installation - Left Side

1 Left Secondary Timing Chain Tensioner Plunger. Procedure Reset the left secondary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool . Install left secondary camshaft drive chain tensioner plunger into body. 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. Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed. Special Tools EN-45027 - Tensioner Tool EN-46112 - Tensioner Retraction Pins Equivalent regional tools: Special Tools .

- Reset the left secondary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool .

- Install left secondary camshaft drive chain tensioner plunger into body.

- 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.

- Slowly release pressure on the left secondary camshaft drive chain tensioner. The left secondary camshaft drive chain tensioner should remain compressed.

Special Tools

- EN-45027 - Tensioner Tool

- EN-46112 - Tensioner Retraction Pins

2 Left Timing Chain Housing 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 Timing Chain Tensioner

4 Left Secondary Timing Chain Tensioner Bolt Procedure Place the chain tensioner into position and loosely install the bolts to the block. Verify the proper placement of the drive chain tensioner gasket tab (5).

Tighten the drive chain tensioner bolts in two passes. Verify the timing marks are in the correct position before releasing the drive chain tensioner. Release the drive chain tensioner by pulling out the EN-46112 -

tensioner retraction pins pin (6) and unlocking the tensioner plunger. Verify the left secondary camshaft

drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. Tighten First

Pass: 5 Nm (44 lb in) Final Pass: 25 Nm (18 lb ft)

- Place the chain tensioner into position and loosely install the bolts to the block.

- Verify the proper placement of the drive chain tensioner gasket tab (5).

- Tighten the drive chain tensioner bolts in two passes.

- Verify the timing marks are in the correct position before releasing the drive chain tensioner.
- Release the drive chain tensioner by pulling out the EN-46112 - tensioner retraction pins pin (6) and unlocking the tensioner plunger.
- Verify the left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One.
- First Pass: 5 Nm (44 lb in)
- Final Pass: 25 Nm (18 lb ft)

5 Left Timing Chain Housing Gasket Tab

6 EN-46112 - Pin

Primary Camshaft Intermediate Drive Chain Installation

1 Primary Camshaft Drive Intermediate Chain Procedure Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket. The left camshaft intermediate drive chain idler timing mark (2) will align with camshaft drive chain timing link (3). The right camshaft intermediate drive chain idler timing mark (4) will align with camshaft drive chain timing link (5). The crankshaft sprocket timing mark (7) will align with camshaft drive chain timing link (6).

- Wrap the primary camshaft drive chain around the large sprockets of each camshaft intermediate drive chain idler and the crankshaft sprocket.

- The left camshaft intermediate drive chain idler timing mark (2) will align with camshaft drive chain timing link (3).

- The right camshaft intermediate drive chain idler timing mark (4) will align with camshaft drive chain timing link (5).

- 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

7 Crankshaft Sprocket Timing Mark

Primary Timing Chain Guide Installation - Lower and Upper

1 Upper Primary Timing Chain Guide

2 Upper Primary Timing Chain Guide Bolt Tighten 25 Nm (18 lb ft)

3 Lower Primary Timing Chain Guide

4 Lower Primary Timing Chain Guide Bolt Tighten 25 Nm (18 lb ft)

Primary Camshaft Intermediate Drive Chain Tensioner Installation

1 Camshaft Intermediate Drive Chain Tensioner Plunger. Procedure Reset the primary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool . Install primary camshaft drive chain tensioner plunger into body. 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. 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 Equivalent regional tools: Special Tools .

- Reset the primary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool .

- Install primary camshaft drive chain tensioner plunger into body.

- 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.

- Slowly release pressure on the primary camshaft drive chain tensioner. The primary camshaft drive chain tensioner should remain compressed.

- EN-46112 - Tensioner Retraction Pins

2 Timing Chain Housing 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.

3 Camshaft Intermediate Drive Chain Tensioner

4 Camshaft Intermediate Drive Chain Tensioner Bolt Procedure Place the drive chain tensioner into position and loosely install the bolts to the block. Verify the proper placement of the drive chain tensioner gasket tab (5). Tighten the drive chain tensioner bolts in two passes. Verify the timing marks are in the correct position before releasing the drive chain tensioner. Release the drive chain tensioner by pulling out the EN-46112 pin (6) and unlocking the tensioner plunger. 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 Nm (44 lb in) Final Pass: 25 Nm (18 lb ft)

- Place the drive chain tensioner into position and loosely install the bolts to the block.
- Release the drive chain tensioner by pulling out the EN-46112pin (6) and unlocking the tensioner plunger.
- Verify the primary and left secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One.

5 Timing Chain Housing Gasket Tab

Stage 1 Alignment Position to the Stage 2 Alignment Position

Preliminary Procedure Remove the EN 48383-1 from the rear of the left camshafts.

Preliminary Procedure

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 Tool EN-48589 - Crankshaft Rotation Socket For equivalent regional tools, refer to Special Tools .

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.

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. Install the EN-48383-2 - retainer onto the rear of the left camshafts. Ensure the EN-48383-2 - retainer is fully seated onto the camshafts. Special Tool EN-48383 - Crankshaft Rotation Tools Equivalent regional tools: Special Tools

- 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.

- Install the EN-48383-2 - retainer onto the rear of the left camshafts.

- Ensure the EN-48383-2 - retainer is fully seated onto the camshafts.

EN-48383 - Crankshaft Rotation 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. Install the EN-48383-3 - retainer onto the rear of the right camshafts. Ensure the EN-48383-3 - retainer is fully seated onto the camshafts. Special Tools EN-48383 - Crankshaft Rotation Tools Equivalent regional tools: Special Tools .

- 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 .

- Install the EN-48383-3 - retainer onto the rear of the right camshafts.

- Ensure the EN-48383-3 - retainer is fully seated onto the camshafts.

EN-48383 - Crankshaft Rotation Tools

4 Stage One Alignment Position

5 Stage Two Alignment Position

Secondary Camshaft Intermediate Drive Chain Installation - Right Side

Note: Ensure that the right (R) camshaft position actuator sprocket alignment triangle marks are used during this step.

1 Secondary Camshaft Intermediate Drive Chain Note: Ensure that the crankshaft is in the stage 2 timing drive assembly position. Procedure 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. Wrap the secondary camshaft intermediate drive chain around both right (R) actuator drive sprockets. Align the right (R) intake camshaft position actuator sprocket alignment triangle mark (5) with the camshaft drive chain timing link. Align the right (R) exhaust camshaft position actuator sprocket alignment triangle mark (6) with the camshaft drive chain timing link. Once aligned, ensure there are 10 chain links (4) between timing marks for the right (R) camshaft position actuator sprockets. 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.

- 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.

- Wrap the secondary camshaft intermediate drive chain around both right (R) actuator drive sprockets.

- Align the right (R) intake camshaft position actuator sprocket alignment triangle mark (5) with the camshaft drive chain timing link.

- Align the right (R) exhaust camshaft position actuator sprocket alignment triangle mark (6) with the camshaft drive chain timing link.
- Once aligned, ensure there are 10 chain links (4) between timing marks for the right (R) camshaft position actuator sprockets.
- 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.

2 Camshaft Drive Chain Timing Link

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

1 Right Secondary Timing Chain Guide

2 Right Secondary Timing Chain Guide Bolt Tighten 25 Nm (18 lb ft)

3 Right Pivot Arm Timing Chain Guide

4 Right Pivot Arm Timing Chain Guide Bolt Tighten 25 Nm (18 lb ft)

Secondary Camshaft Drive Chain Tensioner Installation - Right Side

1 Right Secondary Timing Chain Tensioner Plunger Procedure Reset the right secondary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool . Install right secondary camshaft drive chain tensioner plunger into body. 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. Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed. Special Tools EN-45027 - Tensioner Tool EN-46112 - Tensioner Retraction Pins Equivalent regional tools: Special Tools .

- Reset the right secondary camshaft drive chain tensioner plunger using EN-45027 - tensioner tool .

- Install right secondary camshaft drive chain tensioner plunger into body.

- 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.

- Slowly release pressure on the right secondary camshaft drive chain tensioner. The right secondary camshaft drive chain tensioner should remain compressed.

2 Right Timing Chain Housing 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 Timing Chain Tensioner

4 Right Secondary Timing Chain Tensioner Bolt Procedure Place the right secondary drive chain tensioner into position and loosely install the bolts to the block. Verify the proper placement of the right secondary drive chain tensioner gasket tab (5). Tighten the drive chain tensioner bolts in two passes. Verify the timing marks are in the correct position before releasing the drive chain tensioner. Release the right secondary drive chain tensioner by pulling out the EN-46112 - pin (6) and unlocking the tensioner plunger. Verify all primary and secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One. Remove EN-48383 - Crankshaft Rotation Tools Tighten First Pass: 5 Nm (44 lb in) Final Pass: 25 Nm (18 lb ft) Special Tools EN-46112 - Pin EN-48383 - Crankshaft Rotation Tools Equivalent regional tools: Special Tools .

- Place the right secondary drive chain tensioner into position and loosely install the bolts to the block.

- Verify the proper placement of the right secondary drive chain tensioner gasket tab (5).

- Release the right secondary drive chain tensioner by pulling out the EN-46112 - pin (6) and unlocking the tensioner plunger.

- Verify all primary and secondary camshaft drive chain timing mark alignments by referring to Timing Chain Alignment Diagram - Stage One.

- Remove EN-48383 - Crankshaft Rotation Tools

- EN-46112 - Pin

- EN-48383 - Crankshaft Rotation Tools

5 Right Timing Chain Housing Gasket Tab

6 EN-46112 - Pin

Timing Chain Idler Sprocket Installation - Right Side (Article 12137)

Callout Component Name

1 Right Side Timing Chain Idler Sprocket Procedure Ensure that the right timing chain idler sprocket is being installed. The raised hub and the larger sprocket of the right timing chain idler sprocket is installed towards the block. Place the right timing chain idler sprocket to the cylinder block .

Procedure

- Ensure that the right timing chain idler sprocket is being installed. The raised hub and the larger sprocket of the right timing chain idler sprocket is installed towards the block.
 - Place the right timing chain idler sprocket to the cylinder block .
- 2 Timing Chain Idler Sprocket Shaft Bolt Caution: Refer to Fastener Caution . Tighten 58 Nm (43 lb ft)
58 Nm (43 lb ft)

Engine Front Cover Installation (Article 12096)

Single Use Fasteners and Components

Water Pump Seal

Special Tools

EN-46109 - Guide Pins

For equivalent regional tools, refer to Special Tools .

- Install the 8 mm (0.315 in) guide from the EN-46109 - Guide Pins into the cylinder block positions as shown. [Click for full-size image](#)
- Install the NEW water pump seal. [Click for full-size image](#)
- Install and align the front cover within 10 minutes of applying the sealer.
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant
- Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (1). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (2). Adhesives, Fluids, Lubricants, and Sealers [Click for full-size image](#)
- Place the engine front cover (1) onto the EN-46109 - Guide Pins and slide into position. [Click for full-size image](#)
- Remove the EN-46109 - Guide Pins from the cylinder block.
- Hand start all the engine front cover bolts.
- Tighten the engine front cover bolts (1-23) in the sequence shown to 20 Nm (15 lb ft) . [Click for full-size image](#)
- Tighten the engine front cover bolts (1-23) a second pass in sequence to 20 Nm (15 lb ft) .
- Tighten the engine front cover bolts (1-23) a third pass in sequence an additional 60 degrees .
- Tighten the engine front cover bolts (24) to 15 Nm (11 lb ft) .
- Tighten the engine front cover bolts (25) to 65 Nm (48 lb ft) .
- Place the camshaft position actuator valves (2) in position on the front cover. [Click for full-size image](#)
- Install the camshaft position actuator valve bolts (1) and tighten to 10 Nm (89 lb in) .
- Place the camshaft position sensors (2) in position on the front cover. [Click for full-size image](#)
- Install the camshaft position sensor bolts (1) and tighten to 10 Nm (89 lb in) .

Water Pump Installation (Article 12155)

Single Use Fasteners and Components

- Water Pump Bolt [6x]

- Water Pump Gasket

Callout Component Name

1 Water Pump Gasket Procedure Install a NEW gasket. Do NOT reuse the old gasket.

Procedure

Install a NEW gasket. Do NOT reuse the old gasket.

2 Water Pump

3 Water Pump Bolt [6x] 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. Procedure Install NEW bolts. Do NOT reuse old bolts. Tighten in sequence First Pass:10 Nm (89 lb in) Second Pass:10 Nm (89 lb in) Final Pass: 45 degrees

Install NEW bolts. Do NOT reuse old bolts.

- First Pass:10 Nm (89 lb in)
- Second Pass:10 Nm (89 lb in)
- Final Pass: 45 degrees

4 Water Pump Pulley Procedure Install the EN-46104 - Water Pump Pulley Holding Tool onto the water pump pulley mounting holes. Install the water pump pulley bolts. Remove the EN-46104 - Water Pump Pulley Holding Tool from the water pump pulley. Special Tools EN-46104 - Water Pump Pulley Holding Tool Equivalent regional tools:
Special Tools

- Install the EN-46104 - Water Pump Pulley Holding Tool onto the water pump pulley mounting holes.
- Install the water pump pulley bolts.
- Remove the EN-46104 - Water Pump Pulley Holding Tool from the water pump pulley.

Special Tools

EN-46104 - Water Pump Pulley Holding Tool

5 Water Pump Pulley Bolt [4x] Tighten 10 Nm (89 lb in)

10 Nm (89 lb in)

Camshaft Cover Installation - Left Side (Article 12050)

Single Use Fasteners and Components

- Camshaft Cover Bolt Insulator [15x]
- Gas Engine Ignition Spark Plug [3x]

Special Tools

- EN-46101 - Spark Plug Tube Seal Guide
- EN-48383 - Camshaft Retaining Tools

For equivalent regional tools, refer to Special Tools .

- Remove the EN-48383-2 from the rear of the left camshafts . [Click for full-size image](#)
- Install the EN-46101 - guide onto the spark plug tubes of the left cylinder head . [Click for full-size image](#)
- Install the NEW camshaft cover bolt insulators prior to installing the camshaft cover bolts. [Click for full-size image](#)
- Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant [Click for full-size image](#)
- 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). [Adhesives, Fluids, Lubricants, and Sealers](#)
- Place the left camshaft cover into position onto the left cylinder head. [Click for full-size image](#)
- Loosely install the left camshaft cover bolts. [Click for full-size image](#)
- Tighten the left camshaft cover bolts in the sequence shown. [Click for full-size image](#)
- Tighten the left camshaft cover bolts in the sequence to 10 Nm (89 lb in).
- Tighten the left camshaft cover bolts a second pass in the sequence to 10 Nm (89 lb in) .
- Remove the EN-46101 - guide from the spark plug tubes of the left cylinder head. [Click for full-size image](#)
- Install the NEW spark plugs into the left cylinder head and tighten to 18 Nm (13 lb ft) . [Click for full-size image](#)
- 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: [Click for full-size image](#)
- 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. [Adhesives, Fluids, Lubricants, and Sealers](#)
- Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
- Install the ignition coils.
- Install the ignition coil bolts and tighten to 10 Nm (89 lb in) . [Click for full-size image](#)

Camshaft Cover Installation - Right Side (Article 12051)

Single Use Fasteners and Components

- Camshaft Cover Bolt Insulator [13x]
- Gas Engine Ignition Spark Plug [3x]

Special Tools

EN-46101 - Spark Plug Tube Seal Guide

For equivalent regional tools, refer to Special Tools .

- Install the EN-46101 - guide onto the spark plug tubes of the right cylinder head . [Click for full-size image](#)
- Install the NEW camshaft cover bolt insulators prior to installing the camshaft cover bolts. [Click for full-size image](#)
- Wipe the camshaft cover sealing surface on the right cylinder head with a clean, lint-free cloth.
- Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant [Click for full-size image](#)
- 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). [Adhesives, Fluids, Lubricants, and Sealers](#)
- Place the right camshaft cover into position onto the right cylinder head. [Click for full-size image](#)

- Loosely install the right camshaft cover bolts. Click for full-size image
- Tighten the right camshaft cover bolts in the sequence shown. Click for full-size image
- Tighten the right camshaft cover bolts to 10 Nm (89 lb in) .
- Tighten the right camshaft cover bolts a second pass to 10 Nm (89 lb in) .
- Remove the EN-46101 - guide from the spark plug tubes of the right cylinder head. Click for full-size image
- Install the NEW spark plugs into the right cylinder head and tighten to 18 Nm (13 lb ft) . Click for full-size image
- 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: Click for full-size image
- 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. Adhesives, Fluids, Lubricants, and Sealers
- Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.
- Install the ignition coils.
- Install the ignition coil bolts and tighten to 10 Nm (89 lb in) . Click for full-size image

Intake Manifold Installation (LF1, LFW or LFX) (Article 12110)

- Install the NEW intake manifold gasket (1). Click for full-size image
- Install the intake manifold assembly (2). Click for full-size image
- Install the intake manifold bolts (1).
- Tighten the intake manifold bolts in the sequence shown. Click for full-size image
- Tighten the intake manifold bolts in sequence to 25 Nm (18 lb ft) .
- Tighten the intake manifold bolts a second pass in sequence to 25 Nm (18 lb ft) .
- Install the engine rear noise shield (3). Click for full-size image
- Install the fuel injection fuel rail shield (2).
- Install the fuel injection fuel rail shield bolt (1) and tighten to 10 Nm (89 lb in) .
- Connect the evaporative (EVAP) hose to the upper intake manifold and EVAP solenoid. Click for full-size image
- Connect the positive crankcase ventilation (PCV) tube assembly (1) to the upper intake manifold and the right camshaft cover . Click for full-size image

Automatic Transmission Flex Plate Installation (Article 12044)

Single Use Fasteners and Components

Automatic Transmission Flex Plate Bolt [8x]

Callout Component Name

1 Automatic Transmission Flex Plate

2 Automatic Transmission Flex Plate Bolt [8x] 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. Caution: Refer to Fastener Caution . Procedure Install 2 NEW bolts (2) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position. Install the EN-46106 - Flywheel Holding Tool through the starter mounting hole. Note: The top starter hole will require a longer bolt and nut to secure the tool. Install the remaining NEW flex plate bolts and tighten to specifications. Remove the EN-46106 - Flywheel Holding Tool through the starter mounting hole. Tighten First Pass: 30 Nm (22 lb ft) Final Pass: 45 degrees using the EN-45059 - Angle Meter Special Tools EN-46106 - Flywheel Holding Tool EN-45059 - Angle Meter Equivalent regional tools: Special Tools

Procedure

- Install 2 NEW bolts (2) in location at the top and bottom of the flex plate bolt pattern allowing the flex plate (2) to hang in position.
- Install the EN-46106 - Flywheel Holding Tool through the starter mounting hole.
- Install the remaining NEW flex plate bolts and tighten to specifications.
- Remove the EN-46106 - Flywheel Holding Tool through the starter mounting hole.
- First Pass: 30 Nm (22 lb ft)
- Final Pass: 45 degrees using the EN-45059 - Angle Meter

Special Tools

- EN-46106 - Flywheel Holding Tool
- EN-45059 - Angle Meter

Flywheel Installation (Article 12100)

Special Tools

- EN 46106 - Flywheel Holding Tool
- J 33169 - Clutch Alignment Arbor

For equivalent regional tools, refer to Special Tools .

- Place the engine flywheel in position on the crankshaft .
- 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.
- Install the EN 46106 - tool . Click for full-size image
- Install the remaining NEW engine flywheel bolts and tighten the NEW engine flywheel bolts to 67 Nm (49 lb ft) . Click for full-size image
- Install the clutch driven plate disc and the clutch pressure plate to the engine flywheel. Ensure to align the clutch pressure plate to the pins in the engine flywheel. Click for full-size image
- Loosely install the clutch pressure plate bolts.
- Install the J 33169 - arbor through the clutch driven plate disc and into the end of the crankshaft in order to align the clutch driven plate disc. Click for full-size image
- Tighten the clutch pressure plate bolts to 30 Nm (22 lb ft) .
- Remove the J 33169 - arbor .
- Remove the EN 46106 - tool . Click for full-size image

Crankshaft Balancer Installation (Article 12073)

Special Tools

- EN 46106 - Engine Flywheel Holding Tool
- J 41998-B - Crankshaft Balancer Installer
- J 45059 - Angle Meter

For equivalent regional tools, refer to Special Tools .

- The EN 46106 - tool must be installed onto the flywheel. Click for full-size image
- Use the J 41998-B - installer , nut, bearing and washer to install the crankshaft balancer.
- Apply lubricant to the inside of the crankshaft balancer hub bore (1). Click for full-size image
- Slide the crankshaft balancer (2) into position on the crankshaft. Click for full-size image
- Thread the J 41998-B - installer (1) in the crankshaft. Ensure you engage at least 10 threads of the J 41998-B - installer before pressing the crankshaft balancer in place. Click for full-size image
- 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.
- Remove the J 41998-B - installer .
- Install the NEW crankshaft balancer bolt (1). Click for full-size image
- Tighten the crankshaft balancer bolt.
- Tighten the crankshaft balancer bolt to 100 Nm (74 lb ft) .
- Tighten the crankshaft balancer bolt an additional 150 degrees using the J 45059 - meter .
- Remove the EN 46106 - tool . Click for full-size image

Oil Filter Adapter Installation (Article 12115)

- Position a NEW oil filter adapter gasket onto the oil filter adapter. Click for full-size image
- Install the oil filter adapter bolts (1, 2) into the oil filter adapter. Click for full-size image
- Loosely tighten the oil filter adapter bolts (1, 2).
- Install and loosely tighten the oil filter adapter bolt (3) into the oil filter adapter.
- Tighten the oil filter adapter bolts (1, 2) to 25 Nm (18 lb ft) .
- Tighten the oil filter adapter bolt (3) to 58 Nm (43 lb ft) .
- Install a NEW oil filter cartridge . Click for full-size image
- Lubricate the oil filter cap threads with clean engine oil. Click for full-size image
- Install the oil filter cap and tighten to 25 Nm (18 lb ft) . Click for full-size image

Oil Level Indicator and Tube Installation (Article 12117)

- Install a NEW O-ring on the oil level indicator tube . Click for full-size image
- Install the oil level indicator and tube by sliding the tube down through the lower crankcase hole. Click for full-size image
- Install the oil level indicator tube bracket bolt and tighten to 10 Nm (89 lb in) .

Engine Coolant Thermostat Housing Installation (Article 12091)

- Install the NEW thermostat housing assembly O-ring and gasket [Click for full-size image](#)
- Install the thermostat housing assembly. [Click for full-size image](#)
- Install the thermostat housing assembly bolts and tighten to 10 Nm (89 lb in) .
- Install the NEW heater inlet/outlet pipe assembly O-ring (2) and gasket (1).. [Click for full-size image](#)
- Install the heater inlet/outlet pipe assembly (3). [Click for full-size image](#)
- Install the heater inlet and outlet pipe assembly bolts (2) and tighten to 10 Nm (89 lb in) .
- Install the heater inlet and outlet pipe assembly bolt (1) and tighten to 22 Nm (16 lb ft) .

Water Outlet Installation (Article 12152)

- Install the NEW water outlet gasket (3). [Click for full-size image](#)
- Install the NEW water outlet O-ring seal (2).
- Install the water outlet (1).
- Install the water outlet bolts (4) and tighten to 10 Nm (89 lb in) .

Drive Belt Tensioner Installation (Article 12086)

- Install the drive belt tensioner (2) to the engine front cover . [Click for full-size image](#)
- Install the drive belt tensioner to engine front cover retaining bolts (1) and tighten to 58 Nm (43 lb ft) .

Engine Prelubing (Article 12098)

Single Use Fasteners and Components

Oil Filter

Special Tools

- EN-21867-6 - Oil Pressure Adapter Fitting

- EN-45299 - Engine Preluber

Equivalent regional tools: Special Tools

- Remove the oil filter cap. [Click for full-size image](#)

- Install a NEW oil filter.

- Lubricate the threads of the oil filter cap with clean engine oil.

- Install the oil filter cap and tighten to 25 Nm (18 lb ft) .

- Remove the oil pressure sending unit from the oil filter adapter .

- Install the EN-21867-6 - fitting .

- Install the flexible hose to the adapter and open the valve. [Click for full-size image](#)

- Pump the handle on the EN-45299 - preluber 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.

- Close the valve and remove the flexible hose and adapter from the engine.

- Install the oil pressure sending unit and tighten to 20 Nm (15 lb ft) .

- Top-off the engine oil to the proper level.

Engine Support Fixture (Article 12182)

Special Tools

J 28467-81 - Engine Support Fixture Kit

For equivalent regional tools, refer to Special Tools .

Installation Procedure

- Remove the engine cover . Refer to Intake Manifold Cover Replacement - Rear .

- Use a grade 10.9, M10 X 1.5 X 35 bolt, GM P/N 11519182 or equivalent, in order to install an engine lift bracket (OTC #7100, J 36857 or equivalent) to the front of the left cylinder head in the location shown. [Click for full-size image](#)

- Support the hood and remove the hood support strut.

- Reposition the passenger side wire harness (1) to provide clearance for support fixture leg. [Click for full-size image](#)

- Assemble a J 28467-501 - support leg (1) to each end of the J 28467-518 - main bar (2). [Click for full-size image](#)

- Position the main bar (1) with the support legs over each shock tower. Ensure the rear support legs are located over the reinforced section of the shock tower. [Click for full-size image](#)

- Install the J 28467-7A - lift hook through the J 28467-6A - lift hook bracket . [Click for full-size image](#)

- Install the ½ inch lift hook washer and the J 28467-34 - handle onto the J 28467-7A - lift hook .

- Install the J 28467-6A - assembled lift hook bracket (1) over the J 28467-16 - main bar (2). [Click for full-size image](#)

- Adjust the J 28467-6A - assembled lift hook bracket (1) in order to align the hook with the J 41798 - engine bracket .
- Repeat steps 8–11 for the right lift hook.
- Hand-tighten the lift hook wing nuts securely to remove all slack from the engine support fixture assembly.
- The engine is now supported in the vehicle to perform repairs that require front frame removal.

Removal Procedure

- Loosen and remove the J 28467-81 - kit .
- Remove the J 28467-81 - kit (1). [Click for full-size image](#)
- Remove the engine brackets from the cylinder heads. [Click for full-size image](#)
- Install the hood support strut.
- Install the engine cover . Refer to Intake Manifold Cover Replacement - Rear .

Engine Replacement (Article 12181)

Special Tools

J-38185 - Hose Clamp Pliers

For equivalent regional tools, refer to Special Tools .

Removal Procedure

- Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection .
- Remove the intake manifold cover . Refer to Intake Manifold Cover Replacement - Rear .
- Place a clean drain pan under the radiator drain cock . [Click for full-size image](#)
- Loosen the radiator drain cock (1).
- Drain the cooling system . Refer to Cooling System Draining and Filling .
- Tighten the radiator drain cock (1).
- Relieve the high side fuel system pressure. Refer to Fuel Pressure Relief .
- Discharge the air conditioning (A/C) system. Refer to Refrigerant Recovery and Recharging .
- Remove the front tires. Refer to Tire and Wheel Removal and Installation .
- Remove the transmission. Refer to the appropriate procedure:
 - Transmission Replacement for the 6L45/6L50/6L80/6L90 transmission
 - Transmission Replacement for the Aisin AY6 transmission
 - Transmission Replacement for the Tremec 6-speed transmission
- Remove the oil pan drain plug (1) from the oil pan allow the oil to drain completely. Refer to Engine Oil and Oil Filter Replacement . [Click for full-size image](#)
- Install the oil pan drain plug (1) and NEW O-ring seal (2) and tighten to 20 Nm (15 lb ft) .
- Remove the air cleaner outlet duct hose. Refer to Air Cleaner Outlet Duct Replacement .
- Remove the air cleaner assembly . Refer to Air Cleaner Assembly Replacement .
- Disconnect the power brake booster vacuum sensor electrical connector. [Click for full-size image](#)
- Remove the check valve (1) from the vacuum brake booster.
- Release the power brake booster vacuum hose quick connect (1) from the power brake booster vacuum pump and reposition. [Click for full-size image](#)
- Disengage tension on the heater outlet hose clamp (1) at the heater core using J-38185 - pliers . [Click for full-size image](#)
- Remove the heater outlet hose (2) from the heater core and reposition.
- Disengage tension on the heater inlet hose clamp (1) at the heater core using J-38185 - pliers . [Click for full-size image](#)
- Remove the heater inlet hose (2) from the heater core and reposition.
- Remove A/C evaporator thermal expansion valve tube nut (1). [Click for full-size image](#)
- Remove A/C evaporator thermal expansion valve tube (2) from HVAC module reposition.
- Working under the vehicle, use paint in order to place match marks on the intermediate steering shaft (1) and on the steering gear pinion shaft (3). [Click for full-size image](#)
- Remove the steering gear pinion bolt (2).
- Remove the thread locking patch and clean the threads on the steering gear pinion bolt.
- Disconnect the intermediate steering shaft from the steering gear pinion shaft.
- Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle .
- Remove and discard the disc brake caliper bracket bolts (1). [Click for full-size image](#)
- Remove the disc brake caliper and bracket assembly and support with heavy mechanics wire or equivalent.
- Remove the brake hose bracket bolt (1) from the strut assembly. [Click for full-size image](#)
- Remove the front stabilizer shaft nut (1) and discard the old nut. [Click for full-size image](#)
- Reposition the stabilizer link (2).
- Paint a reference mark (2) of the strut (1) to the steering knuckle (3). [Click for full-size image](#)
- Remove the front strut nuts (1) and the bolts (2). [Click for full-size image](#)

- Using a hydraulic floor jack, support the steering knuckle.
- Disconnect all necessary engine harness electrical connectors. Refer to Powertrain Component Views .
- Remove the front bumper fascia. Refer to Front Bumper Fascia Replacement .
- Convertible vehicle, remove the front end lower structure brace.
- Remove the rear frame bolts (1). Click for full-size image
- Using a suitable engine support table or equivalent, lower the vehicle until the drivetrain and front suspension frame contacts the engine support table.
- Remove the front (2) and rear (1) frame bolts. Click for full-size image
- Lower the frame with the engine until clear the body and raise the vehicle at full height.
- Remove the engine mount nuts and remove the engine from the crossmember. Click for full-size image
- Transfer components as required. Refer to the appropriate procedures.
- Installation Procedure
- Install the engine to the crossmember. Click for full-size image
- Tighten both the engine mount nuts to 80 Nm (59 lb ft) .
- Install the front frame mountings bolts (2) and tighten to 160 Nm (118 lb ft) . Click for full-size image
- Install the front frame mountings bolts (1) and tighten to 160 Nm (118 lb ft) .
- Install the rear frame mountings bolts (1) and tighten to 240 Nm (177 lb ft) . Click for full-size image
- Convertible vehicle, install the front end lower structure brace.
- Install the front bumper fascia. Refer to Front Bumper Fascia Replacement .
- Connect all necessary engine harness electrical connectors. Refer to Powertrain Component Views and Harness Routing Views .
- Align the front strut (1) with the alignment mark (2). Click for full-size image
- Install the front strut bolts (2). Click for full-size image
- Install the nuts (1) and tighten to 80 Nm (59 lb ft) plus an additional 180 degrees .
- Install the front stabilizer shaft nut (1) and tighten to 49 Nm (36 lb ft) . Click for full-size image
- Install the brake hose bracket bolt (1) on the strut assembly and tighten to 9 Nm (80 lb in) . Click for full-size image
- Install 2 new disc brake caliper bracket bolts (1) and tighten to 60 Nm (44 lb ft) plus 90 degrees . Click for full-size image
- Working under the vehicle, align the match marks and connect the intermediate steering shaft (1) to the steering gear pinion shaft (3). Click for full-size image
- Apply thread locking adhesive to the steering gear pinion bolt (2). Refer to Adhesives, Fluids, Lubricants, and Sealers .
- Install the steering gear pinion bolt and tighten to 50 Nm (37 lb ft) .
- Install A/C evaporator thermal expansion valve tube (2) to thermal expansion valve tube. Click for full-size image
- Install A/C evaporator thermal expansion valve tube nut (1) and tighten to 19 Nm (14 lb ft)
- Install the heater inlet hose (2) to the heater core. Click for full-size image
- Engage tension on the heater inlet hose clamp (1) at the radiator using J-38185 - pliers .
- Install the heater outlet hose (2) to the heater core. Click for full-size image
- Engage tension on the heater outlet hose clamp (1) at the radiator using J-38185 - pliers .
- Connect the power brake booster vacuum hose quick connect (1) to the power brake booster vacuum pump. Click for full-size image
- Install the check valve (1) and hose assembly to the vacuum brake booster. Click for full-size image
- Install the air cleaner assembly. Refer to Air Cleaner Assembly Replacement .
- Install the air cleaner outlet duct hose. Refer to Air Cleaner Outlet Duct Replacement
- Install the transmission. Refer to the appropriate procedure:
- Charge the A/C system. Refer to Refrigerant Recovery and Recharging .
- Fill the engine cooling system. Refer to Cooling System Draining and Filling .
- If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to Engine Prelubing .
- If prelubing has not been performed, fill the engine oil. Refer to Engine Oil and Oil Filter Replacement .
- Install the intake manifold cover. Refer to Intake Manifold Cover Replacement - Rear .
- Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection .

Engine Oil Cooler Debris Caution (Article 13046)

Document ID: 2323130

Caution:

If any malfunction is experienced which may cause debris to enter the oil supply, you must replace the engine oil cooler

and hoses if equipped. Debris in the engine oil cooler

and oil cooler hoses may be pulled back into the engine causing severe engine damage.

Cleanliness and Care (Article 12010)

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 proper cleaning and protection procedures to the machined surfaces and to the friction areas.

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.

Disconnect the negative battery cables before you perform any major work on the engine.

Separating Parts (Article 12016)

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.

Replacing Engine Gaskets (Article 12015)

Special Tools

EN-28410 - Gasket Remover

For equivalent regional tools, refer to Special Tools .

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 seal s or valve stem oil seal s 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.
- Tighten the fasteners to the proper specifications.

Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant (Article 12018)

Cleaning Mating Part Surfaces for RTV Joints

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to

ensure good adhesion over the life of the product.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover , cylinder head , engine block , oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area. When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1,600 km (1,000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

Typical Applications

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.
- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover /rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/ cam cover s with press in place gaskets using RTV at corners or T-joints.

Materials Needed

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC –Free Cleaner & Degreaser

Procedure:

- Identify the surfaces to which the RTV will come into contact in the assembled joint.
- Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.
- Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some discoloration of the cloth after wiping however a clean surface should produce the same level of discoloration with successive

wiping with a clean cloth and solvent.

- If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
- Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
- Do not touch the cleaned surface with anything prior to RTV application.
- The surface is now prepared for RTV application.

Sealant Types

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

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:
 - Gasket Eliminator
 - Pipe Sealant
 - Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two components, such as the intake manifold and the engine 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
- Do not use RTV sealant unless the ambient air temperature is at least 18°C (65°F) degrees or higher.
- 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.
- 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.
- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two 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.
- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- 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.
- After properly 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 two 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.
- Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.

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 two parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
- Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.
- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

Engine Mechanical Specifications (LFX) (Article 12223)

Application Specification

Metric English

General

Engine Type V-6

- Engine Type

Displacement 3.6 Liter 220 cu in

- Displacement

RPO LFX

- RPO

VIN 3

- VIN

Bore 94 mm 3.7008 in

- Bore

Stroke 85.6 mm 3.37 in

- Stroke

Compression Ratio 11.5:1

- Compression Ratio

Firing Order 1-2-3-4-5-6

- Firing Order

Spark Plug Gap 0.95–1.10 mm 0.0375–0.0433 in

- Spark Plug Gap

Block

Crankshaft Main Bearing Bore Diameter 72.867–72.881 mm 2.8688–2.8693 in

- Crankshaft Main Bearing Bore Diameter

Cylinder Bore Diameter 93.992–94.008 mm 3.7005–3.7011 in

- Cylinder Bore Diameter

Cylinder Bore Out-of-Round – Production Max. 0.026 mm 0.001 in

- Cylinder Bore Out-of-Round – Production Max.

Cylinder Bore Taper 0.020 mm 0.0008 in

- Cylinder Bore Taper

Camshaft

Camshaft Bearing Inside Diameter – Front Number 1 35.000–35.020 mm 1.3779–1.3787 in

- Camshaft Bearing Inside Diameter – Front Number 1

Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4 27.000–27.020 mm 1.0630–1.0638 in

- Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4

Camshaft End Play 0.072–0.490 mm 0.0028–0.0190 in

- Camshaft End Play

Camshaft Journal Diameter – Front Number 1 34.936–34.960 mm 1.3754–1.3764 in

- Camshaft Journal Diameter – Front Number 1

Camshaft Journal Diameter – Middle and Rear Number 2–4 26.936–26.960 mm 1.0605–1.0614 in

- Camshaft Journal Diameter – Middle and Rear Number 2–4

Camshaft Journal Out-of-Round 0.006 mm 0.0002 in

- Camshaft Journal Out-of-Round

Camshaft Journal to Bore Clearance 0.040–0.084 mm 0.0016–0.0033 in

- Camshaft Journal to Bore Clearance

Camshaft Lobe Lift – Exhaust 42.425–42.725 mm 1.6703–1.6821 in

- Camshaft Lobe Lift – Exhaust

Camshaft Lobe Lift – Intake 42.385–42.685 mm 1.6687–1.6805 in

- Camshaft Lobe Lift – Intake

Camshaft Runout – Front and Rear Number 1 and 4 0.025 mm 0.0010 in

- Camshaft Runout – Front and Rear Number 1 and 4
- Camshaft Runout – Middle 2 and 3 0.050 mm 0.0020 in
- Camshaft Runout – Middle 2 and 3
- Valve Lift – Exhaust 10.8 mm 0.4252 in
- Valve Lift – Exhaust
- Valve Lift – Intake 10.8 mm 0.4252 in
- Valve Lift – Intake
- Connecting Rod
- Connecting Rod Bearing Clearance 0.010–0.070 mm 0.0004–0.0026 in
- Connecting Rod Bearing Clearance
- Connecting Rod Bore Diameter – Bearing End 59.620–59.636 mm 2.3472–2.3479 in
- Connecting Rod Bore Diameter – Bearing End
- Connecting Rod Bore Diameter – Pin End – Production 24.009–24.019 mm 0.9452–0.9456 in
- Connecting Rod Bore Diameter – Pin End – Production
- Connecting Rod Bore Diameter – Pin End – Service Maximum 24.021 mm 0.9457 in
- Connecting Rod Bore Diameter – Pin End – Service Maximum
- Connecting Rod Length – Center to Center 152.400 mm 6.0000 in
- Connecting Rod Length – Center to Center
- Connecting Rod Side Clearance 0.095–0.355 mm 0.00037–0.0140 in
- Connecting Rod Side Clearance
- Connecting Rod Width – Bearing End
- Connecting Rod Width – Bearing End
- Production 21.775 mm 0.8573 in
- Production
- Service 21.725–21.825 mm 0.8553–0.8593 in
- Service
- Connecting Rod Width – Pin End
- Connecting Rod Width – Pin End
- Crankshaft
- Connecting Rod Journal Diameter 55.992–56.008 mm 2.2044–2.2050 in
- Connecting Rod Journal Diameter
- Connecting Rod Journal Out-of-Round 0.005 mm 0.0002 in
- Connecting Rod Journal Out-of-Round
- Connecting Rod Journal Taper 0.005 mm 0.0002 in
- Connecting Rod Journal Taper
- Connecting Rod Journal Width
- 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 End Play
- Crankshaft Main Bearing Clearance 0.031–0.069 mm 0.0012–0.0027 in
- Crankshaft Main Bearing Clearance
- Crankshaft Main Journal Diameter 67.992–68.008 mm 2.6768–2.6775 in
- Crankshaft Main Journal Diameter
- Crankshaft Main Journal Out-of-Round 0.005 mm 0.0002 in
- Crankshaft Main Journal Out-of-Round
- Crankshaft Main Journal Taper 0.005 mm 0.0002 in
- Crankshaft Main Journal Taper
- Crankshaft Main Journal Thrust Wall
- Crankshaft Main Journal Thrust Wall
- Runout 0.000–0.040 mm 0.0000–0.0016 in
- Runout
- Square 0.000–0.010 mm 0.0000–0.0004 in
- Square
- Crankshaft Main Journal Width, #2, 4
- 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

- 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 20.965–20.995 mm 0.8254–0.8266 in
- Crankshaft Pilot Bearing Bore Diameter
- Crankshaft Rear Flange Runout 0.025 mm 0.0010 in
- Crankshaft Rear Flange Runout
- Crankshaft Reluctor Ring Runout – Maximum 1.500 mm 0.0591 in
- Crankshaft Reluctor Ring Runout – Maximum
- Crankshaft Runout 0.030 mm 0.0012 in
- Crankshaft Runout
- Crankshaft Thrust Bearing Clearance 0.076–0.305 mm 0.0030–0.0120 in
- Crankshaft Thrust Bearing Clearance
- Crankshaft Thrust Surface – Height Diameter 95.000 mm 3.7401 in
- Crankshaft Thrust Surface – Height Diameter
- Crankshaft Thrust Surface Runout 0.040 mm 0.0016 in
- Crankshaft Thrust Surface Runout
- Cylinder Head
- Valve Guide Bore – Exhaust 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Exhaust
- Valve Guide Bore – Intake 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Intake
- Valve Guide Installed Height 14.050–14.550 mm 0.5531–0.5728 in
- Valve Guide Installed Height
- Valve Lifter Bore Diameter 12.008–12.030 mm 0.4728–0.4736 in
- Valve Lifter Bore Diameter
- Lubrication System
- Oil Capacity – with Filter 5.7 Liters 6.0 Quarts
- Oil Capacity – with Filter
- Oil Capacity – without Filter 5.2 Liters 5.5 Quarts
- Oil Capacity – without Filter
- Oil Pressure – Minimum @ Idle 69 kPa 10 psi
- Oil Pressure – Minimum @ Idle
- Oil Pressure – Minimum @ 2,000 RPM 207 kPa 30 psi
- Oil Pressure – Minimum @ 2,000 RPM
- Piston Cooling Jet Valve Opening Pressure 2.7 bar 35 psi
- Piston Cooling Jet Valve Opening Pressure
- Piston Ring s
- Piston Ring End Gap
- Piston Ring End Gap
- First Compression Ring – Nominal 0.150–0.250 mm 0.0059–0.0098 in
- First Compression Ring – Nominal
- First Compression Ring – Maximum, Ring in Bore 0.290 mm 0.0114 in
- First Compression Ring – Maximum, Ring in Bore
- Second Compression Ring – Nominal 0.300–0.450 mm 0.0118–0.0177 in
- Second Compression Ring – Nominal
- Second Compression Ring – Maximum, Ring in Bore 0.490 mm 0.0193 in
- Second Compression Ring – Maximum, Ring in Bore
- Oil Control Ring 0.150–0.350 mm 0.0059–0.0138 in
- Oil Control Ring
- Piston Ring to Groove Clearance
- Piston Ring to Groove Clearance
- First Compression Ring 0.030–0.075 mm 0.0012–0.0030 in
- First Compression Ring
- Second Compression Ring 0.015–0.060 mm 0.0006–0.0024 in
- Second Compression Ring
- Oil Control Ring 0.030–0.170 mm 0.0012–0.0067 in
- Piston Ring Thickness
- 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

Pistons and Pins

Piston

- Piston

Piston Diameter – Measured Over Skirt Coating 93.976–94.014 mm 3.6998–3.7013 in

- Piston Diameter – Measured Over Skirt Coating

Piston Diameter – Service Limit Minimum w/more than 10K miles 93.926 mm 3.6979 in

- Piston Diameter – Service Limit Minimum w/more than 10K miles

Piston Pin Bore Diameter 24.004–24.009 mm 0.9450–0.9452 in

- Piston Pin Bore Diameter

Piston Ring Groove Width – First Compression Ring 1.020–1.050 mm 0.0402–0.0413 in

- Piston Ring Groove Width – First Compression Ring

Piston Ring Groove Width – Second Compression Ring 1.210–1.230 mm 0.0476–0.0484 in

- Piston Ring Groove Width – Second Compression Ring

Piston Ring Groove Width – Oil Control Ring 1.510–1.530 mm 0.0594–0.0602 in

- Piston Ring Groove Width – Oil Control Ring

Piston to Bore Clearance – Production; Measured at Skirt Coating 0.022–0.032 mm 0.0009–0.0013 in

- Piston to Bore Clearance – Production; Measured at Skirt Coating

Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles 0.050 mm 0.0020 in

- Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles

Pin

- 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 – Production

Piston Pin Clearance to Connecting Rod Bore – Service Maximum 0.030 mm 0.0012 in

- Piston Pin Clearance to Connecting Rod Bore – Service Maximum

Piston Pin Clearance to Piston Pin Bore – Production 0.004–0.012 mm 0.0002–0.0005 in

- Piston Pin Clearance to Piston Pin Bore – Production

Piston Pin Clearance to Piston Pin Bore – Service Maximum 0.015 mm 0.0006 in

- Piston Pin Clearance to Piston Pin Bore – Service Maximum

Piston Pin Diameter 23.997–24.000 mm 0.9448–0.9449 in

- Piston Pin Diameter

Piston Pin Length 52.600–53.100 mm 2.0709–2.0906 in

- Piston Pin Length

Valve System

Valves

- Valves

Valve Face Angle 44.25 degrees

- Valve Face Angle

Valve Face Runout 0.0500 mm 0.0020 in

- Valve Face Runout

Valve Face Width – Exhaust DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Exhaust

Valve Face Width – Intake DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Intake

Valve Head Diameter – Exhaust 30.470–30.730 mm 1.1996–1.2098 in

- Valve Head Diameter – Exhaust

Valve Head Diameter – Intake 38.170–38.430 mm 1.5028–1.5130 in

- Valve Head Diameter – Intake

Valve Installed Height 35.23–36.69 mm 1.3870–1.4445 in

- Valve Installed Height

Valve Length – Exhaust 95.11 mm 3.74 in

- Valve Length – Exhaust

Valve Length – Intake 100.630 mm 3.9618 in

- Valve Length – Intake

Valve Seat Angle – Seating Surface 45 degrees

- Valve Seat Angle – Seating Surface

Valve Seat Angle – Relief Surface 30 degrees

- Valve Seat Angle – Relief Surface

Valve Seat Angle – Undercut Surface 60 degrees
- Valve Seat Angle – Undercut Surface
Valve Seat Roundness– Maximum 0.025 mm 0.0010 in
- Valve Seat Roundness– Maximum
Valve Seat Runout – Maximum 0.080 mm 0.0031 in
- Valve Seat Runout – Maximum
Valve Seat Width – Exhaust Seating Surface 1.400–1.800 mm 0.0551–0.0709 in
- Valve Seat Width – Exhaust Seating Surface
Valve Seat Width – Exhaust Relief Surface 0.700–0.900 mm 0.0276–0.0354 in
- Valve Seat Width – Exhaust Relief Surface
Valve Seat Width – Intake Seating Surface 1.000–1.400 mm 0.0394–0.0551 in
- Valve Seat Width – Intake Seating Surface
Valve Seat Width – Intake Relief Surface 0.500–0.700 mm 0.0197–0.0276 in
- Valve Seat Width – Intake Relief Surface
Valve Stem Diameter – Exhaust 5.945–5.965 mm 0.2341–0.2348 in
- Valve Stem Diameter – Exhaust
Valve Stem Diameter – Intake 5.945–5.965 mm 0.2341–0.2348 in
- Valve Stem Diameter – Intake
Valve Stem-to-Guide Clearance – Exhaust 0.035–0.075 mm 0.0014–0.0030 in
- Valve Stem-to-Guide Clearance – Exhaust
Valve Stem-to-Guide Clearance – Intake 0.035–0.075 mm 0.0014–0.0030 in
- Valve Stem-to-Guide Clearance – Intake
Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)
- Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)
Valve Lifter (SHLA) Diameter 11.989–12.000 mm 0.4720–0.4724 in
- Valve Lifter (SHLA) Diameter
Valve Lifter (SHLA)-to-Bore Clearance 0.008–0.041 mm 0.0003–0.0016 in
- Valve Lifter (SHLA)-to-Bore Clearance
Rocker Arms
- Rocker Arms
Valve Rocker Arm Ratio 1.68 to 1
- Valve Rocker Arm Ratio
Valve Rocker Arm Roller Diameter 17.750–17.800 mm 0.6988–0.7008 in
- Valve Rocker Arm Roller Diameter
Valve Springs
- Valve Springs
Valve Spring Coil Thickness 3.250 x 3.900 mm 0.1280 x 0.1535 in
- Valve Spring Coil Thickness
Valve Spring Diameter – Inside Top 12.200–12.700 mm 0.4803–0.5000 in
- Valve Spring Diameter – Inside Top
Valve Spring Diameter – Outside Top 20.250 mm 0.7972 in
- Valve Spring Diameter – Outside Top
Valve Spring Diameter – Inside Bottom 17.950–18.450 mm 0.7067–0.7264 in
- Valve Spring Diameter – Inside Bottom
Valve Spring Diameter – Outside Bottom 26.000 mm 1.0236 in
- Valve Spring Diameter – Outside Bottom
Valve Spring Free Length 42.500–45.500 mm 1.6732–1.7913 in
- Valve Spring Free Length
Valve Spring Installed Height – Closed 35.000 mm 1.3779 in
- Valve Spring Installed Height – Closed
Valve Spring Installed Height – Open 24.000 mm 0.9449 in
- Valve Spring Installed Height – Open
Valve Spring Load – Closed 247–273 N 56–61 lb
- Valve Spring Load – Closed
Valve Spring Load – Open 598–662 N 134–149 lb
- Valve Spring Load – Open

Engine Mechanical - Adhesives, Fluids, Lubricants, and Sealers (Except Korea) (Article 12218)

Application Type of Material GM Part Number
United States Canada

Block Pan Rail * Sealant 19369831 19369832
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 19369831 19369832
Engine Front Cover /Split Lines * Sealant 19369831 19369832
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
Intake Manifold Bolt Threadlocker 12345382 10953489
Oil Gallery Threaded Plug Sealant 12346004 10953480
Oil Pan , Engine Front Cover, Crankshaft Rear Oil Seal Housing * Sealant 19369831 (150g cartridge) 19369832
88861417 (75 gram squeeze tube) 88861418
Piston Pin Bores 5W-30 19293000 19286321
Positive Crankcase Ventilation (PCV) Orifice Sealant 19369831 19369832
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
* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

Engine Mechanical - Adhesives, Fluids, Lubricants, and Sealers (Korea) (Article 12220)

Application Type of Material (GMDAT) GMDAT Part Number
Block Pan Rail * Sealant 19369831
Camshaft Prelube Engine Oil Refer to Parts Catalog
Coolant Drain Threaded Plug Sealant 12346004
Coolant Expansion Plugs Sealant 12345382
Coolant and Oil Plug Threads Sealant 12346004
Crankshaft Bearing Surfaces Engine Oil Refer to Parts Catalog
Crankshaft Connecting Rod Bearing Journal Engine Oil Refer to Parts Catalog
Crankshaft Prelube Engine Oil Refer to Parts Catalog
Crankshaft Rear Oil Seal Housing * Sealant 19369831
Engine Front Cover /Split Lines * Sealant 19369831
Engine Oil 5W-30 Refer to Parts Catalog
Engine Oil dexos™ SAE 5W-30 Refer to Parts Catalog
Fuel Injection Fuel Rail Fuel Pressure Sensor Sealing Cone/Threads Engine Oil Refer to Parts Catalog
Fuel Rail Sealing Cone/Threads Engine Oil Refer to Parts Catalog
Oil Gallery Threaded Plug Sealant 12346004
Oil Pan , Engine Front Cover, Crankshaft Rear Oil Seal Housing * Sealant 19369831
Piston Pin Bores Engine Oil Refer to Parts Catalog
Positive Crankcase Ventilation (PCV) Orifice Sealant 19369831
Stationary Hydraulic Lash Adjuster (SHLA) Engine Oil Refer to Parts Catalog
SHLA Bores in Cylinder Head Engine Oil Refer to Parts Catalog
SHLA Pivot Spheres Engine Oil Refer to Parts Catalog
Thread Repair N/A N/A
Valve Stem/Guide ID Engine Oil Refer to Parts Catalog
* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

Engine Mechanical - Fastener Specifications (Article 12227)

Application Specification

Metric English

Automatic Transmission Flex Plate Bolt

First Pass 30 Nm (1) 22 lb ft (1)

- First Pass

Final Pass 45 Degrees

- Final Pass

Camshaft Cover Bolt 10 Nm 89 lb in

Camshaft Intermediate Drive Sprocket Bolt – Idler Sprocket 58 Nm 43 lb ft

Camshaft Position Actuator

Camshaft Bolt 58 Nm 43 lb ft

- Camshaft Bolt

Oil Control Valve Bolt 10 Nm 89 lb in

- Oil Control Valve Bolt

Camshaft Position Sensor Bolt 10 Nm 89 lb in

Close Out Cover Bolt 10 Nm 89 lb in

Clutch Pressure Plate Bolts 30 Nm 22 lb ft

Connecting Rod Bolt

First Pass 25 Nm (1) 18 lb ft (1)

Final Pass 110 Degrees

Coolant Drain Plug – M14 50 Nm 37 lb in

Coolant Drain Plug – M20 75 Nm 55 lb in

Coolant Outlet Bolt 10 Nm 89 lb in

Crankshaft Balancer Bolt

First Pass 100 Nm (1) 74 lb ft (1)

Final Pass 150 Degrees

Crankshaft Main Bearing Bolt – Inner

First Pass 20 Nm (1) 15 lb ft (1)

Final Pass 80 degrees

Crankshaft Main Bearing Bolt – Outer

First Pass 15 Nm (1) 11 lb ft (1)

Crankshaft Main Bearing Bolt – Side

Final Pass 60 Degrees

Crankshaft Position Sensor Bolt 10 Nm 89 lb in

Crankshaft Rear Oil Seal Housing Bolt 10 Nm 89 lb in

Cylinder Head Bolt – M8

Final Pass 75 Degrees

Cylinder Head Bolt – M11

Final Pass 150 degrees

Cylinder Head Core Hole Plug 75 Nm 55 lb ft

Drive Belt Tensioner Bolt 25 Nm 18 lb ft

ECM

Bolt 10 Nm 89 lb in

- Bolt

Bracket Bolt – Front 23 Nm 17 lb ft

- Bracket Bolt – Front

Bracket Bolt – Side 10 Nm 89 lb in

- Bracket Bolt – Side

Grounding Bolt 4.5 Nm 40 lb in

- Grounding Bolt

ECT Sensor 30 Nm 22 lb ft

Engine Flywheel, Manual Trans, Bolt 67 Nm (1) 49 lb ft (1)

Engine Front Cover Studs 15 Nm 11 lb ft

Engine Front Cover Bolt – M6 15 Nm 11 lb ft

Engine Front Cover Bolt – M8

First Pass 20 Nm 14 lb ft

Engine Front Cover Bolt – M12 65 Nm 48 lb ft

Engine Mount

Bracket Bolt to Engine Block – M8 (AWD) 38 Nm 28 lb ft
- Bracket Bolt to Engine Block – M8 (AWD)
Bracket Bolt to Engine Block – M8 (RWD) 22 Nm 16 lb ft
- Bracket Bolt to Engine Block – M8 (RWD)
Bracket Bolt to Engine Block – M10 60 Nm 44 lb ft
- Bracket Bolt to Engine Block – M10
Nut to Engine Mount Bracket 80 Nm 59 lb ft
- Nut to Engine Mount Bracket
Nut to Frame 80 Nm 59 lb ft
- Nut to Frame
Engine Oil Level Switch Bolt 10 Nm 89 lb in
Engine Wiring Harness Bracket
Bolt – Cylinder Head Rear 40 Nm 30 lb ft
- Bolt – Cylinder Head Rear
Bolt – ECM Bracket Side 23 Nm 17 lb ft
- Bolt – ECM Bracket Side
Bolt – ECM Bracket Top 10 Nm 89 lb in
- Bolt – ECM Bracket Top
Bolt – Left Side Oil Filter Adapter 10 Nm 89 lb in
- Bolt – Left Side Oil Filter Adapter
Bolt – Left Side Oil Pan 10 Nm 89 lb in
- Bolt – Left Side Oil Pan
Bolt – Near Crankshaft Position Sensor 50 Nm 37 lb ft
- Bolt – Near Crankshaft Position Sensor
Bolt – Right Side Block Front 23 Nm 17 lb ft
- Bolt – Right Side Block Front
Bolt – Right Side Head Front 10 Nm 89 lb in
- Bolt – Right Side Head Front
Engine Wiring Harness Ground
Bolt – Left Cylinder Head Side 10 Nm 89 lb in
- Bolt – Left Cylinder Head Side
Bolt – Right Cylinder Head Rear 10 Nm 89 lb in
- Bolt – Right Cylinder Head Rear
Evaporative (EVAP) Purge Valve Bolt 10 Nm 89 lb in
Fuel Injection Fuel Rail Fuel Pressure Sensor 33 Nm 25 lb ft
Fuel Feed Pipe Bolt 50 Nm 37 lb ft
Fuel Feed Pipe Nut 28 Nm 21 lb ft
Fuel Pump Bolts – High Pressure
First Pass: 15 Nm (1) 11 lb ft (1)
- First Pass:
Final Pass: 60 Degrees
- Final Pass:
Fuel Rail Bolt 25 Nm 18 lb ft
Fuel Rail Crossover Pipe Fitting 28 Nm 21 lb ft
Generator
Bolt 50 Nm 37 lb ft
Bracket Bolt – Front 50 Nm 37 lb ft
Bracket Bolt – Side 22 Nm 16 lb ft
Cable Nut 13 Nm 115 lb in
- Cable Nut
Ground Cable Bolt 50 Nm 37 lb ft
Heater Inlet and Outlet Pipe Assembly Bolts - M6 10 Nm 89 lb in
Heater Inlet and Outlet Pipe Assembly Bolts - M8 22 Nm 16 lb ft
Idler Pulley Bolt 58 Nm 43 lb ft
Ignition Coil Bolt 10 Nm 89 lb in
Intake Manifold
Brace Bolt – Engine Front Cover M12 65 Nm 48 lb ft
- Brace Bolt – Engine Front Cover M12
Brace Bolt/Ball Stud – Intake Manifold M6 10 Nm 89 lb in
- Brace Bolt/Ball Stud – Intake Manifold M6

Ball Stud to Cam Cover M6 5 Nm 44 lb in
- Ball Stud to Cam Cover M6
Sight Shield Ball Stud 10 Nm 89 lb in
- Sight Shield Ball Stud
Tuning Valve Bolt 10 Nm 89 lb in
- Tuning Valve Bolt
Upper-to-Cylinder Head Bolt – Long 25 Nm 18 lb ft
- Upper-to-Cylinder Head Bolt – Long
Upper-to-Cylinder Head Bolt – Short 25 Nm 18 lb ft
- Upper-to-Cylinder Head Bolt – Short
Upper-to- Lower Intake Manifold Bolt 25 Nm 18 lb ft
- Upper-to- Lower Intake Manifold Bolt
Knock Sensor Bolt 25 Nm 18 lb ft
Manifold Absolute Pressure Sensor (MAP) Bolt 4 Nm 35 lb in
Oil Filter Cap 25 Nm 18 lb ft
Oil Filter Housing Adapter
Bolt – Cylinder Head M10 58 Nm 43 lb ft
- Bolt – Cylinder Head M10
Bolt – Engine Block M8 25 Nm 18 lb ft
- Bolt – Engine Block M8
Oil Gallery Plug – M14 50 Nm 37 lb ft
Oil Gallery Plug – M20 75 Nm 55 lb ft
Oil Level Indicator Tube Bolt 10 Nm 89 lb in
Oil Pan Bolt– Block M8 25 Nm 18 lb ft
Oil Pan Bolt– Crankshaft Rear Oil Seal Housing M6 10 Nm 89 lb in
Oil Pan Drain Plug 25 Nm 18 lb ft
Oil Pan Windage Tray Bolt 10 Nm 89 lb in
Oil Pressure Sender 20 Nm 15 lb ft
Oil Pump Bolt 25 Nm 18 lb ft
Oxygen Sensor Pump Converter Pipe 42 Nm 31 lb ft
PCV Tube Bracket Bolt 10 Nm 89 lb in
Piston Oil Cooling Nozzle Bolt 10 Nm 89 lb in
Power Steering Pump
Bracket to Engine Bolt 58 Nm 43 lb ft
- Bracket to Engine Bolt
Pump to Bracket Bolt 22 Nm 16 lb ft
- Pump to Bracket Bolt
Reservoir Bolt – Lower 25 Nm 18 lb ft
- Reservoir Bolt – Lower
Reservoir Bolt – Upper 9 Nm 80 lb in
- Reservoir Bolt – Upper
Primary Camshaft Drive Chain
Left Lower Guide Bolt – Oil Pump – Second Design 25 Nm 18 lb ft
- Left Lower Guide Bolt – Oil Pump – Second Design
Tensioner Bolt 25 Nm 18 lb ft
- Tensioner Bolt
Upper Guide Bolt 25 Nm 18 lb ft
- Upper Guide Bolt
Radiator Outlet Pipe
Bolt – Generator Bracket 25 Nm 18 lb ft
- Bolt – Generator Bracket
Bolt – Right Cylinder Head Rear 58 Nm 43 lb ft
Bolt – Thermostat Housing 25 Nm 18 lb ft
- Bolt – Thermostat Housing
Secondary Air Injection (SAI) Check Valve Bolt 25 Nm 18 lb ft
Secondary Camshaft Drive Chain
Guide Bolt 25 Nm 18 lb ft
- Guide Bolt
Shoe Bolt 25 Nm 18 lb ft
- Shoe Bolt

Spark Plug 18 Nm 13 lb ft
Starter Motor
Bolt 58 Nm 43 lb ft
Suction Tube Bolt 10 Nm 89 lb in
Suction Screen Bolt 10 Nm 89 lb in
Thermostat Housing Bolt 10 Nm 89 lb in
Throttle Body Bolt 10 Nm 89 lb in
Torque Converter Bolt 60 Nm 44 lb ft
Transmission
Mount Bolt to Transmission – RPO M82 60 Nm 45 lb ft
- Mount Bolt to Transmission – RPO M82
Range Selector Lever Nut 9.5 Nm 84 lb in
- Range Selector Lever Nut
To Engine Bolt 50 Nm 37 lb ft
- To Engine Bolt
Water Pump Bolt
First Pass 10 Nm (1) 89 lb in (1)
Second Pass 10 Nm 89 lb in
- Second Pass
Water Pump Pulley Bolt 10 Nm 89 lb in
1. Use NEW fastener.

Engine Mechanical Specifications (LFX) (Article 12224)

Application Specification

Metric English

General

Engine Type V-6

- Engine Type

Displacement 3.6 Liter 220 cu in

- Displacement

RPO LFX

- RPO

VIN 3

- VIN

Bore 94 mm 3.7008 in

- Bore

Stroke 85.6 mm 3.37 in

- Stroke

Compression Ratio 11.5:1

- Compression Ratio

Firing Order 1-2-3-4-5-6

- Firing Order

Spark Plug Gap 0.95–1.10 mm 0.0375–0.0433 in

- Spark Plug Gap

Block

Crankshaft Main Bearing Bore Diameter 72.867–72.881 mm 2.8688–2.8693 in

- Crankshaft Main Bearing Bore Diameter

Cylinder Bore Diameter 93.992–94.008 mm 3.7005–3.7011 in

- Cylinder Bore Diameter

Cylinder Bore Out-of-Round – Production Max. 0.026 mm 0.001 in

- Cylinder Bore Out-of-Round – Production Max.

Cylinder Bore Taper 0.020 mm 0.0008 in

- Cylinder Bore Taper

Camshaft

Camshaft Bearing Inside Diameter – Front Number 1 35.000–35.020 mm 1.3779–1.3787 in

- Camshaft Bearing Inside Diameter – Front Number 1

Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4 27.000–27.020 mm 1.0630–1.0638 in

- Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4

Camshaft End Play 0.072–0.490 mm 0.0028–0.0190 in

- Camshaft End Play

Camshaft Journal Diameter – Front Number 1 34.936–34.960 mm 1.3754–1.3764 in
- Camshaft Journal Diameter – Front Number 1
Camshaft Journal Diameter – Middle and Rear Number 2–4 26.936–26.960 mm 1.0605–1.0614 in
- Camshaft Journal Diameter – Middle and Rear Number 2–4
Camshaft Journal Out-of-Round 0.006 mm 0.0002 in
- Camshaft Journal Out-of-Round
Camshaft Journal to Bore Clearance 0.040–0.084 mm 0.0016–0.0033 in
- Camshaft Journal to Bore Clearance
Camshaft Lobe Lift – Exhaust 42.425–42.725 mm 1.6703–1.6821 in
- Camshaft Lobe Lift – Exhaust
Camshaft Lobe Lift – Intake 42.385–42.685 mm 1.6687–1.6805 in
- Camshaft Lobe Lift – Intake
Camshaft Runout – Front and Rear Number 1 and 4 0.025 mm 0.0010 in
- Camshaft Runout – Front and Rear Number 1 and 4
Camshaft Runout – Middle 2 and 3 0.050 mm 0.0020 in
- Camshaft Runout – Middle 2 and 3
Valve Lift – Exhaust 10.8 mm 0.4252 in
- Valve Lift – Exhaust
Valve Lift – Intake 10.8 mm 0.4252 in
- Valve Lift – Intake
Connecting Rod
Connecting Rod Bearing Clearance 0.010–0.070 mm 0.0004–0.0026 in
- Connecting Rod Bearing Clearance
Connecting Rod Bore Diameter – Bearing End 59.620–59.636 mm 2.3472–2.3479 in
- Connecting Rod Bore Diameter – Bearing End
Connecting Rod Bore Diameter – Pin End – Production 24.009–24.019 mm 0.9452–0.9456 in
- Connecting Rod Bore Diameter – Pin End – Production
Connecting Rod Bore Diameter – Pin End – Service Maximum 24.021 mm 0.9457 in
- Connecting Rod Bore Diameter – Pin End – Service Maximum
Connecting Rod Length – Center to Center 152.400 mm 6.0000 in
- Connecting Rod Length – Center to Center
Connecting Rod Side Clearance 0.095–0.355 mm 0.00037–0.0140 in
- Connecting Rod Side Clearance
Connecting Rod Width – Bearing End
- Connecting Rod Width – Bearing End
Production 21.775 mm 0.8573 in
- Production
Service 21.725–21.825 mm 0.8553–0.8593 in
- Service
Connecting Rod Width – Pin End
- Connecting Rod Width – Pin End
Crankshaft
Connecting Rod Journal Diameter 55.992–56.008 mm 2.2044–2.2050 in
- Connecting Rod Journal Diameter
Connecting Rod Journal Out-of-Round 0.005 mm 0.0002 in
- Connecting Rod Journal Out-of-Round
Connecting Rod Journal Taper 0.005 mm 0.0002 in
- Connecting Rod Journal Taper
Connecting Rod Journal Width
- 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 End Play
Crankshaft Main Bearing Clearance 0.031–0.069 mm 0.0012–0.0027 in
- Crankshaft Main Bearing Clearance
Crankshaft Main Journal Diameter 67.992–68.008 mm 2.6768–2.6775 in
- Crankshaft Main Journal Diameter
Crankshaft Main Journal Out-of-Round 0.005 mm 0.0002 in
- Crankshaft Main Journal Out-of-Round

Crankshaft Main Journal Taper 0.005 mm 0.0002 in
- Crankshaft Main Journal Taper
Crankshaft Main Journal Thrust Wall
- Crankshaft Main Journal Thrust Wall
Runout 0.000–0.040 mm 0.0000–0.0016 in
- Runout
Square 0.000–0.010 mm 0.0000–0.0004 in
- Square
Crankshaft Main Journal Width, #2, 4
- 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
- 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 20.965–20.995 mm 0.8254–0.8266 in
- Crankshaft Pilot Bearing Bore Diameter
Crankshaft Rear Flange Runout 0.025 mm 0.0010 in
- Crankshaft Rear Flange Runout
Crankshaft Reluctor Ring Runout – Maximum 1.500 mm 0.0591 in
- Crankshaft Reluctor Ring Runout – Maximum
Crankshaft Runout 0.030 mm 0.0012 in
- Crankshaft Runout
Crankshaft Thrust Bearing Clearance 0.076–0.305 mm 0.0030–0.0120 in
- Crankshaft Thrust Bearing Clearance
Crankshaft Thrust Surface – Height Diameter 95.000 mm 3.7401 in
- Crankshaft Thrust Surface – Height Diameter
Crankshaft Thrust Surface Runout 0.040 mm 0.0016 in
- Crankshaft Thrust Surface Runout
Cylinder Head
Valve Guide Bore – Exhaust 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Exhaust
Valve Guide Bore – Intake 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Intake
Valve Guide Installed Height 14.050–14.550 mm 0.5531–0.5728 in
- Valve Guide Installed Height
Valve Lifter Bore Diameter 12.008–12.030 mm 0.4728–0.4736 in
- Valve Lifter Bore Diameter
Lubrication System
Oil Capacity – with Filter 5.7 Liters 6.0 Quarts
- Oil Capacity – with Filter
Oil Capacity – without Filter 5.2 Liters 5.5 Quarts
- Oil Capacity – without Filter
Oil Pressure – Minimum @ Idle 69 kPa 10 psi
- Oil Pressure – Minimum @ Idle
Oil Pressure – Minimum @ 2,000 RPM 207 kPa 30 psi
- Oil Pressure – Minimum @ 2,000 RPM
Piston Cooling Jet Valve Opening Pressure 2.7 bar 35 psi
- Piston Cooling Jet Valve Opening Pressure
Piston Ring s
Piston Ring End Gap
- Piston Ring End Gap
First Compression Ring – Nominal 0.150–0.250 mm 0.0059–0.0098 in
- First Compression Ring – Nominal
First Compression Ring – Maximum, Ring in Bore 0.290 mm 0.0114 in
- First Compression Ring – Maximum, Ring in Bore
Second Compression Ring – Nominal 0.300–0.450 mm 0.0118–0.0177 in
- Second Compression Ring – Nominal
Second Compression Ring – Maximum, Ring in Bore 0.490 mm 0.0193 in

- Second Compression Ring – Maximum, Ring in Bore

Oil Control Ring 0.150–0.350 mm 0.0059–0.0138 in

- Oil Control Ring

Piston Ring to Groove Clearance

- Piston Ring to Groove Clearance

First Compression Ring 0.030–0.075 mm 0.0012–0.0030 in

- First Compression Ring

Second Compression Ring 0.015–0.060 mm 0.0006–0.0024 in

- Second Compression Ring

Oil Control Ring 0.030–0.170 mm 0.0012–0.0067 in

Piston Ring Thickness

- 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

Pistons and Pins

Piston

- Piston

Piston Diameter – Measured Over Skirt Coating 93.976–94.014 mm 3.6998–3.7013 in

- Piston Diameter – Measured Over Skirt Coating

Piston Diameter – Service Limit Minimum w/more than 10K miles 93.926 mm 3.6979 in

- Piston Diameter – Service Limit Minimum w/more than 10K miles

Piston Pin Bore Diameter 24.004–24.009 mm 0.9450–0.9452 in

- Piston Pin Bore Diameter

Piston Ring Groove Width – First Compression Ring 1.020–1.050 mm 0.0402–0.0413 in

- Piston Ring Groove Width – First Compression Ring

Piston Ring Groove Width – Second Compression Ring 1.210–1.230 mm 0.0476–0.0484 in

- Piston Ring Groove Width – Second Compression Ring

Piston Ring Groove Width – Oil Control Ring 1.510–1.530 mm 0.0594–0.0602 in

- Piston Ring Groove Width – Oil Control Ring

Piston to Bore Clearance – Production; Measured at Skirt Coating 0.022–0.032 mm 0.0009–0.0013 in

- Piston to Bore Clearance – Production; Measured at Skirt Coating

Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles 0.050 mm 0.0020 in

- Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles

Pin

- 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 – Production

Piston Pin Clearance to Connecting Rod Bore – Service Maximum 0.030 mm 0.0012 in

- Piston Pin Clearance to Connecting Rod Bore – Service Maximum

Piston Pin Clearance to Piston Pin Bore – Production 0.004–0.012 mm 0.0002–0.0005 in

- Piston Pin Clearance to Piston Pin Bore – Production

Piston Pin Clearance to Piston Pin Bore – Service Maximum 0.015 mm 0.0006 in

- Piston Pin Clearance to Piston Pin Bore – Service Maximum

Piston Pin Diameter 23.997–24.000 mm 0.9448–0.9449 in

- Piston Pin Diameter

Piston Pin Length 52.600–53.100 mm 2.0709–2.0906 in

- Piston Pin Length

Valve System

Valves

- Valves

Valve Face Angle 44.25 degrees

- Valve Face Angle

Valve Face Runout 0.0500 mm 0.0020 in

- Valve Face Runout

Valve Face Width – Exhaust DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Exhaust

Valve Face Width – Intake DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Intake

Valve Head Diameter – Exhaust 30.470–30.730 mm 1.1996–1.2098 in

- Valve Head Diameter – Exhaust
- Valve Head Diameter – Intake 38.170–38.430 mm 1.5028–1.5130 in
- Valve Head Diameter – Intake
- Valve Installed Height 35.23–36.69 mm 1.3870–1.4445 in
- Valve Installed Height
- Valve Length – Exhaust 95.11 mm 3.74 in
- Valve Length – Exhaust
- Valve Length – Intake 100.630 mm 3.9618 in
- Valve Length – Intake
- Valve Seat Angle – Seating Surface 45 degrees
- Valve Seat Angle – Seating Surface
- Valve Seat Angle – Relief Surface 30 degrees
- Valve Seat Angle – Relief Surface
- Valve Seat Angle – Undercut Surface 60 degrees
- Valve Seat Angle – Undercut Surface
- Valve Seat Roundness– Maximum 0.025 mm 0.0010 in
- Valve Seat Roundness– Maximum
- Valve Seat Runout – Maximum 0.080 mm 0.0031 in
- Valve Seat Runout – Maximum
- Valve Seat Width – Exhaust Seating Surface 1.400–1.800 mm 0.0551–0.0709 in
- Valve Seat Width – Exhaust Seating Surface
- Valve Seat Width – Exhaust Relief Surface 0.700–0.900 mm 0.0276–0.0354 in
- Valve Seat Width – Exhaust Relief Surface
- Valve Seat Width – Intake Seating Surface 1.000–1.400 mm 0.0394–0.0551 in
- Valve Seat Width – Intake Seating Surface
- Valve Seat Width – Intake Relief Surface 0.500–0.700 mm 0.0197–0.0276 in
- Valve Seat Width – Intake Relief Surface
- Valve Stem Diameter – Exhaust 5.945–5.965 mm 0.2341–0.2348 in
- Valve Stem Diameter – Exhaust
- Valve Stem Diameter – Intake 5.945–5.965 mm 0.2341–0.2348 in
- Valve Stem Diameter – Intake
- Valve Stem-to-Guide Clearance – Exhaust 0.035–0.075 mm 0.0014–0.0030 in
- Valve Stem-to-Guide Clearance – Exhaust
- Valve Stem-to-Guide Clearance – Intake 0.035–0.075 mm 0.0014–0.0030 in
- Valve Stem-to-Guide Clearance – Intake
- Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)
- Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)
- Valve Lifter (SHLA) Diameter 11.989–12.000 mm 0.4720–0.4724 in
- Valve Lifter (SHLA) Diameter
- Valve Lifter (SHLA)-to-Bore Clearance 0.008–0.041 mm 0.0003–0.0016 in
- Valve Lifter (SHLA)-to-Bore Clearance
- Rocker Arms
- Rocker Arms
- Valve Rocker Arm Ratio 1.68 to 1
- Valve Rocker Arm Ratio
- Valve Rocker Arm Roller Diameter 17.750–17.800 mm 0.6988–0.7008 in
- Valve Rocker Arm Roller Diameter
- Valve Spring s
- Valve Spring s
- Valve Spring Coil Thickness 3.250 x 3.900 mm 0.1280 x 0.1535 in
- Valve Spring Coil Thickness
- Valve Spring Diameter – Inside Top 12.200–12.700 mm 0.4803–0.5000 in
- Valve Spring Diameter – Inside Top
- Valve Spring Diameter – Outside Top 20.250 mm 0.7972 in
- Valve Spring Diameter – Outside Top
- Valve Spring Diameter – Inside Bottom 17.950–18.450 mm 0.7067–0.7264 in
- Valve Spring Diameter – Inside Bottom
- Valve Spring Diameter – Outside Bottom 26.000 mm 1.0236 in
- Valve Spring Diameter – Outside Bottom
- Valve Spring Free Length 42.500–45.500 mm 1.6732–1.7913 in

- Valve Spring Free Length
- Valve Spring Installed Height – Closed 35.000 mm 1.3779 in
- Valve Spring Installed Height – Closed
- Valve Spring Installed Height – Open 24.000 mm 0.9449 in
- Valve Spring Installed Height – Open
- Valve Spring Load – Closed 247–273 N 56–61 lb
- Valve Spring Load – Closed
- Valve Spring Load – Open 598–662 N 134–149 lb
- Valve Spring Load – Open

Thread Repair Specifications (Article 12228)

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)

J 42385– 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

— — J 42385– 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

- 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

- 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

Right Cylinder Head Camshaft Cover Face

- 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

- 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
- 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

Right Cylinder Head Exhaust Face

- 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

Engine Block Front

- 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

- 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

- 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
 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
 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
 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
 4 M6 x 1.0 201 202 N/A 203 204 205 THRU THRU
 Engine Block Left Deck Face
 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
 1 M11 x 2.0 723 N/A N/A 724 725 108 102.5 4.0354 94.0 3.7008
 Engine Front Cover
 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
 Upper Intake Manifold - Front
 Upper Intake Manifold - Rear
 Lower Intake Manifold - Top
 2 M8 x 1.25 206 207 N/A 208 209 210 THRU THRU
 Oil Pan Front
 Oil Pan Left Side
 1 M10 x 1.5 211 212 N/A 213 214 420 33.5 1.3189 27.0 1.0630
 Oil Pan Right Side
 1 M12 x 1.75 856 857 N/A 858 859 855 39.5 1.5551 32.0 1.2598
 Oil Pan Rear
 Oil Pan Top
 1 M6 x 1.0 701 N/A N/A 203 204 205 28.0 1.1024 23.5 0.9252

Engine Mechanical Specifications (LFX) (Article 12225)

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

Cylinder Bore Out-of-Round – Production Max. 0.026 mm 0.001 in

- Cylinder Bore Out-of-Round – Production Max.

Cylinder Bore Taper 0.020 mm 0.0008 in

- Cylinder Bore Taper

Camshaft

Camshaft Bearing Inside Diameter – Front Number 1 35.000–35.020 mm 1.3779–1.3787 in

- Camshaft Bearing Inside Diameter – Front Number 1

Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4 27.000–27.020 mm 1.0630–1.0638 in

- Camshaft Bearing Inside Diameter – Middle and Rear Number 2–4

Camshaft End Play 0.072–0.490 mm 0.0028–0.0190 in

- Camshaft End Play

Camshaft Journal Diameter – Front Number 1 34.936–34.960 mm 1.3754–1.3764 in

- Camshaft Journal Diameter – Front Number 1

Camshaft Journal Diameter – Middle and Rear Number 2–4 26.936–26.960 mm 1.0605–1.0614 in

- Camshaft Journal Diameter – Middle and Rear Number 2–4

Camshaft Journal Out-of-Round 0.006 mm 0.0002 in

- Camshaft Journal Out-of-Round

Camshaft Journal to Bore Clearance 0.040–0.084 mm 0.0016–0.0033 in

- Camshaft Journal to Bore Clearance

Camshaft Lobe Lift – Exhaust 42.425–42.725 mm 1.6703–1.6821 in

- Camshaft Lobe Lift – Exhaust

Camshaft Lobe Lift – Intake 42.385–42.685 mm 1.6687–1.6805 in

- Camshaft Lobe Lift – Intake

Camshaft Runout – Front and Rear Number 1 and 4 0.025 mm 0.0010 in

- Camshaft Runout – Front and Rear Number 1 and 4

Camshaft Runout – Middle 2 and 3 0.050 mm 0.0020 in

- Camshaft Runout – Middle 2 and 3

Valve Lift – Exhaust 10.8 mm 0.4252 in

- Valve Lift – Exhaust

Valve Lift – Intake 10.8 mm 0.4252 in

- Valve Lift – Intake

Connecting Rod

Connecting Rod Bearing Clearance 0.010–0.070 mm 0.0004–0.0026 in

- Connecting Rod Bearing Clearance

Connecting Rod Bore Diameter – Bearing End 59.620–59.636 mm 2.3472–2.3479 in

- Connecting Rod Bore Diameter – Bearing End

Connecting Rod Bore Diameter – Pin End – Production 24.009–24.019 mm 0.9452–0.9456 in

- Connecting Rod Bore Diameter – Pin End – Production

Connecting Rod Bore Diameter – Pin End – Service Maximum 24.021 mm 0.9457 in

- Connecting Rod Bore Diameter – Pin End – Service Maximum

Connecting Rod Length – Center to Center 152.400 mm 6.0000 in

- Connecting Rod Length – Center to Center

Connecting Rod Side Clearance 0.095–0.355 mm 0.00037–0.0140 in

- Connecting Rod Side Clearance

Connecting Rod Width – Bearing End

- Connecting Rod Width – Bearing End

Production 21.775 mm 0.8573 in

- Production

Service 21.725–21.825 mm 0.8553–0.8593 in

- Service

Connecting Rod Width – Pin End

- Connecting Rod Width – Pin End

Crankshaft

Connecting Rod Journal Diameter 55.992–56.008 mm 2.2044–2.2050 in

- Connecting Rod Journal Diameter

Connecting Rod Journal Out-of-Round 0.005 mm 0.0002 in

- Connecting Rod Journal Out-of-Round

Connecting Rod Journal Taper 0.005 mm 0.0002 in

- Connecting Rod Journal Taper

Connecting Rod Journal Width

- 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 End Play
- Crankshaft Main Bearing Clearance 0.031–0.069 mm 0.0012–0.0027 in
- Crankshaft Main Bearing Clearance
- Crankshaft Main Journal Diameter 67.992–68.008 mm 2.6768–2.6775 in
- Crankshaft Main Journal Diameter
- Crankshaft Main Journal Out-of-Round 0.005 mm 0.0002 in
- Crankshaft Main Journal Out-of-Round
- Crankshaft Main Journal Taper 0.005 mm 0.0002 in
- Crankshaft Main Journal Taper
- Crankshaft Main Journal Thrust Wall
- Crankshaft Main Journal Thrust Wall
- Runout 0.000–0.040 mm 0.0000–0.0016 in
- Runout
- Square 0.000–0.010 mm 0.0000–0.0004 in
- Square
- Crankshaft Main Journal Width, #2, 4
- 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
- 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 20.965–20.995 mm 0.8254–0.8266 in
- Crankshaft Pilot Bearing Bore Diameter
- Crankshaft Rear Flange Runout 0.025 mm 0.0010 in
- Crankshaft Rear Flange Runout
- Crankshaft Reluctor Ring Runout – Maximum 1.500 mm 0.0591 in
- Crankshaft Reluctor Ring Runout – Maximum
- Crankshaft Runout 0.030 mm 0.0012 in
- Crankshaft Runout
- Crankshaft Thrust Bearing Clearance 0.076–0.305 mm 0.0030–0.0120 in
- Crankshaft Thrust Bearing Clearance
- Crankshaft Thrust Surface – Height Diameter 95.000 mm 3.7401 in
- Crankshaft Thrust Surface – Height Diameter
- Crankshaft Thrust Surface Runout 0.040 mm 0.0016 in
- Crankshaft Thrust Surface Runout
- Cylinder Head
- Valve Guide Bore – Exhaust 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Exhaust
- Valve Guide Bore – Intake 6.000–6.020 mm 0.2362–0.2370 in
- Valve Guide Bore – Intake
- Valve Guide Installed Height 14.050–14.550 mm 0.5531–0.5728 in
- Valve Guide Installed Height
- Valve Lifter Bore Diameter 12.008–12.030 mm 0.4728–0.4736 in
- Valve Lifter Bore Diameter
- Lubrication System
- Oil Capacity – with Filter 5.7 Liters 6.0 Quarts
- Oil Capacity – with Filter
- Oil Capacity – without Filter 5.2 Liters 5.5 Quarts
- Oil Capacity – without Filter
- Oil Pressure – Minimum @ Idle 69 kPa 10 psi
- Oil Pressure – Minimum @ Idle
- Oil Pressure – Minimum @ 2,000 RPM 207 kPa 30 psi
- Oil Pressure – Minimum @ 2,000 RPM
- Piston Cooling Jet Valve Opening Pressure 2.7 bar 35 psi

- Piston Cooling Jet Valve Opening Pressure

Piston Ring s

Piston Ring End Gap

- Piston Ring End Gap

First Compression Ring – Nominal 0.150–0.250 mm 0.0059–0.0098 in

- First Compression Ring – Nominal

First Compression Ring – Maximum, Ring in Bore 0.290 mm 0.0114 in

- First Compression Ring – Maximum, Ring in Bore

Second Compression Ring – Nominal 0.300–0.450 mm 0.0118–0.0177 in

- Second Compression Ring – Nominal

Second Compression Ring – Maximum, Ring in Bore 0.490 mm 0.0193 in

- Second Compression Ring – Maximum, Ring in Bore

Oil Control Ring 0.150–0.350 mm 0.0059–0.0138 in

- Oil Control Ring

Piston Ring to Groove Clearance

- Piston Ring to Groove Clearance

First Compression Ring 0.030–0.075 mm 0.0012–0.0030 in

- First Compression Ring

Second Compression Ring 0.015–0.060 mm 0.0006–0.0024 in

- Second Compression Ring

Oil Control Ring 0.030–0.170 mm 0.0012–0.0067 in

Piston Ring Thickness

- 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

Pistons and Pins

Piston

- Piston

Piston Diameter – Measured Over Skirt Coating 93.976–94.014 mm 3.6998–3.7013 in

- Piston Diameter – Measured Over Skirt Coating

Piston Diameter – Service Limit Minimum w/more than 10K miles 93.926 mm 3.6979 in

- Piston Diameter – Service Limit Minimum w/more than 10K miles

Piston Pin Bore Diameter 24.004–24.009 mm 0.9450–0.9452 in

- Piston Pin Bore Diameter

Piston Ring Groove Width – First Compression Ring 1.020–1.050 mm 0.0402–0.0413 in

- Piston Ring Groove Width – First Compression Ring

Piston Ring Groove Width – Second Compression Ring 1.210–1.230 mm 0.0476–0.0484 in

- Piston Ring Groove Width – Second Compression Ring

Piston Ring Groove Width – Oil Control Ring 1.510–1.530 mm 0.0594–0.0602 in

- Piston Ring Groove Width – Oil Control Ring

Piston to Bore Clearance – Production; Measured at Skirt Coating 0.022–0.032 mm 0.0009–0.0013 in

- Piston to Bore Clearance – Production; Measured at Skirt Coating

Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles 0.050 mm 0.0020 in

- Piston to Bore Clearance – Service Limit Maximum, w/more than 10k miles

Pin

- 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 – Production

Piston Pin Clearance to Connecting Rod Bore – Service Maximum 0.030 mm 0.0012 in

- Piston Pin Clearance to Connecting Rod Bore – Service Maximum

Piston Pin Clearance to Piston Pin Bore – Production 0.004–0.012 mm 0.0002–0.0005 in

- Piston Pin Clearance to Piston Pin Bore – Production

Piston Pin Clearance to Piston Pin Bore – Service Maximum 0.015 mm 0.0006 in

- Piston Pin Clearance to Piston Pin Bore – Service Maximum

Piston Pin Diameter 23.997–24.000 mm 0.9448–0.9449 in

- Piston Pin Diameter

Piston Pin Length 52.600–53.100 mm 2.0709–2.0906 in

- Piston Pin Length

Valve System

Valves

- Valves

Valve Face Angle 44.25 degrees

- Valve Face Angle

Valve Face Runout 0.0500 mm 0.0020 in

- Valve Face Runout

Valve Face Width – Exhaust DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Exhaust

Valve Face Width – Intake DO NOT GRIND, REPLACE VALVE DO NOT GRIND, REPLACE VALVE

- Valve Face Width – Intake

Valve Head Diameter – Exhaust 30.470–30.730 mm 1.1996–1.2098 in

- Valve Head Diameter – Exhaust

Valve Head Diameter – Intake 38.170–38.430 mm 1.5028–1.5130 in

- Valve Head Diameter – Intake

Valve Installed Height 35.23–36.69 mm 1.3870–1.4445 in

- Valve Installed Height

Valve Length – Exhaust 95.11 mm 3.74 in

- Valve Length – Exhaust

Valve Length – Intake 100.630 mm 3.9618 in

- Valve Length – Intake

Valve Seat Angle – Seating Surface 45 degrees

- Valve Seat Angle – Seating Surface

Valve Seat Angle – Relief Surface 30 degrees

- Valve Seat Angle – Relief Surface

Valve Seat Angle – Undercut Surface 60 degrees

- Valve Seat Angle – Undercut Surface

Valve Seat Roundness– Maximum 0.025 mm 0.0010 in

- Valve Seat Roundness– Maximum

Valve Seat Runout – Maximum 0.080 mm 0.0031 in

- Valve Seat Runout – Maximum

Valve Seat Width – Exhaust Seating Surface 1.400–1.800 mm 0.0551–0.0709 in

- Valve Seat Width – Exhaust Seating Surface

Valve Seat Width – Exhaust Relief Surface 0.700–0.900 mm 0.0276–0.0354 in

- Valve Seat Width – Exhaust Relief Surface

Valve Seat Width – Intake Seating Surface 1.000–1.400 mm 0.0394–0.0551 in

- Valve Seat Width – Intake Seating Surface

Valve Seat Width – Intake Relief Surface 0.500–0.700 mm 0.0197–0.0276 in

- Valve Seat Width – Intake Relief Surface

Valve Stem Diameter – Exhaust 5.945–5.965 mm 0.2341–0.2348 in

- Valve Stem Diameter – Exhaust

Valve Stem Diameter – Intake 5.945–5.965 mm 0.2341–0.2348 in

- Valve Stem Diameter – Intake

Valve Stem-to-Guide Clearance – Exhaust 0.035–0.075 mm 0.0014–0.0030 in

- Valve Stem-to-Guide Clearance – Exhaust

Valve Stem-to-Guide Clearance – Intake 0.035–0.075 mm 0.0014–0.0030 in

- Valve Stem-to-Guide Clearance – Intake

Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)

- Valve Lifters – Stationary Hydraulic Lash Adjuster (SHLA)

Valve Lifter (SHLA) Diameter 11.989–12.000 mm 0.4720–0.4724 in

- Valve Lifter (SHLA) Diameter

Valve Lifter (SHLA)-to-Bore Clearance 0.008–0.041 mm 0.0003–0.0016 in

- Valve Lifter (SHLA)-to-Bore Clearance

Rocker Arms

- Rocker Arms

Valve Rocker Arm Ratio 1.68 to 1

- Valve Rocker Arm Ratio

Valve Rocker Arm Roller Diameter 17.750–17.800 mm 0.6988–0.7008 in

- Valve Rocker Arm Roller Diameter

Valve Spring s

- Valve Spring s

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

Engine Mechanical - Adhesives, Fluids, Lubricants, and Sealers (Except Korea) (Article 12219)

Application Type of Material GM Part Number
 United States Canada
 Block Pan Rail * Sealant 19369831 19369832
 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 19369831 19369832
 Engine Front Cover /Split Lines * Sealant 19369831 19369832
 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
 Intake Manifold Bolt Threadlocker 12345382 10953489
 Oil Gallery Threaded Plug Sealant 12346004 10953480
 Oil Pan , Engine Front Cover, Crankshaft Rear Oil Seal Housing * Sealant 19369831 (150g cartridge) 19369832
 88861417 (75 gram squeeze tube) 88861418
 Piston Pin Bores 5W-30 19293000 19286321
 Positive Crankcase Ventilation (PCV) Orifice Sealant 19369831 19369832
 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
 * Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

Engine Mechanical - Adhesives, Fluids, Lubricants, and Sealers (Korea) (Article 12221)

Application Type of Material (GMDAT) GMDAT Part Number
 Block Pan Rail * Sealant 19369831
 Camshaft Prelube Engine Oil Refer to Parts Catalog
 Coolant Drain Threaded Plug Sealant 12346004

Coolant Expansion Plugs Sealant 12345382
Coolant and Oil Plug Threads Sealant 12346004
Crankshaft Bearing Surfaces Engine Oil Refer to Parts Catalog
Crankshaft Connecting Rod Bearing Journal Engine Oil Refer to Parts Catalog
Crankshaft Prelube Engine Oil Refer to Parts Catalog
Crankshaft Rear Oil Seal Housing * Sealant 19369831
Engine Front Cover /Split Lines * Sealant 19369831
Engine Oil 5W-30 Refer to Parts Catalog
Engine Oil dexos™ SAE 5W-30 Refer to Parts Catalog
Fuel Injection Fuel Rail Fuel Pressure Sensor Sealing Cone/Threads Engine Oil Refer to Parts Catalog
Fuel Rail Sealing Cone/Threads Engine Oil Refer to Parts Catalog
Oil Gallery Threaded Plug Sealant 12346004
Oil Pan , Engine Front Cover, Crankshaft Rear Oil Seal Housing * Sealant 19369831
Piston Pin Bores Engine Oil Refer to Parts Catalog
Positive Crankcase Ventilation (PCV) Orifice Sealant 19369831
Stationary Hydraulic Lash Adjuster (SHLA) Engine Oil Refer to Parts Catalog
SHLA Bores in Cylinder Head Engine Oil Refer to Parts Catalog
SHLA Pivot Spheres Engine Oil Refer to Parts Catalog
Thread Repair N/A N/A
Valve Stem/Guide ID Engine Oil Refer to Parts Catalog
* Ensure proper use of room temperature vulcanizing (RTV) sealant. Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant

All New Technical Service Bulletins (itype_432)

Tsbs

- Engine Replacement After Severe Internal Engine Damage – Replace Intake Manifold (00-06-01-026T, 2025/10/13)
- Diagnostic Aids for Gas Engine Misfire/rough running with DTC P0300-P0308 and/or DTC P050D (26-NA-066, 2026/02/25)
- Fuel and Oil Additives - Facts and Myths - Maximizing Gasoline Fuel Economy (05-00-89-072H, 2026/05/05)
- Information on Rough Idle, Crank No Start, Extended Crank or Misfire Due to Excessive Carbon on Top of Valves or Sticking Valves, Malfunction Indicator Light (MIL) Illuminated - DTC P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307, P0308 Set (16-NA-383, 2026/05/05)
- Diagnostic Tips for Knocking, Rattle, Squeak and/or Squeal Type Noise from Engine – Engine Replacement Recommendations for HFV6 Gen 1 and Gen 2 (19-NA-256, 2025/06/25)
- Repair Guidelines for Engine Component Wear (18-NA-073, 2024/08/19)
- Information on Internal Engine Noise or Damage After Oil Filter Replacement (07-06-01-016K, 2025/07/17)
- Diagnostic Tip for Misfire, Chirp, Squeak, Squeal or Tick Noise, Malfunction Indicator Lamp (MIL) Illuminated - DTC P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307 and/or P0308 Set (19-NA-219, 2024/11/22)
- Information for Engine Concerns Resulting from Lack of Scheduled Maintenance, Improper Service or Aftermarket Calibrations (Gasoline Engines Only) (16-NA-222, 2025/07/18)
- Information on Gasoline Engine Replacement Guidelines after Connecting Rod or Crankshaft Main Bearing Damage – Replace Oil Cooler, Oil Cooler Lines, Oil Tank and Turbocharger (22-NA-074, 2026/02/23)
- Information on Engine Block Cracked at Head Bolt Hole Locations (23-NA-141, 2024/08/07)
- Information on Spin-On Oil Filter Replacement for Gas Engines Designed with New Oil Pump Control Systems (17-NA-157, 2025/11/19)
- Cold Start Misfire and/or Rough Idle – DTC P0300 May Be Set (18-NA-115, 2024/07/23)
- Warranty Administration – Engine and Transmission Assembly Replacement (U.S. Only) (20-NA-138, 2025/11/20)
- Fluid in Spark Plug Tubes, Coolant and/or Oil Leak, Malfunction Indicator Lamp (MIL) Illuminated (21-NA-147, 2025/07/25)
- Information on Engine Oil Consumption Guidelines (01-06-01-011S, 2025/07/28)
- OEM and Remanufactured Engine and Automatic Transmission/Transaxle Identification (06-00-89-031J, 2025/08/05)
- Ticking, Tap, or Rattle Noise from Engine (20-NA-029, 2026/05/27)

All Technical Service Bulletins (itype_100)

Tsbs

- Vehicle - PQC Assembly Replacement (02-07-30-029Z, 2016/04/27)

- Information Assistance for HFV6 Re-Manufactured Engine Drivability Diagnosis Immediately Following Installation (PIP5528F, 2020/06/26)
- PIP5257D: Cooling System Contaminated With Engine Oil (PIP5257D, 2020/04/17)
- Fuel and Oil Additives - Facts and Myths - Maximizing Gasoline Fuel Economy (05-00-89-072H, 2026/05/05)
- Engine Oil Dye May be Mistaken for Contamination on Low Mileage Engines (PI0275B, 2012/02/17)
- Diagnostic Tips for Knocking, Rattle, Squeak and/or Squeal Type Noise from Engine – Engine Replacement Recommendations for HFV6 Gen 1 and Gen 2 (19-NA-256, 2025/06/25)
- Repair Guidelines for Engine Component Wear (18-NA-073, 2024/08/19)
- Vehicle - Reuse of Fasteners and Proper Torque Info (15-NA-069, 2015/11/30)
- Information On Remanufactured Engine Misfire Diagnosis After Installation (17-NA-307, 2017/09/26)
- Information on Clicking/Ticking Sound/Noise Heard During Cold Start (07-06-04-025M, 2020/05/28)
- Engine - dexos 1(R) and dexos 2(R) Oil Specs/Information (11-00-90-001B, 2013/05/21)
- Information for Engine Concerns Resulting from Lack of Scheduled Maintenance, Improper Service or Aftermarket Calibrations (Gasoline Engines Only) (16-NA-222, 2025/07/18)
- Product Quality Center (PQC) Assembly Replacement Process — For Service Agents Not Required to Contact PQC Prior to Assembly Replacement (12-07-30-001E, 2015/03/26)
- Information on Engine Block Cracked at Head Bolt Hole Locations (23-NA-141, 2024/08/07)
- Information on New Torque Specification and Installation Procedure for ACDelco Spin-On Oil Filters (22-NA-009, 2023/03/17)
- Fluid in Spark Plug Tubes, Coolant and/or Oil Leak, Malfunction Indicator Lamp (MIL) Illuminated (21-NA-147, 2025/07/25)
- Ticking, Tap, or Rattle Noise from Engine (20-NA-029, 2026/05/27)
- Information on Engine Overheating, Cooling System Contaminated with Engine Oil (21-NA-108, 2021/05/04)
- SES Light with Fuel Trim and or Oxygen Sensor Codes (PIP4925B, 2018/12/03)
- Engine Replacement After Severe Internal Engine Damage – Replace Intake Manifold (00-06-01-026T, 2025/10/13)
- Needle Bearings Found In The Oil Pan During An Oil Change (PIP5226D, 2020/07/27)
- Diagnostic Aids for Gas Engine Misfire/rough running with DTC P0300-P0308 and/or DTC P050D (26-NA-066, 2026/02/25)
- Fuel System - Cold Start Misfire After Engine/Fuel Sys Repair (PI1296, 2014/08/19)
- Information on Rough Idle, Crank No Start, Extended Crank or Misfire Due to Excessive Carbon on Top of Valves or Sticking Valves, Malfunction Indicator Light (MIL) Illuminated - DTC P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307, P0308 Set (16-NA-383, 2026/05/05)
- Engine - Supplemental Timing Information (PIP4384H, 2014/01/16)
- Information on Internal Engine Noise or Damage After Oil Filter Replacement (07-06-01-016K, 2025/07/17)
- Diagnostic Tip for Misfire, Chirp, Squeak, Squeal or Tick Noise, Malfunction Indicator Lamp (MIL) Illuminated - DTC P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307 and/or P0308 Set (19-NA-219, 2024/11/22)
- Engine Ticking Noise or oil pressure fluctuation On Cold Start (PIP5191C, 2018/11/06)
- Information on Gasoline Engine Replacement Guidelines after Connecting Rod or Crankshaft Main Bearing Damage – Replace Oil Cooler, Oil Cooler Lines, Oil Tank and Turbocharger (22-NA-074, 2026/02/23)
- Information on Spin-On Oil Filter Replacement for Gas Engines Designed with New Oil Pump Control Systems (17-NA-157, 2025/11/19)
- Cold Start Misfire and/or Rough Idle – DTC P0300 May Be Set (18-NA-115, 2024/07/23)
- Information on Improved Oil Filter Gasket Design for Spin-On Oil Filters PF63 PF64 and PF48 (20-NA-213, 2020/10/30)
- DTC P0016 P0017 P0018 P0019 P0008 P0009 (PIP3423P, 2018/08/08)
- Automatic Transmission Shift and Engine Drivability Concerns and/or Malfunction Indicator Lamp (MIL) ON Due to Aftermarket Oil Bath Air Filter Use (04-07-30-013E, 2023/06/07)
- Engine - Oil Leak Prevention After Oil/Filter Change (15-00-90-001, 2015/03/06)
- Warranty Administration – Engine and Transmission Assembly Replacement (U.S. Only) (20-NA-138, 2025/11/20)
- Information on Engine Oil Consumption Guidelines (01-06-01-011S, 2025/07/28)
- OEM and Remanufactured Engine and Automatic Transmission/Transaxle Identification (06-00-89-031J, 2025/08/05)
- Alleged Cylinders Out Of Round (PIP5163D, 2018/08/08)
- Information for Repairing Engine Front Cover Oil Leak, Sealing Surface Preparation and Applying RTV Sealant (12-06-01-003D, 2022/05/02)
- Engine - Crankshaft Rear Oil Seal Leaks (14-06-01-002A, 2014/12/01)
- Engine Controls - Single Cylinder Misfire Diagnostics (PIP5062C, 2014/05/02)

Customer Interest Bulletins (itype_109)

Tsbs

- Engine - Crankshaft Rear Oil Seal Leaks (14-06-01-002A, 2014/12/01)

Repair Tips (itype_110)

Tsbs

- Engine - dexos 1(R) and dexos 2(R) Oil Specs/Information (11-00-90-001B, 2013/05/21)
- Fuel System - Cold Start Misfire After Engine/Fuel Sys Repair (PI1296, 2014/08/19)
- Engine - Oil Leak Prevention After Oil/Filter Change (15-00-90-001, 2015/03/06)
- Engine - Supplemental Timing Information (PIP4384H, 2014/01/16)
- Engine Controls - Single Cylinder Misfire Diagnostics (PIP5062C, 2014/05/02)

Cylinder Leakage Test (Article 12027)

Special Tools

- EN-35667–A - Cylinder Head Leakdown Tester
- EN-51749 - Compression Gauge Tester Kit

Equivalent regional tools: Special Tools

Procedure

A leakage test is 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 spring s
- Stuck valve lifter s
- Incorrect valve lash /adjustment
- Damaged piston
- Worn piston ring s
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block
- Disconnect the battery ground negative cable.
- Remove the spark plugs . Gas Engine Ignition Spark Plug Replacement
- Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
- Thread the EN-51749 - adapter into the spark plug hole.
- Install the EN-35667–A - tester or equivalent.
- Apply shop air pressure to the EN-35667-A - tester and adjust according to the manufacturers instructions.
- 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.
- Perform the leakage test on the remaining cylinders and record the values.

Oil Consumption Diagnosis (Article 12038)

Checks Causes

DEFINITION: Excessive oil consumption (not due to leaks) is the use of 0.9 L (1 qt) or more of engine oil within 3 218 km (2,000 mi). 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 seal s

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

- 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 seal s
- 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

Oil Leak Diagnosis (Article 12039)

Step Action Yes No

Note: 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.

1 Operate the vehicle until it reaches normal operating temperature. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. Wait 15 minutes. Inspect for drippings. Are drippings present?

Go to Step 2 System OK

- Operate the vehicle until it reaches normal operating temperature.
- Park the vehicle on a level surface, over a large sheet of paper or other clean surface.
- Wait 15 minutes.
- Inspect for drippings.

2 Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 3

3 Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. Inspect for leaks at the following locations: Sealing surfaces Fittings Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 4

- Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.
- Inspect for leaks at the following locations:
- Sealing surfaces
- Fittings
- Cracked or damaged components

4 Completely clean the entire engine and surrounding components. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. Wait 15 minutes. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 5

- Completely clean the entire engine and surrounding components.
- Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds.
- 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. Inspect for leaks at the following locations: Sealing surfaces Fittings Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 6

6 Completely clean the entire engine and surrounding components. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 7

- Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area.
- Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface.

7 Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. Inspect for leaks at the following locations: Sealing surfaces Fittings Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 8

8 Use the J 28428-E - High-Intensity Black Light Kit in order to identify the type of fluid, and the

approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 Go to Step 9

9 Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. Inspect for leaks at the following locations: Sealing surfaces Fittings Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak? Go to Step 10 System OK

10 Inspect the engine for mechanical damage. Special attention should be shown to the following areas: 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 in area of leak Cracked or porous components Improper sealant or gasket installation Damaged or worn gaskets or seals Damaged or worn sealing surfaces Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine? Go to Step 11 System OK

- Inspect the engine for mechanical damage. Special attention should be shown to the following areas:

- 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 in area of leak
- Cracked or porous components
- Improper sealant or gasket installation
- Damaged or worn gaskets or seals
- Damaged or worn sealing surfaces
- Inspect the engine for customer modifications.

11 Repair or replace all damaged or modified components. Does the engine still leak oil? Go to Step 1 System OK

Symptoms - Engine Mechanical (Article 12041)

Strategy Based Diagnostics

- Perform a Diagnostic System Check - Vehicle before using the symptom tables, if applicable.
- 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. 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

Base Engine Misfire w/o Internal Engine Noises (Article 12023)

Cause Correction

Abnormalities, severe 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 excessive pulley runout 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 improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition. Repair or replace the flywheel and/or balancer as required. Refer to Flywheel Replacement or Crankshaft Balancer Replacement .

Restricted exhaust system A severe 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 converter s. Repair or replace as required.

Improperly installed or damaged vacuum hoses Repair or replace as required.

Improper sealing between the intake manifold and cylinder head s, intake manifold and plenum duct, plenum duct and water crossover , water crossover and throttle body and/or pressure relief valve and intake manifold.

Replace the intake manifold, plenum duct, gaskets, cylinder heads, throttle body and/or pressure relief valve as required.

Improperly installed or damaged MAP sensor and/or seal The sealing grommet of the MAP sensor should not be torn or damaged. Repair or replace the MAP sensor as required.

Improperly installed or damaged EVAP purge solenoid and/or O-ring seal Repair or replace the EVAP purge solenoid as required.

Worn or loose followers, valve rocker arm s 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 lifter s.

Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . Repair or replace the oil pump as required.

- 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 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 Gas Engine Ignition Spark Plug Inspection for the 3.6L engine. Inspect the cylinder heads, engine block, and/or head gaskets. Repair or replace as required.

- Inspect for spark plugs saturated by coolant. Refer to Gas Engine Ignition Spark Plug Inspection for the 3.6L engine.

- Inspect the cylinder heads, engine block, and/or head gaskets.

- Repair or replace as required.

Worn piston ring s Oil consumption may or may not cause the engine to misfire. Inspect the spark plug s for oil deposits. Refer to Gas Engine Ignition Spark Plug Inspection for the 3.6L engine. 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.

- Inspect the spark plug s for oil deposits. Refer to Gas Engine Ignition Spark Plug Inspection for the 3.6L engine.

- Inspect the cylinders for a loss of compression. Refer to Engine Compression Test .

- Perform cylinder leak down and compression testing to identify the cause.

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 SEVERE 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.

- Systems with SEVERE 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.

Base Engine Misfire w/ Abnormal Internal Lower Engine Noises (Article 12019)

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 Flywheel Replacement or Automatic Transmission Flex Plate Replacement or Crankshaft Balancer Replacement .

Worn or broken piston ring s Oil consumption may or may not cause the engine to misfire. Inspect the spark plugs for oil deposits. Refer to Gas Engine Ignition 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.

- Inspect the spark plugs for oil deposits. Refer to Gas Engine Ignition 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.

Base Engine Misfire w/ Abnormal Valve Train Noise (Article 12020)

Cause Correction

Worn or loose followers, valve rocker arm s The follower, valve rocker arm, and roller bearing should be intact and in the proper position. Replace the followers and/or valve rocker arms, as required.

Stuck valves Carbon buildup on the valve stem can cause the valve not to close properly. Repair or replace the valves 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 (Stationary Hydraulic Lash Adjuster) SHLAs (valve lifter s).

Sticking SHLAs (valve lifters) Replace the SHLAs as required.

Base Engine Misfire w/ Coolant Consumption (Article 12021)

Cause Correction

Faulty cylinder head gaskets and/or cracking or other damage to the cylinder head s 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 Gas Engine Ignition Spark Plug Inspection for the 3.6L engine. 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.

- Inspect for spark plugs saturated by coolant. Refer to Gas Engine Ignition Spark Plug Inspection for the 3.6L engine.

- 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.

Vibration Diagnosis and Correction (Article 12608)

Non Standards

- Vibration Analysis - Engine (12637)
- Engine order Classification (12609)
- Vibration Analysis - Engine/Accessory Isolation (12639)
- Vibration Analysis - Engine Balance (12638)

Base Engine Misfire w/ Excessive Oil Consumption (Article 12022)

Cause Correction

Worn valves, valve guides and/or valve stem oil seals Inspect the spark plugs for oil deposits. Gas Engine Ignition Spark Plug Inspection Repair or replace valves, valve guides and/or valve stem oil seals as required.

- Inspect the spark plugs for oil deposits. Gas Engine Ignition Spark Plug Inspection
- Repair or replace valves, valve guides and/or valve stem oil seals as required.

Worn piston rings Oil consumption may or may not cause the engine to misfire. Inspect the spark plug s for oil deposits. Gas Engine Ignition Spark Plug Inspection Inspect the cylinders for a loss of compression.

Engine Compression Test Perform cylinder leak down and compression testing to determine the cause. Repair or replace piston rings as required.

- Inspect the spark plug s for oil deposits. Gas Engine Ignition Spark Plug Inspection
- Inspect the cylinders for a loss of compression. Engine Compression Test
- Perform cylinder leak down and compression testing to determine the cause.
- Repair or replace piston rings as required.

Engine Noise on Start-Up, But Only Lasting a Few Seconds (Article 12033)

Cause Correction

Incorrect oil filter without anti-drainback feature Install the correct oil filter. Maintenance Items

Incorrect oil viscosity Drain the engine oil and replace with the correct viscosity oil. Adhesives, Fluids, Lubricants, and Sealers

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.

- Inspect the thrust bearing and crankshaft.
- Repair or replace as required.

Damaged or faulty oil filter bypass valve Inspect the oil filter bypass valve for proper operation. Repair or replace as required.

- Inspect the oil filter bypass valve for proper operation.

Malfunctioning camshaft position actuators - improper oil viscosity or contamination. Isolate the noise to a specific camshaft position actuator. Disconnect the electrical connector on the camshaft position actuator solenoid valves and start the vehicle. If noise is gone, repeat procedure to limit to an individual actuator.

Camshaft Position Actuator Replacement - Bank 1 or Camshaft Position Actuator Replacement - Bank 2

Upper Engine Noise, Regardless of Engine Speed (Article 12042)

Cause Correction

Low oil pressure Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . Repair or replace as required.

- Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing .
- Repair or replace as required.

Loose and/or worn follower, valve rocker arm Inspect the follower, valve rocker arm. Repair or replace as required.

- Inspect the follower, valve rocker arm.

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

- 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 Inspect the engine camshaft lobes. Replace the camshaft or camshafts and SHLAs, valve lifters, as required.

- Inspect the engine camshaft lobes.
- 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: The valves The valve guides

- 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

- Stuck valves
- Carbon on the valve stem or valve seat may cause the valve to stay open

Lower Engine Noise, Regardless of Engine Speed (Article 12037)

Cause Correction

Low oil pressure Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . Repair or replace damaged components as required.

- Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing .
- 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. Inspect the accessory drive system. Repair or replace 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.
- Inspect the accessory drive system.
- Repair or replace as required.

Loose or damaged crankshaft balancer Inspect the crankshaft balancer. Repair or replace as required.

- Inspect the crankshaft balancer.

Detonation or spark knock Verify the correct operation of the ignition controls system. Refer Symptoms - Engine Controls .

Loose torque converter bolts Inspect the torque converter bolts and engine flywheel. Repair or replace as required.

- Inspect the torque converter bolts and engine flywheel.

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. Inspect the oil pan. Inspect the oil pump screen.

Repair or replace as required.

- 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.
- Inspect the oil pan.
- Inspect the oil pump screen.

Oil pump screen loose, damaged or restricted Inspect the oil pump screen. Repair or replace as required.

Excessive piston -to- cylinder bore clearance Inspect the piston and cylinder bore. Repair as required.

- Inspect the piston and cylinder bore.
- Repair as required.

Excessive piston pin-to-bore clearance Inspect the piston, piston pin, and the connecting rod . Repair or replace as required.

- Inspect the piston, piston pin, and the connecting rod .

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

- 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

- The crankshaft bearings

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. Verify the pistons, piston pins and connecting rods are installed correctly. Repair as required.

- 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.
- Verify the pistons, piston pins and connecting rods are installed correctly.

Engine Noise Under Load (Article 12034)

Cause Correction

Low oil pressure Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . Repair or replace as required.

- Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing .
- 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 Inspect the torque converter bolts and engine flywheel. Repair as required.

- Inspect the torque converter bolts and engine flywheel.
- Repair as required.

Cracked engine flywheel Inspect the engine flywheel and bolts. Repair as required.

- Inspect the engine flywheel and bolts.

Excessive connecting rod bearing clearance Inspect the following components, and repair as required: The connecting rod bearings The connecting rods The crankshaft

- 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

- The crankshaft bearings
- The crankshaft journals
- The cylinder block crankshaft bearing bore

Engine Will Not Crank - Crankshaft Will Not Rotate (Article 12036)

Cause Correction

Seized accessory drive system component Remove the accessory drive belt or belts. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. Repair or replace as required.

- Remove the accessory drive belt or belts.
- Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location.
- Repair or replace as required.

Hydraulically locked cylinder Coolant/antifreeze in cylinder Oil in cylinder Fuel in cylinder Remove the spark plugs and check for fluid. Inspect for broken head gasket or gaskets. Inspect for cracked engine block or cylinder head . Inspect for a sticking fuel injector. Repair or replace as required.

- Coolant/antifreeze in cylinder
- Oil in cylinder
- Fuel in cylinder
- Remove the spark plugs and check for fluid.
- Inspect for broken head gasket or gaskets.
- Inspect for cracked engine block or cylinder head .
- Inspect for a sticking fuel injector.

Seized automatic transmission torque converter Remove the torque converter bolts. Rotate the crankshaft by hand at the crankshaft balancer or the engine flywheel location. Repair or replace as required.

- Remove the torque converter bolts.

Material in cylinder Broken valve Piston material Foreign material Inspect the cylinder for damaged components and/or foreign materials. Repair or replace as required.

- Broken valve
 - Piston material
 - Foreign material
 - Inspect the cylinder for damaged components and/or foreign materials.
- Seized crankshaft or connecting rod bearing s Inspect the crankshaft and the connecting rod bearings. Repair as required.
- Inspect the crankshaft and the connecting rod bearings.
 - Repair as required.
- Bent or broken connecting rod Inspect the connecting rods. Repair as required.
- Inspect the connecting rods.
- Broken crankshaft Inspect the crankshaft. Repair as required.
- Inspect the crankshaft.
- Seized or broken camshaft Inspect the camshaft or camshafts . Inspect the cylinder head camshaft journals for damage. Repair as required.
- Inspect the camshaft or camshafts .
 - Inspect the cylinder head camshaft journals for damage.
- Seized or broken balance shaft Inspect the balance shaft. Inspect the block for damaged balance shaft bearings. Repair as required.
- Inspect the balance shaft.
 - Inspect the block for damaged balance shaft bearings.
- Seized or broken camshaft timing components Inspect the following sprockets: The crankshaft sprocket The exhaust sprockets The intake sprockets Inspect the following chains: The primary camshaft drive chain The secondary camshaft drive chain s Inspect the following guides: The lower primary camshaft drive chain guide The upper primary camshaft drive chain guides Inspect the secondary camshaft drive chain shoe. Inspect the following tensioners: The primary camshaft drive chain tensioner The secondary camshaft drive chain tensioners Repair as required.
- Inspect the following sprockets:
 - The crankshaft sprocket
 - The exhaust sprockets
 - The intake sprockets
 - Inspect the following chains:
 - The primary camshaft drive chain
 - The secondary camshaft drive chain s
 - Inspect the following guides:
 - The lower primary camshaft drive chain guide
 - The upper primary camshaft drive chain guides
 - Inspect the secondary camshaft drive chain shoe.
 - Inspect the following tensioners:
 - The primary camshaft drive chain tensioner
 - The secondary camshaft drive chain tensioners
- Seized or broken valve train components Inspect the followers, rocker arms. Inspect the lifters. Inspect the valves. Inspect the valve spring s. Repair as required.
- Inspect the followers, rocker arms.
 - Inspect the lifters.
 - Inspect the valves.
 - Inspect the valve spring s.

Coolant in Combustion Chamber (Article 12024)

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. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate . Remove the spark plugs and inspect for spark plug s saturated by coolant or coolant in the cylinder bore . Inspect by performing a Cylinder Leakage Test . During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 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 .

- A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate .

- Remove the spark plugs and inspect for spark plug s saturated by coolant or coolant in the cylinder bore .

- Inspect by performing a Cylinder Leakage Test . During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component.

- 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.

Coolant in Engine Oil (Article 12025)

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. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearing s and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed . 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. 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 .

- Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearing s and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed .

- 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.

- 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.

Tools and Equipment (Article 12017)

- 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 designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools 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 proper tightening of various fasteners.

- To properly 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 component cleaning tank

- A compressed air supply

- Trays or storage containers to keep components and fasteners organized

- An adequate set of hand tools

- Approved engine repair stand

- An approved engine lifting device that adequately supports the weight of the components

Engine Mechanical - Special Tools (Article 12217)

Illustration Tool Number/Description

Click for full-size image CH-25033-C J-25033-C Pulley Installer
Click for full-size image CH-25034-C J-25034-C Pulley Remover
Click for full-size image CH-48027 DW-100-010 EN-49495 J-21867 Digital Pressure Gauge
Click for full-size image DT-5590 J-5590 J-24254 Bearing and Seal Driver
Click for full-size image DT-23129 J-23129 Universal Seal Remover
Click for full-size image DW-110-030 Engine Overhaul Stand
Click for full-size image EN-8062 J-8062 Valve Spring Compressor - Head Off
Click for full-size image EN-8087 J-8087 Cylinder Bore Gauge
Click for full-size image EN-21867-6 J-21867-6 83 93 852 Oil Pressure Adapter Fitting
Click for full-size image EN-22738-B J-22738-B Valve Spring Tester
Click for full-size image EN-24254-A J-24254-A J-24254 Oil Seal Installer
Click for full-size image EN-28410 J-28410 Gasket Remover
Click for full-size image EN-28467-B DW-110-060 J-28467-B Universal Engine Support Fixture
Click for full-size image EN-28467-501 J-28467-501 Engine Support Fixture Adapters
Click for full-size image EN-29184 EN-47635 & J-41998-B EN-47635 J-29184 Oil Seal Installer
Click for full-size image EN-35667-A J-35667-A Cylinder Head Leakdown Tester
Click for full-size image EN-36462-A J-36462-A Engine Support Adapter Leg
Click for full-size image EN-36857 J-36857 Engine Lift Bracket
Click for full-size image EN-38416-2 J-38416-2 Crankshaft Button
Click for full-size image EN-39313 J-39313 Spark Plug Port Adapter
Click for full-size image EN-41712 J-41712 Oil Pressure Switch Socket
Click for full-size image EN-41998-B J-41998-B J-41998 Crankshaft Balancer Installer
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Driveability (itype_131)

Tsbs

- Information Assistance for HFV6 Re-Manufactured Engine Drivability Diagnosis Immediately Following Installation (PIP5528F, 2020/06/26)

Leaks (itype_149)

Tsbs

- Information for Repairing Engine Front Cover Oil Leak, Sealing Surface Preparation and Applying RTV Sealant (12-06-01-003D, 2022/05/02)
- Engine - Crankshaft Rear Oil Seal Leaks (14-06-01-002A, 2014/12/01)

Noise (itype_156)

Tsbs

- Diagnostic Tip for Misfire, Chirp, Squeak, Squeal or Tick Noise, Malfunction Indicator Lamp (MIL) Illuminated - DTC P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307 and/or P0308 Set (19-NA-219, 2024/11/22)
- Engine Ticking Noise or oil pressure fluctuation On Cold Start (PIP5191C, 2018/11/06)
- Information on Clicking/Ticking Sound/Noise Heard During Cold Start (07-06-04-025M, 2020/05/28)
- Diagnostic Tips for Knocking, Rattle, Squeak and/or Squeal Type Noise from Engine – Engine Replacement Recommendations for HFV6 Gen 1 and Gen 2 (19-NA-256, 2025/06/25)
- Ticking, Tap, or Rattle Noise from Engine (20-NA-029, 2026/05/27)

Out of specification (itype_158)

Tsbs

- PIP5257D: Cooling System Contaminated With Engine Oil (PIP5257D, 2020/04/17)
- Needle Bearings Found In The Oil Pan During An Oil Change (PIP5226D, 2020/07/27)

Overheating (itype_160)

Tsbs

- Information on Engine Overheating, Cooling System Contaminated with Engine Oil (21-NA-108, 2021/05/04)

Poor performance (itype_162)

Tsbs

- Information On Remanufactured Engine Misfire Diagnosis After Installation (17-NA-307, 2017/09/26)
- Information Assistance for HFV6 Re-Manufactured Engine Drivability Diagnosis Immediately Following Installation (PIP5528F, 2020/06/26)
- Cold Start Misfire and/or Rough Idle – DTC P0300 May Be Set (18-NA-115, 2024/07/23)
- Diagnostic Tips for Knocking, Rattle, Squeak and/or Squeal Type Noise from Engine – Engine Replacement Recommendations for HFV6 Gen 1 and Gen 2 (19-NA-256, 2025/06/25)

Fluids, Chemicals and Additives (itype_112)

Tsbs

- Fuel and Oil Additives - Facts and Myths - Maximizing Gasoline Fuel Economy (05-00-89-072H, 2026/05/05)

OEM Policies and Procedures (itype_120)

Tsbs

- Vehicle - PQC Assembly Replacement (02-07-30-029Z, 2016/04/27)
- Engine Replacement After Severe Internal Engine Damage – Replace Intake Manifold (00-06-01-026T, 2025/10/13)
- Diagnostic Aids for Gas Engine Misfire/rough running with DTC P0300-P0308 and/or DTC P050D (26-NA-066, 2026/02/25)
- Engine Oil Dye May be Mistaken for Contamination on Low Mileage Engines (PI0275B, 2012/02/17)
- Repair Guidelines for Engine Component Wear (18-NA-073, 2024/08/19)
- Information for Engine Concerns Resulting from Lack of Scheduled Maintenance, Improper Service or Aftermarket Calibrations (Gasoline Engines Only) (16-NA-222, 2025/07/18)
- Information on Gasoline Engine Replacement Guidelines after Connecting Rod or Crankshaft Main Bearing Damage – Replace Oil Cooler, Oil Cooler Lines, Oil Tank and Turbocharger (22-NA-074, 2026/02/23)
- Product Quality Center (PQC) Assembly Replacement Process — For Service Agents Not Required to Contact PQC Prior to Assembly Replacement (12-07-30-001E, 2015/03/26)
- Information on Engine Block Cracked at Head Bolt Hole Locations (23-NA-141, 2024/08/07)
- Information on Spin-On Oil Filter Replacement for Gas Engines Designed with New Oil Pump Control Systems (17-NA-157, 2025/11/19)
- Information on New Torque Specification and Installation Procedure for ACDelco Spin-On Oil Filters (22-NA-009, 2023/03/17)
- Information on Improved Oil Filter Gasket Design for Spin-On Oil Filters PF63 PF64 and PF48 (20-NA-213, 2020/10/30)
- Information on Engine Oil Consumption Guidelines (01-06-01-011S, 2025/07/28)
- OEM and Remanufactured Engine and Automatic Transmission/Transaxle Identification (06-00-89-031J, 2025/08/05)

Vehicle / Component Identification (itype_118)

Tsbs

- Vehicle - Reuse of Fasteners and Proper Torque Info (15-NA-069, 2015/11/30)

Warranty Information (itype_119)

Tsbs

- Warranty Administration – Engine and Transmission Assembly Replacement (U.S. Only) (20-NA-138, 2025/11/20)