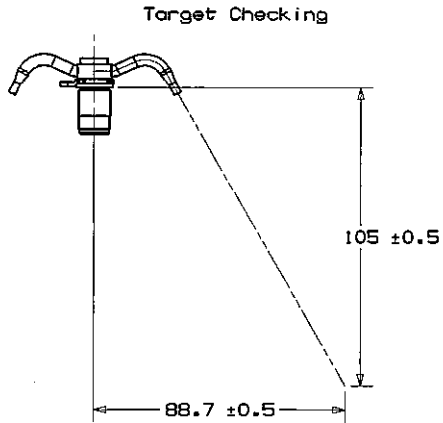


VID Assembly Instructions

Piston Squirter Installation

1) Install piston Squirters and torque to 10 N·m. Check to ensure all Squirters are at proper target angle with upper cylinder wall.



Note: The angle is set during manufacture. If Squirters were not removed, check to ensure they were not bent during the block measurement process.

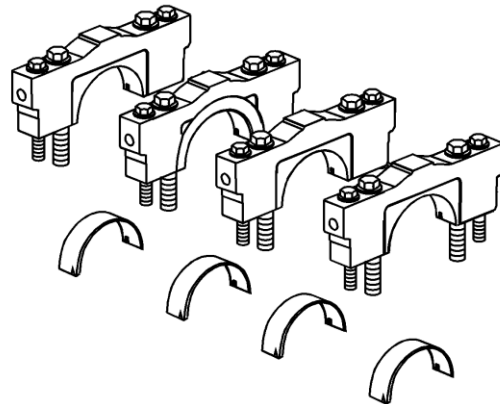


Crankshaft & Bearing Installation

1) Clean the crankcase crank bore with a lint-free cloth. Clean all the oil from the backside of new bearing halves.
2) Install the new upper crankshaft bearings into position. The thrust bearing belongs in the number 3 journal. 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 slot in the engine block. The bearing must fit flush with the upper crankcase.



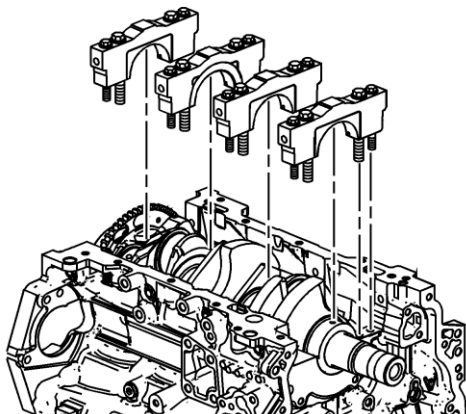
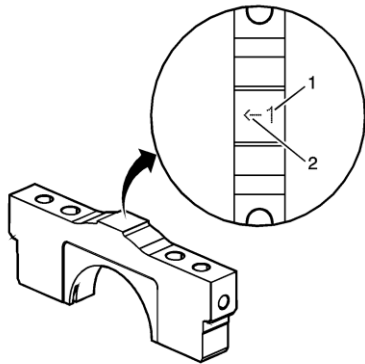
3) Install the new lower crankshaft bearings into position in the main bearing caps.



4) Clean the crankshaft and lubricate the main journals using EF-411. Gently lower the crankshaft into position in the cylinder block.

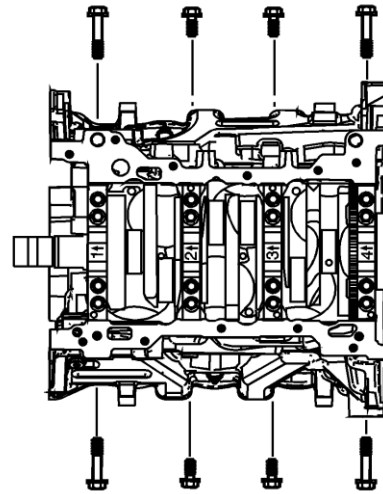


5) Identify the proper order of the main bearing caps. The main bearing caps are numbered 1 through 4, with the front main bearing cap marked with the number 1. The arrow is to be oriented to the front of the engine.



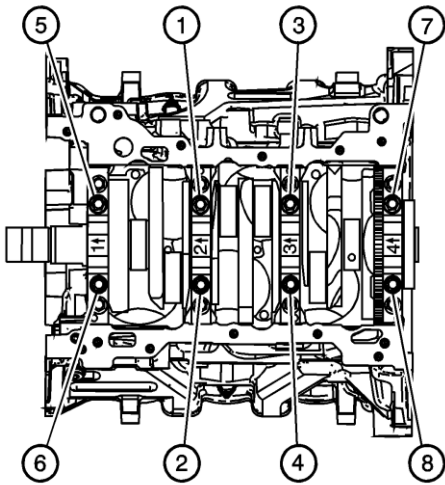
6) Loosely install the inner and outer main bearing cap bolts. Using a soft-faced mallet and a speed handle and socket, lightly tap and draw the main caps into place.

7) If you are not using new side bolts, apply sealant around the flange of the bolt head prior to installation. Install the short/inner and long/outer side bolts.

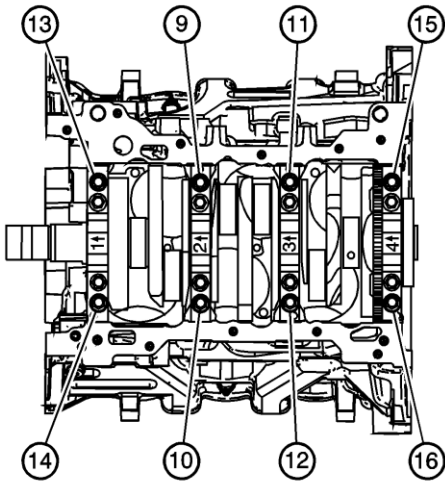


8) After seating main caps and installing side bolts, apply 10 N·m torque to all inner and outer main cap bolts (Do not torque the side main cap bolts at this time). Back off all fasteners one full turn and inspect for proper positioning of all main caps.

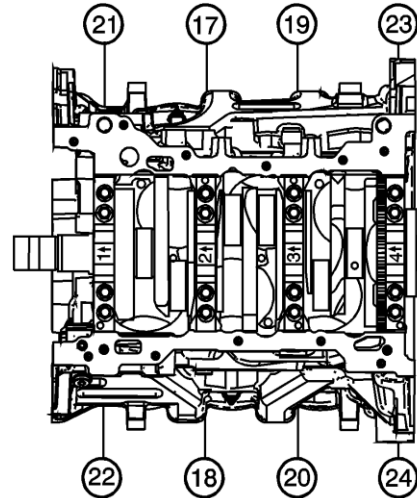
9) Tighten the inner main cap bolts to 20 N·m plus 80 degrees following the proper sequence. (1 – 8)



10) Tighten the outer main cap bolts to 15 N·m plus 110 degrees following the proper sequence. (9 – 16)



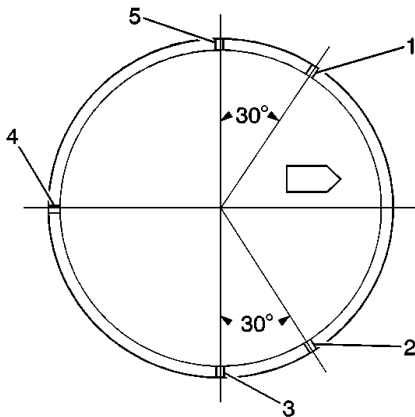
11) Tighten the short/inner and long/outer side bolts (17-24) to 30 N·m plus 60 degrees in the proper sequence.



Ensure the crankshaft rotates freely without binding or noise.

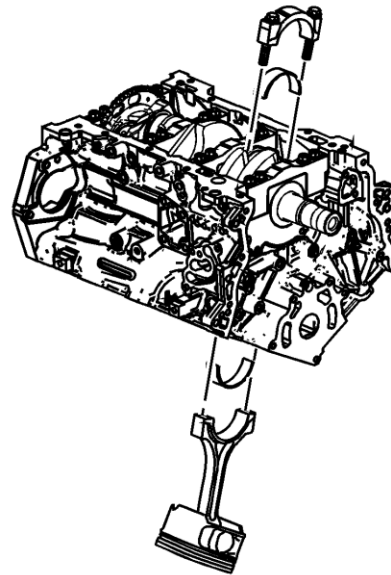
Piston Assembly Installation

- 1) Clean the connecting rod and the connecting rod cap bearing bore with a lint-free cloth.
- 2) Clean all the oil from behind the connecting rod bearing halves.
- 3) Install new upper and lower connecting rod bearings into position. Roll the bearing into position so that the lock tang engages the alignment slot. The bearing must fit flush in the connecting rod.
- 4) Position the piston rings according to the diagram below.



- 4.1) Lower oil control ring – position 1
- 4.2) Upper oil control ring – position 2
- 4.3) Top compression ring – position 3
- 4.4) Oil ring expander – position 4
- 4.5) Second ring – position 5

- 5) Lubricate the piston skirts and piston ring assembly with EF-411 and compress using a piston ring compression tool.
- 6) Position the engine crankshaft to receive the piston assembly. Lubricate the crankshaft and cylinder with EF-411.
- 7) Install the piston assembly into the cylinder with the piston pointed in the forward direction and gently guide the connecting rod into place on the crankshaft journal.



Notice: The piston connecting rods are uni-directional with cracked rod caps. The lock tangs may face inboard or outboard but must be positioned lock tang to lock tang for proper assembly.

Important: DO NOT reuse the old connecting rod bolts.

Notice: Do not lubricate the NEW connecting rod bolts. The NEW bolts have a pre-applied graphite lubricant. Applying lubricant to the connecting rod bolts will affect the clamp load when the

connecting rod bolts are torqued. Improper clamp load can lead to component failure and extensive engine damage.

8) Install the NEW connecting rod bolts into the connecting rod cap.

9) Tighten the new connecting rod bolts to 30 N·m. Then loosen each bolt to zero torque and inspect the rod assembly for proper fit.

10) Final tightening procedure;

10.1) Tighten the connecting rod bolts to 25 N·m.

10.2) Tighten the connecting rod bolts an additional 110 degrees.

Notice: Do not apply the additional 110 degree to each fastener until after both rod cap bolts have been tightened to 25 N·m.

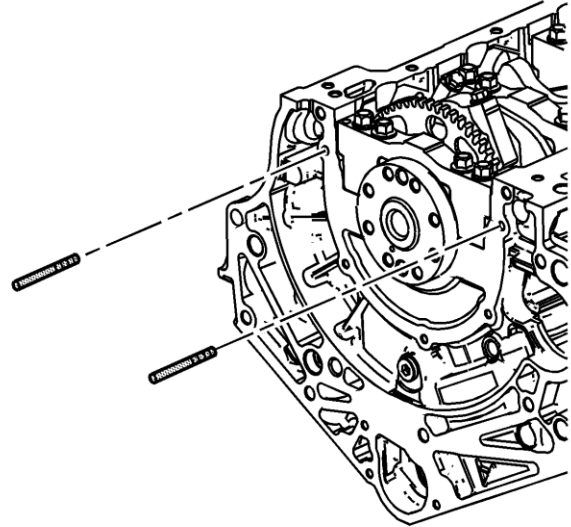
After installation of all six piston assemblies, rotate the engine ensuring there are no problems, i.e., binding scraping, or contact between the piston assemblies and the block or Piston Squirters. Ensure all six Piston Squirters are still in the proper orientation angle.

Crankshaft Rear Oil Seal and Housing Installation

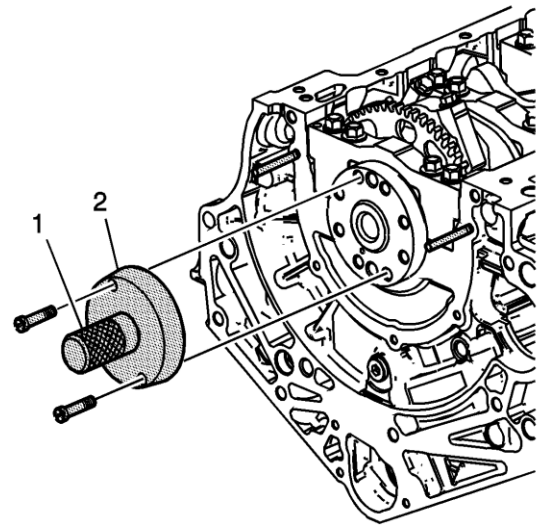
Tools Required

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

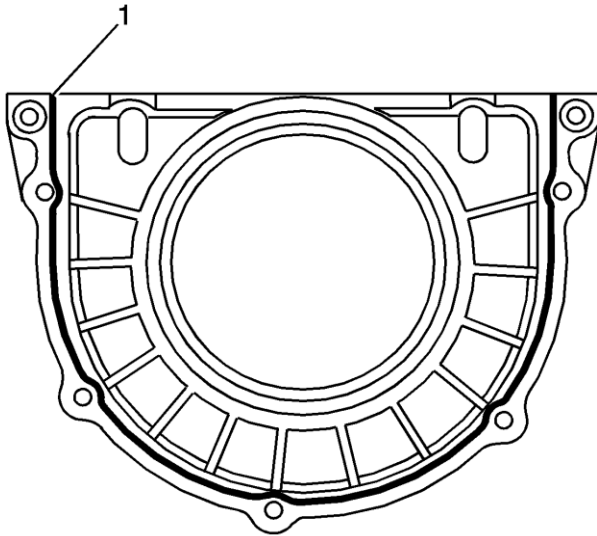
1) Install the 6mm guides from the EN 46109 Guide Pin Set into the two crankshaft rear oil seal housing corner bolt holes of the engine block.



2) Install rear seal installation tool EN 47839 & J 42183 onto the rear of the crankshaft.

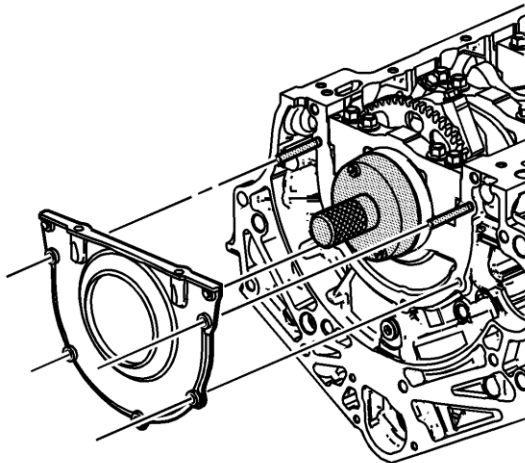


3) Place a 3 mm (0.118 in) bead of RTV sealant, GM P/N 12378521 or equivalent, to the NEW crankshaft rear oil seal housing as shown. (1)

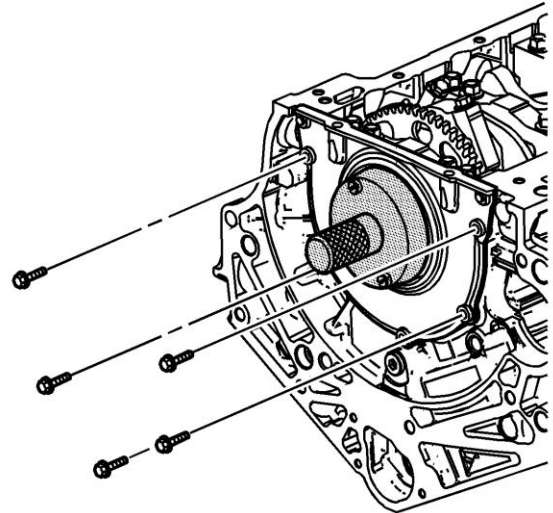


Important: DO NOT allow any engine oil on the area where the crankshaft rear oil seal housing is to be installed.

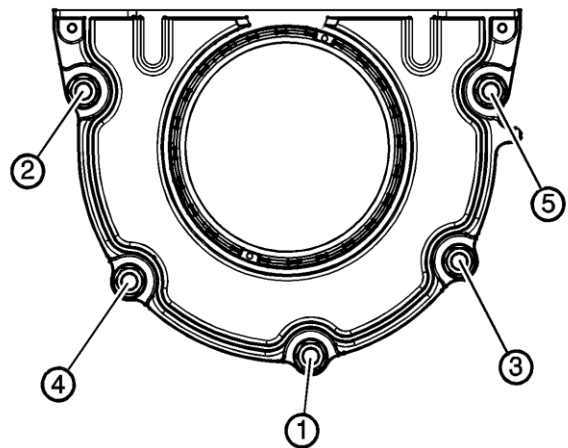
4) Install the crankshaft rear oil seal housing to the engine block.



5) Remove the EN 46109 6 mm guides from the engine block and install the rear oil seal housing bolts.



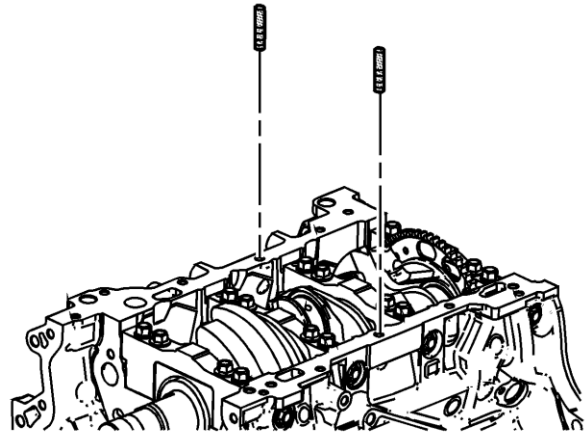
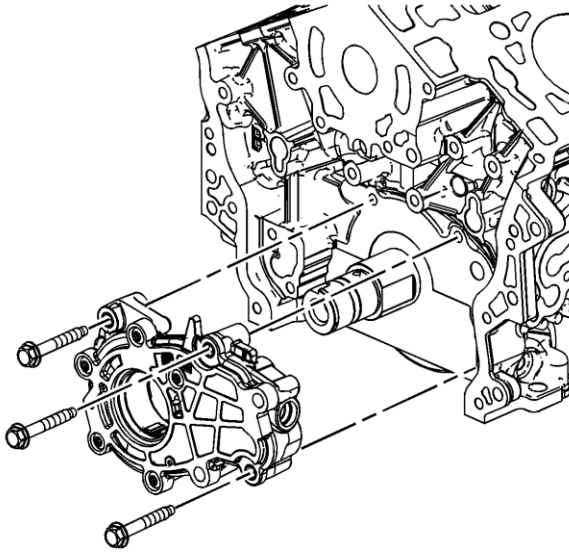
6) Tighten the crankshaft rear housing bolts in sequence to 10 N-m.



7) Remove the rear seal installation tool from the crankshaft.

Oil Pump Installation

- 1) Clean the mating surfaces of the G-rotor oil pump assembly and the engine block and apply a thin film of EF-411.
- 2) Align the G-rotor oil pump driven gear with the crankshaft flats and install the oil pump to the engine block.



- 2) Place a 3 mm bead of RTV sealant, GM P/N 12378521 or equivalent, on the block pan rail and the crankshaft rear oil seal housing (1).

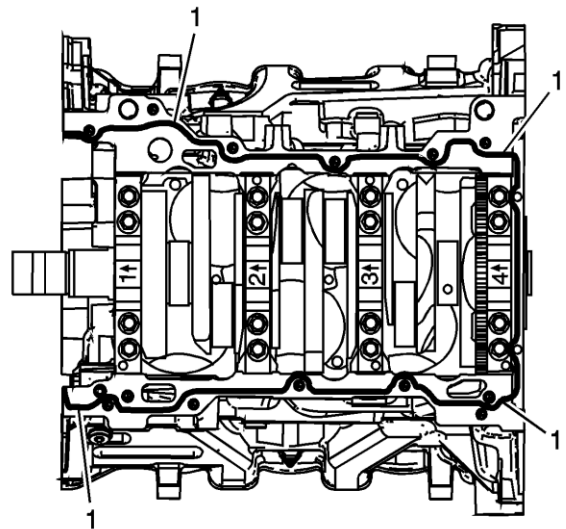
- 2) Align the oil pump body with the mounting holes, install the fasteners and torque the oil pump bolts to 23 N·m.

Oil Pan Installation

Tools Required

EN 46109 Guide Pin Set

- 1) Install the 8 mm guide pins from the EN 46109 guide pin set into the center oil pan rail bolt hole on each side of the engine block.



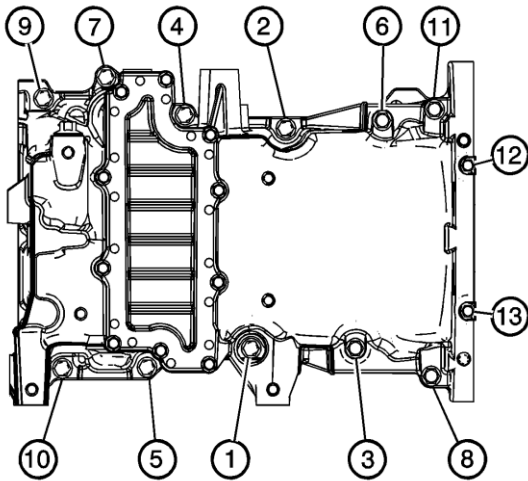
- 3) Position the Sequence VID oil pan onto the block.

4) Loosely install the oil pan bolts.

5) Tighten the oil pan bolts in sequence shown.

5.1) Tighten the 8 mm bolts (1-11) to 23 N·m.

5.2) Tighten the 6 mm bolts (12, 13) to 10 N·m.



Note: View may not be representative of Sequence VID Oil Pan. Also, any time the oil pan is removed and or installed, make sure the oil pickup tube “O-ring” is properly installed

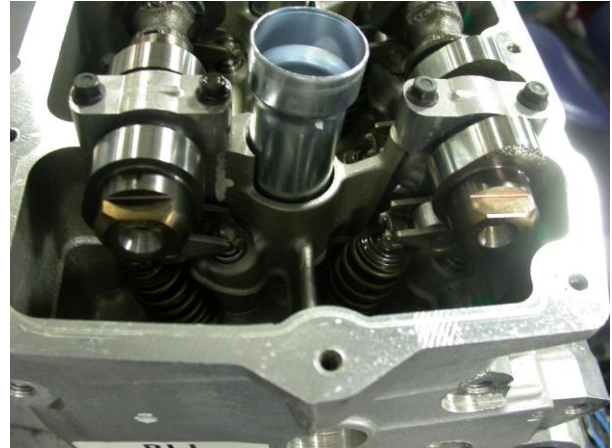
Cylinder Head Installation Camshaft Positioning

Important: This engine is NOT a free spin engine. The camshafts must be properly positioned in the cylinder heads before installation. Using a large open end wrench on the hex cast into the camshaft behind number one journal, position the camshafts so the flat on the back of each camshaft is parallel to the gasket sealing surface for the cylinder head rocker cover.

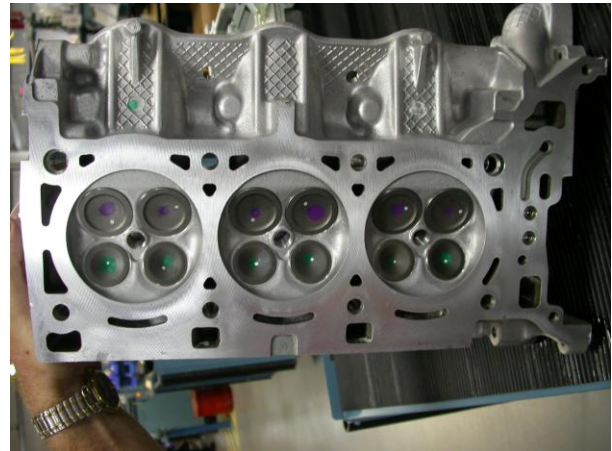
WARNING: DO NOT USE THE CAM GEAR TO POSITION CAMS AS THE VALVE SPRING PRESSURE MAY CAUSE THE CAM TO ROTATE AFTER POSITIONING AND THE LEADING EDGES OF THE CAM GEARS ARE VERY SHARP.

AS AN ADDED MEASURE OF PROTECTION, ROTATE THE CRANKSHAFT SO THERE ARE NO PISTONS AT TDC DURING CYLINDER HEAD INSTALLATION.

Insure all four camshafts are positioned with flats parallel to rocker cover sealing surface.



By positioning the flats parallel, you assure the cam lobes are all on a portion of the base circle and the engine will thereby be a free spin so you can rotate the crankshaft without the pistons hitting the valves.

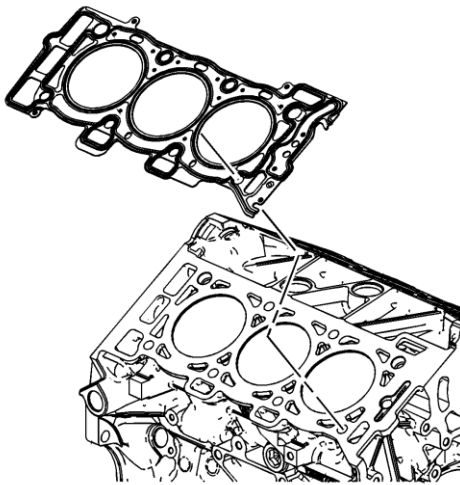


Cylinder Head Installation Right Side

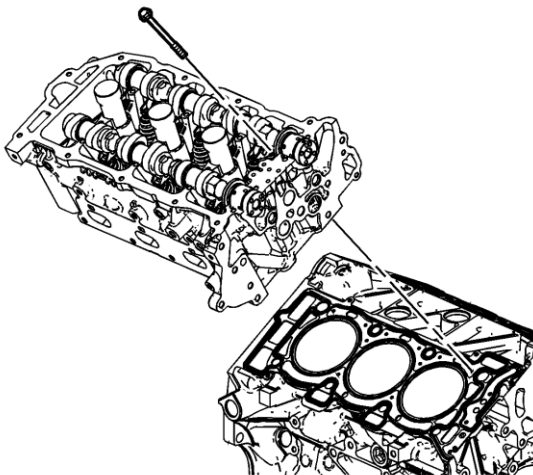
1) Clean the mating surfaces of the engine block deck, cylinder head and fastener bosses and inspect for imperfections.

Important: DO NOT allow oil on the cylinder head bolt bosses.

2) Install a NEW right cylinder head gasket using the deck face locating pins for retention.



3) Place the right cylinder head in position on the deck face.



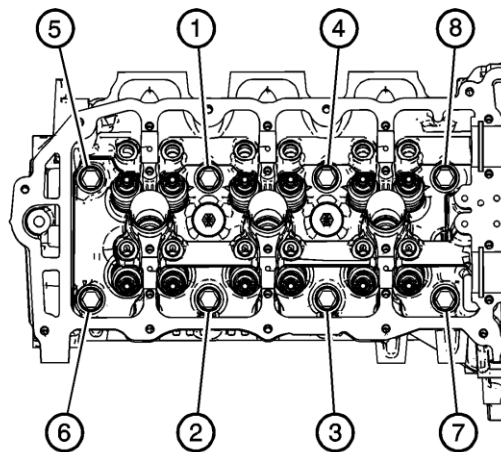
Important: DO NOT reuse the old M11 cylinder head bolts.

4) Install new M11 cylinder head bolts.

Tighten

4.1) Tighten the M11 cylinder head bolts a first pass in sequence to 45 N·m.

4.2) Tighten the M11 cylinder head bolts a second pass in sequence an additional 120 degrees.

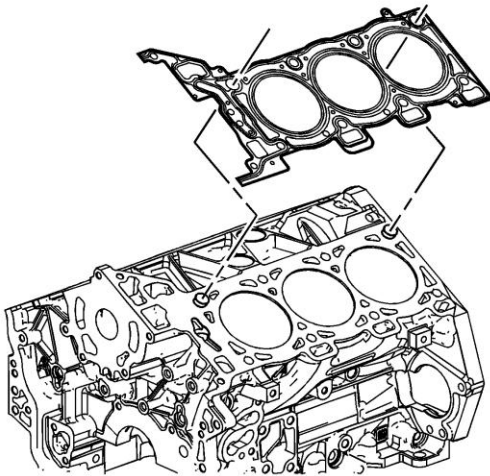


Cylinder Head Installation Left Side

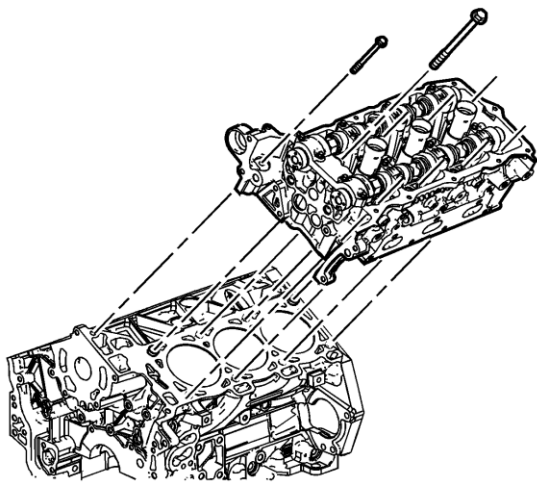
1) Clean the mating surfaces of the engine block deck, cylinder head and fastener bosses and inspect for imperfections.

Important: DO NOT allow oil on the cylinder head bolt bosses.

2) Install a NEW left cylinder head gasket using the deck face locating pins for retention.



3) Place the left cylinder head in position on the deck face.



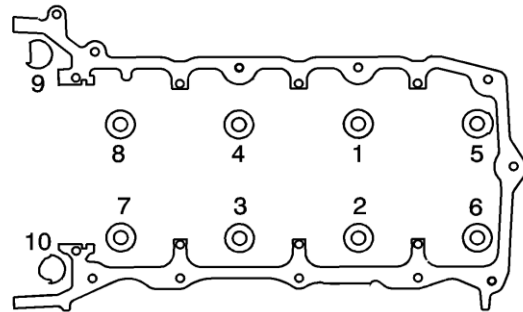
Important: DO NOT reuse the old M11 cylinder head bolts.

4) Install new M11 cylinder head bolts.

Tighten

4.1) Tighten the M11 cylinder head bolts (1 – 8) a first pass in sequence to 45 N·m.

4.2) Tighten the M11 cylinder head bolts a second pass in sequence an additional 120 degrees.



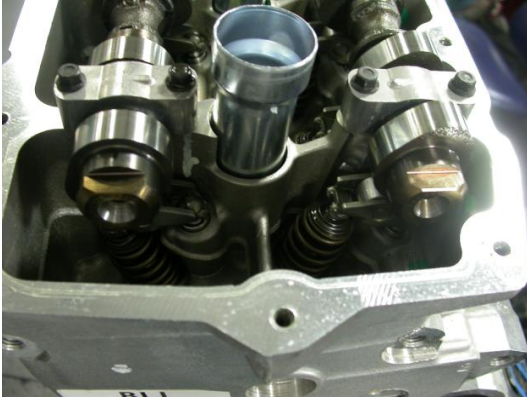
5) Install the 2 front M8 left cylinder head bolts.

Tighten

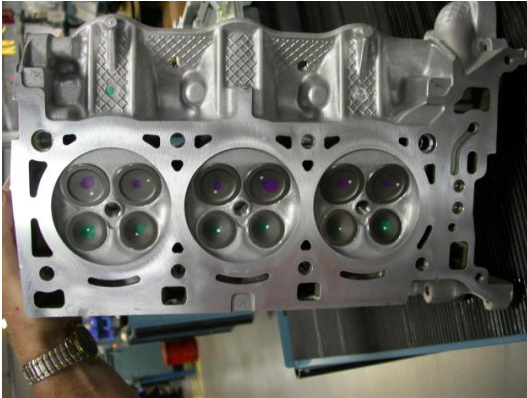
5.1) Tighten the M8 cylinder head bolts a first pass to 15 N·m (11 lb ft).

5.2) Tighten the M8 cylinder head bolts a second pass in sequence an additional 60 degrees.

Timing Chain Installation Insure all four camshafts are positioned with flats parallel to rocker cover sealing surface.



By positioning flats parallel, you assure the cam lobes are all on a portion of the base circle and the engine will thereby be a free spin so you can rotate the crankshaft without the pistons hitting the valves.



Install all four camshaft sprockets, i.e., intakes on the inside cams and exhausts on the outboard camshafts.



Left Intake



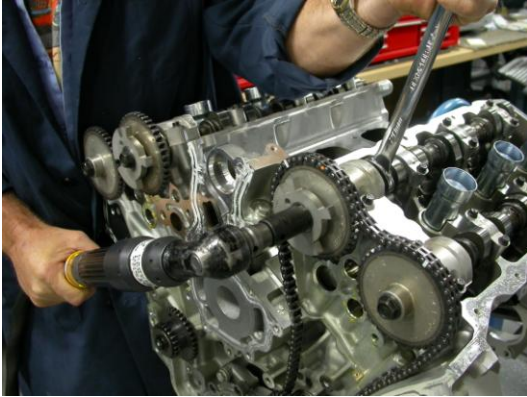
Left Exhaust



Right Intake



Right Exhaust



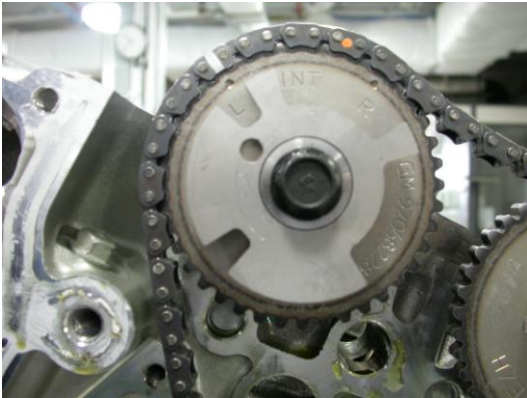
After installation you can torque all four fasteners to 58 +/- 7Nm. Holding camshafts on hex with open end wrench. Note: left side chain assembly was installed before photo taken.



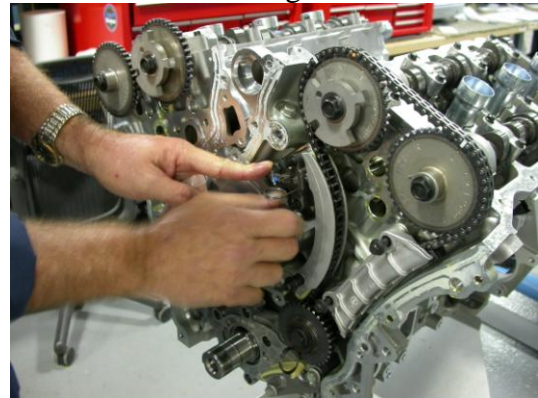
Left side idler w/grenade pin.



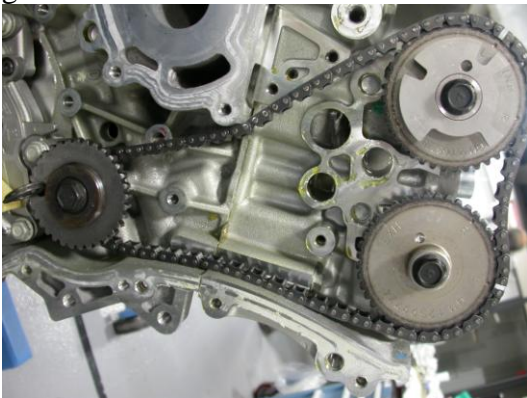
Install left side chain guides.



Install left chain assembly with left side idler gear (do not remove grenade pin), aligning white marks on chain with dots or slots on cam gears identified as "L" Intake and "L" Exhaust on camshaft gears..



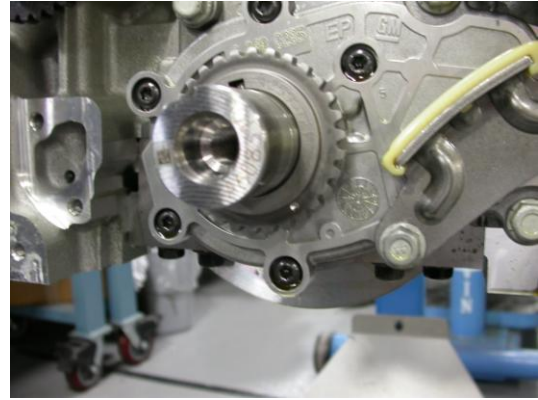
Install left side tensioner and gasket



View of left side chain assembly with grenade pin in idler gear.



Torque tensioner and chain guide fasteners to 23 +/- 3Nm.



View showing left side alignment dots.



Install right side idler gear and torque to 58 +/- 7Nm.



Make sure left side idler gear still has grenade pin holding chain assembly in proper position.



Install crankshaft gear and align dot for left side chain alignment. (Phase 1) alignment step in earlier write up.



Install primary chain assembly over left, right idlers and crankshaft gears with white identification marks aligned with marks on all three gears.



View of primary chain installed.



Install primary chain guides.



Install primary chain tensioner and gasket. Torque tensioner and guide fasteners to 23 +/- 3Nm.



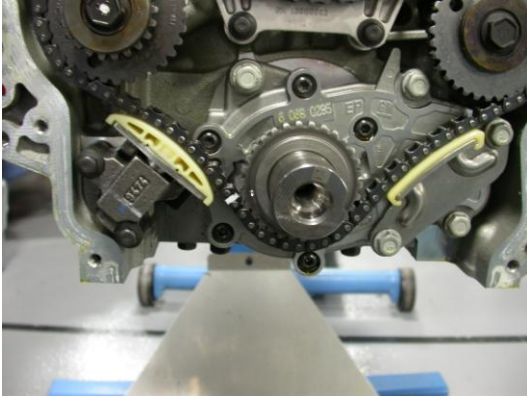
Torque right side idler gear to 58 +/- 7Nm.



Remove grenade pins from left side idler and tensioners for left side and primary chains.



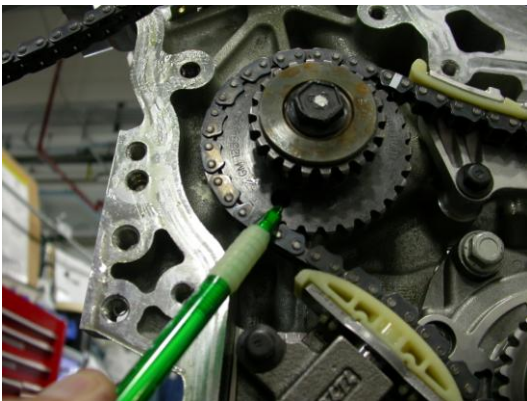
Rotate crankshaft to right side alignment marks. (Phase 2 alignment).



Note white mark on crankshaft gear and alignment mark on oil pump housing.



Holding chain together, install chain guides and tensioner. Note, the right bank is the hardest chain to keep tension on during the assembly process.



At this point, note hole in right side idler gear as noted by ink pin.



Torque tensioner and chain guides to 23 +/- 3Nm.

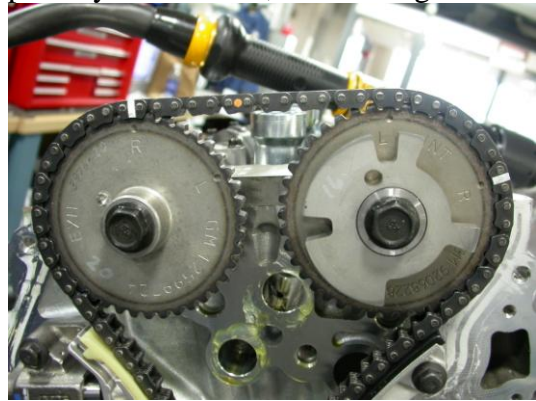
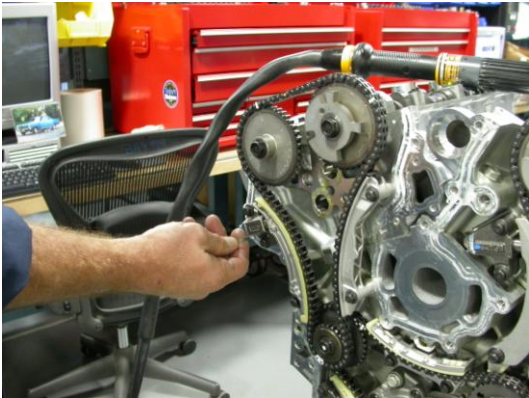


Align right side chain over idler with white link positioned at hole in right side idler and white marks positioned on cam gears at "R" Exhaust and "R" Intake.



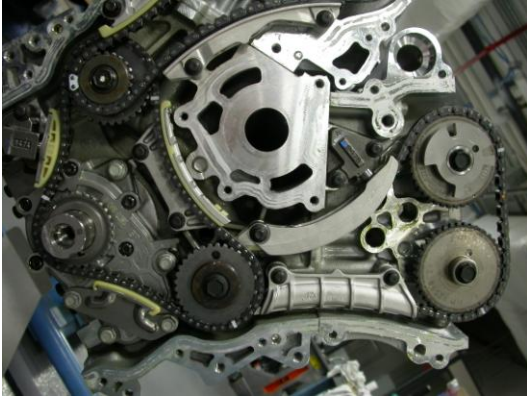


Check alignment on all four cam gears, primary chain idlers, and crank gear.



Remove grenade pin from right side chain tensioner.



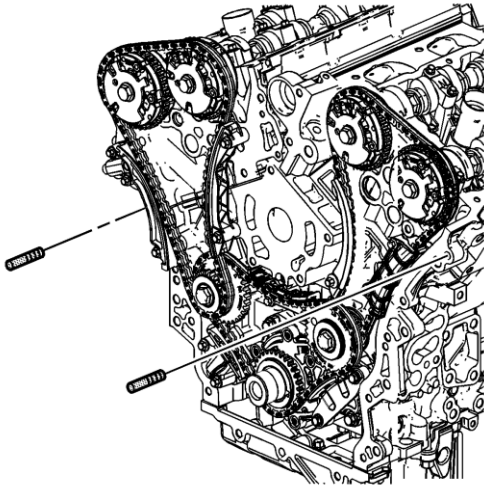


Rotate crankshaft backward (counter clockwise just past left side alignment and then back to left side alignment and check white marks for proper alignment. Rotate crankshaft clockwise to right side alignment and check marks. Make sure chain assemblies do not jump on gears.

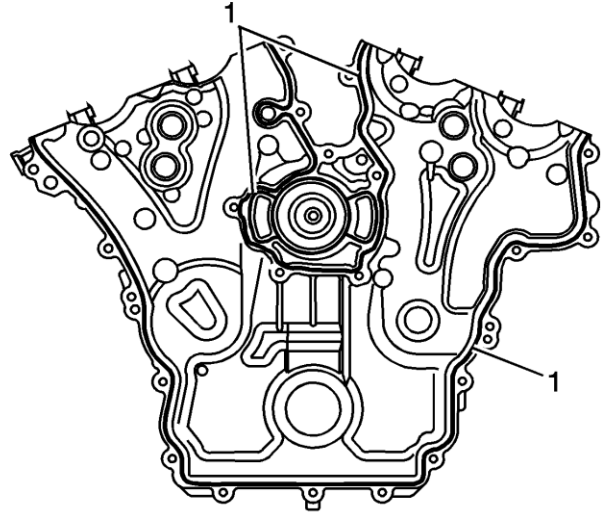
If everything looks good, you have successfully installed the chain assembly.

Front Cover Installation

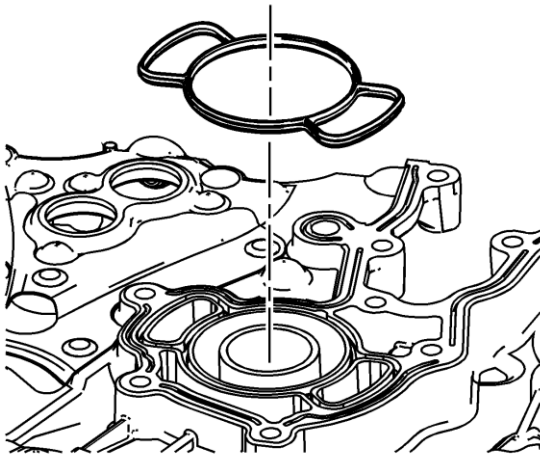
1) Install 8 mm (0.315 in) guide pins into the cylinder block positions as shown.



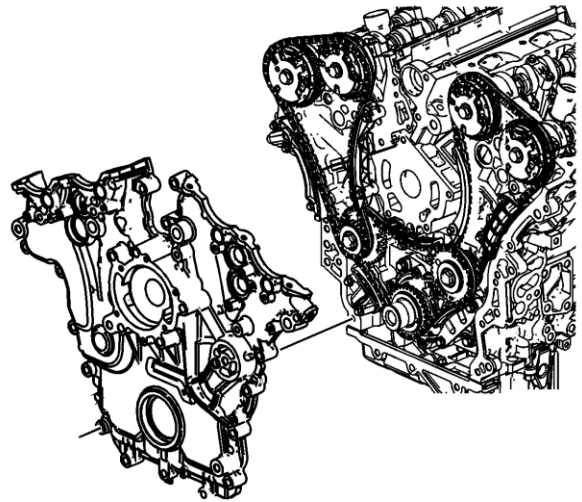
3) Place a 3 mm bead of RTV sealant, GM P/N 12378521 on the engine front cover as shown (1).



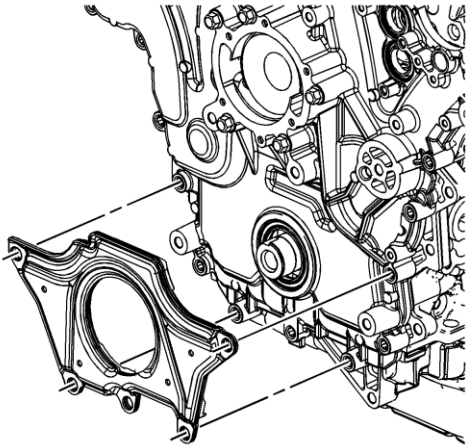
2) Inspect and/or install a NEW engine front cover to cylinder block seal if necessary.



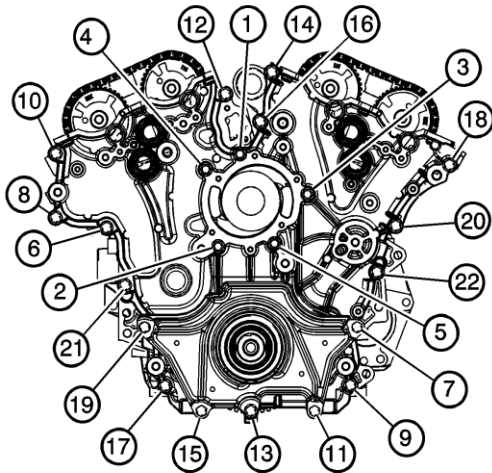
4) Place the engine front cover onto the guide pins and slide into position.



5) Loosely install the front cover bolts and install the engine front cover sound deadener.



6) Tighten the engine front cover bolts in the sequence shown (1-22).

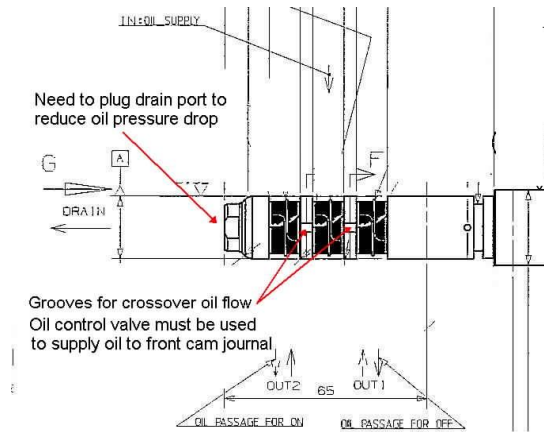


Tighten

Tighten the engine front cover bolts a first pass in sequence to 20 N·m

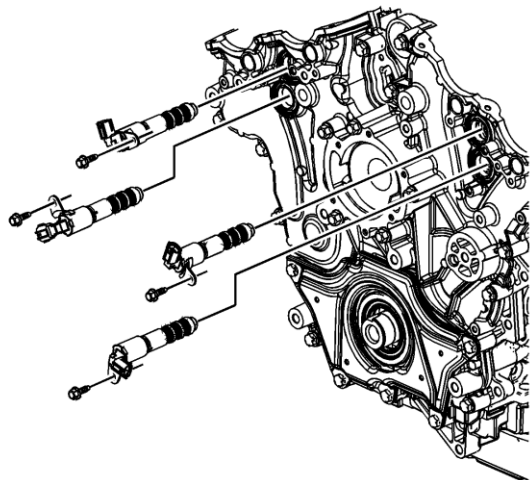
Tighten the engine front cover bolts a second pass in sequence an additional 60 degrees.

VERY IMPORTANT!



For Sequence VID test operation, the camshaft phaser oil control valves must be in place to provide lubrication to the front camshaft journals. The control valve drain ports must be plugged using JB Weld to reduce excessive oil hemorrhaging through the control valves during engine operation as the valves are positioned in a manner that allows complete drainage through the spool valves.

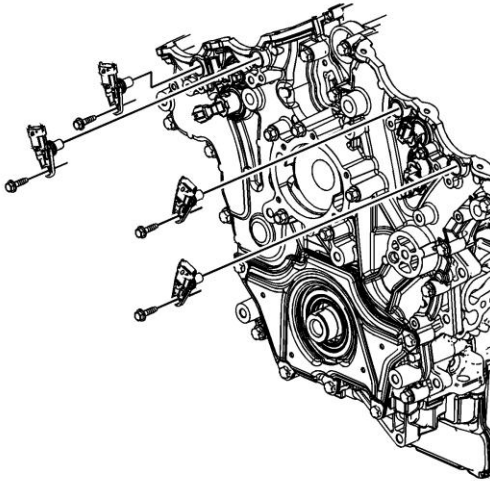
7) Place the camshaft position actuator valves in position on the front cover.



Tighten

Tighten the camshaft position actuator valve bolts to 10 N·m

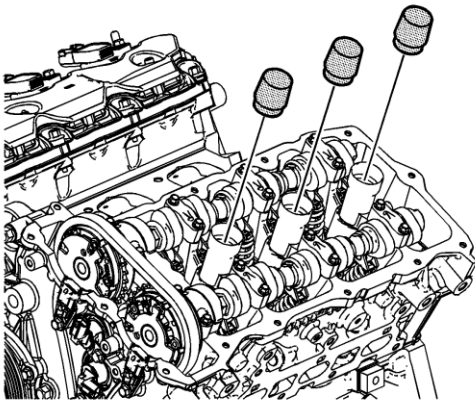
8) Place the camshaft position sensors in position on the front cover.

**Tighten**

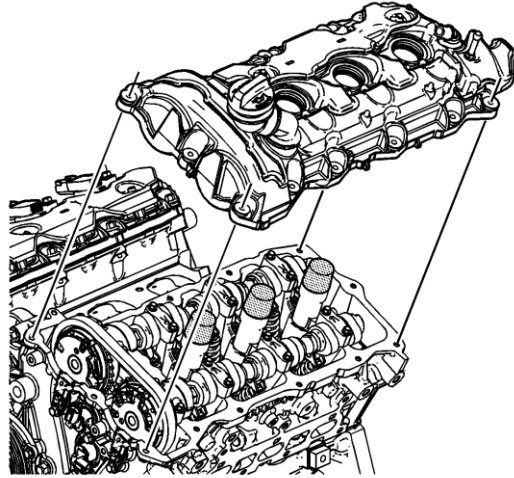
Tighten the camshaft position sensor bolts to 10 N·m

Camshaft Cover Installation

1) Install EN 46101 assembly aid guides onto the spark plug tubes of the left cylinder head.

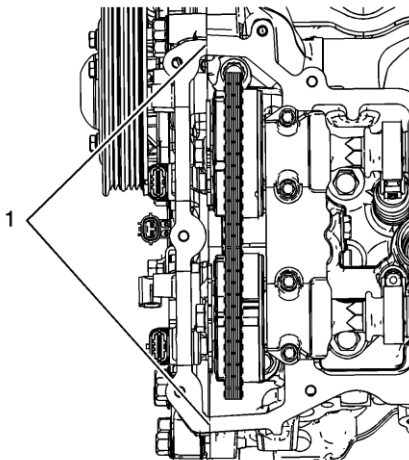


3) Place the left camshaft cover into position onto the left cylinder head.



2) Wipe the camshaft cover sealing surface on the left cylinder head with a clean, lint-free cloth.

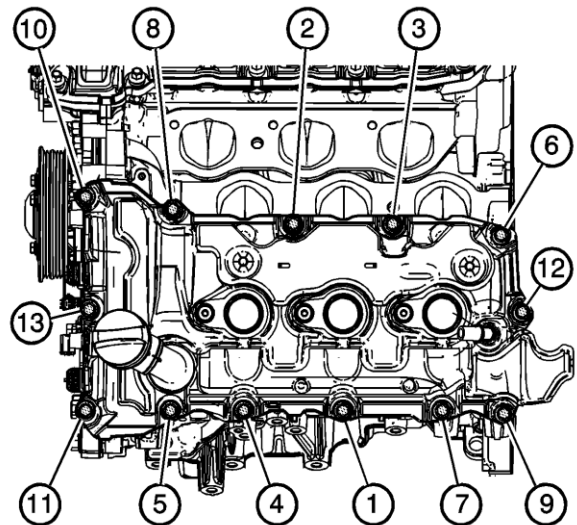
Place a bead 8 mm in diameter by 4 mm in height of RTV sealant, GM P/N 12378521 or equivalent, on the engine front cover split lines (1).



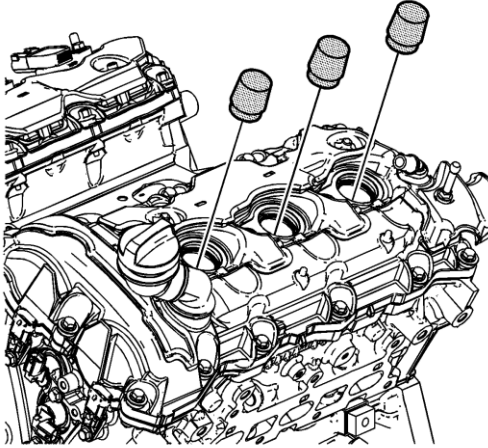
4) Tighten the left camshaft cover bolts in the sequence shown.

Tighten

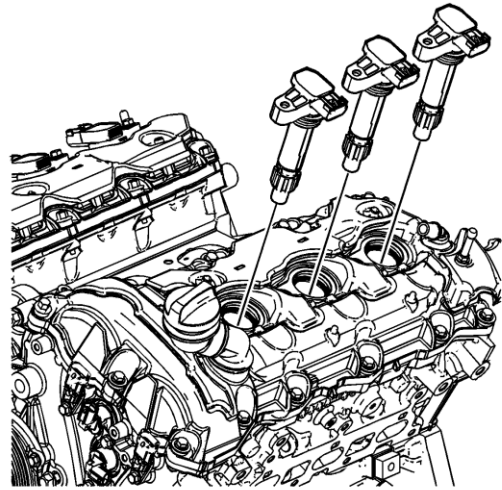
Tighten the left camshaft cover bolts in the sequence to 10 N·m



5) Remove the EN 46101 assembly aids from the spark plug tubes of the left cylinder head.



7) Install the ignition coils.



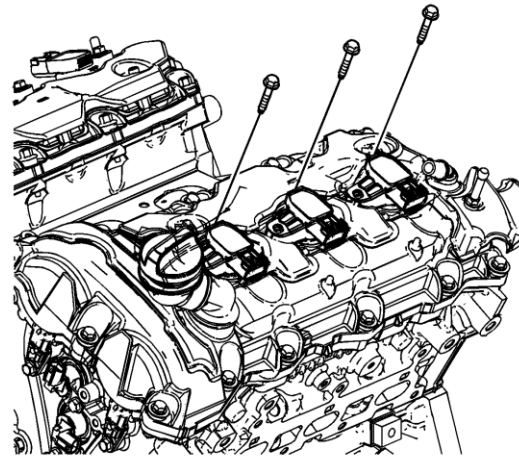
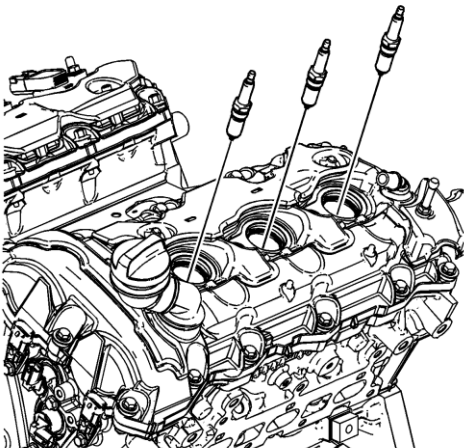
8) **Tighten**

Tighten the ignition coil bolts to 10 N·m

6) Install the NEW spark plugs into the left cylinder head.

Tighten

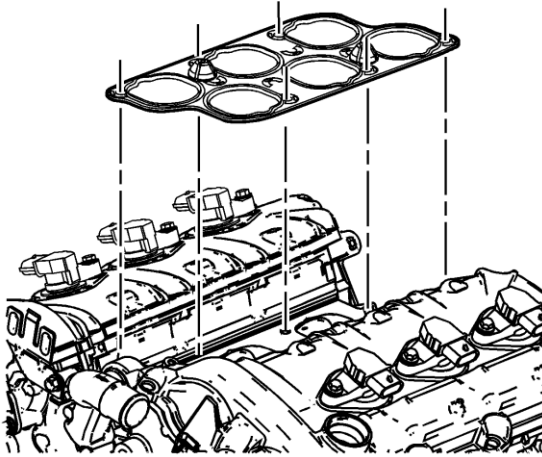
Tighten the spark plugs to 20 N·m



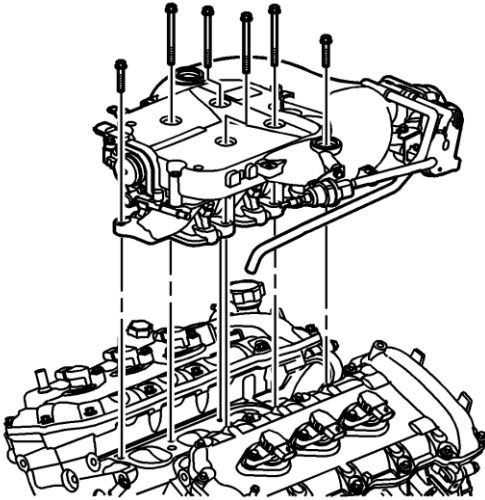
Repeat the same procedure for the right side camshaft cover

Intake Manifold Installation

1) Install the NEW intake manifold gasket



2) Install the intake manifold assembly

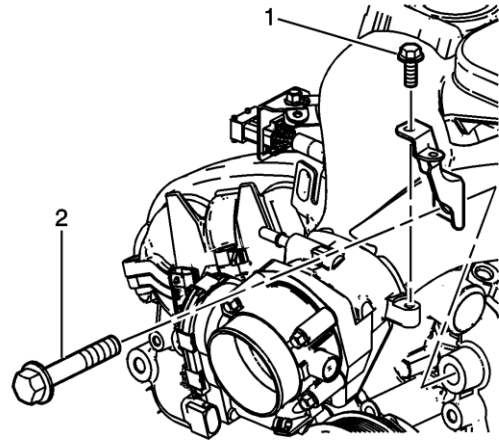


Important: Tighten the intake manifold bolts in a circular pattern starting from the center and moving outward

Tighten

Tighten the intake manifold bolts to 23 N·m

3) Place the intake manifold brace to the engine front cover and intake manifold



First tighten the intake manifold brace bolt (1) to the intake manifold.

Tighten

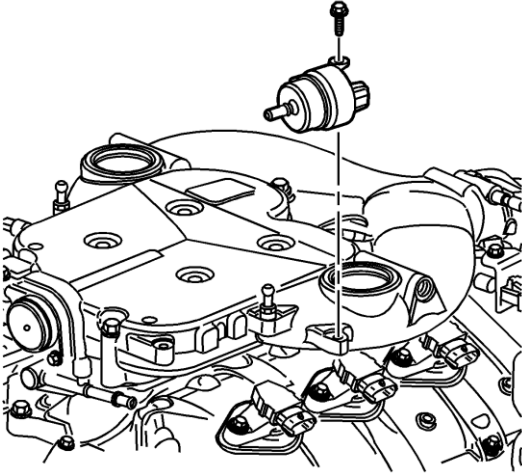
Tighten the intake manifold brace bolt at the intake manifold to 10 N·m

Finally tighten the intake manifold brace bolt (2) to the engine front cover.

Tighten

Tighten the intake manifold brace bolt to the engine front cover to 65 N·m

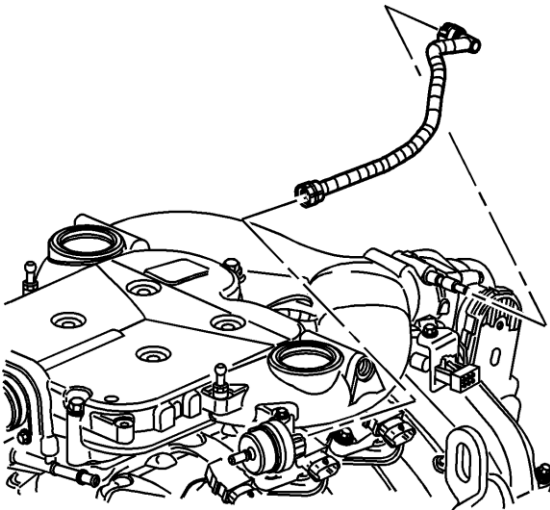
4) Install the EVAP solenoid



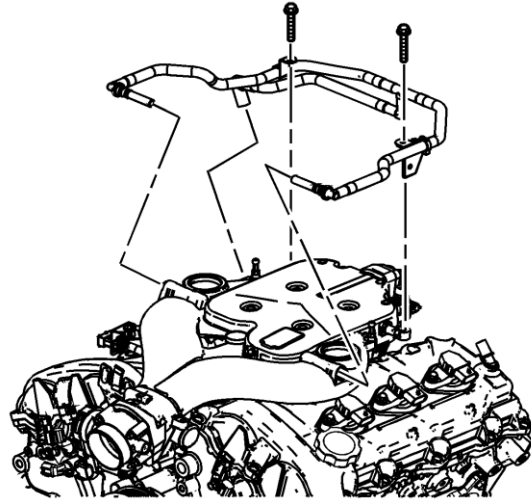
Tighten

Tighten the EVAP solenoid bolt to 10 N·m

5) Connect the EVAP hose to the upper intake manifold and EVAP solenoid



6) Connect the PCV tube assembly to the upper intake manifold and the right camshaft cover

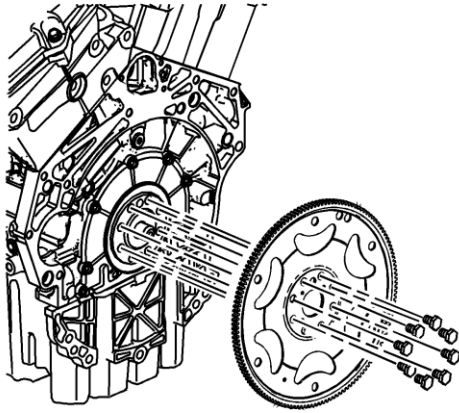


Tighten

Tighten the PCV tube assembly bracket bolts to 10 N·m

Flywheel Installation

1) Install the OHT Flywheel and new fasteners.



2) Install OHT Holding Fixture

View Not Shown

3) **Tighten**

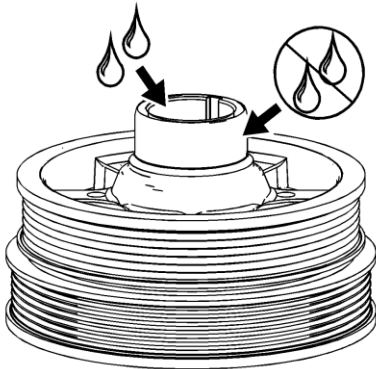
Tighten the NEW engine flywheel bolts to 30 N·m

Tighten the NEW engine flywheel bolts an additional 45 degrees.

Front Balancer Installation

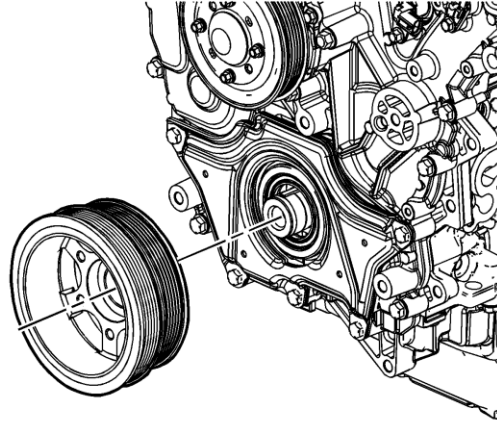
- 1) Install OHT Holding Fixture View Not Shown
- 2) Use the [J 41998-B](#) , nut, bearing and washer to install the crankshaft balancer
- 3) Apply lubricant to the inside of the crankshaft balancer hub bore

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

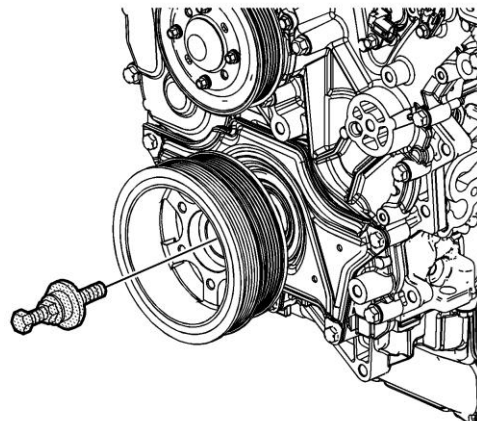


- 4) Place the crankshaft balancer in position on the crankshaft

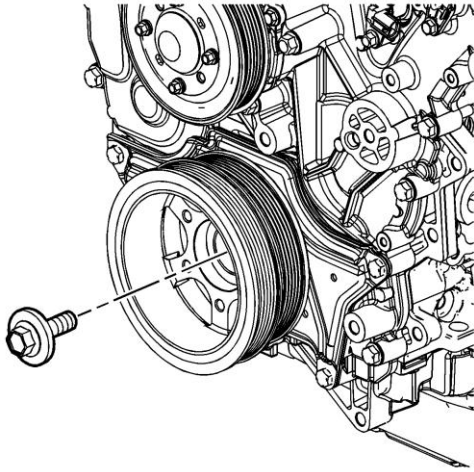
Important: Ensure the crankshaft balancer keyway is aligned with the crankshaft key



- 5) Thread the [J 41998-B](#) in the crankshaft. Ensure you engage at least 10 threads of the [J 41998-B](#) before pressing the crankshaft balancer in place. Push the crankshaft balancer into position by tightening the nut on the [J 41998-B](#) until the large washer bottoms out on the crankshaft end.



6) Remove the J 41998-B balance installation tool and install a new front balance bolt.



With the OHT Holding Fixture in place

Tighten

Tighten the crankshaft balancer bolt to 100 N·m

Tighten the crankshaft balancer bolt an additional 150 degrees.

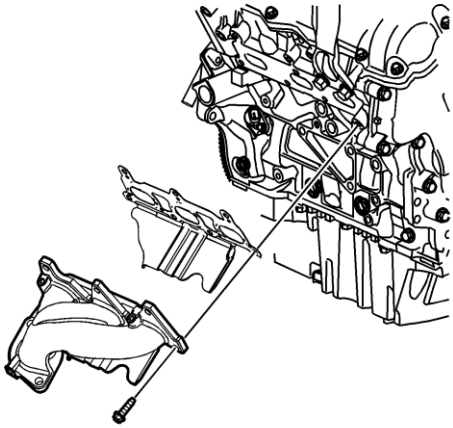
VERY IMPORTANT!

The crankshaft key is not designed to carry the load for the timing chain and oil pump drive. The clamp load applied by the balancer bolt is the load carrying mechanism. If this step is not properly performed, engine failure will result.

Exhaust Manifold Installation

1) Place the right exhaust manifold, exhaust manifold gasket and bolts as an assembly in position on the right cylinder head.

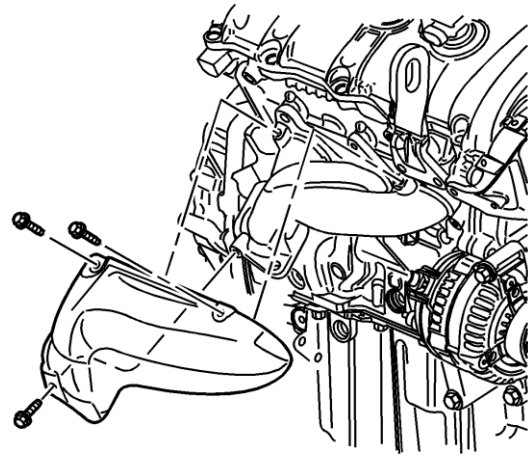
Install the exhaust manifold bolts into the right cylinder head.



Tighten

Tighten the exhaust manifold bolts to 25 N·m

2) Place the right exhaust manifold heat shield in position



Tighten

Tighten the exhaust manifold heat shield bolts to 10 N·m

Repeat the same procedure for the left side exhaust manifold.