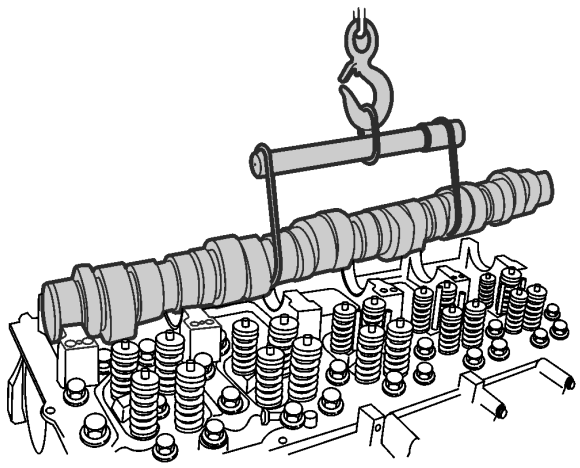
Camshaft, Replacement



W2005134

This information covers guidelines for replacing the camshaft of the Volvo D13F engine.

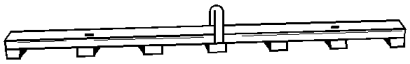
Contents

Note: Information is subject to change without notice.
Illustrations are used for reference only and may differ slightly from the actual engine version. However, key components addressed in this information are represented as accurately as possible.

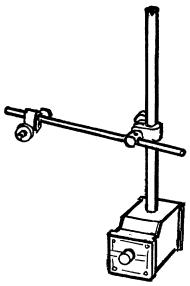
Tools

Special Tools

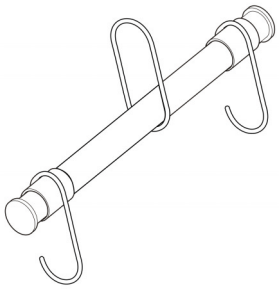
The following special tools are used to replace or repair components. The tools can be ordered from Volvo; please use the specified part number when ordering.



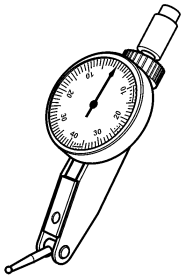
85109250
Rocker Assembly Lift Tool



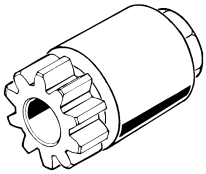
C0000823
9999696
Magnetic Stand



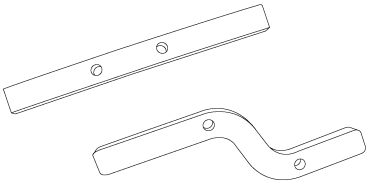
W2005764
85109034
Camshaft Lifting Tool



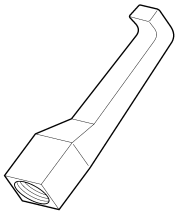
9999683
Dial Indicator



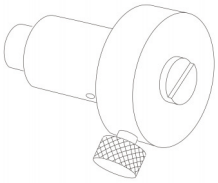
T0012612
88800014
Flywheel Turning Tool



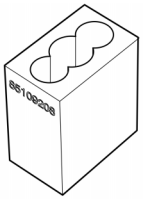
W2006190
85111422A/B
Timing Cover Clamp Tools



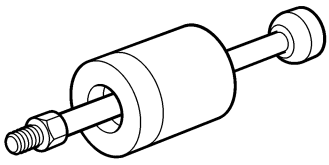
W0002313
85109980
Slide Hammer Adapter



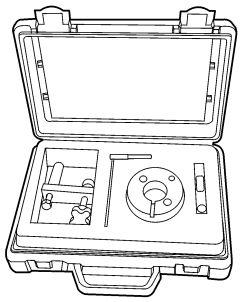
88800031
Sensor Depth Gauge



85109208
Bearing Cap Press Tool



T0010011
9990013
Slide Hammer



J44514B
Camshaft Alignment Tool Kit

Service Procedures

2154-03-02-01
Camshaft, Replacement

You must read and understand the precautions and guidelines in Service Information, group 20, "General Safety Practices, Engine" before performing any procedure. If you are not properly trained and certified in this procedure, ask your supervisor for training before you perform it.

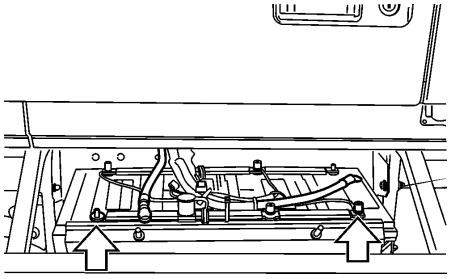
Note: Camshaft bearing journals are numbered 1–7, with matching upper and lower halves. Be sure to note and mark the corresponding journal numbers and install them in the correct sequence with matched upper and lower halves.

Special tools: 9990013, 9999683, 9999696, 85109208, 85109034, 85109250, 85109980, 88800014, 88800031, 85111422A/B, J44514B

Removal

1
Apply the parking brake and place the shift lever in neutral.

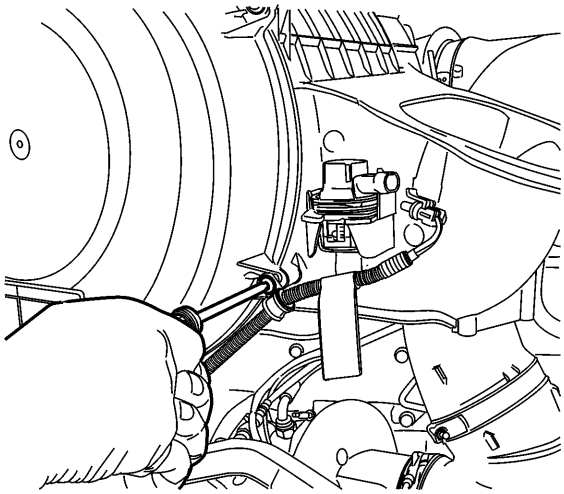
2
Remove all cables from ground (negative) battery terminals to prevent personal injury from electrical shock.



W2003815

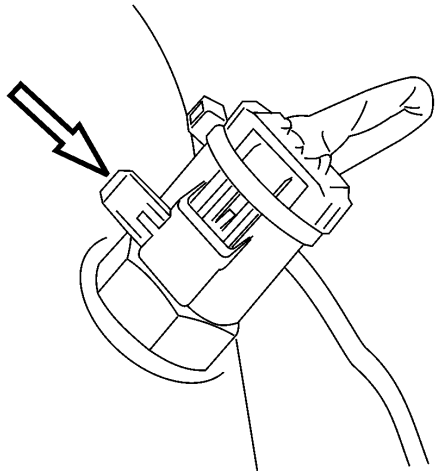
3
Remove inner splash guard as an assembly.

Note: Some models may be equipped with fender extenders, attached to the inner splash guard. Remove these as an assembly.



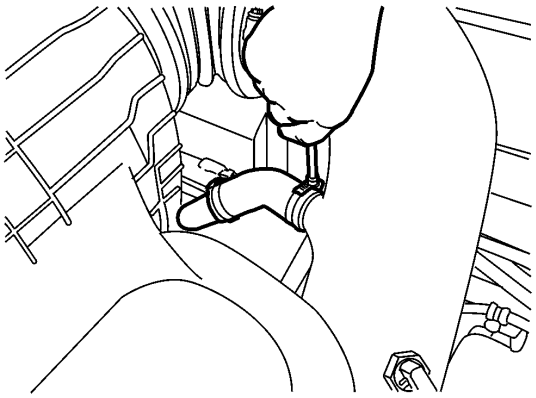
W2003861

4
Disconnect and remove the air filter restriction gauge wiring harness from the air filter housing.



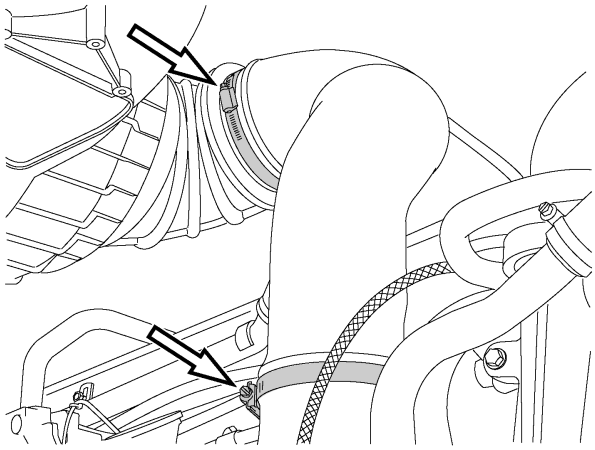
W2004720

5
Unplug the air temperature sensor wiring harness connector. First, remove the lock tab, then separate the connector from the sensor. Also, remove the clamp securing the sensor harness to the fresh air pipe.



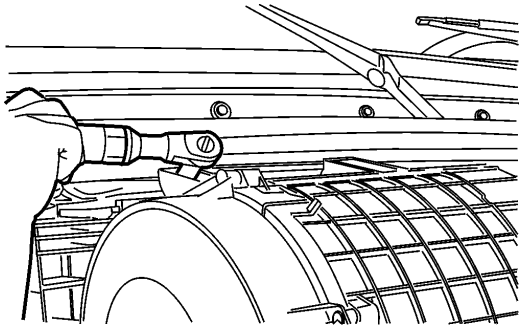
W2004719

6
Loosen the fresh air pipe-to-air compressor hose clamp and position the clamp out of the way.



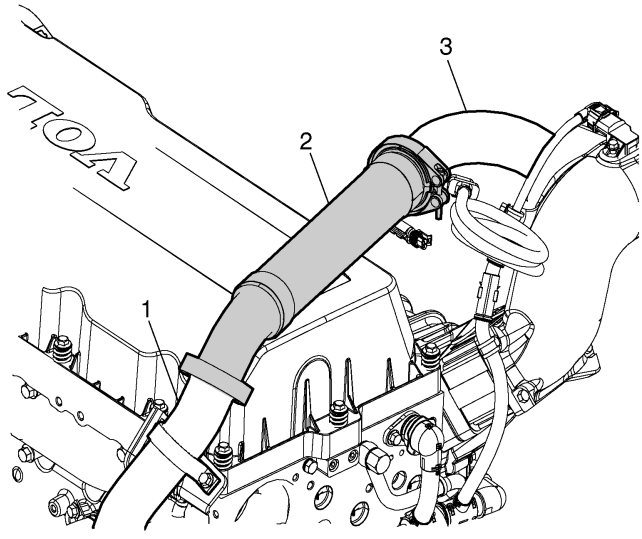
W2006005

7
Loosen the clamps and remove the main fresh air pipe from the air compressor fresh air hose, the air filter housing and turbocharger air inlet elbow.



W2003858

8
Remove the fasteners and lift the air filter housing away from the cab.



W2005960

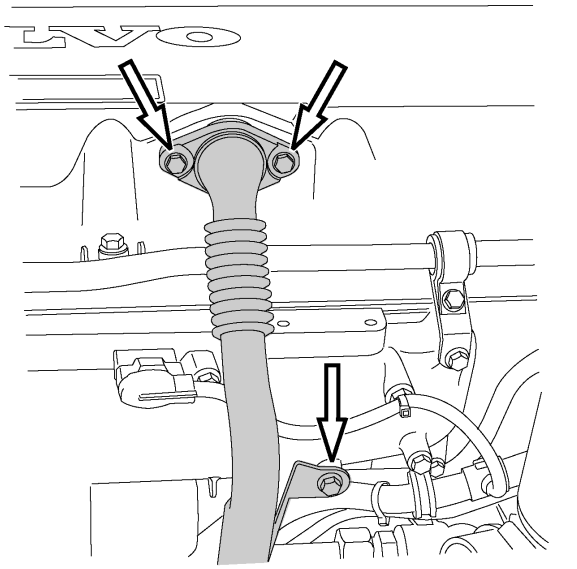
1 Venturi Outlet Pipe
2 Crossover Pipe
3 Mixer Inlet Pipe

9
Loosen the V-clamps and remove the EGR crossover pipe.

10
Loosen the clamp and mounting brackets to allow air compressor fresh air pipe to be removed.

11
Remove the hydrocarbon (aftertreatment fuel) injector harness clips at the valve cover.

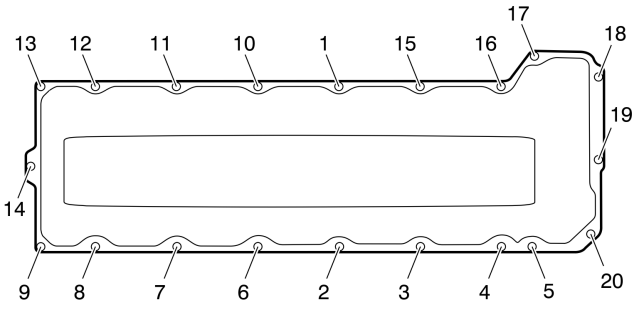
12
Remove the fasteners which secure crankcase ventilation tube and bracket to valve cover and intake manifold. Relocate the tube away from the manifold.



W2006122

13
Disconnect the discharge line and mounting brackets from the air compressor. Move the discharge air line out of the way and strap in place.

14
Remove the spring-loaded bolts from the valve cover.

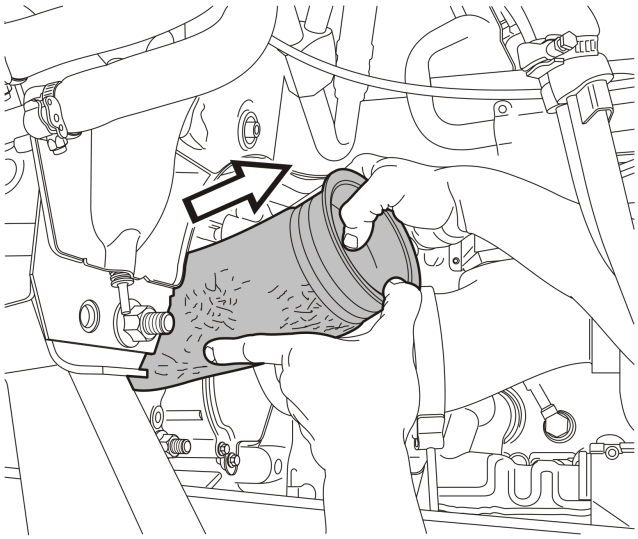


T2022732

15
Lift and remove the valve cover.

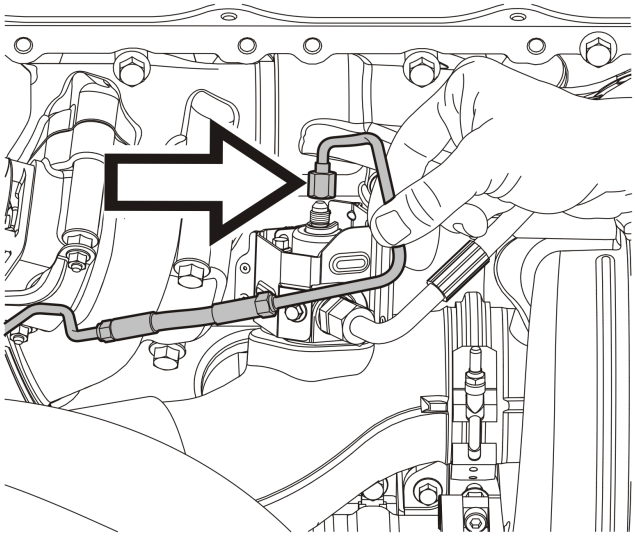
Note: Rotate the valve cover as needed, to clear the camshaft gear and damper.

Note: Dependent upon chassis, engine cover may need to be removed for clearance to remove valve cover.



W2005952

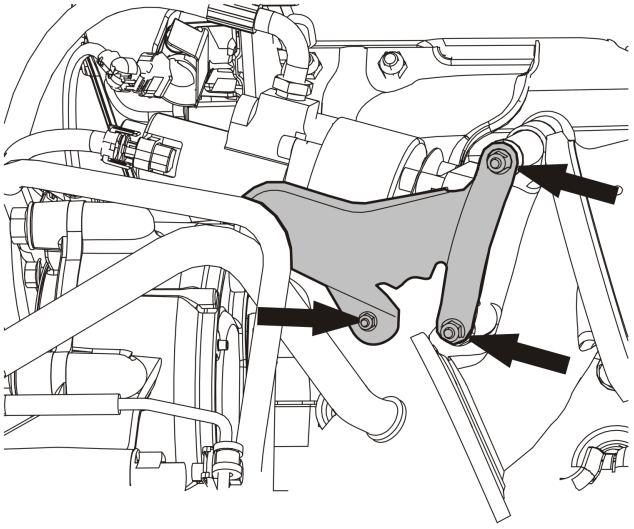
16
Remove the exhaust pipe from between the diffuser pipe and the Diesel Particulate Filter (DPF) muffler inlet pipe. Lift the pipe over the diffuser and out from under the cab.



W2005951

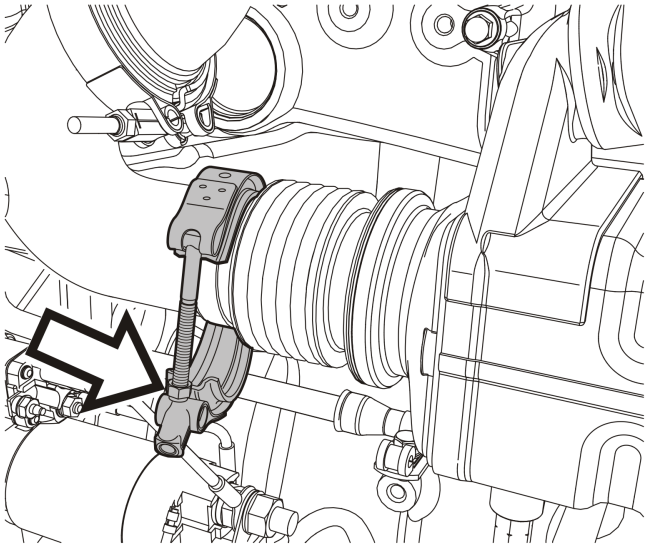
17
Remove the fuel line from the hydrocarbon (aftertreatment fuel) injector.

18
Remove the fasteners securing the hydrocarbon injector fuel line to the EGR valve heat shield.



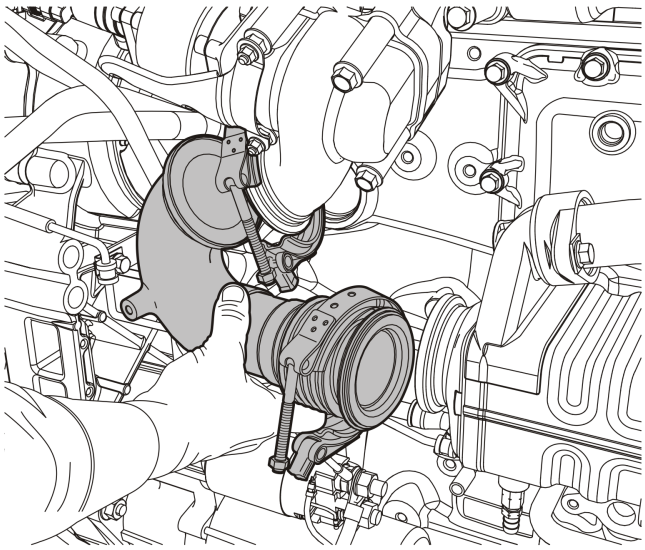
W2005685

19
Remove the fasteners securing the EGR valve heat shield and remove the shield.



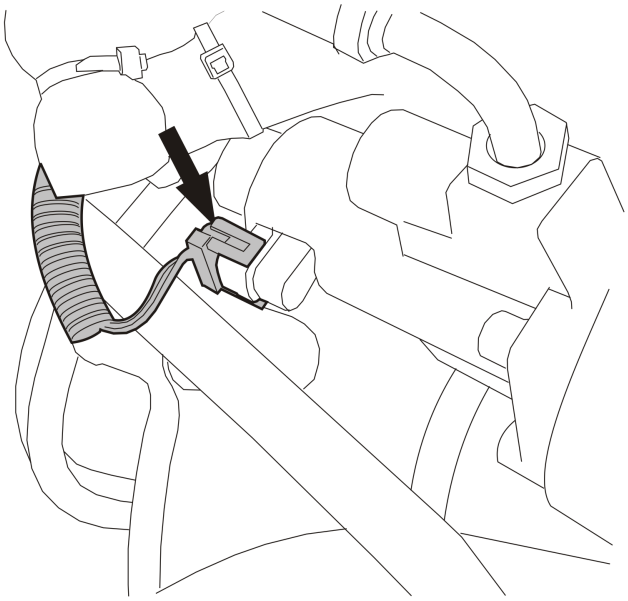
W2005642

20
Loosen the high temperature V-clamps at the EGR hot pipe by removing the nuts from the T-bolts. Free the clamps from the EGR hot pipe flanges.



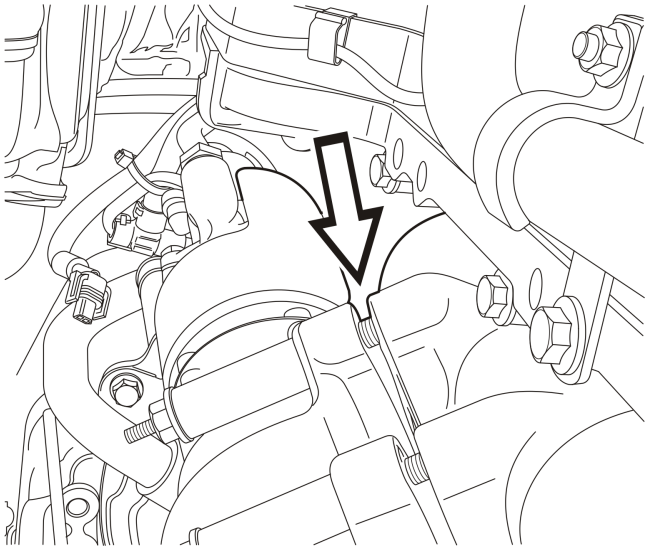
W2005641

21
Remove the EGR hot pipe from between the EGR valve and the EGR cooler.



W2005689

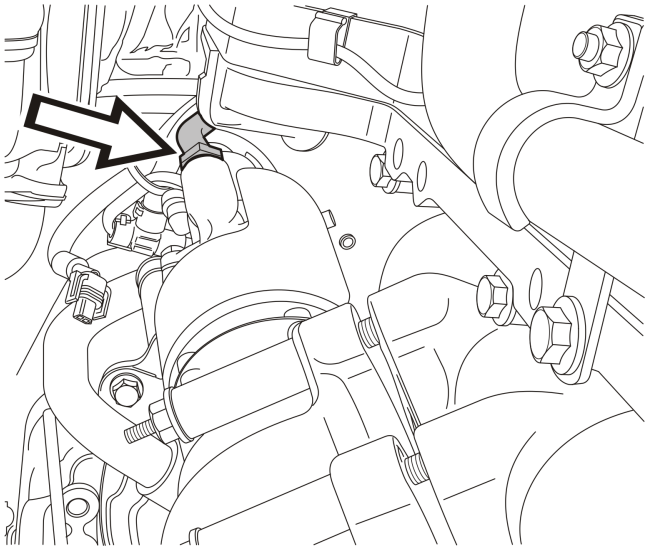
22
Disconnect the wiring harness connector from the EGR valve.



W2005954

23
Loosen, but do not remove, the EGR valve mounting bolts.

Note: Loosening the EGR valve provides clearance for loosening the oil supply line.

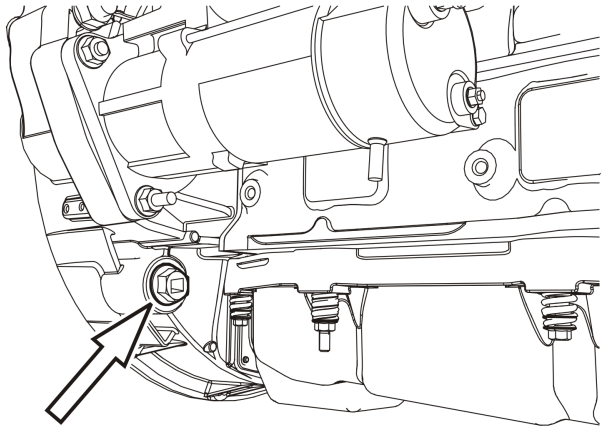


W2005955

24
Disconnect and remove the oil return line from the rear of the EGR valve.

Note: P-clamp fasteners may need to be removed to free oil line.

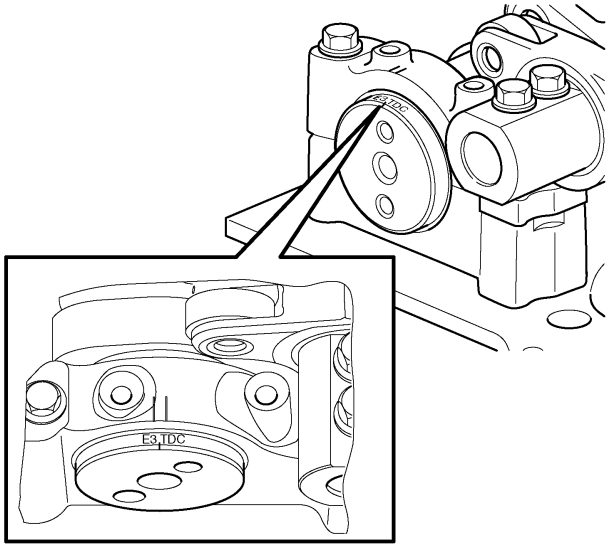
Note: EGR oil supply line will remain attached to the bottom of the EGR valve.



W0002368

25
Remove the plug from the flywheel housing and install the flywheel turning tool.

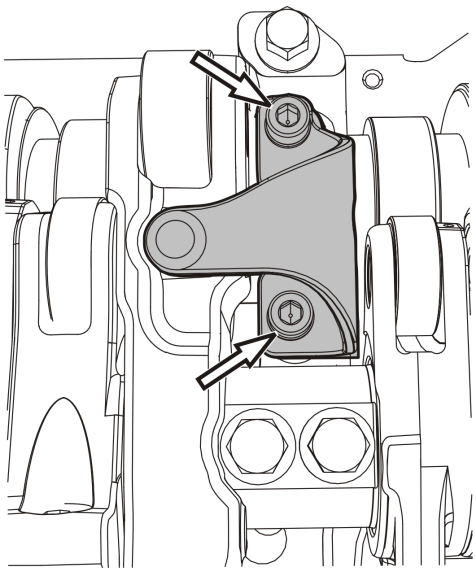
88800014



W2006173

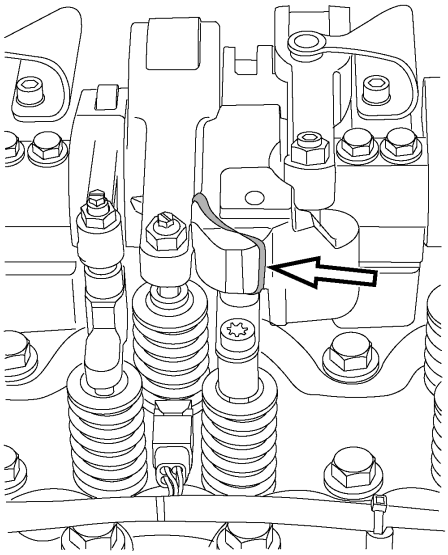
26
Using the engine turning tool, turn the engine over manually so that the camshaft is positioned at top dead center (TDC) by aligning the TDC mark on the camshaft with the timing marks on the No. 1 camshaft bearing cap.

88800014



W2005845

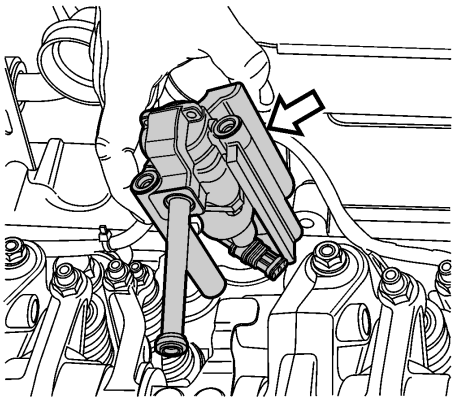
27
Using an Allen wrench, remove all mounting fasteners for the leaf spring on the brake rockers then, remove the leaf springs.



W2006172

28
Secure the pistons in the exhaust rocker arms using rubber bands (or tie straps) to prevent piston damage.

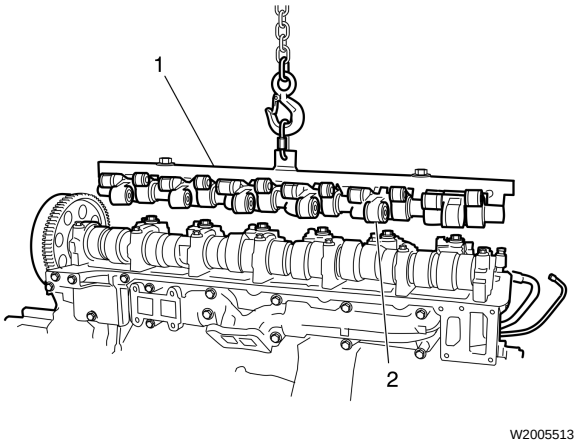
Note: Pistons and rocker arms are matched together and should not be mixed.



W2004839

29
Remove the VEB control valve (if equipped), along with the pipe between the valve and rocker arm shaft.

Note: On engines without the engine brake, an oil flow adapter is used in place of the oil control valve. It is mounted in the same location on the cylinder head and provides oil to the rocker shaft.



W2005513

1 Lifting Tool 85109250
2 Rocker Shaft Assembly

Note: Be sure to preserve the guides on top of each bearing cap.

30
Remove the fasteners attaching the rocker arm shaft to the camshaft bearings caps.

CAUTION

The order of the rocker arm assembly must be maintained. Make certain the sets of four are kept together. Make certain the rocker arms are identified so they can be returned to their original positions on the shaft. Failure to heed this caution may result in severe engine damage.

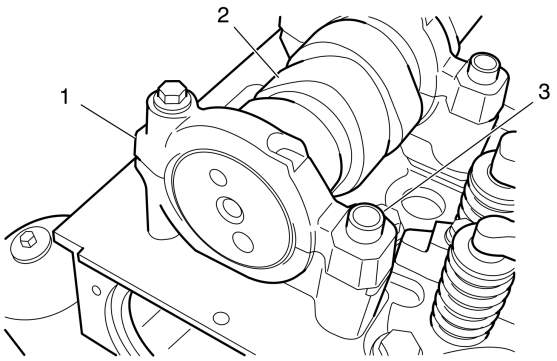
31
Attach the lifting tool to the rocker arm shaft.

85109250

32
Loosen the rocker arm shaft mounting fasteners evenly in stages to avoid bending the shaft. With the aid of an assistant, remove the fasteners and carefully lift off the shaft assembly using the lifting tool. Place the rocker shaft in secure location.

Note: On engines equipped with VEB, ensure the pistons are secured in the exhaust rocker arms with elastic bands so that the pistons do not fall out as the shaft is removed.

85109250



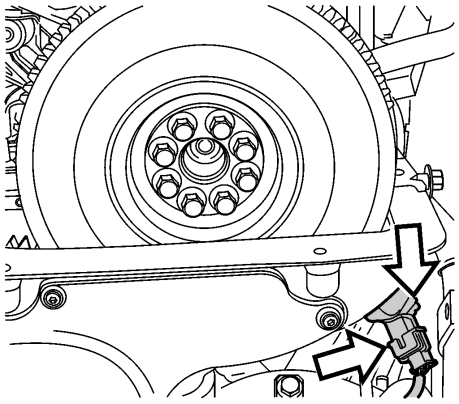
W2005514

1 Camshaft Bearing Cap
2 Camshaft
3 Alignment Sleeve

33
With the rocker shaft assembly removed, check to ensure that the alignment sleeves remain in position on each bearing cap.

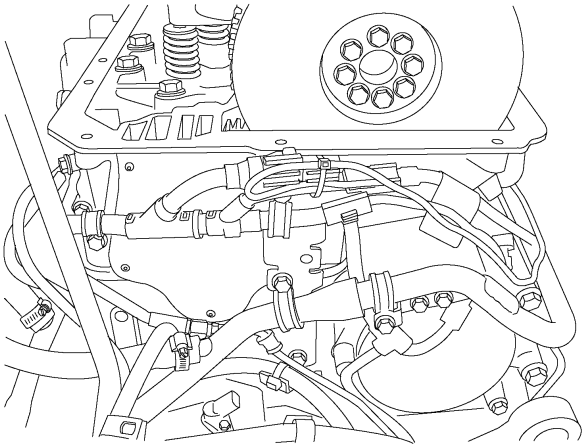
34
Remove the intake and exhaust bridges.

Note: Keep the bridges in order of removal for proper reassembly.



W2005104

35
Disconnect the camshaft (engine) position sensor harness connector. Then, remove the retainer screw and remove the sensor from the engine.

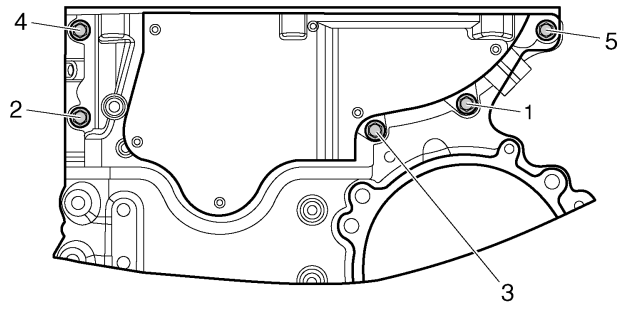


W2006132

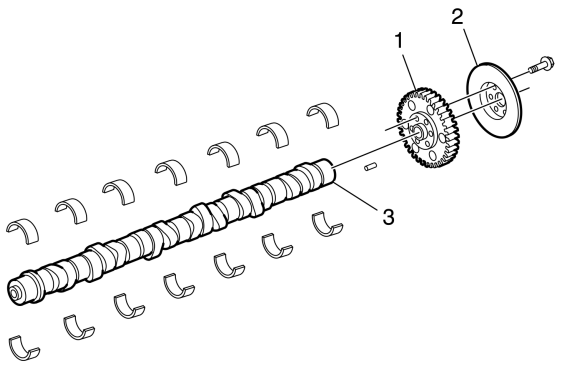
36
Remove all straps, P-clamps and other retainers used to restrain harnesses, oil lines and coolant tubes to the rear of the engine. This will allow the support bracket at the rear of the engine to be removed.

37
Remove support bracket fasteners and remove the rear support bracket.

38
Remove the timing gear cover fasteners and remove the cover.



W2006133



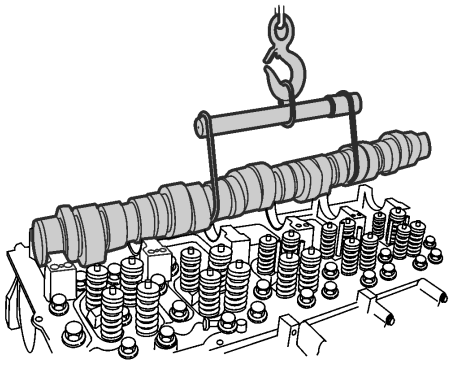
W2005525

1 Camshaft Gear
2 Vibration Damper
3 Camshaft

39
Remove the vibration damper and camshaft gear from the camshaft.

40
Mark the camshaft bearing caps (if not factory marked or identified), so that they can be reinstalled in the original bearing saddle locations. Remove the camshaft bearing cap fasteners and bearing caps. Use the slide hammer adapter 85109980 and slide hammer 9990013 to remove the caps.

85109980, 9990013



W2005134

41
Attach the camshaft lifting tool to the camshaft between the lobs and carefully remove the camshaft from the cylinder head.

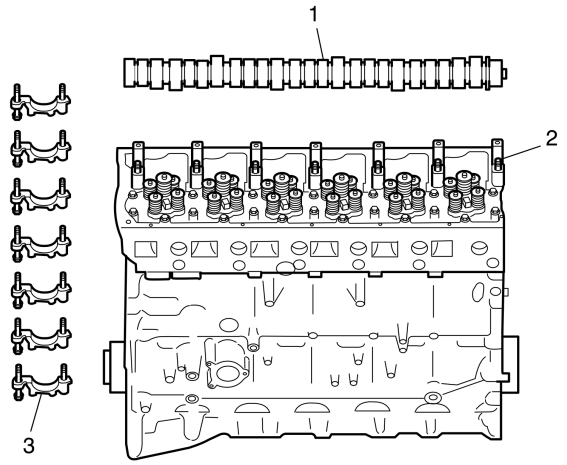
CAUTION

The camshaft is heavy. Do not attempt to remove the camshaft without the help of an assistant and/or the use of a suitable lifting device. Failure to heed this caution may result in severe personal injury and component damage.

Note: If the camshaft is not being replaced, stand the camshaft on end for storage.

85109034

42
If not factory identified, mark the camshaft lower bearing saddles for proper installation and remove them using a pry bar. Remove the No. 7 rearmost saddle using a soft-faced mallet by tapping side to side.



W2005472

1 Camshaft
2 Camshaft Bearing Saddles
3 Camshaft Bearing Caps

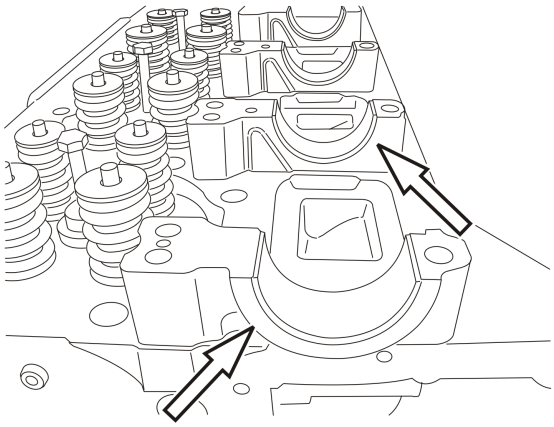
43
Remove the bearings from the camshaft bearing saddles on the cylinder head and from the camshaft bearing caps. Inspect the bearings, bearing caps and cylinder head bearing saddles for wear or damage. Replace component if excessive wear or damage exists.

Note: This procedure presumes that the camshaft bearing brackets are in place on the cylinder head, held in position by guide sleeves. If removed, the brackets must be returned to their original locations along with the respective bearing caps.

Installation

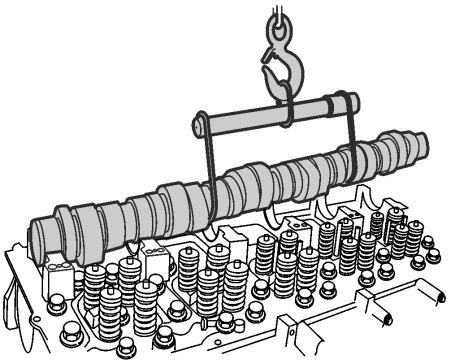
1
Install the camshaft bearing saddles to original positions. Carefully tap the bearing saddles using a soft-faced hammer until fully seated.

2
Insert the camshaft lower bearings and lubricate them with clean engine oil.



W2005237

3
Make sure there is a bearing insert on each camshaft bearing bracket. The bearing inserts at the No. 7 camshaft journal have integral thrust washers.



W2005134

4
Lower the replacement camshaft carefully into place and remove the lifting tool. Rotate the camshaft by hand to ensure the camshaft is not binding in the lower bearing saddles.

CAUTION

The camshaft is heavy. Do not attempt to install the camshaft without the help of an assistant or the use of a suitable lifting device. Failure to heed this caution may result in severe personal injury and component damage.

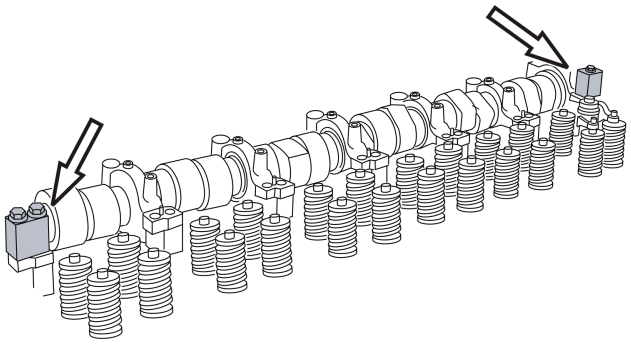
85109034

5
Install the camshaft upper bearings into the bearing caps and lubricate with fresh engine oil. Install the bearing caps to the respective bearing saddles. Final tightening is done later when the rocker arm shaft is installed. Use a soft-faced mallet to seat the bearing caps over the dowel pins.

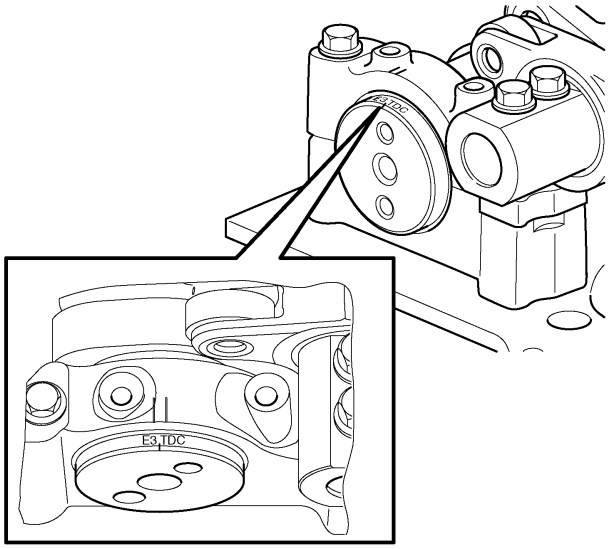
6
Install the bearing cap press tool (2 required) at the number 7 and number 1 bearing caps as shown in the illustration.

Note: The tool is used when adjusting the timing gear backlash when the rockershaft assembly is not installed.

85109208



W0002297

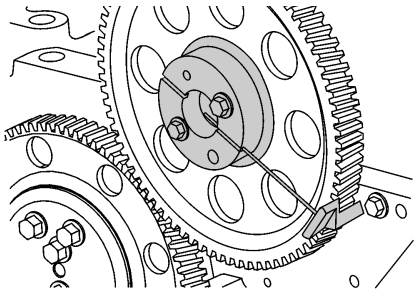


W2006173

7
Make sure the camshaft TDC marking is aligned between the two line markings on the front of the camshaft bearing cap.

8
Install the camshaft timing gear without the damper using the camshaft alignment spacer block J44514B with two bolts. Tighten the bolts to 45 ± 5 Nm (33 ± 4 ft-lb), 90 ± 5 degree rotation.

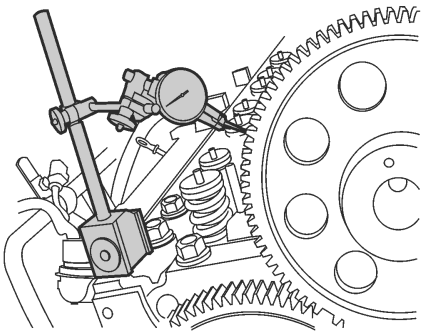
45 ± 5 Nm
(33 ± 4 ft-lb)
90 ± 5 degree rotation.
J44514B



W2005135

9
Position the camshaft gear so that the reference hole in the timing gear plate is between the marks on the gear. Insert the alignment tool into the hole in the cylinder head to engage the camshaft gear teeth with the rod of the tool in the slot of the clamp tool. Rotate the camshaft until this occurs, then remove alignment rod.

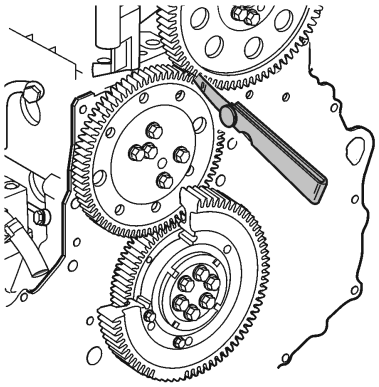
J44514B



W2005136

10
Check the backlash between the camshaft timing gear and the adjustable idler gear. Position the dial indicator against a tooth of the camshaft timing gear and rock the gear back and forth while holding the adjustable gear with the clamp from the kit. Note the value on the dial indicator and compare with the specification of 0.10 ± 0.05 mm (0.004 ± 0.002 inch).

9999683, 9999696, J44514B



T2019208

11
If the gear backlash must be adjusted, slightly loosen the adjustable idler gear screws. Install a 0.1 mm (0.004 inch) feeler gauge on the loaded side of the gear and turn the camshaft in a counterclockwise direction to take up the gear lash. Tighten the screws of the adjustable idler gear. Install the clamp from the camshaft alignment tool kit to secure the adjustable idler gear.

J44514B

12
If a gear backlash adjustment was required, replace all adjustable idler gear bolts, one at a time and tighten to 35 ± 4 Nm (26 ± 3 ft-lb), plus 120 ± 5 degree rotation.

Note: This step is only required if backlash needed to be adjusted.

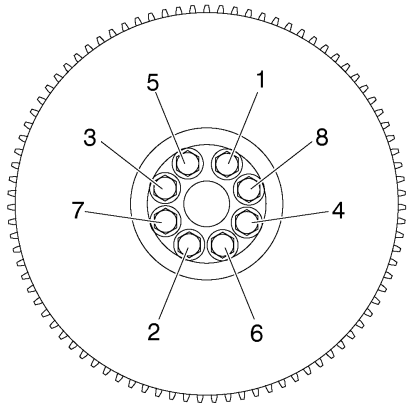
Note: Mark the bolts to aid in tightening the bolts to the degree rotation specification.

35 ± 4 Nm
(26 ± 3 ft-lb)
plus 120 ± 5 degree rotation.

13
Remove the camshaft alignment spacer block from the camshaft timing gear and install the vibration damper and clamp plate using new bolts. Tighten the bolts to 45 ± 5 Nm (33 ± 4 ft-lb), plus 90 ± 5 degree rotation.

Note: Mark the bolts to aid in tightening the bolts to the degree rotation specification.

45 ± 5 Nm
(33 ± 4 ft-lb)
plus 90 ± 5 degree rotation.

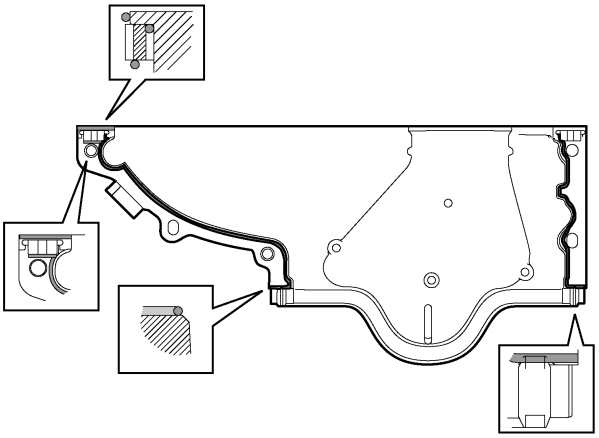


W2006135

14
Remove the bearing cap press tools.

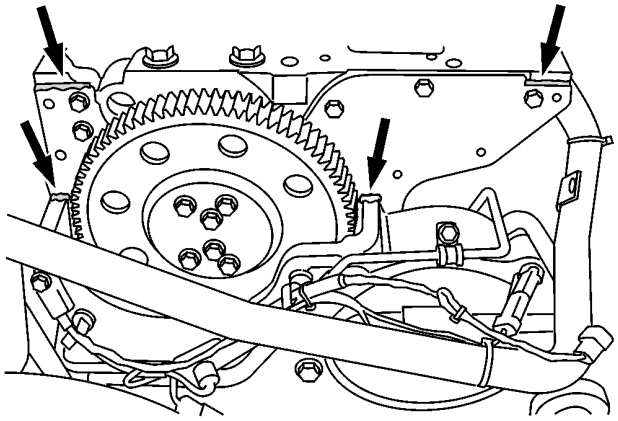
85109208

15
Replace the timing gear cover seals and gaskets.



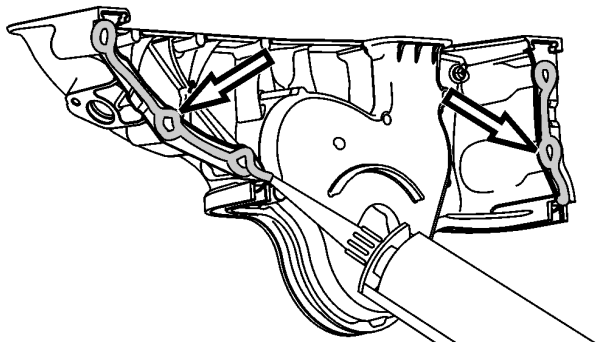
W2006134

16
Apply sealant in the bottom corners where the timing gear plate and the flywheel housing meet. Also apply sealant to the top of the timing gear plate (in the corner) next to the cylinder head.

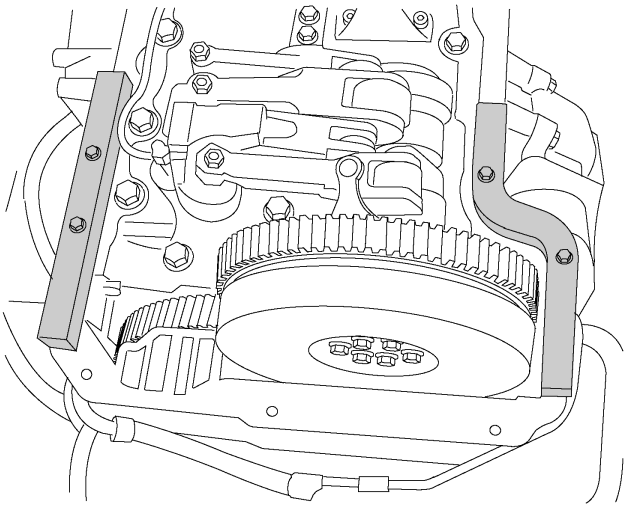


W2005102

17
Apply sealant to the mating surfaces of the timing gear cover.



W2005137



W2006191

18
Position the timing gear cover, install the fasteners and loosely tighten. Install the timing cover clamp tools so that the timing gear cover surface is flush with the seal surface on the cylinder head.

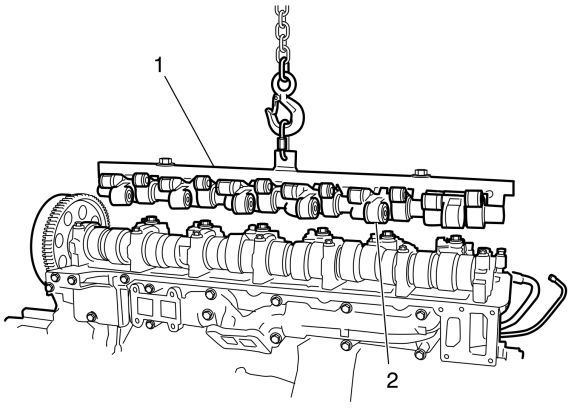
85111422A, 85111422B

19
Oil the valve bridges and the camshaft lobes with engine oil. Install the valve bridges over their respective exhaust and intake valves.

20
Using the lifting tool and an assistant, place the shaft with rocker arms and springs in position on the inboard side of the camshaft bearing caps. Install and tighten the rocker arm shaft bolts a little at a time, evenly across the entire shaft so that the shaft does not become distorted, bent or fractured.

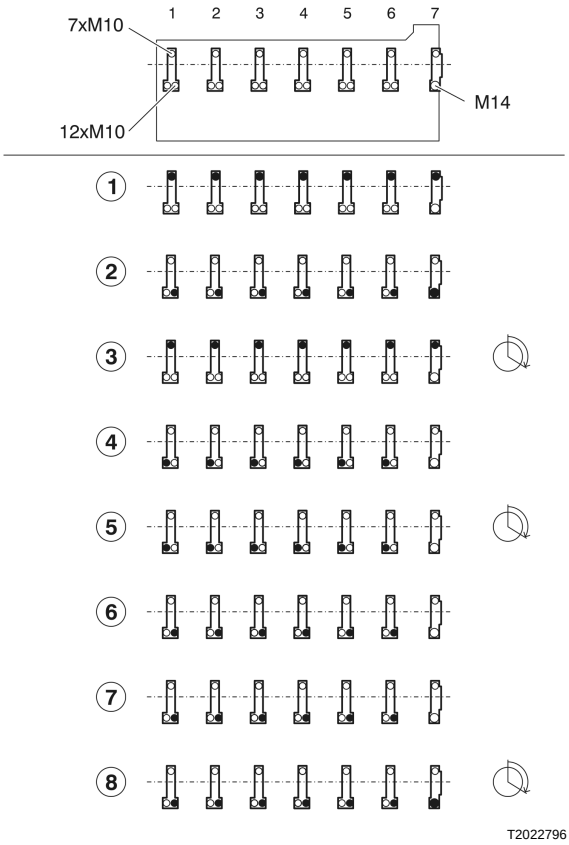
Note: Make sure that the rocker arm shaft is seated properly in the guide dowels of the camshaft bearing caps. On engines equipped with the VEB, remove the restraints (rubber bands or tie straps) securing the exhaust rocker arm pistons.

85109250



W2005513

1 Lifting Tool 85109250
2 Rocker Shaft Assembly

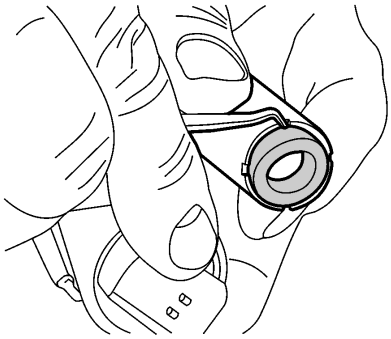


21
Torque-tighten and angle tighten all camshaft bearing cap and rocker arm shaft bolts in the sequence shown, to the following specification:

Note: Tighten the bolts in the following steps to ensure that the rocker arm shaft is fully seated without bending.

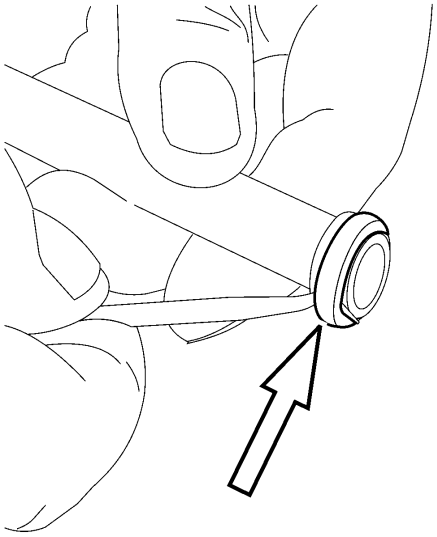
Tightening Sequence and Torque Specifications

Discard screws with four marks when removed and substitute new screws.	
Step 1. Torque-tighten marked bolts of bearing caps 1–7.	25 ± 3 Nm (19 ± 2 ft-lb)
Step 2. Torque-tighten marked bolts (in stages) in order 4, 3, 5, 2, 6,1, 7. **Note:** The bolts must be tightened in stages to ensure that the rocker arm shaft is seated without bending.	60± 5 Nm (44 ± 4ft-lb)
Step 3. Angle-tighten marked bolts of bearing caps 1–7.	90 ± 5 degrees
Step 4. Torque-tighten marked bolts of bearing caps 1–6.	25 ± 3 Nm (19 ± 2 ft-lb)
Step 5. Angle-tighten marked bolts of bearing caps 1–6.	120 ± 5 degrees
Step 6. Completely loosen the marked bolts of bearing caps 1–6.	
Step 7. Torque-tighten marked bolts of bearing caps 1–6.	25 ± 3 Nm (19 ± 2 ft-lb)
Step 8. Angle-tighten marked bolts of bearing caps 1–6 and the bolt of bearing cap 7.	120 ± 5 degrees



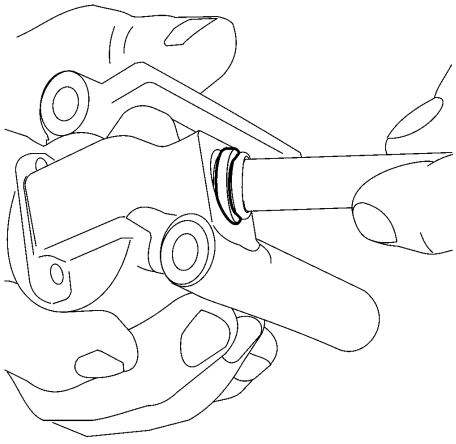
W2004855

22
Replace the O-ring at the bottom of the VEB control valve, if equipped with engine brake.



W2004853

23
Clean the VEB control valve oil pipe and replace the O-rings. Lubricate the pipe hole in the rocker arm shaft and the O-rings on the pipe.

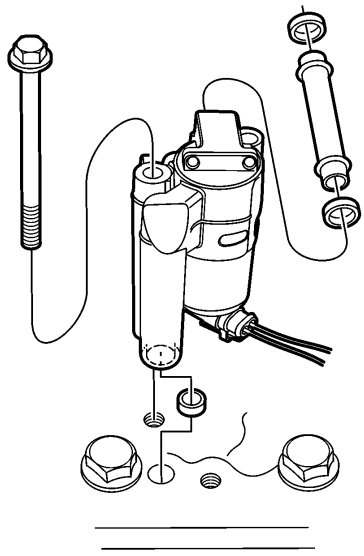


W2004854

24
Insert the oil pipe into the oil hole of the VEB control valve.

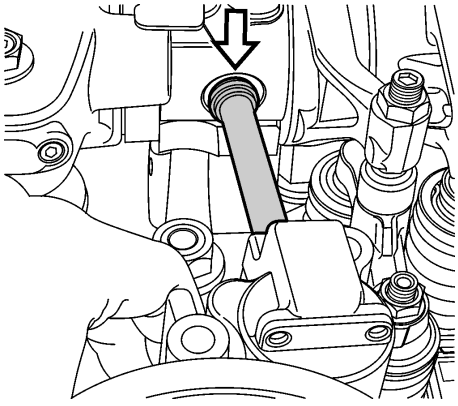
Note: Make sure that the O-ring is seated fully in the valve.

25
Install a new VEB control valve sealing washer.



W2004869

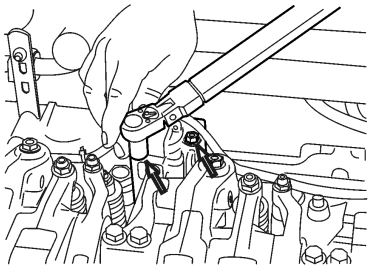
26
Position the VEB control valve on the cylinder head.



W2004857

27
Align the VEB oil pipe and O-ring with the hole in the rocker shaft.

Note: For engines without VEB, an oil flow adapter is used in place of the engine brake control valve and is mounted in the same manner. Also, no springs are required for the exhaust rocker arms.

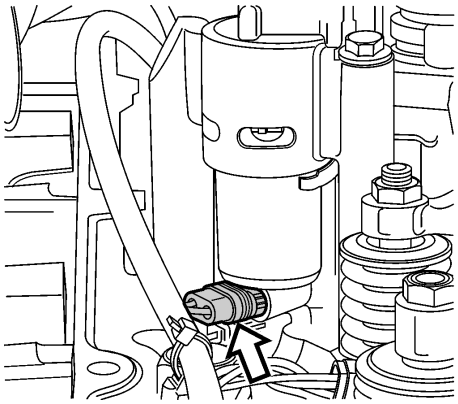


W2004858

28
Install the VEB control valve bolts and tighten to 24 ± 4 Nm (18 ± 3 ft-lb).

Note: Make sure the VEB oil pipe O-ring is fully seated.

24 ± 4 Nm
(18 ± 3 ft-lb)

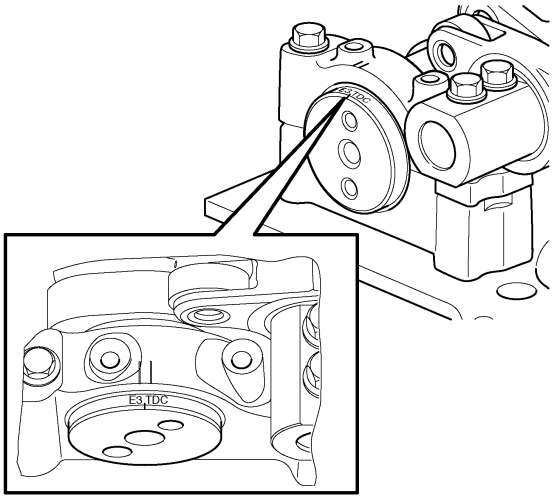


W2004837

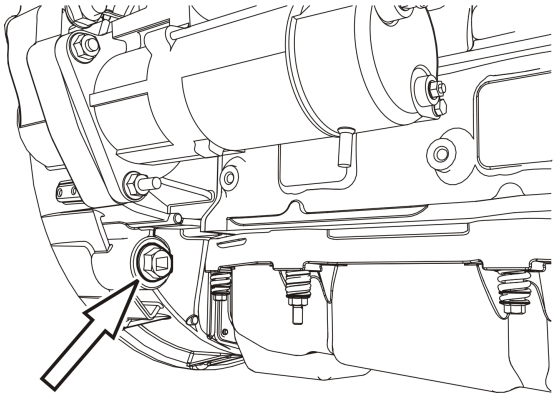
29
Plug-in the VEB control valve harness connector.

30
Reposition the fuel injector harness over the VEB control valve and secure with tie straps.

31
When adjusting the valves, make sure to start with the camshaft cylinder alignment marks between the two lines on the front camshaft.



W2006173



W0002368

32
Adjust the inlet, exhaust and unit injectors using the pattern outlined in the chart below. Use flywheel turning tool 88800014 to advance the engine to the next setting.

Note: Ensure the flywheel turning tool is well greased before attempting to rotate the flywheel.
Camshaft markings for setting of valves and unit injectors:

- **Without VEB:** Markings 1–6, apply to adjustment of inlet valves, exhaust valves and unit injectors.
- **With VEB:** Markings 1–6, apply to adjustment of inlet valves and unit injector.

Markings E1–E6, apply to adjustment of exhaust valves.

Valve and Injector Settings

Cam Position	Injector	Intake Exhaust	Exhaust (VEB)	VEB Rocker
5	X	X		
E6			X	X
3	X	X		
E2			X	X
6	X	X		
E4			X	X
2	X	X		
E1			X	X
4	X	X		
E5			X	X
1	X	X		
E3			X	X

33
Adjust the valves and unit injectors to the lash settings below:

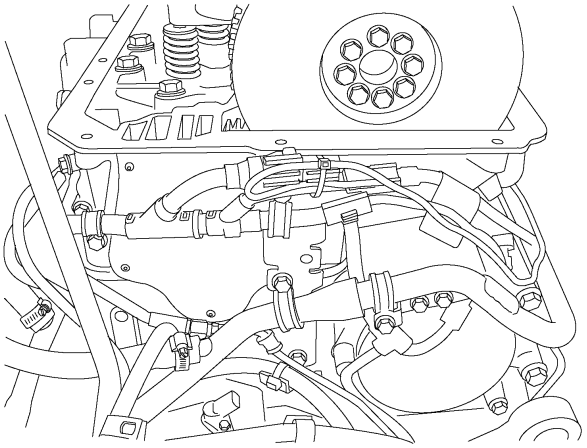
- Inlet Valve Clearance: 0.20 mm (0.008 inch)
- Exhaust Valve Clearance: 0.80 mm (0.031 inch)
- Exhaust Valve Clearance, VEB: 1.00 mm (0.039 inch)
- Exhaust Brake Rocker Clearance, VEB: 3.6 ± 0.1 mm (0.142 ± 0.004 inch) [Between rocker roller and camshaft.]
- Adjust the unit injector to zero lash and then turn 4 flats (240° CW).

Note: Torque-tighten valve adjustment locknuts to specification following each valve adjustment.

If further instructions on adjusting valves and unit injectors are required, refer to group 21.

34
Position the rear support bracket onto the rear of engine and install support bracket fasteners to secure.

35
Install all tie straps, P-clamps and other retainers used to restrain harnesses, oil lines and coolant tubes to the rear of the engine.

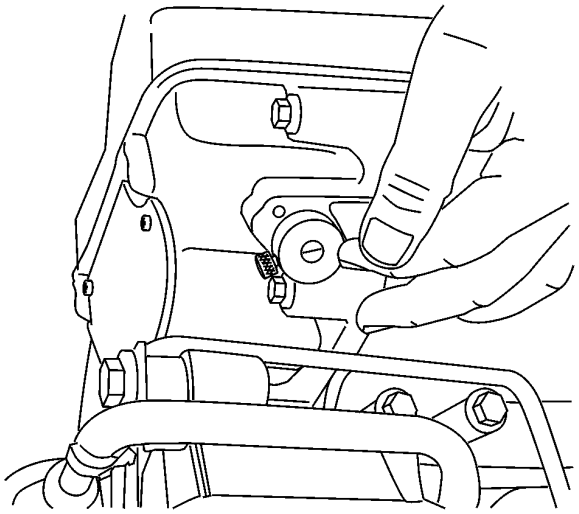


W2006132

36
Check for proper camshaft position sensor clearance using the sensor depth gauge to determine if shims are required for sensor depth. The camshaft position sensor clearance specification is 0.3–1.0 mm (0.011–0.039 inch).

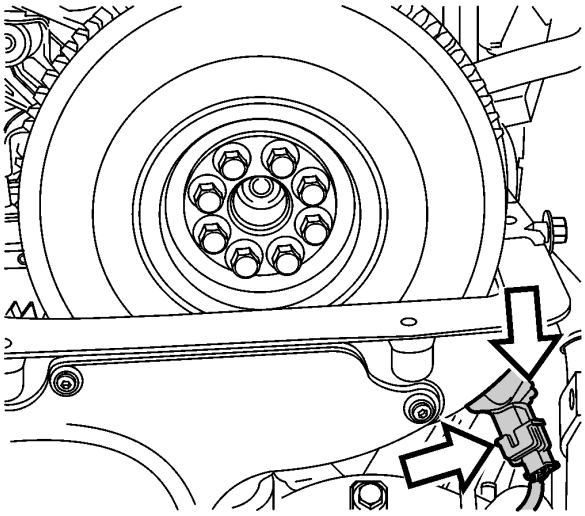
1 Rotate the engine until a tooth of the camshaft toothed wheel is aligned with the sensor bore.
2 Insert the depth gauge into the sensor bore until the outer part of the gauge is fully seated against the timing gear cover.
3 Loosen the thumb screw of the gauge and push the inner part of the gauge in until it contacts a tooth of the toothed wheel.
4 Tighten the thumb screw to secure the inner part of the gauge.
5 Carefully remove the gauge from the camshaft sensor bore and observe the location of steps between the inner and outer portions of the gauge:

- Both steps below the surface of the gauge = no shims required.
- One step below the surface of the gauge = one shim required.
- Both steps above the surface of the gauge = two shims required.



W2005068

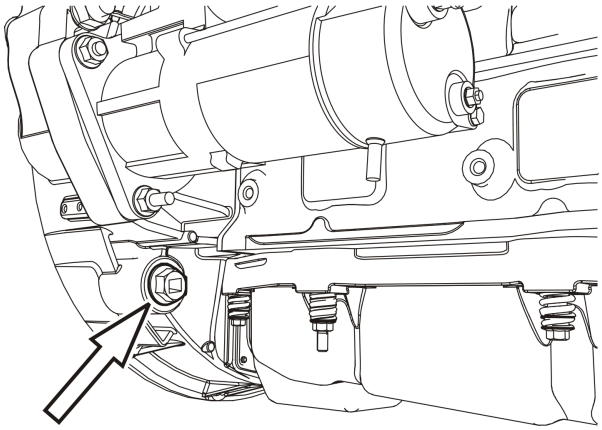
88800031



W2005104

37
Install the camshaft position sensor with appropriate shim(s), new O-ring, secure with bolt and plug in harness connector.

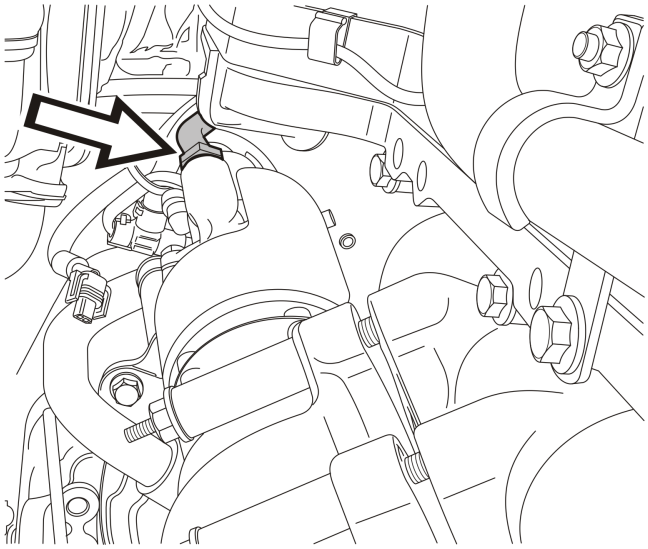
Note: The camshaft position sensor shim part number is 20556179.



W0002368

38
Remove flywheel turning tool 88800014. Reinstall the dust plug.

88800014



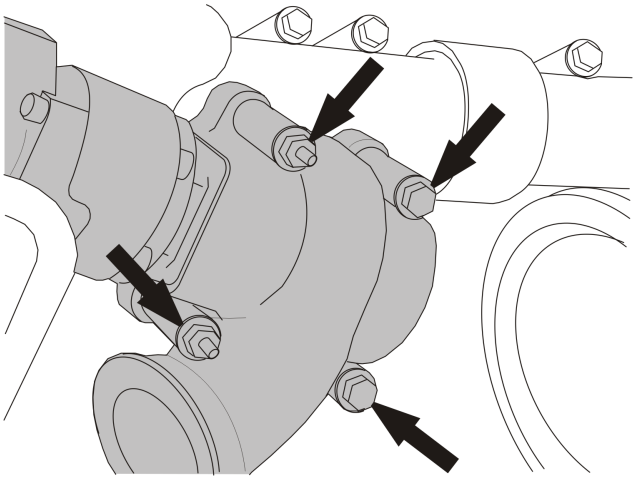
W2005955

39
Install EGR valve oil return line and torque-tighten to specification.

Note: EGR valve oil supply line was not loosened during this procedure.

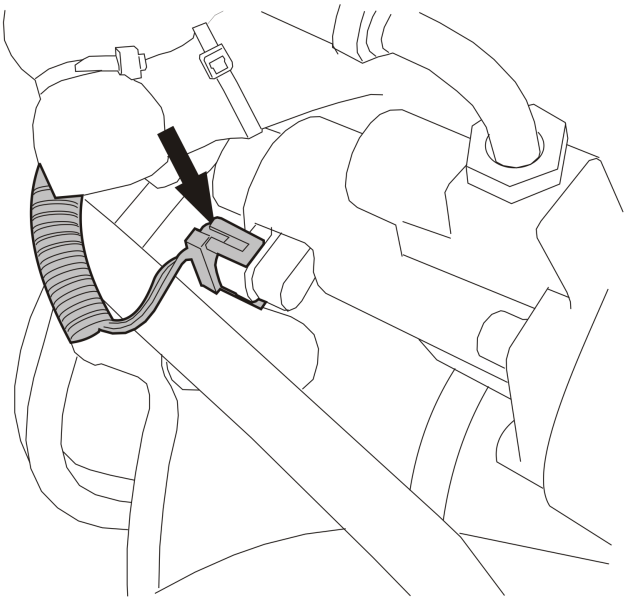
40
With the EGR valve near the exhaust manifold ports, remove mounting bolts and then slip a new metal gasket between the valve and the exhaust manifold. Start new bolts to hold the EGR valve and gasket in place.

41
Torque-tighten the EGR valve mounting bolts to specification.

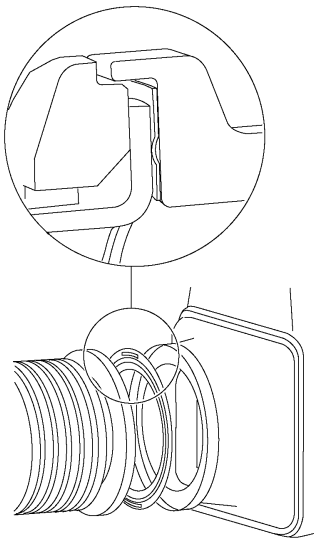


W2005693

42
Connect the wiring harness connector to the EGR valve.



W2005689

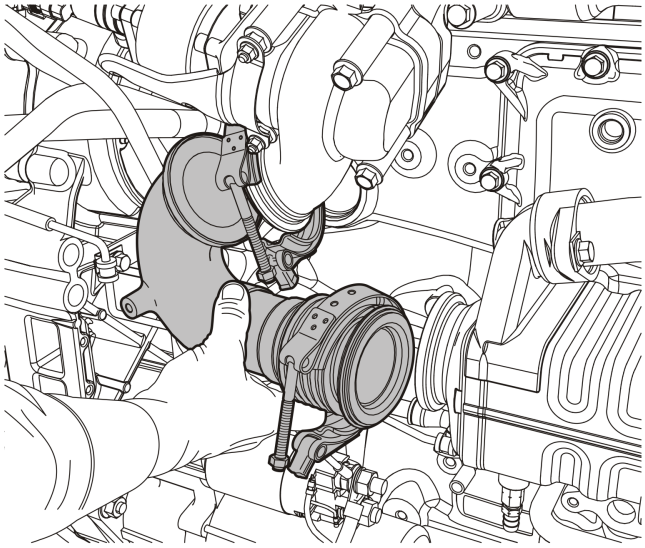


W2006187

43
Install new high-temperature gaskets into the EGR valve end of the hot pipe and the inlet of the EGR cooler. Ensure the gaskets lay flat against the flange surfaces with the bead of the gasket facing toward the EGR hot pipe.

Note: Gaskets are one-time use only. Do not reuse gaskets.

44
Inspect the V-clamps and T-bolt threads for wear or damage. If they are OK, apply anti-sieze compound to the T-bolt threads. Lubricate the v-inserts of the clamps.

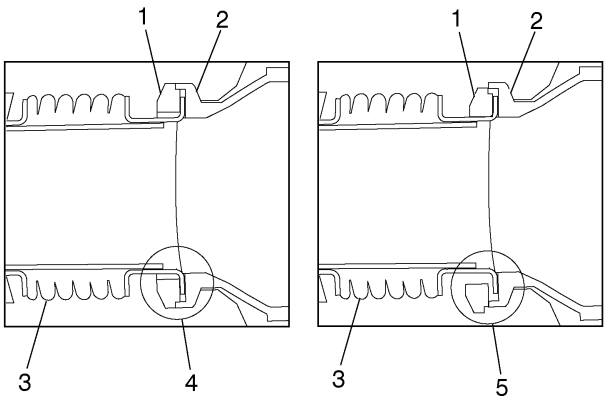


W2005641

45
Hook the upper V-clamp over the EGR valve flange. Place the remaining V-clamp over the bellows on the hot pipe.

46
Lubricate the flange on the EGR cooler inlet and the flange on the EGR hot pipe with fresh engine oil. Lubrication aids in proper V-clamp installation.

47
Position the EGR hot pipe between the EGR valve and the EGR cooler. Make sure the flanges engage properly. Slide the upper V-clamp over the EGR valve flange and tighten the clamp until snug. Slide the lower V-clamp over the EGR cooler flange and tighten the clamp until snug.



W2006163

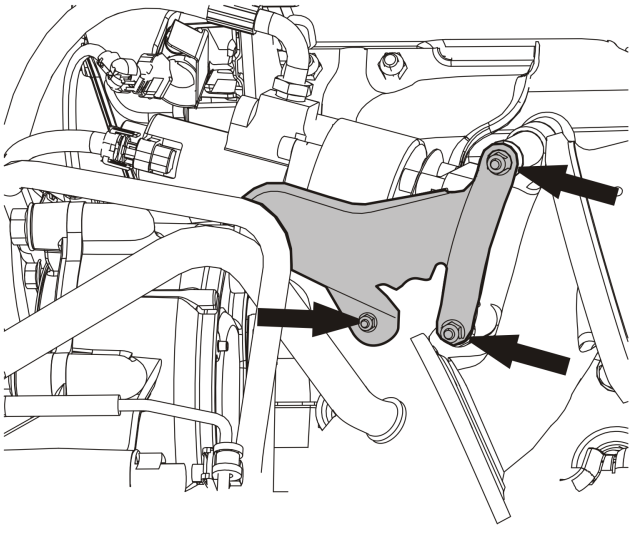
1 EGR Pipe Floating Flange
2 EGR Cooler Flange
3 EGR Pipe
4 Flange Assembled Correctly
5 Flange Assembled Incorrectly

48
Visually inspect the floating flange through the gap in the V-band clamp to make sure it is properly seated in the EGR cooler flange. The floating flange must be concentric with the EGR cooler flange.

Note: If the floating flange is not properly seated in the EGR cooler flange, the gasket will not be compressed and the seal will leak.

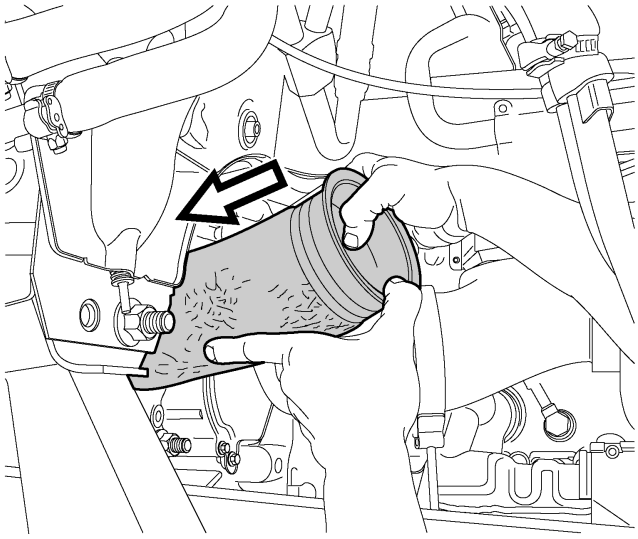
49
Position the upper V-clamp so that the T-bolt clears the heat shield. Tighten both clamps to specification.

Note: After reaching the specified torque, inspect the V-clamps to make sure that no portion of the clamp has “bottomed out.”



W2005685

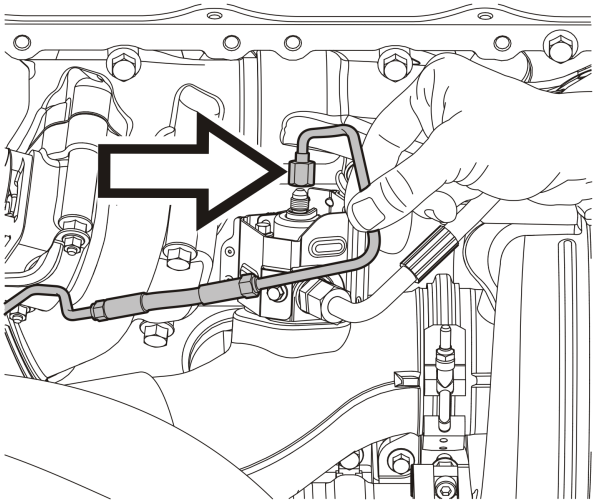
50
Place the EGR heat shield in position over the EGR valve. Install the fasteners to secure the shield to the cylinder block and to the studs on the valve mounting bolt heads. Tighten the fasteners to specification.



W2006038

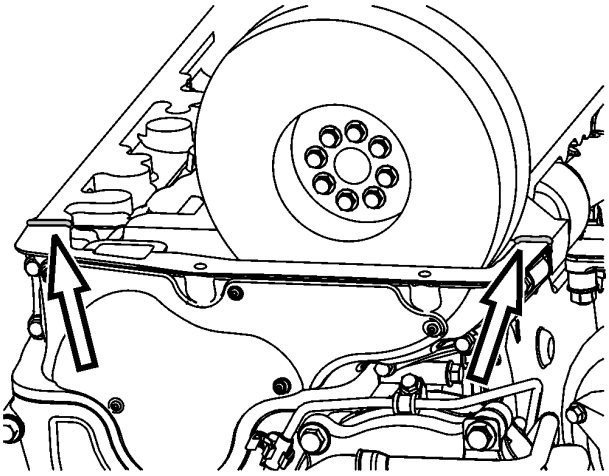
51
Position the exhaust pipe between the diffuser pipe and the DPF muffler inlet pipe and loosely install the V-clamps.

52
Position the diffuser against the turbo and loosely install the new V-clamp. Adjust the exhaust pipe and diffuser pipe as needed and then, tighten the V-clamps to specification.



W2005951

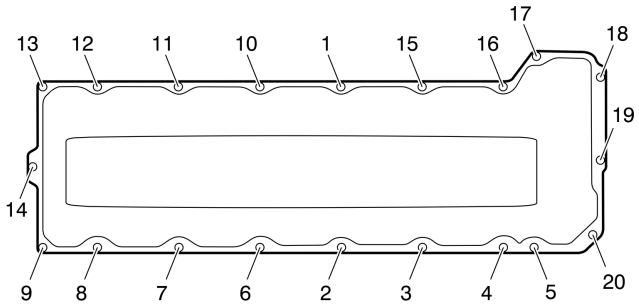
53
Install the fuel line to the hydrocarbon injector. Install the hydrocarbon injector fuel line clamp to the EGR valve heat shield.



W2005157

54
Apply a 2 mm (0.079 inch) bead of Volvo sealant to the area where the timing cover and the cylinder head meet. This parting line is on both sides of the cylinder head. Carefully position the valve cover on the cylinder head and make sure that the seal remains properly seated.

Note: This step is very critical to ensure no oil leaks occur.



T2022732

55
Install the spring-loaded bolts in the valve cover. Torque-tighten the valve cover bolts to 24 ± 4 Nm (18 ± 3 ft-lb) in the sequence shown.

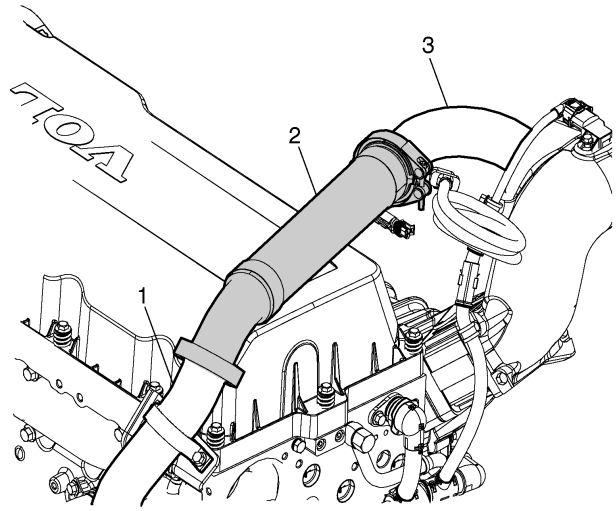
Note: Install the engine cover, if removed for clearance.

Note: The bolt springs provide even tension on the valve cover gasket.

24 ± 4 Nm
(18 ± 3 ft-lb)

56
Connect the discharge line and mounting brackets for the main air line to the air compressor.

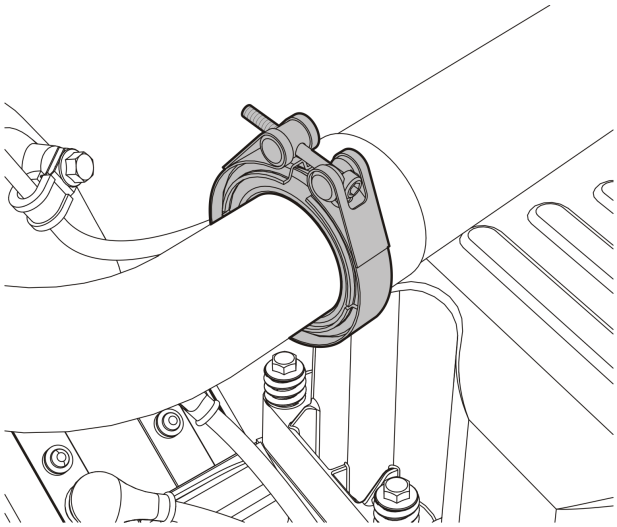
57
Install the hydrocarbon injector harness clips to the valve cover.



W2005960

1 Venturi Outlet Pipe
2 Crossover Pipe
3 Mixer Inlet Pipe

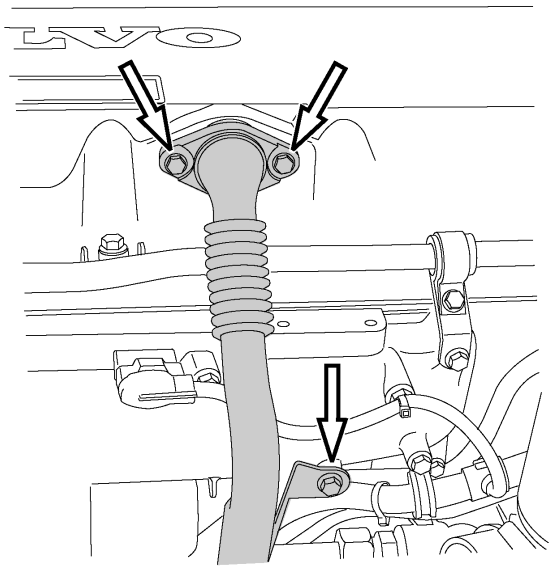
58
Inspect the crossover pipe V-clamps for wear or damage, replace as necessary. Position the crossover pipe (with new O-rings) between the venturi outlet pipe and the mixer inlet pipe. Lubricate V-clamp threads and v-inserts.



W2005804

59
Install a V-clamp at each end of the crossover pipe and tighten the clamps to secure the pipe.

Note: Make sure the O-rings remain in place while positioning the pipe.



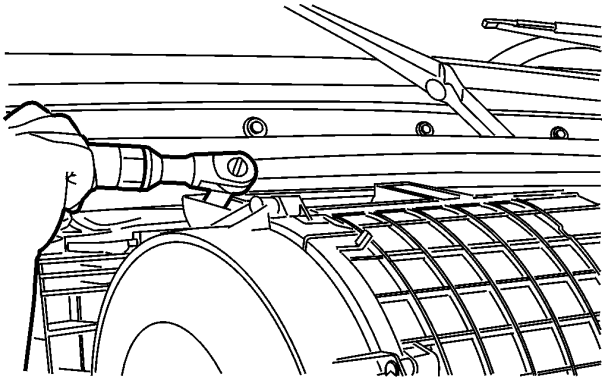
W2006122

60
Install the fasteners securing crankcase ventilation tube and bracket to valve cover and intake manifold. Torque-tighten fasteners to 24 ± 4 Nm (18 ± 3 ft-lb).

Note: Inspect the crankcase ventilation tube O-ring and replace if necessary.

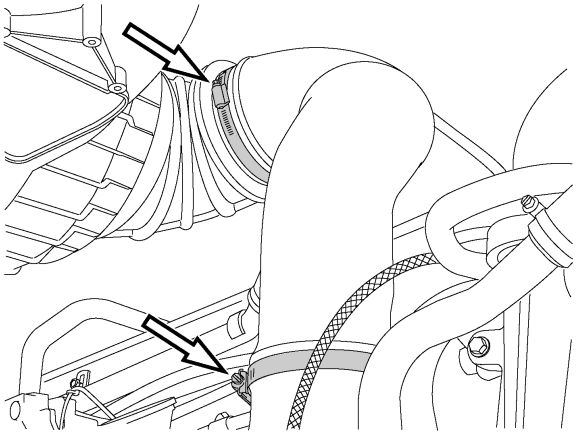
Note: Ensure that the same bolts that were removed at disassembly are reinstalled in the same location. Damage to the valve cover will result if too long of bolts are installed.

24 ± 4 Nm
(18 ± 3 ft-lb)



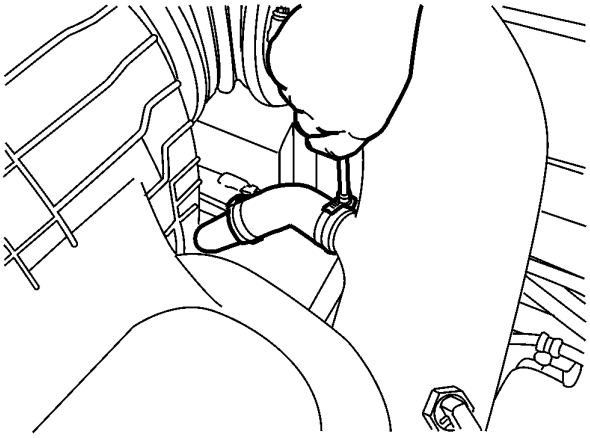
W2003858

61
Position the air filter housing against the cab and install fasteners to secure.



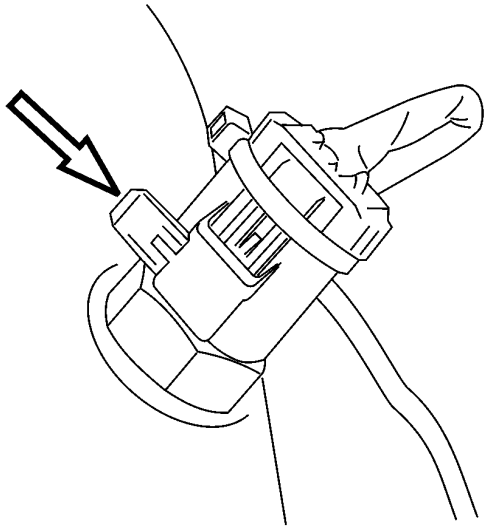
W2006005

62
Install the main fresh air pipe between the air filter housing and the turbocharger air inlet elbow. Position the clamps and tighten to secure.



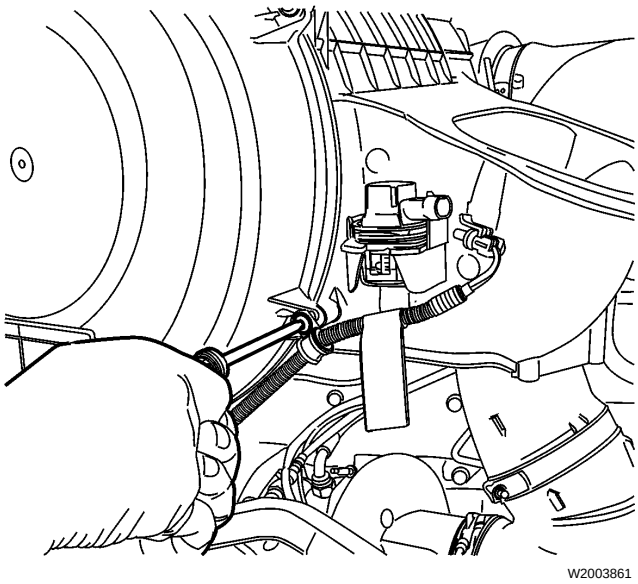
W2004719

63
Install the air compressor fresh air hose to the main fresh air pipe, position the clamp and tighten to secure.



W2004720

64
Install the air temperature sensor connector to the sensor. Insert and secure the connector lock tab. Install the sensor harness clamp to the main fresh air pipe.



W2003861

65
Connect and secure the air filter restriction gauge wiring harness to air filter housing.

66
Install the inner splash guard assembly.

67
Install all previously removed cables to the ground (negative) battery terminals.

68
Start the engine, check for leaks and proper operation.