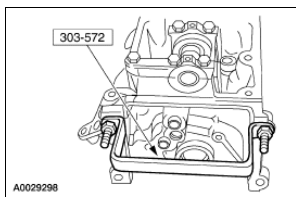


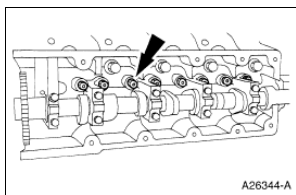
**All cylinder heads**

5. Remove the special tools from both ends of the cylinder head.



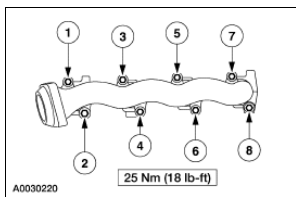
6. **NOTE:** Lubricate the hydraulic lash adjusters with clean engine oil.

Install the hydraulic lash adjusters in their original locations.



**RH cylinder head**

7. Install the RH exhaust manifold gaskets and the exhaust manifold. Tighten the nuts in the sequence shown.

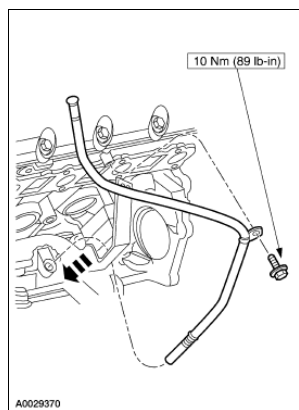


**LH cylinder head**

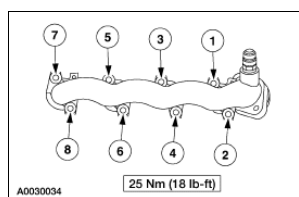
8. **NOTE:** Lubricate the O-ring seal with clean engine oil.

Install the oil level indicator tube.

- Install a new O-ring seal on the oil level indicator tube.
- Install the oil level indicator tube.
- Install the bolt.



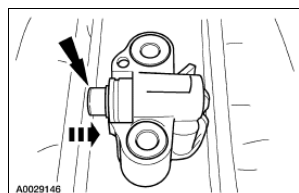
9. Install the LH exhaust manifold and the exhaust manifold gaskets. Tighten the nuts in the sequence shown.



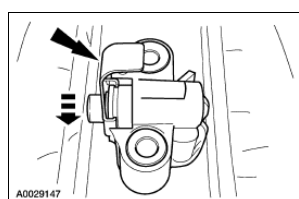
### All cylinder heads

10. **⚠ CAUTION: Timing chain procedures must be followed exactly or damage to valves and pistons will result.**

Compress the tensioner plunger, using a vise.

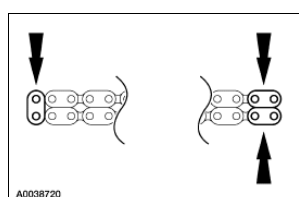


11. Install a retaining clip on the tensioner to hold the plunger in during installation.

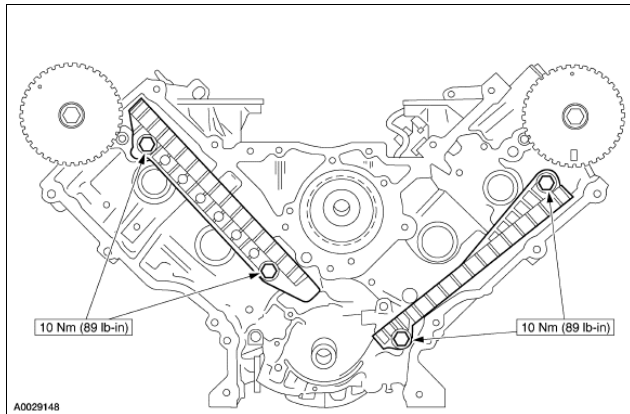


12. Remove the tensioner from the vise.

13. If the copper links are not visible, mark two links on one end and one link on the other end, and use as timing marks.

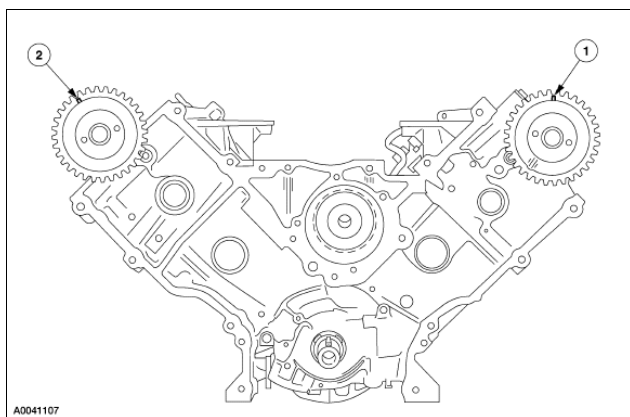


14. Install the timing chain guides.



15. Pre-position the camshafts.

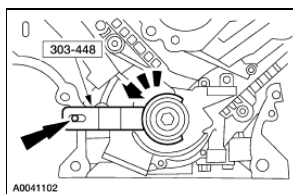
1. Rotate the LH camshaft until the timing mark is approximately at 12 o'clock.
2. Rotate the RH camshaft until the timing mark is approximately at 11 o'clock.



16. **⚠ CAUTION:** Rotate the crankshaft counterclockwise only. Do not rotate past position shown or severe piston and valve damage can occur.

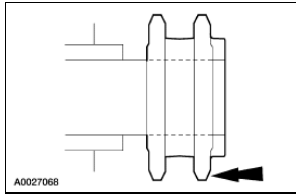
**NOTE:** The number one piston is at top dead center (TDC) when the stud on the engine block fits into the slot in the handle of the special tool.

Position the crankshaft so the number one cylinder is at TDC with the special tool.

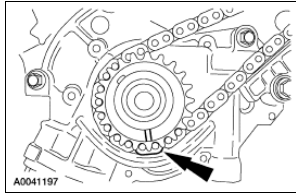


17. Remove the Crankshaft Holding Tool.

18. Install the crankshaft sprocket, making sure the flange faces forward.

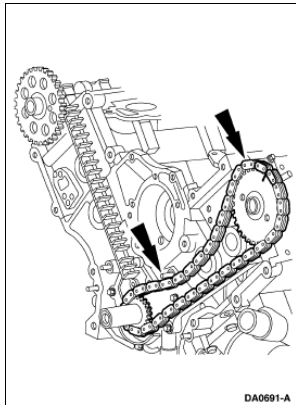


19. Position the lower end of the LH (inner) timing chain on the crankshaft sprocket, aligning the timing mark on the outer flange of the crankshaft sprocket with the single copper (marked) link on the chain.



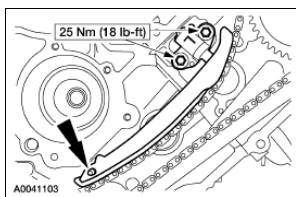
20. **NOTE:** Make sure the upper half of the timing chain is below the tensioner arm dowel.

Position the timing chain on the camshaft sprocket with the camshaft sprocket timing mark positioned between the two copper (marked) chain links.

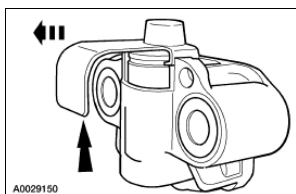


21. **NOTE:** The LH timing chain tensioner arm has a bump near the dowel hole for identification.

Position the LH timing chain tensioner arm on the dowel pin and install the LH timing chain tensioner.

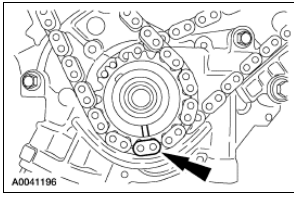


22. Remove the retaining clip from the LH timing chain tensioner.

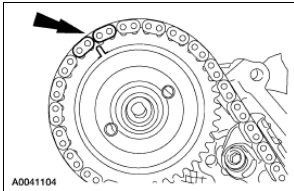


23. Position the lower end of the RH (outer) timing chain on the crankshaft sprocket, aligning the timing

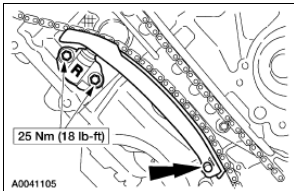
mark on the sprocket with the single copper (marked) chain link.



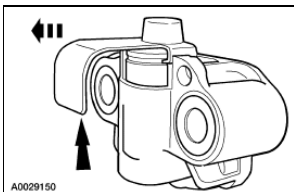
24. Install the RH timing chain on the camshaft sprocket. Make sure the camshaft sprocket timing mark is positioned between the two copper (marked) chain links.



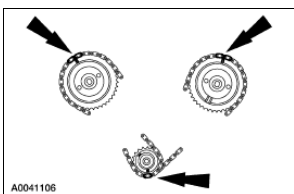
25. Position the RH timing chain tensioner arm on the dowel pin and install the RH timing chain tensioner.



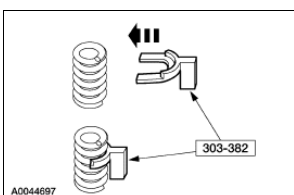
26. Remove the retaining clip from the RH timing chain tensioner.



27. As a post-check, verify correct alignment of all timing marks.



28. Install the special tool between the valve spring coils to prevent valve stem seal damage.

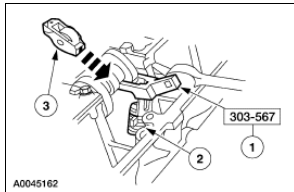


29. **NOTE:** Lubricate the camshaft roller followers using clean engine oil.

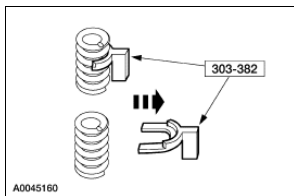
**NOTE:** Position the cam lobe away from the camshaft roller follower location prior to installing each camshaft roller follower.

Install the camshaft roller followers.

1. Install the special tool.
2. Compress the valve spring.
3. Install the camshaft roller followers in their original locations.



30. Remove the special tool.

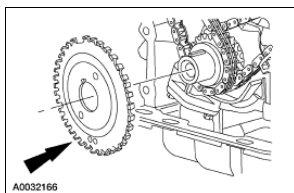


31. **⚠ CAUTION:** When installing the spark plugs, use care not to exceed the recommended torque.

Install the eight spark plugs.

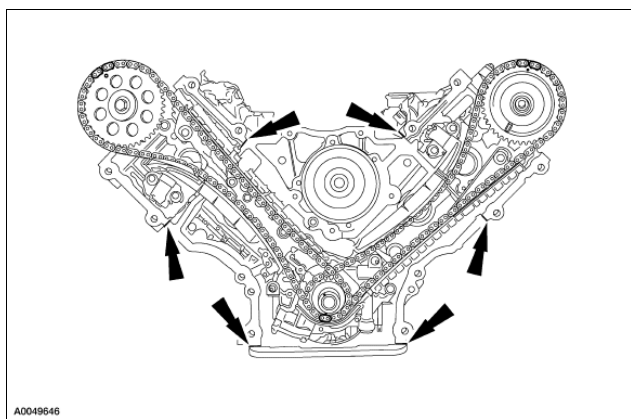
- Tighten the spark plugs to 18 Nm (13 lb-ft).

32. Install the crankshaft sensor ring on the crankshaft.

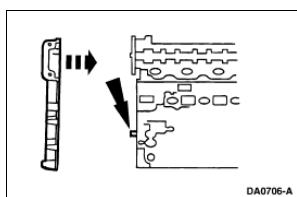


33. **NOTE:** If the front cover is not secured within four minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Follow the directions on the packaging. Failure to follow this procedure can cause future oil leakage.

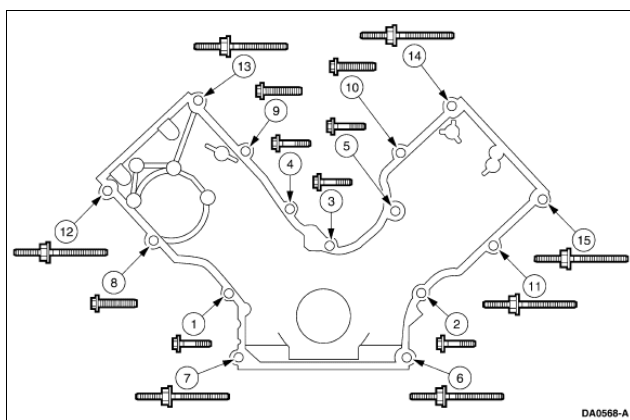
Apply a bead of silicone gasket and sealant along the cylinder head-to-cylinder block surface and the oil pan-to-cylinder block surface, at the locations shown.



34. Install a new engine front cover gasket on the engine front cover. Position the engine front cover. Install the fasteners finger-tight.



35. Tighten the engine front cover fasteners in sequence in three stages.  
 Stage 1: Tighten fasteners 1 through 5 to 25 Nm (18 lb-ft).  
 Stage 2: Tighten fasteners 6 and 7 to 48 Nm (35 lb-ft).  
 Stage 3: Tighten fasteners 8 through 15 to 48 Nm (35 lb-ft).



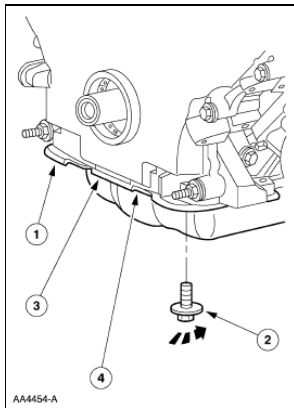
Item	Part Number	Description
1	N806177	Bolt, Hex Flange Head Pilot, M8 x 1.25 x 53
2	N806177	Bolt, Hex Flange Head Pilot, M8 x 1.25 x 53
3	N806177	Bolt, Hex Flange Head Pilot, M8 x 1.25 x 53
4	N806177	Bolt, Hex Flange Head Pilot, M8 x 1.25 x 53
5	N806177	Bolt, Hex Flange Head Pilot, M8 x 1.25 x 53
6	N808529	Stud, Hex Head Pilot, M10 x 1.5 x 59 M10 x 1.5 x 30
7	N808529	Stud, Hex Head Pilot, M10 x 1.5 x 59 M10 x 1.5 x 30
8	N808142	Screw and Washer, Hex Pilot, M10 x 1.5 x 57.5
9	N808142	Screw and Washer, Hex Pilot, M10 x 1.5 x 57.5

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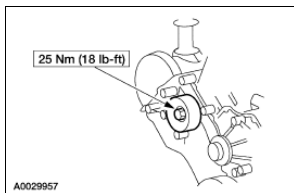
10	N808142	Screw and Washer, Hex Pilot, M10 x 1.5 x 57.5
11	N808140	Stud and Washer, Hex Head Pilot, M10 x 1.5 x 68 M8 x 1.25 x 27
12	N808140	Stud and Washer, Hex Head Pilot, M10 x 1.5 x 68 M8 x 1.25 x 27
13	N808140	Stud and Washer, Hex Head Pilot, M10 x 1.5 x 68 M8 x 1.25 x 27
14	N808140	Stud and Washer, Hex Head Pilot, M10 x 1.5 x 68 M8 x 1.25 x 27
15	N808140	Stud and Washer, Hex Head Pilot, M10 x 1.5 x 68 M8 x 1.25 x 27

36. Loosely install the bolts, then tighten the bolts in two stages, in the sequence shown.

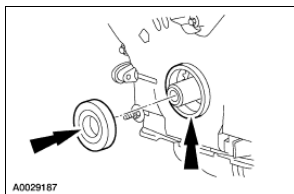
- Stage 1: Tighten to 20 Nm (15 lb-ft).
- Stage 2: Tighten an additional 90 degrees.



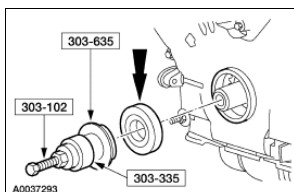
37. Position the belt idler pulley and install the bolt.



38. Lubricate the engine front cover and the front oil seal inner lip with clean engine oil.



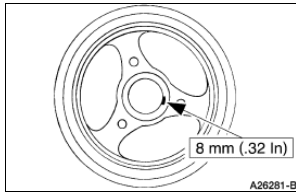
39. Use the special tools to install the crankshaft front oil seal into the engine front cover.



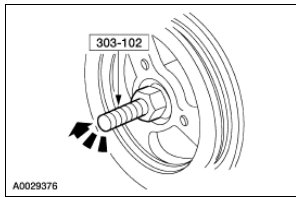


40. **NOTE:** If not secured within four minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Follow the directions on the packaging. Failure to follow this procedure can cause future oil leakage.

Apply silicone gasket and sealant to the Woodruff key slot on the crankshaft pulley.



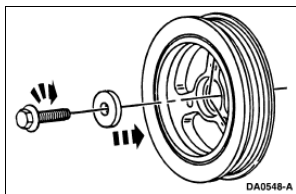
41. Use the special tool to install the crankshaft pulley.



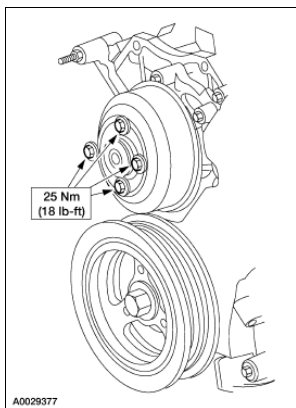
42. **NOTE:** Use a suitable strap wrench (303-D055) to hold the pulley while tightening the bolt.

Tighten the new crankshaft pulley bolt in four stages.

- Stage 1: Tighten to 90 Nm (66 lb-ft).
- Stage 2: Loosen 360 degrees.
- Stage 3: Tighten to 50 Nm (37 lb-ft).
- Stage 4: Tighten an additional 90 degrees.

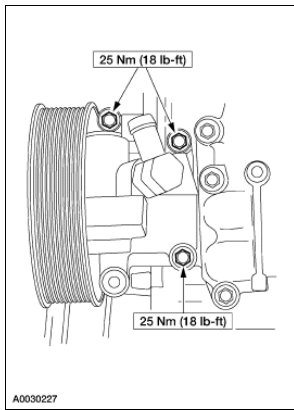


43. Position the coolant pump pulley on the coolant pump and install the bolts.

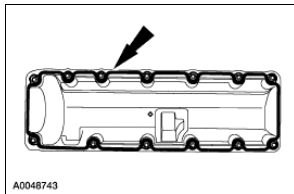


44. **NOTE:** The front lower hole in the power steering pump is not used.

Position the power steering pump and install the bolts.

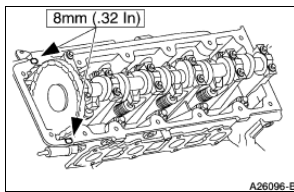


45. If a new gasket is being installed, apply instant adhesive completely around the gasket groove in the LH valve cover. Install the new valve cover gasket.

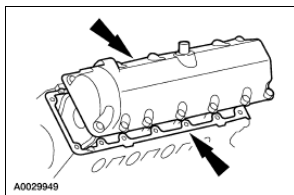


46. **NOTE:** If not secured within four minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Follow the directions on the packaging. Failure to follow this procedure can cause future oil leakage.

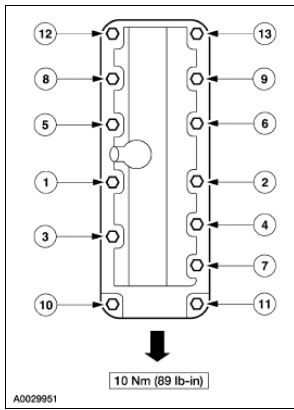
Apply silicone gasket and sealant in two places where the engine front cover meets the cylinder head.



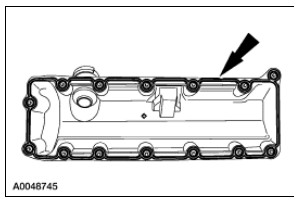
47. Position the LH valve cover and gasket on the cylinder head and install the bolts loosely.



48. Tighten the bolts in the sequence shown.

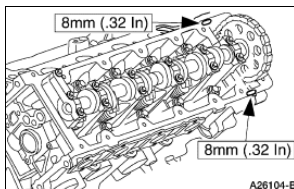


49. If a new gasket is being installed, apply instant adhesive completely around the gasket groove in the RH valve cover. Install the new valve cover gasket.

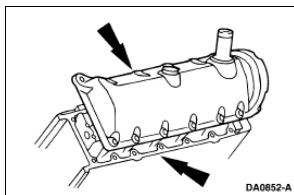


50. **NOTE:** If not secured within four minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Follow the directions on the packaging. Failure to follow this procedure can cause future oil leakage.

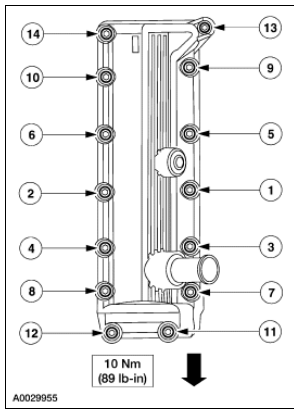
Apply silicone gasket and sealant in two places where the engine front cover meets the cylinder head.



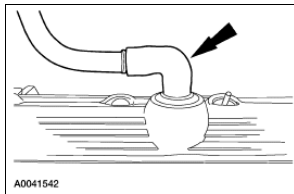
51. Position the RH valve cover and gasket on the cylinder head and install the bolts loosely.



52. Tighten the bolts in the sequence shown.

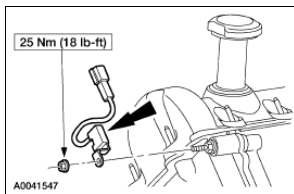


53. Install the crankcase ventilation tube on the LH valve cover.



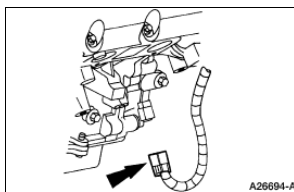
54. **NOTE:** RH shown, LH similar.

Install the radio frequency interference capacitors.

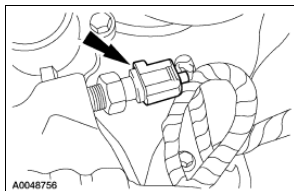


55. Roughly position the engine control sensor wiring harness and mount it on the valve cover studs.

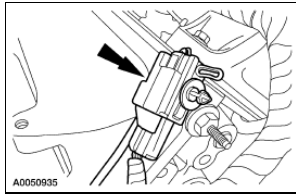
56. Connect the CKP sensor electrical connector.



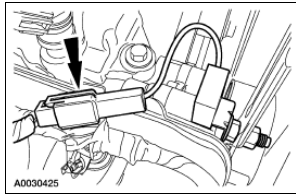
57. Connect the oil pressure switch electrical connector.



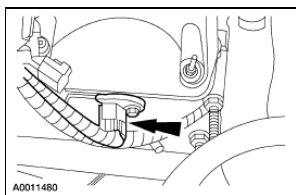
58. Connect the knock sensor electrical connector.



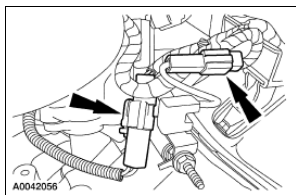
59. Connect the RH radio frequency interference capacitor electrical connector.



60. Connect the CMP sensor electrical connector.

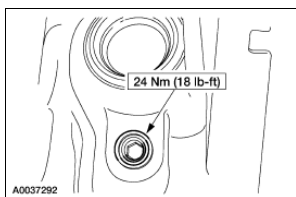


61. Connect the LH radio frequency interference capacitor and CHT sensor electrical connectors.



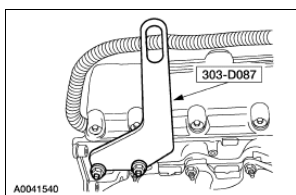
62. **NOTE:** LH shown, RH similar.

Install the cylinder block drain plugs.

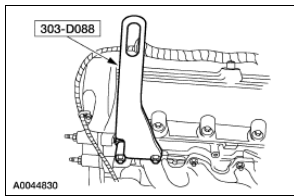


63. Install the RH engine mount.  
• Tighten the bolts to 63 Nm (46 lb-ft).

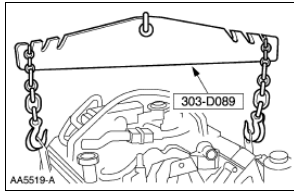
64. Install the special tool.



65. Install the special tool.

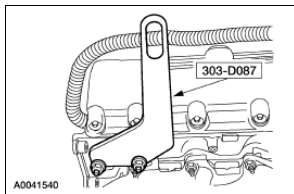


66. Install the special tool and remove the engine from the work stand.

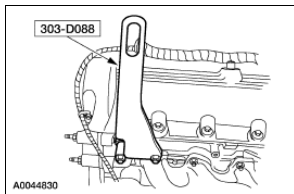


67. Lower the engine onto wooden blocks.

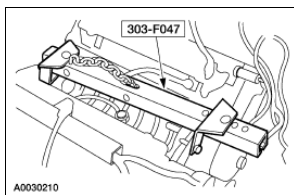
68. Remove the special tool.



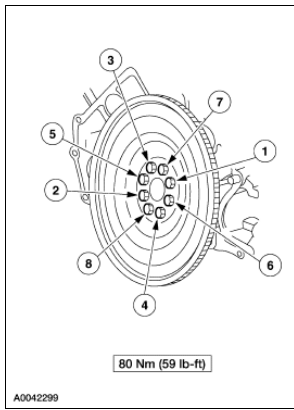
69. Remove the special tool.



70. Install the special tool and raise the engine.



71. Install the flexplate or the flywheel and bolts. Tighten the bolts in the sequence shown.



72. Install the engine. For additional information, refer to Engine in this section.

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## General Specifications

Item	Specification
Displacement (CID)	6.8l (415)
No. cylinder	10
Bore/stroke	90.215/105.8 mm
Fire order	1-6-5-10-2-7-3-8-4-9
Oil pressure @ 93.33°C (200°F)	18 psi @ 650 rpm - 100 psi @ 4,000 rpm
<b>Cylinder Head/Valve Train</b>	
Combustion chamber volume	52.6 - 51.6 cc
Valve seat width intake	2.1-1.9 mm
Valve seat width exhaust	2.1-1.9 mm
Valve seat angle	45.00-44.50 degrees
Valve seat runout (T.I.R.)	0.025 mm
<b>Valve Arrangement (Front to Rear)</b>	
Valve stem guide clearance	
intake	0.069-0.020 mm
exhaust	0.095-0.045 mm
Valve head diameter	
intake	44.63-44.37 mm
exhaust	34.12-33.88 mm
Valve face runout (limit)	0.05 mm
Valve face angle	45.75-45.25 degrees
Valve stem diameter	
intake	6.995-6.975 mm
exhaust	6.970-6.949 mm
Valve stem diameter (list oversizes)	
intake	n/a
exhaust	n/a
Valve spring compression pressure	
Intake (N @ spec. length)	667.3 N @ 28.02 mm
Exhaust (N @ spec. length)	667.3 N @ 28.02 mm
Valve spring free length	
intake	50.2 mm
exhaust	50.2 mm
Valve spring installed pressure N @ spec. length	
intake	289.1 N @ 40.01 mm



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exhaust	289.1 N @ 40.01 mm
Valve springs installed pressure N @ spec. length	service limit
intake	274.6 N @ 40.01 mm
exhaust	274.6 N @ 40.01 mm
Valve springs	out of square limit
intake	2.5 degrees
exhaust	2.5 degrees
Valve guide inside diameter	7.044-7.015 mm
<b>Camshaft</b>	
Lobe lift	
intake	6.5808 mm
exhaust	6.5855 mm
Lobe lift	allowable lift loss
	0
Valve lift @ zero lash	
intake	12.00 mm
exhaust	12.00 mm
Camshaft end play	0.25-0.188 mm
End play service limit	0.025-0.188 mm
Journal to bearing clearance	0.076-0.025 mm
Clearance service limit	
Journal diameters	26.962-26.936 mm
Journal inside diameter (cap assembled)	27.012-26.987 mm
Camshaft runout: full indicator measurement on all journals when supported on front and rear journals.	0.09 mm (5 places)
Cylinder bore diameter	
grade 1	90.200-90.210 mm
grade 2	90.210-90.220 mm
grade 3	90.220-90.230 mm
<b>Piston</b>	
Piston diameter (grade 2) at right angle to pin bore	90.180 ± 0.005 mm
Piston to bore clearance	(-0.005) to +0.025 mm
Pin bore diameter (piston)	22.008-22.014 mm
Pin diameter	22.0005-22.0030 mm
Clearance (neg. or pos.)	0.01395-0.005 mm
Pin bore diameter (rod)	22.012-22.024 mm
Clearance	0.009-0.0235 mm
Ring groove width	
top	1.503-1.505 mm
intermediate	1.502-1.504 mm
Oil control	3.030-3.050 mm
Piston ring gap	
top	0.13-0.28 mm
intermediate	0.25-0.40 mm
Oil control	0.15-0.65 mm

<b>Crankshaft</b>	
Main bearing journal diameter	67.482-67.504
maximum out-of-round	0.0075 mm between cross sections
maximum taper (straightness)	0.004 mm
Runout: firm of center journals when located on front and rear journal	0.05 mm (3 places)
Clearance crankshaft journal to main bearing clearance	0.048-0.024 mm
Connecting rod journal diameter	53.003-52.983 mm
Maximum out-of-round	0.0075 mm between cross sections
maximum taper	0.004 mm
Crankshaft end play	0.075-0.377
<b>Connecting Rod</b>	
Big end journal inside diameter with assembled liners	53.049-53.027 mm
Rod bearing to journal clearance	0.064-0.026 mm
Pin bore diameter (rod)	22.024-22.012 mm
<b>Balance Shaft System</b>	
Balance shaft journal diameter	26.962-26.936 mm
Clearance balance shaft journal to cylinder head	0.076-0.025 mm
Cylinder head B/S journal diameter	27.012-26.987 mm
Gear backlash	0.0076-0.1295 mm
Balance shaft endplay	0.04-0.18 mm
Rod length (centerline bore-to-bore)	169.1 mm
<b>Alignment</b>	
bore-to-bore max. twist	± 0.05 mm
bore-to-bore max. bend	± 0.038 mm
<b>Side play (as assembled to crank)</b>	
standard play	0.410 ± 0.26 mm
max. play	0.670 mm
<b>Sealants and Lubricants</b>	
Silicone Gasket and Sealant F7AZ-19554-EA	WSE-M4G323-A4
Motorcraft Premium Engine Coolant VC-4-A (in Oregon, VC-5; in Canada, CXC-10)	ESE-M97B44-A
Motorcraft Premium Gold Engine Coolant VC-7-A (in Oregon, VC-7-B)	WSS-M97B51-A1
SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP	WSS-M2C153-H
Metal Surface Cleaner F4AZ-19A536-RA	WSE-M5B392-A

## Torque Specifications

Description	Nm	lb-ft	lb-in
Balancer shaft bearing cap bolts and studs	10		89

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Valve cover bolts	10		89
Camshaft bearing cap bolts	10		89
Camshaft sprocket bolts <sup>a</sup>			
Cylinder head temperature sensor (CHT)	26	19	
Camshaft position sensor bolt	10		89
Crankshaft position sensor bolt	10		89
Connecting rod bolts <sup>a</sup>			
Crankshaft damper pulley bolt <sup>a</sup>			
Crankshaft main bearing bolts (cross- mounted) <sup>a</sup>			
Crankshaft main bearing bolts (vertical) <sup>a</sup>			
Cylinder head bolts <sup>a</sup>			
EGR valve to intake manifold bolts <sup>a</sup>			
Exhaust manifold nuts	25	18	
Exhaust manifold studs	10		89
Drive belt idler pulley bolt	25	18	
Flexplate bolts	80	59	
Engine front cover bolts (1-7)	25	18	
Engine front cover bolts (6-15)	45	33	
Fuel injection supply manifold bracket bolts	10		89
Heater return tube studs	48	35	
Ignition coil	6		53
Knock sensor bolt	20	15	
Lower intake manifold to upper intake manifold bolts <sup>a</sup>			
Upper intake manifold to cylinder head bolts <sup>a</sup>			
Intake manifold tuning valve screws <sup>a</sup>			
Oil cooler assembly to oil filter adapter bolts	58	43	
Oil filter	15	11	
Oil filter adapter bolt	25	18	
Oil filter adapter bolt	58	43	
Oil filter adapter nut	25	18	
Wiring harness bracket nut	15	11	
Oil filter adapter stud	10		89
Oil level indicator tube bolt	10		89
Oil pan bolts <sup>a</sup>			
Oil pan drain plug	13		10
Oil pressure sender	14	10	
Oil pump bolts	10		89
Oil pump screen pickup tube bolts	10		89
Oil pump screen pickup tube spacer	25		18
Power steering pump bolts	25	18	
Rear main oil seal retainer bolts	10		89
Spark plugs	10		89
Thermostat housing bolts	10		89
Idle air control valve screws <sup>a</sup>			

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Throttle body adapter to intake manifold bolts <sup>a</sup>			
Throttle body to throttle body adapter bolts <sup>a</sup>			
Timing chain guide bolts	10		89
Timing chain hydraulic tensioner bolts	25	18	
Water pump bolts	25	18	
Water pump pulley bolts	25	18	
Water temperature sensor	19	14	
EGR valve to exhaust manifold tube fittings <sup>a</sup>			
Brake booster vacuum hose bracket nut	10		89
Power steering bracket upper bolts	10		89
Power steering bracket lower bolts	40	30	
Fuel charging wiring connector bolt	5		44
42-pin bulkhead connector bolts	6		53
Starter relay nuts (5.4L engine)	10		89
Transmission cooler line nut	25	18	
Wiring harness bracket nut	15	11	
42-pin connector bolt	6		53
Accelerator control splash shield bolts	7		62
Remote oil filter adapter line bolts (4x4 vehicles)	10		89
Oil cooler insert	55	41	
Oil cooler bolt (4x4 vehicles)	57	42	
Engine mount cross bolts	63	46	
Engine mount through bolts	80	59	
Engine mount nuts	90	66	
Engine mount bolts	80	59	
Cable bracket nut	25	18	
Ground strap nut	25	18	
Dual convertor Y-pipe nuts	40	30	
Transmission mount nuts	92	68	
Power steering pump bolts motorhome chassis	25	18	
Torque converter nuts	40	30	
Transmission to engine bolts	48	35	
Transmission shift cable bracket bolt motorhome chassis	10		89
Accelerator cable bracket bolts	10		89
Engine oil indicator tube bracket bolt	10		89
Transmission oil pan bolts	15	11	
Oil pressure sensor	15	11	
Fan shroud bolts	10		89
EGR back pressure transducer nuts	10		89
Radio interference capacitor bolt	10		89
EVR solenoid bracket bolts	10		89
EGR transducer bracket bolts	10		89
Accumulator suction line nut	10		89
Wiring bracket nut	25	18	

<sup>a</sup> Refer to the procedure in this section.

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