



## Cylinder Head

Special Tool(s)	
 ST2806-A	Alignment Pins, Cylinder Head 303-1040 (SR-015486)
 ST1326-A	Handle 205-153 (T80T-4000-W)
 ST1335-A	Holding Tool, Crankshaft 303-448 (T93P-6303-A)
 ST2212-A	Installer, Differential Bearing Cone 205-142 (T80T-4000-J)
 ST1326-A	Installer, Front Cover Oil Seal 303-335 (T88T-6701-A2 plate only)
 ST3249-A	Installer, Front Crank Seal and Damper 303-1531

 <p>ST2983-A</p>	<p>Installer, Spark Plug Tube Seal 303-1247/2</p>
 <p>ST1438-A</p>	<p>Strap Wrench 303-D055 (D85L-6000-A) or equivalent</p>

<b>Material</b>	
<b>Item</b>	<b>Specification</b>
Motorcraft® Metal Surface Prep ZC-31-A	—
Motorcraft® SAE 5W-20 Premium Synthetic Blend Motor Oil (US); Motorcraft® SAE 5W-20 Super Premium Motor Oil (Canada) XO-5W20-QSP (US); CXO-5W20- LSP12 (Canada)	WSS- M2C945-A
Motorcraft® SAE 5W-50 Full Synthetic Motor Oil XO-5W50-QGT	WSS- M2C931-B
Motorcraft® Silicone Gasket Remover ZC-30	—
Motorcraft® Orange Antifreeze/Coolant Concentrated VC-3-B (US); CVC-3-B2 (Canada)	WSS- M97B44-D
Motorcraft® Silicone Brake Caliper Grease and Dielectric Compound XG-3-A	ESE-M1C171- A
Motorcraft® Silicone Gasket and Sealant TA-30	WSE- M4G323-A4

## Installation

**NOTE:** The Boss® 302 requires Motorcraft® SAE 5W-50 Full Synthetic Motor Oil, all other 5.0L (4V) engines require Motorcraft® SAE 5W-20 Premium Synthetic Blend Motor Oil.

### All cylinder heads

1. Verify the crankshaft keyway is in the 9 o'clock position.



2. **NOTICE:** Make sure all coolant residue and foreign material are cleaned from the block surface and cylinder bore. Failure to follow these instructions may result in engine damage.

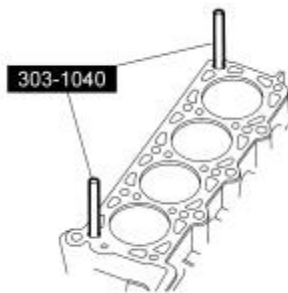
**NOTICE:** The use of sealing aids (aviation cement, copper spray and glue) is not permitted. The gasket must be installed dry. Failure to follow these instructions may result in future oil leakage.

**NOTICE:** The cylinder head bolts must be discarded and new bolts installed. They are a tighten-to-yield design and cannot be reused.

**NOTE:** Do not turn the crankshaft until instructed to do so.

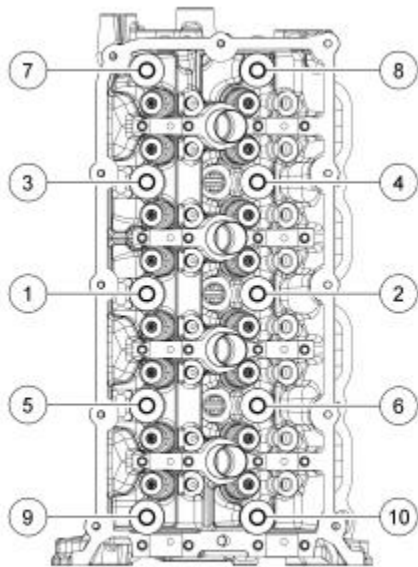
**NOTE:** LH shown, RH similar.

Using the Cylinder Head Alignment Pins, position the cylinder head gaskets and cylinder heads over the dowels and install the cylinder head bolts loosely.



### RH cylinder head

3. Tighten the new RH cylinder head bolts in 4 stages in the sequence shown.
  - Stage 1: Tighten to 25 Nm (18 lb-ft).
  - Stage 2: Tighten to 40 Nm (30 lb-ft).
  - Stage 3: Tighten an additional 90 degrees.
  - Stage 4: Tighten an additional 90 degrees.

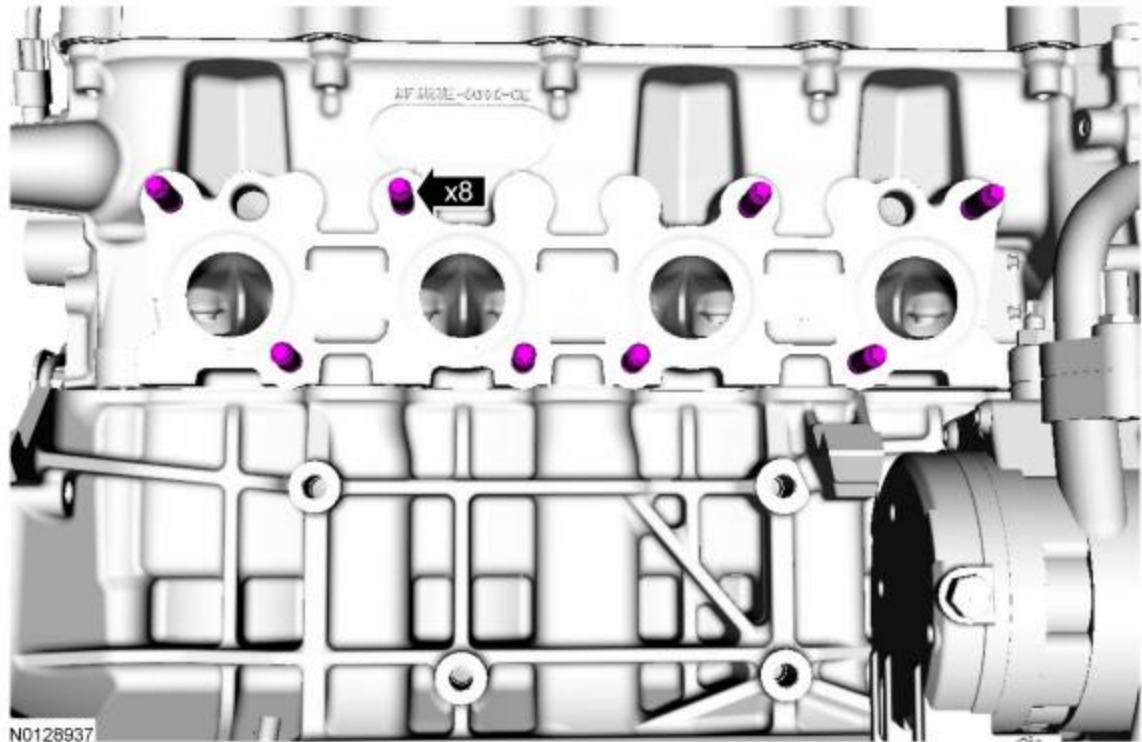


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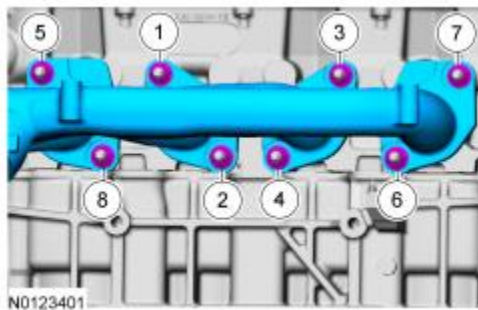
4. **NOTICE: Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraper to clean the sealing surfaces.**

Clean the exhaust manifold mating surface of the cylinder head with metal surface prep. Follow the directions on the packaging.

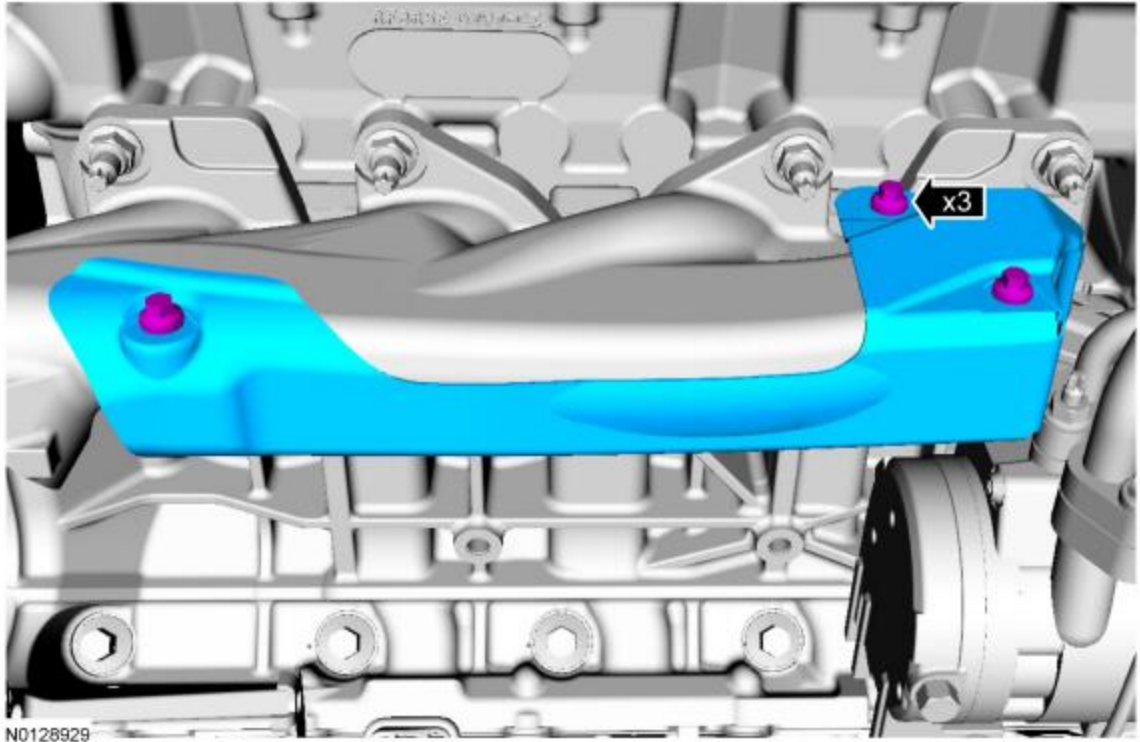
5. Install 8 new RH exhaust manifold studs.
  - Tighten to 25 Nm (18 lb-ft).



6. Install a new gasket, the RH exhaust manifold and 8 new nuts.
  - Tighten the nuts in the sequence shown in 2 stages.
    - Stage 1: Tighten to 24 Nm (18 lb-ft).
    - Stage 2: Tighten to 32 Nm (24 lb-ft).



7. Install the RH exhaust manifold heat shield and the 3 bolts.
  - Tighten to 12 Nm (106 lb-in).



8. Install the Cylinder Head Temperature (CHT) sensor.
  - Tighten to 11 Nm (97 lb-in).

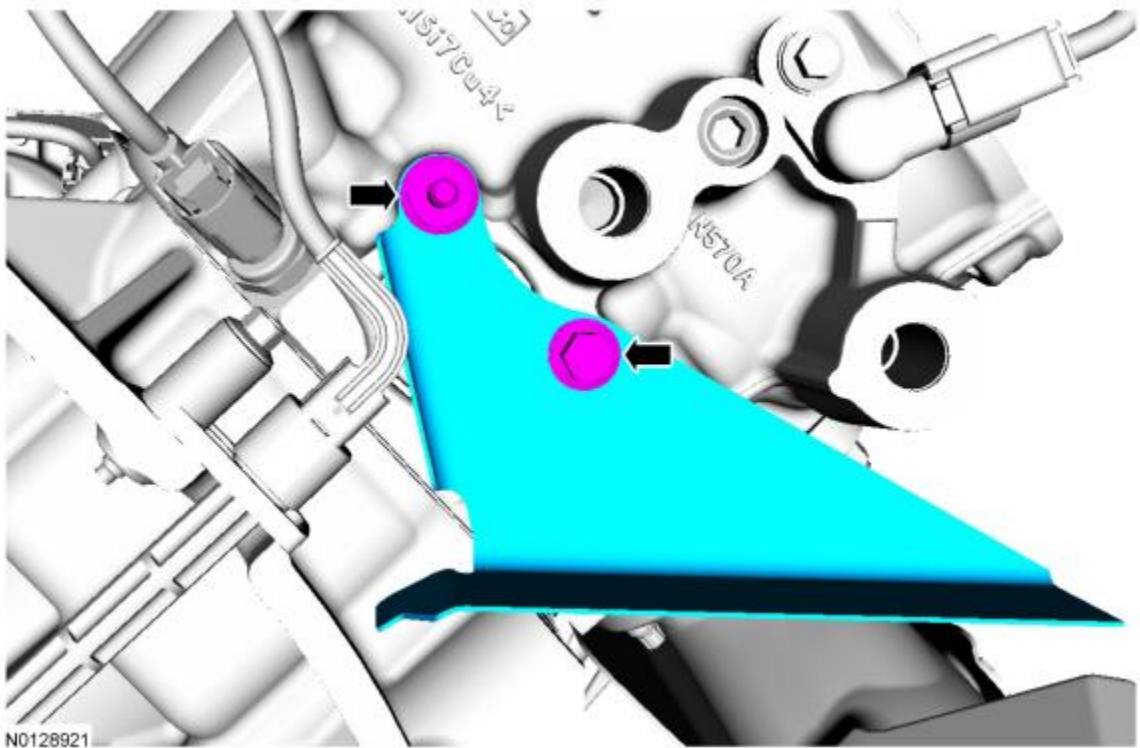


9. Connect the Cylinder Head Temperature (CHT) sensor electrical connector.



10. Install the heat shield, the bolt and the stud bolt on the RH cylinder head.

- Tighten to 10 Nm (89 lb-in).



11. **NOTICE:** Lubricate the O-ring seal with clean engine coolant prior to installing.

Using a new O-ring seal, install the coolant outlet pipe.

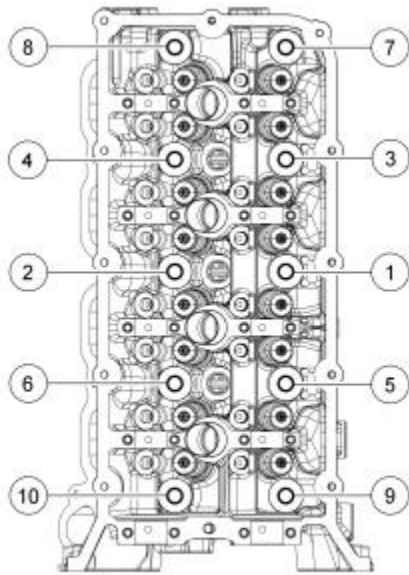
- Tighten to 10 Nm (89 lb-in).



### LH cylinder head

12. Tighten the new LH cylinder head bolts in 4 stages in the sequence shown.

- Stage 1: Tighten to 25 Nm (18 lb-ft).
- Stage 2: Tighten to 40 Nm (30 lb-ft).
- Stage 3: Tighten an additional 90 degrees.
- Stage 4: Tighten an additional 90 degrees.



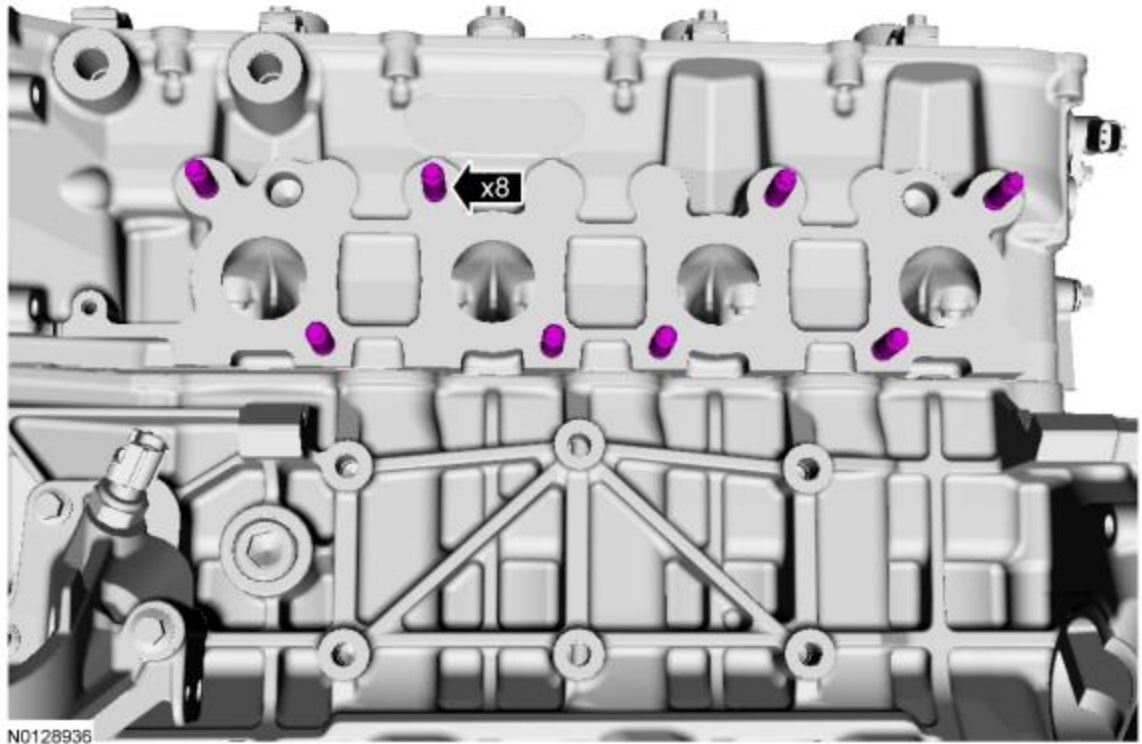
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13. **NOTICE:** Do not use metal scrapers, wire brushes, power abrasive discs or other abrasive means to clean the sealing surfaces. These tools cause scratches and gouges which make leak paths. Use a plastic scraper to clean the sealing surfaces.

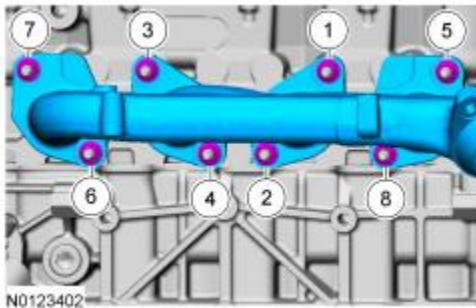
Clean the exhaust manifold mating surface of the cylinder head with metal surface prep. Follow the directions on the packaging.

14. Install 8 new LH exhaust manifold studs.
  - Tighten to 25 Nm (18 lb-ft).

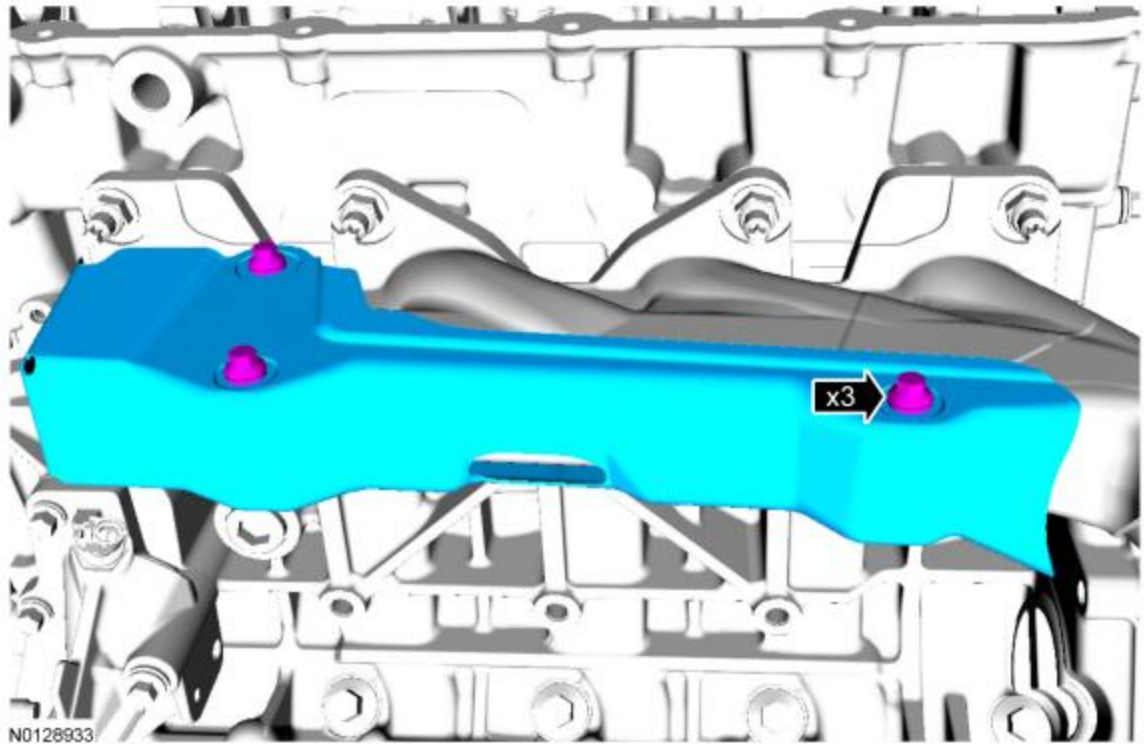




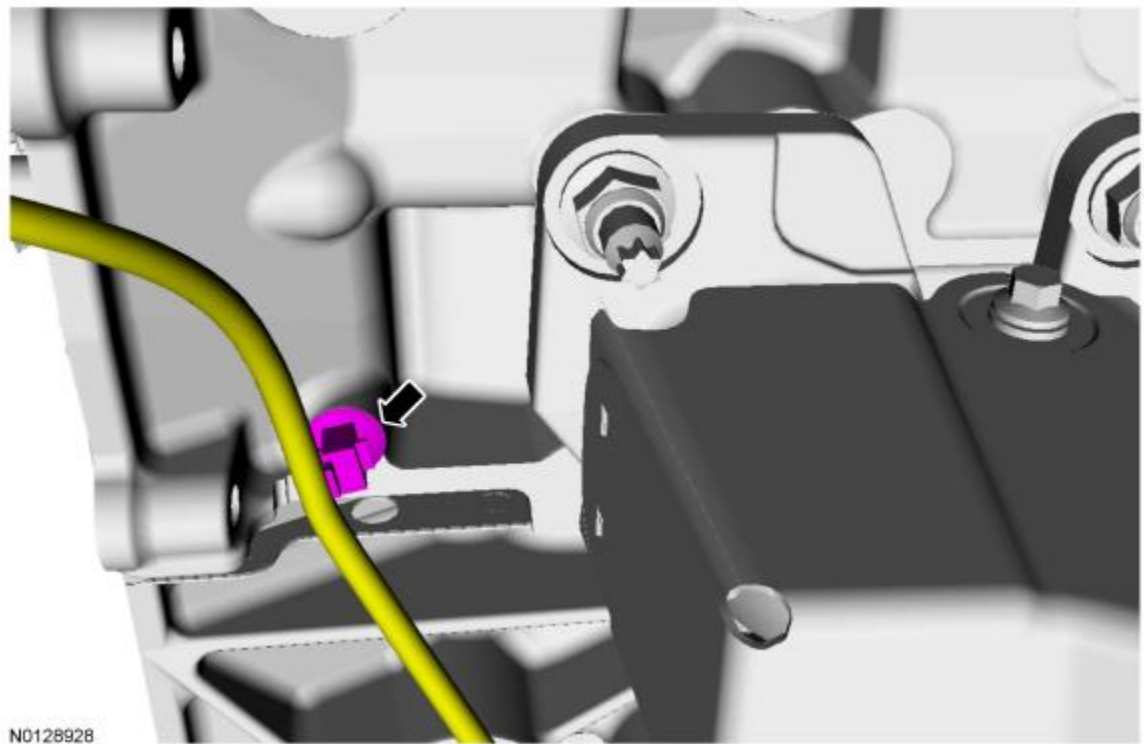
15. Install a new gasket, the LH exhaust manifold and 8 new nuts.
- Tighten in the sequence shown in 2 stages.
    - Stage 1: Tighten to 24 Nm (18 lb-ft).
    - Stage 2: Tighten to 32 Nm (24 lb-ft).



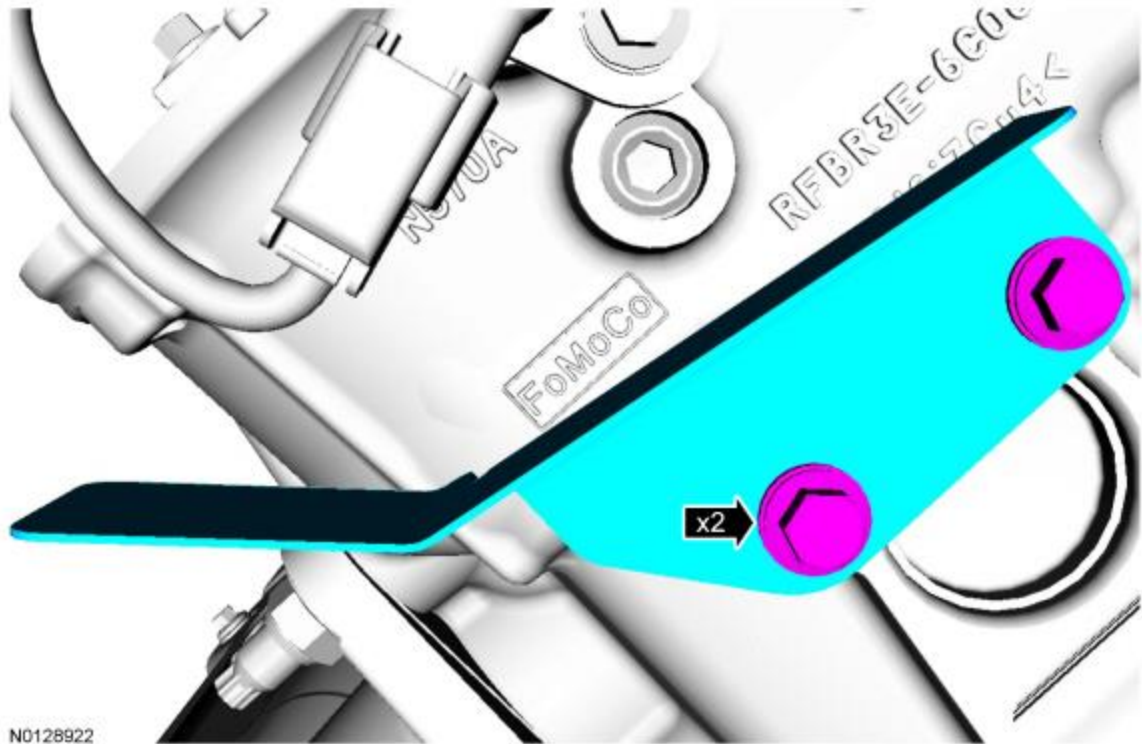
16. Install the LH exhaust manifold heat shield and the 3 bolts.
- Tighten to 12 Nm (106 lb-in).



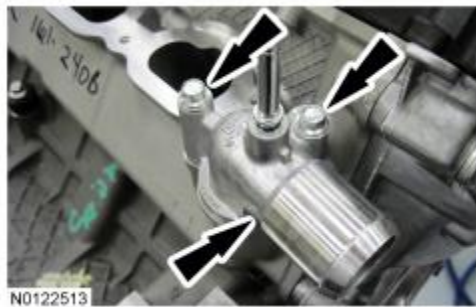
17. Attach the wiring harness retainer to the LH cylinder head.



18. Install the heat shield and the 2 bolts to the LH cylinder head.  
• Tighten to 10 Nm (89 lb-in).



19. Using a new gasket, install the coolant outlet and 2 bolts.
  - Tighten to 10 Nm (89 lb-in).



20. **NOTE:** Lubricate the camshaft roller follower and hydraulic lash adjuster assemblies with clean engine oil prior to installation.

Install the 16 camshaft roller follower and hydraulic lash adjuster assemblies.



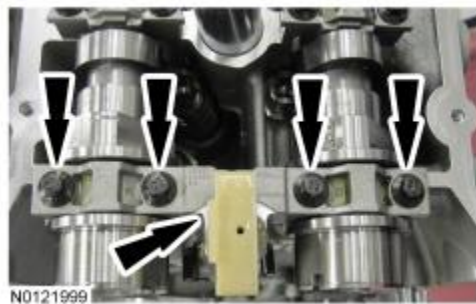
21. **NOTE:** Lubricate the camshafts with clean engine oil prior to installation.

Install the LH intake and exhaust camshafts in the neutral position. Align the D-slots as shown in the illustration.



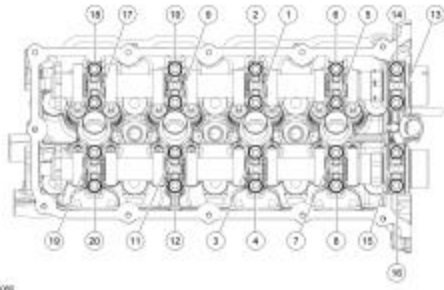
22. Install the 8 camshaft bearing caps and the 16 bolts. Do not tighten the bolts at this time.

23. Install the LH front camshaft bearing mega cap and the 4 bolts. Do not tighten the bolts at this time



24. Tighten the bolts in the sequence shown in 2 stages.

- Stage 1: Tighten to 6 Nm (53 lb-in).
- Stage 2: Tighten an additional 45 degrees.



25. **NOTE:** Intake camshaft shown, exhaust camshaft similar.

Install the Variable Camshaft Timing (VCT) system oil filter in the intake and exhaust camshafts.



26. Install the secondary timing chain onto the LH VCT assemblies. Align the colored links on the secondary timing chain with the timing marks on the VCT assemblies as shown in the illustration.

1. The timing mark on the intake VCT assembly should align between the 2 consecutive colored links.
2. The timing mark on the exhaust VCT assembly should align with the single colored link.



27. Install the LH VCT assemblies and the secondary timing chain onto the LH camshafts to a position 2 mm (0.078 in) from fully seated. The timing mark on the exhaust VCT assembly should be in the 11 o'clock position.



28. **NOTE:** It may be necessary to rotate the exhaust camshaft slightly (using a wrench on the flats of the camshaft) to seat the VCT assemblies onto the camshafts.

Rotate the secondary timing chain tensioner 90 degrees so the ramped area is facing forward and fully seat the VCT assemblies onto the camshafts.

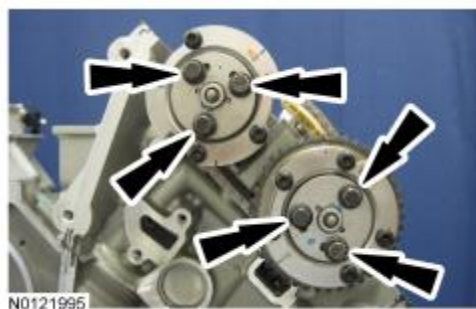
- If the secondary timing chain is not centered over the tensioner, reposition the VCT assemblies until they are fully seated on the camshafts.



29. **NOTE:** Use a wrench on the flats of the camshaft to hold the camshafts while tightening the VCT assembly bolts.

Install the 3 LH intake VCT assembly bolts and the 3 LH exhaust VCT assembly bolts.

- Tighten to 15 Nm (133 lb-in) plus an additional 90 degrees.



30. Install the LH primary timing chain.

- Align the colored link on the timing chain with the timing mark on the LH VCT assembly.



31. Align the remaining colored link on the timing chain with the timing mark on the crankshaft sprocket.



32. **NOTE:** It may be necessary to rotate the crankshaft slightly to provide enough slack in the chain to install the LH timing chain guide. Return the crankshaft keyway to the 9 o'clock position after installing the LH timing chain guide.

Install the LH timing chain guide and bolt.

- Tighten to 10 Nm (89 lb-in).



33. **NOTE:** It may be necessary to rotate the crankshaft slightly to provide enough slack in the chain to install the LH timing chain tensioner arm. Return the crankshaft keyway to the 9 o'clock position after installing the LH timing chain tensioner arm.

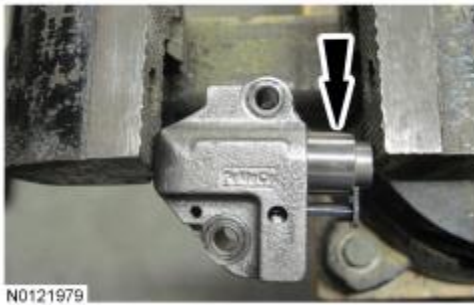
Install the LH timing chain tensioner arm.



**NOTE:** Complete the following 3 steps on both the LH and RH primary timing chain tensioners.

34. **NOTICE:** Do not compress the ratchet assembly or damage to the tensioner will occur.

Compress the primary timing chain tensioner plunger, using an edge of a vise.



35. Using a small screwdriver or pick, push back and hold the ratchet mechanism, then push the ratchet arm back into the tensioner housing.

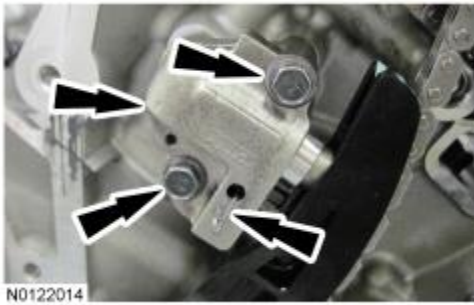


36. Install a suitable pin into the hole of the tensioner housing to hold the ratchet assembly and plunger in place during installation.





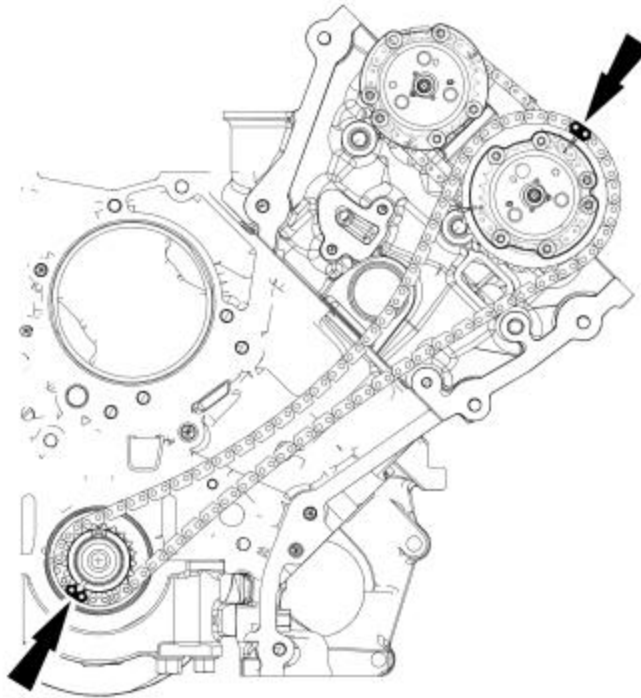
37. Install the LH primary timing chain tensioner and 2 bolts.
- Tighten to 10 Nm (89 lb-in).
  - Remove the holding pin from the tensioner.



38. Using the crankshaft holding tool, rotate the crankshaft clockwise until the crankshaft keyway is at the 12 o'clock position.



39. With the crankshaft keyway at the 12 o'clock position, verify the timing mark alignment is correct.

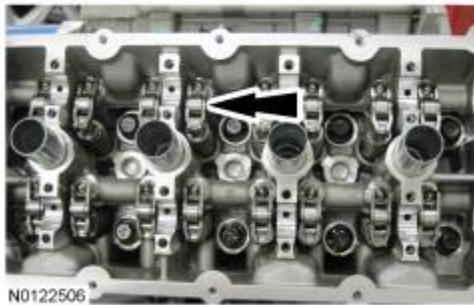


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### RH cylinder head

40. **NOTE:** Lubricate the camshaft roller follower and hydraulic lash adjuster assemblies with clean engine oil prior to installation.

Install the 16 camshaft roller follower and hydraulic lash adjuster assemblies.



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41. **NOTE:** Lubricate the camshafts with clean engine oil prior to installation.

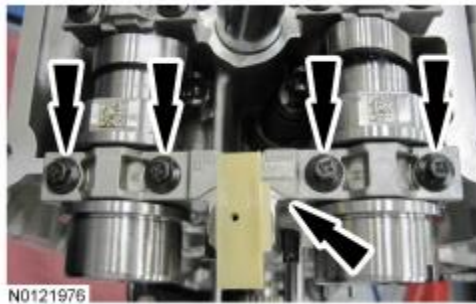
Install the RH intake and exhaust camshafts in the neutral position. Align the D-slots as shown in the illustration.



42. Install the 8 camshaft bearing caps and the 16 bolts. Do not tighten the bolts at this time.

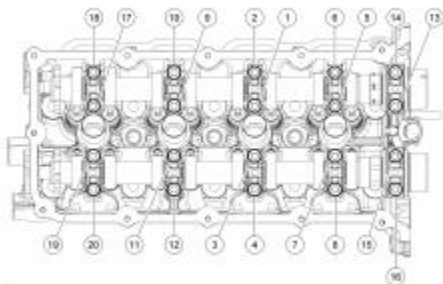


43. Install the RH front camshaft bearing mega cap and the 4 bolts. Do not tighten at this time



44. Tighten the bolts in the sequence shown in 2 stages.

- Stage 1: Tighten to 6 Nm (53 lb-in).
- Stage 2: Tighten an additional 45 degrees.



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45. **NOTE:** Intake camshaft shown, exhaust camshaft similar.

Install the VCT system oil filter in the intake and exhaust camshafts.



46. Install the secondary timing chain onto the RH VCT assemblies. Align the colored links on the secondary timing chain with the timing marks on the VCT assemblies as shown in the illustration.

1. The timing mark on the intake VCT assembly should align between the 2 consecutive colored links.
2. The timing mark on the exhaust VCT assembly should align with the single colored link.



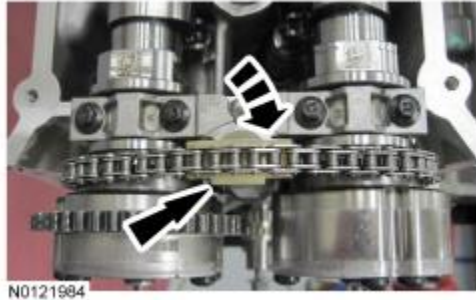
47. Install the RH VCT assemblies and the secondary timing chain onto the RH camshafts to a position 2 mm (0.078 in) from fully seated. The timing mark on the exhaust VCT assembly should be in the 1 o'clock position.



48. **NOTE:** It may be necessary to rotate the exhaust camshaft slightly (using a wrench on the flats of the camshaft) to seat the VCT assemblies onto the camshafts.

Rotate the secondary timing chain tensioner 90 degrees so the ramped area is facing forward and fully seat the VCT assemblies onto the camshafts.

- If the secondary timing chain is not centered over the tensioner, reposition the VCT assemblies until they are fully seated on the camshafts.



49. **NOTE:** Use a wrench on the flats of the camshaft to hold the camshafts while tightening the VCT assembly bolts.

Install the 3 RH intake VCT assembly bolts and the 3 RH exhaust VCT assembly bolts.

- Tighten to 15 Nm (133 lb-in) plus an additional 90 degrees.



### All cylinder heads

50. Install the RH primary timing chain.

- Align the colored link on the timing chain with the timing mark on the RH VCT assembly.



51. Align the remaining colored link on the timing chain with the timing mark on the crankshaft sprocket.



52. **NOTE:** It may be necessary to rotate the crankshaft slightly to provide enough slack in the chain to install the RH timing chain guide. Return the crankshaft keyway to the 12 o'clock position after installing the RH timing chain guide.

Install the RH timing chain guide and bolt.

- Tighten to 10 Nm (89 lb-in).



53. **NOTE:** It may be necessary to rotate the crankshaft slightly to provide enough slack in the chain to install the RH timing chain tensioner arm. Return the crankshaft keyway to the 12 o'clock position after installing the RH timing chain tensioner arm.

Install the RH timing chain tensioner arm.

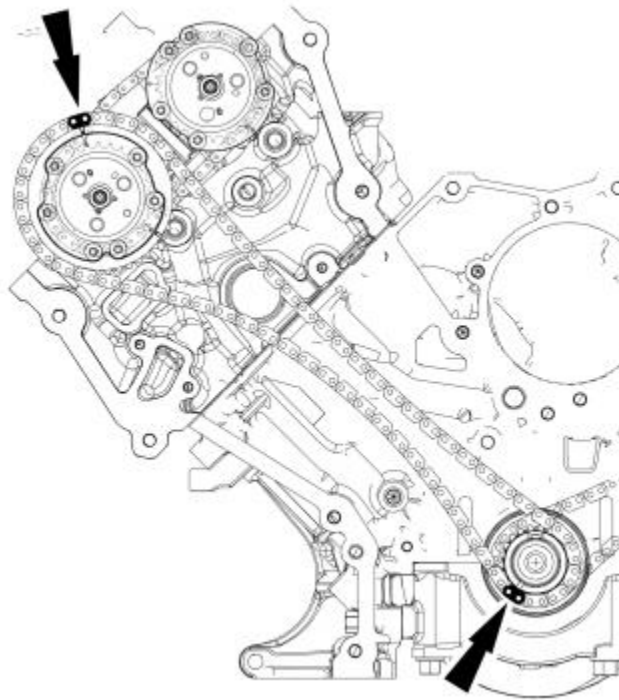


54. Install the RH primary timing chain tensioner and 2 bolts.
- Tighten to 10 Nm (89 lb-in).

- Remove the holding pin from the tensioner.



55. With the crankshaft keyway still at the 12 o'clock position, verify the timing mark alignment is correct.



56. **NOTICE:** The Variable Camshaft Timing (VCT) variable force solenoid pins must be fully depressed to avoid interference with the VCT valve tips when installing the engine front cover. Failure to follow these instructions can result in damage to the engine.

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

Fully depress the VCT variable force solenoid pins.



57. **NOTE:** The engine front cover must be installed and all fasteners final tightened within 5 minutes of applying the sealer. If this cannot be accomplished, install the engine front cover and tighten fasteners 6, 7, 8, 9, 10 and 11 to 8 Nm (71 lb-in) within 5 minutes of applying the sealer. All of the fasteners must then be final tightened within 1 hour of applying the sealer. If this time limit is exceeded, all 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 to the cylinder head-to-cylinder block joints and the oil pan-to-cylinder block joints as illustrated.

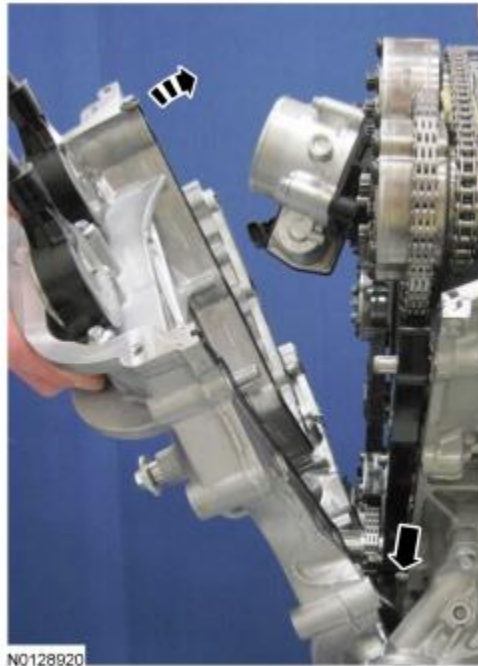


58. **NOTE:** Make sure that the engine front cover gasket is in place on the engine front cover before installation.

Using new gaskets, position the engine front cover onto the dowels.



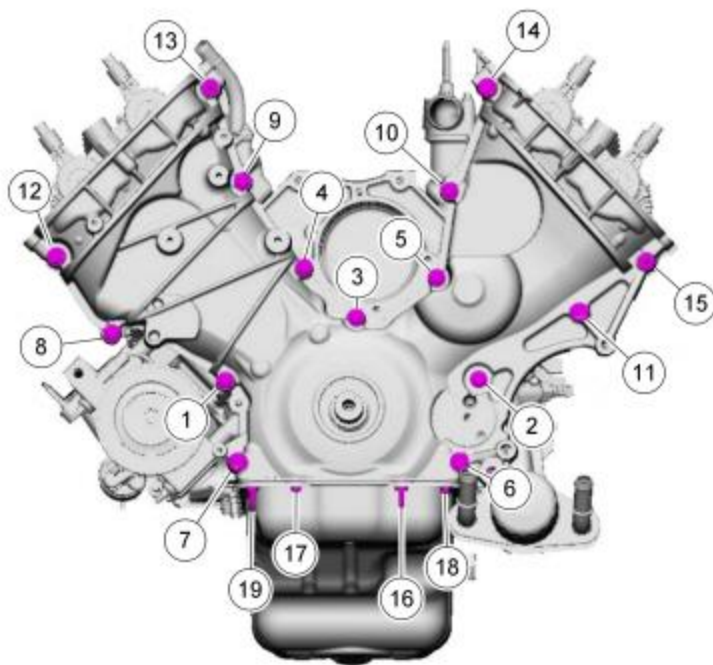
- Install the 13 engine front cover bolts, 2 stud bolts, 2 oil pan-to-engine front cover bolts and 2 oil pan-to-engine front cover stud bolts finger-tight.



59. **NOTE:** The engine front cover must be installed and all fasteners final tightened within 5 minutes of applying the sealer. If this cannot be accomplished, install the engine front cover and tighten fasteners 6, 7, 8, 9, 10 and 11 to 8 Nm (71 lb-in) within 5 minutes of applying the sealer. All of the fasteners must then be final tightened within 1 hour of applying the sealer. If this time limit is exceeded, all 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.

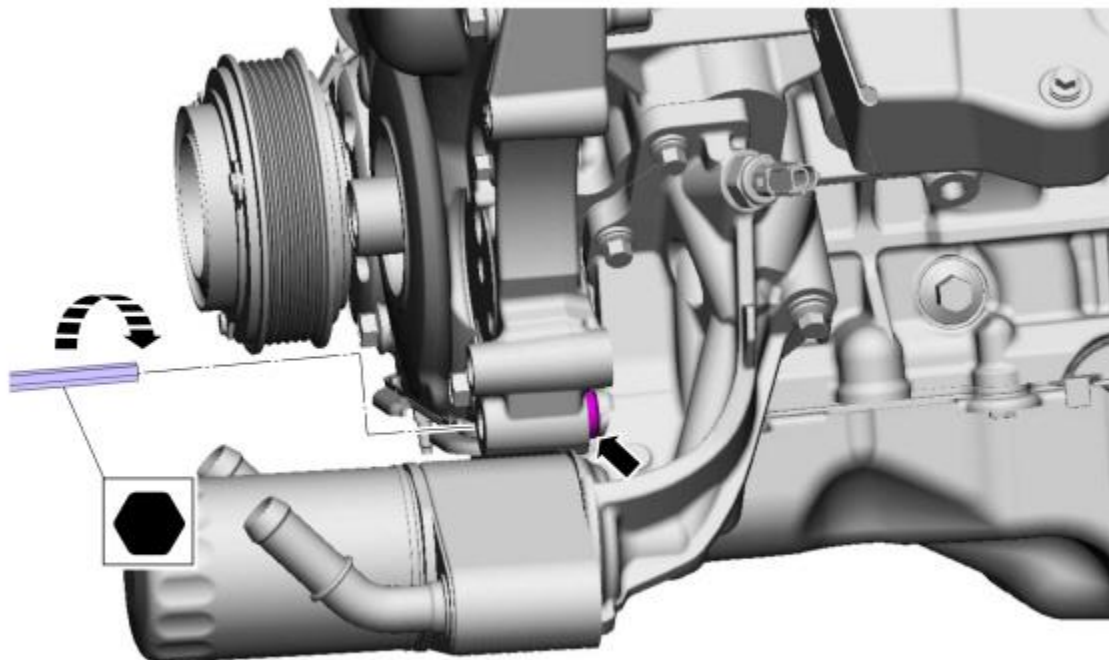
Tighten the bolts in the sequence shown in 2 stages.

- Stage 1: Tighten bolts 1-15 to 25 Nm (18 lb-ft) and bolts 16-19 to 10 Nm (89 lb-in).
- Stage 2: Tighten bolts 1-15 an additional 60 degrees and bolts 16-19 an additional 45 degrees.



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60. Using a 10 mm Hex Bit, rotate the engine front cover jackscrew into contact with the oil filter adapter to 5 Nm (44 lb-in).

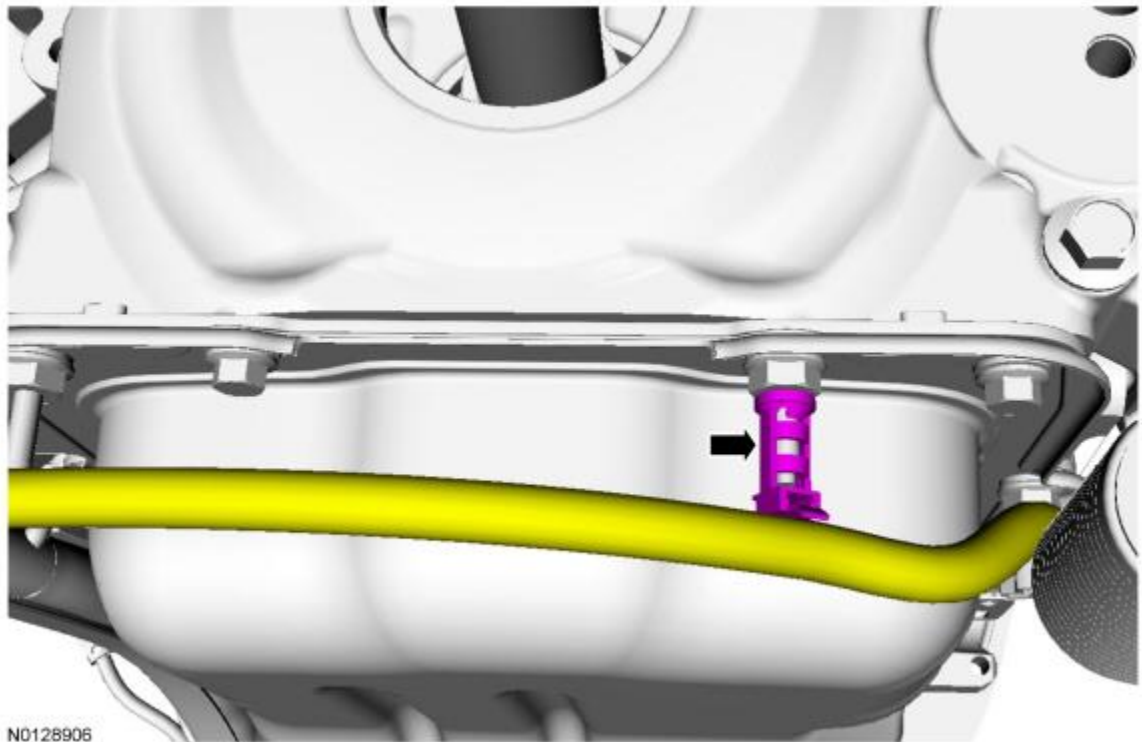


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61. Install the engine front cover-to-oil filter adapter bolt and tighten to 25 Nm (18 lb-ft) plus an additional 60 degrees.



62. Position the wiring harness and install the wiring harness retainer to the oil pan stud bolt.



63. **NOTE:** Lubricate the engine front cover bore and the crankshaft front oil seal inner lip with clean engine oil.

Using the Front Crank Seal and Damper Installer and the Front Cover Oil Seal Installer (plate only), install the crankshaft front oil seal.



64. **NOTE:** If not secured within 5 minutes, the sealant must be removed and the sealing area cleaned with silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

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



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65. Lubricate the crankshaft pulley sealing surface with clean engine oil prior to installation.



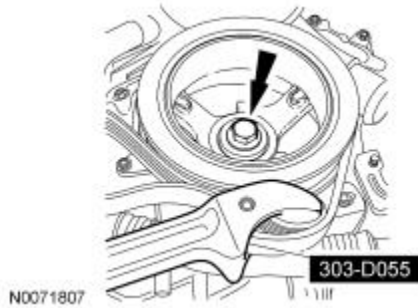
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66. Using the Front Crank Seal and Damper Installer and the Front Cover Oil Seal Installer (plate only), install the crankshaft pulley.



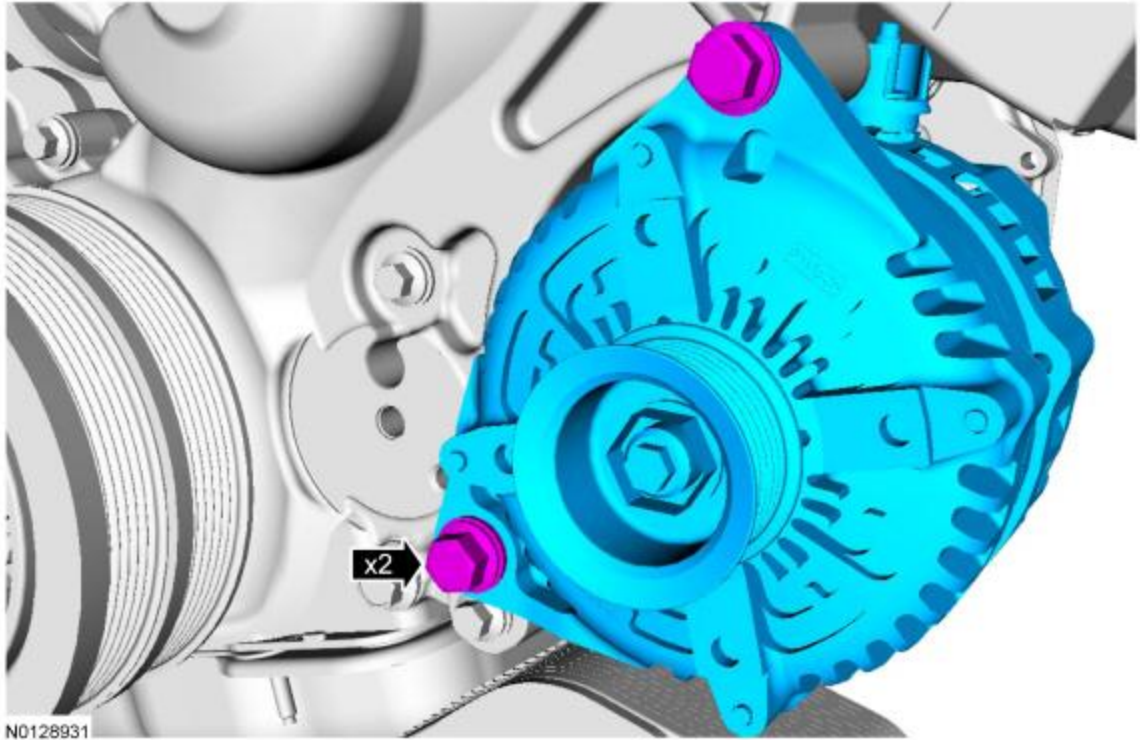
67. Using the Strap Wrench, install a new crankshaft pulley bolt and the original washer, tighten the bolt in 4 stages:

- Stage 1: Tighten to 140 Nm (103 lb-ft).
- Stage 2: Loosen 360 degrees.
- Stage 3: Tighten to 100 Nm (74 lb-ft).
- Stage 4: Tighten an additional 90 degrees.

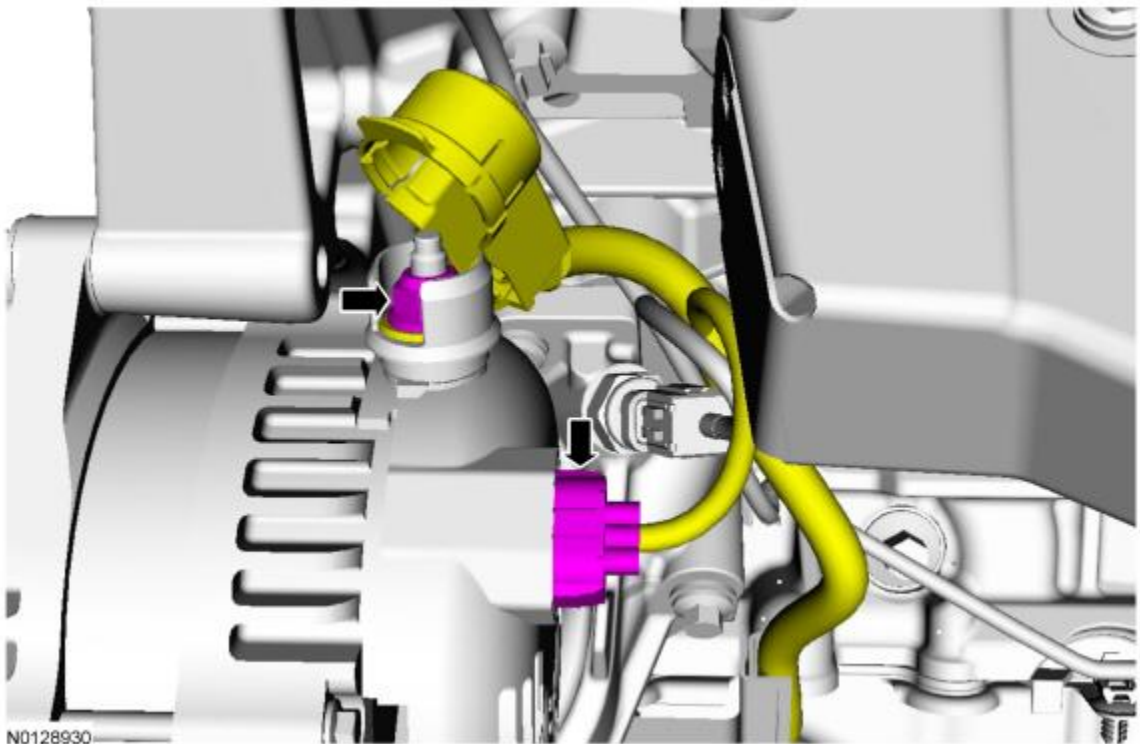


68. Install the generator and the 2 bolts.

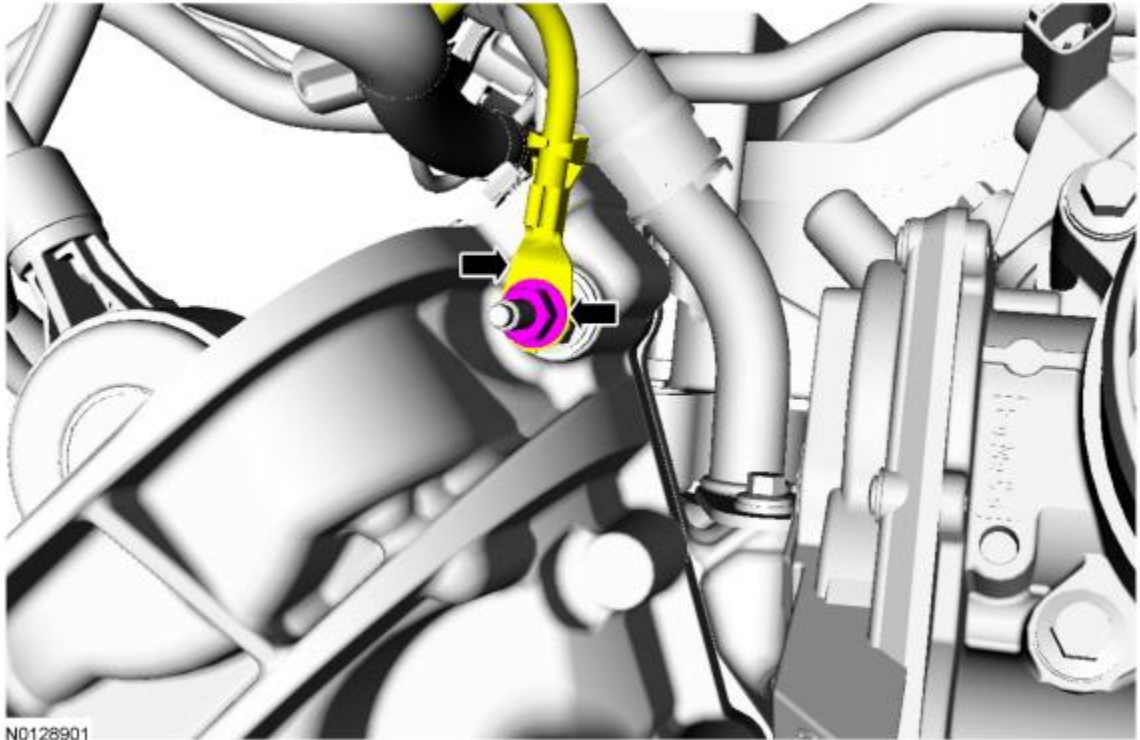
- Tighten to 48 Nm (35 lb-ft).



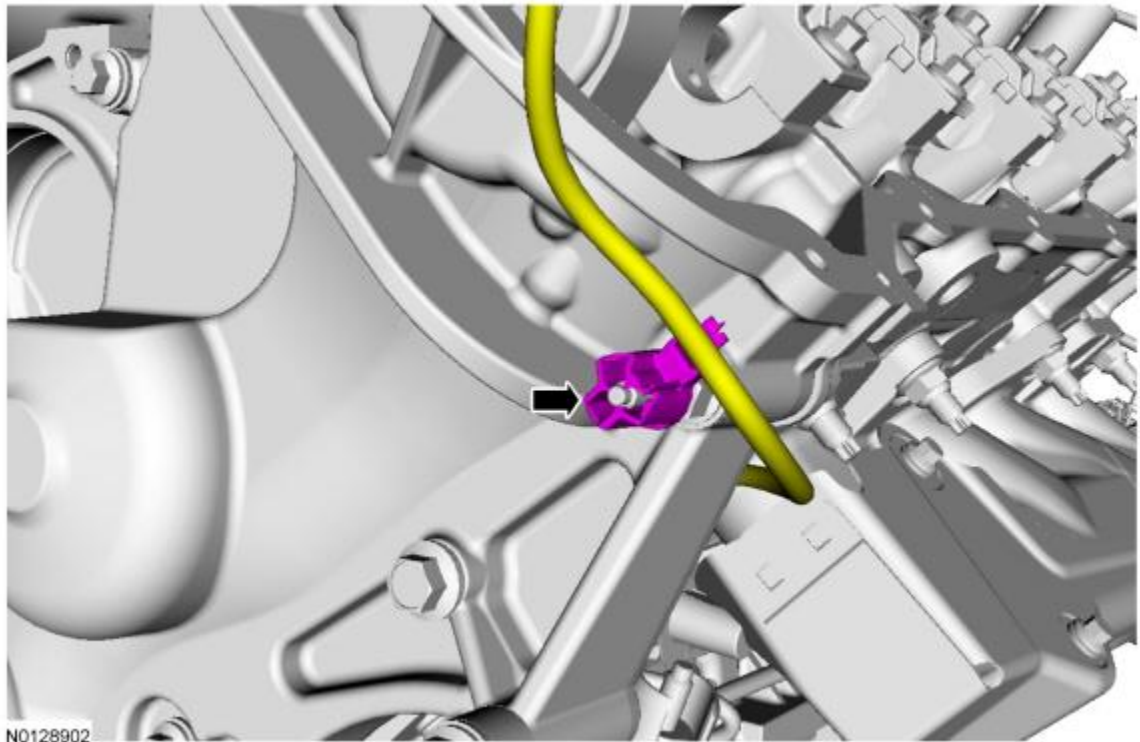
69. Connect the wiring harness connector to the generator.
- Install the B+ wire and nut onto the generator.
    - Tighten to 17 Nm (150 lb-in).



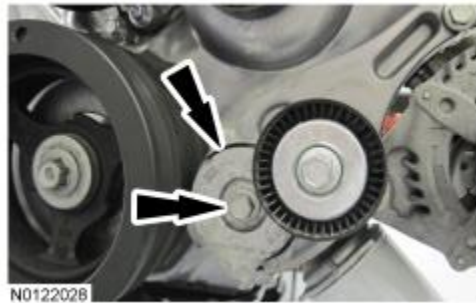
70. Install the ground wire and nut to the engine front cover stud bolt.
- Tighten to 10 Nm (89 lb-in).



71. Attach the wiring harness retainer to the engine front cover stud bolt.



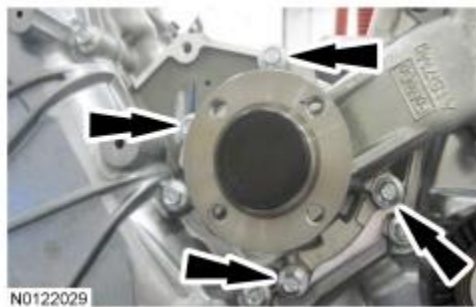
72. Install the accessory drive belt tensioner and the bolt.
- Tighten to 48 Nm (35 lb-ft).



73. **NOTE:** Lubricate the new coolant pump O-ring seal with clean engine coolant.

Using a new O-ring seal, install the coolant pump and the 4 bolts.

- Tighten to 20 Nm (177 lb-in) plus an additional 60 degrees.

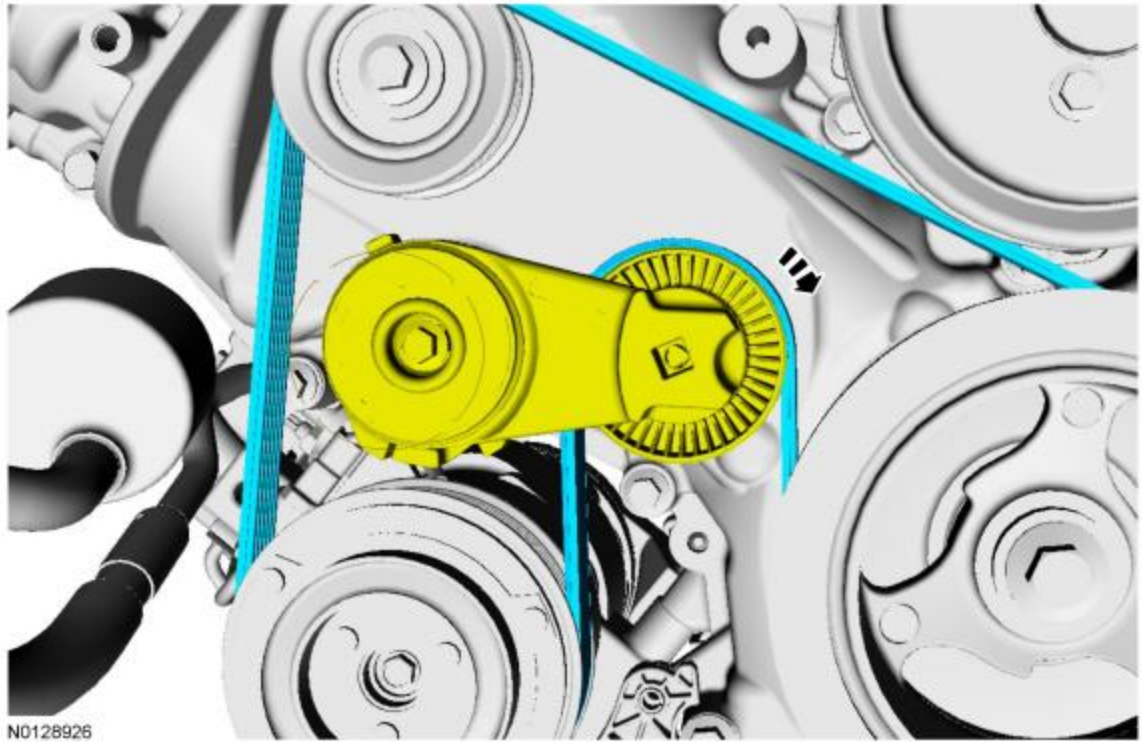


74. Install the coolant pump pulley and the 4 bolts.

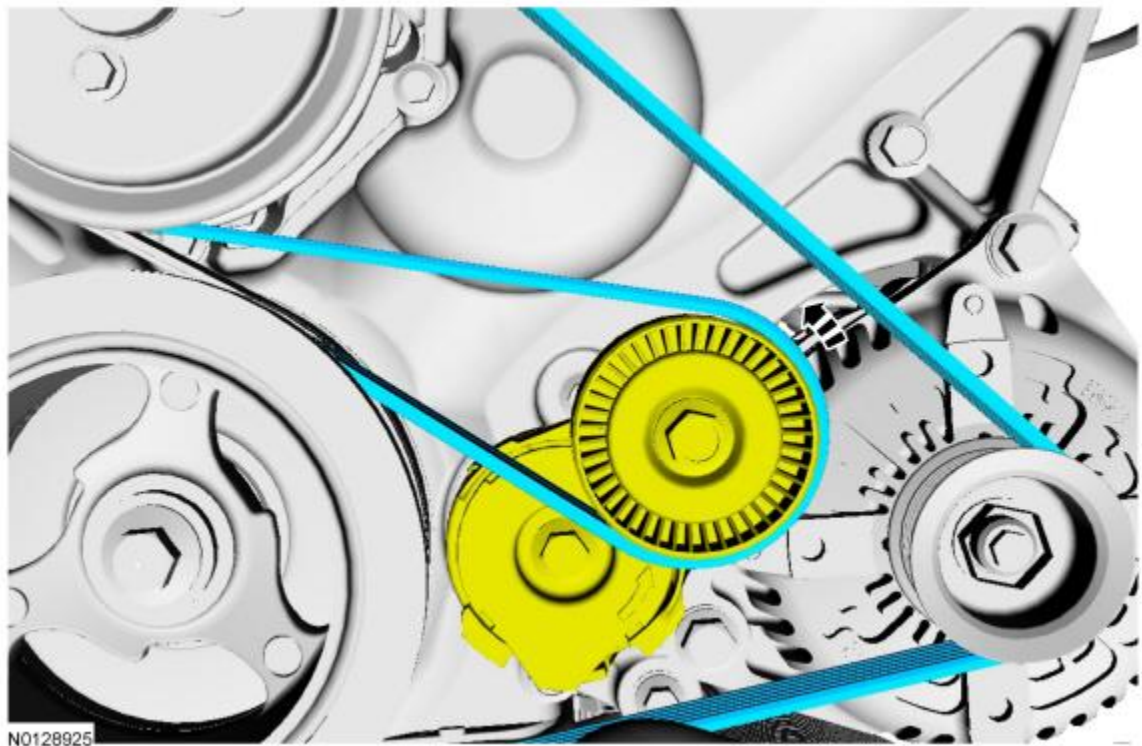


75. Rotate the A/C compressor belt tensioner clockwise and install the A/C compressor belt.

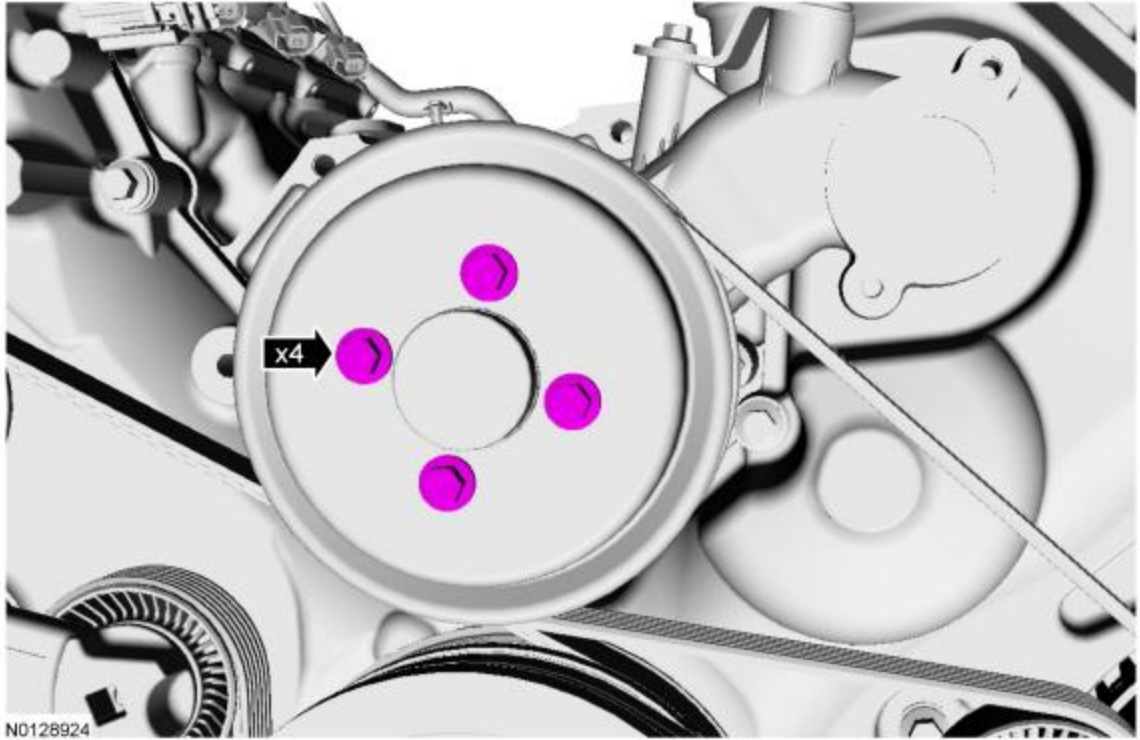




76. Rotate the accessory drive belt tensioner counterclockwise and install the accessory drive belt.



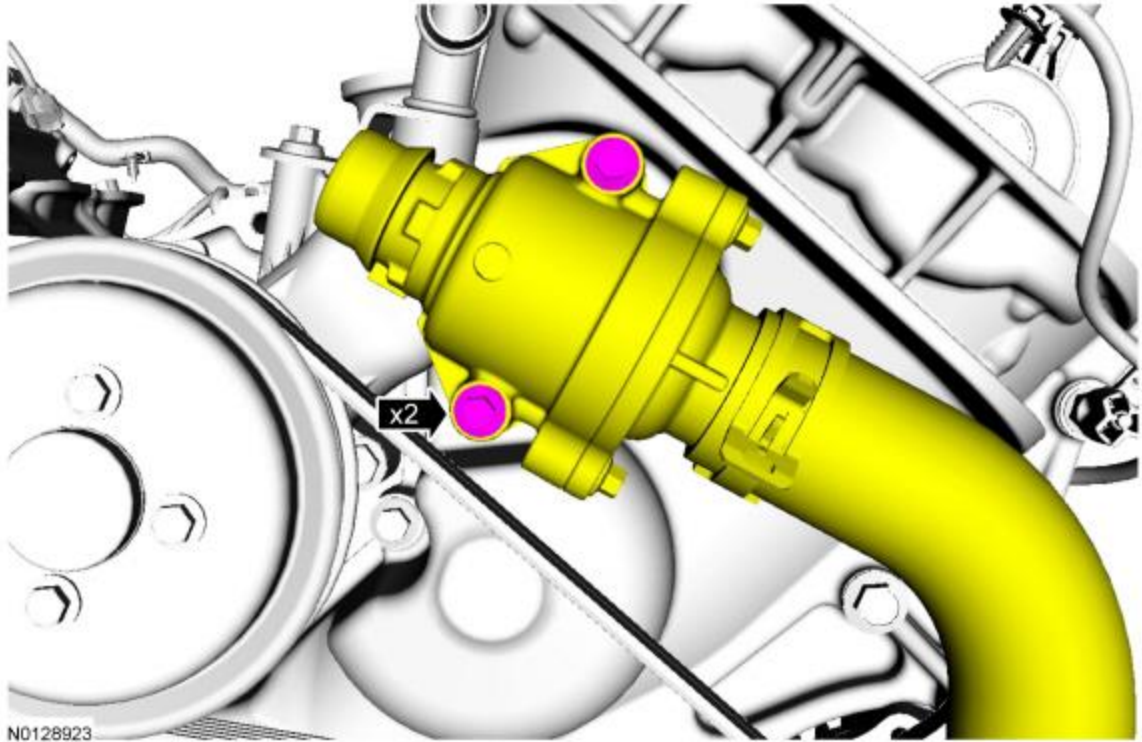
77. Tighten the 4 coolant pump pulley bolts to 25 Nm (18 lb-ft).



78. **NOTE:** Lubricate the new thermostat housing O-ring seal with clean engine coolant.

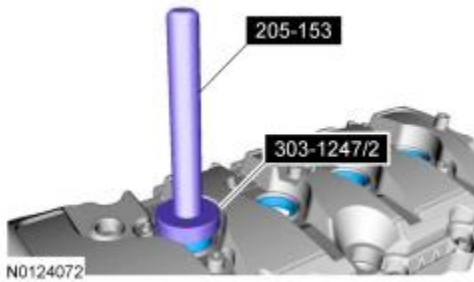
Using a new thermostat housing O-ring seal, install the thermostat housing and the 2 bolts.

- Tighten to 10 Nm (89 lb-in).



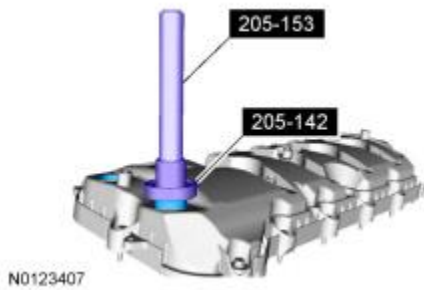
79. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the VCT Spark Plug Tube Seal Installer and Handle, install new spark plug tube seals.



80. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the Differential Bearing Cone Installer and Handle, install new VCT variable force solenoid seal(s).

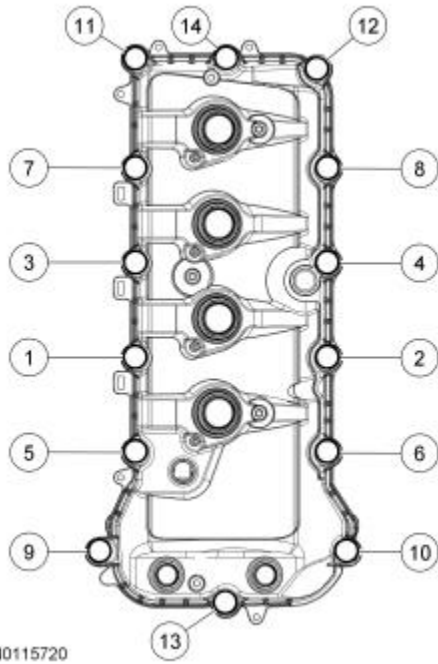


81. **NOTE:** If the valve cover is not installed and the fasteners tightened within 5 minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

Apply an 8 mm (0.31 in) bead of silicone gasket and sealant to the engine front cover-to-LH cylinder head joints.



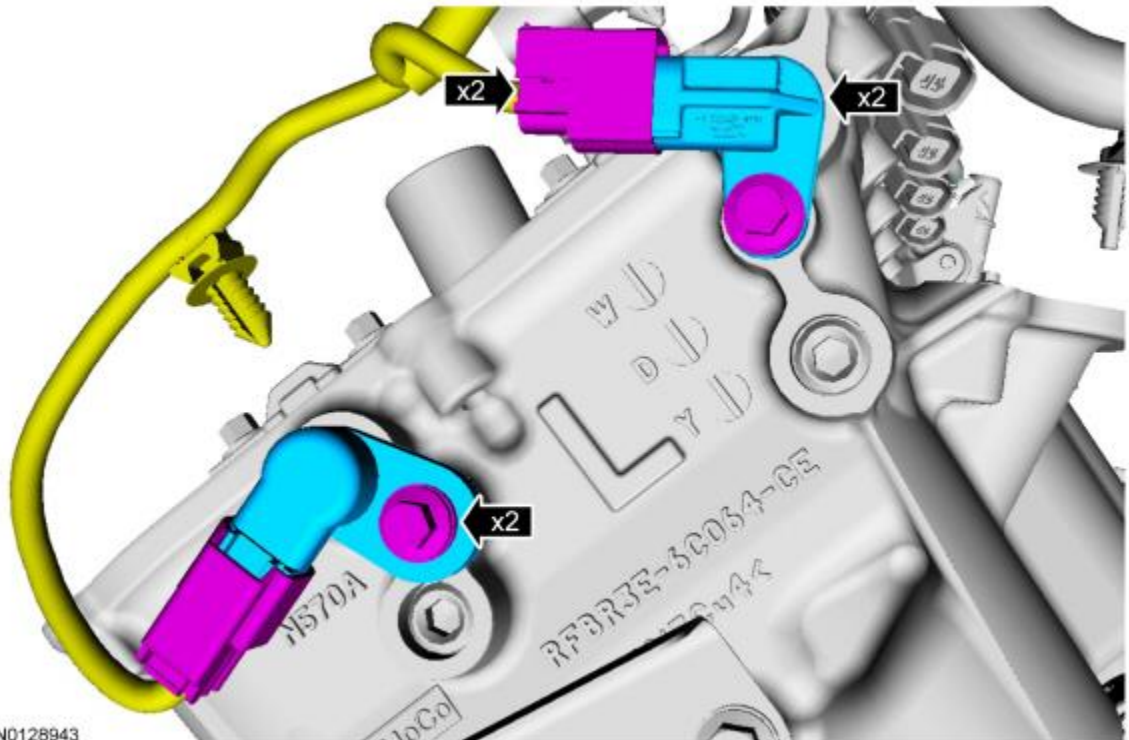
82. Position the LH valve cover and new gasket on the cylinder head.
- Tighten the fasteners in the sequence shown to 10 Nm (89 lb-in).



83. Install the oil level indicator.

84. If removed, install the LH intake and exhaust Camshaft Position (CMP) sensors and the 2 bolts.

- Tighten to 10 Nm (89 lb-in).
- Connect the LH intake and exhaust CMP sensor electrical connectors.



85. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the VCT Spark Plug Tube Seal Installer and Handle, install new spark plug tube seals.



86. **NOTE:** Installation of new seals is only required if damaged seals were removed.

Using the Differential Bearing Cone Installer and Handle, install new VCT variable force solenoid seal(s).



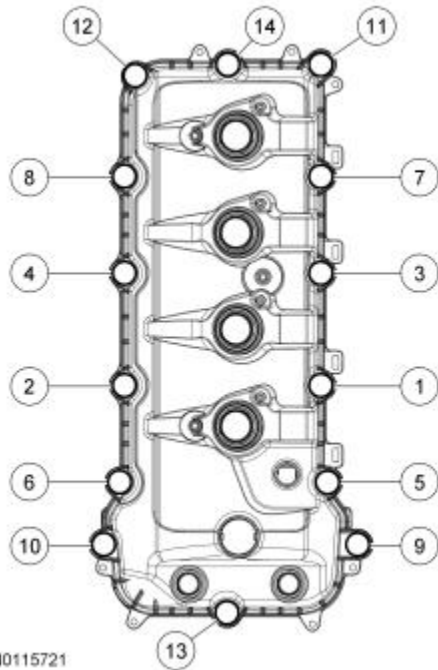
87. **NOTE:** If the valve cover is not installed and the fasteners tightened within 5 minutes, the sealant must be removed and the sealing area cleaned. To clean the sealing area, use silicone gasket remover and metal surface prep. Failure to follow this procedure can cause future oil leakage.

Apply an 8 mm (0.31 in) bead of silicone gasket and sealant to the engine front cover-to-RH cylinder head joints.



88. Position the RH valve cover and new gasket on the cylinder head.

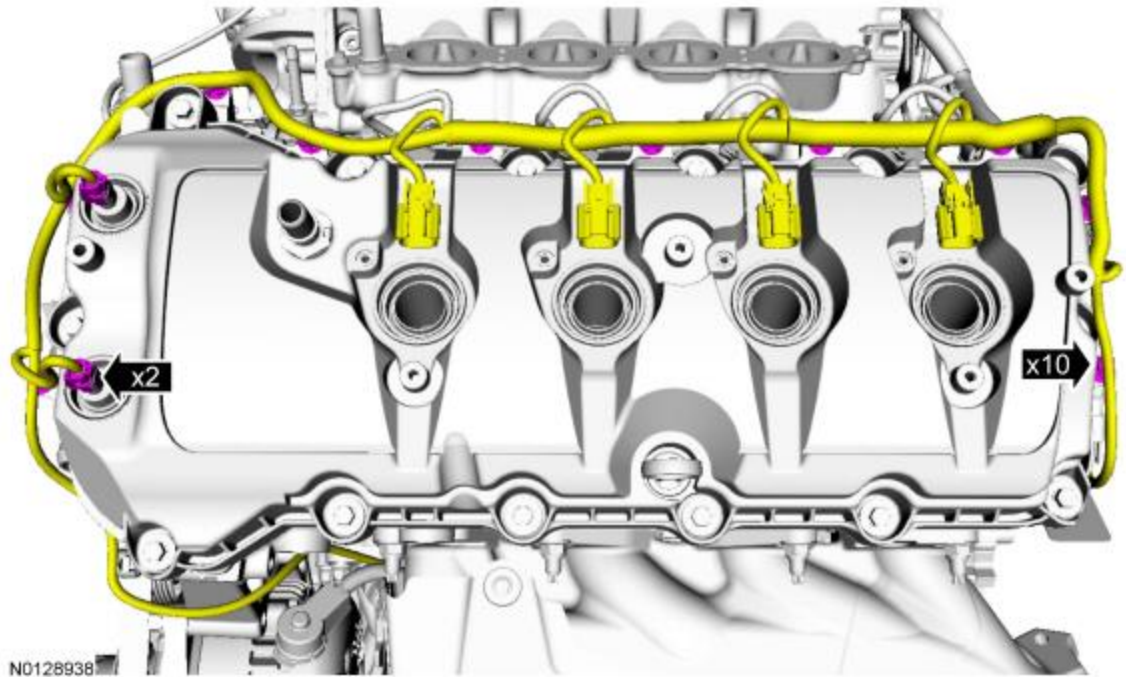
- Tighten the bolts in the sequence shown to 10 Nm (89 lb-in).



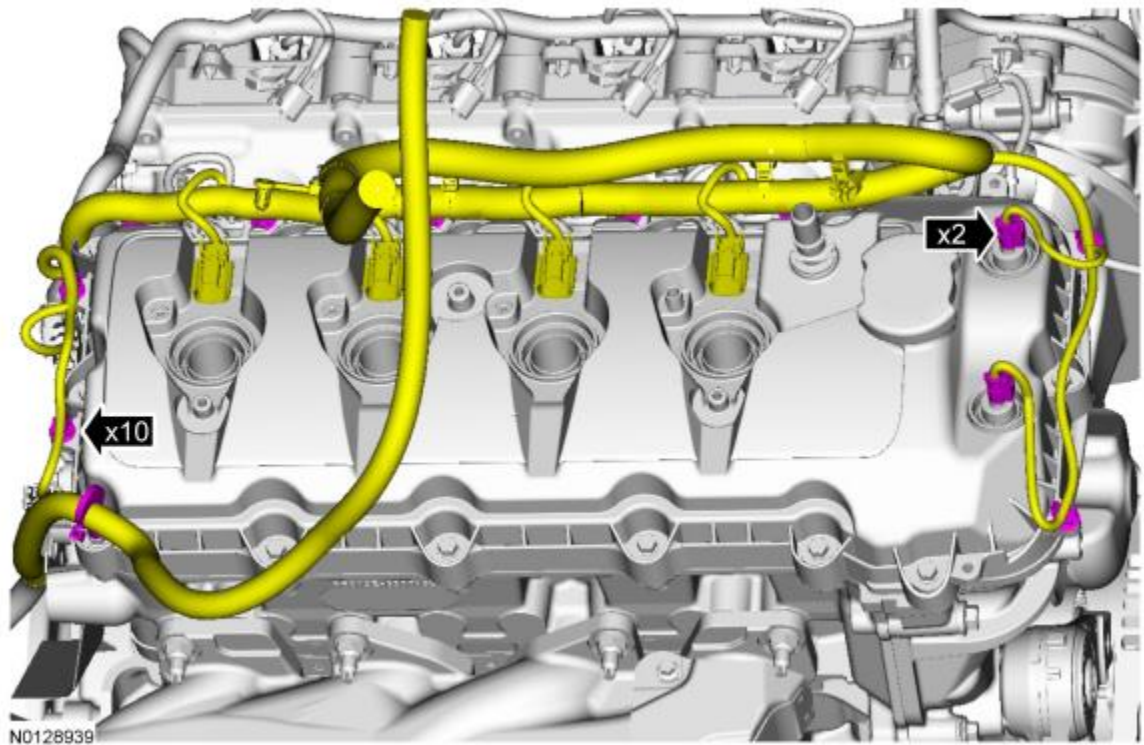
89. If removed, install the RH intake and exhaust CMP sensors and the 2 bolts.
- Tighten to 10 Nm (89 lb-in).
  - Connect the RH intake and exhaust CMP sensor electrical connectors.



90. Connect the 2 VCT variable force solenoid electrical connectors.
- Attach the 10 wiring harness retainers to the LH valve cover.



91. Connect the 2 Variable Camshaft Timing (VCT) variable force solenoid electrical connectors.
- Attach the 10 wiring harness retainers to the RH valve cover.



92. Inspect the coil seals for rips, nicks or tears. Remove and discard any damaged coil seals.



- To install, slide the new coil seal onto the coil until it is fully seated at the top of the coil.



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

**NOTE:** Apply a small amount of dielectric grease to the inside of the ignition coil-on-plug boots before attaching to the spark plugs. RH shown, LH similar.

Install the 8 ignition coils and 8 bolts.

- Tighten to 6 Nm (53 lb-in).



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

Connect the 8 ignition coil electrical connectors.



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95. Install the engine. For additional information, refer to [Engine](#) in this section.