**Engine**

Special Tool(s)

<table>
<thead>
<tr>
<th>Tool Code</th>
<th>Description</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST1287A</td>
<td>Installer, Power Steering Pump Pulley</td>
<td>211-185 (T91P-3A733-A)</td>
</tr>
<tr>
<td>ST303016</td>
<td>Reamer, Cylinder Ridge</td>
<td>303-016 (T64L-6011-EA)</td>
</tr>
<tr>
<td>ST1327A</td>
<td>Installer, Crankshaft Vibration Damper</td>
<td>303-102 (T74P-6316-B)</td>
</tr>
<tr>
<td>ST1328A</td>
<td>Installer, Crankshaft Rear Main Oil Seal</td>
<td>303-178 (T82L-6701-A)</td>
</tr>
<tr>
<td>ST1971A</td>
<td>Installer, Front Cover Oil Seal</td>
<td>303-335 (T88T-6701-A)</td>
</tr>
<tr>
<td>303384</td>
<td>Bolts, Crankshaft Rear Main Oil Seal Installer</td>
<td>303-384 (T91P-6701-A)</td>
</tr>
<tr>
<td>ST1971A</td>
<td>Service Set, Water Pump Pulley</td>
<td>303-S455 (T94P-6312-AH)</td>
</tr>
</tbody>
</table>
Assembly

1. Install the knock sensor.

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Super premium SAE 5W20 motor oil</td>
<td>XO-5W20-QSP meeting Ford specification WSS-M2C153-H</td>
</tr>
<tr>
<td>Silicone gasket and sealant</td>
<td>F7AZ-19554-EA meeting Ford specification WSE-M4G323-A4</td>
</tr>
<tr>
<td>Metal surface cleaner</td>
<td>F4AZ-19A536-RA meeting Ford specification WSE-M5B392-A</td>
</tr>
<tr>
<td>Gasket maker</td>
<td>F8AZ-19B508-AB meeting Ford specification WSK-M2G348-A5</td>
</tr>
</tbody>
</table>

2. Check the camshaft journal diameters. For additional information, refer to Section 303-00.

3. Check the crankshaft main journal diameters. For additional information, refer to Section 303-00.

4. **CAUTION:** Use only a plastic scraper when removing old gasket material.

   Clean all the mating faces and reusable parts thoroughly and check for damage.

5. **NOTE:** Never remove pipe plugs or alignment dowels unless they are to be serviced.

   Reseal oil passage blanking plugs, as necessary.
   - Use gasket maker F8AZ-19B508-AB meeting Ford specification WSK-M2G348-A5.

6. **NOTE:** The main bearings are a precision selective fit. For additional information, refer to Section 303-00.

   Install the upper crankshaft bearings and thrust washer into the cylinder block.
   1. Install the upper crankshaft thrust washer.
   2. Install the upper crankshaft main bearings.
- Lubricate the bearings and thrust washer. Use super premium SAE 5W20 motor oil XO-5W20-QSP meeting Ford specification WSS-M2C153-H.

7. **CAUTION:** Avoid damage to any crankshaft journal bearing surfaces.

   Install the crankshaft.

8. **NOTE:** Using a suitable lever of similar tool position the crankshaft rearward before installation of upper thrust bearings.

   **NOTE:** Visually inspect the bearings to verify that the bearing oil holes align with cylinder block oil feed holes

   **NOTE:** Align assembly tab on thrust bearing to machining spot face on cylinder block.

   Install the lower crankshaft bearings into the cylinder block.
   1. Install the lower crankshaft thrust main bearing into lower cylinder block.
   2. Install the lower crankshaft main bearings into lower cylinder block.
   - Lubricate the bearings and thrust washer. Use super premium SAE 5W20 motor oil XO-5W20-QSP meeting Ford specification WSS-M2C153-H.
9. **NOTE:** Sealant application must stop 6 mm from the rear crankshaft bore on each side.

**NOTE:** Install the lower cylinder block and tighten all bolts to specification within four minutes of applying sealant.

Apply a bead of sealant to the cylinder block housing.
- Use silicone gasket and sealant F7AZ-19554-EA meeting Ford specification WSE-M4G323-A4.
- Apply a 3 mm bead to area shown.
- Apply a 1 mm bead to area shown.

10. **CAUTION:** Make sure all dowels are fully seated into the lower cylinder block before tightening bolts.

**NOTE:** Tighten the bolts in the indicated sequence.

**NOTE:** Do not lubricate lower cylinder block bolts.

**NOTE:** Do not rotate crankshaft until all bolts are tightened to specification.
NOTE: Before installing the fasteners use a lever or similar tool to lightly seat the crankshaft forward.

NOTE: Bolts must be tightened to specification within four minutes of applying sealant.

Position the bulkhead housing on the cylinder block and tighten the fasteners in the indicated sequence.
- Push crankshaft rearward to seat the crankshaft thrust washer.

11. **CAUTION:** Bolts 1 through 16 are tighten-to-yield and must be replaced.

Complete the tightening sequence in four stages as indicated.
- Stage 1: Bolts 1-8, 25 Nm.
- Stage 2: Bolts 9-16, 40 Nm.
- Stage 3: Bolts 1-16, 90 degrees.
- Stage 4: Bolts 17-22, 25 Nm.
- Check that the crankshaft rotates freely.
12. Remove excess sealant which may squeeze out at the front cover sealing surface.

13. **CAUTION:** Use appropriate protection to prevent damage to the crankshaft bearing journals and cylinder bore surfaces.

Position the crankshaft with journal at the bottom of the stroke.

14. **NOTE:** Install the pistons with the arrow to front of the engine.

Compress the rings and install the piston and connecting rod.
- Lubricate all piston components. Use super premium SAE 5W20 motor oil XO-5W20-QSP meeting Ford specification WSS-M2C153-H.

15. **CAUTION:** When assembling the connecting rods and connecting rod caps, it is imperative that bearing slots and tangs be located on the same side of the connecting rods.

**CAUTION:** Connecting rod bolts are tighten to yield and must not be reused.

Position the connecting rod cap on the appropriate connecting rod and alternately tighten the bolts
in three stages as indicated.
- Stage 1: 23 Nm.
- Stage 2: 43 Nm.
- Stage 3: 90 degrees.

16. Check the connecting rod side clearance. For additional information, refer to Section 303-00.

17. Rotate the crankshaft to make sure the crankshaft and pistons are operating correctly.

18. Remove the crankshaft bolt and washer.

19. **NOTE**: Tighten the bolts in the indicated sequence.

   Install the oil pump.

20. Position the oil pan baffle and install the nuts in two stages.
   - Stage 1: 5 Nm.
   - Stage 2: 45 degrees.
21. **NOTE:** Lubricate a new O-ring seal with light engine oil before installation.

Position the oil intake tube and install the bracket nut in two stages.
- Stage 1: 5 Nm.
- Stage 2: 45 degrees.

22. Install the oil intake tube bolts.

23. Install the oil separator.
   - Use a new gasket with the guide(s) facing the cylinder block.
24. **Install the power steering pump bracket.**
   - Align the bracket with the locating sleeves.

25. **CAUTION:** Cylinder head bolts are installed and tightened in two phases.

   **NOTE:** Tighten the bolts in the indicated sequence in two stages.

   **NOTE:** Left-hand and right-hand cylinder head gaskets are not interchangeable.

   Install the cylinder heads (left-hand shown).
   - Use a new cylinder head gasket and align the cylinder head with the locating sleeves.
   - Insert new cylinder head bolts with washers.
   - Stage 1: 40 Nm.
   - Stage 2: 90 degrees.

26. **NOTE:** Loosen the bolts in the indicated sequence one full turn (360 degrees).

   Loosen the cylinder head bolts (right-hand shown).
27. Tighten the cylinder head bolts in the indicated sequence in three stages (left-hand shown).
   - Stage 1: 40 Nm.
   - Stage 2: 90 degrees.
   - Stage 3: 90 degrees.

28. Check all camshaft specifications. For additional information, refer to Section 303-00.

29. Install the crankshaft timing sprocket.

30. Install the crankshaft pulley washer and bolt.
31. Position the crankshaft.
   - Turn the key clockwise to the 11 o'clock position.

32. Install the hydraulic lash adjusters (left-hand shown).
   - Lubricate the hydraulic lash adjusters with engine assembly lubricant before installation.

33. **NOTE:** Lubricate the camshafts before installation. Use super premium SAE 5W20 motor oil XO-5W20-QSP meeting Ford specification WSS-M2C153-H.

   Install the left-hand camshafts.
34. **CAUTION:** Do not install thrust caps 1L and 5L at this time, or damage to the thrust caps may occur.

Install the left-hand camshaft caps in their original positions.
- Loosely install the camshaft cap bolts.

35. **NOTE:** Lubricate the camshafts before installation. Use super premium SAE 5W20 motor oil XO-5W20-QSP meeting Ford specification WSS-M2C153-H.

Install the right-hand camshafts.

36. **CAUTION:** Do not install thrust caps 5R and 1R at this time or damage to the thrust caps may result.

Install the right-hand camshaft caps in their original positions.
- Loosely install the camshaft cap bolts.
37. Remove the crankshaft pulley bolt and washer, while maintaining the 11 o'clock crankshaft keyway position.

38. **NOTE:** The colored links of the timing chain and the marks on the timing sprockets must line up.

   Install the left-hand timing chain.
   1. Install the left-hand chain guide and bolts (black material).
   2. Install the crankshaft sprocket.
   3. Install the timing chain.
39. Grip the left-hand timing chain tensioner in a vise with jaw protectors.

40. **CAUTION:** During tensioner compression, do not release the ratchet stem until the tensioner piston is fully bottomed in its bore or damage to the ratchet stem will result.

   Hold the left-hand timing chain tensioner ratchet lock mechanism away from the ratchet stem with a small pick.

41. **NOTE:** The piston should retract with minimal force. If binding occurs, reposition the tensioner to eliminate side loading.
Slowly compress the left-hand timing chain tensioner.

42. **NOTE:** The wire must remain in the timing chain tensioner until the tensioner is installed into the engine with the piston bottomed in the bore.

Retain piston with a 1.5 mm wire or paper clip.

43. Install the left-hand timing chain tensioner.
   1. Install the left-hand tensioner arm (black material).
   2. Install the tensioner adapter plate left-hand, the timing chain tensioner and bolts.

44. **NOTE:** The colored links of the timing chain and the marks on the sprocket must line up.

Install the right-hand timing chain.
   1. Install the tensioner arm and bolts (tan material).
   2. Install the timing chain.
45. Grip the right-hand timing chain tensioner in a vise with jaw protectors.

46. **CAUTION:** During tensioner compression, do not release the ratchet stem until the tensioner piston is fully bottomed in its bore, or damage to the ratchet stem will result.

   Hold the right-hand timing chain tensioner ratchet lock mechanism away from the ratchet stem with a small pick.

47. **NOTE:** The piston should retract with minimal force. If binding occurs, reposition the tensioner to eliminate side loading.
Slowly compress the right-hand timing chain tensioner.

48. **NOTE:** The wire must remain in the timing chain tensioner until the tensioner is installed with the piston bottomed in the bore.

Retain piston with a 1.5 mm wire or paper clip.

49. Install the right-hand timing chain tensioner.
   1. Install the tensioner arm (tan material).
   2. Install the tensioner adapter plate right-hand, the timing chain tensioner and bolts.

50. **CAUTION:** Crankshaft keyway must be in the 11 o'clock position before installation of the left-hand cylinder head roller finger followers.

   **NOTE:** Check that all the timing marks and reference flags are in the correct position before installing the roller finger followers.

   **NOTE:** Lash adjusters and roller finger followers must be installed in their original positions.

Install the left-hand lash adjusters and roller finger followers.
- Lubricate the roller finger followers with engine assembly lubricant.

51. **CAUTION:** Do not install the left-hand cylinder head camshaft journal thrust caps until camshaft journal caps are installed or damage to the thrust caps may occur.

   **NOTE:** With left-hand cylinder head roller finger followers installed, align camshaft end play using thrust caps as a guide before tightening journal caps.

   Tighten the left-hand camshaft cap bolts in the indicated sequence in several passes.

52. Install the crankshaft pulley, washer and bolt.
53. **CAUTION:** Rotating the crankshaft counterclockwise may cause the timing chains to bind and may cause engine damage.

Rotate the engine clockwise to locate the crankshaft keyway to the 3 o'clock position.

54. **CAUTION:** The crankshaft keyway must be in the 3 o'clock position before installation of the right-hand cylinder head roller finger followers. Failure to do so may lead to engine damage.

**NOTE:** Roller finger followers must be installed in their original locations.

Install the right-hand roller finger followers.
- Lubricate the roller finger followers with engine assembly lubricant.

55. **CAUTION:** Do not install right-hand cylinder head camshaft journal thrust caps until camshaft journal caps are installed, or damage to the thrust caps may occur.

**NOTE:** With right-hand cylinder head roller finger followers installed, align camshaft end play using thrust caps as a guide before tightening journal caps.

Tighten the right-hand camshaft cap bolts in the indicated sequence in several passes.
56. Remove the right-hand and left-hand chain tensioner retaining wires (left-hand shown).

57. Remove the crankshaft pulley bolt and washer.

58. Install the camshaft position (CKP) sensor pulse wheel.
   - Install the wheel with the indentation toward the front.
   - Use the keyway marked 2.5L (blue paint stripe).
59. **NOTE:** Install the engine front cover within six minutes of applying the sealant.

Apply a 6 mm dot of sealant to the mating faces.
- Clean the front cover to cylinder block and cylinder head sealing surfaces with metal surface cleaner.

60. **NOTE:** The engine front cover must be installed in a two-step sequence.

Install the engine front cover.
- Use new gaskets in the engine front cover.
- Note locating dowels and the locations of the studs.
- Install the bolts and studs in the indicated sequence and tighten in two steps.
- Tighten the bolts and studs one-quarter turn (90 degrees) after engine front cover contacts cylinder block and cylinder heads.
61. **NOTE:** Tighten the bolts and studs in the indicated sequence.

**NOTE:** 3, 4, 8, 10, 11, 14, 15, 16 are stud locations.

Install the remaining engine front cover bolts and studs.

62. **NOTE:** Lubricate the new O-ring seals with light engine oil before installation.

Install the sensors and wiring brackets.
- Install the CKP sensor.
- Install the CMP sensor.
63. Using the special tools, install the crankshaft front oil seal.
   - Lubricate the outer ring and sealing lip with engine oil.

64. Apply silicon gasket and sealant F7AZ-19554-EA meeting Ford specification WSE-M4G323-A4 to the front of the crankshaft on the inside diameter surface of the crankshaft pulley at the keyway.
   - Before applying the sealant, clean sealing surfaces with metal surface cleaner F7AZ-19A536-RA meeting Ford specification WSE-M5B392-A to remove all residues that may interfere with the sealants ability to adhere.

65. **NOTE:** Use the crankshaft pulley bolt washer for installation.

   Using the special tool, install the crankshaft pulley.
   - Remove the special tool and the crankshaft pulley washer.

66. **NOTE:** Use a new bolt.

   Install the crankshaft pulley bolt and washer.
   1. Using a suitable strap wrench, hold the crankshaft pulley.
   2. Tighten the crankshaft pulley bolt in four stages.
      - Stage 1: 120 Nm.
- Stage 2: Back off bolt one full turn.
- Stage 3: 50 Nm.
- Stage 4: 90 degrees.

67. Install the power steering pump and bracket.
   - Loosely install all bolts and studs.

68. **NOTE:** The longer 84 mm bolts should be tightened first.

   Tighten the power steering pump bolts.

69. Tighten the power steering pump stud nuts.
70. **CAUTION: Tightening the pulley with the dimple facing the power steering pump, will bend the pulley.**

**NOTE:** The dimple on the pulley must face toward the front of the engine.

Install the power steering pump belt pulley.

71. Install the camshaft oil seal retainer.
   - Use a new gasket and align the retainer on the locating dowels.

72. **CAUTION: The running surface of the camshaft must not be damaged.**

   **NOTE:** Lubricate the camshaft oil seal with engine oil.

   Using the special tools, install the camshaft oil seal.
   1. Install the special tool.
   2. Position a new seal and the special tool.
   3. Install the special tool and install the seal.
73. Using the special tool, install the water pump drive pulley.
   - After installation remove the special tool.

74. Coat the mating faces of the cylinder heads with sealant.
   - Use silicone gasket and sealant F7AZ-19554-EA meeting Ford specification WSE-M4G323-A4.

75. Install the left-hand spark plugs.

76. Install the right-hand spark plugs.
77. **NOTE:** Install the bolts in the indicated sequence.

Install the cylinder head covers.
- Use new gaskets.

78. Install the fuel charging wiring bracket to the cylinder head cover.

79. Coat the mating faces with sealant.
- Use silicone gasket and sealant F7AZ-19554-EA meeting Ford specification WSE-M4G323-A4.
- Apply a 10 mm diameter dot of sealant onto the cylinder block at the indicated areas.

80. **NOTE:** Note the locations of the studs.

**NOTE:** Install the bolts and studs in the indicated sequence.

**NOTE:** Install the oil pan and tighten the bolts within six minutes of applying sealant.

Install the oil pan.
- Use a new gasket.

81. On SVT equipped vehicles, install the oil cooler.
- Apply Engine oil to the oil cooler gasket, oil cooler insert O-ring seal, and oil filter gasket before installation.
82. Install the oil pressure switch.

83. **NOTE:** If studs were removed, install short end of studs into cylinder head.

**NOTE:** Install the nuts in the indicated sequence.

Install the left-hand exhaust manifold with the catalytic converter.
- Use a new gasket.

84. Install the oil filter.
85. Position the right-hand exhaust manifold and install the nuts in the indicated sequence.

86. Install the generator bracket.

87. Install the generator.
   1. Install the generator bolts.
   2. Install the bracket bolt.

88. **NOTE:** Alternate bolt tightening to correctly seat the crankshaft rear oil seal until it is flush with the cylinder block.

   Using the special tools, install the crankshaft rear oil seal.
   - Lubricate the outer ring and sealing lip with engine oil.
89. **NOTE:** Use a suitable strap wrench to hold the crankshaft pulley.

Install the flywheel.
1. Install the backing plate.
2. Install the flywheel and tighten the bolts working diagonally.

90. Install the water pump.
1. Position the pump.
2. Install new bolts and tighten them in two stages.
   - Stage 1: 10 Nm.
   - Stage 2: 90 degrees.

91. Connect the water pump coolant hoses.
1. Connect the coolant hose to the oil filter adapter.
2. Connect the coolant hose to the cylinder block.
92. Install the water bypass.
   - Use new O-ring seals and lubricate them with coolant.

93. Install the PCV valve and hoses.
   1. Connect the PCV valve and hoses.
   2. Install the bracket nut.

94. Install the water pump drive belt.
   - Rotate the belt tensioner clockwise to relieve tension on the belt.
95. **NOTE:** Lubricate and install the O-ring seal on the oil level indicator tube and lubricate with clean engine oil before installation.

Install the oil level indicator tube.
1. Position the oil level indicator tube using a twisting motion.
2. Install the oil level indicator tube bracket bolt.

96. **NOTE:** Use new gaskets with the locating lugs facing downwards.

**NOTE:** Install the bolts in the indicated sequence.

Install the lower part of the intake manifold.

97. Install the fuel injection system wiring harness.
1. Connect the fuel injector electrical connectors beginning at the front of the engine.
2. Connect the ECT sensor electrical connector.
3. Connect the DPFE sensor electrical connector.

98. Connect the knock sensor electrical connector.
99. Connect the CKP sensor electrical connector.
   1. Connect the harness clip.
   2. Connect the CKP sensor electrical connector.

100. Connect the CMP sensor and left hand heated oxygen sensor (HO2S) electrical connectors.
   - Attach the retainer.

101. Connect the oil pressure switch electrical connector.

102. Connect the left-hand HO2S electrical connector.
103. **NOTE:** Use new gaskets with the locating lugs pointing downwards.

**NOTE:** Install the bolts in the indicated sequence.

Install the upper part of the intake manifold.

104. Connect the throttle position (TP) sensor and the fuel injector pressure sensor electrical connectors.

105. Connect the idle air control (IAC) valve electrical connector.
106. Position the vacuum harness and connect the vacuum lines.

107. Connect the EGR valve, fuel pressure sensor and intake manifold vacuum hoses.

108. Install the ignition coil.
   1. Position the coil.
   2. Position the capacitor.
   3. Position the ground cable.
   4. Install the bolts.
   5. Connect the ignition coil electrical connector.

109. Connect the six spark plug wires to the spark plugs.

110. Install the IMRC control unit.
    1. Install the bolts.
    2. Connect the electrical connector.
111. Connect the IMRC cable.
   1. Connect the cable to the retainer.
   2. Connect the cable end.

112. Position the wiring harness.

113. Attach the wiring harness to the right-hand valve cover and install two nuts.

114. Attach the in-line connectors to the bracket.

115. Connect the engine coolant temperature (ECT) sending unit.
116. Connect the EGR vacuum regulator solenoid electrical connector.

117. Connect the DPFE sensor electrical connector.

118. Connect the generator electrical connections.
   1. Install the battery positive voltage cable.
   2. Install the voltage regulator electrical connector.
   3. Position the stator circuit electrical connector.

119. Install the connecting shaft bracket to the cylinder block.
120. Connect the right-hand HO2S electrical connector.

121. Connect the exhaust gas recirculation (EGR) tube and the EGR valve.
   1. Connect the hoses to the EGR tube to the differential pressure feedback EGR.
   2. Connect the tube fitting.