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Description

FRONT COVER ASSEMBLIES

The front cover assembly was modified as a production running change from Generation 1 to Generation 2 for International® DT 466, DT 570 and HT 570 Diesel Engines.

- Generation 1 front cover assemblies include a water pump wear plate; Generation 2 front cover assemblies do not have a water pump wear plate.
- Generation 2 front cover assemblies have additional bolts to secure the front cover (front half) to the front cover (rear half).
- Generation 1 and Generation 2 front cover assemblies are not interchangeable.
- Some Generation 2 front covers are equipped with a sound shield. When replacing a front cover equipped with a sound shield, replace it only with a cover equipped with a sound shield, to ensure that noise reduction requirements are maintained.

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

See removal and installation procedures for Generation 1 (Mounting Bolts) and Generation 2 (Mounting Bolts), listed in the Table of Contents in this section.

GEROTOR OIL PUMP ASSEMBLY

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Removal, inspection, and installation procedures for the Gerotor oil pump assembly, show the 8 lobe gerotor oil pump. Removal, inspection, and installation procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

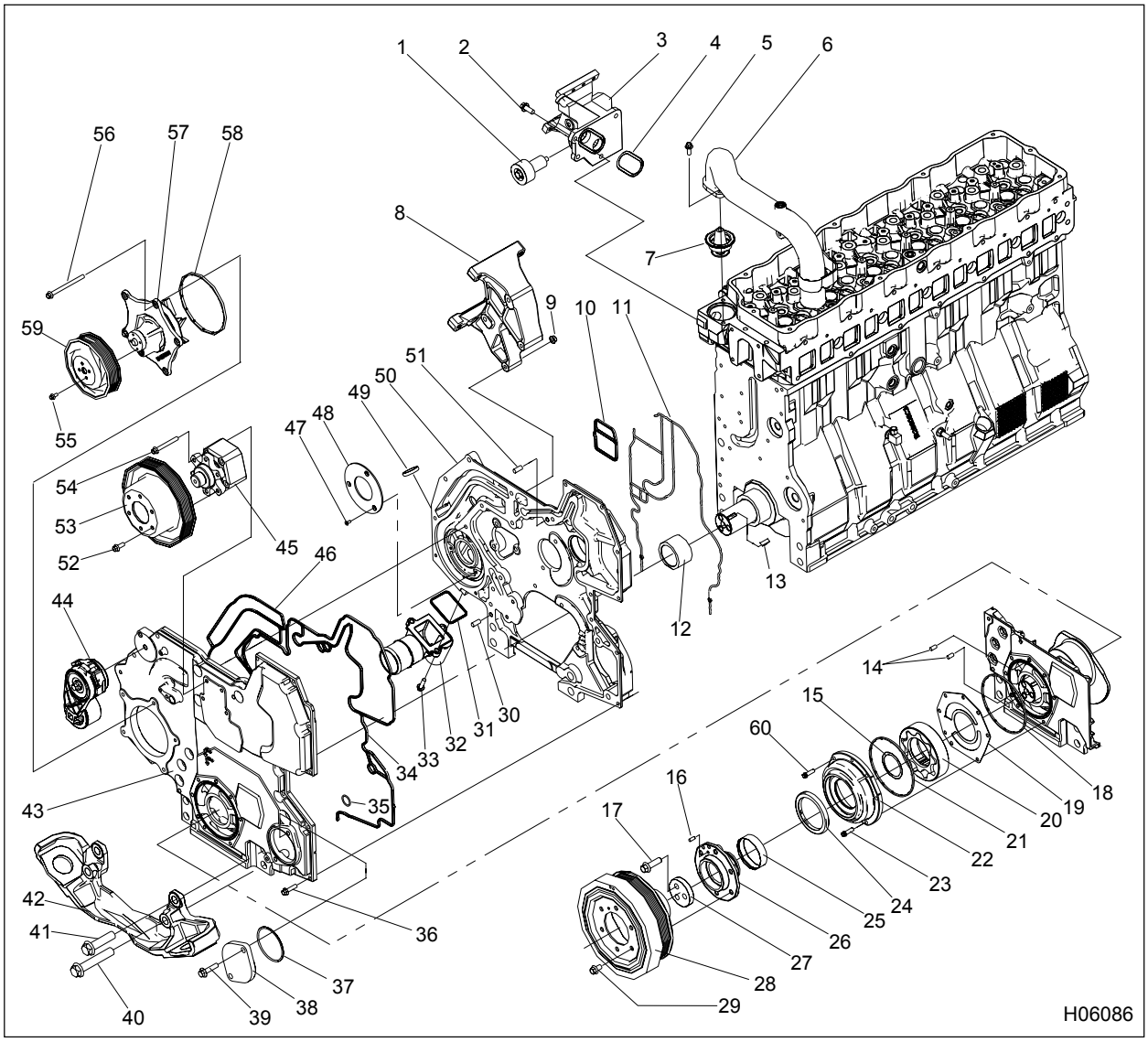

Figure 209 Front cover related components (less gear train)

1. Flat idler pulley assembly
2. Bolt, M10 x 25 (4)
3. Water supply housing
4. Coolant port seal
5. Bolt, M8 x 25 (2)
6. Water outlet tube assembly
7. Thermostat assembly
8. Alternator bracket
9. Nut, M8
10. Coolant gasket
11. Oil gasket
12. Oil pump drive
13. Vibration damper key
14. Dowels (2)
15. Washer, seal
16. Pin, 6 mm x 16 mm
17. Bolt, M12 x 40 (3)
18. Oil pump (housing plate) seal
19. Oil pump housing plate
20. Gerotor oil pump assembly
21. Oil pump (housing) seal
22. Oil pump housing
23. Bolt, M8 x 25 (4) See bolt locations (Figure 228)
24. Front oil seal
25. Wear sleeve
26. Damper hub
27. Damper retaining plate
28. Vibration damper
29. Bolt, M10 x 16 (6)
30. Dowel
31. Water inlet gasket
32. Water inlet elbow
33. Bolt, M8 x 30 (3)
34. Front cover gasket (oil)
35. O-ring seal
36. Bolt, M8 x 30 see bolt locations (Figure 252)
37. O-ring seal (#235), PTO equipped only
38. End cover adapter, PTO equipped only
39. Bolt, M10 x 40 (2), PTO equipped only
40. Bolt, M18 x 100 (2)
41. Bolt, M18 x 70 (2)
42. Front engine mount
43. Cover, front half (PTO equipped)
44. Auto tensioner
45. Fan drive assembly
46. Coolant gasket
47. Flat head socket screw, M5 (3)
48. Water pump wear plate (Generation 1 front covers only)
49. Cup plug
50. Cover, rear half
51. Dowel
52. Bolt, M8 x 20 (6)
53. Fan drive pulley
54. Bolt, (4) see bolt sizes (Table 18)
55. Bolt, M6 x 12 (4)
56. Bolt, (5) see water pump (Figure 272)
57. Water pump assembly
58. Water pump seal
59. Water pump pulley
60. Bolt, M8 x 60 (2) see bolt locations (Figure 228)

Checking Gear Train Timing without Removing Front Cover

Valve train failures from broken or bent push rods, valves, rocker arms and worn valve keepers and/or rotators in many instances could be caused by improper timing of the gear train. Depending on valve lash setting, if the camshaft gear is improperly timed by one tooth early, the engine pistons will strike the intake valve heads or if the timing is set one tooth late, the exhaust valves may contact pistons.

NOTE: Before attempting to check gear train timing, it will be necessary to remove the valve cover, valve cover gasket, and high-pressure oil manifold or Diamond Logic® engine brake. See the appropriate sections of this manual regarding removal and installation procedures.

DT 466 Engines Only

Method One – Using a Feeler Gauge

1. Rotate the engine to approximately TDC (Top Dead Center) compression on No. 1 cylinder (no valves open). Set the lash on the No. 1 intake valve to the nominal lash setting of 0.48 mm (0.019 in).

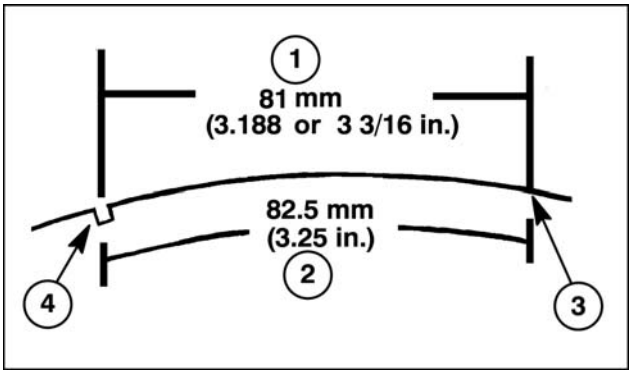

Figure 210 Checking Engine Gear Train Timing

1. Straight line dimension
2. Radial distance dimension
3. Scribe mark
4. Damper timing notch

2. Scribe a mark on the damper pulley at a radial distance of 82.5 mm (3.25 in) or a straight line distance of 81 mm (3.188 in) clockwise from the timing notch as viewed from the front of the engine.
3. Place a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve. Slowly rotate the engine forward (clockwise) until the intake valve starts to lift and the feeler gauge becomes tight. The mark should line up with the TDC arrow on the front cover or be within 3.5 crankshaft degrees of it. 3.5 degrees is equivalent to a radial (or straight) line distance of 6.8 mm (0.27 in) at the damper pulley.

NOTE: One tooth “out of time” on the gear train equals approximately 11 degrees of movement or 21.4 mm (27/32 in) of radial distance of damper pulley.

4. If the timing on the No. 1 valve is within specifications, the other valves, barring extreme camshaft lobe wear or poor adjustment, will also be in time. If timing is found to be incorrect, removal of the front cover is required to inspect the punch marks on the gear train.

Method Two – Using a Dial Indicator

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke to 0.48 mm (0.019 in). Install a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve.
2. Position the magnetic base dial indicator on the valve cover fence of the cylinder head rail with the indicator tip on the No. 1 intake rocker arm tip.
3. Zero the dial indicator.
4. Rotate the engine approximately one full revolution in either direction to a position 360 degrees from starting point.
5. The dial indicator should read within the range of 0.13-0.25 mm (0.005-0.010 in) from the starting position for proper gear train timing.
6. If dial indicator readings are found to be outside of this range, removal of the front cover is required to inspect the punch marks on the gear train.

DT 570 and HT 570 Engines Only

Method One – Using a Feeler Gauge

1. Rotate the engine to approximately TDC (Top Dead Center) compression on No. 1 cylinder (no valves open). Set the lash on the No. 1 intake valve to the nominal lash setting of 0.48 mm (0.019 in).

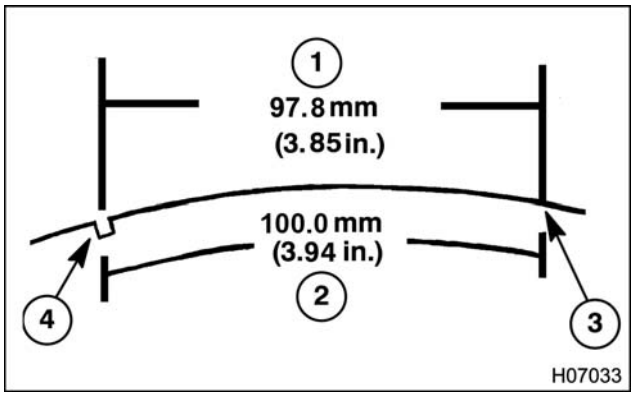

Figure 211 Checking Engine Gear Train Timing

1. Straight line dimension
2. Radial distance dimension
3. Scribe mark
4. Damper timing notch

2. Scribe a mark on the damper pulley at a radial distance of 100.0 mm (3.94 in) or a straight line distance of 97.8 mm (3.85 in) clockwise from the timing notch as viewed from the front of the engine.
3. Place a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve. Slowly rotate the engine forward (clockwise) until the intake valve starts to lift and the feeler gauge becomes tight. The mark should line up with the TDC arrow on the front cover or be within 3.5 crankshaft degrees of it. 3.5 crank degrees is equivalent to a radial (or straight) line distance of 8.1 mm (0.32 in) at the damper pulley.

NOTE: One tooth “out of time” on the gear train equals approximately 11 degrees of movement or 21.4 mm (27/32 in) of radial distance of damper pulley.

4. If the timing on the No. 1 valve is within specifications, the other valves, barring extreme camshaft lobe wear or poor adjustment, will also be in time. If timing is found to be incorrect, removal of the front cover is required to inspect the punch marks on the gear train.

Method Two – Using a Dial Indicator

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke to 0.48 mm (0.019 in). Install a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve.
2. Position the magnetic base dial indicator on the valve cover fence of the cylinder head rail with the indicator tip on the No. 1 intake rocker arm tip.
3. Zero the dial indicator.
4. Rotate the engine approximately one full revolution in either direction to a position 360 degrees from starting point.
5. The dial indicator should read within the range of 0.13-0.25 mm (0.005-0.010 in) from the starting position for proper gear train timing.
6. If dial indicator readings are found to be outside of this range, removal of the front cover is required to inspect the punch marks on the gear train.

Removal

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not open pressurized Freon® lines.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

Alternator Bracket

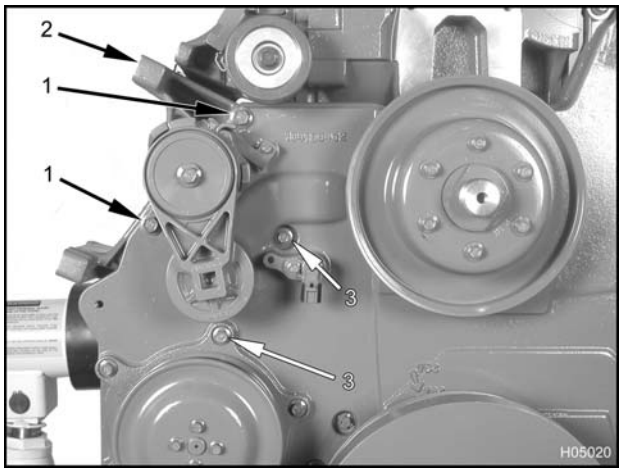

Figure 212 Alternator bracket bolts

1. Bolt, M10 x 120 (2)
2. Alternator bracket
3. Bolt, M8 x 100 (2)

1. Remove M8 bolt and harness routing guide.
2. Remove two hex flange bolts and nuts (M10 x 120).
3. Remove two hex flange bolts and nuts (M8 x 100).
4. Remove alternator bracket.

Flat Idler Pulley and Automatic Belt Tensioner

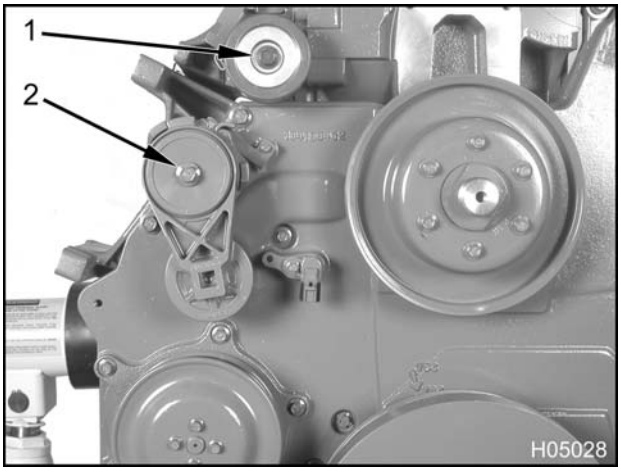

Figure 213 Flat idler pulley and automatic belt tensioner

1. Flat idler pulley assembly mounting bolt, M10 x 80
2. Automatic belt tensioner assembly mounting bolt, M10 x 80

1. Remove flat idler pulley mounting bolt (M10 x 80) and assembly from the water supply housing.
2. Remove automatic belt tensioner mounting bolt (M10 x 80) and assembly from the front cover assembly.

Water Supply Housing

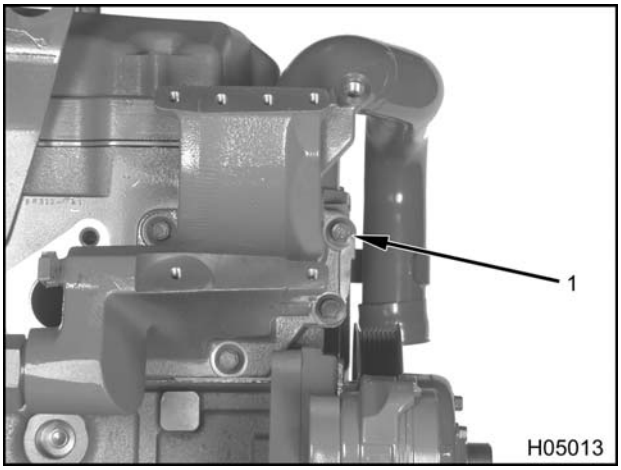

Figure 214 Water supply housing bolts

1. Bolt, M10 x 25 (4)

1. Support water supply housing and remove four water supply housing bolts (M10 x 25).

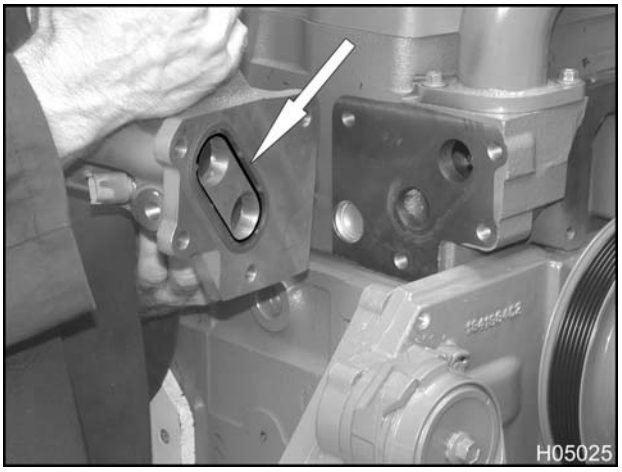

Figure 215 Water supply housing and coolant port seal

2. Tap water supply housing with a hammer to break coolant seal. Remove housing and discard coolant port seal.

Water Inlet Elbow, Water Outlet Tube, and Thermostat

1. Remove three hex flange bolts (M8 x 30) securing water inlet elbow to front cover.

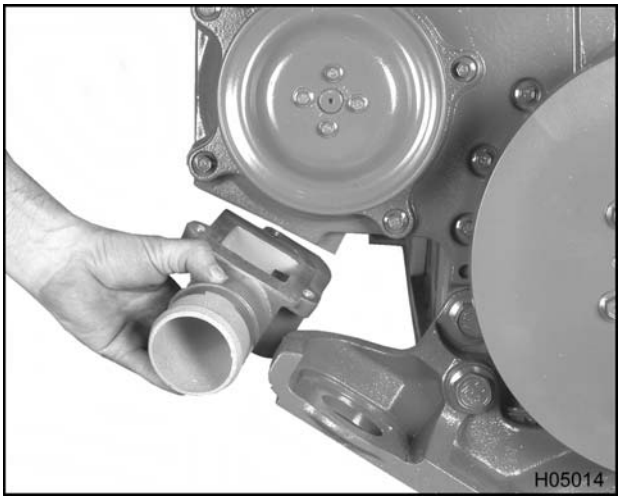

Figure 216 Water inlet elbow

2. Tap water inlet elbow with a hammer to break coolant seal. Remove water inlet elbow and discard gasket seal.

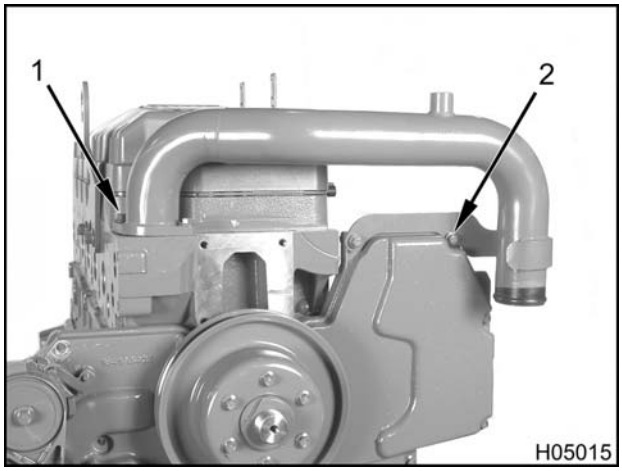

Figure 217 Water outlet tube assembly

1. Bolt, M8 x 25 (2)
2. Hex flange nut, M8 (2)

3. Remove two water outlet tube assembly bolts (M8 x 25) at the cylinder head.
4. Remove two hex flange nuts (M8) retaining the water outlet tube assembly to front cover and remove tube assembly.

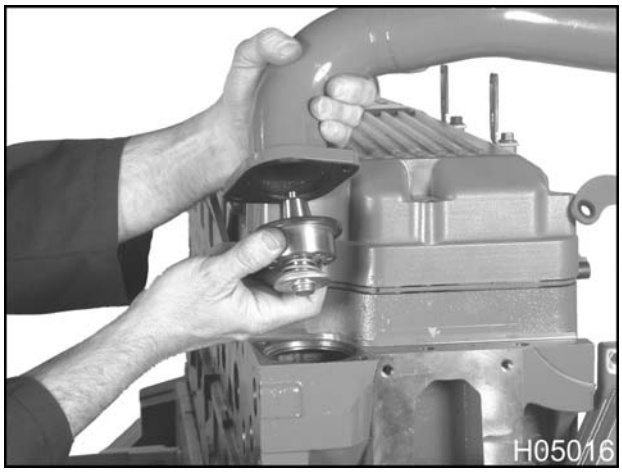

Figure 218 Thermostat assembly

5. Lift thermostat out of cylinder head.

NOTE: The thermostat seal cannot be purchased separately. It is only available with the thermostat assembly.

Fan Drive Hub

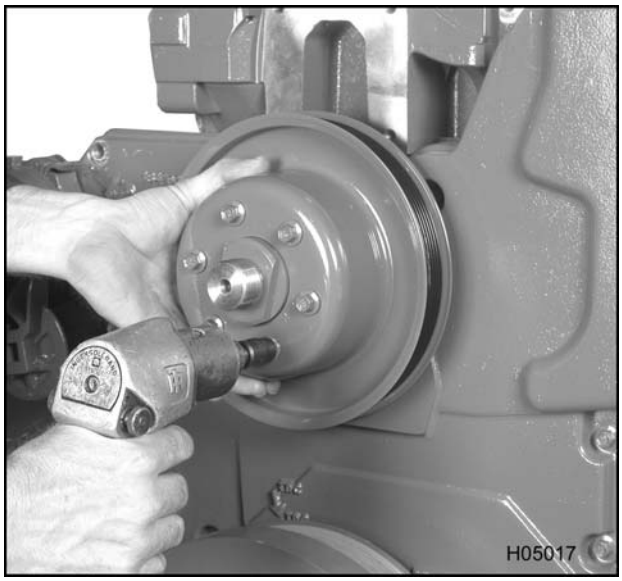

Figure 219 Removing the fan drive pulley

1. Remove six hex flange bolts (M8 x 20) and the fan drive pulley.

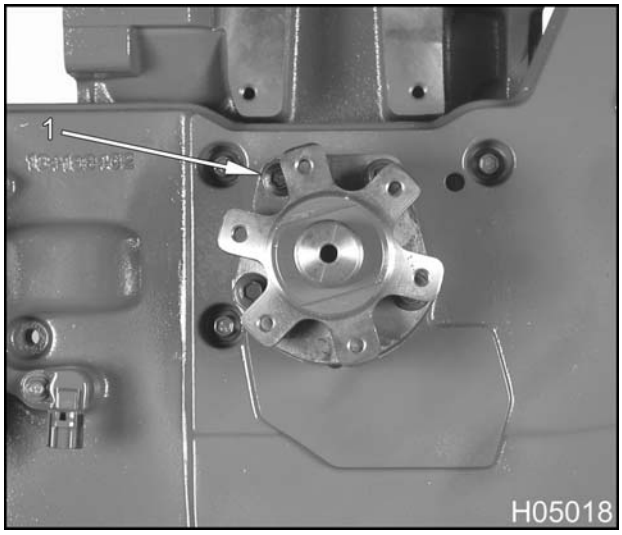

Figure 220 Fan hub assembly (typical)

1. Bolt, M8 x 65 (4)

2. Remove four hex flange bolts. See fan drive applications (Table 18).
3. Remove fan hub assembly.

Water Pump Assembly

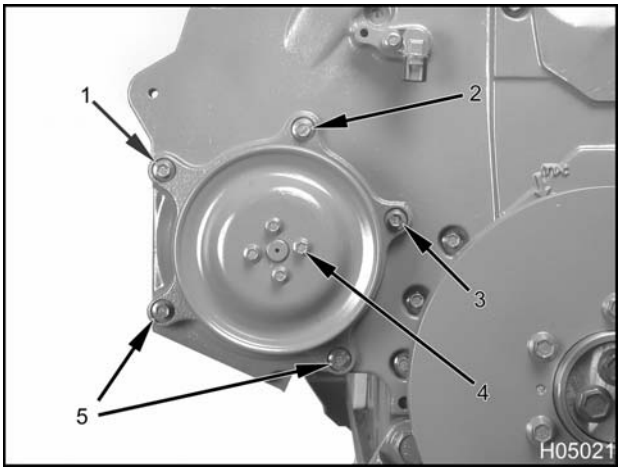

Figure 221 Water pump assembly

1. Bolt, M8 x 55 , nut, M8 (1)
2. Bolt, M8 x 100, nut, M8 (1)
3. Bolt, M8 x 16 (1)
4. Bolt, M6 x 12 (4)
5. Bolt, M8 x 40 (2)

1. Remove four pulley bolts (M6 x 12).
2. Remove water pump pulley.
3. Remove one water pump assembly nut (M8) and bolt (M8 x 55).
4. Remove one water pump assembly nut (M8) and bolt (M8 x 100).
5. Remove one water pump assembly bolt (M8 x 16).
6. Remove two water pump assembly bolts (M8 x 40).

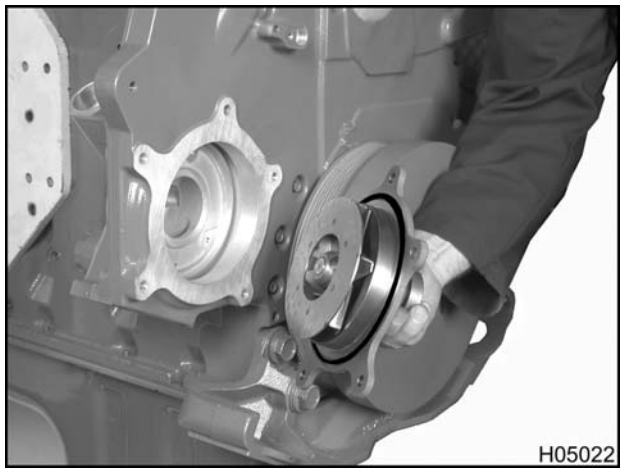

Figure 222 Water pump assembly

7. Remove water pump assembly. Remove and discard seal.

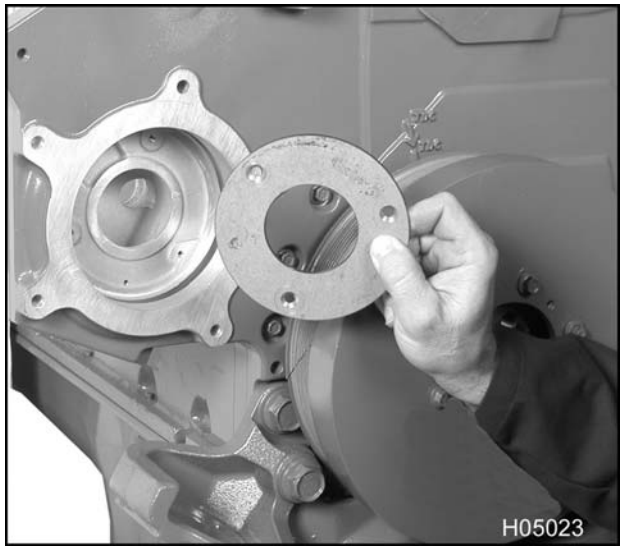

Figure 223 Water pump wear plate (Generation 1 front covers only)

8. If applicable, remove three flat head hex socket screws (M5) securing the water pump wear plate to the rear half of the front cover and remove water pump wear plate.

Vibration Damper, Damper Hub, and Wear Sleeve

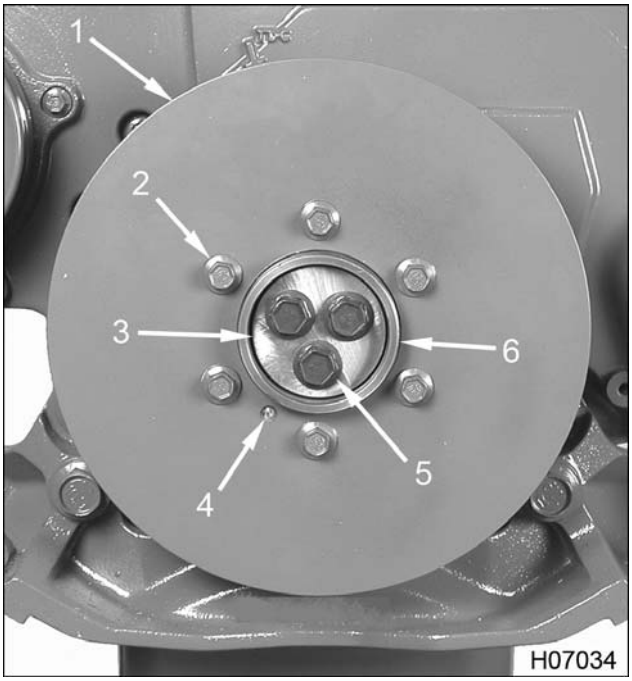

Figure 224 Vibration damper assembly

1. Vibration damper
2. Bolt, M10 x 16 (6)
3. Damper retaining plate
4. Dowel
5. Bolt, M12 x 40 (3)
6. Damper hub assembly

1. Remove six M10 x 16 bolts securing the vibration damper to the damper hub assembly and remove the vibration damper.
2. Remove and discard three M12 x 40 bolts securing the damper retaining plate.
3. Remove and discard damper retaining plate.

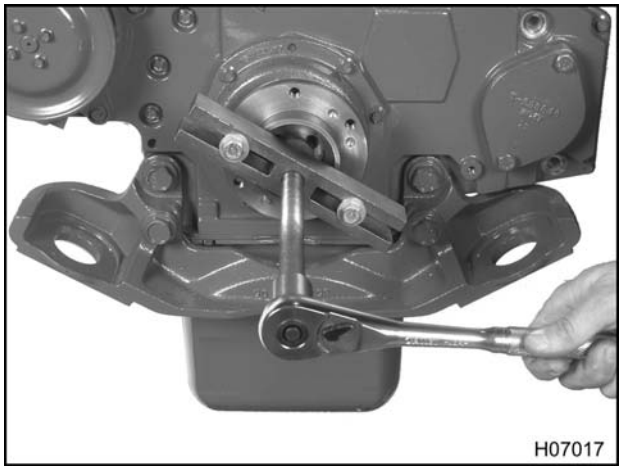

Figure 225 Removing the damper hub assembly

4. Install two M10 x 80 bolts and washers through H-bar puller (Table 21) and into the damper hub. Install M10 x 80 bolt heads at equal lengths from the vibration damper mounting surface.
5. Tighten H-bar center shaft to pull damper hub off of crankshaft and remove damper hub.

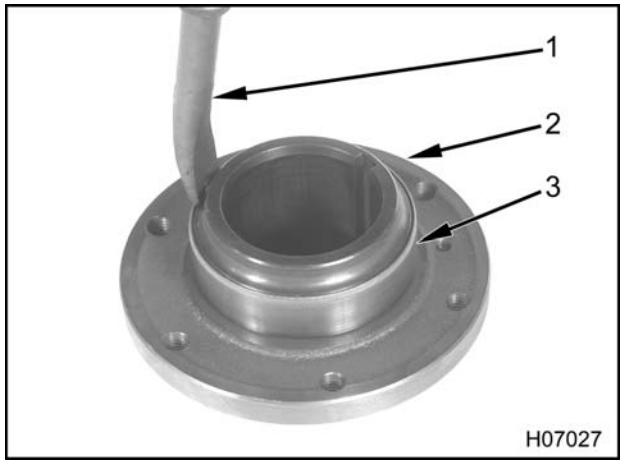

Figure 226 Removing the wear sleeve with a muffler chisel

1. Muffler Chisel
2. Vibration damper hub
3. Wear Sleeve

CAUTION: To prevent engine damage, do not damage or distort damper hub while removing wear sleeve.

6. Split the wear sleeve with a muffler chisel to remove it from the damper. Be careful not to damage the vibration damper hub.

Gerotor Assembly Oil Pump and Front Oil Seal

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Removal procedures for the gerotor oil pump assembly, show the 8 lobe gerotor oil pump. Removal procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

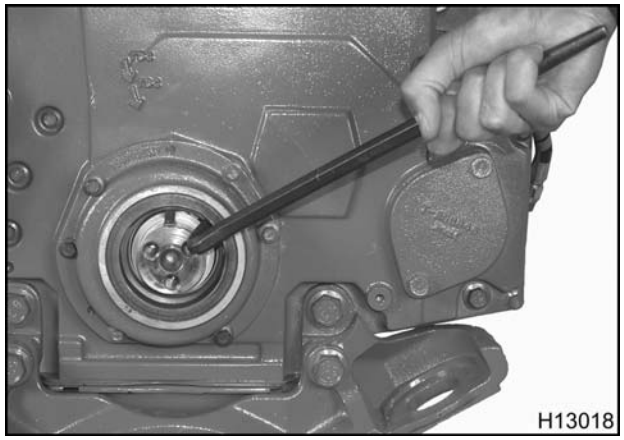

Figure 227 Removing front oil seal

NOTE: Be careful not to damage the crankshaft or front oil seal mounting surface while removing the front oil seal.

1. Remove front oil seal with a heel bar while oil pump housing assembly is still attached to front cover. Discard the front oil seal.

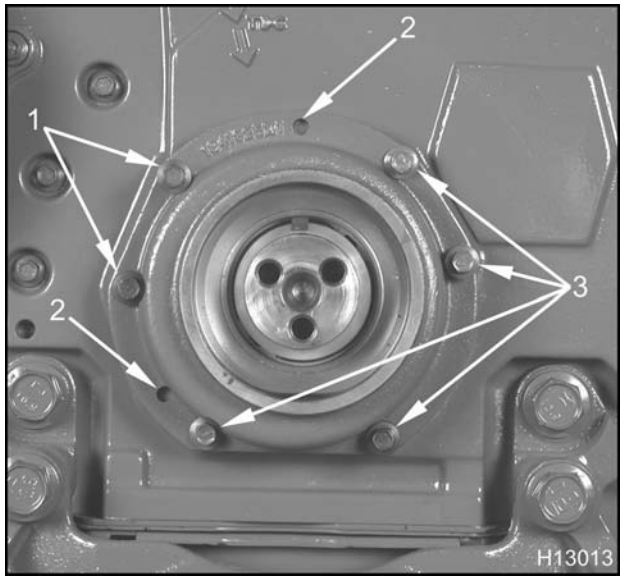

Figure 228 Oil pump housing mounting bolts

1. Bolt, M8 x 60 (2)
2. Dowels (2)
3. Bolt, M8 x 25 (4)

2. Remove two bolts (M8 x 60) retaining the oil pump housing cover.

3. Remove four bolts (M8 x 25) retaining the oil pump housing cover.

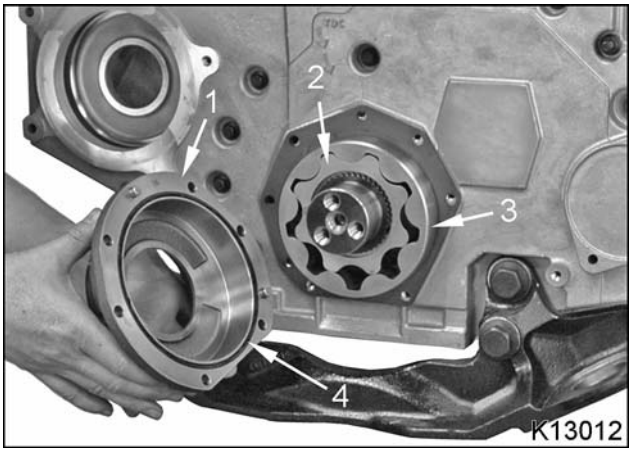

Figure 229 Oil pump housing, rotors, and oil pump (housing) seal

1. Oil pump and rotor housing
2. Inner rotor
3. Outer rotor
4. Oil pump (housing) seal

4. Remove oil pump housing cover and discard oil pump (housing) seal.

CAUTION: To prevent engine damage, use permanent marker to identify internal engine components and their orientation. Do not use paint or temporary markers.

5. Mark inner and outer rotors with a permanent marker, if oil pump is to be reused. Mark will indicate rotor turning direction and orientation to front cover.

6. Remove outer rotor.

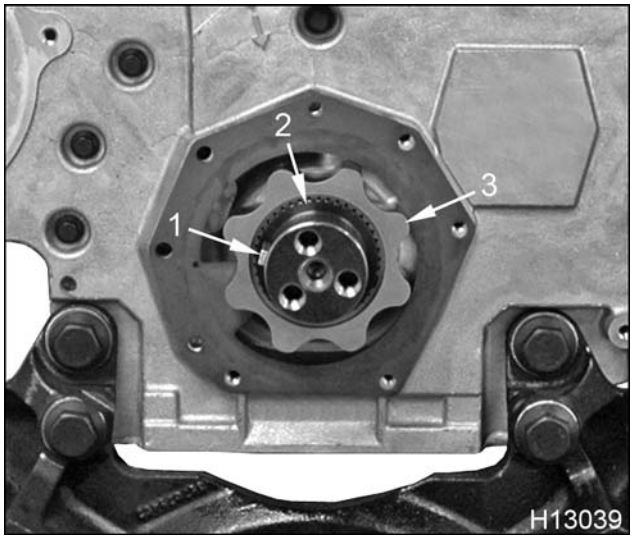

Figure 230 Vibration damper key, washer seal, and inner rotor

1. Vibration damper key
2. Washer seal
3. Inner rotor

CAUTION: To prevent engine damage, do not damage or distort the crankshaft keyway groove during vibration damper key removal.

7. Carefully tap the vibration damper key out of the crankshaft with a hammer and chisel.

8. Remove washer seal and inner rotor from crankshaft.

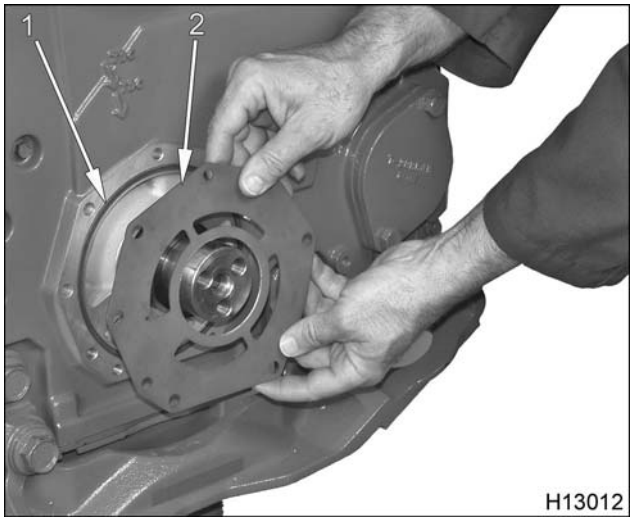

Figure 231 Oil pump housing plate and seal

1. Oil pump (housing plate) seal
2. Oil pump housing plate

9. Remove oil pump housing plate and discard oil pump (housing plate) seal.
10. See disassembly of crankshaft oil pump drive (spline) (Crankshaft Disassembly, page 250) for procedure relating to oil pump drive.

Front Engine Mount

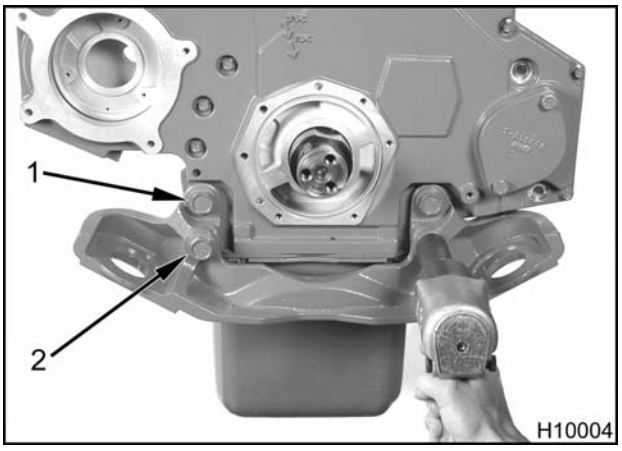

Figure 232 Front engine mounting bracket

1. Bolt, M18 x 70 (2)
2. Bolt, M18 x 100 (2)

1. Remove two upper bolts (M18 x 70).
2. Support engine mounting bracket and remove two lower bolts (M18 x 100).
3. Remove front engine mounting bracket.

Front Cover (Front Half)

Generation 1 (Mounting Bolts)

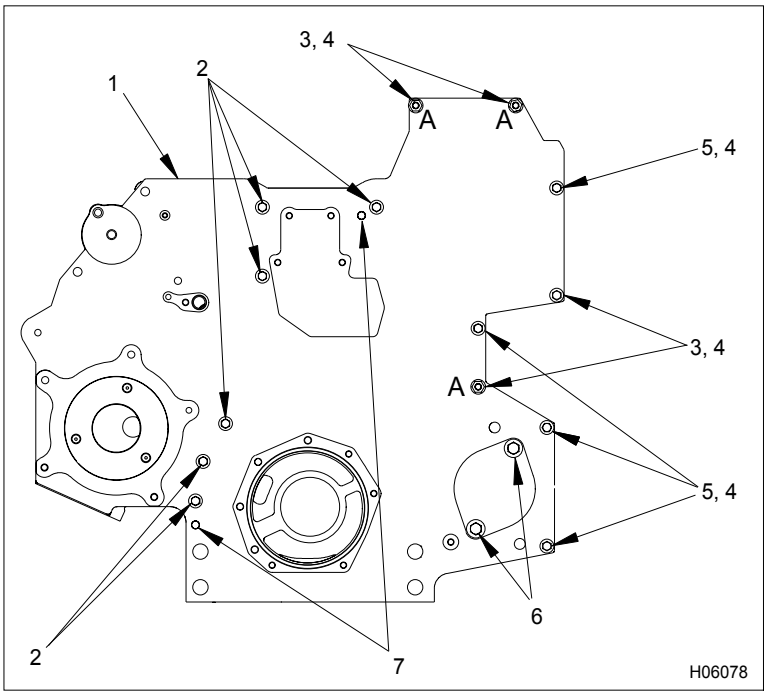

Figure 233 Front cover mounting bolts – front half (Generation 1)

1. Front cover (front half)
2. Hex flange bolt, M8 x 45 (6)
3. Hex flange bolt, M8 x 40 (4)
4. Hex flange nut, M8 (8)
5. Hex flange bolt, M8 x 30 (4)
6. Heavy hex flange bolt, M10 x 25 (2) (PTO equipped engines only)
7. Dowel hole

CAUTION: To prevent engine damage, the oil pan and oil suction tube must be removed before the front cover can be removed.

1. Remove six hex flange bolts (M8 x 45).
2. Remove four hex flange bolts (M8 x 40) and nuts (M8).
3. Remove four hex flange bolts (M8 x 30) and nuts (M8).
4. Remove front cover (front half) by sliding off the two dowel pins.
5. Remove the oil and coolant gaskets and O-ring seal from the inside of the front cover, as required and discard.

Generation 2 (Mounting Bolts)

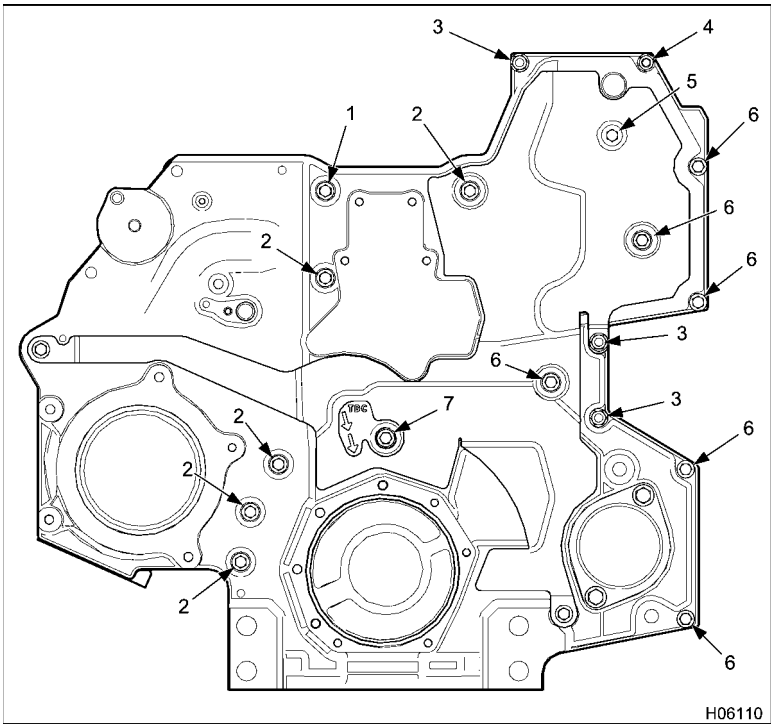

Figure 234 Front cover mounting bolts – front half (Generation 2)

1. M8 x 45 hex flange bolt (patch bolt)
2. M8 x 45 bolt (5)
3. M8 x 50 special bolt (nut on front) (3)
4. M8 x 73 stud bolt (nut on back)
5. M8 x 75 bolt – dog point (nut on back)
6. M8 x 50 bolt (nut on back) (6)
7. Seal assembly – M8 x 50 bolt and seal washer
8. Dowel hole

CAUTION: To prevent engine damage, the oil pan (Removing the Oil Pan, page 206) and oil suction tube (Removing the Oil Suction Tube, page 207) must be removed before the front cover can be removed.

1. Remove M8 x 75 bolt – dog point and nut (nut on back).
2. Remove Seal Assembly – M8 x 50 bolt and seal washer.
3. Remove six M8 x 50 special bolts and nuts.
4. Remove M8 x 73 stud bolt and nut (nut on back).
5. Remove M8 x 45 mm hex flange patch bolt.
6. Remove five M8 x 45 bolts.
7. Remove front cover (front half) by sliding off the two dowel pins.
8. Remove the oil and coolant gaskets and O-ring seal from the inside of the front cover, as required and discard.

Idler Gears

NOTE: Before removing any gears from the gear train, check the backlash between each gear and the camshaft end play. See the inspection procedures (Inspection, page177) in this section.

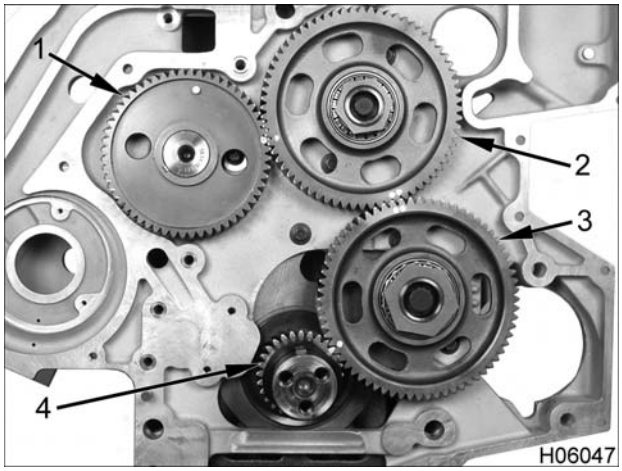

Figure 235 Gear train locations

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

Figure 236 Removing the lower idler gear

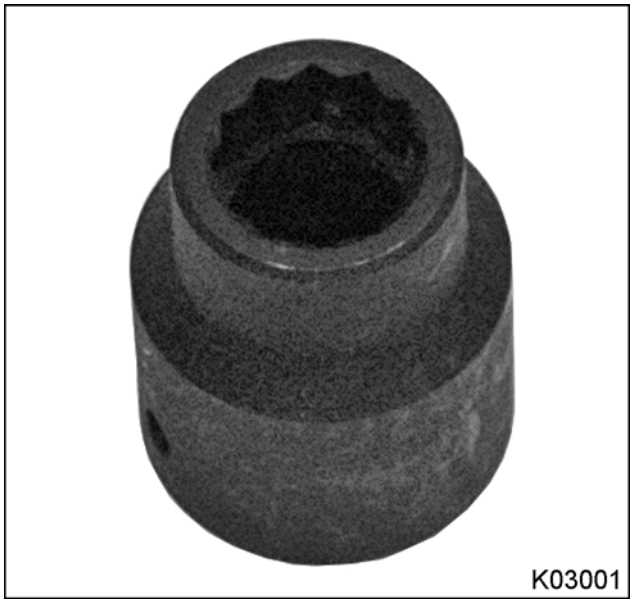

Figure 237 Lower Idler Gear Socket

1. Remove M20 x 70 lower idler gear mounting bolt using Lower Idler Gear Socket (Table 21) and a 3/4 inch drive breaker bar.
2. Remove lower idler gear.

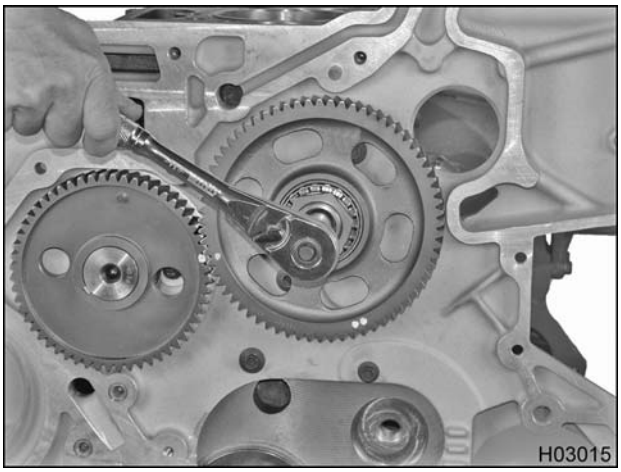

Figure 238 Removing the upper idler gear

3. Remove M16 x 65 upper idler gear mounting bolt using a 16 mm 12 point impact socket (Table 21) and a 1/2 inch drive breaker bar.
4. Remove upper idler gear.

NOTE: If required, Measure Camshaft End Play (page 267) after removing the upper idler gear.

Front Cover (Rear Half)

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

NOTE: Generation 1 (rear half) front covers include a water pump wear plate.

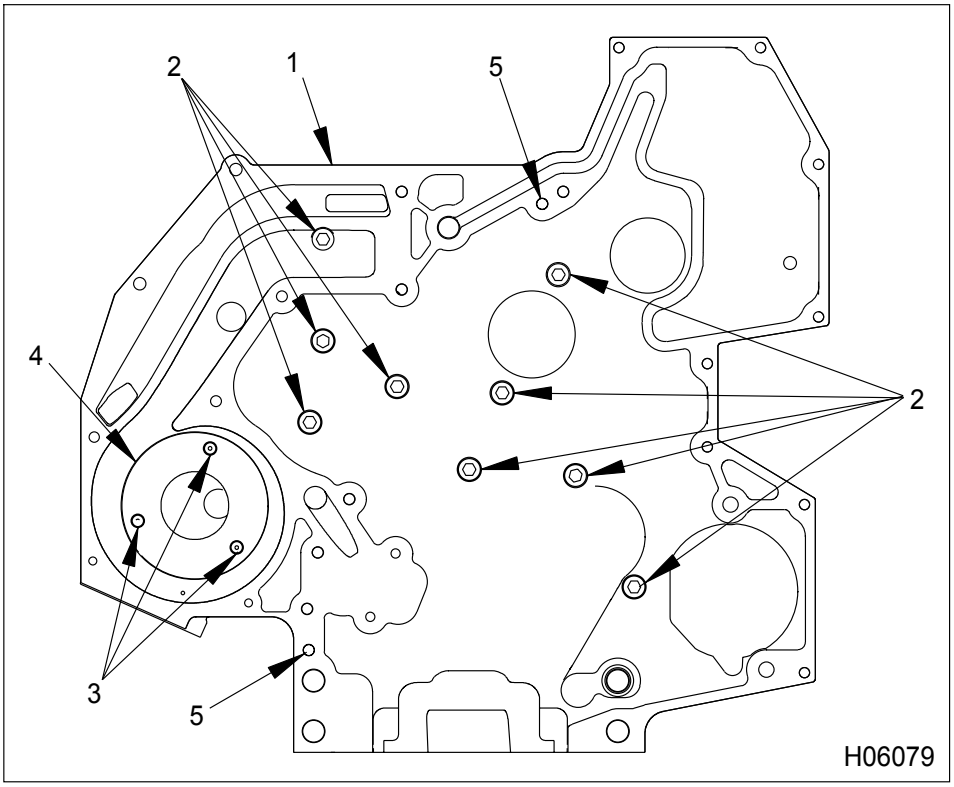

Figure 239 Front cover mounting bolts – rear half (Generation 1)

1. Front cover assembly (rear half)
2. Special hex flange bolt, M8 x 20 (9)
3. Flat head hex socket, M5 (3)
4. Wear plate
5. Dowel pin locations

1. Remove the camshaft or camshaft assembly before removing front cover (rear half). See “Crankcase, Crankshaft, and Camshaft” section in this manual for removal procedure.
2. Remove nine mounting bolts (M8 x 20) that secure the rear half of the front cover to the crankcase. Pull cover straight outward to slide dowels out of the crankcase. These dowels are retained in the rear half of the front cover.
3. Remove the oil and coolant gaskets from the rear half of the front cover and discard.

Inspection

Checking Lower Idler Gear Backlash

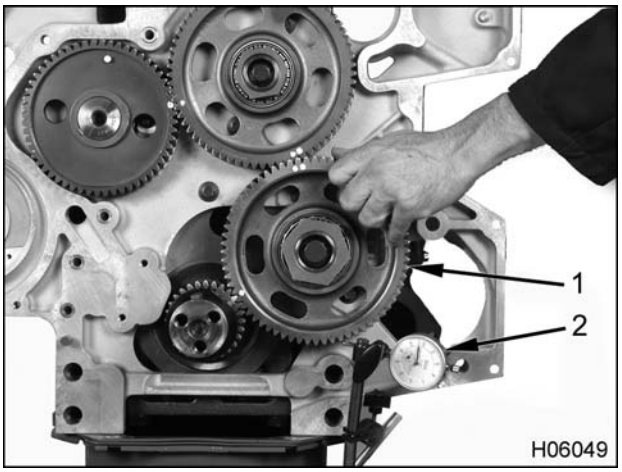

Figure 240 Checking lower idler gear backlash

1. Lower idler gear
2. Dial indicator

1. Clamp a dial indicator onto the front cover.
2. Place the tip of the dial indicator as tangent as possible to a gear tooth, and zero dial indicator.
3. Rock lower idler gear back and forth. Record the reading on the dial indicator face. If the backlash exceeds specifications, replace lower idler gear.

Checking Upper Idler Gear Backlash

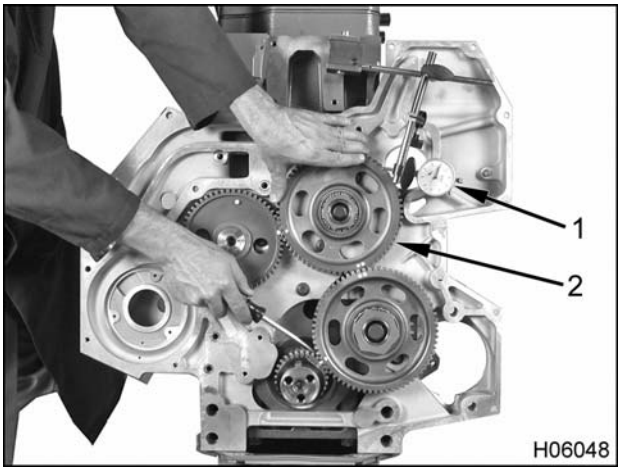

Figure 241 Checking upper idler gear backlash

1. Dial indicator
2. Upper idler gear

1. Mount a dial indicator on top of the crankcase.
2. Place the tip of the dial indicator as tangent as possible to a gear tooth and zero dial indicator.
3. Place a screwdriver between the crankshaft and the lower idler gear to keep the lower idler gear from rotating.
4. Rock upper idler gear back and forth. Record the reading on the dial indicator. If the backlash exceeds specifications, replace upper idler gear.

Checking Camshaft Gear Backlash

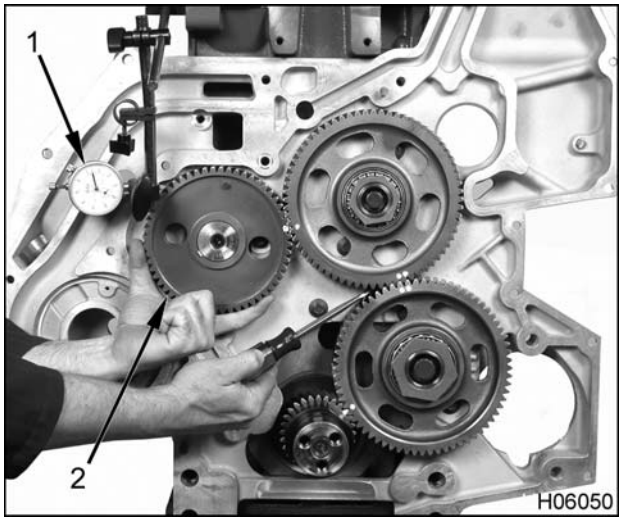

Figure 242 Checking camshaft gear backlash

1. Dial indicator
2. Camshaft gear

NOTE: Pressure exerted by the valve train must be relieved before doing the following procedure.

1. Clamp a dial indicator on the front cover or the cylinder head if the dial indicator stand is magnetic
2. Place the tip of the dial indicator as tangent as possible to a gear tooth and zero dial indicator.
3. Place a screwdriver between the upper idler gear and the lower idler gear to keep the upper idler gear from rotating.
4. Rotate the camshaft gear back and forth. Record reading on the dial indicator face. If the backlash exceeds specifications, replace camshaft gear.

Gerotor Oil Pump Clearance

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Inspection procedures for the gerotor oil pump assembly show the 8 lobe gerotor oil pump. Inspection procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

Measuring Oil Pump Side Clearance

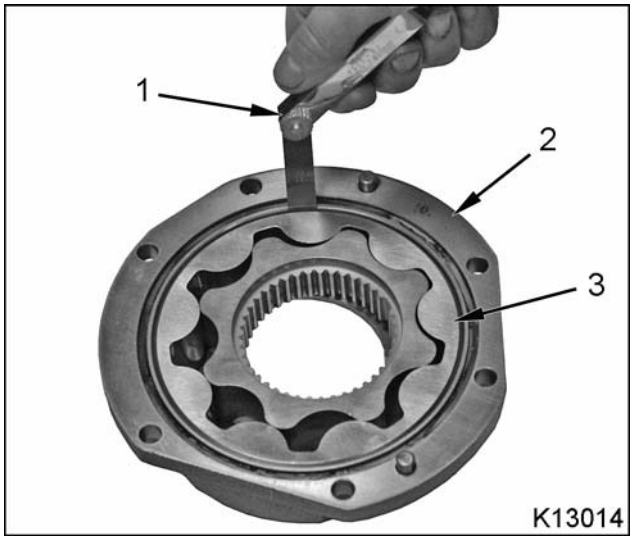

Figure 243 Oil pump side clearance measurement

1. Feeler gauge
2. Oil pump and rotor housing
3. Outer rotor

1. Coat outer rotor with oil and install rotor in oil pump and rotor housing.
2. Check oil pump side clearance Specification (Table 19) and choose the appropriate thickness feeler gauge (Table 21).
3. Insert feeler gauge between the oil pump and rotor housing and outer rotor.
4. Replace oil pump and rotor assembly if not within specification.

1. Place a straightedge (Table 21) across the oil pump mounting surface.
2. Check oil pump end clearance Specification (Table 19) and choose the appropriate thickness feeler gauge (Table 21).
3. Slide feeler gauge between the straightedge and the oil pump inner and outer rotors.
4. Replace oil pump and rotor assembly if not within specification.

Measuring Oil Pump End Clearance

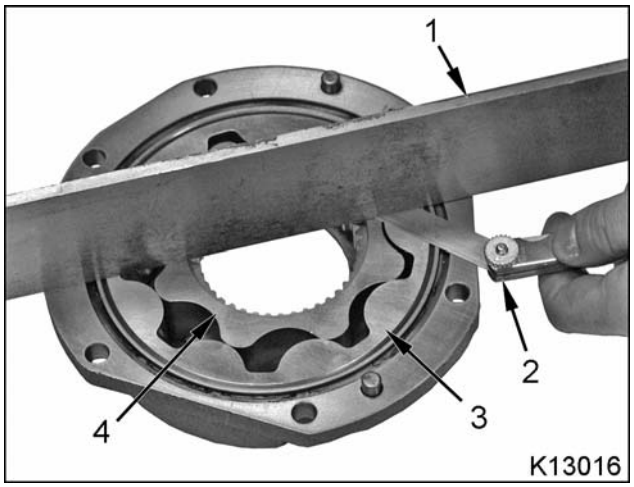

Figure 244 Oil pump end clearance measurement

1. Straightedge
2. Feeler gauge
3. Outer rotor
4. Inner rotor

Installation

Front Cover

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

Gaskets

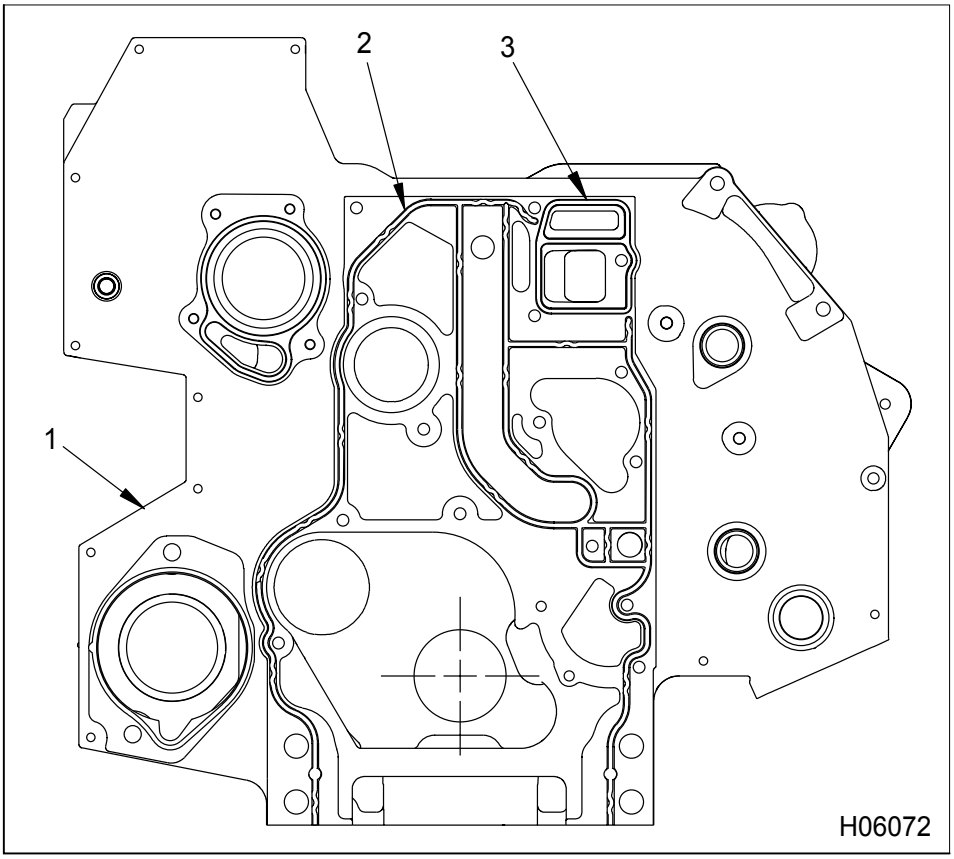

Figure 245 Front cover gaskets – rear half, crankcase side

1. Front cover assembly (rear half, crankcase side)
2. Oil gasket
3. Coolant gasket

1. Install a new oil gasket onto the crankcase side of the front cover (rear half).
2. Install a new coolant gasket onto the crankcase side of the front cover (rear half).

Mounting Bolts (Rear Half)

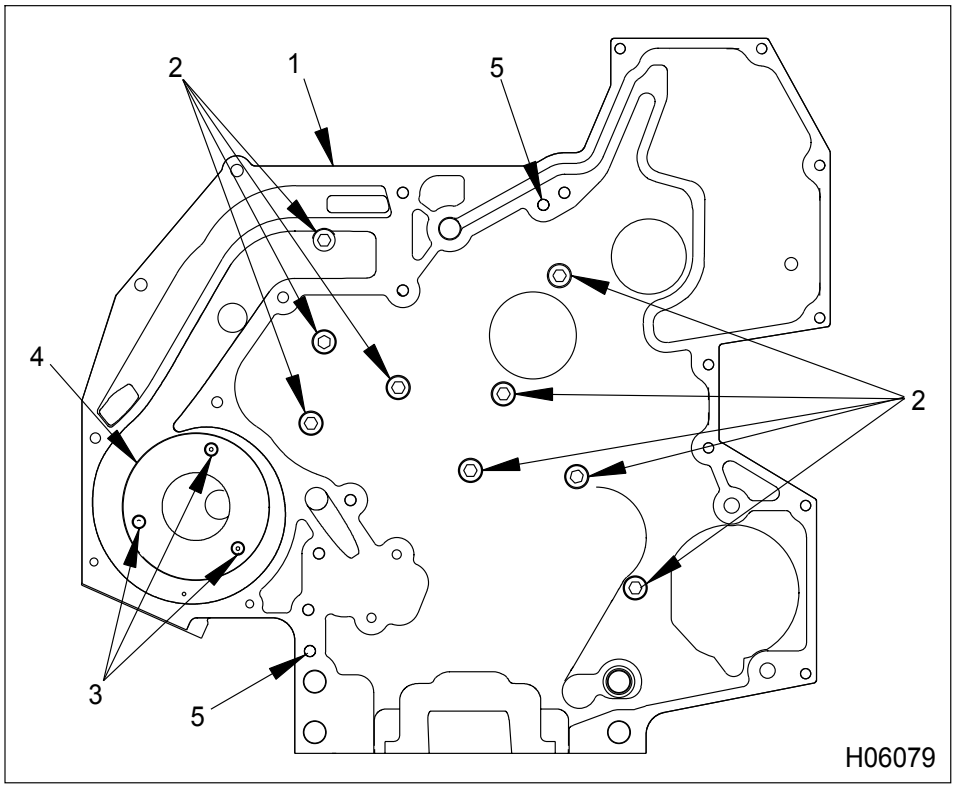

Figure 246 Front cover mounting bolts – rear half

1. Front cover assembly (rear half)
2. Special hex flange bolt, M8 x 20 (9)
3. Flat head hex socket, M5 (3)
4. Wear plate
5. Dowel pin

1. Position the rear half of the front cover onto the crankcase and install all nine mounting bolts finger tight. Then tighten the mounting bolts to the special torque value (Table 20).
2. Install the camshaft or camshaft assembly after installing front cover (rear half). See “Crankcase, Crankshaft, and Camshaft” section in this manual for removal procedure.

Idler Gears

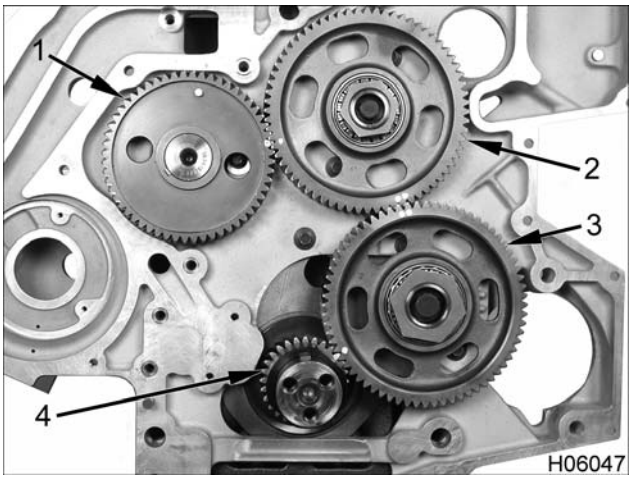

Figure 247 Gears and timing marks

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

NOTE: When installing the gears in the gear train, the timing marks on the edge of each gear must be correctly aligned and oriented (facing outward). Once the gears are properly installed, the crankshaft will require 34 revolutions to align the timing marks again.

- The upper idler gear and camshaft gear are matched with one dimple on each gear
- The upper idler gear and lower idler gear are matched with two dimples on each gear
- The lower idler gear and crankshaft gear are matched with one dimple on each gear

Figure 248 Installing the lower idler gear mounting bolt

1. Install and hand tighten the lower idler gear and mounting bolt (M20 x 70) with timing marks facing outward. Align single timing marks between the crankshaft and lower idler gear.

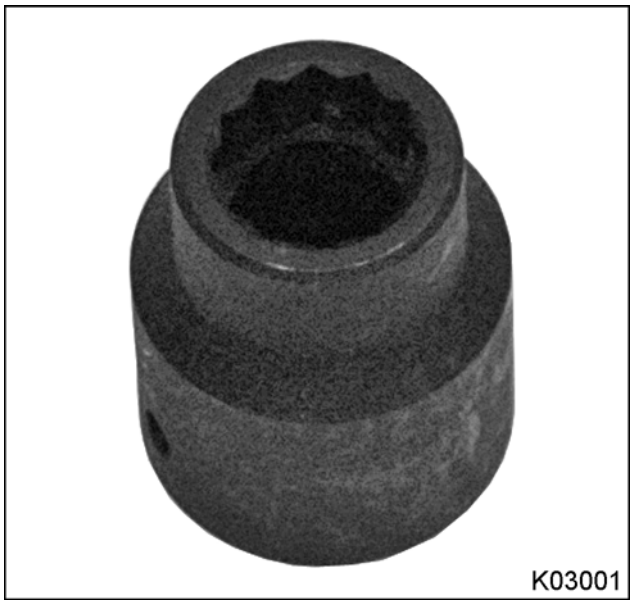

Figure 249 Lower Idler Gear Socket

2. Tighten the M20 x 70 bolt to the special torque value (Table 20) using Lower Idler Gear Socket (Table 21).

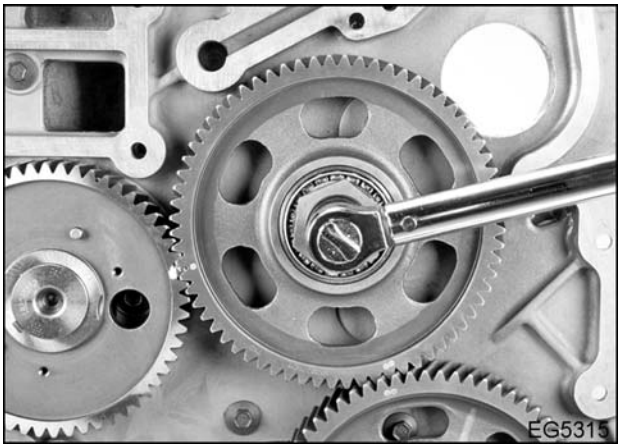

Figure 250 Installing the upper idler gear mounting bolt

3. Install the upper idler gear and mounting bolt (M16 x 65) with timing marks facing outward. Align the single marks on the camshaft gear and upper idler gear and the dual marks on the lower idler gear with those on the upper gaer. Tighten M16 x 65 bolt to the special torque value (Table 20), using a 16 mm 12 point impact socket (Table 21).
4. Check gear backlash between upper idler gear and camshaft gear. See Checking Camshft Gear Backlash.
5. Check gear backlash between high-pressure pump and upper idler gear (Table 19).
6. Check high-pressure pump end play.
7. Check camshaft end play.

NOTE: If equipped with an air compressor, check gear backlash between air compressor drive gear and lower idler gear.

8. If a Generation 1 front cover (rear half) is reused, install wear plate onto the front cover (rear half) and insert three flat head hex socket screws (M5). Tighten screws to the special torque value (Table 20).

Front Cover (Front Half)

Gaskets

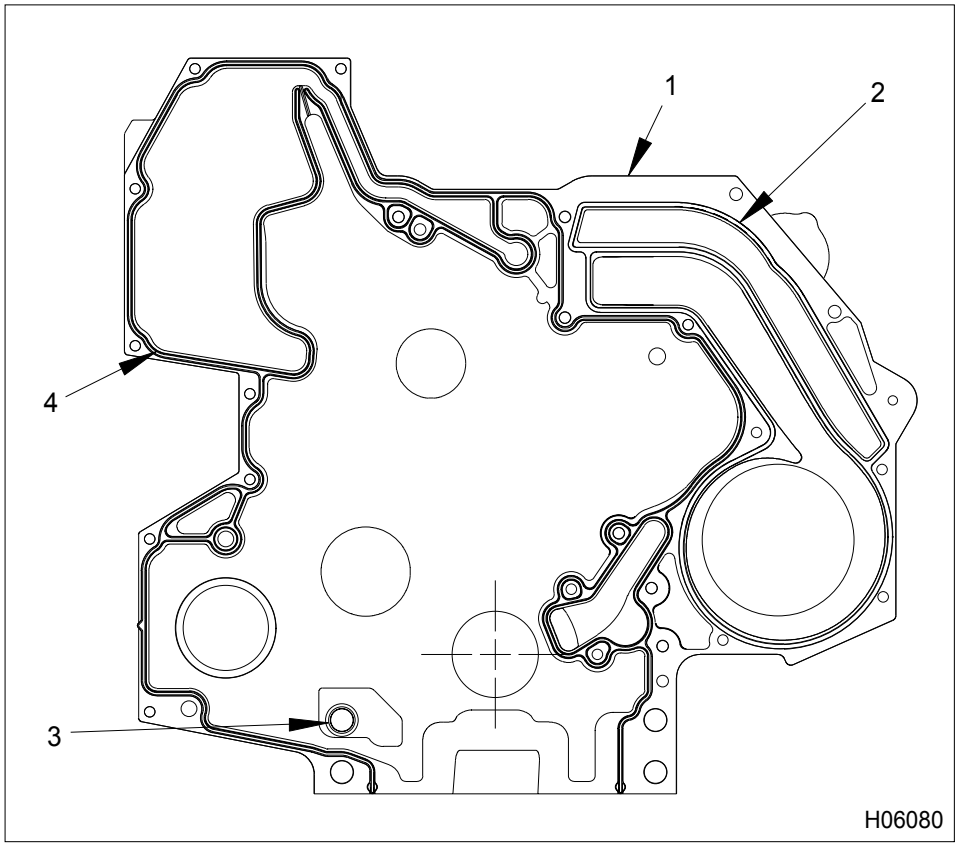

Figure 251 Front cover gaskets – front half

1. Front cover (front half)
2. Front cover gasket (coolant)
3. O-ring seal
4. Front cover gasket (oil)

1. Install new front cover coolant and oil gaskets into the front half of the front cover.
2. Install a new O-ring seal into the front half of the front cover

Generation 1 (Mounting Bolts)

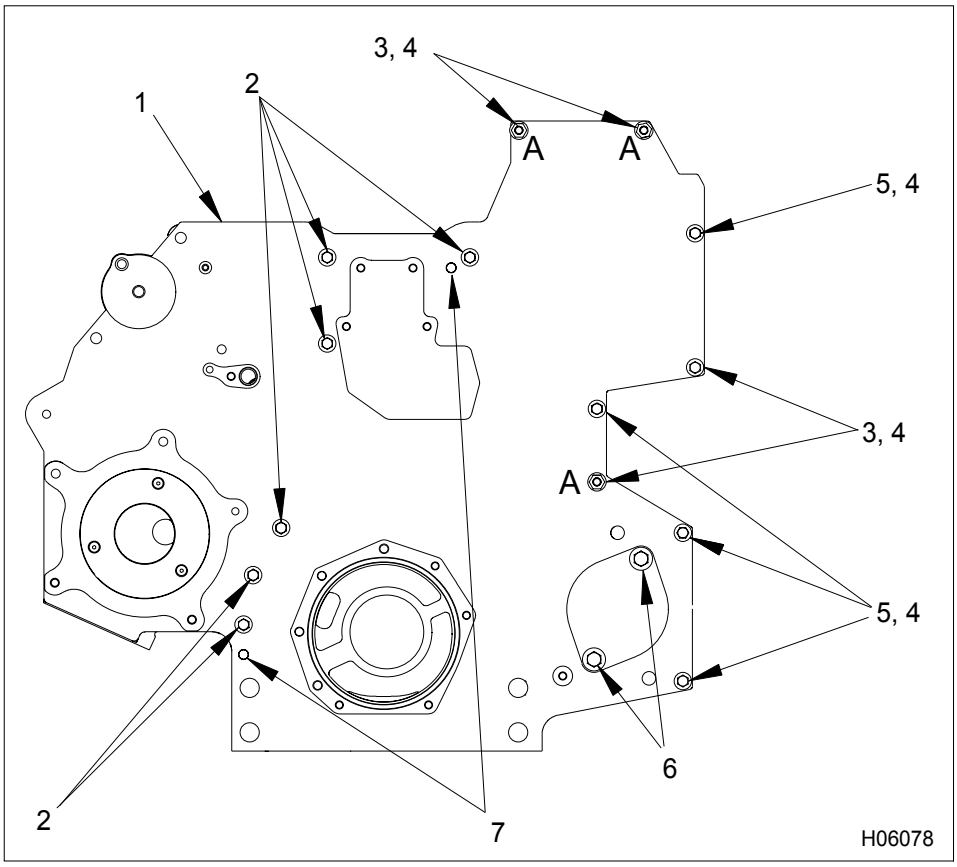

Figure 252 Front cover mounting bolts – front half (Generation 1)

1. Front cover (front half)
2. Hex flange bolt, M8 x 45 (6)
3. Hex flange bolt, M8 x 40 (4), **Note:** Bolts marked **A** to be inserted from rear side of cover.
4. Hex flange nut, M8 (8)
5. Hex flange bolt, M8 x 30 (4)
6. Heavy hex flange bolt, M10 x 25 (2) (PTO equipped engines only)
7. Dowel hole

1. Position the forward half of the front cover onto the rear half of the front cover using the two dowels as a guide.

Thread all mounting bolts finger tight, then tighten bolts to the standard torque value (General Torque Guidelines, page445).

Generation 2 (Mounting Bolts)

NOTE: Generation 2 front cover assemblies have additional bolts to secure the front cover half to the rear half.

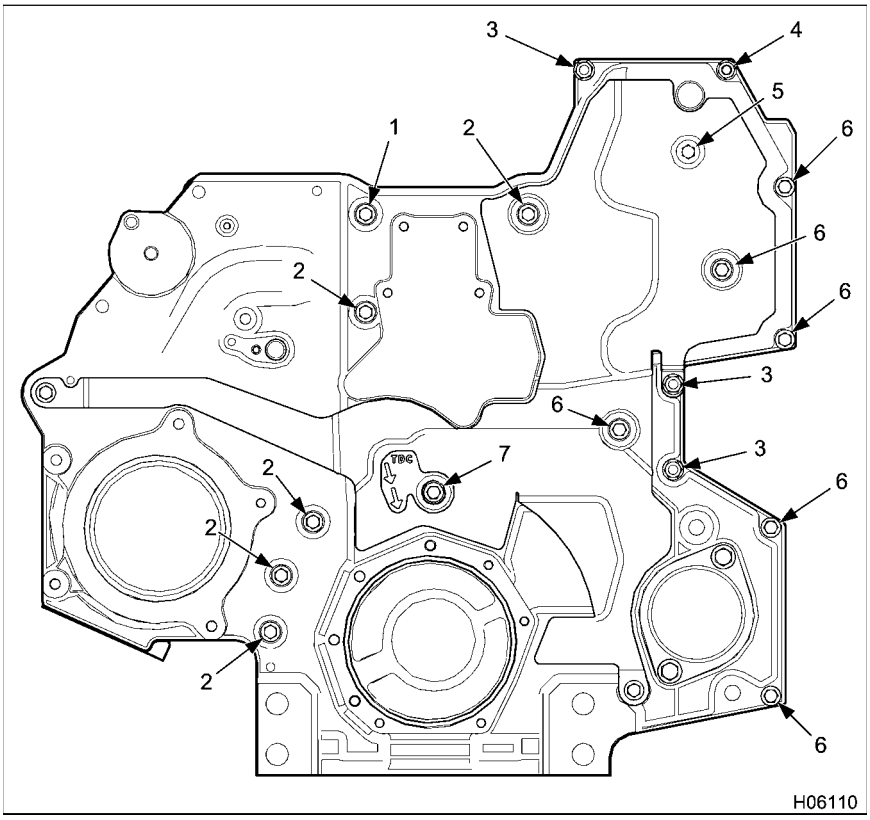

Figure 253 Front cover mounting bolts – front half (Generation 2)

1. M8 x 45 hex flange bolt (patch bolt)
2. M8 x 45 bolt (5)
3. M8 x 50 special bolt (nut on front) (3)
4. M8 x 73 stud bolt (nut on back)
5. M8 x 75 bolt – dog point (nut on back)
6. M8 x 50 bolt (nut on back) (6)
7. Seal assembly – M8 x 50 bolt and seal washer
8. Dowel hole

1. Align dowel holes in front cover (front half) with dowel pins in rear half of front cover, and install front cover (front half).
2. Install new M8 x 75 bolt – dog point and nut (nut on back) finger tight.
3. Install new Seal Assembly – M8 x 50 bolt and seal washer finger tight.
4. Install six M8 x 50 special bolts and nuts finger tight.
5. Install M8 x 73 stud bolt and nut (nut on back) finger tight.
6. Install new M8 x 45 mm hex flange patch bolt finger tight.
7. Install five M8 x 45 bolts finger tight.
8. Tighten all mounting bolts to the standard torque value (General Torque Guidelines, page445) .

Front Engine Mount

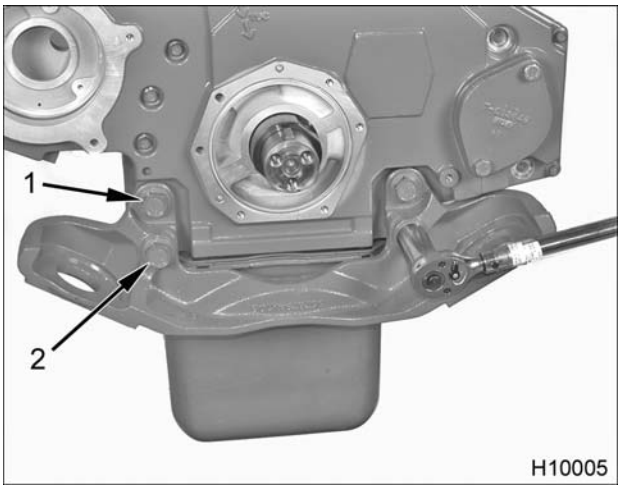

Figure 254 Front engine mount

1. Bolt, M18 x 70 (2)
2. Bolt, M18 x 100 (2)

1. Position front engine mount onto front cover assembly.
2. Install two upper bolts (M18 x 70) finger tight.
3. Install two lower bolts (M18 x 100) finger tight.
4. Tighten all four bolts to the special torque value (Table 20) .

Gerotor Oil Pump Assembly and Front Oil Seal

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Installation procedures for the gerotor oil pump assembly show the 8 lobe gerotor oil pump. Installation procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

1. If removed, install new oil pump drive (spline) onto the crankshaft, (Crankshaft Assembly, page268).

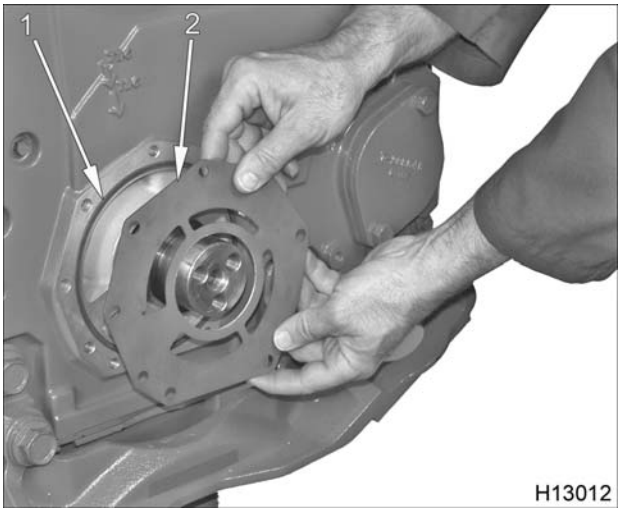

Figure 255 Oil pump housing plate and seal

1. Oil pump (housing plate) seal
2. Oil pump housing plate

2. Place oil pump (housing plate) seal into front cover recess. Align oil pump housing plate with dowels.

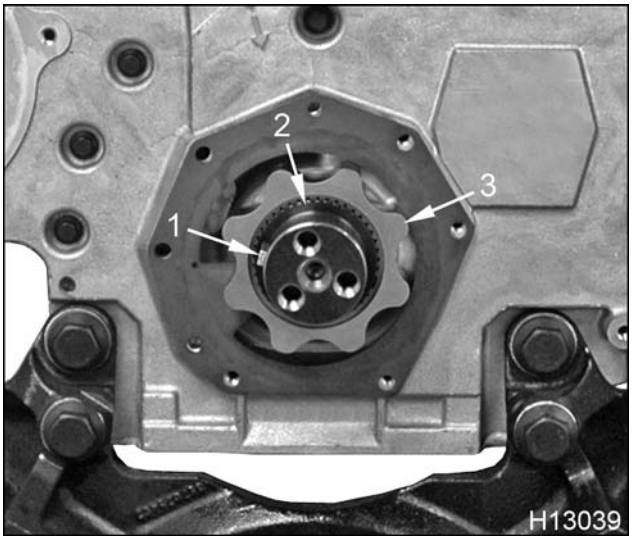

Figure 256 Vibration damper key, washer seal, and inner rotor

1. Vibration damper key
2. Washer seal
3. Inner rotor

NOTE: If reusing the original gerotor oil pump assembly, make sure the marks added during the removal process are properly oriented for installation.

3. Slide oil pump inner rotor onto oil pump drive (spline).
4. Install the washer seal with outer bevel oriented towards the front.

   CAUTION: To prevent engine damage, do not mark or distort the crankshaft keyway groove during vibration damper key installation.

5. Carefully tap the vibration damper key into place on the crankshaft with a hammer.

Figure 257 Applying Loctite® hydraulic sealant to front oil seal

6. Apply Loctite® hydraulic sealant to the outside edge of the front oil seal.

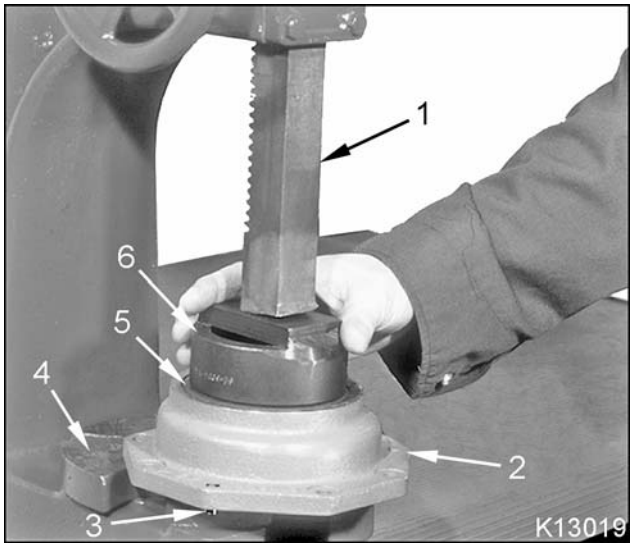

Figure 258 Front oil seal installation

1. Press ram
2. Oil pump and rotor housing
3. Dowel pin (2)
4. Press table
5. Front oil seal
6. Front Seal and Wear Sleeve Installer

7. Place oil pump and rotor housing, new front oil seal, and Front Seal and Wear Sleeve Installer (Table 21) on press table.
8. Position oil pump housing on press table so housing mating surface is level and supported. Dowel pins should be recessed in press table openings.
9. Position press ram on the center of the Front Seal and Wear Sleeve Installer and carefully press the front oil seal into the oil pump housing until seal is fully seated.

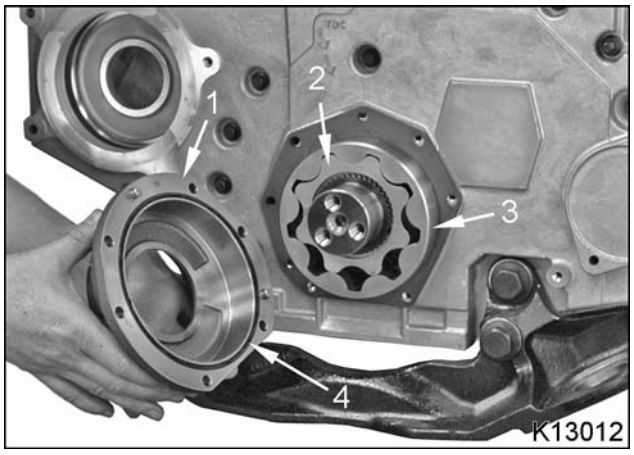

Figure 259 Oil pump housing, rotors, and oil pump (housing) seal

1. Oil pump and rotor housing
2. Inner rotor
3. Outer rotor
4. Oil pump (housing) seal

10. Install a new oil pump (housing) seal in the oil pump and rotor housing groove.
11. Coat the outer rotor with clean engine oil.

CAUTION: To prevent engine damage, make sure used oil pump inner and outer rotors rotate in the same direction as before removal. See marks added during removal for proper rotor orientation.

12. Install the outer rotor on the inner rotor.
13. Lightly coat the inside sealing surface of the front oil seal with clean engine oil.
14. Align two oil pump and rotor housing dowels with two front cover dowel holes and install oil pump and rotor housing.

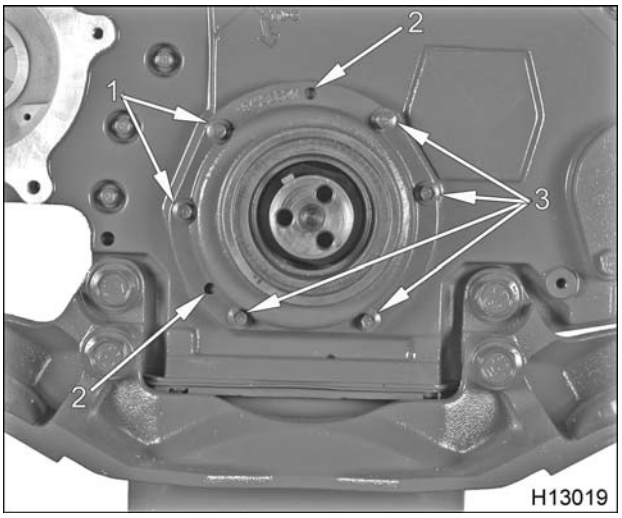

Figure 260 Oil pump housing mounting bolt locations

1. Bolt, M8 x 60 (2)
2. Dowels (2)
3. Bolt, M8 x 25 (4)

15. Install four M8 x 25 bolts finger tight.
16. Install two M8 x 60 bolts finger tight.
17. Tighten four M8 x 25 bolts and two M8 x 60 bolts to special torque (Table 20).

POSE Dust Seal and Wear Sleeve

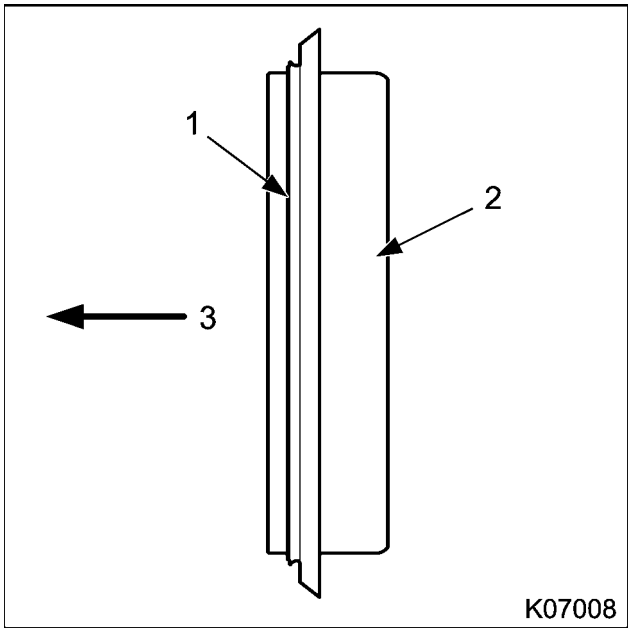

Figure 261 Wear sleeve with POSE dust seal

1. POSE dust seal
2. Wear sleeve
3. Front of engine

NOTE: DT 466 engines equipped with an 8 lobe oil pump use a wear sleeve without a POSE dust seal. DT 466 engines equipped with a 10 lobe oil pump use a wear sleeve with a POSE dust seal. All DT 570 and HT 570 engines equipped with an 8 lobe oil pump use a wear sleeve with a POSE dust seal.

NOTE: If service kit contains more than one wear sleeve, use sleeve that has the same width as the current wear sleeve.

CAUTION: A new front oil seal and wear sleeve (with a POSE dust seal) must be installed as a set for engines equipped with a 10 lobe oil pump.

NOTE: The chamfer (rounded edge) of the wear sleeve outside diameter must face in, toward the engine.

1. Apply Loctite® 569 Hydraulic Sealant (Table 21) to the inside diameter of a new wear sleeve.

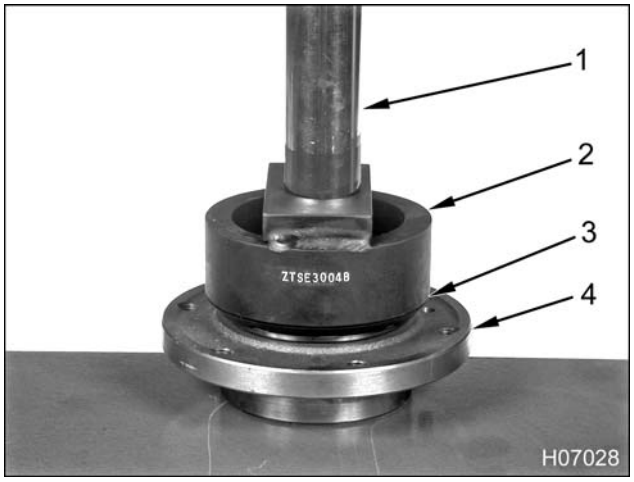

Figure 262 Front seal and wear sleeve installation

1. Press ram
2. Front Seal and Wear Sleeve Installer
3. POSE dust seal
4. Damper hub

2. Center the damper hub, new wear sleeve (with or without a POSE dust seal as appropriate for application), and Front Seal and Wear Sleeve Installer (Table 21) under press ram.
3. Carefully press the new wear sleeve on the damper hub until sleeve is fully seated.
4. Wipe any excess sealant off the outside diameter of the wear sleeve.

Vibration Damper Hub and Damper Retaining Plate

1. Mark damper hub with 100 °C (212 °F) Thermo-melt crayon (Table 21).

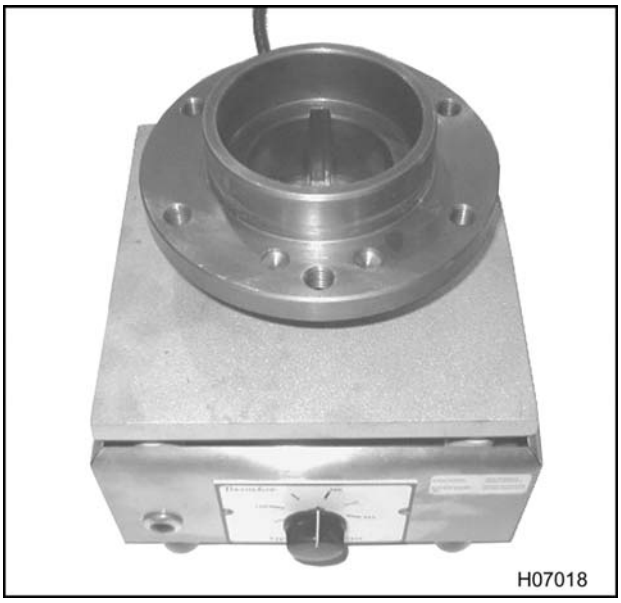

Figure 263 Heating the vibration damper hub

2. Heat vibration damper hub on a hot plate (Table 21) . Do not heat to more than 212 °F.

WARNING: To prevent serious personal injury, possible death, do not pick up the vibration damper hub with exposed hands. Wear heat protective gloves due to the extremely hot vibration damper hub.

Figure 264 Installation of vibration damper hub

WARNING: To prevent personal injury or death, wear heat insulated gloves when handling heated components.

WARNING: To prevent personal injury or death, damper hub must be completely seated on the crankshaft.

3. Install heated vibration damper hub onto the crankshaft. Use Heat Insulated Gloves (Table 21) specifically designed for extremely hot objects.

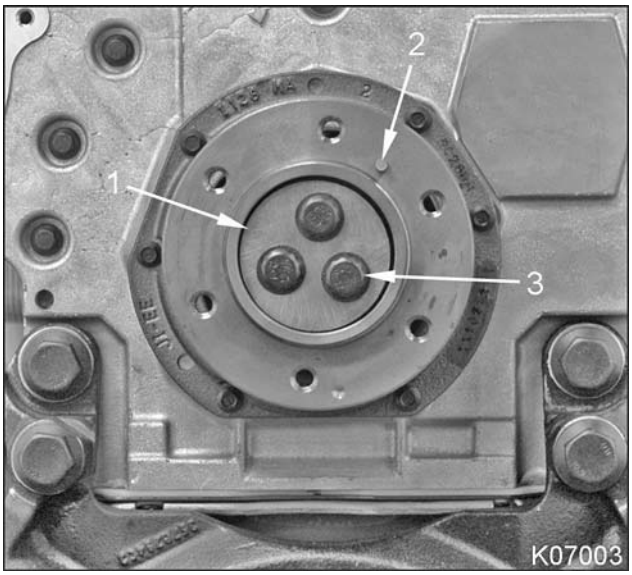

Figure 265 Damper retaining plate

1. Damper retaining plate
2. Dowel pin
3. Bolt M12 x 40 (3)

CAUTION: To prevent engine damage, only use 15.2 mm (0.60) in thick damper retainer and Class 12.9 damper bolts.

4. Verify that new damper retainer is 15.2 mm (0.60) in thick and new M12 x 40 damper bolts are Class 12.9.
5. Position new damper retaining plate and install three new M12 x 40 bolts.
6. Tighten three M12 x 40 damper bolts to special torque (Table 20).

7. Retighten three M12 x 40 damper bolts in sequence to special torque (Table 20) several times until each bolt has no movement.

Vibration Damper assembly

Three Rubber Vibration Damper Kits are available for International® DT 570 and HT 570 Diesel Engines. See (TSI-08-12-20 Rubber Vibration Damper Replacement Kits, page480).

CAUTION: To prevent engine damage, verify damper hub dowel pin is aligned with dowel hole of the vibration damper assembly.

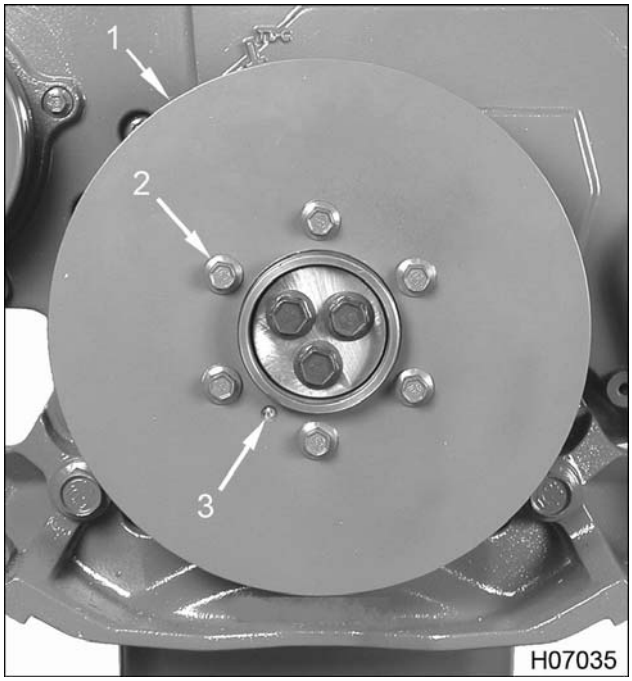

Figure 266 Vibration damper assembly

1. Vibration damper
2. Bolt, M10 x 16 (6)
3. Dowel pin

1. Align dowel hole in vibration damper with dowel pin on damper hub and install six M10 x 16 bolts finger tight.
2. Torque bolts to special torque (Table 20).

Fan Drive

Table 18 Fan Drive Mounting Bolt Sizes

Fan drive mounting configuration	Bolt size	Torque	Quantity
High-mount, Horton (20 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
High-mount, Horton (18.3 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
Mid-mount, Horton (16.2 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
Low-mount (Horton 12.2 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
High-mount (spin-on)	M8 x 1.25 x 30	Standard	2
	M8 x 1.25 x 65	Standard	2
Mid-mount (spin-on)	M8 x 1.25 x 30	Standard	2
	M8 x 1.25 x 65	Standard	2
Low-mount (bolt-on and spin-on)	M8 x 1.25 x 65	Standard	4

NOTE: The table located at the back of this section covers fan drive configurations diameters and ratios (Table 19).

1. Install fan hub assembly.

NOTE: The standard fan hub assembly is serviced as a unit. The assembly is made up of the following nonserviceable items:

- Fan and pulley mounting hub
- Fan bearing hub
- Bearing assembly
- M10 x 70 bolt
- Fan bearing retainer

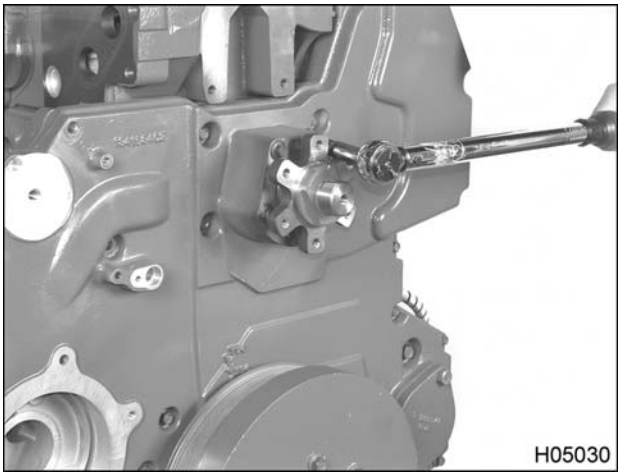

Figure 267 Torquing the fan drive mounting bolts (typical)

2. Install the hex flange bolts required (Table 18) and tighten to the standard torque value (General Torque Guidelines, page 445), unless otherwise noted (Table 20).

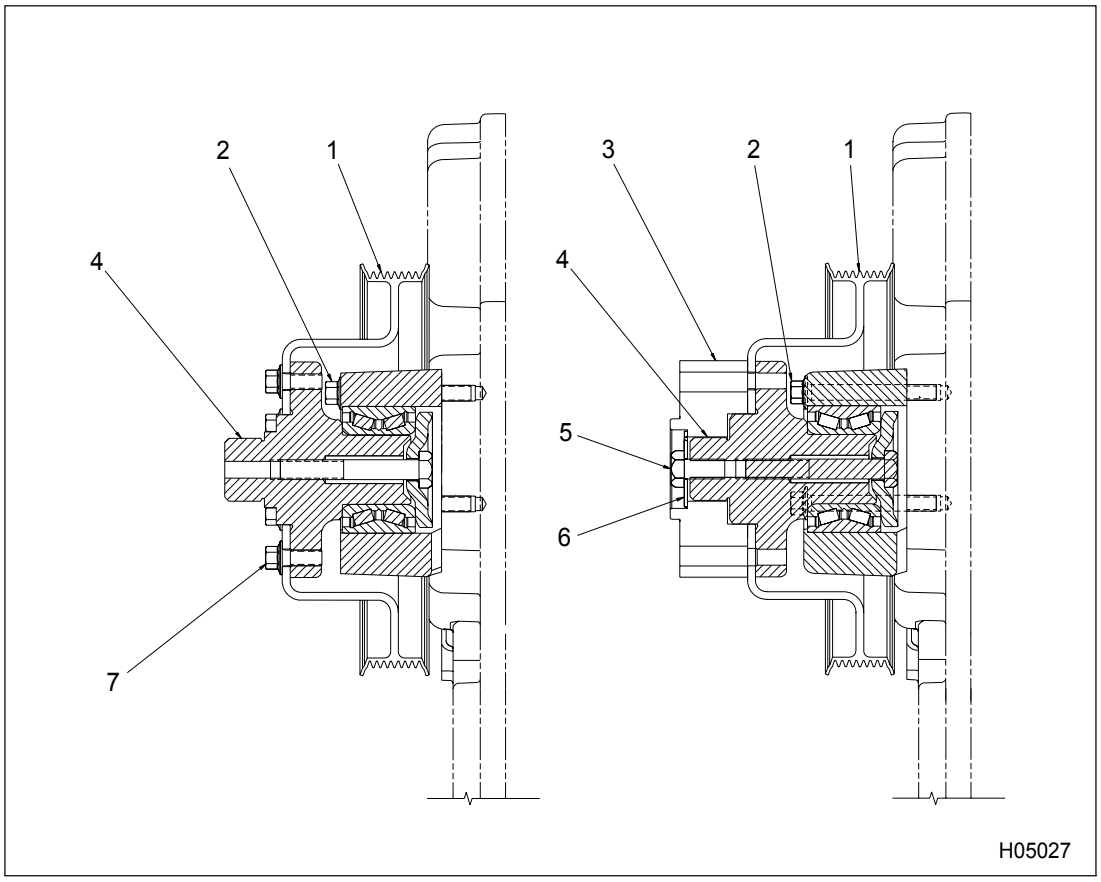

Figure 268 Spin-on fan drive (left) and bolt-on fan drive (right)

1. Fan pulley
2. Bolt, M8 x 65 (4)
3. Fan spacer
4. Fan hub assembly (cross-hatched)
5. Bolt, M10 x 20
6. Spacer retainer washer
7. Bolt, M8 x 20 (6)

3. Install the fan pulley and spacer as required for application.

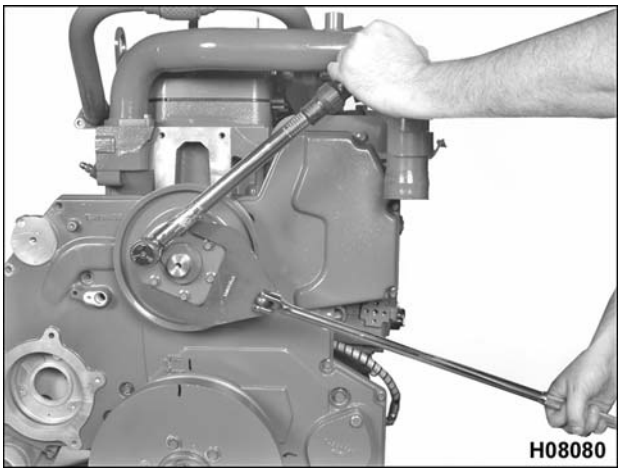

Figure 269 Torquing the fan drive pulley bolts

4. Install six M8 x 20 hex flange bolts to the fan pulley and tighten to the standard torque value (General Torque Guidelines, page445) .

Horton DriveMaster

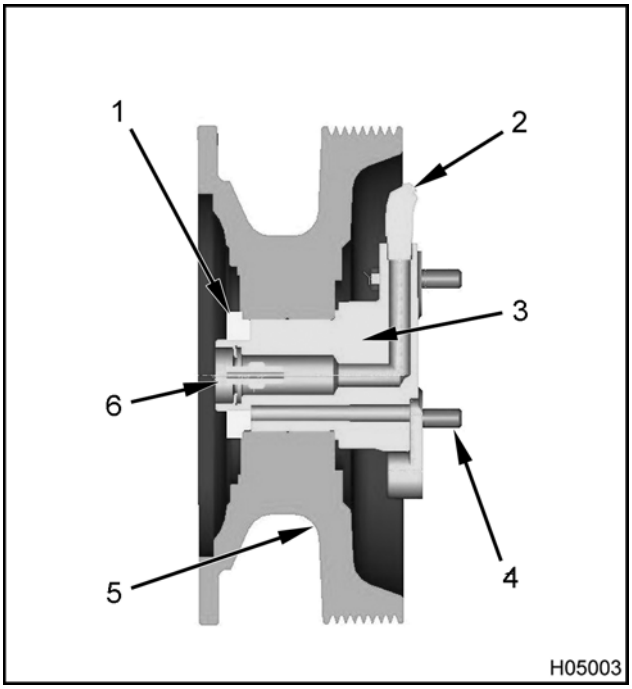

Figure 270 Horton DriveMaster (low mount version)

1. Bearing retainer nut assembly (shoulder relief faces engine)
2. Air channel inlet
3. Bracket assembly
4. Bolt, M8 x 30 (4)
5. Fan pulley
6. Air cartridge (Note: Horton service part only)

1. Install bracket assembly and four M8 X30 hex flange bolts . Torque bolts to the standard torque value (General Torque Guidelines, page445).
2. Slide fan pulley onto bracket with clutch mounting flange facing front.
3. Install bearing nut, making sure bearing nut shoulder relief is facing towards engine.
4. Tighten bearing retainer nut to the special torque (Table 20).

Water Pump Assembly

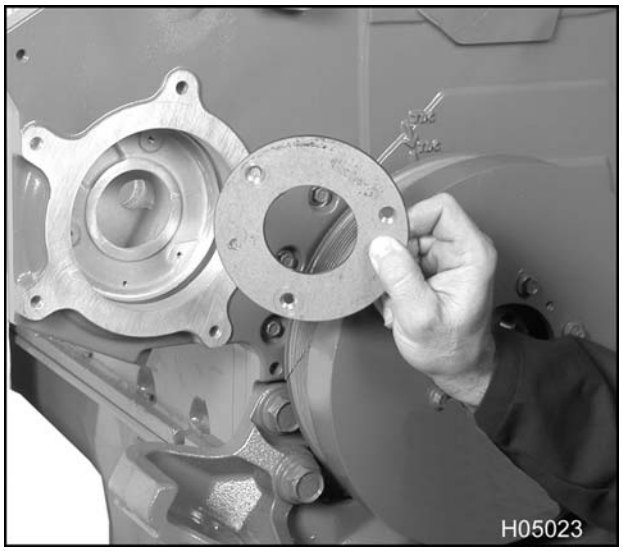

Figure 271 Water pump wear plate (Generation 1 front covers only)

1. If applicable, install three flat head hex socket screws (M5) to secure the water pump wear plate to the rear half of the front cover, if not done previously during front cover installation.
2. Tighten M5 hex socket screws to the special torque (Table 20).
3. Install the water pump seal into the water pump seal recess.
4. Position water pump assembly into front cover.

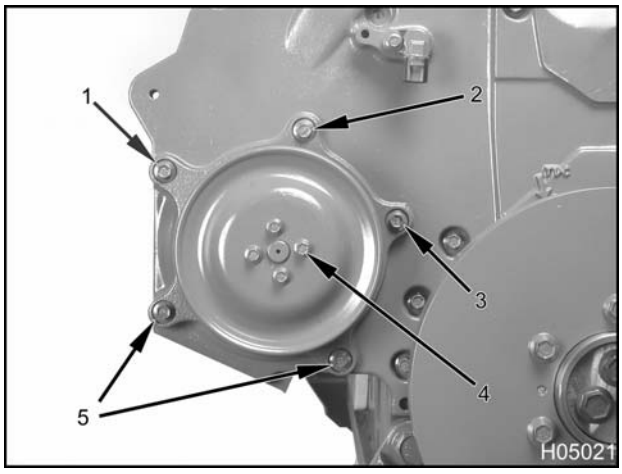

Figure 272 Water pump assembly

1. Bolt, M8 x 55, nut M8 (1)
2. Bolt, M8 x 100, Nut, M8
3. Bolt, M8 x 16 (1)
4. Bolt, M6 x 12 (4)
5. Bolt, M8 x 40 (2)

5. Install one water pump assembly bolt (M8 x 100) from the raer half of the front cover. Thread nut (M8) on finger tight.
6. Install one water pump assembly bolt (M8 x 55) from the rear half of the front cover. Thread nut (M8) on finger tight.
7. Install one water pump assembly bolt (M8 x 16) finger tight.
8. Install two water pump assembly bolts (M8 x 40) finger tight.
9. Tighten all water pump bolts to the standard torque value (General Torque Guidelines, page 445) .
10. Install water pump pulley and secure with four pulley bolts (M6 x 12). Tighten bolts to the standard torque value (General Torque Guidelines, page445) .

Water Supply Housing

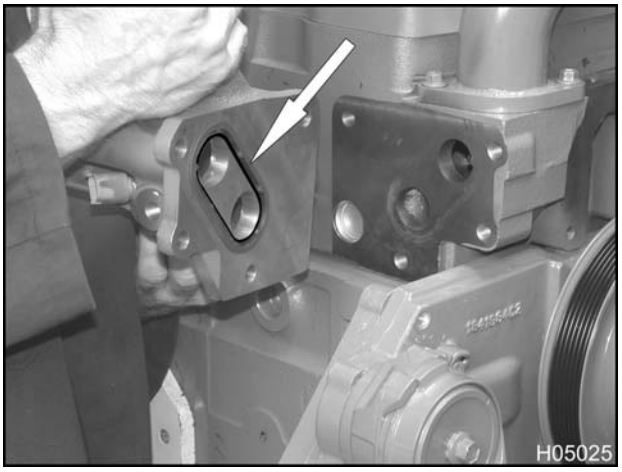

Figure 273 Water supply housing and coolant port seal

1. Position coolant port seal into machined recess at water supply housing.

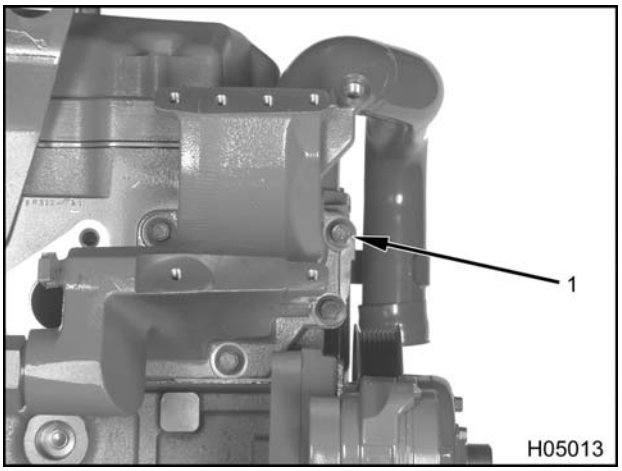

Figure 274 Water supply housing bolts

1. Bolt, M10 x 25 (4)

2. Install water supply housing and secure with four water supply housing bolts (M10 x 25).

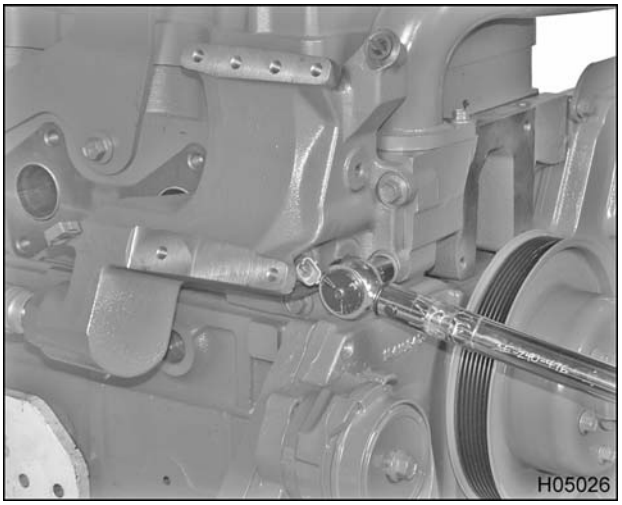

Figure 275 Torquing the water supply housing bolts

3. Tighten all bolts to the standard torque value (General Torque Guidelines, page445) .

Alternator Bracket

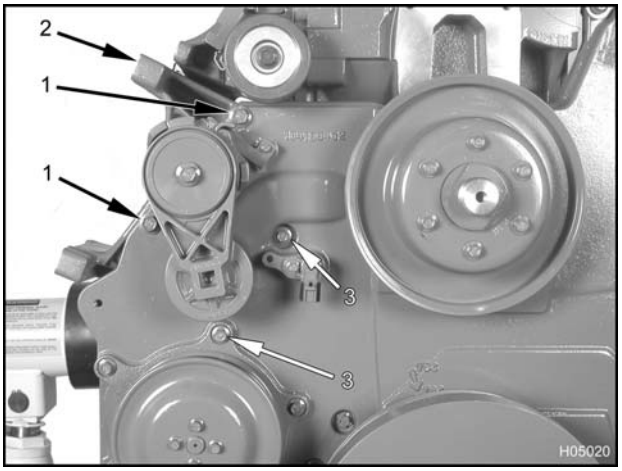

Figure 276 Alternator bracket

1. Bolt, M10 x 120 (2)
2. Alternator bracket
3. Bolt, M8 x 100 (2)

1. Position alternator bracket to backside of front cover and install two bolts (M10 x 120) and hex flange nuts (M10) finger tight.
2. Install the two remaining bolts (M8 x 100) and hex flange nuts (M8) finger tight.

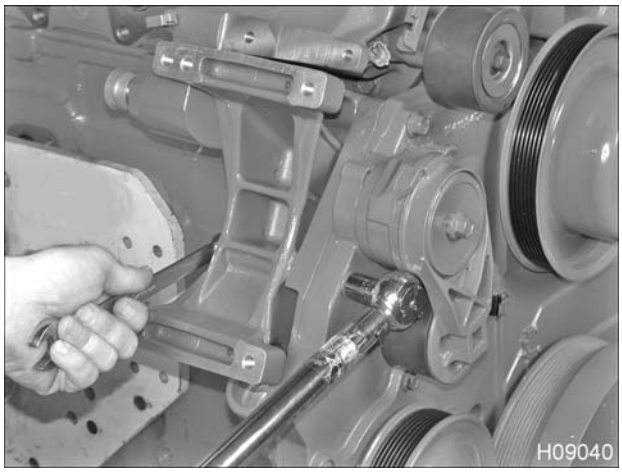

Figure 277 Torquing the alternator bracket bolts

3. Tighten all alternator bracket bolts to the standard torque value (General Torque Guidelines, page 445) .
4. Install harness routing guide and secure guide with an M8 bolt.

Flat Idler Pulley and Automatic Belt Tensioner

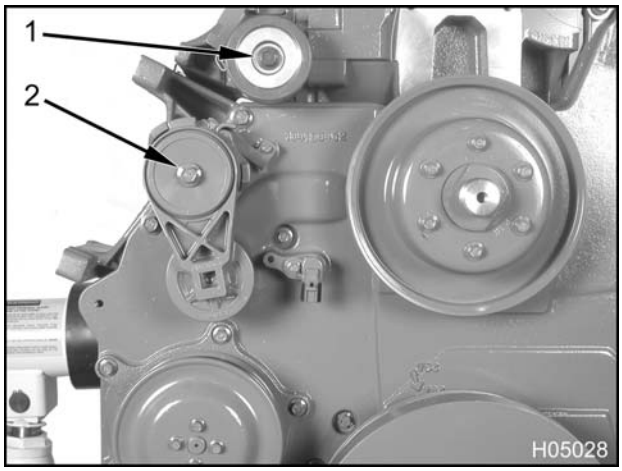

Figure 278 Flat idler pulley and automatic belt tensioner

1. Flat idler pulley assembly mounting bolt, M10 x 80
2. Automatic belt tensioner assembly mounting bolt, M10 x 80

1. Install M10 x 80 bolt through flat idler pulley assembly and into the water supply housing. Tighten bolt to the standard torque value (General Torque Guidelines, page 445).
2. Install M10 x 80 bolt through the automatic belt tensioner assembly to the front cover assembly and tighten to the special torque (Table 20).

Water Inlet Elbow, Water Outlet Tube, and Thermostat

1. Install a water inlet gasket into the machined recess at the front cover.

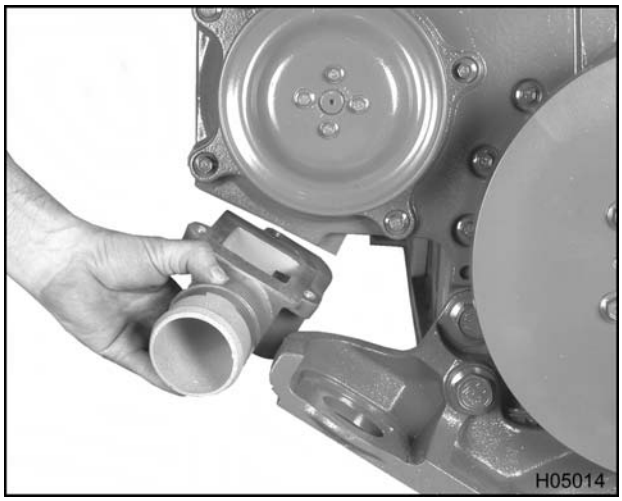

Figure 279 Water inlet elbow

2. Install water inlet (side port) elbow.
3. Install and tighten three hex flange bolts (M8 x 30) to the standard torque value (General Torque Guidelines, page 445) .

NOTE: The thermostat seal cannot be purchased separately. It is only available with the thermostat assembly.

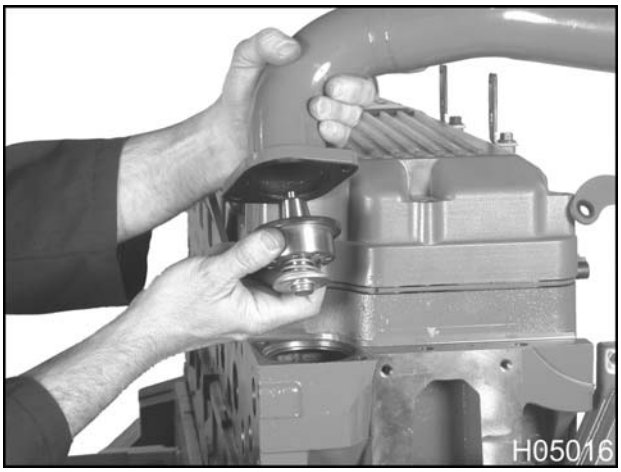

Figure 280 Thermostat assembly

4. Install a new thermostat and gasket into cylinder head.

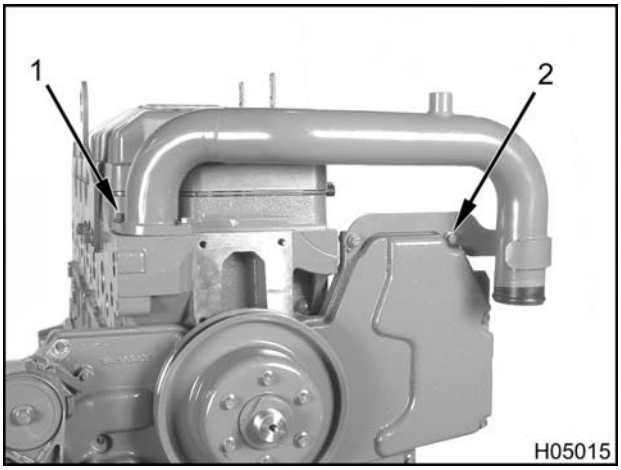

Figure 281 Water outlet tube assembly

1. Bolt, M8 x 25 (2)

5. Install water outlet tube assembly and secure with two water outlet tube assembly bolts (M8 x 25) at the cylinder head. Tighten to the special torque value (Table 20) .

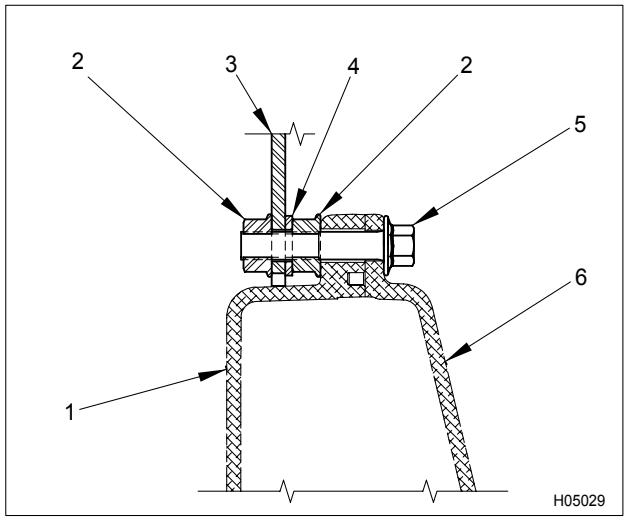

Figure 282 Water outlet tube assembly connection at front cover

1. Front cover (front half)
2. Hex flange nut, M8 (4)
3. Water outlet tube assembly (bracket)
4. Washer (2)
5. Hex flange bolt, M8 x 40 (2)
6. Front cover (rear half)

6. Install nuts, bolts and washers to secure the water outlet tube assembly at the front cover. Tighten nuts and bolts to the special torque value (Table 20).

Specifications

Table 19 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications

Camshaft gear end play	0.33 mm (0.013 in)
Camshaft gear-to-upper idler gear backlash	0.46 mm (0.018 in)
High-pressure pump end play	0.45 -1.22 mm (0.018 - 0.48 in)
Lower idler gear-to-air compressor gear backlash	0.508 mm (0.020 in)
Lower idler gear-to-crankshaft gear backlash	0.36 mm (0.014 in)
Oil pump end clearance	0.05 -0.13 mm (0.002-0.005 in)
Oil pump side clearance	0.36 - 0.48 mm (0.014 - 0.019 in)
Upper idler gear-to-high-pressure oil pump gear backlash	0.48 mm (0.019 in)
Upper idler gear-to-lower idler gear backlash	0.48 mm (0.019 in)
Vibration damper face runout (max.)	1.52 mm (0.060 in)
Vibration damper maximum allowable member misalignment	1.50 mm (0.060 in)

Fan Drive Configurations Diameters and Ratios

Engine fan drive configuration	Fan CL to Crankshaft CL, mm (in)	Pulley Diameter OBD, mm (in)	Drive Ratio
466 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	0.894 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	1.08 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	219.4 (8.636)	1.2 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	1.2 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	0.99 : 1
466 mid-mount, (Horton DriveMaster)	411 (16.2)	201.2 (7.92)	1.08 : 1
466 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.08 : 1
570 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 mid-mount, (spin-on)	411 (16.2)	201.2 (7.92)	1.08 : 1

Table 19 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications (cont.)

466 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
466 low-mount, Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.3 : 1
570 low-mount, (Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.3 : 1
466 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.3 : 1

NOTE: The high-mount and mid-mount fan drives share the same part number, however the fan drive is inverted depending upon application.

Special Torque

Table 20 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Special Torques

Automatic belt tensioner assembly	50 N·m (37 lbf·ft)
Damper retaining plate bolts	163 N·m (120 lbf·ft) Retorque all bolts until no movement
End cover adapter (PTO equipped engines only)	52 N·m (38 lbf·ft)
Fan drive, high-mount, Horton DriveMaster (20, 18.3 in.)	26 N·m (19 lbf·ft)
Fan drive, mid-mount, Horton DriveMaster (16.2 in.)	26 N·m (19 lbf·ft)
Fan drive, low-mount, Horton DriveMaster (12.2 in.)	26 N·m (19 lbf·ft)
Fan spacer retaining bolt, M10 x 20 (bolt-on drive only)	52 N·m (38 lbf·ft)
Front cover mounting bolts (rear half)	26 N·m (19 lbf·ft)
Front engine mounting bracket bolts (4)	386 N·m (284 lbf·ft)
Horton DriveMaster bearing retainer nut	177 N·m (130 lbf·ft)
Lower idler gear mounting bolt	639 N·m (470 lbf·ft)
Oil pump and rotor housing M8 bolts	25 N·m (18 lbf·ft)
Upper idler gear mounting bolt	326 N·m (240 lbf·ft)
Viscous or rubber vibration damper mounting bolts	54 N·m (40 lbf·ft)
Water outlet tube assembly at cylinder head	33 N·m (24 lbf·ft)
Water outlet tube assembly at front cover	33 N·m (24 lbf·ft)
Wear plate (water pump)	7 N·m (60 lbf·in)

Special Service Tools

Table 21 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mounts, and Gear Train Special Service Tools

Dial indicator set	Obtain locally
Feeler gauge	Obtain locally
Front seal and wear sleeve installer	ZTSE3004B
Heat Insulated Gloves	Obtain locally
H-bar puller	Obtain locally
Hot plate	Obtain locally
Loctite® 569 Hydraulic Sealant	Obtain locally
Lower Idler Gear Socket	ZTSE4383
Slide hammer puller set	ZTSE1879
Straightedge	Obtain locally
Thermo-melt crayon, 100 °C (212 °F)	Obtain locally
16 mm 12 point impact socket	Obtain locally

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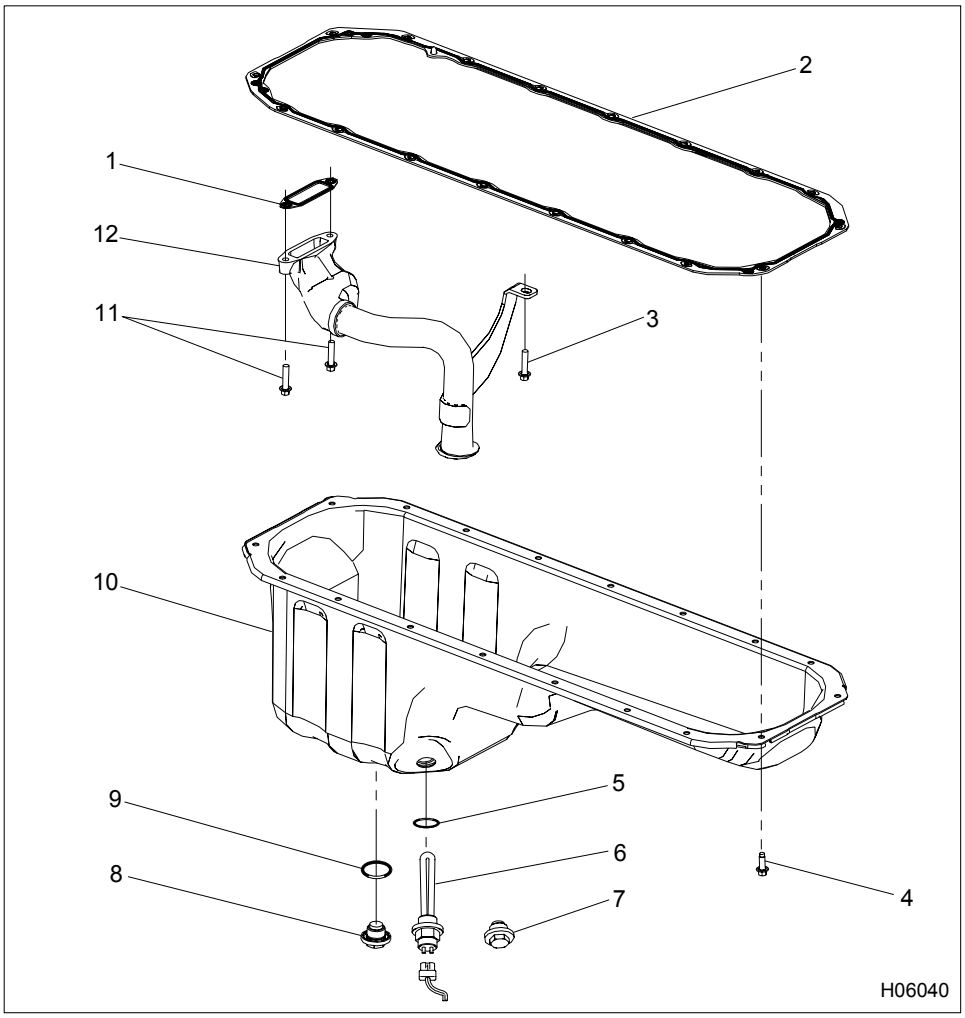

Figure 283 Oil pan and oil suction tube components

1. Oil suction tube gasket
2. Oil pan gasket
3. Bolt, M10 x 25 (1)
4. Bolt, M8 x 24 (18)
5. Heater element gasket
6. Oil heating element assembly (optional)
7. Plug (without oil pan heater)
8. Oil drain plug
9. Oil drain plug gasket
10. Oil pan (typical)
11. Bolt, M8 x 35 (2)
12. Oil suction tube assembly (typical)

Removal

Removing the Oil Pan

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

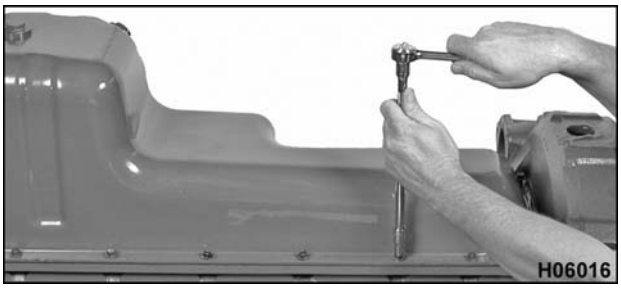

Figure 284 Removing the oil pan mounting bolts

1. Remove 18 (M8 x 24) oil pan mounting bolts.

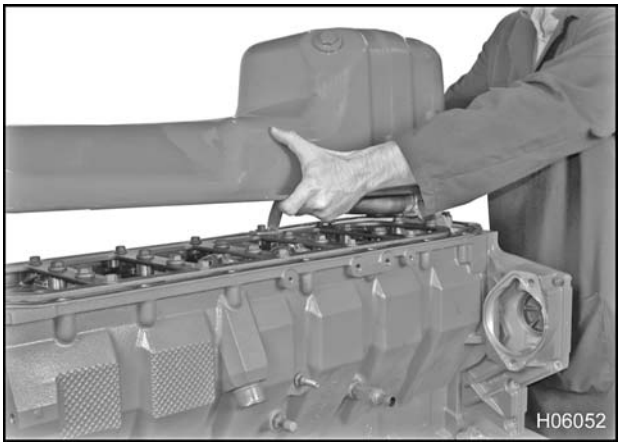

Figure 285 Removing the oil pan

2. Lift the oil pan from the engine.

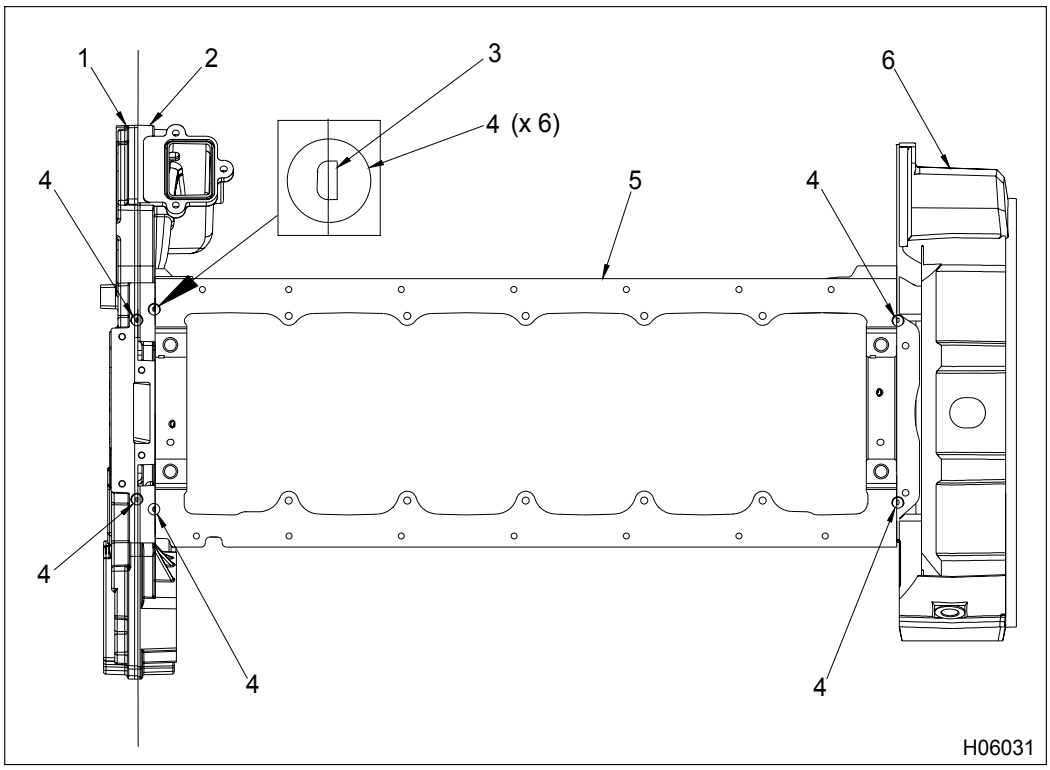

Figure 286 RTV sealant locations

1. Front cover (front half)
2. Front cover (rear half)
3. Gasket
4. RTV sealant locations
5. Crankcase
6. Flywheel housing

3. Use a knife or scraper to cut through the RTV sealant under the oil pan gasket at six locations on the crankcase mounting surface.

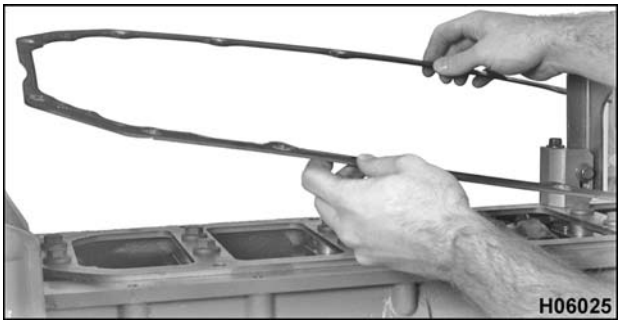

Figure 287 Removing the oil pan gasket

4. Remove the oil pan gasket from the crankcase mounting surface and discard.

Removing the Oil Suction Tube

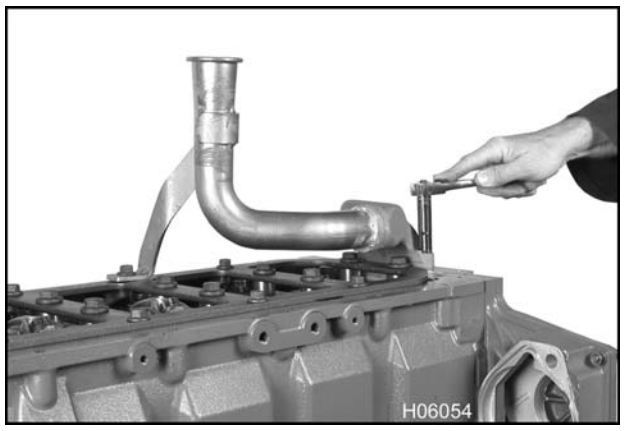

Figure 288 Removing the oil suction tube

1. Remove two (M8 x 35) mounting bolts from the oil suction tube.

2. Remove mounting bolt (M10 x 25) from the oil suction tube bracket.

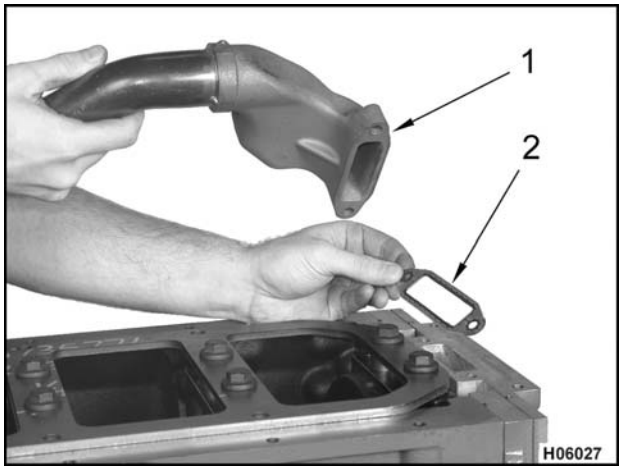

Figure 289 Removing the oil suction tube and gasket

1. Oil suction tube assembly
2. Gasket

3. Remove the oil suction tube assembly and gasket from the front cover and discard gasket.

Cleaning and Inspection

Oil Pan

1. Remove any used RTV sealant from the crankcase, oil pan, and oil pan gasket.
2. Clean the oil pan, front cover, flywheel housing and crankcase mating surfaces thoroughly with a suitable solvent.
3. Make sure that the oil suction tube is free of any obstructions.
4. Check the oil pan and oil suction tube for cracks and damage. Replace components as necessary.
5. Inspect oil pan heating element (if equipped) for an open circuit.

Installation

Installing the Oil Suction Tube

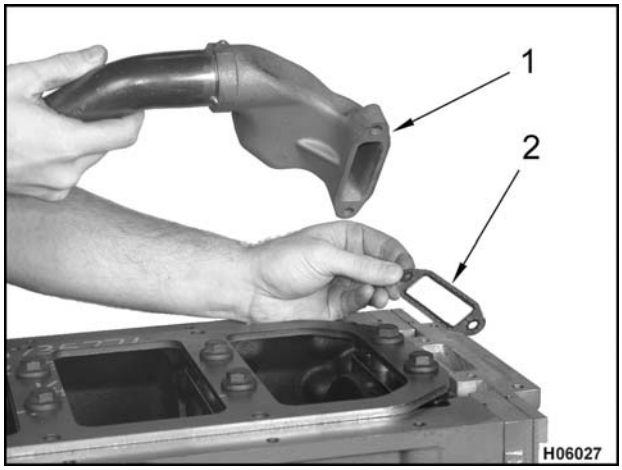

Figure 290 Installing the oil suction tube and gasket

1. Oil suction tube assembly
2. Gasket

1. Place a new gasket onto the front cover and install the oil suction tube assembly.

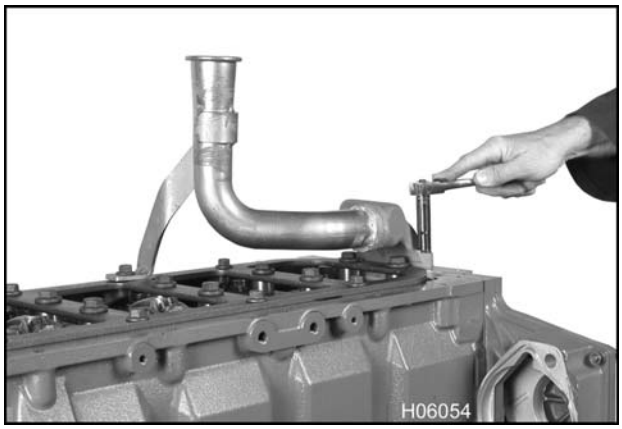

Figure 291 Installing the oil suction tube

2. Install two mounting bolts (M8 x 35) for the oil suction tube and one mounting bolt (M10 x 25) to hold down bracket.
3. Torque both bolts (M8 x 35) to the special torque value (Table 23).

4. Torque bracket bolt (M10 x 25) to the special torque value (Table 23).

Installing the Oil Pan

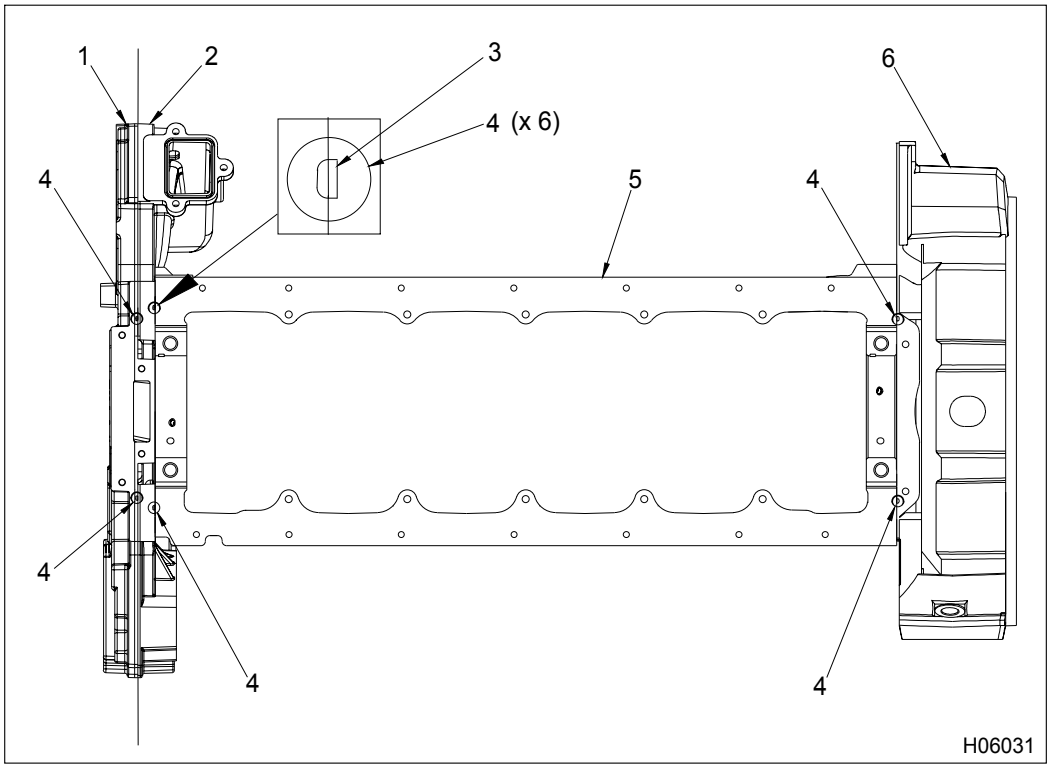

Figure 292 RTV sealant locations – see inset (typical)

1. Front cover (front half)
2. Front cover (rear half)
3. Gasket
4. Sealant, Wacker T-442, (6 locations)
5. Crankcase
6. Flywheel housing

1. Apply a circular dab of T-442 Wacker RTV sealant (Table 24) approximately 19 mm (0.75 in) in diameter to the six locations on the crankcase mounting surface. These locations coincide with gasket joints between the front cover halves, crankcase, and flywheel housing.

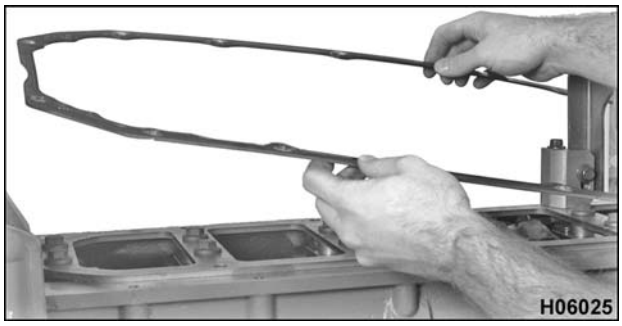

Figure 293 Installing the oil pan gasket

2. Before the RTV sealant dries (tack free), install a new oil pan gasket on the crankcase mounting surface. Make sure that the dowel on the gasket is aligned with the hole on the crankcase mounting surface.

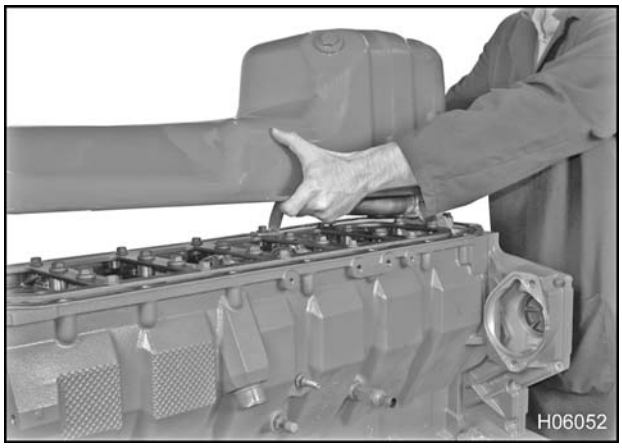

Figure 294 Installing the oil pan

3. Install the oil pan onto the crankcase.

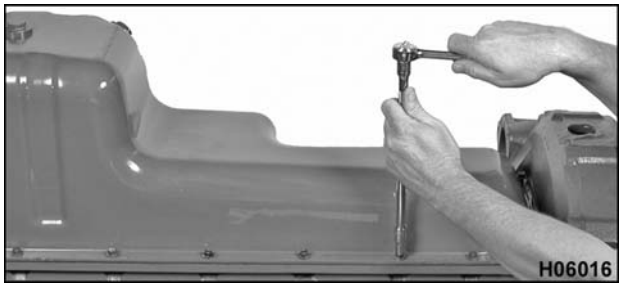

Figure 295 Installing oil pan mounting bolts

4. Install 18 oil pan mounting bolts (M8 x 24). Tighten all bolts to the special torque value (Table 23).

300 Watt Oil Pan Heater (Optional)

An optional 300 Watt Oil Pan Heater is available for service. See (1171848R1 300 Watt Oil Pan Heater Kit, page495) for installation procedure.

Specifications

Table 22 Oil Fill Specifications

Dry engine (after rebuild and new filter)	34 L (36 quarts US)
Wet engine (after oil drain and filter change)	28 L (30 quarts US)

Special Torque

Table 23 Oil Pan and Oil Suction Tube Special Torques

Oil pan drain plug	68 N·m (50 lbf·ft)
Oil heating element assembly (optional)	68 N·m (50 lbf·ft)
Oil pan heater plug	68 N·m (50 lbf·ft)
Oil pan mounting bolts	32 N·m (24 lbf·ft)
Oil suction tube bracket, M10 x 25	63 N·m (46 lbf·ft)
Oil suction tube, M8 x 35	27 N·m (20 lbf·ft)

Special Service Tools

Table 24 Special Tools

Wacker T – 442 RTV sealant	Obtain locally

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Description

A few changes were made for model year 2004:

- Piston skirts for DT 466 and 570 cubic inch displacements have a notch cast into each side of the skirt for piston cooling tube clearance.
- The combustion bowl has been centered within the piston crown. The pistons are symmetrical, and therefore do not require orientation.
- Connecting rods have a fractured surface at the cap and rod bolted joint. These are mated parts and are not interchangeable with other connecting rods. It is important that serial numbers on the connecting rod and connecting rod cap must match and appear together.

Additional changes running changes were made after model year 2004:

- New piston cooling tubes were released for service.
- New connecting rod assemblies were released for service.

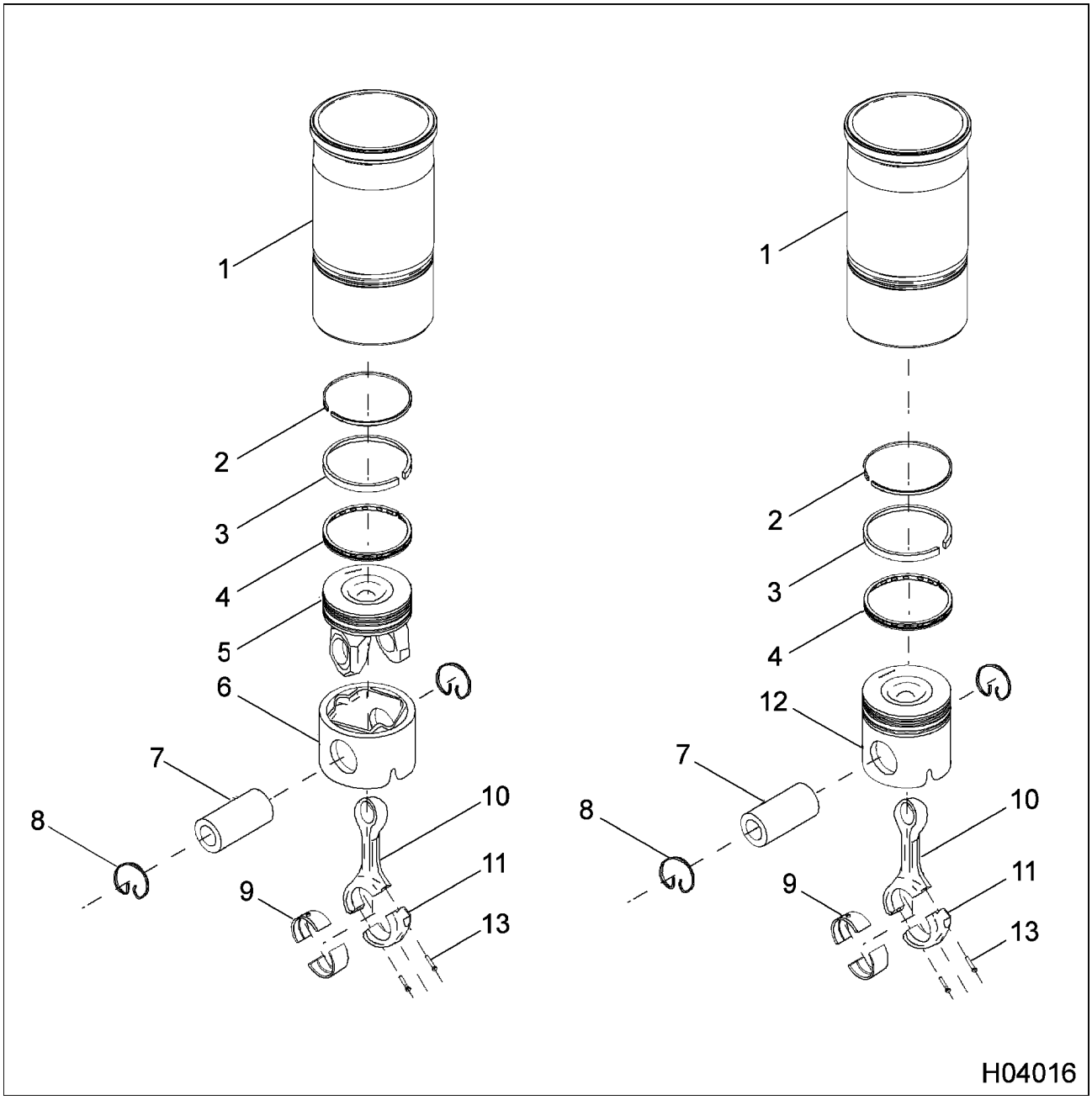

Figure 296 Connecting rods, pistons, and rings

1. Cylinder sleeve
2. Top compression ring
3. Intermediate compression ring
4. Oil control ring
5. Piston crown (570)
6. Piston skirt (570)
7. Piston pin
8. Retaining ring (2)
9. Bearing shells (2)
10. Connecting rod
11. Connecting rod cap
12. Piston, one-piece aluminum (466)
13. Connecting rod bolt (2)

Removal

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

WARNING: To prevent personal injury or death, disconnect ground (-) cable from battery before doing service or diagnostic procedures.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

CAUTION: To prevent engine damage, keep the fractured mating surfaces of the connecting rod and cap clean and free of lint and debris. Do not allow the mating surfaces to rest on any surface. Do not bump the mating surfaces or drop the connecting rod or cap. This could cause chipping and wear on the mating surface, resulting in improper mating during installation and possible engine damage.

CAUTION: If a carbon ridge has developed at the top of the cylinder sleeve, use a razor knife to scrape it off before removing the piston assemblies. Care must be taken not to damage the sleeve bore surface when removing the carbon.

Piston Cooling Tubes

NOTE: Old piston cooling tubes and bolts can be reused or replaced with new piston cooling tubes and bolts.

Old Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

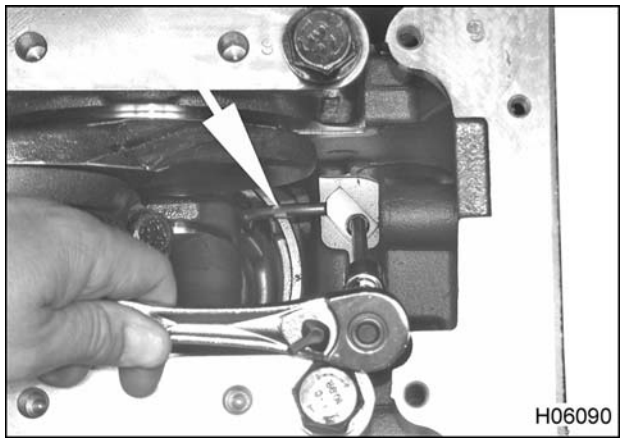

Figure 297 Old piston cooling tube

1. Remove M6 x 16 patch type bolt from piston cooling tubes.

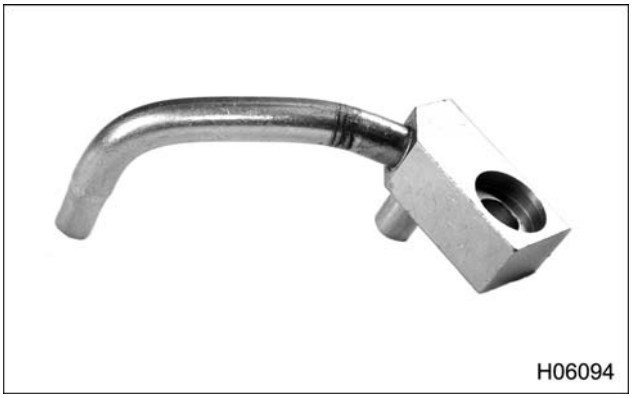

Figure 298 Old piston cooling tube

2. Remove six old piston cooling tubes only if replacing with new.

New Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

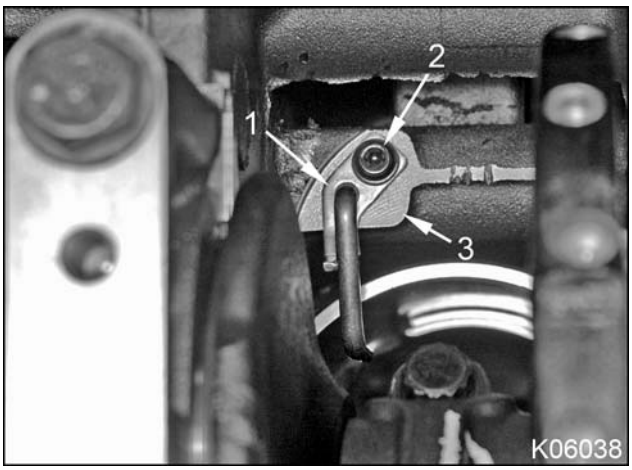

Figure 299 New piston cooling tube

1. Piston cooling tube (6)
2. M6 x 12 bolt (6)
3. Mounting pad (6)

1. Remove M6 x 12 bolt from piston cooling tubes and bolts.

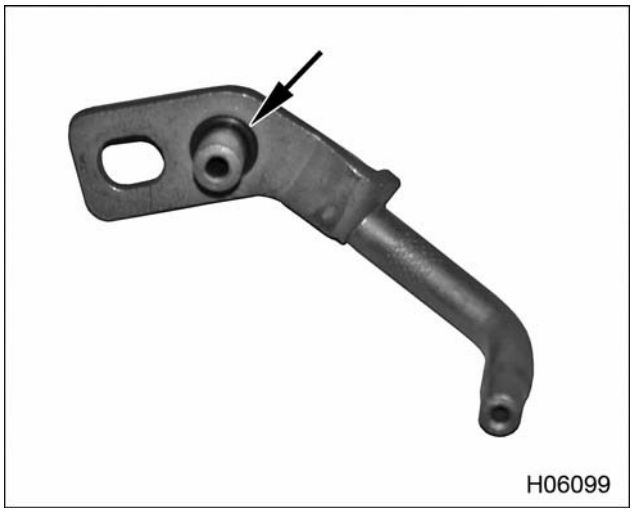

Figure 300 O-ring (underside) of new piston cooling tube

2. Remove and discard O-rings.

Removing Piston and Connecting Rod Assembly

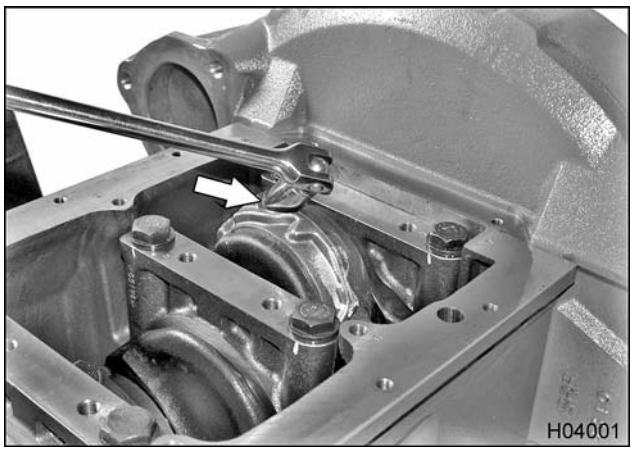

Figure 301 Loosening connecting rod bolts

1. Loosen both connecting rod bolts two turns.
2. Rock the two bolts on the rod cap to loosen.
3. Repeat procedure for all other connecting rods.
4. Rotate the engine to a vertical position with the front end up.

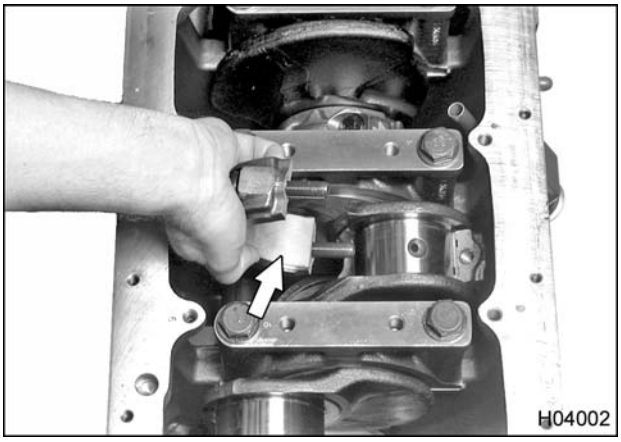

Figure 302 Removing connecting rod cap and bolts

5. Unscrew the bolts completely. Remove the cap and bolts as a unit.
6. Discard connecting rod cap bolts.

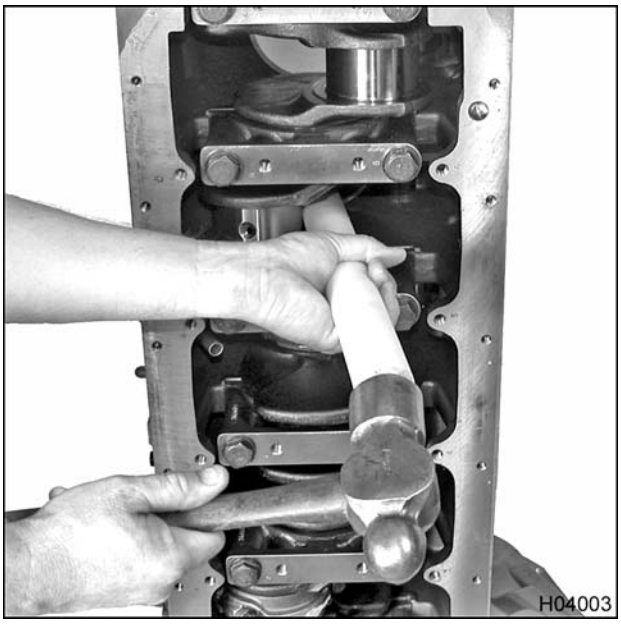

Figure 303 Pushing out piston and connecting rod assembly

7. Do not push on rod fractured surface. Use a hammer with a plastic or wooden handle or a non-marring punch to push the piston out of the cylinder sleeve.

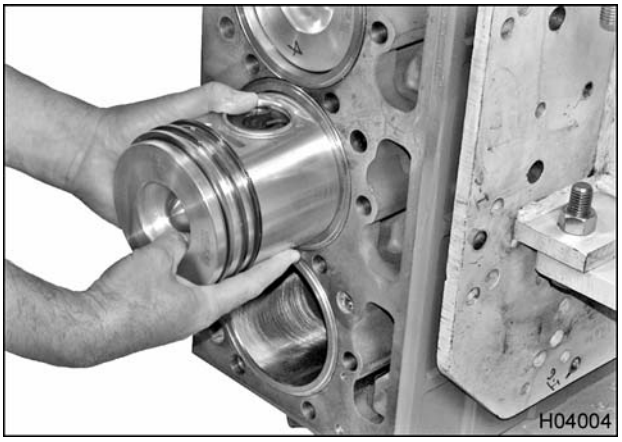

Figure 304 Removing piston and connecting rod assembly from cylinder sleeve

8. Once the piston rings are free of the cylinder sleeve, remove the assembly from the top of the crankcase.
9. For installation purposes, mark each piston, connecting rod, and cap with the cylinder number from which it was removed. Also mark the front of each piston as it was installed in the engine.

Disassembling Piston and Connecting Rod Assembly

⚠ WARNING: To prevent serious personal injury or possible death, wear safety glasses when removing piston pin retaining rings.

Figure 305 Removing piston pin retaining rings

1. Use pliers to remove the two piston pin retaining rings.

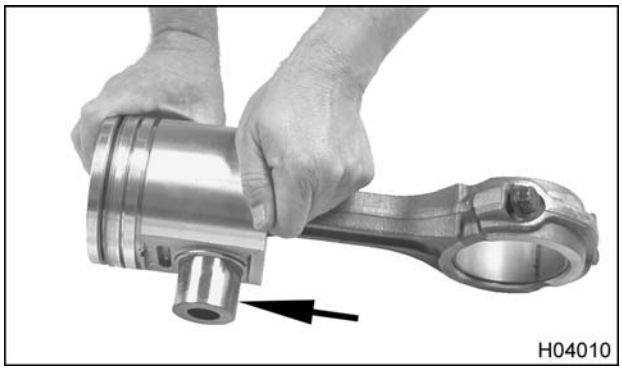

Figure 306 Removing piston pin

2. Remove the piston pin from the bore by hand. Separate the piston from the connecting rod. Mark the front of the piston pin with the cylinder number from which it was removed.

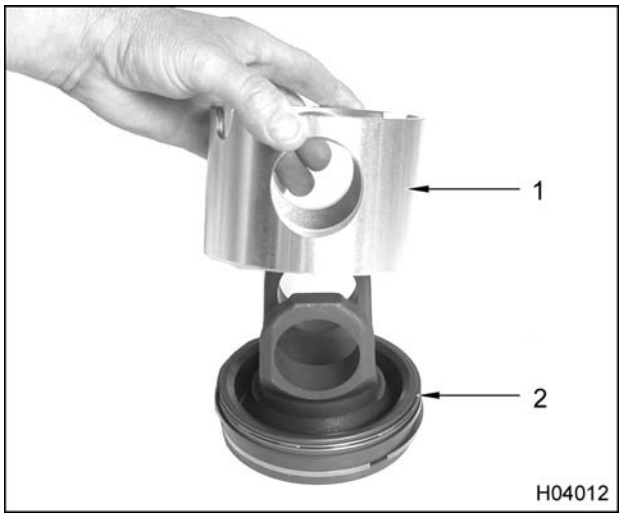

Figure 307 Removing piston skirt from crown (570 engine only)

1. Skirt
2. Crown

3. **For 570 engines only:** Mark the orientation of the piston skirt to the crown for installation purposes. Remove the piston skirt from the crown.

Figure 308 Removing piston rings (DT 466 piston shown)

4. Use a piston ring expander tool (Table 34) to remove the piston rings.

Cylinder Sleeve Removal

NOTE: Before installing the puller, bar the engine over so the crankshaft journal is located at the bottom (low point) of its travel. This prevents possible damage to the journal by the puller lifting jaws during puller installation.

NOTE: When you remove the sleeve from puller, mark the sleeve with its cylinder bore number. Also mark the sleeve position in the engine block for the purposes of inspection and assembly.

1. Position the cylinder sleeve puller in the sleeve and spread the lifting jaws so the tangs grip the bottom of the sleeve (Figure 309).

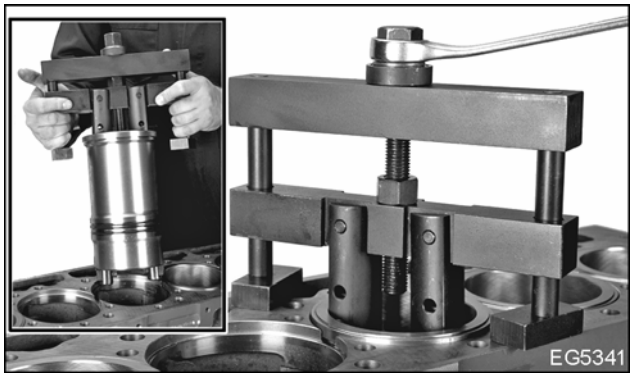

Figure 309 Removing cylinder sleeve from crankcase

2. With the lifting bridge firmly on the crankcase top deck, turn the forcing nut to break the cylinder sleeve loose from the crankcase.
3. Lift sleeve and puller from the crankcase.
4. Use a pick to remove the crevice seal at the lower counterbore area of each cylinder sleeve. Discard crevice seal.

Cleaning

Pistons and Related Components

CAUTION: To prevent engine damage, do not use a caustic solvent or wire brushes, or bead blasting media to clean aluminum pistons.

1. Soak aluminum pistons and skirts in a soap and water solution. Use a non-metallic brush to clean the pistons.
2. Scrub the piston ring grooves thoroughly. Make sure that the four oil drain holes in the oil ring grooves are not blocked.

CAUTION: To prevent engine damage, do not clean the fractured mating surfaces of the connecting rods.

3. Use a suitable solvent and a non-metallic brush to clean the connecting rods and caps, piston rings, pins, retainers, and steel piston crowns. Thoroughly clean the connecting rod bolt holes and threads.
4. Clean crevice seal bore area of any scale, deposits, or sealant (located in crankcase.)

Inspection

Pistons

CAUTION: To prevent engine damage, when replacing only the steel piston crown, the original orientation of the reused aluminum piston skirt to the sleeve must be maintained upon reassembly.

Inspect the pistons for scuffed or scored skirts and worn ring lands. Replace damaged pistons as required. For two-piece pistons, the aluminum piston skirt or steel piston crown may be replaced individually.

Top and Intermediate Compression Ring Grooves

Table 25 DT 466 Piston Ring Gauge Selection

Engine Rating	Ring / Groove Type	Gauge Diameter, mm (in)
225 bhp and below	Top / keystone cross section	3.1 (0.122)
	Intermediate / rectangular	N/A
230 bhp and above	Top / keystone cross section	3.1 (0.122)
	Intermediate / keystone cross section	2.8 (0.110)

Table 26 DT 570 and HT 570 Piston Ring Gauge Selection

Engine Rating	Ring / Groove Type	Gauge Diameter, mm (in)
All 570 series engines	Top / keystone cross section	3.2 (0.126)
	Intermediate / rectangular	N/A

Figure 310 Measuring ring grooves with piston ring gauge pins

1. Install the piston ring gauge pins into the top compression ring groove. Make sure that the gauge pins are parallel.
2. Use an outside micrometer to measure the diameter of the piston over gauge pins. Record the reading.
3. Repeat the procedure for the intermediate compression ring groove, if its cross section is keystone-shaped. If the ring groove has a rectangular cross section, the height of the groove must be checked with gauge blocks.

If either measurement exceeds specifications, the piston ring groove is worn, and the piston must be replaced. For two-piece pistons, replace only the steel piston crown.

Oil Control Ring Groove

Figure 311 Measuring side clearance of oil control ring groove

1. Place the edge of a new oil control ring in the groove. Roll the oil control ring entirely around the piston to ensure that the ring is free in its groove.
2. With the edge of the oil control ring still in the groove, use a feeler gauge to check the side

clearance between the ring and the top of its groove. Record the reading.

If the measurement exceeds the specification, the oil control ring groove is worn out. Replace the piston. For two-piece pistons, replace only the steel piston crown.

Piston-to-Cylinder Sleeve Running Clearance

Figure 312 Measuring piston skirt diameter

1. With the piston at room temperature, use an outside micrometer to measure the piston skirt diameter. Place the micrometer 90 degrees from the piston pin bore. For one-piece pistons (466 engine), measure at 28.58 mm (1.125 in) from the bottom of the piston. For two-piece pistons (570 engine), measure at 3.00 mm (0.118 in) from the bottom of the piston skirt. Record the reading.
2. Subtract the measurement from the inside diameter of the cylinder sleeve (Checking Cylinder Sleeves, page 227). The result is the running clearance between the piston and the cylinder sleeve.

   If the running clearance is not within the specification for the one-piece piston, replace the cylinder sleeve, piston and rings. For two-piece pistons, replace the cylinder sleeve, aluminum piston skirt, crown and rings.

Piston Rings

CAUTION: To prevent engine damage, whenever a piston is removed from a cylinder, replace the piston rings. Faulty piston rings cannot always be detected by visual inspection. Therefore, if the rings are replaced, the cylinder sleeves need to be replaced as well.

1. Inspect the new piston rings for cleanliness. Use a suitable solvent to clean the piston rings if necessary.

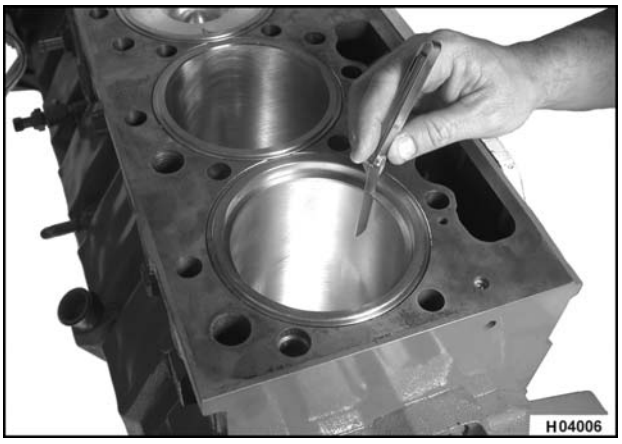

Figure 313 Checking piston ring end gap

2. Push the piston ring down into the cylinder bore. Make sure that the piston ring is perpendicular to the cylinder wall.
3. Use a feeler gauge to measure the end gap between the ends of each piston ring.

   Discard any piston ring that does not meet specifications.

Piston Pins

1. Inspect piston pins for corrosion, nicks, and obvious wear. Do not use pins with nicks or heavy scratches with the two-piece steel crown. Engine failure will result. Install new piston pins.

Figure 314 Measuring piston pin outside diameter

2. Use an outside micrometer to measure the outside diameter of each piston pin at two places.
3. If the outside diameter is less than minimum Specification (Table 31), install new piston pin.
4. Measure each piston pin bore.
5. Calculate piston pin clearance. Subtract the outside diameter of the piston pin from the inside diameter of the piston pin bore.

   NOTE: Piston pin clearance = (inside diameter of the piston pin bore) – (outside diameter of the piston pin)

6. If piston pin clearance in piston exceeds Specifications (Table 31), install new connecting rod.

Connecting Rods

Piston Pin Bushing

Figure 315 Measuring piston pin bushing inside diameter

Use a telescoping gauge and an outside micrometer to measure the inside diameter of the piston pin bushing at two locations that are 90 degrees apart. Record the readings.

Connecting Rod Cap Bolts

1. Inspect the connecting rod cap bolts for nicks and thread damage. Replace the bolts as required.
2. Lubricate the threads of the connecting rod cap bolts with clean engine oil. Install the cap without the bearing shells on the connecting rod and install the bolts by hand. Match serial numbers on the connecting rod and cap (on same side of fractured rod).

   If resistance is met, clean the bolt holes in the connecting rod and try installing new bolts. If the new bolts do not turn in freely, replace the connecting rod. The threads in the bolt holes cannot be tapped.

3. Tighten the connecting rod cap bolts to the special torque value (Table 33).

Connecting Rod Bearing Bore

1. Inspect the finished surface of the connecting rod bearing bore for nicks, burrs, and scoring. Replace connecting rod as required.

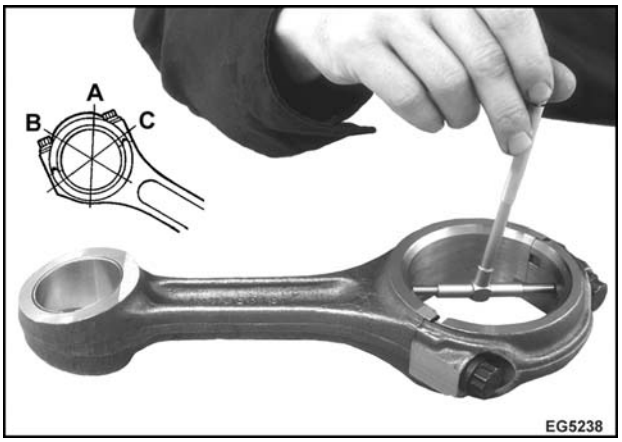

Figure 316 Connecting rod bearing bore for out-of-round

2. Use an inside micrometer to measure the inside diameter of the connecting rod bearing bore at three locations that are 60 degrees apart. Record the readings.

   If the difference between measurement **B** and the average of measurements **A** and **C** exceeds the specification for out-of-round, replace the connecting rod.

Figure 317 Measuring connecting rod bearing bore taper

3. Use a telescoping gauge and an outside micrometer to measure the inside diameter of the connecting rod bearing bore at the edge of each side of the bore. Record the readings.

   If the difference between the two measurements exceeds the bore taper specification, replace the connecting rod assembly.

Bend and Twist

Engine component wear patterns can often be identified and used to diagnose a problem. Some common examples of connecting rod wear patterns include the following:

- A shiny surface on the edge of the piston pin bushing usually indicates that a connecting rod is bent or a piston pin hole is not positioned properly in relation to the piston skirt and piston ring grooves.
- Abnormal wear on the connecting rod bearing may indicate that a connecting rod is bent or the bearing bore is too tapered.
- A twisted connecting rod will not create an easily identifiable wear pattern, although severely twisted connecting rods will disturb the action of the entire piston and connecting rod assembly and may be the cause of excessive oil consumption.

If any of these conditions exist, use a suitable alignment fixture to check the connecting rod for bends and twists. Follow the instructions of the alignment fixture manufacturer. If a bend or twist exceeds the specification, replace the connecting rod.

Bearing Fitting Procedures and Bearing Running Clearance

CAUTION: To prevent engine damage, do not attempt to reduce journal-to-bearing running clearance by reworking the bearing cap or the bearings. Grind the crankshaft to the next available under size or replace crankshaft.

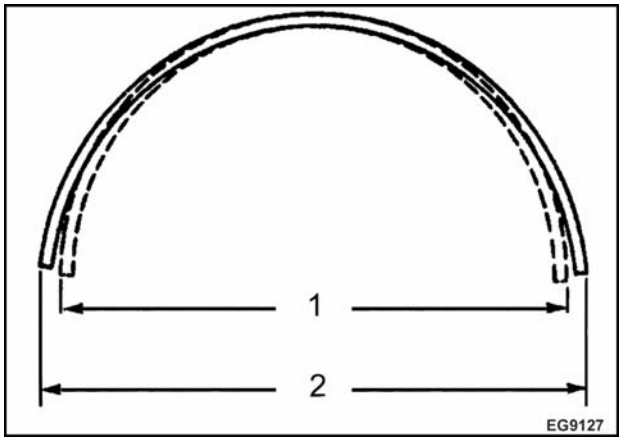

Figure 318 Effects of bearing crush

1. Diameter at open ends after bearing crush load
2. Diameter at open ends before bearing crush load

NOTE: Connecting rod bearings must fit tightly in the connecting rod bore. When bearings are inserted in the connecting rod and cap, they protrude slightly above the parting surface. This protrusion is required to achieve bearing crush. Bearing crush forces the ends inward at the parting line when a load is applied by tightening the bolts. Some snap may be lost in normal use, but bearing replacement is not required because of a nominal loss of snap.

When the connecting rod bearing is installed and the connecting rod cap bolts are tightened, the bearing is compressed, ensuring a positive contact between the backside of the bearing and the machined surface of the connecting rod bore.

Bearing Running Clearance

1. Install new bearings in the connecting rod and cap.

CAUTION: To prevent engine damage, install connecting rod cap and connecting rod with matching serial numbers on the same side. If the rod cap is reversed or not installed on its matching connecting rod, the fractured mating surfaces will be damaged. This can loosen the rod cap. A new connecting rod assembly must be installed.

2. Match serial numbers on the connecting rod and rod cap (on same side of fractured rod) and install the connecting rod and cap on the crankshaft. See Installing Piston and Connecting Rod Assembly (page237).
3. Remove the connecting rod cap. Wipe the oil from the face of the bearings in the cap and the exposed portion of the crankshaft.
4. Place a piece of undamaged Plastigage® across the full width of the connecting rod bearing, about 6 mm (0.25 in) from the center of the connecting rod cap.

CAUTION: To prevent engine damage, do not torque-to-yield connecting rod cap bolts while doing this measurement procedure.

CAUTION: To prevent engine damage, when torquing connecting rod bolts use a torque wrench that is known to be accurate. Correct torque of connecting rod cap bolts is important.

5. Install the connecting rod cap bolts and tighten to 109 N·m (80 lbf·ft).

NOTE: Do not turn the crankshaft. This will smear the Plastigage® making it unusable.

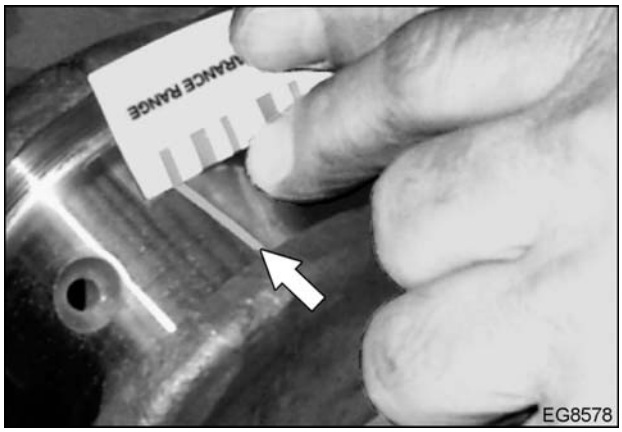

Figure 319 Measuring Plastigage® with scale

6. Remove the connecting rod cap. The Plastigage® material will adhere to the bearing shell or the crankshaft. Do not remove the Plastigage®.
7. Use the Plastigage® paper scale to measure the widest point of the flattened material. Numbers in the graduated marks on the scale indicate the running clearance in thousandths of an inch or millimeters.

NOTE: If running clearance is not to specification, it may be necessary to grind the crankshaft and install an undersized bearings. Check running clearance again before condemning the crankshaft.

8. Remove the Plastigage® material. Repeat the test for each connecting rod bearing.

Connecting Rod Side Clearance

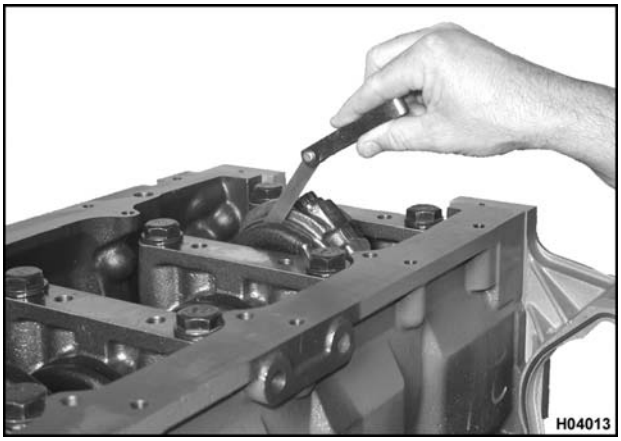

Figure 320 Measuring connecting rod side clearance

Place a feeler gauge between the connecting rod and crankshaft journal. This is the connecting rod side clearance.

If there is too little side clearance, the connecting rod may be damaged or the bearing may be out of position. If there is too much clearance, the connecting rod or crankshaft may be damaged.

Checking Cylinder Sleeves

1. Inspect the inside surface of the cylinder sleeves for scuffing, scoring and polishing. Inspect the outside surface for cavitation. Replace the cylinder sleeves with piston rings as required.
2. To check the cylinder sleeves for wear (taper), use one of the following methods:

Telescoping Gauge Method

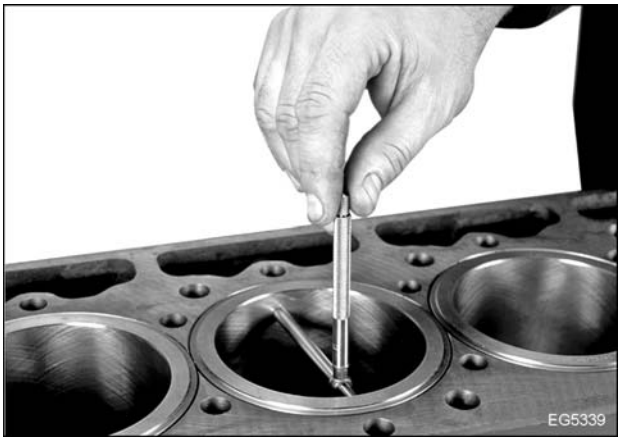

Figure 321 Checking cylinder sleeve inside diameter with telescoping gauge

Figure 322 Measuring telescoping gauge

a. Use a telescoping gauge and an outside micrometer to measure the inside diameter of each cylinder sleeve at the top of piston ring travel and below the area of piston ring travel. Record the readings.

b. Subtract the lower reading from the higher reading. The result is the cylinder sleeve taper.

   If the result exceeds the specification, replace the cylinder sleeve.

Dial Bore Gauge Method

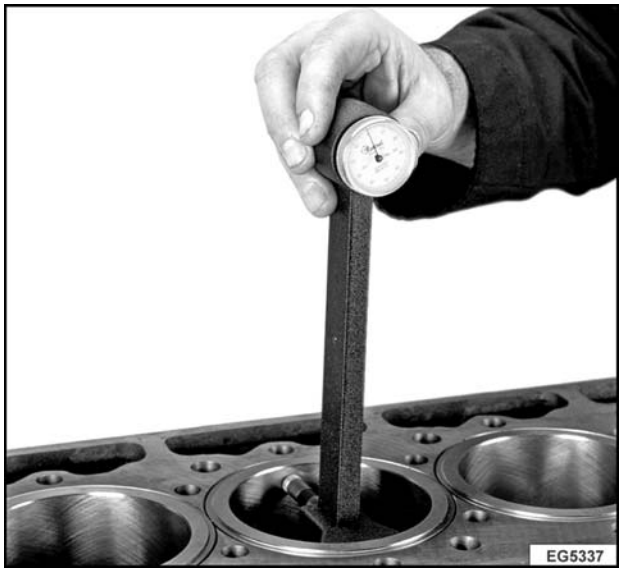

Figure 323 Checking cylinder sleeve inside diameter with dial bore gauge

a. Use a dial bore gauge to measure the inside diameter of the each cylinder sleeve at the top of piston ring travel and below the area of piston ring travel. Record the readings.

b. Subtract the lower reading from the higher reading. The result is the cylinder sleeve taper.

   If the result exceeds the specification, replace the cylinder sleeve.

Feeler Gauge Method

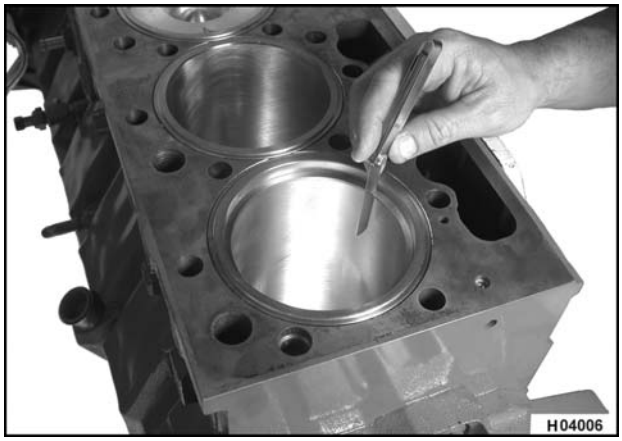

Figure 324 Checking cylinder sleeve piston ring end gap

a. Install a top compression ring squarely above the top of the piston ring travel area. Use a feeler gauge to measure the piston ring end gap. Record the measurement.

b. Move the top compression ring squarely below the bottom of the piston ring travel area. Use a feeler gauge to measure the piston ring end gap. Record the measurement.

   Every increase of 0.07 mm (0.003 in) between the measurements equals a 0.025 mm (0.001 in) increase in cylinder sleeve inside diameter. If the cylinder sleeve is worn beyond the specification, replace the cylinder sleeve.

Checking Counterbore Depth

Use one of the following methods to check the depth of the crankcase counterbore:

Surface Gauge Method

NOTE: Clean counterbore surface and remove existing shims if any before measuring counterbore depth.

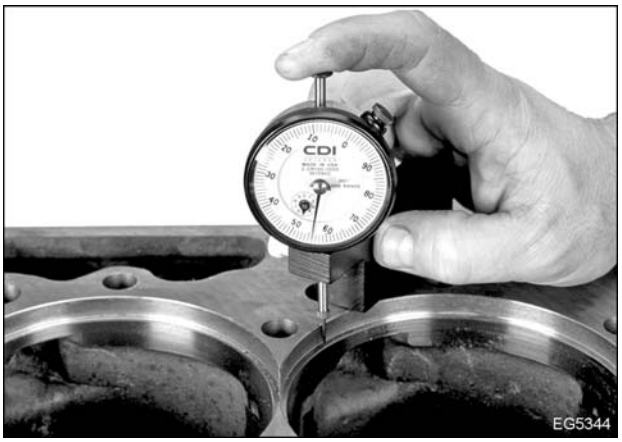

Figure 325 Checking counterbore depth with surface gauge

1. Place the indicator tip of the surface gauge on the crankcase. Zero the dial indicator.
2. Move the indicator tip onto the counterbore ledge. Record the counterbore depth reading on the dial indicator.
3. Take counterbore depth measurements at four evenly spaced locations around the counterbore ledge.
4. Compare the counterbore depth variation between the four measurements with those listed in specifications (Table 32).

   If the maximum variation between the four measurements exceeds the specification, resurface the counterbore.

Depth Micrometer Method

NOTE: Clean counterbore surface and remove existing shims if any before measuring counterbore depth.

Figure 326 Checking counterbore depth with depth micrometer

1. Place a depth micrometer onto the counterbore ledge. Record the counterbore depth reading.
2. Take counterbore depth measurements at four evenly spaced locations around the counterbore ledge.
3. Compare the counterbore depth variation between the four measurements with specifications.

   If the maximum variation between the four measurements exceeds the specification, resurface the counterbore.

Checking Cylinder Sleeve Protrusion

CAUTION: To prevent engine damage, do not apply holding adapters to the "fire dam" ridge of the cylinder sleeve. Clamping forces should not be applied to this ridge as internal cracking could develop adjacent to the shim land.

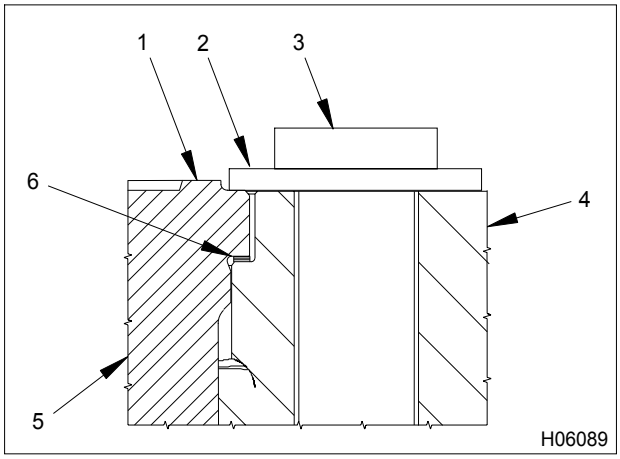

Figure 327 Cylinder sleeve clamping details

1. Fire dam (highest point on cylinder sleeve)
2. Clamping tool (washer)
3. Clamping bolt
4. Crankcase
5. Cylinder sleeve
6. Shim pack

1. Clean the cylinder sleeve, cylinder sleeve crevice bore, and crankcase counterbore surface.

   CAUTION: To prevent engine damage, do not "torque-to- yield" the holding adapter bolts (as when installing cylinder head bolts). This will prevent stretching the bolts and risking the indentation of tooling marks on the cylinder sleeve.

2. Install the cylinder sleeve in the cylinder bore without the crevice seal.

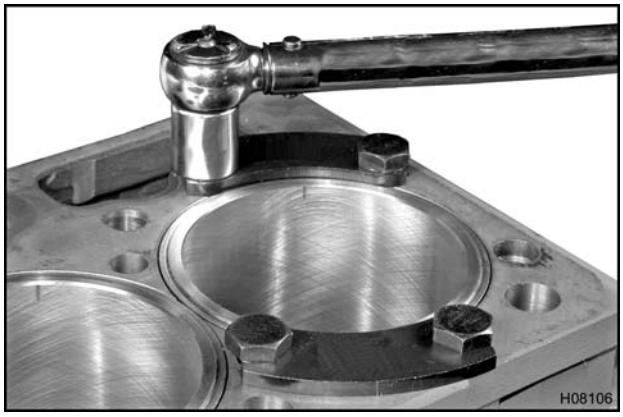

Figure 328 Installing the holding adapters

3. Install the cylinder sleeve holding adapters (Table 34) with 10.9 or higher grade bolts and hardened washers. Tighten bolts in two stages:

   A. 55 N·m (40 lbf·ft)

   B. 110 N·m (80 lbf·ft)

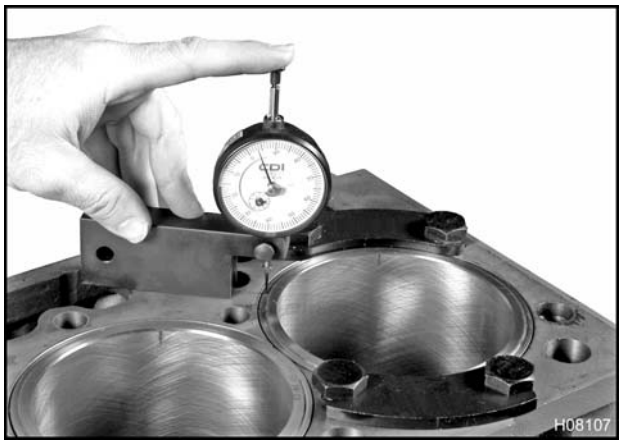

Figure 329 Measuring cylinder sleeve protrusion

4. Place the indicator tip of a surface gauge on the cylinder sleeve flange. Zero the dial indicator.
5. Move the surface gauge until the indicator tip slides off the flange to the surface of the crankcase. Record the cylinder sleeve protrusion reading on the dial indicator.

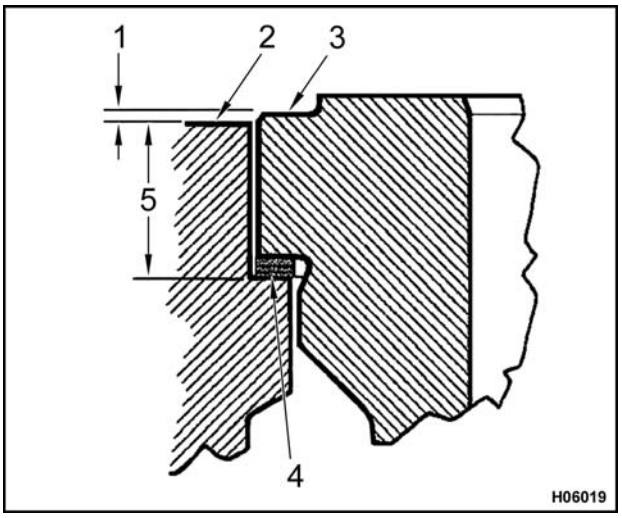

Figure 330 Checking cylinder sleeve protrusion

1. Cylinder sleeve protrusion
2. Top surface of crankcase
3. Cylinder sleeve flange
4. Shim to suit
5. Counterbore

6. Take cylinder sleeve protrusion readings from three evenly spaced locations around the cylinder sleeve. Average the three readings to determine the cylinder sleeve protrusion.

   If the cylinder sleeve protrusion does not meet the specification, remove the cylinder sleeve and install the necessary amount of shims to meet the specification.

NOTE: Shims are available as a package consisting of the following:

Table 27 Cylinder Sleeve Shim Sizes

Shim size (mm)	Shim size (in)
0.05	0.002
0.10	0.004
0.25	0.010
0.51	0.020
0.81	0.032

Reconditioning

Resurfacing the Counterbore

The following steps will require the use of the cylinder sleeve counterbore tool kit. See piston, piston ring, and connecting rod special service tools (Table 34).

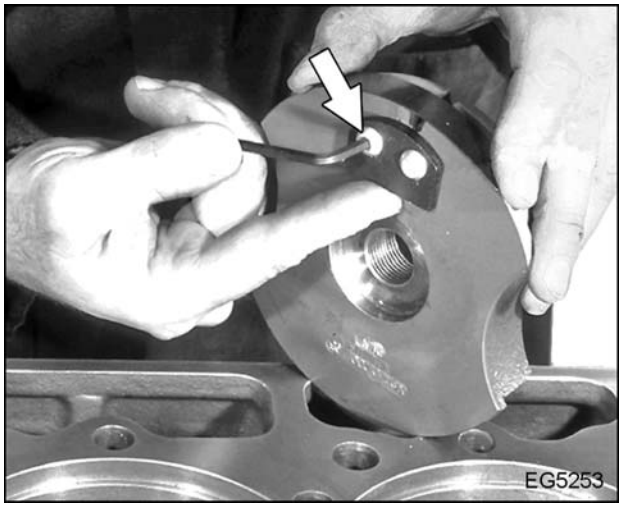

Figure 331 Setting tool bit

1. To set the tool bit for the counterbore cutting head (Table 34), place a 0.20-0.25 mm (0.008-0.010 in) feeler gauge on the outside diameter of the cutting head. Push the tool bit out until it touches the feeler gauge. Use a hex head wrench to lock the tool bit in place.

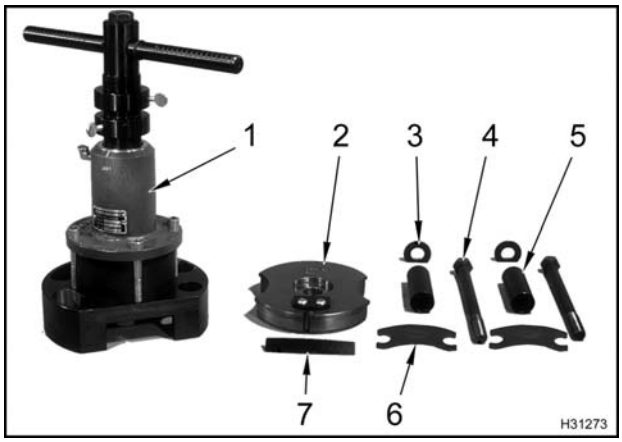

Figure 332 Counterboring tool components

1. Driver unit and adapter plate
2. Cutting head
3. Washer (2)
4. Mounting bolt (2)
5. Spacer (2)
6. Locking plate (2)
7. Feeler gauge

2. Install the cutting head on the driver unit and adapter plate of the counterboring tool.

Figure 333 Positioning counterboring tool

1. Turn knuckles
2. Locking screws
3. Mounting bolt (2)
4. Washer (2)
5. Spacer (2)
6. Locking plate (2)

3. Pull the plunger and lift up on the handle to raise the cutting head. Mount the counterboring tool on the crankcase. Install the washers and mounting bolts finger tight, then tighten the bolts to 45 N·m (33 lbf·ft).

4. To lower the cutting head, loosen the locking screws and the turn knuckles. Pull the plunger up to the desired height. Tighten the turn knuckles and locking screws.

NOTE: Do not remove more than 0.05 mm (0.002 in) of material at any one attempt.

5. To set the depth of the cut, use one of the following methods:

   Graduated Marks on Tool

   a. Loosen the locking screw and turn the adjusting nut counterclockwise until it contacts the housing of the driver unit.

   b. Back off the adjusting nut by the amount of the desired cut. Each graduated mark equals 0.03 mm (0.001 in).

   c. Tighten the locking screw.

   Feeler Gauge

   a. Loosen the locking screw on the upper turn knuckle and insert the correct size of feeler gauge between the turn knuckles.

   b. Rotate the upper turn knuckle until the feeler gauge is barely held between the turn knuckles.

   c. Tighten the locking screw and remove the feeler gauge.

CAUTION: To prevent engine damage, do not rotate the handle counterclockwise when the tool bit is in contact with the counterbore ledge as damage to the tool bit could result as well.

6. To cut the counterbore, rotate the handle smoothly in a clockwise direction until the driver unit turns freely and is bottomed out between the adjusting nut and the top of the driver unit housing.

7. Remove the counterboring tool and clean the counterbore area. Check the depth of the counterbore (Checking Counterbore Depth, page 229).

Installation

Cylinder Sleeve Installation

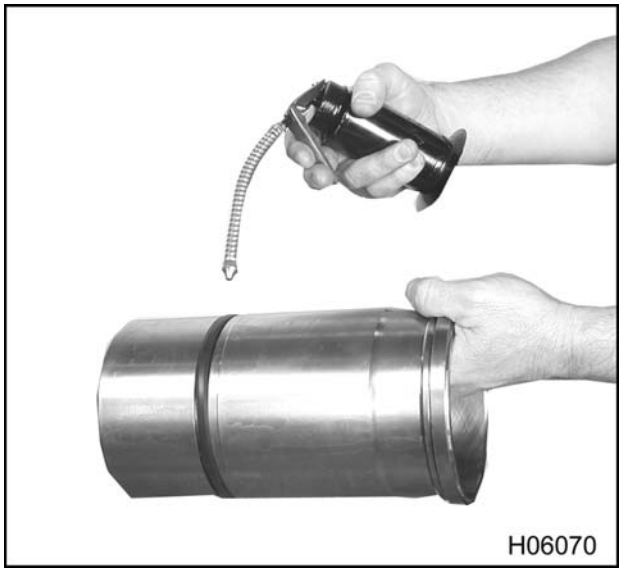

Figure 334 Lubricate cylinder sleeve crevice seal

1. Lubricate the crevice seal with clean engine oil and install into cylinder sleeve groove (without twisting).

   NOTE: Each cylinder sleeve has one crevice seal.

2. If required, ensure the proper shim(s) are installed in the crankcase counterbore necessary to bring the cylinder sleeve protrusion within specifications.

3. Make sure the crevice seal is properly aligned in the groove.

Figure 335 Lubrication of cylinder sleeve bore

4. Apply clean engine oil to the lower crankcase counterbore and crevice seal bore, then carefully install the cylinder sleeve.

Figure 336 Installation of cylinder sleeve

5. After installation, check cylinder sleeve protrusion (Checking Cylinder Sleeve Protrusion, page229).

6. Check cylinder sleeve bore dimensions and sleeve taper per specifications (Table 32). If the cylinder sleeve is not measuring up to specifications, check for an improperly aligned crevice seal.

Assembling Piston and Connecting Rod Assembly

Figure 337 Installing piston rings (466 piston shown)

NOTE: Make sure that the top side of both compression rings (marked with a dot) are facing up. The oil control ring may be installed with either side facing up, if new.

1. Use a piston ring expander tool (Table 34) to install the piston rings. Install the oil control ring first, then intermediate compression ring, and finally the top compression ring.

CAUTION: To prevent engine damage, orientation of a reused piston skirt is very important due to wear patterns. Install the skirt on the crown using the original skirt orientation.

NOTE: New piston skirts may be oriented in either direction due to piston skirt symmetry.

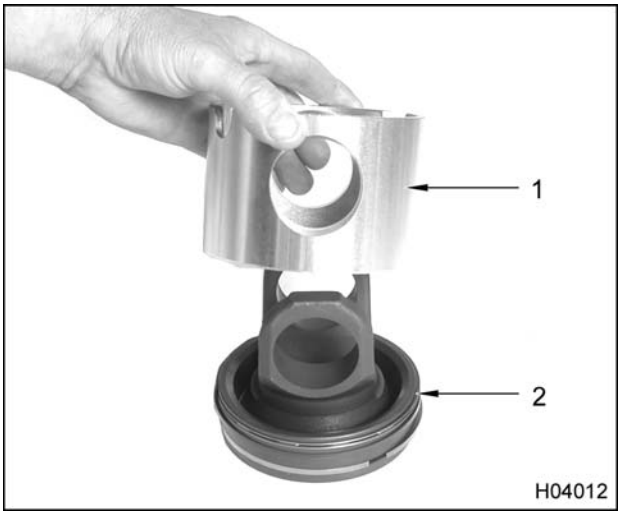

Figure 338 Installing piston skirt on crown (570 engine only)

1. Skirt
2. Crown

2. **For 570 engines only:** Install the piston skirt on the crown. Make sure that the oil jet cutouts on the skirt are facing away from the crown.
3. Lubricate the piston pin bore with clean engine oil.

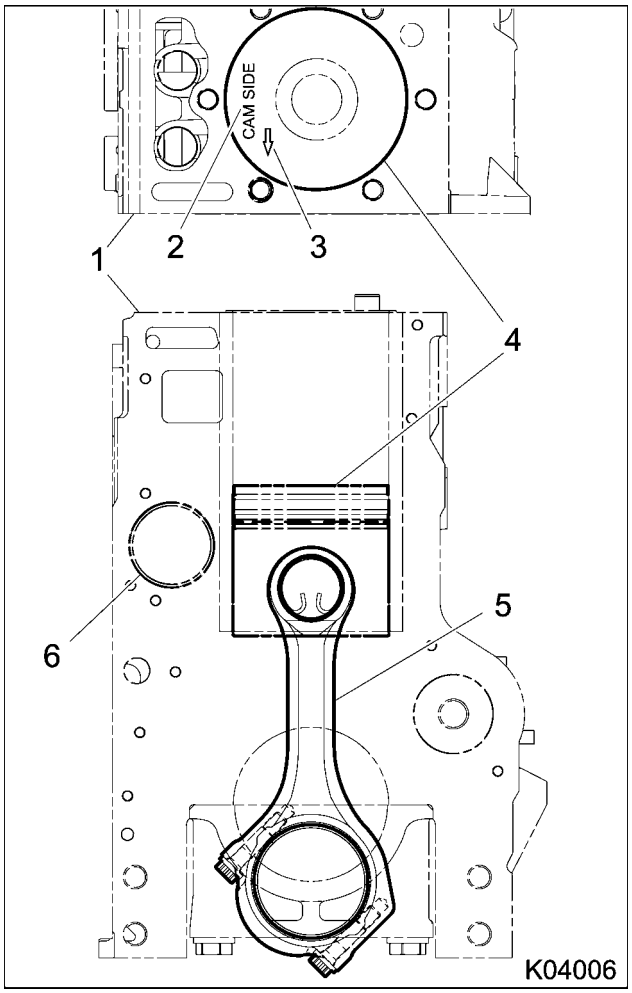

Figure 339 Piston and connecting rod orientation

1. Crankcase
2. CAM SIDE stamp
3. Arrow stamp
4. Piston
5. Connecting rod
6. Camshaft bore

NOTE: One piece pistons are stamped CAM SIDE or with an arrow.

- Install piston with CAM SIDE over short leg of the connecting rod.
- Install piston with arrow stamp (on left side of piston) over short leg of the connecting rod.

Figure 340 Installing piston pin

CAUTION: To prevent engine damage, do not mix connecting rods with M12 bolts and connecting rods with M11 bolts in the same engine. If one or more connecting rods must be replaced make sure all connecting rods in each engine are the same type.

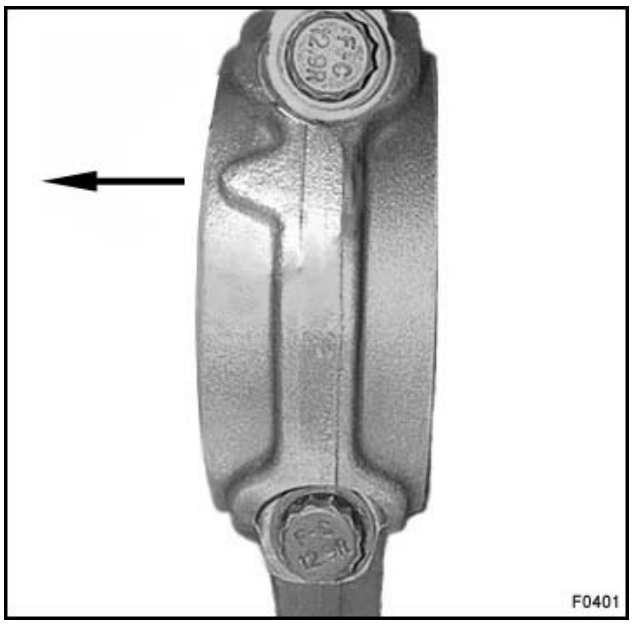

Figure 341 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

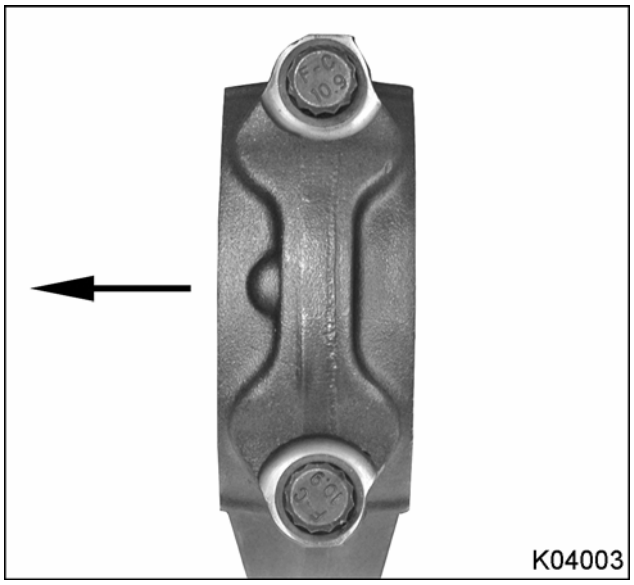

Figure 342 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

4. Align the bores in the connecting rod and piston and install the piston pin.

WARNING: To prevent serious personal injury or possible death, wear safety glasses when installing retaining rings.

Figure 343 Installing piston pin retaining rings

5. Use pliers to install the piston pin retaining rings.

Installing Piston and Connecting Rod Assembly

CAUTION: To prevent engine damage, do not allow the connecting rod or connecting rod cap fractured mating surfaces to contact any surface other then its matched fractured surface. Contacting any other surface can cause misalignment of the mating surface, resulting in connecting rod bearing and engine failure.

NOTE: Turn crankshaft so connecting rod journals 1 and 6 are at Bottom Dead Center (BDC). Install piston and connecting rod assemblies 1 and 6 first. Then repeat the procedure for piston and connecting rod assemblies 2 and 5. Finish with piston and connecting rod assemblies 3 and 4.

1. Install connecting rod bearings into connecting rods and connecting rod caps dry (without oil).
2. Lubricate piston rings with clean engine oil. Stagger piston ring gaps approximately 120 degrees from each other.
3. Install the piston ring compression tool (Table 34) over the piston rings.
4. Lubricate the cylinder sleeve and connecting rod bearing shell with clean engine oil.

CAUTION: To prevent engine damage, install each piston with the arrow to the front of the engine and the CAM SIDE mark toward the cam side of the engine.

CAUTION: To prevent engine damage, make sure that the longer side of the connecting rod bolted joint is oriented opposite the camshaft side of the engine.

5. Carefully install the piston and connecting rod assembly without rod cap into the cylinder sleeve with the arrow on the piston crown pointing to the front of the engine. Use a wooden or plastic handle to carefully push the assembly into the cylinder sleeve. Do not scratch the cylinder wall.

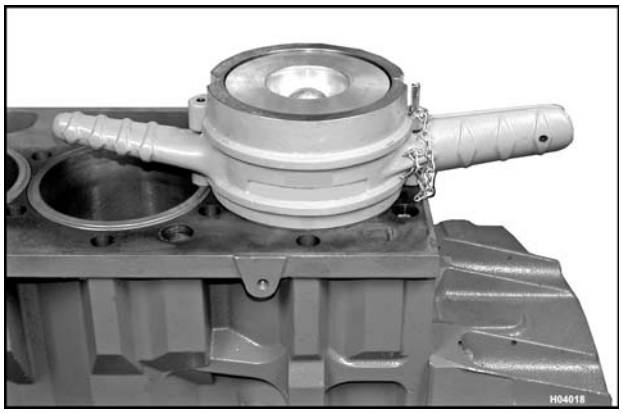

Figure 344 Installing the piston ring compression tool

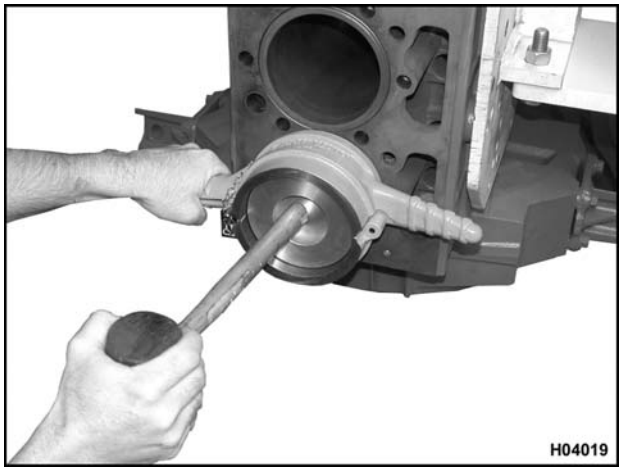

Figure 345 Installing the piston and connecting rod assembly

6. Carefully guide the piston and connecting rod assembly onto the crankshaft connecting rod journal.

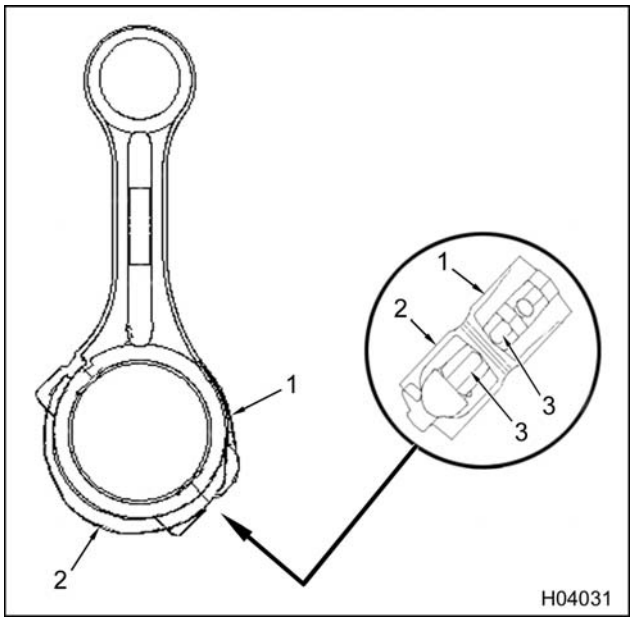

Figure 346 Matching serial number on connecting rod and connecting rod cap

1. Connecting rod
2. Connecting rod cap
3. Serial number

CAUTION: To prevent engine damage, install connecting rod cap and connecting rod with matching serial numbers on the same side. If the rod cap is reversed or not installed on its matching connecting rod, the fractured mating surfaces will be damaged. This can loosen the rod cap. A new connecting rod assembly must be installed.

The fractured mating surfaces of each rod and cap pair are precisely matched. Always keep each cap with its respective rod. If unsure, match the serial number on each connecting rod and connecting rod cap.

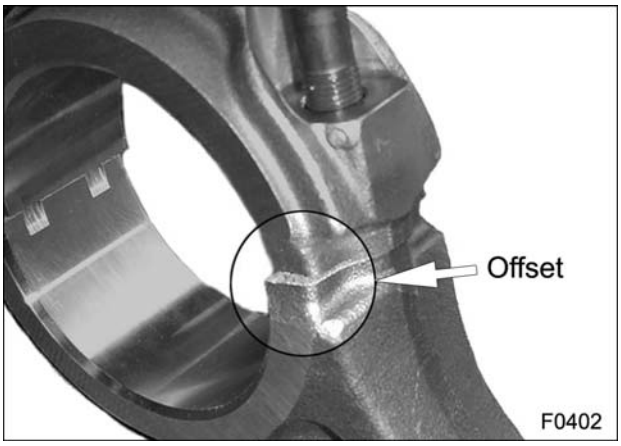

Figure 347 An offset indicates incorrect rod cap assembly

The rod cap can only be correctly installed on the connecting rod if it is oriented in the correct direction. If the rod cap is reversed during assembly of the connecting rod, an obvious offset will be seen at the mating surfaces. If the connecting rod assembly is installed on the crankshaft in this manner, the connecting rod must be replaced. Also check the crankshaft journal fillets for damage. Such damage will require replacement of the crankshaft.

7. Lubricate the inside diameter of the connecting rod cap bearing.

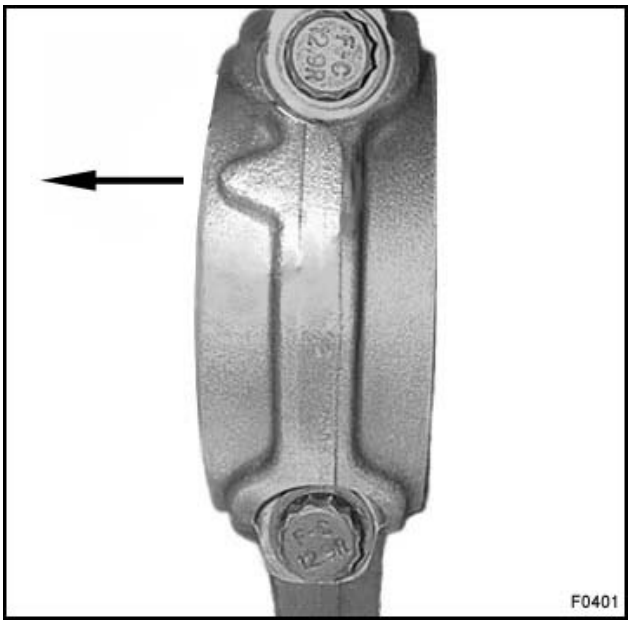

Figure 348 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

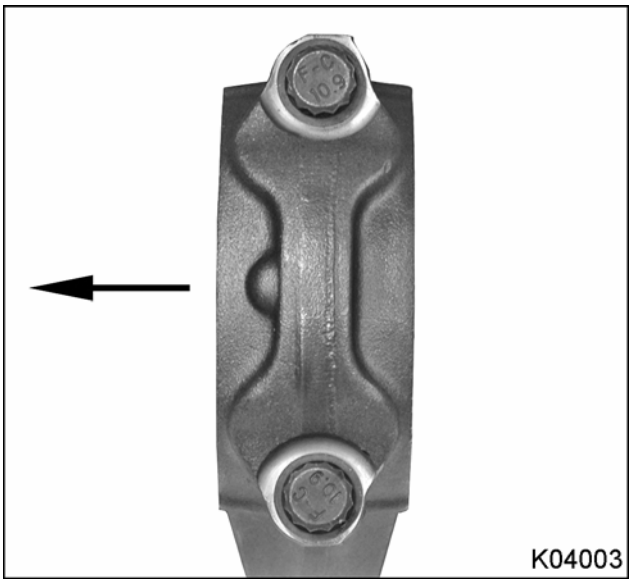

Figure 349 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

NOTE: Each rod end cap has a protrusion for correct orientation in the engine during installation. The protrusion must face toward the front of the engine.

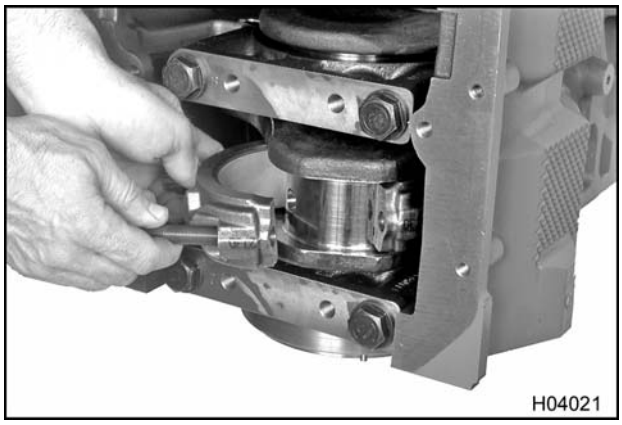

Figure 350 Installing the connecting rod cap

8. Carefully install connecting rod cap over the crankshaft journal and install two new M11 or M12 connecting rod cap bolts, depending on connecting rod version, finger tight.

Torque Procedure for Connecting Rods with M12 Bolts

CAUTION: To prevent engine damage, follow the connecting rod torque procedure for the specific connecting rods in the engine.

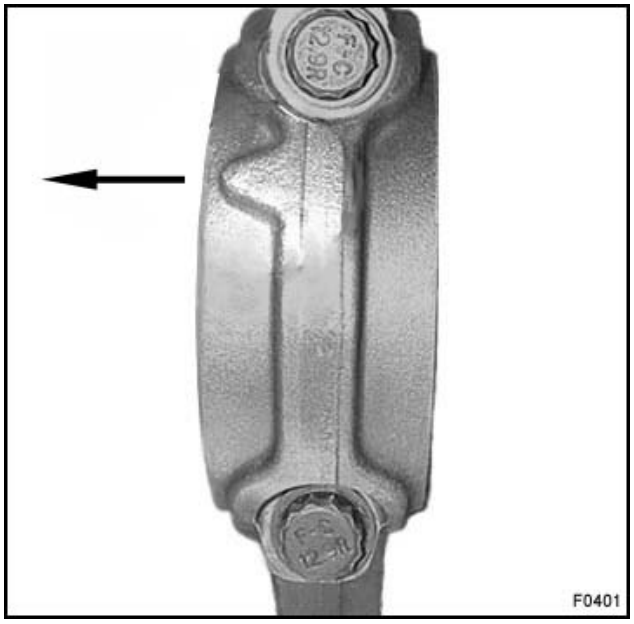

Figure 351 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

NOTE: If doing a bearing fit procedure, (Bearing Fitting Procedures and Bearing Running Clearance, page 225) tighten new M12 connecting rod cap bolts to 109 N·m (80 lbf·ft).

For final assembly, tighten new M12 connecting rod cap bolts to 163 N·m (120 lbf·ft).

Torque-to-yield Procedure for New Connecting Rod with M11 Bolts

CAUTION: To prevent engine damage, follow the connecting rod torque procedure for the specific connecting rods in the engine.

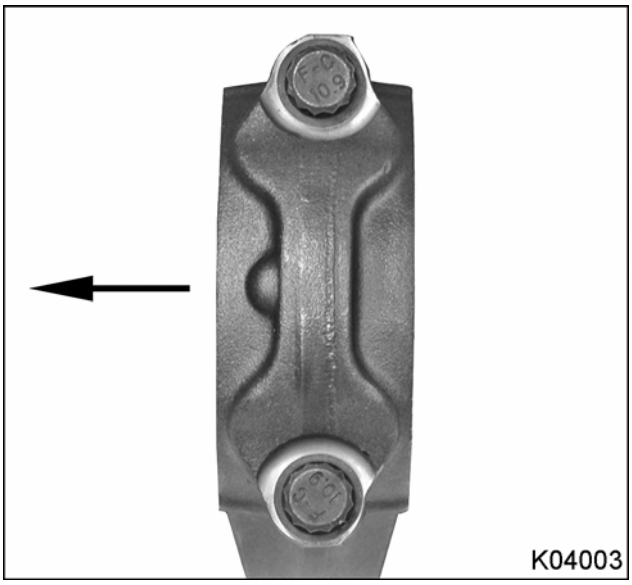

Figure 352 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

NOTE: If doing a bearing fit procedure (Bearing Fitting Procedures and Bearing Running Clearance, page 225), do not torque-to-yield connecting rod cap bolts. Tighten new M11 connecting rod cap bolts to 109 N·m (80 lbf·ft)

1. For final assembly, tighten new M11 connecting rod cap bolts to 41 N·m (30 lbf·ft).

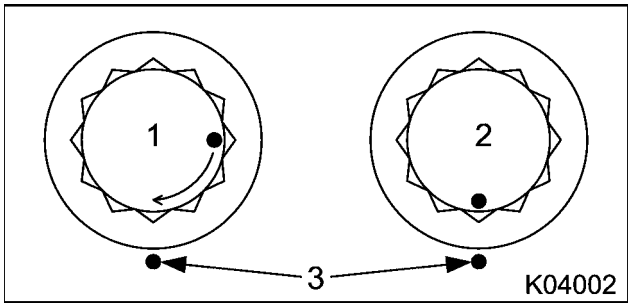

Figure 353 Torque-to-yield marks for M11 bolts

1. Connecting rod bolt with permanent marker spot (before torque-to-yield)
2. Connecting rod bolt with permanent marker spot (after torque-to-yield)
3. Permanent marker spot on connecting rod cap

CAUTION: To prevent engine damage, use permanent marker to identify internal engine components and their orientation. Do not use paint or temporary markers.

2. Using a permanent marker, mark each connecting rod bolt and put another mark on a 15 mm 12 point socket directly in line with the mark on each rod bolt.
3. Mark the surface of the connecting rod cap 90° clockwise from each mark on the rod bolt.
4. Align mark on socket with mark on the rod bolt and install socket on the rod bolt.
5. Torque-to-yield each M11 connecting rod cap bolt by rotating bolt exactly 90 degrees clockwise (1/4 turn). The mark on the socket and bolt should be aligned with the mark on the surface of the connecting rod cap.

Piston Cooling Tubes

Old Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

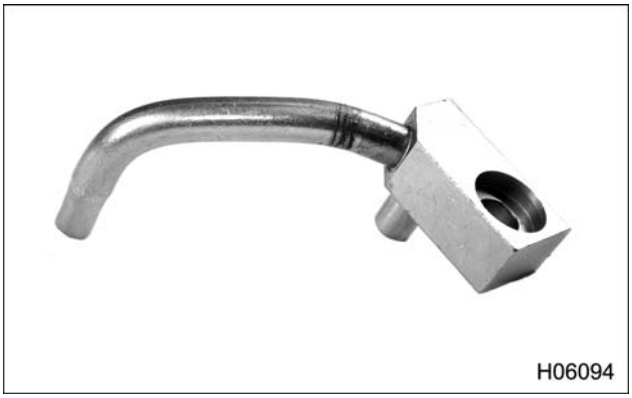

Figure 354 Old piston cooling tube

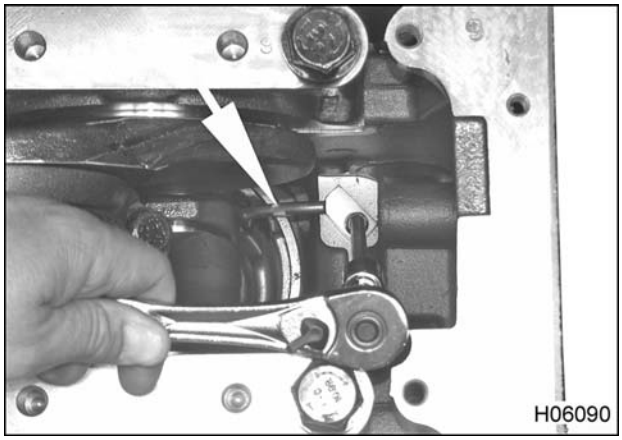

Figure 355 Old piston cooling tube

CAUTION: To prevent engine damage, the piston cooling tubes use a special patch type mounting bolt. Do not substitute.

NOTE: Piston cooling tubes are self aligning.

1. Place piston cooling tubes onto crankcase mounting pad.
2. When installing the piston cooling tube bolts (M6 x 16), do A or B below:
   A. Install **new** piston cooling tube mounting bolts (patch type).
   B. Remove oil residue, and apply Loctite® #242 to the threads of existing piston cooling tube mounting bolts (patch type), and install M6 x 16 bolts.
3. Tighten M6 x 16 bolts to the special torque value (Table 33).

New Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

CAUTION: To prevent engine damage, the correct piston cooling tubes must be installed.

NOTE: The non-knurled piston cooling tube is required for DT 466 engines. The knurled piston cooling tube is required for DT 570 and HT 570 engines.

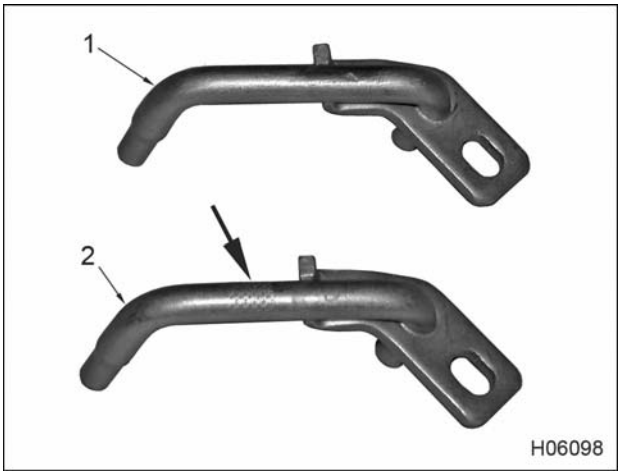

Figure 356 New piston cooling tubes

1. New piston cooling tube (non-knurled) – DT 466 engines
2. New piston cooling tube (knurled) – DT 570 and HT 570 engines

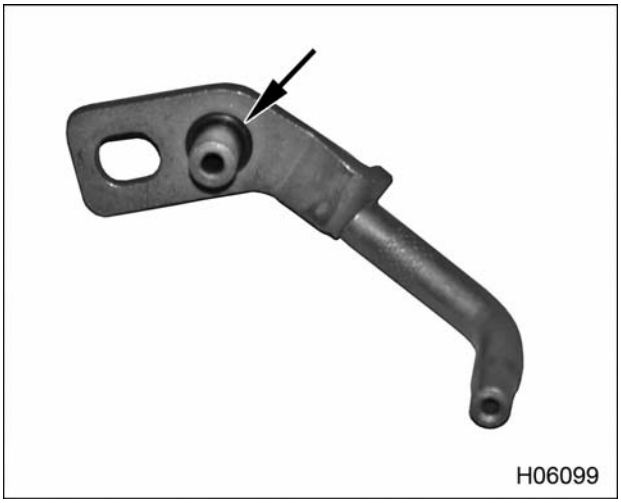

Figure 357 O-ring (underside) of new piston cooling tube

1. Put a new O-ring on each piston cooling tube.

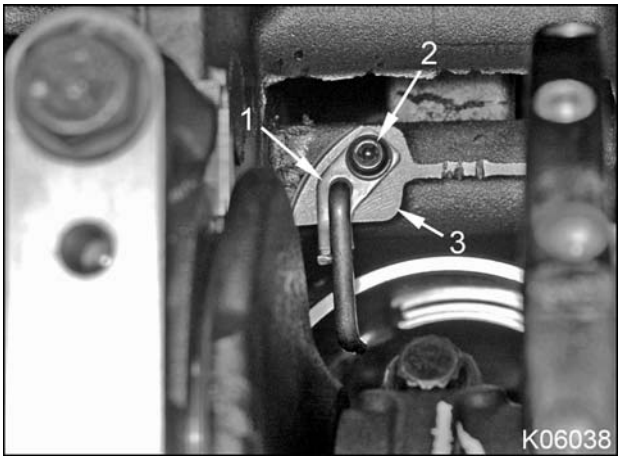

Figure 358 Installation of new piston cooling tube

1. Piston cooling tube (6)
2. M6 x 12 bolt (6)
3. Crankcase mounting pad (6)

NOTE: The new piston cooling tubes are self aligning.

2. Position piston cooling tubes on crankcase mounting pads.

CAUTION: To prevent engine damage, the piston cooling tubes use a special patch type mounting bolt. Do not substitute.

3. When installing the piston cooling tube bolts (M6 x 16), do do A or B below:
   A. Install **new** piston cooling tube mounting bolts (patch type).
   B. Remove oil residue, and apply Loctite® #242 to the threads of existing piston cooling tube mounting bolts (patch type), and install M6 x 12 bolts.
4. Tighten M6 x 16 bolts to the special torque value (Table 33).

Engine Run-In Procedure

⚠ WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

If new pistons or piston rings have been installed, do the following engine run-in procedure:

1. Run the engine at low idle with no load for 5 minutes. Check for leaks in the water, lube oil, fuel and air induction systems.
2. Check the turbocharger for any of the following conditions:
   - Unusual noise
   - Oil leaks
   - Air leaks
   - Excessive exhaust smoke
   - Excessive vibration
   - Loose mounting
3. Shut the engine off and correct any condition to prevent damage to the engine or turbocharger.
4. Start the engine and drive the vehicle (unloaded) for 25 minutes in city mode, then drive the vehicle (unloaded) for an additional 15 minutes in highway mode.
5. Return to idle and check for leaks.

Specifications

Table 28 Connecting Rod Specifications

Bend (max.)	0.06 mm (0.003 in)
Center-to-center distance between connecting rod bearing bore and piston pin bushing bore	219.4 - 219.5 mm (8.638 - 8.642 in)
Connecting rod bearing bore inside diameter	85.130 - 85.156 mm (3.3516 - 3.3526 in)
Connecting rod bearing inside diameter (installed)	80.05 - 80.10 mm (3.1518 - 3.1536 in)
Connecting rod bearing bore out-of-round (max.)	0.02 mm (0.00078 in)
Connecting rod bearing bore taper (max.)	0.02 mm (0.00078 in)
Connecting rod bearing running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod side clearance on crankshaft	0.13 - 0.48 mm (0.005 - 0.019 in)
Piston pin bushing inside diameter	46.393 - 46.401 mm (1.8265 - 1.8268 in)
Twist (max.)	0.05 mm (0.002 in)

Table 29 Piston Specifications

466 piston configuration	
Piston material	Aluminum alloy
Piston rings	
225 bhp and below	Top ring - keystone cross section Intermediate - rectangular cross section
230 bhp and above	Top ring - keystone cross section Intermediate - keystone cross section
570 piston configuration	
Piston crown	Steel crown, two-piece articulated
Piston skirt	Aluminum alloy
Piston rings	
All 570 series engines	Top ring – keystone cross section Intermediate – rectangular cross section
466 and 570 piston specifications	

Table 29 Piston Specifications (cont.)

Running clearance between piston and cylinder sleeve	**466 piston:** 0.076 - 0.128 mm (0.0030 - 0.0050 in)
	570 piston: 0.063 - 0.115 mm (0.0025 - 0.0045 in)
Skirt diameter	**466 piston:** 116.44 - 116.49 mm (4.584 - 4.586 in)
	570 piston: 116.48 - 116.51 mm (4.586 - 4.587 in)
Top compression ring groove width, 466 measure over 0.122 gauge pins	115.90 - 115.68 mm (4.563 - 4.554 in)
Top compression ring groove width, 570 measure over 0.126 gauge pins	116.74 - 116.50 mm (4.596 - 4.587 in)
Intermediate compression ring groove width (keystone shaped ring) measure over 0.110 gauge pins	115.92 - 115.73 mm (4.564 - 4.556 in)
Intermediate compression ring groove width (rectangular shaped ring), 466	3.05 - 3.03 mm (0.120 - 0.119 in)
Intermediate compression ring groove width (rectangular shaped ring), 570	3.05 - 3.03 mm (0.120 - 0.119 in)
Oil control ring, side clearance, 466	0.076 - 0.026 mm (0.0030 - 0.0010 in)
Oil control ring, side clearance, 570	0.080 - 0.030 mm (0.0031 - 0.0012 in)

Table 30 Piston Ring Specifications

Intermediate compression ring end gap	1.65 - 1.90 mm (0.065 - 0.075 in)
Oil control ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)
Top compression ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)

Table 31 Piston Pin Specifications

Clearance in piston	**466 piston:** 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	0.035 - 0.048 mm (0.0014 - 0.0019 in)
	570 skirt (vertical plane): 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	570 skirt (horizontal plane): 0.0280 - 0.0574 mm (0.00114 - 0.00226 in)
	570 crown: 0.038 - 0.053 mm (0.0015 - 0.0021 in)
Diameter	46.352 - 46.357 mm (1.8249 - 1.8251 in)
Length	96.57 - 96.82 mm (3.802 - 3.812 in)

Table 32 Cylinder Sleeve Specifications

Allowable variation of counterbore depth between four points (max.)	0.03 mm (0.001 in)
Counterbore depth before adding shims (max.)	10.49 mm (0.413 in)
Counterbore depth (including shims- if any)	8.84 - 8.89 mm (0.348 - 0.350 in)
Cylinder sleeve protrusion	0.05 - 0.13 mm (0.002 - 0.005 in)
Cylinder sleeve taper, at top of ring travel (max.)	0.10 mm (0.004 in)
Flange thickness	8.94 - 8.96 mm (0.352 - 0.353 in)
Inside diameter	114.50 - 116.60 mm (4.590 - 4.591 in)

Special Torque

Table 33 Connecting Rod Special Torque

Connecting rod bolts (verify connecting rod type)	See Torque Procedures for Connecting Rod with M12 Bolts (page241) or M11 Bolts (page241).
Piston cooling tube bolts, M6 x 12	13 N·m (115 lbf·in)
Piston cooling tube bolts, M6 x 16	13 N·m (115 lbf·in)

Special Service Tools

Table 34 Piston, Piston Ring, and Connecting Rod Special Service Tools

Counterbore cutting head	ZTSE25144A
Cylinder bore gauge	Obtain locally
Cylinder sleeve counterbore tool kit	ZTSE2514
Cylinder sleeve holding adapters (set of 3)	ZTSE4672
Cylinder sleeve puller	ZTSE2536
Dial indicator set	Obtain locally
EGR water coolant supply plate	ZTSE4648
Piston ring compressor tool	ZTSE4396
Piston ring expander	Obtain locally
Piston ring gauge pins (set of 3)	ZTSE4653
Telescoping gauge set	Obtain locally

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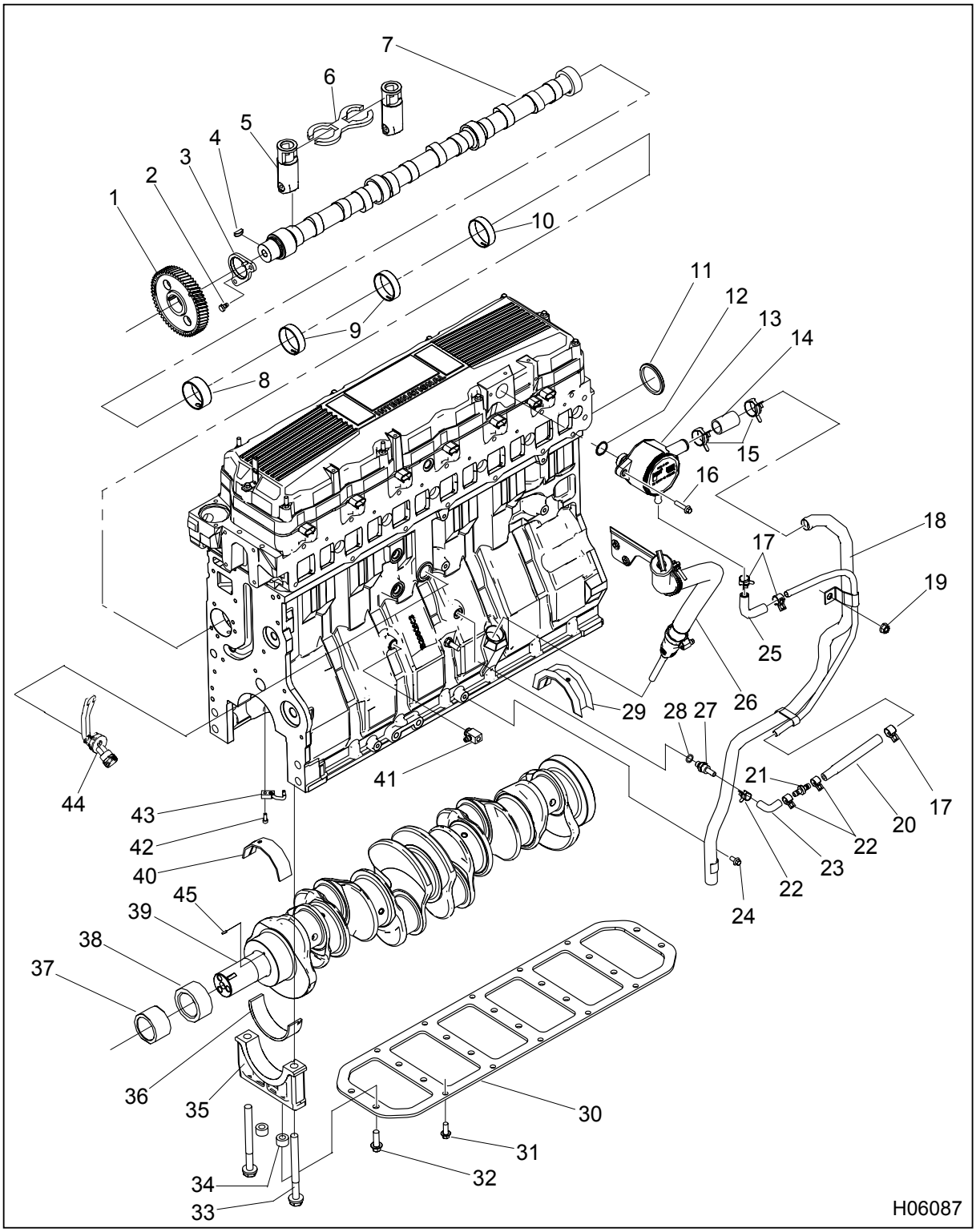

Figure 359 Crankcase, Crankshaft, and Camshaft

1. Camshaft gear assembly
2. Bolt, M8 x 20 (2)
3. Camshaft thrust plate
4. Key, 1/2 x 1/2
5. Roller tappet assembly (12)
6. Roller tappet guide (6)
7. Camshaft
8. Front camshaft bushing
9. Intermediate camshaft bushings (2)
10. Rear camshaft bushing
11. Camshaft seal ring, rear
12. O-ring, #214
13. Breather assembly
14. Hose, 1 in. I.D.
15. Clamp, 1 in. diameter (2)
16. Bolt, M8 x 35 (2)
17. Clamp, 1/2 in. diameter (3)
18. Vent and drain tube assembly
19. Nut, M10
20. Reducer hose
21. Check valve
22. Clamp (3)
23. Rubber elbow
24. Bolt, M8 x 16
25. Drain hose elbow
26. Oil level gauge assembly (Figure 361)
27. Fitting assembly, M12
28. O-ring seal
29. Main bearing, upper (#7 thrust)
30. Crankcase ladder (DT 570 >300 bhp)
31. Bolt, M10 x 25 (10)
32. Bolt, M12 x 35 (14)
33. Bearing cap bolt, M15 x 162 (14)
34. Spacer (14)
35. Main bearing cap (7)
36. Main bearing, lower (7)
37. Oil pump drive (spline)
38. Crankshaft gear
39. Crankshaft
40. Main bearing, upper (6)
41. Tee assembly, M12
42. Bolt, piston cooling tube (6)
43. Piston cooling tube assembly (6) (see “Power Cylinders”)
44. Block heater assembly (option)
45. Slotted pin, 5/32 x 5/16

Removal

Crankcase Ventilation System

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

WARNING: To prevent personal injury or death, disconnect ground (-) cable from battery before doing service or diagnostic procedures.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

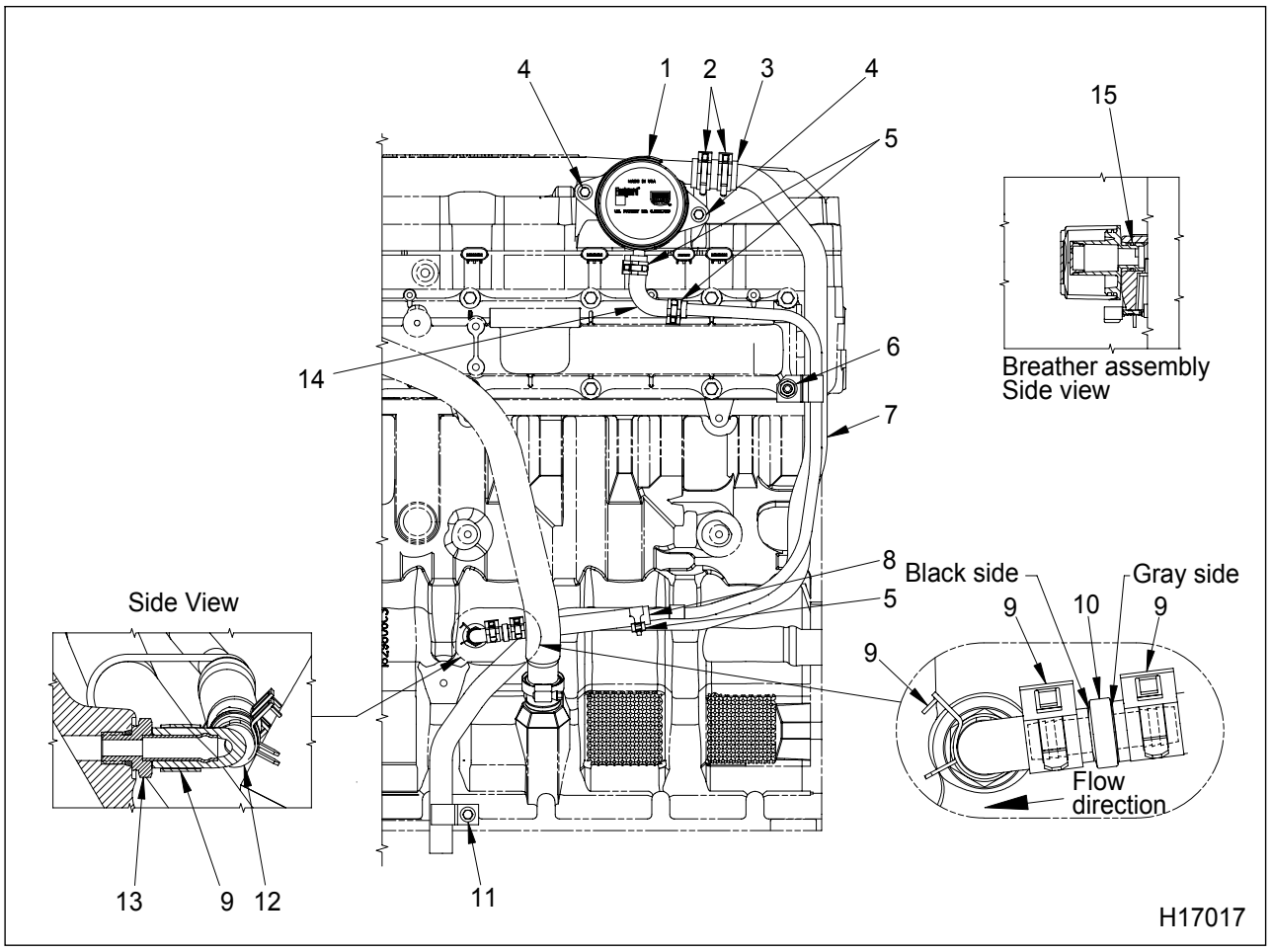

Figure 360 Crankcase ventilation system

1. Breather assembly
2. Clamp, 25.4 mm (1 in) diameter (2)
3. Hose, 25.4 mm (1 in) I.D.
4. Bolt, M8 x 35 (2)
5. Clamp, 1/2 in. diameter (3)
6. Nut, M10
7. Vent and drain tube assembly
8. Reducer hose
9. Clamp (3)
10. Check valve
11. Bolt, M8 x 16
12. Rubber elbow
13. Fitting assembly, M12
14. Drain hose elbow
15. O-ring, #214

NOTE: Have an oil pan handy before disconnecting the oil drain hose. It is possible for a column of oil to be maintained above the check valve, as the check valve does require a certain amount of pressure to allow passage of oil back to the crankcase.

To remove the crankcase ventilation system as an assembled unit, do the following steps.

1. Move clamp (1/2 in) out of way and remove reducer hose from vent and drain tube assembly. Allow tube and reducer hose to drain. Reconnect reducer hose and clamp.
2. Remove clamp and rubber elbow on the crankcase side of the check valve. Leave fitting assembly in crankcase unless evidence of leaking is occurring from fitting O-ring.
3. Remove the bolt (M8 x 16) securing the vent and drain tube assembly to the crankcase, located at the end of the vent tube.
4. Remove two bolts (M8 x 35) securing the breather assembly to the valve cover.

5. Remove the nut (M10) securing the vent and drain tube to the intake manifold.
6. Carefully pull breather assembly out of valve cover.
7. Remove breather and tubing assembly and place in solvent wash tank.

Oil Level Gauge

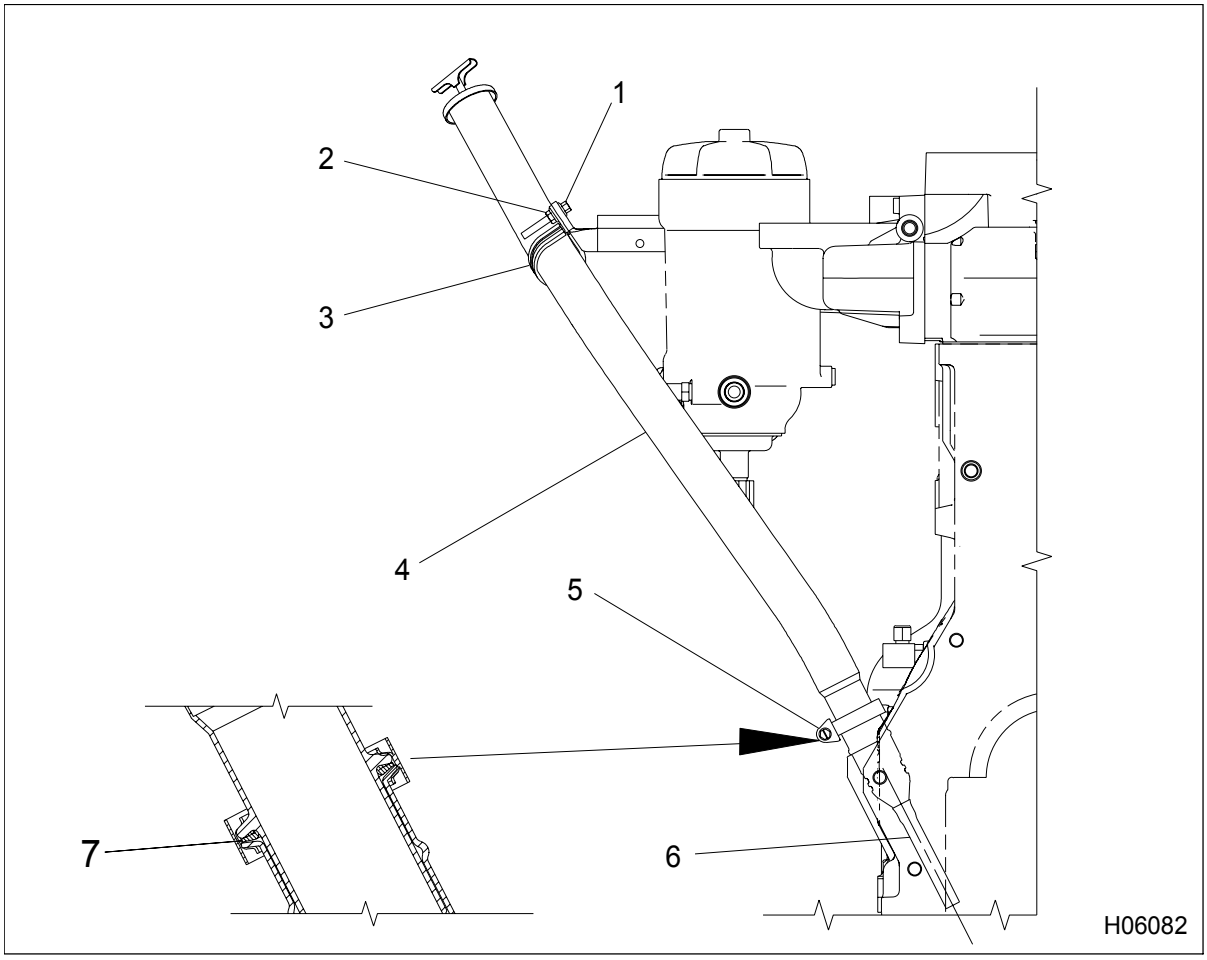

Figure 361 Oil level gauge assembly

1. Bolt, M6 x 40
2. Nut, M6
3. Cushioned clamp
4. Oil filler tube
5. Tube clamp
6. Oil level gauge tube
7. Oil dipstick tube seal

1. Remove the oil filler tube bolt (M6 x 40) and nut (M6) at the fuel filter bracket.
2. Remove the tube clamp at the crankcase and discard oil dipstick tube seal.
3. If necessary, remove oil level gauge tube from crankcase by using a brass drift and hammer.

Crankcase Ladder (DT 466 series – 225 hp and 245 hp @ 2600 rpm) and all 570 ratings

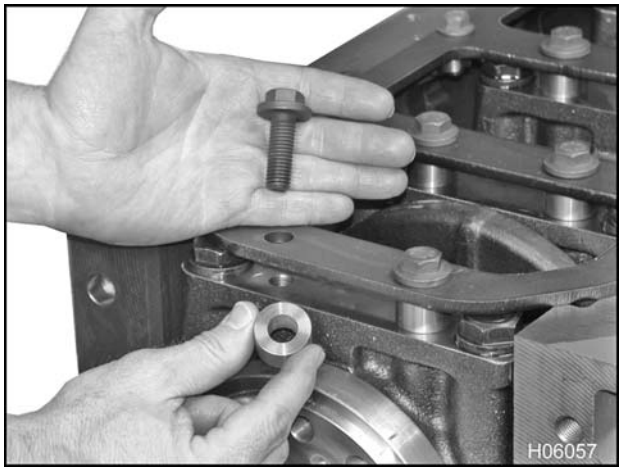

Figure 362 Crankcase ladder hardware

NOTE: Refer to the following for information regarding the removal or installation of these related components:

- Oil pan (Removing the Oil Pan, page206)
- Oil suction tube (Removing the Oil Suction Tube, page207)

1. Remove 14 crankcase ladder bolts (M12 x 35) and spacers.
2. Remove 10 crankcase ladder bolts (M10 x 25).

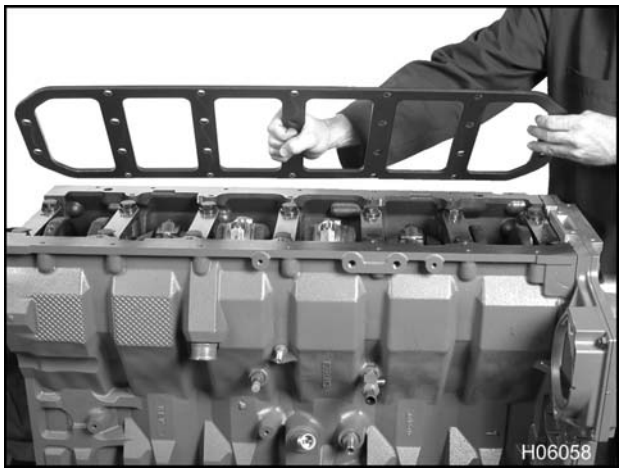

Figure 363 Removing the crankcase ladder

3. Remove the crankcase ladder.

Crankshaft Disassembly

NOTE: Before removing the crankshaft, it may be necessary to remove the piston assemblies (Removing Piston and Connecting Rod Assembly, page218).

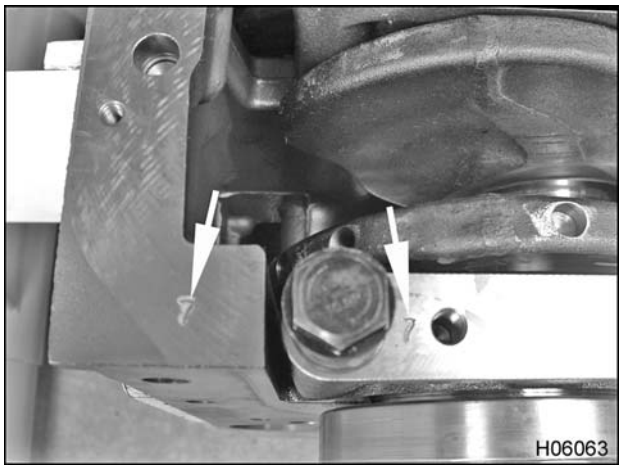

Figure 364 Main bearing cap identification stamps

1. Verify that the main bearing caps and crankcase are numbered. You may have to degrease accordingly to gain access to the stamped numbers.
2. Loosen all the main bearing bolts (M15 x 162).

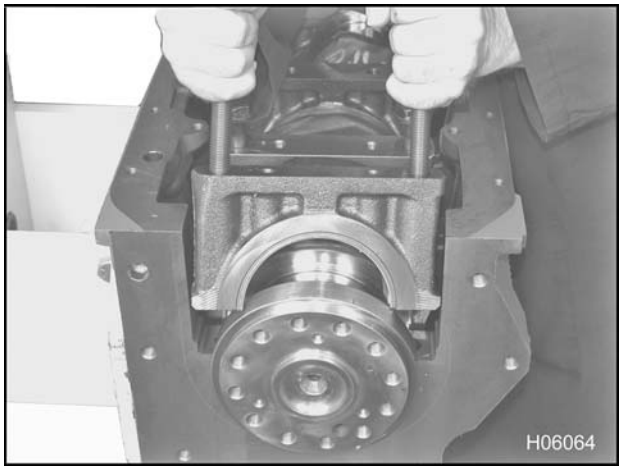

Figure 365 Removing the main bearings

3. Lift up both bolts until about half the threads are exposed. Use both bolts to rock main bearing cap free from crankcase.
4. Discard all of the removed main bearing bolts. These are not reusable due to the permanent stretch they received from “torque-to-yield”.

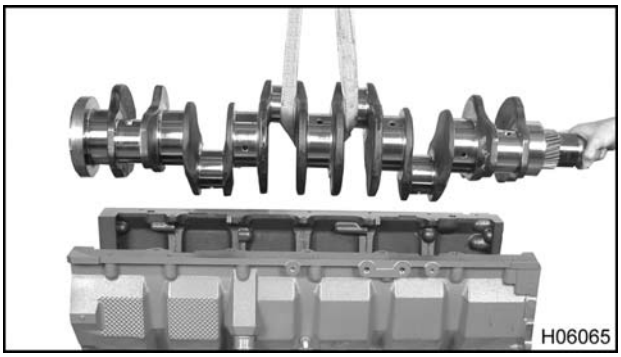

Figure 366 Removing the crankshaft assembly

5. Place an appropriately sized sling around the middle of the crankshaft and attach it to a hoist or crane. Lift crankshaft out of crankcase and place on workbench.
6. Visually inspect the crankshaft gears for chipping or wear. Replace as required.
7. Place a chisel between the gear teeth and strike the chisel with a hammer to split the gear.

Figure 367 Removing oil pump drive spline

8. Remove the oil pump drive first to access the crankshaft gear.
9. Be careful not to damage the crankshaft during gear removal.

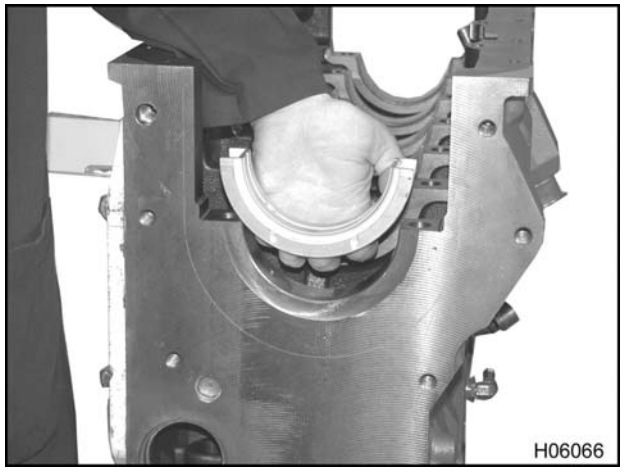

Figure 368 Removing the number seven upper thrust bearing

10. Remove upper main bearing shells by pushing them out of main bearing saddle with your thumbs. Mark the upper shells with bearing number and orientation. Set aside each upper bearing shell with the lower shells until a proper inspection can be done.

Cam Gear from Camshaft

NOTE: If removing the whole camshaft assembly, skip to next procedure.

1. Install gear puller making sure claws are positively engaged with cam gear and the threaded shaft is aligned with camshaft.

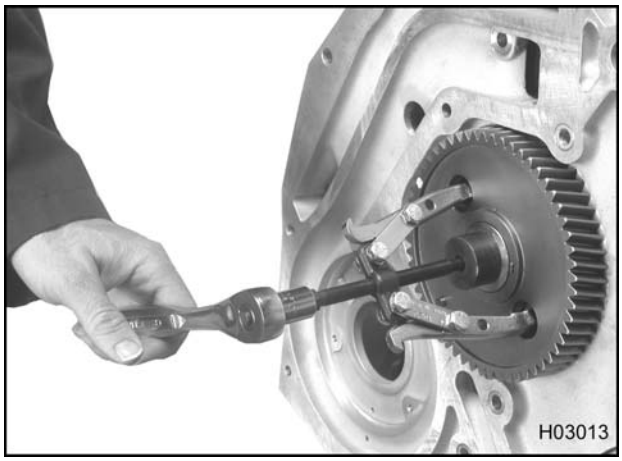

Figure 369 Removing camshaft gear

2. Using a socket or wrench apply force to tool until gear is just about off. Use both hands to remove cam gear and tool.

Camshaft Disassembly

NOTE: Use this procedure to remove the cam gear and camshaft as a unit.

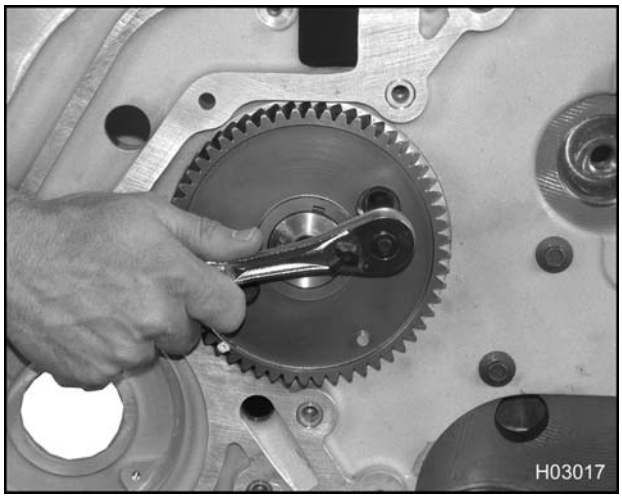

Figure 370 Removing camshaft thrust plate bolts

1. Remove the two camshaft thrust plate bolts (M8 x 20).

Figure 371 Removing the camshaft assembly

2. Carefully remove the camshaft assembly from the crankcase.

Camshaft Bushings

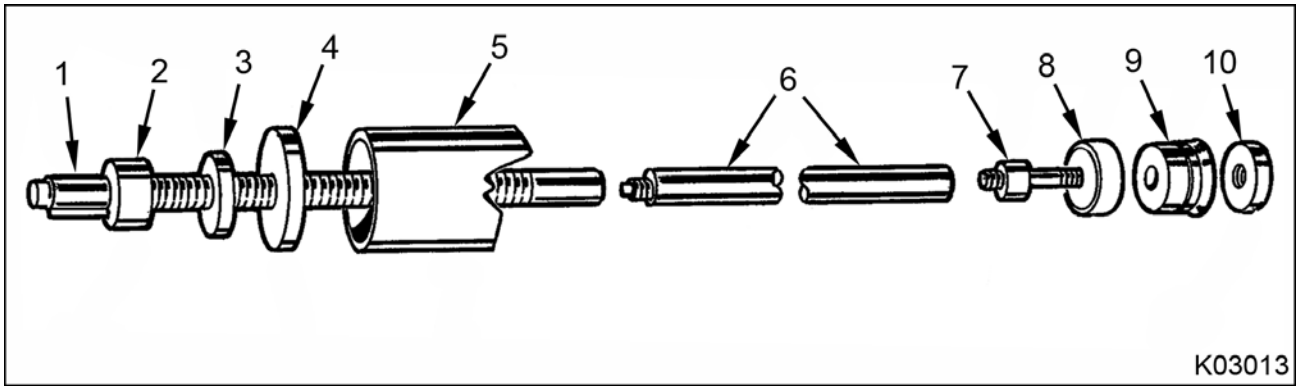

Figure 372 Camshaft Bushing Puller (installer)

1. Puller screw
2. Pulling nut
3. Thrust bearing
4. Pulling plate
5. Pulling spacer
6. Extension tube
7. Puller screw extension
8. Camshaft bearing (not part of tool)
9. Expanding collet
10. Backup nut

NOTE: Although the inside diameter of each camshaft bushing is the same, the outside diameters and widths are different depending on bearing location. The bearing diameters have changed from previous designs and this determines how bushing are removed and installed.

Table 35

Bushing Location	Outside Diameter (nominal)	Width (nominal)
Front	65.5 mm (2.50 in)	25.4 mm (1.00 in)
Rear	65.5 mm (2.50 in)	17.8 mm (0.70 in)
Intermediate	63.0 mm (2.48 in)	17.8 mm (0.70 in)

Remove the front and rear bushings (1) first. The rear bearing and camshaft seal ring **must** be removed from the rear of the crankcase. It is recommended that the intermediate bushings be removed according to the following illustration.

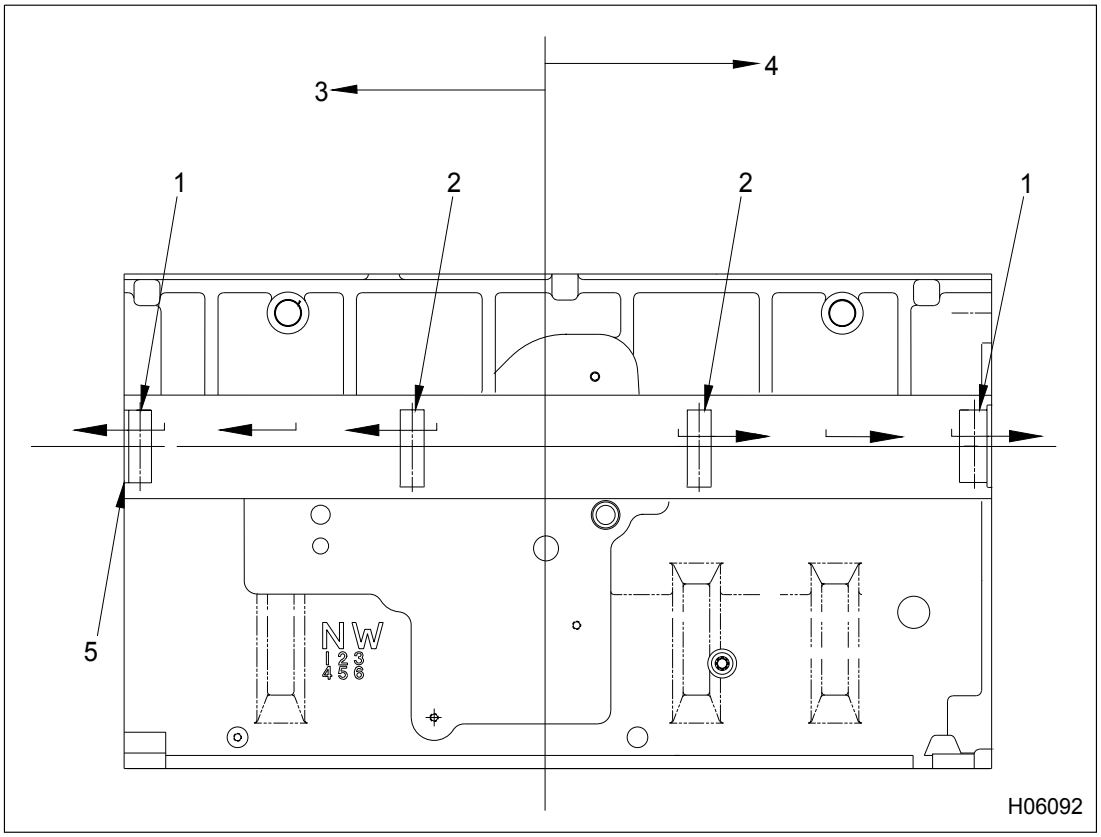

Figure 373 Pulling direction for camshaft bushing removal

1. Front and rear bushings
2. Intermediate bushings
3. Rear half of engine
4. Front half of engine
5. Camshaft seal ring

1. Assemble the correct expanding collet size and backup nut onto the expanding mandrel.
2. With the collet collapsed, install the collet assembly into the camshaft bushing. Tighten the backup nut onto the expanding mandrel until the collet fits the camshaft bearing.
3. Assemble the puller screw and extension, if necessary. Install the puller screw onto the expanding mandrel.
4. Hold the end of the puller screw with a wrench to keep it from turning. Tighten the pulling nut against the thrust bearing and the pulling plate until the camshaft bushing is removed.

Coolant Heater (if equipped)

1. Make sure coolant has been drained out of the engine or at least drained to a level below the coolant heater, if simply servicing the heater.
2. Loosen 5/32 in hex socket head cap screw sufficient to remove the coolant heater from the crankcase.
3. Clean out coolant heater cavity at crankcase.

Cleaning and Inspection

Cleaning the Crankcase

CAUTION: To prevent engine damage, the oil cooler must be replaced if there was a bearing failure. Debris from a bearing failure cannot be removed from the oil cooler.

NOTE: The best way to clean the crankcase during engine overhaul is in a chemical bath or hot tank. This removes all carbonaceous material and mineral deposits that collect in the cooling passages. If the hot tank is not available, use the following cleaning procedure.

1. Clean all old gasket material from the surfaces of the crankcase, if any.

Figure 374 Removing crankcase plugs

2. Remove the main oil gallery cup plug, located at the rear of the crankcase by using a hammer and chisel. Knockout main oil gallery cup plug.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

3. With the plugs removed from the crankcase, clean the crankcase as follows:
   a. Use a nylon brush (Table 40) with soap and water to clean oil galleries.
   b. Clean cross drillings using a nylon brush (Table 40) with soap and water.
   c. Use filtered compressed air to blow out oil galleries and cross drillings.
   d. Clean all threaded holes with an appropriately sized tap (Table 40).
4. Install a new main oil gallery cup plug as follows:
   a. Clean the mating surfaces of the plug and crankcase.
   b. Apply Loctite® 262 to the outside edge of the cup plug.
   c. Use an arbor to drive the cup plug in. The arbor must be approximately 6 mm (1/4 in) smaller in diameter than the plug that is being installed.
   d. Recess the cup plug 3.2 mm (1/8 in).
5. Install new plugs in the rear of the crankcase.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

6. Inspect the piston cooling tubes for damage and blockage as follows:
   a. Inspect both ends of the tube. Verify that the flanged end next to the bearing saddle is intact and the orifice end protruding from the crankcase is not broken. Replace any tubes that are damaged.
   b. Hold tube under running water in a sink. Water should stream out of tube end. If not, blockage will have to be physically removed by compressed air or piston oil tube must be replaced.

Crankcase Ventilation

1. Place breather and tubing assembly (Figure 360) into a solvent parts cleaner and disassemble.
2. Thoroughly clean all hoses, clamps, tubing, check valve and breather assembly. Run solvent through each end of the check valve to confirm directional flow.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

3. Blow dry with filtered compressed air.
4. Inspect all rubber hoses for cracking or deformation. Replace components as necessary.

Crankshaft and Main Bearings

Perform the following steps:

1. Clean the bearing inserts and caps thoroughly in solvent and dry with filtered compressed air . **Do not scrape gum or varnish deposits from bearing shells**.
2. Clean all the internal oil passages of the crankshaft using a stiff nylon brush (Table 40). Loosen all dirt, sludge and deposits which may have accumulated. Flush the oil passages with a suitable non-caustic solvent.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

3. Blow passages dry with filtered compressed air .
4. Inspect the crankshaft journals (main and rod) for scratches, grooves and scoring. Use dye penetrant methods to check for cracks.
5. Inspect all bearing inserts. Replace bearings that are scored, chipped or worn.

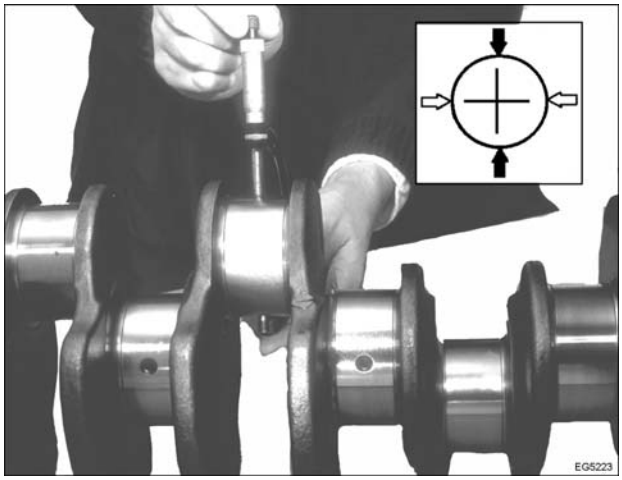

Figure 375 Inspecting the crankshaft journals

6. Measure the diameter of each journal using a micrometer. Measure each journal at two points, right angles to each other. Move the micrometer over the entire width of the journal.

NOTE: If journals exceed maximum out-of-round specification, crankshaft must be reground or replaced. The crankshaft can be ground to the following undersizes:

- 0.25 mm (0.010 in)
- 0.51 mm (0.020 in)
- 0.76 mm (0.030 in)

Checking Camshaft Assembly

1. Use a soft bristle brush and a suitable solvent to clean the camshaft and cam gear.
2. Inspect the cam gear for worn and damaged teeth. Replace the gear assembly, if necessary.
3. Inspect the camshaft for scuffed, scored and cracked lobes. Replace the camshaft if necessary.
4. Inspect the camshaft thrust plate for wear, cracks, and distortion. Use an outside micrometer to measure the thickness of the thrust plate. If the thrust plate is too worn or damaged, replace the thrust plate.

Checking Camshaft Lobes and Journals

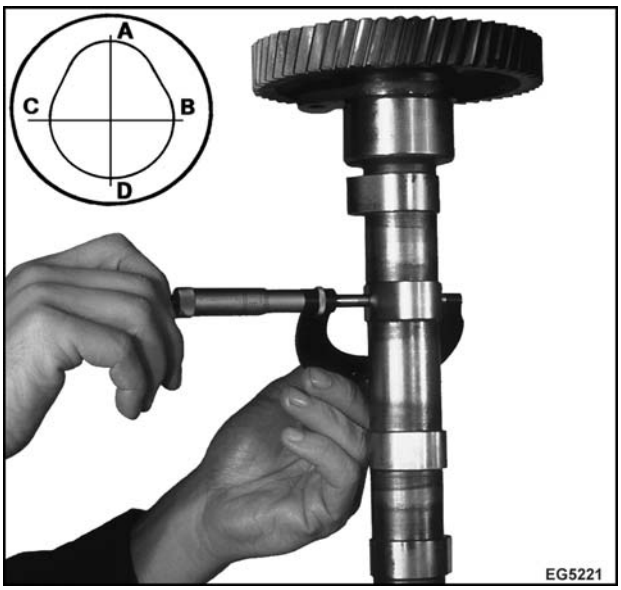

Figure 376 Checking camshaft lobes and journals for wear

1. Use an outside micrometer to measure across each camshaft lobe from A-D and B-C. Subtract measurement B-C from measurement A-D. This is the cam lobe lift.

   If any measurement exceeds the specification, replace the camshaft.

2. Use an outside micrometer to measure the diameter of each camshaft journal.

   If any measurement exceeds the specification (Table 38), replace the camshaft.

Installation

Coolant Heater (if equipped)

1. If servicing a leaky coolant heater, replace O-ring on heater assembly.
2. Place nonpetroleum base lubricant around O-ring area and install into crankcase. Orient electrical connector so that it is facing downward (6 o'clock position).
3. Tighten the 5/32 in hex socket head cap screw to the special torque value (Table 39).
4. Replenish coolant level if only servicing coolant heater.

Camshaft Bushings

1. Identify each camshaft bushing according to its outside diameter.

Table 36

Bushing Location	Outside Diameter (nominal)	Width (nominal)
Front	65.5 mm (2.50 in)	25.4 mm (1.00 in)
Rear	65.5 mm (2.50 in)	17.8 mm (0.70 in)
Intermediate	63.0 mm (2.48 in)	17.8 mm (0.70 in)

2. Lubricate each new camshaft bushing and crankcase bushing bore with clean engine oil.

Figure 377 Camshaft bushing installation tool

3. Install new camshaft bearing onto the expanding collet. Tighten collet by turning adjusting nut until the bushing is held securely in place.

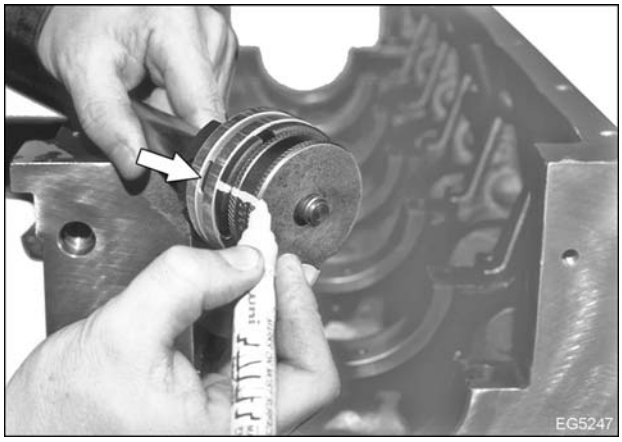

Figure 378 Marking oil hole location on bushing

4. Mark the bearing oil hole location on the backup nut of the installation tool to help align the oil hole in the bushing with the oil hole in the crankcase. Repeat this step for each bushing.

CAUTION: To prevent engine damage, camshaft bushings must be installed in the proper order due to differing outside diameters. Both intermediate cam bushings have an outer diameter that is slightly smaller than bushings used in the front and rear positions.

Cam bearings oil holes must align with oil holes in cylinder block.

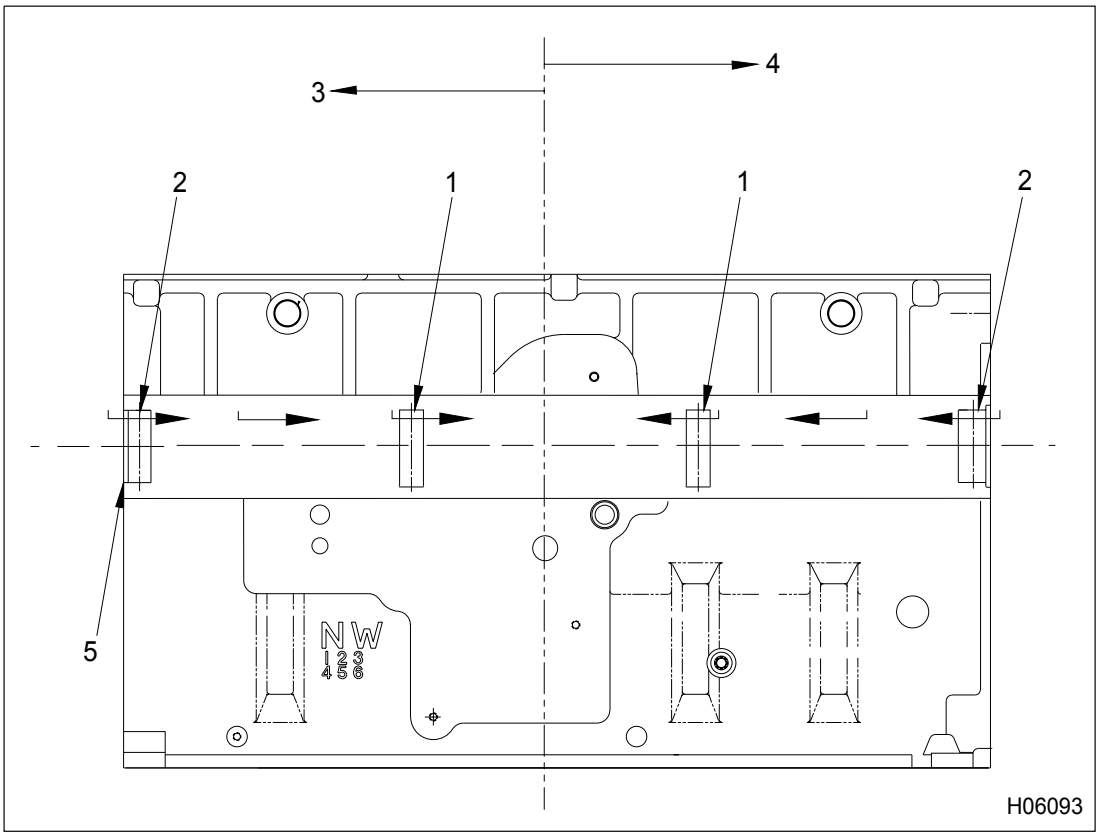

Figure 379 Pulling direction for camshaft bushing installation

1. Intermediate bushings
2. Front and rear bushings
3. Rear half of engine
4. Front half of engine
5. Camshaft seal ring

5. Install the rear intermediate bushings through the rear of the crankcase. Pull the bushing into place from the front of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
6. Install the front intermediate bushing through the front of the crankcase. Pull the bushing into place from the rear of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect oil hole alignment.

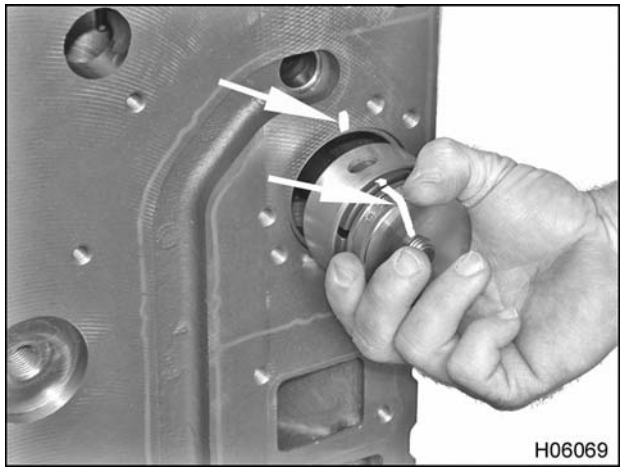

Figure 380 Paint marks indicating oil hole alignment

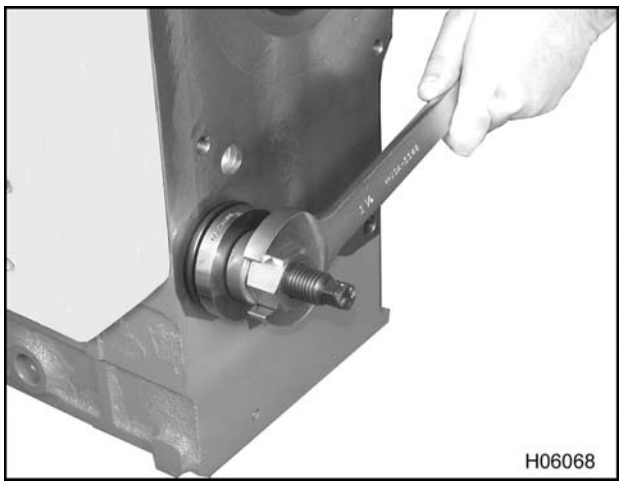

Figure 381 Pulling in the front bushing

7. Install the front bushing through the front of the crankcase. Pull the bushing into place from the rear of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
8. Install the rear bushing through the rear of the crankcase. Pull the bushing into place from the front of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
9. Install camshaft seal ring in rear of crankcase.

Camshaft Assembly

NOTE: Use this procedure to install the cam gear and camshaft as a unit.

Figure 382 Installing camshaft assembly

1. Rotate crankcase to a vertical position.
2. Lubricate all camshaft journals and bushings with clean engine oil.
3. Install the camshaft assembly in the crankcase.

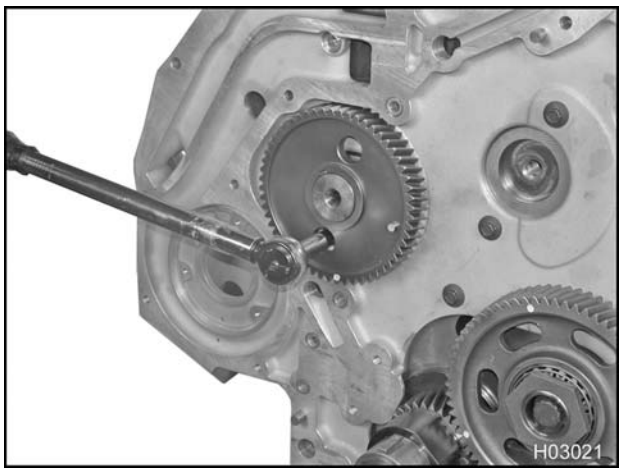

Figure 383 Torquing camshaft thrust plate bolts

4. Install the two camshaft thrust plate bolts (M8 x 20). Tighten the bolts to the special torque value (Table 39).

Cam Gear on Camshaft

WARNING: To prevent serious personal injury or possible death, wear heat resistant gloves when handling heated components.

Figure 384 Heating the camshaft gear

CAUTION: To prevent engine damage, do not heat the cam gear above 177 °C (350 °F). This will turn the gear blue and reduce wear resistance. Do not use any gear turned blue.

1. If the camshaft gear was removed from the camshaft, heat the cam gear on a hot plate (Table 40) or other controlled heat source to 149-177 °C (300-350 °F).
2. Pull camshaft assembly forward prior to sliding heated gear onto camshaft.

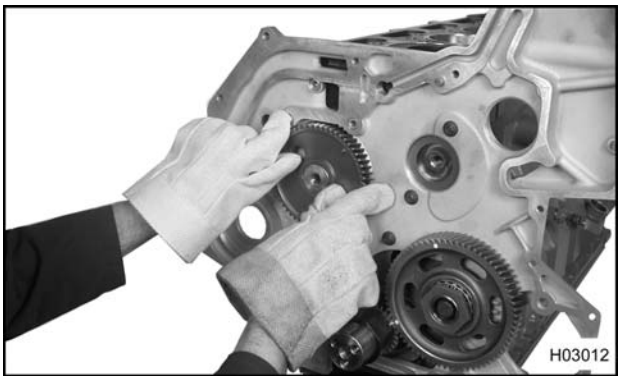

Figure 385 Installing cam gear on camshaft

3. Use heat resistant gloves to install the heated cam gear onto the camshaft. The cam gear should slide onto the camshaft with only slight hand pressure. Hold the cam gear (while thoroughly seated) until it cools onto the camshaft (approximately 30 seconds).

NOTE: Heated gear should easily slide onto camshaft. Do not tap into place to avoid camshaft end play issues. If gear does not slide easily, reheat gear and try again.

Checking Camshaft End Play

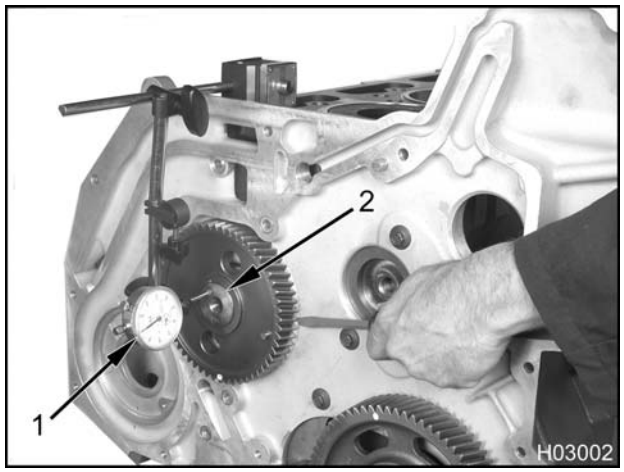

Figure 386 Checking camshaft end play

1. Dial indicator set
2. Camshaft

1. Mount magnetic base of a dial indicator set (Table 40) on a flat engine surface.
2. Place the tip of the dial indicator on the end of the camshaft and zero the dial indicator.
3. Use a screwdriver to pry the camshaft gear back and forth. Record the reading on the dial indicator.

   If the end play exceeds the specification, remove the cam gear and pull the camshaft forward. Repeat the procedure.

Crankshaft Assembly

1. Rotate the engine so the main bearing saddles are facing up. Clean the bearing saddles with a lint-free cloth. The supports must be free of oil. Do not lubricate the back side of the bearing inserts.

WARNING: To prevent serious personal injury or possible death, wear heat resistant gloves when handling heated components.

2. With gears removed, heat the crankshaft gear and oil pump drive spline, using a hot plate (Table 40), to 188-202 °C (370-395 °F).
3. Position the slotted locating pin (5/32 x 5/16) onto the crankshaft.

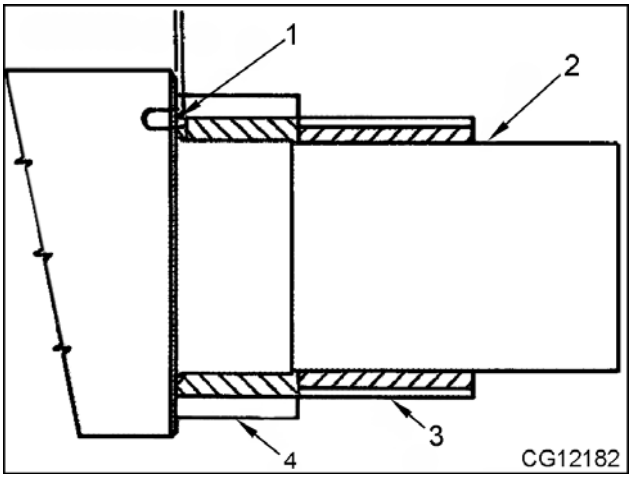

Figure 387 Installing crankshaft gear

1. Slotted pin, 5/32 x 5/16
2. Crankshaft
3. Oil pump drive spline
4. Crankshaft gear

4. Using gloves specifically designed for extremely hot objects, install heated crankshaft gear first, aligning the slotted pin with hole in crankshaft gear. Press the gear into place holding against crankshaft shoulder.
5. Slide the hot oil pump drive (splined) up against the crankshaft gear (no orientation required).
6. Hold oil pump drive and crankshaft gear in place until cool enough to sufficiently hold onto crankshaft.

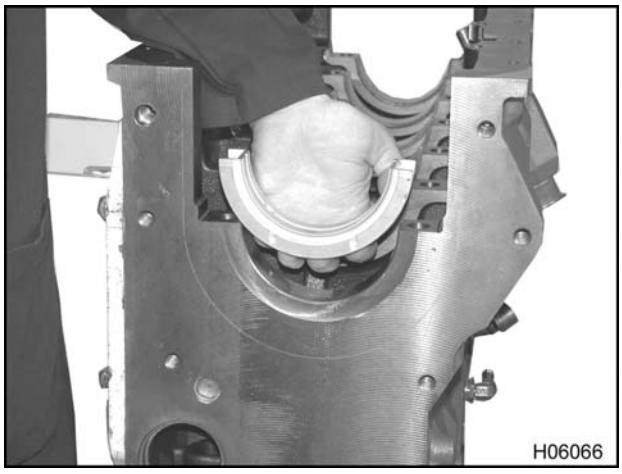

Figure 388 Installing the number seven thrust bearing

7. Install the thrust bearing into the number seven upper bearing saddle. Make sure the locking tangs on the bearings are snapped into the crankcase.
8. Install the remaining six upper bearing inserts into the saddles. Make sure the locking tangs on the bearings are snapped into the crankcase.
9. Apply Prussian Blue® to the crankshaft main bearing journals.

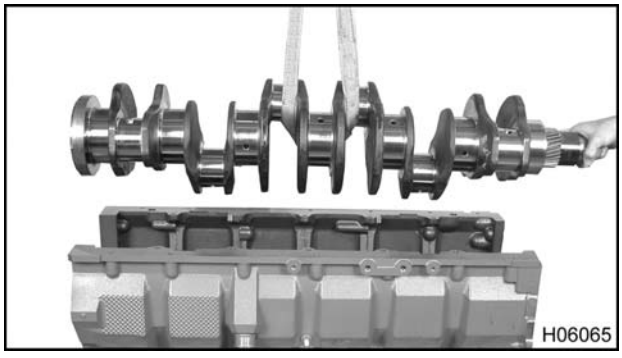

Figure 389 Installing the crankshaft assembly

10. Using an appropriate lifting sling, carefully lower the crankshaft onto the main bearing inserts in the crankcase.

NOTE: Do not install the main bearing caps and lower bearing inserts at this time.

11. Rotate the crankshaft 180 degrees (1/2 turn).

12. Carefully remove the crankshaft and inspect the upper bearing inserts for an even transfer of bluing agent from the journals to the bearings.

NOTE: If voids appear in the bluing transfer, crankcase integrity is considered questionable.

13. If the crankcase is not damaged and is free of distortion and burrs around upper bearing insert seats, then clean all Prussian Blue® from the bearings and crankshaft journals.

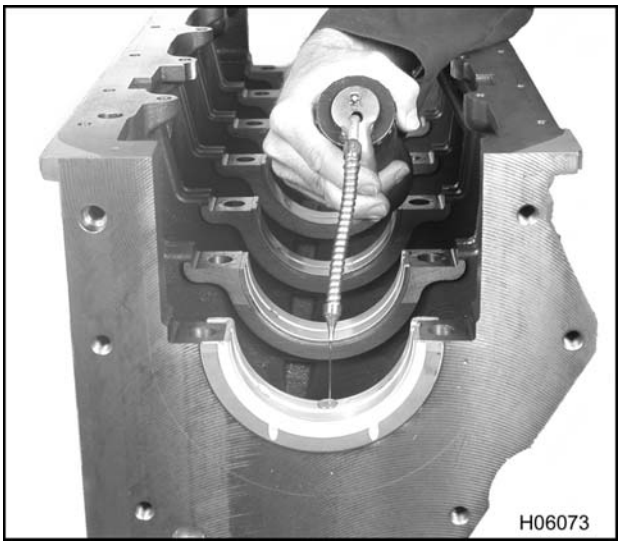

Figure 390 Lubricating the upper main bearing inserts

14. Lubricate the upper main bearing inserts with clean engine oil.

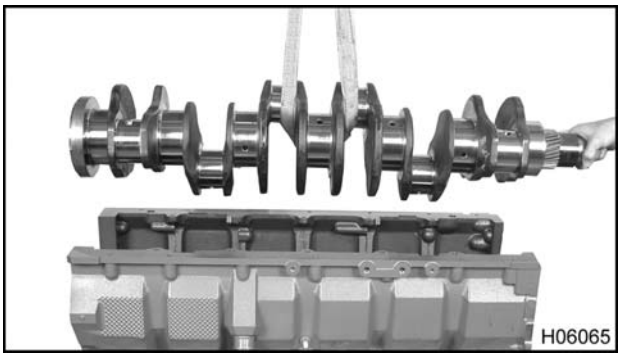

Figure 391 Installing the crankshaft assembly

15. Using an appropriate lifting sling, carefully lower the crankshaft onto the main bearings.

Bearing Fitting Procedure

1. Install a new bearing insert into the bearing cap, as required. The bearing surface of the bearing caps must be free of oil. Do not lubricate the backside of the bearing inserts. Make sure the locking tangs on the bearing inserts are snapped into the bearing cap notch.

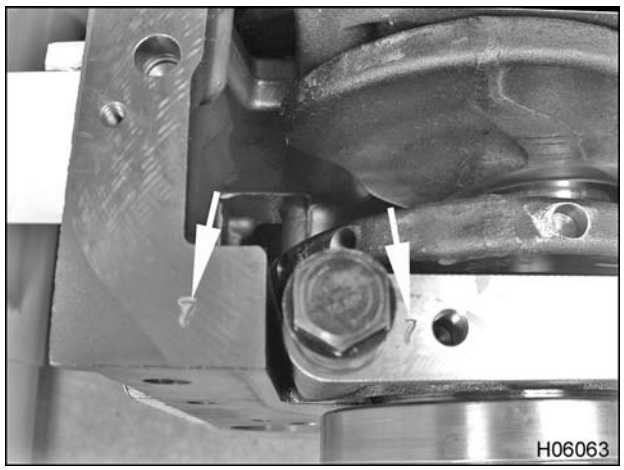

Figure 392 Main bearing cap identification stamps

2. Align each main bearing cap with its identification stamp.
3. Check bearing clearance as follows:
   a. Clean the bearing surface and the exposed half of the crankshaft journal. Make sure these surfaces are free of oil.
   b. Install the lower inserts and bearing caps. Oil the threads of new main bearing bolts with clean engine oil.
   c. Torque bolts in the following steps in a circular pattern.

      NOTE: This two step torque procedure to 177 N·m (130 lbf·ft), simply checks bearing fit and will not permanently stretch the new main bearing bolts. Do not follow the torque-to-yield procedure until final assembly.

      1. Tighten each main bearing bolt to 136 N·m (100 lbf·ft) using the recommended torque sequence (Figure 395).

2. Tighten each main bearing bolt to 177 N·m (130 lbf·ft) using the recommended torque sequence (Figure 395).

d. Remove one bearing cap and insert at a time. Leave the remaining caps tight while checking the fit of the bearing with the cap removed.

e. Wipe oil from all contact surfaces of the exposed journal, bearing insert and cap that is removed.

f. Place a piece of Plastigage® across the full width of the bearing surface on the crankshaft journal (or bearing insert) approximately 6 mm (¼ in) off center. Install the bearing cap and tighten the cap bolt to 177 N·m (130 lbf·ft).

NOTE: Do not turn the crankshaft.

NOTE: In chassis service only: When bearing oil clearance is checked, the crankshaft will have to be supported and held against the upper main bearing halves to get a correct Plastigage® reading. Use a jack at the crankshaft counterweight nearest to each main bearing being checked to apply local support. Failure to support the crankshaft will result in inaccurate readings.

g. Remove the bearing cap and insert.

h. Do not disturb the Plastigage®. Use the scale on the Plastigage® envelope to measure the widest point of the flattened Plastigage®. This reading indicates the bearing clearance in thousandths of an inch or millimeters.

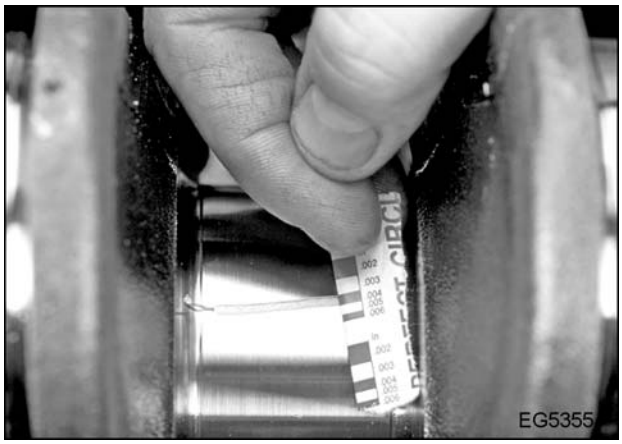

Figure 393 Measuring widest point of flattened Plastigage®

i. If the bearing clearance is not within specifications, the crankshaft must be replaced or reground and undersize bearings installed.

Main Bearings and Caps

CAUTION: To prevent engine damage, use new main bearing cap bolts whenever the bearing caps are serviced.

NOTE: The thrust bearing located at number 7 is found only in the upper half. All seven lower bearings share the same part number.

1. Clean the Plastigage® from main bearing and or crankshaft journal surfaces.
2. Coat all bearing surface journals with clean engine oil.
3. Apply clean engine oil to main bearing bolts (threads and under head).
4. Place the No. 1 through No. 7 main bearing caps with the lower bearing inserts installed.

NOTE: Make sure the main bearings are installed with the arrow pointing to the cam side and numbered from the front of the engine to the rear.

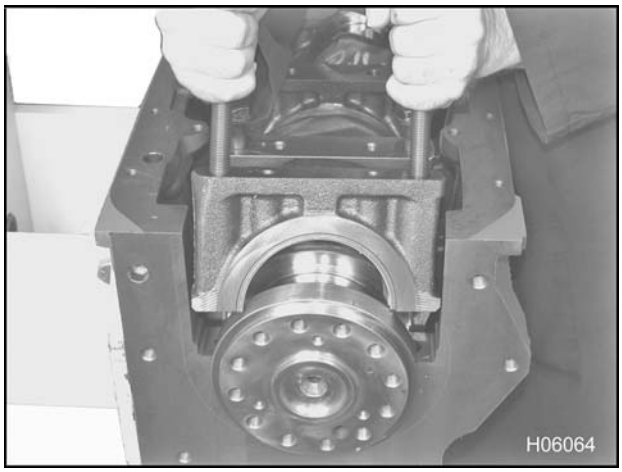

Figure 394 Installing the main bearing caps

5. Align and seat each of the main bearing caps.

Torque Procedure for Torque-to-Yield Main Bearing Bolts

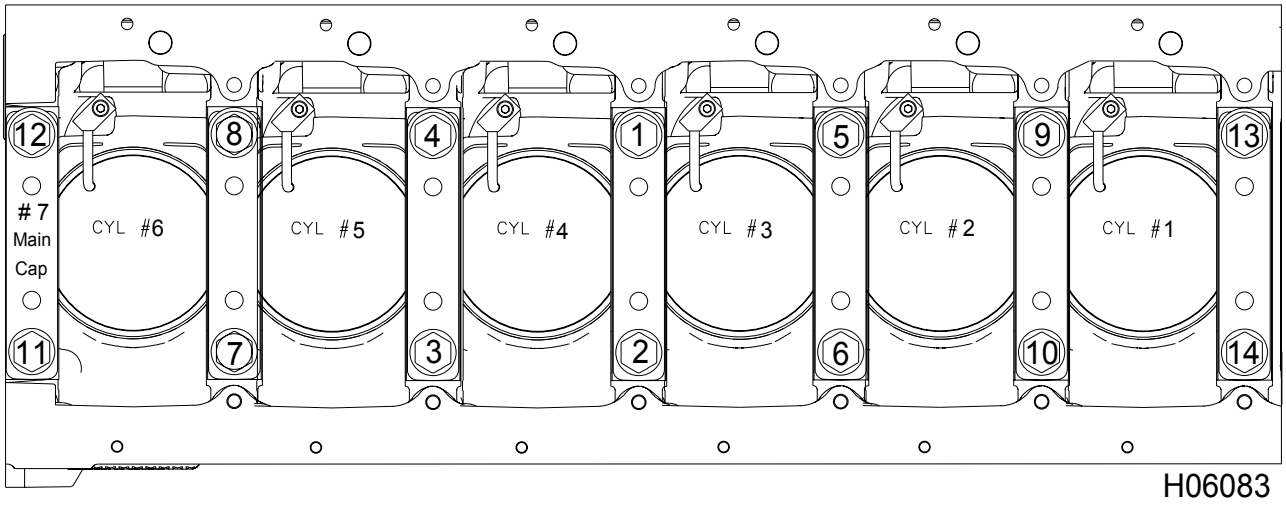

Figure 395 Recommended main bearing bolt torque sequence

1. Torque new bolts for main bearing caps 1 through 7.
   a. Tighten each main bearing bolt to 136 N·m (100 lbf·ft) using the recommended torque sequence.

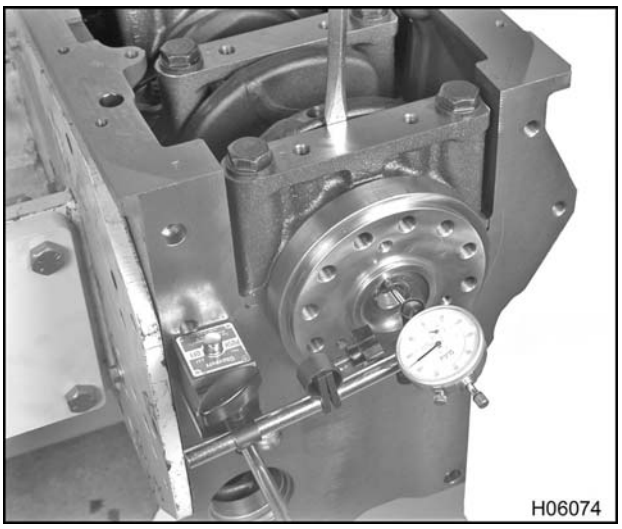

Figure 396 Checking crankshaft end play

   Check crankshaft end play using a dial indicator as follows:
   1. Mount the dial indicator onto crankcase with indicator tip on crankcase flange face.
   2. Lightly pry the crankshaft forward and zero indicator.
   3. Pry crankshaft rearward and record dial indicator reading. Repeat to ensure an accurate reading.
   4. If end play exceeds specifications, replace thrust bearing and recheck crankshaft end play. If end play is less than specified, loosen the thrust bearing cap, reposition, torque and check end play again.

   b. Tighten each main bearing bolt to 177 N·m (130 lbf·ft) using the recommended torque sequence.

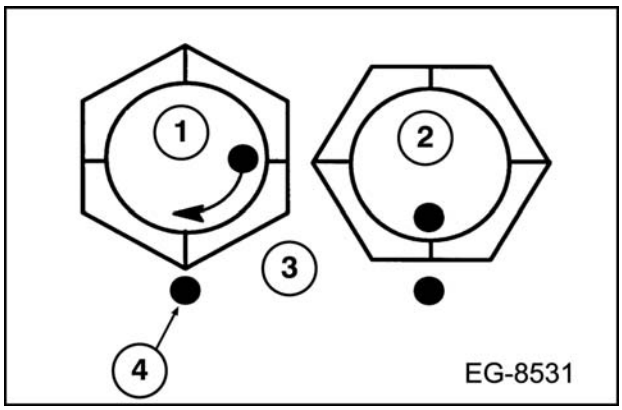

Figure 397 Crankshaft main bearing bolt

1. Head of bolt with mark, position 1
2. Head of bolt with mark, position 2 (bolt stretches)
3. Main cap surface
4. Mark (permanent marker)

c. Use a permanent marker to add a mark on each bolt head and another mark 90° clockwise on the main cap. Also mark the socket to match the bolt marking.

d. Rotate each crankshaft main bearing bolt (Figure 397) 90 degrees (1/4 turn).

Crankcase Ladder (DT 466 series – 225 hp and 245 hp @ 2600 rpm) and all 570 ratings

NOTE: The crankcase ladder is symmetrical; therefore, it does not matter which way it is installed.

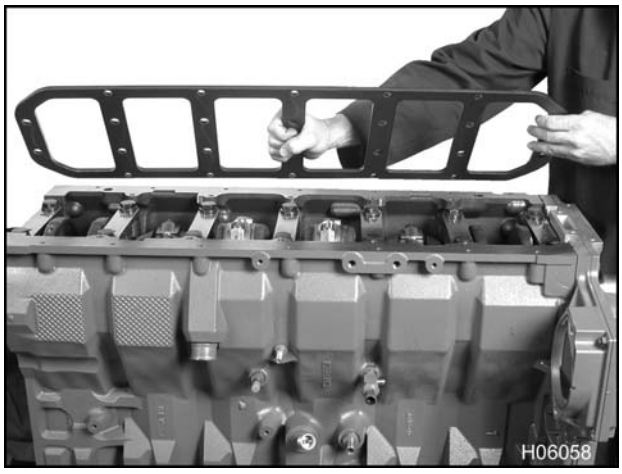

Figure 398 Installing the crankcase ladder

1. Install crankcase ladder onto crankcase.

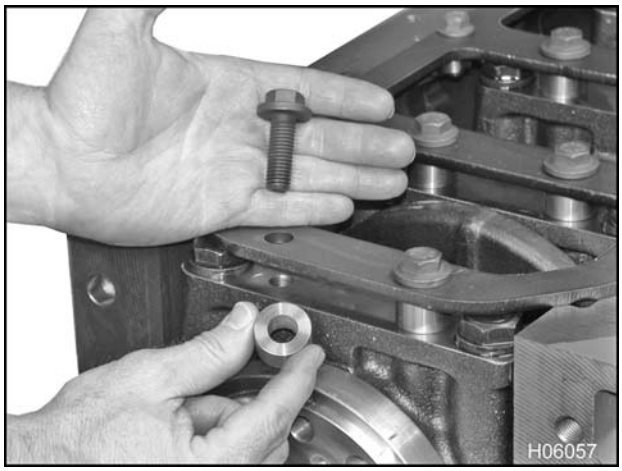

Figure 399 Crankcase ladder hardware

2. Install 14 crankcase ladder spacers and bolts (M12 x 35) to the 14 inboard bolt holes finger tight.
3. Install 10 crankcase ladder bolts (M10 x 25) to the 10 outboard bolt holes finger tight.

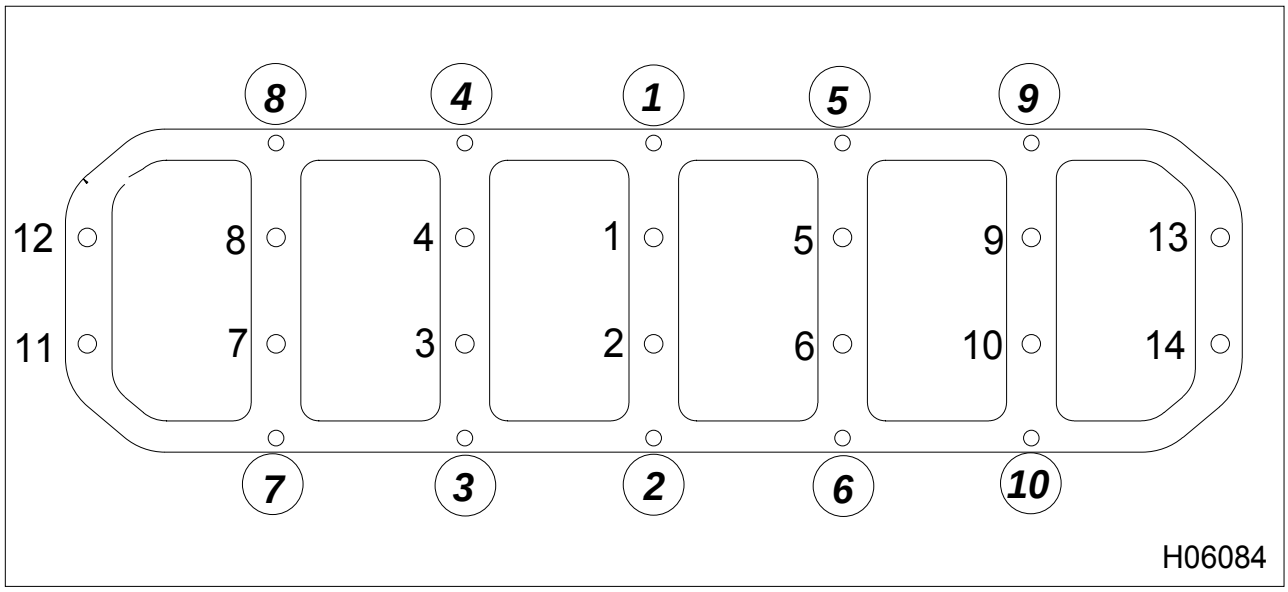

Figure 400 Recommended crankcase ladder torque sequence

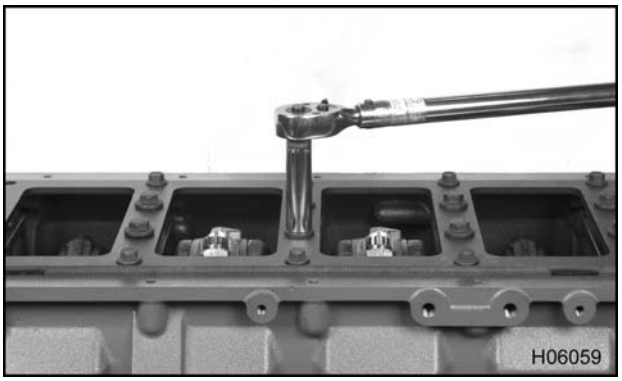

Figure 401 Torquing the crankcase ladder bolts

4. Using the recommended crankcase ladder torque sequence, tighten the inboard bolts (M12 x 35) to the special torque value (Table 39).
5. Using the recommended crankcase ladder torque sequence, tighten the outboard bolts (M10 x 25) to the special torque value (Table 39). These bolts are indicated by the circled numbers in the above illustration.

Oil Level Gauge

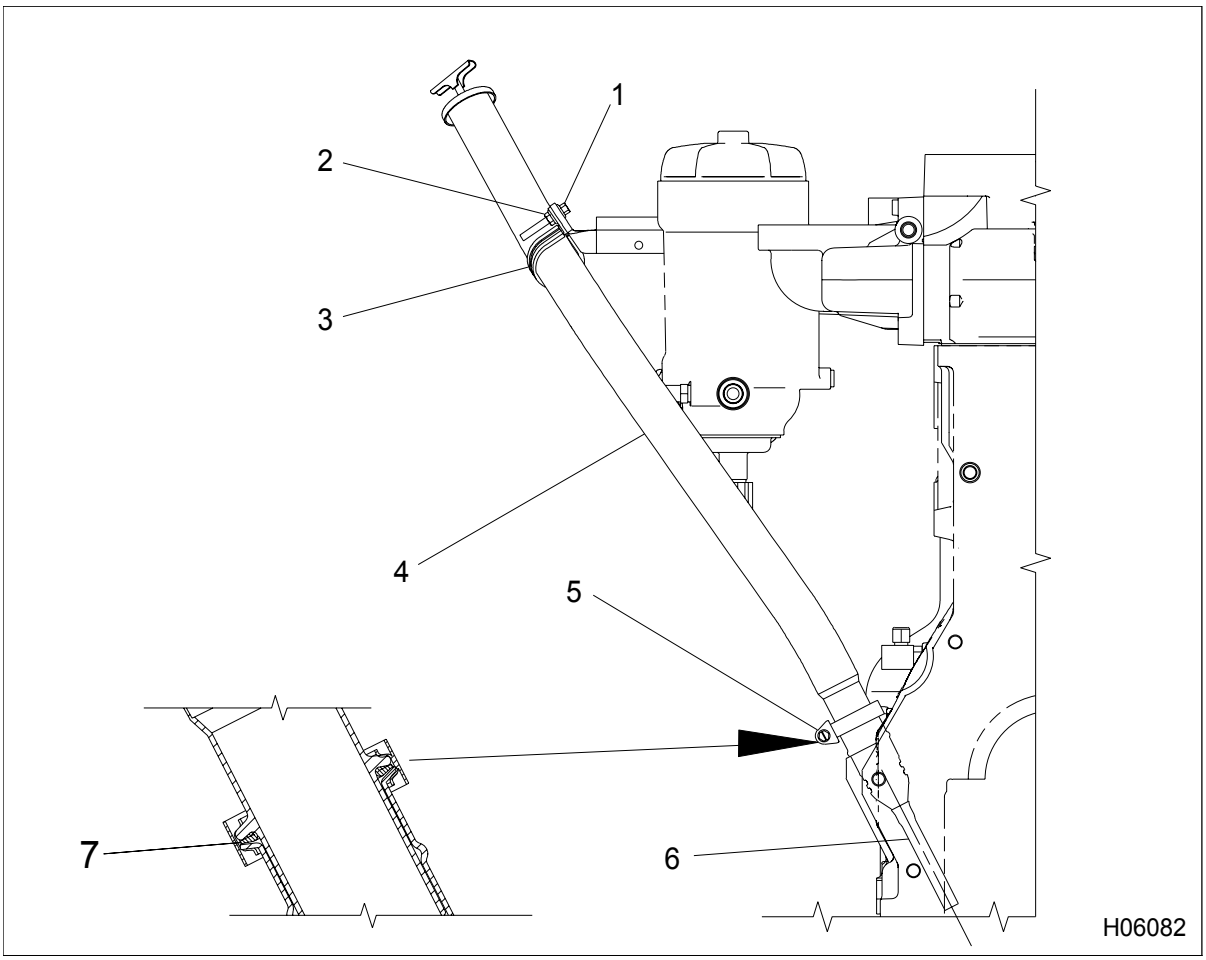

Figure 402 Oil level gauge assembly

1. Bolt, M6 x 40
2. Nut, M6
3. Cushioned clamp
4. Oil filler tube
5. Tube clamp
6. Oil level gauge tube
7. Oil dipstick tube seal

1. If removed earlier, install the oil level gauge tube by first applying Loctite® #277 around entire circumference of tube and casting. Drive tube into crankcase until bead of tube is seated in chamfer of crankcase boss.
2. Install a new oil dipstick tube seal between oil filler tube and crankcase oil tube flange.
3. Install the tube clamp at the crankcase.
4. Install the oil filler tube bolt (M6 x 40) and nut (M6) at the fuel filter bracket.

Crankcase Ventilation System

1. If fitting assembly (M12) was leaking at the crankcase, replace O-ring. Tighten fitting to the standard torque value (General Torque Guidelines, page445) .

   CAUTION: To prevent engine damage, do not use any type of impact tools to seat the (M8 x 35) bolts. Using impact tools will cause thread damage.
2. Install a new O-ring onto breather assembly and push into valve cover grommet.

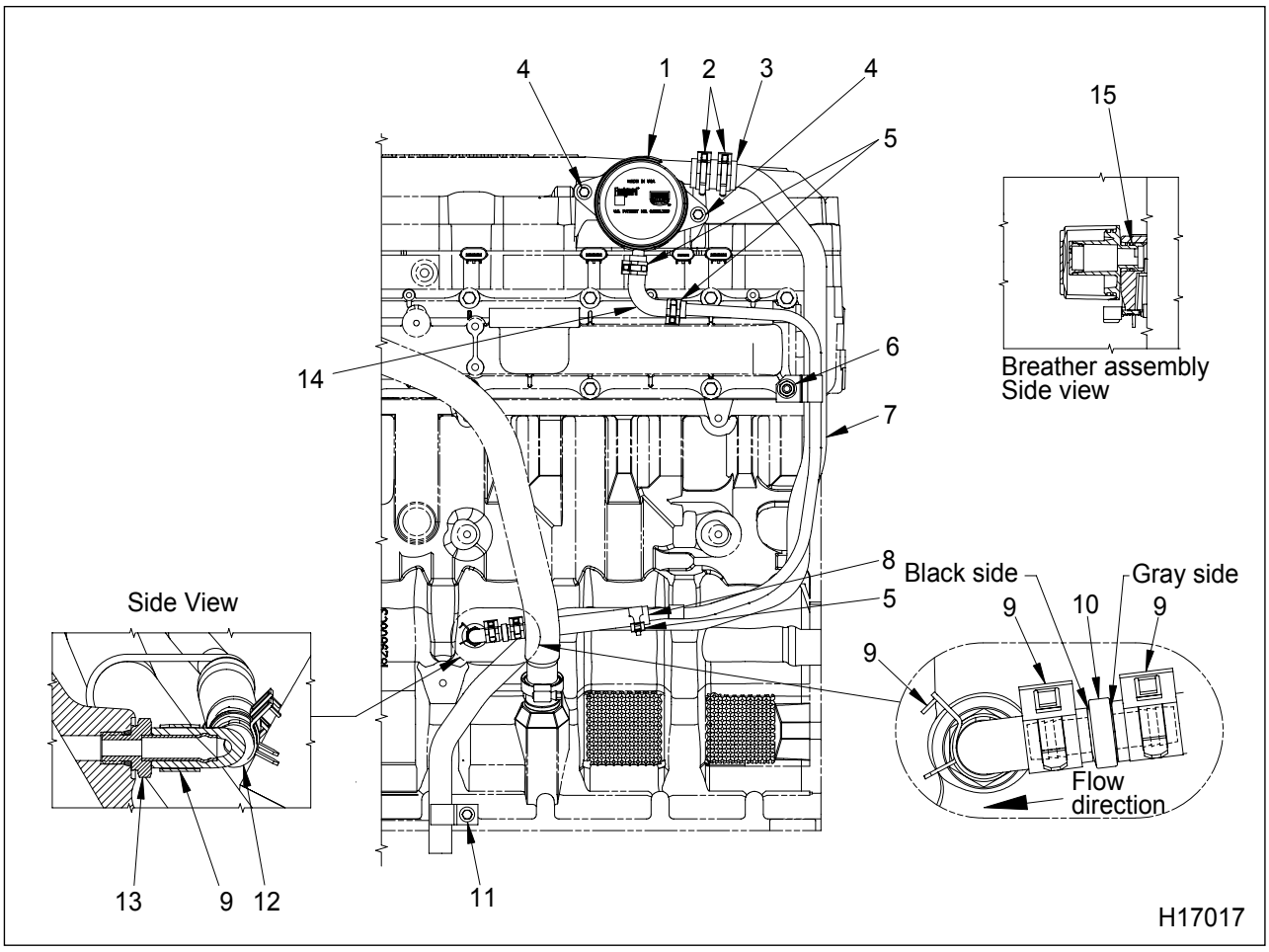

Figure 403 Crankcase ventilation

1. Breather assembly
2. Clamp, (1 in) diameter (2)
3. Hose, (1 in) I.D.
4. Bolt, M8 x 35 (2)
5. Clamp, 1/2 in diameter (3)
6. Nut, M10
7. Vent and drain tube assembly
8. Reducer hose
9. Clamp (3)
10. Check valve
11. Bolt, M8 x 16
12. Rubber elbow
13. Fitting assembly, M12
14. Drain hose elbow
15. O-ring, #214

3. Position drain hose elbow and one inch hose onto breather assembly. Secure with clamps, see illustration.
4. Place appropriate hose clamps onto vent and drain tube assembly. Position vent and drain tube assembly into breather assembly hoses.
5. Align vent and drain tubing assembly bracket with intake manifold stud. Thread nut (M10) onto stud finger tight.
6. Attach bottom of vent tubing to crankcase and secure with bolt (M8 x 16).
7. Combine rubber elbow, clamps, check valve, and reducer hose, making sure check valve is oriented correctly. Connect to drain side of tubing and clamp.
8. Tighten all hardware to the standard torque value (General Torque Guidelines, page445) and move clamps into their sealing positions.

Specifications

Table 37 Crankshaft Specifications

Type	Steel forged, induction hardened, grindable
Main Bearing journal diameter	
Standard size	107.95 ± 0.015 mm (4.250 ± 0.0006 in)
0.254 mm (0.010 in) undersized	107.70 ± 0.015 mm (4.240 ± 0.0006 in)
0.508 mm (0.020 in) undersized	107.44 ± 0.0152 mm (4.230 ± 0.0006 in)
0.762 mm (0.030 in) undersized	107.19 ± 0.0152 mm (4.220 ± 0.0006 in)
Damper mounting area runout (maximum)	0.03 mm (0.001 in)
Flywheel mounting surface runout (maximum)	0.05 mm (0.002 in)
Main bearing journal maximum out-of-round	0.05 mm (0.002 in)
Main bearing journal taper (maximum per inch)	0.071 mm (0.0028 in)
Main bearing thrust face runout (TIR maximum)	0.03 mm (0.001 in)
Main bearing width (except rear thrust)	34.19 ± 0.13 mm (1.346 ± 0.005 in)
Number of main bearings	7
Rear oil seal journal runout (maximum)	0.08 mm (0.003 in)
Thrust taken by	No. 7 rear upper main bearing
Thrust bearing journal length	34.404 ± 0.038 mm (1.3545 ± 0.0015 in)
Connecting rod journal diameter	
Standard Size	80.0 ± 0.0152 mm (3.1500 ± 0.0006 in)
0.0254 mm (0.010 in) undersized	79.7 ± 0.0152 mm (3.1400 ± 0.0006 in)
0.508 mm (0.020 in) undersized	79.5 ± 0.0152 mm (3.1300 ± 0.0006 in)
0.762 mm (0.030 in) undersized	79.2 ± 0.0152 mm (3.1200 ± 0.0006 in)
Center line of main bearing bore to head deck	368.3 ± 0.05 mm (14.50 ± 0.002 in)
Connecting rod bearing to crankshaft running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod bearing width	40.01 mm (1.575 in)
Connecting rod journal maximum out-of-round	0.0064 mm (0.00025 in)
Connecting rod journal taper (maximum per inch)	0.0069 mm (0.00027 in)
Crankshaft end play	0.15-0.31 mm (0.006 - 0.012 in)
Crankshaft end play maximum wear limit	0.51 mm (0.020 in)
Crankshaft flange outside diameter	155.58 mm (6.125 in)
Crankshaft gear backlash	0.08-0.41 mm (0.003 - 0.016 in)
Main bearing to crankshaft running clearance	0.046 - 0.127 mm (0.0018 - 0.0050 in)
Connecting rod to crankshaft side clearance	0.30 ± 0.11 mm (0.012 ± 0.005 in)
Standard size to 0.51 mm (0.020 in) undersized	34.404 ± 0.03 mm (1.3545 ± 0.010 in)

Table 38 Crankcase Specifications

Cap attachment	2 bolts per cap
Coolant heater rating	1250 W, 120 V
Counterbore depth in crankcase	8.865 ± 0.025 at 132 mm (0.349 ± 0.001 at 5.189 in)
Crankcase deck flatness	0.08 mm (0.003 in)
Crankcase main bearing bore diameter	116.421 ± 0.0127 mm (4.4583 ± 0.0005 in)
Cylinder sleeve counterbore maximum allowable depth	9.25 mm (0.364 in)
Main bearing type	Precision replaceable
Material	Steel-backed copper, lead, tin
Maximum allowable variation of counterbore depth (between four points)	0.025 mm (0.001 in)
Piston cooling tube dia. (spray hole) DT 466	1.91 - 2.06 mm (0.075 - 0.081 in)
Piston cooling tube dia. (spray hole) DT 570, HT 570	2.26 - 2.41 mm (0.089 - 0.095 in)
Roller tappet outside diameter	28.435 - 28.448 mm (1.1195 -1.1200 in)
Sleeve protrusion above crankcase	0.05 - 0.13 mm (0.002 - 0.005 in)
Tappet bore diameter	28.51 - 28.55 mm (1.123 - 1.124 in)
Thrust taken by	No. 7 rear upper main bearing
Camshaft	
Bushing I.D. (installed)	58.03 - 58.12 mm (2.285-2.288 in)
Cam lobe lift, exhaust	6.91 mm (0.272 in)
Cam lobe lift, intake	6.68 mm (0.263 in)
Camshaft end play	0.18 - 0.33 mm (0.007 - 0.013 in)
Camshaft journal diameter	57.95 - 58.98 mm (2.282 - 2.283 in)
Camshaft radial clearance	0.05 - 0.17 mm (0.002 - 0.007 in)
Maximum permissible cam lobe wear	0.25 mm (0.010 in)
Service bushings furnished to size	Yes
Thrust plate thickness (new)	6.96 - 7.01 mm (0.274 - 0.276 in)
Camshaft bushing bore diameter in crankcase	
Front	65.51 - 63.55 mm (2.501 - 2.502 in)
Intermediate front	63.01 - 63.04 mm (2.481 - 2.482 in)
Intermediate rear	63.01 - 63.04 mm (2.481 - 2.482 in)
Rear	65.51 - 63.55 mm (2.501 - 2.502 in)

Special Torque

Table 39 Crankcase, Crankshaft and Camshaft Special Torques

Camshaft thrust plate bolts	26 N·m (19 lbf·ft)
Crankcase ladder, M12 x 35	122 N·m (90 lbf·ft)
Coolant heater bolt	4.5 - 5.1 N·m (40 - 45 lbf·in)
Crankcase ladder, M10 x 25	63 N·m (46 lbf·ft)
Crankshaft main bearing cap bolt torque and sequence	(Torque Procedure for Torque-to-Yield Main Bearing Bolts, page271)

Special Service Tools

Table 40 Crankcase, Crankshaft and Camshaft Special Service Tools

Cam gear puller	ZTSE4411
Camshaft bushing puller	ZTSE2893B
Dial indicator set	Obtain locally
Hot plate	Obtain locally
Nylon brush	ZTSE4389
Plastigage®.	Obtain locally
Prussian Blue®	Obtain locally
Tap, cylinder head bolt holes	ZTSE4671
Tap set	ZTSE4386
Stiff nylon brush	ZTSE4392