Table of Contents

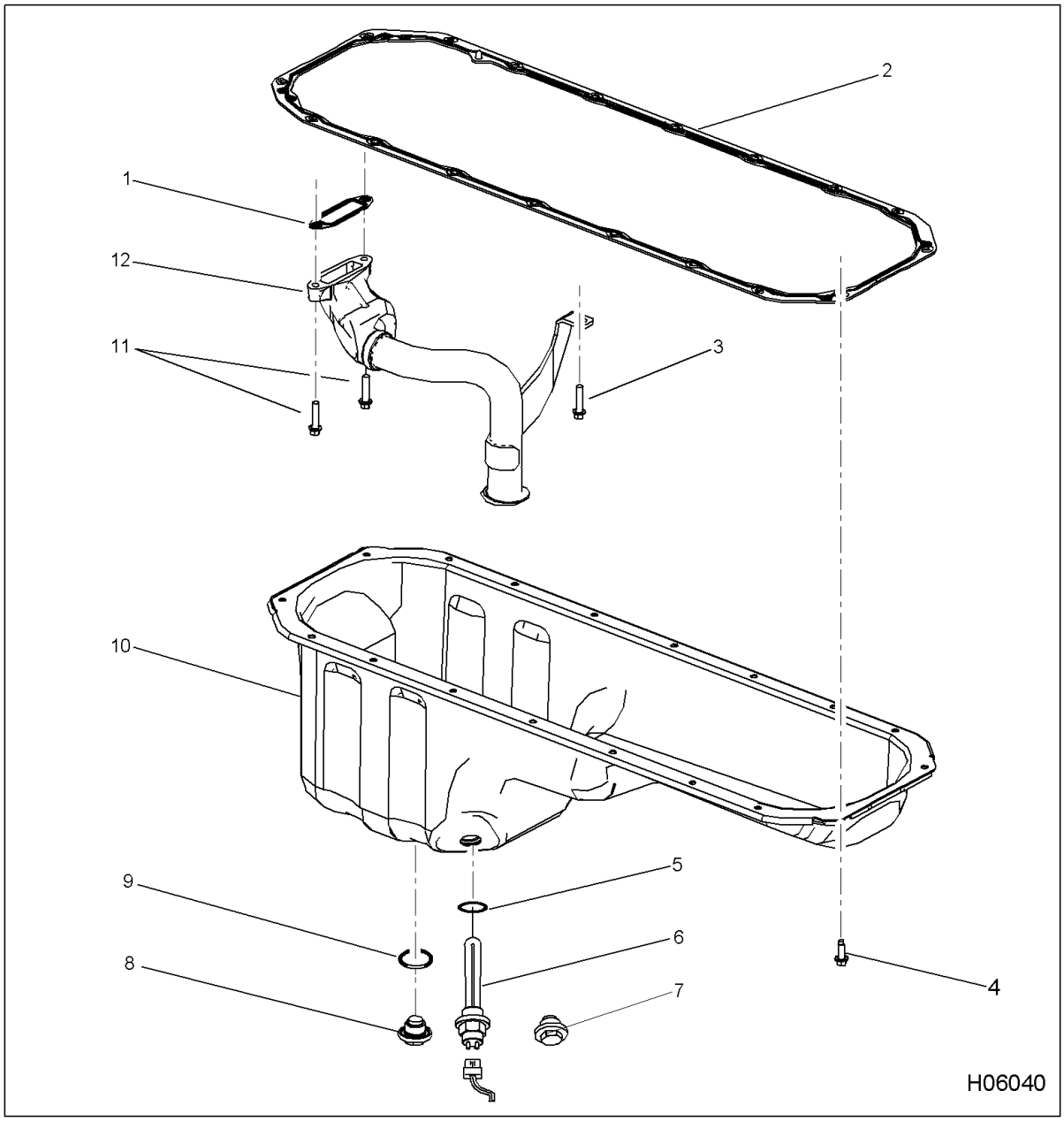

Figure 259 Oil pan and oil suction tube components

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. Heater element (optional feature)
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

WARNING: To avoid 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 avoid 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.

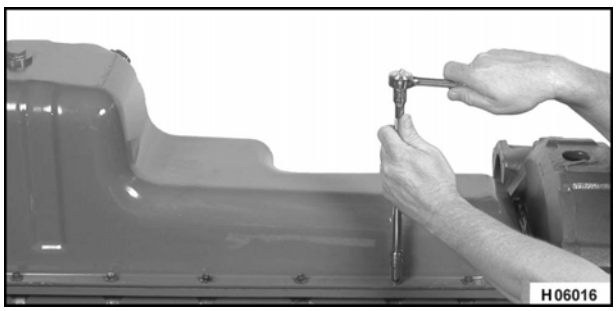

Figure 260 Removing the oil pan mounting bolts

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

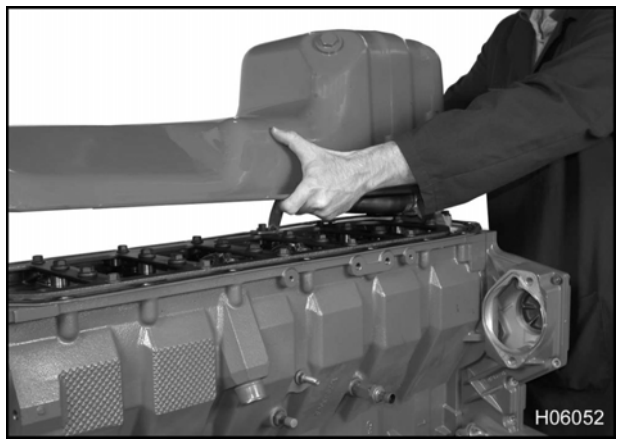

Figure 261 Removing the oil pan

2. Lift the oil pan from the engine.

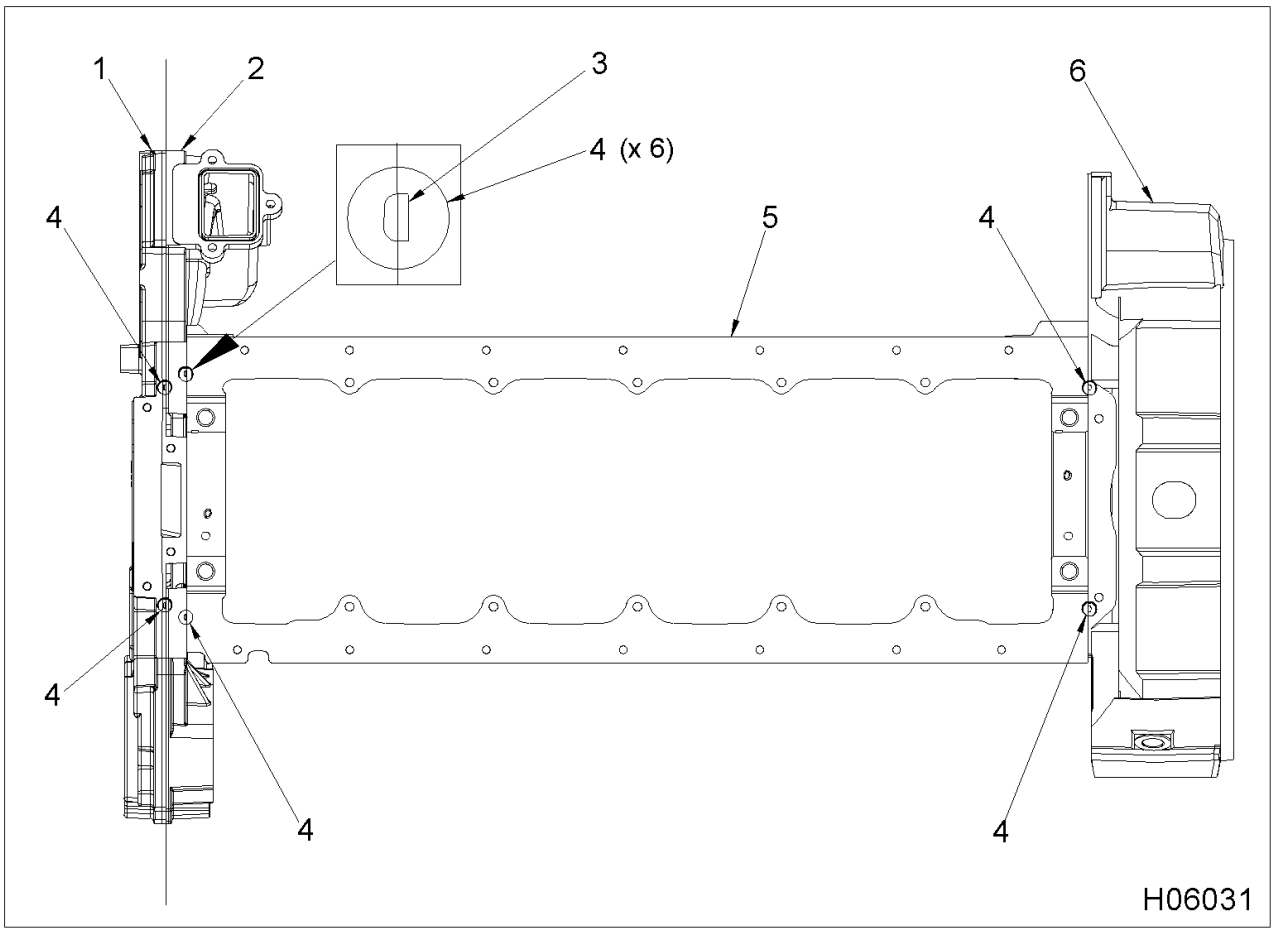

Figure 262 RTV sealant locations

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.

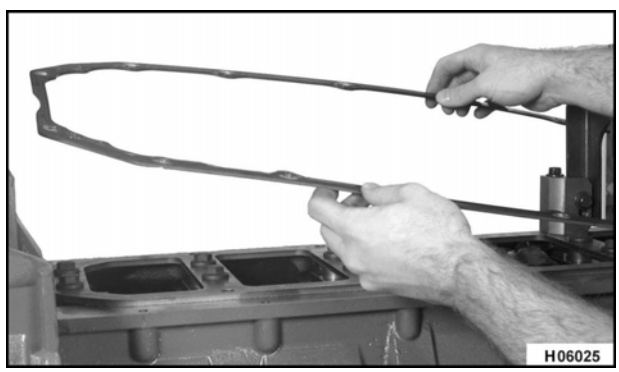

Figure 263 Removing the oil pan gasket

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

Removing the Oil Suction Tube

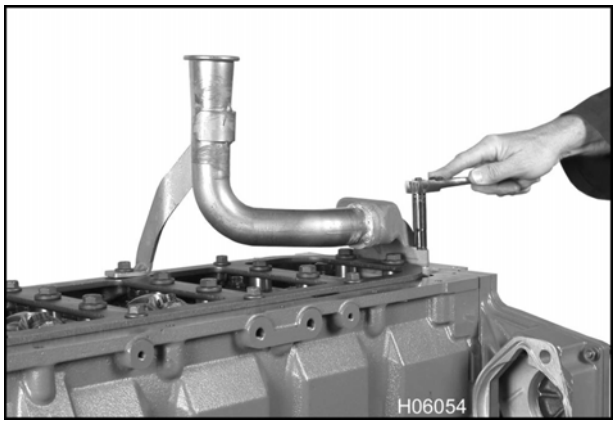

Figure 264 Removing the oil suction tube

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.

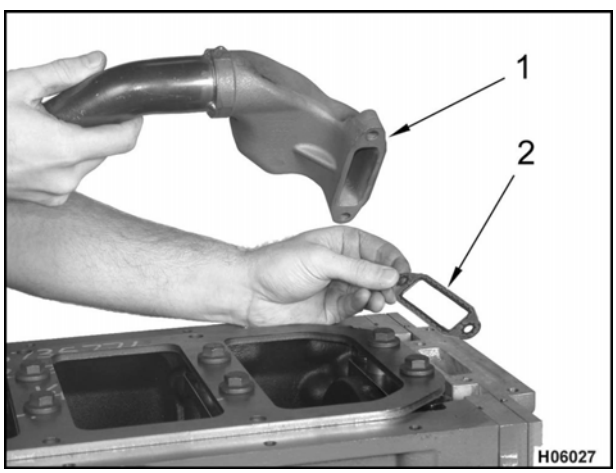

Figure 265 Removing the oil suction tube and gasket

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 high resistance or an open circuit condition.

Installation

Installing the Oil Suction Tube

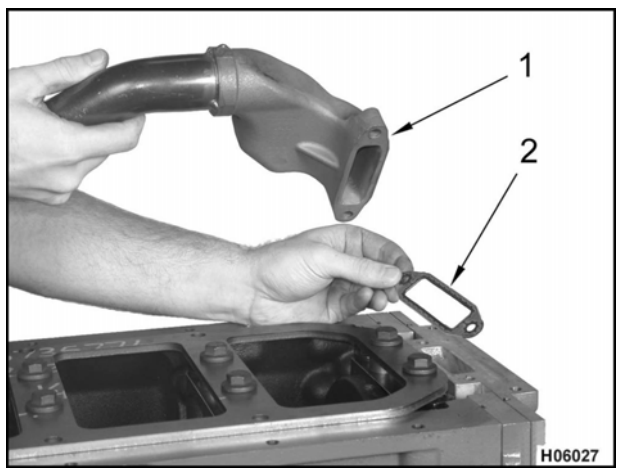

Figure 266 Installing the oil suction tube and gasket

1. Oil suction tube assembly
2. Gasket

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

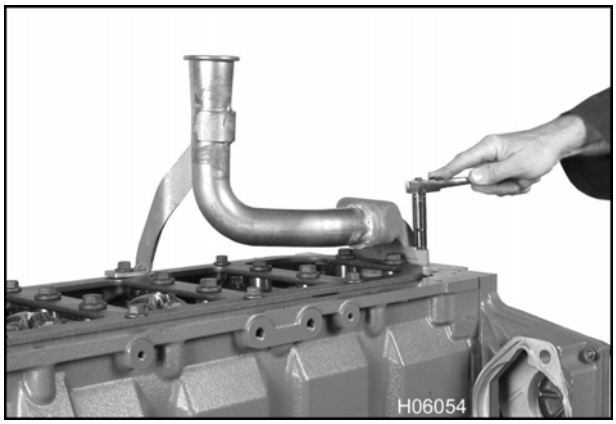

Figure 267 Installing the oil suction tube

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 24).
4. Torque bracket bolt (M10 x 25) to the special torque value (Table 24).

Installing the Oil Pan

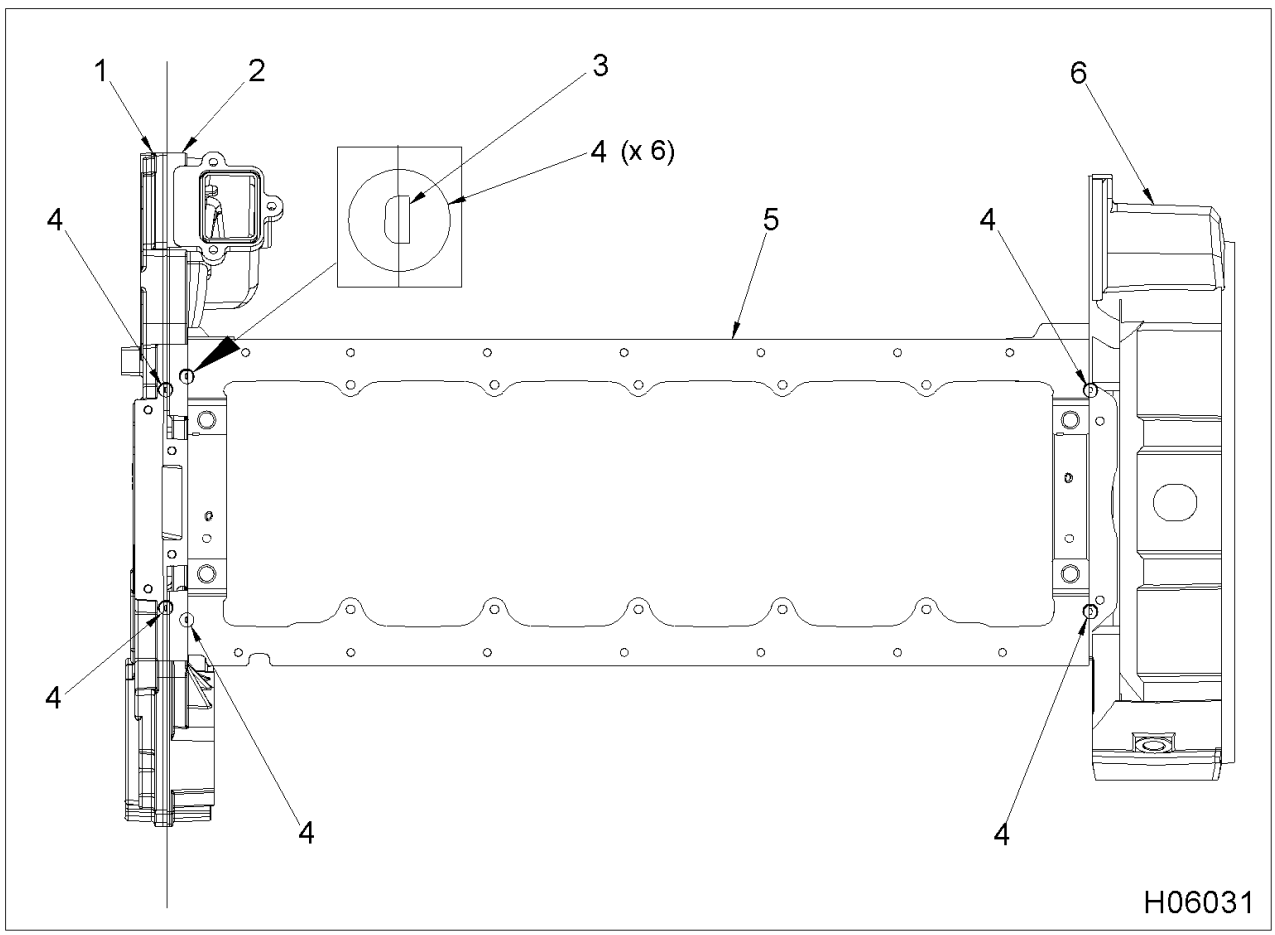

Figure 268 RTV sealant locations, see inset (typical)

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 approximately 19 mm (0.75 in) in diameter to the six locations on the crankcase mounting surface. These locations coincide with gasketed joints between the front cover halves, crankcase and flywheel housing.

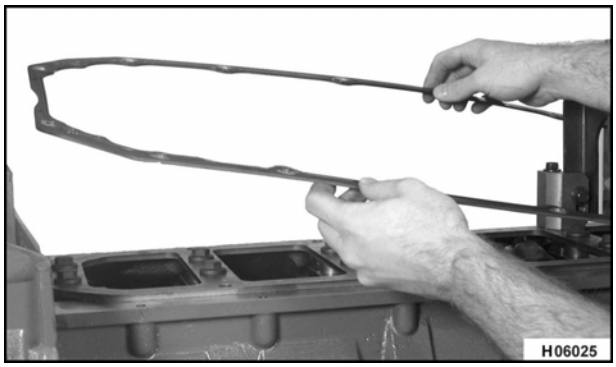

Figure 269 Installing the oil pan gasket

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.

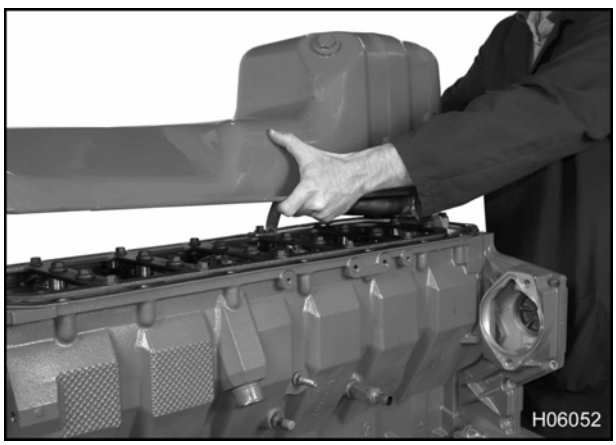

Figure 270 Installing the oil pan

3. Install the oil pan onto the crankcase.

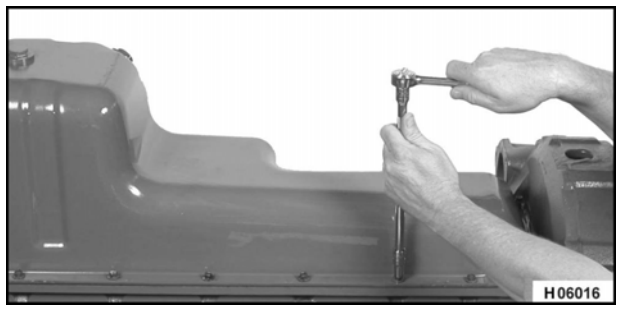

Figure 271 Installing oil pan mounting bolts

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

SPECIFICATIONS

Table 23 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 24 Oil Pan and Oil Suction Tube Special Torques

Oil pan drain plug	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)

Table of Contents

Description

There are a few changes that have occurred in the power cylinder for the 2004 model year:

- Piston skirts for both 466 and 570 cubic inch displacements now 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 and connecting rod cap must match and appear together.

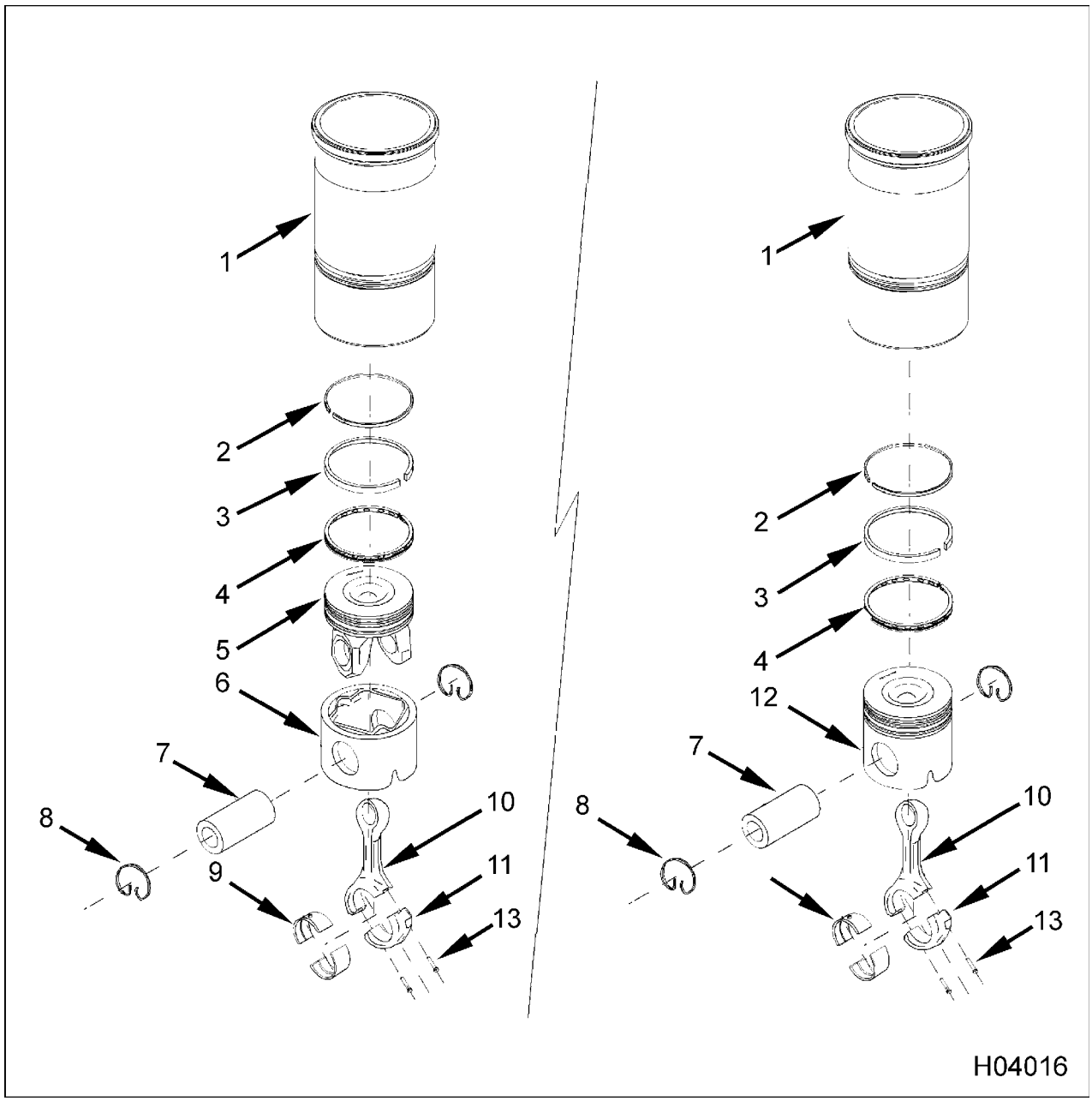

Figure 272 Exploded view of connecting rods, pistons, and rings

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

Piston Cooling Tubes

WARNING: To avoid 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 avoid 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.

CAUTION: To avoid 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.

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

NOTE: You may need to rotate crankshaft in order to gain access to some piston cooling tubes.

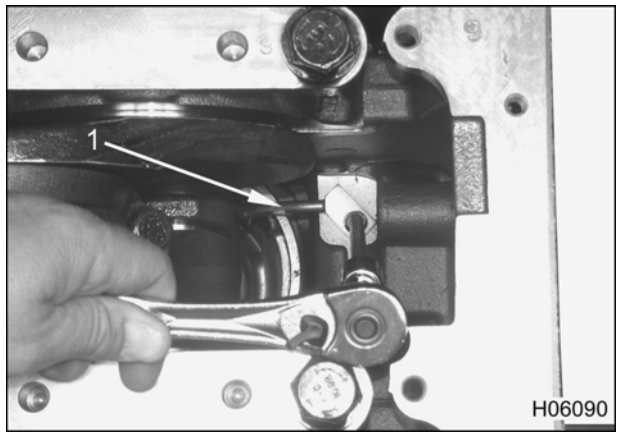

Figure 273 Removing the piston cooling tube

1. Piston cooling tube

1. Remove the six patch type bolts (M6 x 16) securing all the piston cooling tubes. Patch type bolts are reusable, only if you add Loctite® #242 to the bolt threads upon reinstallation.
2. Remove all piston cooling tube assemblies.

Removing Piston and Connecting Rod Assembly

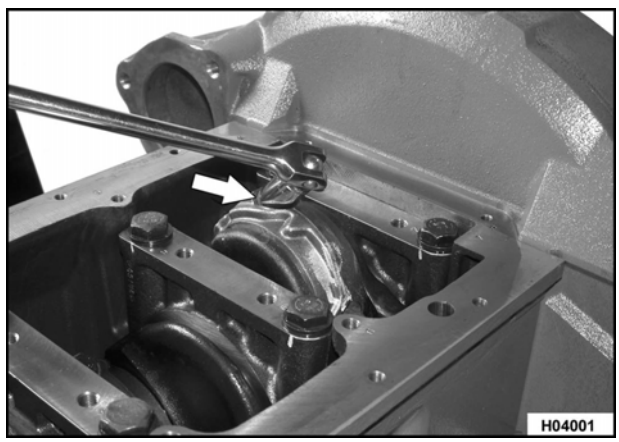

Figure 274 Loosening connecting rod bolts

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.

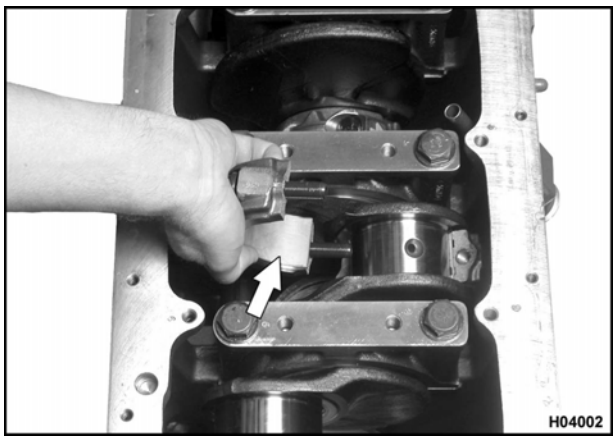

Figure 275 Removing connecting rod cap and bolts

5. Unscrew the bolts completely. Remove the cap and bolts as a unit.

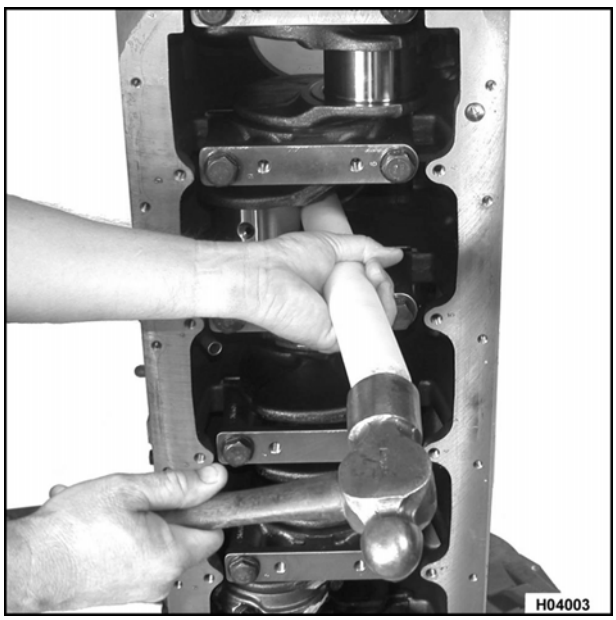

Figure 276 Pushing out piston and connecting rod assembly

6. 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.

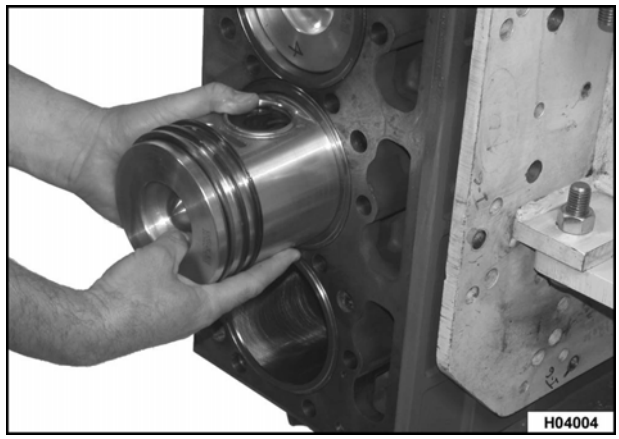

Figure 277 Removing piston and connecting rod assembly from cylinder sleeve

7. Once the piston rings are free of the cylinder sleeve, remove the assembly from the top of the crankcase.
8. 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 avoid serious personal injury or possible death, wear safety glasses when removing piston pin retaining rings.

Figure 278 Removing piston pin retaining rings

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

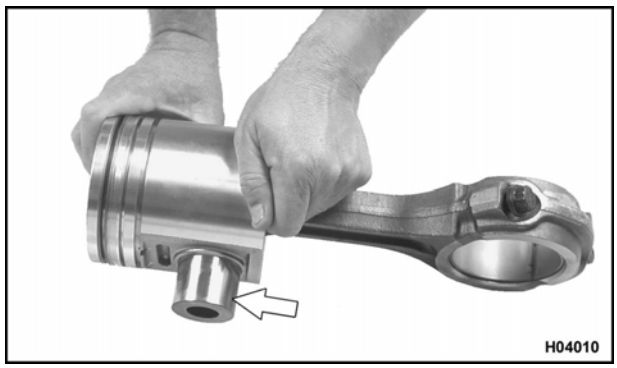

Figure 279 Removing piston pin

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.

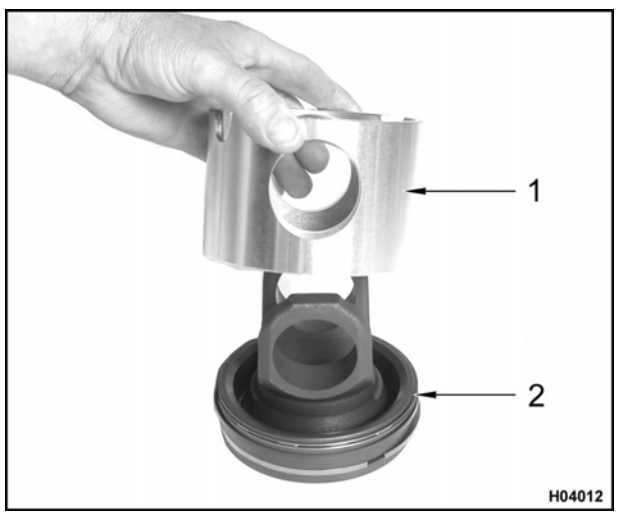

Figure 280 Removing piston skirt from crown (570 engine only)

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 281 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 282).

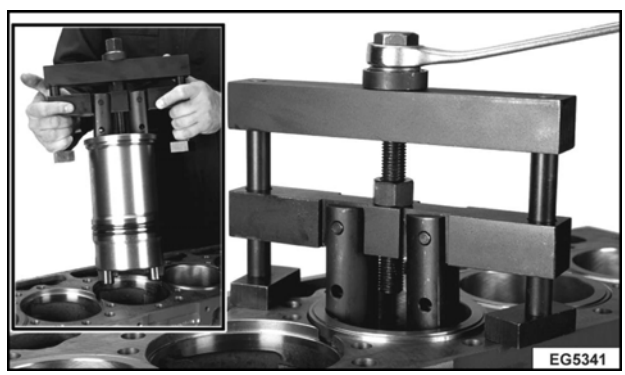

Figure 282 Removing cylinder sleeve from crankcase

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 pic to remove the crevice seal at the lower counterbore area of each cylinder sleeve. Discard crevice seal.

Cleaning

Pistons and Related Components

CAUTION: To avoid 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.
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.

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

4. Clean crevice seal bore area of any scale, deposits, or sealant (located in crankcase.)

Inspection

Pistons

CAUTION: To avoid 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 Table

Engine Rating	Ring / Land 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 Table

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

Figure 283 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 284 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 285 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 (See Checking Cylinder Sleeves, page 204). 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 avoid 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.

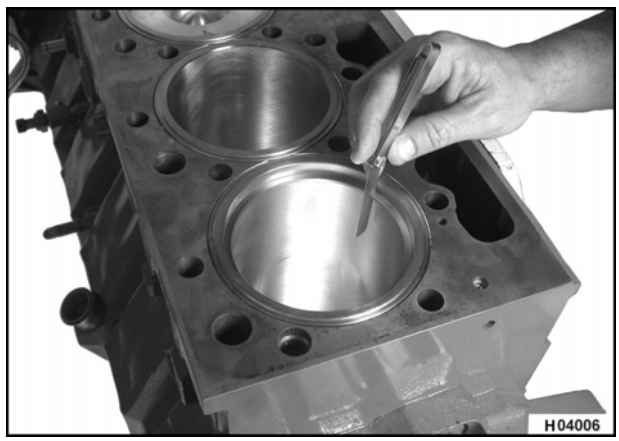

Figure 286 Checking piston ring end gap

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.

Connecting Rods

Piston Pin Bushing

Figure 287 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.

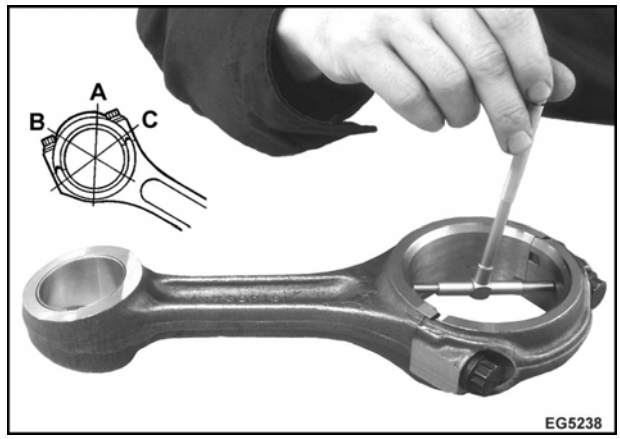

Figure 288 Connecting rod bearing bore for out-of-round

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 289 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.

Piston Pins

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

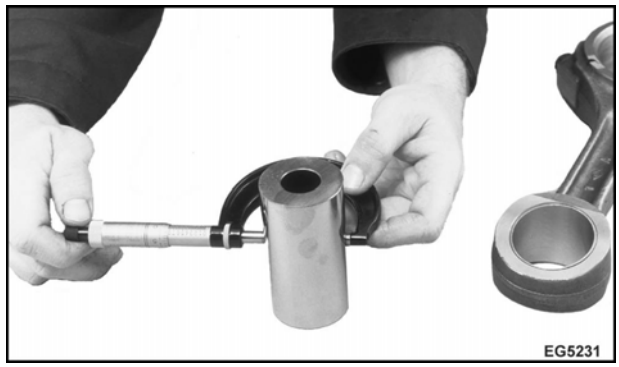

Figure 290 Measuring piston pin outside diameter

2. Use an outside micrometer to measure the outside diameter of the each piston pin at two locations. Record the readings.

   If the outside diameter of the piston pin is less than the minimum specification, replace the piston pin.

3. To check the piston pin clearance in the connecting rod, subtract the outside diameter of the piston pin from the inside diameter of the piston pin bushing.

   If clearance exceeds specifications, replace the connecting rod.

Bearing Fitting Procedures

CAUTION: To avoid 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.

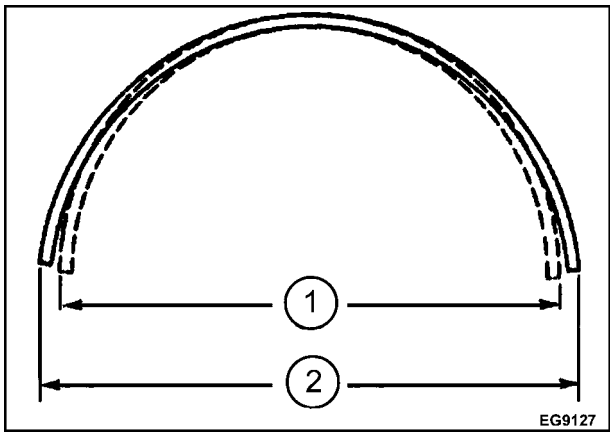

Figure 291 Effects of bearing crush

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

Bearing shells must fit tightly in the bore. When bearing shells are inserted into the connecting rod and cap, they protrude slightly above the parting surface. This protrusion is required to achieve **bearing crush**.

Across the open ends, bearing shells are slightly larger than the diameter of the connecting rod bore into which they are assembled. This condition is designed into the bearing shell, causing it to force the ends inward at the parting line when a bearing crush 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 assembly is drawn up tight, 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 bearing shells in the connecting rod and cap.
2. Install the connecting rod and cap on the crankshaft (See Installing Piston and Connecting Rod Assembly, page 212).
3. Remove the connecting rod cap. Wipe the oil from the face of the bearing shell in the cap and the exposed portion of the crankshaft.

NOTE: Correct mating of connecting rod and cap are required to prevent damage to fractured surface.

4. Place a piece of undamaged Plastigage® across the full width of the bearing shell about 6 mm (0.25 in) from the center of the connecting rod cap.

NOTE: The torque for the connecting rod cap bolts is very important. Use a torque wrench that is known to be accurate.

5. Install the connecting rod cap and tighten the bolts alternately and evenly to the special torque value (Table 33).

NOTE: Do not turn the crankshaft. Doing this will only smear the Plastigage® rendering it useless.

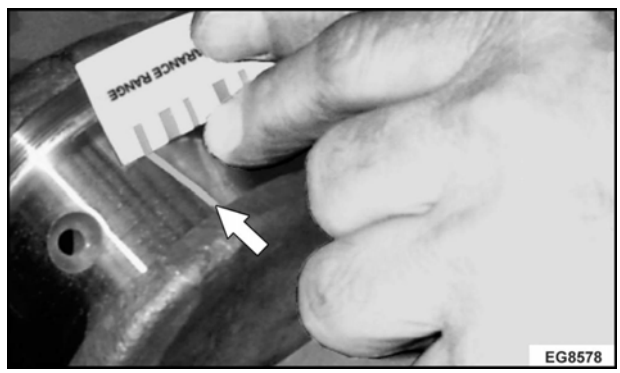

Figure 292 Measuring Plastigage® with scale

6. Remove the connecting rod cap. The Plastigage® material will adhere to either 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. The numbers within the graduated marks on the wrapper scale indicate the running clearance in thousandths of an inch or millimeters.

NOTE: With the use of precision bearings, few problems should be encountered. However, if proper running clearance is not achieved, a problem with the crankshaft may still exist. Regrinding the crankshaft and using undersized bearings may be necessary. Check the running clearance again before condemning the crankshaft.

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

Connecting Rod Side Clearance

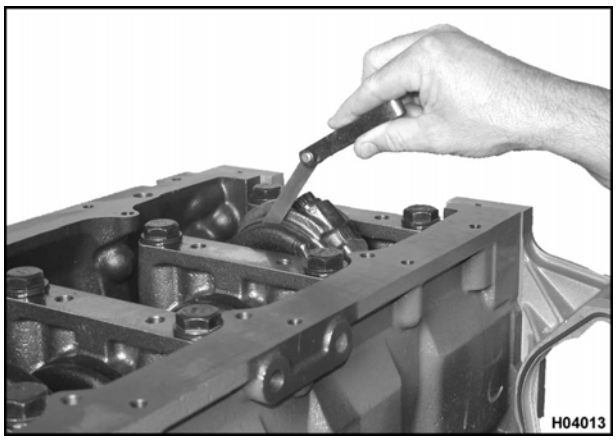

Figure 293 Measuring connecting rod side clearance

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

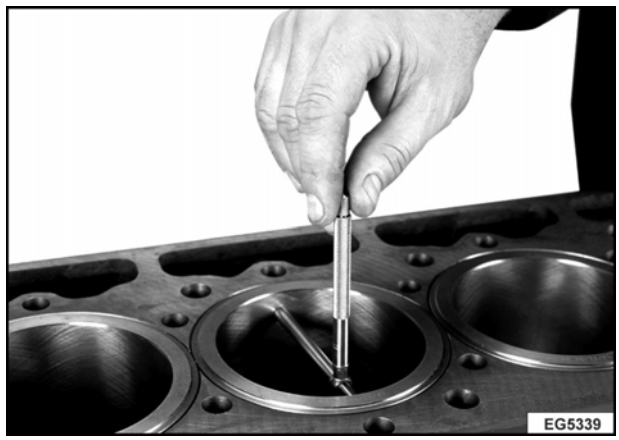

Figure 294 Checking cylinder sleeve inside diameter with telescoping gauge

Figure 295 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 296 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

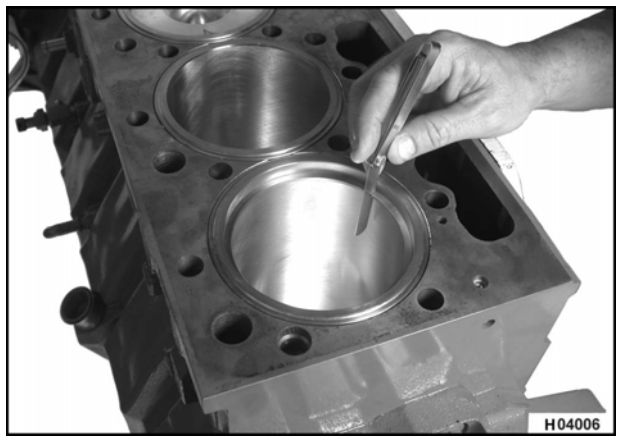

Figure 297 Checking cylinder sleeve piston ring end gap

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 298 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 and 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 299 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 and 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 avoid 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.

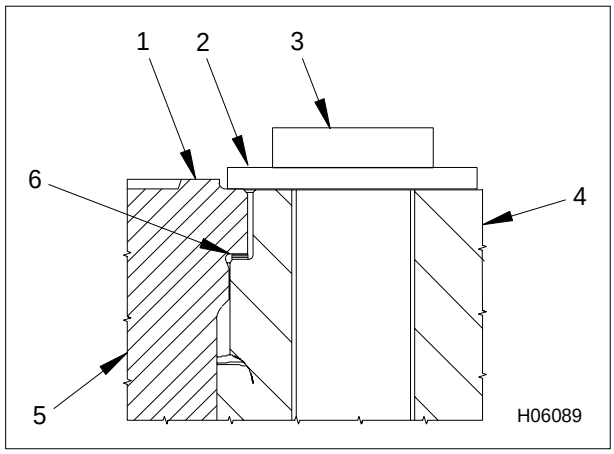

Figure 300 Cylinder sleeve clamping details

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 avoid 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.

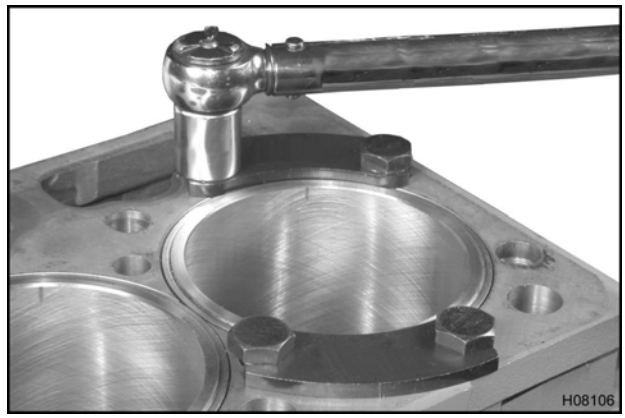

Figure 301 Installing the holding adapters

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)

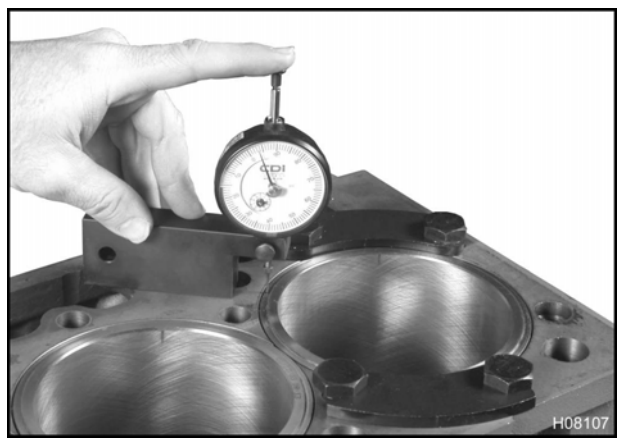

Figure 302 Measuring cylinder sleeve protrusion

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.

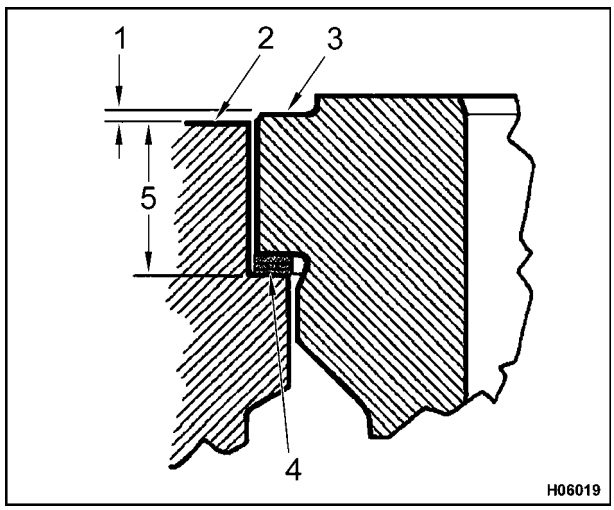

Figure 303 Checking cylinder sleeve protrusion

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 304 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.

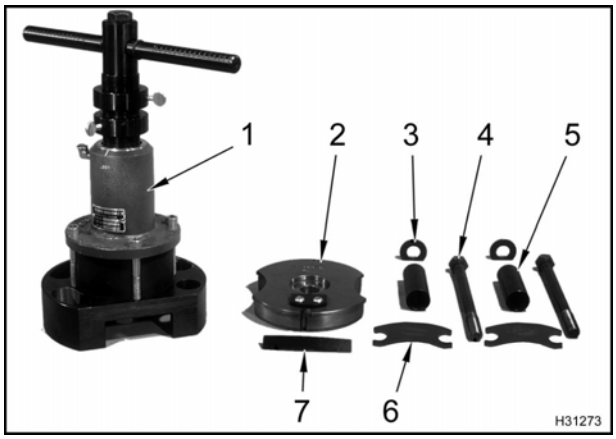

Figure 305 Counterboring tool components

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.

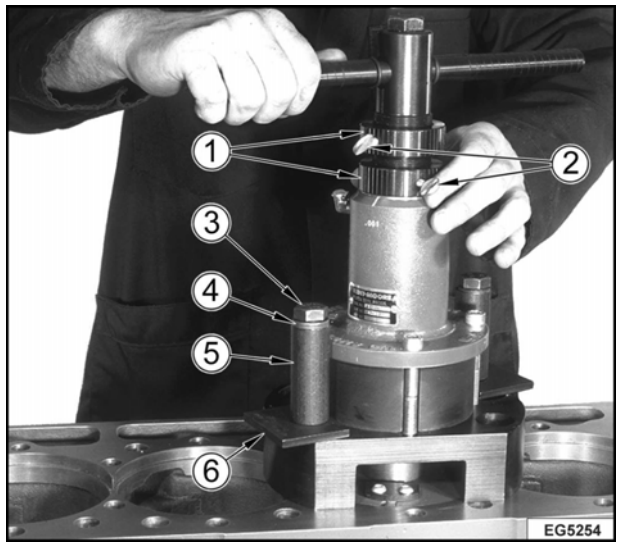

Figure 306 Positioning counterboring tool

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 avoid 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 (See Checking Counterbore Depth, page 205).

Installation

Cylinder Sleeve Installation

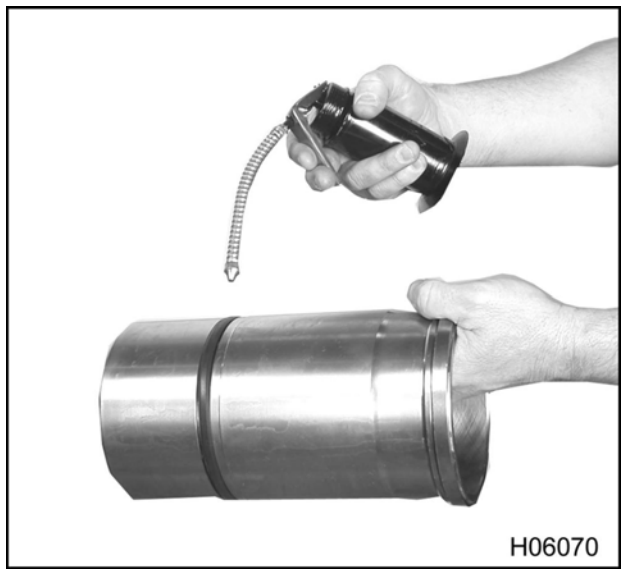

Figure 307 Lubricate cylinder sleeve crevice seal

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 308 Lubricate cylinder sleeve bore

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

Figure 309 Install cylinder sleeve

5. After installation, check cylinder sleeve protrusion (See Checking Cylinder Sleeve Protrusion, page 206).
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 310 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 avoid 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.

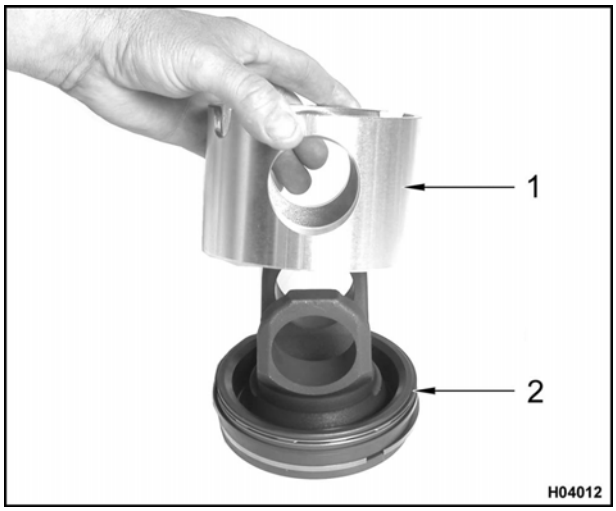

Figure 311 Installing piston skirt on crown (570 engine only)

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 312 Installing the piston pin

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

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

Figure 313 Installing piston pin retaining rings

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

Installing Piston and Connecting Rod Assembly

CAUTION: To avoid 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 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.

NOTE: Turn the crankshaft so that the No. 1 and No. 6 connecting rod journals are at TDC. Install the No. 1 and No. 6 piston and connecting rod assemblies first. Then repeat the procedure for the No. 2 and No. 5 assemblies. Finish with the No. 3 and No. 4 assemblies.

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

1. Lubricate the piston rings with clean engine oil. Stagger the piston ring gaps approximately 120 degrees around the piston.

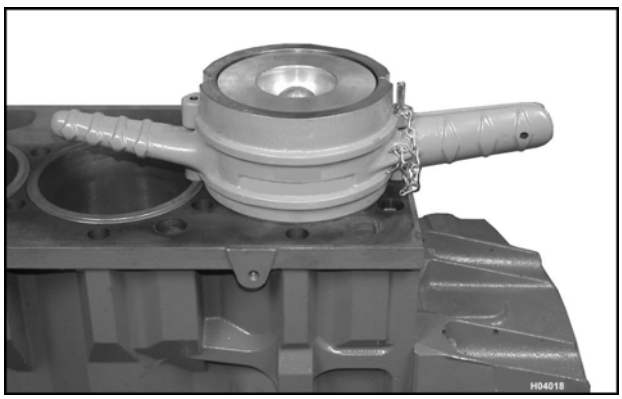

Figure 314 Installing the piston ring compression tool

2. Install the piston ring compression tool (Table 34) over the piston rings.
3. Lubricate the cylinder sleeve and connecting rod bearing shell with clean engine oil.

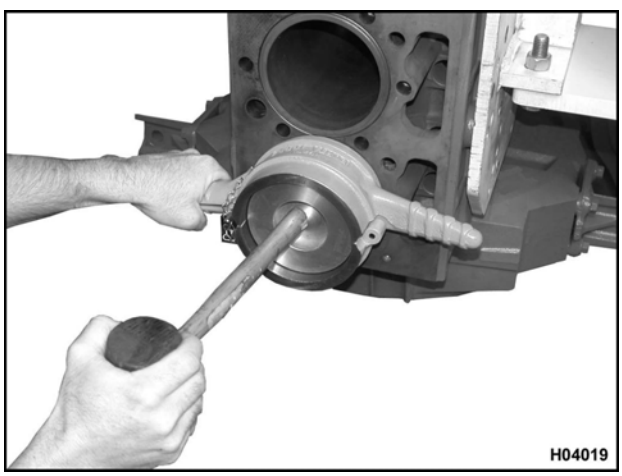

Figure 315 Installing the piston and connecting rod assembly

4. Insert the piston and connecting rod assembly without the rod cap into the cylinder sleeve. Use a wooden or plastic handle to carefully push the assembly into the cylinder sleeve. Do not scratch the cylinder wall.
5. Carefully guide the piston and connecting rod assembly onto the crankshaft connecting rod journal.

CAUTION: To avoid engine damage, always make sure the rod cap serial number is assembled to the same side as the connecting rod serial number (they must match). If the rod cap is reversed when assembled to the connecting rod or a rod cap is not installed on its original matching connecting rod, the fractured mating surfaces will be ruined. This may cause the rod cap to come loose and cause severe engine damage. The entire connecting rod assembly must then be replaced.

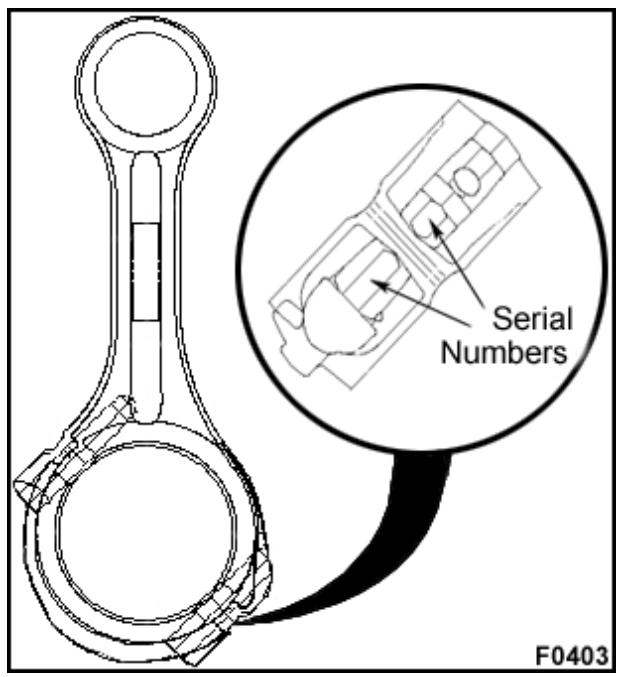

Figure 316 Matching serial number locations

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 numbers on the sides of each rod and cap.

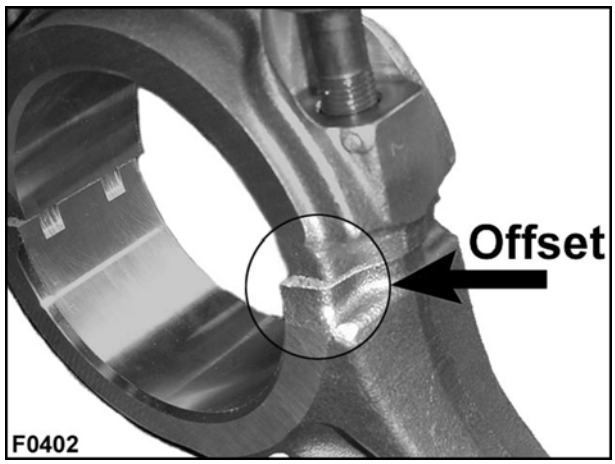

Figure 317 An offset indicates incorrect rod cap assembly

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.

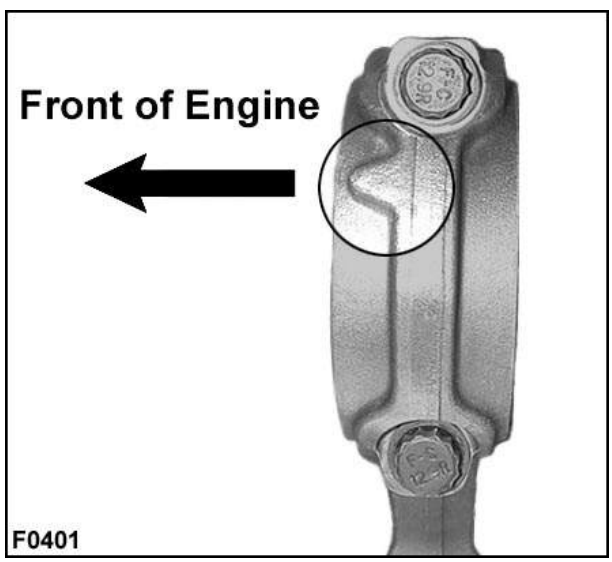

Figure 318 Arrow for correct orientation

NOTE: Each rod cap has an arrow for correct orientation in the engine during installation. The arrow must point toward the front of the engine.

6. Lubricate the bearing shell in the connecting rod cap with clean engine oil.

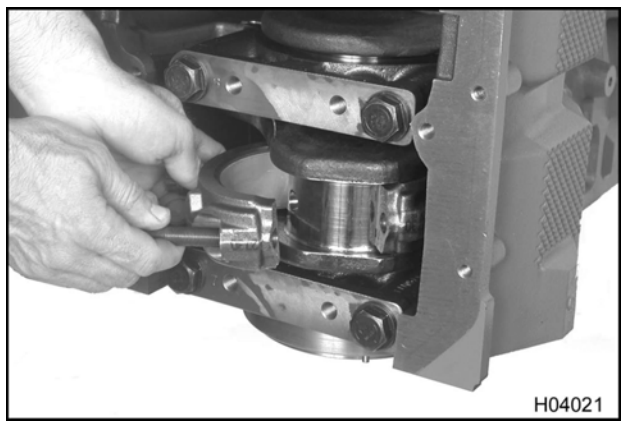

Figure 319 Installing the connecting rod cap

7. Install the cap and two bolts.

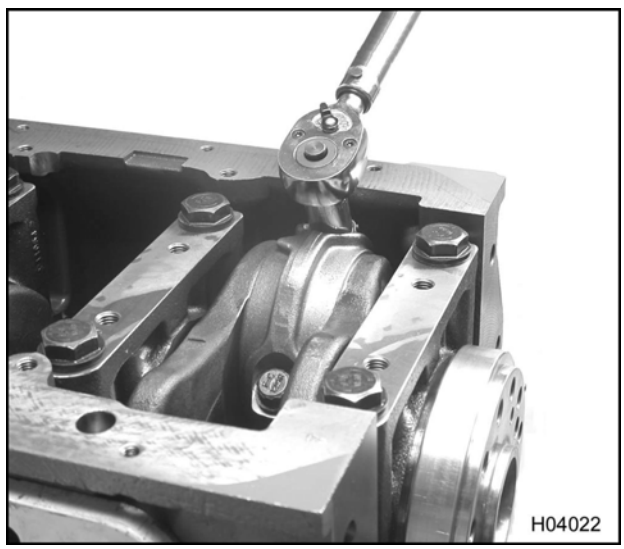

Figure 320 Torquing the connecting rod cap bolts

8. Torque the connecting rod cap bolts to the special torque value (Table 33).

Piston Cooling Tubes

NOTE: You may need to rotate crankshaft in order to gain access to some piston cooling tubes.

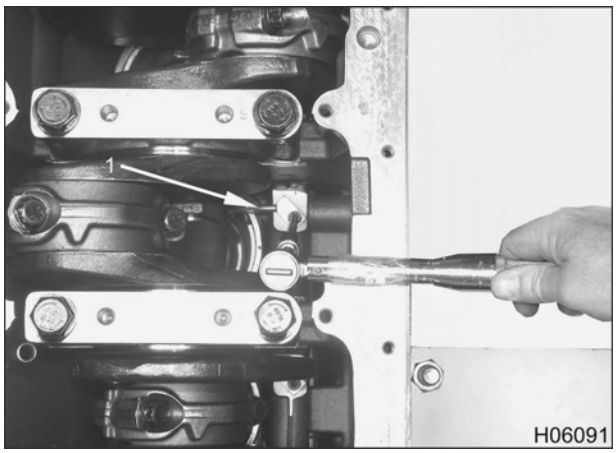

Figure 321 Installing the piston cooling tube

1. Piston cooling tube

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

NOTE: The bolt-on 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 either of the following:
   A. Install brand **new** piston cooling tube mounting bolts (patch type), or
   B. Remove oil residue and apply Loctite® #242 to the threads of existing piston cooling tube mounting bolts (patch type).
3. Tighten each piston cooling tube mounting bolt to the standard torque value (See General Torque Guidelines, page 409).

Engine Run-In Procedure

WARNING: To avoid 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.

If new pistons or piston rings have been installed, use 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

   Shut the engine off and rectify any of these conditions immediately to avoid possible turbocharger or engine damage.
3. 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.
4. 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.)	0.05 mm (0.002 in)
Connecting rod bearing bore taper (max.)	0.13 mm (0.005 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	
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)
Piston ring gap with new cylinder sleeve (all engines)	
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	163 N·m (120 lbf·ft)

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