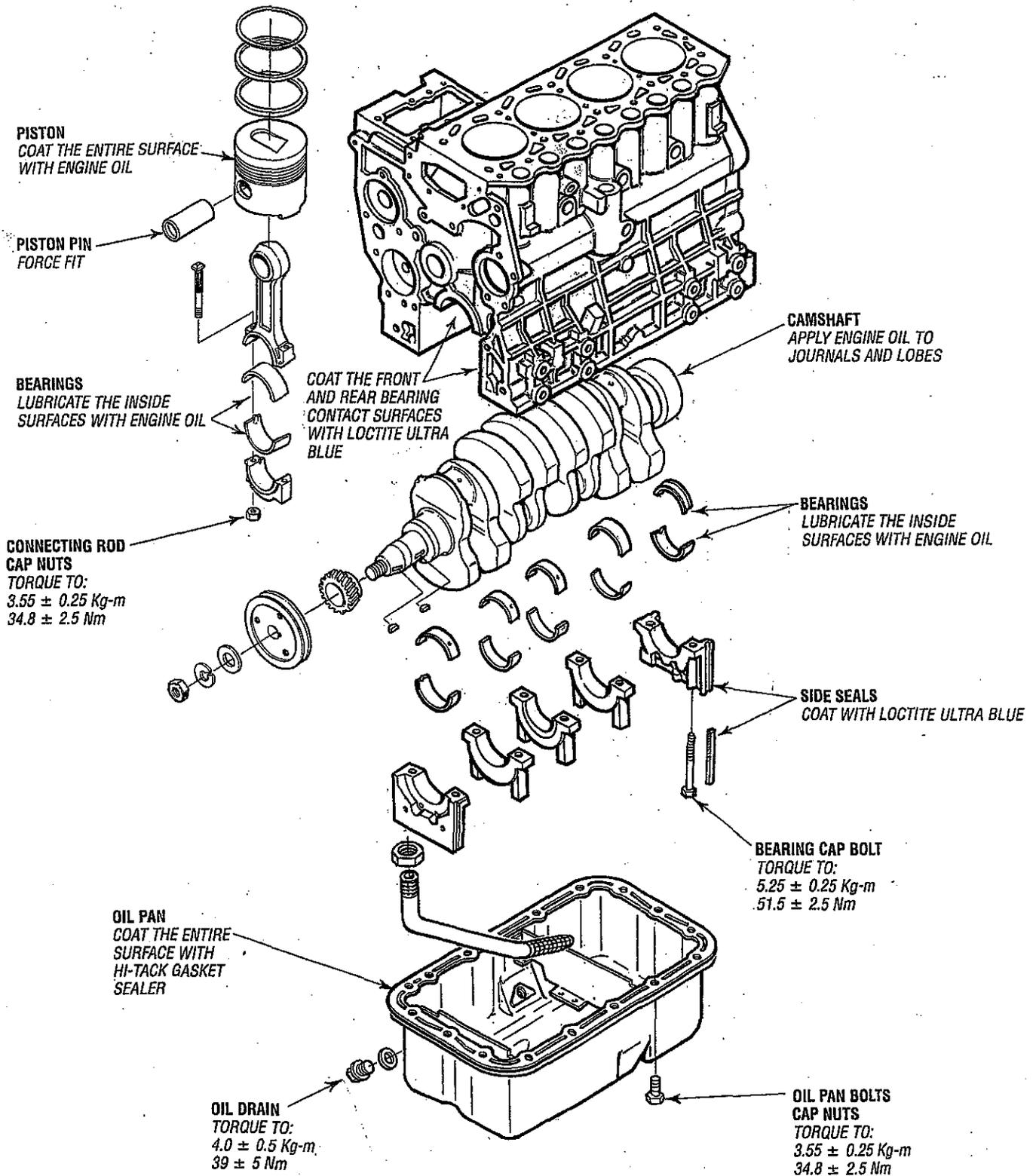


ASSEMBLY

CYLINDER BLOCK, CRANKSHAFT, PISTONS AND OIL PAN

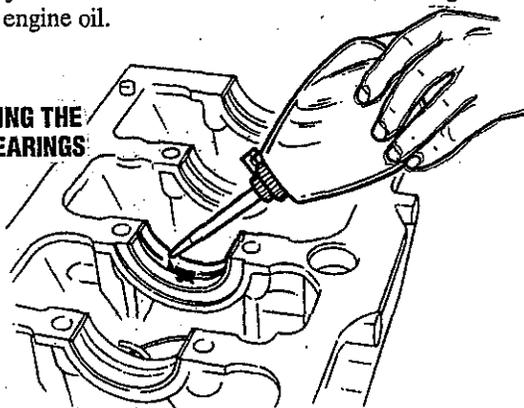


ASSEMBLY

1. Main bearing installation.

- Install the upper halves of the main bearings in the cylinder block and the lower halves in the main bearing caps so their tabs fit into the notches in the cylinder block and the main bearing caps..
- Install the flanged bearing in the No.3 journal.
- Lightly lubricate the inside surfaces of the bearings with engine oil.

INSTALLING THE MAIN BEARINGS



2. Crankshaft installation.

- Clean the crankshaft with cleaning solvent and blow dry with compressed air.
- Fasten a hoist to the crankshaft and hold it in horizontal position. Carefully put the crankshaft in position in the cylinder block.
- Lightly lubricate the crankshaft journals with engine oil.

3. Main bearing cap installation.

- Coat the mating surfaces of the rear bearing cap and cylinder block with Loctite Ultra-Blue.
- Install the main bearing caps in position. Make sure the number (arrow head) on the main bearing cap is toward the front of the engine.
- Tighten the main bearing cap bolts finger tight only.

CAUTION: Install the front and rear bearing caps in position so their end faces are even with the end faces of the cylinder block.

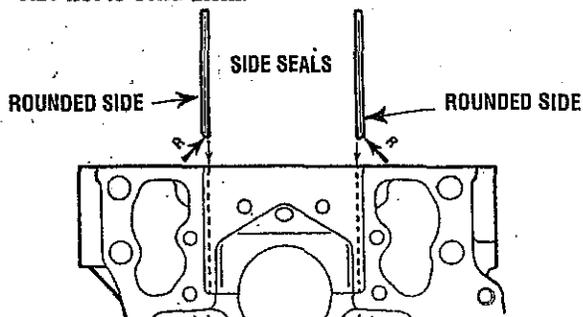
- Tighten the bolts holding the main bearing caps in steps to the specified torque.

TORQUE: 38 ± 2 lb-ft (5.25 ± 0.25 Kgf-m)

- Make sure the crankshaft rotates freely without binding or catching.
- Measure the end play for the crankshaft. Make reference to *End play measurement* for crankshaft. If the end play is incorrect, loosen the bolts holding the main bearing caps once and tighten them again.

4. Side seal installation.

- Coat the side seals with Loctite Ultra Blue.
- Insert the side seals between the cylinder block and the front and rear caps and push them in by hand as far as possible, with their rounded side toward the outside of the cylinder block.
- Using a flat plate, push the seals into position, taking care not to bend them.



5. Piston assembling to connecting rod.

- Set Piston Setting Tool (special tool) in a hydraulic (l) in press.
- Put the connecting rod on the Tool and lubricate the bore in the rod for the piston pin with engine oil.
- Put the piston in position on the connecting rod, making sure the model identification on the rod is on the same side as the arrow head on the top of the piston. Put the piston pin in position.
- Insert the push rod of the Tool into the bore in the piston for the piston pin and press the pin with the press.

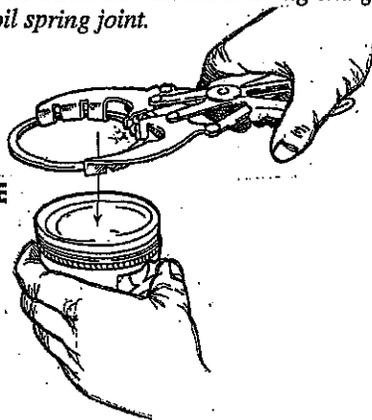
CAUTION: Observe the indicator of the press when pressing the piston pin. If the force of the press is ready to exceed 50kfg (110 lbf) [490N], stop pressing the pin and check the bores in the piston and connecting rod for alignment.

- After assembling the piston and connecting rod, make sure the connecting rod moves freely.

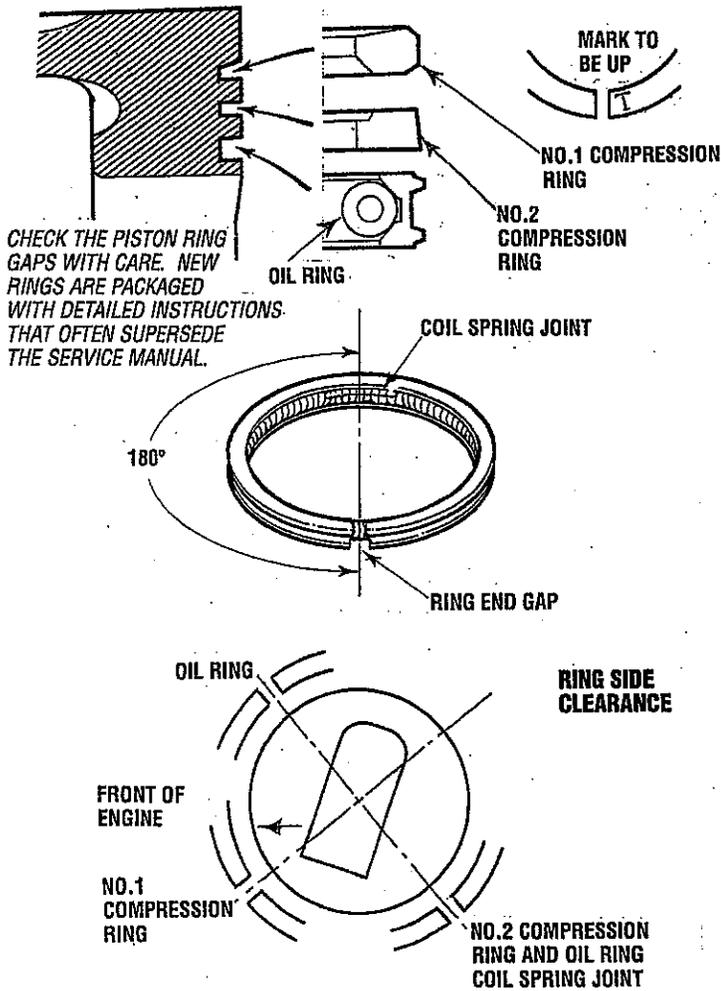
6. Using a piston ring pliers, install the piston rings on the piston.

NOTE: The piston rings must be installed with the side that has the mark "T" toward the top of the piston. The oil ring must be installed with the coil ring end gap 180° apart from the coil spring joint.

INSTALLING THE PISTON RINGS



ASSEMBLY



7. Piston and connecting rod installation.

- Lubricate the piston and piston rings with engine oil.
- Move the piston rings on the piston so that the end gaps are apart from a direction parallel to, or traverse to, the piston pin.
- Install the connecting rod bearing (upper half) to the rod, making sure the tab in the back of the bearing is in the notch of the connecting rod.
- Turn the crankshaft until the crankpin for the piston and connecting rod to be installed is at the top center.
- Hold the piston and connecting rod with "FRONT" mark (arrow head) on the top of the piston toward the front (timing gear case side) of the engine.
- Using a piston guide (commercially available), put the piston and connecting rod into the cylinder from the top of the cylinder block.

CAUTION: Do not use a hammer when installing the piston and connecting rod as this will damage the piston rings and crankpin.

8. Connecting rod cap installation.

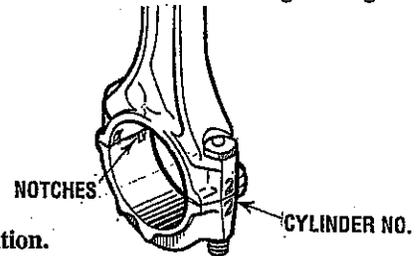
- Push the piston into position until the big end of the connecting rod is put into position over the crankpin. Then turn the crankshaft 180° while pushing on the top of the piston.
- Install the lower half of the connecting rod bearing in the connecting rod cap, making sure the tab in the back of the bearing is in the notch of the cap.
- Install the bearing cap to the connecting rod.

NOTE: Make sure the number on the cap is the same as the number on the connecting rod. In case of a new connecting rod having no cylinder number, install the cap to the rod with the notches on the same side.

- Tighten the connecting rod cap nuts in steps to the specified torque.

TORQUE: 25.7 ± 2 lb-ft (3.55 ± 0.25 Kgf-m)

- Check the thrust clearance for the connecting rod big end.



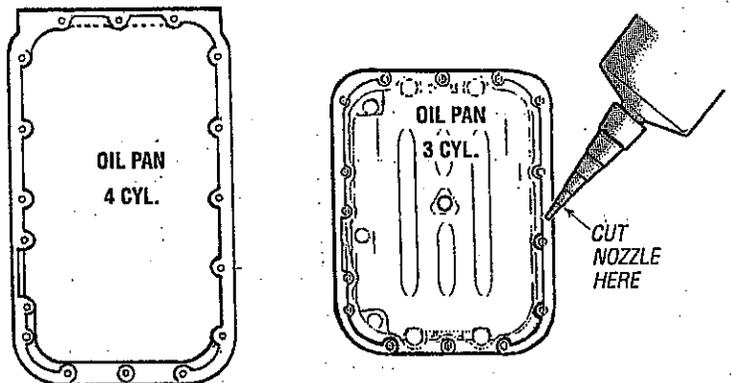
9. Oil screen installation.

- Lay the cylinder block with the bottom (oil pan side) up.
- Install the oil screen in position.

NOTE: The oil screen must be installed in position so that it is below the oil level line and away from the oil pan.

10. Oil pan installation. Clean the mating surfaces of the oil pan and cylinder block and coat them with Hi-Tack Gasket Sealer. Tighten the bolts that hold the oil pan to the cylinder block in a crisscross pattern to the specified torque.

TORQUE: 8.3 ± 1.1 lb-ft (1.15 ± 0.15 Kgf-m)



NOTE: Squeeze out a 4mm (0.2 in) thick bar of sealing compound Hi-Tack Gasket sealer from the tube and put it on the flange of the oil pan as shown. To squeeze out a 4mm (0.2 in) thick bar, cut the nozzle of the tube as shown.

ASSEMBLY TIMING GEARS AND FLYWHEEL

TAPPETS
LUBRICATE WITH
ENGINE OIL

NEW GASKET

THRUST PLATE BOLT
TORQUE TO:
 $1.1 \pm 0.1 \text{ Kg-m}$
 $10.8 \pm 1 \text{ Nm}$

OIL SEAL
LUBRICATE
WITH ENGINE OIL

CAMSHAFT
APPLY ENGINE OIL TO
JOURNALS AND LOBES

NEW GASKET

PULLEY NUT
TORQUE TO:
 $17.5 \pm 2.5 \text{ Kg-m}$
 $172 \pm 25 \text{ Nm}$

NEW GASKET

BACK PLATE BOLT
TORQUE TO:
 $6.5 \pm 1 \text{ Kg-m}$
 $64 \pm 10 \text{ Nm}$

OIL SEAL
APPLY ENGINE OIL
TO SEAL LIP

GASKET
REPLACE

FLYWHEEL BOLT
TORQUE TO:
 $13.5 \pm 0.5 \text{ Kg-m}$
 $132 \pm 5 \text{ Nm}$

ASSEMBLY

11. Front plate installation.

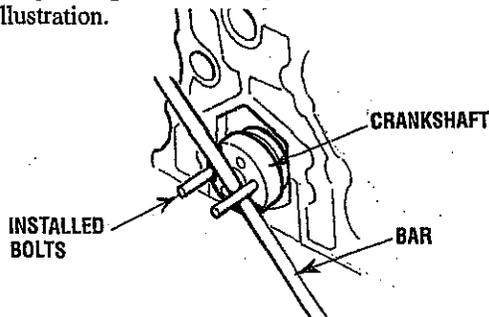
- Scrape the gasket from the cylinder block and front plate.
- Coat the gasket contact surface of the cylinder block with adhesive and put a new gasket in position, making sure the holes in the gasket are all in alignment with the holes in the cylinder block.
- Put the front plate in position. Install four bolts and tighten them.

12. Oil pump installation.

- Make sure the packing has been put in position on the oil pump.
- Put the oil pump in position on the cylinder block. Install the bolts and tighten them evenly.
- Make sure the oil pump gear rotates freely.

13. Engine turning.

- Install two bolts (M12 x 1.25) in the flywheel bolts holes in the crankshaft.
- Put a bar between the bolts and turn the crankshaft to bring No.1 piston to the top center as shown in the illustration.



14. Fuel injection pump camshaft installation.

- Put the camshaft (with bearing and gear) in position in the cylinder block.
- Hit the gear with a plastic hammer to fit the bearing in position.
- Make sure the camshaft rotates freely.
- Tighten the stopper bolt.

15. Camshaft installation.

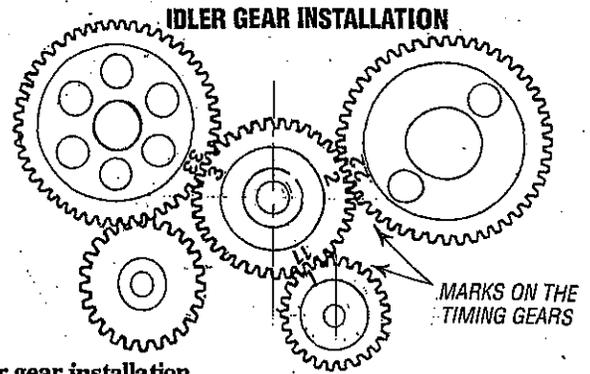
- Lubricate the lobes and journals with engine oil.
- Put the camshaft (with gear) in position in the cylinder block.

CAUTION: Do not cause damage to the lobes and journals when the camshaft is installed.

- Tighten the bolts that hold the thrust plate to the specified torque.

TORQUE: 8 ± 0.7 lb-ft (1.1 ± 0.1 Kgf-m)

- Make sure the camshaft rotates freely, Check the end play for the camshaft.



16. Idler gear installation.

- Lubricate the idler gear with engine oil.
- Install the idler gear in position with its "3", "2" and "11" marks in alignment with the the "33" mark on the fuel injection pump camshaft gear, the "22" mark on the camshaft gear and the "1" mark on the crankshaft gear respectively.
- Check the backlash of the gears. Make reference to *Timing gear backlash measurement*.

17. Timing gear case installation.

- Coat the gasket with adhesive and put it in position on the front plate.
- Lubricate the oil seal with engine oil.
- Tighten the bolts that hold the timing gear case.

18. Crankshaft pulley nut tightening.

- Install two bolts (M12 x 1.25) in the flywheel bolt holes in the crankshaft and hold the crankshaft.
- Tighten the crankshaft pulley nut to the specified torque.

TORQUE: 127 ± 18 lb-ft (17.5 ± 2.5 Kgf-m)

WARNING: Check the strength of the bolts and bar used for holding the crankshaft.

- P.T.O. gear installation. Install the P.T.O. gear in position in the timing gear case with the side that has no oil hole toward the rear of the engine.

- Tappet installation. Lubricate the tappets with engine oil and put them in position in the cylinder block.

21. Oil seal case installation.

- Put a new gasket in position on the oil seal case.
- Lubricate the oil seal with engine oil and install the oil seal in position in the cylinder block.

22. Rear plate installation.

- Put a new gasket in position on the rear plate.
- Put the rear plate in position on the cylinder block with its dowel holes in alignment with the dowels. Tighten the bolts that hold the rear plate to the specified torque.

TORQUE: 47 ± 7 lb-ft (6.5 ± 1 Kgf-m)

NOTE: Install the starter to the rear plate before installing the plate to the cylinder block for convenience of rear plate installation.

ASSEMBLY

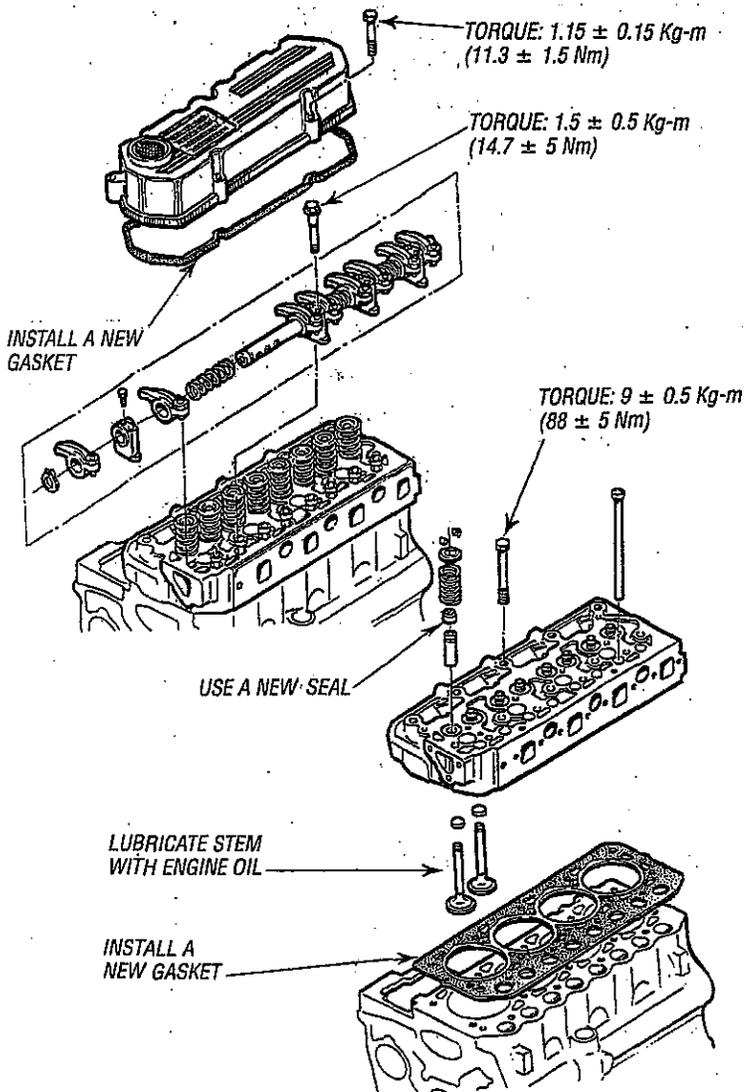
23. Flywheel installation.

- Install a safety bar (M12x 1.25) in the rear end of the crankshaft.
- Put the flywheel in position in alignment with the safety bar.
- Install three of four bolts in the flywheel and tighten them finger tight only.
- Remove the safety bar. Install the last bolt in the flywheel and tighten it finger tight only.
- Have someone hold the crankshaft pulley with a wrench to prevent the flywheel from rotating.
- Tighten the four bolts that hold the flywheel to the specified torque.

TORQUE: 98 ± 4 lb-ft (13.5 ± 0.5 Kgf-m)

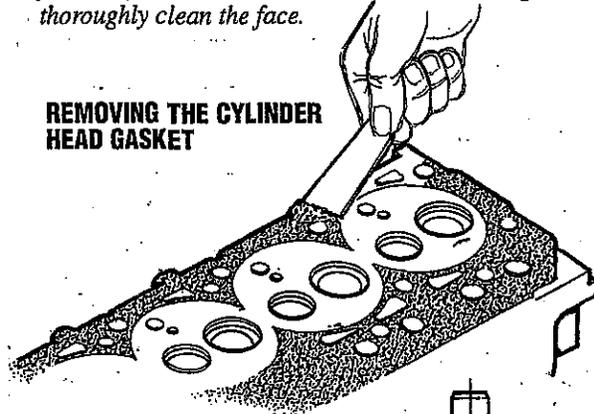
WARNING: Always signal to each other to prevent possible personal injury.

CYLINDER HEAD AND VALVE MECHANISM



24. Cylinder head bottom face cleaning. Scrape the gasket from the bottom face of the cylinder head.

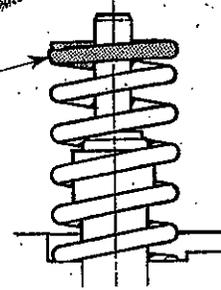
NOTE: After scraping the gasket, rub off gasket remnants from the face with an oilstone smeared with engine oil and thoroughly clean the face.



REMOVING THE CYLINDER HEAD GASKET

WHITE ENAMEL

INSTALLING THE VALVE SPRING



25. Valve stem seal installation. Install the valve stem seal in position in the valve guide. After installation, make sure the seal is in its correct position.

NOTE: Improper stem seal installation can cause a failure to seal against downward flow of oil along the stem.

26. Install the valve spring with the white enameled end up.

27. Valve block installation. Put compression on the valve spring with a valve lifter and install the block in position on the valve top.

CAUTION: Do not put excessive compression on the valve spring. This can cause the retainer to hit and damage the stem seal.

28. Cylinder head gasket installation.

- Thoroughly clean the top faces of the cylinder block and pistons,
- Install two guide bolts (M10 x 1.25) in the bolt holes in the cylinder block.
- Put a new cylinder head gasket in position on the cylinder block, making sure the guide bolts are all in alignment with their respective holes in the gasket..

CAUTION: Do not use any gasket adhesive or other substances on the top face of the cylinder block.

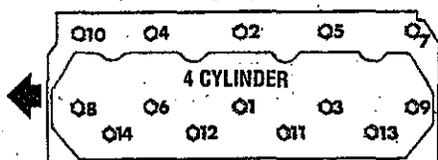
ASSEMBLY

29. **Installation of the cylinder head.** Place the cylinder head in position on the cylinder block, making sure the guide bolts are all in alignment with their respective bolt holes in the head.

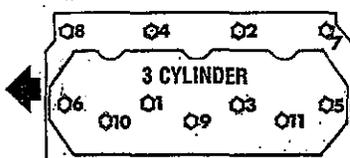
30. Cylinder head bolt tightening

- Remove the guide bolts and install the bolts that hold the cylinder head to the cylinder block.
- Tighten the bolts in number sequence in two or three steps to the specified torque.

TORQUE: 65 ± 4 lb-ft (9 ± 0.5 Kgf-m)



FRONT



31. Valve push rod installation.

- Put the valve push rod into position through the bore in the cylinder head.
- Make sure the ball end of the push rod has been put into position over the top of the tappet.

32. Rocker shaft assembly.

- Install the rocker arms, brackets and springs on the rocker shaft. Secure the brackets to the shaft by tightening the bolts.
- Make sure the rocker arms move freely.

33. Rocker shaft assembly installation.

- Install the valve caps in position on the top of the valves.
- Put the rocker shaft assembly in position on the cylinder head. Tighten the bolts that hold the rocker shaft assembly to the specified torque.

TORQUE: 11 ± 4 lb-ft (1.5 ± 0.5 Kgf-m)

- Adjust the valve clearance, see *VALVE CLEARANCE* in this manual.

34. Rocker cover installation.

- Make sure the gasket is assembled to the rocker cover,
- Tighten the bolts that hold the rocker cover to the specified torque.

TORQUE: 8.3 ± 1.1 lb-ft (11.5 ± 0.15 Kgf-m)

35. Tighten the bolts that hold the air intake to the specified torque.

TORQUE: 13.4 ± 2.5 lb-ft (1.85 ± 0.35 Kgf-m)

36. Tighten the bolts that hold the exhaust manifold to the specified torque.

TORQUE: 13.4 ± 2.5 lb-ft (1.85 ± 0.35 Kgf-m)

37. Fuel injection nozzle installation.

- Put the gasket on the nozzle.
- Put the nozzle assembly in position in the cylinder head and tighten it to the specified torque.

TORQUE: 40 ± 4 lb-ft (5.5 ± 0.5 Kgf-m)

38. Put the fuel injection pump in position on the cylinder block and tighten the bolts that hold the pump to the specified torque.

39. Put the flywheel assembly in position on the rear end of the fuel injection pump camshaft and tighten the sliding sleeve shaft to the specified torque.

TORQUE: 26 ± 4.3 lb-ft (3.6 ± 0.6 Kgf-m)

40. Install the sliding sleeve on the sliding sleeve shaft and make sure the sleeve moves freely.

41. Fuel injection nozzle installation.

- Install the governor assembly in position while putting the tie rod and spring into position in the injection pump.
- Install the tie rod to the pin of the control rack and secure it with the tie rod spring.
- Install the tie rod cover in position.

42. Fuel injection line installation.

- Put the fuel leak-off in position and connect it to the fuel injection nozzles.
- Put the fuel injection lines in position and connect them to the fuel injection pump. Install the clamps.

43. Pressure relief valve installation.

Put the relief valve in position on the cylinder block and tighten it to the specified torque.

TORQUE: 36 ± 4 lb-ft (5 ± 0.5 Kgf-m)

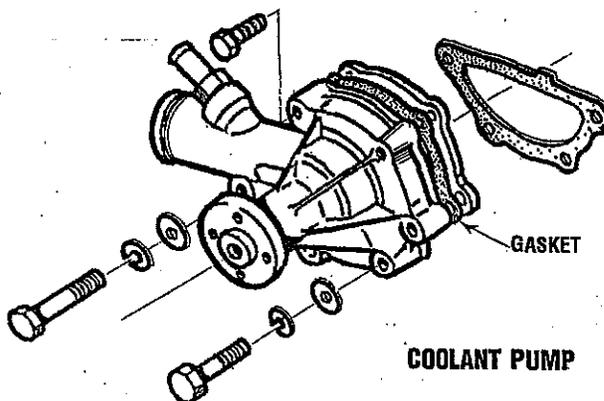
44. Install the oil filter.

Lightly lubricate the gasket with engine oil and install the new filter element by hand. When the gasket contacts the base, tighten one more turn.

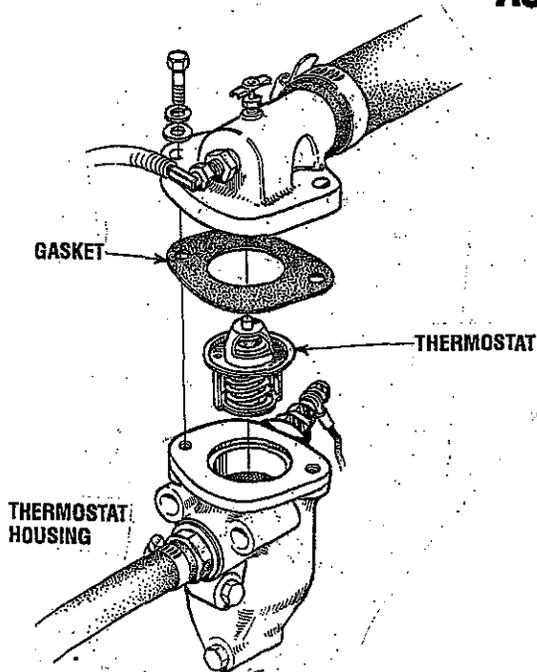
45. Coolant pump.

Check the impeller and shaft for rotation. If they do not rotate freely or have noise, replace the coolant pump assembly.

46. Put a new gasket in position on the water pump flange. Install the water pump onto the cylinder block.



ASSEMBLY

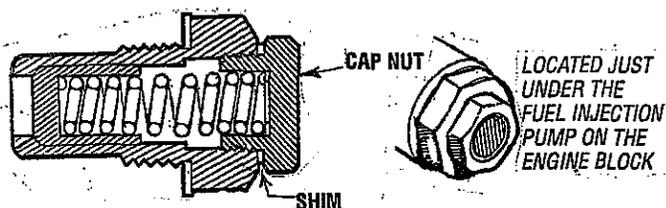


47. **Install the thermostat.** Put the thermostat in the thermostat housing with a new gasket and install the thermostat housing in position on the cylinder head.

48. **Oil pump.** Visually check the pump for rough roatolon or other defects. Replace the pump assembly if defective.

49. **Oil pressure relief valve.** Check the valve seat for contact and check the spring for damage. Measure the oil pressure at which the relief valve opens (the oil pressure with the engine running at the rated rpm). If the pressure is not correct, remove the cap nut and increase or decrease the amount of shims. The engine oil pressure tap is located on the right side of the engine.

RELIEF VALVE OPENING PRESSURE: 50 ± 7 psi (3.5 ± 0.5 Kgf-m)



50. **Install the glow plugs in position in the precombustion chamber and tighten them to the specified torque. For testing, refer to GLOW PLUGS in this manual.**

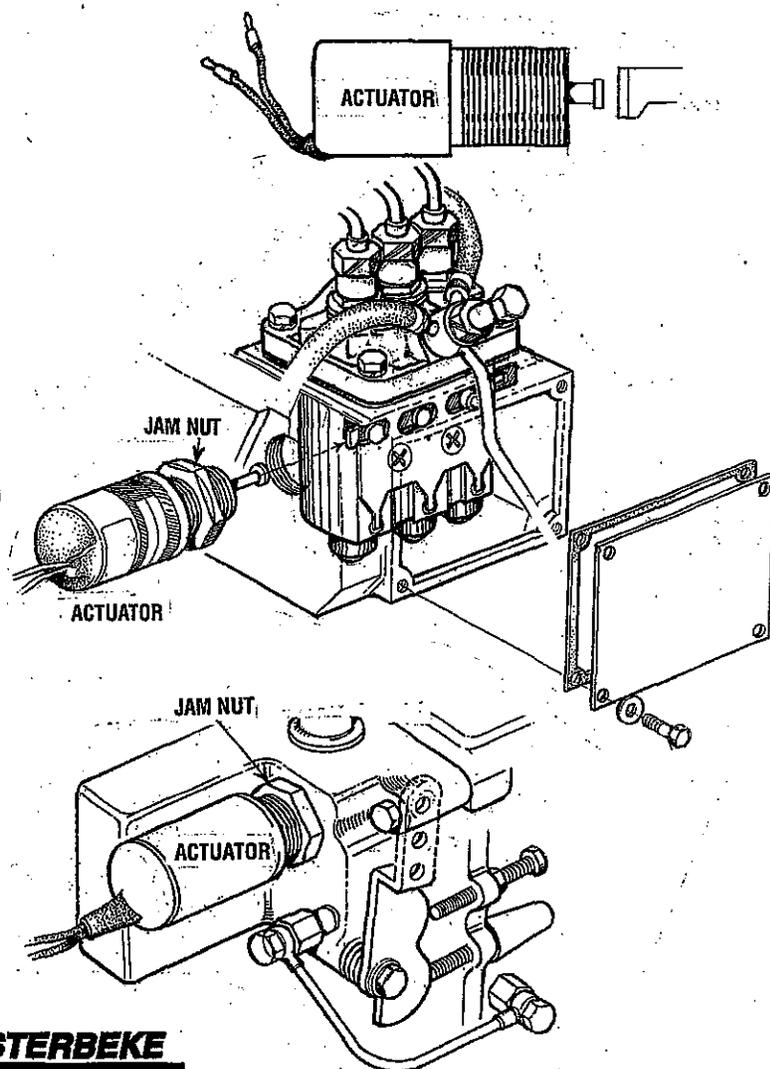
TORQUE: 12.7 ± 1.8 psi (1.75 ± 0.25 Kgf-m)

51. **Alternator installation.**

- Put the alternator in position. Install the adjusting bolt in position to hold the alternator in position.
- Put the belt in position on the pulley. Move the alternator away from the engine to make an adjustment to the belt.
- Tighten the bolts.
- Make sure the tension of the belt is correct, about 2" deflection at the center with pressure.

52. **Actuator Installation.**

- Apply some teflon sealant to the threads of the actuator and thread the actuator into its mounting boss 4 to 5 turns.
- Connect the actuators electrical wires into the engine harness. Turn OFF the AC breaker and start the engine. **Note:** The engine speed may not be at the desired speed (1500 or 1800 rpm).
- With the engine running, depress the stop switch to verify the engine will shut down. If it does not and just goes to a very slow idle, slowly thread the actuator in until it shuts down and then thread it in an additional 1/2 turn and secure it in place with the jam nut.
- Unplug the actuators electrical connections from the harness and untwist the wires so they lay properly and reconnect them into the engine harness.
- Turn ON the AC breaker and start and stop the engine to ensure proper actuator adjustment for good engine shut down.
- The actuator may need further adjustments once the unit has been run under a good amperage load. An additional 1/2 turn maybe needed after the unit has run under such conditions and is found only to go to a slow idle and not a full shutdown.



EXHAUST MANIFOLD / HEAT EXCHANGER

EXHAUST MANIFOLD

The exhaust manifold, which was disassembled from the cylinder head, should be inspected before reassembly.

1. Remove the exhaust elbows from the lower surface of the manifold. Clean and inspect for cracks and defects. Replace as needed.
2. Remove the exhaust nipples, elbows and plugs from the manifold.
3. Remove water connectors from the ends of the manifold. Be sure to note the proper location and arrangement of each for proper alignment.
4. Examine all parts for defects, corrosion and wear and replace as needed.
5. Flush out the manifolds interior with a liquid cleaner and rinse thoroughly with fresh water.
6. Use a pipe cleaner to clear the passage that connects the coolant recovery tank tubing.
7. Flush out the coolant recovery tank and it's connecting tube.

ASSEMBLY

1. If the manifold was removed as an assembly and left intact, it can be replaced on the cylinder head in the reverse order of removal. Do not reuse the gaskets; install new ones.

Manifold Mounting

Bolts Torque Values 20 - 24 ft-lb (2.7 - 3.3 m-kg)

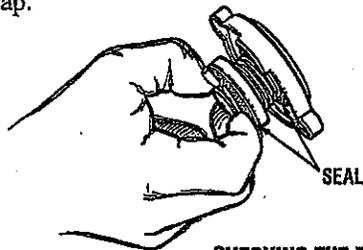
2. If the manifold has been disassembled, follow the steps below.
 - a. Loosely attach the elbows to the cylinder head and the manifold using new gaskets. Do not use any gasket sealant.
 - b. Gradually tighten each fitting to make sure of proper alignment of all the parts. This should be done in three steps.

Manifold Mounting

Bolts Torque Values 20 - 24 ft-lb (2.7 - 3.3 m-kg)

- c. Reinstall the exhaust connections and plugs into the manifold using Loctite-Anti-Seize on the threads.

Check the manifold pressure cap. Open the valve by pulling it and make sure it closes when released. Make certain the upper and lower seals are in good condition. If any doubt, replace the cap.



CHECKING THE PRESSURE CAP

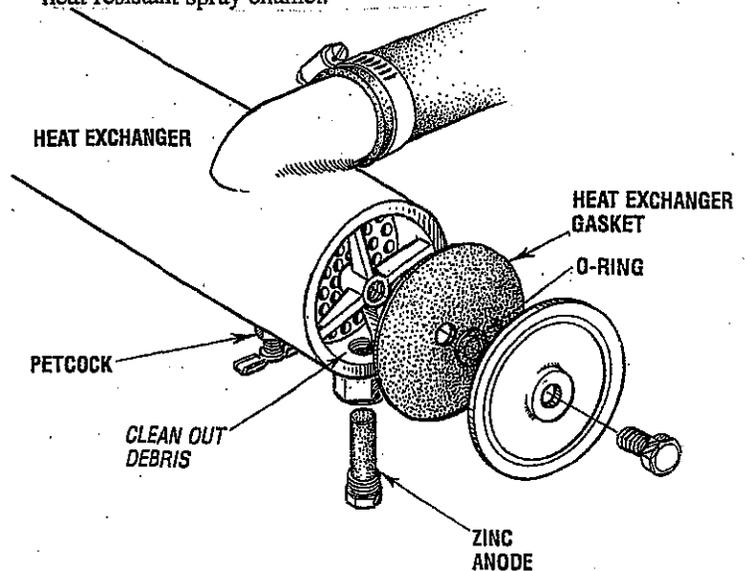
HEAT EXCHANGER

The heat exchanger should be inspected and serviced during an engine overhaul.

1. Disconnect the hoses and remove the hose fittings, petcock, drain plugs and zinc anode. Also, remove the end fittings and gaskets.
2. Inspect the tube (casing) for wear and dents, if at all suspect replace the heat exchanger.
3. Clean out any zinc debris and pressure test the coolant and raw water passages.
4. When reassembling, install new gaskets and O-rings. Apply some lubricant to the new gaskets and to the petcocks and fittings as you install them.
5. Install a new zinc anode.

NOTE: All of the above can be accomplished by sending the heat exchanger to a heat exchanger service shop. They will also service transmission and engine oil coolers.

6. Repaint the assembled heat exchanger with Westerbeke heat resistant spray enamel.



AFTER COMPLETED ENGINE ASSEMBLY

7. Reconnect all hoses, replacing them as needed.
8. Refill the system with coolant as detailed above.
9. Pressure test system and check for leaks.

FUEL INJECTION PUMP

NOTE: Injector pump servicing should be performed by a qualified injector shop.

Disassembly Procedure

1. Tappet removal.

- Hold the injection pump in a vise with the side that has the tappets up.
- Straighten the lock plate away from the tappet guide pin with a screwdriver.
- Rotate the tappet guide pin 180° to unlock it from the housing.
- Remove the tappet guide pin with a needle-nose pliers while pushing down on the tappet. Remove the tappet.
- Do Steps (b) through (d) again for the remainder of the tappets.

CAUTION: The tappet can be thrown from the housing when the tappet guide pin is removed. Hold the tappet to prevent it from falling.

2. Plunger removal.

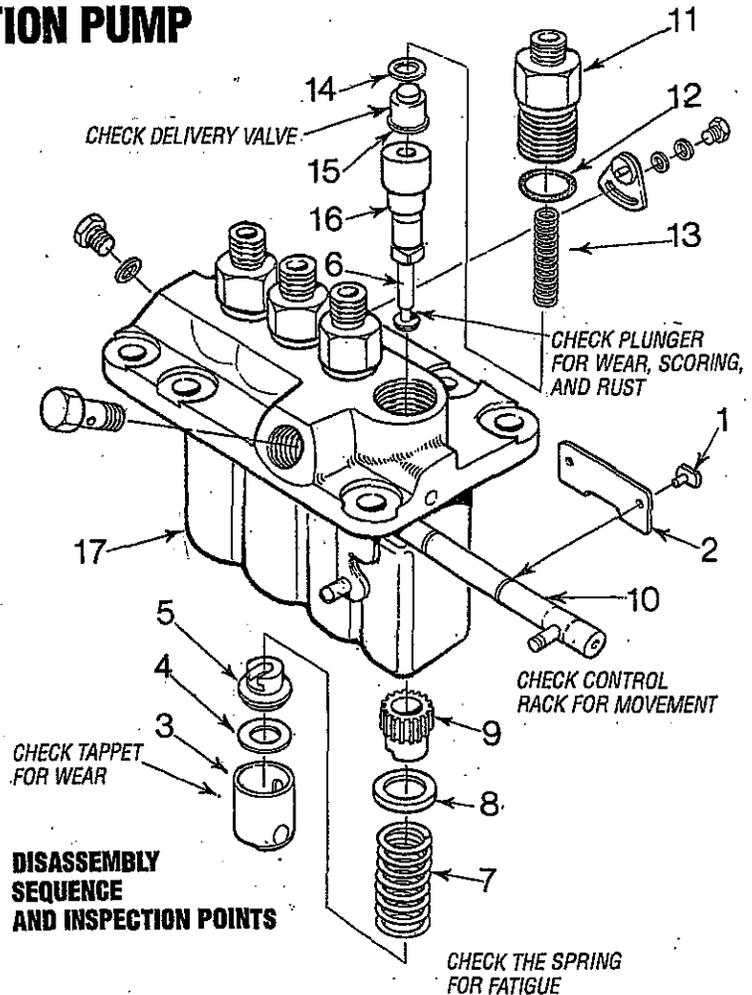
- Remove the tappet adjusting shim.
- Remove the lower spring seat and plunger with a tweezers.
- Remove the plunger spring.
- Remove the upper spring seat and control sleeve.
- Do Steps (b) through (d) again for the remainder of the plungers.
- Remove the control rack.

3. Delivery valve removal.

- Turn the injection pump upside down and hold it in a vise.
- Remove the delivery valve holder.
- Remove the delivery valve spring.
- Remove the delivery valve gasket.
- Remove the delivery valve with a tweezers.
- Do Steps (b) through (e) again for the remainder of the delivery valves.
- Remove the barrels from the housing.

NOTE: When replacing the plungers and barrels or delivery valves, do not loosen the adjusting plates between the pumping elements.

After these parts have been replaced, the injection quantity must be measured. A Pump Tester Cam Box is needed for the measurement of the injection quantity. Keep the disassembled injection pump parts in clean diesel fuel.



CAUTION: The delivery valves, plungers and barrels are finely finished parts. Keep them as clean as possible.

Keep the plungers with their respective barrels for installation. Do not use plungers or barrels with other barrels or plungers.

Assembly procedure

- Put each barrel in position in the housing with its slot in alignment with the dowel of the housing and put it straight down into the bore.

NOTE: If the slot in the barrel is not aligned with the dowel of the housing, the O-ring will not seat correctly (still visible) after the delivery valve holder has been installed.

- Install the delivery valve, gasket, spring and O-ring on the barrel and tighten the delivery valve holder finger tight. Do this step for the remainder of the delivery valves.

CAUTION: Anytime the injection pump is disassembled, a new O-ring must be installed.

Make sure the threads of the delivery valve holder do not cause damage to the O-rings.

FUEL INJECTION PUMP

3. Install each control sleeve with the center tooth in alignment with the line mark of the control rack. Put the plungers in position in the barrels.

CAUTION: Make sure the notch in the plunger is toward the adjusting plate

4. Tappet installation. Move the control rack back and forth while pushing down on each tappet to align the slot in the tappet with the hole in the housing for the tappet guide pin. Install the lock plates and tappet guide pins in position.

CAUTION: Anytime the injection pump is disassembled, new lock plates must be used.

5. Put the delivery valve holders in position and tighten them to the specified torque.

CAUTION: Do not overtighten the delivery valve holders. This can put end force on the barrels, resulting in a failure of the plungers to move freely. If the holders are not tightened to the specified torque, engine oil would leak in the injection pump.

DELIVERY VALVE HOLDER TORQUE 4.5 ± 0.5 Kg-m (44 ± 5 Nm)

6. Inspection after assembly.

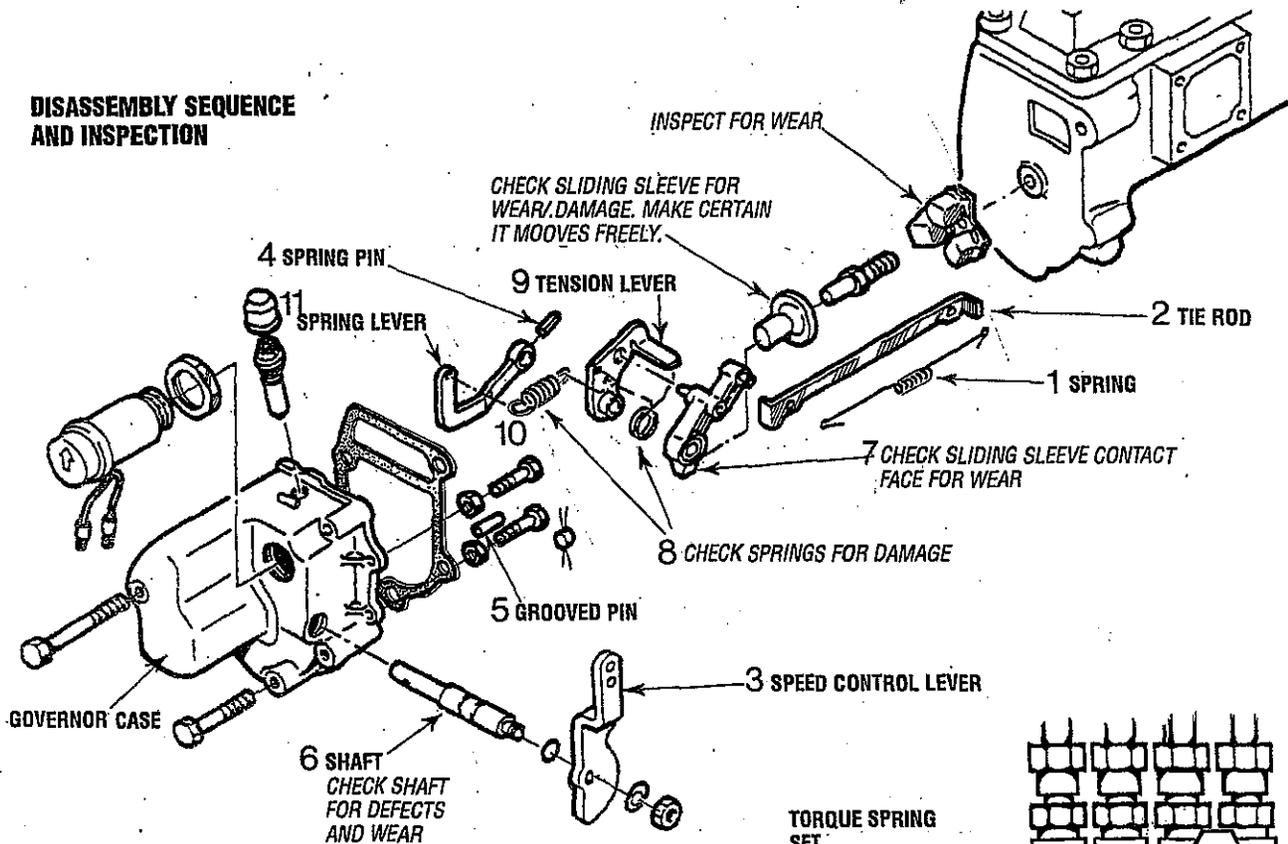
- a. After the injection pump has been assembled, check to see if the control rack moves freely without any binding or catching.
- b. If the control rack fails to move freely, the possible causes are:
 - Pumping element(s) sticking.
 - Foreign particles lodged between control rack and sleeves.
 - Overtightening of delivery valve holder(s).
Disassemble and check the injection pump to locate the cause of the trouble.
- c. After the injection pump has been finally assembled, check the injection timing.

IMPORTANT

NOTE: When removing the injection pump for service by a fuel injection shop. **DO NOT** send the timing shims found under the injection pump with the pump. Leave them with the engine. The injection shop does not need the shims for any repairs or service being performed on the pump. Install the pump back on the engine using these timing shims to place the injection pump back into proper timing with the engine.

GOVERNOR

DISASSEMBLY SEQUENCE AND INSPECTION



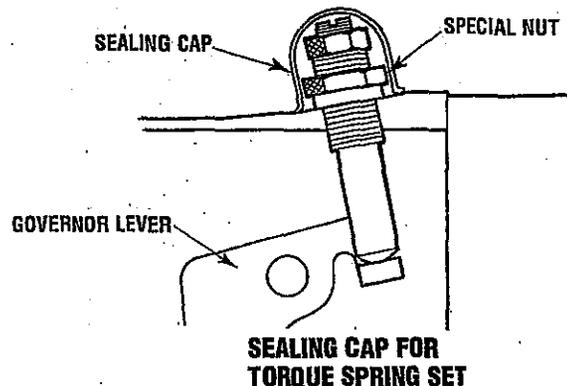
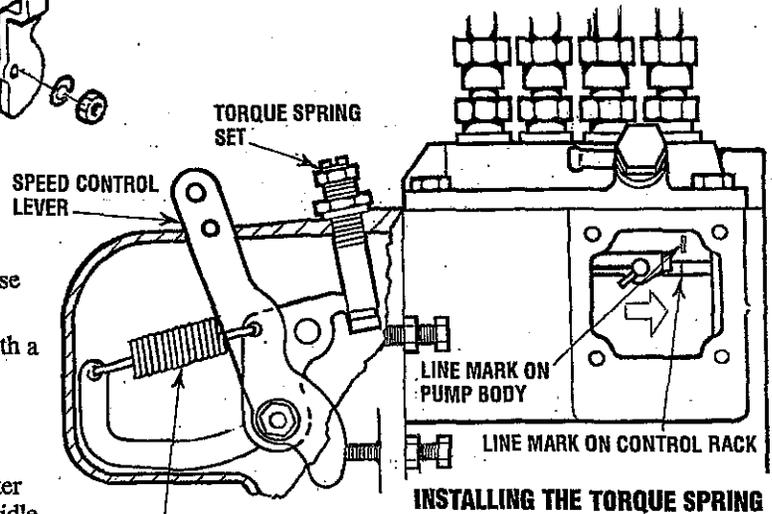
1. Assembly.

- Install the levers in position.
- Put the O-ring on the governor shaft.
- Put the governor shaft in position in the governor case and put the levers on the governor shaft.
- Install the grooved pin and spring pin in position with a hammer.
- Install the tie rod and tie rod spring in position.

2. Torque spring set installation.

The torque spring set is to be installed and adjusted after an adjustment is made to the low idle speed and high idle speed, with the engine at a standstill.

- Remove the tie rod cover.
- Move the speed control lever to the high idle position and hold it there.
- Pull the tie rod in the direction of arrow head to the point where a slight resistance is encountered. In this position, the tie rod does not pull on the governor spring.
- Turn in the torque spring set while lightly pulling the tie rod until the line mark on the control rack is aligned with the line mark on the pump body.
- With these line marks aligned, lock the torque spring set in position by tightening the special nut.
- Install the sealing cap over the torque spring set and stake the cap in position.



FUEL INJECTION TIMING

PREPARATION

- Close the fuel shut-off valve.
- Disconnect the No.1 fuel injection pipe from the cylinder head and injection pump.
- Remove No.1 delivery valve holder from the injection pump. Remove the delivery valve and spring from the holder. Restore the delivery valve holder only to the injection pump.
- Connect the fuel injection pipe to the injection pump.
- Hold the speed control lever in the low speed position. (Generator) remove the actuator.

INSPECTION (Fuel Flow Method)

- Open the fuel shut-off valve. Depress and hold the prime button.

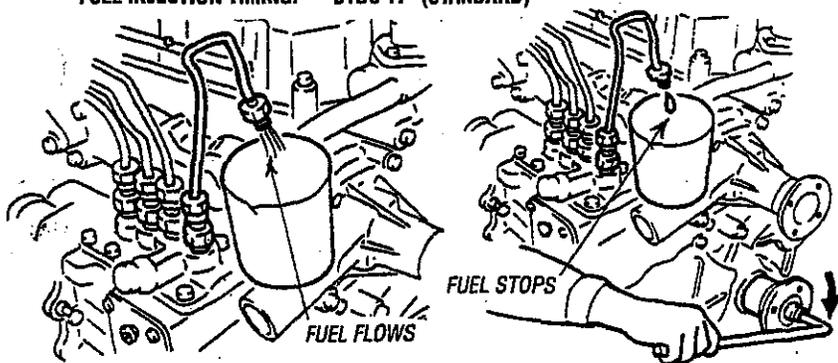
NOTE: The prime button energizes the electric fuel pump sending high pressure fuel through the injection pipe. Direct this fuel flow into a proper container.

- Slowly turn the crankshaft clockwise, looking at the open end of the injection pipe. The instant fuel stops coming out is the fuel injection timing.

NOTE: Turn the crankshaft in the reverse direction just a little and do step b again to verify the injection timing.

- The fuel injection timing is correct if the IT mark on the crankshaft pulley is aligned with the mark on the timing gear case when fuel stops from the injection pipe.

FUEL INJECTION TIMING: BTDC 17° (STANDARD)



ALTERNATE METHOD

In the fuel flow method, the delivery valve has to be removed. As a result, there is a good chance for dirt particles to get inside the fuel injection pump. In this alternate method, however, it is not necessary to remove the delivery valve.

- Disconnect No.1 fuel injection pipe at the fuel injection nozzle (cylinder head).
- Prime the fuel system.
- Slowly turn the crankshaft clockwise until fuel just swells at the free end of the injection pipe and, at that instant, check the position of the IT mark with respect to the mark on the gear case. This timing is approximately 1° retarded. Take this 1° retardation into account when making a shim adjustment.

ADJUSTMENT

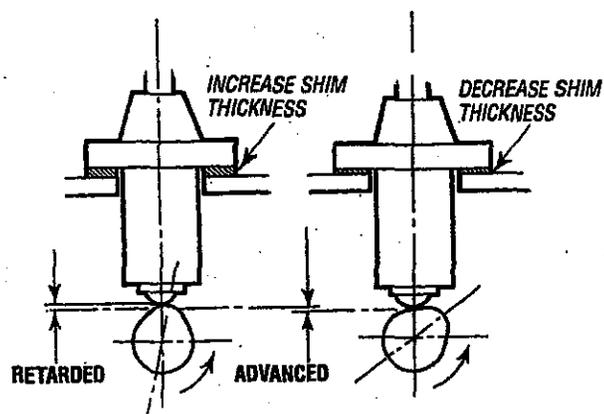
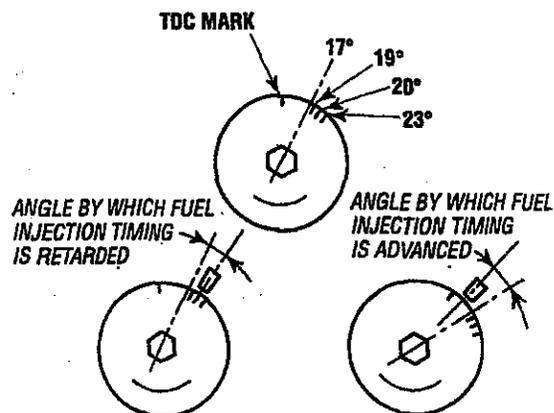
- If the fuel injection timing is incorrect, change the thickness of shims under the fuel injection pump. An increase or decrease of the shims by 0.1mm (0.004 in) will vary the timing by 1°.
- Increase the thickness of the shims to retard the timing or decrease it to advance the timing.

ADJUSTMENT RANGE: STANDARD ± 1.5°

Four kinds of shims are available in thicknesses 0.2mm (0.0079 in), 0.3mm (0.0118 in), 0.4mm (0.0157 in) and 0.8mm (0.0315 in). These shims have no identification, measure the thickness of each shim with calipers before using it.

CAUTION: Apply sealant to both faces of each shim to prevent oil leaks.

- After the timing has been adjusted, make sure it is correct.
- Close the fuel filter valve and restore the delivery valve and injection pipe to the original state.



FUEL INJECTORS

REMOVING THE INJECTORS

NOTE: Injector must be serviced in a "clean room" environment.

1. Disconnect the high pressure lines from the injectors and loosen the lines at their attachment to the injection pump and move them out of the way of the injectors. Avoid bending the lines.
2. Remove the fuel return line in its entirety from the top of the injectors. Take care not to lose the sealing washers and banjo bolt that attaches the fuel return line to each injector.
3. Unscrew the injector from the cylinder head using a suitable deep socket.

NOTE: Clean the area around the base of the injector prior to lifting it out of the cylinder head to help prevent any rust or debris from falling down into the injector hole. If the injector will not lift out easily and is held in by carbon build up or the like, work the injector side to side with the aid of the socket wrench to free it and then lift it out.

4. The injector seats in the cylinder head on a copper sealing washer. This washer should be removed with the injector and replaced with a new washer when the injector is reinstalled.

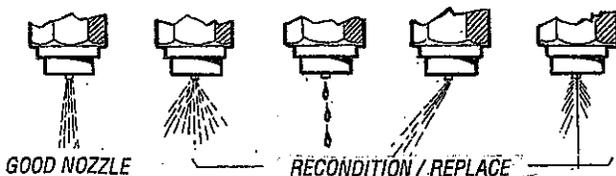
NOTE: Greatest possible care should be taken in handling the nozzles as they are precisely machined. The nozzle and the needle valve are matched parts. Do not mix their original combinations. Disassemble and wash each nozzle assembly separately.

Carbon deposits on the nozzle body must be removed with a piece of hard wood. However, it would be advisable not to clean the surrounding area of the nozzle orifice to avoid possible damage to the orifice.

INJECTION TESTING/ADJUSTMENT

1. Using the nozzle tester, check the spray pattern and injection starting pressure of nozzle and, if it exceeds the limit, adjust or replace the nozzle. When using nozzle tester, take the following precautions:

CAUTION: The spray injected from the nozzle is of such velocity that it may penetrate deeply into the skin of fingers and hands, destroying tissue. If it enters the bloodstream, it may cause blood poisoning.



- a. If the diesel fuel of the nozzle tester is discolored, replace it. At the same time, clean or replace the fuel filter.
- b. Mount the nozzle and nozzle holder on the nozzle tester.
- c. Operate the hand lever of nozzle tester several times to bleed the air in the nozzle line, then move the hand lever at intervals of one stroke per second while reading the injection starting pressure.

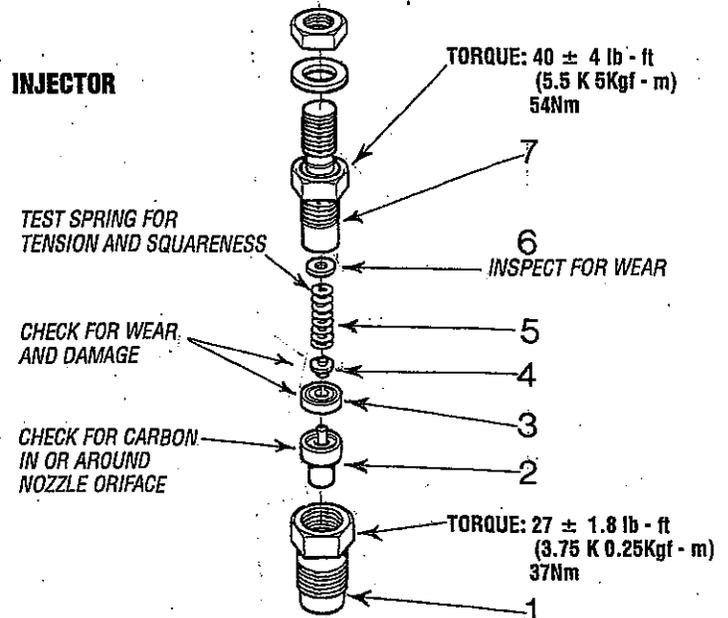
INJECTOR STARTING PRESSURE 1991^{psi} (140^{kgf-cm})

- d. If the fuel injection starting pressure is not within the specification, it can be adjusted by removing or adding shims in the injector body to achieve proper pressure.

NOTE: An increase or decrease of shim thickness by 0.004 in (0.1mm) will vary the injection pressure by 142 psi (10 kgf-cm). Ten shims are available in thickness from 1.25 mm to 170 mm (0.0492 in to 0.0669 in) in increments of 0.0020 in (0.05 mm).

- e. When replacing the shim, grip the retaining nut in a vise and remove the body with a wrench. Tighten the retaining nut to the specified torque.

NOZZLE BODY TORQUE 27 ± 1.8 lb-ft (3.75 ± 0.25 kgf-m)



DISASSEMBLY AND INSPECTION

1. Clamp the nozzle holder in a vise, remove the nozzle nut and disassemble the nozzle body, spring, and needle.
2. Clean the disassembled parts with clean diesel fuel.

INSTALLING

1. Install in the reverse order of removal.

NOTE: The copper washers should not be reused. Replace with new washers.

2. Tighten the nozzle on the cylinder head to the specified torque.

NOZZLE TORQUE 40 ± 4 lb-ft (5.5 ± 0.5 kgf-m)

GLOW PLUG TESTING

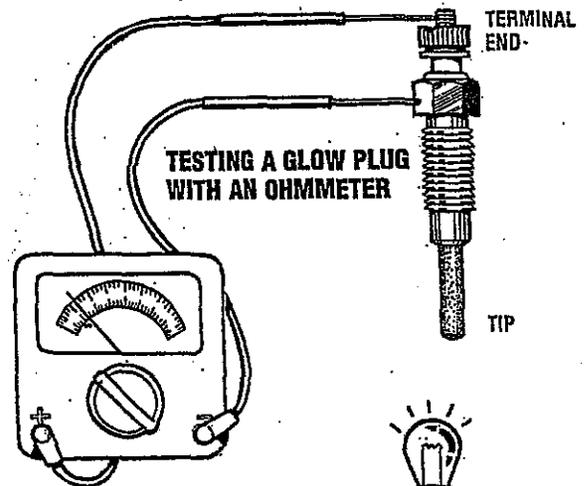
GLOW PLUGS

To inspect the plug, remove the electrical terminal connections, then unscrew or unclamp each plug from the cylinder head. Thoroughly clean each plug's tip and threads with a soft brush and cleaning solution to remove all the carbon and oil deposits. While cleaning, examine the tip for wear and burn erosion; if it has eroded too much, replace the plug.

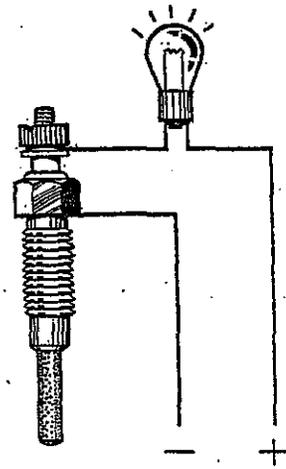
An accurate way to test glow plugs is with an ohmmeter. Touch one prod to the glow plug's wire connection, and the other to the body of the glow plug, as shown. A good glow plug will have a 1.0 - 1.5 ohm resistance. This method can be used with the plug in or out of the engine. You can also use a multimeter to test the power drain (8 - 9 amps per plug).

Re-install the plugs in the engine and test them again. The plugs should get very hot (at the terminal end) within 7 to 15 seconds. If the plugs don't heat up quickly, check for a short circuit. When reinstalling the glow plugs, use anti-seize compound on the threads.

⚠ WARNING: *These glow plugs will become very hot to the touch. Be careful not to burn your fingers when testing the plugs.*



TESTING A GLOW PLUG USING A TEST LIGHT



⚠ WARNING: *Do not keep a glow plug on for more than 30 seconds.*

GLOW PLUG TIGHTENING TORQUE . 7 - 11 ft-lb (1.0 - 1.5 m-kg)

STARTER MOTOR

DESCRIPTION

The starter can be roughly divided into the following sections:

- A motor section which generates a drive power.
- An overrunning clutch section which transmits an armature torque, preventing motor overrun after starting.
- A switch section (solenoid) which is operated when actuating the overrunning clutch through a lever and which supplies load current to the motor.

The starter is a new type, small, light-weight and is called a high-speed internal-reduction starter. The pinion shaft is separate from the motor shaft; the pinion slides only on the pinion shaft. A reduction gear is installed between the motor shaft and a pinion shaft. The pinion sliding part is not exposed outside the starter so that the pinion may slide smoothly without becoming fouled with dust and grease. The motor shaft is supported at both ends on ball bearings. The lever mechanism, switch and overrunning clutch inner circuit are identical to conventional ones.

ADJUSTMENT AND REPAIR

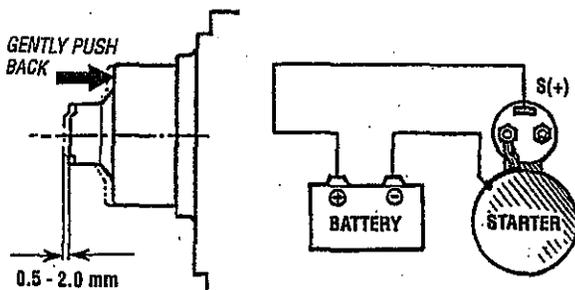
If any abnormality is found by the following tests, the starter should be disassembled and repaired.

Pinion Gap Inspection

1. Connect a battery (12V) between the starter terminal S and the starter body, and the pinion drive should rotate out and stop.

CAUTION: Never apply battery voltage for over 10 seconds continuously.

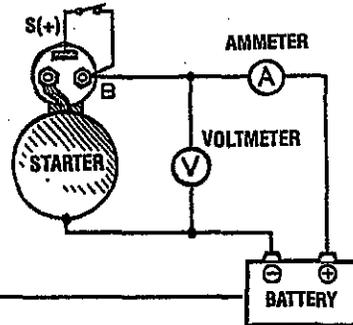
2. Lightly push the pinion back and measure the return stroke (called pinion gap).
3. If the pinion gap is not within the standard range, 0.0197 - 0.0788in (0.5 to 2.0mm), adjust it by increasing or decreasing the number of shims on the solenoid. The gap is decreased as the number of shims increases.



PINION GAP

No-Load Test

1. Connect the ammeter, voltmeter, and battery to the starter as illustrated.
2. When the switch is closed, the pinion must protrude and the starter must run smoothly (at 3000 rpm or more). If the current or starter speed is out of specification, disassemble the starter and repair it.

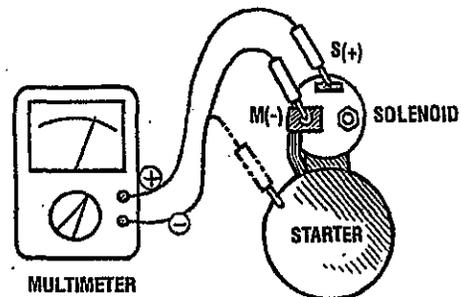


CAUTION: Use thick wires as much as possible and tighten every terminal securely. This is a solenoid shift-type starter which makes a rotating sound louder than that of a direct-drive type starter. When detecting starter rotation at the pinion tip, be careful not to come in contact with the pinion gear when it protrudes.

SOLENOID

Perform the following tests. If any test result is not satisfactory, replace the solenoid assembly.

1. Inspect the solenoid for continuity between terminals (+) and (-) and between terminals S and the body and M and the body. There should be no continuity found between terminals S and M. Continuity will be found between terminals S and the body and terminal M and the body.

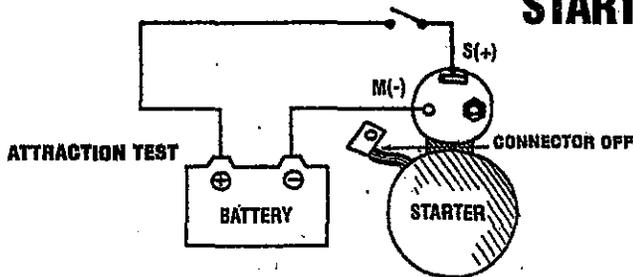


NOTE: Disconnect the wire from terminal M.

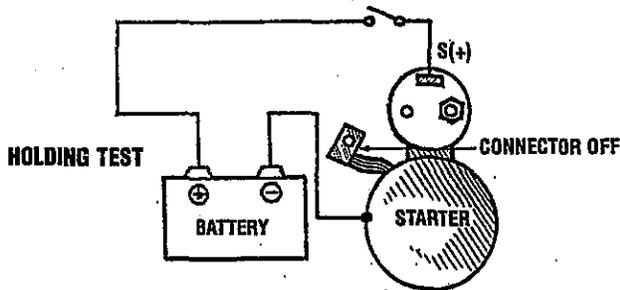
2. Connect a battery to the solenoid's terminal S for (+) and M for (-). Have a switch in the + lead and close it. The pinion drive should extend fully out.

CAUTION: Do not apply battery current for more than 10 seconds when testing the solenoid.

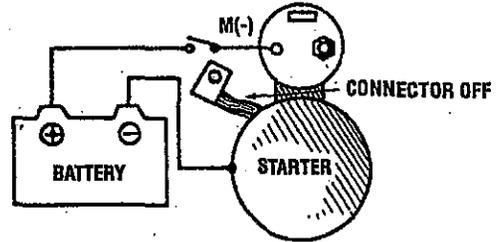
STARTER MOTOR



3. *Holding test.* With a battery connected to the solenoid terminal S (+) and to the starter body, manually pull out the pinion fully. The pinion must remain at that position even when released from holding with your hand.

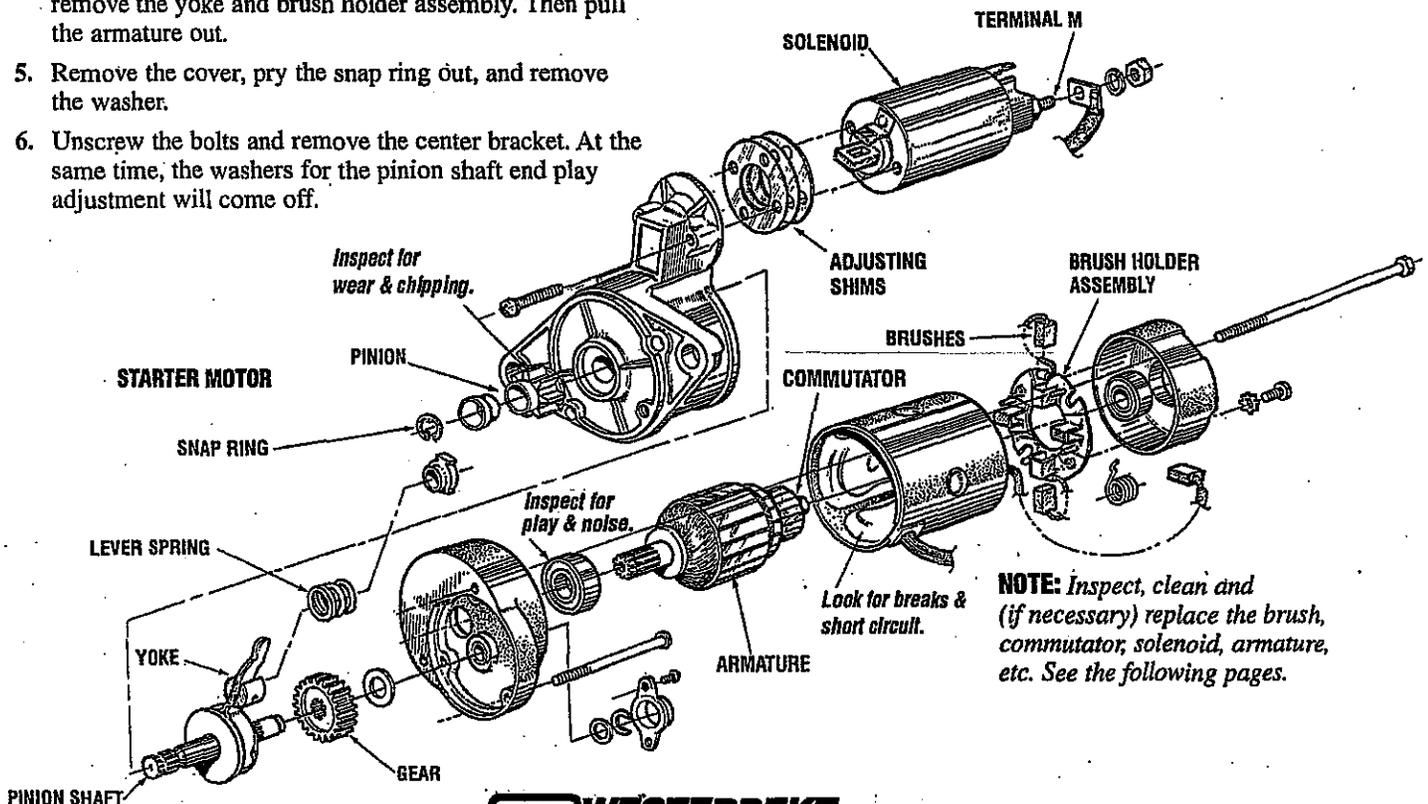


4. *Return test:* With a battery connected to the solenoid terminal M (-) and to the starter body, manually pull out the pinion fully. The pinion must return to its original position when released from holding by hand.



STARTER ASSEMBLY

1. Disconnect the wire from the solenoid terminal M (-).
2. Loosen the two screws fastening the solenoid. Remove the solenoid assembly.
3. Remove the two long through bolts and two screws fastening the brush holder. Remove the rear bracket.
4. With the brushes pulled away from the armature, remove the yoke and brush holder assembly. Then pull the armature out.
5. Remove the cover, pry the snap ring out, and remove the washer.
6. Unscrew the bolts and remove the center bracket. At the same time, the washers for the pinion shaft end play adjustment will come off.
7. Pull out the reduction gear lever and lever spring from the front bracket.
8. On the pinion side, pry the snap ring out, and pull out the pinion and pinion shaft.
9. At each end of the armature, remove the ball bearing with a bearing puller. It is impossible to replace the ball bearing press-fitted in the front bracket. If that bearing has worn off, replace the front bracket assembly.

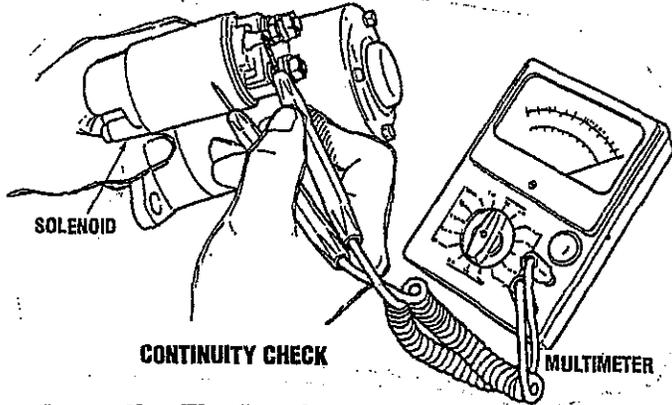


STARTER MOTOR

STARTER INSPECTION

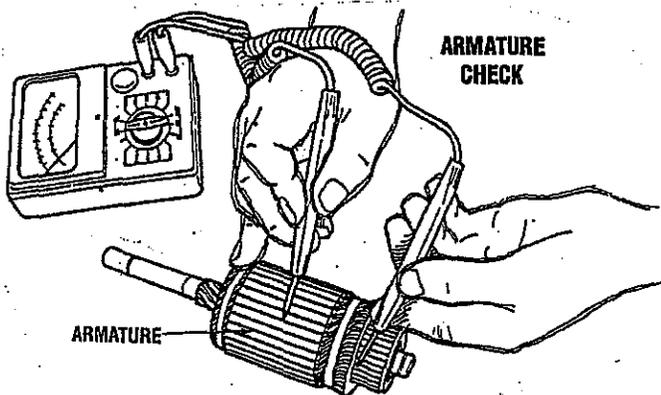
Solenoid

Inspect the solenoid for continuity between terminals S and M and between terminals S and body. No continuity should be found between S and M; Continuity should be found between S and the body and M and the body.

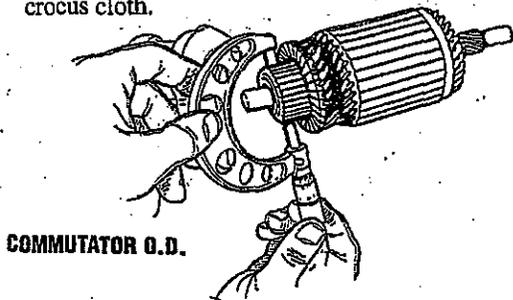


Inspecting The Armature

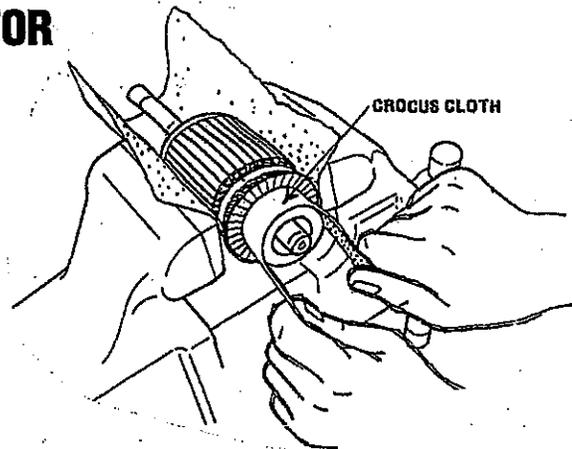
1. Check the armature with a growler tester. If it is short circuited, replace the armature. Also check for insulation between the commutator and its shaft. If poorly insulated, replace the armature.



2. Measure the commutator O.D. and the depth of undercut. Repair or replace it if the service limit is exceeded. Also, check the commutator outside surface for dirtiness and roughness. If rough, polish the commutator with fine crocus cloth.

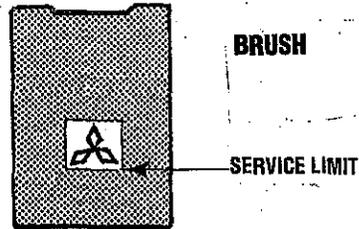


COMMUTATOR OUTSIDE DIAMETER
STANDARD 1.26 in (32 mm)
LIMIT 1.22 in (31 mm)



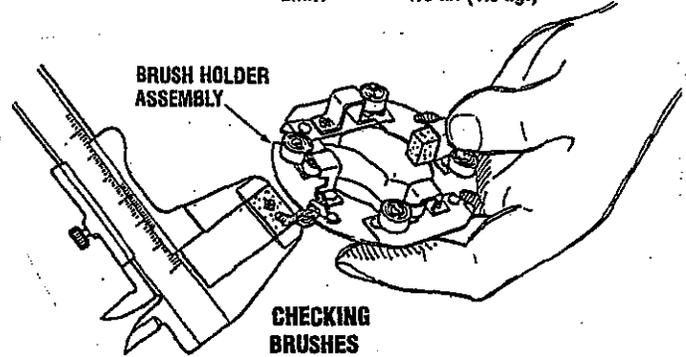
Brush and Brush Holder Inspection

1. Check the brushes. If worn out beyond the service limit, replace the brushes.

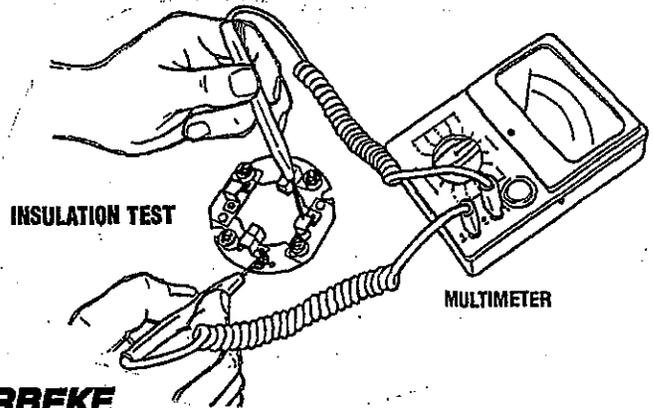


2. Check the brush spring tension. A weak or defective spring will cause excessive brush wear; replace the springs if suspect.

BRUSH HEIGHT
STANDARD 6.6 lbf (3.0 kgf)
LIMIT 4.0 lbf (1.8 kgf)



3. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Also check the brush holders for proper staking.

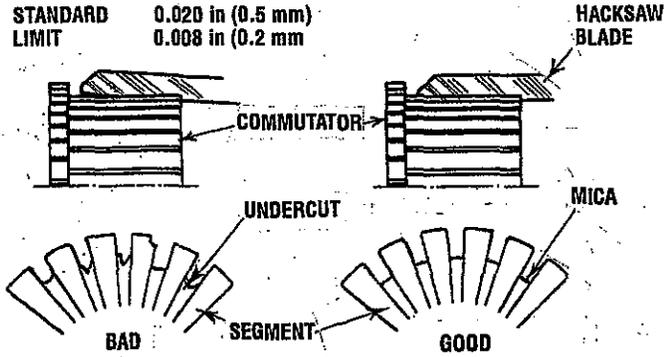


STARTER MOTOR

COMMUTATOR MICA UNDERCUT

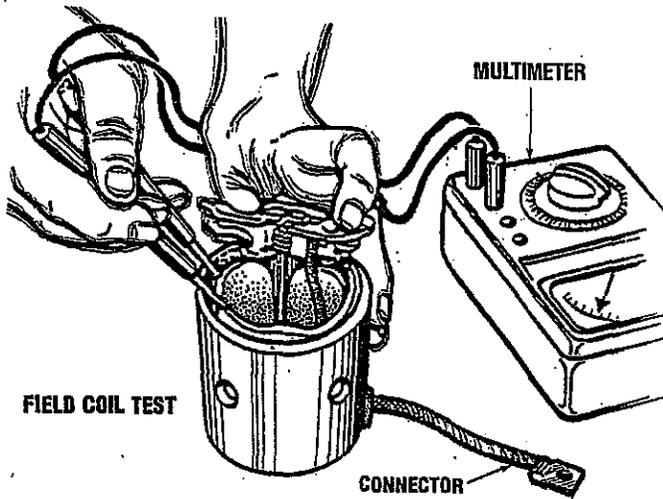
Measure the undercut of mica insulation between the adjacent segments. If undercut exceeds the limit, recondition the mica or replace the armature.

STANDARD 0.020 in (0.5 mm)
LIMIT 0.008 in (0.2 mm)



Field Coil Inspection

1. Check for insulation between one end (brush) of the coil and yoke.
2. Check for continuity between both ends (brushes) of the coil.
3. Check the poles and coil for tightness.

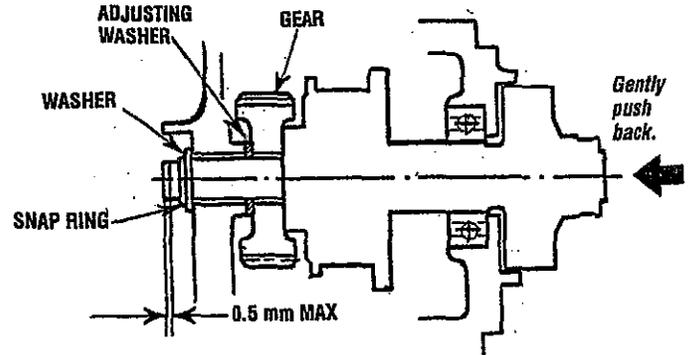


STARTER ADJUSTMENT AND REASSEMBLY

CAUTION: Before installing, thoroughly clean the starter flange and mounting surfaces, remove all oil, old paint, and rust. Starter performance largely depends on the quality of the wiring. Use wire of sufficient size and grade between the battery and starter and fully tighten to the terminal.

Reassemble the starter assembly in the reverse order of disassembly, making sure of the following:

1. **Pinion shaft end play adjustment.** Set the end play (thrust gap) to between 0.5 to 2mm by inserting an adjusting washer between the center bracket and the reduction gear.
 - a. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.
 - b. Measure end play by moving the pinion shaft in the axial direction. If the end play exceeds 0.5mm, increase the number of adjusting washers inserted.



2. **Greasing.** Whenever the starter has been overhauled, apply grease to the following parts:
 - a. Armature shaft gear and reduction gear.
 - b. All bearings.
 - c. Bearing shaft washers and snap rings.
 - d. Bearing sleeves.
 - e. Pinion.
 - f. Sliding portion of lever.

CAUTION: Never smear the starter fitting surface, terminals, brushes, or commutator with grease.

3. After reassembly, check by conducting a no-load test again.

RAW WATER PUMP (PN. 48080)

Disassembly

NOTE: Refer to the following page for parts list and exploded view.

The pump, as removed from the engine, will have hose attachment nipples threaded into its inlet and outlet ports. They may be left in place or removed if they interfere with the pump disassembly. Note the port location and positioning if removed.

1. Remove the six cover plate screws, cover plate, and the cover plate gasket.

NOTE: Replacement of the cover plate gasket is recommended; however, if you are going to reuse it, keep the gasket submerged in water until the pump is reassembled. If it's allowed to dry, the gasket will shrink and not be reusable.

2. Remove the impeller with its drive screw from the pump housing.
3. Remove the screw and sealing washer and remove the cam from the pump housing.
4. Remove the wear plate and leave the pin in place.
5. Remove the front circlip, washer and water seal.
6. Remove the rear circlip
7. Support the pump housing at the mounting flange end. Using an arbor press and with a suitable drift, carefully press the shaft with bearings from the pump housing.
8. The slinger and oil seal will remain in the housing. Remove the oil seal and slinger.
9. Support the bearings inner race and push the shaft out of the bearings.

Inspection

Inspect all parts and replace those showing wear, cracks or corrosion.

Reassembly

1. Support the bearings inner race: Press the shaft into the bearings so that the drive end of the shaft extends beyond the second bearings inner race by 19/32" (15mm) 1/32" (.5mm)

NOTE: The seals' flat surfaces that have printing and numbers face toward each other.

2. Install the oil seal in the pump housing.
3. Support the pump. Lubricate the shaft and slide it thru the oil seal and press the bearings with shaft into the housing so that the outer bearing just clears the rear circlip retaining groove.
4. Install the rear circlip and press the shaft with bearings so that the outer bearing seats on the rear circlip.
5. Lubricate the slinger and slide it onto the shaft so that it is visible midway through the slotted openings of the pump housing.
6. Lubricate the inner half of the water seal, slide it over the shaft and seat it in the pump housing. Install the outer half, washer and front clip to hold the seal in place.
7. Install the wear plate and cam. Apply sealant (Permatex #1) to the cam screw threads and inner cam surfaces. Remove excess.
8. Lubricate and install the impeller. Blade positioning does not matter.
NOTE: Use the lubricant that comes with the impeller. Coat only the surface. Do not over-apply.
9. Install the O-ring and cover plate.

(continued)

ENGINE ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

NOTE: Retorque the cylinder head bolts before adjusting the engine's valves. See TORQUING THE CYLINDER HEAD BOLTS.

WARNING: Adjust the valve clearance when the engine is cold. Valves are adjusted by cylinder in the firing order of the engine. Tighten the cylinder head bolts to the specified torque before adjusting the valves.

Pull off the air breather pipe from the rocker cover and take off the rocker cover bolts and the rocker cover to expose the rocker shaft and valve assembly.

Remove the glow plugs from each of the cylinders to enable the crankshaft to be easily rotated by hand to position each cylinder for valve adjustment.

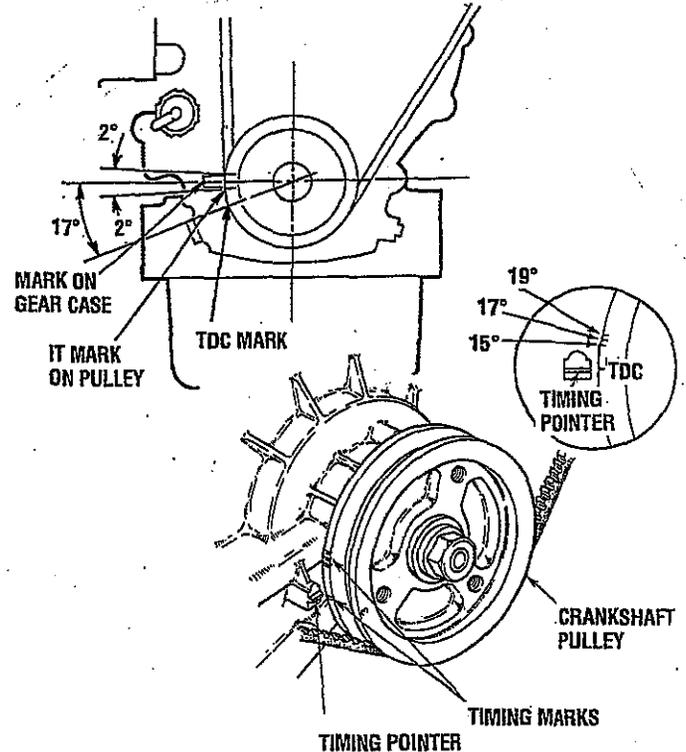
Valves are adjusted with the cylinder in the piston being adjusted at Top Dead Center (TDC) of its compression stroke. Each cylinder is adjusted following the engine's firing order (1-3-2 for WESTERBEKE three cylinder engines).

Valve adjustment beginning with cylinder #1. Rotate the crankshaft slowly and observe the operation of the valves for cylinder #1. Watch for the intake valve to open indicating the piston is on it's intake stroke (the piston is moving down in the cylinder). Continue to rotate the crankshaft slowly and look for the intake valve to close. This indicates the piston is now starting it's compression stroke (the piston is moving up in the cylinder towards TDC).

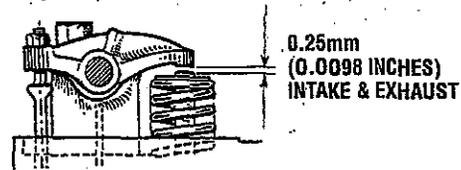
Align the TDC mark on the crankshaft front pulley with the timing marker on the front gear case cover when positioning the #1 Piston at TDC of it's compression stroke. Confirm this by rotating the crankshaft approximately 20 degrees before and after this point and the two valves for the #1 cylinder should not move.

Adjust the valves in #1 cylinder for both intake and exhaust. Proceed to the next cylinder in the firing order.

Rotate the crankshaft 240 degrees in the normal direction of rotation and adjust the next cylinder's valves in the firing order. Rotate the crankshaft another 240 degrees and adjust the valves of the next cylinder in the firing order.



Adjust each valve's clearance by inserting a (0.0098 INCHES) (0.25mm) feeler gauge between the rocker arm and the valve stem. Make sure to adjust all valves while the engine is cold.



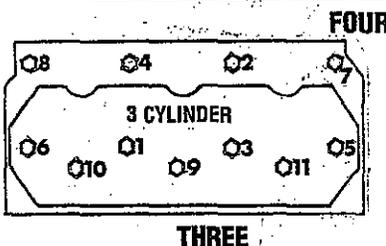
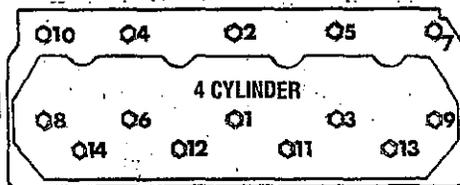
Re-install the glow plugs (use anti-seize compound on the threads) and assemble the rocker cover and rocker cover bolts. See TIGHTENING TORQUE SCHEDULE in this manual.

CYLINDER HEAD BOLT LOOSENING SEQUENCE

Make the following adjustments when the engine is cold.

- Remove the cylinder head cover.
- Slightly loosen the cylinder head bolts and retighten them to the specified torque in the number sequence shown below.

TIGHTENING TORQUE 65 ± 4 lb-ft (88 ± 5 Nm)



ENGINE ADJUSTMENTS

TESTING ENGINE COMPRESSION

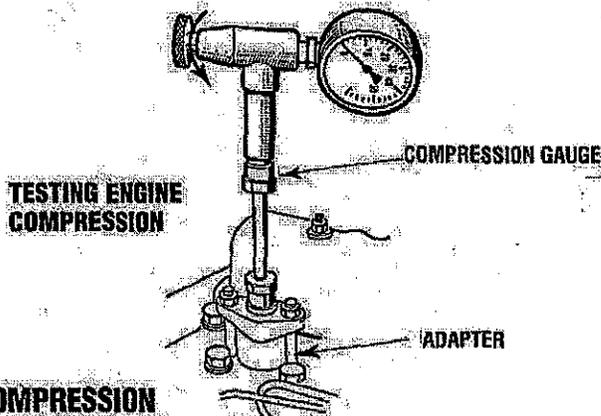
Make certain the oil level (dipstick) is at the correct level and the air intake filter is clean. The battery and starter motor must also be in good condition.

- Warm the engine to normal operating temperature.
- Move the control lever to a position for shutting off the fuel. (Disconnect the wires if a fuel shutdown solenoid is used).
- Remove all the glow plugs from the engine and install the compression gauge/adaptor combination to the cylinder on which the compression is to be measured.
- Close the raw water seacock (thru-hull).
- Crank the engine and allow the gauge to reach a maximum reading, then record that reading.
- Repeat this process for each cylinder.

(minimum)
COMPRESSION PRESSURE 427 psi (30 kg/cm²) at 280 rpm 384 psi (27 kg/cm²)
MAXIMUM PERMISSIBLE DIFFERENCE BETWEEN CYLINDERS
42.7 psi (3 kg/cm²)

NOTE: If the readings are below the limits, the engine needs repair.

- Re-install the glow plugs (use anti-seize compound on the threads) and reset the fuel shut-off to the run position.
- Open the raw water seacock (thru-hull).



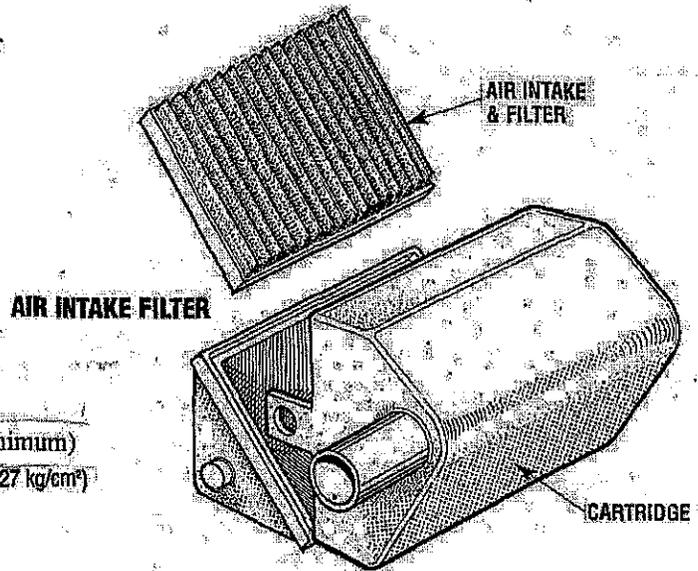
LOW COMPRESSION

When low compression is found, determine the cause by applying a small amount of oil in the cylinder thru the glow plug hole. Allow the oil to settle.

Install the pressure gauge and repeat the above test. If the compression reading rises dramatically, the fault is with the rings. If the compression valve does not rise, the problem is with the valves.

A slight rise in compression would indicate a problem with both the rings and the valves.

AIR INTAKE FILTER/SILENCER



The filter cartridge should be cleaned every 100 operating hours. Tap the cartridge on a flat surface to dislodge loose dirt or clean with compressed air. If the filter cartridge is badly contaminated or oily, replace it.

NOTE: Failure to properly maintain the air intake filter can result in engine oil consumption and filter deterioration and ingestion into the engine.

DRIVE BELT ADJUSTMENT

Excessive drive belt tension can cause rapid wear of the belt and reduce the service life of the fresh water pump's bearing. A slack belt or the presence of oil on the belt can cause belt slipping, resulting in high operating temperatures.

The drive belt is properly adjusted if the belt can be deflected no less than 3/8 inch (10mm) and no more than 1/2 inch (12mm) as the belt is depressed with the thumb at the midpoint between the two pulleys on the longest span of the belt. A spare belt or belts should always be carried on board.

WARNING: Never attempt to check or adjust the drive belt's tension while the engine is in operation.

Adjusting Belt Tension

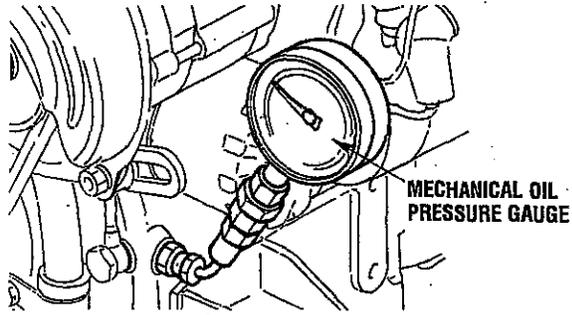
- Loosen the alternator pivot bolt.
- Loosen the alternator adjusting bolt.
- With the alternator loose, swing it outward until the drive belt is tensioned correctly.
- Tighten both bolts.
- Check the tension again after the engine has been in operation.

ENGINE ADJUSTMENTS

OIL PRESSURE

The engine's oil pressure, during operation, is indicated by the oil pressure gauge on the instrument panel. During normal operation, the oil pressure will range between 40 and 60 psi (2.8 and 4.2 kg/cm²).

NOTE: A newly started, cold engine can have an oil pressure reading up to 60 psi (4.2 kg/cm²). A warmed engine can have an oil pressure reading as low as 35 psi (2.5 kg/cm²). These readings will vary depending upon the temperature of the engine and the rpms.



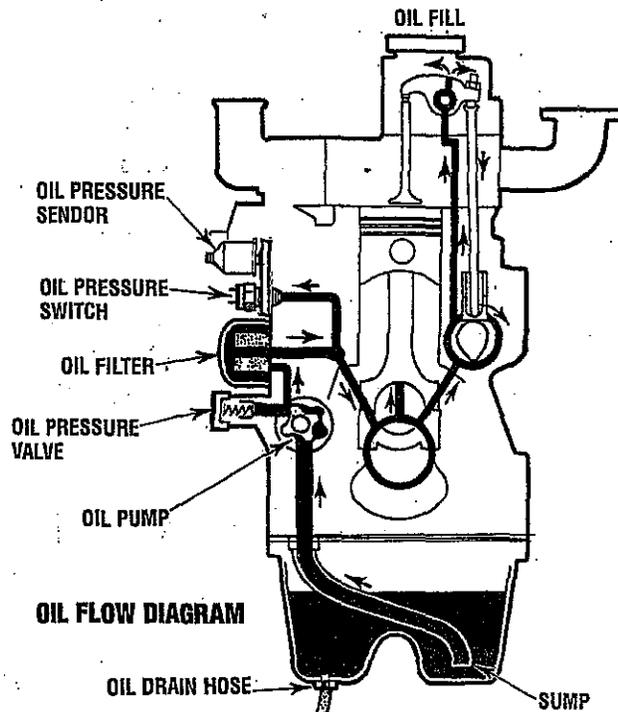
OIL PRESSURE [GENERATOR]

Oil pressure at 1800 (or 1500) rpm should maintain a reading of 50 psi.

TESTING OIL PRESSURE

To test the oil pressure, remove the oil pressure sender, then install a mechanical oil pressure gauge in its place. After warming up the engine, set the engine speed at 1800 rpm and read the oil pressure gauge.

OIL PRESSURE 50 psi at 1800 rpm.
SENDER AND SWITCH TORQUE 9 - 13 ft-lb (1.2 - 1.8 m - kg).



OIL FLOW DIAGRAM

LOW OIL PRESSURE

The specified safe minimum oil pressure is 4.3 + 1.4 psi (0.3 + 0.1 kg/cm²). A gradual loss of oil pressure usually indicates a worn bearings. For additional information on low oil pressure readings, see the *ENGINE TROUBLESHOOTING* chart.

OIL PRESSURE RELIEF VALVE

An oil pressure relief valve is located on the engine block just below the injection pump. This valve opens at approximately 50 psi [343 kpa] and maintains that pressure.

ENGINE ADJUSTMENTS

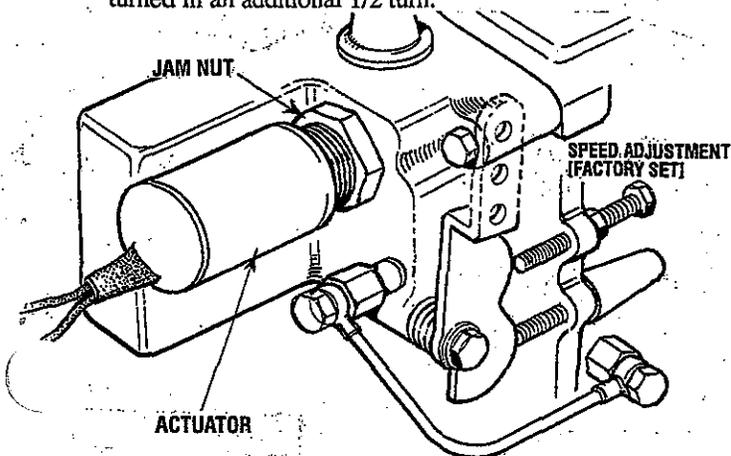
ACTUATOR (ELECTRONIC GOVERNING)

The ECU (Electronic Control Unit) in the control box on the generator controls the engine speed electronically. The ECU senses engine speed from a signal sent to it from a MPU (Magnetic Pick Up) positioned on the flywheel bellhousing over the flywheel's ring gear teeth. The ECU continuously monitors this signal and if there is any discrepancy in this signal the ECU adjusts the DC voltage to the ACTUATOR positioning its plunger to let the injection pump fuel rack to allow more or less fuel delivery to maintain a constant engine speed depending on the amperage load on the generator. Maintaining a steady Hertz operation of the AC generator.

The following instructions are for adjusting or replacing the actuator.

1. Turn OFF the DC breaker on the control box.
2. Unplug the actuator from the engine harness. Back off the 1 7/16 jam nut that secures the actuator and unscrew it from the engine block.
3. Apply a small amount of teflon sealant to the actuators threads and screw it into the engine block 4 to 5 full turns. Just snug up the jam nut. Reconnect the actuator to the engine harness. Turn ON the DC breaker on the control box. **NOTE: Turn OFF the AC circuit breaker on the generator.**
4. Start the engine. Monitor the generator output frequency that it is operating at the selected frequency.
5. With the engine running, depress the STOP switch to test for proper engine shut down. If the engine does not shut down and only goes to a slow idle speed, loosen the jam nut and thread the actuator in slowly until a full shut down takes place. Then thread the actuator in 1/2 turn and secure it in place with a jam nut. Un-twist the actuator wires as needed. This adjustment should now allow the engine to start and stop under normal operating conditions.

A final adjustment may be necessary after the genset has operated approximately 20 minutes and has reached its normal operating temperature. If the engine shuts down properly under normal operating conditions, but fails to shut down fully under more extreme conditions such as running at high amperage loads for a long period of time and/or under extreme ambient temperatures. The actuator may need to be turned in an additional 1/2 turn.

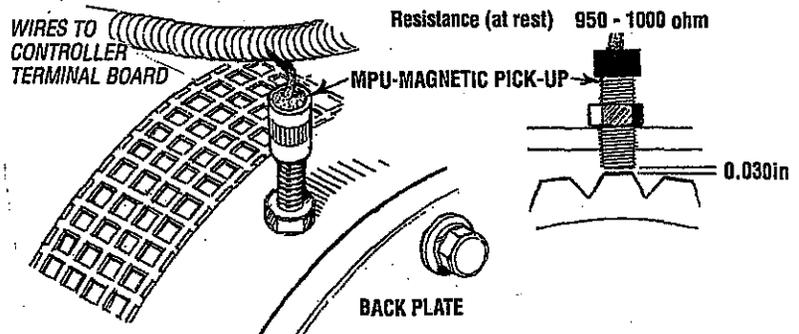


MAGNETIC PICK-UP [MPU] INSTALLATION

The MPU is installed in the threaded opening on the side of the flywheel bellhousing. This positions the MPU over the teeth of the flywheel ring gear.

Viewing through this opening, manually rotate the engine crankshaft so as to position the flat of one of the ring gear's teeth directly under the opening. Thread the MPU into the opening until it gently contacts the flat of this tooth (Thread is 3/8" x 24). Back the MPU out of the opening one turn and then lock it in this position with the jam nut. This will position the end of the MPU approximately 0.030 inches away from the flats of the ring gear teeth.

To ensure the MPU is positioned correctly, slowly rotate the crankshaft by 360° by hand to assure there is no physical contact between the MPU and the ring gear teeth. If contact is felt between the MPU and the flywheel teeth, the MPU may be damaged. Remove the MPU and inspect it. Replace if necessary and repeat the above installation procedure.



NOTE: If replacing the Magnetic Pick-Up (MPU) it **MUST** be replaced without cutting and splicing into the existing wiring cable. Doing so will cause an erratic AC signal to the controller.

GOVERNOR CIRCUIT VOLTAGES

Below are the voltages normally found in the governor circuit when the system is functioning normally. These voltages are an approximate and should be of help in troubleshooting a system that is not functioning correctly.

DC Voltage into Controller

Bat + to Bat - (battery charging voltage 13.5 - 14.5 VDC)
(Terminal block #1 and #2)

DC Voltage to Actuator

ACT to ACT (5.5 - 6.5 VDC)
(Terminal block #5 and #6)

AC Voltage from MPU into Controller

MPU to MPU (2.5 - 7.0 VAC)
(Terminal block #3 and #4)

This voltage spread is the result of the distance the MPU is positioned from the flat of the flywheel ring gear tooth. The closer to the tooth, the higher the AC signal. The further away, the lower the AC signal.

SERVICE DATA - STANDARDS AND LIMITS

| Component | Standard mm (inches) | Repair Limit mm (inches) |
|--------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------------------------------|
| ENGINE COMPONENTS | | |
| Compression pressure..... | 427 psi at 280 rpm (30.0 kg/cm ²) 2942 kPa | 384 psi (27.0 kg/cm ²) 2648 kPa |
| Maximum permissible difference between average compression pressure of all cylinders | 42.7 psi (3.0kg/cm ²) 294 kPa | |
| Injection timing at BTDC..... | 17° | |
| Rocker arm bore for shaft..... | 18.910 - 18.930 (0.74449 - 0.74527) | |
| Rocker arm shaft O.D..... | 18.880 - 18.898 (0.74331 - 0.7440) | |
| Clearance between rocker arm and shaft (oil clearance)..... | 0.012 - 0.050 0.00047 - 0.00197 | 0.200 (0.00787) |
| Valve stem O.D..... | 0.260 (6.6) | |
| Height of valve guide..... | 0.39 (10) | |
| Valve clearance..... | 0.25 (0.0098) | |
| Stem to guide clearance | | |
| Intake..... | 0.02 - 0.05 (0.008 - 0.0020) | 0.10 (0.0039) |
| Exhaust..... | 0.05 - 0.085 (0.0020 - 0.00335) | 0.15 (0.0059) |
| Valve margin..... (valve lip thickness) | 1.0 (0.039) | 0.5 (0.020) |
| Valve sinkage..... | 0.5 ± 0.25 (0.020 ± 0.0098) | 1.5 (0.059) |
| Valve seat | | |
| Angle..... | 45° | |
| Width..... | 1.3 - 1.8 (0.051 - 0.071) | 2.5 (0.098) |
| Valve spring | | |
| Free length..... | 47 (1.85) | 46 (1.81) |
| Length under test force..... | 39.1 (1.54) 30.5 (1.20) | |
| Test force 39.1 (1.54) [kgf (lbf)(N)] | 13.9 ± 0.7 30.6 ± 1.5 136 ± 7 | -15% |
| Test force 30.5 (1.20) [kgf (lbf)(N)] | 29 ± 2 64 ± 4.4 284 ± 20 | -15% |
| Warpage of cylinder head (bottom face)..... | 0.05 (0.0020) max | 0.10 (0.0039) |
| Bend (dial reading) of valve push rod..... | | 0.3 (0.012) |
| Timing Gear Backlash | | |
| Crankshaft gear/idler gear..... | 0.04 - 0.12 (0.0016 - 0.0047) | 0.30 (0.0118) |
| Idler gear/camshaft gear..... | 0.04 - 0.12 (0.0016 - 0.0047) | 0.30 (0.0118) |
| Idler gear/fuel injection pump camshaft gear..... | 0.04 - 0.12 (0.0016 - 0.0047) | 0.30 (0.0118) |
| Camshaft gear/P.T.O. gear..... | 0.08 - 0.19 (0.0031 - 0.0075) | 0.30 (0.0118) |
| Fuel injection pump camshaft gear and oil pump gear..... | 0.07 - 0.20 (0.0028 - 0.0079) | 0.30 (0.0118) |
| Lobe height of camshaft..... | 35.72 (1.4063) | 34.72 (1.3669) |

| Component | Standard mm (inches) | Repair Limit mm (inches) |
|---------------------------------------------------------------|------------------------------------------------------------|-----------------------------|
| ENGINE COMPONENTS | | |
| Lobe height of fuel injection pump camshaft..... | 44 (1.73) | 43 (1.3669) |
| Flatness of flywheel..... | 0.15 (0.0059) max | 0.50 (0.0197) |
| Clearance between tappet and cylinder block..... | | 0.15 (0.0059) |
| Clearance between camshaft journal and bushing..... | | 0.15 (0.0059) |
| Clearance between idler gear and shaft..... | 0.03 - 0.07 (0.0012 - 0.0028) | 0.20 (0.0079) |
| Warpage of cylinder block top face..... | 0.05 (0.0020) max | 0.10 (0.0039) |
| Bore in cylinder block..... | 78.0 ^{max} (3.07 ^{max}) | 78.2 (3.079) |
| Taper and out-of- round of cylinder..... | 0.01 (0.0004)max | |
| Piston Pin O.D..... | 22.944 - 23.00 (0.90527 - 0.90551) | |
| Diameter of piston | | |
| Standard..... | 77.93 - 77.95 (3.0681 - 3.0689) | 77.80 (3.0630) |
| 0.25 (0.0098) Oversize..... | 78.18 - 78.20 (3.0779 - 3.0787) | 78.05 (3.0728) |
| 0.50 (0.0197) Oversize..... | 78.43 - 78.45 (3.0878 - 3.0886) | 78.30 (3.0827) |
| Clearance between piston pin and piston..... | 0.006 - 0.018 (0.00024 - 0.00071) | 0.050 (0.00197) |
| Clearance between piston ring and groove | | |
| No.1 Compression ring..... | 0.06 - 0.10 (0.0024 - 0.0039) | 0.30 (0.0118) |
| No.2 Compression ring..... | 0.05 - 0.09 (0.0020 - 0.0035) | 0.20 (0.0079) |
| Oil ring..... | 0.03 - 0.7 (0.0012 - 0.0028) | 0.20 (0.0079) |
| Clearance between ends of piston ring | | |
| No.1 Compression ring..... | 0.15 - 0.30 (0.0059 - 0.0118) | 1.50 (0.059) |
| No.2 Compression ring..... | 0.15 - 0.35 (0.0059 - 0.0138) | 1.50 (0.059) |
| Oil ring..... | 0.20 - 0.40 (0.0079 - 0.0157) | 1.50 (0.059) |
| Clearance between piston and cylinder..... | 0.035 - 0.086 (0.00138 - 0.00339) | 0.300 (0.01181) |
| Clearance between crankpin and connecting rod bearing..... | 0.025 - 0.072 (0.00098 - 0.00283) | 0.150 (0.00591) |
| Thrust clearance for connecting rod big end..... | 0.10 - 0.35 (0.0039 - 0.0138) | 0.50 (0.0197) |
| Connecting rod bend/twist | | |
| | 0.05/100 (0.0020/3.94 max.) 0.15/100 (0.0059/3.94 max.) | |

SERVICE DATA - STANDARDS AND LIMITS

| Component | Specified Value / Standard inches(mm) | Repair Limit inches(mm) |
|-----------|------------------------------------------|----------------------------|
|-----------|------------------------------------------|----------------------------|

ENGINE COMPONENTS

| | | |
|----------------------------------------------------------|----------------------------------------|--------------------|
| Crankshaft | | |
| Diameter of journal | 51.985 - 52.000 (2.04665 - 2.04724) | |
| Diameter of crankpin | 47.950 - 47.965 1.88779 - 1.88838) | |
| Runout | 0.025 (0.00098) | 0.05 (0.0020) |
| Clearance between journal and main bearing | 0.030 - 0.077 (0.00118 - 0.00303) | 0.100 (0.00394) |
| Clearance between crankpin and connecting rod bearing | 0.025 - 0.072 (0.00098 - 0.00283) | 0.150 (0.00591) |
| End play | 0.050 - 0.175 (0.00197 - 0.00689) | 0.150 (0.01969) |

LUBRICATION SYSTEM

| | |
|------------------------------------------------------------------|-------------------------------------------------------------|
| Pressure relief valve setting | 50 ± 7 psi 3.5 ± 0.5 kgf/cm ² 343 ± 49 kPa |
| Pressure difference at which oil pressure switch is closed | 7 ± 1.4 psi 0.5 ± 0.1 kgf/cm ² 49 ± 10 kPa |

FUEL SYSTEM

| | |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Injection pressure (valve opening pressure) | 1991 ⁺⁷¹ psi 140 ⁺⁵ kgf/cm ² 13729 ⁺⁴⁹⁰ kPa |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------|

STARTER MOTOR

| | |
|------------------------------------|---------------------------------------------------------------------|
| Pinion clearance | 0.5 - 2.0 (0.20 - 0.079) |
| No-load characteristics 3 Cylinder | |
| Terminal | 11.5V |
| Current draw | 100A maximum |
| Rpm | 3000 minimum |
| No-load characteristics 4 Cylinder | |
| Terminal | 11V |
| Current draw | 130A maximum |
| Rpm | 3850 minimum |
| Brush length |wear limit line |
| Brush spring tension | 3.0 kgf 1.8 kgf 6.6 lbf 4.0 lbf 29.4N 17.7N |
| Runout of commutator | 0.03 0.10 (0.0012) (0.0039) |
| Diameter of commutator | .3231 (1.26) (1.22) |
| Undercut of mica | .0502 (0.020) (0.008) |

| Component | Sealant | Mating Part |
|-----------|---------|-------------|
|-----------|---------|-------------|

THREAD PARTS

| | | |
|---------------------|--------------------------------------------------------|----------------|
| Stop solenoid | Loctite #587 Ultra Blue | Governor case |
| Water drain joint | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Cylinder block |
| Oil pressure switch | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Cylinder block |
| Torque spring set | Loctite #587 Ultra Blue | Governor case |

PRESS FIT PARTS

| | | |
|----------------|--------------------------------------------------------|-----------------------|
| Sealing cap | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Cylinder block |
| Sealing cap | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Cylinder head |
| Sealing cap | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Cylinder head & block |
| Expansion plug | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | Governor block |
| Dipstick guide | Loctite Gasket Sealer #2 or High-Tack Gasket Sealer | |

OTHERS

| | | |
|---------------------------------------|--------------------------|-----------------------------------------|
| Side seal | Loctite #587 Ultra Blue | Cylinder block and main bearing caps |
| Main bearing caps (front and rear) | Loctite #587 Ultra Blue | Cylinder block |
| Oil pan | Loctite #5699 Ultra Gray | Cylinder block |