SECTION 5

CYLINDER POWER ASSEMBLY

CONTENTS PAGE

CYLINDER POWER ASSEMBLY

DESCRIPTION

Sections 2, 3, and 4 contain information on the cylinder head, piston and connecting rod, and the cylinder liner respectively. Procedures are provided in these sections for disassembly and assembly of the power assembly components beyond what is done during removal from and installation into the engine. Also, the information concerning cleaning, inspection, and the qualification of components is detailed in these sections.

The following procedures are for the removal and installation of a cylinder power assembly, component by component, and the removal and installation of the power assembly as a unit.

COMPONENT BY COMPONENT REMOVAL

1. After draining the cooling system, remove the top deck cover over the affected cylinder. It is advisable to remove the front latches first, then the rear latches.

2. Remove the air box and oil pan handhole covers for the cylinder being removed and the opposing cylinder on the other side of the engine.

3. Remove the piston cooling oil pipe.

4. Remove the bolts holding the water inlet tube to the cylinder liner and remove the saddle strap nuts holding the tube to the water manifold.

5. Remove the gasket from the water manifold.

6. Open all cylinder test valves using the test valve wrench. This will facilitate manual barring of the engine.

7. When removing a fork rod assembly, bar the engine over until the piston is 120° after top dead center. This will allow removal of the basket halves and the connecting rod bearing shells at one crankpin position.

8. Loosen the cylinder test valve packing nut and remove the cylinder test valve and seal. The entire test valve assembly must be removed before removal of the head, or damage to the head and/or the test valve will occur.

9. Disconnect the rocker arm oil line at the camshaft bearing block, Fig. 5-1. Also disconnect the line on the opposite cylinder, opposite bank. Remove the gaskets between the oil lines and the blocks.

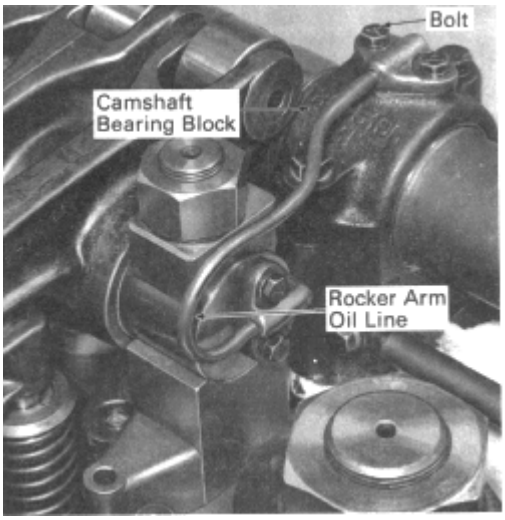


Fig. 5-1 - Rocker Arm Oil Line Removal

10. Loosen the locknuts on the exhaust valve rocker arms and the injector rocker arm. Back off the adjusting screws about two complete turns on the three rocker arms.

11. Remove the rocker arm shaft nuts, washers, and the rocker arm shaft caps, Fig. 5-2.

12. Take off the rocker arm shaft assembly with rocker arms, taking care not to drop the rocker arms.

13. Remove rocker arm shaft supports and valve bridge assemblies.

NOTE: For further breakdown of the valve bridge assemblies, refer to "Exhaust Valve Bridge Assembly" in Section 2.

14. Remove the fuel line assembly, Fig. 5-3. Also remove the fuel line from the opposite cylinder on the opposite bank of the engine. Care should be taken that the spherical seats on fuel line are not scratched or nicked as this could cause leakage.

15. Remove the injector adjusting link assembly by removing the two spring retainers and the two clevis pins.

16. Remove the injector crab stud nut, spherical washer, and the injector crab.

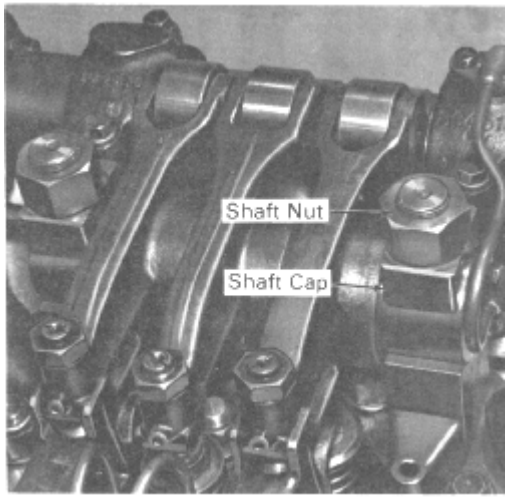


Fig. 5-2 - Rocker Arm Assembly Removal

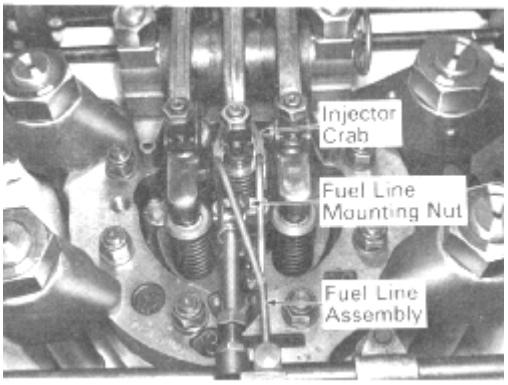


Fig. 5-3 - Fuel Line Assembly Removal

17. Using the injector pry bar, Fig. 5-4, remove the injector from the tapered well in the cylinder head. Protect the injector from dirt and damage by using an injector holding rack.

18. Remove the cylinder head overspeed trip assembly as it usually interferes with removal of the head.

19. The rocker arm shaft assembly with rocker arms and the injector on the opposite cylinder, opposite bank of the engine should also be removed. It is not necessary to remove the overspeed trip assembly from this cylinder.

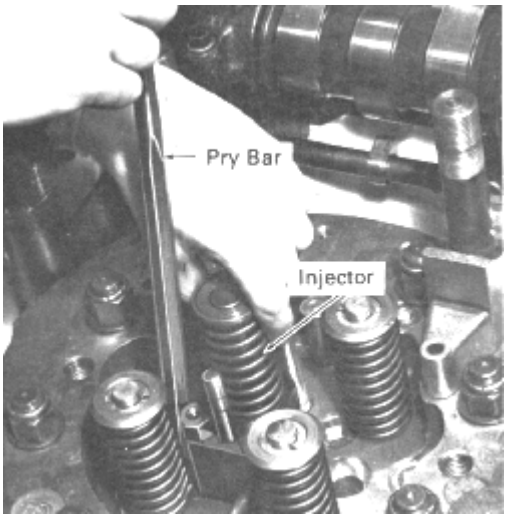


Fig. 5-4 - Removing Injector With Pry Bar

20. Place a piston holding tool, Fig. 5-5, in the injector well on the opposite cylinder, opposite bank of the engine and thread the rod into the piston pulling eyebolt hole in the crown of the piston.

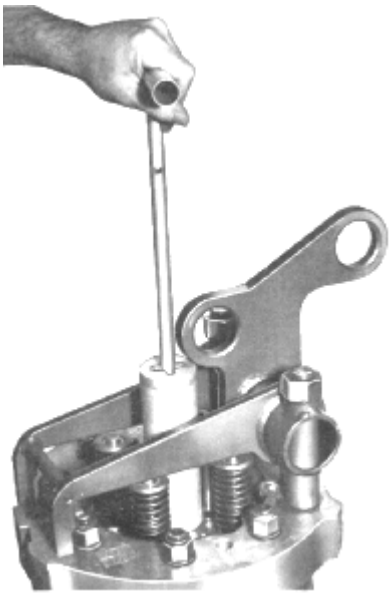


Fig. 5-5 - Piston Holding Tool

21. Remove the cylinder head to liner stud nuts and washers.

22. Remove the crab nuts from the crab bolts using an air torque multiplier set or equivalent. Place the drive socket on the crab nut to be removed and the anchor on the crab nut above or below the crab nut to be removed. Position the multiplier so that the output is over the drive socket.

23. Install the air motor and set the pressure between 310-344 kPa (45-50 psi). Squeeze the air valve and the crab nut should break loose. If the wrench stalls out, increase the air pressure until the crab nut breaks loose.

24. After removing all crabs, place thread protectors over crab bolts.

25. Be sure that the head puller holes, located at the 3 o'clock and 9 o'clock positions on the head, are free of dirt and oil and install the cylinder head removing fixture, Fig. 5-6. Make sure that the bolts are bottomed to support the weight of the head.

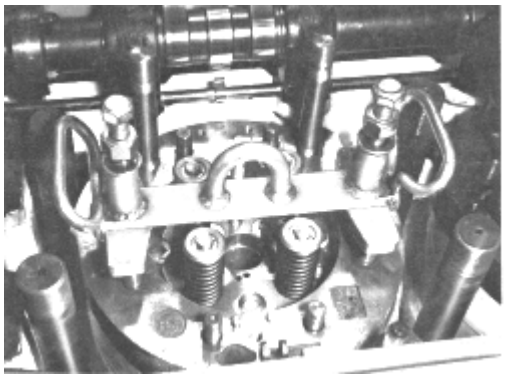


Fig. 5-6 - Cylinder Head Removing Fixture

26. Break the cylinder head free of the liner by turning the jacking screws, working first on one side and then the other until the head has broken free from the liner.

27. Using a suitable lifting device, remove the head.

28. Place the head in a cylinder head carrying basket having a soft wooden disc in the bottom to protect the machined fireface from being nicked or scratched.

NOTE: For further breakdown of the cylinder head, refer to "Exhaust Valve And Spring Removal" in Section 2.

29. Remove the lifting device and head removing fixture.

30. Remove the cylinder head seat ring.

31. Remove and discard the cylinder head to liner water seals and the head to liner gasket.

32. Install the piston pulling eyebolt in the threaded hole in the crown of the piston and hand tighten. Excessive pressure in the threaded hole may cause damage to the crown area.

If a power assembly containing a blade rod is to be changed out, the following Steps apply:

33. The opposing fork rod will have to be held out of the way so that the blade rod can be removed.

34. Remove the lower basket bolts and nuts using the spring-loaded basket bolt wrench, Fig. 5-7. with a ratchet and extension.

NOTE: Rod assembly removed from engine to clearly show tool application.

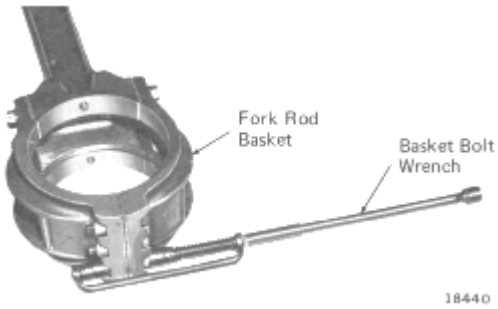


Fig. 5-7 - Basket Bolt Wrench Application

35. Remove the upper bolts from the inboard basket half.

36. Remove the bolts from the other basket half while holding the basket and lower connecting rod bearing shell.

37. Remove the bolts, basket, and bearing while maintaining the same relative upright position to prevent dropping the bearing shell or the basket into the oil pan.

38. Install the connecting rod positioning clamp on the blade rod, Fig. 5-8. The clamp should fit up far enough on the blade rod so that when the rod is lifted it will not strike the cylinder liner.

39. Using a suitable lifting device, raise the piston and fork rod assembly and apply fork rod support, Fig. 5-9, to the outboard side of the fork rod using two basket bolts. Rotate crankshaft in normal direction so that support will rest in oil pan. Protect upper bearing and continue rotation to position blade rod for removal.

40. Lift the piston and blade rod assembly until the protective boot can be applied.

41. Remove the upper connecting rod bearing shell.

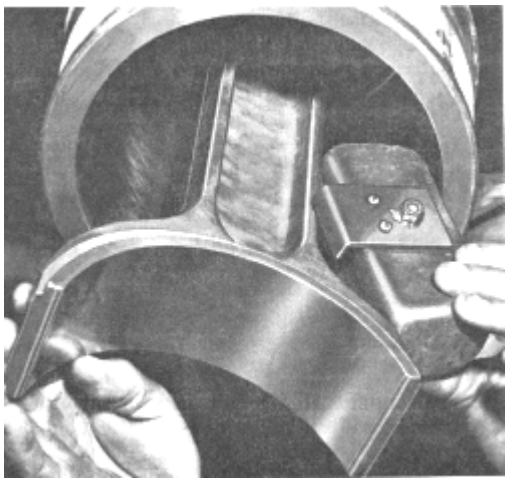


Fig. 5-8 - Connecting Rod Positioning Clamp Application

Fig. 5-9 - Fork Rod Support

42. Guide the blade rod assembly and remove it from the engine.

NOTE: For further disassembly of the connecting rod assembly, refer to Section 3.

If a power assembly containing a fork rod is to be changed out, the following Steps apply in addition to Steps 1 through 38.

43. Using a suitable lifting device, raise the piston and fork rod assembly enough so that the dowels in the fork rod clear the dowel holes in the upper connecting rod bearing and the inboard ends of the forks contact the bearing. As the fork rod is lifted, the upper connecting rod bearing should be held in place from the opposite side of the engine.

44. Lift the piston and blade rod assembly so that the piston holding tool, Fig. 5-5, can be positioned to hold the piston and rod at the top of the liner. The upper bearing shell should be removed as the piston and blade rod assembly is being raised.

45. Install the positioning clamp on the fork rod, and apply the protective boot.

46. Guide the fork rod assembly and remove it from the engine.

NOTE: For further disassembly of the connecting rod assembly, refer to Section 3.

47. Place the cylinder liner lifter over the liner studs and secure it with the stud nuts.

48. Attach the lifting device and remove the liner from the engine.

UNIT REMOVAL

A complete cylinder power assembly consists of the head, valves, liner, piston and rings, piston pin, bearing insert, carrier, thrust washer, snap ring, connecting rod, and the basket on fork rod assemblies.

NOTE: Locomotive long hood need not be removed to change out a cylinder power assembly if the hoist set is used.

1. After draining the cooling system, remove the top deck cover over the affected cylinder. It is advisable to remove the front latches first, then the rear latches.

2. Remove the air box and oil pan handhole covers for the cylinder being removed and the opposing cylinder on the other side of engine.

3. Remove the piston cooling oil pipe.

4. Remove the bolts holding the water inlet tube to the cylinder liner and remove the saddle strap nuts holding the tube to the water manifold.

5. Remove the gasket from the water manifold.

6. Open all cylinder test valves using the test valve wrench. This will facilitate manual barring of the engine.

7. When removing an assembly with a fork rod, bar the engine over until the piston is 120° after top dead center in the cylinder being removed. This will allow removal of the basket halves and the connecting rod bearing shells at one crankpin position.

8. Loosen the cylinder test valve packing nut and remove the cylinder test valve and seal. The entire test valve assembly must be removed before removal of the cylinder or damage to the head and/or the test valve will occur.

9. Disconnect the rocker arm oil line, Fig. 5-1, at the camshaft bearing block. Also disconnect the line on the opposite cylinder, opposite bank. Remove the gaskets between the oil lines and the blocks.

10. Loosen the locknuts on the exhaust valve rocker arms and the injector rocker arm. After this has been accomplished, back off the adjusting screws on the three rocker arms.

11. Remove the rocker arm shaft nuts, washers, and the rocker arm shaft caps, Fig. 5-2.

12. Take off the rocker arm shaft assembly with rocker arms taking care not to drop the rocker arms.

13. Remove rocker arm shaft supports and valve bridge assemblies.

14. Remove the fuel line assembly, Fig. 5-3. Also remove the fuel line from the opposite cylinder on the opposite bank of the engine. Care should be taken that the spherical seats on the fuel line are not scratched or nicked as this could cause leakage.

15. Remove the injector adjusting link assembly by removing the two spring retainers and the two clevis pins.

16. Remove the injector crab stud nut, spherical washer, and the injector crab.

17. Using the injector pry bar, Fig. 5-4, remove the injector from the tapered well in the cylinder head. Protect the injector from dirt and damage by using an injector holding rack.

18. Remove the cylinder head overspeed trip assembly as it usually interferes with cylinder removal.

19. The rocker arm shaft assembly with rocker arms and the injector on the opposite cylinder, opposite bank of the engine should also be removed. It is not necessary to remove the overspeed trip assembly from this cylinder.

20. Remove the lower basket bolts and nuts using the spring-loaded basket bolt wrench, Fig. 5-7, with a ratchet and extension.

21. Remove the upper bolts from the inboard basket half.

22. Remove the bolts from the other basket half while holding the basket and lower connecting rod bearing shell.

23. Remove the bolts, basket, and bearing while maintaining the same relative upright position to prevent dropping the bearing shell or the basket into the oil pan.

24. Install the connecting rod positioning clamp on the rod up far enough so that when the rod is lifted it will not strike the cylinder liner.

If a power assembly containing a blade rod is to be removed, the following Steps apply:

25. Screw the piston holding tool, Fig. 5-5, into the threaded hole in the crown of the piston and fork rod assembly.

26. Using a suitable lifting device, raise the fork rod assembly and apply the fork rod support, Fig. 5-9, while holding the upper bearing shell in place.

27. Rotate the crankshaft in normal direction so support will rest in oil pan. Protect the upper bearing and continue rotation to position blade rod for removal.

28. Remove the crab nuts from the crab bolts using an air torque multiplier set or equivalent. Place the drive socket on the crab nut to be removed and the anchor on the crab nut above or below the crab nut to be removed. Position the multiplier so that the output is over the drive socket.

29. Install the air motor and set the pressure between 310-344 kPa (45-50 psi). Squeeze the air valve and the crab nut should break loose. If the wrench stalls out, increase the air pressure until the crab nut breaks loose.

30. After removing all crabs, place thread protectors over crab bolts.

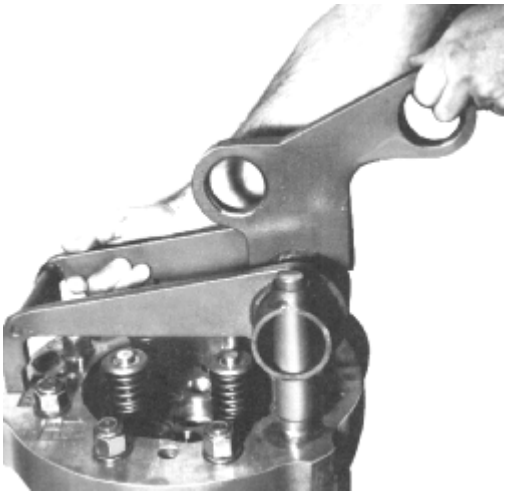


Fig. 5-10 - Lifting Clamp Application

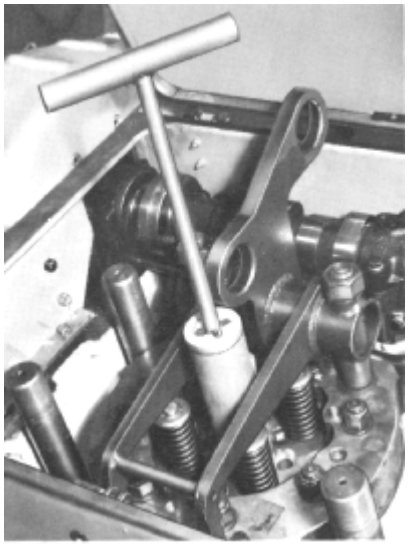


Fig. 5-11 - Piston Holding Tool Application

31. Apply and attach lifting clamp, Fig. 5-10, to cylinder being removed, and screw in the piston holding tool, Fig. 5-11.

NOTE: If the hoist set is used, Fig. 5-12, disregard the lifting clamp and piston holding tool.

32. Lift the piston holding tool and remove upper bearing shell. Continue raising the piston and blade rod assembly until the piston holding tool can be secured to hold the assembly at the top of the liner.

Fig. 5-12 - Power Assembly Hoist Set Application

33. Attach an overhead chain hoist to the lifting clamp or attach a hoist set. While guiding the power assembly, remove it from the engine.

If a power assembly containing a fork rod is to be removed, the following Steps apply in addition to Steps 1 through 24.

34. Screw the piston holding tool into the threaded hole in the crown of the piston and blade rod assembly.

35. Remove the crab nuts from the crab bolts using an air torque multiplier set or equivalent. Place the drive socket on the crab nut to be removed and the anchor on the crab nut above or below the crab nut to be removed. Position the multiplier so that the output is over the drive socket.

36. Install the air motor and set the pressure between 310-344 kPa (45-50 psi). Squeeze the air valve and the crab nut should break loose. If the wrench stalls out, increase the air pressure until the crab nut breaks loose.

37. After removing all crabs, place thread protectors over crab bolts.

38. Attach the lifting clamp to the cylinder being removed, and screw in the piston holding tool.

NOTE: If a hoist set is used, Fig. 5-12, disregard the lifting clamp and piston holding tool.

39. Lift the piston holding tool while holding the upper bearing shell. Continue raising until the piston holding tool can be secured to hold the assembly at the top of the liner.

Fig. 5-13 - Power Assembly Removal 22115 With Lifting Clamp And Hoist

40. Install the connecting rod positioning clamp on the fork rod.

41. Lift the blade rod assembly and remove the upper bearing shell.

42. Attach an overhead chain hoist to the lifting clamp, Fig. 5-13, or attach a hoist set, Fig. 5-12. While guiding the power assembly, remove it from the engine.

COMPONENT BY COMPONENT INSTALLATION

The power assembly components to be installed should be either new, remanufactured, or otherwise qualified parts. Prior to component installation, the crankcase upper and lower pilot bore should be checked and the dimensions should be within the tolerances shown in the Service Data pages of Section 4. In the case of the lower bore, the dimension is taken with the lower liner bore insert installed; if a rebuilt or remanufactured liner and/or piston is used, the piston to liner clearance will have to be measured as described in the Service Data pages of Section 3.

1. Place a clean and inspected piston on a clean work bench.

2. Apply the spring-loaded oil control ring in the bottom groove.

3. Apply the spring to the groove first then, using the piston ring expander, apply the ring so that the spring will fit into the groove in the ring. The ends of the spring must be 180° from the ring gap. Rings that are marked "TOP" on one side of the ring are placed in the groove with this marking facing the crown of the piston.

CAUTION: Be sure the spring is fully seated in its groove in the back of the ring. Attempting to install the piston and ring assembly into the liner with the spring not fully seated, or with a loop of spring protruding between the ring groove and ring, will result in a badly kinked spring or broken ring.

4. Using the ring expander, apply the double hook scraper oil control ring in the next groove up.

5. Apply the compression rings to the piston beginning with the bottom compression ring and ending with the No. 1 compression ring, Fig. 5-14. A ring marked "TOP GROOVE ONLY" must be installed in the No. 1 compression groove only.

Fig. 5-14 - Installation Of Top Compression Ring

6. The compression rings must be staggered so that the gaps of the first and second rings are 180° to each other. the third, 90° to the second ring, and the fourth ring 180° to the third. The oil control ring gaps should be 180° to each other.

7. If a new piston pin is to be used, a new bearing insert must be installed.

8. Carefully wipe out the insert slot ill the carrier and examine the bearing insert to make sure that is is clean.

9. Apply the bearing insert in one end of the carrier slot and slide along the carrier bore. If a new bearing insert is not to be used, the old bearing insert must be applied in the same relative position from which it was removed.

10. Center the bearing insert so that the tangs, when bent, will be adjacent to the counterbores of the carrier to prevent endwise movement.

11. Using an indenter tool, Fig. 5-15, strike the center of tire tangs to bend them into the carrier counterbore.

Fig. 5-15 -- Piston Pin Bearing Insert Installation

12. Examine all mating surfaces of the carrier, piston pin, bearing insert, and connecting rod to be sure they are clean and smooth.

13. Manually coat the carrier bearing insert and the piston pin with clean oil, and insert the pin into the carrier.

14. Rotate the pin, while moving it slowly across the bearing insert, to check freedom of movement.

15. Install the piston pin so that the small identification hole in the end of the pin is at the same end as the piston cooling inlet hole in the carrier. When reusing these components, they must be kept in their same relative position.

16. Place the carrier assembly in the carrier holding fixture, Fig. 5-16, and secure it with the T-handle.

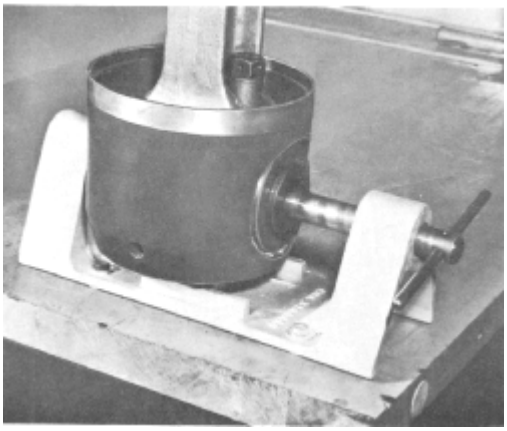


Fig. 5-16 - Carrier In Holding Fixture

17. Lubricate piston pin bolts with Texaco Threadtex No. 2303. Place the connecting rod on the piston pin and apply the piston pin bolt assemblies. Tighten bolts snugly (approximately 13 N-m [10 ft-Ibs]) and perform a "finger tightness check." If a spacer can be rotated when a twisting effort is applied with a finger grip, the bolt assembly should be removed and inspected for the cause of not clamping.

18. When assembling the rod and carrier assembly, the piston cooling oil hole in the carrier must be on the same side as the dowel pin in the serrations of the fork rod and, on a blade rod, on the side opposite the long toe. This will ensure proper position of the hole when the assembly is installed in the engine.

19. Using a 300 ft-Ib capacity torque wrench and extension, torque the piston pin bolts. To torque the bolts to the desired 610 N -m (450 ft-Ibs), a torque reading of 300 ft-Ibs is required when using the extension. The spacer should again be given a "finger tightness check" after the bolts are tight.

20. Place the piston and ring assembly on work bench with the open end up.

21. Check that the interior is clean and that the platform is free of any foreign material.

22. Apply some clean oil to the platform.

23. Place the thrust washer on the platform and apply clean oil to the thrust washer.

24. Carefully place the carrier and rod assembly into the piston and check the assembly for free rotation in the piston.

25. Using the snap ring tool, position the piston snap ring in the piston, Fig. 5-17.

Fig. 5-17 - Installing Piston Snap Ring

26. Check that the snap ring to carrier clearance does not exceed 0.64 mm (.025').

27. Perform a pre-installation inspection of the cylinder liner. Inspect liner water seal counterbores for nicks which may cut the water seals. Make sure that the counterbores and liner bore are clean. Check that the water inlet tube deflector is the correct type and is properly fitted in position in the cylinder liner.

28. Wipe the inside of the liner with a clean, oily cloth.

29. Apply the liner lifter, Fig. 5-18, over the liner studs and secure with the stud nuts.

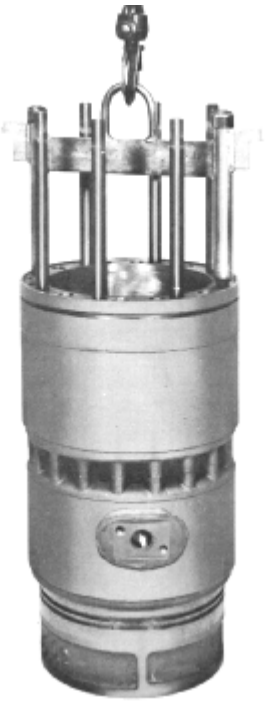


Fig. 5-18 - Liner Installation Using Liner Lifter

30. Attach a suitable lifting device to the liner lifter, raise slightly, and install lower liner seal (marked EMD PA) in upper groove. Install lower liner seal (marked EMD VIT and with red paint) in lower groove. Coat seals with an approved lubricant.

31. Lower the cylinder liner into place in the crankcase bore. Preliminary alignment can be obtained by positioning the pilot stud of the liner at the 5 o'clock position.

32. Place the piston ring compressor and guide over the studs on the cylinder liner.

33. Oil the ring compressor.

34. Place a protective boot over the end of the connecting rod.

35. Position the piston and rod assembly over the bore, and manually spread a film of oil on the outside of the piston.

36. Check that the ring gap positions have not changed.

37. Lower the piston and rod assembly into the liner.

38. Make sure that the serial number on the rod is facing outboard.

39. Lower the assembly until the piston crown is parallel to the top of the liner.

40. Oil the inside and outside surfaces of the connecting rod bearing shells and place the upper bearing in position on the connecting rod journal.

41. Hold the bearing shell in place while lowering the blade rod to rest on the upper bearing surface. If applicable, remove the piston holding tool.

NOTE The blade or fork rod opposite to the rod being installed was positioned out of the way during "Component By Component Removal" by use of a piston holding tool for a blade rod or a fork rod support, Fig. 5-9.

42. If applicable, remove fork rod support and lower the fork rod until the rod makes contact with the bearing surface. The fork rod dowels should enter the bearing dowel holes without binding.

43. Be sure that the serial number on the basket matches the serial number on the connecting rod, Fig. 5-19.

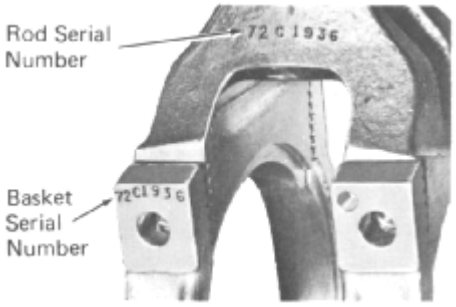


Fig. 5-19 - Rod And Basket Identification

44. Apply the lower connecting rod bearing to the dowel basket half, oil the bearing surface. and place the basket half on the fork rod. When applying fork rod baskets be sure that the serial number on the prong of the dowel half is on the dowel side of the rod.

45. Lubricate all upper basket bolts with Texaco Threadtex No. 2303 and tighten the upper hasket fork rod bolts just enough to mate the serrations and to hold the bearing in place.

46. Apply the other basket half to the fork rod, tightening the rod bolts enough to mate the serrations.

47. Apply the lower basket bolts, washers, and locknuts.

48. Snug the four top basket bolts to approximately 13 N-m (10 ft-lbs) to firmly mesh the serrations. Give each washer a "finger tightness check." If a washer can be rotated by grasping with the fingers, the bolt assembly should be removed and inspected for the cause of not clamping.

49. Using the spring-loaded basket bolt wrench, Fig. 5-7, torque the lower basket bolts to 102 N-m (75 ft-lbs).

50. Torque the upper basket bolts to 258 N-m (190 ft-lbs) and perform a "finger tightness check" on the washers.

51. Remove the connecting rod positioning clamp and piston holding tool from the blade rod assembly on the opposite bank of the engine.
52. Disconnect the lifting device from the eyebolt.

53. Remove the piston ring compressor and guide from the engine. Remove the piston pulling eyebolt.

54. Install the liner to head water seals and heat dam insulators.

55. Install the head-to-liner gasket, Fig. 5-20, making sure that the proper gasket is used and that the gasket is placed over the liner studs with the part number and "EMD TOP 645" stamp facing up, and the the notched ear of the gasket is placed over the pilot stud of the liner.

56. Attach the head fixture and lifting device to the head, and partially raise head. Check that the injector well is covered.

NOTE: At time of head installation, the exhaust valves have already been applied to the head. For this installation, refer to "Exhaust Valve Installation" in Section 2.

57. Apply a light coat of silicone grease to water outlet elbow seals and install two brown seals to the grooves entering the crankcase and a red seal to the groove between the elbow and the cylinder head. Bolt elbow to cylinder head and torque to specified value.

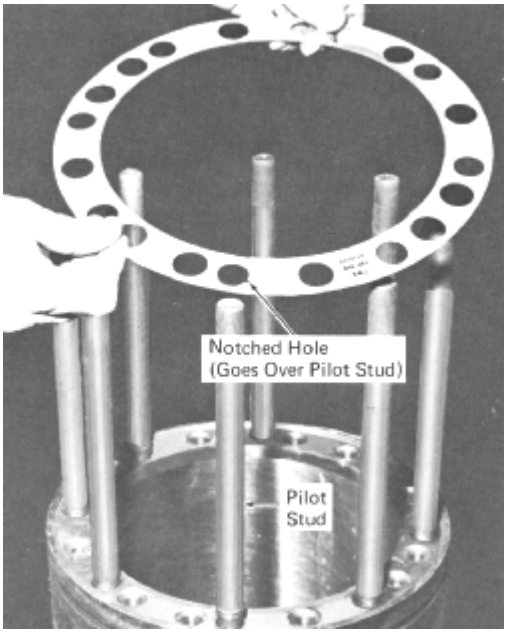


Fig. 5-20 - Head To Liner Gasket

58. Check that the bottom surface of the head is clean and place the seat ring, Fig. 5-21, on the head, making sure that the chamfered side is facing up.

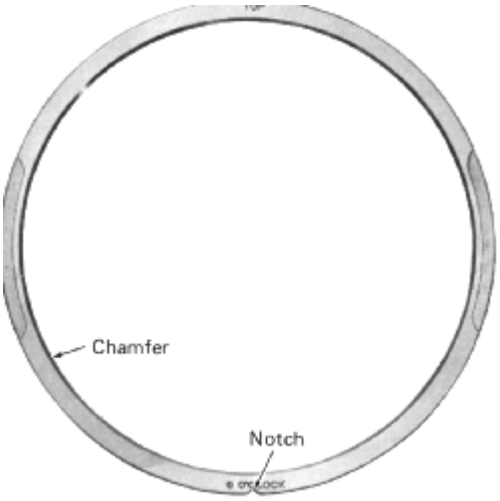


Fig. 5-21 - Cylinder Head Seat Ring

59. Lower the head slowly into position making sure that the notch in the seat ring is at the 6 o'clock position.

60. Line up the water discharge elbow with the mating hole in the crankcase, Fig. 5-22. Be careful that the seals are not damaged or twisted in the grooves while the head is lowered into position. Before the head contacts the liner, re-check the position of the seat ring notch and finish lowering the head. Remove the head fixture and lifting device.

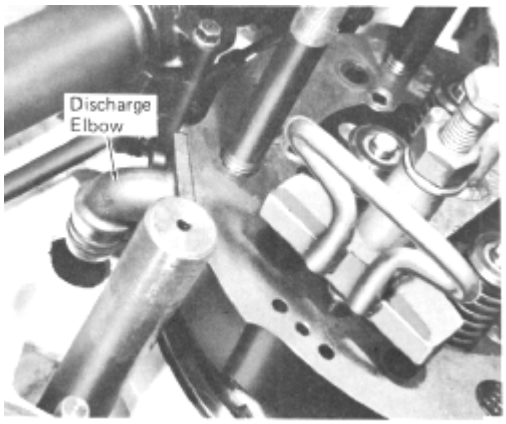


Fig. 5-22 - Water Discharge Elbow Alignment

61. Apply Texaco Threadtex No. 2303 to cylinder liner studs and stud nuts.

62. Apply the liner washers and stud nuts, and snug them down.

63. Following the sequence as shown in Fig. 5-23, torque the head-to-liner nuts to 102 N-m (75 ft-lbs).

64. Remove thread protectors, and make sure that crab bolts, crab seats, and crab nuts are free from burrs and are lubricated with Texaco Threadtex No. 2303.

65. Apply crabs and crab nuts. Center the crab bolts by manually seating the nuts while moving the crab bolts back and forth.

66. After seating the crab nuts, torque them to approximately 407 N-m (300 ft-lbs). Check that the crabs are positioned so that a wrench can be applied to the head-to-liner stud nuts.

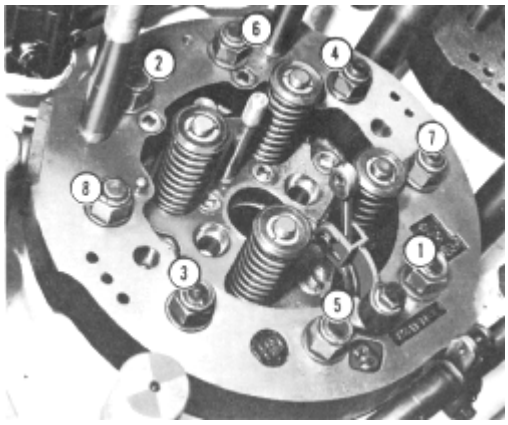


Fig. 5-23 - Head-To-Liner Nut Tightening Sequence

67. Tighten the liner stud nuts to a final torque of 325 N-m (240 ft-lbs), following the same sequence as before.

68. Using an air motor and torque multiplier with a power ratio of 38:1, or any mechanical advantage wrench, final torque the crab nuts to 2 440 N-m (1800 ft-lbs). If a 12:1 power wrench is used with a 300 ft-lb capacity hand torque wrench, the pointer should indicate 150 ft-lbs for the final pass.

69. Install the overspeed trip mechanism, and torque the bolts to 32 N-m (24 ft-lbs).

70. Uncover the injector well and install the injector into the cylinder head. Check that the locating dowel is properly seated.

71. Lubricate the threads on the injector stud and nut. Place the injector crab over the crab stud. Place the spherical side of the washer into the spherical seat of the crab. Apply and snug down the nut.

72. Be sure that the injector crab is not cocked at an angle so that it would prevent the entry of the injector timing tool, and torque the crab nut to 68 N-m (50 ft-lbs).

73. Install the injector adjusting link assembly using the two clevis pins and spring retainers. 74. Attach the fuel manifold to the top deck cover frame. Connect the fuel lines from the manifold to the injector. Care must be taken not to damage the spherical seats of the fuel lines as fuel leakage could occur.

75. Position the valve bridges in the cylinder head.

NOTE: At time of installation, valve bridges are an assembly. For buildup, refer to "Valve Bridge And Hydraulic Lash Adjuster" in Section 2.

76. Lubricate the shaft studs with Texaco Threadtex No. 2303 and install the rocker arm shaft assembly, Fig. 5-

24. Apply the shaft caps with the short toe facing out.

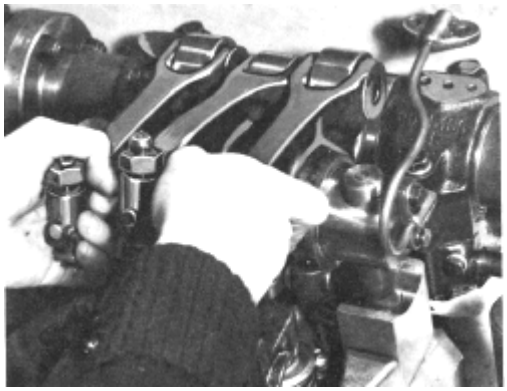


Fig. 5-24 - Rocker Arm Shaft Installation

77. Make sure that the hardened washer is used between the rocker arm shaft nuts and the shaft caps and that all contact surfaces are clean and free from burrs. Apply the washers and nuts to the shaft studs.

78. Alternately torque the shaft nuts to 203 N-m (150 ft-lbs) on the first pass, and to a final torque of 407 N-m (300 ft-lbs).

79. Use a new gasket and attach the rocker arm oil line to the camshaft bearing bracket. Refer to the procedures in this section for injector timing and adjustment of the hydraulic lash adjusters.

80. Coat a new seal with Dow 4 silicone grease and place in the groove at the liner end of the water inlet tube, Fig. 5-25.

81. Position saddle straps around the water manifold and then through the inlet tube flange.

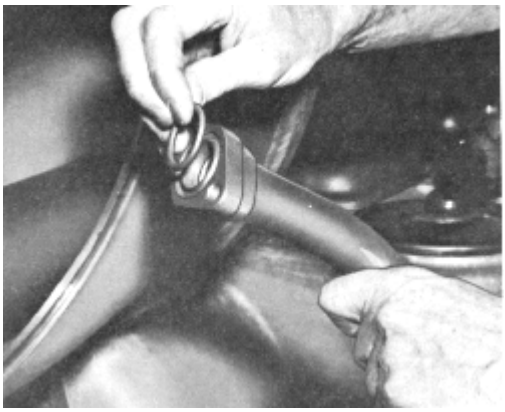


Fig. 5-25 - Applying Seal To Water Inlet Tube

82. After the strap nuts have been applied and tightened finger tight, check that the seal is seated in the groove, position the tube on the finer, and finger tighten the bolts.

83. Take a new gasket and shape it to fit around the water manifold. Insert the gasket between the tube flange and manifold making sure the sides of the gasket are flush with the sides of the flange, and that the ends of the gasket are within the clamping radius of the flange.

84. Torque the strap nuts to 20 N-m (15 ft-lbs).

85. Prior to torquing the tube to liner bolts, remove the bolts and washers from the flange. If the tube moves, it must be repositioned on the water manifold; if no movement is detected, the tube to liner bolts and washers may be re-applied and torqued to 41 N-m (30 ft-lbs).

86. Using a new gasket, place the piston cooling oil pipe against the piston cooling oil manifold.

87. Place the nozzle end of the pipe into the liner bore so that the dowels on the pipe align with the dowel holes in the liner.

88. If the bolt holes in either of the flanges do not line up, replace the pipe. No attempt should be made to fit the pipe by bending it. This would place a stress on the pipe which could result in subsequent failure.

89. Install the fine thread bolts into the manifold, and the coarse thread bolts into the liner. Torque bolts to 27 N-m (20 ft-lbs).

90. Check proper alignment of the piston cooling oil pipe by placing the alignment gauge into the nozzle of the pipe, Fig. 5-26. Bar over the engine to bottom dead center of the cylinder being checked. At the same time, rotate the gauge to make sure it does not bind in the carrier hole.

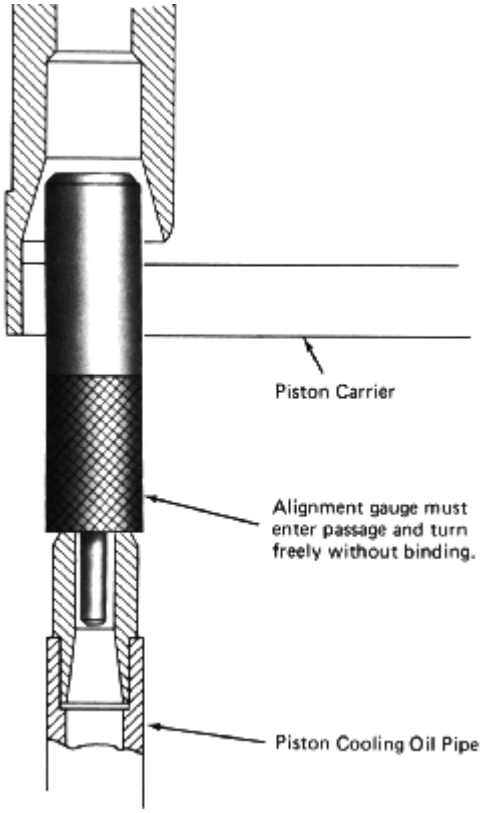


Fig. 5-26 - Piston Cooling Oil Pipe Alignment

91. If the gauge indicates misalignment, replace the pipe. Do not use the gauge to align the pipe.

92. It is important, after installing a power assembly, to determine the head to piston clearance. This will provide the information necessary to evaluate the amount of subsequent wear, or a change in head to piston relationship. The procedure for applying the lead wire in wire holder is as follows:

a. Place a length of 1/8" diameter lead wire in each end of the wire holder and position the holder on top of a piston of the same size as the one being checked in the engine. Each end of the wire should be at least 3.18 mm (1/8") from the outside diameter of the piston.

b. Bar the engine over until the piston being checked is at bottom dead center.

c. Apply the lead wire and holder through a liner port and position it on top of the piston so that it is parallel with the crankshaft.

d. Bar the engine over one complete revolution to compress the lead wire. Remove the wire from the engine and measure the inboard portion of both compressed ends of the wire, Fig. 5-27.

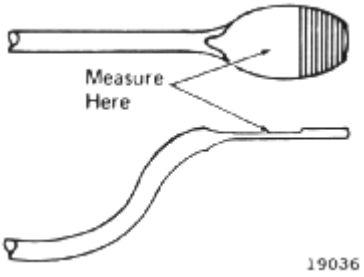


Fig. 5-27 - Lead Wire Measurement

NOTE: It is important that the thinner of the two compressed areas be measured to provide the minimum piston to head clearance.

e. Within the maximum clearance and minimum clearance, the difference in micrometer indications between the two compressed ends should not exceed 0.13 mm (0.005'). If it does, repeat the process as the wire may have changed position.

f. If the difference is still greater than 0.13 mm (0.005') after a second reading, change out the power assembly.

93. Place a new packing seal in the cylinder test valve bore and install the valve body and packing nut.

94. Tighten the valve body into the cylinder head and snug down the packing nut.

95. Torque the packing nut to 88 N-m (65 ft-lbs) and install the needle valve.

96. Refill the cooling system and check for water leaks.

97. Install the top deck and handhole covers.

98. Bar the engine over one complete revolution and close all the cylinder test valves.

99. Start the engine and raise the water temperature to 76° C (170° F). After running the engine, shut it down and re-check the torque on the crab and liner stud nuts. Also re-check for oil and water leaks.

UNIT INSTALLATION

Left and right banks of the engine are determined by looking toward the "front" (governor end) of the engine when standing at the "rear" (coupling end) of the engine. The power assemblies with blade rods are installed in the right bank with the "long toe" of the slipper foot facing the center of the engine. The cylinder assemblies with fork rods are installed in the left bank.

1. The complete power assembly is packaged in either a storage type metal reinforced container, Fig. 5-28, or expendable cardboard and wood container. The metal cover on the stor age type container is removed by using a wrench and turning the hex head fasteners on the side of the container. The cover forms the top and three sides of the container.

Fig. 5-28 - Power Assembly And Container

2. Remove the card containing the applicable seals and gaskets and, if a power assembly with a fork rod, the small box containing the basket bolts.

3. Remove the two nuts and bolts holding the top mounting block to the rocker arm studs, and take off the block.

4. Remove the piston holding bolt and block.

5. Insert a clean rag into the injector well and remove the tape from around the liner ports. 6. If the power assembly has a fork rod, remove the connecting rod basket from the metal bracket at the front of the container, Fig. 5-28.
7. The assembly has been coated with an antirust compound which does not have to be removed and is totally compatible with lube oil.

8. Install the rocker arm shaft supports making sure that the locating dowel holes are properly positioned.

9. Install the lifting clamp, Fig. 5-29, and secure it with the rocker arm shaft nuts.

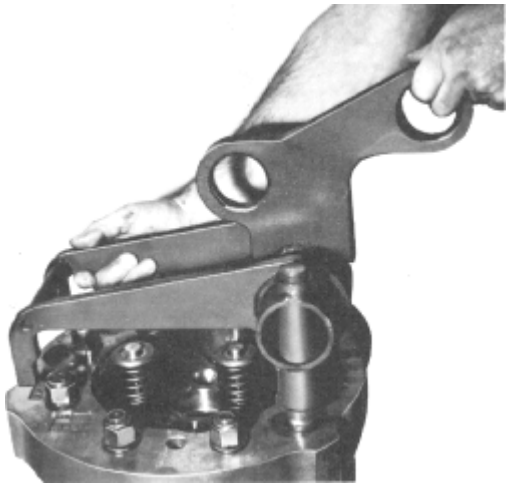


Fig. 5-29 - Lifting Clamp Application

NOTE: If the hoist set is used, disregard references to the use of the lifting clamp and piston holding tool on the power assembly being installed.

10. Remove the rag from the injector well and apply the piston holding tool, Fig. 5-30.

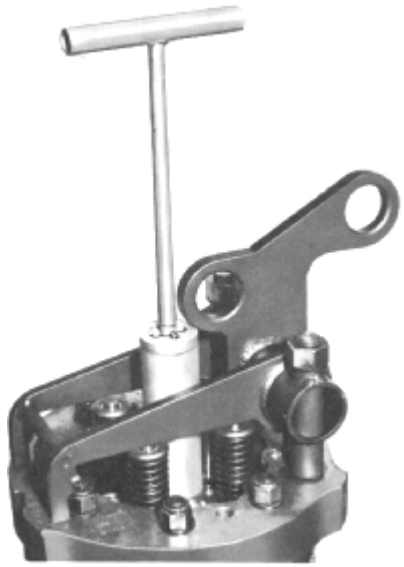


Fig. 5-30 - Piston Holding Tool Application

11. Use the hoist set or attach a chain hoist to the eye at the center of the lifting clamp and remove the power assembly from the container.

12. Support the assembly on a suitable stand and attach the connecting rod positioning clamp.

13. Be sure and check, if a fork rod, that the rod and basket serial numbers match, Fig. 5-31.

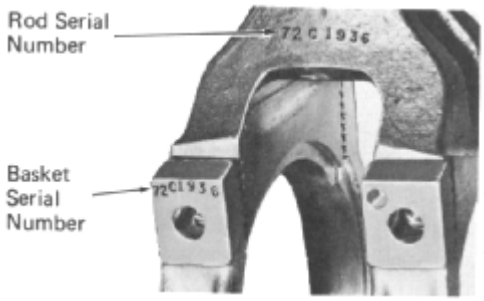


Fig. 5-31 - Rod And Basket Identification

14. Before applying the water discharge elbow, inspect the internal and external seal grooves. Apply a light coat of silicon grease to water outlet elbow seals and install two grey-brown seals to the grooves entering the crankcase and a red seal to the groove between the elbow and the cylinder head. Bolt elbow to cylinder head, and torque to specified value.

15. Change the hoist to the end hole of the lifting clamp, Fig. 5-32, to position it at the proper angle for installation in the engine.

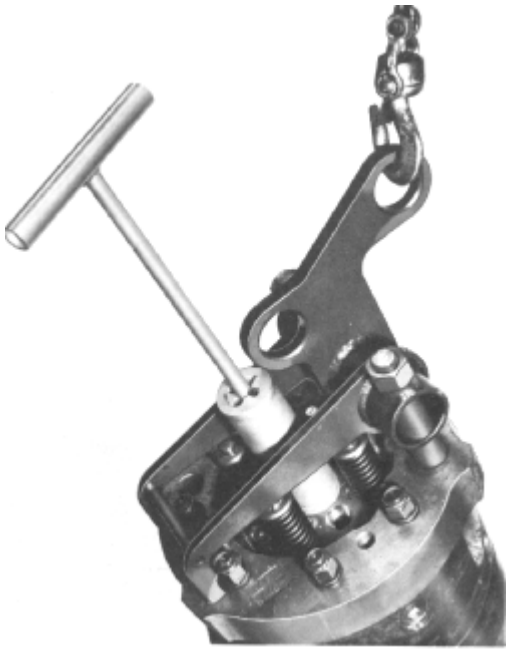


Fig. 5-32 - Power Assembly Installation With Lifting Clamp And Hoist

16. Raise assembly and install lower liner seal (marked EMD PA) in upper groove. Install lower liner seal (marked EMD VIT and with red paint) in lower groove. Coat seals with an approved lubricant.

17. Place the seat ring on the assembly, Fig. 5-33, making sure that the chamfered side is facing up, and the notch is at the 6 o'clock position. Place thread protectors on cylinder head crab bolts.

18. Lower the assembly slowly into the crankcase bore, lining up the water discharge elbow with the mating hole in the crankcase, Fig. 5-34. Be careful that the seals are not damaged or twisted in the grooves while the head is lowered into position.

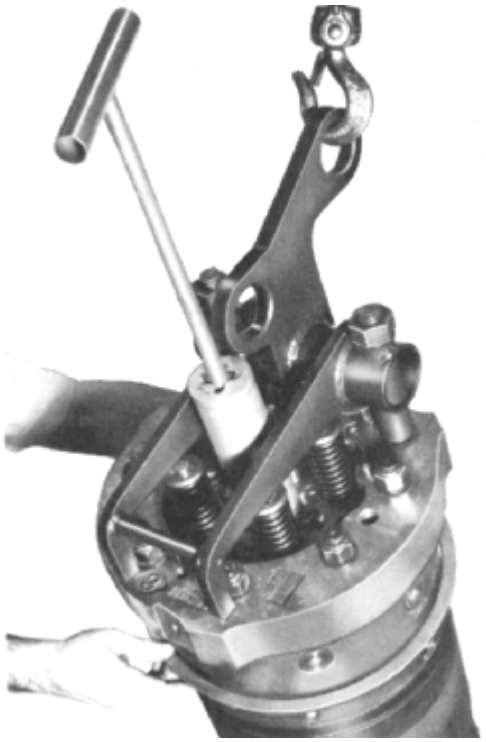


Fig. 5-33 - Seat Ring Installation

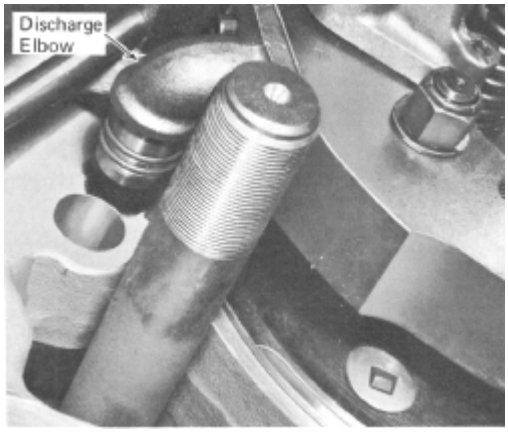


Fig. 5-34 - Water Discharge Elbow Alignment

19. Before the head contacts the crankcase, recheck the position of the seat ring notch and lower the assembly into final position.

20. Remove the chain hoist from the lifting clamp and attach it to the piston holding tool in the power assembly being installed.

NOTE: The blade or fork rod opposite to the rod in the power assembly being installed was positioned out of the way during "Unit Removal" by use of a piston holding tool.

21. Oil the inside and outside surfaces of the connecting rod bearing shells and place the upper bearing in position on the connecting rod journal.

22. Hold the bearing shell in place while lowering the blade rod to rest on the upper bearing surface.

23. Lower the fork rod until the rod makes contact with the bearing surface. The fork rod dowels should enter the bearing dowel holes without binding.

24. Remove the hoist set or remove the piston holding tool and the lifting clamp and place a clean rag in the injector well.

25. Remove the connecting rod positioning clamp from each connecting rod. Also remove the piston holding tool from the opposite cylinder.

26. Apply the lower connecting rod bearing to the dowel basket half, oil the bearing surface, and place the basket half on the fork rod. When applying fork rod baskets be sure that the serial number on the prong of the dowel half is on the dowel side of the rod.

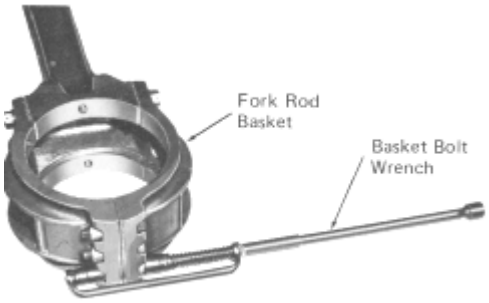
27. Lubricate all upper basket bolts with Texaco Threadtex No. 2303 and, tighten the upper basket fork rod bolts just enough to mate the serrations and to hold the bearing in place.

28. Apply the other basket half to the fork rod, tightening the rod bolts enough to mate the serrations.

29. Apply the lower basket bolts, washers, and locknuts.

30. Snug the four top basket bolts to approximately 13 N-m (10 ft-lbs) to firmly mesh the serrations. Give each washer a "finger tightness check." If a washer can be rotated by grasping with the fingers, the bolt assembly should be removed and inspected for the cause of not clamping.

31. Using the spring-loaded basket bolt wrench, Fig. 5-35, torque the lower basket bolts to 102 N-m (75 ft-lbs).



NOTE: Rod assembly removed from engine to clearly show tool application.

Fig. 5-35 - Basket Bolt Wrench Application

32. Torque the upper basket bolts to 258 N-m (190 ft-lbs) and perform a "finger tightness check" on the washers.

33. Remove thread protectors and make sure that crab bolts, crab seats, and crab nuts are free from burrs, and are lubricated with Texaco Threadtex No. 2303.

34. Apply crabs and nuts. Center the crab bolts by manually seating the nuts while moving the crab bolts back and forth.

35. After seating the crab nuts, torque them to approximately 407 N-m (300 ft-lbs). Check that the crabs are positioned so that a wrench can be applied to the head to liner stud nuts.

36. Check the head to liner stud nut torque of 325 N-m (240 ft-lbs) starting with the pilot stud and using the tightening sequence as shown in Fig. 5-23.

37. Using an air motor and torque multiplier with a power ratio of 38:1, or any mechanical advantage wrench, final torque the crab nuts to 2 440 N-m (1800 ft-lbs). If a 12:1 power wrench is used with a 300 ft-Ib capacity hand torque wrench, the pointer should indicate 150 ft-lbs for the final pass.

38. Install the overspeed trip mechanism, and torque the bolts to 32 N-m (24 ft-lbs).

39. Uncover the injector well and install the injector into the cylinder head. Check that the locating dowel is properly seated.

40. Lubricate the threads on the injector stud and nut. Place the injector crab over the crab stud. Place the spherical side of the washer into the spherical seat of the crab. Apply and snug down the nut.

41. Be sure that the injector crab is not cocked at an angle so that it would prevent the entry of the injector timing tool, and torque the crab nut to 68 N-m (50 ft-lbs).

42. Install the injector adjusting link assembly using the two clevis pins and spring retainers. 43. Connect the fuel lines from the manifold to the injector. Care must be taken not to damage the spherical seats of the fuel lines as fuel leakage could occur.

44. Position the valve bridges in the cylinder head.

NOTE: At time of installation, valve bridges are an assembly. For buildup, refer to "Valve Bridge And Hydraulic Lash Adjuster" in Section 2.

45. Lubricate the shaft studs with Texaco Threadtex No. 2303 and install the rocker arm shaft assembly, Fig. 5-24. Apply the shaft caps with the short toe facing out.

46. Make sure that the hardened washer is used between the rocker arm shaft nuts and the shaft caps and that all contact surfaces are clean and free from burrs. Apply the washers and nuts to the shaft studs.

47. Alternately torque the shaft nuts to 203 N-m (150 ft-lbs) on the first pass, and to a final torque of 407 N-m (300 ft-lbs).

48. Use a new gasket and attach the rocker arm oil line to the camshaft bearing bracket. Refer to the procedures in this section for injector timing and adjustment of the hydraulic lash adjusters.

49. Coat a new seal with Dow 4 silicone grease and place in the groove at the liner end of the water inlet tube, Fig. 5-25.

50. Position saddle straps around the water manifold and then through the inlet tube flange. 51. After the strap nuts have been applied and tightened finger tight, check that the seal is seated in the groove, position the tube on the liner, and finger tighten the bolts

.

52. rake a new gasket and shape it to fit around the water manifold. Insert the gasket between the tube flange and manifold making sure the sides of' the gasket are flush with the sides of the flange, and that the ends of the gasket are within the clamping radius of the flange.

53. Torque the strap nuts to 20 N-m (15 ft-lbs). 54. Prior to torquing the tube to liner bolts, remove the bolts and washers from the flange. If the tube moves, it must be repositioned on the water manifold, if no movement is detected the tube to liner bolts and washers may be reapplied and torqued to 41 N-m (30 ft-lbs).

55. Using a new gasket, place the piston cooling oil pipe against the piston cooling oil manifold.

56. Place the nozzle end of the pipe into the liner bore so that the dowels on the pipe align with the dowel holes in the liner.

57. If the bolt holes in either of the flanges do not line up, replace the pipe. No attempt should be made to fit the pipe by bending it. This would place a stress on the pipe which Could result in subsequent failure.

58. Install the fine thread bolts into the manifold, and the coarse thread bolts into the liner. Torque bolts to 27 N-m (20 ft-lbs).

59. Check proper alignment of the piston cooling oil pipe by placing the alignment gauge into the nozzle of the pipe, Fig. 5-26. Bar over the engine to bottom dead center of the cylinder being checked. At the same time, rotate the gauge to make sure it does not bind in the carrier hole.

60. If the gauge indicates misalignment, replace the pipe. Do not use the gauge to align the pipe.

61. It is important, after installing a power assembly, to determine the head to piston clearance. This will provide the information necessary to evaluate the amount of subsequent wear, or a change in head to piston relationship. The procedure for applying the lead wire in wire holder is as follows:

    a. Using a piston of the same size as the one being checked in the engine, place a length of 1/8" diameter lead wire in each end of the wire holder. When positioned on top of- the piston, each end of the wire should be at least 3.18 mm (1/8") from the outside diameter of the piston.

    b. Bar the engine over until the piston being checked is at bottom dead center.

    c. Apply the lead wire through a liner port and position it on top of the piston so that it is parallel with the crankshaft.

    d. Bar the engine over one complete revolution to compress the lead wire. Remove the wire from the engine and measure the inboard portion of both compressed ends of the wire, Fig. 5-36.

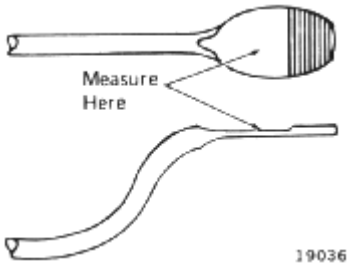


Fig. 5-36 - Lead Wire Measurement

NOTE: It is important that the thinner of the two compressed areas be measured to provide the minimum piston to head clearance.

    e. Within the maximum clearance and minimum clearance, the difference in micrometer readings should not exceed 0.13 mm (0.005"). If it does, repeat the process as the wire may have changed position.

    f. If the difference is still greater than 0.13 mm (0.005') after a second reading, change out the power assembly.

62. Place a new packing seal in the cylinder test valve bore and install the valve body and packing nut.

63. Tighten the valve body into the cylinder head and snug down the packing nut.

64. Torque the packing nut to 88 N-m (65 ft-lbs) and install the needle valve.

65. Refill the cooling system and check for water leaks.

66. Install the top deck and handhole covers.

67. Bar the engine over one complete revolution and close all the cylinder test valves.

68. Start the engine and raise the water temperature to 76° C (170° F). After running the engine, shut it down and re-check the torque on the crab and liner stud nuts. Also re-check for oil and water leaks.

POWER ASSEMBLY PACKAGING

WARNING: Failure to comply with the proper packaging procedures, when returning power assemblies, can result in injury to personnel or costly damage to components.

The container, in which the power assembly is shipped, has been specially constructed to prevent damage to components. To properly package the assembly being returned, the following procedure should be used:

1. Before attempting to move the assembly, place the piston holding block over the injector hole and over the injector crab stud and secure with the bolt threaded into the threaded lifting eye hole in the crown of the piston.

2. Attach the lifting clamp assembly and hoist. 3. Position assembly in shipping container so that liner is firmly seated and connecting rod straddles support in bottom of container.

4. Remove hoist and lifting clamp assembly.

5. Place top mounting block over rocker arm shaft studs and secure with washers and nuts. Make sure that the block attaching bolts holding the block to the container are secure.

6. On fork rod assemblies, make sure each half of the basket is properly positioned and secured to the main body of the container.

7. Place container cover in position and secure.

ADJUSTING HYDRAULIC LASH ADJUSTERS

Application of properly operating lash adjusters, correct setting, and subsequent inspection at regular maintenance intervals is very important to valve operation. Improperly set or defective lash adjusters cause the exhaust valves to be subjected to increased stress which leads to ultimate failure and probable damage to the engine.

After complete cylinder head assembly or power assembly has been installed, the lash adjusters must be set.

1. Open cylinder test valve and rotate crankshaft so that piston is at or near top dead center of the cylinder being set.

2. Loosen rocker arm adjusting screw locknuts.

3. Turn rocker arm adjusting screw down until the last valve just touches the hydraulic lash adjuster plunger, or use a 0.001 " shim between valve tip and adjuster plunger, and then turn it down 1-1/2 turns.

4. Check valve bridge spherical seat to be sure that it is spring-loaded against the cylinder head spherical seat. If the bridge spring spherical seat is not spring-loaded against the cylinder head spherical seat, turn down the rocker arm adjusting screw until no movement is felt, and then turn it another 1/4 turn.

5. Tighten rocker arm adjusting screw locknut.

6. After running the engine until lube oil reaches operating temperature, check the clearance between lash adjuster bodies and the end of the valve stems with the piston near top center. If the clearance is less than minimum, the cylinder head should be removed for reconditioning or rejection. Use minimum clearance gauge, Fig. 5-37, to gauge clearance between lash adjuster and exhaust valve. This gauge is 1/16" thick and should fit between lash adjuster body and valve stem top, to ensure the minimum clearance.

TIMING THE INJECTOR

With the injector installed, make timing adjustment as follows:

1. Set the flywheel at 0° top dead center of the cylinder being timed. See Table 1 in Section 7 for top dead center settings.

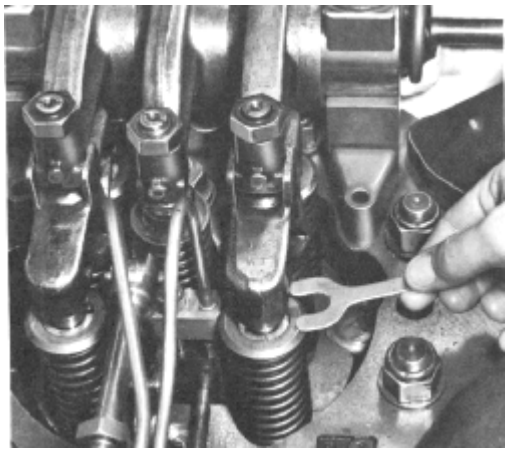


Fig. 5-37 - Checking Lash Adjuster To Valve Clearance

2. Insert injector timing gauge into the hole provided for it in the injector body, Fig. 5-38.

3. Loosen locknut and turn the rocker arm adjusting screw until the shoulder of the gauge just passes over the injector follower guide.

NOTE: Injectors cannot be timed if the overspeed has been tripped. It must first be reset and the engine crankshaft barred over at lease one revolution.

4. Tighten adjusting screw locknut while holding adjusting screw in position with a screwdriver.

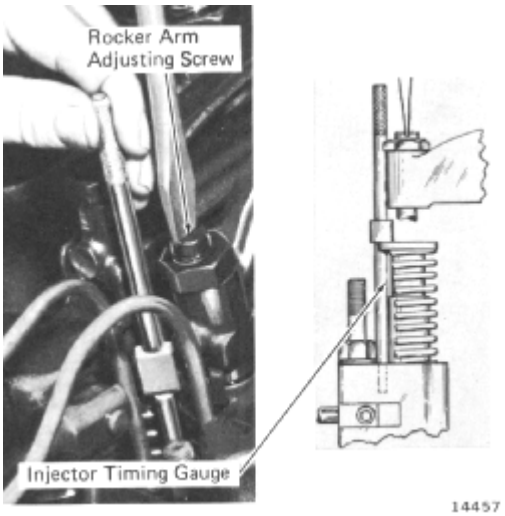


Fig. 5-38 - Timing Injector

5. Recheck setting.

CRAB NUT TIGHTNESS CHECK AND RETORQUING

All new or replaced power assemblies should have the crab nuts checked for tightness at interval specified in Scheduled Maintenance Program. Using a torque wrench, tighten to 2 440 N-m (1800 ft-lbs) any nut that turns at a lower value. If the nut does not turn at 2 440 N-m (1800 ft-lbs), do NOT tighten further.

Retorque crab nuts at intervals specified in Scheduled Maintenance Program. When retorquing crab nuts, loosen all nuts one flat [approximately 1 356 N-m (1000 ft-lbs)] and retorque to 2 440 N-m (1800 ft-lbs).

SERVICE DATA
CYLINDER POWER ASSEMBLY

SPECIFICATIONS

Clearance and dimensional limits listed below are defined as follows:

1. New limits are those to which new parts are manufactured. (Drawing tolerances.)

2. Minimum, maximum, and tolerance measurements are provided as service limits. At time of rebuild or any time unscheduled maintenance is performed, the service limits should not be exceeded. Engine components within these limits may be reused with the assurance that they will perform satisfactorily until the next scheduled overhaul.

Carrier to piston snap ring clearance -

New	0.05-0.38 mm (.002"-.015")
Max.	0.64 mm (.025")

Piston to cylinder head clearance -

New Min.	0.51 mm (.020")
New Max.	1.73 mm (.068")
Differential reading between ends of lead wire	0.13 mm (.005")

An increase in compression clearance of 0.76 mm (.030") from the assembly value at the time of installation condemns the assembly. Any sudden increase should be investigated immediately.

EQUIPMENT LIST

	Part No.
Test valve wrench	8032587
Crab stud protector tubes	8034600
Injector timing gauge	8034638
Piston pulling eyebolt	8040413
Injector prybar	8041183
Fork rod support	8052958
Cylinder head carrying basket	8060247
Blade rod protector boot	8062033
Fork rod protector boot	8062034
Crab nut socket	8065580
Piston cooling pipe alignment gauge	8071720
Cylinder head removing fixture	8075894
Crab nut box wrench handle (60")	8084091
Piston cooling pipe cleaning tool	8087086
Lash adjuster minimum clearance gauge	8107788
Cylinder liner lifter	8116358
Torque wrench (3/4" drive [0-300 ft-lbs])	8157121
Snap ring remover	8171633
Torque wrench extension (use w/torque wrench 8157121)	8210136
Piston carrier holding fixture	8236589
Basket bolt wrench	8236718
Wire holder (has contour of piston crown to hold lengths of lead wire for piston to head clearance check)	8243220
Wire (lead 1/8" dia., use with holder 5 lb spool)	8243220 8243661
Crab nut power wrench	8250855
Thread lubricant (5 gal.)	8307731
Bearing insert to carrier indenter tool	8311268
Piston ring compressor and guide (standard size)	8330363
Piston ring expander	8349892
Power assembly hoist set	8351724

Lifting clamp assembly	8417858
Piston holding tool	8417859
Connecting rod positioning clamp assembly	8417881
Silicone grease (8 oz. tube)	8425724
Injector holding rack	8431626