

## DISASSEMBLY

1. Use low pressure spray to thoroughly clean exterior surfaces of engine prior to disassembly. Dirt caked on cooling fins and other areas can fall into crankcase bore or stick to subassemblies as parts are removed. Abrasive particles can damage machined surfaces or plug oil passageways.

## NOTE

*It is assumed that each step performed on one cylinder is automatically repeated on the other.*

2. Alternately loosen the six rocker cover bolts following the pattern shown in A of Figure 3-22. Remove the rocker cover bolts.

## NOTE

*If the engine is left in the chassis for service, use the **ROCKER COVER WRENCH (HD-47258)** and **ROCKER HOUSING WRENCH (HD-47248)** to remove the rocker cover and rocker housing bolts, respectively. These tools are especially useful when removing the bolts on the left side of the engine (particularly the rear) where there is close proximity to the frame. With both an external and internal hex, the bolts also can be removed with either a 7/16 inch socket or open end/box wrench (open spaces), or a short 3/16 inch allen wrench (tight spaces). See Figure 3-20.*

3. Remove the rocker cover and gasket. Discard the gasket.
4. Insert the blade of a small screwdriver into cast loop of spring cap retainer (at top of upper push rod cover), and while pushing down on spring cap, rotate bottom of screwdriver toward outboard side to remove. See Figure 3-21. Repeat step on second push rod cover.
5. Collapse upper and lower push rod covers.

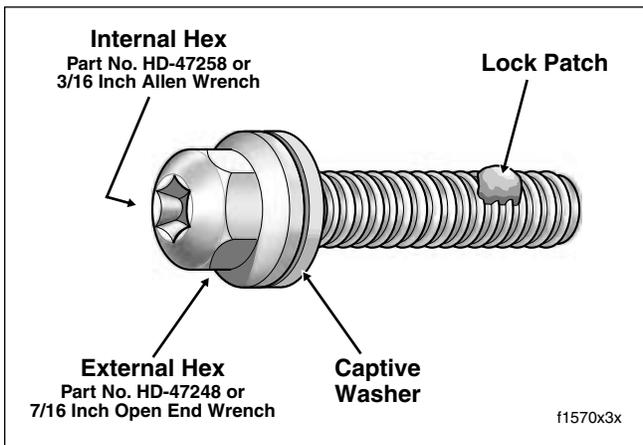


Figure 3-20. Rocker Cover Bolt (1-1/4 Inch)

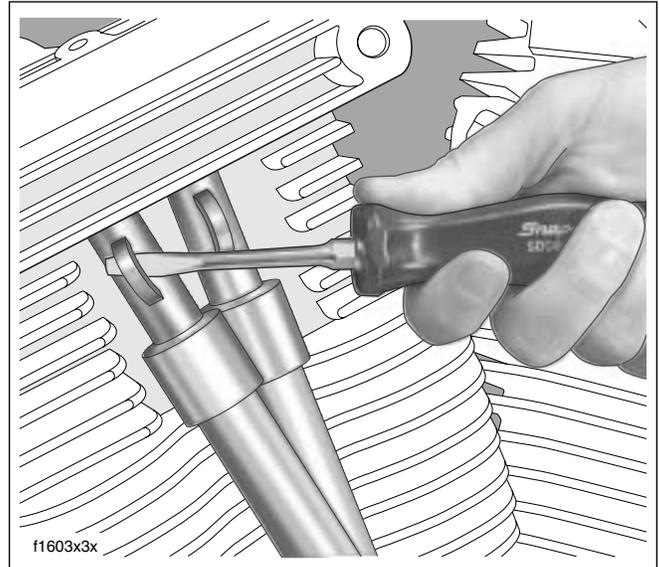


Figure 3-21. Remove Spring Cap Retainer

6. To remove the rocker arm support plate, **both** lifters of the cylinder being serviced must be on the base circle (or lowest position) of the cam.

## CAUTION

**Removing the rocker arms with the valve train loaded can result in bent push rods, damaged bushings or warped support plate.**

To find the base circle, it is first necessary to rotate the engine. Based on the level of disassembly required, three methods of engine rotation are presented below.

- a. With primary cover installed - With vehicle on center stand, place the transmission in 5th gear and rotate rear wheel in a clockwise direction (as viewed from right side) until the base circle is found. See step 6(d) to find the base circle.
- b. With primary cover removed - Remove primary cover. Place the transmission in neutral. Fit a 1-1/2 inch socket on the compensating sprocket shaft nut. Rotate nut in a counterclockwise direction until the base circle is found. See step 6(d) to find the base circle.

## CAUTION

**Do not attempt to rotate engine by removing cam cover and placing socket on crank or primary cam sprocket flange bolt. Head of flange bolt can break off possibly resulting in damage to flywheel or camshaft.**

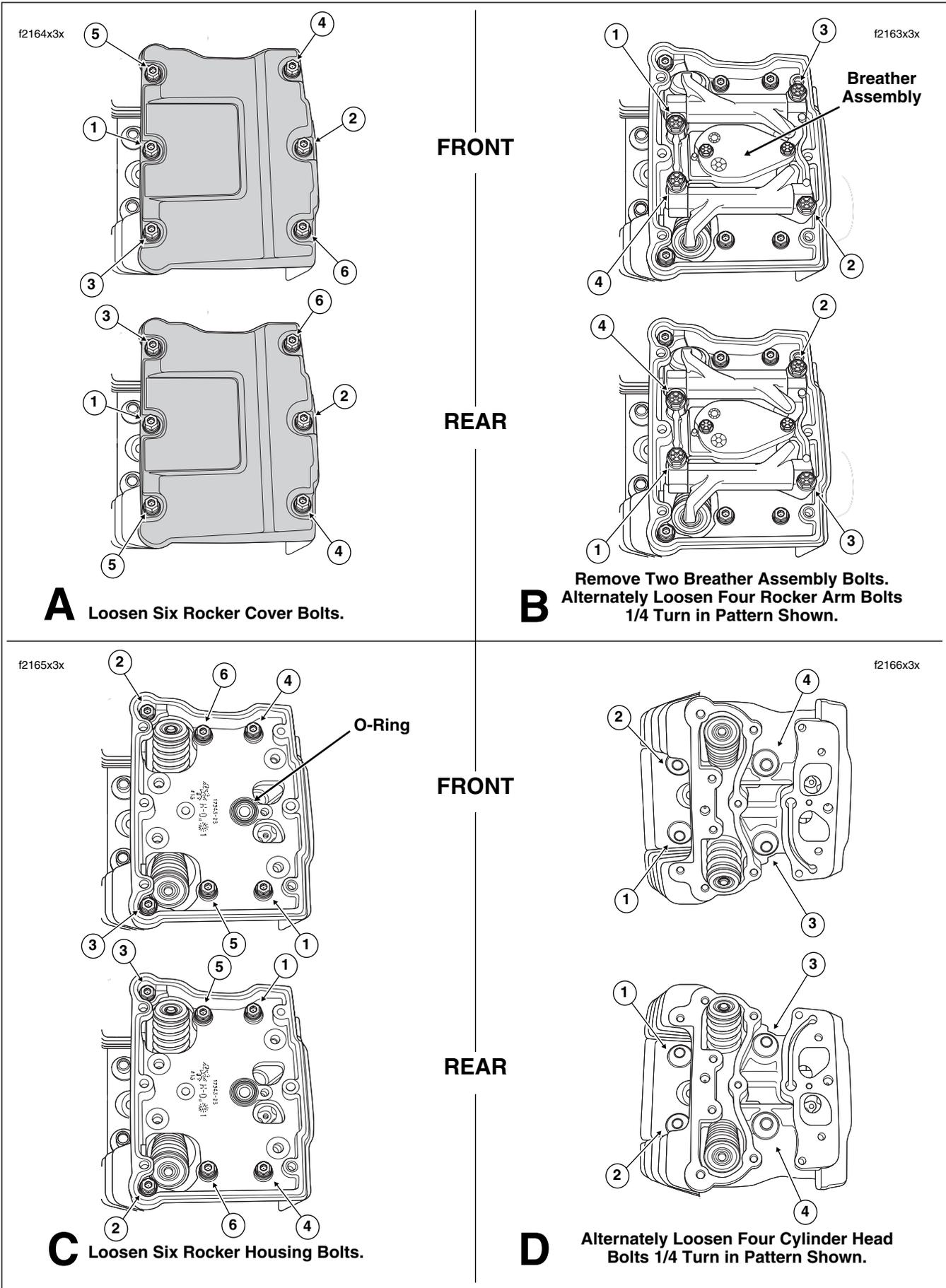
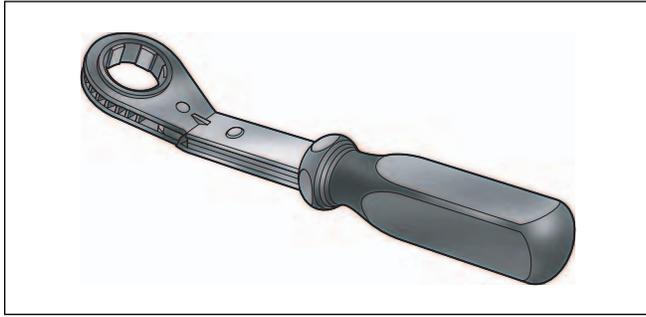


Figure 3-22. Top End Disassembly



**Figure 3-23. Engine Rotation Wrench (Part No. HD-47257)**

- c. With engine mounted in engine stand - Obtain the ENGINE ROTATION WRENCH (HD-47257). See [Figure 3-23](#). Install tool on sprocket shaft and rotate in a counterclockwise direction until the base circle is found. See step 6(d) to find the base circle.
  - d. Finding the base circle: Using one of the methods above, rotate engine until piston is at Top Dead Center (TDC) of compression stroke. To accomplish this, first raise lower push rod cover to access intake lifter (inside hole of lifter cover). Place index finger on top of the intake lifter. While rotating engine, feel lifter rise (valve open) and fall (valve closed). Now place finger tightly over spark plug hole and rotate engine again. In the compression stroke, air will be forced out against your finger until the piston reaches the TDC position. Stop engine rotation when the flow of air through the spark plug hole stops. Direct the beam of a small flashlight into spark plug hole to verify piston is at TDC. Both intake and exhaust valves are now closed and the push rods are in the unloaded position (and should turn freely).
7. Remove two bolts to release breather assembly from the rocker arm support plate. See B of [Figure 3-22](#). See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, BREATHER ASSEMBLY.
  8. Alternately loosen each of the four rocker arm support plate bolts just 1/4 turn following the pattern shown in B of [Figure 3-22](#). Continue turning the bolts in these increments until loose.
  9. When the rocker arm support plate bolts are free of the cylinder head, lift the support plate assembly from the rocker housing. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, ROCKER ARM ASSEMBLY.

**NOTE**

*Always service each cylinder separately. After the first cylinder is serviced the engine must be rotated to find the base circle on the second cam. Service on the remaining cylinder can then proceed.*

10. Remove the intake and exhaust push rods. Tag the push rods as they are removed, so that they can be installed in their original locations. Also take note of their orientation to be able to discern top from bottom at time of installation.
11. Remove push rod covers from cylinder head and lifter cover bores. Remove three O-rings from push rod covers and discard. If O-ring is missing from upper push rod cover, be sure to dislodge it from the cylinder head bore.
12. Using a crosswise pattern, remove the four allen head socket screws to release the lifter cover. Remove the lifter cover and gasket. Discard the gasket.
13. Remove the anti-rotation pin. Remove the hydraulic lifters. Tag lifters as they are removed, so that they can be installed in their original locations. Also take note of their orientation (by observing location of the oil hole) to be able to discern front from rear at time of installation.
14. Place the lifters in clean plastic bags to keep out dust, dirt and debris. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, PUSH RODS/LIFTERS/COVERS.
15. Remove O-ring from groove around breather baffle hole in rocker housing. Discard the O-ring.
16. Alternately loosen the six rocker housing bolts following the pattern shown in C of [Figure 3-22](#). Remove the rocker housing bolts.

**NOTE**

*If the engine is left in the chassis for service, use the ROCKER HOUSING WRENCH (HD-47248) for best results.*

17. Remove the rocker housing and gasket. Discard the gasket.

**CAUTION**

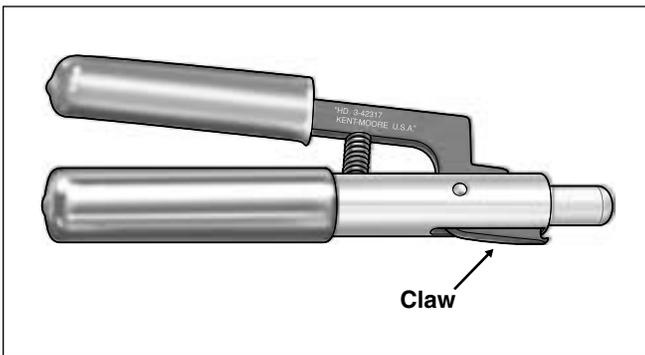
**To prevent distortion of the cylinder head, cylinder and cylinder studs, gradually loosen the cylinder head bolts in the specified pattern.**

18. Alternately loosen each of the four cylinder head bolts just 1/4 turn following the pattern shown in D of [Figure 3-22](#). Continue turning the bolts in these increments until loose. Remove the cylinder head bolts.

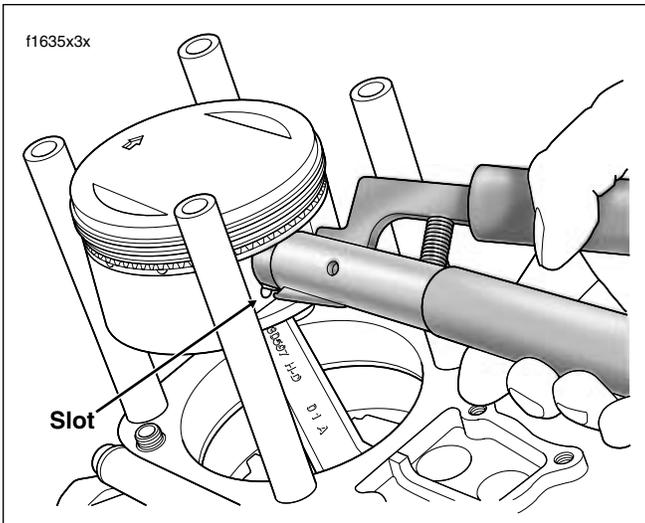
**NOTE**

*Save the cylinder head gasket if not damaged. The gasket is needed to install the CYLINDER TORQUE PLATES (HD-42324A) when measuring, boring or honing of the cylinder is required.*

19. Remove cylinder head and head gasket. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, CYLINDER HEAD.



**Figure 3-24. Piston Pin Circlip Remover/Installer (Part No. HD-42317A)**



**Figure 3-25. Remove Piston Pin Circlip**

20. Raise the cylinder just enough to place clean shop towels under the piston. This will prevent any dirt or debris, such as broken ring pieces, from falling into the crankcase bore.

### CAUTION

**Exercise caution to avoid bending the cylinder studs. Even a slight bend or nick can cause a stress riser leading to stud failure.**

21. Carefully remove the cylinder to avoid bending the cylinder studs. As the piston becomes free of the cylinder, hold it upright to prevent it from striking the studs or dragging across the stud thread area. Mark the cylinder "F(ront)" or "R(ear)" to identify location.
22. Slide plastic tubing, rubber hose or conduit over each cylinder stud. Material approximately 6 inches (152 mm) long with an I.D. of 1/2 inch (12.70 mm) will protect cylinder studs and piston from damage.

23. Remove O-ring seal from the bottom of the cylinder liner. Discard O-ring seal. See Section 3.11 [SUBASSEMBLY SERVICE AND REPAIR, CYLINDER](#).
24. Remove O-ring from ring dowel on "downside" of cylinder deck. Discard the O-ring.

### CAUTION

**Always wear proper eye protection when removing circlips. Slippage may propel the ring with enough force to cause eye injury.**

25. Verify that clean shop towels are properly positioned over the crankcase bore to prevent the piston pin circlip from falling into the crankcase.
26. Remove the piston pin circlip as follows:
  - a. Insert the PISTON PIN CIRCLIP REMOVER/INSTALLER (HD-42317A) into the piston pin bore until claw on tool is positioned in slot of piston (directly under circlip). See [Figure 3-25](#).
  - b. Squeeze the handles of the tool together and pull from bore. In the event that the circlip should fly out, hold a shop towel over the bore during removal. Remove circlip from claw and discard.

### NOTE

*It is not necessary to remove both piston pin circlips during piston removal. Leave the second circlip in the pin bore.*

27. Remove the piston pin. If piston pin is difficult to remove, use PISTON PIN REMOVER (HD-42320A). See [Figure 3-26](#). Proceed as follows:
  - a. Remove acorn nut and spacer from rod end of tool.
  - b. Slide rod end through piston pin. Install spacer and acorn nut to end of rod.
  - c. Position rubber-coated tips of tool on flat each side of pin bore.
  - d. Turn handle in a clockwise direction until piston pin is pulled free of bore. See [Figure 3-27](#).
28. Remove the piston. Be sure to hold the rod shank upright to prevent it from striking the crankcase. Place a piece of foam-type water pipe insulation around each rod (about 3 inches long with a 2-1/4 inch O.D. and a 1 inch I.D.) to prevent damage if contact should occur.
29. Turn the piston over and mark the pin boss with the letters "F(ront)" or "R(ear)" to identify location. See Section 3.11 [SUBASSEMBLY SERVICE AND REPAIR, PISTON](#) and [UPPER CONNECTING ROD](#).
30. If performing a top end overhaul only, see Section 3.11 [SUBASSEMBLY SERVICE AND REPAIR, TOP END](#), before proceeding to Section 3.9 [TOP END OVERHAUL, ASSEMBLY](#), which follows. If performing a complete engine overhaul, see Section 3.10 [BOTTOM END OVERHAUL, DISASSEMBLY](#).

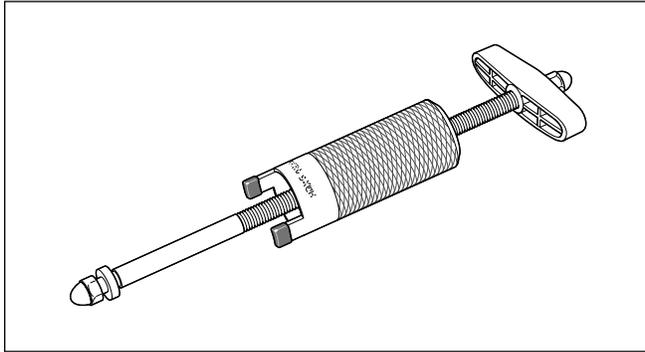


Figure 3-26. Piston Pin Remover (Part No. HD-42320A)

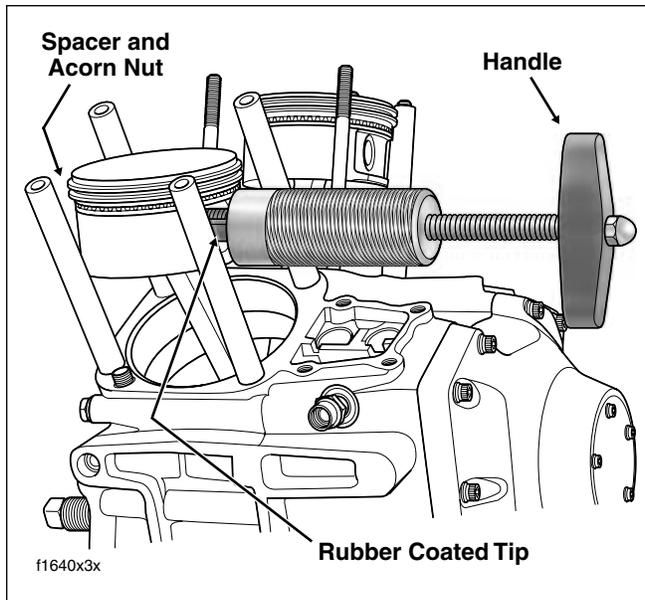


Figure 3-27. Remove Piston Pin

## ASSEMBLY

### NOTE

*It is assumed that each step performed on one cylinder is automatically repeated on the other.*

1. Slide plastic tubing, rubber hose or conduit over each cylinder stud, if removed. Material approximately 6 inches (152 mm) long with an I.D. of 1/2 inch (12.70 mm) will protect cylinder studs and piston from damage.
2. Apply clean H-D 20W50 engine oil to piston pin, piston bosses and upper connecting rod bushing.
3. Remove water pipe insulation from rod shank.
4. Place piston over rod end so that the arrow stamped at the top of the piston points toward the front of the engine.

5. Insert piston pin through pin bore and upper connecting rod bushing. Push pin until it contacts circlip installed in opposite pin boss.

### CAUTION

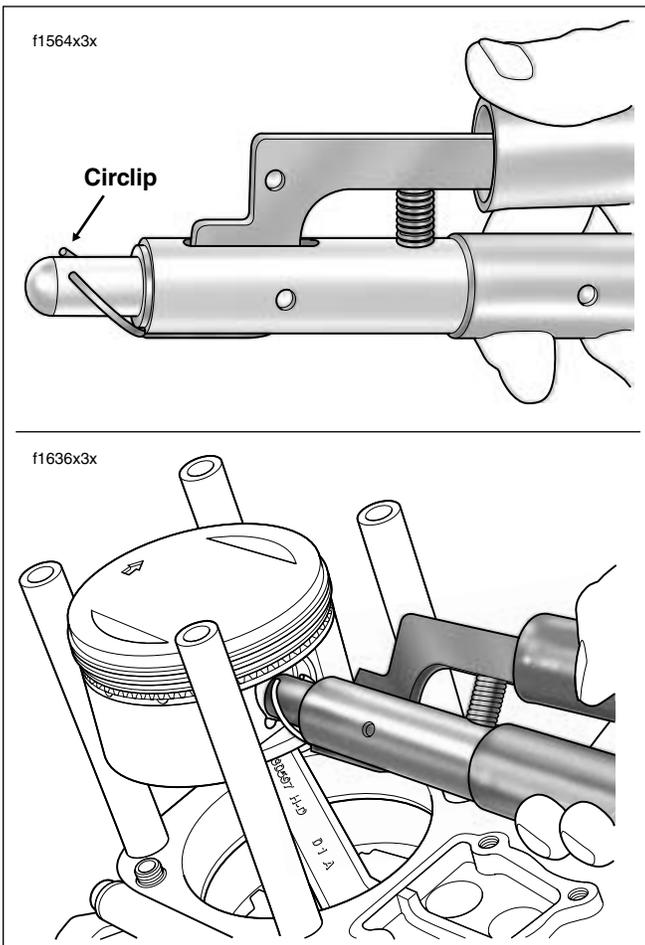
**Do not reuse piston pin circlips. The circlips may weaken during removal causing them to break or dislodge during engine operation, a condition that will result in engine damage.**

6. Place clean shop towels over the cylinder and lifter bores to prevent the piston pin circlip from falling into the crankcase. Verify that the circlip groove is clean and free of dirt and grime.
7. Install **new** piston pin circlip with the PISTON PIN CIRCLIP REMOVER/INSTALLER (HD-42317A). Proceed as follows:
  - a. Slide circlip down nose of tool until it contacts claw. Lightly squeeze handles of tool to capture circlip in claw.
  - b. Releasing pressure on handles, rotate circlip so that the end gap is centered at top of tool and then recapture in claw.
  - c. Tilt the circlip forward until the end gap contacts nose of tool. See upper frame of [Figure 3-28](#).
  - d. Insert the tool into the piston pin bore until claw is aligned with slot in piston.
  - e. Firmly push the tool into the piston pin bore until it bottoms. Release handles and remove tool.
  - f. Inspect the circlip to verify that it is fully seated in the groove.

### CAUTION

**O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.**

8. Install **new** O-ring over “downside” cylinder deck ring dowel (that is, rear dowel on rear cylinder, front dowel on front cylinder). Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation. Verify that O-ring is properly seated in groove.
9. Install **new** O-ring seal at the bottom of the cylinder liner. Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation.



**Figure 3-28. Install Piston Pin Circlip**

**NOTE**

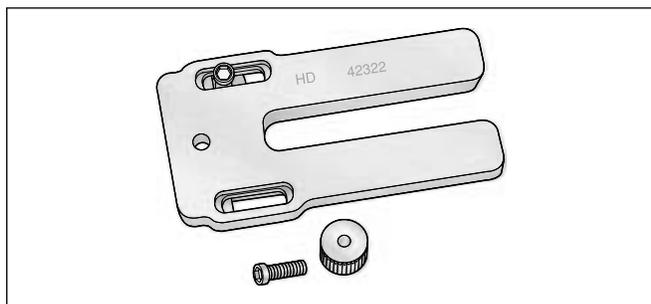
*Excessive lubrication of cylinder sleeve O-ring seal will result in oil weepage between cylinder and crankcase as engine is run, a condition that may be incorrectly diagnosed as an oil leak.*

10. Verify that the piston ring end gaps are properly staggered. If necessary, see Section 3.11 **SUBASSEMBLY SERVICE AND REPAIR, PISTON**.
11. Apply clean H-D 20W50 engine oil to piston, piston rings and cylinder bore.
12. Remove plastic tubing or rubber hose from cylinder studs. Rotate engine until piston is at top dead center. If necessary, see step 31 for methods of engine rotation.
13. Install the PISTON SUPPORT PLATE (HD-42322). Proceed as follows:
  - a. Slide both adjustable knobs on tool down slots away from forked end. Tighten knobs when contact is made with flats at end of slots.

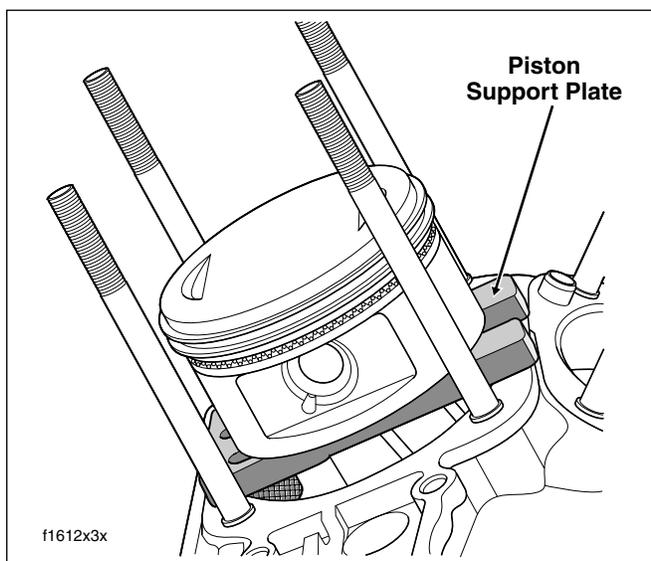
- b. With the forked end of the tool pointing towards the center of the engine and the adjustable knobs facing downward, capture shank of connecting rod in fork. Lay tool on cylinder deck so that adjustable knobs contact wall of cylinder bore.
- c. Rotate engine until piston skirt is centered and firmly seated on top of support plate. See Figure 3-30.

14. Install cylinder as follows:

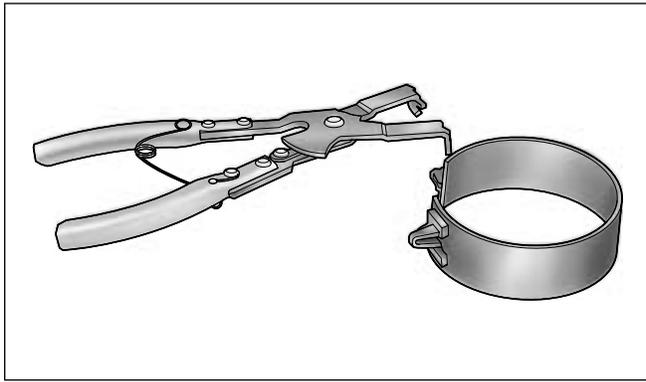
- a. Obtain the PISTON RING COMPRESSOR (HD-96333-51E).
- b. Fit tabs on pliers into slots of ring compressor band (HD-96333-103). The arrow stamped on the band indicates the side that faces up, so disregard the word "bottom." Place band around piston. Press the lever on the right side of the pliers to open the jaws for band expansion.
- c. Orient tool so that the top of the band is positioned between the top compression ring and the piston crown. Tightly squeeze handles of tool to compress piston rings. The ratcheting action of the tool allows release of the handles after the rings are compressed.



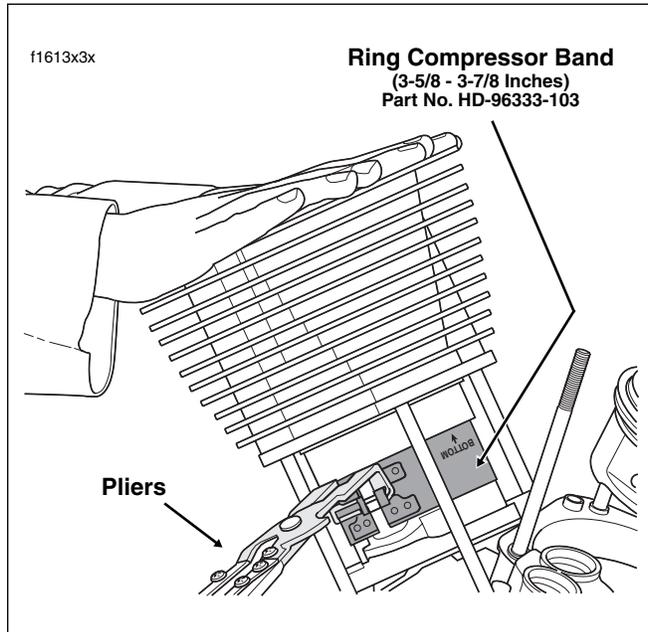
**Figure 3-29. Piston Support Plate (Part No. HD-42322)**



**Figure 3-30. Install Piston Support Plate**



**Figure 3-31. Piston Ring Compressor  
(Part No. HD-96333-51E)**



**Figure 3-32. Install Cylinder**

- d. Note that the cylinders should have been marked with the letters "F(ront)" or "R(ear)" to identify location. With the indent in the cooling fins facing the right side of the engine, gently slide cylinder over the cylinder studs and the piston crown resting it on the top of the ring compressor band.
- e. Place the palms of both hands at the top of the cylinder. Push down on the cylinder with a sharp, quick motion to pass the piston ring area. See [Figure 3-32](#).
- f. Rotate the engine slightly to raise piston off support plate. Remove pliers from band and then remove band from around shank of connecting rod. Remove piston support plate.
- g. Remove shop towels from around the crankcase bore exercising caution to keep out any dirt or debris.

- h. Carefully set the cylinder over the two ring dowels in the cylinder deck. Push down on the cylinder until it is fully seated in the crankcase bore.

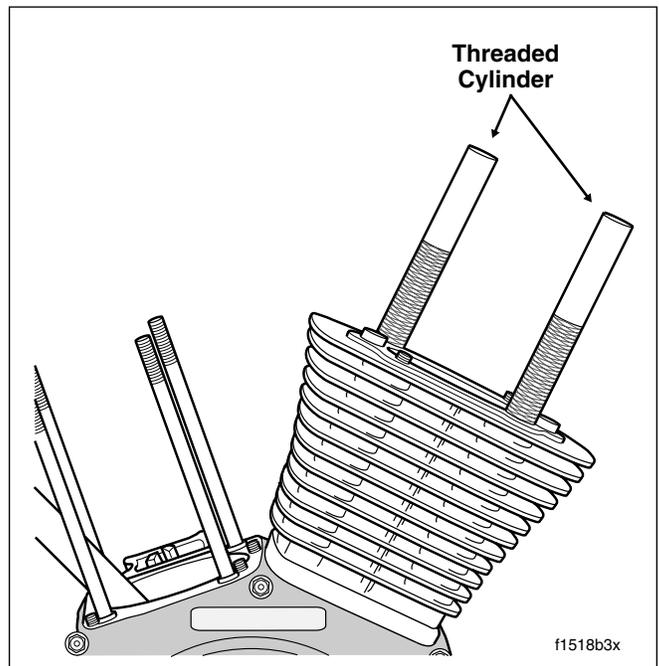
**NOTE**

To hold the first cylinder in position while installing the second, install threaded cylinders (HD-95952-1) from **CONNECTING ROD CLAMPING TOOL (HD-95952-33B)** onto cylinder studs with the knurled side down. This will prevent the piston rings from raising the cylinder as the engine is rotated to bring the other piston into position for installation of the second cylinder. See [Figure 3-33](#).

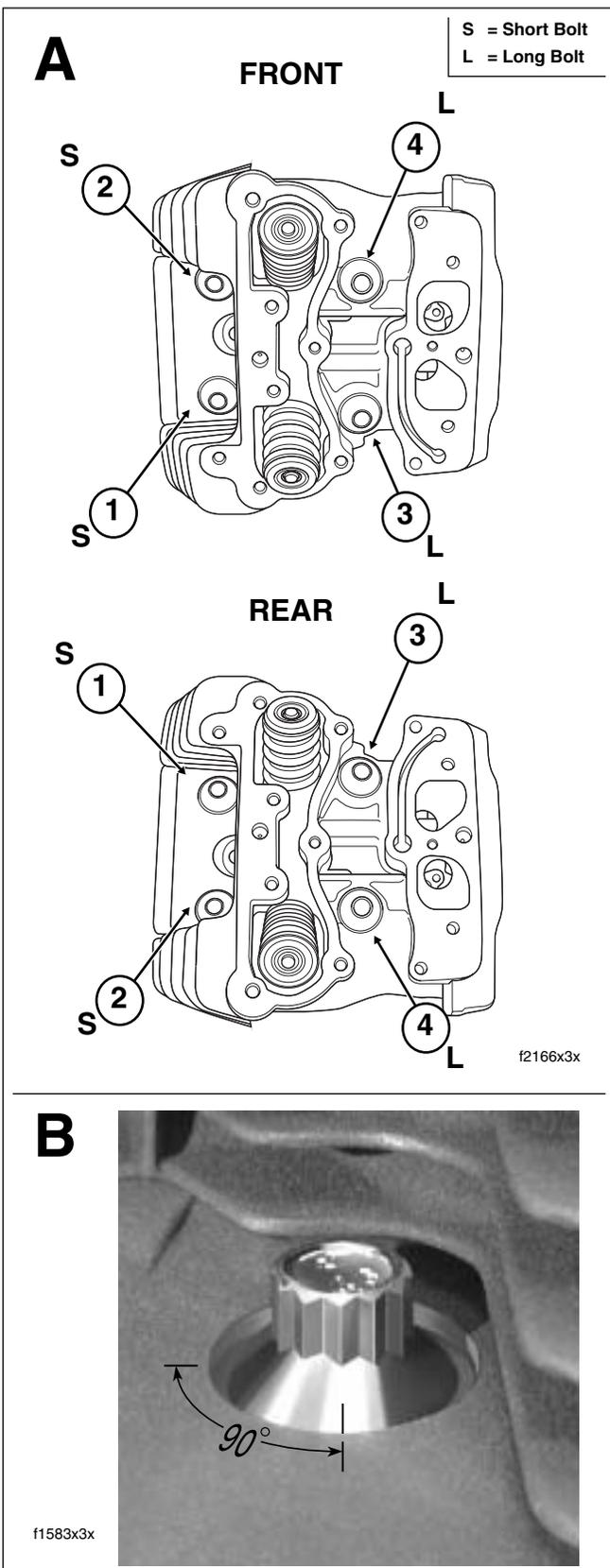
15. With the part number topside, place the head gasket over the two ring dowels in the upper flange of the cylinder.
16. Note that the word "Front" or "Rear" is cast into the top of the cylinder head to ensure proper installation. With the indent in the cooling fins facing the right side of the engine (for accommodation of the push rods and covers), carefully set the cylinder head over the two cylinder ring dowels. To avoid damage to machined surfaces or ring dowels, lower the cylinder head at an angle that closely approximates the angle of the crankcase.

**CAUTION**

Thoroughly clean and lubricate the threads of the cylinder head bolts before installation. Friction caused by dirt and grime will result in a false torque indication.



**Figure 3-33. Install Threaded Cylinders to Studs  
(Part No. HD-95952-1)**



**Figure 3-34. Cylinder Head Torque Sequence and Bolt Size**

17. Lightly oil threads and shoulders of cylinder head bolts with clean H-D 20W50 engine oil.
18. Start the cylinder head bolts onto the cylinder studs, two short bolts on the left side of the engine, two long bolts on the right.
19. Tighten the four cylinder head bolts as follows:

**CAUTION**

**Improperly tightened cylinder head bolts may result in gasket leaks, stud failure and distortion of the cylinder and/or cylinder head.**

- a. Alternately turn each cylinder head bolt until finger tight.
- b. Tighten the cylinder head bolts to 120-144 **in-lbs** (13.6-16.3 Nm) in the sequence shown in A of [Figure 3-34](#).
- c. Following the same sequence, tighten each bolt to 15-17 **ft-lbs** (20.3-23.1 Nm).
- d. Using a grease pencil, mark a straight line on the cylinder head bolt continuing the line over onto the cylinder head. Using the marks as a guide, turn each bolt 1/4 turn or 90 degrees. See B of [Figure 3-34](#). Be sure to tighten the cylinder head bolts in the sequence shown in A of [Figure 3-34](#).

**NOTE**

For best results, obtain Snap-on® Torque Angle Gauge TA360.

20. Install a **new** rocker housing gasket on the cylinder head flange.

**CAUTION**

**Even though all bolt holes (rocker housing, rocker arm support plate and breather assembly) may appear to be in alignment, the rocker housing gasket may be installed upside down. An upside down gasket will result in an open breather channel causing an oil leak when the vehicle is started, possibly resulting in engine and/or property damage.**

21. Verify that the rocker housing gasket is installed correctly by noting that the breather channel is concealed. See [Figure 3-35](#).
22. With the indent facing forward, place the rocker housing into position aligning the holes in the housing with those in the gasket.
23. Apply a small dab of Loctite Medium Strength Threadlocker 243 (blue) to threads of six rocker housing bolts. Start the rocker housing bolts, two long bolts on the left side of the engine, four intermediate bolts in the interior. Alternately tighten the bolts to 120-168 **in-lbs** (13.6-18.9 Nm) in the pattern shown in [Figure 3-36](#).

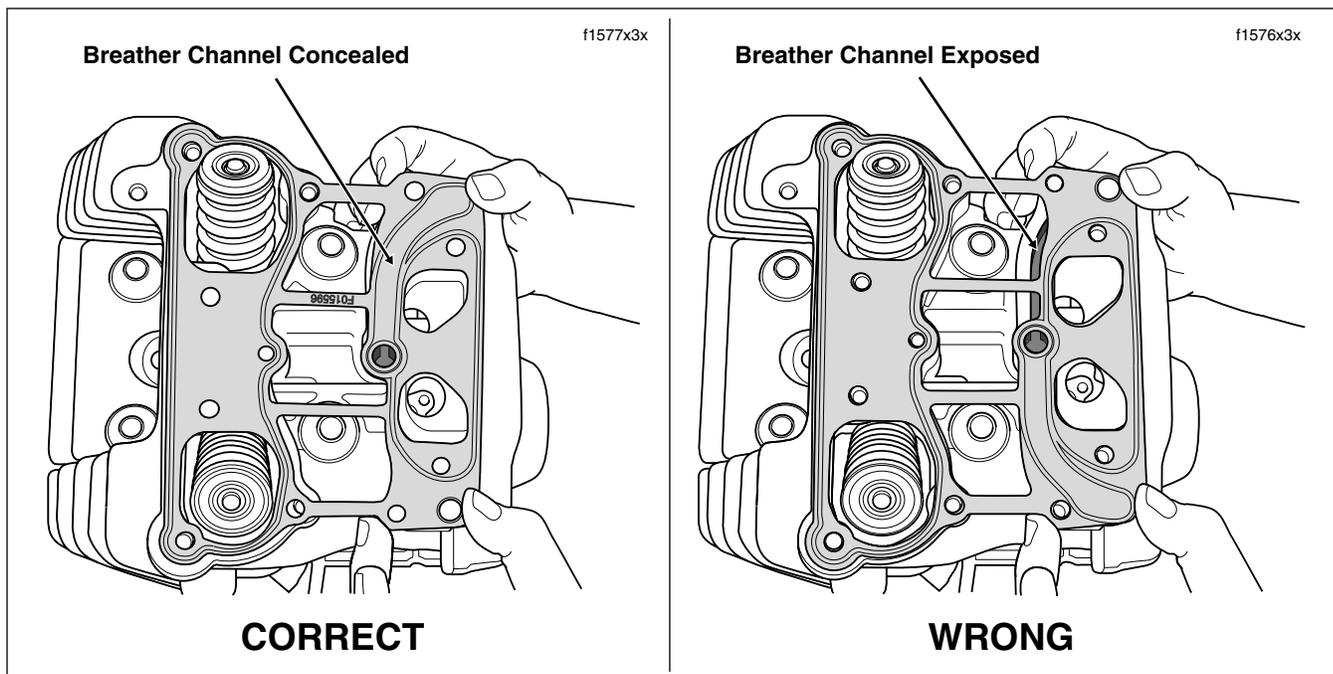


Figure 3-35. Install Rocker Housing Gasket (Rear Cylinder Shown)

#### NOTE

If the engine was left in the chassis for service, use the **ROCKER HOUSING WRENCH (HD-47248)** to start the rocker housing bolts. With both an external and internal hex, the bolts also can be installed with either a 7/16 inch socket or open end/box wrench (open spaces), or a short 3/16 inch allen wrench (tight spaces). For best results, final tighten the bolts on the left side of the engine (where there is close proximity to the frame) to 120-168 **in-lbs** using a torque wrench with a 1/4 inch drive.

#### CAUTION

**O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.**

24. Install **new** O-ring in groove around breather baffle hole in rocker housing. Apply a thin film of clean H-D 20W50 engine oil to O-ring before installation. See [Figure 3-36](#).
25. Install the hydraulic lifters in the crankcase bores with the flats facing forward and rearward. To preserve existing wear patterns, orientation of the oil hole (inboard or outboard) should have been noted during disassembly. To avoid damage, do not drop lifters onto cam lobes.
26. Place anti-rotation pin on the machined flat between the blocks cast into the crankcase. See [Figure 3-37](#).

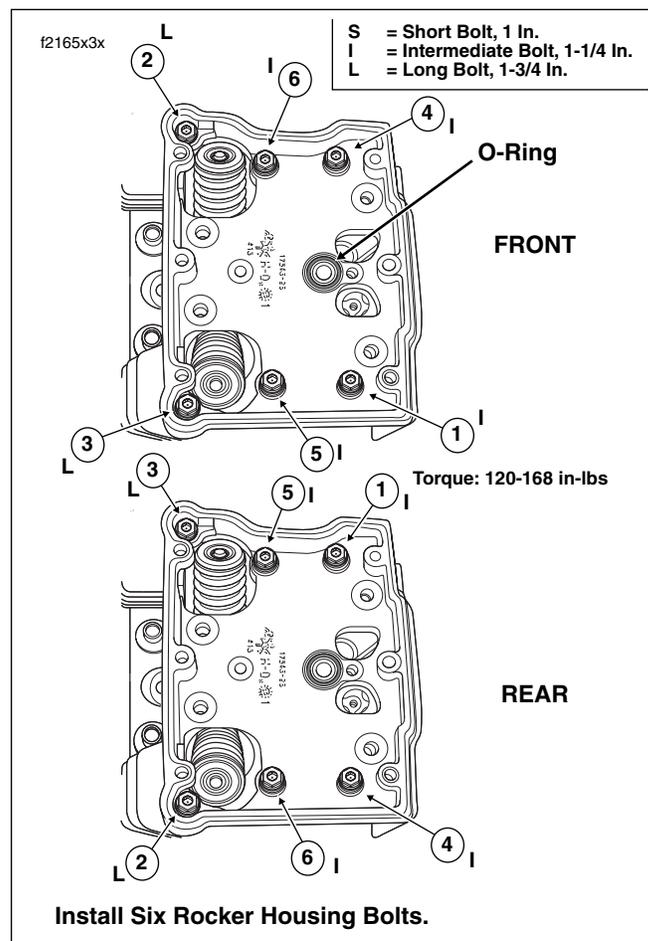
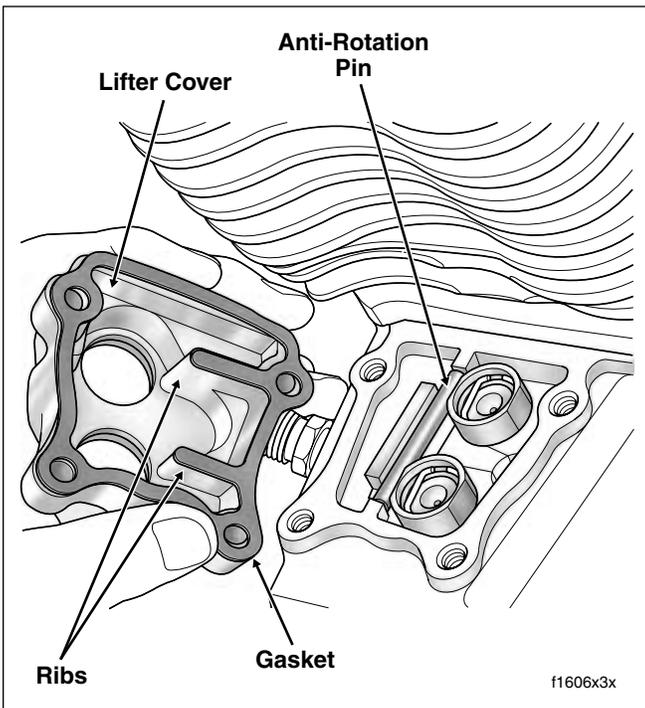


Figure 3-36. Rocker Housing Torque Sequence and Bolt Size



**Figure 3-37. Install Lifters and Lock Position With Anti-Rotation Pin**

27. Install a **new** lifter cover gasket aligning the holes in the gasket with those in the cover.

#### CAUTION

**Movement or loss of the anti-rotation pin can result in lifter rotation causing catastrophic engine damage.**

28. Install the lifter cover and start the four allen head socket screws (1/4 x 1 inch). During installation, verify that the anti-rotation pin is held in place by the ribs cast into the inboard side of the lifter cover. See [Figure 3-37](#). Tighten the lifter cover screws to 90-120 **in-lbs** (10.2-13.6 Nm) in a crosswise pattern.
29. Hand compress the push rod cover assembly and fit the O-ring end of the lower push rod cover into the lifter cover bore. Expanding the assembly, fit the O-ring end of the upper push rod cover into the cylinder head bore.

**Table 3-3. Push Rod/Cover Locations**

Cylinder	Cover and Push Rod*	Lifter Cover Bore	Cylinder Head/ Rocker Housing Bore
Front	Intake	Inside	Rear
	Exhaust	Outside	Front
Rear	Intake	Inside	Front
	Exhaust	Outside	Rear

\* Push Rods Are Color Coded - Intake (Silver), Exhaust (Black)

Do **not** install the spring cap retainers at this time. To ensure proper installation, take note of [Table 3-3](#).

30. Install the push rods in their original positions. Be sure to remove any tags that may have been used for marking location and orientation. To ensure proper installation, take note of [Table 3-3](#). For example, if reassembling the rear cylinder, slide the intake push rod (silver) through the front hole in the rocker housing engaging the lifter socket in the inside hole of the lifter cover. Slide the exhaust push rod (black) through the rear hole in the rocker housing engaging the lifter socket in the outside hole of the lifter cover.
31. To install the rocker arm support plate, **both** lifters of the cylinder being serviced must be on the base circle (or lowest position) of the cam.

#### CAUTION

**Installing the rocker arms and rotating the engine with the valve train loaded can result in bent push rods and/or valve damage.**

To find the base circle, it is first necessary to rotate the engine. Based on the level of disassembly, three methods of engine rotation are presented below.

- With primary cover installed - With vehicle on center stand, place the transmission in 5th gear and rotate rear wheel in a clockwise direction (as viewed from right side) until the base circle is found. See step 31(d) to find the base circle.
- With primary cover removed - Remove primary cover. Place the transmission in neutral. Fit a 1-1/2 inch socket on the compensating sprocket shaft nut. Rotate nut in a counterclockwise direction until the base circle is found. See step 31(d) to find the base circle.

#### CAUTION

**Do not attempt to rotate engine by removing cam cover and placing socket on crank or primary cam sprocket flange bolt. Head of flange bolt can break off possibly resulting in damage to flywheel or camshaft.**

- With engine mounted in engine stand - Obtain the ENGINE ROTATION WRENCH (HD-47257). See [Figure 3-23](#). Install tool on sprocket shaft and rotate in a counterclockwise direction until the base circle is found. See step 31(d) to find the base circle.
- Finding the base circle: Using one of the methods above, rotate engine until piston is at Top Dead Center (TDC) of compression stroke. To accomplish

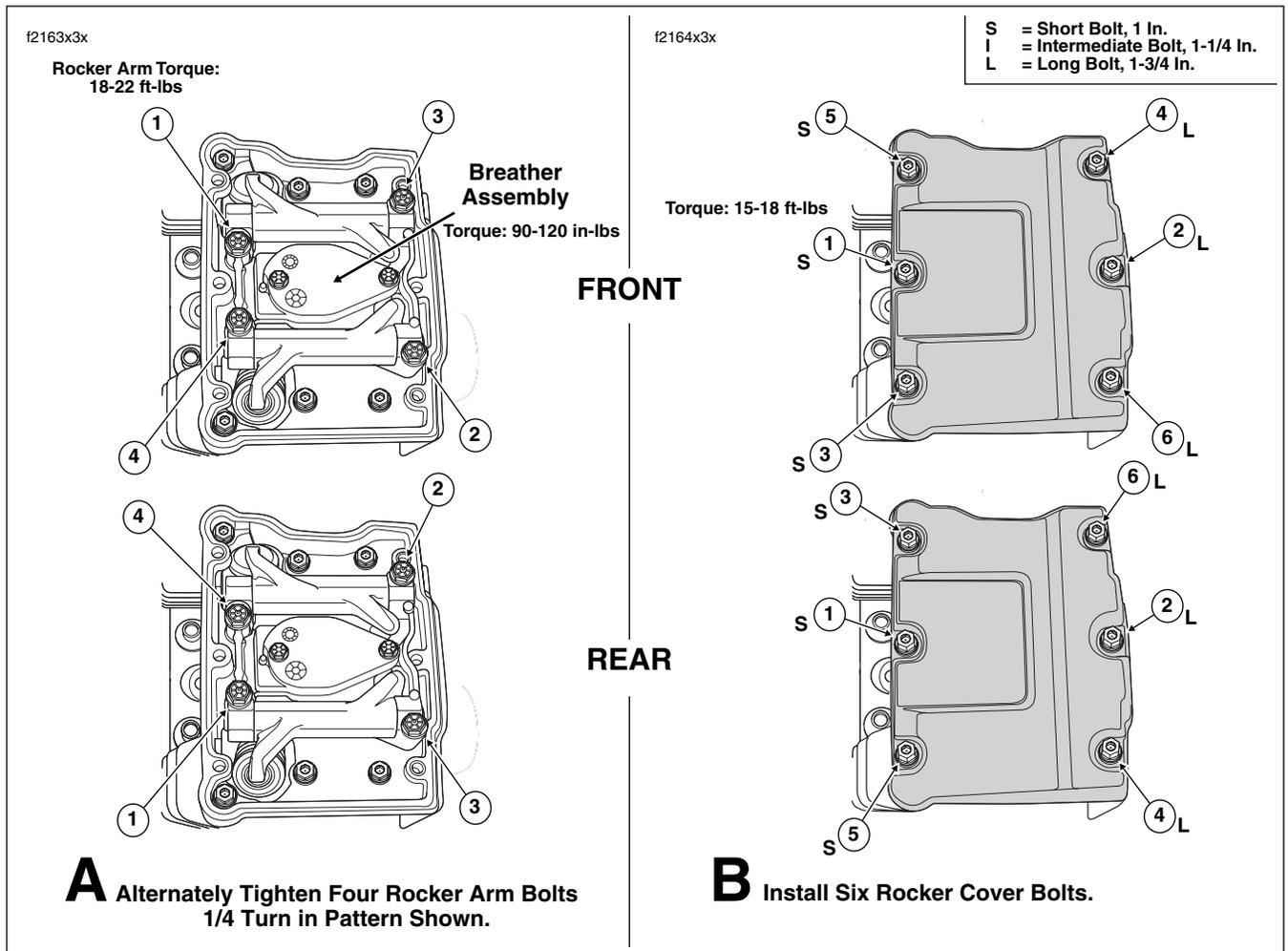


Figure 3-38. Rocker Arm/Rocker Cover Torque Sequence and Bolt Size

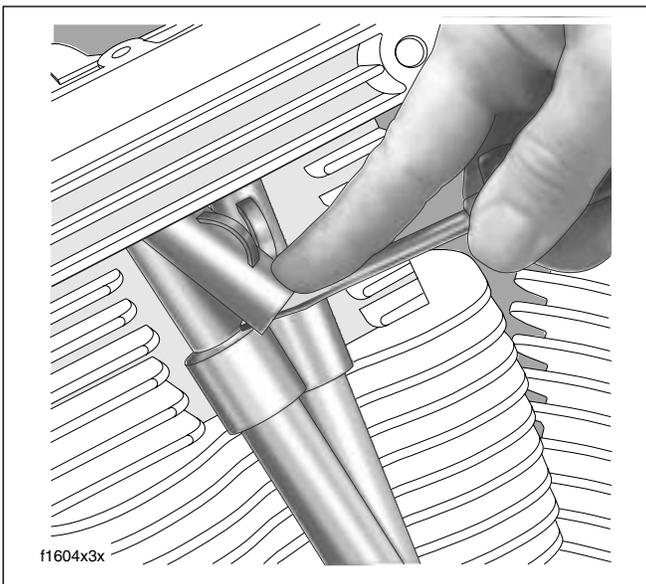
this, first raise lower push rod cover to access intake lifter (inside hole of lifter cover). Place index finger on top of the intake lifter. While rotating engine, feel lifter rise (valve open) and fall (valve closed). Now place finger tightly over spark plug hole and rotate engine again. In the compression stroke, air will be forced out against your finger until the piston reaches the TDC position. Stop engine rotation when the flow of air through the spark plug hole stops. Direct the beam of a small flashlight into spark plug hole to verify piston is at TDC. Both intake and exhaust valves are now closed and the push rods are in the unloaded position.

32. Place the rocker arm support plate assembly into the rocker housing. Start the four rocker arm support plate bolts into the cylinder head.
33. Place breather assembly at top of rocker arm support plate. Apply a small dab of Loctite Medium Strength Threadlocker 243 (blue) to threads of two breather assembly bolts. Start bolts into cylinder head.

34. Alternately tighten each of the four rocker arm support plate bolts just 1/4 turn following the pattern shown in A of Figure 3-38. Continue turning the bolts in these increments until snug. Following the same numerical sequence, tighten the bolts to 18-22 ft-lbs (24.4-29.8 Nm).
35. Alternately tighten the two breather assembly bolts to 90-120 **in-lbs** (10.2-13.6 Nm).

#### NOTE

*If the engine was left in the chassis for service, final tighten the rocker arm support plate bolt on the rear left side of the rear cylinder using a 3/8 inch drive torque wrench with a 1/2 inch flank drive "dog bone" torque adapter (Snap-On FRDH161). Since any extension can act as a torque multiplier, the torque wrench must be perpendicular to the torque adapter when the bolt is tightened. The 90 degree orientation between the tools cancels the multiplier effect and prevents the bolt from being over-tightened. If the adapter is kept inline with the torque wrench, the multiplier effect is in force and distortion of the rocker housing will occur.*



**Figure 3-39. Install Spring Cap Retainer**

36. Lift up lower push rod covers and verify that both push rods spin freely.

**NOTE**

*Always service each cylinder separately. After the first cylinder is serviced the engine must be rotated to find the base circle on the second cam. Service on the remaining cylinder can then proceed.*

37. Complete installation of the push rod covers as follows:
- Verify that the O-ring ends of the upper and lower push rod covers fit snugly into the cylinder head and lifter cover bores.
  - Lodge the upper edge of spring cap retainer into the cylinder head bore leaving the bottom edge free.
  - Insert blade of small screwdriver between bottom edge of spring cap retainer and top of spring cap.
  - While simultaneously depressing spring cap with tip of screwdriver, use forefinger to slide bottom edge of spring cap retainer down shaft towards tip of screwdriver blade. As spring cap reaches its full length of travel, spring cap retainer should be in approximate position against upper push rod cover. See [Figure 3-39](#).

**NOTE**

*For best results, be sure that screwdriver, spring cap and spring cap retainer are free of grease and oil.*

- Verify that spring cap retainer is seated tightly against upper push rod cover.
38. Install a **new** rocker cover gasket on the rocker housing flange. Place the rocker cover into position aligning the holes in the cover with those in the gasket.

39. Apply a small dab of Loctite Medium Strength Threadlocker 243 (blue) to threads of six rocker cover bolts. Start the rocker cover bolts, three short bolts on the left side of the engine, three long bolts on the right. Tighten the bolts to 15-18 ft-lbs (20.3-24.4 Nm) in the pattern shown in B of [Figure 3-38](#).

**NOTE**

*If the engine was left in the chassis for service, final tighten the three rocker cover bolts on the left side of the rear cylinder using a 3/8 inch drive torque wrench with a 7/16 inch flank drive "dog bone" torque adapter (Snap-On FRDH141). Since any extension can act as a torque multiplier, the torque wrench must be perpendicular to the torque adapter when the bolts are tightened. The 90 degree orientation between the tools cancels the multiplier effect and prevents the bolts from being over-tightened. If the adapter is kept inline with the torque wrench, the multiplier effect is in force and distortion of the rocker cover will occur.*

40. If engine was left in the chassis for service, see Section [3.6 ASSEMBLING MOTORCYCLE AFTER STRIPPING](#). If engine was removed for service, see Section [3.8 INSTALLING ENGINE IN CHASSIS](#).

## DISASSEMBLY

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY. If only servicing cam compartment components, see steps 1-11. If performing a complete engine overhaul, reference steps 1-29.

## NOTE

The cam support plate and lifter cover use the same short allen head socket screw (1/4 x 1 inch). Only the cam cover uses the longer screw (1/4 x 1-1/4 inches). For ease of assembly, do not mix short and long screws. Store long screws inside cam cover to avoid confusion. The short screws are interchangeable.

2. Remove the ten allen head socket screws to release the cam cover. Remove and discard the cam cover gasket.

3. Using a colored marker, mark the crank sprocket and one of the links of the primary cam chain. Maintaining the original direction of rotation during assembly may prolong service life.
4. Remove the flange bolt and flat washer from the crank sprocket. See Figure 3-40.
5. Remove the flange bolt and flat washer from the primary cam sprocket.

## NOTE

If too much loctite, or perhaps the wrong loctite, was used to install the primary cam sprocket flange cam bolt, it may be very difficult to remove. In these cases, break down loctite using heat from a small propane torch. Apply flame evenly around bolt head in a circular motion, but not for so long as to turn bolt blue. Do not direct heat at chain tensioner assembly and other components or damage will result. Other methods of removal, such as use of a large breaker bar, also may result in damage to chain drive and other components.

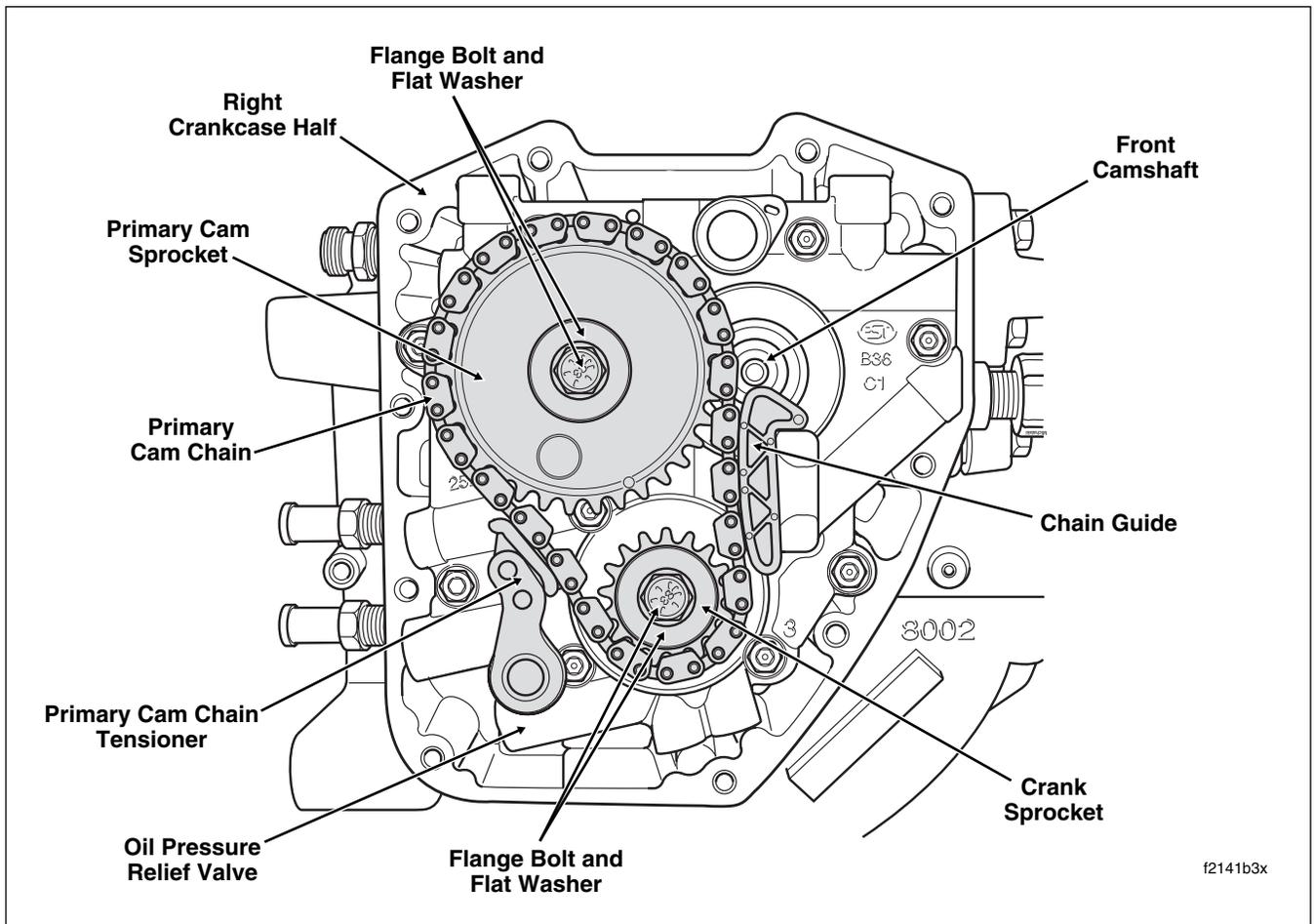
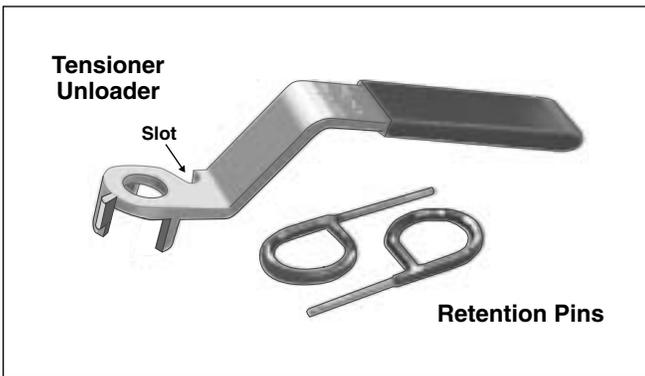
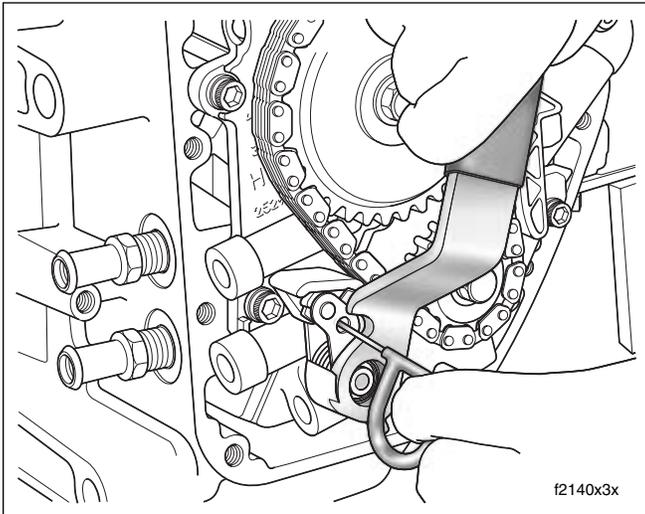


Figure 3-40. Cam Support Plate Assembly



**Figure 3-41. Cam Chain Tensioner Unloader with Retention Pins (Part No. HD-42313)**



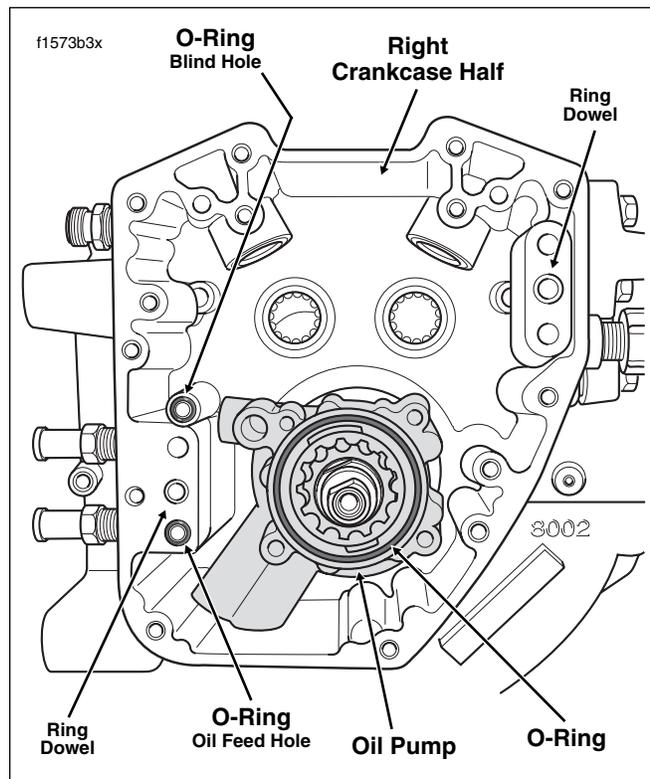
**Figure 3-42. Retract Primary Cam Chain Tensioner**

### ⚠ WARNING

Use extreme caution when operating propane torch. Read the manufacturers instructions carefully before use. Do not direct open flame or heat toward any fuel system component. Extreme heat can cause fuel ignition and explosion. Inadequate safety precautions could result in death or serious injury.

6. Using the CAM CHAIN TENSIONER UNLOADER (HD-42313), retract the primary cam chain tensioner as follows:
  - a. With the handle pointing toward the front of the cam support plate, place cup of tool over spring coil. Correctly positioned, the slot in the tool should be adjacent to the hole in the tensioner. See Figure 3-42.
  - b. Rotate the handle of the tool in a counterclockwise direction until the hole in the tensioner is aligned with the hole in the boss of the cam support plate.
  - c. Insert a retention pin through the hole in the tensioner and into the hole in the cam support plate.

7. Insert small pry bar (seal remover) between inboard side of primary cam sprocket and cam support plate. Working around its circumference, carefully ease primary cam sprocket off splines of rear camshaft until loose.
8. Ease off crank sprocket with a slightly smaller pry bar (seal remover). Remove the primary cam sprocket, primary cam chain and crank sprocket.
9. Remove the primary cam sprocket spacer from the rear camshaft.
10. Squeeze tabs to remove chain guide from between blocks cast into cam support plate.
11. Release the cam support plate from the oil pump flange. Alternately loosen and then remove the four allen head socket screws following the pattern shown in B of Figure 3-50.
12. Release the cam support plate from the crankcase flange. Alternately loosen and then remove the six allen head socket screws following the pattern shown in A of Figure 3-50.
13. Two ring dowels in crankcase flange locate cam support plate (lower rear, upper front). See Figure 3-43. Insert small pry bar (seal remover) between inboard side of cam support plate and crankcase flange in area adjacent to ring dowels. Alternately work each side free and then carefully ease cam support plate from end of crankshaft. See Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, CAM SUPPORT PLATE.



**Figure 3-43. Oil Pump Assembly**

**CAUTION**

Do not pull the retention pin from the primary cam chain tensioner after removal of the cam support plate. With 35-40 pounds of spring pressure behind the tensioner, allowing it to accelerate through its full length of travel will result in spring stretching and/or cracking of the tensioner shoe. Furthermore, if the tensioner should contact fingers or other parts of the hand, minor or moderate injury may occur.

14. Remove O-ring from groove around oil feed hole in crankcase flange (directly below rear ring dowel). Remove O-ring from groove around blind hole in boss (directly above oil return hole in crankcase flange). Discard O-rings. See [Figure 3-43](#).
15. Pull oil pump from crankshaft. Remove O-ring from outboard side of oil pump housing. Remove O-ring from scavenge port stub. Discard O-rings. See [Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, OIL PUMP](#).

**WARNING**

Be sure that stator mount flange (sprocket shaft side) is **NOT** facing up when the case halves are separated or the flywheel assembly will drop to the floor. Dropping the flywheel assembly may result in parts damage and minor or moderate injury.

16. Rotate crankcase in the engine stand so that the cam cover flange is facing upward. Remove the nine crankcase bolts in the left case half. Follow the sequence shown in [Figure 3-46](#).

**CAUTION**

Never move or lift the crankcase by grasping the cylinder studs. The crankcase is too heavy to be carried in this manner and may be dropped. Dropping the crankcase may result in parts damage and minor or moderate injury.

17. Using pry points, loosen case halves. Lift right crankcase half off end of crankshaft.
18. Remove O-rings from two ring dowels in split line face of right case half. Discard the O-rings.
19. See [Section 3.11 SUBASSEMBLY SERVICE AND REPAIR, CRANKCASE](#).

**ASSEMBLY**

1. If removed, install left crankcase half in engine stand so that the split line face is vertical.
2. To prevent damage to the sprocket shaft bearing, slide CRANKSHAFT GUIDE (HD-42326A) over end of sprocket shaft. Install flywheel assembly into left case half. Remove tool.

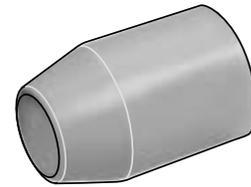


Figure 3-44. Crankshaft Guide (Part No. HD-42326A)

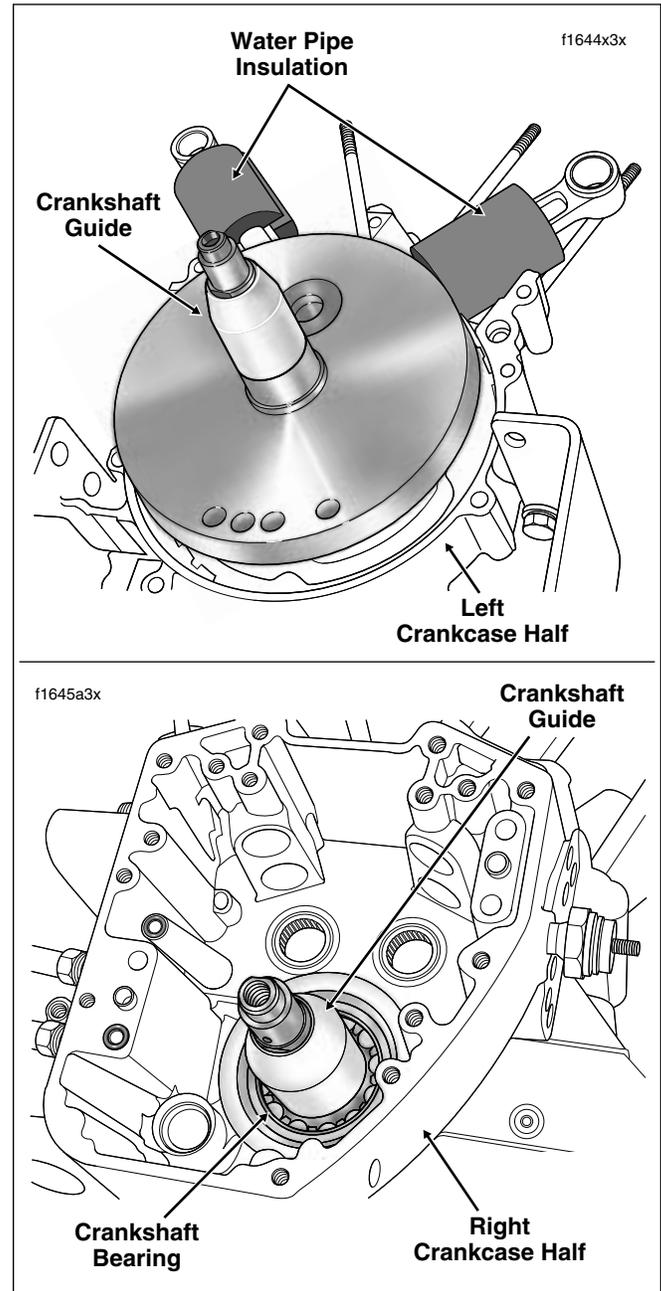


Figure 3-45. Install Crankshaft Guide to Protect Crankshaft Bearing

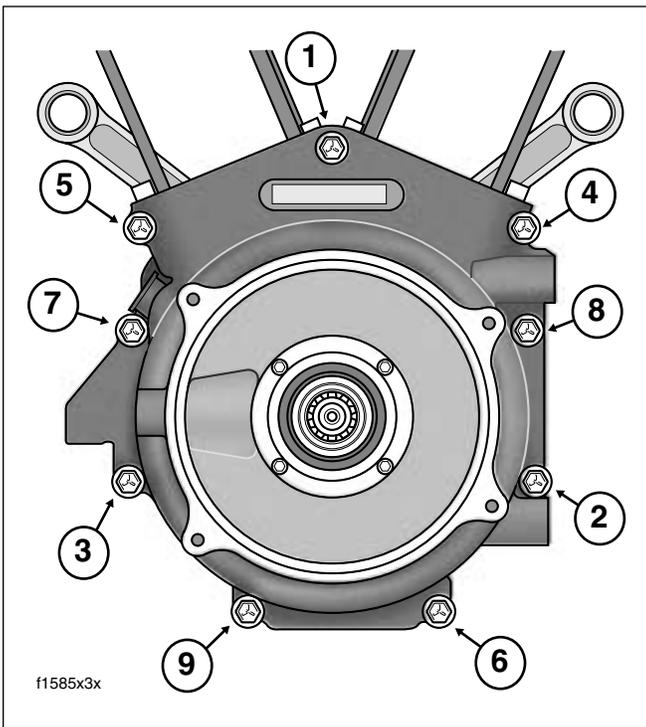


Figure 3-46. Crankcase Torque Sequence (Left Side View)

### CAUTION

O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use **new** O-rings keeping them packaged until use to avoid confusion.

3. Install **new** O-rings over two ring dowels in split line face of right case half.
4. Apply a **small** bead of sealant approximately 0.056 inch (1.4 mm) wide to the split line face. For best results, use High-Performance Sealant (gray), Part No. HD-99650-02.
5. To prevent damage to the crankshaft bearing, place CRANKSHAFT GUIDE (HD-42326A) over end of crankshaft. Mate case halves sliding bearing in right crankcase half over end of crankshaft. Remove tool. See [Figure 3-45](#).
6. Start the nine crankcase bolts and tighten as follows:
  - a. Alternately turn each crankcase bolt until finger tight.
  - b. Tighten the crankcase bolts to 10 ft-lbs (13.6 Nm) in the sequence shown in [Figure 3-46](#).
  - c. Following the same sequence, tighten each bolt to 15-19 ft-lbs (20.3-25.8 Nm).

7. Rotate crankcase in the engine stand so that the stator mount flange (sprocket shaft side) is facing upward. Install service thrust washer on sprocket shaft with the ink stamp facing out (and the chamfer inboard). If using OE part without markings, orient as required to preserve existing wear pattern.
8. To install **new** oil seal into bearing bore, obtain pilot, Nice bearing, large flat washer and handle from SPROCKET SHAFT TIMKEN BEARING CONE INSTALLER (HD-97225-55B) and proceed as follows:
  - a. Verify that seal lip garter spring is in place on both sides of seal.
  - b. Thread pilot onto sprocket shaft until contact is made with shoulder.
  - c. With the lettering facing outside, slide oil seal over pilot until it contacts bearing bore.
  - d. Slide SPROCKET SHAFT OIL SEAL INSTALLER (HD-39361A) over pilot until it contacts oil seal. See [Figure 3-47](#).

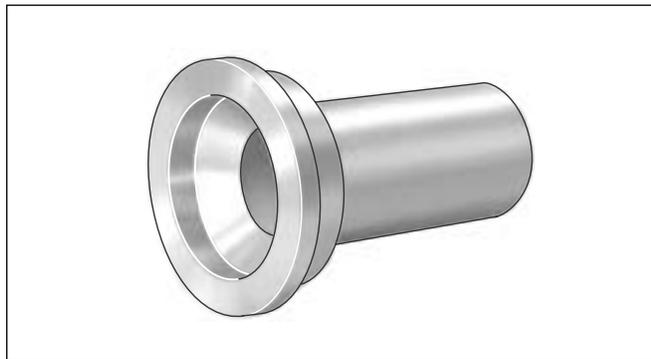


Figure 3-47. Sprocket Shaft Oil Seal Installer (Part No. HD-39361A)

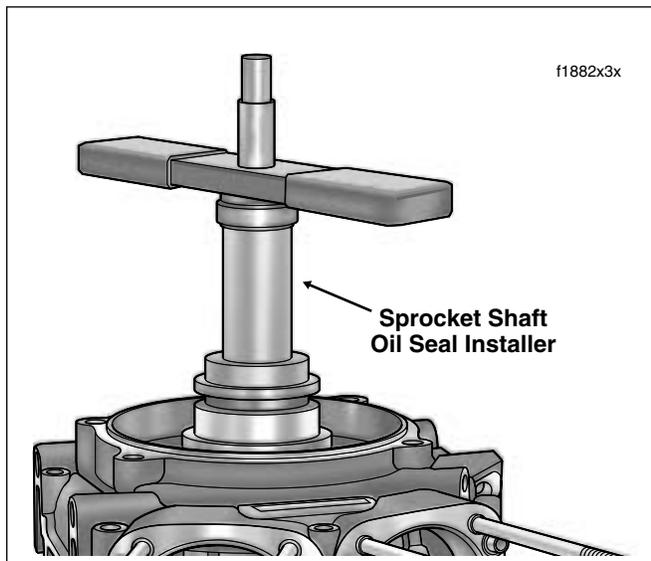


Figure 3-48. Install Oil Seal In Bore

- e. Slide Nice bearing and large flat washer over pilot until contact is made with seal installer.
  - f. Thread handle onto pilot shaft.
  - g. Rotate handle in a clockwise direction until oil seal installer makes firm contact with crankcase stator mount. See [Figure 3-48](#).
  - h. Remove handle, flat washer, Nice bearing, seal installer and pilot from sprocket shaft.
9. Slide sprocket shaft spacer over end of sprocket shaft. Push spacer into oil seal until seated against bearing race.
  10. Rotate crankcase in the engine stand so that the cam cover flange is facing upward.
  11. Install oil pump as follows:

**CAUTION**

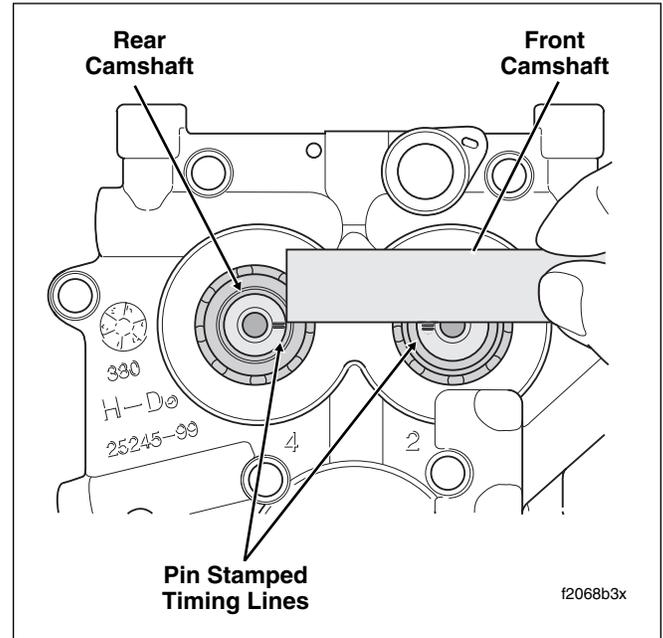
**O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.**

- a. Install **new** O-ring on scavenge port stub of oil pump housing. Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation.
- b. Slide oil pump housing onto crankshaft fitting O-ring on scavenge port stub into crankcase bore at back of cam compartment. Firmly push on scavenge port stub with thumb to be sure that it is snug in bore. Inspect O-ring on stub to verify that it is not pinched or distorted.
- c. Separate the gerotor gears into two sets, one wide (scavenge) and the other narrow (feed).

**NOTE**

*Lubricate parts with clean H-D 20W50 engine oil during assembly.*

- d. Fit the smaller of the **wide** gerotor gears into the larger. Slide the wide gerotor set down the crankshaft until it bottoms in the oil pump housing.
- e. Slide the first of two separator plates down the crankshaft until it contacts the wide gerotor set. Install wave washer and second separator plate.
- f. Fit the smaller of the **narrow** gerotor gears into the larger. Slide the narrow gerotor set down the crankshaft until it contacts the separator plate.

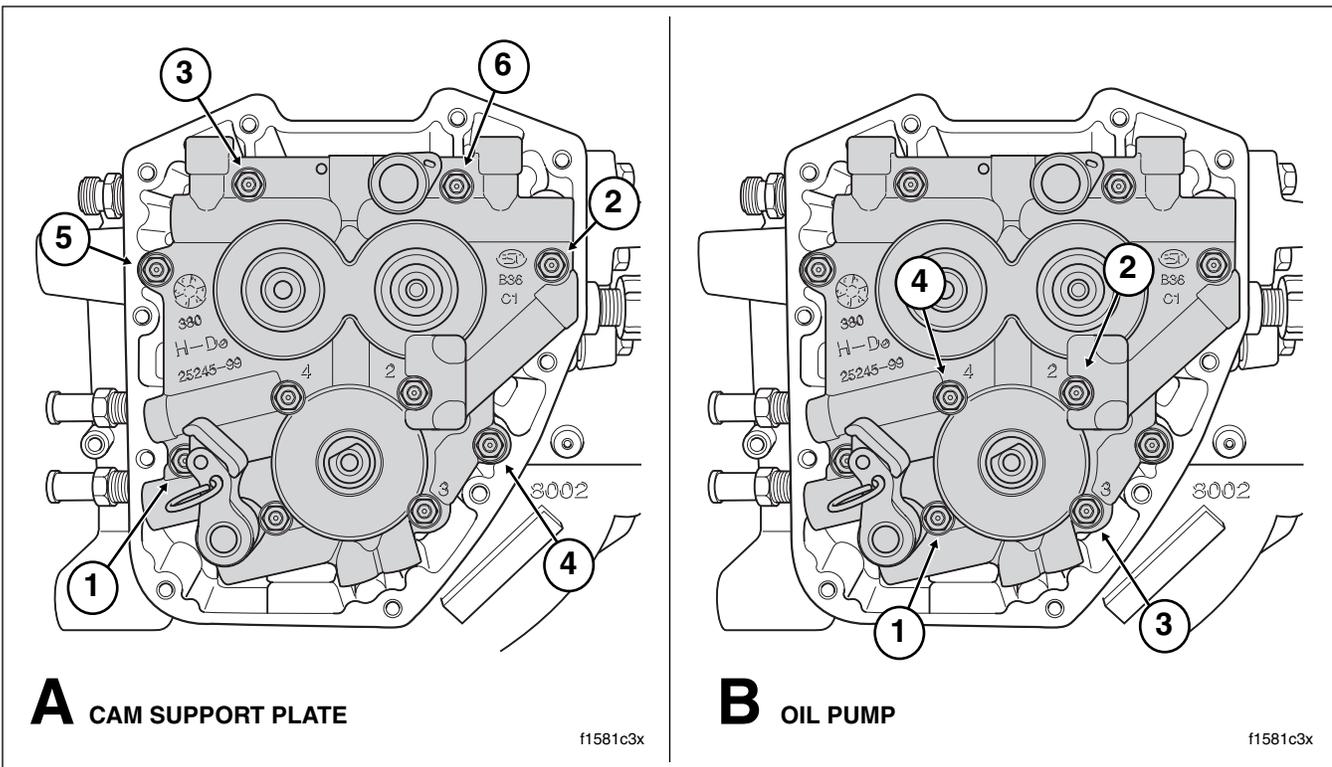


**Figure 3-49. Verify Alignment of Timing Lines on Front and Rear Camshafts**

**CAUTION**

**O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.**

- g. Install **new** O-ring in groove on outboard side of oil pump housing. See [Figure 3-43](#). Apply a very thin film of clean H-D 20W50 engine oil to O-ring before installation.
12. Install **new** O-ring in groove around oil feed hole in crankcase flange (directly below rear ring dowel). Install **new** O-ring around blind hole in boss (directly above oil return hole in crankcase flange). Apply a thin film of H-D 20W50 engine oil to O-rings before installation.
13. If not retracted, place cup of CAM CHAIN TENSIONER UNLOADER (HD-42313) over spring coil of secondary cam chain tensioner positioning finger on tool between tensioner and shoe. Rotate tool in a counterclockwise direction inserting retention pin through hole in boss on **primary cam chain side** of cam support plate. Pin engages hooks on tensioner to hold it in the retracted position. For best results, place cam support plate in a vise using brass jaw inserts to prevent casting damage.
14. Lubricate cam needle bearings with clean H-D 20W50 engine oil.



**Figure 3-50. Cam Support Plate/Oil Pump Torque Sequence**

15. Using a straightedge, verify that the pin stamped timing lines on the ends of the front and rear camshafts are in alignment (although they may be somewhat difficult to see). See [Figure 3-49](#). If necessary, rotate camshafts in order to make this observation.
16. Aligning bushing in cam support plate with end of crankshaft, slide cam support plate over crankshaft onto two ring dowels in crankcase flange. Use a rubber mallet to fully seat cam support plate on ring dowels.
17. Install the six allen head socket screws (1/4 x 1 inch) to secure the cam support plate to the crankcase flange. Tighten screws to 90-120 **in-lbs** (10.2-13.6 Nm) in the pattern shown in A of [Figure 3-50](#).
18. Secure the cam support plate to the oil pump flange as follows:
  - a. Start two allen head socket screws (1/4 x 1 inch) into holes 3 and 4. See B of [Figure 3-50](#).
  - b. Obtain two ALIGNMENT TOOLS used to install lifter guides on Evolution engines (HD-33443). Loosely install alignment tools in holes 1 and 2.
  - c. While rotating the engine, alternately snug and then tighten the alignment tools to 40-45 **in-lbs** (4.5-5.1 Nm).
  - d. Alternately snug and then tighten the screws in holes 3 and 4 to 40-45 **in-lbs** (4.5-5.1 Nm).
  - e. Remove the alignment tool from hole 1. Install the allen head socket screw and tighten to 40-45 **in-lbs** (4.5-5.1 Nm).
  - f. Repeat step 18(e) to replace alignment tool in hole 2 with allen head socket screw.
  - g. Final tighten all four screws to 90-120 **in-lbs** (10.2-13.6 Nm). Use the pattern shown in B of [Figure 3-50](#). Numbers cast adjacent to the bolt holes also indicate the oil pump torque sequence.

**NOTE**

*If only realigning the oil pump, first loosen all screws following the pattern shown in B of [Figure 3-50](#). Remove screws from holes 1 and 2 and then follow the alignment procedure starting at step 18(b).*

19. Pull retention pin from hole in cam support plate to release secondary cam chain tensioner.
20. Squeeze tabs and install chain guide between blocks cast into cam support plate.
21. Install primary cam sprocket spacer onto rear camshaft.
22. If using the original cam support plate, camshafts, primary cam sprocket, crank sprocket and flywheel assembly, then move to step 23. However, if any of these parts have been replaced, then proceed as follows:

**NOTE**

*For methods of engine rotation, see Section 3.9 TOP END OVERHAUL, DISASSEMBLY, step 6.*

- a. Install primary cam sprocket onto splines of rear camshaft. Install long flange bolt with thicker flat washer to secure sprocket to end of camshaft.
- b. Install crank sprocket onto crankshaft. Install short flange bolt with smaller diameter flat washer (that is, washer from bulk inventory) to secure sprocket to end of crankshaft.

## NOTE

Use of smaller diameter flat washer with crank sprocket flange bolt allows room on sprocket face for placement of straightedge under step 22(e).

- c. To prevent rotation, position the CRANKSHAFT/CAMSHAFT SPROCKET LOCKING TOOL (HD-42314) between the crank and primary cam sprockets. See Figure 3-52. The handle of the tool is stamped “Crank” and “Cam” to ensure proper orientation. Tighten the crank and primary cam sprocket flange bolts to 15 ft-lbs (20.3 Nm). Remove the sprocket locking tool.
- d. Push on rear camshaft to remove end play.

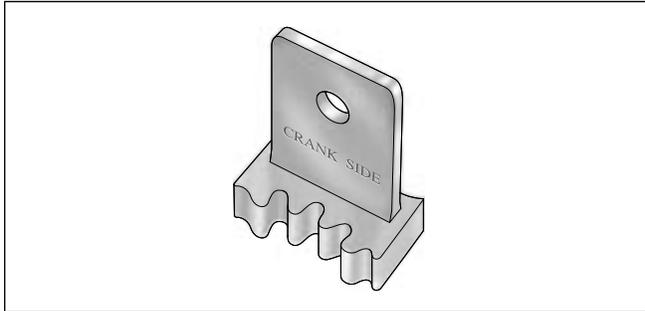


Figure 3-51. Crankshaft/Camshaft Sprocket Locking Tool (Part No. HD-42314)

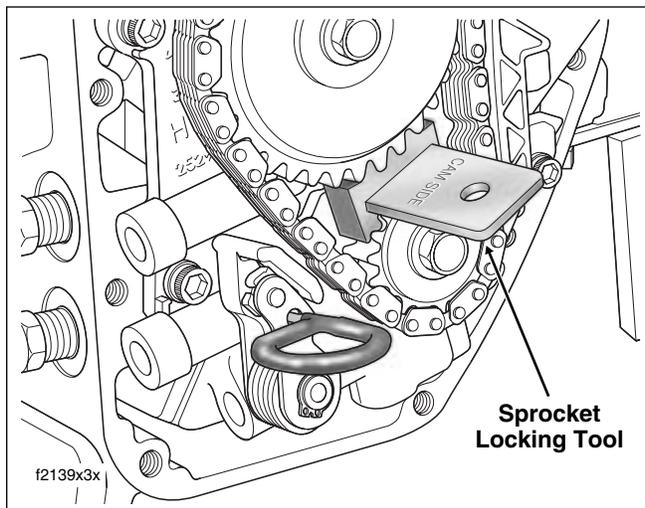


Figure 3-52. Lock Crank and Primary Cam Sprockets Before Tightening Flange Bolts

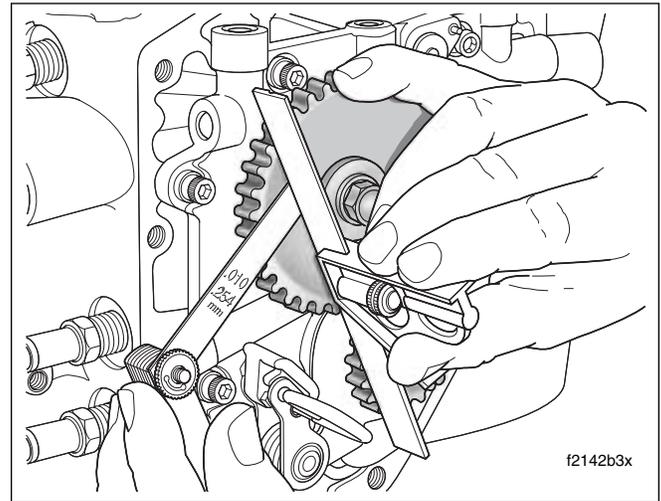


Figure 3-53. Check Alignment of Crank and Primary Cam Sprocket Faces

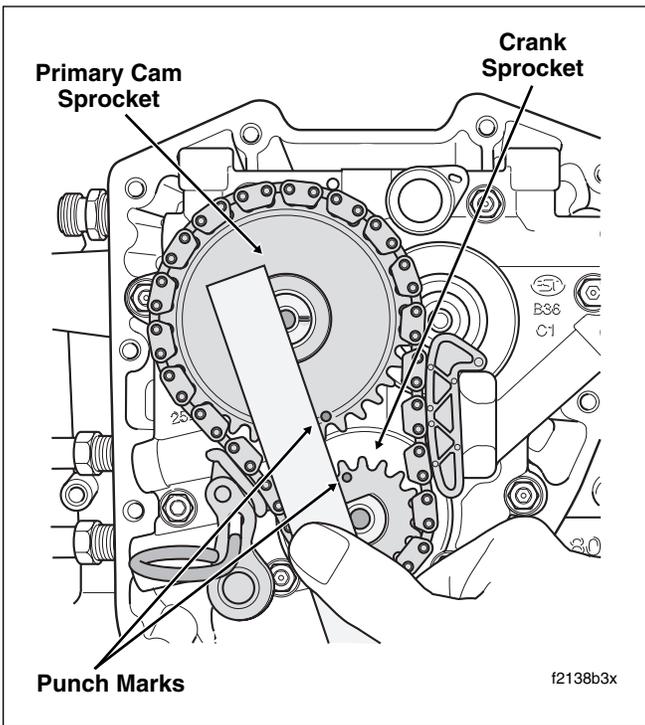
- e. Place a straightedge across the crank and primary cam sprocket faces. Try to insert a 0.010 inch feeler gauge between the straightedge and each sprocket face. See Figure 3-53. If the feeler gauge does not fit at either location, then proceed to step 22(f).

On the other hand, if the crank sprocket is “proud” (that is, rises above the face of the primary cam sprocket) more than 0.010 inch, remove the flange bolt and primary cam sprocket, and noting the part number stamped on the existing spacer, replace it with the next larger size. See spacer sizes listed in Table 3-4. Replace the spacer with the next smaller size only if the primary cam sprocket is “proud” (rises above the face of the crank sprocket) more than 0.010 inch. Return to step 21 to repeat the check with the new spacer installed.

Table 3-4. Primary Cam Sprocket Spacers

Spacer Size	H-D Part Number
0.287	25722-00
0.297	25723-00
0.307	25721-00
0.317	25719-00
0.327	25717-00
0.337	25725-00

- f. Remove both crank and primary cam sprockets. Discard smaller diameter flat washer obtained from bulk inventory.
23. Install the primary cam chain and sprocket assembly as follows:



**Figure 3-54. Verify Alignment of Crank and Primary Cam Sprocket Punch Marks**

- a. Place the primary cam sprocket in the cam chain. Hold the sprocket allowing the chain to hang loose. Rotate the sprocket so that the punch mark on the sprocket root faces straight downward.

**NOTE**

To maintain the original direction of rotation, verify that the colored mark placed on the chain link and crank sprocket is facing away from the cam support plate during installation.

- b. Place the crank sprocket in the opposite end of the chain with the punch mark on the sprocket tooth facing straight upward.
  - c. Maintaining the position of the sprockets on the chain with the punch marks in alignment, start the primary cam sprocket onto the splines of the rear camshaft. Apply a thin film of clean H-D 20W50 engine oil to the splines before installation.
  - d. Maintaining the position of the crank sprocket on the chain, rotate the primary cam sprocket in a clockwise direction until the flat on the crank sprocket is aligned with the flat on the crankshaft. Install the crank sprocket.
24. Rotate the primary cam sprocket in a clockwise direction until the punch mark on the root is aligned with the punch mark on the crank sprocket tooth. Lay a straight-edge across the centerline of the crank and primary cam sprocket flange bolt holes to verify that the punch marks are in alignment. See [Figure 3-54](#).

**NOTE**

If the punch marks are not in alignment, then the sprockets must be removed and reinstalled. The vehicle will not run properly if the sprockets are misaligned by even one tooth.

**NOTE**

Both crank and primary cam sprocket flange bolts are specially hardened, while the flat washers are of a special diameter and thickness. Therefore, use only genuine Harley-Davidson parts when replacement is necessary. The crank and primary cam sprocket flange bolts and flat washers are **NOT** interchangeable.

25. Install crank sprocket and primary cam sprocket flange bolts and flat washers as follows:

**NOTE**

Exercise caution to avoid mixing oil on washer with thread-locker on bolt or sealing integrity may be compromised.

- a. Apply a thin film of clean H-D 20W50 engine oil to both sides of flat washers.
- b. Install thinner flat washer on short flange bolt.
- c. Install thicker flat washer on long flange bolt.
- d. Apply Loctite Primer 7649 (P/N 98968-99) to threads of flange bolts.
- e. Apply one drop of Loctite High Strength Thread-locker 262 (red) to threads of flange bolts.
- f. Install short flange bolt with thinner flat washer to secure crank sprocket to end of crankshaft.
- g. Install long flange bolt with thicker flat washer to secure primary cam sprocket to end of camshaft.
- h. Position CRANKSHAFT/CAMSHAFT SPROCKET LOCKING TOOL (HD-42314) between the crank and primary cam sprockets to prevent rotation. See [Figure 3-52](#). The handle of the tool is stamped "Crank" and "Cam" to ensure proper orientation.
- i. Alternately tighten the crank and primary cam sprocket flange bolts to 15 ft-lbs (20.3 Nm).
- j. Loosen each flange bolt one full turn.
- k. Tighten the crank sprocket flange bolt to 24 ft-lbs (32.5 Nm).
- l. Tighten the primary cam sprocket flange bolt to 34 ft-lbs (46.1 Nm).
- m. Remove the sprocket locking tool.

**CAUTION**

Ease the primary cam chain tensioner into the unloaded position using the proper tool. Do not pull the retention pin to unload the tensioner or the pin may be damaged. Furthermore, if the tensioner should contact fingers or other parts of the hand, minor or moderate injury may occur.

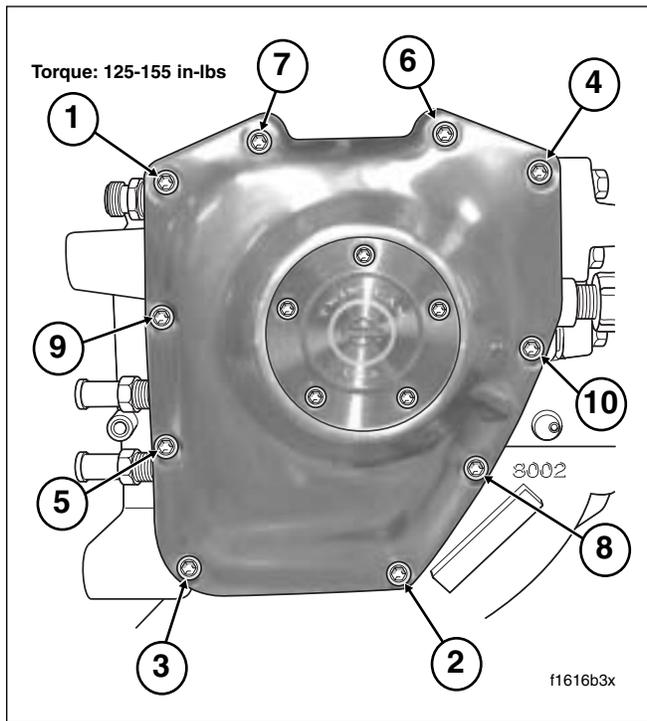


Figure 3-55. Cam Cover Torque Sequence

26. Hold the retracted primary cam chain tensioner with the CAM CHAIN TENSIONER UNLOADER (HD-42313), pull retention pin from hole in cam support plate and ease the assembly into the unloaded position.
27. Apply clean H-D 20W50 engine oil to crank and primary cam sprockets.

#### CAUTION

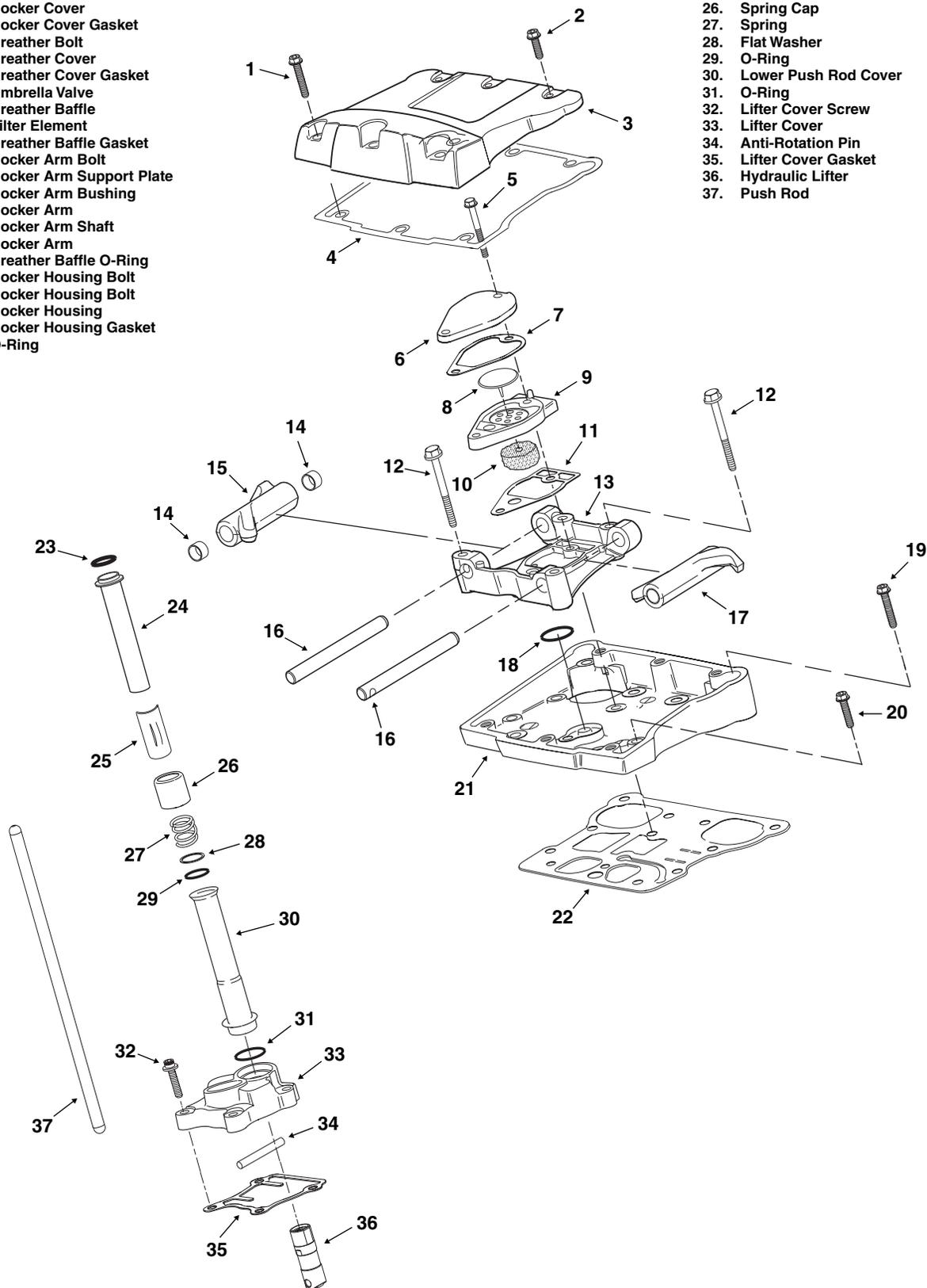
Before cam cover installation, verify cleanliness of blind holes in the crankcase flange. Tightening screws with dirt, water or oil in the holes can cause the casting to crack or break. Damage to the casting requires replacement of the right crankcase half.

28. Align holes in **new** cam cover gasket with those in the crankcase flange.
29. Install the cam cover using ten allen head socket screws (1/4 x 1-1/4 inches). Alternately tighten screws to 125-155 **in-lbs** (14.1-17.5 Nm) following the pattern shown in [Figure 3-55](#).
30. If performing a complete engine overhaul, see Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 1-39. If only cam compartment components were serviced, just see steps 29-39.

## Legend:

1. Bolt
2. Bolt
3. Rocker Cover
4. Rocker Cover Gasket
5. Breather Bolt
6. Breather Cover
7. Breather Cover Gasket
8. Umbrella Valve
9. Breather Baffle
10. Filter Element
11. Breather Baffle Gasket
12. Rocker Arm Bolt
13. Rocker Arm Support Plate
14. Rocker Arm Bushing
15. Rocker Arm
16. Rocker Arm Shaft
17. Rocker Arm
18. Breather Baffle O-Ring
19. Rocker Housing Bolt
20. Rocker Housing Bolt
21. Rocker Housing
22. Rocker Housing Gasket
23. O-Ring

24. Upper Push Rod Cover
25. Spring Cap Retainer
26. Spring Cap
27. Spring
28. Flat Washer
29. O-Ring
30. Lower Push Rod Cover
31. O-Ring
32. Lifter Cover Screw
33. Lifter Cover
34. Anti-Rotation Pin
35. Lifter Cover Gasket
36. Hydraulic Lifter
37. Push Rod



f2239x3x

Figure 3-56. Rocker Arm/Breather/Lifter Assemblies (Exploded View)

## TOP END

### BREATHER ASSEMBLY

#### Removal

1. See Section [3.9 TOP END OVERHAUL, DISASSEMBLY](#), steps 1-7.

#### Disassembly

1. Remove two bolts and lift breather assembly from rocker arm support plate. See [Figure 3-57](#).
2. Remove the breather cover and gasket. Remove the breather baffle and gasket. Discard gaskets.
3. Pull filter element from bore on inboard side of breather baffle. Pull stem of umbrella valve from hole at top of breather baffle. Discard both filter element and umbrella valve.

#### Cleaning and Inspection

1. Clean all parts in a non-volatile cleaning solution or solvent.
2. Thoroughly dry all parts with low pressure compressed air.
3. Set a straightedge diagonally across the length of the breather cover intersecting the opposite corners of the gasket surface. Slide a feeler gauge beneath the straightedge to check the breather cover for warpage. Repeat the step checking the opposite diagonal. Discard the breather cover if any low spot exceeds 0.005 inch (0.13 mm).
4. Repeat step 3 to inspect the gasket surface of the breather baffle for flatness. Discard the breather baffle if any low spot exceeds 0.005 inch (0.13 mm).

#### Assembly

1. Insert stem of **new** umbrella valve through center hole at top of breather baffle. Carefully pull rubber bead on stem through hole in baffle. Use denatured alcohol or glass cleaner to lubricate stem, if necessary. Verify that rubber bead is pulled completely through hole and resides on bottom side of baffle.
2. Press **new** filter element into bore at bottom of baffle. Hole in filter element accommodates umbrella valve stem.

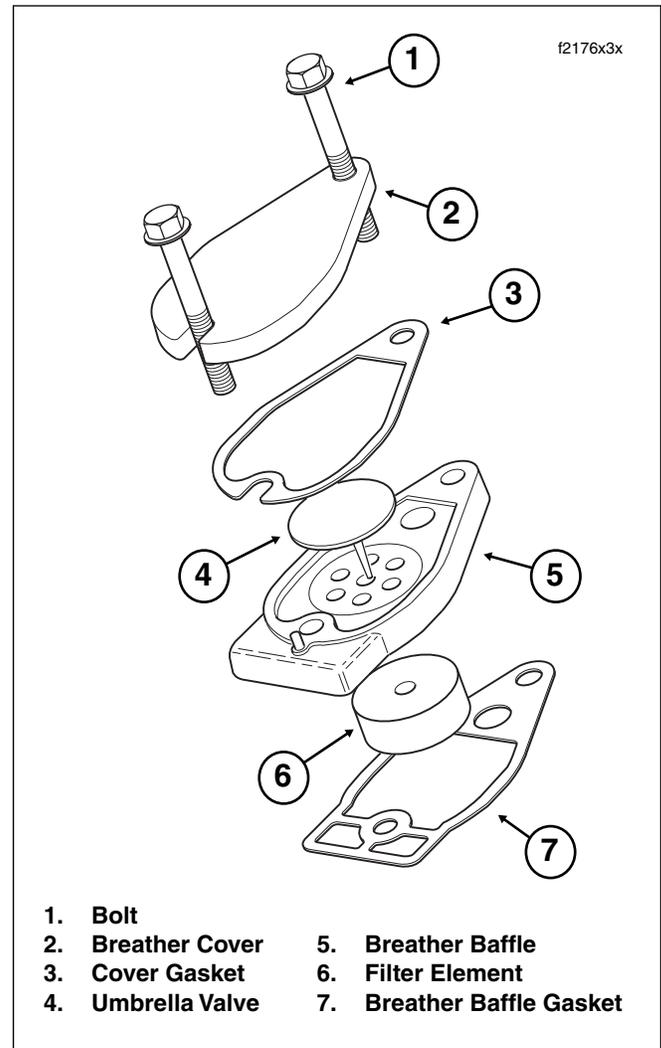


Figure 3-57. Breather Assembly

3. Place breather baffle gasket on a clean flat surface. Aligning holes, place breather baffle, cover gasket and breather cover on top. Slide two screws through stackup to keep assembly together until time of installation.

#### Installation

1. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 33-39.

## ROCKER ARM ASSEMBLY

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-9.

### Disassembly

1. Remove the four bolts from the rocker arm support plate. If necessary, slightly wiggle the two bolts on the push rod side (right) to disengage them from the notches in the rocker arm shafts.
2. Using a hammer and brass drift, tap left side of rocker arm shafts so that the notched ends exit the rocker arm support plate first. Mark the shafts so that they are installed in their original locations at time of assembly.

3. Remove the rocker arms from the rocker arm support plate. Mark the rocker arms to indicate location.

### Cleaning and Inspection

1. Clean all parts in a non-volatile cleaning solution or solvent. Thoroughly dry with low pressure compressed air.
2. Check rocker arms for uneven wear or pitting where contact is made with the valve stem tips. Check for concave wear where rocker arms contact the push rod ends. Replace rocker arm if excessive wear is found at either location.
3. Verify that oil holes in rocker arms and rocker arm support plate are clean and open.
4. Inspect rocker arm shafts for scratches, burrs, scoring or excessive wear. Replace as necessary.

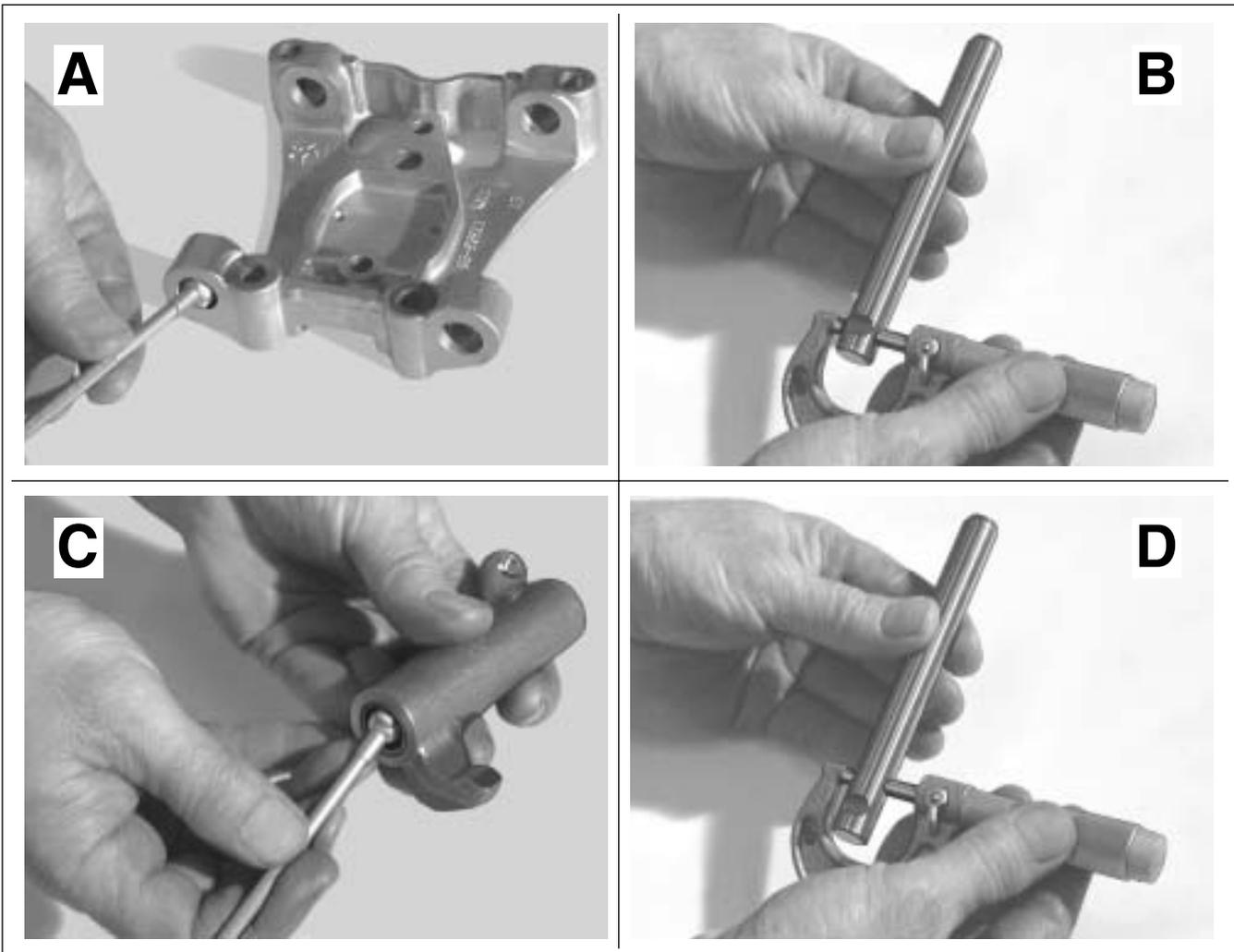


Figure 3-58. Measure Rocker Arm Assembly for Wear

5. Measure the inside diameter of the rocker arm support plate bore. See A of [Figure 3-58](#). Measure the outside diameter of the rocker arm shaft where it fits in the bore. See B of [Figure 3-58](#). Repeat the measurement on opposite side of support plate and shaft. Replace the shaft or support plate if any measurement equals or exceeds 0.0035 inch (0.089 mm).
6. Measure the inside diameter of the rocker arm bushing. See C of [Figure 3-58](#). Measure the outside diameter of the rocker arm shaft where it rides in the bushing. See D of [Figure 3-58](#). Repeat the measurement on opposite side of rocker arm and shaft. Replace the shaft or bushings if any measurement equals or exceeds 0.0035 inch (0.089 mm).
7. To replace rocker arm bushings, proceed as follows:

**NOTE**

*Remove, install and ream one bushing at a time.*

- a. Obtain a 9/16"-18 (14.29 mm) tap. Turn tap into bushing until tight. Place rocker arm under ram of arbor press with tap at bottom. Slide a discarded rocker arm shaft through open end of rocker arm until contact is made with tap. Using shaft as driver (and untapped bushing as pilot), press against shaft until both tap and bushing are free. See upper frame of [Figure 3-59](#).
- b. Using a suitable driver, press **new** bushing into side of rocker arm until flush with casting. See center frame of [Figure 3-59](#). Be sure to orient bushing so that split line faces top of rocker arm.

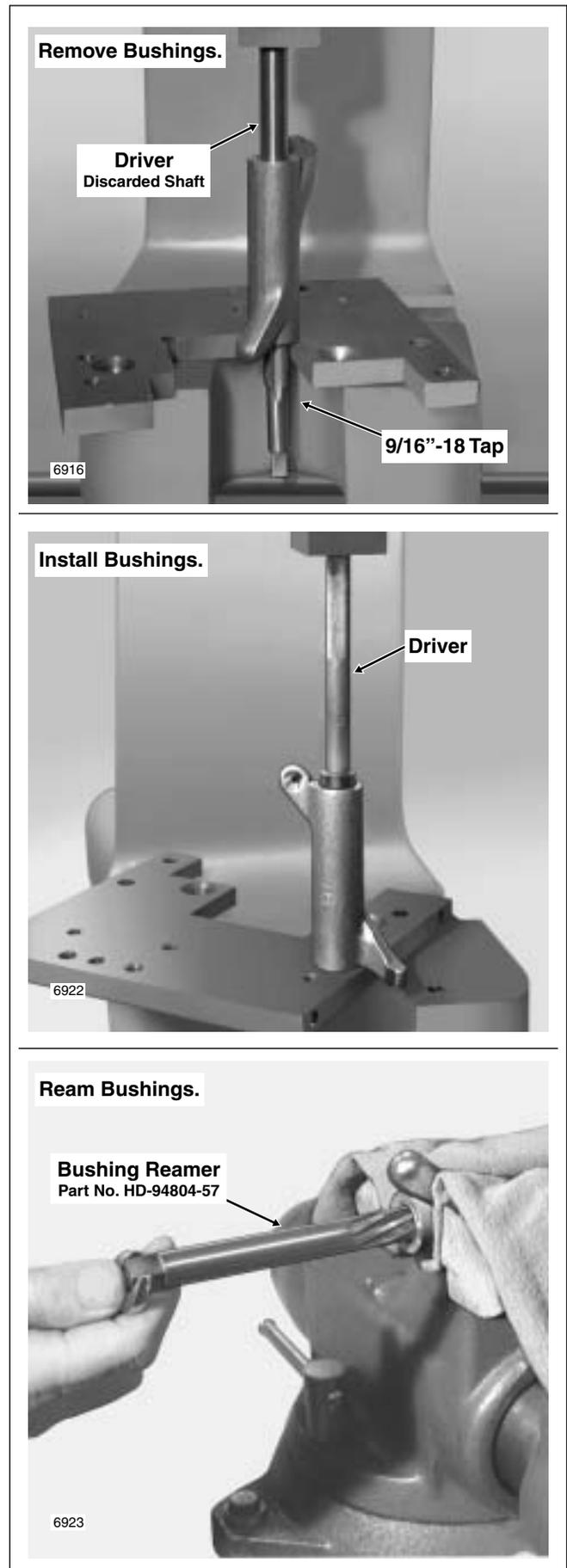
**CAUTION**

**Never back reamer out of rocker arm or new bushing will be damaged.**

- c. Lock rocker arm in a vise using brass jaw inserts or shop towels to prevent casting damage. Insert tapered end of **ROCKER ARM BUSHING REAMER (HD-94804-57)** into old bushing in rocker arm. Note that old bushing on drive side of reamer serves as pilot. See lower frame of [Figure 3-59](#). Rotate reamer until new bushing on far side is reamed, and then continuing in the same direction, draw drive side of reamer from new bushing.
- d. Repeat steps 7(a) thru 7(c) to remove, install and ream second bushing.

**Assembly**

1. Place the rocker arms into position on the rocker arm support plate.
2. Push the un-notched ends of the rocker arm shafts into the right side of the support plate and then into the rocker arms. As they approach their fully installed positions, rotate the shafts so that the notches are aligned with the bolt holes in the support plate.



**Figure 3-59. Replace Rocker Arm Bushings**

3. To check for proper end play, insert a feeler gauge between the rocker arm and support plate. See [Figure 3-60](#). Repeat measurement on other rocker arm. Replace the rocker arm, rocker arm support plate, or both if end play exceeds 0.025 inch (0.635 mm).
4. Install the four bolts in the rocker arm support plate. For proper assembly, remember that the two bolts on the push rod side (right) must engage the notches in the rocker arm shafts.

## Installation

1. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 31-39.



**Figure 3-60. Check End Play**

## PUSH RODS/LIFTERS/COVERS

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-14.

### Disassembly

1. With the exception of the lifter covers, all parts should have been disassembled and marked during the removal procedure. Disassemble the lifter covers as follows:
  - a. Separate upper and lower push rod covers.
  - b. Remove O-ring from seat at bottom of lower push rod cover. Discard O-ring.
  - c. Remove O-ring from seat at top of upper push rod cover. Slide O-ring, flat washer, spring and spring cap from body of upper push rod cover. Discard O-rings.

### Cleaning and Inspection

1. Scrape old gasket material from the lifter cover flange. Old gasket material left on mating surfaces will cause leaks.
2. With the exception of the hydraulic lifters, clean all parts in a non-volatile cleaning solution or solvent. Verify that the O-ring seats and contact surfaces of the push rod covers are completely clean.
3. Thoroughly dry all parts with low pressure compressed air. Verify that all oil holes are clean and open.
4. Verify that the hydraulic lifter rollers turn freely and are free of flat spots, scuff marks and pitting. If flat spots exist, examine the cam lobe on which the lifter operates.
5. Inspect the lifter socket for signs of wear. Verify that the plunger of the hydraulic lifter is fully extended up against the C-clip. Use index finger to pump plunger to verify lifter operation.
6. Examine the push rods. Replace any push rods that are bent, dented, broken or discolored. Replace the rod if the ball ends show signs of excessive wear or damage.
7. Cover all parts with a clean plastic sheet to protect them from dust and dirt.

### Assembly

1. With the exception of the lifter covers, all parts will be assembled during the installation procedure. Assemble the lifter covers as follows:

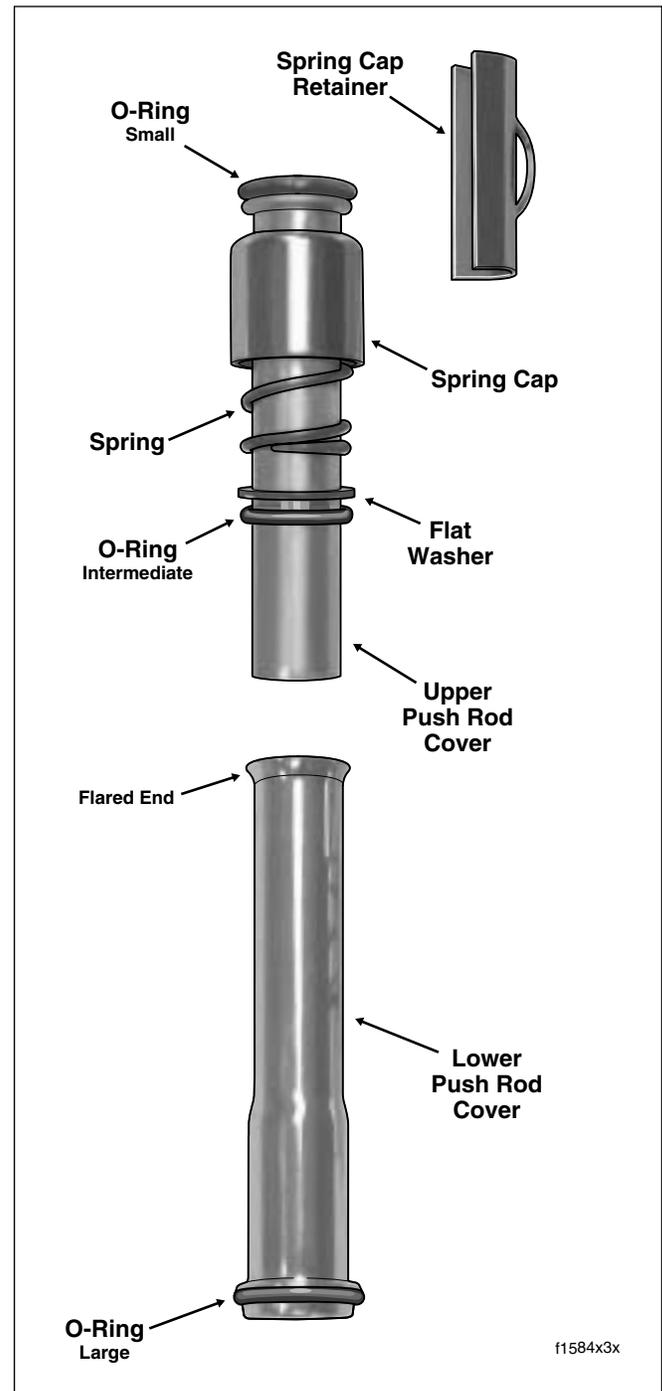


Figure 3-61. Push Rod Cover Assembly

#### CAUTION

O-rings that are missing, distorted, pinched or otherwise damaged will result in either oil leakage or low oil pressure. Use of the wrong O-ring will have the same results. Since many O-rings are similar in size and appearance, always use new O-rings keeping them packaged until use to avoid confusion.

- a. Obtain three **new** o-rings- small, intermediate and large.
- b. Install small O-ring on seat at the top of the upper push rod cover.
- d. Fit the straight end of the upper push rod cover into the flared end of the lower push rod cover.
- e. Install large O-ring on seat at bottom of lower push rod cover.

*NOTE*

*Apply a very thin film of clean H-D 20W50 engine oil to O-rings before installation.*

- c. Slide the spring cap, spring, flat washer and intermediate size O-ring onto the body of the upper push rod cover. Move parts up body until spring cap contacts upper O-ring seat.

**Installation**

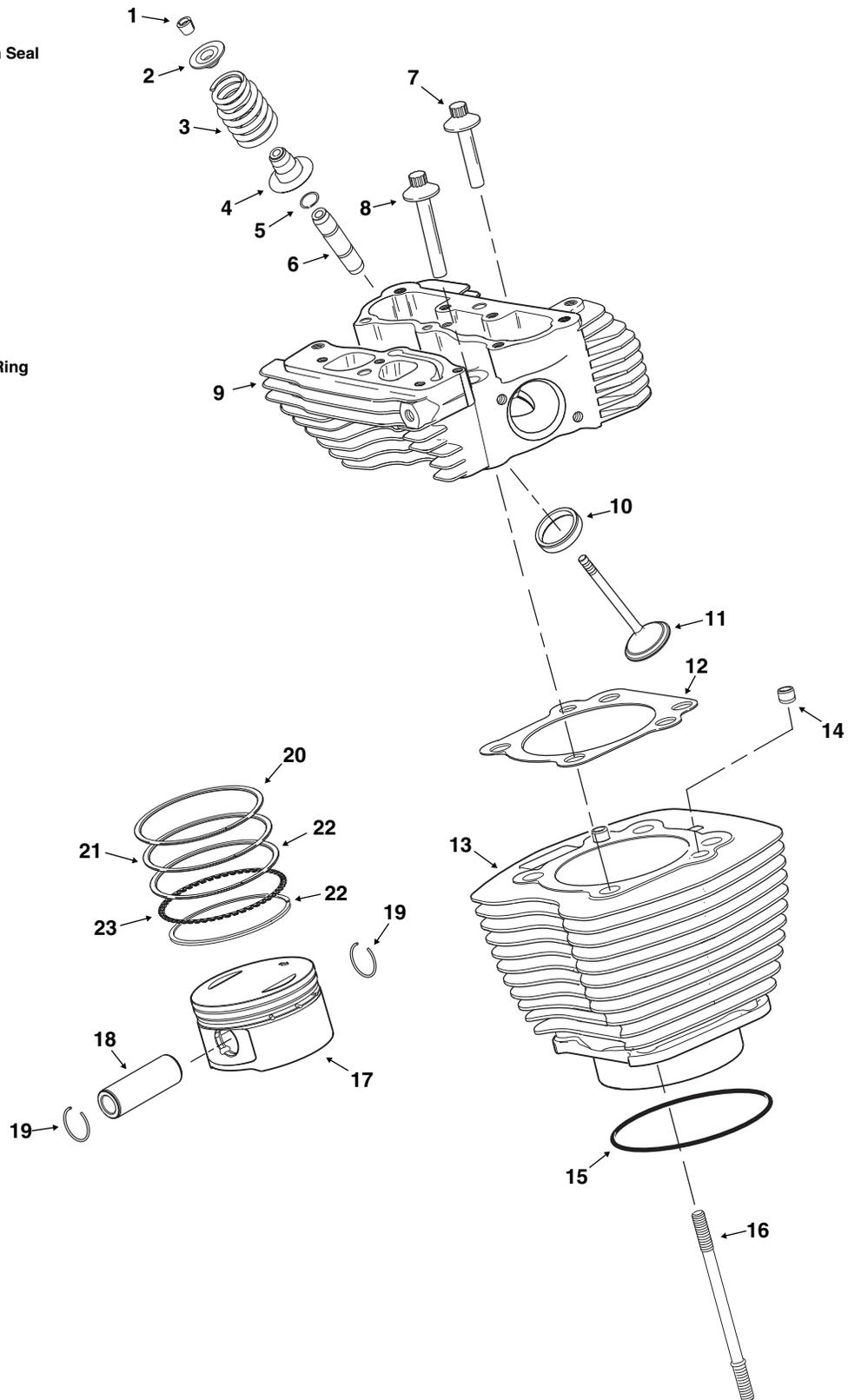
1. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 25-39.

# NOTES

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## Legend:

1. Tapered Keepers
2. Spring Retainer
3. Valve Spring
4. Spring Seat/Valve Stem Seal
5. Lock Ring
6. Valve Guide
7. Cylinder Head Bolt
8. Cylinder Head Bolt
9. Cylinder Head
10. Valve Seat
11. Valve
12. Cylinder Head Gasket
13. Cylinder
14. Ring Dowel
15. O-Ring Seal
16. Cylinder Stud
17. Piston
18. Piston Pin
19. Circlip
20. Top Compression Ring
21. Second Compression Ring
22. Oil Rail
23. Oil Rail Spacer



f2412x3x

Figure 3-62. Cylinder Head/Cylinder/Piston Assemblies (Exploded View)

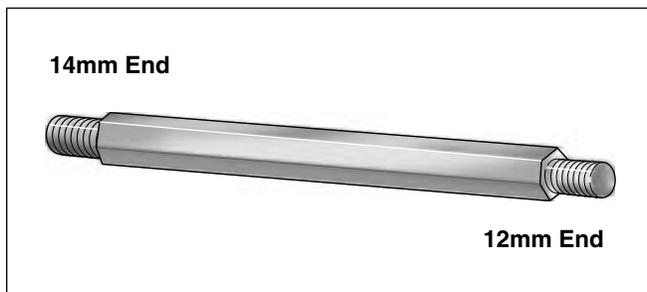
## CYLINDER HEAD

### Removal

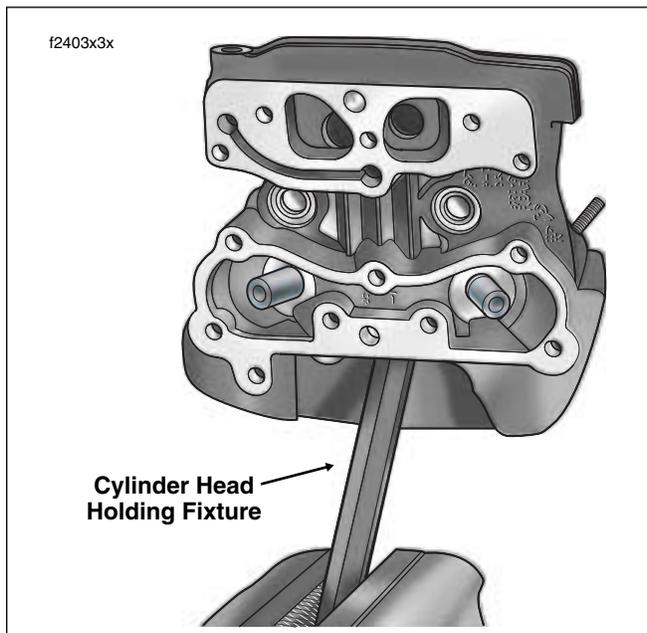
1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-11 and 15-19.

### Disassembly

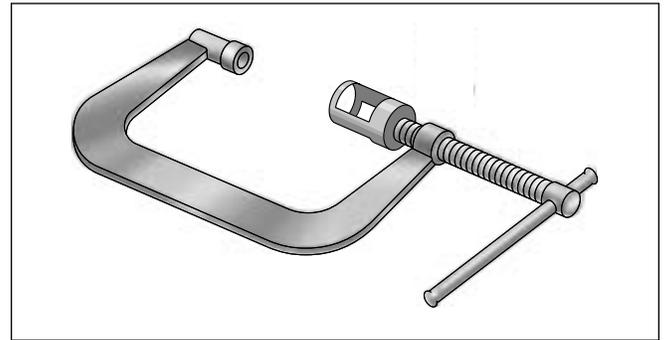
1. Before proceeding with the disassembly procedure, determine if cylinder head reconditioning is necessary. Proceed as follows:
  - a. Raise valve ports of cylinder head to strong light source. If light is visible around edges of seats, then move to step 2 to recondition cylinder head.
  - b. Fill ports at top of cylinder head with solvent. Wait ten full seconds and then check for leakage into combustion chamber. If solvent leakage into combustion chamber is evident, then move to step 2 to recondition cylinder head.



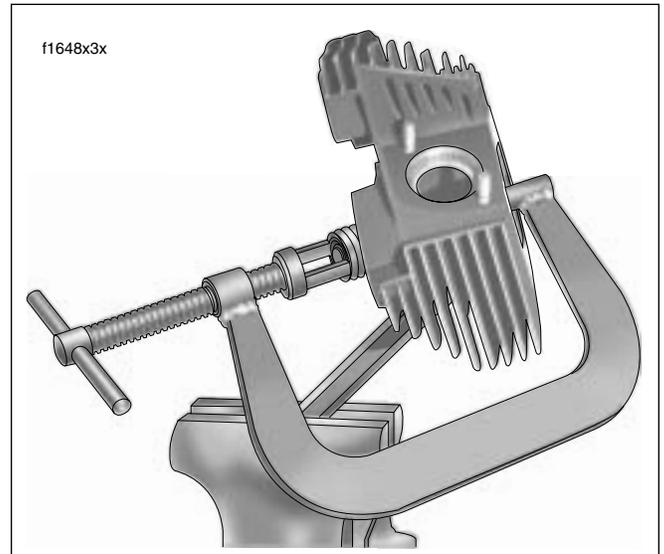
**Figure 3-63. Cylinder Head Holding Fixture (Part No. HD-39786)**



**Figure 3-64. Install Cylinder Head Holding Fixture in Vise**



**Figure 3-65. Valve Spring Compressor (Part No. HD-34736B)**



**Figure 3-66. Compress Valve Springs**

2. Obtain the CYLINDER HEAD HOLDING FIXTURE (HD-39786) and proceed as follows:
  - a. Note that both ends of the fixture are threaded, one end at 14mm and the other at 12mm. Thread the 12mm end of the tool into the spark plug hole of the cylinder head.
  - b. Clamp tool in vise at a 45 degree angle (or one that offers a comfortable working position). See [Figure 3-64](#).
3. Obtain the VALVE SPRING COMPRESSOR (HD-34736B) and proceed as follows:
  - a. Place tool over cylinder head so that the blunt end is centered on the valve head and adapter at end of forcing screw is seated on the valve spring retainer. See [Figure 3-66](#).
  - b. Rotate forcing screw to compress valve spring.
  - c. If spring retainer has not broken free of tapered keepers, give head of tool a sharp tap with a soft mallet. Using magnetic rod or small screwdriver, remove the keepers from the valve stem groove.

- d. Rotate forcing screw to release the valve spring compression.
4. Remove the spring retainer and valve spring.
5. Slide the valve from the valve guide.
6. Twist and remove the valve stem seal/spring seat from the top of the valve guide. Discard the valve stem seal/spring seat.
7. Mark the bottom of the valve “F(ront)” or “R(ear)” to indicate the cylinder head from which it was removed. Also, separate and tag the tapered keepers, valve spring and spring retainer so that they are installed on the same valve at time of assembly.
8. Repeat steps 3-7 to remove the other valve components.
9. Release the cylinder head holding fixture from the vise and then remove the tool from the spark plug hole.

## Cleaning and Inspection

### Cleaning

1. Remove old gasket material from cylinder head. Gasket material left on sealing surfaces will cause leaks.
2. Remove all carbon deposits from combustion chamber and machined surfaces of cylinder head. Exercise caution to avoid removing any metal material. For best results, use an air tool with a **worn** wire brush. Scraping may result in scratches or nicks.
3. To soften stubborn deposits, soak the cylinder head in a chemical solution, such as GUNK HYDRO-SEAL or other carbon and gum dissolving agent. Repeat step 2 as necessary.

### CAUTION

**Do not use glass or sand to bead blast surfaces exposed to the engine oil. Bead blasting materials become lodged in the pores of the casting where they cannot be removed through ordinary cleaning methods. Only after the engine is put into use will heat expansion cause this material to be released, and the resulting oil contamination will accelerate wear and lead to engine failure. If bead blasting must be employed, use walnut shells or other soft non-damaging abrasive that can be digested in the engine oil.**

### CAUTION

**Be aware that bead blasting materials may also enter threaded holes adversely affecting fastener engagement and torque indication. Carefully cover all threaded holes if bead blasting is employed.**

4. Thoroughly clean the cylinder head, spring retainers, tapered keepers, valves and valve springs in a non-volatile cleaning solution or solvent. Follow up with a thorough wash in hot soapy water. Blow dry with compressed air.

### Inspection

#### Cylinder Head

1. Check for scratches and nicks on all gasket sealing surfaces.
2. With the combustion chamber side facing upward, set a straightedge diagonally across the length of the cylinder head intersecting the upper and lower corners of the gasket surface. Slide a feeler gauge beneath the straightedge to check the head for warpage. Checking the opposite diagonal, repeat the procedure to verify that the gasket surface is flat (especially if a head gasket was blown). Discard the head if any low spot is 0.006 inch (0.15 mm) or greater.

#### NOTE

*For good results, use one of the CYLINDER TORQUE PLATES (HD-42324A) in lieu of the straightedge. Lay the upper plate flat on the machined surface of the head. As a preliminary check, see if the plate rocks from side to side. A head on which the plate rocks is immediately suspect. Insert a feeler gauge between the plate and head at various locations to see if warpage exceeds above specification.*

3. Verify that oil passageways are open and clean.

#### Valve Guides

1. Inspect external surfaces for cracks (particularly the combustion chamber side). Replace the guide if any cracks are found.
2. To verify cleanliness of valve guides, lightly hone bore using the VALVE GUIDE HONE (B-45525) and then scrub with the VALVE GUIDE CLEANING BRUSH (HD-34751) to remove any dust or debris. Polish the valve stem with fine emery cloth or steel wool to remove carbon buildup, and then check valve stem to guide clearance as follows:

Carefully measure the inside diameter of the valve guide using an inside ball micrometer. Measure the outside diameter of the valve stem with an outside micrometer. The valve stem and/or guide are excessively worn if the clearance exceeds the limits shown in [Table 3-5](#). Repeat measurements with a new valve to determine if the guide must be replaced.

**Table 3-5. Service Wear Limits**

Valve	Valve Stem to Guide Clearance
Intake	0.0038 inch (0.0965 mm)
Exhaust	0.0038 inch (0.0965 mm)

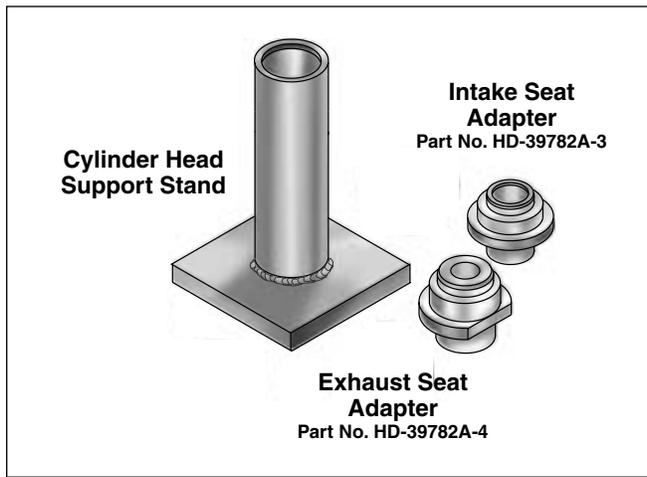


Figure 3-67. Cylinder Head Support Stand (Part No. HD-39782A)

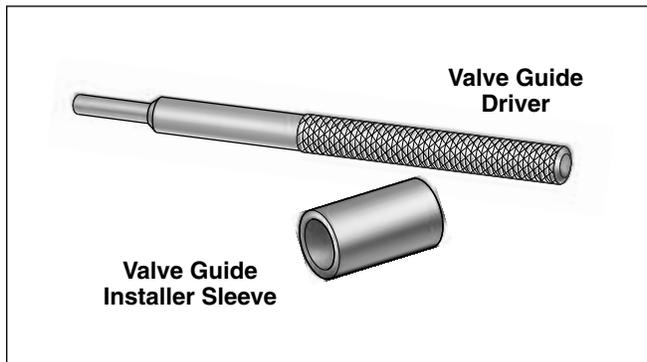


Figure 3-68. Valve Guide Driver (Part No. B-45524-1) and Valve Guide Installer Sleeve (Part No. B-45524-2A)

### Valves

1. Replace the valve if there is evidence of burning or cracking.
2. Inspect the end of the valve stem for pitting or uneven wear. Replace the valve if either of these conditions are found.
3. Inspect for burrs around the valve stem keeper groove. Remove burrs with a fine tooth file if found.
4. To determine if the valve stem is excessively worn, see INSPECTION, VALVE GUIDES, step 2.

### Valve Springs

1. Inspect springs for broken or discolored coils. Replace springs if either of these conditions are found.
2. Set the intake and exhaust valve springs on a level surface and use a straightedge to check for proper squareness and height.
3. Check free length of springs using a dial vernier caliper or load test with the VALVE SPRING TESTER (HD-96796-47). Replace springs if free length or compression force do not meet specifications. See Section 3.1 SPECIFICATIONS.

### Tapered Keepers

1. Inspect parts for damage or rust pits. Replace as necessary.
2. Inspect inboard side of tapered keepers for excessive wear. Upraised center must be pronounced and fit snugly in valve stem groove. Place keepers into groove and verify that they grip tightly without sliding.

### Valve Seats

1. Inspect seats for cracking, chipping or burning. Replace seats if any evidence of these conditions are found.
2. Check seats for recession by measuring valve stem protrusion. See VALVE AND SEAT REFACING in this section, steps 5-6.

## VALVE GUIDE REPLACEMENT

### Removal

#### NOTE

If valve guide replacement is necessary, always install new guide before refacing valve seat.

1. Obtain the CYLINDER HEAD SUPPORT STAND (HD-39782A) and proceed as follows:
  - a. Insert sleeve of intake or exhaust seat adapter into tube at top of support stand. See Figure 3-67.
  - b. Position cylinder head so that valve seat is centered on seat adapter. Support stand ensures that valve guide and seat are perpendicular. If perpendicularity is not achieved, the cylinder head valve guide bore will be damaged during the press procedure.

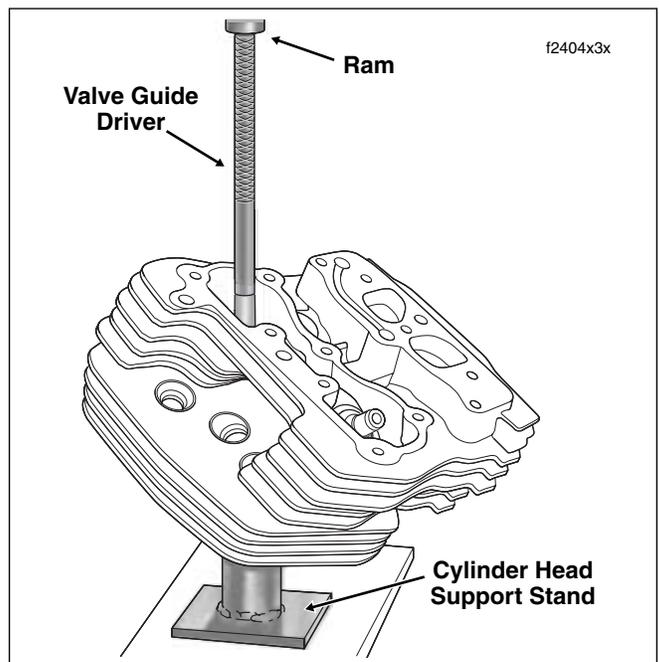


Figure 3-69. Remove Valve Guide

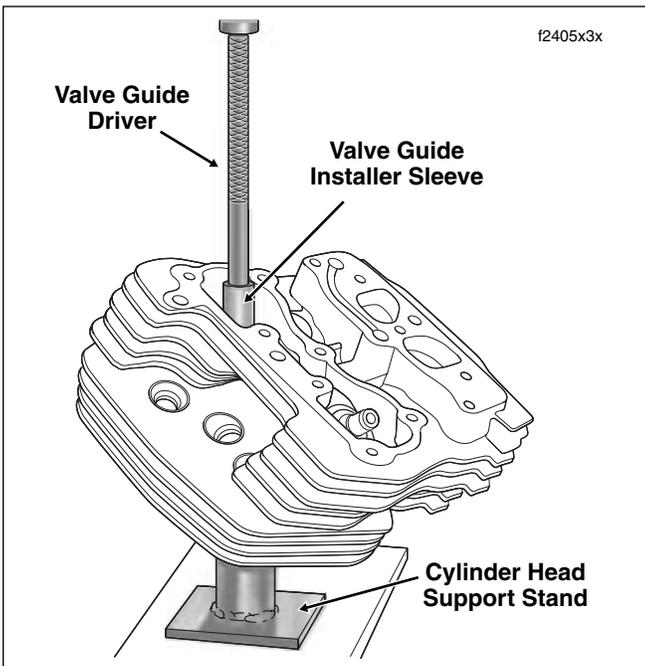


Figure 3-70. Install Valve Guide

### CAUTION

Do not press out the valve guide from the bottom of the cylinder head. Carbon buildup on the combustion chamber side of the guide can deeply gouge the cylinder head bore diminishing the likelihood of achieving the proper interference fit and possibly requiring replacement of the cylinder head casting.

- Remove lock ring from valve guide groove. Discard lock ring.

### NOTE

Lock ring is present on both OEM intake and exhaust valve guides.

- At the top of the cylinder head, insert VALVE GUIDE DRIVER (B-45524-1) into valve guide bore until stopped by shoulder.
- Center valve guide driver under ram of arbor press. Apply pressure until valve guide drops free of cylinder head. Discard the valve guide. See [Figure 3-69](#).

### Installation

- Measure the outside diameter of a **new** standard valve guide, and then measure the cylinder head valve guide bore. The valve guide should be 0.0020-0.0033 inch (0.051-0.084 mm) larger than the bore.

If clearance is not within specification, then select one of the following oversize guides - 0.001 inch (0.025 mm), 0.002 inch (0.05 mm) or 0.003 inch (0.08 mm).

### NOTE

Since some material is typically removed when the guide is pressed out, it is normal to go to the next larger size for the proper interference fit.

- Measure cylinder head bore and outside diameter of selected oversize guide to verify correct interference fit.
- Obtain the CYLINDER HEAD SUPPORT STAND (HD-39782A), VALVE GUIDE DRIVER (B-45524-1) and VALVE GUIDE INSTALLER SLEEVE (B-45524-2A). Proceed as follows:
  - Insert sleeve of intake or exhaust seat adapter into tube at top of support stand. Position cylinder head so that valve seat is centered on seat adapter. Support stand ensures that valve guide and seat are perpendicular. If perpendicularity is not achieved, cylinder head valve guide bore will be damaged during the press procedure.
  - Apply Vaseline to lightly lubricate external surfaces of valve guide. Spread lubricant so that thin film covers entire surface area.
  - At top of cylinder head, start valve guide into bore.
  - Place installer sleeve over valve guide, and then insert tapered end of valve guide driver into sleeve.
  - Center valve guide driver under ram of arbor press and apply pressure only until valve guide is started in bore and then back off ram slightly to allow guide to center itself. See [Figure 3-70](#).

### CAUTION

Always back off ram to allow the valve guide to find center. Pressing guide into cylinder head in one stroke can bend driver, break guide, distort cylinder head casting and/or damage cylinder head valve guide bore.

- Verify that support stand and driver are square. Center driver under ram and press valve guide further into bore, but then back off ram again to allow valve guide to find center.
  - Repeat step 3(f) and then apply pressure to driver until installer sleeve contacts machined area of cylinder head.
  - Install **new** lock ring into valve guide groove. Verify that lock ring is square and fully seated in the groove.
- Obtain the CYLINDER HEAD HOLDING FIXTURE (HD-39786) and proceed as follows:
    - Thread the 12mm end of the tool into the spark plug hole of the cylinder head.
    - Clamp tool in vise at a 45 degree angle (or one that offers a comfortable working position).

### NOTE

Valve guides must be reamed to within 0.0005 - 0.0001 inch (0.013 - 0.0025 mm) of finished size.

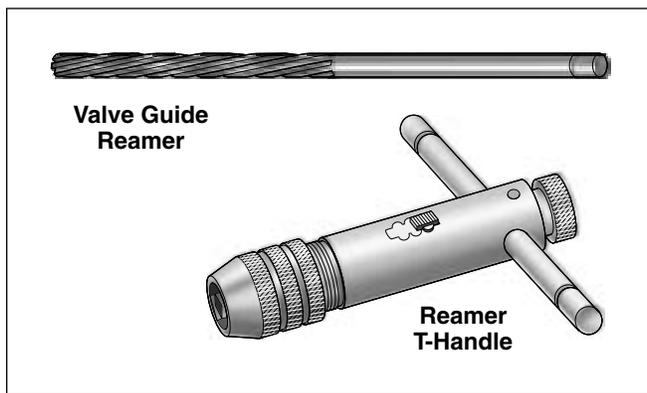


Figure 3-71. Valve Guide Reamer (Part No. B-45523) and Reamer T-Handle (Part No. HD-39847)

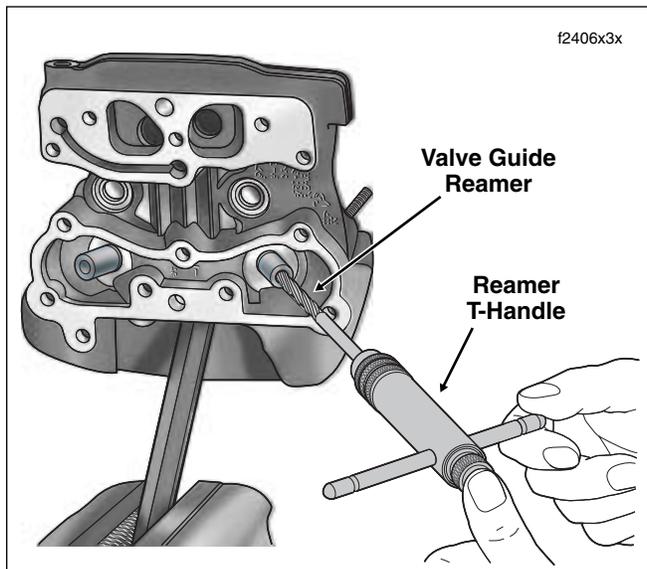


Figure 3-72. Ream Valve Guide Bore

5. Obtain the VALVE GUIDE REAMER (B-45523), REAMER T-HANDLE (HD-39847) and REAMER LUBRICANT (HD-39964). Proceed as follows:
  - a. Install T-handle on reamer.
  - b. Apply a liberal amount of reamer lubricant to valve guide bore and bit of reamer. Start bit of reamer into bore at top of cylinder head.
  - c. Placing thumb on drive socket of reamer T-handle, apply slight pressure on reamer while rotating in a clockwise direction. See [Figure 3-72](#). Squirt additional lubricant onto reamer and into guide as necessary.

#### CAUTION

For best results, do not push on reamer or apply pressure to the reamer handle. While excessive pressure results in a rough cut, bore will be tapered if pressure is not centrally applied.

- d. Continue rotating reamer T-handle until entire bit has passed through valve guide bore and shank of reamer rotates freely.

#### CAUTION

Never back reamer out of valve guide or bore will be damaged.

- e. Remove T-handle from reamer, and carefully pulling on bit, draw shaft of reamer out combustion chamber side of valve guide.

#### CAUTION

Abrasive particles can damage machined surfaces and plug oil passageways possibly resulting in engine failure.

6. Direct compressed air into the valve guide bore to remove any metal shavings or debris.
7. Clean valve guide bore with the VALVE GUIDE CLEANING BRUSH (HD-34751).
8. Obtain the VALVE GUIDE HONE (B-45525) and REAMER LUBRICANT (HD-39964). Proceed as follows:

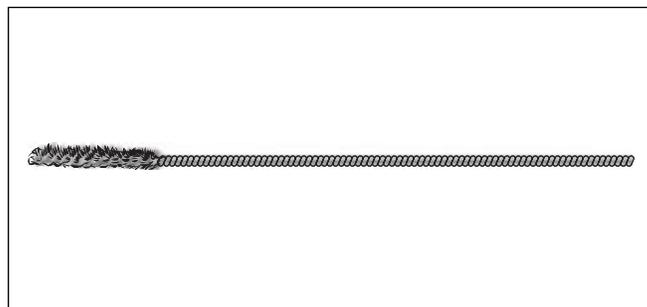


Figure 3-73. Valve Guide Hone (Part No. B-45525)

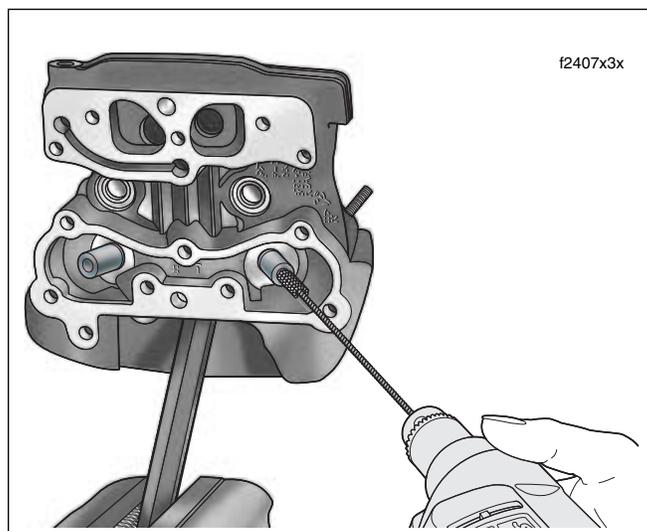


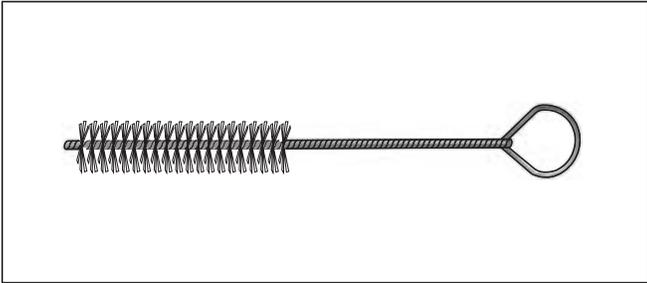
Figure 3-74. Hone Valve Guide Bore

- a. Install hone in a high speed electric drill.
- b. Apply reamer lubricant to finishing stones of hone and valve guide bore.
- c. Start finishing stones of hone into bore.
- d. Activating the drill, move the entire length of the finishing stone arrangement forward and backward through the bore for 10 to 12 complete strokes. See [Figure 3-74](#). Work for a crosshatch pattern of approximately 60°.

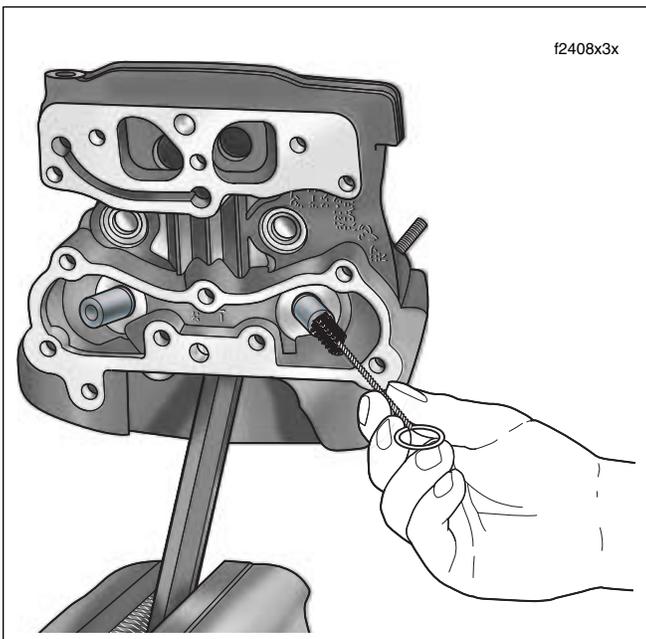
**CAUTION**

**Abrasive particles can damage machined surfaces and plug oil passageways possibly resulting in engine failure.**

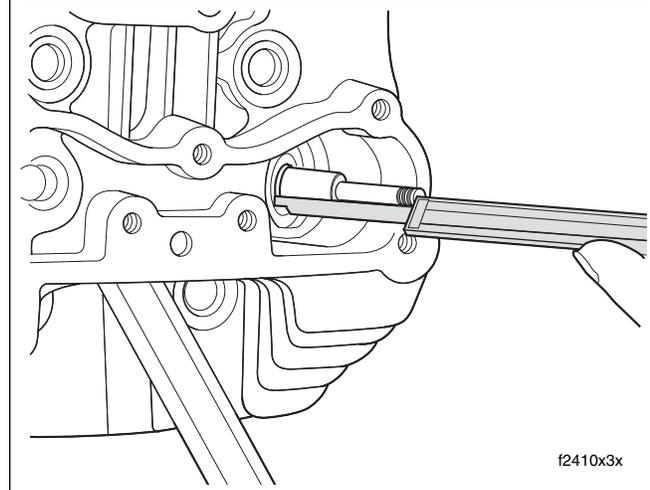
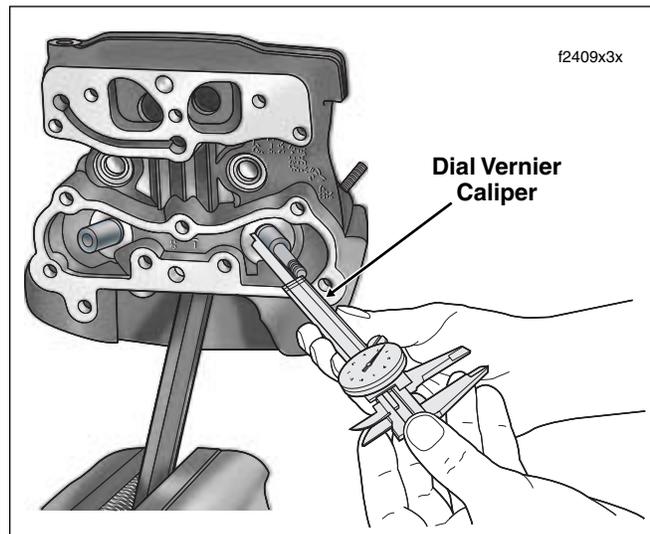
9. Direct compressed air into the valve guide bore to remove any debris and then clean with the VALVE GUIDE CLEANING BRUSH (HD-34751). See [Figure 3-76](#).



**Figure 3-75. Valve Guide Brush (Part No. HD-34751)**



**Figure 3-76. Scrub Valve Guide Bore**



**Figure 3-77. Measure Valve Stem Protrusion**

**NOTE**

*Always verify valve stem to valve guide clearance after honing, since a worn reamer may cut the bore undersize.*

10. Measure the inside diameter of the valve guide with an inside ball micrometer. Measure the outside diameter of the valve stem with an outside micrometer. The valve stem may be excessively worn or the valve guide bore undercut if the clearance is not within the limits (low end preferable) shown in [Table 3-6](#).

**Table 3-6. New Parts Limits**

Valve	Valve Stem to Guide Clearance
Intake	0.001 - 0.003 inch (0.0254-0.0762 mm)
Exhaust	0.001 - 0.003 inch (0.0254-0.0762 mm)

11. Using cleaning solvent, thoroughly clean cylinder head and valve guide bore. Scrub valve guide bore with the VALVE GUIDE CLEANING BRUSH (HD-34751). For best results, use a thin engine oil and clean valve guide

bore with the type of swabs or patches found in gun cleaning kits. Continue to wipe bore until clean cloth shows no evidence of dirt or debris. Follow up with a thorough wash in hot soapy water. Blow dry with compressed air.

## VALVE AND SEAT REFACING

### NOTE

Verify correct valve stem to valve guide clearance before refacing. See [Table 3-6](#). If new guides must be installed, complete that task before refacing valves and seats.

1. Hold the valve firmly against a wire wheel in a bench grinder. Remove all carbon deposits from the valve head, face and stem, but exercise caution to avoid removing any metal. Carbon left on the stem may affect alignment in the valve refacer. Polish the valve stem with steel wool or crocus cloth to remove any marks that might be left by the wire wheel.
2. Install valve (both intake and exhaust) in a valve refacer set to a 45 degree angle. The valve refacer is required equipment, since accuracy in matching the angle of the valve face with the angle of the valve seat is critical.

Do not remove any more metal than is necessary to clean up and true the valve face. Removing metal reduces the service life of the valve. The amount of grinding needed to retrue the valve is a clear indication of its condition. Discard the valve if it cannot be quickly refaced while maintaining a good margin. Valves that do not clean up quickly are either warped, excessively worn or too deeply pitted to be used.

Obtain a **new** valve if grinding leaves the margin less than 0.0313 inch (0.795 mm). A valve in this condition does not seat normally, burns easily and may crack or cause pre-ignition.

3. Obtain the CYLINDER HEAD HOLDING FIXTURE (HD-39786) and proceed as follows:
  - a. Thread the 12mm end of the tool into the spark plug hole of the cylinder head.
  - b. Clamp tool in vise at a 45 degree angle (or one that offers a comfortable working position).
4. Obtain the NEWAY VALVE SEAT CUTTER SET (HD-35758A) and cut valve seat angle to 46°.

### NOTE

Do not remove any more metal than is necessary to clean up the seat (that is, to provide a uniform finish and remove pitting).

5. From the bottom of the cylinder head, insert the valve stem into the valve guide. Push on bottom of valve until it contacts the valve seat.
6. Placing finger at bottom of valve to keep valve seated, use a dial vernier caliper to check the distance from the top of the valve stem to the machined area on the cylinder head. See [Figure 3-77](#).

Seat wear and valve refacing causes the valve stem protrusion to change. If protrusion exceeds 2.069 inches (52.55 mm), then replace the valve seat or cylinder head.

### CAUTION

Do not shorten the valve by grinding on the end of the stem. Grinding replaces the hardened case with mild steel which results in accelerated wear.

7. Remove valve from cylinder head. Apply magic marker or similar product to valve seat and allow to thoroughly dry.
8. Insert the valve stem into the valve guide. Push on bottom of valve until it contacts the valve seat.
9. Obtain the VALVE LAPPING TOOL (HD-96550-36A) and proceed as follows:
  - a. Attach suction cup at end of tool to valve head.

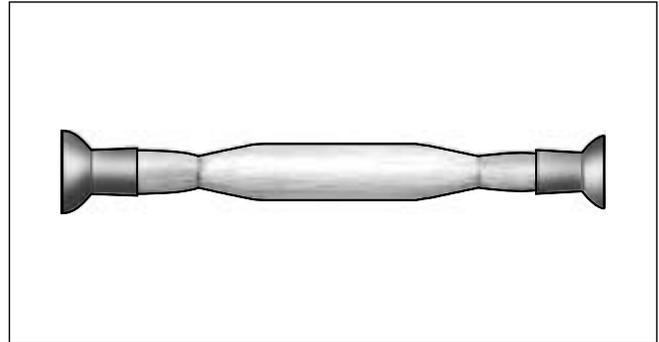


Figure 3-78. Valve Lapping Tool (Part No. HD-96550-36A)

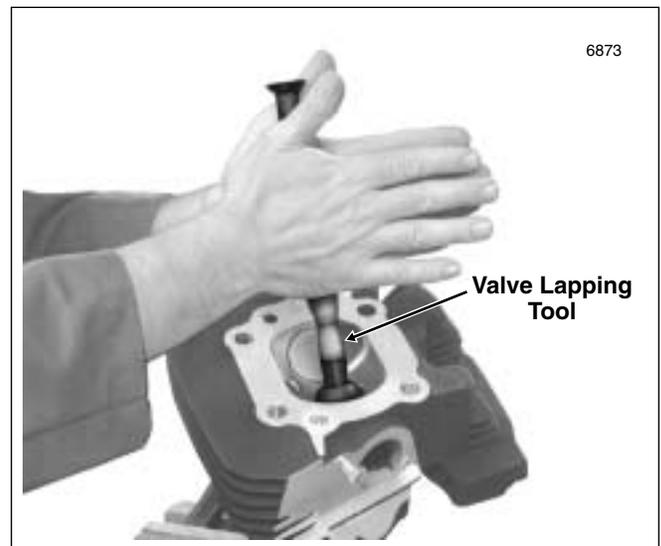
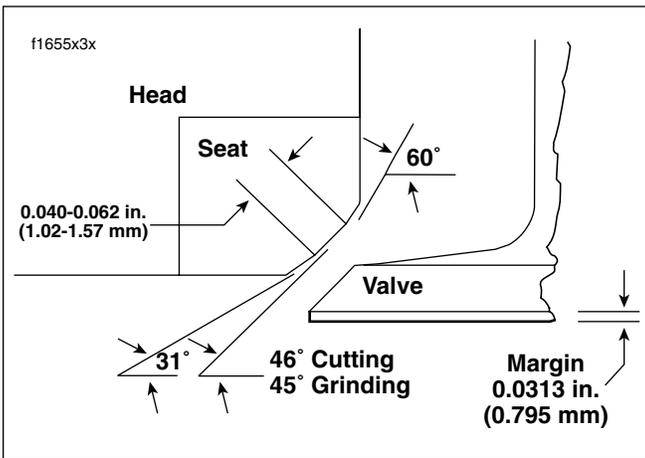


Figure 3-79. Oscillate Tool to Create Contact Area



**Figure 3-80. Valve Seat Angles**

- b. Holding shank of tool between the palms of both hands, oscillate the tool back and forth a few times. See [Figure 3-79](#).
10. Remove the valve from the cylinder head and carefully inspect the mating surfaces under a good light.

Inspection of the valve seat should show an unbroken contact area of uniform width. If the seat is not concentric with the valve guide, then the cutter will remove more material in one spot than another. Carbon deposits may have caused the guide to be pressed in crooked, the guide may be cracked, or the cutter blade or cutter pilot have not have been properly cleaned.

#### NOTE

*If the results are not acceptable, then recut the valve seat or replace the valve guide.*

11. Inspect the contact pattern on the valve seat to be sure area is 0.040-0.062 inch (1.02-1.57 mm) wide and contacts the valve two-thirds of the way towards the outer edge of the valve face. See [Figure 3-80](#). If necessary, modify the seat pattern as follows:
- Use the 31° angle cutter to lower the valve seat surface and reduce its width.
  - Use the 60° angle cutter to raise the valve seat surface and reduce its width.
  - Use the 46° angle cutter to widen the valve seat surface.
12. Using a magic marker, mark three equally spaced vertical lines across the valve face and then insert the valve back into the cylinder head.
13. Attach suction cup of VALVE LAPPING TOOL (HD-96550-36A) to valve head, and holding shank of tool between the palms of both hands, oscillate the tool back and forth a few times.

- Remove the valve and perform a final inspection of the contact pattern. If necessary, return to step 11.
- Remove the valve from the cylinder head. Use contact cleaner to thoroughly clean magic marker and/or dye from valve face and seat, if present.
- Release the cylinder head holding fixture from the vise and then remove the tool from the spark plug hole.
- To confirm quality of valve and seat refacing work, proceed as follows:
  - Insert valve in guide, and holding valve to seat, raise port to strong light source. If light is visible around edge of seat, then valves and seats must be reconditioned.
  - Holding valve to seat, fill port at top of cylinder head with solvent. Wait ten full seconds and then check for leakage into combustion chamber. If solvent leakage into combustion chamber is evident, then valves and seats must be reconditioned.
- Clean valves, cylinder head and valve seats in solvent. Follow up with a thorough wash in hot soapy water. Blow dry with compressed air.

## Assembly

- Obtain the CYLINDER HEAD HOLDING FIXTURE (HD-39786) and proceed as follows:
  - Thread the 12mm end of the tool into the spark plug hole of the cylinder head.
  - Clamp tool in vise at a 45 degree angle (or one that offers a comfortable working position).

#### NOTE

*At the time of disassembly, all parts should have been marked or tagged so that they are installed on the same valve (and in the same head).*

- Run the VALVE GUIDE CLEANING BRUSH (HD-34751) through the valve guide bore to verify cleanliness.
- Using TORCO MPZ or another suitable product, apply a liberal amount of engine assembly lube to valve stem.
- From the bottom of the cylinder head, insert the valve stem into the valve guide.
- To distribute the assembly lube evenly around the valve stem and guide, hand spin the valve as it is installed. Work the valve back and forth in the bore to verify that it slides smoothly and seats properly.
- Remove the valve and apply a second coat of assembly lube to the valve stem. Install the valve in the valve guide.

#### CAUTION

**Failure to install plastic capsule will cause the valve stem seal to catch the edge of the valve stem keeper groove. The resulting damage will lead to leakage around the valve stem, excessive oil consumption and valve sticking.**

7. Push on bottom of valve until it contacts the valve seat. Placing finger at bottom of valve to keep valve seated, slide plastic capsule over valve stem tip and keeper groove. See [Figure 3-81](#).
8. Apply a very thin film of clean H-D 20W50 engine oil to capsule.
9. Obtain **new** valve stem seal and spring seat. Assemble parts as shown in [Figure 3-82](#).
10. Slide valve stem seal/spring seat over capsule and down valve stem until contact is made with top of valve guide and machined area of cylinder head casting. Remove capsule from valve stem tip.

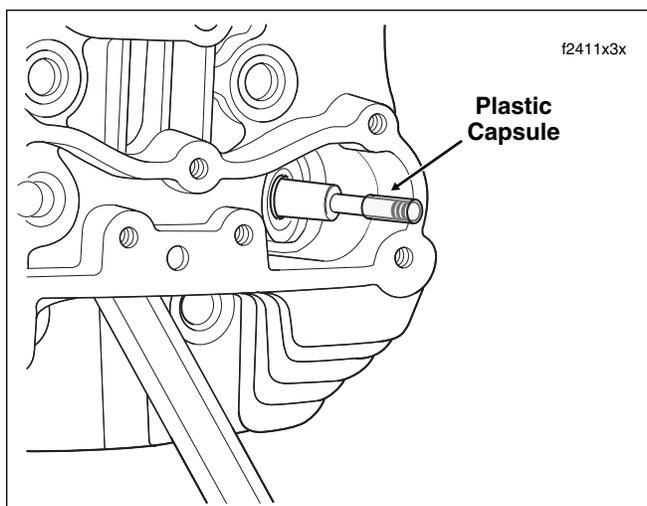
#### CAUTION

Removing the valve after seal installation will cause the valve stem seal to catch the edge of the valve stem keeper groove. The resulting damage will lead to leakage around the valve stem, excessive oil consumption and valve sticking.

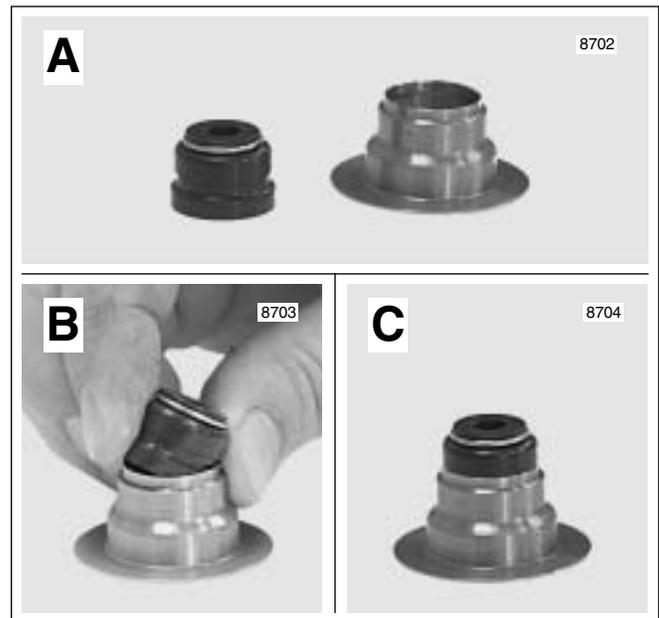
11. Apply a liberal amount of assembly lube to valve stem tip and keeper groove.
12. With the smaller diameter coils topside, install the valve spring over the valve guide. Place the spring retainer on top of the valve spring.
13. Obtain the VALVE SPRING COMPRESSOR (HD-34736B) and proceed as follows:
  - a. Place tool over cylinder head so that the blunt end is centered on the valve head and adapter at end of forcing screw is seated on the spring retainer.

#### CAUTION

Over-compressing the valve spring can damage the valve stem seal resulting in leakage around the valve stem, excessive oil consumption and valve sticking.



**Figure 3-81. Lubricate Plastic Capsule**



**Figure 3-82. Valve Stem Seal/Spring Seat Assembly**

- b. Rotate forcing screw to compress valve spring.
  - c. With the tapered side down, fit the keepers into the valve stem groove. For best results, apply a dab of grease to the inboard side of the keepers before installation and use a magnetic rod for easy placement.
  - d. Arranging tapered keepers so that the gaps are evenly spaced, turn forcing screw to release valve spring compression.
14. Tap the end of the valve stem once or twice with a soft mallet to ensure that tapered keepers are tightly seated in the valve stem groove.
  15. Repeat steps 1-14 to install the other valve components.
  16. Release the cylinder head holding fixture from the vise and then remove the tool from the spark plug hole.
  17. Cover the cylinder head to protect it from dust and dirt until time of installation.

## Installation

See Section 3.9 [TOP END OVERHAUL, ASSEMBLY](#), steps 15-24 and 29-39.

## CYLINDER

### Removal

1. See Section 3.9 TOP END OVERHAUL, DISASSEMBLY, steps 1-11 and 15-24.

### Cleaning and Inspection

#### CLEANING

1. Scrape old gasket material from the machined surface at the top of the cylinder. Old gasket material left on the mating surface will cause leaks.
2. Clean cylinder in a non-volatile cleaning solution or solvent. Thoroughly dry with low pressure compressed air. Verify that oil passageways are clean and open.
3. Inspect the cylinder bore for defects or damage in the ring travel area. Replace cylinders that are severely scored, scuffed, scratched, burnt or gouged.
4. Using Magnaflux Dye Penetrant, inspect the cylinder for cracks. If no cracks are found, thoroughly wash cylinder to remove traces of dye.
5. Use a file to carefully remove any nicks or burrs from the machined surfaces of the cylinder.
6. Using a feeler gauge and the CYLINDER TORQUE PLATES (HD-42324A), check the machined surfaces for flatness. Proceed as follows:
  - a. Lay gasket side of the upper plate (without vise grip) flat against the head gasket surface.
  - b. As a preliminary check, see if the plate rocks from side to side. A cylinder on which the plate rocks is immediately suspect.
  - c. Insert a feeler gauge between the plate and cylinder at various locations.
  - d. The head gasket surface must be flat within 0.006 inch (0.15 mm).
  - e. Now turn the cylinder upside down and lay the seal side of the lower plate (with vise grip) flat against the O-ring seal surface. Repeat steps 6(b) and 6(c).
  - f. The O-ring seal surface must be flat within 0.004 inch (0.102 mm).
  - g. Replace the cylinder (and piston) if either surface is not within specification.

#### INSPECTION

#### CAUTION

Failure to use the cylinder torque plates can produce measurements that vary by as much as 0.001 inch (0.025 mm), possibly resulting in the use of parts that are not suitable for service.

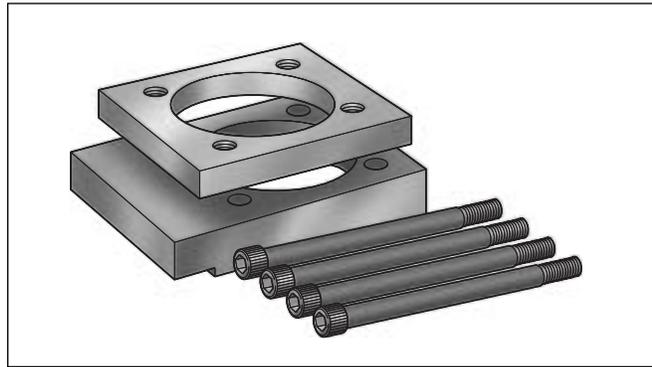


Figure 3-83. Cylinder Torque Plates  
(Part No. HD-42324A)

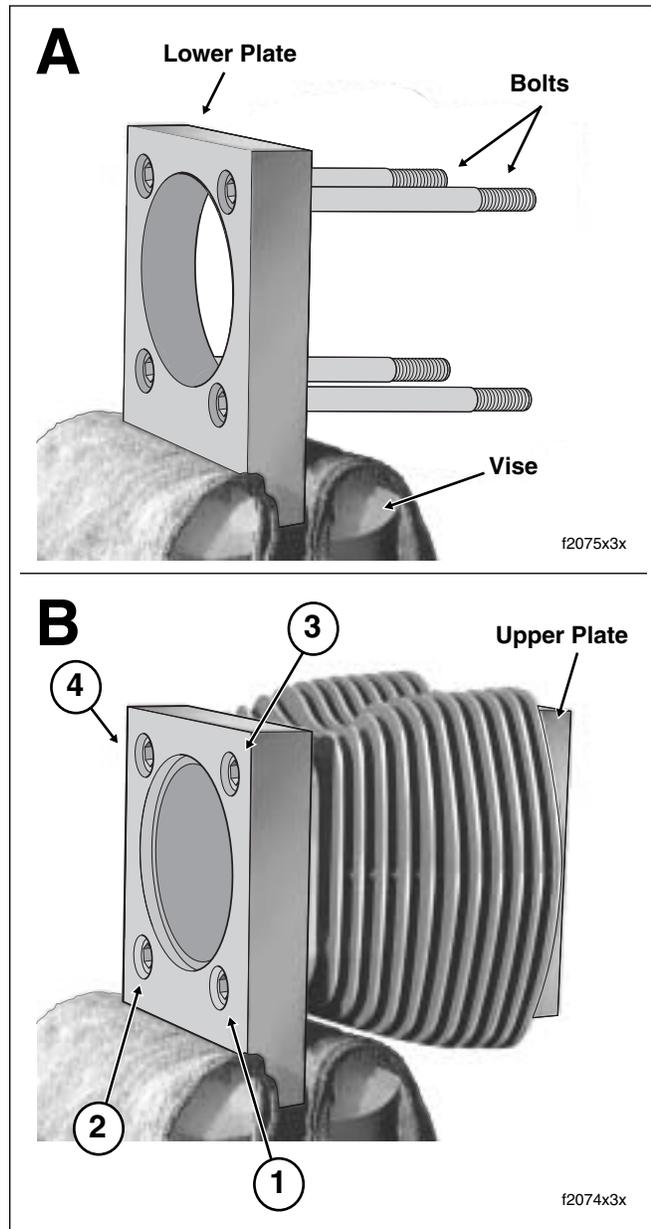


Figure 3-84. Install Cylinder to Torque Plates

1. To simulate an assembled cylinder for accurately measuring cylinder taper and out-of-round conditions, as well as for boring, honing or deglazing, obtain the CYLINDER TORQUE PLATES (HD-42324A). Install the torque plates as follows:
  - a. Remove O-ring seal from cylinder sleeve, if installed.
  - b. Place used head gasket over two ring dowels at top of cylinder.
  - c. Install brass jaws or shop towels around teeth of vise to prevent damage to tool. Clamp stepped side of lower plate in vise with the simulated split line (machined strip) facing away.
  - d. Lightly oil threads and shoulders of four bolts with clean H-D 20W50 engine oil. Slide bolts all the way through holes of lower plate. See A of [Figure 3-84](#).
  - e. Slide cylinder down bolts with the indent in the cooling fins facing upward.
  - f. With the head gasket in place, align holes in upper plate with ends of bolts. Blind holes in upper plate accommodate ring dowels in cylinder. Alternately tighten four bolts into upper plate until finger tight.
  - g. Tighten the bolts to 120-144 **in-lbs** (13.6-16.3 Nm) in the sequence shown in B of [Figure 3-84](#).
  - h. Following the same sequence, tighten each bolt to 15-17 **ft-lbs** (20.3-23.1 Nm).
  - i. Using a grease pencil, mark a straight line on one of the bolts continuing the line over onto the lower plate. Repeat step for remaining three bolts. Using the marks as a guide, turn each bolt 1/4 turn or 90 degrees. Be sure to tighten the bolts in the sequence shown in B of [Figure 3-84](#).

**NOTE**

*For best results, obtain Snap-on® Torque Angle Gauge TA360.*

- j. For purposes of inspection, remove the assembly from the vise and place on bench top.
2. See [Figure 3-85](#). Using an inside micrometer or dial bore gauge, check cylinder bore for out-of round and taper. Proceed as follows:
  - a. At the top of the piston ring travel zone (starting about 0.50 inch or 12.70 mm from the top of the cylinder), measure the cylinder diameter at two locations- parallel and perpendicular to the crankshaft. Write the readings down.
  - b. Repeat the two measurements at the center of the piston ring travel zone.



**Figure 3-85. Measure for Out-of-Round and Taper**

- c. Repeat the measurements again at the bottom of the bore at a point below the piston ring travel zone.
  - d. Rebore the cylinder if the parallel and perpendicular measurements at either the top, middle or bottom of the bore vary by more than 0.002 inch (0.051 mm), which indicates an out-of-round condition.

Rebore the cylinder if the top, middle and bottom bore diameters either parallel or perpendicular to the crankshaft vary by more than 0.002 inch (0.051 mm), which indicates excessive taper.

**CAUTION**

**Maximum cylinder wear occurs at the very top of top ring travel. Minimum wear occurs below ring travel. Failure to measure the cylinder at these points may result in a faulty decision regarding the suitability of the cylinder for continued use.**

3. If cylinders are not scuffed or scored, and are not worn beyond the service limits described under step 2(d), see [DEGLAZING CYLINDER](#) on the next page.

On the other hand, if cylinders are worn beyond the service limits, then they must be rebored and/or honed to accept the next standard oversize piston. See [BORING AND HONING CYLINDER](#) on the next page.

**DEGLAZING CYLINDER****NOTE**

*Deglazing removes wear patterns, minor scuff marks and scratches without enlarging the bore diameter.*

1. Lightly swab the cylinder bore with a cloth dipped in clean engine oil.
2. Obtain a 240 grit flexible ball-type deglazing tool with a bristle tip or finishing stone arrangement able to produce a 60° cross hatch pattern.
3. Install the deglazing tool in a slow-speed drill. The speed at which the tool rotates determines the speed at which it must be stroked up and down the bore to produce the desired cross hatch pattern.
4. Starting at the bottom of the cylinder, move the deglazing tool up and down the entire length of the cylinder bore for 10 to 12 complete strokes.
5. Stop to examine the cylinder bore and/or take measurements. A precise 60° cross hatch pattern in the piston travel area is the most important.

**CAUTION**

**The angular cross hatch pattern ensures an even flow of oil onto the cylinder walls and promotes longer cylinder, piston and ring life. An improper crosshatch pattern will result in insufficient oil retention and possible piston seizure and/or high oil consumption.**

**CAUTION**

**Failure to remove all abrasive particles may result in premature cylinder, piston and ring wear and possible engine failure.**

6. Thoroughly wash the cylinder bore with liquid dishwashing soap and warm water to remove all abrasive particles and residual grit. Continue cleaning until a clean cloth shows no evidence or dirt or debris.
7. Hot rinse the cylinder and dry with moisture free compressed air. Immediately apply a thin film of clean engine oil to prevent rusting.
8. With the cylinder at room temperature, check the piston clearance in the cylinder in which the piston will run. See [PISTON, INSPECTION](#), step 5.

**BORING AND HONING CYLINDER**

1. Bore the cylinder to 0.003 inch (0.08 mm) under the desired finished size. See [Table 3-7](#).

**CAUTION**

**An improper crosshatch pattern or too fine a hone will result in insufficient oil retention and possible piston seizure and/or high oil consumption.**

2. Hone the cylinder to its finished size using a 280 grit rigid hone.
3. Stop frequently to examine the cylinder bore and/or take measurements. Remember, a precise 60° cross hatch pattern in the piston travel area is important.
4. Thoroughly wash the cylinder bore with liquid dishwashing soap and warm water to remove all abrasive particles and residual grit. Continue cleaning until a clean cloth shows no evidence or dirt or debris.

**Table 3-7. Oversize Pistons**

Piston	Cylinder Bore Finished Size
Standard	3.7500 - 3.7505 in. (95.250 - 95.263 mm)
0.005 In. (0.13 mm) <b>Oversize</b>	3.7550 - 3.7555 in. (95.377 - 95.390 mm)
0.010 In. (0.25 mm) <b>Oversize</b>	3.7600 - 3.7605 in. (95.504 - 95.517 mm)

Example: A 0.005 in. (0.13 mm) oversize piston will have the proper running clearance with a cylinder bore size of 3.7550 - 3.7555 in. (95.377 - 95.390 mm).

5. Hot rinse the cylinder and dry with moisture free compressed air. Immediately apply a thin film of clean engine oil to prevent rusting.
6. With the cylinder at room temperature, check the piston clearance in the cylinder in which the piston will run. See [PISTON, INSPECTION](#), step 5.

**Installation**

1. See Section [3.9 TOP END OVERHAUL, ASSEMBLY](#), steps 8-24 and 29-39.