

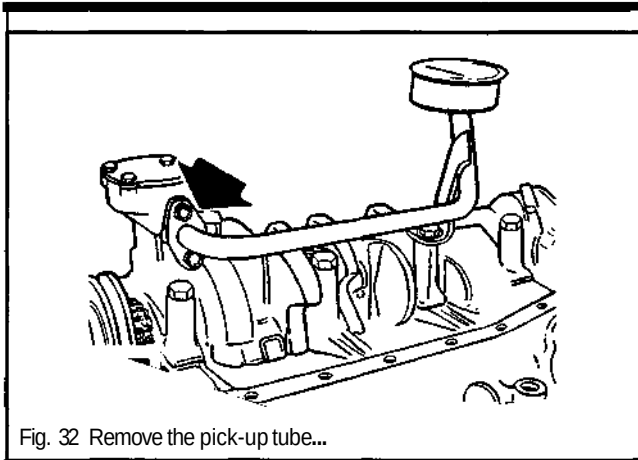


Fig. 32 Remove the pick-up tube...

the applications in the following procedures, it was not always year or model specific. Please read the procedures FIRST in order to determine which one is appropriate for your particular engine's configuration.

1. Remove the engine as detailed previously.
2. Loosen the bolts and remove the flywheel housing and cover plate.
3. Remove the three mounting bolts and pull off the rear torsional damper.
4. Remove four of the six flywheel retaining bolts. Loosen the other two, any two is fine, and back them out about half way. Using the two bolts as a stop, carefully pull the flywheel off of the crankshaft flange. Remove the two bolts and flywheel.

To Install:

5. Position the flywheel over the dowel pin on the flange and make sure that the holes line up correctly. Coat the bolt threads with engine oil, install them and tighten to 59 ft. lbs. (82 Nm). Tighten the six bolts in a diagonal star pattern.
6. Install the torsional damper and tighten the bolts securely.
7. Install the housing and plate. Coat all mounting bolts with engine oil and tighten the 9116 in. housing bolts to 30 ft. lbs. (41 Nm), tighten the 5116 in. plate bolts securely.
8. Install the engine.

Models With A Timing Ring

- ◆ See Figures 34 and 35



Over the years, these engines were equipped in a variety of configurations—flywheel and torsional damper, flywheel, damper and coupler, flywheel and coupler, etc. And for a number of years, some models also had a timing ring attached. Early models are usually the ones equipped with a damper, while Cobra, SP and DP models usually were equipped with the coupler. King Cobra models are usually the ones that use the timing ring. Although we have attempted to narrow the applications in the following procedures, it was not always year or model specific. Please read the procedures FIRST in order to determine which one is appropriate for your particular engine's configuration.

1. Remove the engine from the boat as detailed previously in this section.
2. Loosen and remove any connections attached to either of the ground studs on each side of the flywheel. Move the electrical leads out of the way.
3. Loosen the 5 retaining bolts and slide out the lower housing cover.
4. Although not strictly necessary, we recommend removing the starter.
5. Locate the timing sensor cover on the housing, loosen the two nuts and lift off the cover. Remove the two nuts and washers and then pull out the sensor and position it out of the way.
6. Cut the plastic tie that secures the housing drain hose and the pull the hose out of the fitting.
7. Remove the flywheel housing retaining nuts/bolts and pull off the housing. Take note of the positioning of the oil cooler and its bracket.
8. Slide an offset wrench behind the coupler and loosen the six flywheel mounting nuts gradually and as you would the lug nuts on your car or truck—that is, in a diagonal star pattern. Remove the coupler.
9. Mark the dowel hole on the timing ring and pry it off the flywheel. Remove the flywheel.

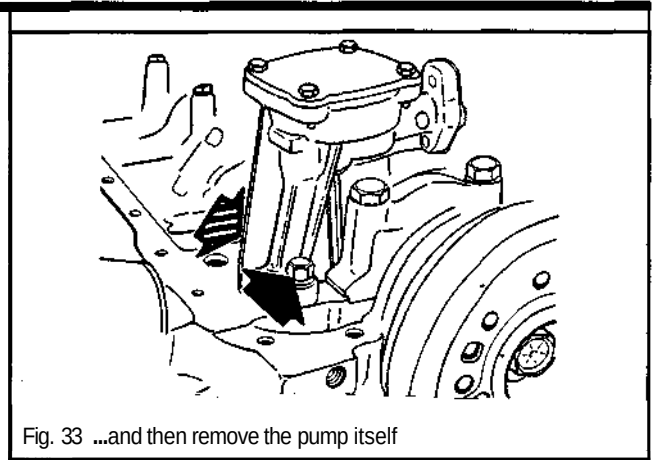


Fig. 33 ...and then remove the pump itself

To Install:

10. Thoroughly clean the flywheel mating surface and check it for any nicks, cracks or gouges. Check for any broken teeth.
11. Install the flywheel over the dowel on the crankshaft.
12. Position the timing ring over the locating pin making sure the pin is in the correct hole—you did mark it, right? Press the ring into position.
13. Slide the coupler over the studs so that it sits in the recess on the flywheel. Install new lock washers and tighten the mounting nuts to 40-45 ft. lbs. (54-61 Nm). Once again use the star pattern while tightening the bolts.
14. Install the flywheel housing and attach the oil cooler. Tighten the nuts/bolts to 32-40 ft. lbs. (43-54 Nm).
15. Install the washer, lock washer and inner nut on the ground stud and tighten it to 15-20 ft. lbs. (20-27 Nm). Attach the electrical leads, install another lock washer and then tighten the outer nut securely.
16. Slide the drain hose in and attach it with a new plastic tie.
17. Position the timing sensor onto the mounting studs and press in on the spring tab so that the sensor seats itself correctly over the timing ring. Install the washers and nuts, with the tab still depressed, and tighten them to 48-64 inch lbs. (5-7 Nm). Once the nuts are tightened, press in on the spring tab again and confirm that the tab DOES NOT touch the timing ring. If it does, loosen the nuts and try it again.

✖✖ WARNING

If the sensor tab comes in contact with the teeth of the timing ring, it will be damaged on engine start-up.

18. Install the sensor and tighten the nuts to 48-64 inch lbs. (5-7 Nm).
19. Coat both sides of a new gasket with Gasket Sealing Compound and position it onto the cover. Slide the cover into position and tighten the bolts to 60-84 inch lbs. (7-9 Nm).
20. Install the engine.

Models With A Coupler

- ◆ See Figures 34, 35 and 36



□ Over the years, these engines were equipped in a variety of configurations—flywheel and torsional damper, flywheel, damper and coupler, flywheel and coupler, etc. And for a number of years, some models also had a timing ring attached. Early models are usually the ones equipped with a damper, while Cobra, SP and DP models usually were equipped with the coupler. King Cobra models are usually the ones that use the timing ring. Although we have attempted to narrow the applications in the following procedures, it was not always year or model specific. Please read the procedures FIRST in order to determine which one is appropriate for your particular engine's configuration.

1. Remove the engine from the boat as detailed previously in this section.
2. Loosen and remove any connections attached to either of the ground studs on each side of the flywheel. Move the electrical leads out of the way.
3. Although not strictly necessary, we recommend removing the starter.
4. Loosen the 4 or 5 retaining bolts and slide out the lower housing cover.

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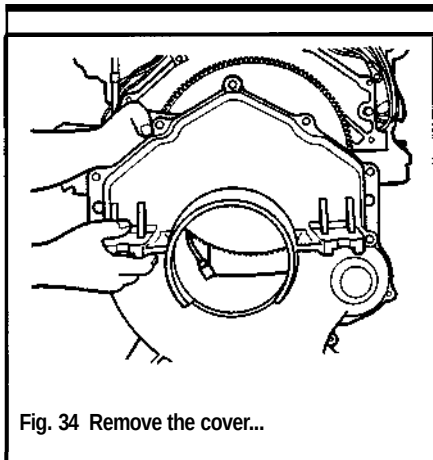


Fig. 34 Remove the cover...

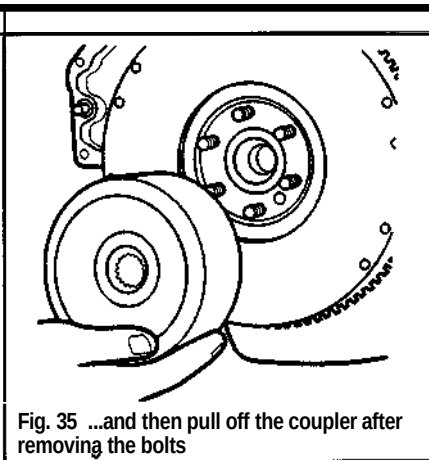


Fig. 35 ...and then pull off the coupler after removing the bolts

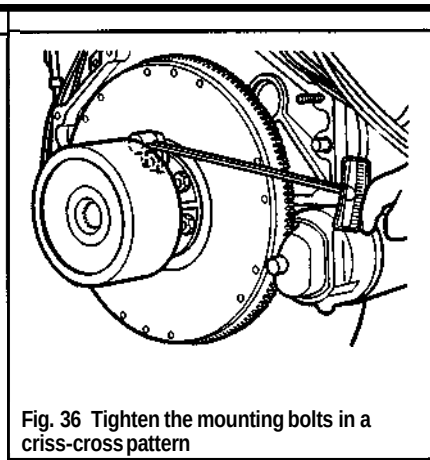


Fig. 36 Tighten the mounting bolts in a criss-cross pattern

5. Cut the plastic tie that secures the housing drain hose and the pull the hose out of the fitting.

6. Remove the oil cooler and bracket, take note of the positioning of both and secure them out of the way.

7. Remove the flywheel housing.

8. Slide an offset wrench behind the coupler and loosen the six flywheel mounting nuts gradually and as you would the lug nuts on your car or truck—that is, in a diagonal star pattern.

9. Remove the coupler and then the flywheel.

To Install:

10. Thoroughly clean the flywheel mating surface and check it for any nicks, cracks or gouges. Check for any broken teeth.

11. Install the flywheel over the dowel on the crankshaft.

12. Slide the coupler over the studs so that it sits in the recess on the flywheel. Install new lock washers and tighten the mounting nuts to 40-45 ft. lbs. (54-61 Nm) except on 1992 engines where the spec is 35-40 ft. lbs. (47-54 Nm). Once again use the star pattern while tightening the bolts.

4. Install the flywheel housing and attach the oil cooler. Tighten the bolts to 28-36 ft. lbs. (38-49 Nm) on 1987-91 engines or 32-40 ft. lbs. (43-54 Nm) on 1992-96 engines.

13. Install the washer, lock washer and inner nut on the ground stud and tighten it to 20-25 ft. lbs. (27-34 Nm) on 1987-91 engines or 15-20 ft. lbs. (20-27 Nm) on 1992-96 engines. Attach the electrical leads, install another lock washer and then tighten the outer nut securely.

14. Coat both sides of a new gasket with Gasket Sealing Compound and position it onto the cover. Slide the cover into position and tighten the bolts to 60-84 inch lbs. (7-9 Nm).

15. Slide the drain hose in and attach it with a new plastic tie.

16. Install the engine.

To Install:

6. Thoroughly clean the groove surface.

7. Coat the new seal with clean engine oil.

8. On 5.0L engines, position it into a Seal Driver (#T82L-6701-A) so that the seal's lip faces the cylinder block. Position the driver and seal over the crankshaft and then thread the attaching screws into the holes in the crankshaft. Tighten them securely, and alternately, until the seal is fully seated in the groove. The rear edge of the seal must be within 0.005 in. (0.127mm) of the outer edge of the cylinder block.

9. On 5.8L engines, insert the seal, lip facing forward, into a Seal Driver (#T65P-6701-A) and then position the tool over the centerline of the crankshaft. Keeping the tool perfectly straight, hit the drive end with a mallet until the leading edge of the tool comes into contact with the cylinder block.

10. On either engine, inspect the seal and groove surface after removing the tool to make sure nothing was damaged during installation.

11. Install the flywheel and engine coupler. Install the cover and flywheel housing.

12. Install the starter. Install the engine.

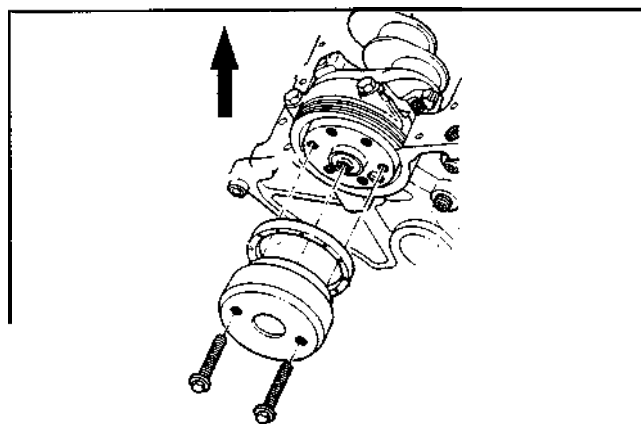


Fig. 37 Use this driver on the 5.0L engine...

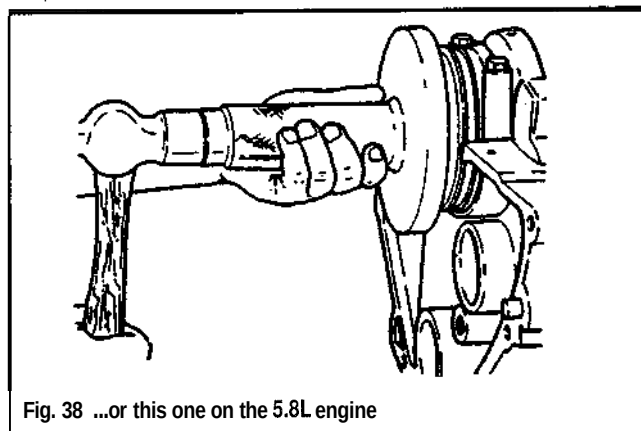


Fig. 38 ...or this one on the 5.8L engine

Rear Main Oil Seal

REMOVAL & INSTALLATION

5.0L And 5.8L Engines

◆ See Figures 37 and 38



It is not necessary to remove the oil pan or rear main bearing cap when removing the one-piece oil seal on these engines although you may find it easier to do just that.

1. Remove the engine.

2. Remove the flywheel housing and cover as detailed in this section.

3. Remove the engine coupler and flywheel from the engine as detailed in this section.

4. Using a sharp awl or punch, carefully punch a hole into metal surface of the seal between the cylinder block and the lip.

5. Install a slide hammer (#T77L-9533-B), screw in the threaded end and remove the seal. Be very careful not to scratch or mar the seal or groove surfaces.

7.5L Engines



◆ See Figures 39, 40 and 41

These engines utilize a split-lip style rear main seal. The seal can be removed without removing the crankshaft. You will need to remove the engine for this procedure though.

1. Remove the engine as detailed previously in this section (although not strictly necessary, it's highly recommended).

2. Remove the oil pan and pump as detailed previously in this section.

3. Loosen all of the main bearing cap bolts just enough so that the crankshaft drops down 1/32 in. at the rear.

4. Loosen the retaining bolts and remove the rear main bearing cap. Carefully insert a small prybar or awl and remove the lower half of the seal from the cap. Do not damage the seal seating surface.

5. Using a hammer and a small drift or punch, tap on the end of the upper seal until it starts to protrude from the other side of the race. Grab the protruding end with pliers and pull out the remaining seal half. OMC makes a seal removal tool for this purpose also, or many people will thread a small screw into one end of the seal and then pull it out that way—choose which way works best for you.

Upper and lower seals must be replaced as a pair. Never replace only one seal.

6. Clean the seal grooves thoroughly with a small bottle brush.

7. Check that you have the correct new seals. Coat the entire seal half in clean engine oil.

8. Install the upper half of the seal (undercut side facing front of the engine) by rotating it on the journal until about 1/8 in. (3.2mm) is protruding from the parting surface. Be very careful here, as you need to make sure that no seal rubber has been shaved off by the bottom edge of the seal groove.

9. Tighten up all bearing cap bolts (except the rear) to 95-105 ft. lbs. (129-142 Nm) to bring the crankshaft back up into position.

10. Insert the lower seal half into the main bearing cap in the same manner as you did with the upper seal.

11. Make sure that the capblock mating surfaces and the seal ends are free of any oil and then apply a small amount of Perfect Seal to the cap at the rear of the top mating surface. Do not apply sealer forward of the side seal groove.

12. Install the bearing cap and tighten the bolts on all caps to 95-105 ft. lbs. (129-142 Nm).

13. Install the oil pump and pan.

14. Install the engine.

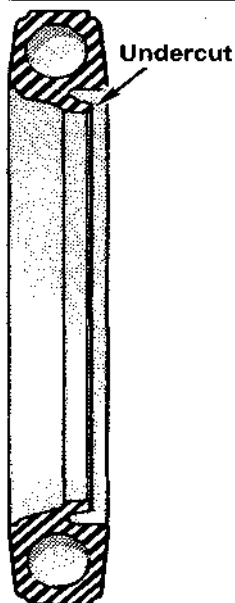


Fig. 39 These engines use a split-lip oil seal

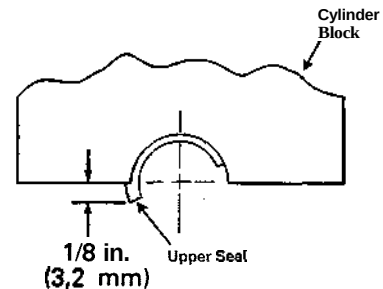


Fig. 40 Position the new upper seal as shown...

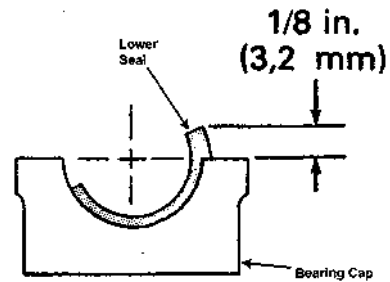


Fig. 41 ...and then position the lower seal

Vibration Damper, Pulley And Hub

REMOVAL & INSTALLATION

◆ See Figure 42



1. Disconnect the battery cables.
2. Remove the bracket mounting bolts for the alternator, raw water and power steering pump. Swivel them in to relieve belt tension.
3. Remove the drive belt(s) as detailed in the Maintenance section.
4. Drain the engine and manifolds.
5. Remove the three bolts and pull off the drive pulley attached to the balancer.

6. Remove the balancer retaining bolt and install special tool #T58P-6316-D onto the damper. Tighten the tool press bolt and remove the damper; don't lose the crankshaft key. OMC suggests that you DO NOT use a conventional gear puller for this procedure.

To Install:

7. Inspect the crank key and then install it into the shaft. Using a little adhesive will make this easier.
8. Coat the front cover oil seal lip with Ford Multi-Purpose grease and then install the damper so that the key and keyway align. Use a proper installation tool (#T79T-6316-A) to press the assembly into place on the crankshaft. Be sure that you thread the tool into the crankshaft at least 1/2 in. to protect the threads. In a pinch you can use a block of wood and a plastic mallet, but be careful that the pulley does not shift on its mountings while you're hammering. Or, you can use a large washer and a 7/16-20 x 4 in. bolt, but we suggest the tool.

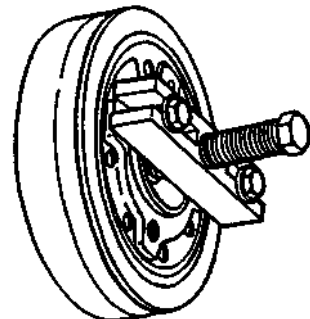


Fig. 42 Use a special tool to remove the damper

9. Install the retaining bolt and tighten it to 70-90 ft. lbs. (95-122 Nm). Squirt a little RTV sealant into the crankshaft keyway to guard against oil seepage.
10. Install the drive pulley and tighten the bolts to 22-32 ft. lbs (30-43 Nm).
11. Install the drive belts and make sure that they are adjusted properly.
12. Connect the battery cables.

Front Cover And Oil Seal

REMOVAL & INSTALLATION



◆ See Figures 43 and 44

■ This procedure may require engine removal, depending upon your particular boat. If necessary, remove the engine as detailed previously in this section.

■ It is not necessary to remove the front cover in order to remove the oil seal.

1. Open the drain valves and drain the coolant from the block and exhaust manifold. Loosen the alternator and power steering brackets (or the idler pulley) to provide slack, and then remove the drive belts.
2. Drain the oil if you haven't already done so.
3. Remove the alternator and power steering pump bracket bolts.
4. Remove the water circulation pump. The factory actually suggests that you can leave the pump on the cover, but we think removing it facilitates the process—either way will work, so you decide for yourself.
5. Remove the vibration damper and pulley as detailed previously in this section.
6. Remove the few oil pan-to-front cover bolts. Loosen the cover mounting bolts and pry the front cover outward slightly. Insert a razor knife between the cover and block so that it is flush with the inside of the cover and then carefully cut the oil pan gasket at each side of the cover.
7. Remove the cover.
8. If the oil seal needs replacement, position a seal remover tool (#T70P-6B070-B) over the seal and cover. Tighten the thru-bolts to force the puller under the flange and then tighten the puller bolts alternately until the seal is removed.
9. Remove the front cover gasket.

To Install:

10. Clean all gasket material from the cover and block mating surfaces with a scraper or putty knife. Be careful not to knock any pieces of gasket into the timing assembly.
11. If you removed the oil seal, coat a new one with Ford Multi-Purpose grease and insert it into the installation tool (#T70P-6B070-A). Position the seal and tool over the end of the crankshaft and push it forward until the seal starts seating itself into the cover. Screw the installation screw with its

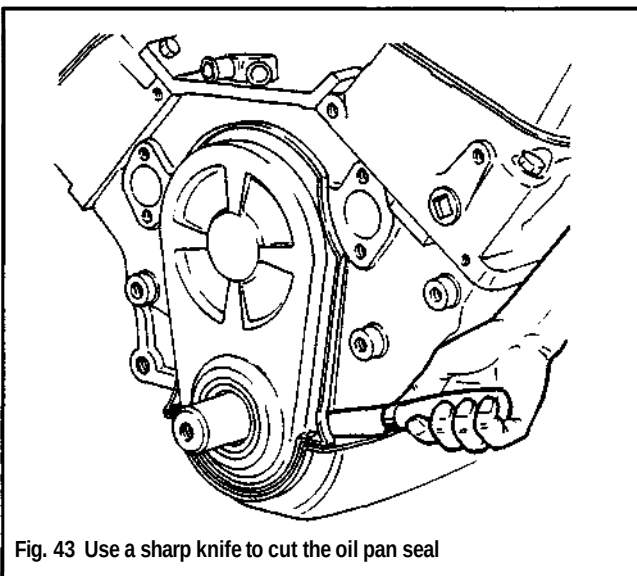


Fig. 43 Use a sharp knife to cut the oil pan seal

washer and nut into the end of the crank and then tighten the nut against the washer and sleeve while forcing the seal into the cover. Remove the tool and inspect the front edge of the seal for damage.

12. Take a new oil pan gasket and cut out a portion of it equal to that which you cut previously when removing the cover. Coat the oil pan mating surface with RTV sealer and carefully position the cut gasket into the flange. While you have the sealer out, run a small bead along the joints where the three (pan, cover and block) surfaces come in contact with one another.

13. Coat the lip of the oil seal with engine oil. Coat both sides of a new gasket with sealant and then position the gasket onto the engine. Install the cover so that all the bolt holes line up and then use an alignment tool (#T61P-6019-B) to ensure proper cover-to-block alignment. Coat the mounting bolt threads with Ford Perfect Seal and screw them in finger-tight. Push in on the alignment tool and tighten the cover-to-pan bolts to 9-11 ft. lbs. (13-14 Nm). Tighten the cover-to-block bolts to 12-18 ft. lbs. (17-24 Nm). Remove the tool.

14. Install the vibration damper and its pulley.

15. Install the circulation pump and its pulley (or just the pulley if you chose earlier to leave the pump attached to the cover). Pull the belts back on. Check their tension adjustment.

16. Install the engine if removed. Add oil and water/coolant, start the engine and check for any leaks.

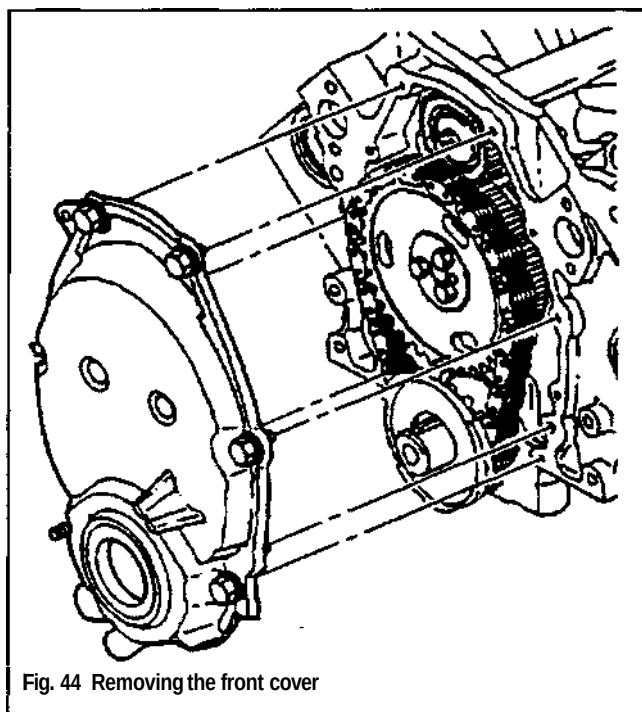


Fig. 44 Removing the front cover

Timing Chain And Sprockets

REMOVAL & INSTALLATION



◆ See Figures 45, 46 and 47

1. Disconnect the battery cables.
2. Remove the mounting bolts for the alternator and power steering pump brackets.
3. Remove the crankshaft pulley and harmonic balancer as previously detailed in this section.
4. Remove the front cover as previously detailed in this section.
5. Rotate the camshaft slightly so that it creates tension on one side of the timing chain (either side is OK). Find a reference point on the same side of the cylinder block as the side that the timing chain is tight on and then measure from this point to the outer edge of the chain.
6. Rotate the camshaft in the opposite direction until the other side of the chain is tight. Press the inner side of the chain outward until it stops and then measure from your reference point on the cylinder block (obviously, do

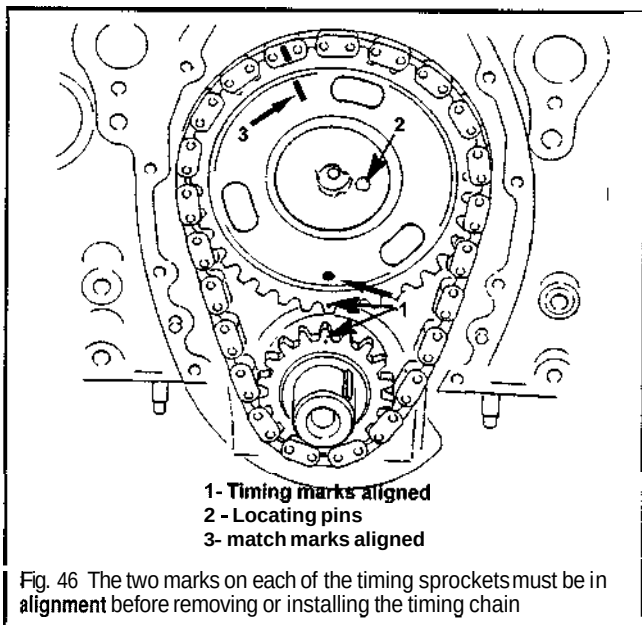
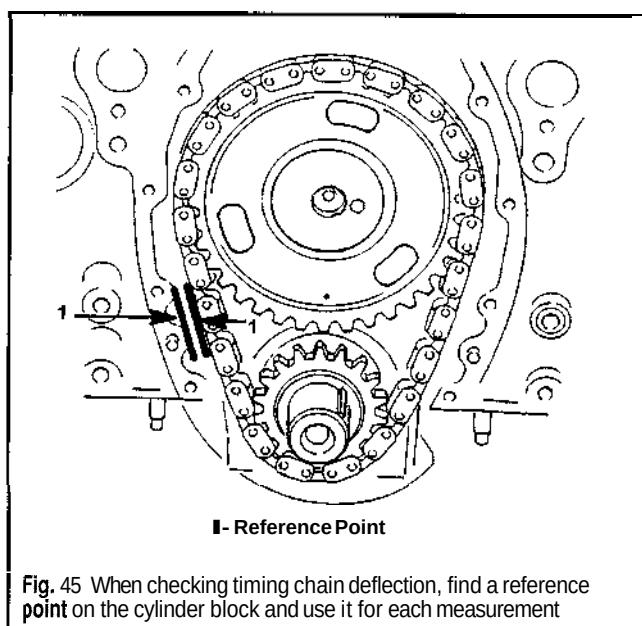
this from the same side of the chain as you did in the previous step) to the outer edge of the chain. This is timing chain deflection and it should be no more than 0.500 in. (12.7mm). If it is more than specification, the chain will require replacement.

7. Look carefully at the camshaft and crankshaft sprockets—you should notice a small indent on the front edge of one of the teeth on each sprocket (it may actually be at the base of the tooth on some sprockets). Bump the engine over until these two marks are in alignment as shown in the illustration—crank mark at 12:00 and cam mark at 6:00, a remote starter will work or you can screw the damper bolt back into the crankshaft and turn it with a wrench.

8. Dab a little paint across one of the chain links and the camshaft sprocket. Loosen the camshaft sprocket retaining bolt and remove it along with the fuel pump eccentrics. Grasp the two sprockets at top and bottom, with the chain still attached, and wiggle them off the shafts as an assembly. They should come off readily, but if not, tap the bottom edge lightly with a rubber mallet.

*** WARNING

Never rotate the crankshaft once the timing chain has been removed. If moved, you'll risk damage to the pistons and/or valve train.



To Install:

9. Clean the chain and sprockets in solvent and let them air dry. Check the chain for wear and damage, making sure there are no loose or cracked links. Check the sprockets for cracked or worn teeth.

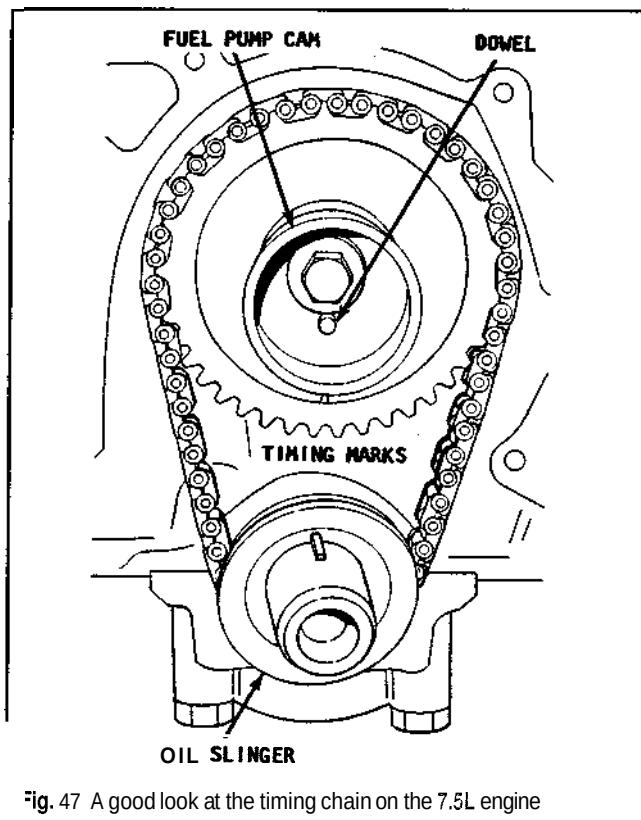
10. Install the timing chain onto the camshaft sprocket so that the paint marks made during removal match up. If they do, and you haven't moved the engine, the timing marks on the two sprockets should also. Hold the sprocket/chain in both hands so the chain is hanging down, engage the chain around the crankshaft sprocket making sure that the timing mark is pointing up, and then slide the assembly onto the two shafts making sure the dowel pin aligns with the hole in the camshaft sprocket. Do not force them!

11. Install the two-piece fuel pump eccentric and washer. Install the camshaft bolt and tighten it to 40-45 ft. lbs. (55-61 Nm).

*** CAUTION

Never force either of the sprockets onto their shafts or use a hammer.

12. Install the front cover, vibration damper and water pump pulley.
13. Install and adjust the drive belts.
14. Reconnect the alternator and power steering brackets.



Camshaft

CHECKING LIFT



◆ See Figures 48, 49 and 50

If the shaft is out of the engine, you can use a micrometer to take the heel-to-lobe measurement and the side-to-side measurement. Subtract the second measurement from the first to get lobe lift. Most times though, the shaft will still be in the cylinder block so perform the following procedure.

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■ Check each lobe consecutively, from front to back.

1. Tag and disconnect the electrical connectors at the ignition coil.
2. Remove the cylinder head cover and rocker arms as detailed previously.
3. Install a solid push rod into the bore, or use an adapter for ball end rods. Make sure that the rod is seated against the lifter, which is seated on the camshaft lobe.
4. Using a special adaptor, connect a dial indicator so that its tip is positioned on the end of the pushrod—the adaptor should screw onto the end of the rocker stud.
5. Slowly rotate the crankshaft in the direction of engine rotation until the valve lifter is riding on the heel (back side of lobe) of the camshaft lobe. The pushrod should be at its lowest point when the lifter is on the heel.

□ A remote starter works well for turning the engine over in this situation.

6. Set the indicator to 0 and then rotate the engine until the pushrod is at the highest point of its travel. Camshaft lift should be as detailed in the Engine Specifications chart.
7. Continue rotating the engine until the pushrod is back at its lowest position—make sure that the indicator still reads 0.
8. Repeat this procedure for the remaining pushrods.
9. Install the rocker arms and adjust the valve clearance.
10. Install the cylinder head cover and reconnect the coil leads.

REMOVAL & INSTALLATION



MODERATE

1. Remove the cylinder head covers and rocker assemblies as previously detailed in this section. Remove the pushrods.
2. Remove the intake manifold.
3. Remove the lifters. Match mark the lifters to their bores and then lift them out and store them in a rack with labels so they can be reinstalled in their original locations.
4. Remove the front cover and timing chain/sprockets as previously detailed in this section.
5. Remove the fuel pump and push rod.
6. Remove the thrust plate/retainer.
7. Thread the cap bolt back into the camshaft bolt hole and carefully pull the camshaft out of the cylinder block. You may have to wiggle it back and forth a bit, so be sure you don't lean it up or down or else you could damage the bearings. Do not cant the shaft while removing it.

To Install:

8. Inspect the camshaft as detailed previously.
9. Coat the camshaft journals with engine oil. Coat the camshaft lobes with engine oil.
10. Carefully insert the shaft into the cylinder block and slide it all the way in. Be very careful not to damage the bearings.

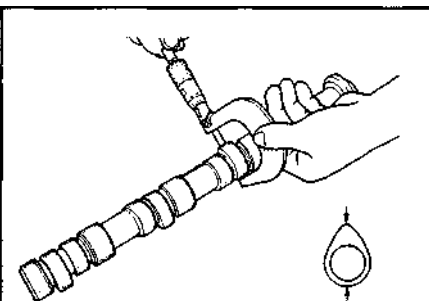


Fig. 48 Use a micrometer when checking the camshaft lift with the shaft out of the engine

Dimension A Minus
Dimension B Equals
The Cam Lobe Lift

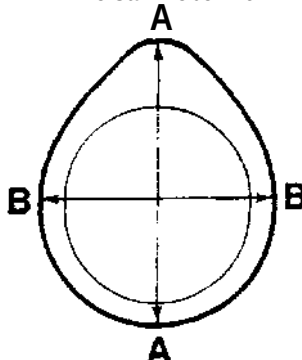


Fig. 49 Measure the camshaft lobe at these two points with the micrometer

11. Remove the installation bolt and install the thrust plate/retainer.
12. Install the sprockets, fuel pump eccentrics, timing chain and front cover.
13. Drop the lifters back into their original bores so that they are aligned with the match marks and then install the push rods.
14. Install the intake manifold.
15. Install the rocker assemblies and the cylinder head covers.

Cylinder Head

REMOVAL & INSTALLATION

◆ See Figure 51 and 52



1. Drain the water from the cylinder block and manifold.
2. Remove the fuel line support brackets. Disconnect the fuel line at the carburetor/throttle body and fuel pump, plug the fitting holes and remove the line.
3. Remove the cylinder head cover and rocker assemblies/push rods as detailed previously in this section.
4. Remove the intake and exhaust manifolds as previously detailed; you can leave the carburetor/throttle body attached to the intake manifold if you like.
5. If you intend to remove the valve lifters, now is the time to do it. Either way, make sure that you cover the valley of the cylinder block carefully with plenty of rags to prevent dirt from entering any of the passages or settling on any components.
6. Tag and disconnect the spark plug wires at the plugs; move them out of the way. Although not necessary, it's a good idea to remove the plugs themselves also; plug the holes if you do.
7. Remove or relocate any components or connections that may interfere with the removal of an individual cylinder head.
8. Loosen the cylinder head bolts in the reverse order of the illustrated tightening sequence and then carefully lift the head off the block. You may need to persuade it with a rubber mallet—be careful! Set the head down carefully on two support blocks; do not sit it on cement.

■ Its always a good idea to keep a record of which bolts came from which holes. It may sound silly, but on many engines they are different sizes and you wouldn't be the first person to break off a long bolt while tightening it in a short hole. Spend the extra few seconds and do this!

To Install:

9. Carefully, and thoroughly, remove all residual head gasket material from the cylinder head and block mating surfaces with a scraper or putty knife. Check that the mating surfaces are free of any nicks or cracks. Make sure there is no dirt or old gasket material in any of the bolt holes. Refer to the Engine Rebuilding section found for complete details on inspection and refurbishing procedures.

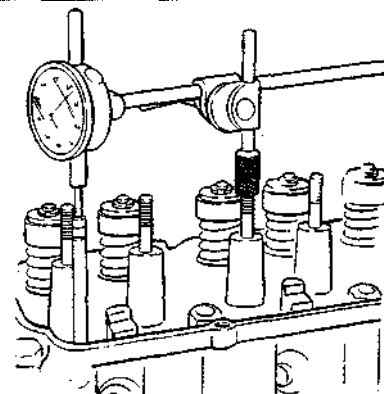


Fig. 50 Use a dial indicator when checking the camshaft lift with the shaft in the engine—typical

10. Inspect the head bolts on 5.0L engines. Engines may be equipped with one of two types of bolts. You may reuse all standard head bolts if this is what your engine has, but must replace any "torque-to-yield" bolts as shown in the accompanying illustration.

11. Position a new gasket over the cylinder block dowel pins. Do not use any sealer as the gasket is coated with a lacquer which will provide the proper sealing effect once the engine gets to normal operating temperature the first time. DO NOT use automotive-type steel gaskets. Many times the gasket will be marked, make sure the word UP is facing, you guessed it, 'up', if noted on your gasket.

12. Position the cylinder head over the dowels in the block. Install the head bolts finger tight. It never hurts to use new bolts, although it's not necessary (except as noted earlier).

13. Tighten the bolts, a little at a time, in the sequence illustrated, until the proper tightening torque is achieved.

- 1989-93 5.0L engines: the first step should be 50 ft. lbs. (68 Nm), the second step should be 60 ft. lbs. (81 Nm), the third step should be 65-70 ft. lbs. (88-95 Nm). In sequence.
- 1994-96 5.0L engines with standard bolts: the first step should be 55-65 ft. lbs. (75-88 Nm), the second step should be 65-72 ft. lbs. (88-98 Nm). In sequence.
- 1994-96 5.0L engines with "torque-to-yield bolts: tighten all the bolts, in sequence, to 25-35 ft. lbs. (34-47 Nm). Next, tighten them to 45-55 ft. lbs. (61-75 Nm). Finally, tighten all bolts an additional 85°-95° (114 turn). Obviously you will need a torque/angle meter for these last passes.
- 1989-93 5.8L engines: the first step should be 90 ft. lbs. (122 Nm), the second step should be 100 ft. lbs. (136 Nm), the third step should be 112 ft. lbs. (152 Nm). In sequence.
- 1994-96 5.8L engines: the first step, in sequence, should be 95-105 ft. lbs. (129-143 Nm), the second step should be 105-112 ft. lbs. (143-151 Nm).
- engines: the first step should be 80 ft. lbs. (108 Nm), the second step should be 110 ft. lbs. (149 Nm), the third step should be 135 ft. lbs. (184 Nm). In sequence,

14. Install the rocker assemblies and the cylinder head cover.

15. Install the manifolds and connect the fuel line. Don't forget to remove the fitting plugs.

16. Install the spark plugs if they were removed and then connect the plug wires.

17. Install or connect any other components removed to facilitate getting the head off.

18. Add coolant/water, connect the battery and check the oil. Start the engine and run it for a while to ensure that everything is operating properly. Keep an eye on the temperature gauge.

19. It never hurts to re-tighten the cylinder head bolts again after 20 hours of operation.

Engine Circulating Pump

REMOVAL & INSTALLATION

◆ See Figure 53



1. Disconnect the battery cables and then drain all water from the block and manifolds.
2. Drain all water/coolant from the cylinder block.
3. Loosen, but do not remove, the pump pulley mounting bolts.
4. Loosen the power steering pump and alternator bracket bolts and swivel them in until you are able to remove the belt(s). Different engines may have different systems, follow the belt back and loosen the appropriate components.
5. Now you can remove the pump pulley bolts along with the lock washers and clamping ring. Pull off the pulley.
6. Remove the two power steering pump bracket bolts, the brace from the alternator bracket, the Torx® retaining bolt and the pump.
7. Disconnect the large water hose at the pump.
8. Tag and disconnect the electrical leads at the alternator and move them out of the way. Remove the bracket bolts and lift off the alternator.
9. Remove the mounting bolts and lift the pump off of the block. There's a good chance you will need to persuade the pump—tap it lightly with a rubber mallet.

To Install:

10. Carefully scrape any old gasket material off both mounting surfaces. Inspect the pump for blockage, cracks or any other damage. Inspect the impeller for cracks. Replace either if necessary.
11. Coat both sides of a new gasket with sealant and position on the cylinder block. Make sure that all of the holes are lined up.
12. Position the pump and screw in all bolts except those that attach the alternator and power steering pump brackets. Tighten the bolts to 12-18 ft. lbs. (17-24 Nm).
13. Reconnect the water hoses and tighten the hose clamps securely.
14. Position the spacer and the Torx® bolt behind the rear power steering pump bracket and tighten it securely. Attach the other bracket to the pump and tighten the 2 bolts.
15. Install the alternator and tighten the bracket-to-pump bolts to 18-20 ft. lbs. (24-27 Nm).
16. Attach the steering pump brace to the alternator and tighten the bolt securely.
17. Position the pump pulley and clamping ring on the boss. Screw the mounting bolts and lock washers in and tighten them to 14-20 ft. lbs. (19-27 Nm).
18. Install the drive belt(s) and adjust them as detailed previously. Start the engine and check the system for leaks.

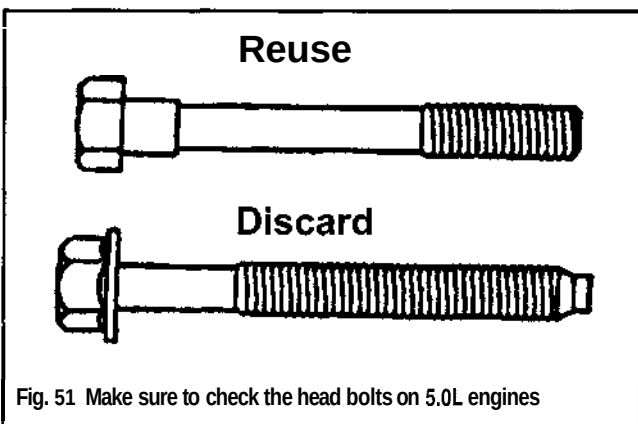


Fig. 51 Make sure to check the head bolts on 5.0L engines

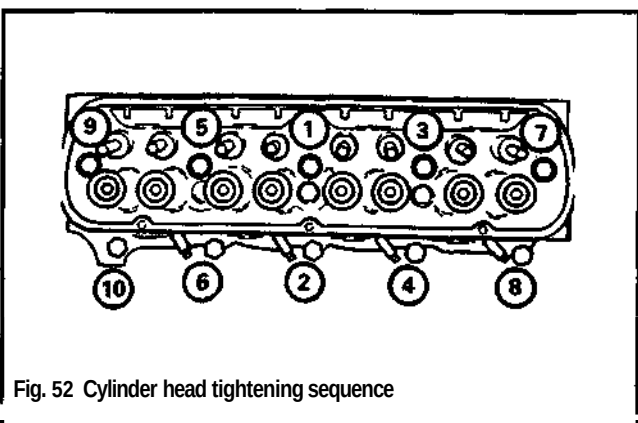


Fig. 52 Cylinder head tightening sequence

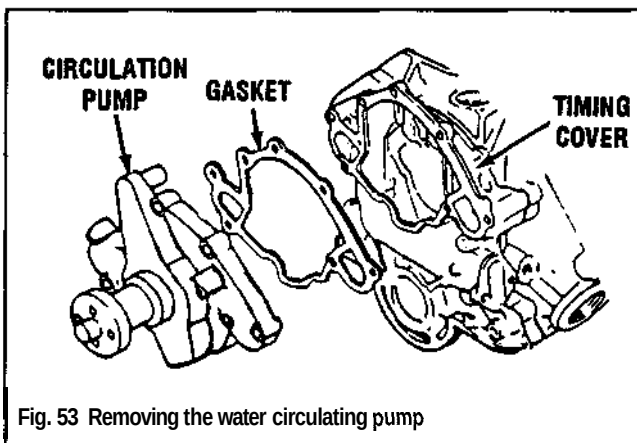
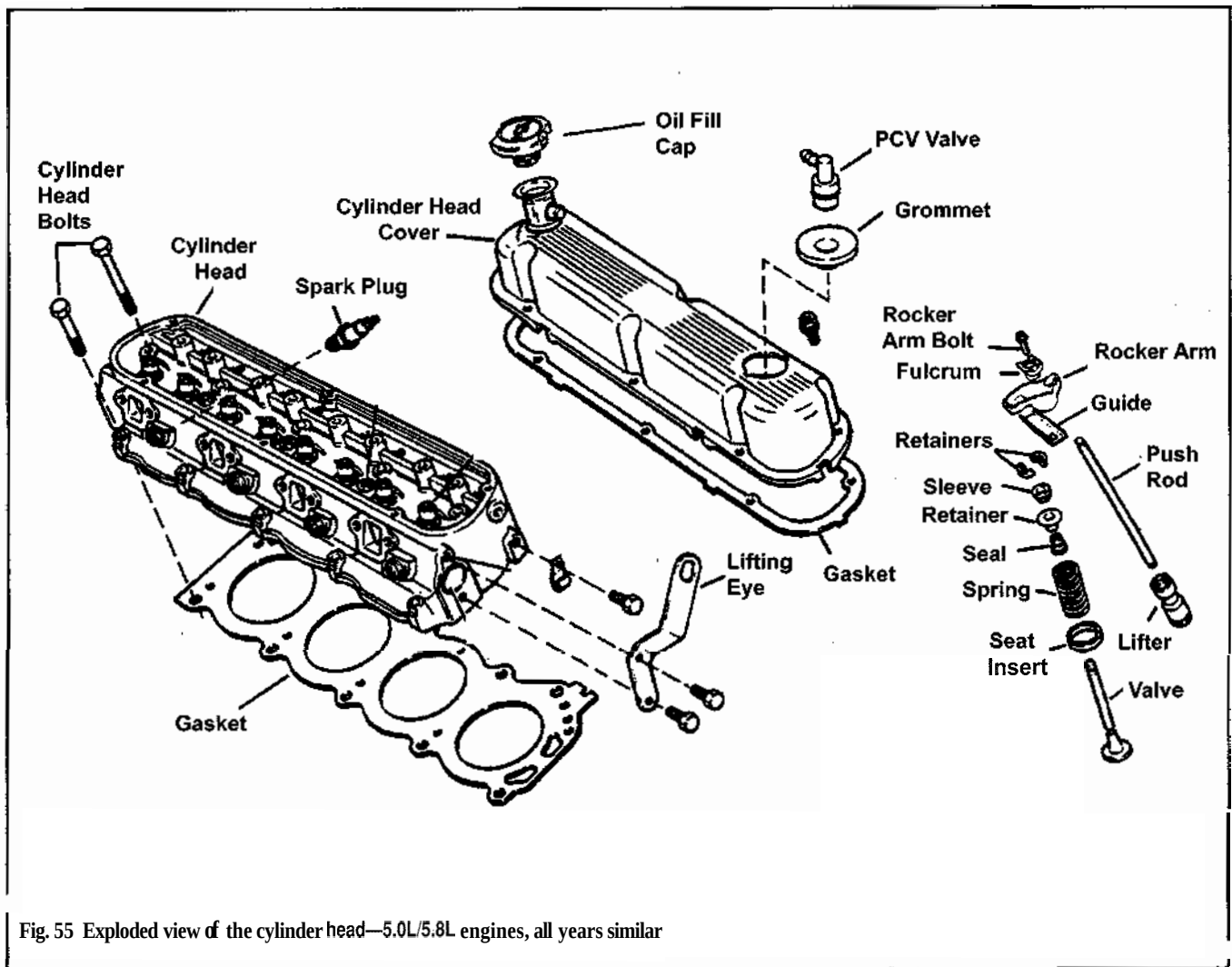


Fig. 53 Removing the water circulating pump

EXPLODED VIEWS



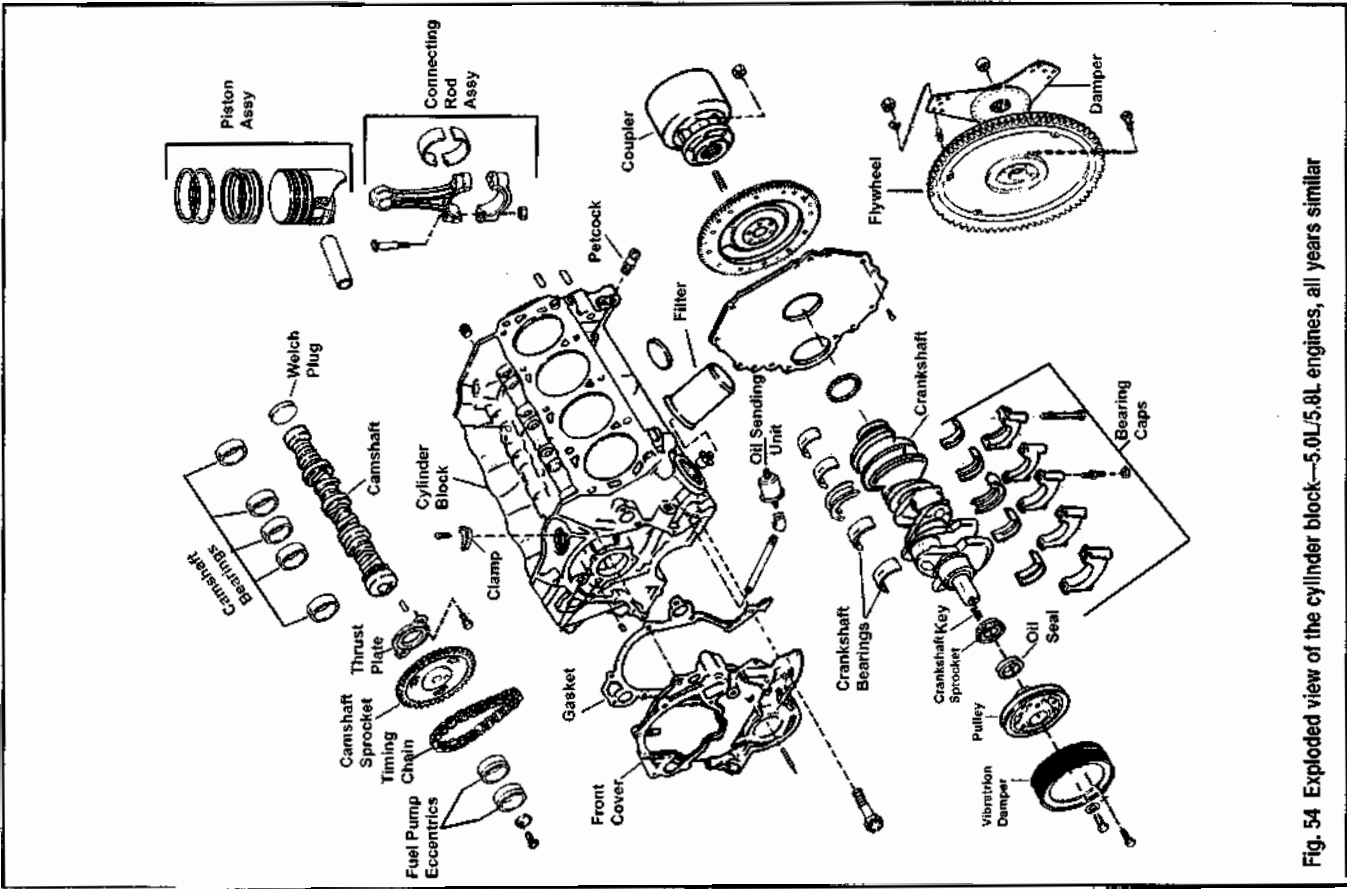


Fig. 54 Exploded view of the cylinder block—5.0L/5.8L engines, all years similar

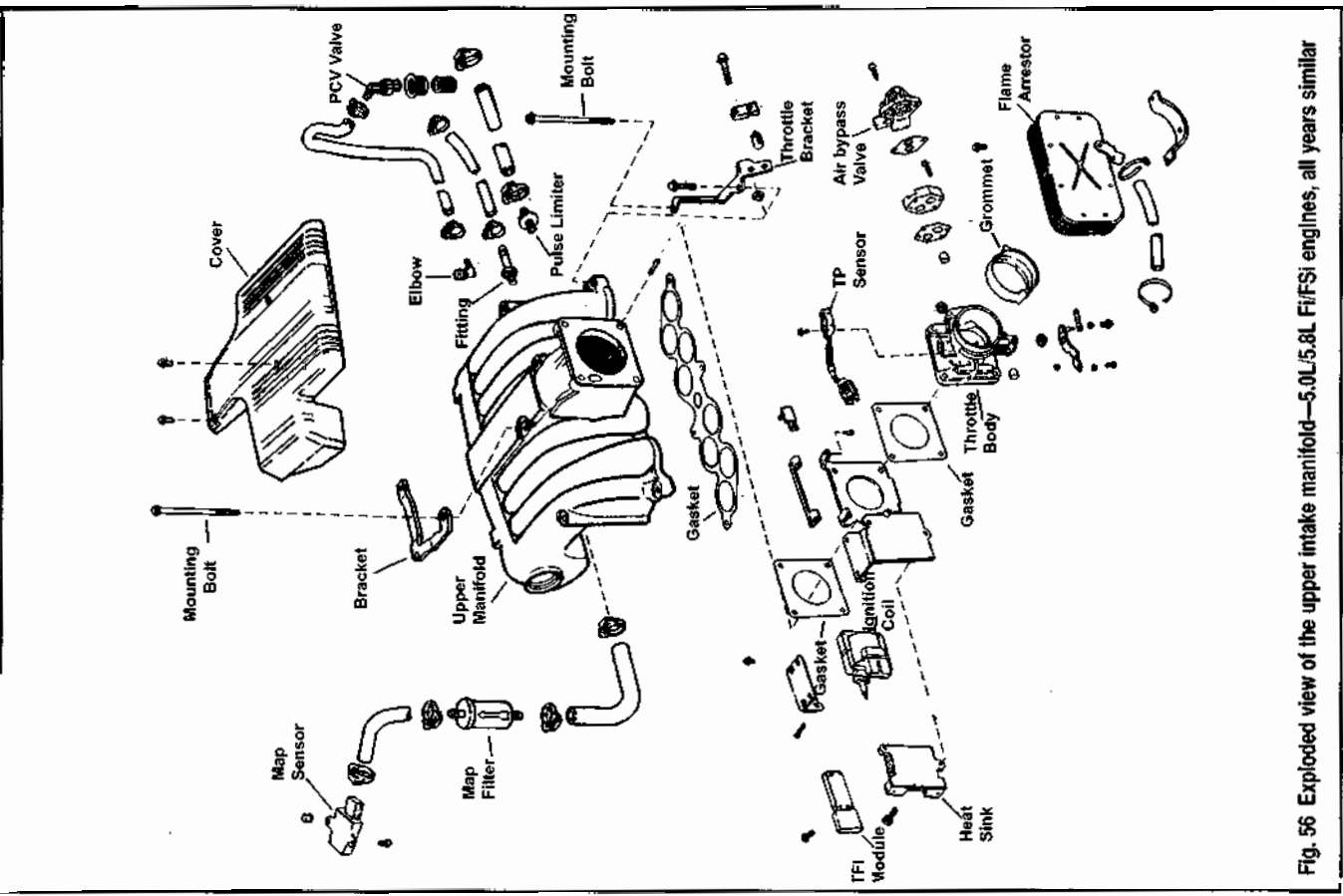


Fig. 56 Exploded view of the upper intake manifold—5.0L/5.8L FIFSI engines, all years similar

TORQUE SPECIFICATIONS					
Component			ft. lbs.	inch lbs.	Nm
Alternator	Bracket		18-20	-	24-27
Camshaft	Sprocket		40-45	-	55-61
Connecting Rod Cap	5.0L		19-24	-	26-33
	5.8L/7.5L		40-45	-	54-61
Coolant Temp Sender			18-22	-	24-30
Crankshaft	Main Bearing Cap				
		5.0L	60-70	-	81-95
		5.8L/7.5L	95-105	-	129-142
	Pulley Bolt		22-32	-	30-43
Cylinder Head	5.0L	1989-93	Step 1	50	68
			Step 2	60	81
			Step 3	65-70	8-95
		1994-96	Stretch Bolts		
			Step 1	25-35	34-47
			Step 2	45-55	61-75
			Step 3	1/4 turn	1/4 turn
		1994-96	Standard Bolts		
			Step 1	55-65	75-88
			Step 2	65-72	88-98
	5.8L	1989-93	Step 1	90	122
			Step 2	100	135
			Step 3	112	152
		1994-96	Step 1	95-105	129-143
			Step 2	105-112	143-151
	7.5L		Step 1	80	108
			Step 2	110	149
			Step 3	135	184
	Cover	1987-93	-	60-72	7-8
		1994-96	-	36-60	4-6
Cylinder Head Cover		1987-93	-	60-72	7-8
		1994-96	-	36-60	4-6
Engine Mounts	Front				
		5.0L/5.8L			
			To engine	32-40	43-54
			Top nut	40-50	54-60
				50-70	68-95
			Bolt/Lower Nut	60-75	81-102
		7.5L	To engine	32-40	43-54
			Top nut	100-120	136-163
			Locknut	28-30	38-40
	Rear		Mount	20-25	27-34
				12-14	16-20
				12-18	16-24
Exhaust Elbow	To Manifold	1987-90			
		1991-96			
Exhaust Manifold					
Exhaust Pipe					
Flywheel	Bellhousing	1987-91			
		1992-96			
	Coupler Nut		40-45 ①		54-61 ①
	Coupler Stud	1987-91			
		1992-96			
	cover		-	60-84	7-9

① 1992: 35-40 ft. lbs. (47-50)

Component		ft. lbs.	inch lbs.	Nm	
Front Cover	To Block	12-18	-	17-24	
	To Oil Pan	9-11	-	13-14	
Fuel Pump		18-20	-	24-27	
Intake Manifold	5.0L/5.8L	23-25 ①	-	31-34 ①	
	7.5L	25-27	-	34-40	
Main Bearing Cap	5.0L	60-70	-	81-95	
	5.8L/7.5L	95-105	-	129-142	
Manifolds	Exhaust	20-26	-	27-35	
	Intake	5.0L/5.8L	23-25 ②	31-34 ②	
	7.5L	25-27	-	34-40	
Oil Pan	Ft/Fsi	9-11	-	13-14	
	All others	-	84-108	10-12	
	5/16-18 Bolts	-	108-132	12-15	
Oil Pump	Cover	-	72-120	6-16	
	Inlet Tube To Bracket	10-15	-	14-20	
	Inlet Tube Bracket	22-32	-	30-43	
	Mounting Bolts	22-32	-	30-43	
Oil Pressure Sender	Sender/Adaptor	10-14	-	14-19	
Oil Withdrawal Tube (flare)		15-18	-	20-24	
Power Steering Pump	Bracket	26-30	-	35-41	
	Lines	Large Fitting	15-17	-	20-23
		Small Fitting	10-12	-	14-16
Rocker Arm		18-25	-	24-34	
Spark Plugs	5.0L/5.8L	1989-90	15-20	20-27	
		1991-95	5-10	7-13	
	7.5L	1996	10-15	14-20	
				5-10	7-11
Starter Motor	Bolts	24-30	-	33-41	
	Bracket	16-19	-	22-26	
Timing Chain Cover	To Block	12-18	-	17-24	
	To Oil Pan	9-11	-	13-14	
Torsional Damper		59	-	82	
Valve Cover	1987-93	-	60-72	7-8	
	1994-96	-	36-60	4-6	
Vibration Damper		70-90	-	95-122	
Water (Circulating) Pump	Mounting Bolts	12-18	-	17-24	
	Pulley	14-20	-	19-27	
Water Temperature Sender		18-22	-	24-30	

① Fi and FSi models: figure is for lower manifold; upper manifold - 12-18 ft. lbs. (16-24 Nm)

ENGINE SPECIFICATIONS - 5.0L/5.8L

Component	Standard (in.) ①	Metric (mm) ①
Cylinder Bore	Diameter	5.0L 4.0004-0.0052 101.61-101.73
	5.8L 4.0000-0.0048 101.60-101.72	
	Production	0.0015 Max 0.038 Max
	Service Limit	0.0015 Max 0.127 Max
Taper	Production	0.0015 Max 0.025 Max
	Service Limit	0.010 Max 0.254 Max
Cylinder Head	Surface Flatness	0.0018-0.0026 0.046-0.066
	0.003 (in 6 in.) 0.076 (in 153mm)	
Piston	Clearance	5.0L 3.9894-3.9900 101.58-101.58
	Diameter	Red 3.9898-4.0002 101.59-101.61
	Blue 0.003 Over	
	1989-91 4.0008-4.0014 101.62-101.64	
Piston Pin	Clearance	1992-96 4.0020-4.0026 101.65-101.67
	5.0L 3.9978-3.9984 101.54-101.56	
	Red 3.9990-3.9996 101.58-101.59	
	Blue 0.003 Over	
Piston Ring - Compression	Clearance	1989-91 4.0002-4.0008 101.61-101.62
	1992-96 4.0014-4.0020 101.64-101.65	
	5.0L 0.0002-0.0004 0.008-0.009	
	5.8L 0.0003-0.0005 0.0076-0.0127	
Piston Ring - Oil	Standard	0.0008 Max 0.0203 Max
	Diameter	0.9120-0.9123 23.164-23.172
	0.001 Over	0.9130-0.9133 23.190-23.197
	0.002 Over	0.9140-0.9143 23.216-23.223
Piston Rings - Valve system	Side Clearance	Production 0.002-0.004 0.051-0.102
	Service Limit	+0.002 Max +0.051 Max
	Gap	0.010-0.020 0.254-0.508
	Side clearance	Snug 0.381-1.337
Valve system	Gap	0.015-0.095 44 deg 44 deg
	Face Angle	Hydraulic 0.0007-0.0027 0.018-0.069
	Lifter	Clearance Production Service Limit 0.005 Max 0.127
Collapsed Gap	Production	5.0L 0.068-0.165 2.55 Max
	5.8L 0.123-0.173 3.12-4.39	
	Service Limit	5.0L 0.071-0.193 1.80-4.90
	5.8L 0.098-0.198 2.49-5.03	
Push Rod	Diameter	0.8740-0.8745 22.189-22.213
	Run Out	0.015 Max 0.381 Max
	Rocker Arm Lift Ratio	1.61:1
	Seat Angle	45 deg 45 deg
Spring Free Length	Intake	5.0L (1989-91) 0.080-0.080 1.52-2.03
	5.8L (1992-96) 1.94 49.28	
	5.0L (1995-96 EFI) 2.06 52.32	
	5.8L (1989-91) 2.06 52.32	
Total	Production	5.8L (1992-96) 2.056 52.22
	Service Limit	0.002 0.051
	0.0006 Max 0.015 Max	
	0.0006 Max 0.015 Max	

ENGINE SPECIFICATIONS - 5.0L/5.8L

Component	Standard (in.) ①	Metric (mm) ①
Camshaft	Bearing Clearance	Production 0.001-0.003 0.025-0.076
	Service Limit	0.006 0.152
	End Play	Production 0.001-0.007 0.025-0.178
	Service Limit	0.009 0.229
Journal Diameter	#1	2.0805-2.0815 52.845-52.870
	#2	2.0855-2.0865 52.464-52.489
	#3	2.0905-2.0915 52.083-52.108
	#4	2.0355-2.0365 51.702-51.727
Journal Out-of-Round	#5	2.0205-2.0215 51.321-51.346
	0.005 Max	0.127 Max
	5.0L (1989-91) 0.2303 5.85	
	5.0L (1992-93) 0.2375 6.033	
Lobe Lift	5.0L (1994-96) 0.26 6.804	
	5.0L 0.3 7.62	
	(1995-96 EFI) 0.26 6.804	
	5.0 HO 0.278 7.051	
Exhaust	5.8L 0.3 7.62	
	(1995-96 EFI) 0.238 6.045	
	5.0L (1989-91) 0.247 6.274	
	5.0L (1992-93) 0.278 7.061	
Intake	5.0L 0.3 7.62	
	(1995-96 EFI) 0.278 7.061	
	5.0 HO 0.283 7.188	
	5.8L 0.3 7.62	
Loss	(1995-96 EFI) 0.005 Max 0.127 Max	
	0.005 Max 0.127 Max	
	0.5 12.7	
	0.5 12.7	
Timing Chain Deflection	Production	0.0008-0.0015 0.020-0.038
	Service Limit	0.0008-0.0025 0.020-0.064
	5.0L 2.1228-2.1236 53.92-53.94	
	5.8L 2.3103-2.3111 58.68-58.70	
Bearing Clearance	Production	0.0006 MAX 0.015 Max
	Service Limit	0.010-0.020 0.25-0.51
	0.023 0.58	
	0.0006 MAX 0.015 Max	
Connecting Rod	Production #1	0.0001-0.0015 0.0025-0.0381
	Service Limit #2, 3, 4, 5	0.0005-0.0015 0.0127-0.0381
	0.0001-0.0020 0.0025-0.0508	
	0.0005-0.0024 0.0127-0.0610	
Crankshaft	Production	0.0008-0.0015 0.0203-0.0381
	Service Limit	0.0008-0.0026 0.0203-0.0660
	0.004-0.008 0.102-0.203	
	2.2482-2.2490 57.10-57.13	
Journal Diameter	5.0L 2.9894-3.0002 76.19-76.21	
	5.8L 0.0006 Max 0.015 Max	
	0.002 0.051	
	0.0006 Max 0.015 Max	
Out-of-round	Production	0.0006 Max 0.015 Max
	Service Limit	0.002 0.051
	0.0006 Max 0.015 Max	
	0.0006 Max 0.015 Max	
Taper	Production	0.0006 Max 0.015 Max
	Service Limit	0.002 0.051
	0.0006 Max 0.015 Max	
	0.0006 Max 0.015 Max	

ENGINE SPECIFICATIONS - 5.0L/5.8L

Component				Standard (in.) ①	Metric (mm) ①
Valve System (Cont'd)	Spring Free Length	Exhaust	5.0L (1989-91)	1.87	47.5
			5.0L (1992-96)	1.86	47.24
			5.0L (1995-96 EFI)	1.877	47.68
			5.8L (1989-91)	1.87	47.5
			5.8L (1992-96)	1.877	47.68
			5.8L (1995-96 EFI)	1.877	47.68
	Spring Assembled Ht.	Intake	5.0L (1989-91)	1.66-1.72	42.16-43.69
			5.0L (1992-93)	1.77-1.80	44.96-45.72
			5.0L (1994-96)	1.18	27.43
			5.0L (1995-96 EFI)	1.78	45.21
			5.8L (1989-91)	1.77-1.81	44.96-45.97
			5.8L (1992-93)	1.77-1.80	44.96-45.72
			5.8L (1994-96)	1.18	27.43
			5.8L (1995-96 EFI)	1.78	45.21
		Exhaust	5.0L (1989-91)	1.59-1.63	40.39-41.40
			5.0L (1992-93)	1.58-1.61	40.13-40.89
			5.0L (1994-96)	1.6	40.64
			5.8L (1989-91)	1.59-1.63	40.39-41.40
			5.8L (1992-93)	1.58-1.61	40.13-40.89
			5.8L (1994-96)	1.6	40.64
			5.8L (1995-96 EFI)	1.6	40.64
		Open	5.0L (1989-91)	190-210 lbs. @ 1.31	841-941 N @ 33.27
			5.0L (1992-93)	195-215 lbs. @ 1.15	867-956 N @ 29.21
			5.0L (1994-96)	194-214 lbs. @ 1.33	863-952 N @ 33.78
			5.0L (1995-96 EFI)	194-214 lbs. @ 1.33	863-952 N @ 33.78
			5.8L (1989-91)	190-210 lbs. @ 1.31	841-941 N @ 33.27
			5.8L (1992-93)	195-215 lbs. @ 1.15	867-956 N @ 29.21
			5.8L (1994-96)	208-228 lbs. @ 1.33	925-1014 N @ 33.78
			5.8L (1995-96 EFI)	194-214 lbs. @ 1.33	863-952 N @ 33.78
			5.0L (1989-91)	190-210 lbs. @ 1.31	841-941 N @ 33.27
			5.0L (1992-96)	195-215 lbs. @ 1.15	867-956 N @ 29.21
			5.8L (1989-91)	190-210 lbs. @ 1.31	841-941 N @ 33.27
			5.8L (1992-96)	195-215 lbs. @ 1.15	867-956 N @ 29.21
		Closed	5.0L (1989-91)	76-84 lbs. @ 1.69	340-376 N @ 42.92
			5.0L (1992-96)	74-82 lbs. @ 1.78	329-365 N @ 45.21
			5.8L (1992-96)	74-82 lbs. @ 1.78	329-365 N @ 45.21
			5.0L (1989-91)	76-84 lbs. @ 1.69	340-376 N @ 42.92
			5.0L (1992-96)	71-79 lbs. @ 1.60	318-353 N @ 40.64
			5.8L (1989-91)	71-79 lbs. @ 1.79	318-353 N @ 45.47
			5.8L (1992-96)	71-79 lbs. @ 1.60	318-353 N @ 40.64
			Service Limit	-10% @ Length	-10% @ Length
		Stem Diameter	Intake	0.3416-0.3423	8.677-8.694
			Exhaust	0.3411-0.3418	8.664-8.682
	Stem-to-Guide Clear.	Production	Intake	0.0010-0.0027	0.0254-0.0686
			Exhaust	0.0015-0.0032	0.038-0.081
		Wear Limit		0.0055	0.1397

ENGINE SPECIFICATIONS - 7.5L

Component			Standard (in.) ①	Metric (mm) ①
Camshaft	Bearing Clearance	Production	0.001-0.003	0.025-0.076
		Service Limit	0.006	0.152
	End Play	Production	0.001-0.006	0.025-0.152
		Service Limit	0.009	0.229
	Journal Diameter		2.1238-2.1248	53.95-53.97
	Journal Out-of-Round		0.0005 Max	0.0127 Max
	Lobe Lift	Intake	0.285	6.604
		Exhaust	0.29	7.061
		Loss	0.005 Max	0.127 Max
	Runout		0.005 Max	0.127 Max
	Timing Chain Deflection		0.5	12.7
Connecting Rod	Bearing Clearance	Production	0.0008-0.0015	0.020-0.038
		Service Limit	0.0008-0.0025	0.020-0.064
	Journal Diameter		2.4992-2.5000	63.48-63.50
	Out-of-round		0.0004 MAX	0.010 Max
	Side Clearance	Production	0.010-0.020	0.25-0.51
		Service Limit	0.023	0.58
	Taper		0.0004 MAX	0.010 Max
Crankshaft	Bearing Clearance	Production	0.0008-0.0015	0.020-0.038
		Service Limit #1	0.0008-0.0020	0.020-0.051
		#2,3,4,5	0.0008-0.0025	0.020-0.064
	Crankshaft End Play	Production	0.004-0.008	0.102-0.203
		Service Limit	0.012	0.31
	Journal Diameter		2.9994-3.0002	76.19-76.21
	Out-of-round	Production	0.0006 Max	0.015 Max
		Total	0.002	0.051
	Taper		0.0005 Max	0.012 Max
Cylinder Bore	Diameter		4.3600-4.3636	110.74-110.84
	Out-of-round	Production	0.0015 Max	0.038 Max
		Service Limit	0.005 Max	0.127 Max
	Taper	Production	0.001 Max	0.025 Max
		Service Limit	0.010 Max	0.254 Max
Cylinder Head	Surface Flatness		0.003 (in 6 in.)	0.076 (in 153mm)
Piston	Clearance		0.0022-0.0030	0.056-0.076
	Diameter	Red	4.3585-4.3591	110.71-110.72
Piston Pin	Clearance		0.0002-0.0005	0.006-0.0127
	Diameter	Standard	1.0398-1.0403	26.41-26.42
		0.001 Over	1.0410-1.0413	26.44-26.45
Piston Rings - Compression	Side Clearance	Production	0.002-0.004	0.051-0.102
		Service Limit	+0.006 Max	+0.152 Max
	Gap		0.010-0.020	0.254-0.508
Piston Rings - Oil	Side clearance		Snug	Snug
	Gap		0.010-0.035	0.254-0.889

ENGINE SPECIFICATIONS - 7.5L

Component		Standard (in.) ①	Metric (mm) ①
Valve system	Face Angle	44 deg.	44 deg.
	Lifter	Hydraulic	Hydraulic
	Clearance	Production	0.0007-0.0027
		Service Limit	0.005 Max
	Collapsed Gap	Production	1.905-4.445
		Service Limit	2.54-3.81
		Diameter	0.8740-0.8745
	Push Rod	Run Out	0.015 Max
	Rocker Arm Lift Ratio	1.73:1	1.73:1
	Seat Angle	45 deg.	45 deg.
	Seat Width	0.060-0.080	1.52-2.03
	Spring Free Length	2.06	52.32
	Spring Assembled Ht.	1.80-1.83	45.72-46.48
	Spring Pressure	Open	300-330 lbs. @ 1.32
		Closed	87-97 @ 1.82
		Service Limit	-10% @ Length
Stem Diameter	Intake	0.3416-0.3423	8.677-8.694
	Exhaust	0.3416-0.3423	8.677-8.694
Stem-to-Guide Clear.	Production	Intake	0.0010-0.0027
		Exhaust	0.0010-0.0027
	Wear Limit		0.0055

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7

ENGINE OVERHAUL

ENGINE RECONDITIONING 7-2

ENGINE RECONDITIONING

Determining Engine Condition

Anything that generates heat and/or friction will eventually burn or wear out (for example, a light bulb generates heat, therefore its life span is limited). With this in mind, a running engine generates tremendous amounts of both; friction is encountered by the moving and rotating parts inside the engine and heat is created by friction and combustion of the fuel. However, the engine has systems designed to help reduce the effects of heat and friction and provide added longevity. The oiling system reduces the amount of friction encountered by the moving parts inside the engine, while the cooling system reduces heat created by friction and combustion. If either system is not maintained, a break-down will be inevitable. Therefore, you can see how regular maintenance can affect the service life of your engine. If you do not drain, flush and refill your cooling system at the proper intervals, deposits will begin to accumulate, thereby reducing the amount of heat it can extract from the coolant. The same applies to your oil and filter; if it is not changed often enough it becomes laden with contaminants and is unable to properly lubricate the engine. This increases friction and wear.

There are a number of methods for evaluating the condition of your engine. A compression test can reveal the condition of your pistons, piston rings, cylinder bores, head gasket(s), valves and valve seats. An oil pressure test can warn you of possible engine bearing, or oil pump failures. Excessive oil consumption, evidence of oil in the engine air intake area and/or bluish smoke from the exhaust may indicate worn piston rings, worn valve guides and/or valve seals.

COMPRESSION TEST

◆ See Figure 1



Please refer also to the Maintenance section for details specific to your engine.

A noticeable lack of engine power, excessive oil consumption and/or poor fuel mileage measured over an extended period are all indicators of internal engine wear. Worn piston rings, scored or worn cylinder bores, blown head gaskets, sticking or burnt valves, and worn valve seats are all possible culprits. A check of each cylinder's compression will help locate the problem.

A screw-in type compression gauge is more accurate than the type you simply hold against the spark plug hole. Although it takes slightly longer to use, it's worth the effort to obtain a more accurate reading.

1. Make sure that the proper amount and viscosity of engine oil is in the crankcase, then ensure the battery is fully charged.
2. Warm-up the engine to normal operating temperature, then shut the engine OFF.
3. Disable the ignition system.
4. Label and disconnect all of the spark plug wires from the plugs.
5. Thoroughly clean the cylinder head area around the spark plug ports, then remove the spark plugs.
6. Set the throttle plate to the fully open (wide-open throttle) position. You can block the throttle linkage open for this, or you can have an assistant operate the throttle lever in the boat.
7. Install a screw-in type compression gauge into the No. 1 spark plug hole until the fitting is snug.

*** WARNING

Be careful not to cross-thread the spark plug hole.

8. According to the tool manufacturer's instructions, connect a remote starting switch to the starting circuit.
9. With the ignition switch in the OFF position, use the remote starting switch to crank the engine through at least five compression strokes (approximately 5 seconds of cranking) and record the highest reading on the gauge.
10. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes and/or time as the first.
11. Compare the highest readings from each cylinder to that of the others. The indicated compression pressures are considered within specifications if the lowest reading cylinder is within 75 percent of the

pressure recorded for the highest reading cylinder. For example, if your highest reading cylinder pressure was 150 psi (1034 kPa), then 75 percent of that would be 113 psi (779 kPa). So the lowest reading cylinder should be no less than 113 psi (779 kPa).

11. If a cylinder exhibits an unusually low compression reading, pour a tablespoon of clean engine oil into the cylinder through the spark plug hole and repeat the compression test. If the compression rises after adding oil, it means that the cylinder's piston rings and/or cylinder bore are damaged or worn. If the pressure remains low, the valves may not be seating properly (a valve job is needed), or the head gasket may be blown near that cylinder. If compression in any two adjacent cylinders is low, and if the addition of oil doesn't help raise compression, there is leakage past the head gasket. Oil and coolant in the combustion chamber, combined with blue or constant white smoke from the exhaust, are symptoms of this problem. However, don't be alarmed by the normal white smoke emitted from the exhaust during engine warm-up or from cold weather operation. There may be evidence of water droplets on the engine dipstick and/or oil droplets in the cooling system if a head gasket is blown.

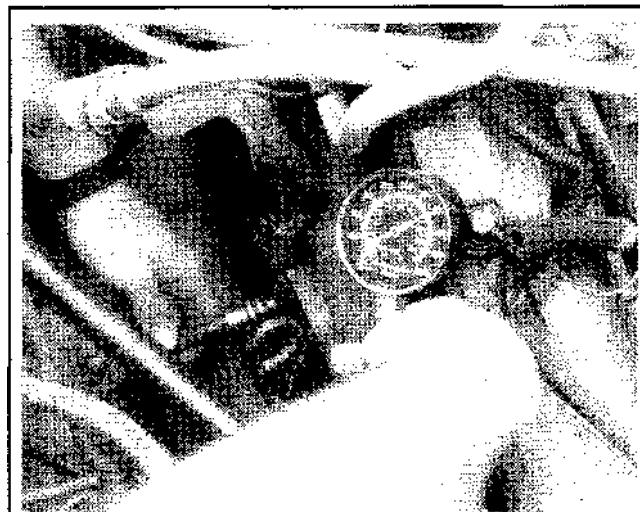


Fig. 1 A screw-in type compression gauge is more accurate and easier to use without an assistant

OIL PRESSURE TEST



Check for proper oil pressure at the sending unit passage with an** externally mounted mechanical oil pressure gauge (as opposed to relying on a factory installed dash-mounted gauge). A tachometer may also be needed, as some specifications may require running the engine at a specific rpm.

1. With the engine cold, locate and remove the oil pressure sending unit.
 2. Following the manufacturer's instructions, connect a mechanical oil pressure gauge and, if necessary, a tachometer to the engine.
 3. Start the engine and allow it to idle.
 4. Check the oil pressure reading when cold and record the number. You may need to run the engine at a specified rpm, so check the specifications.
 5. Run the engine until normal operating temperature is reached.
 6. Check the oil pressure reading again with the engine hot and record the number. Turn the engine OFF.
 7. Compare your hot oil pressure reading to that given in the chart. If the reading is low, check the cold pressure reading against the chart. If the cold pressure is well above the specification, and the hot reading was lower than the specification, you may have the wrong viscosity oil in the engine. Change the oil, making sure to use the proper grade and quantity, then repeat the test.
- Low oil pressure readings could be attributed to internal component wear, pump related problems, a low oil level, or oil viscosity that is too low. High oil pressure readings could be caused by an overfilled crankcase, too high of an oil viscosity or a faulty pressure relief valve.

Buy or Rebuild?

Now that you have determined that your engine is worn out, you must make some decisions. The question of whether or not an engine is worth rebuilding is largely a subjective matter and one of personal worth. Is the engine a popular one, or is it an obsolete model? Are parts available? Will it get acceptable gas mileage once it is rebuilt? Is the vessel it's being put into worth keeping? Would it be less expensive to buy a new engine, have your engine rebuilt by a pro, rebuild it yourself or buy a used engine? Or would it be simpler and less expensive to buy another boat? If you have considered all these matters and more, and have still decided to rebuild the engine, then it is time to decide how you will rebuild it.

The editors feel that most engine machining should be performed by a professional machine shop. Don't think of it as wasting money, rather, as an assurance that the job has been done right the first time. There are many expensive and specialized tools required to perform such tasks as boring and honing an engine block or having a valve job done on a cylinder head. Even inspecting the parts requires expensive micrometers and gauges to properly measure wear and clearances. Also, a machine shop can deliver to you clean, and ready to assemble parts, saving you time and aggravation. Your maximum savings will come from performing the removal, disassembly, assembly and installation of the engine and purchasing or renting only the tools required to perform the above tasks. Depending on the particular circumstances, you may save 40 to 60 percent of the cost doing these yourself.

A complete rebuild or overhaul of an engine involves replacing all of the moving parts (pistons, rods, crankshaft, camshaft, etc.) with new ones and machining the non-moving wearing surfaces of the block and heads. Unfortunately, this may not be cost effective. For instance, your crankshaft may have been damaged or worn, but it can be machined undersize for a minimal fee.

So, as you can see, you can replace everything inside the engine, but, it is wiser to replace only those parts which are really needed, and, if possible, repair the more expensive ones. Later we will break the engine down into its two main components: the cylinder head and the engine block. We will discuss each component, and the recommended parts to replace during a rebuild on each.

Engine Overhaul Tips

Most engine overhaul procedures are fairly standard. In addition to specific parts replacement procedures and specifications for your individual engine, this is also a guide to acceptable rebuilding procedures. Examples of standard rebuilding practice are given and should be used along with specific details concerning your particular engine; which are found in the Engine Mechanical section.

Competent and accurate machine shop services will ensure maximum performance, reliability and engine life. In most instances it is more profitable for the do-it-yourself mechanic to remove, clean and inspect the component, buy the necessary parts and deliver these to a shop for actual machine work.

Much of the assembly work (crankshaft, bearings, piston rods, and other components) is well within the scope of the do-it-yourself mechanic's tools and abilities. You will have to decide for yourself the depth of involvement you desire in an engine repair or rebuild.

TOOLS

The tools required for an engine overhaul or parts replacement will depend on the depth of your involvement. With a few exceptions, they will be the tools found in a mechanic's tool kit. More in-depth work will require some or all of the following:

- A dial indicator (reading in thousandths) mounted on a universal base
- Micrometers and telescope gauges
- Jaw and screw-type pullers
- Scraper
- Valve spring compressor
- Ring groove cleaner
- Piston ring expander and compressor
- Ridge reamer
- Cylinder hone or glaze breaker
- Plastigage®
- Engine stand

The use of most of these tools is illustrated in the procedures. Many can be rented for a one-time use from a local parts jobber or tool supply house specializing in marine or automotive work.

Occasionally, the use of special tools is called for. See the information on Special Tools and the Safety Notice in the front of this manual before substituting another tool.

OVERHAUL TIPS

Aluminum has become extremely popular for use in engines, due to its low weight. Observe the following precautions when handling aluminum parts:

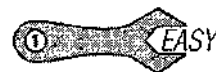
- Never hot tank aluminum parts (the caustic hot tank solution will eat the aluminum).
- Remove all aluminum parts (identification tag, etc.) from engine parts prior to the tanking.
- Always coat threads lightly with engine oil or anti-seize compounds before installation, to prevent seizure.
- Never over-tighten bolts or spark plugs especially in aluminum threads.

When assembling the engine, any parts that will be exposed to frictional contact must be pre-lubed to provide lubrication at initial start-up. Any product specifically formulated for this purpose can be used, but engine oil is not recommended as a pre-lube in most cases.

When semi-permanent (locked, but removable) installation of bolts or nuts is desired, threads should be cleaned and coated with Loctite® or another similar, commercial non-hardening marine sealant.

CLEANING

◆ See Figures 2, 3, 4 and 5



Before the engine and its components are inspected, they must be thoroughly cleaned. You will need to remove any engine varnish, oil sludge and/or carbon deposits from all of the components to insure an accurate inspection. A crack in the engine block or cylinder head can easily become overlooked if hidden by a layer of sludge or carbon.

Most of the cleaning process can be carried out with common hand tools and readily available solvents or solutions. Carbon deposits can be chipped away using a hammer and a hard wooden chisel. Old gasket material and varnish or sludge can usually be removed using a scraper and/or cleaning solvent. Extremely stubborn deposits may require the use of a power drill with a wire brush. If using a wire brush, use extreme care around any critical machined surfaces (such as the gasket surfaces, bearing saddles, cylinder bores, etc.). Use of a wire brush is NOT RECOMMENDED on any aluminum components. Always follow any safety recommendations given by the manufacturer of the tool and/or solvent. You should always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

An alternative to the mess and hassle of cleaning the parts yourself is to drop them off at a local marina or machine shop (or even an automotive garage). They will, more than likely, have the necessary equipment to properly clean all of the parts for a nominal fee.



Fig. 2 Use a gasket scraper to remove the old gasket material from the mating surfaces

7-4 ENGINE OVERHAUL

✖ ✖ CAUTION

Always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

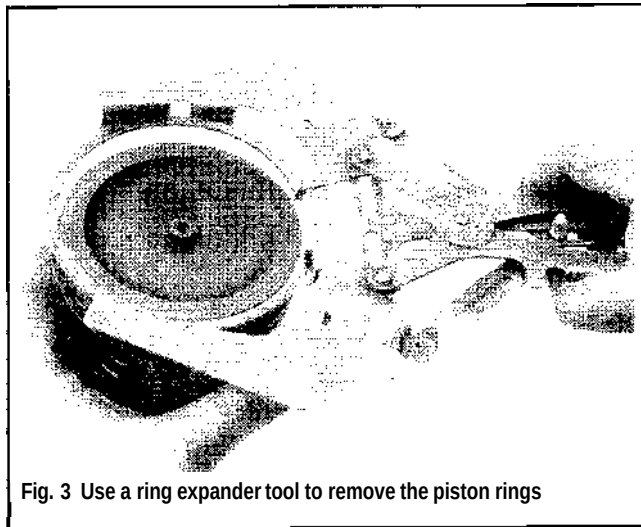


Fig. 3 Use a ring expander tool to remove the piston rings

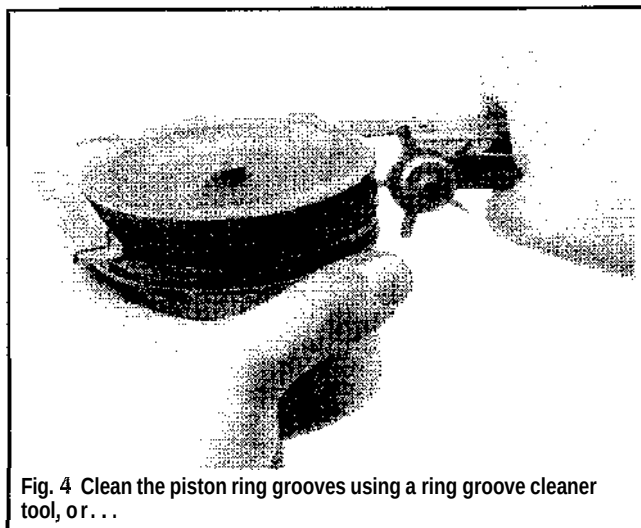


Fig. 4 Clean the piston ring grooves using a ring groove cleaner tool, or...



Fig. 5 ... use a piece of an old ring to clean the grooves. Be careful, the ring can be quite sharp

Remove any oil galley plugs, freeze plugs and/or pressed-in bearings and carefully wash and degrease all of the engine components including the fasteners and bolts. Small parts such as the valves, springs, etc., should be placed in a metal basket and allowed to soak. Use pipe cleaner type brushes, and clean all passageways in the components. Use a ring expander and remove the rings from the pistons. Clean the piston ring grooves with a special tool or a piece of broken ring. Scrape the carbon off of the top of the piston. You should never use a wire brush on the pistons. After preparing all of the piston assemblies in this manner, wash and degrease them again.

✖ ✖ WARNING

Use extreme care when cleaning around the cylinder head valve seats. A mistake or slip may cost you a new seat.

When cleaning the cylinder head, remove carbon from the combustion chamber with the valves installed. This will avoid damaging the valve seats.

REPAIRING DAMAGED THREADS



◆ See Figures 6, 7, 8, 9 and 10

Several methods of repairing damaged threads are available. Heli-Coil® (shown here), Keenserts® and Microdot® are among the most widely used. All involve basically the same principle — drilling out stripped threads, tapping the hole and installing a pre-wound insert — making welding, plugging and oversize fasteners unnecessary.

Two types of thread repair inserts are usually supplied: a standard type for most inch coarse, inch fine, metric coarse and metric fine thread sizes and a spark plug type to fit most spark plug port sizes. Consult the individual tool manufacturer's catalog to determine exact applications. Typical thread repair kits will contain a selection of pre-wound threaded inserts, a tap (corresponding to the outside diameter threads of the insert) and an installation tool. Spark plug inserts usually differ because they require a tap equipped with pilot threads and a combined reamer/tap section. Most manufacturers also supply blister-packed thread repair inserts separately in addition to a master kit containing a variety of taps and inserts plus installation tools.

Before attempting to repair a threaded hole, remove any snapped, broken or damaged bolts or studs. Penetrating oil can be used to free frozen threads. The offending item can usually be removed with locking pliers or using a screw/stud extractor. After the hole is clear, the thread can be repaired, as shown in the series of accompanying illustrations and in the kit manufacturer's instructions.

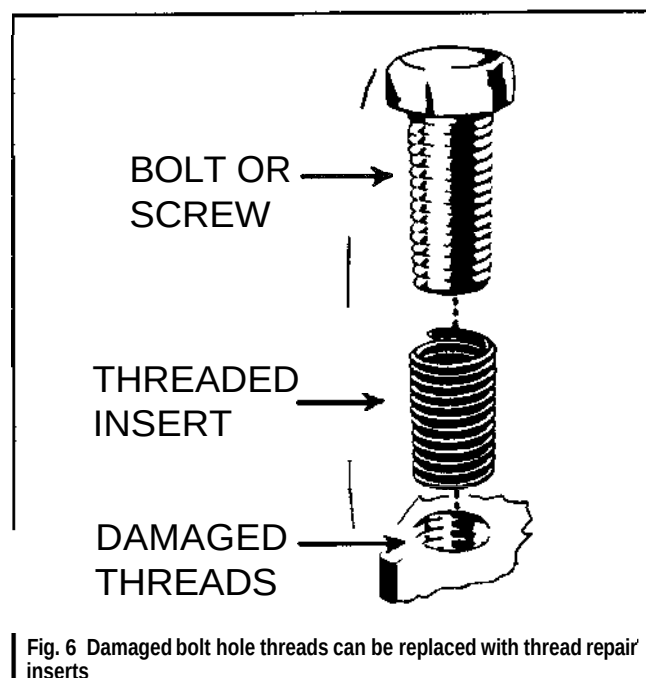


Fig. 6 Damaged bolt hole threads can be replaced with thread repair inserts

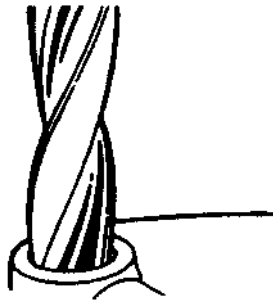


Fig. 7 Drill out the damaged threads with the specified size bit. Be sure to drill completely through the hole or to the bottom of a blind hole

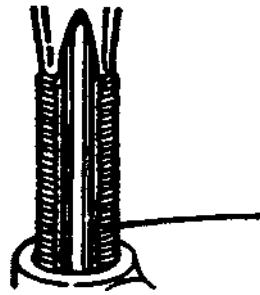


Fig. 8 Using the kit, tap the hole in order to receive the thread insert. Keep the tap well oiled and back it out frequently to clean out the chips

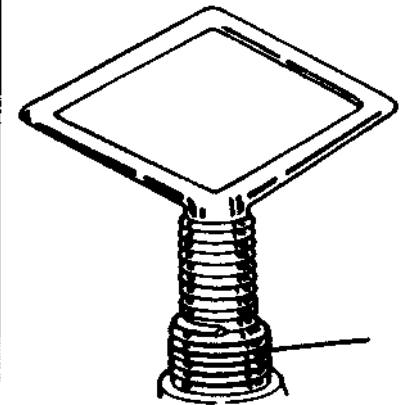


Fig. 9 Screw the insert onto the installer tool until the tang engages the slot. Thread the insert into the hole until it is **114-112** turn below the top surface, then remove the tool and break off the tang using a punch

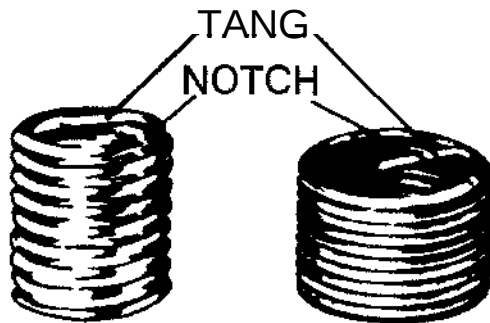


Fig. 10 Standard thread repair insert (left), and spark plug thread insert

Engine Preparation

To properly rebuild an engine, you must first remove it from the vessel, then disassemble and diagnose it. Ideally you should place your engine on an engine stand. This affords you the best access to the engine components. Follow the manufacturer's directions for using the stand with your particular engine. Remove the flywheel or coupler before installing the engine to the stand.

Now that you have the engine on a stand, and assuming that you have drained the oil and water/coolant from the engine, it's time to strip it of all but the necessary components. Before you start disassembling the engine, you may want to take a moment to draw some pictures, or fabricate some labels or containers to mark the locations of various components and the bolts and/or studs which fasten them. Modern day engines use a lot of little brackets and clips which hold wiring harnesses and such, and these holders are often mounted on studs and/or bolts that can be easily mixed up. The manufacturer spent a lot of time and money designing your engine/boat, and they wouldn't have wasted any of it by haphazardly placing brackets, clips or fasteners on the boat. If it's present when you disassemble it, put it back when you assemble, you will regret not remembering that little bracket which holds a wire harness out of the path of a rotating part.

You should begin by unbolting any accessories still attached to the engine, such as the water pump, power steering pump, alternator, etc. Then, unfasten any manifolds (intake or exhaust) which were not removed during the engine removal procedure. Finally, remove any covers remaining on the engine such as the rocker arm, front or timing cover and oil pan. Some front covers may require the balancer and/or crank pulley to be removed beforehand. The idea is to reduce the engine to the bare necessities (cylinder head(s), valve train, engine block, crankshaft, pistons and connecting rods), plus any other 'in block' components such as oil pumps, balance shafts and auxiliary shafts.

Finally, remove the cylinder head(s) from the engine block and carefully place on a bench. Disassembly instructions for each component follow later.

Cylinder Head

There are two basic types of cylinder heads used on today's engines: Overhead Valve (OHV) and the Overhead Camshaft (OHC). The latter can also be broken down into two subgroups: the Single Overhead Camshaft (SOHC) and the Dual Overhead Camshaft (DOHC). Generally, if there is only a single camshaft on a head, it is just referred to as an OHC head. An engine with an OHV cylinder head is also known as a pushrod engine.

Most cylinder heads these days are made of an aluminum alloy due to its light weight, durability and heat transfer qualities. However, cast iron was the material of choice in the past, and is still used on many engines today. Whether made from aluminum or iron, all cylinder heads have valves and seats. Most use two valves per cylinder, while the more hi-tech engines will utilize a multi-valve configuration using 3, 4 and even 5 valves per cylinder. When the valve contacts the seat, it does so on precision machined surfaces, which seals the combustion chamber. All cylinder heads have a valve guide for each valve. The guide centers the valve to the seat and allows it to move up and down within it. The clearance between the valve and guide can be critical. Too much clearance and the engine may consume oil, lose vacuum and/or damage the seat. Too little, and the valve can stick in the guide causing the engine to run poorly if at all, and possibly causing severe damage. The last component all cylinder heads have in common are valve springs. The spring holds the valve against its seat. It also returns the valve to this position when the valve has been opened by the valve train or camshaft. The spring is fastened to the valve by a retainer and valve locks (sometimes called keepers). Aluminum heads will also have a valve spring shim to keep the spring from wearing away the aluminum.

An ideal method of rebuilding the cylinder head would involve replacing all of the valves, guides, seats, springs, etc. with new ones. However, depending on how the engine was maintained, often this is not necessary. A major cause of valve, guide and seat wear is an improperly tuned engine. An engine that is running too rich, will often wash the lubricating oil out of the guide with gasoline, causing it to wear rapidly. Conversely, an engine which is running too lean will place higher combustion temperatures on the valves and seats allowing them to wear or even burn. Springs fall victim to the operating habits of the individual. A driver who often runs the engine rpm to the redline will wear out or break the springs faster than one that stays well below it. Unfortunately, 'hours of operation' takes it toll on all of the parts. Generally, the valves, guides, springs and seats in a cylinder head can be machined and re-used, saving you money. However, if a valve is burnt, it may be wise to replace all of the valves, since they were all operating in the same environment. The same goes for any other component on the cylinder head. Think of it as an insurance policy against future problems related to that component.

Unfortunately, the only way to find out which components need replacing, is to disassemble and carefully check each piece. After the cylinder head(s) are disassembled, thoroughly clean all of the components.

7-6 ENGINE OVERHAUL

DISASSEMBLY

OHV Heads



◆ See Figures 11 through 22

Before disassembling the cylinder head, you may want to fabricate some containers to hold the various parts, as some of them can be quite small (such as keepers) and easily lost. Also keeping yourself and the components organized will aid in assembly and reduce confusion. Where possible, try to maintain a components' original location; this is especially important if there is not going to be any machine work performed on the components.

1. If you haven't already removed the rocker arms and/or shafts, do so now.
2. Position the head so that the springs are easily accessed.
3. Use a valve spring compressor tool, and relieve spring tension from the retainer.

Due to engine varnish, the retainer may stick to the valve locks. A gentle tap with a hammer may help to break it loose.

4. Remove the valve locks from the valve tip and/or retainer. A small magnet may help in removing the locks.
5. Lift the valve spring(s), tool and all, off of the valve stem.
6. Remove the valve seal from the stem and guide. If the seal is difficult to remove with the valve in place, try removing the valve first, then the seal. Follow the steps below for valve removal.
7. Position the head to allow access for withdrawing the valve.

■ **Cylinder heads that have seen a lot of hours and/or abuse may have mushroomed the valve lock groove and/or tip, causing difficulty in removal of the valve. If this has happened, use a metal file to carefully remove the high spots around the lock grooves and/or tip. Only file it enough to allow removal.**

8. Remove the valve from the cylinder head.
9. If equipped, remove the valve spring shim. A small magnetic tool or screwdriver will aid in removal.
10. Repeat Steps 3 through 9 until all of the valves have been removed



Fig. 11 When removing a valve spring, use a compressor tool to relieve the tension from the retainer...

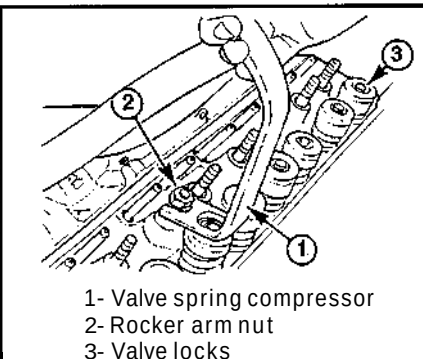


Fig. 12 ...you may also find a compressor that looks like this

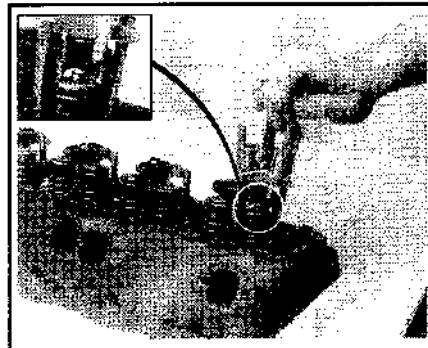


Fig. 13 A small magnet will help in removal of the valve locks



Fig. 14 Be careful not to lose the small valve locks (keepers)



Fig. 15 Remove the valve seal from the valve stem—O-ring type seal shown



Fig. 16 Removing an umbrella type seal



Fig. 17 Invert the cylinder head and withdraw the valve from the valve guide bore

INSPECTION

Now that all of the cylinder head components are clean, it's time to inspect them for wear and/or damage. To accurately inspect them, you will need some specialized tools:

- A 0–1 in. micrometer for the valves
- A dial indicator or inside diameter gauge for the valve guides
- A spring pressure test gauge

If you do not have access to the proper tools, you may want to bring the components to a shop that does.

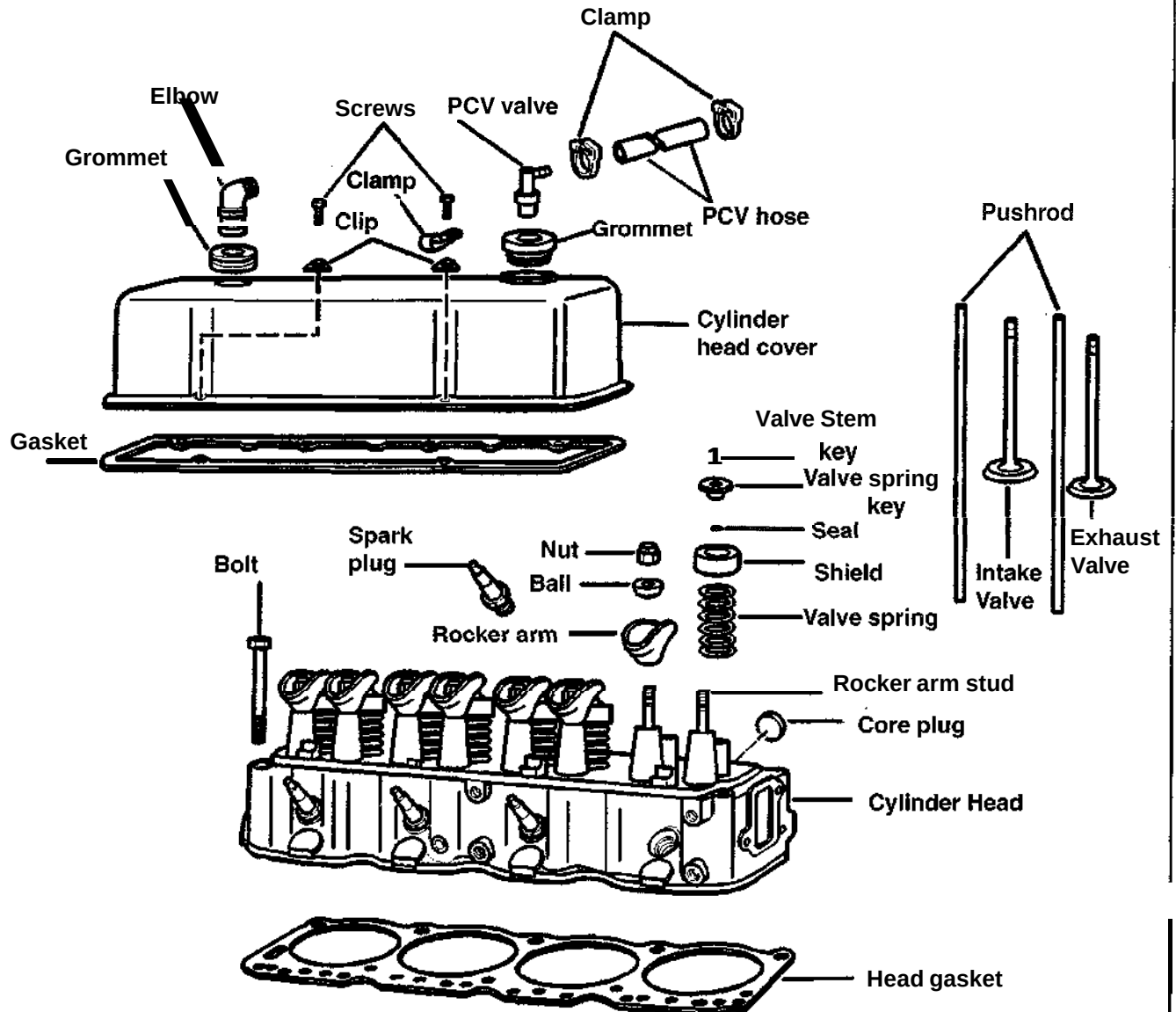


Fig. 18 Exploded view of the cylinder head—3.0L 4 cylinder engines

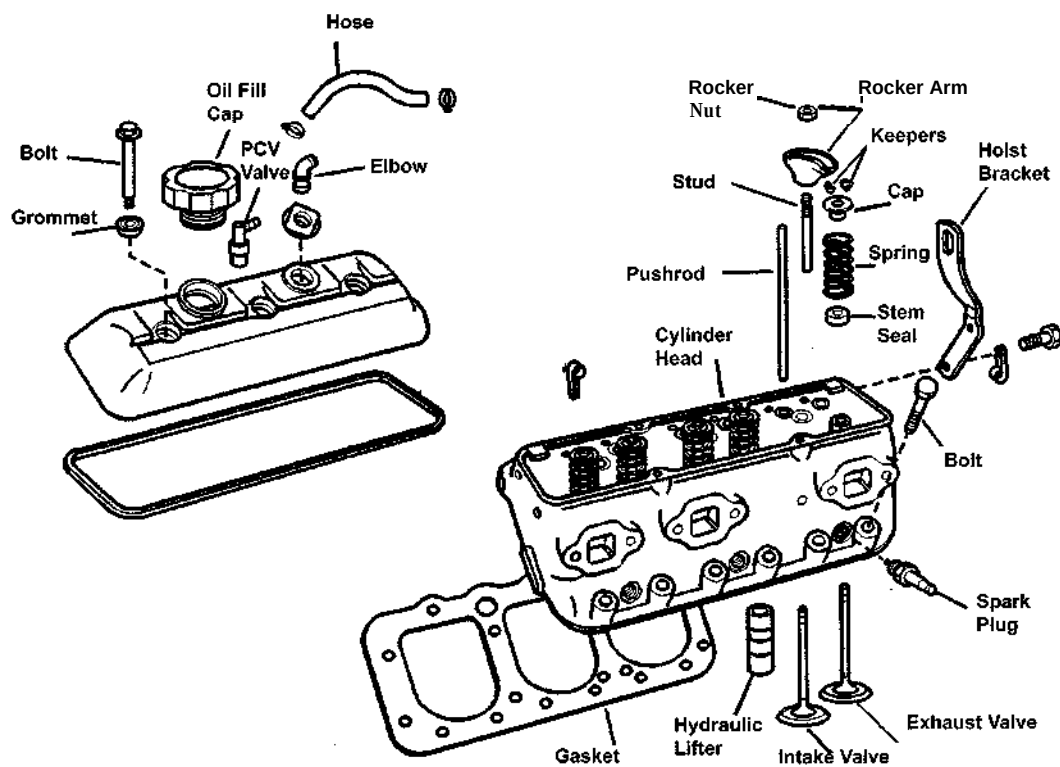


Fig. 19 Exploded view of the cylinder head—4.3L V6 engines

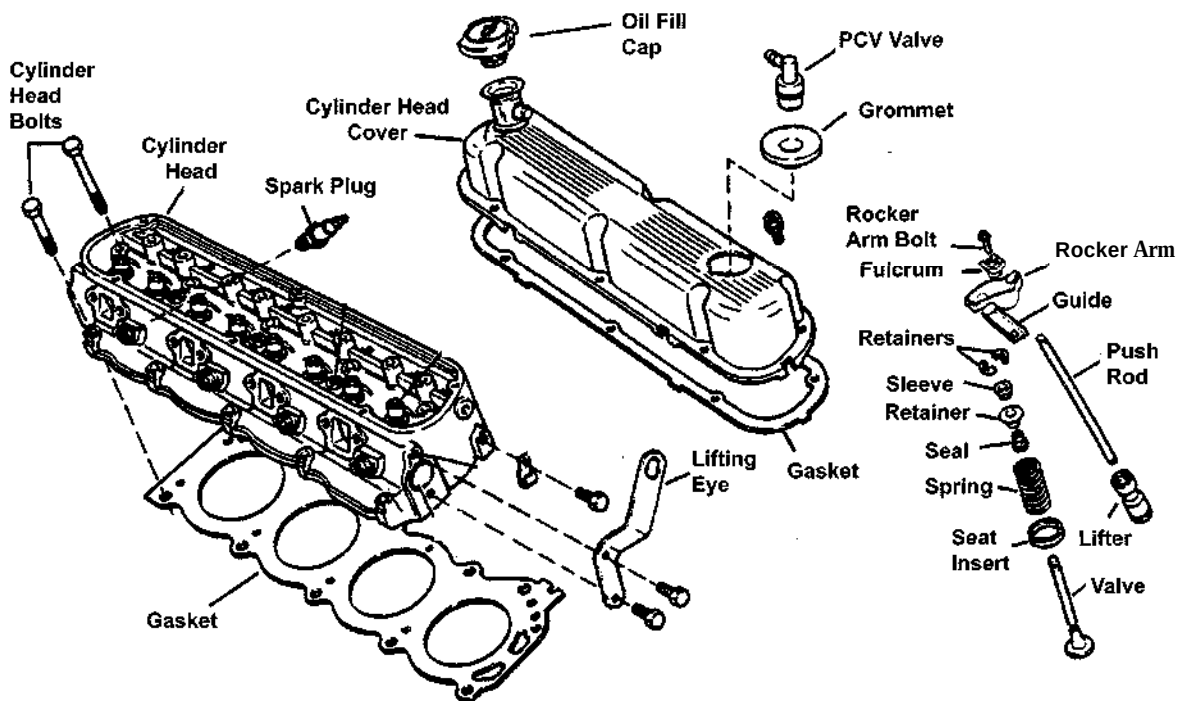


Fig. 20 Exploded view of the cylinder head—5.0L and 5.8L Ford V8 engines

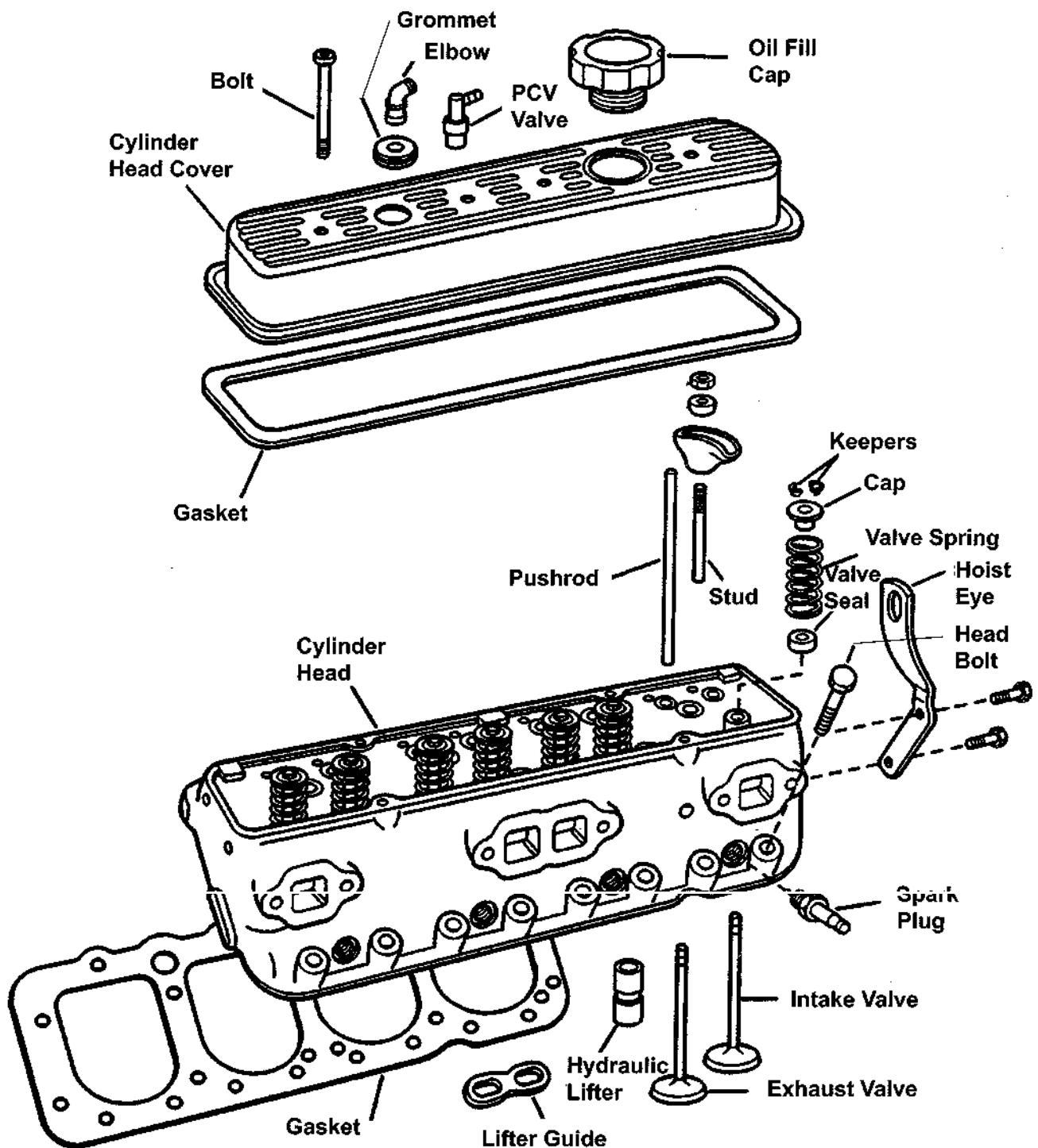
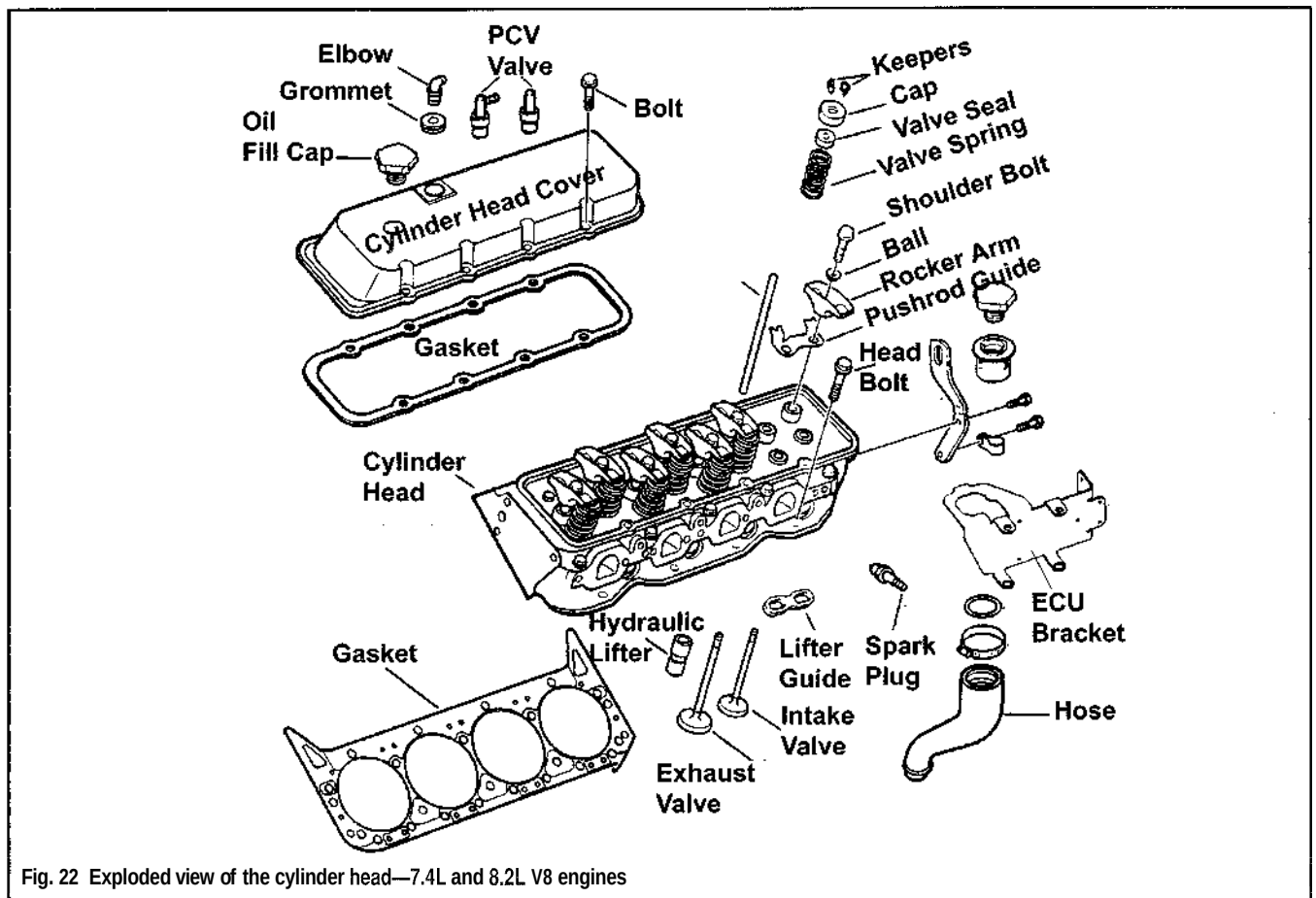


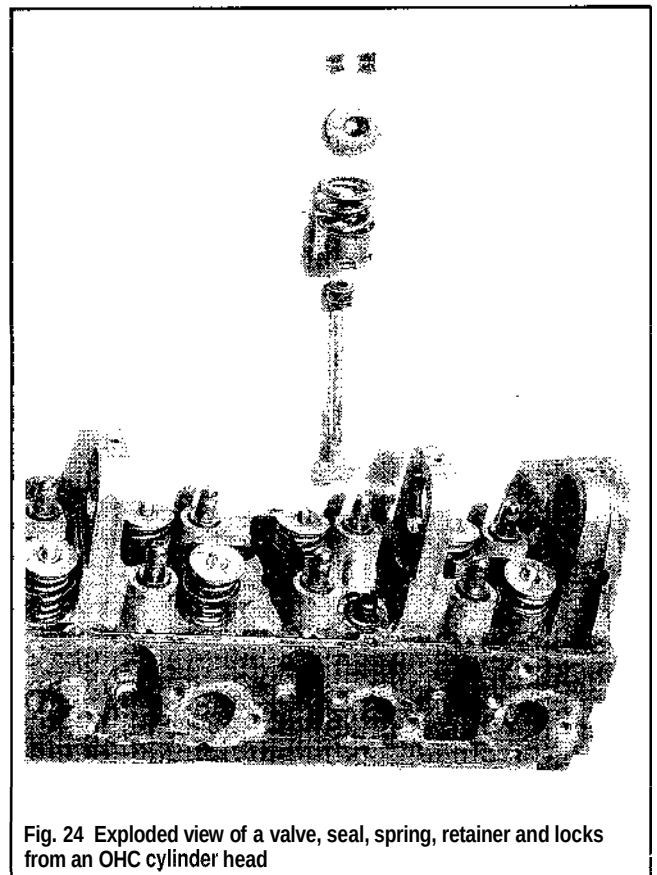
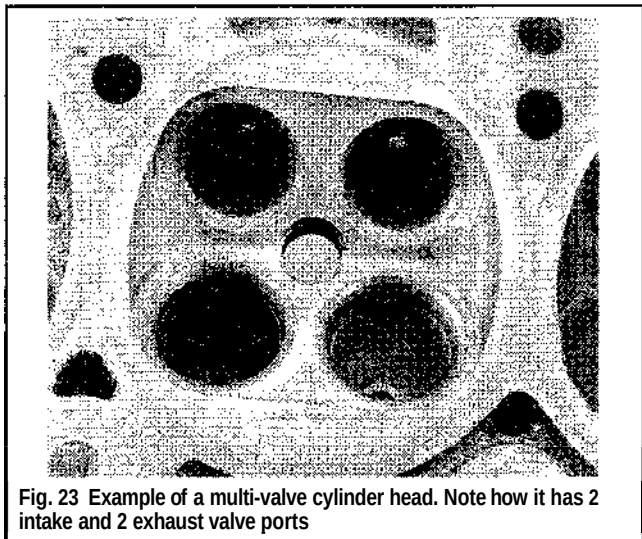
Fig. 21 Exploded view of the cylinder head—5.0L and 5.7L GM V8 engines



OHC Heads

◆ See Figures 23 and 24

Whether it is a single or dual overhead camshaft cylinder head, the disassembly procedure is relatively unchanged. One aspect to pay attention to is careful labeling of the parts on the dual camshaft cylinder head. There will be an intake camshaft and followers as well as an exhaust camshaft and followers and they must be labeled as such. In some cases, the components are identical and could easily be installed incorrectly. **DO NOT MIX THEM UP!** Determining which is which is very simple; the intake camshaft and components are on the same side of the head as was the intake manifold. Conversely, the exhaust camshaft and components are on the same side of the head as was the exhaust manifold.



Cup Type Camshaft Followers

† See Figures 25, 26 and 27

Most cylinder heads with cup type camshaft followers will have the valve spring, retainer and locks recessed within the follower's bore. You will need a C-clamp style valve spring compressor tool, an OHC spring removal tool (or equivalent) and a small magnet to disassemble the head.

1. If not already removed, remove the camshaft(s) and/or followers. Mark their positions for assembly.

2. Position the cylinder head to allow use of a C-clamp style valve spring compressor tool.

■ It is preferred to position the cylinder head gasket surface facing you with the valve springs facing the opposite direction and the head laying horizontal.

3. With the OHC spring removal adapter tool positioned inside of the follower bore, compress the valve spring using the C-clamp style valve spring compressor.

4. Remove the valve locks. A small magnetic tool or screwdriver will aid in removal.

5. Release the compressor tool and remove the spring assembly.

6. Withdraw the valve from the cylinder head.

7. If equipped, remove the valve seal.

■ Special valve seal removal tools are available. Regular or needlenose type pliers, if used with care, will work just as well. If using ordinary pliers, be sure not to damage the follower bore. The follower and its bore are machined to close tolerances and any damage to the bore will effect this relationship.

8. If equipped, remove the valve spring shim. A small magnetic tool or screwdriver will aid in removal.

9. Repeat Steps 3 through 8 until all of the valves have been removed.

ROCKER ARM TYPE CAMSHAFT FOLLOWERS

◆ See Figures 28 through 36

Most cylinder heads with rocker arm-type camshaft followers are easily disassembled using a standard valve spring compressor. However, certain models may not have enough open space around the spring for the standard tool and may require you to use a C-clamp style compressor tool instead.

1. If not already removed, remove the rocker arms and/or shafts and the camshaft. If applicable, also remove the hydraulic lash adjusters. Mark their positions for assembly.

2. Position the cylinder head to allow access to the valve spring.

3. Use a valve spring compressor tool to relieve the spring tension from the retainer.

■ Due to engine varnish, the retainer may stick to the valve locks. A gentle tap with a hammer may help to break it loose.

4. Remove the valve locks from the valve tip and/or retainer. A small magnet may help in removing the small locks.

5. Lift the valve spring, tool and all, off of the valve stem.

6. If equipped, remove the valve seal. If the seal is difficult to remove with the valve in place, try removing the valve first, then the seal. Follow the steps below for valve removal.

7. Position the head to allow access for withdrawing the valve.

Cylinder heads that have seen a lot of miles and/or abuse may have mushroomed the valve lock groove and/or tip, causing difficulty in removal of the valve. If this has happened, use a metal file to carefully remove the high spots around the lock grooves and/or tip. Only file it enough to allow removal.

8. Remove the valve from the cylinder head.

9. If equipped, remove the valve spring shim. A small magnetic tool or screwdriver will aid in removal.

10. Repeat Steps 3 through 9 until all of the valves have been removed.

INSPECTION

Now that all of the cylinder head components are clean, it's time to inspect them for wear and/or damage. To accurately inspect them, you will need some specialized tools:

- A 0-1 in. micrometer for the valves
- A dial indicator or inside diameter gauge for the valve guides
- A spring pressure test gauge

If you do not have access to the proper tools, you may want to bring the components to a shop that does.

Valves

◆ See Figures 37 and 38



The first thing to inspect are the valve head margin and face for any cracks, excessive wear or burning. The margin is the best place to look for burning. It should have a squared edge with an even width all around the diameter. When a valve burns, the margin will look melted and the edges rounded. Also inspect the valve head for any signs of tulipping. This will show as a lifting of the edges or dishing in the center of the head and will usually not occur to all of the valves. All of the heads should look the same, any that seem dished more than others are probably bad. Next, inspect the valve lock grooves and valve tips. Check for any burrs around the lock grooves, especially if you had to file them to remove the valve. Valve tips should appear flat, although slight rounding with high mileage engines is normal. Slightly worn valve tips will need to be machined flat. Last, measure the valve stem diameter with the micrometer. Measure the area that rides within the guide, especially towards the tip where most of the wear occurs. Take several measurements along its length and compare them to each other. Wear should be even along the length with little to no taper. If no minimum diameter is given in the specifications, then the stem should not read more than 0.001 in. (0.025mm) below the unworn area of the valve stem. Any valves that fail these inspections should be replaced.

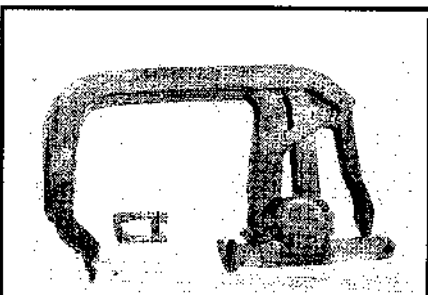


Fig. 25 C-clamp type spring compressor and an OHC spring removal tool (center) for cup type followers



Fig. 26 Most cup type follower cylinder heads retain the camshaft using bolt-on bearing caps

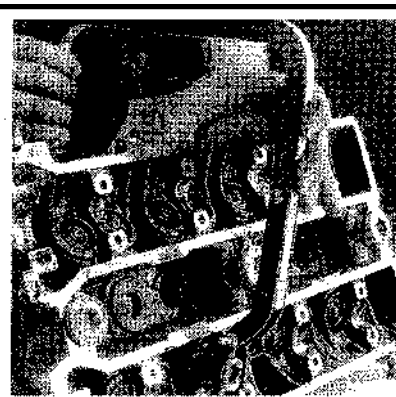


Fig. 27 Position the OHC spring tool in the follower bore, then compress the spring with a C-clamp type tool

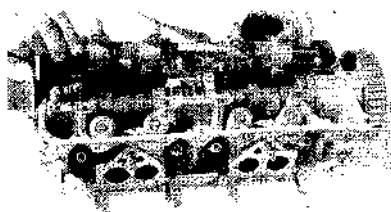


Fig. 28 Example of the shaft mounted rocker arms on some OHC heads

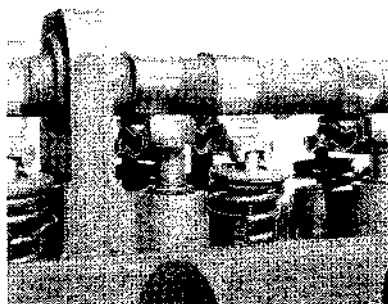


Fig. 29 Another example of the rocker arm type OHC head. This model uses a follower under the camshaft

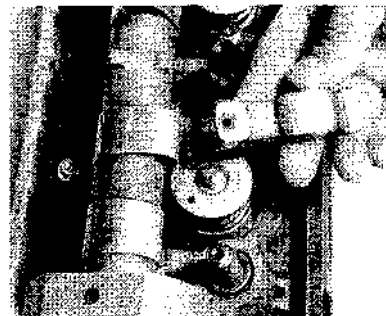


Fig. 30 Before the camshaft can be removed, all of the followers must first be removed ...

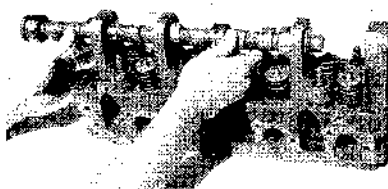


Fig. 31 ... then the camshaft can be removed by sliding it out (shown), or unbolting a bearing cap (not shown)



Fig. 32 Compress the valve spring ...



Fig. 33 ... then remove the valve locks from the valve stem and spring retainer



Fig. 34 Remove the valve spring and retainer from the cylinder head



Fig. 35 Remove the valve seal from the guide. Some gentle prying or pliers may help to remove stubborn ones

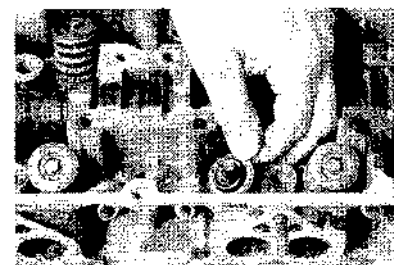


Fig. 36 All aluminum and some cast iron heads will have these valve spring shims. Remove all of them as well

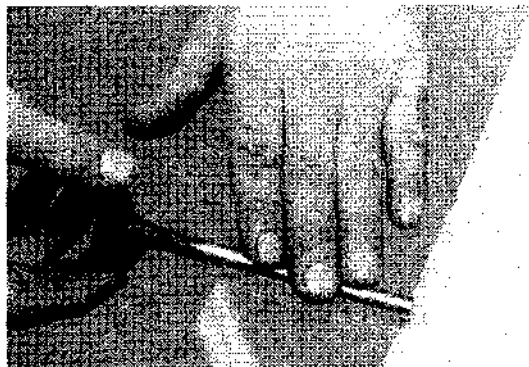


Fig. 37 Valve stems may be rolled on a flat surface to check for bends

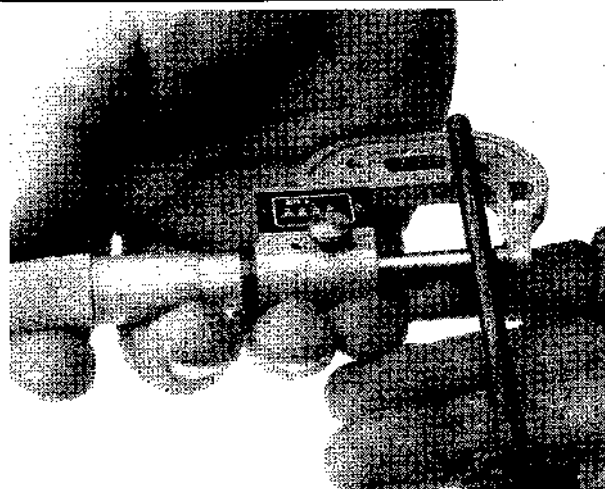


Fig. 38 Use a micrometer to check the valve stem diameter

Springs, Retainers and Valve Locks

◆ See Figures 39 and 40



The first thing to check is the most obvious, broken springs. Next check the free length and squareness of each spring. If applicable, insure to distinguish between intake and exhaust springs. Use a ruler and/or carpenter's square to measure the length. A carpenter's square should be used to check the springs for squareness. If a spring pressure test gauge is available, check each spring's rating and compare to the specifications chart. Check the readings against the specifications given. Any springs that fail these inspections should be replaced.

The spring retainers rarely need replacing, however they should still be checked as a precaution. Inspect the spring mating surface and the valve lock retention area for any signs of excessive wear. Also check for any signs of cracking. Replace any retainers that are questionable.

Valve locks should be inspected for excessive wear on the outside contact area as well as on the inner notched surface. Any locks which appear worn or broken and its respective valve should be replaced.

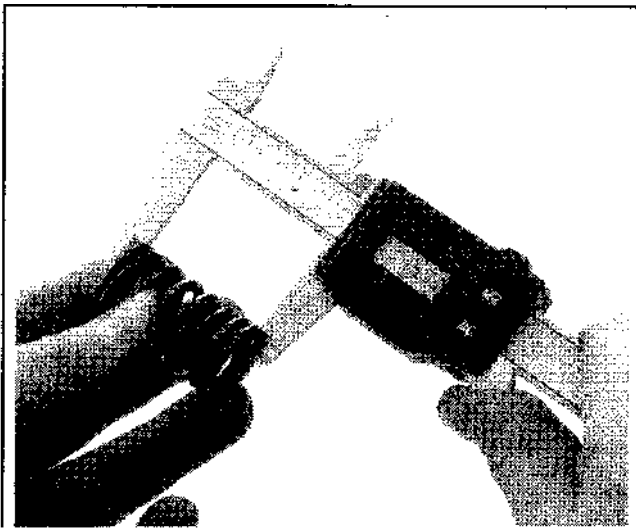


Fig. 39 Use a caliper to check the valve spring free-length

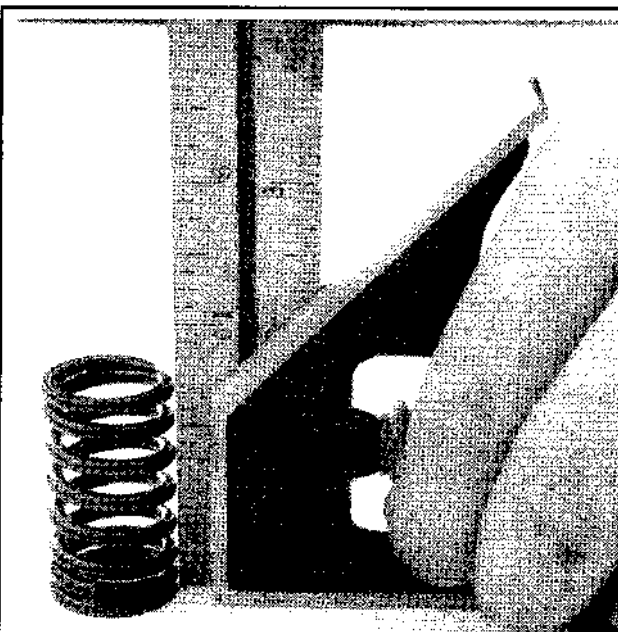


Fig. 40 Check the valve spring for squareness on a flat surface; a carpenter's square can be used

Cylinder Head



There are several things to check on the cylinder head: valve guides, seats, cylinder head surface flatness, cracks and physical damage.

Valve Guides

◆ See Figure 41

Now that you know the valves are good, you can use them to check the guides, although a new valve, if available, is preferred. Before you measure anything, look at the guides carefully and inspect them for any cracks, chips or breakage. Also if the guide is a removable style (as in most aluminum heads), check them for any looseness or evidence of movement. All of the guides should appear to be at the same height from the spring seat. If any seem lower (or higher) from another, the guide has moved. Mount a dial indicator onto the spring side of the cylinder head. Lightly oil the valve stem and insert it into the cylinder head. Position the dial indicator against the valve stem near the tip and zero the gauge. Grasp the valve stem and wiggle towards and away from the dial indicator and observe the readings. Mount the dial indicator 90 degrees from the initial point and zero the gauge and again take a reading. Compare the two readings for a out of round condition. Check the readings against the specifications given. An Inside Diameter (I.D.) gauge designed for valve guides will give you an accurate valve guide bore measurement. If the I.D. gauge is used, compare the readings with the specifications given. Any guides that fail these inspections should be replaced or machined.

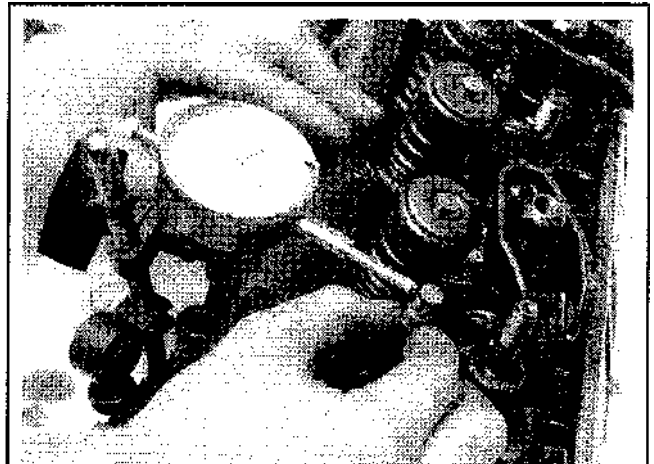


Fig. 41 A dial gauge may be used to check valve stem-to-guide clearance; read the gauge while moving the valve stem

Valve Seats

A visual inspection of the valve seats should show a slightly worn and pitted surface where the valve face contacts the seat. Inspect the seat carefully for severe pitting or cracks. Also, a seat that is badly worn will be recessed into the cylinder head. A severely worn or recessed seat may need to be replaced. All cracked seats must be replaced. A seat concentricity gauge, if available, should be used to check the seat run-out. If run-out exceeds specifications the seat must be machined (if no specification is given use 0.002 in. or 0.051mm).

Cylinder Head Surface Flatness

◆ See Figures 42 and 43

After you have cleaned the gasket surface of the cylinder head of any old gasket material, check the head for flatness.

Place a straightedge across the gasket surface. Using feeler gauges, determine the clearance at the center of the straightedge and across the cylinder head at several points. Check along the centerline and diagonally on the head surface. If the warpage exceeds 0.003 in. (0.076mm) within a 6.0 in. (15.2cm) span, or 0.006 in. (0.152mm) over the total length of the head, the cylinder head must be resurfaced. After resurfacing the heads of a V-type engine, the intake manifold flange surface should be checked, and if necessary, milled proportionally to allow for the change in its mounting position.

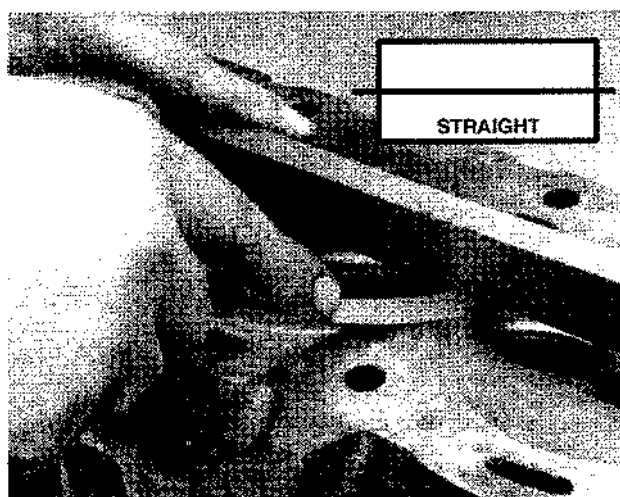


Fig 42 Check the head for flatness across the center of the head surface using a straightedge and feeler gauge

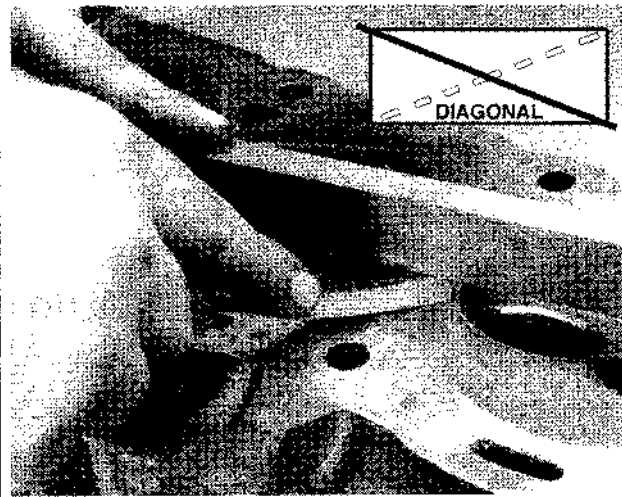


Fig 43 Checks should also be made along both diagonals of the head surface

Cracks And Physical Damage

Generally, cracks are limited to the combustion chamber, however, it is not uncommon for the head to crack in a spark plug hole, port, outside of the head or in the valve spring/rocker arm area. The first area to inspect is always the hottest: the exhaust seat/port area.

A visual inspection should be performed, but just because you don't see a crack does not mean it is not there. Some more reliable methods for inspecting for cracks include Magnaflux®, a magnetic process or Zyglol®, a dye penetrant. Magnaflux® is used only on ferrous metal (cast iron) heads. Zyglol® uses a spray on fluorescent mixture along with a black light to reveal the cracks. It is strongly recommended to have your cylinder head checked professionally for cracks, especially if the engine was known to have overheated and/or leaked or consumed coolant. Contact a local shop for availability and pricing of these services.

Physical damage is usually very evident. For example, a broken mounting ear from dropping the head or a bent or broken stud and/or bolt. All of these defects should be fixed or, if not repairable, the head should be replaced.

Camshaft and Followers

Inspect the camshaft(s) and followers as described earlier.

REFINISHING & REPAIRING



Many of the procedures given for refinishing and repairing the cylinder head components must be performed by a machine shop. Certain steps, if the inspected part is not worn, can be performed yourself inexpensively. However, you spent a lot of time and effort so far; why risk trying to save a couple bucks if you might have to do it all over again?

Valves



Any valves that were not replaced should be refaced and the tips ground flat. Unless you have access to a valve grinding machine, this should be done by a machine shop. If the valves are in extremely good condition, as well as the valve seats and guides, they may be lapped in without performing machine work.

It is a recommended practice to lap the valves even after machine work has been performed and/or new valves have been purchased. This insures a positive seal between the valve and seat.

Lapping The Valves

Before lapping the valves to the seats, read the rest of the cylinder head procedure to insure that any related parts are in acceptable enough condition to continue.

☐ Before any valve seat machining and/or lapping can be performed, the guides must be within factory recommended specifications.

1. Invert the cylinder head.
2. Lightly lubricate the valve stems and insert them into the cylinder head in their numbered order.
3. Raise the valve from the seat and apply a small amount of fine lapping compound to the seat.
4. Moisten the suction head of a hand-lapping tool and attach it to the head of the valve.
5. Rotate the tool between the palms of both hands, changing the position of the valve on the valve seat and lifting the tool often to prevent grooving.
6. Lap the valve until a smooth, polished circle is evident on the valve and seat.
7. Remove the tool and the valve. Wipe away all traces of the grinding compound and store the valve to maintain its lapped location.

⚠ WARNING

Do not get the valves out of order after they have been lapped. They must be put back with the same valve seat with which they were lapped.

Springs, Retainers and Valve Locks

There is no repair or refinishing possible with the springs, retainers and valve locks. If they are found to be worn or defective, they must be replaced with new (or known good) parts.

Cylinder Head



Most refinishing procedures dealing with the cylinder head must be performed by a machine shop. Read the procedures below and review your inspection data to determine whether or not machining is necessary.

Valve Guide

☐ If any machining or replacements are made to the valve guides, the seats must be machined.

Unless the valve guides need machining or replacing, the only service to perform is to thoroughly clean them of any dirt or oil residue.

There are only two types of valve guides used on automobile engines: the replaceable-type (all aluminum heads) and the cast-in integral-type (most cast iron heads). There are four recommended methods for repairing worn guides.

- Knurling
- Inserts
- Reaming oversize
- Replacing

Knurling is a process in which metal is displaced and raised, thereby reducing clearance, giving a true center, and providing oil control. It is the least expensive way of repairing the valve guides. However, it is not necessarily the best, and in some cases, a knurled valve guide will not stand up for more than a short time. It requires a special knurlizer and precision reaming tools to obtain proper clearances. It would not be cost effective to purchase these tools, unless you plan on rebuilding several of the same cylinder head.

Installing a guide insert involves machining the guide to accept a bronze insert. One style is the coil-type which is installed into a threaded guide. Another is the thin-walled insert where the guide is reamed oversize to accept a split-sleeve insert. After the insert is installed, a special tool is then run through the guide to expand the insert, locking it to the guide. The insert is then reamed to the standard size for proper valve clearance.

Reaming for oversize valves restores normal clearances and provides a true valve seat. Most cast-in type guides can be reamed to accept an valve with an oversize stem. The cost factor for this can become quite high as you will need to purchase the reamer and new, oversize stem valves for all guides which were reamed. Oversizes are generally 0.003 to 0.030 in. (0.076 to 0.762 mm), with 0.015 in. (0.381 mm) being the most common.

To replace cast-in type valve guides, they must be drilled out, then reamed to accept replacement guides. This must be done on a fixture which will allow centering and leveling off of the original valve seat or guide, otherwise a serious guide-to-seat misalignment may occur making it impossible to properly machine the seat.

Replaceable-type guides are pressed into the cylinder head. A hammer and a stepped drift or punch may be used to install and remove the guides. Before removing the guides, measure the protrusion on the spring side of the head and record it for installation. Use the stepped drift to hammer out the old guide from the combustion chamber side of the head. When installing, determine whether or not the guide also seals a water jacket in the head, and if it does, use the recommended sealing agent. If there is no water jacket, grease the valve guide and its bore. Use the stepped drift, and hammer the new guide into the cylinder head from the spring side of the cylinder head. A stack of washers the same thickness as the measured protrusion may help the installation process.

Valve Seats

■ **Before any valve seat machining can be performed, the guides must be within factory recommended specifications.**

If any machining or replacements were made to the valve guides, the seats must be machined.

If the seats are in good condition, the valves can be lapped to the seats, and the cylinder head assembled. See the valves procedures for instructions on lapping.

If the valve seats are worn, cracked or damaged, they must be serviced by a machine shop. The valve seat must be perfectly centered to the valve guide, which requires very accurate machining.

Cylinder Head Surface

If the cylinder head is warped, it must be machined flat. If the warpage is extremely severe, the head may need to be replaced. In some instances, it may be possible to straighten a warped head enough to allow machining. In either case, contact a professional machine shop for service.

Cracks And Physical Damage

Certain cracks can be repaired in both cast iron and aluminum heads. For cast iron, a tapered threaded insert is installed along the length of the crack. Aluminum can also use the tapered inserts; however welding is the preferred method. Some physical damage can be repaired through brazing or welding. Contact a machine shop to get expert advice for your particular dilemma.

Any OHC cylinder head that shows excessive warpage should have the camshaft bearing journals align bored after the cylinder head has been resurfaced.

⚠ WARNING

Failure to align bore the camshaft bearing journals could result in severe engine damage including but not limited to: valve and piston damage, connecting rod damage, camshaft and/or crankshaft breakage.

ASSEMBLY



The first step for any assembly job is to have a clean area in which to work. Next, thoroughly clean all of the parts and components that are to be assembled. Finally, place all of the components onto a suitable work space and, if necessary, arrange the parts to their respective positions.

OHV Engines

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head. If possible, maintain their original locations.
2. If equipped, install any valve spring shims which were removed.
3. If equipped, install the new valve seals, keeping the following in mind:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, it is installed just after compressing the spring but before the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor tool and compress the spring.
6. Assemble the valve locks to the stem.
7. Relieve the spring pressure slowly and insure that neither valve lock becomes dislodged by the retainer.
8. Remove the spring compressor tool.
9. Repeat Steps 2 through 8 until all of the springs have been installed.

OHC Engines

◆ See Figure 44

CUP TYPE CAMSHAFT FOLLOWERS

To install the springs, retainers and valve locks on heads which have these components recessed into the camshaft follower's bore, you will need a small screwdriver-type tool, some clean white grease and a lot of patience. You will also need the C-clamp style spring compressor and the OHC tool used to disassemble the head.

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head. If possible, maintain their original locations.
2. If equipped, install any valve spring shims which were removed.
3. If equipped, install the new valve seals, keeping the following in mind:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, it is installed just after compressing the spring but before the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor and the OHC tool, then compress the spring.
6. Using a small screwdriver as a spatula, fill the valve stem side of the lock with white grease. Use the excess grease on the screwdriver to fasten the lock to the driver.
7. Carefully install the valve lock, which is stuck to the end of the screwdriver, to the valve stem then press on it with the screwdriver until the grease squeezes out. The valve lock should now be stuck to the stem.
8. Repeat Steps 6 and 7 for the remaining valve lock.
9. Relieve the spring pressure slowly and insure that neither valve lock becomes dislodged by the retainer.
10. Remove the spring compressor tool.
11. Repeat Steps 2 through 10 until all of the springs have been installed.
12. Install the followers, camshaft(s) and any other components that were removed for disassembly.

7-16 ENGINE OVERHAUL

ROCKER ARM TYPE CAMSHAFT FOLLOWERS

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head. If possible, maintain their original locations.
2. If equipped, install any valve spring shims which were removed.
3. If equipped, install the new valve seals, keeping the following in mind:
 - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
 - If the seal is an O-ring type, it is installed just after compressing the spring but before the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor tool and compress the spring.
6. Assemble the valve locks to the stem.
7. Relieve the spring pressure slowly and insure that neither valve lock becomes dislodged by the retainer.
8. Remove the spring compressor tool.
9. Repeat Steps 2 through 8 until all of the springs have been installed.
10. Install the camshaft(s), rockers, shafts and any other components that were removed for disassembly.

Engine Block

GENERAL INFORMATION

A thorough overhaul or rebuild of an engine block would include replacing the pistons, rings, bearings, timing belt/chain assembly and oil pump. For OHV engines also include a new camshaft and lifters. The block would then have the cylinders bored and honed oversize (or if using removable cylinder sleeves, new sleeves installed) and the crankshaft would be cut undersize to provide new wearing surfaces and perfect clearances. However, your particular engine may not have everything worn out. What if only the piston rings have worn out and the clearances on everything else are still within factory specifications? Well, you could just replace the rings and put it back together, but this would be a very rare example. Chances are, if one component in your engine is worn, other components are sure to follow, and soon. At the very least, you should always replace the rings, bearings and oil pump. This is what is commonly called a "freshen up".

Cylinder Ridge Removal



Because the top piston ring does not travel to the very top of the cylinder, a ridge is built up between the end of the travel and the top of the cylinder bore.

Pushing the piston and connecting rod assembly past the ridge can be difficult, and damage to the piston ring lands could occur. If the ridge is not removed before installing a new piston or not removed at all, piston ring breakage and piston damage may occur.

☐ It is always recommended that you remove any cylinder ridges before removing the piston and connecting rod assemblies. If you know that new pistons are going to be installed and the engine block

will be bored oversize, you may be able to forego this step. However, some ridges may actually prevent the assemblies from being removed, necessitating its removal.

There are several different types of ridge reamers on the market, none of which are inexpensive. Unless a great deal of engine rebuilding is anticipated, borrow or rent a reamer.

1. Turn the crankshaft until the piston is at the bottom of its travel.
2. Cover the head of the piston with a rag.
3. Follow the tool manufacturers instructions and cut away the ridge, exercising extreme care to avoid cutting too deeply.
4. Remove the ridge reamer, the rag and as many of the cuttings as possible. Continue until all of the cylinder ridges have been removed.

DISASSEMBLY



◆ See Figures 45, 46 47 48 49 and 50

The engine disassembly instructions following assume that you have the engine mounted on an engine stand. If not, it is easiest to disassemble the engine on a bench or the floor with it resting on the bell housing or transmission mounting surface. You must be able to access the connecting rod fasteners and turn the crankshaft during disassembly. Also, all engine covers (timing, front, side, oil pan, whatever) should have already been removed. Engines which are seized or locked up may not be able to be completely disassembled, and a core (salvage yard) engine should be purchased.

On OHV engines, if not done during the cylinder head removal, remove the pushrods and lifters, keeping them in order for assembly. Remove the timing gears and/or timing chain assembly, then remove the oil pump drive assembly and withdraw the camshaft from the engine block. Remove the oil pick-up and pump assembly. If equipped, remove any balance or auxiliary shafts. If necessary, remove the cylinder ridge from the top of the bore. See the cylinder ridge removal procedure.

On OHC engines, if not done during the cylinder head removal, remove the timing chain/belt and/or gear/sprocket assembly. Remove the oil pick-up and pump assembly and, if necessary, the pump drive. If equipped, remove any balance or auxiliary shafts. If necessary, remove the cylinder ridge from the top of the bore. See the cylinder ridge removal procedure.

Rotate the engine over so that the crankshaft is exposed. Use a number punch or scribe and mark each connecting rod with its respective cylinder number. The cylinder closest to the front of the engine is always number 1. However, depending on the engine placement, the front of the engine could either be the flywheel or damper/pulley end. Generally the front of the engine faces the bow. Use a number punch or scribe and also mark the main bearing caps from front to rear with the front most cap being number 1 (if there are five caps, mark them 1 through 5, front to rear).

✱✱ WARNING

Take special care when pushing the connecting rod up from the crankshaft because the sharp threads of the rod bolts/studs will score the crankshaft journal. Insure that special plastic caps are installed over them, or cut two pieces of rubber hose to do the same.

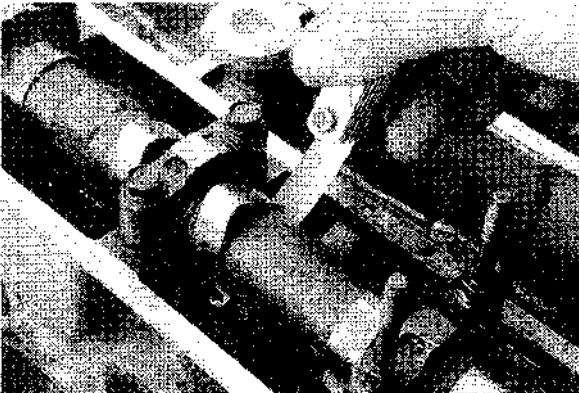


Fig. 44 Once assembled, check the valve clearance and correct as needed

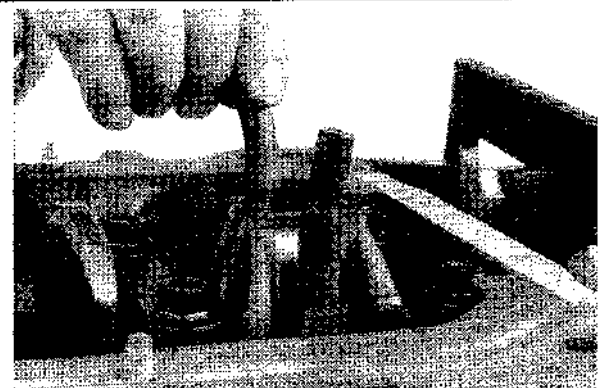


Fig. 45 Place rubber hose over the connecting rod studs to protect the crankshaft and cylinder bores from damage



Fig. 46 Carefully tap the piston out of the bore using a wooden dowel

Again, rotate the engine, this time to position the number one cylinder bore (head surface) up. Turn the crankshaft until the number one piston is at the bottom of its travel, this should allow the maximum access to its connecting rod. Remove the number one connecting rods fasteners and cap and place two lengths of rubber hose over the rod bolts/studs to protect the crankshaft from damage. Using a sturdy wooden dowel and a hammer, push the connecting rod up about 1 in. (25mm) from the crankshaft and remove the upper bearing insert. Continue pushing or tapping the connecting rod up until the piston rings are out of the cylinder bore. Remove the piston and rod by hand, put the upper half of the bearing insert back into the rod, install the cap with its bearing insert installed, and hand-tighten the cap fasteners. If the parts are kept in order in this manner, they will not get lost and you will be able to tell which bearings came from what cylinder if any problems are discovered and diagnosis is necessary. Remove all the other piston assemblies in the same manner. On V-style engines, remove all of the pistons from one bank, then reposition the engine with the other cylinder bank head surface up, and remove that bank's piston assemblies.

The only remaining component in the engine block should now be the crankshaft. Loosen the main bearing caps evenly until the fasteners can be turned by hand, then remove them and the caps. Remove the crankshaft from the engine block. Thoroughly clean all of the components.

INSPECTION



Now that the engine block and all of its components are clean; it's time to inspect them for wear and/or damage. To accurately inspect them, you will need some specialized tools:

- Two or three separate micrometers to measure the pistons and crankshaft journals
- A dial indicator

- Telescoping gauges for the cylinder bores
- A rod alignment fixture to check for bent connecting rods

If you do not have access to the proper tools, you may want to bring the components to a shop that does.

Generally, you shouldn't expect cracks in the engine block or its components unless it was known to leak, consume or mix engine fluids, it was severely overheated, or there was evidence of bad bearings and/or crankshaft damage. A visual inspection should be performed on all of the components, but just because you don't see a crack does not mean it is not there. Some more reliable methods for inspecting for cracks include Magnaflux®, a magnetic process or Zyglol®, a dye penetrant. Magnaflux® is used only on ferrous metal (cast iron). Zyglol® uses a spray on fluorescent mixture along with a black light to reveal the cracks. It is strongly recommended to have your engine block checked professionally for cracks, especially if the engine was known to have overheated and/or leaked or consumed coolant. Contact a local shop for availability and pricing of these services.

Engine Block



Engine Block Bearing Alignment

Remove the main bearing caps and, if still installed, the main bearing inserts. Inspect all of the main bearing saddles and caps for damage, burrs or high spots. If damage is found, and it is caused from a spun main bearing, the block will need to be align-bored or, if severe enough, replacement. Any burrs or high spots should be carefully removed with a metal file.

Place a straightedge on the bearing saddles, in the engine block, along the centerline of the crankshaft. If any clearance exists between the straightedge and the saddles, the block must be align-bored.

Align-boring consists of machining the main bearing saddles and caps by means of a flycutter that runs through the bearing saddles.

Deck Flatness

The top of the engine block where the cylinder head mounts is called the deck. Insure that the deck surface is clean of dirt, carbon deposits and old gasket material. Place a straightedge across the surface of the deck along its centerline and, using feeler gauges, check the clearance along several points. Repeat the checking procedure with the straightedge placed along both diagonals of the deck surface. If the reading exceeds 0.003 in. (0.076mm) within a 6.0 in. (15.2cm) span, or 0.006 in. (0.152mm) over the total length of the deck, it must be machined. Always check the Specification chart for your specific engine.

Cylinder Bores

◆ See Figure 51

The cylinder bores house the pistons and are slightly larger than the pistons themselves. A common piston-to-bore clearance is 0.0015–0.0025 in. (0.0381mm–0.0635mm). Refer to the Specification chart for your specific engine. Inspect and measure the cylinder bores. The bore should be checked for out-of-roundness, taper and size. The results of this inspection will determine whether the cylinder can be used in its existing size and condition, or a rebore to the next oversize is required (or in the case of removable sleeves, have replacements installed).

The amount of cylinder wall wear is always greater at the top of the cylinder than at the bottom. This wear is known as taper. Any cylinder that has a taper of 0.0012 in. (0.305mm) or more, must be re-bored. Measurements are taken at a number of positions in each cylinder: at the top, middle and bottom and at two points at each position; that is, at a point 90 degrees from the crankshaft centerline, as well as a point parallel to the crankshaft centerline. The measurements are made with either a special dial indicator or a telescopic gauge and micrometer. If the necessary precision tools to check the bore are not available, take the block to a machine shop and have them mike it. Also if you don't have the tools to check the cylinder bores, chances are you will not have the necessary devices to check the pistons, connecting rods and crankshaft. Take these components with you and save yourself an extra trip.

For our procedures, we will use a telescopic gauge and a micrometer. You will need one of each, with a measuring range which covers your cylinder bore size.

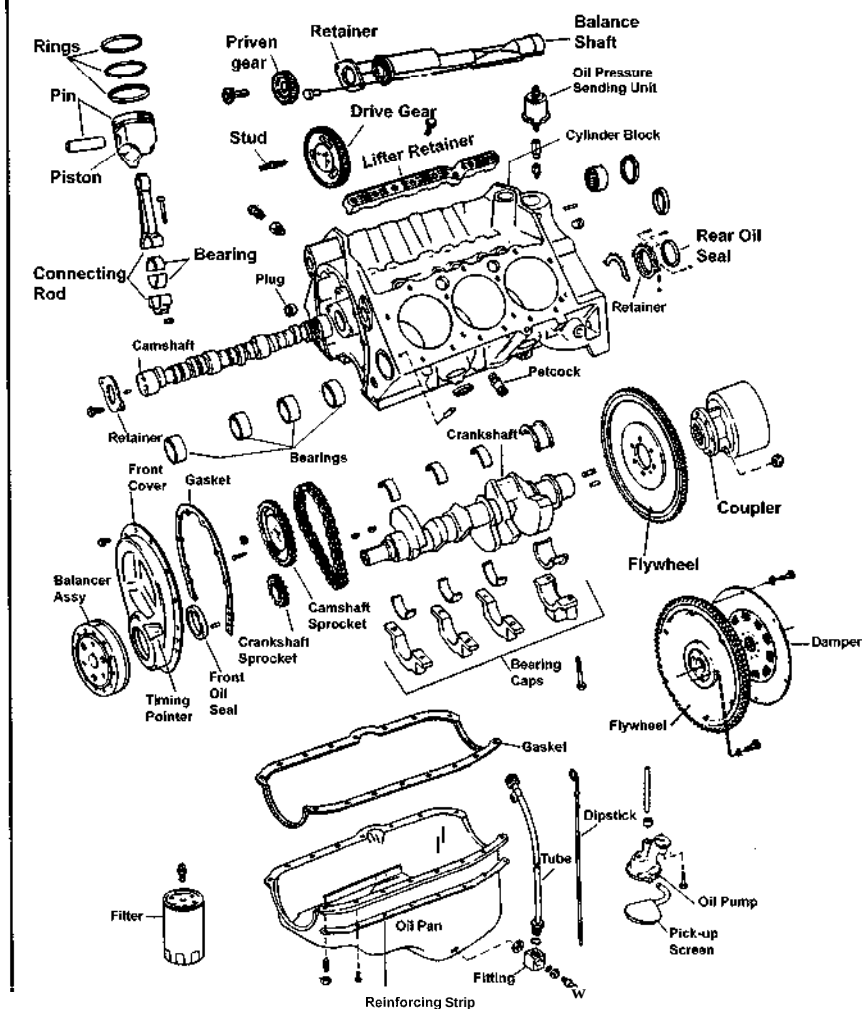


Fig. 48 Exploded view of the cylinder block—4.3L V6 engines

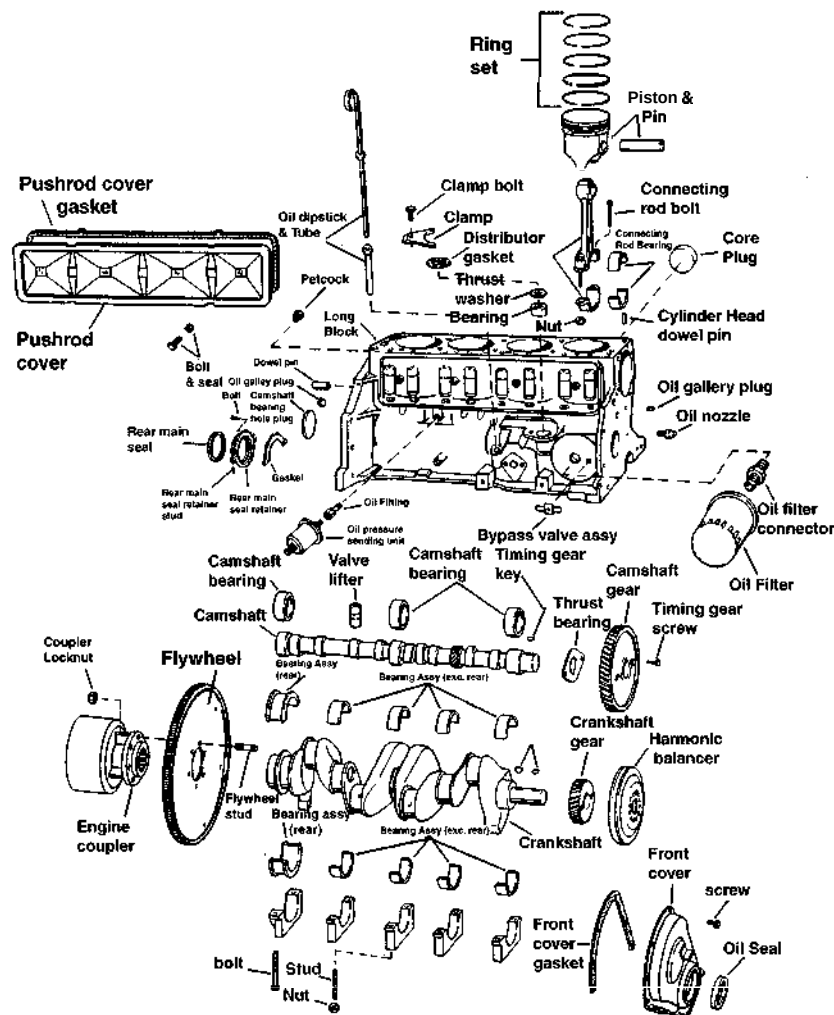


Fig. 47 Exploded view of the cylinder block—3014 cylinder engines

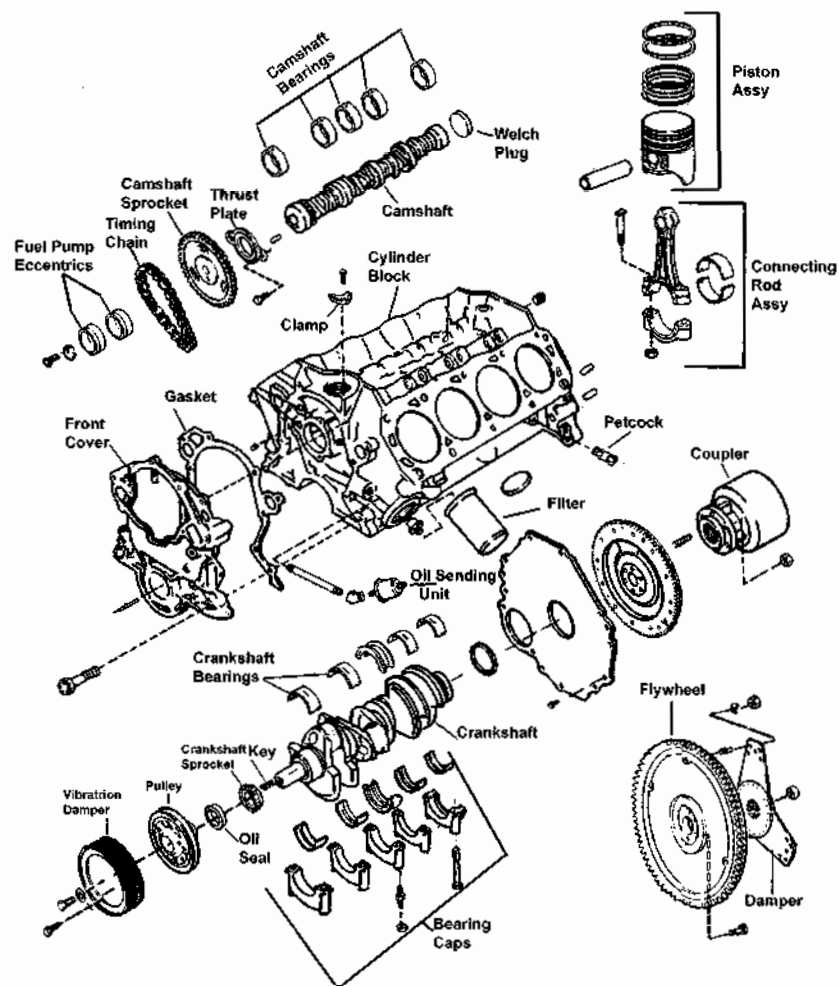


Fig. 50 Exploded view of the cylinder block—Ford V8 engines

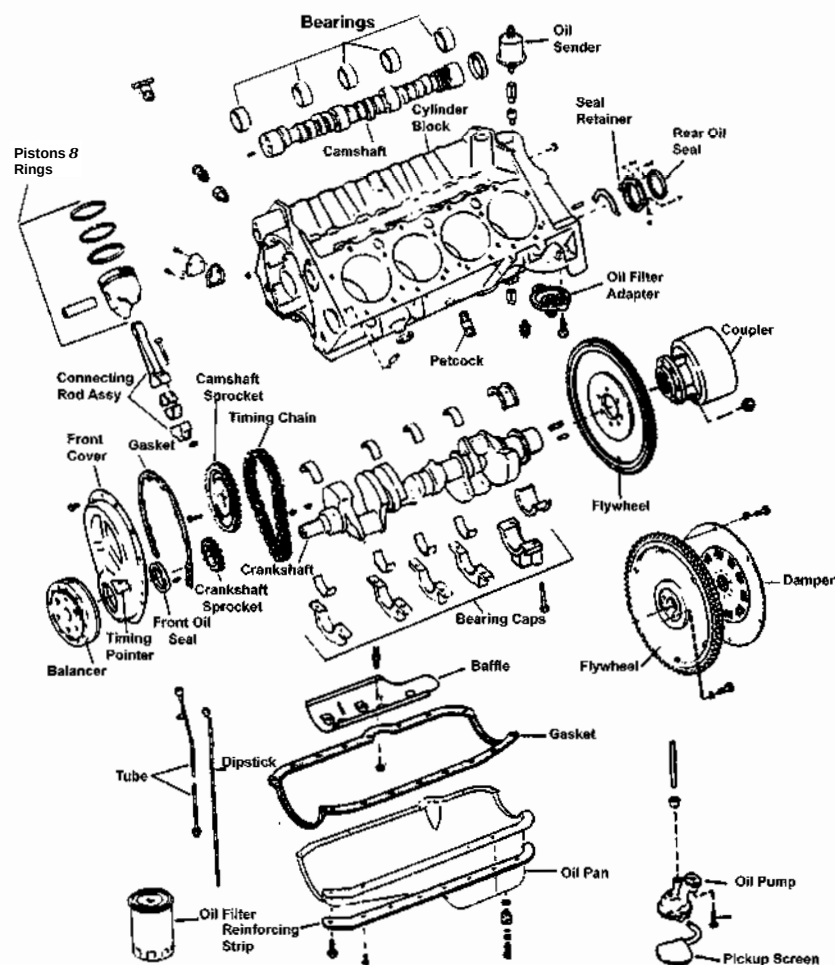


Fig. 49 Exploded view of the cylinder block—GM V8 engines

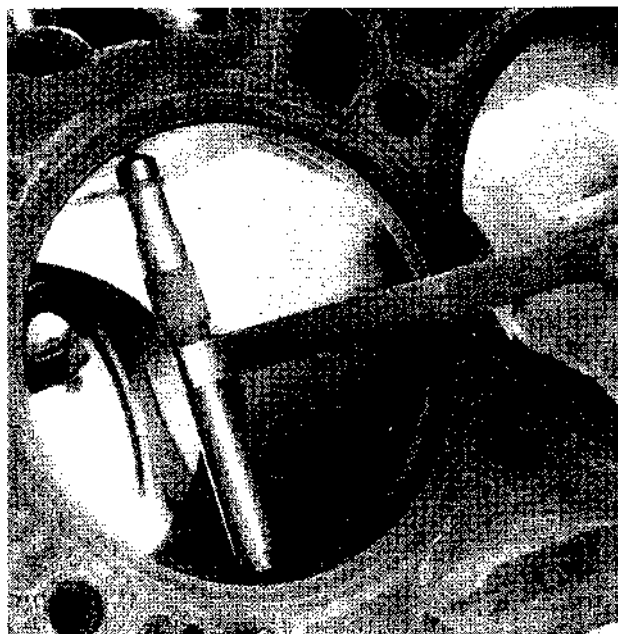


Fig. 51 Use a telescoping gauge to measure the cylinder bore diameter—take several readings within the same bore

1. Position the telescoping gauge in the cylinder bore, loosen the gauges lock and allow it to expand.

■ **Your first two readings will be at the top of the cylinder bore, then proceed to the middle and finally the bottom, making a total of six measurements.**

2. Hold the gauge square in the bore, 90 degrees from the crankshaft centerline, and gently tighten the lock. Tilt the gauge back to remove it from the bore.

3. Measure the gauge with the micrometer and record the reading.

4. Again, hold the gauge square in the bore, this time parallel to the crankshaft centerline, and gently tighten the lock. Again, you will tilt the gauge back to remove it from the bore.

5. Measure the gauge with the micrometer and record this reading. The difference between these two readings is the out-of-round measurement of the cylinder.

6. Repeat Steps 1 through 5, each time going to the next lower position, until you reach the bottom of the cylinder. Then go to the next cylinder, and continue until all of the cylinders have been measured.

The difference between these measurements will tell you all about the wear in your cylinders. The measurements which were taken 90 degrees from the crankshaft centerline will always reflect the most wear. That is because at this position is where the engine power presses the piston against the cylinder bore the hardest. This is known as thrust wear. Take your top, 90 degree measurement and compare it to your bottom, 90 degree measurement. The difference between them is the taper. When you measure your pistons, you will compare these readings to your piston sizes and determine piston-to-wall clearance.

Crankshaft



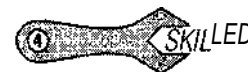
Inspect the crankshaft for visible signs of wear or damage. All of the journals should be perfectly round and smooth. Slight scores are normal for a used crankshaft, but you should hardly feel them with your fingernail. When measuring the crankshaft with a micrometer, you will take readings at the front and rear of each journal, then turn the micrometer 90 degrees and take two more readings, front and rear. The difference between the front-to-rear readings is the journal taper and the first-to-90 degree reading is the out-of-round measurement. Generally, there should be no taper or out-of-roundness found, however, up to 0.0005 in. (0.0127mm) for either can be overlooked. Also, the readings should fall within the factory specifications for journal diameters.

If the crankshaft journals fall within specifications, it is recommended that it be polished before being returned to service. Polishing the crankshaft insures that any minor burrs or high spots are smoothed, thereby reducing the chance of scoring the new bearings.

Pistons and Connecting Rods

Pistons

◆ See Figure 52



The piston should be visually inspected for any signs of cracking or burning (caused by hot spots or detonation), and scuffing or excessive wear on the skirts. The wrist pin attaches the piston to the connecting rod. The piston should move freely on the wrist pin, both sliding and pivoting. Grasp the connecting rod securely, or mount it in a vise, and try to rock the piston back and forth along the centerline of the wrist pin. There should not be any excessive play evident between the piston and the pin. If there are C-clips retaining the pin in the piston then you have wrist pin bushings in the rods. There should not be any excessive play between the wrist pin and the rod bushing. Normal clearance for the wrist pin is approx. 0.001–0.002 in. (0.025mm–0.051mm). Please refer to the Specification chart for your specific engine.

Use a micrometer at 90 degrees to the piston, perpendicular to the wrist pin, on the skirt. Compare the reading to its original cylinder measurement obtained earlier. The difference between the two readings is the piston-to-wall clearance. If the clearance is within specifications, the piston may be used as is. If the piston is out of specification, but the bore is not, you will need a new piston. If both are out of specification, you will need the cylinder rebored and oversize pistons installed. Generally if two or more pistons/bores are out of specification, it is best to rebore the entire block and purchase a complete set of oversize pistons.

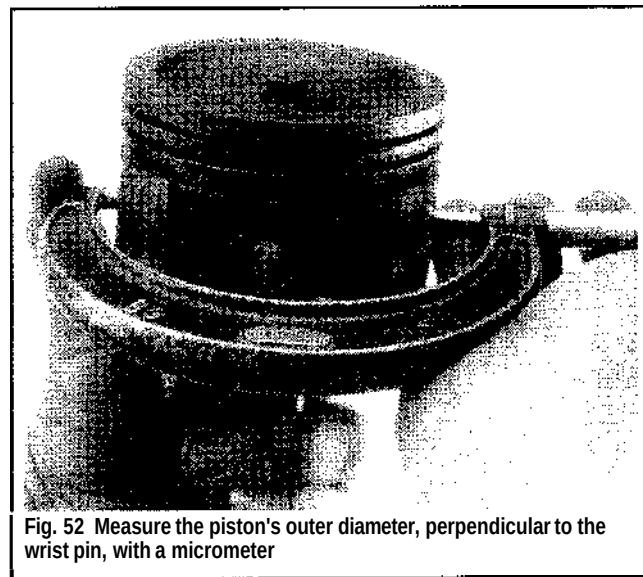


Fig. 52 Measure the piston's outer diameter, perpendicular to the wrist pin, with a micrometer

Connecting Rod

You should have the connecting rod checked for straightness at a machine shop. If the connecting rod is bent, it will unevenly stress the bearing and piston, as well as place greater stress on these components. Any bent or twisted connecting rods must be replaced. If the rods are straight and the wrist pin clearance is within specifications, then only the bearing end of the rod need be checked. Place the connecting rod into a vise, with the bearing inserts in place, install the cap to the rod and torque the fasteners to specifications. Use a telescoping gauge and carefully measure the inside diameter of the bearings. Compare this reading to the rods original crankshaft journal diameter measurement. The difference is the oil clearance. If the oil clearance is not within specifications, install new bearings in the rod and take another measurement. If the clearance is still out of specifications, and the crankshaft is not, the rod will need to be reconditioned by a machine shop.

■ You can also use Plastigage® to check the bearing clearances. The assembling procedure has complete instructions on its use.

Camshaft

Inspect the camshaft and lifters/followers as described earlier.

Bearings

All of the engine bearings should be visually inspected for wear and/or damage. The bearing should look evenly worn all around with no deep scores or pits. If the bearing is severely worn, scored, pitted or heat blued, then the bearing, and the components that use it, should be brought to a machine shop for inspection. Full-circle bearings (used on most camshafts, auxiliary shafts, balance shafts, etc.) require specialized tools for removal and installation, and should be brought to a machine shop for service.

Oil Pump

☐ **The oil pump is responsible for providing constant lubrication to the whole engine and so it is recommended that a new oil pump be installed when rebuilding the engine.**

Completely disassemble the oil pump and thoroughly clean all of the components. Inspect the oil pump gears and housing for wear and/or damage. Insure that the pressure relief valve operates properly and there is no binding or sticking due to varnish or debris. If all of the parts are in proper working condition, lubricate the gears and relief valve, and assemble the pump.

REFINISHING

◆ See Figure 53



Almost all engine block refinishing must be performed by a machine shop. If the cylinders are not to be re-bored, then the cylinder glaze can be removed with a ball hone. When removing cylinder glaze with a ball hone, use a light or penetrating type oil to lubricate the hone. Do not allow the hone to run dry as this may cause excessive scoring of the cylinder bores and wear on the hone. If new pistons are required, they will need to be installed to the connecting rods. This should be performed by a machine shop as the pistons must be installed in the correct relationship to the rod or engine damage can occur.

Pistons and Connecting Rods

◆ See Figure 54



Because of the tools necessary, only pistons with the wrist pin retained by C-clips are serviceable by the DIYer or technician. Press fit pistons require special Presses and/or heaters to remove/install the connectina rod and should only be performed by a machine shop.

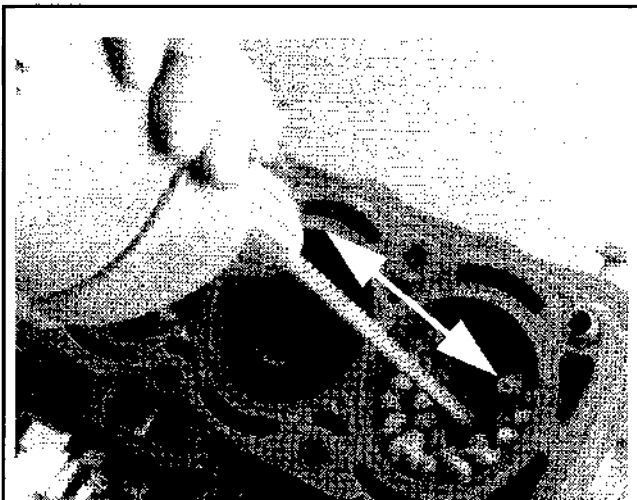


Fig. 53 Use a ball type cylinder hone to remove any glaze and provide a new surface for seating the piston rings

All pistons will have a mark indicating the direction to the front of the engine and the must be installed into the engine in that manner. Usually it is a notch or arrow on the top of the piston, or it may be the letter F cast or stamped into the piston.

C-Clip Type Pistons

1. Note the location of the forward mark on the piston and mark the connecting rod in relation.
2. Remove the C-clips from the piston and withdraw the wrist pin.

☐ **Varnish build-up or C-clip groove burrs may increase the difficulty of removing the wrist pin. If necessary, use a punch or drift to carefully tap the wrist pin out.**

3. Insure that the wrist pin bushing in the connecting rod is usable and lubricate it with assembly lube.
4. Remove the wrist pin from the new piston and lubricate the pin bores on the piston.
5. Align the forward marks on the piston and the connecting rod and install the wrist pin.
6. The new C-clips will have a flat and a rounded side to them. Install both C-clips with the flat side facing out.
7. Repeat all of the steps for each piston being replaced.

ASSEMBLY

Before you begin assembling the engine, first give yourself a clean, dirt free work area. Next, clean every engine component again. The key to a good assembly is cleanliness.

Mount the engine block into the engine stand and wash it one last time using water and detergent (dishwashing detergent works well). While washing it, scrub the cylinder bores with a soft bristle brush and thoroughly clean all of the oil passages. Completely dry the engine and spray the entire assembly down with an anti-rust solution such as WD-40® or similar product. Take a dean lint-free rag and wipe up any excess anti-rust solution from the bores, bearing saddles, etc. Repeat the final cleaning process on the crankshaft. Replace any freeze or oil galley plugs which were removed during disassembly.

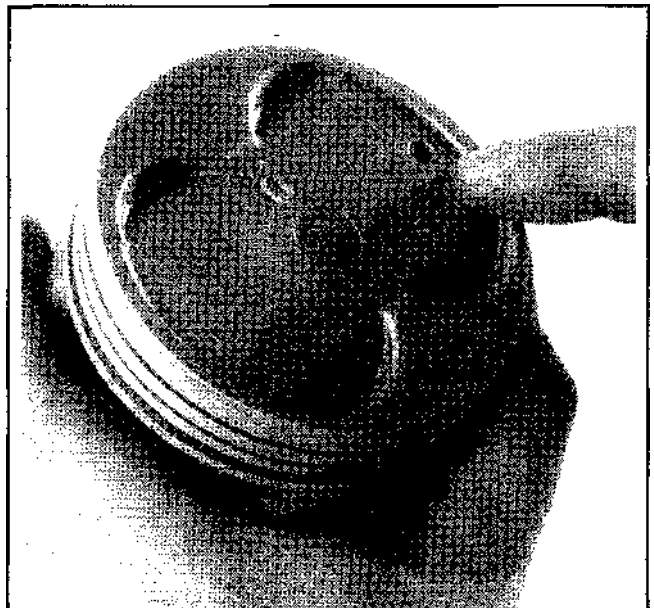


Fig. 54 Most pistons are marked to indicate positioning in the engine (usually a mark means the side facing the front)

7-22 ENGINE OVERHAUL

Crankshaft

◆ See Figures 55, 56, 57, 58 and 59



1. Remove the main bearing inserts from the block and bearing caps.
2. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearing. Be sure that the bearing inserts and bearing bores are clean. Foreign material under inserts will distort bearing and cause failure.
3. Place the upper main bearing inserts in bores with tang in slot.

□ The oil holes in the bearing inserts must be aligned with the oil holes in the cylinder block.

4. Install the lower main bearing inserts in bearing caps.
5. Clean the mating surfaces of block and rear main bearing cap.
6. Carefully lower the crankshaft into place. Be careful not to damage bearing surfaces.
7. Check the clearance of each main bearing by using the following procedure:
 - a. Place a piece of Plastigage® or its equivalent, on bearing surface across full width of bearing cap and about 1/4 in. off center.
 - b. Install cap and tighten bolts to specifications. Do not turn crankshaft while Plastigage® is in place.
 - c. Remove the cap. Using the supplied Plastigage® scale, check width of Plastigage® at widest point to get maximum clearance. Difference between readings is taper of journal.
 - d. If clearance exceeds specified limits, try a 0.001 in. or 0.002 in. undersize bearing in combination with the standard bearing. Bearing clearance must be within specified limits. If standard and 0.002 in. undersize bearing does not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.

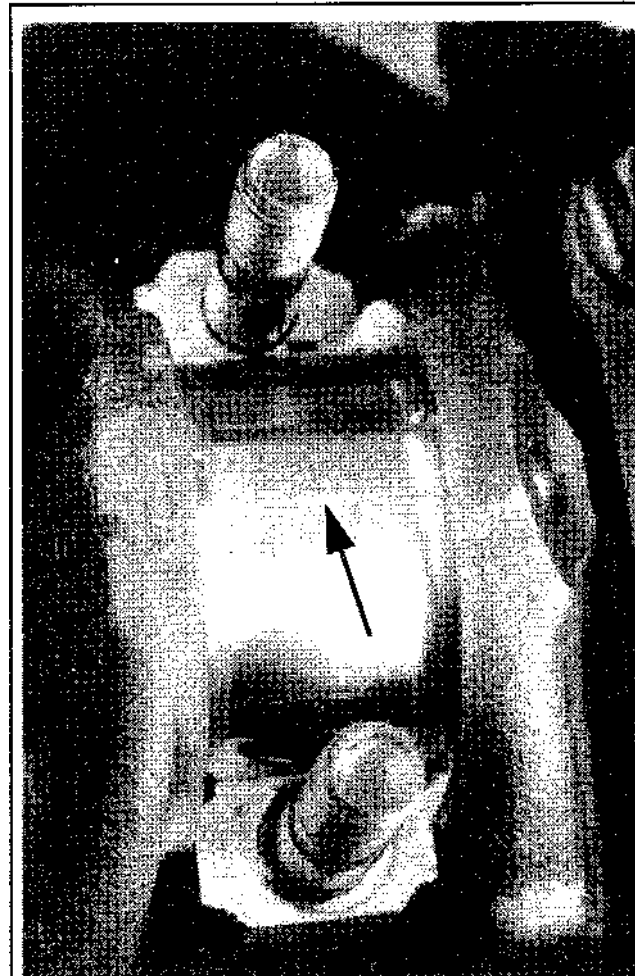


Fig. 55 Apply a strip of gauging material to the bearing journal, then install and torque the cap

8. Install the rear main seal.
9. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings. Install the rear main bearing cap. Install all bearing caps except the thrust bearing cap. Be sure that main bearing caps are installed in original locations. Tighten the bearing cap bolts to specifications.
10. Install the thrust bearing cap with bolts finger-tight.
11. Pry the crankshaft forward against the thrust surface of upper half of bearing.
12. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This aligns the thrust surfaces of both halves of the bearing.
13. Retain the forward pressure on the crankshaft. Tighten the cap bolts to specifications.
15. Measure the crankshaft end-play as follows:
 - a. Mount a dial gauge to the engine block and position the tip of the gauge to read from the crankshaft end.
 - b. Carefully pry the crankshaft toward the rear of the engine and hold it there while you zero the gauge.
 - c. Carefully pry the crankshaft toward the front of the engine and read the gauge.
 - d. Confirm that the reading is within specifications. If not, install a new thrust bearing and repeat the procedure. If the reading is still out of specifications with a new bearing, have a machine shop inspect the thrust surfaces of the crankshaft, and if possible, repair it.
16. Rotate the crankshaft so as to position the first rod journal to the bottom of its stroke.

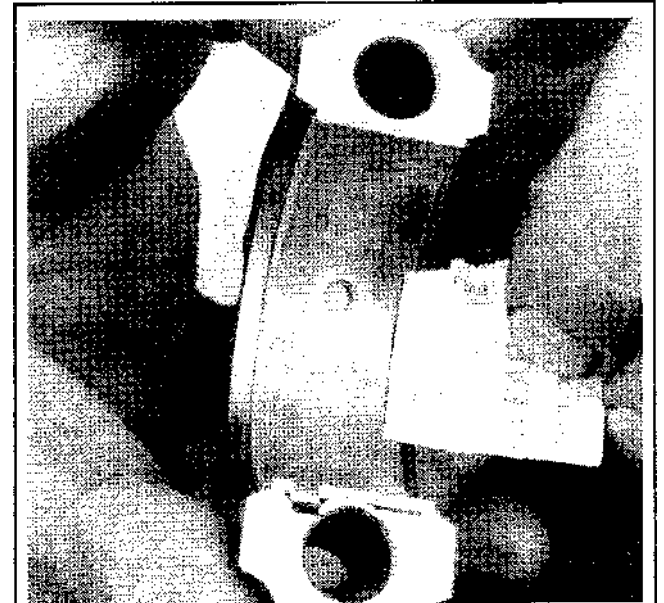


Fig. 56 After the cap is removed again, use the scale supplied with the gauging material to check the clearance

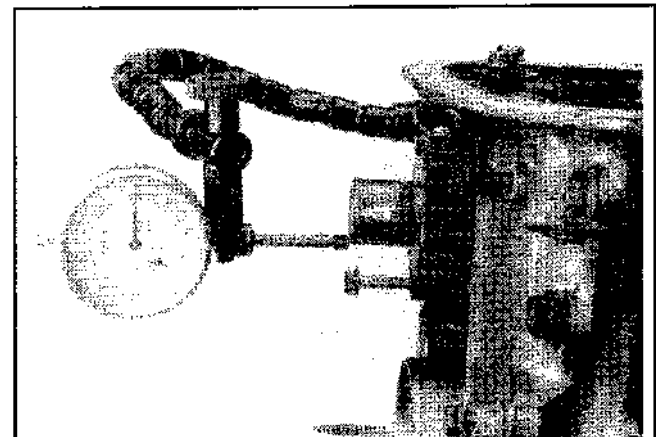
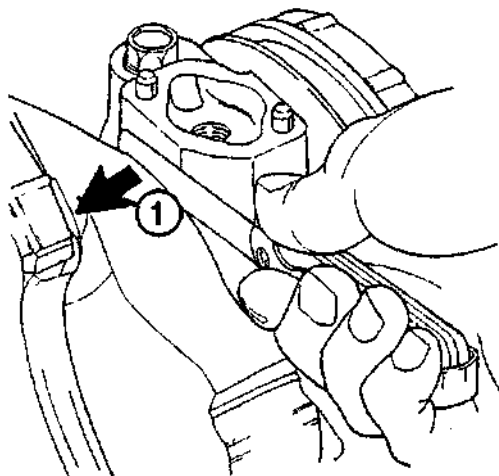


Fig. 57 A dial gauge may be used to check crankshaft end-play...



1- Force crankshaft to forward position

Fig. 58 ...or you can use a feeler gauge

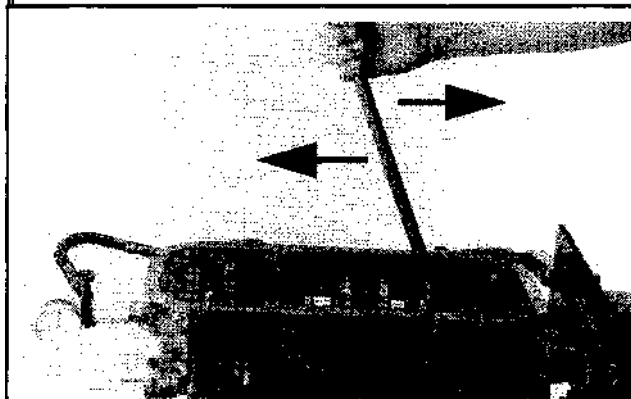


Fig. 59 Carefully pry the crankshaft back and forth while reading the dial gauge for end-play

Pistons and Connecting Rods



◆ See Figures 60, 61, 62, 63, 64, 65, 66 and 67

1. Before installing the piston/connecting rod assembly, oil the pistons, piston rings and the cylinder walls with light engine oil. Install connecting rod bolt protectors or rubber hose onto the connecting rod bolts/studs. Also perform the following:

- a. Select the proper ring set for the size cylinder bore.
- b. Position the ring in the bore in which it is going to be used.
- c. Push the ring down into the bore area where normal ring wear is not encountered.
- d. Use the head of the piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore.
- e. Measure the gap between the ends of the ring with a feeler gauge. Ring gap in a worn cylinder is normally greater than specification. If the ring gap is greater than the specified limits, try an oversize ring set.
- f. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land according to specification. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. If the lower lands have high steps, the piston should be replaced.

2. Unless new pistons are installed, be sure to install the pistons in the cylinders from which they were removed. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one engine or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number. The notch on the piston head goes toward the front of the engine.

3. Install all of the rod bearing inserts into the rods and caps.

4. Install the rings to the pistons. Install the oil control ring first, then the second compression ring and finally the top compression ring—Use a piston ring expander tool to aid in installation and to help reduce the chance of breakage.

5. Make sure the ring gaps are properly spaced around the circumference of the piston. Fit a piston ring compressor around the piston and slide the piston and connecting rod assembly down into the cylinder bore, pushing it in with the wooden hammer handle. Push the piston down until it is only slightly below the top of the cylinder bore. Guide the connecting rod onto the crankshaft bearing journal carefully, to avoid damaging the crankshaft.

6. Check the bearing clearance of all the rod bearings, fitting them to the crankshaft bearing journals. Follow the procedure in the crankshaft installation above.

7. After the bearings have been fitted, apply a light coating of assembly oil to the journals and bearings.

8. Turn the crankshaft until the appropriate bearing journal is at the bottom of its stroke. then push the piston assembly all the way down until the connecting rod bearing seats on the crankshaft journal. Be careful not to allow the bearing cap screws to strike the crankshaft bearing journals and damage them.

9. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal.

10. Prime and install the oil pump and the oil pump intake tube.

11. Install the auxiliary/balance shaft assembly if equipped.

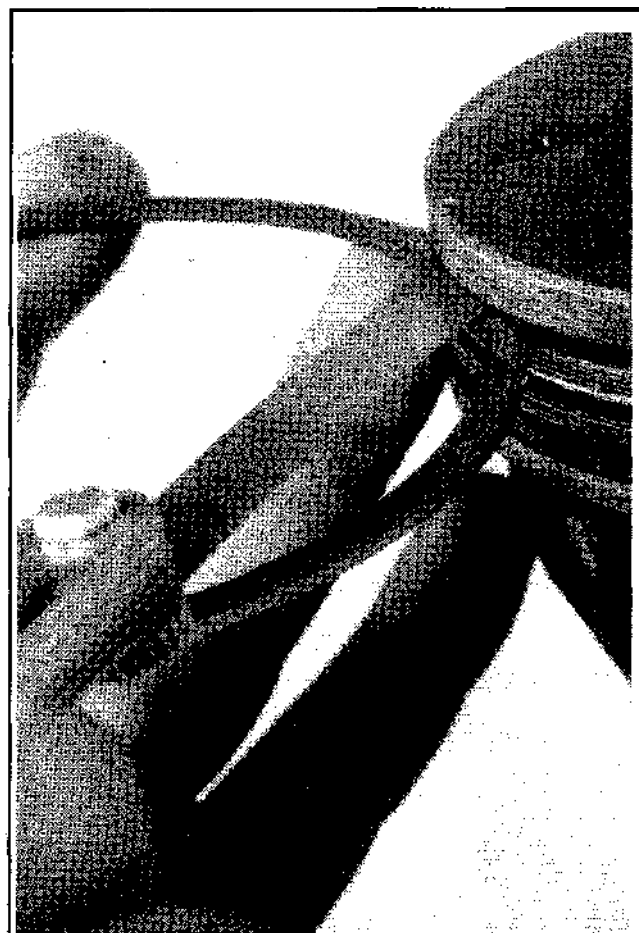


Fig. 60 Checking the piston ring-to-ring groove side clearance using the ring and a feeler gauge

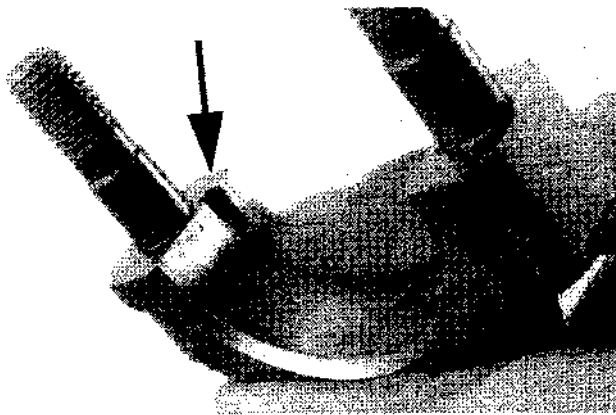


Fig. 61 The notch on the side of the bearing cap matches the tang on the bearing insert

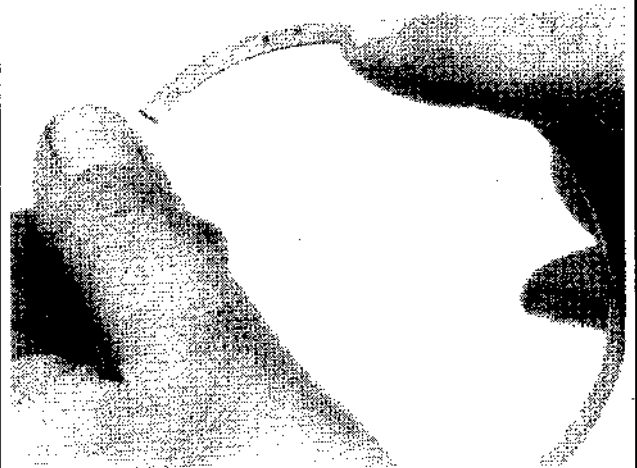


Fig. 62 Most rings are marked to show which side of the ring should face up when installed to the piston

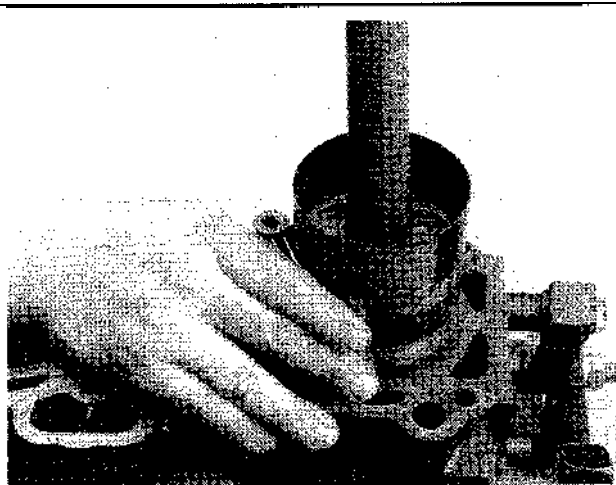


Fig. 63 Install the piston and rod assembly into the block using a ring compressor and the handle of a hammer

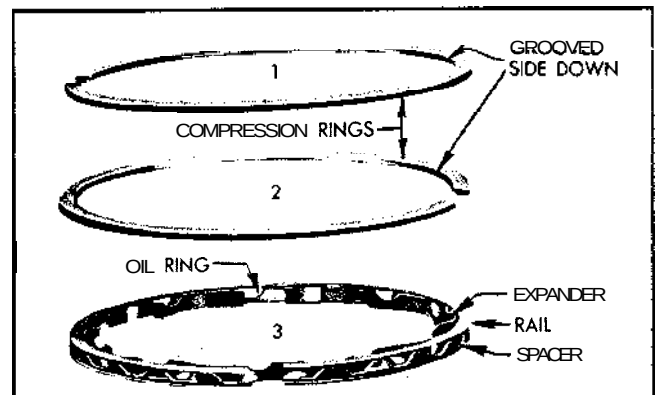


Fig. 64 Piston ring arrangement

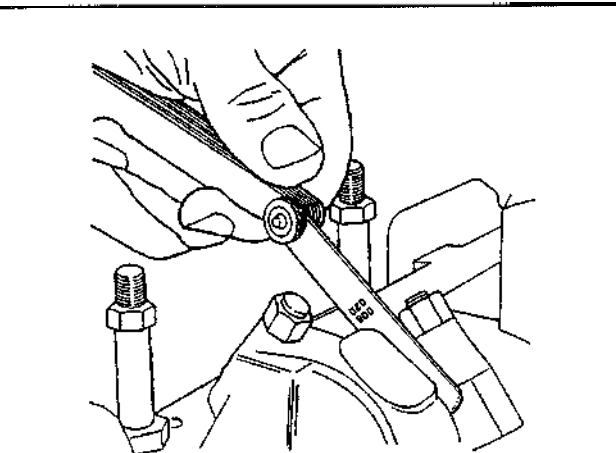


Fig. 65 Checking the connecting rod side clearance

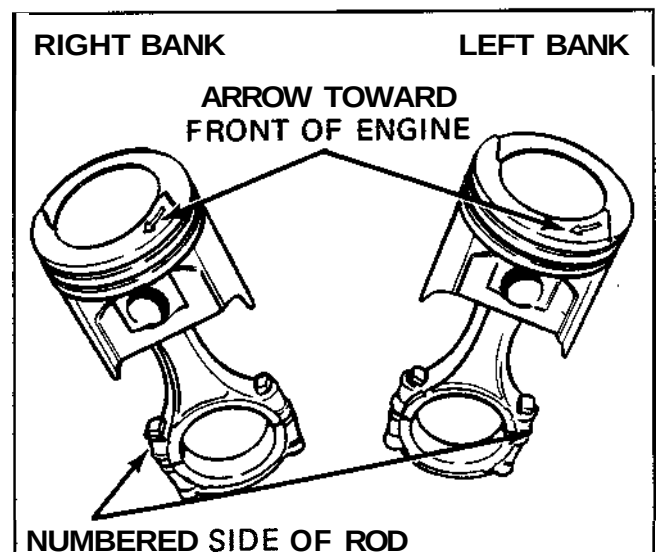


Fig. 67 Piston and rod positioning on a Ford V8, looking aft

Camshaft, Lifters And Timing Assembly

1. Install the camshaft.
2. Install the lifters/followers into their bores.
3. Install the timing gears/chain assembly.

Cylinder Head(S)

1. Install the cylinder head(s) using new gaskets.
2. Assemble the rest of the valve train (pushrods and rocker arms and/or shafts).

Engine Start-up and Break-in**STARTING THE ENGINE**

Now that the engine is installed and every wire and hose is properly connected, go back and double check that all coolant and vacuum hoses are connected. Check that your oil drain plug is installed and properly tightened. If not already done, install a new oil filter onto the engine. Fill the crankcase with the proper amount and grade of engine oil. Fill the cooling system with a 50/50 mixture of coolant/water on models with a closed system.

1. Connect the battery.
2. Start the engine. Keep your eye on your oil pressure indicator; if it does not indicate oil pressure within 10 seconds of starting, turn the engine off.

✱✱ WARNING

Damage to the engine can result if it is allowed to run with no oil pressure. Check the engine oil level to make sure that it is full. Check for any leaks and if found, repair the leaks before continuing. If there is still no indication of oil pressure, you may need to prime the system.

3. Confirm that there are no fluid leaks (oil or other).
4. Allow the engine to reach normal operating temperature.
5. At this point you can perform any necessary checks or adjustments, such as checking the ignition timing.
6. Install any remaining components that were removed.

BREAKING IT IN

Make the first hours on the new engine, easy ones. Vary the speed but do not accelerate hard. Most importantly, do not lug the engine, and avoid sustained high speeds until at least 20 hours. Check the engine oil and coolant levels frequently. Expect the engine to use a little oil until the rings seat. Change the oil and filter at 20 hours and then follow the normal maintenance intervals from there out.

KEEP IT MAINTAINED

Now that you have just gone through all of that hard work, keep yourself from doing it all over again by thoroughly maintaining it. Not that you may not have maintained it before, heck you could have had a couple of thousand hours on it before doing this. However, you may have bought the vehicle used, and the previous owner did not keep up on maintenance. Which is why you just went through all of that hard work. See?

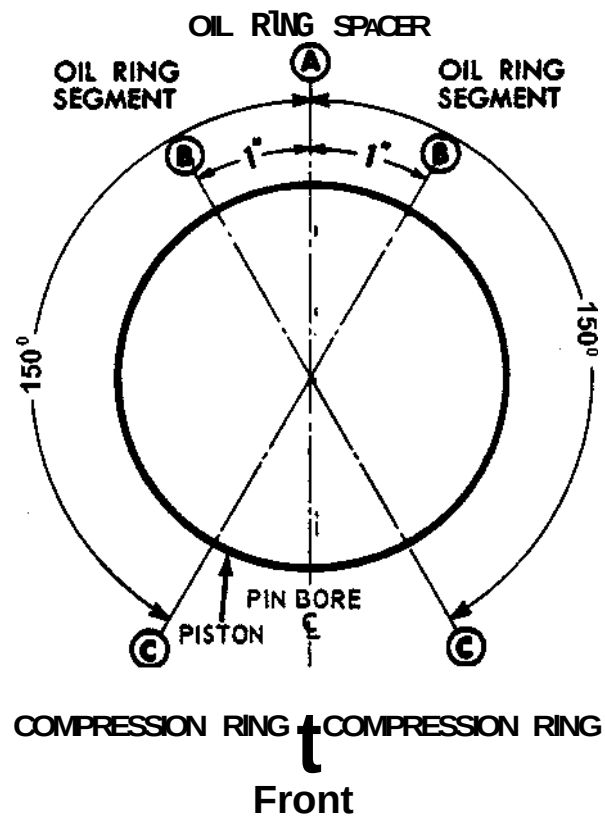


Fig. 66 Piston ring spacing