ENGINES 1B

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FOUR-CYLINDER ENGINE

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GENERAL

The 151 CID (2.5 liter) four-cylinder engine (fig. 1B-1, 2 and 3) installed in CJ vehicles has a cross-flow cylinder head, five main crankshaft bearings, hydraulic valve tappets, conventional ball socket valve rocker arms, a camshaft that is gear driven directly from the crankshaft and a coolant heated aluminum intake manifold.

Identification

The three-character engine identification code is stamped into the left hand rear top corner of the block (fig. 1B-4).

In addition, engines built for sale in Georgia and Tennessee have a nonrepeating number stamped into the left rear block flange (fig. 1B-4).

Three-Character Engine Code

The following three-character engine ID codes represent the data listed adjacent to each code.

- WCP—49S, Manual Trans, WO/AC
- WCT—49S, Auto Trans, WO/AC
- WCU—Calif. Manual Trans, WO/AC
- WCW—Calif., Auto Trans, WO/AC

Engine Mounting

Resilient rubber cushions support the engine (fig. 1B-5) and transmission at three points: at each side on the centerline of the engine and at the rear between the transmission extension housing and the rear support crossmember. Replacement of a cushion may be accomplished by supporting the weight of the engine or transmission at the area of the cushion.

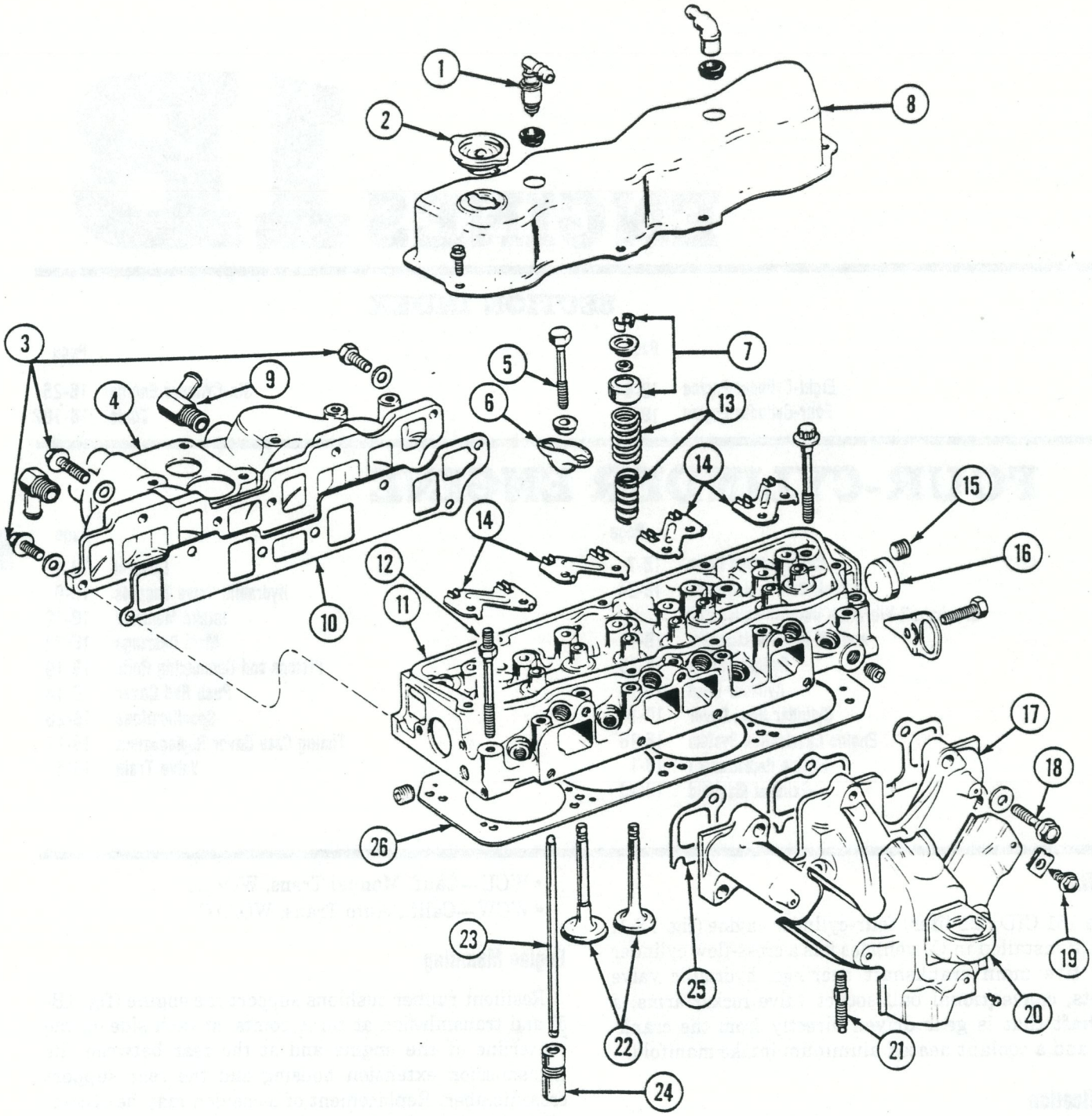
NOTE: *Remove the screws that attach the shroud to the radiator to prevent damage to the shroud by the fan.*

ENGINE REPLACEMENT

Removal

(1) Open hood.

(2) Remove battery negative cable from battery. Remove body ground wire from dash panel.



1. PCV VALVE
2. OIL FILLER CAP
3. INTAKE MANIFOLD ATTACHING BOLTS
4. INTAKE MANIFOLD
5. ROCKER ARM CAPSCREW
6. ROCKER ARM
7. VALVE SPRING RETAINER ASSEMBLY
8. CYLINDER HEAD COVER (ROCKER COVER)
9. COOLANT HOSE FITTING
10. INTAKE MANIFOLD GASKET
11. CYLINDER HEAD
12. CYLINDER HEAD STUD
13. VALVE SPRING
14. PUSH ROD GUIDE
15. CYLINDER HEAD PLUG
16. CYLINDER HEAD CORE PLUG
17. EXHAUST MANIFOLD
18. EXHAUST MANIFOLD BOLT
19. OIL LEVEL INDICATOR TUBE ATTACHING SCREW
20. EXHAUST MANIFOLD HEAT SHROUD (HEAT SHIELD)
21. EXHAUST MANIFOLD TO EXHAUST PIPE STUD
22. VALVES
23. PUSH ROD
24. TAPPET
25. EXHAUST MANIFOLD GASKET
26. CYLINDER HEAD GASKET

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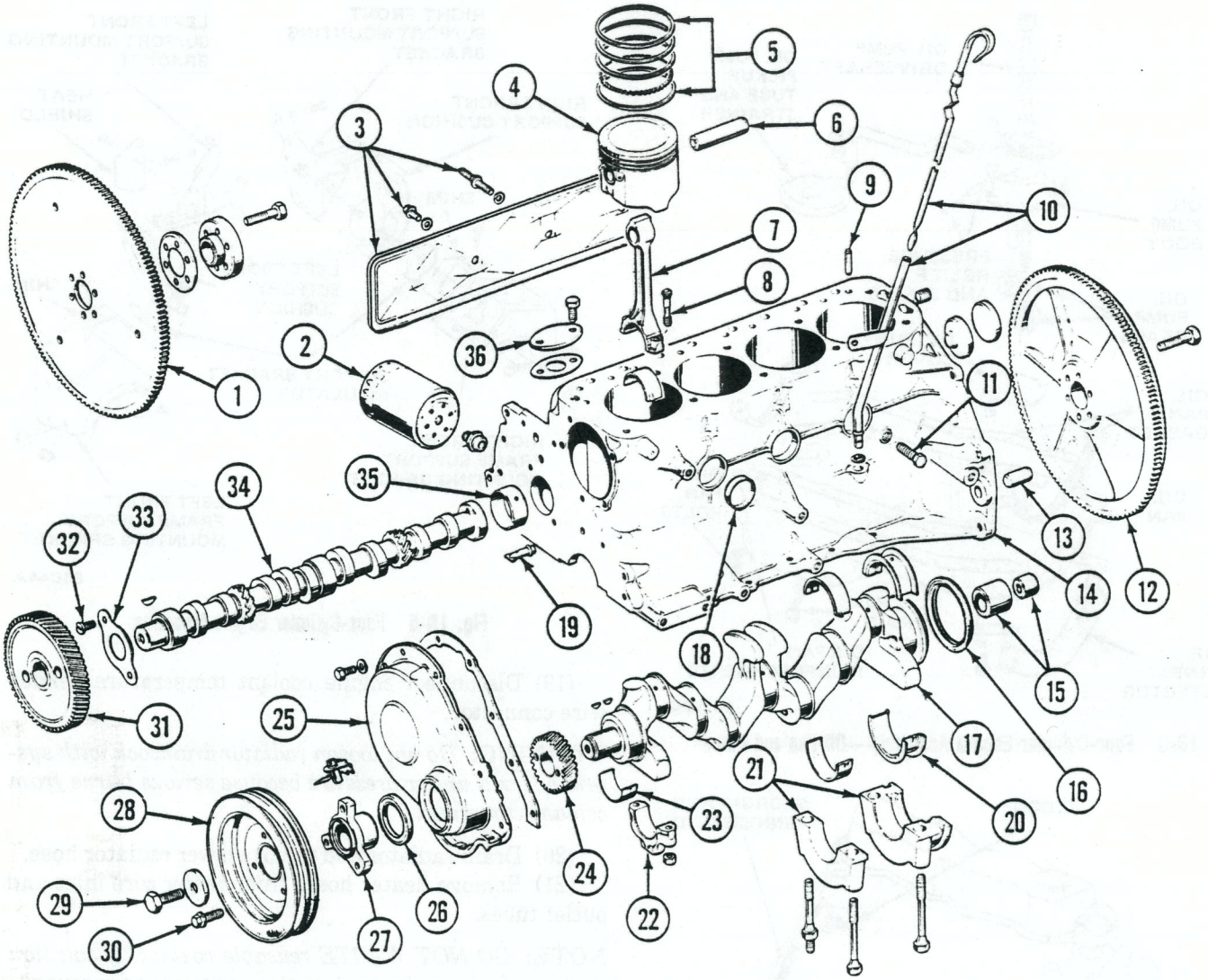
Fig. 1B-1 Four-Cylinder Engine Assembly—Head



1. DRIVE PLATE AND RING GEAR (AUTOMATIC TRANS)
2. OIL FILTER
3. PUSH ROD COVER AND BOLTS
4. PISTON
5. PISTON RING
6. PISTON PIN
7. CONNECTING ROD
8. CONNECTING ROD BOLT
9. DOWEL
10. OIL LEVEL INDICATOR AND TUBE
11. BLOCK DRAIN
12. FLYWHEEL AND RING GEAR (MANUAL TRANS)
13. DOWEL
14. CYLINDER BLOCK
15. PILOT AND/OR CONVERTER BUSHING
16. REAR OIL SEAL
17. CRANKSHAFT
18. BLOCK CORE PLUG
19. TIMING GEAR OIL NOZZLE
20. MAIN BEARINGS
21. MAIN BEARING CAPS
22. CONNECTING ROD BEARING CAP
23. CONNECTING ROD BEARING
24. CRANKSHAFT GEAR
25. TIMING GEAR COVER (FRONT)
26. TIMING GEAR COVER OIL SEAL
27. CRANKSHAFT PULLEY HUB
28. CRANKSHAFT PULLEY
29. CRANKSHAFT PULLEY HUB BOLT
30. CRANKSHAFT PULLEY BOLT
31. CRANKSHAFT TIMING GEAR
32. CAMSHAFT THRUST PLATE SCREW
33. CAMSHAFT THRUST PLATE
34. CAMSHAFT
35. CAMSHAFT BEARING
36. OIL PUMP DRIVESHAFT RETAINER PLATE, GASKET AND BOLT

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Fig. 1B-2 Four-Cylinder Engine Assembly—Block

(3) Remove air cleaner assembly.

(4) Raise vehicle and support with safety stands.

(5) Remove exhaust pipe from exhaust manifold. Disconnect oxygen sensor connector, if equipped.

(6) Disconnect battery cable and solenoid wire from starter motor solenoid.

(7) Remove starter motor bolts and rear bracket nut. Remove starter motor.

(8) Disconnect wire connector from distributor and from oil pressure sending unit.

(9) Remove engine mounting nuts.

(10) Remove hydraulic clutch slave cylinder and flywheel inspection plate (manual transmission only).

(11) Remove transmission clutch/converter housing-to-engine bolts. Automatic transmission, disconnect converter from drive plate.

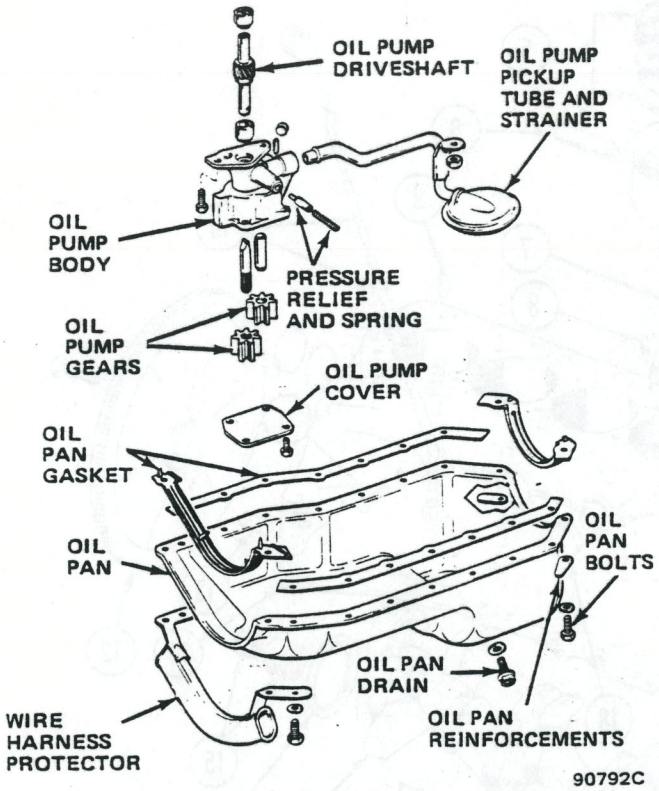


Fig. 1B-3 Four-Cylinder Engine Assembly—Oil Pan and Pump

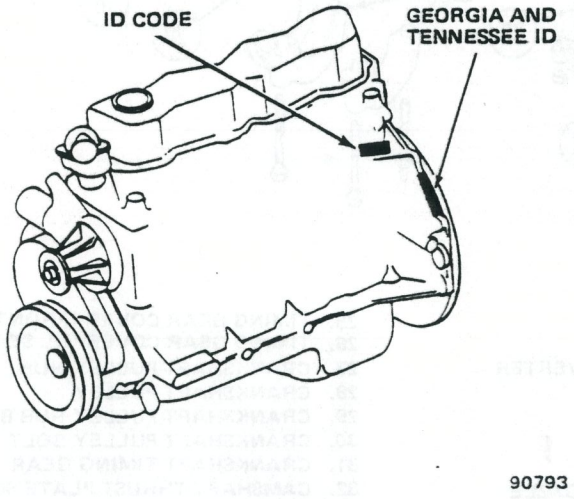


Fig. 1B-4 Engine ID Code Locations

(12) Lower vehicle.

(13) Support transmission with floor jack.

(14) Identify, tag and remove vacuum hoses from canister and carburetor.

(15) Remove bowl vent hose from carburetor. Disconnect mixture control solenoid wire connector from carburetor, if equipped.

(16) Remove wires from alternator.

(17) Disconnect throttle cable from bracket and from carburetor.

(18) Disconnect choke and solenoid wires at carburetor.

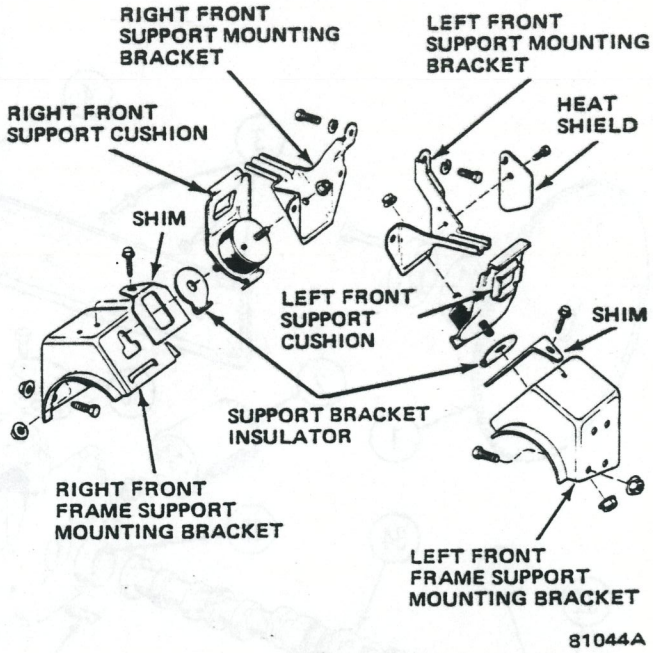


Fig. 1B-5 Four-Cylinder Engine Mounting

(19) Disconnect engine coolant temperature sender wire connector.

WARNING: *Do not loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(20) Drain radiator and remove lower radiator hose.

(21) Remove heater hoses from heater core inlet and outlet tubes.

NOTE: *DO NOT WASTE reusable coolant. If solution is clean, drain coolant into a clean container for reuse.*

NOTE: *It may be necessary to attach a flexible hose to draincock to route coolant to container.*

(22) Remove fan shroud bolts. Remove upper radiator hose, radiator and shroud.

(23) Remove power steering hoses at pump.

CAUTION: *Manual transmission may have to be raised to provide a smooth engine/transmission separation.*

(24) Attach engine hoisting sling and remove engine.

Installation

(1) Lower engine into engine compartment. If manual transmission, ensure that transmission shaft mates correctly with clutch disc and pilot bushing.

(2) Connect power steering hoses.

(3) Connect and secure heater hoses to heater core with clamps.

(4) Connect following wire connectors:

(a) Coolant Temperature sender

(b) Oil pressure sender

(c) Choke and solenoid
(d) Mixture control solenoid, if equipped.

(5) Connect vacuum hoses to canister and carburetor. Ensure hoses are connected correctly according to identifying tags that were attached prior to removal.

(6) Connect bowl vent hose to carburetor.

(7) Connect alternator wires.

(8) Attach throttle cable to carburetor. Secure cable in position with bracket.

(9) Position fan shroud over fan. Install radiator and connect upper and lower radiator hoses. Attach shroud to radiator. Fill system with coolant.

NOTE: *Refer to Chapter 1C—Cooling Systems for additional information.*

(10) Raise vehicle.

(11) Automatic transmission, connect converter to drive plate.

(12) Install transmission clutch/converter housing-to-engine bolts. Tighten bolts with 35 foot-pounds (47 N•m) torque.

(13) Install flywheel inspection plate and hydraulic clutch slave cylinder (manual transmission only). Tighten bolts with 225 inch-pounds (25 N•m) torque.

(14) Install engine mounting nuts. Tighten with 34 foot-pounds (46 N•m) torque.

(15) Install starter motor. Tighten bolts with 27 foot-pounds (37 N•m) torque and bracket nut with 40 inch-pounds (4.5 N•m) torque.

(16) Connect battery cable and solenoid wire to starter motor solenoid.

(17) Connect distributor wire connector.

(18) Connect exhaust pipe to exhaust manifold. Tighten securing nuts with 35 foot-pounds (50 N•m) torque. Connect oxygen sensor wire connector, if equipped.

(19) Connect battery negative cable and body ground wire.

(20) Install air cleaner.

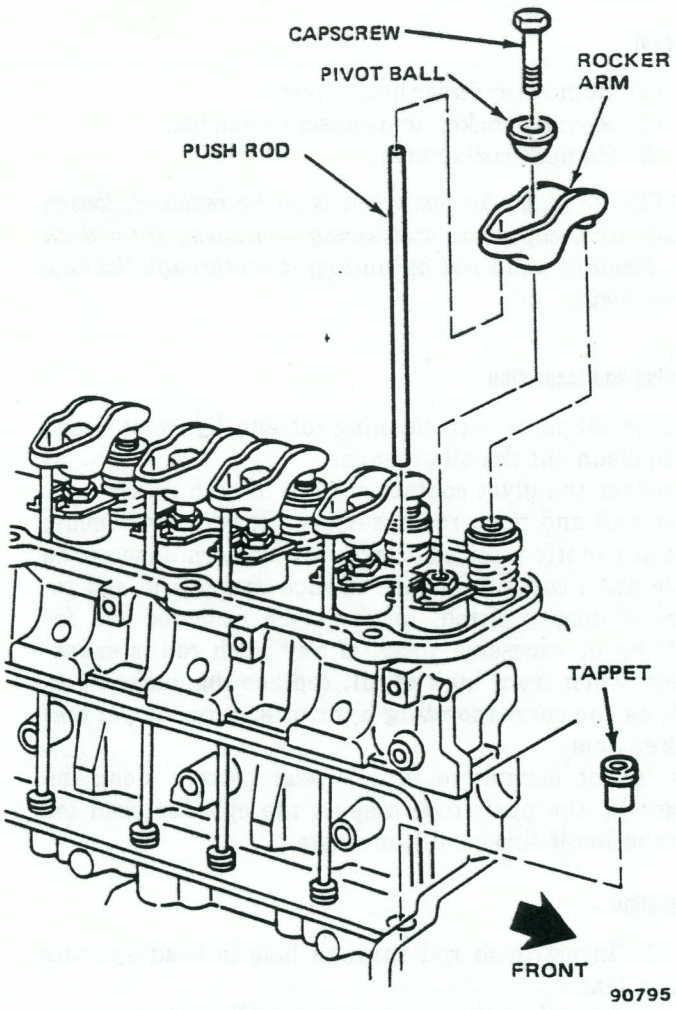
WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

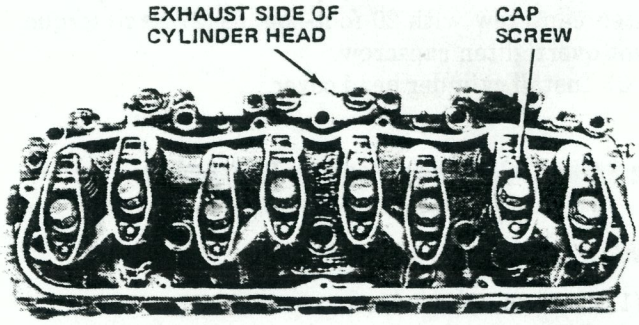
(21) Start engine and inspect for leaks. Refill fluids as necessary.

VALVE TRAIN

General

Motion is transmitted from the camshaft through the hydraulic tappet and push rod to the rocker arm. Each rocker arm moves on its pivot ball and transmits the camshaft motion to the valve. The rocker arm and pivot ball are retained by a capscrew (fig. 1B-6).





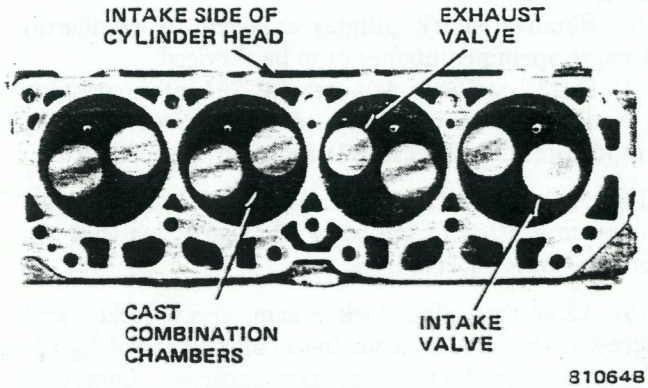


Fig. 1B-6 Valve Train

Rocker Arm and Push Rod

Removal

(1) Remove cylinder head cover.
(2) Remove rocker arm capscrew and ball.
(3) Remove rocker arm.

NOTE: *If only the push rod is to be replaced, loosen rocker arm capscrew and swing arm away from push rod. Remove push rod by pulling it up through the hole in the head.*

Cleaning and Inspection

Clean all parts with cleaning solvent. Use compressed air to clean out the oil passages.

Inspect the pivot contact surface of each rocker arm, pivot ball and push rod assembly. Replace components that are scuffed, pitted or excessively worn. Inspect the valve stem contact surface of each rocker arm and replace if deeply pitted. Inspect each push rod end for scuffing or excessive wear. **If any push rod is excessively worn from lack of oil, replace the push rod as well as the corresponding hydraulic valve tappet and rocker arm.**

It is not normal to find a wear pattern along the length of the push rod. Inspect the cylinder head for obstruction if this condition exists.

Installation

(1) Insert push rod through hole in head and into tappet seat.
(2) Install rocker arm, pivot ball and capscrew. Tighten capscrew with 20 foot-pounds (27 N•m) torque. Do not overtighten capscrew.
(3) Install cylinder head cover.

Valve Springs, Shields and/or Seal Replacement

Removal

(1) Remove cylinder head cover.
(2) Remove rocker arms of valve spring components to be serviced.
(3) Remove spark plug(s) adjacent to cylinder(s) with valve spring components to be serviced.
(4) Install air hose Adapter J-22794 into spark plug hole and apply air pressure to hold valves in place. Apply minimum of 90 psi (621 kPa) air pressure.

NOTE: *An adapter can be constructed by welding an air hose connection to the body of a spark plug with the porcelain insulator removed.*

(5) After removing rocker arm, screw rocker arm capscrew into cylinder head. Insert slotted end of Tool J-5892-1 under head of rocker arm capscrew. Compress valve spring (fig. 1B-7) and hold to allow removal of valve spring retainer cap locks. Remove tool, retainer locks, cap, shield, spring, and valve stem oil seal (fig. 1B-8).

NOTE: *Retain components in same order removed to facilitate installation in original position.*

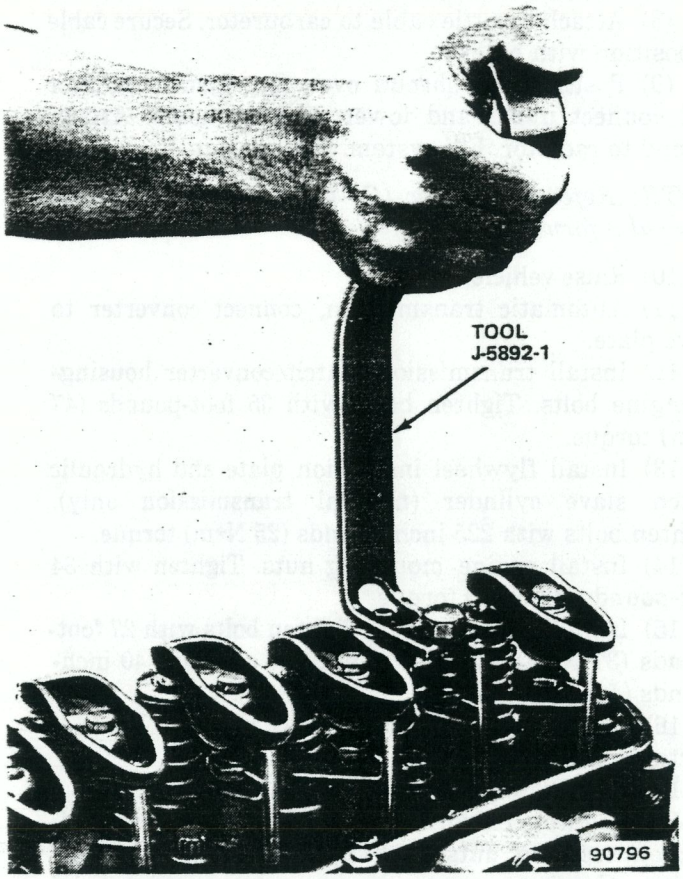


Fig. 1B-7 Compressing Valve Springs

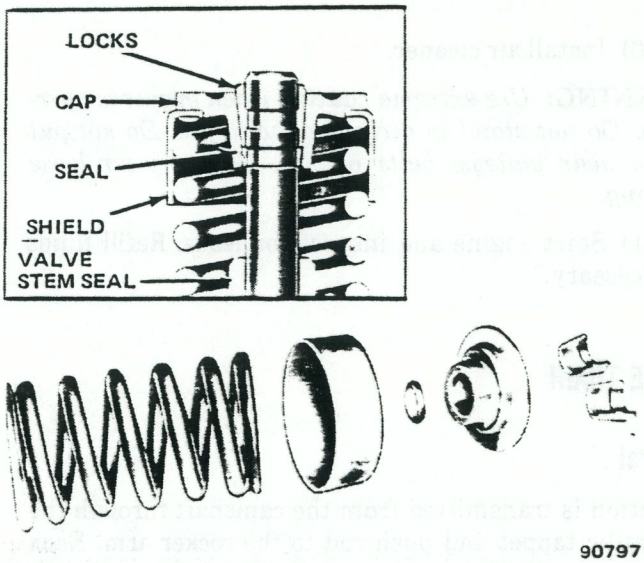


Fig. 1B-8 Upper Valve Train Components

Valve Spring Tension Test

Use Valve Spring Tester J-8056, or equivalent, to test each valve spring for the specified tension values (fig. 1B-9). Replace springs that are not within specification and that bind because of warpage.

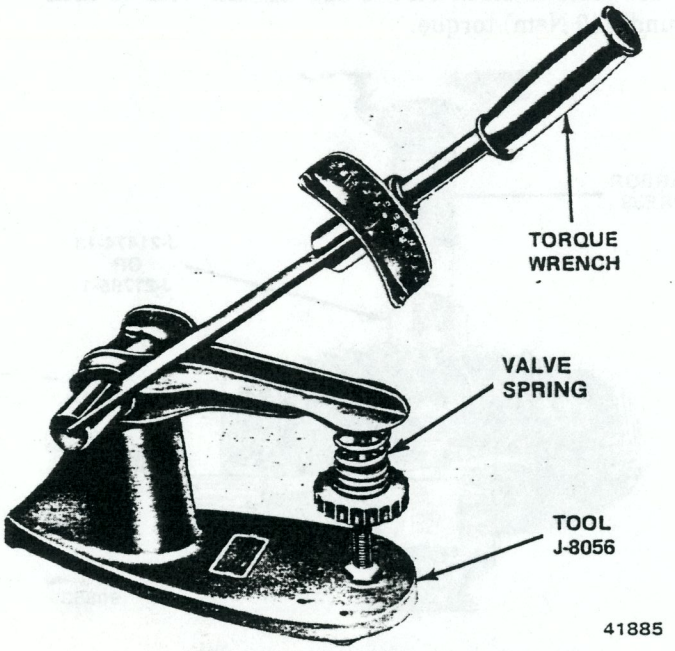


Fig. 1B-9 Testing Valve Spring—Typical

Installation

Always install a new valve stem oil seal whenever valve spring retainer cap locks have been disturbed.

(1) Position oil seal, spring, shield and cap over valve stem.

(2) With Tool J-5892-1, compress valve spring and install retainer cap locks. Remove tool.

(3) Install rocker arm, pivot ball and capscrew over stud. Tighten capscrew with 20 foot-pounds (27 N•m) torque. Do not overtighten.

(4) Install cylinder head cover.

(5) Remove air hose adapter and install spark plug.

CAMSHAFT AND DRIVE

The cast iron camshaft is supported by three bearings and is gear driven. An iron crankshaft gear drives the camshaft through a plastic composition timing gear with a steel hub (fig. 1B-10).

The cam lobes are ground, hardened and tapered with the high side toward the rear. This, coupled with the spherical face on the tappet, causes the tappets to rotate.

The camshaft bearings are lubricated through oil holes that intersect the main oil gallery.

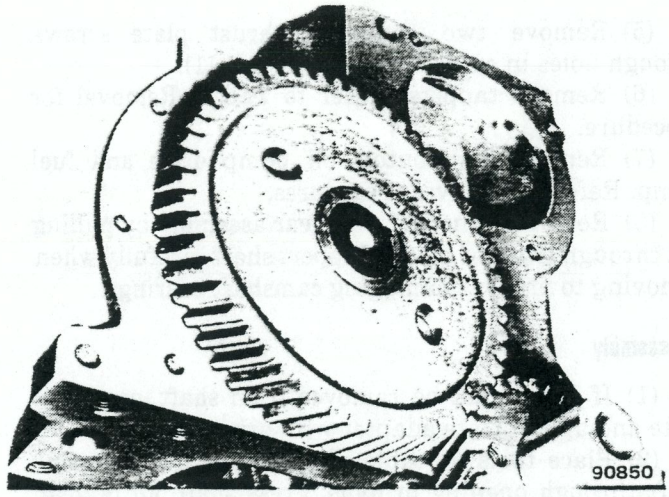


Fig. 1B-10 Camshaft and Crankshaft Gears

Camshaft Replacement

Removal

(1) Remove air cleaner.

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(2) Drain cooling system.

NOTE: *Do not waste reusable coolant. If solution is clean, drain coolant into a clean container for reuse.*

NOTE: *It may be necessary to attach a flexible hose to the drains to route the coolant to the container.*

(3) Remove timing gear cover. Refer to Timing Gear Cover Removal for procedure.

(4) Disconnect radiator hoses at radiator. Remove radiator. Refer to Radiator Removal in Chapter 1C—Cooling Systems.

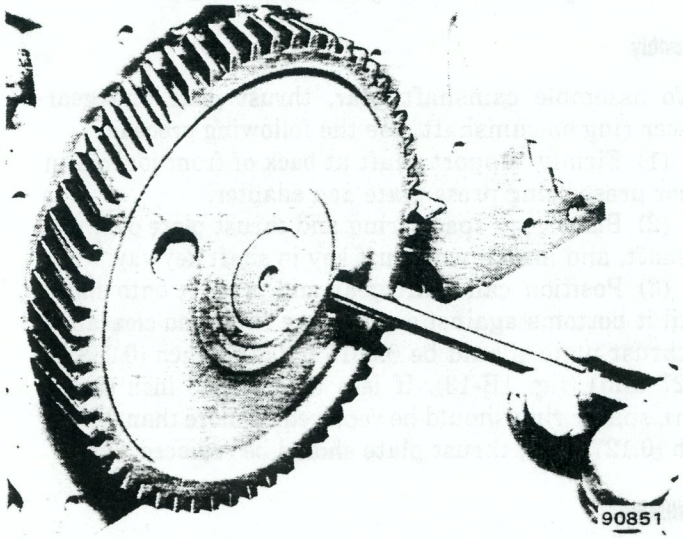


Fig. 1B-11 Removing Camshaft Thrust Plate Screws

(5) Remove two camshaft thrust plate screws through holes in camshaft gear (fig. 1B-11).

(6) Remove tappets. Refer to Tappet Removal for procedure.

(7) Remove distributor, oil pump drive and fuel pump. Refer to removal procedures.

(8) Remove camshaft and gear assembly by pulling out through front of block. Support shaft carefully when removing to prevent damaging camshaft bearings.

Disassembly

(1) If gear must be removed from shaft, use press plate and appropriate adapter with arbor press.

(2) Place tools on table of arbor press. Place camshaft through opening in tools. Press shaft out of gear using socket wrench or other suitable tool (fig. 1B-12).

NOTE: *Thrust plate must be properly aligned to ensure woodruff key in shaft does not damage it when the shaft is pressed out of gear.*

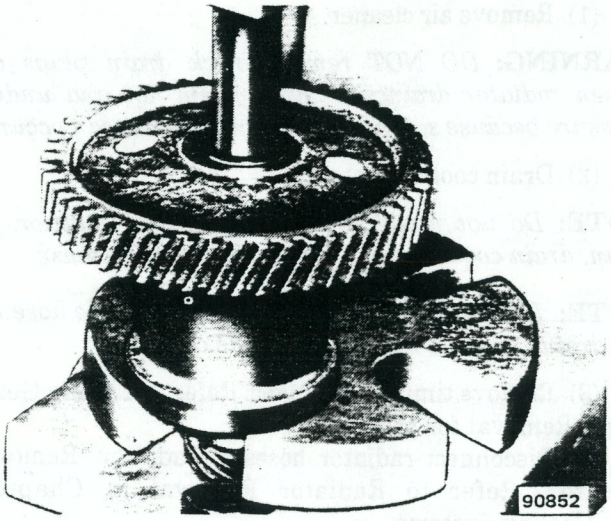


Fig. 1B-12 Removing Camshaft Timing Gear

Assembly

To assemble camshaft gear, thrust plate and gear spacer ring on camshaft, use the following procedure.

(1) Firmly support shaft at back of front journal in arbor press using press plate and adapter.

(2) Place gear spacer ring and thrust plate over end of shaft, and install woodruff key in shaft keyway.

(3) Position camshaft gear and press it onto shaft until it bottoms against gear spacer ring. End clearance of thrust plate should be 0.0015 to 0.0050 inch (0.038 to 0.127 mm) (fig. 1B-13). If less than 0.0015 inch (0.038 mm), spacer ring should be replaced. If more than 0.0050 inch (0.127 mm), thrust plate should be replaced.

Installation

(1) Thoroughly coat camshaft journals with high quality engine oil supplement (EOS).

(2) Install camshaft assembly in engine block. Use care to prevent damaging bearings or camshaft.

(3) Turn crankshaft and camshaft so that valve timing marks on gear teeth are aligned. Engine is now in number four cylinder firing position. Install camshaft thrust plate-to-block screws and tighten with 75 inch-pounds (10 N•m) torque.

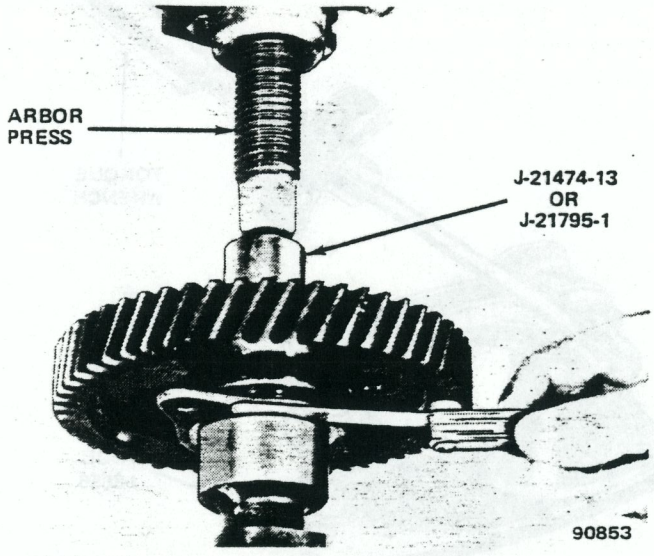


Fig. 1B-13 Installing Camshaft Timing Gear and Measuring Thrust Plate End Clearance

(4) Install timing gear cover and gasket.

(5) Line up keyway in hub with key on crankshaft and slide hub onto shaft. Install center bolt and tighten with 160 foot-pounds (212 N•m) torque.

(6) Install valve tappets, push rods, push rod cover, oil pump shaft and gear assembly and fuel pump. Install distributor according to following procedure.

(a) Turn crankshaft 360 degrees to firing position of number one cylinder (number one exhaust and intake valve tappets both on base circle (heel) of camshaft and timing notch on vibration damper indexed with top dead center mark [TDC] on timing degree scale).

(b) Install distributor and align shaft so that rotor arm points toward number one cylinder spark plug contact.

(7) Install rocker arms and pivot balls over push rods. With tappets on base circle (heel) of camshaft, tighten rocker arm capscrews with 20 foot-pounds (27 N•m) torque. Do not overtighten.

(8) Install cylinder head cover. Refer to Cylinder Head Cover Installation for procedure.

(9) Install intake manifold. Refer to Intake Manifold Installation for procedure.

(10) Install radiator and lower radiator hose.

(11) Install belt, fan and shroud. Tighten fan bolts with 18 foot-pounds (34 N•m) torque. Install upper radiator hose. Tighten belts.

NOTE: *The fan assembly and pulley must be installed with the drive belt(s) in position on pulleys.*

(12) Install engine coolant.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(13) Start engine. Inspect for oil and coolant leaks. Adjust ignition timing.

(14) Install air cleaner.

Camshaft Bearings

NOTE: *Engine must be removed for camshaft bearing service.*

Replacement

(1) With camshaft and flywheel/drive plate removed, drive out expansion plug from rear cam bearing from inside block.

(2) Using Bearing Remover J-21473-1, drive front bearing toward rear and rear bearing toward front.

(3) Install extension J-21054-1 and drive center bearing out toward rear (fig. 1B-14).

(4) Position replacement bearing on tool and install.

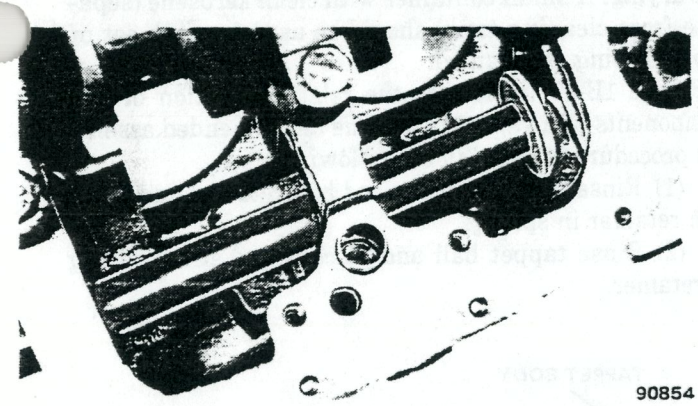


Fig. 1B-14 Removing Center Camshaft Bearing—Typical

NOTE: *Install bearings by reversing procedure listed above. Ensure oil holes are aligned.*

NOTE: *The front bearing must be driven approximately 1/8 inch (3.2 mm) behind front of cylinder block to expose oil hole for timing gear oil nozzle.*

HYDRAULIC VALVE TAPPETS

Hydraulic valve tappets are used to keep all parts of the valve train in constant contact. Each tappet automatically adjusts to maintain zero lash under all conditions.

The hydraulic tappet assembly (fig. 1B-15) consists of a steel body, plunger, push rod seat, metering valve, plunger spring, ball check valve and spring, ball check valve retainer, and retainer ring.

The tappet operates in a guide bore that intersects with the main oil gallery.

The operating cycle of the hydraulic tappet begins when the tappet is on the heel of the cam lobe (engine valve closed). A groove in the tappet body aligns with the tappet oil gallery, admitting pressurized oil into the tappet. A hole and groove arrangement admits the oil to the inside of the plunger. Oil is forced past the plunger check valve and fills the chamber between the plunger and tappet body. When the chamber is full, pressurized oil flows around the metering disc, which controls the amount of oil that flows up the push rod to lubricate the rocker arm assembly. These events all take place while the tappet is on the heel of the cam lobe. As the cam turns, the lobe begins exerting force on the tappet body. This force is transmitted by the trapped oil in the tappet chamber to the plunger and finally to the pushrod and rocker arm assembly. The engine valve opens. While the valve is open, the trapped oil is subjected to considerable pressure and some of it escapes between the plunger and the tappet body (leak-down). The cycle is completed as the cam lobe rotates back to the starting position and another charging cycle begins. In this way, zero valve lash is maintained.

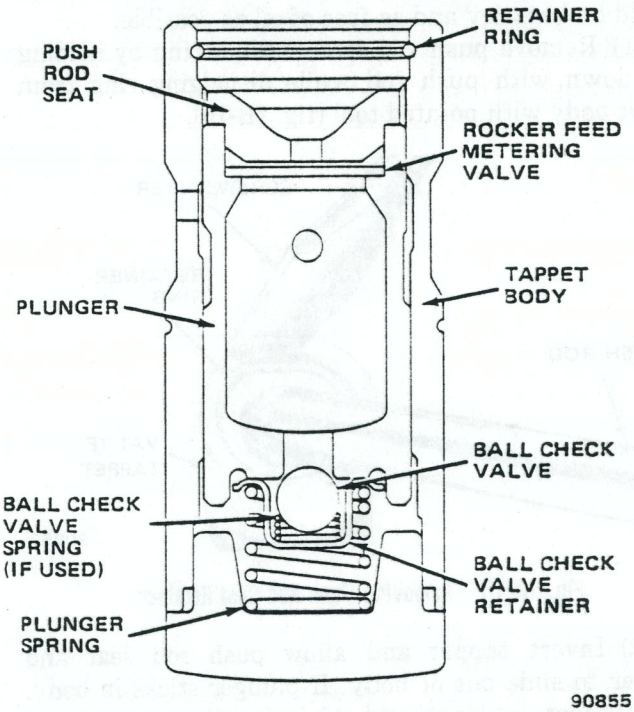


Fig. 1B-15 Hydraulic Valve Tappet

Replacement

(1) Remove cylinder head cover, intake manifold and push rod cover. Refer to removal procedures.

(2) Loosen rocker arm and rotate for access clearance to push rod.

(3) Remove push rod and valve tappet. Hydraulic Valve Tappet Remover J-3049 will facilitate removal of tappet.

NOTE: *If a replacement tappet is to be installed, ensure that all sealer coating is removed from inside of replacement tappet and test for correct leak-down rate.*

Disassembly

Because of the important function that hydraulic valve tappets have in the operation of an engine and the close manufacturing tolerances, proper handling, and above all, cleanliness, cannot be overstressed when servicing the components.

New tappets are serviced as individual units packaged with a plastic coating. Do not remove coating until ready to test the leak-down rate. It is not necessary to remove the oil from replacement tappets prior to testing the leak-down rate because it is special leak-down test oil.

Valve Tappet Cleaning Tank J-5821 is recommended for cleaning valve tappets. The tank should only be used for cleaning valve tappets and should be kept covered when not in use. All servicing should be done in an area isolated from grinders and other sources of dust and foreign material.

Tappets should at all times be stored in a covered box that will maintain them in a clean condition. The box should be kept dry and as free of oil as possible.

(1) Remove push rod seat retainer ring by holding seat down with push rod while dislodging ring from tappet body with pointed tool (fig. 1B-16).

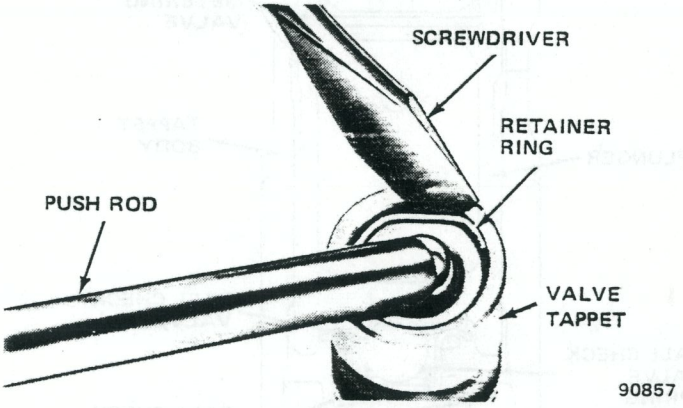


Fig. 1B-16 Removing Push Rod Seat Retainer

(2) Invert tappet and allow push rod seat and plunger to slide out of body. If plunger sticks in body, place tappet in large end of hydraulic valve tappet plunger remover Tool (J-4160) with push rod end of tappet downward. Hold tool firmly in hand with thumb over tappet body and sharply strike tool against block of wood until plunger falls out.

NOTE: *It may be necessary to soak a tappet that has a stuck plunger in cleaning solvent for several minutes before plunger can be removed.*

(3) With oil drained from tappet bodies, place all components of each tappet assembly in separate compartment of tray.

NOTE: *The valve tappet body and plunger are selectively fitted and must not be interchanged with other tappets. Also, keeping all components of each tappet separate will aid in trouble diagnosis.*

Cleaning and Inspection

Thoroughly clean and inspect tappet surfaces for nicks, scratches and scores. Inspection of the check ball and seat should be done with a magnifying glass. The tappet base should also be inspected for wear. If heavy wear is indicated on the cam mating surface, the same lobe of the cam should also be examined. Always clean tappets using only approved solvent and a soft brush. Never use a wire brush or sand paper.

Assembly

All components must be absolutely clean when assembling a hydraulic valve tappet. Because lint and dust may adhere to the components, they should not be dried with compressed air or wiped with a cloth. All parts should be rinsed in clean kerosene and assembled without drying. A small container with clean kerosene (separate from cleaning tank) should be used for each set of tappets being overhauled.

Figure 1B-17 illustrates the relative position of the components of a valve tappet. The recommended assembly procedure is listed in the following steps.

(1) Rinse plunger spring and ball retainer and position retainer in spring.

(2) Rinse tappet ball and place it and small spring in retainer.

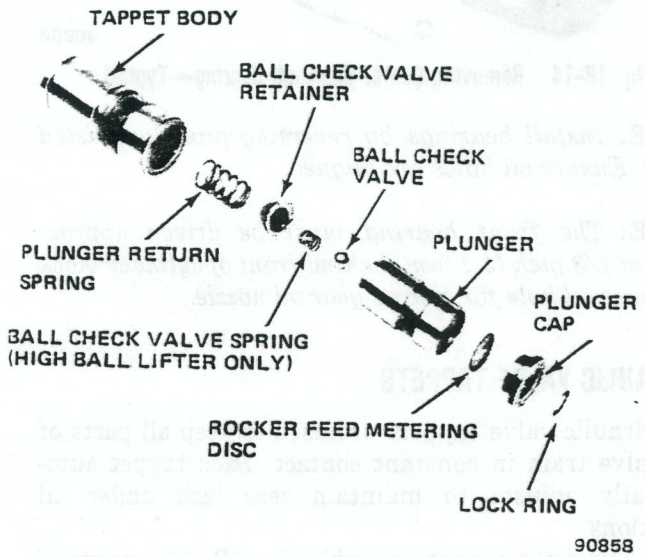


Fig. 1B-17 Hydraulic Valve Tappet—Exploded View

(3) Rinse plunger and place on retainer so that seat on plunger mates with ball.

(4) Invert plunger with parts assembled thus far and, after rinsing tappet body, position body over spring and plunger.

(5) Place tappet body on clean paper, rinse and install push rod seat and retainer ring.

(6) After tappet has been assembled, place in tappet box and close lid to preserve cleanliness.

Leak-Down Test

After all tappets have been assembled, the leak-down rate must be tested before they are installed in the engine. Hydraulic Valve Tappet Leak-Down Tester J-5790 (fig. 1B-18) is designed for testing the leak-down rate of tappets to determine whether or not they are within the specified limits. As with previous service operations involving tappets, cleanliness is paramount. The tester cup and ram should be thoroughly cleaned and testing should be done in an area free of dust and dirt. The testing procedure is described in the following steps:

(1) Fill tester cup to approximately one inch from top with special fluid (J-5268 or equivalent) that is available from tester manufacturer.

(2) Swing weight arm up out of way, raise ram, and position tappet into boss in center of tester cup.

(3) Adjust ram (with weight arm clear of ram) so that pointer is positioned at set line (marked "S"). Tighten jamnut to maintain set position.

(4) Operate tappet through full travel of plunger by pumping weight arm to fill tappet with test fluid and force out air (tappet must be completely submerged at all times). Continue pumping for several strokes after definite resistance is detected.

(5) Raise weight arm to allow plunger spring to expand fully; lower arm onto ram and turn handle slowly (1 revolution every 2 seconds).

Time indicator travel from lower line (first line above set line) to line marked 0.094 or 3/32 inch (2.39 mm), while still rotating cup with handle (fig. 1B-18). Tappet is satisfactory if leak-down interval is between 12 and 90 seconds.

Installation

(1) Place each tappet in original tappet boss.

(2) Replace push rods.

(3) Position rocker arms and pivot balls on push rods.

(4) With tappet on base circle (heel) of camshaft, tighten each rocker arm capscrew with 20 foot-pounds (27 N•m) torque. Do not over tighten.

(5) Replace push rod cover.

(6) Install intake manifold.

(7) Install cylinder head cover.

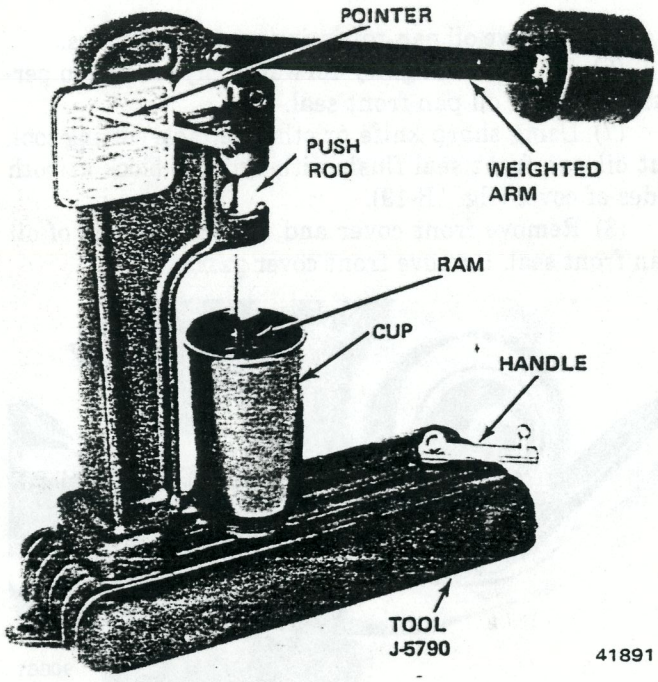


Fig. 1B-18 Testing Leak-Down Rate

CRANKSHAFT VIBRATION DAMPER PULLEY HUB AND OIL SEAL REPLACEMENT

(1) Remove drive belts.

(2) Remove center bolt and slide damper and hub from shaft.

(3) Carefully pry oil seal from front cover with a large screwdriver. Do not bend or distort sheet metal cover.

(4) Install new seal with helical lip toward rear of engine. Drive seal carefully into place using Tool J-23042.

(5) Coat oil seal contact area of vibration damper with engine oil.

(6) Position hub on crankshaft and slide into position until it contacts crankshaft gear.

(7) Install center bolt and tighten with 160 foot-pounds (212 N•m) torque.

(8) Install belts and adjust tensions. Refer to Chapter 1C—Cooling Systems for procedures.

NOTE: *Damper-to-hub bolts should have a locking agent applied to their threads. Coat threads with Drylock 299, or equivalent, before installing.*

TIMING CASE COVER REPLACEMENT

(1) Remove battery negative cable.

(2) Remove crankshaft vibration damper pulley hub. Refer to Crankshaft Vibration Damper Pulley Hub Replacement.

(3) Remove alternator bracket.

(4) Remove fan and shroud nuts. Loosen belts. Remove fan and shroud.

(5) Remove oil pan-to-timing case cover screws.

(6) Pull cover slightly forward only enough to permit cutting of oil pan front seal.

(7) Using sharp knife or other suitable cutting tool, cut oil pan front seal flush with cylinder block at both sides of cover (fig. 1B-19).

(8) Remove front cover and attached portion of oil pan front seal. Remove front cover gasket.

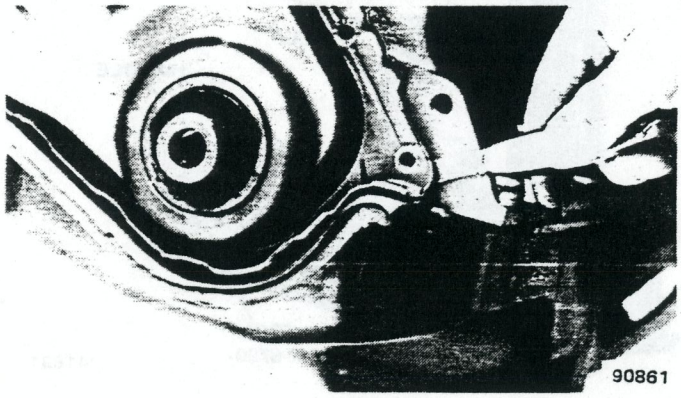


Fig. 1B-19 Cutting Pan Gasket

(9) Clean gasket surfaces on block and timing case cover.

(10) Cut tabs from replacement oil pan front seal (fig. 1B-20). Use sharp instrument to ensure clean cut.

(11) Install seal on timing gear cover. Press tips into holes provided in cover.

(12) Coat gasket with gasket sealer and place in position on cover.

(13) Apply 1/8-inch (3 mm) bead of RTV sealant to joint formed at oil pan and cylinder block (fig. 1B-21).

(14) Install Alignment Tool J-23042 in timing case cover seal (fig. 1B-22).

NOTE: *It is important that an alignment tool be used to align the timing case cover so that vibration damper hub installation will not damage seal and to ensure that seal is positioned evenly around hub.*

(15) Position timing case cover on block. Insert and partially tighten two oil pan-to-timing case cover screws.

(16) Install timing case cover-to-block attaching screws.

(17) Tighten all cover attaching screws to specifications and remove centering Tool J-23042.

(18) Install alternator bracket.

(19) Install pulley hub. Refer to Crankshaft Vibration Damper Pulley Hub Replacement.

(20) Install fan and shroud.

NOTE: *The fan assembly and pulleys must be installed with the drive belts in position on pulleys. Tighten attaching nuts with 18 foot-pounds (34 N•m) torque.*

(21) Tighten belts.

(22) Connect battery negative cable.

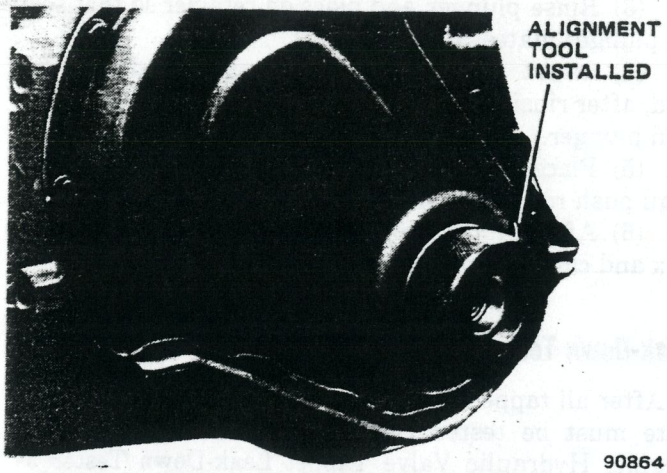


Fig. 1B-20 Oil Pan Seal Modification

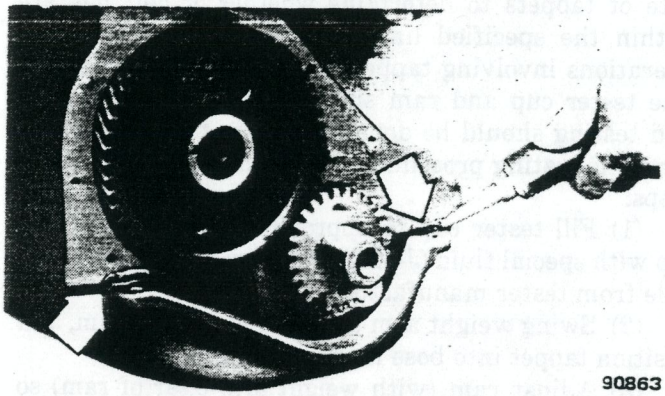


Fig. 1B-21 Applying RTV Sealant

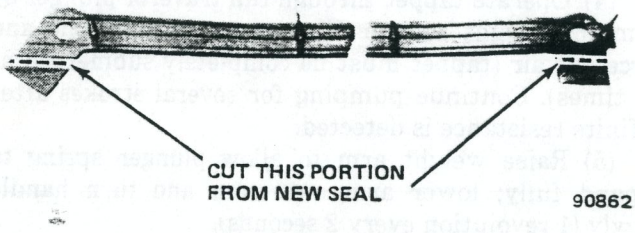


Fig. 1B-22 Timing Case Cover Alignment Tool Installed

INTAKE MANIFOLD

The intake manifold is cast aluminum and has a single level design. A cast passage in the manifold allows engine coolant to pass through to utilize hot coolant heat to warm the manifold and carburetor. This results in better fuel vaporization. An EGR port is also cast in the manifold and receives exhaust gas from an internal exhaust passage through the cylinder head.

Intake Manifold Replacement

WARNING: *The battery negative cable must be removed to prevent a potential fire hazard when the fuel pipe is disconnected.*

(1) Remove battery negative cable.
(2) Remove air cleaner and PCV valve hose.

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(3) Drain cooling system.

NOTE: *DO NOT WASTE reusable coolant. If solution is clean, drain into a clean container for reuse.*

(4) Tag and remove vacuum hoses (ensure distributor vacuum advance hose is removed).
(5) Disconnect fuel pipe and electrical wire connections from carburetor.
(6) Disconnect carburetor throttle linkage. Remove carburetor and carburetor spacer.
(7) Remove bellcrank and throttle linkage brackets and move to one side for clearance.
(8) Remove heater hose at intake manifold.
(9) Remove alternator. Note position of spacers for installation.
(10) Remove manifold-to-cylinder head bolts and remove manifold.
(11) Position replacement gasket and install replacement manifold on cylinder head. Start all bolts.
(12) Tighten manifold-to-cylinder head bolts using sequence illustrated in figure 1B-23. Tighten all bolts with 37 foot-pounds (50 N•m) torque.

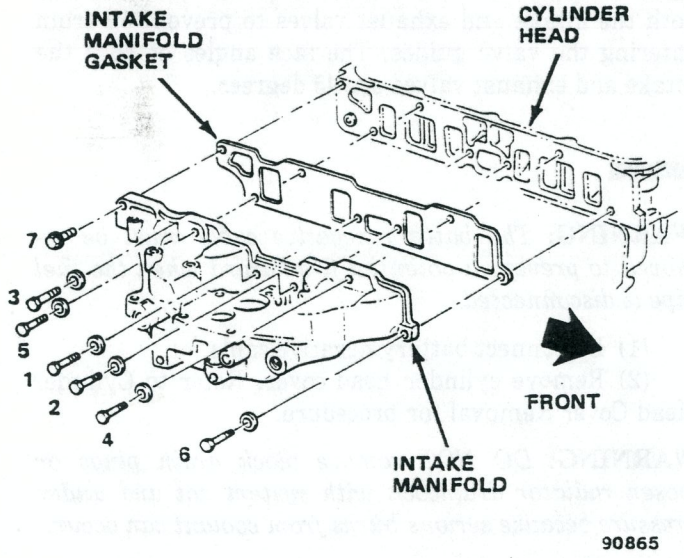


Fig. 1B-23 Intake Manifold Bolt Tightening Sequence

(13) Connect heater hose to intake manifold.
(14) Install bellcrank and throttle linkage brackets.
(15) Connect carburetor throttle linkage to brackets and bellcrank.
(16) Install carburetor spacer and tighten bolts with 15 foot-pounds (20 N•m) torque.
(17) Install carburetor and gasket. Tighten nuts with 15 foot-pounds (20 N•m) torque.
(18) Install fuel pipe and electrical wire connections. Install vacuum hoses.
(19) Install battery negative cable.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(20) Refill cooling system. Start engine and inspect for leaks.
(21) Install air cleaner and PCV valve hose.

EXHAUST MANIFOLD

The exhaust manifold is made of cast nodular iron. The manifold is equipped with a heat stove that is used to provide heated air for the carburetor air intake. This results in better fuel vaporization.

Exhaust Manifold Replacement

(1) Remove air cleaner and heated air tube.
(2) Remove engine oil dipstick tube attaching bolt.
(3) Remove oxygen sensor, if equipped.
(4) Raise vehicle and disconnect exhaust pipe from manifold. Lower vehicle.
(5) Remove exhaust manifold bolts and remove manifold and gasket.
(6) Install replacement gasket and exhaust manifold on cylinder head. Tighten all bolts with 39 foot-pounds (52 N•m) torque in the sequence illustrated in figure 1B-24.
(7) Install dipstick tube attaching bolt.

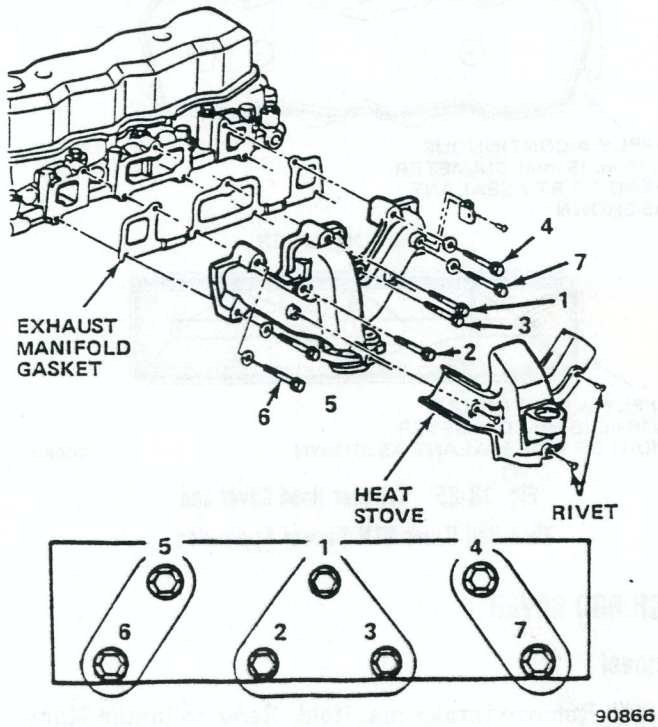


Fig. 1B-24 Exhaust Manifold Tightening Sequence

(8) Install heated air tube and air cleaner.
(9) Install oxygen sensor, if removed.
(10) Raise vehicle and connect exhaust pipe to manifold. Tighten bolts with 35 foot-pounds (50 N•m) torque. Lower vehicle.

CYLINDER HEAD COVER

Removal

(1) Remove air cleaner.
(2) Remove PCV valve (or hose).
(3) Remove cylinder head cover bolts.
(4) Remove spark plug wires from spark plugs and bracket clips.
(5) Remove cylinder head cover by tapping with a rubber hammer to loosen RTV gasket seal. Do not pry on cover.

Installation

(1) Thoroughly clean sealing surfaces on cylinder head cover and cylinder head.
(2) Apply continuous 3/16-inch (5 mm) diameter bead of RTV sealant on cylinder head cover as illustrated in figure 1B-25.
(3) Position cover on head, install retaining bolts and tighten with 7 foot-pounds (10 N•m) torque.
(4) Install spark plug wires, PCV valve (or hose) and air cleaner.

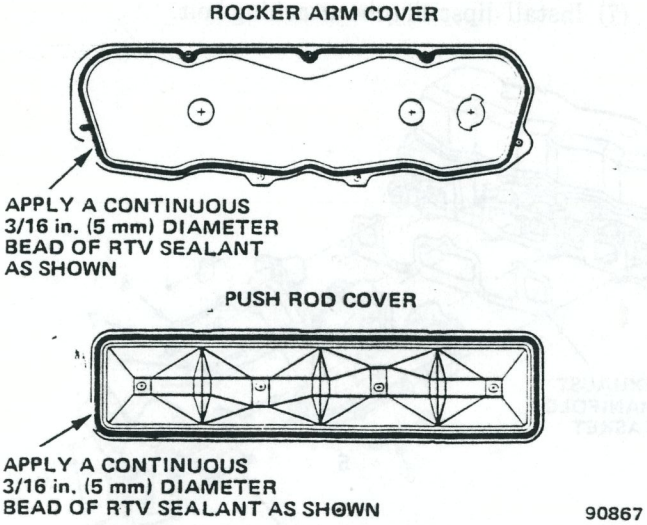


Fig. 1B-25 Cylinder Head Cover and Push Rod Cover RTV Sealant Application

PUSH ROD COVER

Removal

(1) Remove intake manifold. Refer to Intake Manifold for replacement procedure.
(2) Remove push rod cover bolts and remove cover.

Installation

(1) Thoroughly clean sealing surfaces on push rod cover and cylinder block.
(2) Apply continuous 3/16-inch (5 mm) bead of RTV sealant on push rod cover as illustrated in figure 1B-25.
(3) Install cover and cover-to-block bolts. Tighten bolts with 75 inch-pounds (9 N•m) torque.
(4) Install intake manifold. Refer to Intake Manifold for replacement procedure.

CYLINDER HEAD

The cast iron cylinder head is designed to provide a compression ratio of 8.3:1. It is cast with individual intake and exhaust ports for each cylinder. The valve guides are cast integral with the head and the rocker arms are retained on individual threaded studs. The combustion chambers are cast to ensure uniform shape for all cylinders. The spark plugs are located near the intake valves to provide maximum combustion efficiency. The intake valves have 46 degree seat angles and are large to provide sufficient air/fuel intake for high power requirements. The exhaust valve seat angle is also 46 degrees. The 46 degree seat angle assures valve-to-seat contact at the outer diameter of the seat.

External shields are used on both the intake and exhaust valves to reduce the amount of oil splashed against the stems. Valve stem seals are also used on both the intake and exhaust valves to prevent oil from entering the valve guides. The face angles of both the intake and exhaust valves are 45 degrees.

Removal

WARNING: *The battery negative cable must be removed to prevent a potential fire hazard when the fuel pipe is disconnected.*

(1) Disconnect battery negative cable.
(2) Remove cylinder head cover. Refer to Cylinder Head Cover Removal for procedure.

WARNING: *DO NOT remove block drain plugs or loosen radiator draincock with system hot and under pressure because serious burns from coolant can occur.*

(3) Drain block.

NOTE: *DO NOT WASTE reusable coolant. If solution is clean, drain coolant into a clean container for reuse.*

(4) Remove exhaust pipe.
(5) Tag and disconnect vacuum hoses.

NOTE: *Ensure vacuum advance hose is tagged and disconnected.*

(6) Remove alternator and put aside. Do not misplace spacers.

(7) Disconnect fuel pipe from carburetor. Move pipe over and align with opening in intake manifold to facilitate cylinder head removal.

(8) Remove rear heater hose and upper radiator hose.

(9) Remove power steering pump and bracket assembly.

NOTE: *Do not disconnect power steering hoses from pump or gear.*

(10) Remove dipstick.

(11) Remove rocker arm assemblies and push rods.

NOTE: *Note location of rocker arms to facilitate installation in their original locations.*

CAUTION: *To prevent slipping, use a 12 mm 12-point socket wrench to ensure a tight fit on the bolt heads.*

(12) Remove cylinder head bolts.

(13) Remove cylinder head by inserting pry bar into alternator bracket and prying upward.

Installation

The gasket mating surfaces on both the head and the block must be smooth and clean, i.e., no foreign matter, nicks or heavy scratches. The cylinder head bolt threads in the block and on the cylinder head bolts must also be clean, if not, bolt tightening torque will be inaccurate.

(1) Place replacement cylinder head gasket in position over dowel pins and flat on cylinder block.

(2) Carefully guide cylinder head into place over dowel pins and gasket.

(3) Coat underside of heads and threads of cylinder head bolts with sealing compound and install finger-tight.

CAUTION: *To prevent slipping, use a 12 mm 12-point socket wrench to ensure a tight fit on the bolt heads.*

(4) Tighten cylinder head bolts in steps following sequence depicted in figure 1B-26. The final torque is 92 foot-pounds (125 N•m).

(5) Install push rods, rocker arm assemblies and cylinder head cover. Tighten rocker arm capscrews with 20 foot-pounds (27 N•m) torque. Refer to Cylinder Head Cover for procedure.

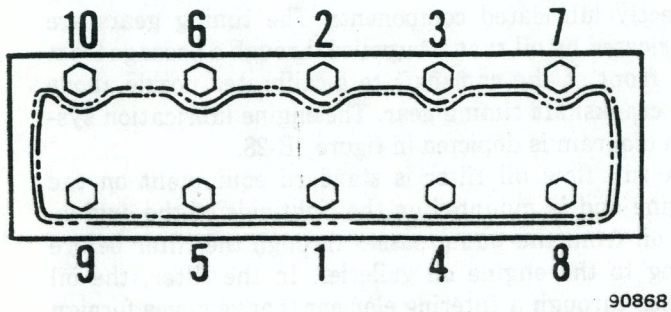


Fig. 1B-26 Cylinder Head Tightening Sequence

(6) Install power steering pump and bracket.

(7) Install alternator and tighten belt to specified tension. Refer to Chapter 1C—Cooling Systems for procedure.

(8) Connect fuel pipe to carburetor.

(9) Install heater hose and upper radiator hose, tighten clamps.

(10) Connect vacuum hoses.

(11) Install exhaust pipe. Tighten nuts with 18 foot-pounds (24 N•m) torque.

(12) Refill cooling system with coolant.

(13) Install dipstick.

(14) Connect battery negative cable.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(15) Start engine and inspect for leaks.

Valves and Seats

Reconditioning of valves and valve seats is very important because the seating of the valves must be precise for the engine to produce specified power and provide reliable performance.

Another important factor is the cooling of the valve heads. Close contact between each valve and its seat is imperative to ensure that the heat in the valve head will be properly transferred to the cylinder head.

Several different types of equipment are available for refacing valves and valve seats. The instructions provided by the manufacturer of the equipment being used should be carefully followed to attain proper results.

Regardless of the type of equipment used it is essential that valve bores be free from carbon and other foreign matter to ensure correct centering of the pilot in the guide.

Valve Guide Bores

Valves with oversize stems are available for both intake and exhaust valves. Guides should be reamed and replacement oversize valves installed whenever clearances exceed specifications.

Cylinder Head Disassembly

(1) With cylinder head removed, remove rocker arm capscrews, pivot balls and rocker arms. Install capscrews.

(2) Using Tool J-5892-1, compress each valve spring and remove locks. Release tool and remove spring cap, spring shield, spring, and oil seal. Wash all parts in cleaning solvent and dry thoroughly.

(3) Remove valves from cylinder head and place in rack in proper sequence to facilitate assembly in their original positions.

(4) Clean all carbon from combustion chambers and valve ports.

(5) Thoroughly clean valve guides using Tool J-8101.

(6) Clean all carbon and sludge from push rods and rocker arms.

(7) Clean valve stems and head on buffing wheel. Inspect valves for burned heads, cracked faces and damaged stems.

(8) Remove carbon and other deposits from head gasket mating surfaces.

(9) Inspect cylinder head for cracks in exhaust ports, combustion chambers, and external cracks in water jacket.

(10) Measure fit of valve stems in their respective guides.

NOTE: *Excessive valve stem-to-guide clearance will cause reduced power, rough idling and noisy valves, and may cause valve breakage. Insufficient clearance will result in noisy and sticky functioning of the valve and cause rough idling.*

(a) Using a micrometer, measure diameter of valve stem in three places; top, center and bottom. Exhaust valves have tapered stems and are approximately 0.001-inch (0.025 mm) larger at top of stem than at head end.

(b) Insert telescoping gauge in valve guide bore to measure valve-to-valve guide clearance (fig. 1B-27).

(c) If clearance is not within specified limits, use next oversize valve stem size and ream bore to fit using suitable reamer with Tool J-5830-02. Service valves are available with standard, 0.003-inch (0.076 mm) and 0.005-inch (0.127 mm) oversize stem diameters.

(11) Test valve spring tension with suitable tester. Refer to Valve Spring Tension Testing.

NOTE: *Springs should be tested by compressing to a specified height, and measuring force required to maintain that height. (See Specifications.) Weak springs should be replaced if not within 10 force-pounds (44 N) of the specified load (without dampers).*

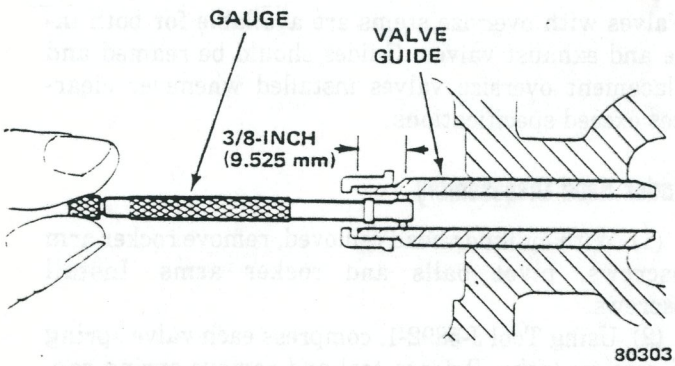


Fig. 1B-27 Measuring Valve Guide Bore with Telescoping Gauge

Cylinder Head Assembly

(1) Insert valve in original port.

(2) Assemble valve spring and related parts according to following procedure:

(a) Set valve spring, shield and cap in place.

(b) Compress spring with Tool J-5892-1.

(c) With Tool J-22330 install oil seal in lower groove of stem. Ensure seal is flat and not twisted.

(d) Install locks and release compressing tool. Ensure locks are seated properly in upper groove of valve stem.

(3) Install remaining valves according to procedure described above.

(4) Test each valve stem oil seal by placing Valve Seal Installer and Tester Tool J-22330 over end of valve stem and against cap.

(5) Measure installed height of valve springs using a narrow, thin scale. Use of a cutaway scale will help. Measure from top of spring seat to top of valve spring or oil shield. If spring exceeds specified height, install 1/16-inch (1.59 mm) valve spring seat shim.

CAUTION: *Never shim a spring excessively. Installed height should never be less than specified minimum height.*

ENGINE LUBRICATION SYSTEM

Engine lubrication is accomplished through a gear type pump that pumps engine oil from the oil pan sump, through the full flow oil filter and into an oil passage that runs along the right side of the block and intersects the hydraulic valve tappet bores. Oil from this passage is routed to the crankshaft main and camshaft bearings through smaller drilled passages. Oil is supplied to the rocker arms through holes in the hydraulic valve tappets, which force oil up through the tubular push rods to the rocker arms. The oil is metered by a disc located within each tappet body.

Two valves are incorporated into the lubrication system to ensure the proper flow of oil. A bypass valve is located within the oil filter mounting boss that will continue oil flow in the event that the filter becomes clogged or restricted. The pressure regulator valve located in the oil pump body maintains adequate pressure for the lubrication system and bypasses any excess oil back to the oil pan sump.

Many internal engine parts have no direct oil source and are either gravity or splash lubricated from other directly lubricated components. The timing gears are lubricated by oil that is supplied through a passage from the front of the camshaft to a calibrated nozzle above the crankshaft timing gear. The engine lubrication system diagram is depicted in figure 1B-28.

A full flow oil filter is standard equipment on the engine and is mounted on the right side of the engine. All oil from the pump passes through the filter before going to the engine oil galleries. In the filter, the oil passes through a filtering element that removes foreign particles.

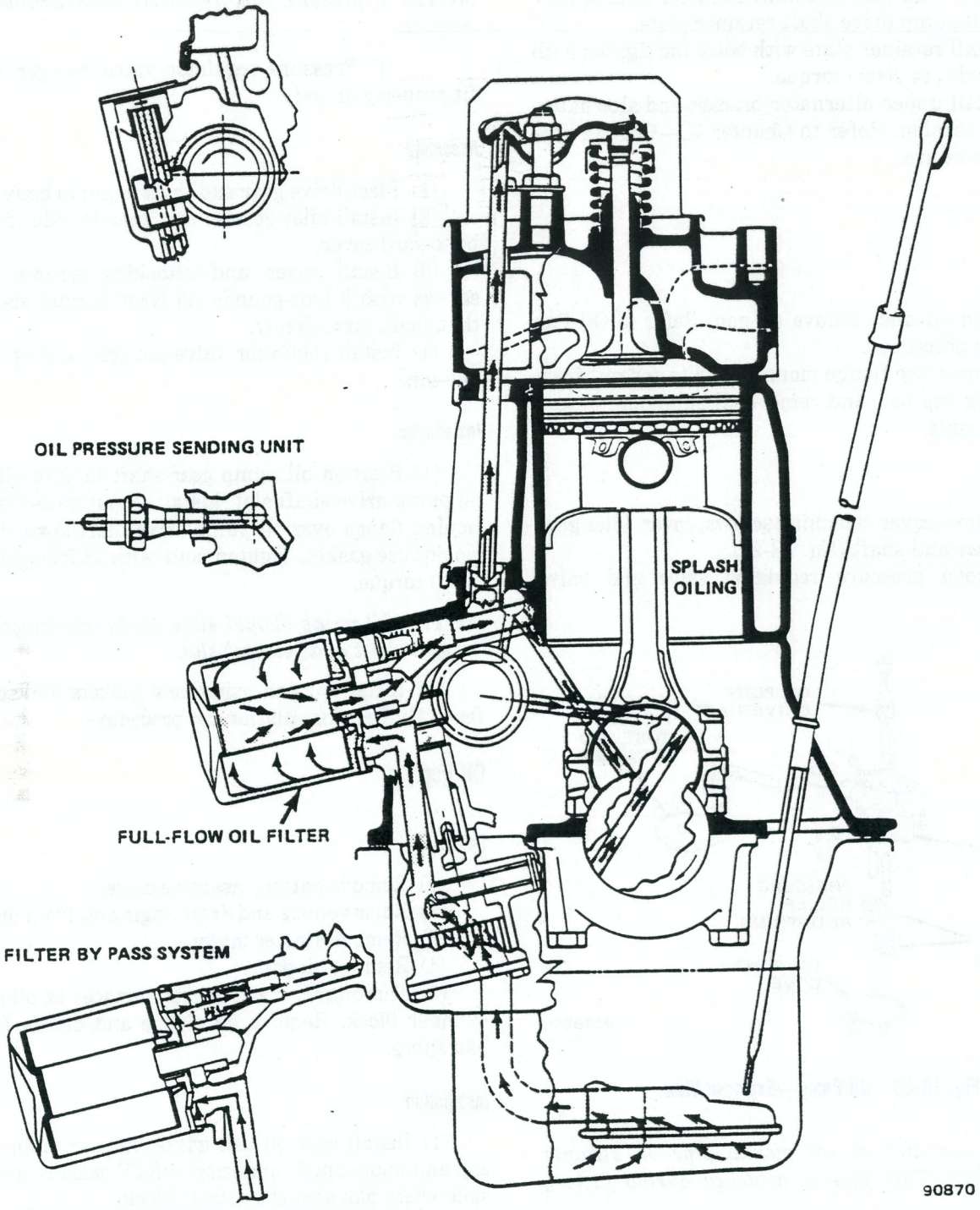


Fig. 1B-28 Engine Lubrication System Diagram

Oil Pump Drive Shaft

Removal

(1) Remove alternator and upper bracket.

(2) Remove oil pump drive shaft retainer plate bolts and remove bushing and shaft assembly.

Installation

(1) Install oil pump drive shaft assembly by turning shaft until it meshes with camshaft drive gear and inserts properly in oil pump body.

(2) Thoroughly clean sealing surfaces on cylinder block and retainer plate.

(3) Apply 1/16-inch (1.6 mm) diameter bead of RTV sealant to oil pump drive shaft retainer plate.

(4) Install retainer plate with bolts and tighten with 10 foot-pounds (14 N•m) torque.

(5) Install upper alternator bracket and alternator. Adjust belt tension. Refer to Chapter 1C—Cooling Systems for procedure.

Oil Pump

Removal

(1) Drain oil and remove oil pan. Refer to Oil Pan Removal for procedure.

(2) Remove two flange mounting bolts and nut from main bearing cap bolt and remove oil pump and pickup assembly as unit.

Disassembly

(1) Remove cover attaching screws, cover, idler gear and drive gear and shaft (fig. 1B-29).

(2) Remove pressure regulator valve and valve parts.

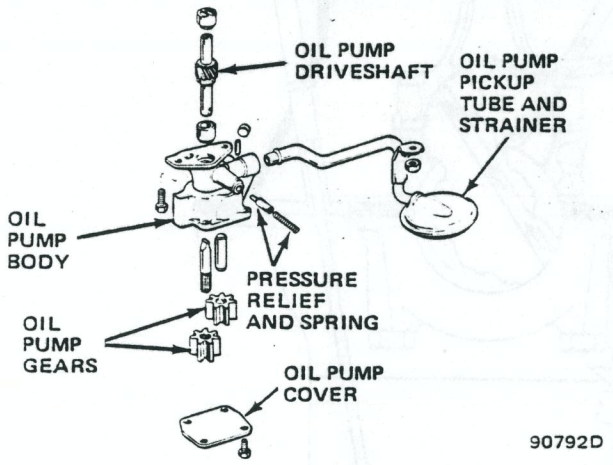


Fig. 1B-29 Oil Pump—Exploded View

NOTE: *Do not disturb oil pickup pipe on strainer screen or body. This pipe is attached during factory assembly.*

(3) If any of the following discrepancies are observed during inspection, complete pump assembly should be replaced.

(a) Pump body has cracks or excessive wear.

(b) Pump gears have cracks, excessive wear and damage.

(c) Shaft is loose in housing.

(d) Inside of cover has wear that would permit oil to leak past ends of gears.

(e) Oil pick-up assembly has damage to strainer screen or relief grommet.

NOTE: *If present, remove debris from strainer screen surface.*

(f) Pressure regulator valve plunger does not fit properly in body.

Assembly

(1) Place drive gear and shaft in pump body.

(2) Install idler gear so that smooth side of gear will be toward cover.

(3) Install cover and attaching screws. Tighten screws with 9 foot-pounds (17 N•m) torque and ensure that shaft turns freely.

(4) Install regulator valve plunger, spring, retainer and pin.

Installation

(1) Position oil pump gear shaft tang to align with oil pump drive shaft slot. Install oil pump-to-block positioning flange over oil pump drive shaft lower bushing. Do not use gasket. Tighten bolts with 18 foot-pounds (25 N•m) torque.

NOTE: *Oil pump should slide easily into place. If not, remove shaft and relocate slot.*

(2) Install oil pan using new gaskets and seals. Refer to Oil Pan Installation for procedure.

Oil Pan

Removal

(1) Remove battery negative cable.

(2) Raise vehicle and drain engine oil from oil pan.

(3) Remove starter motor.

(4) Remove oil pan.

(5) Thoroughly clean gasket surfaces of oil pan and cylinder block. Remove all sludge and debris from oil pan sump.

Installation

(1) Install rear oil pan gasket in rear main bearing cap and apply small quantity of RTV sealant in depression where pan gasket contacts block.

(2) Position gasket on oil pan. Apply 1/8 x 1/4-inch (3 x 6 mm) bead of RTV sealant at split lines of front and side gasket.

(3) Position oil pan. Insert and tighten screws with 45 inch-pounds (5 N•m) torque.

(4) Install starter motor. Tighten 3/8-inch bolts with 17 foot-pounds (24 N•m) torque. Tighten nut with 40 inch-pounds (4.5 N•m) torque. Connect battery cable and solenoid wire to starter motor solenoid.

(5) Lower vehicle.

(6) Connect battery negative cable. Refill crankcase with oil.

PISTONS AND CONNECTING RODS

The pistons are lightweight, cast aluminum with slipper skirt and cam ground so that the diameter across the thrust face is larger than the diameter fore and aft of the engine. Two compression rings and one oil control ring are used. All are located above the piston pin.

The piston pins are offset toward the thrust side (right-hand side) to provide a gradual change in thrust pressure against the cylinder wall as the piston travels within the cylinder. The piston pins are tempered steel and have a floating fit in the pistons. They are retained in the connecting rods by a press fit.

The connecting rods are made of Armasteel. Full pressure lubrication is directed to the connecting rods by drilled oil passages from the adjacent main bearing journal. Oil holes at the connecting rod journals are located so that oil is supplied to give maximum lubrication just prior to full bearing load.

Removal

(1) Remove cylinder head according to procedure described in Cylinder Head Removal.

(2) Remove oil pan according to procedure described in Oil Pan Removal.

(3) Remove ridge and/or deposits from upper end of cylinder bores with ridge reamer tool. Before ridge or deposits are removed, turn crankshaft until piston is at bottom of stroke and place a cloth on top of piston to collect cuttings. After ridge and/or deposits are removed, turn crankshaft until piston is at top of stroke and remove cloth and cuttings.

(4) Inspect connecting rod and piston for cylinder number identification and, if not identified, mark them.

(5) Remove bearing cap and install Connecting Rod Bolt Guide Set J-6305-11.

(6) Carefully remove connecting rod and piston assembly by pushing out with knurled handle of long guide.

Disassembly

CAUTION: *Use care at all times when handling and servicing connecting rods and pistons. To prevent possible damage to these units, do not clamp rod or piston in vise because they may become distorted. Do not allow pistons to strike against one another, against hard objects or bench surfaces because distortion of piston contour or nicks in the soft aluminum material may result.*

(1) Remove piston rings using suitable piston ring removal tool.

(2) Install guide bushing of Piston Pin Removal and Installation Tool J-24086.

(3) Position piston and connecting rod assembly on support and place assembly on arbor press (fig. 1B-30).

(4) Press pin out of connecting rod with Piston Pin Removal Tool J-24086.

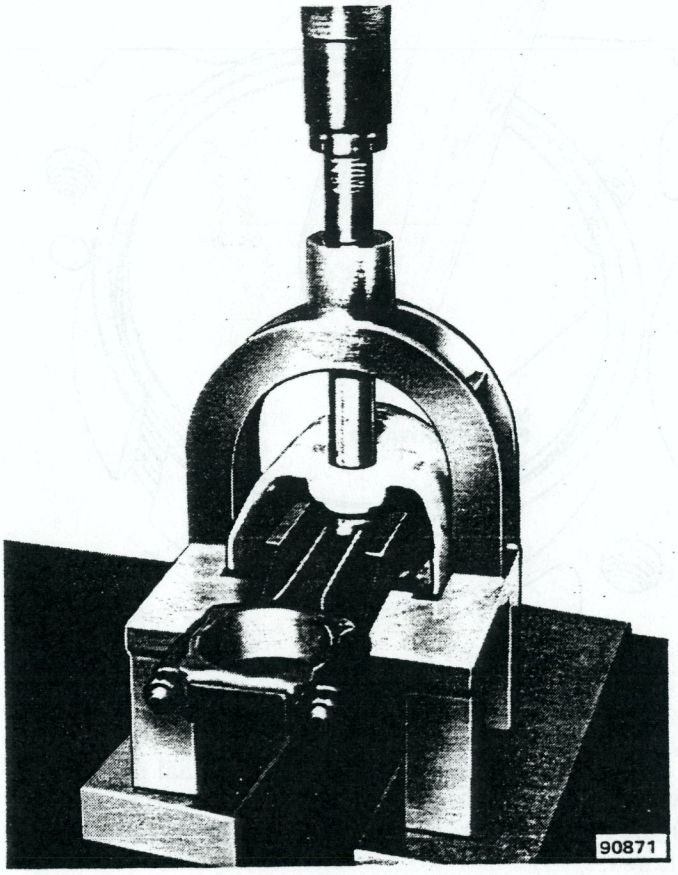


Fig. 1B-30 Removing Piston Pin

(5) Remove assembly from press, remove piston pin from support and remove tool from piston and rod.

(6) Clean carbon, varnish, and gum deposits from piston surfaces, including underside of piston head. Clean ring grooves and oil holes in oil ring groove with appropriate cleaning tools and solvent.

(7) Clean piston pin, rod, cap, bolts and nuts in appropriate solvent. Reinstall cap on connecting rod to prevent inadvertent mixing of caps and connecting rods.

(8) Carefully examine piston for rough or scored surfaces; cracks in skirt or head; cracked, broken, or worn ring lands; and scored, galled, or worn piston bosses. Damaged or defective pistons should be replaced.

(9) Inspect piston pin for scoring, roughness, or uneven wear and proper fit.

(10) Inspect rod bearing inserts to ensure they are not damaged. Fit of bearings should be determined when engine is being assembled.

Assembly

There are two notches cast in the top of all piston heads to facilitate proper installation. The pistons should always be installed with the notches toward the front of the engine (fig. 1B-31).

(1) Lubricate piston pin holes in piston and connecting rod lightly with graphite lubricant.

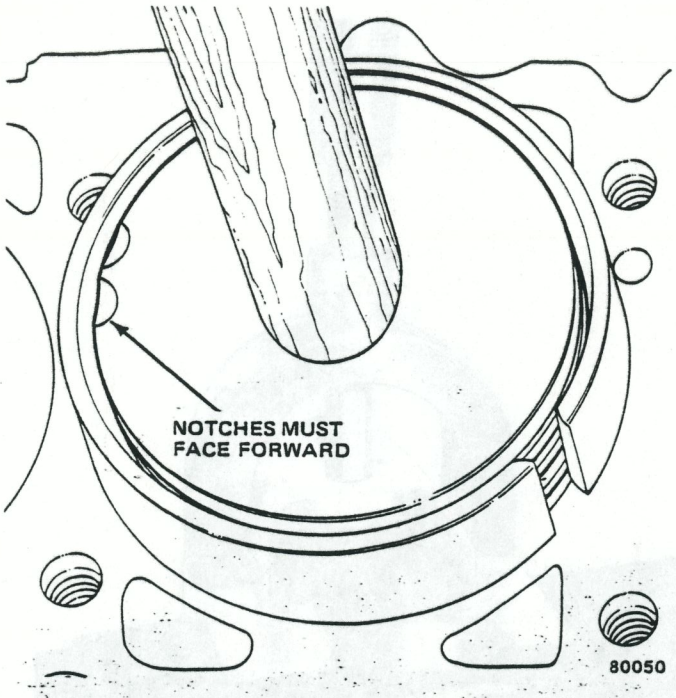


Fig. 1B-31 Installing Piston in Cylinder

(2) Position connecting rod in its original piston so that raised notch side of rod (fig. 1B-32) at bearing end is 180 degrees opposite notches in top of piston when installed.

(3) Position piston and rod on support, and insert pilot through piston and rod. Note positions of notches.

(4) Place support on arbor press, start pin into position and press on installation tool until guide bushing bottoms (fig. 1B-30).

(5) Remove installation tool and support assembly from piston and connecting rod assembly.

(6) Inspect piston pin for freedom of movement in piston bore.

(7) Install piston rings with appropriate installation tool. Refer to Piston Ring Installation for procedure.

Installation

(1) Install Connecting Rod Bolt Guide Set J-6305-11 on connecting rod bolts.

(2) Using appropriate piston ring compressor, insert rod and piston assembly into cylinder so that notches in top of piston is facing front of engine (fig. 1B-31).

(3) From beneath engine, position connecting rod with upper bearing insert in place against journal.

(4) Remove Guide Set J-6305-11 and install lower bearing insert and cap. Tighten capnuts with 30 foot-pounds (40 N•m) torque.

(5) Install oil pan.

(6) Install cylinder head, intake manifold and exhaust manifold.

(7) Connect fuel pipe and vacuum hoses to carburetor.

(8) Install push rods, place rocker arms in position and tighten rocker arm nuts. Do not over tighten nuts.

(9) Install cylinder head cover.

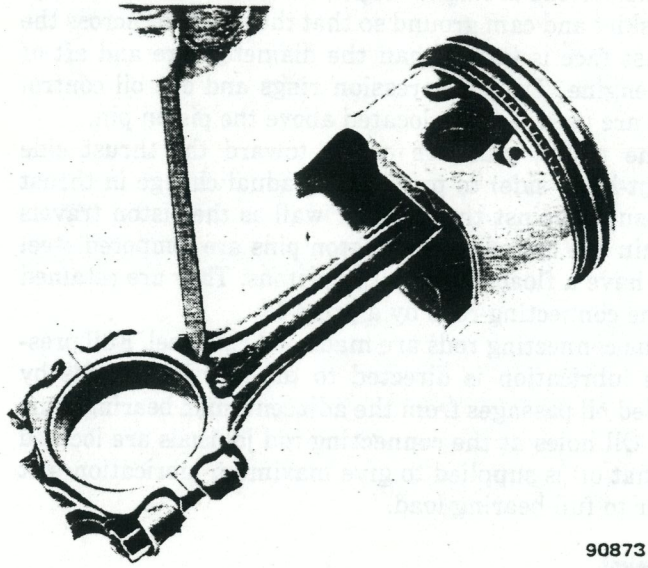


Fig. 1B-32 Raised Notch Location

Connecting Rod Bearings

The connecting rod bearings are the precision insert type and should be replaced if the clearances are excessive. Service bearings are available in standard size, 0.001-inch (0.025 mm), 0.002-inch (0.050 mm) and 0.010-inch (0.254 mm) undersize for use with replacement and remanufactured crankshafts.

Replacement and Inspection

Before removal of the connecting rod and cap, stamp the side of the connecting rod and cap with corresponding cylinder number to assure matched reassembly.

(1) With oil pan and oil pump removed, remove connecting rod cap and bearing.

(2) Inspect bearing inserts for evidence of wear or damage.

(3) Wipe bearings and journal clean of oil.

(4) Measure journal for out-of-round or taper with micrometer. If not within specification, replace or recondition crankshaft. If within specification and replacement bearing inserts are to be installed, measure maximum diameter of journal to determine required size of replacement bearing inserts.

(5) If within specification, measure replacement or original bearing clearances with Plastigage, or equivalent.

(6) If bearing is being fitted to out-of-round journal, allow for maximum diameter of journal. If bearing is fitted to minimum diameter and journal is out-of-round, interference between bearing and journal will result and rapid bearing failure will occur.

(a) Place strip of Plastigage on full width of journal on area that is contacted by bearing (parallel to crankshaft).

(b) Install bearing inserts in connecting rod and cap.

(c) Install rod and bearing cap and evenly tighten nuts with 30 foot-pounds (40 N•m) torque.

NOTE: *Do not turn the crankshaft with the Plastigage installed.*

(d) Remove bearing cap and, with scale on envelope, measure width of Plastigage strip at widest point (fig. 1B-33).

(e) If clearance exceeds specification, select correct replacement size bearing inserts and remeasure clearance.

NOTE: *Ensure that size of removed bearing is ascertained to determine correct size for replacement bearing inserts. If the clearance cannot be brought to specification, the journal must be ground undersize. If the journal is already at maximum undersize, the crankshaft must be replaced.*

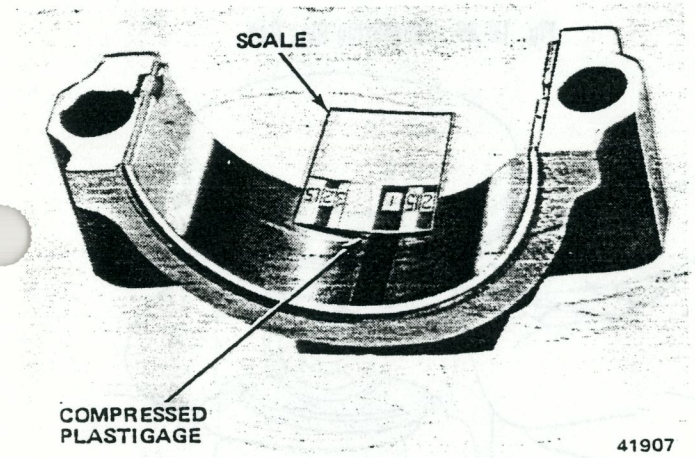


Fig. 1B-33 Connecting Rod Bearing Clearance Measurement with Plastigage

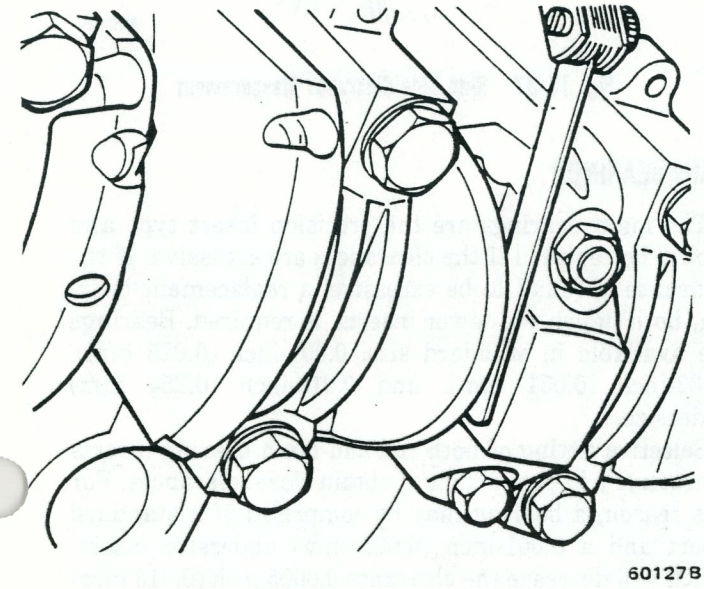


Fig. 1B-34 Measuring Connecting Rod Side Clearance

(7) Coat bearing surface with oil, install inserts, rod and bearing cap. Tighten nuts with 30 foot-pounds (40 N•m) torque.

(8) When all connecting rod bearings have been installed, tap each rod lightly (parallel with journal) to ensure they have correct clearance.

(9) Measure all connecting rod side clearances (refer to Specifications) between connecting rod caps (fig. 1B-34).

Piston Fit

Pistons should be fitted in the bores by actually measuring the fit (measure OD of piston at the measuring locations and ID of cylinder bore). Refer to engine specifications for correct clearances. If cylinder bores have been reconditioned, or if pistons are being replaced, reconditioning of bores and fitting of pistons should be closely coordinated.

If bore has been honed, it should be washed thoroughly with hot, soapy water and a stiff bristle brush. Thoroughly oil bores after washing.

Using a cylinder measurement gauge, measure the cylinder bore crosswise to the block to determine the smallest diameter. Record the smallest diameter of each bore.

NOTE: *When measuring cylinder bores and pistons, it is very important that the block and pistons be at room temperature. If any or all of the parts are warmer or cooler than normal room temperature, improper fitting will result.*

Measure the piston skirt perpendicular (90 degrees from) to the piston pin boss (piston pin removed) and at the measuring locations indicated in figure 1B-35.

NOTE: *Ensure the micrometer is in full contact.*

As the pistons are measured, they should be marked for size identification and the measurements recorded.

If there is excessive clearance between a cylinder bore and the piston that was originally installed, a replacement piston should be used. Replacement pistons are available in both standard size and oversize.

Because the sizes are nominal or basic sizes, it is important that replacement pistons be measured to ensure proper fit. All replacement pistons are equipped with selectively fitted piston pins.

After all measurements have been completed, match the replacement pistons with cylinders that will provide the correct clearance. Honing of the cylinder bore may be necessary to effect a proper fit. When properly mated, mark each piston with the matching cylinder number to ensure it will not become mis-matched.

Piston Pins

Piston pins normally do not become loose enough to cause a knock or tapping until after very high mileage accumulation on the engine and in such instances the piston and rod can be reamed and oversize pins installed.

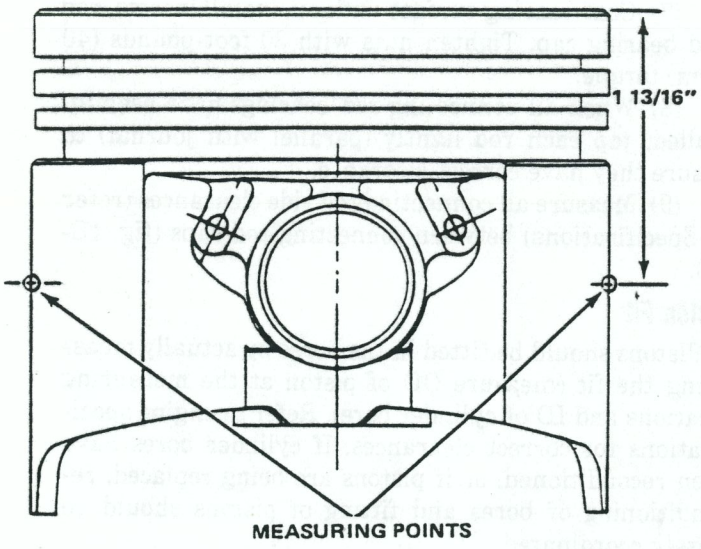


Fig. 1B-35 Piston Measurement Locations

The piston pin fit specification in the piston is 0.0002 to 0.0004 inch (0.005 to 0.010 mm) loose with pin and bosses clean and dry.

NOTE: *Piston and pin must be at room temperature when determining fit and pin must gravity-fall from the piston.*

Piston Rings

Installation

Replacement rings are available for standard size pistons and for 0.010-inch (0.254 mm) and 0.030-inch (0.762 mm) oversize pistons. When selecting rings, ensure they correspond to the size of the piston (i.e., standard rings for standard pistons, 0.010-inch oversize rings for 0.010-inch oversize pistons, etc.). Ring gap and side clearance should be measured when installing rings as follows:

(1) Inspect pistons to ensure that ring grooves and oil return holes have been properly cleaned.

(2) Place ring at lower end of ring travel area in cylinder bore. Level ring in bore by pushing it into position with inverted piston.

(3) Measure gap between ends of ring with feeler gauge (fig. 1B-36). Refer to Specifications.

NOTE: *An incorrect ring gap indicates that the wrong size rings are being used. If rings are selected according to the size of the bore, they should have the proper gap. It should not be necessary to alter ring gap by filing.*

(4) Install rings on piston with appropriate ring installation tool to prevent breakage or fracture of rings, or damage to pistons.

(5) Measure side clearance of rings in ring groove (fig. 1B-37). Refer to Specifications. If side clearance is excessive, piston must be replaced.

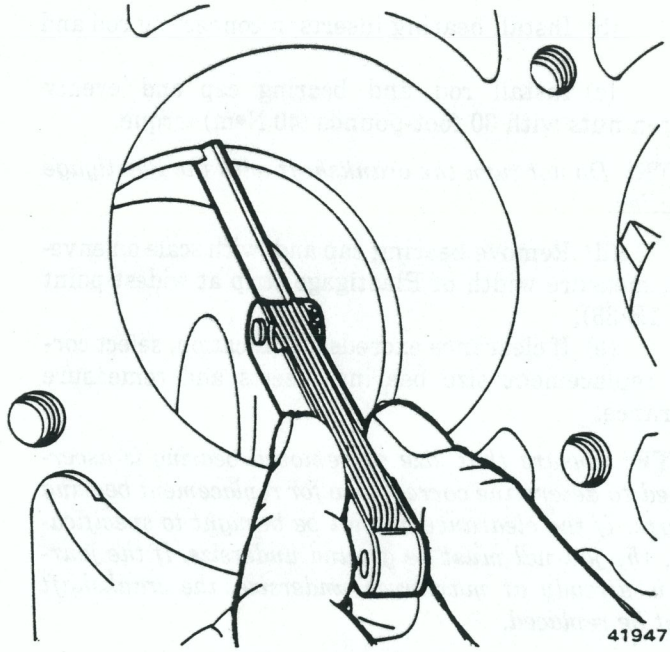


Fig. 1B-36 Measuring Ring Gap

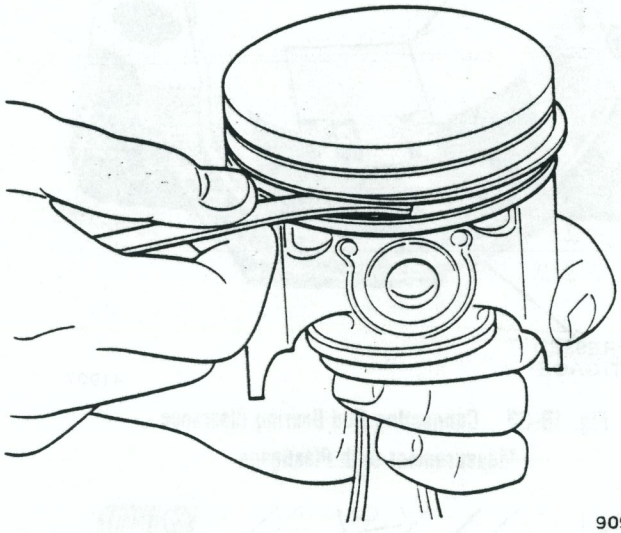


Fig. 1B-37 Ring Side Clearance Measurement

MAIN BEARINGS

The main bearings are the precision insert type and should be replaced if the clearances are excessive. If the clearance is found to be excessive, a replacement bearing, both upper and lower inserts, is required. Bearings are available in standard size, 0.001-inch (0.025 mm), 0.002-inch (0.051 mm), and 0.010-inch (0.254 mm) undersize.

Selective fitting of both rod and main bearing inserts is necessary in production to obtain close tolerances. For this reason, a bearing may be comprised of a standard insert and a 0.001-inch (0.025 mm) undersize insert, which will decrease the clearance 0.0005 inch (0.013 mm) from that of two standard bearing inserts.

Inspection

In general, the lower insert (except No. 1 bearing) will have greater wear and the most distress from fatigue. If upon inspection the lower insert is suitable for use, it can be assumed that the upper insert is also satisfactory. If the lower insert has evidence of wear or damage, both upper and lower inserts should be replaced. Never replace one insert without replacing the other.

Clearance Measurement

To obtain the most accurate results with Plastigage, or equivalent, certain precautions must be observed. If the engine has been removed from the vehicle and turned upside down, the crankshaft will rest on the upper bearings and the total clearance can be measured between the lower bearing insert and journal. If the engine is installed in the vehicle, the crankshaft should be supported upward to remove the clearance from the upper bearing insert. The total clearance can then be measured between the lower bearing insert and journal.

To assure proper seating of the crankshaft, all bearing cap bolts must be tightened with the specified torque. In addition, before measuring the fit of bearings, the surface of the crankshaft journal and bearing should be wiped clean of oil.

(1) With oil pan and oil pump removed and starting with rear main bearing, remove bearing cap and wipe oil from journal and bearing cap.

(2) Place strip of Plastigage on full width of bearing surface area (parallel with crankshaft) on journal.

NOTE: *Do not rotate the crankshaft while the Plastigage is between the bearing and journal.*

(3) Install bearing cap and insert. Tighten retaining bolts evenly with 65 foot-pounds (88 N•m) torque.

(4) Remove bearing cap. Flattened Plastigage will be adhering to either bearing insert or journal.

(5) Without removing Plastigage, measure its compressed width (at the widest point) (fig. 1B-38).

NOTE: *Normally, main bearing journals wear evenly and are not out-of-round. However, if a bearing is being fitted to an out-of-round journal, fit to the maximum diameter of the journal. If the bearing is fitted to the minimum diameter and the journal is out-of-round, interference between the bearing and journal will result and rapid bearing failure will occur. If the flattened Plastigage tapers toward the middle or ends, there is a difference in clearance indicating taper, low spot or an irregularity in the bearing or journal. Measure the journal with a micrometer if the flattened Plastigage indicates more than 0.0005-inch (0.013 mm) difference.*

(6) If bearing clearance is within specification, bearing inserts are satisfactory. If clearance is not within specification, replace inserts. Always replace both upper and lower inserts as a unit.

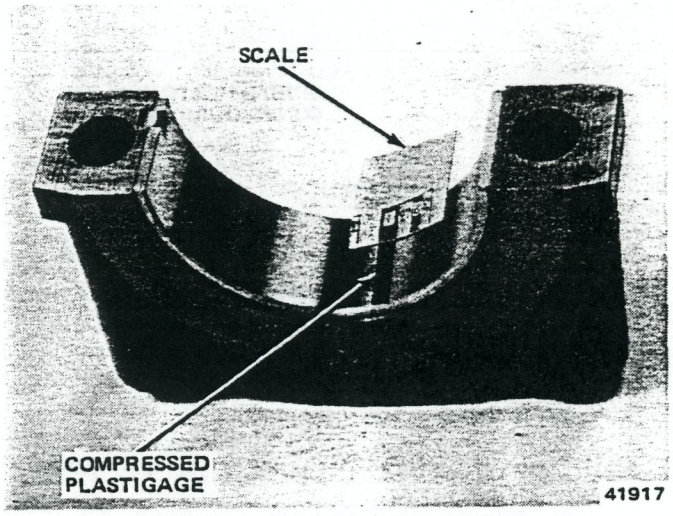


Fig. 1B-38 Measuring Bearing Clearance

(7) Standard 0.001-inch (0.254 mm) or 0.002-inch (0.508 mm) undersize bearing inserts should produce correct clearance.

(8) Proceed to next journal. After clearances of all journals and bearings have been measured, rotate crankshaft to ensure that there is no excessive drag.

(9) Measure crankshaft end play (refer to Specifications) by forcing crankshaft to extreme front position. Measure at front end of thrust bearing with feeler gauge.

Replacement

Main bearings may be replaced with either the crankshaft installed or removed from the engine.

Crankshaft Removed From Engine

(1) Remove and inspect crankshaft.

(2) Remove main bearing inserts from cylinder block and main bearing caps.

(3) Coat bearing surfaces of replacement main bearing inserts with oil and position in cylinder block and main bearing caps. Install crankshaft and caps with arrows pointing toward rear of engine. Tighten caps with 65 foot-pounds (88 N•m) torque.

Crankshaft Installed

(1) With oil pan, oil pump and spark plugs removed, remove cap from main bearing requiring replacement and remove lower bearing insert from cap.

(2) Insert upper main bearing insert removal and installation tool in oil hole in crankshaft journal. If tool is not available, tool (fig. 1B-39) may be fabricated from cotter pin by bending as required.

(3) Rotate crankshaft clockwise as viewed from front of engine. This will roll upper bearing insert out of block.

(4) Apply oil to replacement upper bearing insert and position plain (unnotched) end between crankshaft

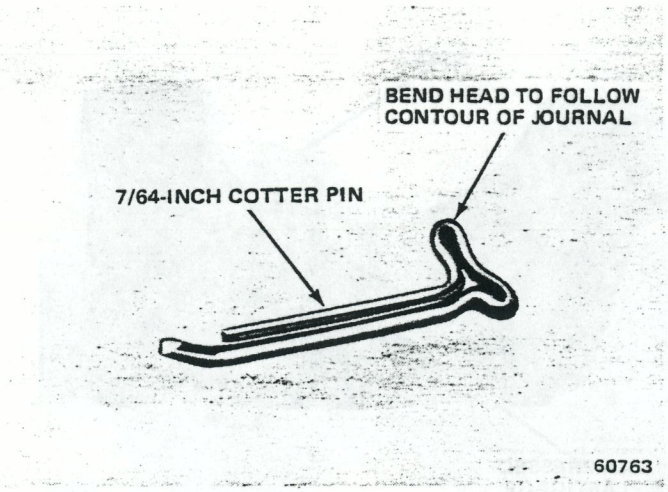


Fig. 1B-39 Fabricated Upper Main Bearing Insert Removal and Installation Tool

and indented or notched side of block. Rotate bearing into place and remove tool from oil hole in crankshaft journal.

(5) Apply oil to replacement lower bearing insert and install in bearing cap.

(6) Install main bearing cap with arrows pointing toward rear of engine.

(7) Tighten main bearing cap bolts with 65 foot-pounds (88 N•m) torque.

Rear Main Bearing Oil Seal Replacement

Removal

The rear main bearing oil seal is a one piece unit and can be removed and installed without removal of the oil pan or crankshaft.

(1) Disconnect battery negative cable.

(2) Raise vehicle.

(3) Remove transmission and transfer case as an assembly. Refer to Transmission Removal in Chapter 2B or 2C for procedure.

(4) Remove starter motor cable and solenoid wire. Remove starter motor.

(5) If manual transmission, remove inspection plate from flywheel housing.

(6) If manual transmission, remove hydraulic clutch slave cylinder from flywheel housing.

(7) Remove flywheel/drive plate housing bolts and housing from engine.

(8) If manual transmission, remove clutch pressure plate and disc assembly by loosening bolts 1/4 turn in equal amounts until pressure is relieved.

(9) Mark flywheel/drive plate location to facilitate correct assembly. Remove bolts and flywheel/drive plate.

(10) Using a small blade screwdriver, pry out rear main oil seal. Use care to prevent damaging seating groove or crankshaft.

Installation

(1) Center replacement seal over crankshaft with lip of seal facing toward front of engine. With a soft hammer (plastic), tap around perimeter of seal until it seats in groove. Use care to prevent seal from binding on crankshaft and not seating properly.

(2) Attach flywheel/drive plate to crankshaft and tighten bolts with 68 foot-pounds (93 N•m) torque.

(3) If manual transmission, install clutch pressure plate and disc assembly. Tighten bolts 1/4 turn in equal amounts until assembly is flush against flywheel. Tighten bolts with 18 foot-pounds (25 N•m) torque.

NOTE: *Use Alignment Tool J-5824-01, or equivalent, to align clutch disc prior to tightening bolts.*

(4) Install flywheel/drive plate housing and tighten bolts with 35 foot-pounds (47 N•m) torque.

(5) If manual transmission, install inspection plate on flywheel housing.

(6) If manual transmission, install hydraulic clutch slave cylinder on flywheel housing. Tighten bolts with 18 foot-pounds (25 N•m) torque.

(7) Install transmission/transfer case assembly. Refer to Chapter 2B for procedure.

(8) Install starter motor, cable and solenoid wire. Refer to Chapter 2B or 2C for procedure.

(9) Lower vehicle.

(10) Connect battery negative cable.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(11) Start engine and inspect for leaks.

CRANKSHAFT REPLACEMENT

Removal

(1) Remove engine from vehicle.

(2) Mount engine on suitable stand.

(3) Remove spark plugs.

(4) Remove fan and pulley.

(5) Remove crankshaft vibration damper and hub assembly.

(6) Remove oil pan and oil pump assembly.

(7) Remove timing case cover.

(8) Remove crankshaft timing gear.

(9) Remove connecting rod bearing caps and bearing inserts. Mark each for installation identity.

(10) Move connecting rod and piston assemblies away from crankshaft.

(11) Remove main bearing caps with bearing inserts and mark for installation identity.

(12) Remove crankshaft and upper bearing inserts. Mark inserts for installation identity.

Installation

(1) With upper main bearing inserts installed, position replacement crankshaft in block.

(2) Install main bearing caps (with lower bearing inserts), but do not tighten cap bolts. Oil bearings prior to assembly.

(3) Move connecting rods (with upper bearing inserts installed) and pistons into place.

(4) Install rod bearing caps (with bearing inserts), but do not tighten nuts. Apply oil to bearings prior to assembly.

(5) With rubber mallet, strike both ends of crankshaft to center thrust bearing. Rearward first, forward last.

(6) Tighten main bearing caps (65 foot-pounds, 88 N•m), then measure crankshaft end play. It should be between 0.0015 inch (0.038 mm) and 0.0085 inch (0.216 mm).

(7) Tighten connecting rod bearing caps (30 foot-pounds, 40 N•m).

(8) Measure bearing clearances using Plastigage method.

(9) Install key from original crankshaft in replacement crankshaft keyway.

(10) Install crankshaft timing gear and ALIGN TIMING MARKS ON TIMING GEARS BY ROTATING CRANKSHAFT, IF NECESSARY.

(11) Install timing case cover using replacement seal and gaskets.

(12) Install oil pump assembly and oil pan using replacement rear seal in rear main bearing cap and replacement front seal for timing case cover. Press front seal tips into holes in timing case cover.

(13) Coat front cover oil seal contact area of vibration damper hub with oil and push into position.

(14) Install fan pulley and fan.

NOTE: *The fan assembly and pulley must be installed with the drive belt(s) in position on pulley.*

(15) Install spark plugs.

(16) Remove engine from stand.

(17) Install engine in vehicle.

CYLINDER BLOCK

The cylinder block is manufactured from cast iron and has 4 in-line cylinders that are numbered from front to rear, 1 through 4. Five main bearings support the crankshaft, which is retained by recessed bearing caps that are machined with the block for proper alignment and clearances.

The cylinders are completely encircled by coolant jackets. (For details of engine cooling system, refer to Chapter 1C—Cooling Systems.)

Cylinder Bores

Inspect cylinder bores for out-of-round or excessive taper with an accurate Cylinder Measurement Gauge Tool J-8087, or equivalent. Measure at top, middle and bottom of bore (fig. 1B-40).

Measure cylinder bore parallel and at right angles to the centerline of the engine to determine out-of-roundness. Variation in measurement from top to bottom of cylinder indicates the taper in the cylinder. Figure 1B-41 illustrates the areas in the cylinder bore where wear

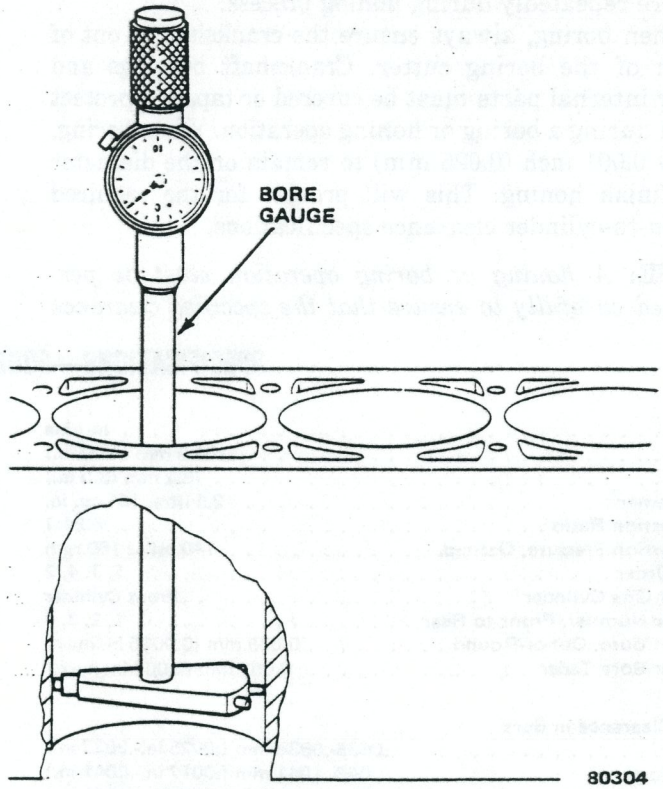


Fig. 1B-40 Measuring Cylinder Bore with Bore Gauge

normally occurs. If dimension A is larger than dimension B by 0.002 inch (0.051 mm) or more, it indicates the necessity for cylinder boring and installing replacement rings and pistons. Cylinder bores can be measured by setting the cylinder measurement gauge dial at zero in the cylinder bore at the location of desired measurement. Lock dial indicator at zero before removing from cylinder bore, and measure across the gauge contact points with outside micrometer (with the gauge at the same zero setting when removed from the cylinder).

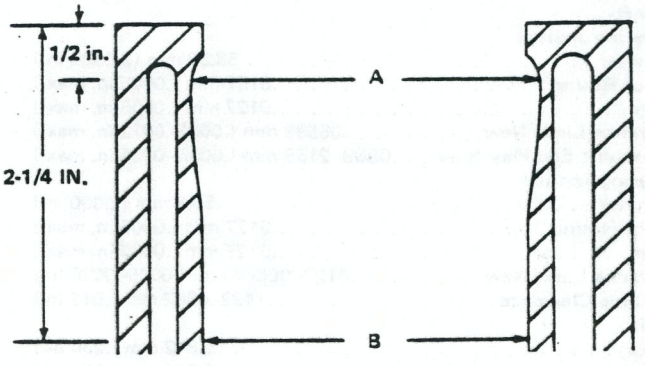


Fig. 1B-41 Normal Cylinder Bore Wear Pattern

Honing or Boring

If a piston other than standard size is to be installed, the cylinder should be bored, rather than honed, to obtain a true bore.

When honing to eliminate taper in the cylinder, use full strokes. Measure cylinder at top, middle and bottom of bore repeatedly during honing process.

When boring, always ensure the crankshaft is out of reach of the boring cutter. Crankshaft bearings and other internal parts must be covered or taped to protect them during a boring or honing operation. When boring, allow 0.001 inch (0.025 mm) to remain on the diameter for finish honing. This will provide for the required piston-to-cylinder clearance specifications.

NOTE: *A honing or boring operation must be performed carefully to ensure that the specified clearance between pistons, rings, and cylinder bores is maintained.*

By measuring the piston to be installed at the measuring locations and adding the mean of the clearance specification, the correct finish hone cylinder dimension can be determined. It is important that both the cylinder and piston be measured at normal room temperature.

After honing and before the piston is inserted for fit, each cylinder bore must be thoroughly cleaned. Use a hot, soapy water solution and wipe dry to remove all traces of abrasive. If all traces of abrasive are not removed, rapid wear of new rings and piston will result. After washing, thoroughly oil cylinder bores.

Intermixing different size pistons has no effect on engine balance because all pistons from standard size up to 0.030-inch (0.762 mm) oversize weigh exactly the same.

SPECIFICATIONS—FOUR-CYLINDER ENGINE

Type	In-Line
Bore	101.6 mm (4.00 in.)
Stroke	76.2 mm (3.0 in.)
Displacement	2.5 litre, 151 cu. in.
Compression Ratio	8.24:1
Compression Pressure, Desired	140 psi at 160 rpm
Firing Order	1, 3, 4, 2
Number One Cylinder	Front Cylinder
Cylinder Number, Front to Rear	1, 2, 3, 4
Cylinder Bore, Out-of-Round	0.038 mm (0.0015 in. max.)
Cylinder Bore Taper	0.051 mm (0.002 in. max.)
Piston	
Piston Clearance in Bore	
Top	.0635-.0838 mm (.0025 in.-.0033 in.)
Bottom	.043-.1041 mm (.0017 in.-.0041 in.)
Piston Diameter	101.519-101.580 mm (3.9968-3.9992 in.)
Compression Ring Side Clearance Top	.0762 mm (.0030 in.)
Compression Ring Side Clearance Bottom	.0762 mm (.0030 in.)
Compression Ring Width	
Top	1.9685-1.9812 mm (.0775-.0780 in.)
Bottom	1.9685-1.9812 mm (.0775-.0780 in.)
Upper Compression Ring Gap	.25-.56 mm (.010-.022 in.)
Lower Compression Ring Gap	.25-.71 mm (.010-.028 in.)
Oil Ring Gap	.381-1.397 mm (.015-.055 in.)
Piston Pin	
Diameter	23.547-23.557 mm (.92705-.92745 in.)
Length	76.2 mm (3.00 in.)
Pin to Piston	
Clearance	.003-.013 mm (.0003-.0005 in.)
Fit in Rod	Press
Crankshaft	
Main Bearing Journal	
Diameter	58.39 mm (2.2988 in.)
Out of Round	.0127 mm (.0005 in. max.)
Taper	.0127 mm (.0005 in. max.)
Clearance Limit New	.05588 mm (.0005-.0022 in. max.)
Crankshaft End Play New	.0889-.2159 mm (.0035-.0085 in. max.)
Rod Bearing Journal	
Diameter	50.8 mm (2.000 in.)
Out of Round	.0127 mm (.0005 in. max.)
Taper	.0127 mm (.0005 in. max.)
Clearance Limit New	.0127-.06604 mm (.0005-.0026 in.)
Rod Side Clearance	.1492-.4362 mm (.017 in.)
Lobe Lift	
Intake	5.842 mm (.230 in.)
Exhaust	5.842 mm (.230 in.)
Journal Diameter	47.4726 mm (1.869 in.)
Journal Clearance	.01778-.0685 mm (.0007-.0027 in.)
End Play Clearance	.031-0.127 mm (.0015-.1150 in.)
Valves	
Valve Train	
Lash Intake and Exhaust	0
Rocker Arm Ratio	1.75:1
Push Rod Length	226.746 mm (8.927 in.)
Valve Tappet	
Leak-Down Rate	12 to 90 sec. with 50 lb. load
Tappet Body Diameter	21.3868-21.4046 mm(.8120-.8427 in.)
Plunger Travel	3.175 mm (.125 in.)
Clearance in Boss	.635 mm (.0025 in.)
Tappet Bore Diameter	21.425-21.450 mm(.8435-.8445 in.)
Intake Valves	
Face Angle	45°
Seat Angle	46°
Head Diameter	43.688 mm (1.72 in.)
Stem Diameter	8.6995-8.68172 mm (.3425-.3418 in.)
Overall Length	115.75 mm (1.557 in.)
Stem-to-Guide Clearance	.0254-.06858 mm (.0010-.0027 in.)
Valve Seat Width	.897-1.897 mm (.353-.0747 in.)
Valve Installed Height (Spring Seat to Valve Tip)	52.265 mm (2.057 in.)
Exhaust	
Face Angle	45°
Seat Angle	46°
Head Diameter	38.4 mm (1.50 in.)
Stem Diameter	8.766-8.682 (3.418-3.125 in.)
Overall Length	114.02 (4.489 in.)
Stem-to-Guide Clearance Top	.0254-.06858 mm (.0010-.0027 in.)
Valve Seat Width	1.468-2.468 mm (.058-.097 in.)
Valve Installed Height (Spring Seat to Valve Tip)	44.024 mm (1.73 in.)
Valve Springs	
Intake and Exhaust	
Valve Spring Pressure and Length-Valve Closed	347-383 N at 42.16 mm (78-86 lb. at 1.66 in.)
Valve Spring Pressure and Length-Valve Open	.765-801 N at 31.85 mm (172-180 lb. at 1.254 in.)
Oil Capacity	
Without Filter Change	2.838 litre (3 qts.)
With Filter Change	2.838 litre (3 qts.)
Filter Type (full flow)	PF40 or equivalent
Oil Pressure at rpm	248-283 kPa (36-41 psi) at 2000 rpm
Oil Pump Gear to Body Clearance	0.10 mm (.004 in.) maximum
Gear End Clearance, Feeler Gauge	0.05-0.13 mm (0.0020-.005 in.) Above Pump Body

Torque Specifications

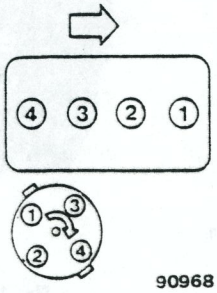
rvice Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Adapter to Intake Manifold Bolt	15	12-18	20	16-24
Camshaft Thrust Plate to Block Bolt	80 in-lb	77-83 in-lb	9	6-12
Carburetor to Manifold Nut	15	13-18	20	24
Clutch Housing-to-Engine Bolts	54	51-57	73	70-76
Connecting Rod Nut	30	27-33	40	37-43
Converter-to-Drive Plate Bolts	40	35-40	54	51-57
Crankshaft Pulley Hub Bolt	160	157-163	220	212-221
Cylinder Head Cover Bolt	7	4-10	10	7-13
Cylinder Head Cover Screws	7	5-10	10	7-14
Cylinder Head to Block Bolt	92	81-103	125	110-140
Distributor Clamp Pivot to Block Bolt	12	9-15	17	14-21
Distributor Retaining Clamp Bolt	9	6-12	12	9-15
Drive Plate Ring Gear Assembly to Crankshaft Bolt	45	42-48	60	57-63
EGR Valve to Manifold Bolt	150 in-lb	147-153 in-lb	12	9-15
Exhaust Manifold to Cylinder Head Bolt	39	36-42	52	49-55
Exhaust Pipe to Manifold Nut	35	30-40	47	41-50
Fan and Pulley to Water Pump Bolt	18	15-21	24	21-27
Flywheel to Crankshaft Bolt	68	65-71	93	90-96
Fuel Pump to Block Bolt	15	12-18	20	17-23
Intake Manifold to Cylinder Head Bolt	37	34-40	50	47-53
Main Bearing to Block Bolt	65	62-68	88	85-91
Oil Filter	12	9-15	17	14-20
Oil Filter to Block Connector	35	32-38	47	44-50
Oil Pan Drain Plug	25	23-28	34	31-37
il Pan Bolts	45 in-lbs	43-48 in-lbs	5	2-8
il Pump Cover Bolt	9	6-12	17	14-20
Oil Pump to Block Bolt	18	15-21	25	22-28
Oil Pump to Drive Shaft Plate Bolt	10	7-13	14	11-17
Oil Screen Support Nut	28	25-31	38	35-41
Pressure Plate to Flywheel Bolts	18	15-22	25	20-30
Pulley to Crankshaft Hub Bolts	25	22-28	34	31-37
Push Rod Cover to Block Bolt	80 in-lb	77-83 in-lb	9	6-12
Radiator Hoses All Clamps	25 in-lb	22-28 in-lb	3	1-6
Rocker Arm Capscrew	20	17-23	27	24-30
Starter to Block Bolt	17	14-20	24	21-27
Thermostat Housing Bolt	22	19-25	30	27-33
Timing Case Cover Bolt	45 in-lb	42-48 in-lb	5	2-8
Timing Case Cover to Block Bolt	80 in-lb	77-83 in-lb	9	6-12
Water Outlet Housing Bolt	17	14-20	23	20-26
Water Pump to Block Bolt	17	14-20	23	20-26

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.

90892

Four-Cylinder Engine Firing Order



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SIX-CYLINDER ENGINE

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GENERAL

The 258 CID (4.2 liter), in-line, overhead valve, lightweight six-cylinder engine (figs. 1B-42 and 1B-43) operates only on no-lead gasoline. The cylinders are numbered from front to rear and the firing order is 1-5-3-6-2-4. Crankshaft rotation is clockwise, viewed from the front. The crankshaft is supported by seven two-piece bearings (inserts). The camshaft is supported by four one-piece, line bored bearings.

The six-cylinder engine features a quench-head combustion chamber design. The combustion chamber shape, both in the head and in the piston crown, compresses the combustion mixture closer to the spark plug. In most applications, this permits the use of more advanced ignition timing for better fuel economy.

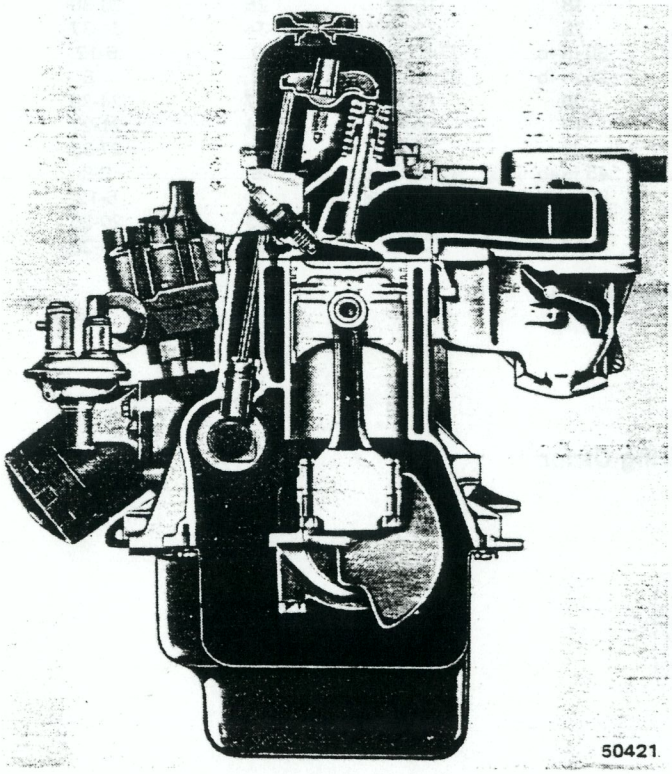
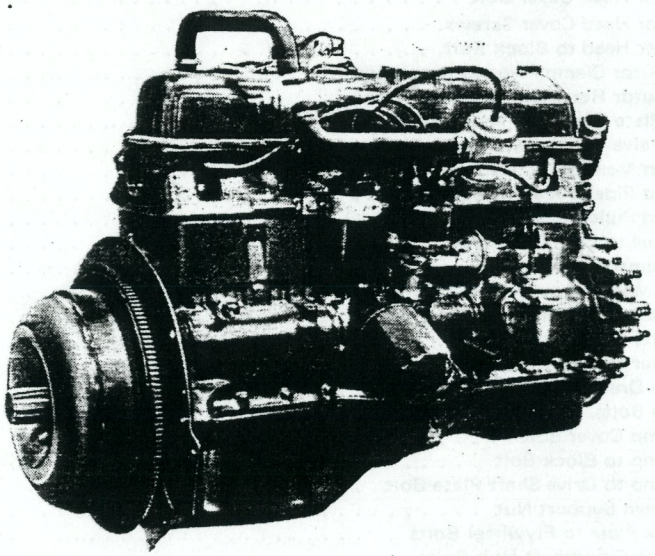


Fig. 1B-42 Six-Cylinder Engine Assembly—Sectional View



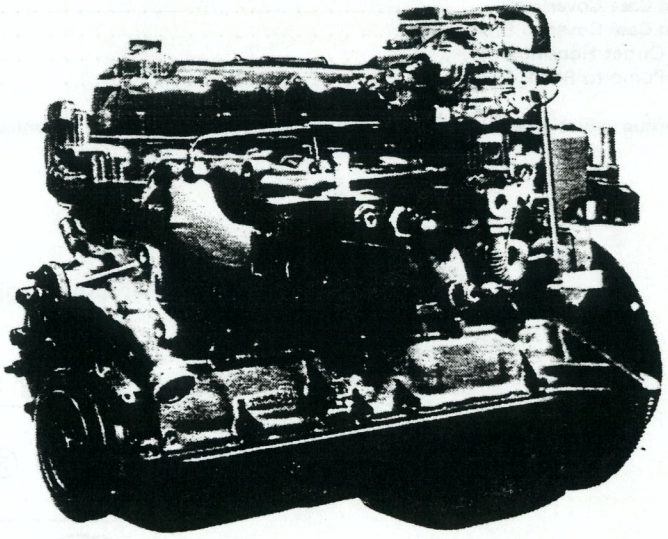


Fig. 1B-43 Six-Cylinder Engine Assembly—Typical

Identification

Build Date Code

The engine Build Date Code is located on a machined surface on the left side of the block (viewed from front) between the No. 2 and No. 3 cylinders (fig. 1B-44).

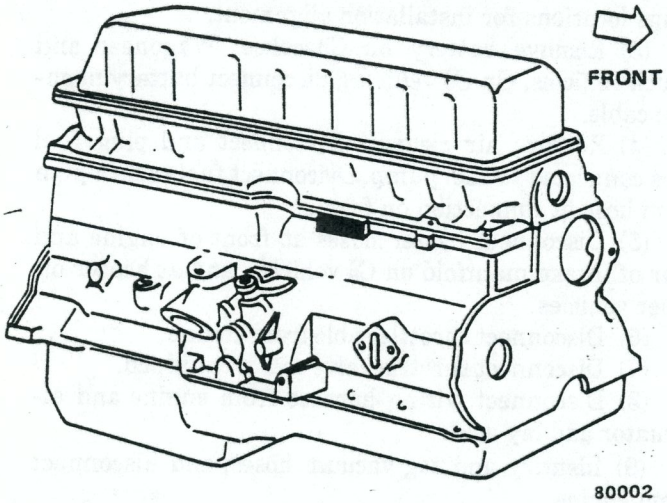


Fig. 1B-44 Engine Build Date Location

The numbers in the code identify the year, month and day that the engine was built.

The code letter identifies the cubic inch displacement, carburetor type and compression ratio. The data are decoded as listed in the Engine Build Date Code Chart.

Engine Build Date Code

Letter Code	CID	Carburetor	Compression Ratio
C	258	2V	8.0:1

1st Character (Year)	2nd and 3rd Characters (Month)	4th Character (Engine Type)	5th and 6th Characters (Day)
0 - 1980 1 - 1981	01 - 12	C	01 - 31

EXAMPLE: 4 10 C 18 60257

The example code identifies a 258 CID (4.2 liter) engine with 2V carburetor and 8.0:1 compression ratio that was built on October 18, 1980.

Oversize or Undersize Components

Some engines may be built with oversize or undersize components, such as oversize cylinder bores, undersize crankshaft main bearing journals, undersize connecting rod journals or oversize camshaft bearing bores. These engines are identified by a letter code stamped on a boss between the ignition coil and distributor (fig. 1B-45). The letters are decoded as listed in the Oversize or Undersize Components chart.

Oversize or Undersize Components

Code Letter	Definition	
B	All cylinder bores	-0.010-inch (0.254mm) oversize
M	All crankshaft main bearing journals	-0.010-inch (0.254mm) undersize
P	All connecting rod bearing journals	-0.010-inch (0.254mm) undersize
C	All camshaft bearing bores	-0.010-inch (0.254mm) oversize

EXAMPLE: The code letters PM mean that the crankshaft main bearing journals and connecting rod journals are 0.010-inch undersize.

60258

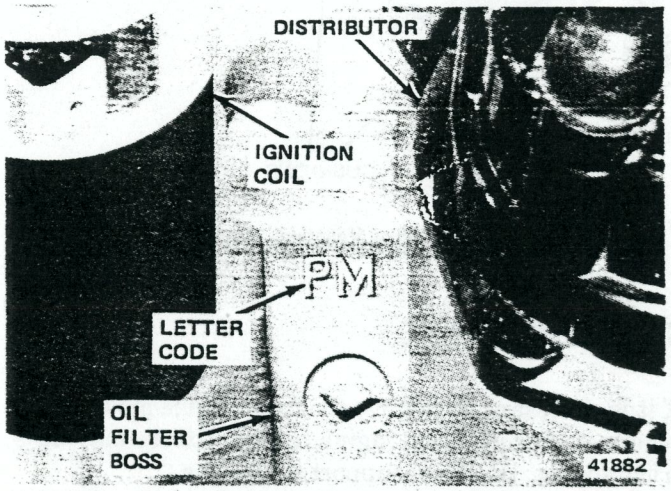


Fig. 1B-45 Oversize or Undersize Letter Code Location

SHORT ENGINE ASSEMBLY (SHORT BLOCK)

A service replacement short engine assembly (short block) may be installed whenever the original engine block is worn or damaged beyond feasible repair. It consists of engine block, piston and rod assemblies, crankshaft, camshaft, timing sprockets and chain.

NOTE: *Short engine assemblies have an S stamped on the same surface as the build date code for identification.*

Installation includes transfer of component parts from the worn or damaged original engine. Follow the appropriate procedures for cleaning, inspection, installation and tightening as outlined in this chapter.

ENGINE MOUNTING

Resilient rubber cushions support the engine and transmission at three points: at each side on the centerline of the engine and at the rear between the transmission extension housing and the rear support crossmember (fig. 1B-46). Replacement of a cushion may be accomplished by supporting the weight of the engine or transmission at the area of the cushion.

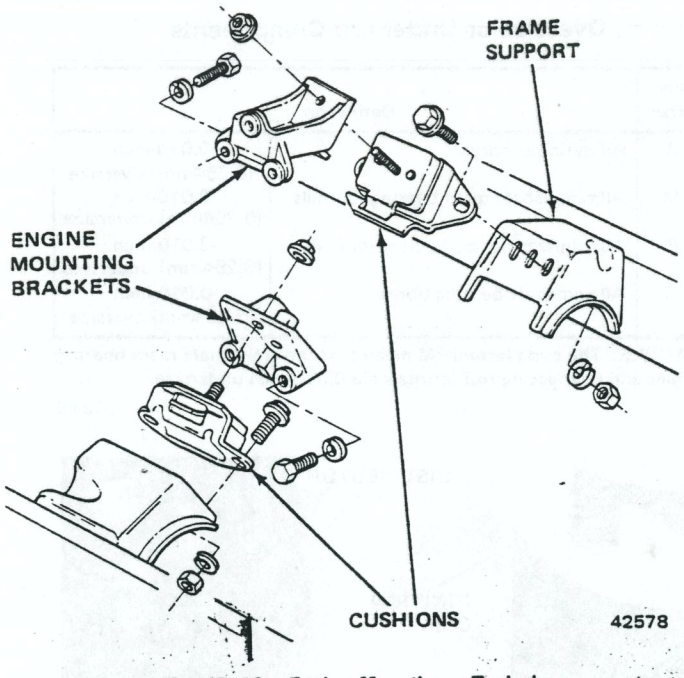


Fig. 1B-46 Engine Mounting—Typical

ENGINE HOLDING FIXTURE

If it is necessary to remove the front engine mounting brackets or cushions, an engine holding fixture may be fabricated (fig. 1B-47) to support the engine.

The engine also may be supported by a jack placed under the oil pan skid plate. Use a board between the jack and skid plate to distribute the weight evenly.

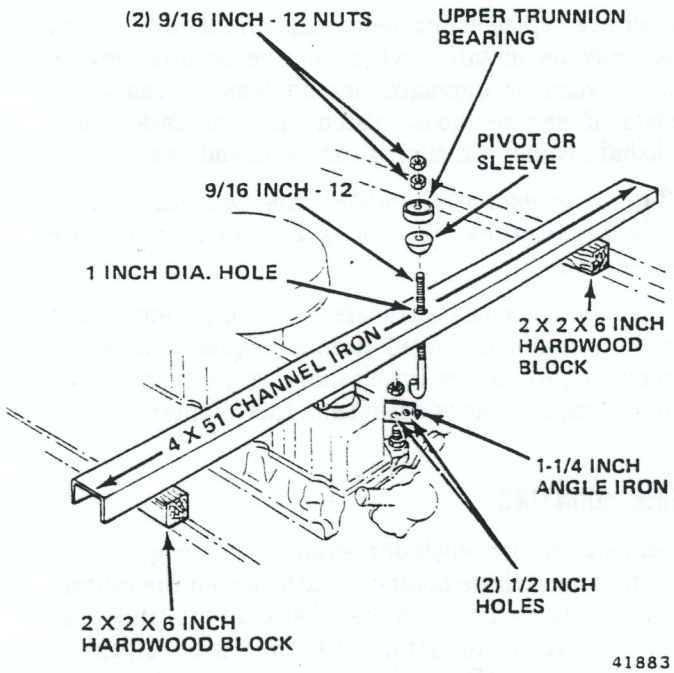


Fig. 1B-47 Engine Holding Fixture

ENGINE REMOVAL

The engine is removed without the transmission and flywheel/drive plate housing. Raise the vehicle slightly to provide working clearance.

(1) Drain cooling system.

NOTE: *Drain coolant in a clean container for re-use.*

(2) On all vehicles except CJ, remove hood. Mark hinge locations for installation alignment.

(3) Remove battery on Cherokee, Wagoneer and Truck vehicles. On CJ vehicles, disconnect battery negative cable.

(4) Remove air cleaner. Disconnect and plug fuel pipe connected to fuel pump. Disconnect fuel return pipe from hose at connection on frame.

(5) Disconnect heater hoses at front of engine and rear of intake manifold on CJ vehicles, and at heater on other vehicles.

(6) Disconnect throttle cable from engine.

(7) Disconnect throttle valve rod, if equipped.

(8) Disconnect wiring harness from engine and alternator and lay aside.

(9) Identify and tag vacuum hoses, and disconnect from engine.

(10) Disconnect shroud, if equipped, from radiator.

(11) Remove radiator, fan and shroud. Install bolt in pulley after fan is removed to maintain pulley in alignment with bolt holes in water pump.

(12) Disconnect cable from starter motor. Remove starter motor.

(13) Remove engine mount cushion-to-frame attaching nuts.

(14) Disconnect exhaust pipe.

(15) If equipped with manual transmission:

(a) Remove flywheel housing bolts.

(b) Remove clutch linkage and shield.

(16) If equipped with automatic transmission:

(a) Remove drive plate access cover.

(b) Mark converter and drive plate to facilitate correct installation alignment.

(c) Remove converter-to-drive plate bolts. Rotate crankshaft for access to each bolt.

(d) Remove drive plate housing-to-engine bolts. Remove oil pan screws that retain transmission fluid cooler lines.

(17) Support transmission with jack.

(18) If equipped with power steering, disconnect hoses at steering gear. Tie hoses to engine to prevent draining.

(19) If equipped with air conditioning:

(a) Turn compressor service fitting valve stem to seat position.

(b) Loosen service fitting.

(c) Allow compressor refrigerant to escape.

(d) Remove fittings from compressor.

(20) Attach engine lift device. Pull engine forward to disengage from transmission. Lift upward to remove.

ENGINE INSTALLATION

(1) Remove right mount from engine.
(2) Lower engine into compartment. Attach engine to transmission.
(3) Install flywheel/drive plate housing bolts and remove transmission jack.
(4) Attach engine mount to block. Lower engine and tighten all engine mount bolts and nuts.
(5) If equipped with manual transmission:
(a) Install flywheel housing shield and clutch linkage.
(b) Adjust clutch, if necessary.
(6) If equipped with automatic transmission:
(a) Align marks on converter and drive plate. Install converter-to-drive plate bolts.
(b) Install drive plate access cover.
(c) Attach transmission fluid cooler lines to engine with oil pan screws.
(7) Install exhaust pipe.
(8) Install starter motor and connect cable.
(9) Remove lifting device.
(10) Connect fuel supply and return pipes.
(11) If equipped with power steering, connect hoses to steering gear.
(12) Connect electrical wires and vacuum hoses.
(13) Connect heater hoses.
(14) Install fan. If equipped with shroud, position roud over fan blades.
(15) Install radiator and attach shroud to radiator.
(16) Connect radiator hoses. If equipped with automatic transmission, connect fluid cooler lines to radiator.
(17) Install throttle linkage.
(18) Connect throttle valve rod and retainer. Install throttle valve and spring.
(19) If equipped with air conditioning:
(a) Connect service valves to compressor.
(b) Open valve to mid-position.
(c) Open service port slightly. Allow small amount of refrigerant to escape to purge compressor of air.
(d) Tighten port cap.
(20) Install battery, if removed, and connect cables.
(21) Install coolant.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(22) Start engine. While engine is warming up, in- all hood.
(23) Inspect for fuel, oil and water leaks. Turn engine off and check fluid levels.
(24) Install air cleaner and road-test vehicle.

VALVE TRAIN

General

The six-cylinder engine has overhead valves that are operated by push rods and rocker arms. A chain-driven camshaft is mounted in the cylinder block. Hydraulic valve tappets provide automatic valve lash adjustments.

Rocker Arm Assembly

The intake and exhaust rocker arms of each cylinder pivot on a bridge and pivot assembly that is secured with two capscrews as illustrated in figure 1B-48. The bridge and pivot assembly maintains correct rocker arm-to-valve tip alignment. Each rocker arm is actuated by a hollow steel push rod with a hardened steel ball at each end. The hollow push rods route oil to the rocker arm assemblies.

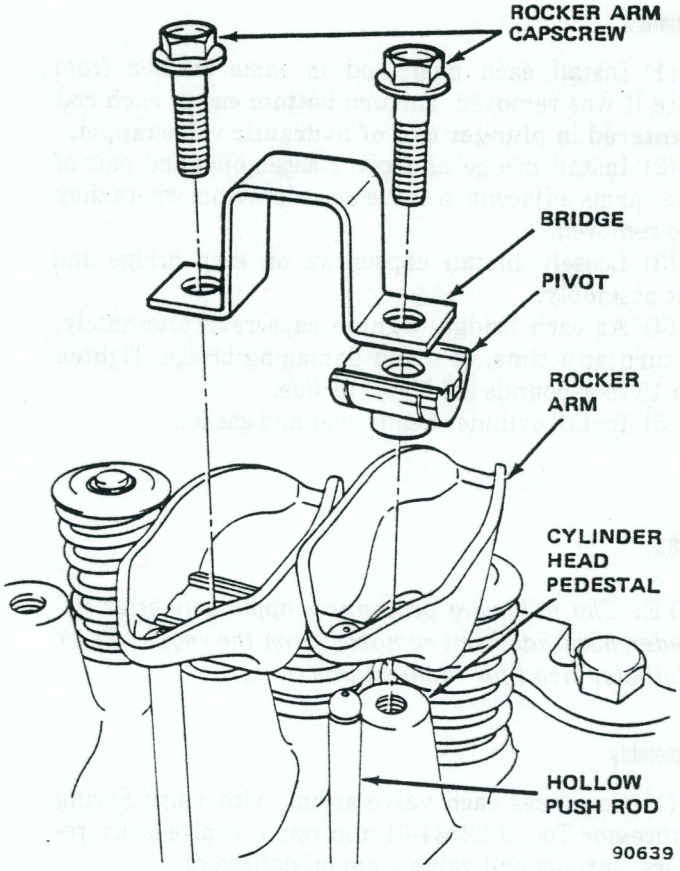


Fig. 1B-48 Rocker Arm Assembly

Removal

(1) Remove cylinder head cover and gasket.
(2) Remove two capscrews at each bridge and pivot assembly. Alternately loosen capscrews one turn at a time to avoid damaging bridge.
(3) Remove bridge and pivot assemblies and corresponding pairs of rocker arms and place on bench in same order as removed.

(4) Remove push rods and place on bench in same order as removed.

Cleaning and Inspection

Clean all parts with a cleaning solvent and use compressed air to blow out oil passages in the rocker arms and push rods.

Inspect the pivoting surface of each rocker arm and pivot. Replace any parts that are scuffed, pitted or excessively worn. Inspect valve stem tip contact surface of each rocker arm and replace any rocker arm that is deeply pitted. Inspect each push rod end for excessive wear and replace as required. If any push rod is excessively worn because of lack of oil, replace the push rod and inspect the corresponding tappet.

It is not normal to find a wear pattern along the length of the push rod. Examine the cylinder head for obstruction if this condition exists.

Installation

(1) Install each push rod in same location from where it was removed. **Ensure bottom end of each rod is centered in plunger cap of hydraulic valve tappet.**

(2) Install bridge and pivot assemblies and pair of rocker arms adjacent to same cylinders from where they were removed.

(3) Loosely install capscrews on each bridge and pivot assembly.

(4) At each bridge, tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten with 19 foot-pounds (26 N•m) torque.

(5) Install cylinder head cover and gasket.

Valves

NOTE: *The following procedures apply only after the cylinder head has been removed from the engine. Refer to Cylinder Head for removal procedure.*

Disassembly

(1) Compress each valve spring with Valve Spring Compressor Tool J-22534-01 and remove valve locks, retainers, springs and valve stem oil deflectors.

(2) Remove valves and place in rack in same order as removed from cylinder head.

Cleaning and Inspection

(1) Clean all carbon deposit from combustion chambers, valve ports, valve stems and head.

(2) Clean all foreign matter and gasket cement from cylinder head machined surface.

(3) Inspect for cracks in combustion chambers and valve ports.

(4) Inspect for cracks in gasket mating surface around each coolant passage.

(5) Inspect valves for burned, cracked or warped heads. Inspect for scuffed or bent valve stems. Replace valves displaying any damage.

Valve Refacing

Use a valve refacing machine to reface intake and exhaust valves to the specified angle. After refacing, at least 1/32-inch (0.787 mm) margin must remain. If not, replace the valve. Examples of correct and incorrect valve refacing are illustrated in figure 1B-49.

The valve stem tip can be resurfaced and rechamfered when worn. Do not remove more than 0.020 inch (0.508 mm).

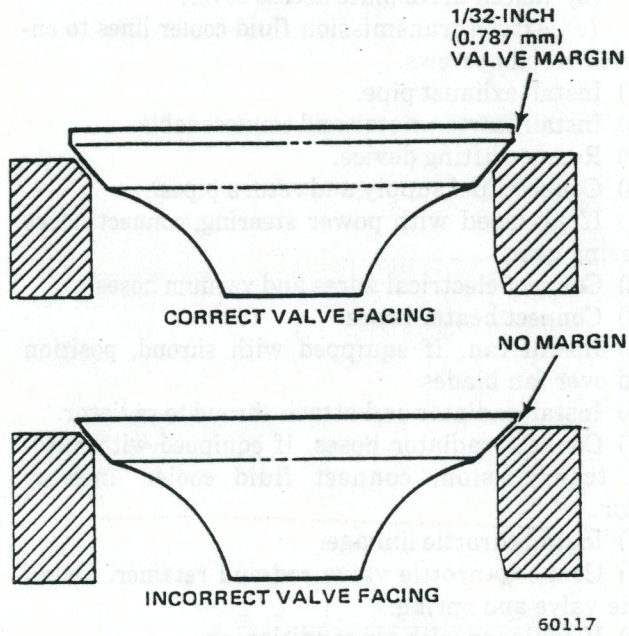


Fig. 1B-49 Valve Refacing

Valve Seat Refacing

Install a pilot of the correct size in the valve guide and reface the valve seat to the specified angle with a dressing stone in good condition. Remove only enough metal to provide a smooth finish.

Use tapered stones to obtain the specified seat widths when required.

Control seat runout to a maximum of 0.0025 inch (0.064 mm) (fig. 1B-50).

Valve Stem Oil Deflector Replacement

Nylon valve stem oil deflectors are installed on each valve stem to prevent lubricating oil from entering the combustion chamber through the valve guides. Replace the oil deflectors whenever valve service is performed or if the deflectors have deteriorated.

Valve stem oil deflector replacement requires removal of valve spring(s). Refer to Valve Springs for procedure.

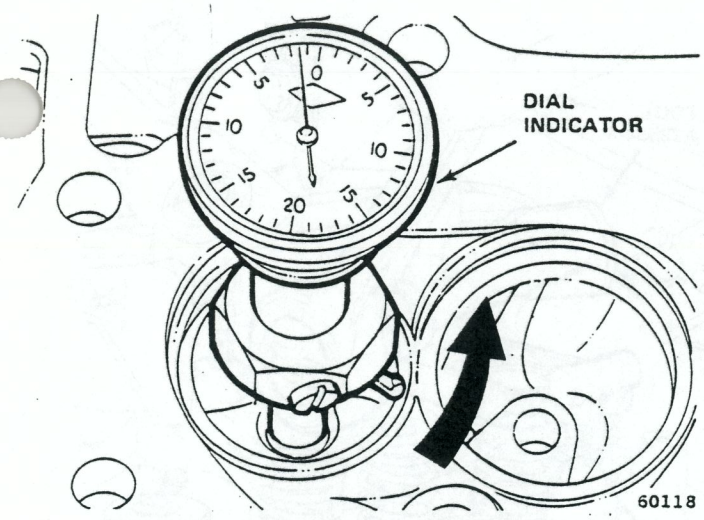


Fig. 1B-50 Measuring Valve Seat Runout

Valve Guides

The valve guides are an integral part of the cylinder head and are not replaceable. When the stem-to-guide clearance is excessive, ream the valve guide bores to accommodate the next larger oversize valve stem. Oversize service valves are available with 0.003-inch (0.076 mm), 0.015-inch (0.381 mm), and 0.030-inch (0.762 mm) stem diameter sizes. Refer to Valve Guide Reamer Sizes chart for reamer sizes.

Valve Guide Reamer Sizes

Reamer Tool Number	Size
J-6042-1	0.003-inch (.076 mm)
J-6042-5	0.015-inch (.381 mm)
J-6042-4	0.030-inch (.762 mm)

60260

NOTE: *Ream valve guides in steps, starting with the 0.003-inch (0.076 mm) oversize reamer and progressing to the size required.*

Valve Stem-to-Guide Clearance

Valve stem-to-guide clearance may be measured by either of the following two methods.

Preferred Method:

(1) Remove valve from head and clean valve guide bore with solvent and bristle brush.

(2) Insert telescoping gauge into valve guide bore approximately 3/8 inch (9.525 mm) from valve spring side of head (fig. 1B-51) with contacts crosswise to cylinder head. Measure telescoping gauge contacts with micrometer.

(3) Repeat measurement with contacts lengthwise to cylinder head.

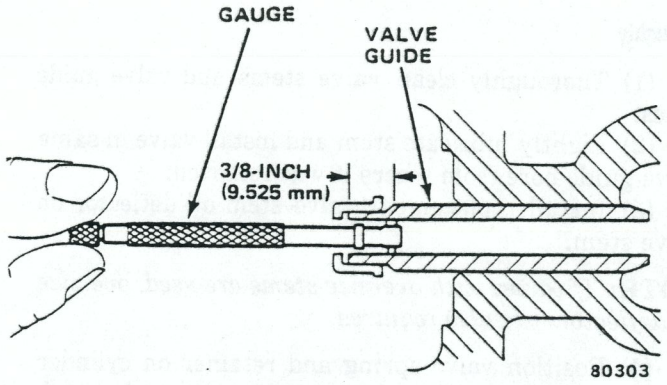


Fig. 1B-51 Valve Stem-to-Guide Clearance Measurement with Telescoping Gauge

(4) Compare crosswise to lengthwise measurements to determine out-of-roundness. If measurements differ by more than 0.0025 inch (0.064 mm), ream guide bore to accommodate oversize valve stem.

(5) Compare valve guide bore diameter with diameter listed in Specifications. If measurement differs more than 0.003 inch (0.076 mm), ream guide to accommodate oversize valve stem.

Alternate Method:

(1) Use dial indicator to measure lateral movement of valve stem with valve installed in its guide and barely off valve seat (fig. 1B-52).

(2) Correct clearance is 0.001 to 0.003 inch (0.025 mm to 0.076 mm). If indicated movement exceeds acceptable clearance, ream guide to accommodate oversize valve stem.

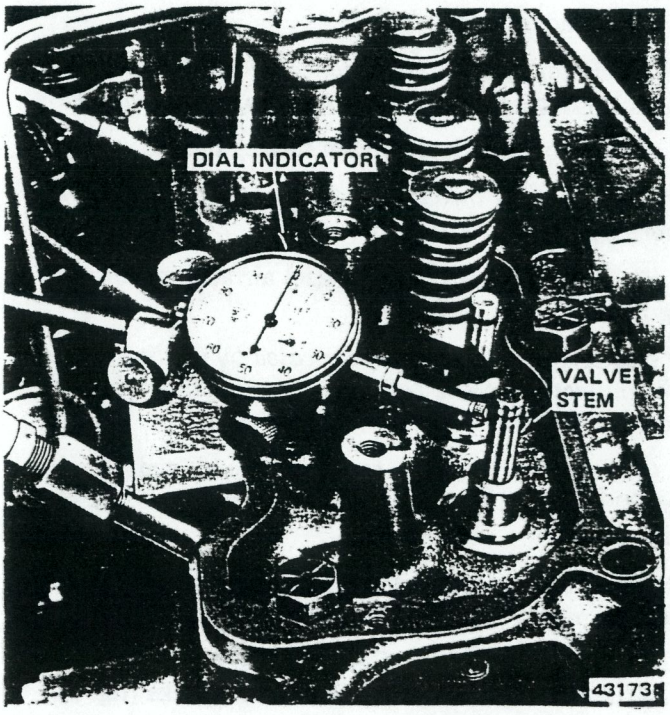


Fig. 1B-52 Valve Stem-to-Guide Clearance Measurement with Dial Indicator

Assembly

(1) Thoroughly clean valve stems and valve guide bores.

(2) Lightly lubricate stem and install valve in same valve guide bore from where it was removed.

(3) Install replacement valve stem oil deflector on valve stem.

NOTE: *If valves with oversize stems are used, oversize oil deflectors are also required.*

(4) Position valve spring and retainer on cylinder head and compress valve spring with compressing tool. Install valve locks and release tool.

(5) Tap valve spring from side-to-side with hammer to assure spring is properly seated on cylinder head.

Valve Springs

Valve Spring and Oil Deflector Removal

NOTE: *This procedure is for removal of valve springs and oil deflectors with the cylinder head installed on the engine. Refer to Valves for removal procedure with the head removed from the engine.*

The valve spring is held in place on the valve stem by a retainer and a pair of conical-type valve locks. The locks can be removed only by compressing the valve spring.

(1) Remove cylinder head cover.

(2) Remove bridge and pivot assemblies and rocker arms.

(3) Remove push rods.

NOTE: *Retain push rods, bridge and pivot assemblies and rocker arms in same order and position as removed.*

(4) Remove spark plug from each cylinder.

NOTE: *Steps (5) through (9) apply to each cylinder to be serviced.*

(5) Install 14-mm (thread size) air adapter in spark plug hole.

NOTE: *An adapter can be fabricated by welding an air hose connection to the body of a spark plug having the porcelain removed.*

(6) Connect air hose to adapter and maintain at least 90 psi (620 kPa) in cylinder to force valves against their seats.

NOTE: *On vehicles equipped with air conditioning, use a flexible air adapter when servicing No. 1 cylinder.*

(7) Use Valve Spring Remover and Installer Tool J-22534-01 to compress spring and remove locks (fig. 1B-53).

(8) Remove valve spring and retainer.

(9) Remove valve stem oil deflector.

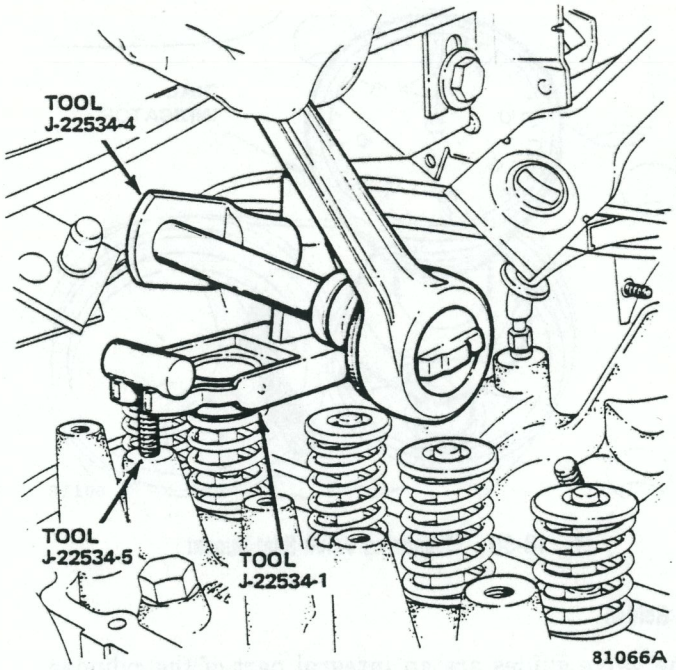


Fig. 1B-53 Valve Spring Removal

Valve Spring Tension Test

Use Valve Spring Tester J-8056, or equivalent, to test each valve spring for the specified tension value (fig. 1B-54). Replace valve springs that are not within the specification.

Oil Deflector and Valve Spring Installation

NOTE: *The following procedure applies to each cylinder being serviced.*

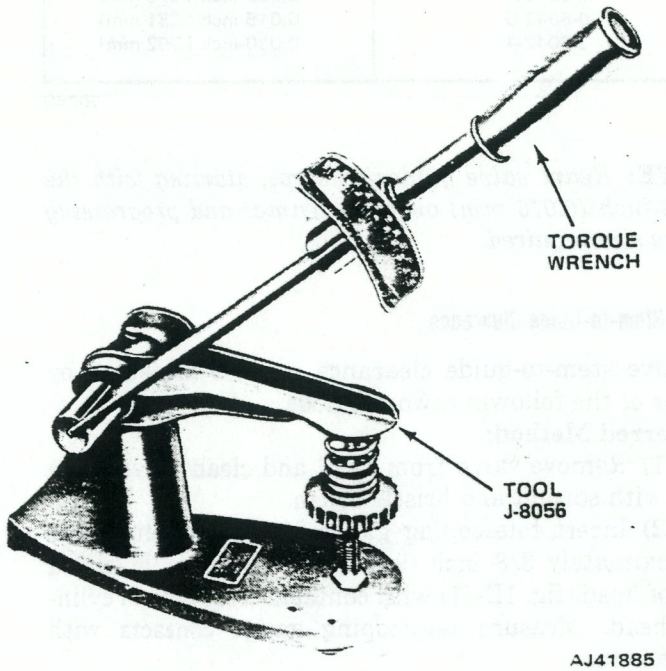


Fig. 1B-54 Valve Spring Tester—Typical

(1) Use 7/16-inch deep socket and small hammer to gently tap oil deflector onto valve stem.

CAUTION: *Install the deflector carefully to prevent damage from the sharp edges of the valve lock groove.*

(2) Install valve spring and retainer.

(3) Compress valve spring with tool J-22534-01 and position valve locks. Release spring tension and remove tool.

NOTE: *Tap spring from side-to-side to ensure spring is seated properly on cylinder head.*

(4) Disconnect air hose, remove adapter from spark plug hole and install spark plug.

(5) Install push rods. Ensure bottom end of each rod is centered in plunger cap of hydraulic valve tappet.

(6) Install rocker arms and bridge and pivot assembly. At each bridge and pivot assembly tighten capscrews alternately, one turn at a time, to avoid damaging bridge.

(7) Install cylinder head cover. Refer to Cylinder Head Cover for procedure.

CAMSHAFT AND BEARINGS

The camshaft is supported by form steel-shelled, babbitt-lined bearings pressed into the block and line reamed. The step-bored camshaft bearing bores are larger at the front bearing than at the rear to permit easy removal and installation of the camshaft. Camshaft bearings are pressure lubricated.

NOTE: *It is not advisable to replace camshaft bearings unless the special removal and installation tools are available.*

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear. The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face. Camshaft end play is zero during engine operation.

Measuring Cam Lobe Lift

(1) Remove cylinder head cover.

(2) Remove bridge and pivot assemblies and rocker arms.

(3) Remove spark plugs.

(4) Install dial indicator on end of push rod. Use piece of rubber tubing to hold dial indicator plunger squarely on push rod (fig. 1B-55).

(5) Rotate crankshaft until cam lobe base (heel) circle (push rod down) is under valve tappet. Set dial indicator to zero.

(6) Rotate crankshaft until push rod reaches its maximum upward travel. Note distance on dial indicator. Correct cam lobe lift is 0.242 to 0.254 inch (6.147 to 6.451 mm).

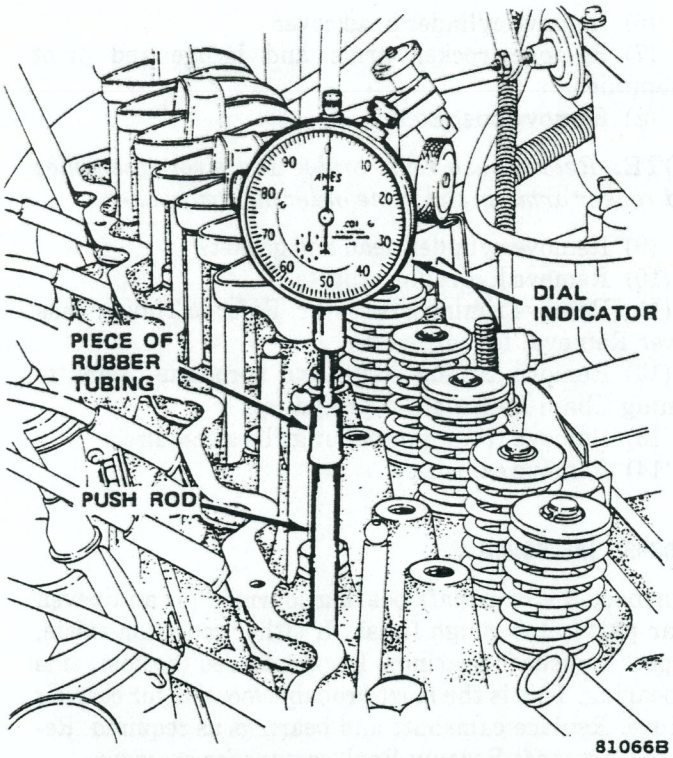


Fig. 1B-55 Cam Lobe Lift Measurement and Valve Timing

Valve Timing

(1) Disconnect ignition wires and remove spark plugs.

(2) Remove cylinder head cover.

(3) Remove bridge and pivot assembly and rocker arms from No. 1 cylinder.

(4) Rotate crankshaft until No. 6 piston is at TDC on compression stroke.

(5) Rotate crankshaft counterclockwise (viewed from front of engine) 90°.

(6) Install dial indicator on end of No. 1 cylinder intake valve push rod. Set dial indicator to zero (fig. 1B-55).

(7) Rotate crankshaft clockwise (viewed from front of engine) until dial indicator pointer indicates 0.016-inch (0.406 mm) lift.

(8) Timing mark on vibration damper should be indexed with TDC mark on timing degree scale. If timing mark is more than 1/2 inch (12.7 mm) from TDC in either direction, valve timing is incorrect.

Camshaft Removal

(1) Drain cooling system.

NOTE: *Drain coolant in clean container if reusable.*

(2) Remove radiator and fan assembly.

(3) Remove air conditioner condenser and receiver assembly as charged unit, if equipped.

(4) Remove fuel pump.

(5) Remove distributor and ignition wires.

(6) Remove cylinder head cover.
(7) Remove rocker arms and bridge and pivot assemblies.
(8) Remove push rods.

NOTE: *Retain push rods, bridge and pivot assemblies and rocker arms in the same order as removed.*

(9) Remove cylinder head and gasket.
(10) Remove hydraulic tappets.
(11) Remove timing case cover. Refer to Timing Case Cover Removal for procedure.
(12) Remove timing chain and sprockets. Refer to Timing Chain Removal for procedure.
(13) Remove front bumper or grille as required.
(14) Remove camshaft.

Camshaft Inspection

Inspect the camshaft bearing journals for an uneven wear pattern or rough finish. If either condition exists, inspect camshaft bearings. Inspect loaded (bottom) side of bearing. This is the most probable location for bearing failure. Replace camshaft and bearings as required. Refer to Camshaft Bearing Replacement for procedure.

Inspect the distributor drive gear for damage or excessive wear. Replace if necessary.

Inspect each cam lobe and the corresponding hydraulic valve tappet for wear. If the face of the tappet(s) is worn concave, the corresponding camshaft lobe(s) will also be worn. Replace both the camshaft and the tappet(s).

If the camshaft appears to have been rubbing heavily against the timing case cover, examine the oil pressure relief holes in the rear cam journal. These holes relieve oil pressure between the end of the camshaft and the rear bearing plug.

Camshaft Installation

(1) Lubricate camshaft with Jeep Engine Oil Supplement (E.0.S), or equivalent.
(2) Install camshaft carefully to prevent damaging camshaft bearings.
(3) Install timing chain, crankshaft sprocket and camshaft sprocket with timing marks aligned. Refer to Timing Chain Installation for procedure.
(4) Install camshaft sprocket retaining screw and tighten.
(5) Install timing case cover with replacement oil seal. Refer to Timing Case Cover Installation for procedure.
(6) Install vibration damper.
(7) Install damper pulley, if removed.
(8) Install engine fan and hub assembly.
(9) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling Systems.
(10) Install fuel pump.
(11) Rotate crankshaft until No. 1 piston is at TDC position on compression stroke.
(12) Install distributor and ignition wires. Install distributor with rotor aligned with No. 1 terminal on cap when distributor housing is fully seated on block.
(13) Install hydraulic tappets. Lubricate tappets and all valve train components with Jeep Engine Oil Supplement (EOS), or equivalent.

NOTE: *The EOS must remain in the engine for at least 1,000 miles (1 609 km) but need not be drained until the next scheduled oil change.*

(14) Install cylinder head and gasket.
(15) Install push rods.
(16) Install rocker arms and bridge and pivot assemblies. Alternately tighten capscrews for each bridge one turn at a time to avoid damaging bridge.
(17) Install cylinder head cover. Refer to Cylinder Head Cover for procedure.
(18) Install air conditioner condenser and receiver assembly, if equipped.

CAUTION: *Open both service valves before the air conditioning system is operated.*

(19) Install radiator, connect hoses and fill cooling system with specified mixture. Refer to Chapter 1C—Cooling Systems.
(20) Install front bumper or grille, if removed.
(21) Check ignition timing and adjust as required.

Camshaft Bearing Replacement

Camshaft bearing replacement requires that the engine be removed from the vehicle. Remove timing case cover, crankshaft, camshaft and rear bearing plug. When installing bearings, use a screw-type tool that provides steady force. Do not use a driver-type tool to install bearings. Care must be taken to align oil holes in bearings with oil galleries in the block. It is not necessary to line ream camshaft bearings after installation.

HYDRAULIC VALVE TAPPETS

The hydraulic valve tappet consists of the tappet body, plunger, plunger return spring, check valve assembly metering disc, plunger cap and lockring (fig. 1B-56).

The tappet operates in a guide bore that intersects with the main oil gallery.

Operation

The operating cycle of the hydraulic tappet begins when the tappet is on the heel (base circle) of the cam lobe (engine valve closed). A groove in the tappet body aligns with the tappet oil gallery to admit pressurized oil into the tappet (fig. 1B-57). A hole and groove arrangement admits the oil to the inside of the plunger. Oil is

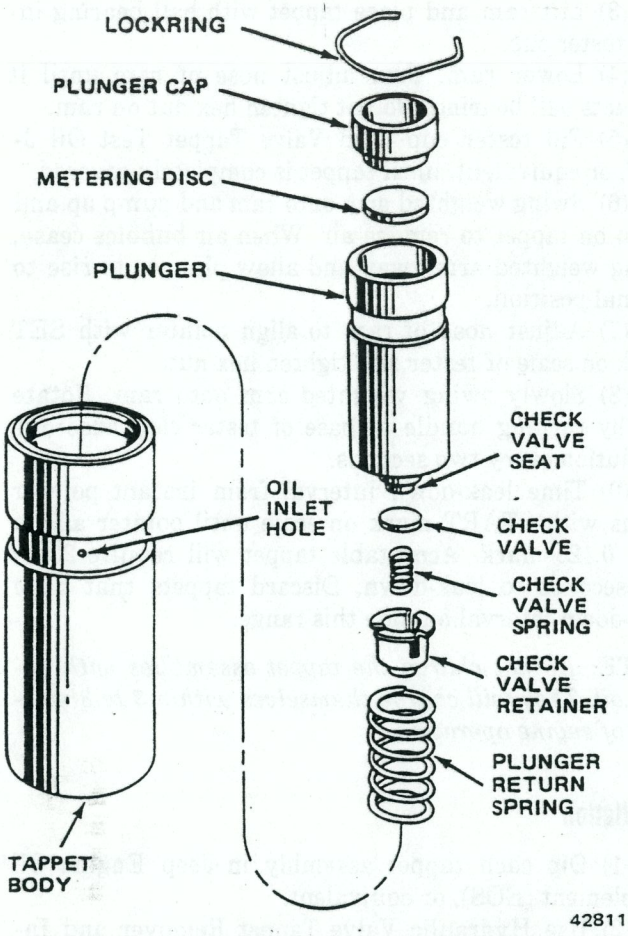


Fig. 1B-56 Hydraulic Valve Tappet Components

forced past the plunger check valve and fills the chamber between the plunger and tappet body. When the chamber is full, additional oil in the plunger body unseats the metering disc, and a spurt of oil flows up inside the push rod to lubricate the rocker assembly. These events described above all occur while the tappet is on the heel of the cam lobe. As the cam turns, the lobe begins exerting force on the tappet body. This force is transmitted by the trapped oil in the tappet chamber to the plunger and finally to the push rod and rocker assembly. The engine valve opens. While the valve is open, the trapped oil is subjected to considerable pressure and some of it escapes between the plunger and the tappet body (leak-down). The cycle is completed as the cam lobe rotates back to the starting position and another charging cycle begins. In this way, zero valve lash is maintained and engine noise is reduced.

Removal

(1) Drain cooling system.

NOTE: *Drain coolant in clean container if reusable.*

(2) Remove cylinder head cover.

(3) Remove bridge and pivot assemblies and rocker arms.

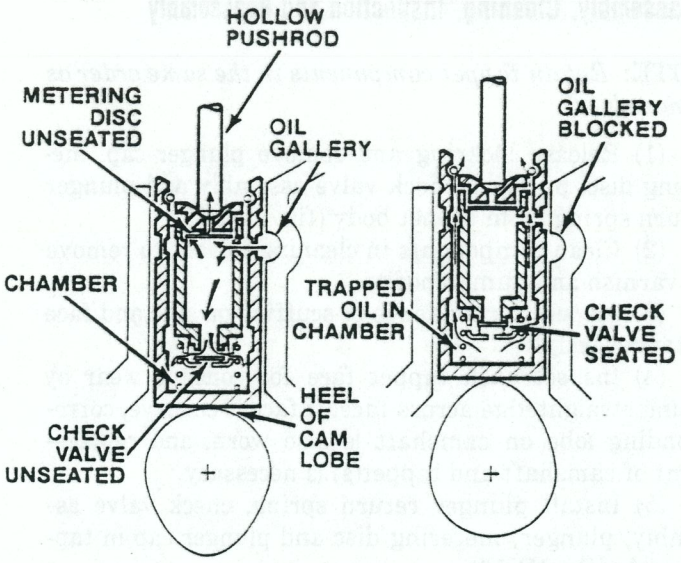


Fig. 1B-57 Hydraulic Valve Tappet Operation

NOTE: *When removing the two capscrews from each bridge, alternately loosen each screw one turn at a time to avoid damaging bridge.*

(4) Remove push rods.

NOTE: *Retain rocker arms, bridge and pivot assemblies and push rods in the same order as removed.*

(5) Remove cylinder head and gasket.

(6) Remove tappets through push rod openings in block with Hydraulic Valve Tappet Remover and Installer Tool J-21884 (fig. 1B-58).

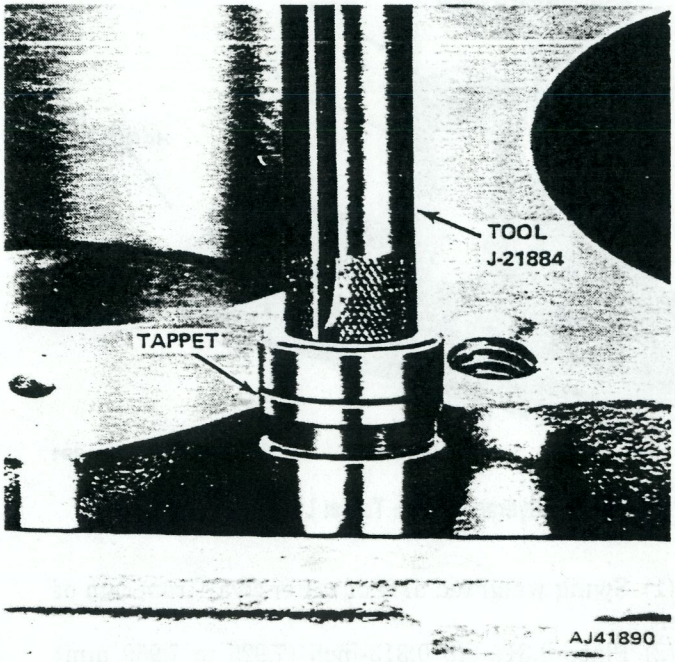


Fig. 1B-58 Hydraulic Valve Tappet Removal

Disassembly, Cleaning, Inspection and Reassembly

NOTE: *Retain tappet components in the same order as removed.*

(1) Release lockring and remove plunger cap, metering disc, plunger, check valve assembly and plunger return spring from tappet body (fig. 1B-56).

(2) Clean components in cleaning solvent to remove all varnish and gum deposits.

(3) Inspect for evidence of scuffing on side and face of tappet body.

(4) Inspect each tappet face for concave wear by laying straightedge across face. If face is concave, corresponding lobe on camshaft is also worn, and replacement of camshaft and tappet(s) is necessary.

(5) Install plunger return spring, check valve assembly, plunger, metering disc and plunger cap in tappet body (fig. 1B-56).

(6) Compress plunger assembly using push rod on plunger cap, and install lockring.

Hydraulic Valve Tappet Leak-Down Test

After cleaning, inspection and reassembly, leak-down test each tappet to ensure zero-lash operation. Figure 1B-59 illustrates tool J-5790, which can be used to accurately test tappet leak-down rate.

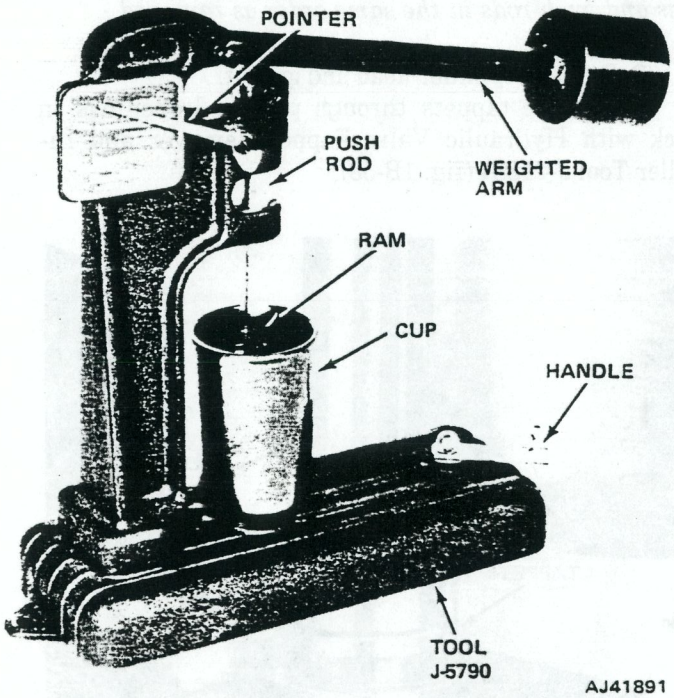


Fig. 1B-59 Hydraulic Valve Tappet Leak-Down Rate Tester

(1) Swing weighted arm of tester away from ram of tester.

(2) Place 0.312- to 0.313-inch (7.925 to 7.950 mm) diameter ball bearing on tappet plunger cap.

(3) Lift ram and place tappet with ball bearing inside tester cup.

(4) Lower ram, then adjust nose of ram until it contacts ball bearing. Do not tighten hex nut on ram.

(5) Fill tester cup with Valve Tappet Test Oil J-5268, or equivalent, until tappet is completely covered.

(6) Swing weighted arm onto ram and pump up and down on tappet to remove air. When air bubbles cease, swing weighted arm away and allow plunger to rise to normal position.

(7) Adjust nose of ram to align pointer with SET mark on scale of tester and tighten hex nut.

(8) Slowly swing weighted arm onto ram. Rotate cup by turning handle at base of tester clockwise one revolution every two seconds.

(9) Time leak-down interval from instant pointer aligns with START mark on scale until pointer aligns with 0.125 mark. Acceptable tappet will require 20 to 110 seconds to leak-down. Discard tappets that have leak-down interval outside this range.

NOTE: *Do not charge the tappet assemblies with engine oil. They will charge themselves within 3 to 8 minutes of engine operation.*

Installation

(1) Dip each tappet assembly in Jeep Engine Oil Supplement (EOS), or equivalent.

(2) Use Hydraulic Valve Tappet Remover and Installer Tool J-21884 to install each tappet in same bore from where it was removed.

(3) Install cylinder head and replacement gasket and tighten screws. Refer to Cylinder Head Installation for tightening sequence.

(4) Install push rods in same order as removed.

(5) Install rocker arms and bridge and pivot assemblies. Loosely install capscrews at each bridge. Tighten capscrews alternately, one turn at a time, to avoid damaging or breaking bridge.

(6) Pour remaining EOS over entire valve train.

NOTE: *The EOS must remain in the engine for at least 1,000 miles (1 607 km) but need not be drained until the next scheduled oil change.*

(7) Install cylinder head cover. Refer to Cylinder Head Cover for procedure.

(8) Install coolant.

TIMING CASE COVER

The timing case cover is provided with a seal and oil slinger to prevent oil leakage at the vibration damper hub (fig. 1B-60). A socket is attached in the cover for the use of a magnetic timing probe. A graduated timing degree scale is located on the cover for standard ignition timing.

It is important that the timing case cover be properly aligned with the crankshaft to prevent eventual damage to the oil seal. The oil seal may be replaced without removing the timing case cover.

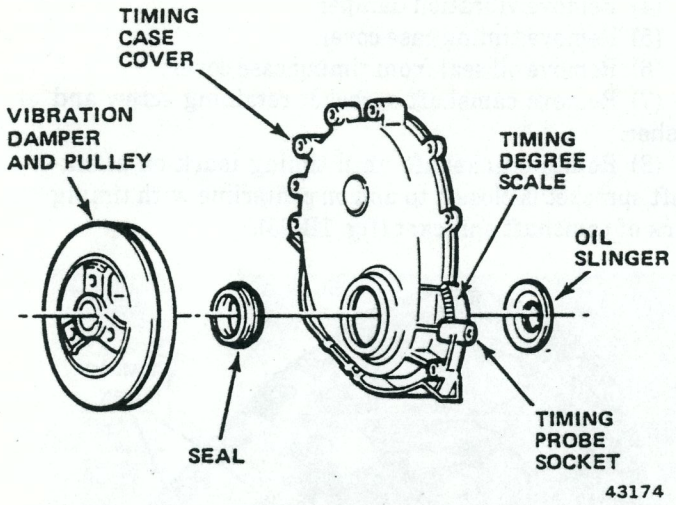


Fig. 1B-60 Timing Case Cover

Removal

(1) Remove drive belt(s), engine fan and hub assembly, damper pulley and vibration damper. Refer to Vibration Damper and Pulley Removal for procedure.

(2) Remove oil pan-to-timing case cover screws and cover-to-block screws.

(3) Remove timing case cover and gasket from engine.

(4) Cut off oil pan gasket end tabs flush with front face of cylinder block and remove gasket tabs.

(5) Clean timing case cover, oil pan and cylinder block gasket surfaces.

(6) Remove crankshaft oil seal from timing case cover.

Installation

(1) Apply seal compound (Perfect Seal, or equivalent) to both sides of replacement timing case cover gasket and position gasket on cylinder block.

(2) Cut end tabs off replacement oil pan gasket corresponding to pieces cut off original gasket. Cement these pieces on oil pan.

(3) Coat oil pan seal end tabs generously with Permatex No. 2, or equivalent, and position seal on timing case cover (fig. 1B-61).

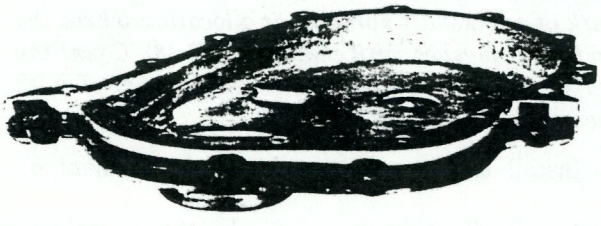


Fig. 1B-61 Oil Pan Front Seal Installation

(4) Position timing case cover on engine. Place Timing Case Cover Alignment Tool and Seal Installer J-22248 in crankshaft opening of cover (fig. 1B-62).

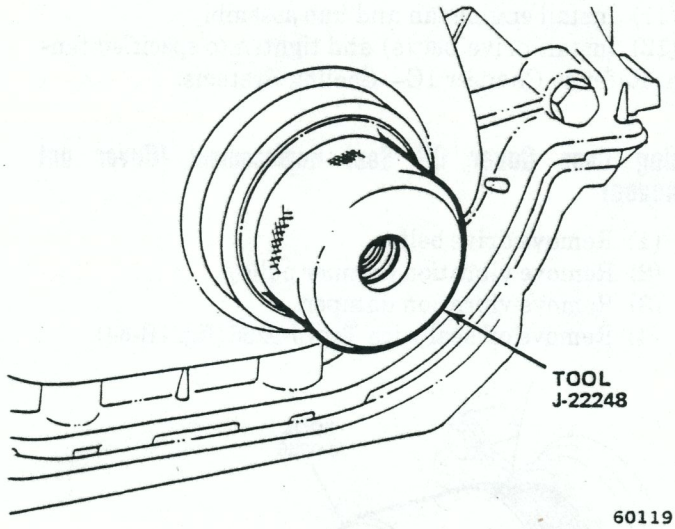


Fig. 1B-62 Timing Case Cover Alignment

(5) Install cover-to-block screws and oil pan-to-cover screws. Tighten cover-to-block screws with 5 foot-pounds (7 N•m) torque and oil pan-to-cover screws with 11 foot-pounds (15 N•m) torque.

(6) Remove cover aligning tool and position replacement oil seal on tool with seal lip facing outward. Apply light film of Perfect Seal, or equivalent, on outside diameter of seal.

(7) Insert draw screw from Tool J-9163 into seal installing tool. Tighten nut against tool until tool contacts cover (fig. 1B-63).

(8) Remove tools and apply light film of engine oil to seal lip.

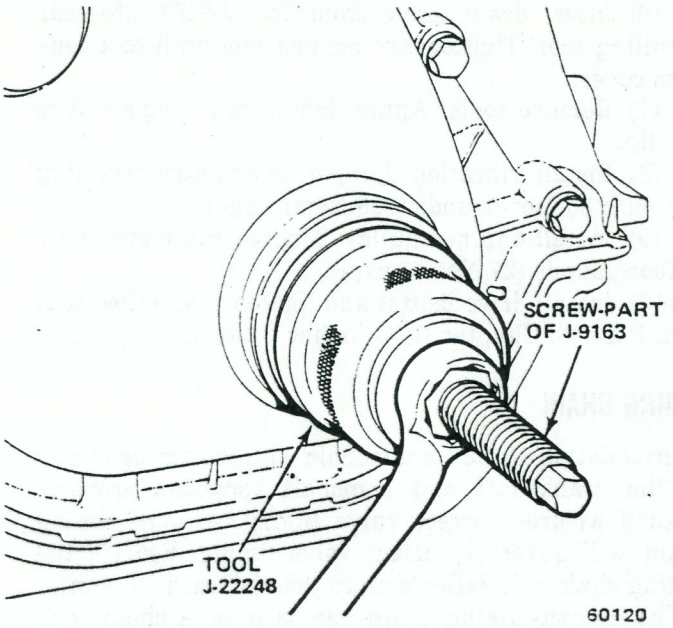


Fig. 1B-63 Timing Case Cover Oil Seal Installation

(9) Install vibration damper and tighten retaining screw with 80 foot-pounds (108 N•m) torque.

(10) Install damper pulley. Tighten capscrews with 20 foot-pounds (27 N•m) torque.

(11) Install engine fan and hub assembly.

(12) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling Systems.

Timing Case Cover Oil Seal Replacement (Cover not Removed)

(1) Remove drive belts.
(2) Remove vibration damper pulley.
(3) Remove vibration damper.
(4) Remove oil seal with Tool J-9256 (fig. 1B-64).

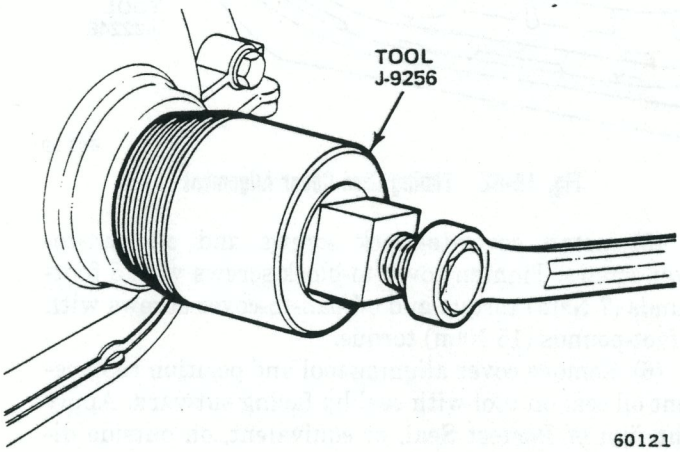


Fig. 1B-64 Timing Case Cover Oil Seal Removal

(5) Position replacement oil seal on Timing Case Cover Alignment Tool and Seal Installer J-22248 with seal lip facing outward. Apply light film of Perfect Seal, or equivalent, to outside diameter of seal.

(6) Insert draw screw from Tool J-9163 into seal installing tool. Tighten nut against tool until tool contacts cover.

(7) Remove tools. Apply light film of engine oil to seal lip.

(8) Install vibration damper and tighten retaining bolt with 80 foot-pounds (108 N•m) torque.

(9) Install damper pulley. Tighten capscrews with 20 foot-pounds (27 N•m) torque.

(10) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling Systems.

TIMING CHAIN

Installation of the timing chain with the timing marks of the crankshaft and camshaft sprockets properly aligned assures correct valve timing. A worn timing chain will adversely affect valve timing. Replace the timing chain if it deflects more than 1/2 inch (13 mm).

The correct timing chain has 48 pins. A chain with more than 48 pins will cause excessive slack.

Removal

(1) Remove drive belt(s).
(2) Remove engine fan and hub assembly.
(3) Remove vibration damper pulley.
(4) Remove vibration damper.
(5) Remove timing case cover.
(6) Remove oil seal from timing case cover.
(7) Remove camshaft sprocket retaining screw and washer.
(8) Rotate crankshaft until timing mark on crankshaft sprocket is closest to and on centerline with timing mark of camshaft sprocket (fig. 1B-65).

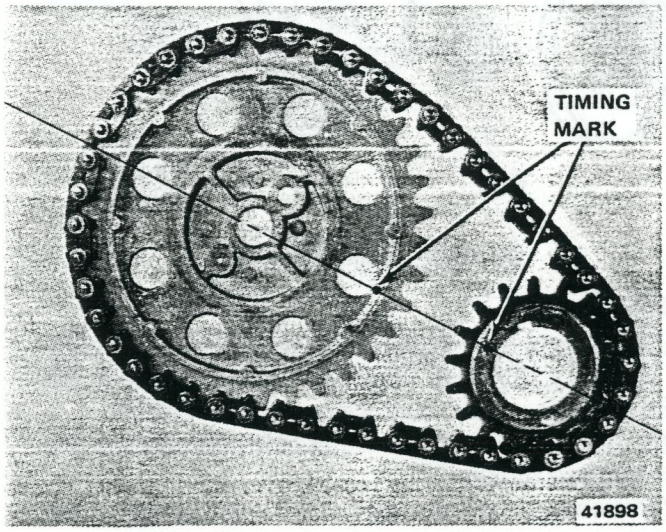


Fig. 1B-65 Timing Sprocket Alignment

(9) Remove crankshaft sprocket, camshaft sprocket and timing chain as assembly. Disassemble chain and sprockets.

Installation

(1) Assemble timing chain, crankshaft sprocket and camshaft sprocket with timing marks aligned (fig. 1B-65).

(2) Install assembly on crankshaft and camshaft.

(3) Install camshaft sprocket retaining screw and washer and tighten with 50 foot-pounds (68 N•m) torque.

NOTE: *To verify correct installation of the timing chain, position timing mark of the camshaft sprocket at approximately one o'clock position. This positions timing mark of crankshaft sprocket at a location where the adjacent tooth meshes with chain (fig. 1B-66). Count the number of chain pins between timing marks of both sprockets. There must be 15 pins.*

(4) Install timing case cover and replacement oil seal.

(5) Install vibration damper and tighten retaining bolt with 80 foot-pounds (108 N•m) torque.

(6) Install damper pulley and tighten capscrews with 20 foot-pounds (27 N•m) torque.

(7) Install engine fan and hub assembly.

(8) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling Systems.

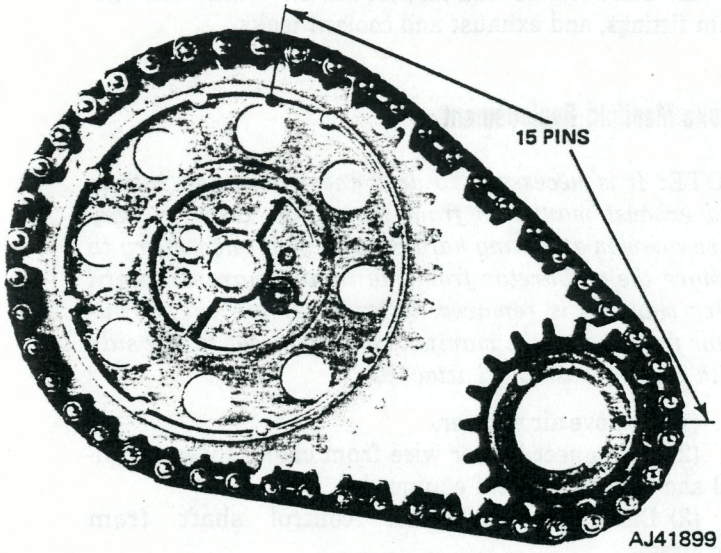


Fig. 1B-66 Timing Chain Installation

INTAKE AND EXHAUST MANIFOLDS

The aluminum intake and cast iron exhaust manifolds (fig. 1B-67) are attached to the cylinder head on the left side of the engine. A gasket is used between the intake manifold and the cylinder head. No gasket is used between the exhaust manifold and cylinder head.

An exhaust gas recirculation (EGR) valve is mounted on the side of the intake manifold. The intake manifold has an electric heater that improves fuel vaporization during warmup and shortens choke operation time. Coolant is also routed through the intake manifold to improve fuel vaporization.

Intake and Exhaust Manifold Removal

(1) Remove air cleaner. Disconnect fuel pipe, carburetor air horn vent hose, solenoid wire, if equipped, and choke heater wire.

(2) Disconnect throttle cable from throttle bellcrank. Disconnect throttle valve rod, if equipped.

(3) Disconnect PCV vacuum hose and heater wire from intake manifold.

(4) Drain coolant below intake manifold level.

NOTE: *Do not waste reusable coolant. Drain into clean container for reuse.*

(5) Disconnect coolant hoses from intake manifold.

(6) Disconnect spark CTO valve vacuum hoses.

(7) Disconnect vacuum hose from EGR valve. Disconnect EGR tube fittings from intake and exhaust manifold.

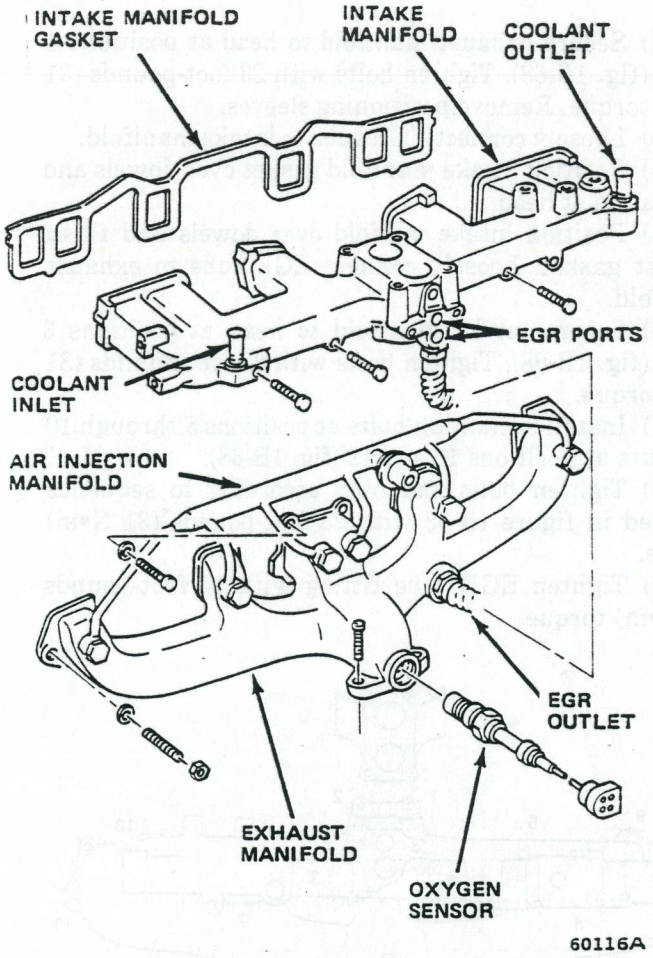


Fig. 1B-67 Intake and Exhaust Manifolds

(8) Disconnect air injection hoses at air pump and air injection manifold check valve. Disconnect diverter valve vacuum hose and remove diverter valve with hoses attached.

(9) Remove air pump/power steering mounting bracket, if equipped.

(10) Remove air pump.

(11) Detach power steering pump, if equipped, and set aside. Do not remove hoses.

(12) Remove air conditioner drive belt idler pulley assembly from cylinder head, if equipped.

(13) Disconnect exhaust pipe from exhaust manifold flange. Remove oxygen sensor, if equipped.

(14) Remove manifold attaching bolts, nuts and clamps. Remove intake and exhaust manifolds. Discard intake manifold gasket.

(15) Clean mating surfaces of manifolds and cylinder head.

Intake and Exhaust Manifold Installation

(1) Position exhaust manifold over end studs on cylinder head and install positioning sleeves over end studs.

(2) Secure exhaust manifold to head at positions 1 and 2 (fig. 1B-68). Tighten bolts with 23 foot-pounds (31 N•m) torque. Remove positioning sleeves.

(3) Loosely connect EGR tube to intake manifold.

(4) Position intake manifold gasket over dowels and flush against head.

(5) Position intake maifold over dowels and flush against gasket. Loosely connect EGR tube to exhaust manifold.

(6) Secure intake manifold to head at positions 3 and 4 (fig. 1B-68). Tighten bolts with 23 foot-pounds (31 Nm) torque.

(7) Install remaining bolts at positions 5 through 10 and nuts at positions 11 and 12 (fig. 1B-68).

(8) Tighten bolts and nuts according to sequence depicted in figure 1B-68 with 23 foot-pounds (31 N•m) torque.

(9) Tighten EGR tube fitting with 30 foot-pounds (41 N•m) torque.

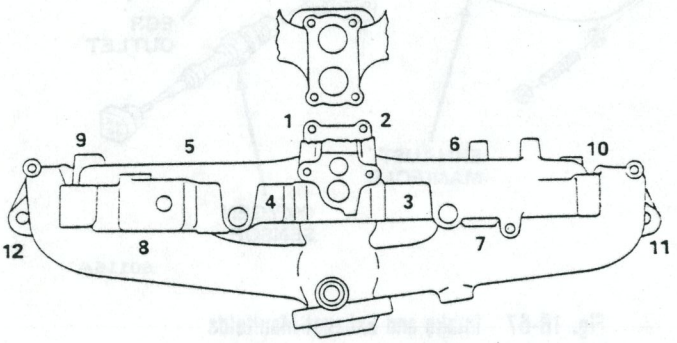


Fig. 1B-68 Manifold Tightening Sequence

(10) Position flange gasket and connect exhaust pipe to exhaust manifold flange. Tighten nuts with 20 foot-pounds (27 N•m) torque. Install oxygen sensor, if removed.

(11) Connect fuel pipe and air horn vent hose to carburetor. Connect solenoid wire, if equipped.

(12) Install AC drive belt idler pulley assembly, if removed.

(13) Install air pump, if removed.

(14) Install air pump/power steering pump mounting bracket, if removed.

(15) Install diverter valve. Connect air hoses to air pump and check valve. Connect vacuum hose.

(16) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling Systems.

(17) Install spark CTO valve vacuum hoses.

(18) Connect vacuum hose to EGR valve.

(19) Connect throttle cable and PCV hose. Connect throttle valve rod, retainer and spring. Connect intake manifold heater wire.

(20) Connect coolant hoses to intake manifold.

(21) Install air cleaner.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(22) Start engine and inspect for air leaks into vacuum fittings, and exhaust and coolant leaks.

Intake Manifold Replacement

NOTE: *It is necessary to disconnect both the intake and exhaust manifolds from the engine because they have common attaching hardware. It is not necessary to remove the carburetor from the intake manifold until after manifold is removed. After removing the carburetor from the intake manifold, it may be set to one side with vacuum hoses still attached.*

(1) Remove air cleaner.

(2) Disconnect heater wire from choke cover terminal and solenoid wire, if equipped.

(3) Disconnect carburetor control shaft from carburetor.

(4) Remove carburetor from intake manifold and set aside. Remove carburetor insulator block.

(5) Remove carburetor mounting studs from intake manifold.

(6) Remove intake and exhaust manifolds from engine. Refer to Intake and Exhaust Manifold Removal for procedure.

(7) Remove throttle control bracket.

(8) Remove EGR valve and studs and install in replacement manifold.

(9) Remove intake manifold heater and install in replacement manifold.

(10) Install throttle control bracket. Tighten nuts with 2 to 4 foot-pounds (3 to 5 N•m) torque.

(11) Install vacuum hose fittings.

(12) Install intake and exhaust manifolds. Refer to Intake and Exhaust Manifold Installation for procedure.

(13) Install vacuum hoses.

(14) Install carburetor studs, replacement gaskets and spacer.

(15) Install carburetor and connect linkage, fuel pipe and hoses.

(16) Tighten carburetor mounting nuts with 14 foot-pounds (19 N•m) torque.

(17) Connect and choke heater wire to choke cover terminal.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(18) Start engine and inspect for leaks.

(19) Install air cleaner.

Exhaust Manifold Replacement

NOTE: *It is necessary to disconnect both the intake and exhaust manifolds from the engine because they have common attaching hardware. It is not necessary to remove the carburetor from the intake manifold until after manifold is removed. After removing the carburetor from the intake manifold, it may be set to one side with vacuum hoses still attached.*

(1) Remove air cleaner.
(2) Disconnect choke heater wire from choke cover terminal.
(3) Disconnect carburetor control shaft from carburetor.
(4) Remove carburetor from intake manifold and set aside.
(5) Remove intake and exhaust manifolds from engine. Refer to Intake and Exhaust Manifold Removal for procedure.
(6) Remove throttle control bracket.
(7) Remove spark CTO valve hose clamp and install on replacement manifold.
(8) Remove air injection manifold and fittings and install on replacement manifold.
(9) Install throttle control bracket. Tighten nuts with 2 to 4 foot-pounds (3 to 5 N•m) torque.
(10) Install intake and exhaust manifolds. Refer to Intake and Exhaust Manifold Installation for procedure.
(11) Install carburetor spring bracket.
(12) Install carburetor on intake manifold.
(13) Tighten carburetor mounting nuts with 14 foot-pounds (19 N•m) torque.
(14) Install carburetor control shaft. Install throttle return spring.
(15) Connect choke heater wire to choke cover terminal.
(16) Connect exhaust pipe to exhaust manifold. Tighten nuts with 20 foot-pounds (27 N•m) torque.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(17) Start engine and inspect for leaks.
(18) Install air cleaner.

CYLINDER HEAD AND COVER

The cylinder head incorporates hardened exhaust valve seats and exhaust valves with flash chrome stems.

Cylinder Head Cover

CAUTION: *Cylinder head cover is molded plastic. Use care when removing and installing.*

Removal

(1) Remove air cleaner and PCV molded hose.
(2) Disconnect distributor vacuum spark advance hose at spark CTO valve. Disconnect fuel pipe at fuel pump and move aside to allow removal of cylinder head cover.
(3) Disconnect PCV valve from grommet in cylinder head cover. Disconnect hoses from canister.
(4) Remove cylinder head cover holddown nuts. Insert thin bladed tool (e.g., razor blade or putty knife) between cover and head and cut RTV sealant to loosen from head.

CAUTION: *Do not strike cover with mallet to loosen RTV sealant.*

(5) Inspect cylinder head cover for cracks.

Installation

A room temperature vulcanizing (RTV) silicone rubber adhesive is required for installation. Use Jeep Gasket-in-a-Tube, or equivalent.
(1) Remove adhesive and gasket material from sealing surface area.
(2) Wipe gasket mating surface on cylinder head with oily rag. This prevents adhesion but permits sealing.
(3) Apply 1/8-inch (3.2 mm) bead of silicone along entire length of cover flange.
(4) Before silicone begins to cure, install cover on cylinder head. Do not allow silicone to contact rocker arms.

CAUTION: *Do not overtighten nuts because cover may crack from excess stress.*

(5) Initially, tighten nuts by hand, then tighten with 24 inch-pounds (3 N•m) torque.
(6) Connect PCV valve to grommet in cylinder head cover, connect canister hoses.
(7) Install air cleaner and connect PCV hose.

Cylinder Head

Removal

(1) Drain coolant and disconnect hoses from thermostat housing.
(2) Remove air cleaner.
(3) Remove cylinder head cover and sealant. Refer to Cylinder Cover Removal for procedure.
(4) Remove bridge and pivot assemblies and rocker arms. Alternately loosen each capscrew one turn at a time to avoid damaging bridge.
(5) Remove push rods.

NOTE: *Retain push rods, bridge and pivot assemblies and rocker arms in same order as removed.*

(6) Disconnect power steering pump, air pump and brackets. Lay pumps and brackets aside. Do not disconnect hoses.

(7) Remove intake and exhaust manifolds from cylinder head. Refer to Intake and Exhaust Manifold Removal for procedure.

(8) If equipped with air conditioning, perform the following:

(a) Remove air conditioning drive belt idler pulley bracket from cylinder head.

(b) Loosen alternator drive belt. Remove alternator bracket-to-head mounting bolt.

(c) Remove bolts from compressor mounting bracket and set compressor aside.

(9) Disconnect ignition wires and remove spark plugs.

(10) Disconnect coolant temperature sending unit wire and battery negative cable.

(11) Remove ignition coil and bracket assembly.

(12) Remove cylinder head bolts, cylinder head and gasket.

Cleaning and Inspection

(1) Thoroughly clean machined surfaces of cylinder head and block. Remove all deposits and gasket cement.

(2) Remove carbon deposits from combustion chambers and top of pistons.

(3) Use straightedge and feeler gauge to determine flatness of cylinder head and block mating surfaces. Refer to Specifications.

Installation

(1) If cylinder head is to be replaced and original valves used, measure valve stem diameter. Only standard size valve stems can be used with service replacement cylinder head unless replacement head valve guide bores are reamed to accommodate oversize valve stems. Remove all carbon deposits and reface valves as outlined within Valve Refacing procedure.

(2) Install valves in cylinder head using replacement valve stem oil deflectors.

(3) Transfer all detached components from original head that are not included with replacement head. Do not install coolant temperature sending unit until coolant is installed. This permits trapped air to escape from block and head.

CAUTION: *Do not apply sealing compound on head and block mating surfaces. Do not allow sealing compound to enter cylinder bore.*

(4) Apply an even coat of Perfect Seal sealing compound, or equivalent, to both sides of replacement head gasket and position gasket flush on block with word TOP facing upward.

(5) Install cylinder head. Tighten bolts in sequence with 85 foot-pounds (115 N•m) torque (fig. 1B-69).

(6) Connect battery negative cable.

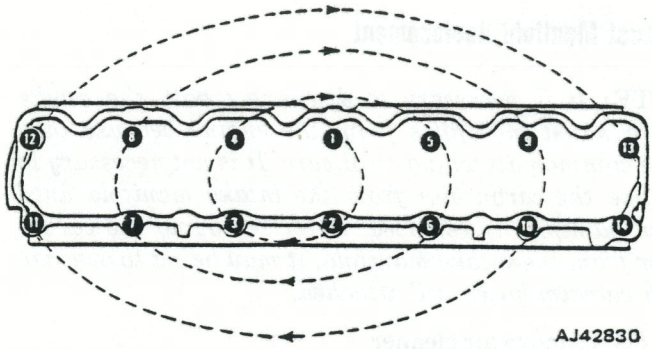


Fig. 1B-69 Cylinder Head Tightening Sequence

(7) Install ignition coil and bracket assembly.

(8) Install spark plugs and connect ignition wires.

(9) Attach air conditioning compressor mounting bracket to cylinder head, if removed.

(10) Install intake and exhaust manifolds. Refer to figure 1B-68 for correct tightening sequence. Refer to Intake Manifold Replacement for procedure.

(11) Install alternator bracket on head. Install alternator, belt and adjust tension. Refer to Chapter 1C—Cooling Systems for procedure.

(12) Install power steering bracket and pump. Adjust belt tension. Refer to Chapter 1C—Cooling Systems for procedure.

(13) Install air pump bracket on head. Install air pump and belt. Adjust belt tension. Refer to Chapter 1C—Cooling Systems for procedure.

(14) Install each push rod in its original location.

(15) Install rocker arms and bridge and pivot assemblies in original locations. Loosely install capscrews for each bridge and tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten screws with 19 foot-pounds (26 N•m) torque.

(16) Install cylinder head cover. Use silicone rubber (RTV) sealant.

(17) Connect coolant hoses to thermostat housing and fill cooling system to specified level. Refer to Cooling System Specifications, Chapter 1C. Install temperature sending unit.

NOTE: *The head gasket is constructed of aluminum-coated embossed steel and does not require the head bolts to be retightened after the engine has been operated.*

(18) Install fuel pipe and vacuum advance hose.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(19) Operate engine with radiator cap off. Inspect for leaks and continue operating engine until thermostat opens. Add coolant, if required. To vent air from system refer to Chapter 1C—Cooling Systems.

(20) Install air cleaner.

LUBRICATION SYSTEM

General

A gear-type positive displacement pump is mounted at the underside of the block opposite the No. 4 main bearing (fig. 1B-70). The pump brings oil up through the pickup screen and inlet tube from the sump at the rear of the oil pan. The oil is driven between the drive and idler gears and the pump body, then is forced through the outlet to the block. An oil gallery in the block routes the oil to the inlet side of the full flow oil filter. After passing through the filter element, the oil flows from the center outlet of the filter head through an oil gallery up to the main oil gallery, which extends the entire length of the block.

Smaller galleries extend downward from the main oil gallery to the upper insert of each main bearing. The crankshaft is drilled internally to route oil from the main bearing journals (except No. 4) to the connecting rod journals. Each connecting rod bearing cap has a small squirt hole. Oil passes through the squirt hole and is thrown off as the rod rotates. This oil throw-off lubricates the camshaft lobes, distributor drive gear, cylinder walls and piston pins.

The hydraulic valve tappets receive oil directly from the main oil gallery. Oil is also routed to the camshaft bearings through galleries. The front camshaft bearing journal directs oil through the camshaft sprocket to the timing chain. Rotation of the sprocket lubricates the crankshaft sprocket and chain. Oil drains back to the oil pan under the No. 1 main bearing cap.

The oil supply for the rocker arms and bridge and pivot assemblies is provided by the hollow push rods from the hydraulic valve tappets. Oil passes from each tappet through the hollow push rod to a hole in the corresponding rocker arm. Oil from the rocker arms lubricates the valve train components, then flows down through the push rod guide bores in the cylinder head past the valve tappet area, and returns to the oil pan.

Oil Filter

A full flow oil filter, mounted on the lower right side of the engine, is accessible through the hood opening. A bypass valve incorporated in the filter mounting head on the cylinder block provides a safety factor if the filter should become inoperative as a result of dirt or sludge accumulation (fig. 1B-71).

CAUTION: *Use the short, 4.25-inch (107.95 mm) filter on six-cylinder engine CJ vehicles. If the long, 5.44-inch (138.18 mm) filter is used, it may contact the engine support bracket or frame rail. This can puncture the filter and result in a loss of oil and possible engine damage.*

Tool J-22700 will facilitate removal of the oil filter. Before installation, apply a thin film of oil to the replacement filter gasket. Turn filter until gasket contacts the seat of the filter head. Tighten by hand only, following the instructions on the replacement filter. If the instructions are not printed on the filter, tighten the filter until the gasket contacts the seat and then tighten an additional 3/4 turn.

Operate engine at fast idle and check for leaks.

Oil Pump

The positive-displacement gear-type oil pump is driven by the distributor shaft, which is driven by a gear connected to the camshaft. Lubrication oil is pumped from the sump through an inlet tube and screen assembly that is pressed into the pump body (fig. 1B-71). The pump incorporates a non-adjustable pressure relief valve to regulate maximum pressure. The spring tension is calibrated for 75 psi (517 kPa) maximum pressure. In the relief position, the valve permits oil to bypass through a passage in the pump body to the inlet side of the pump.

Removal

NOTE: *Oil pump removal or replacement will not affect the distributor timing because the distributor drive gear remains in mesh with the camshaft gear.*

(1) Drain engine oil.

(2) Remove oil pan. Refer to Oil Pan Removal for procedure.

CAUTION: *Do not disturb position of oil inlet tube and screen assembly in pump body. If tube is moved within pump body, a replacement tube and screen assembly must be installed to assure an airtight seal.*

(3) Remove oil pump retaining screws, oil pump and gasket.

Disassembly and Inspection

(1) Remove cover retaining screws, cover and gasket from pump body.

(2) Measure gear end clearance.

- **Preferred Method:**

(a) Place strip of Plastigage across full width of each gear end (fig. 1B-72).

(b) Apply a bead of Loctite 515, or equivalent, around perimeter of pump cover and install. Tighten screws with 70 inch-pounds (8 N•m) torque.

(c) Remove pump cover and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope. Correct clearance by this method is 0.002 to 0.006 inch (0.002 inch preferred) [0.051 to 0.203 mm (0.051 mm preferred)].

- **Alternate Method:**

(a) Place straightedge across ends of gears and pump body.

(b) Select feeler gauge that fits snugly but freely between straightedge and pump body (fig. 1B-73).

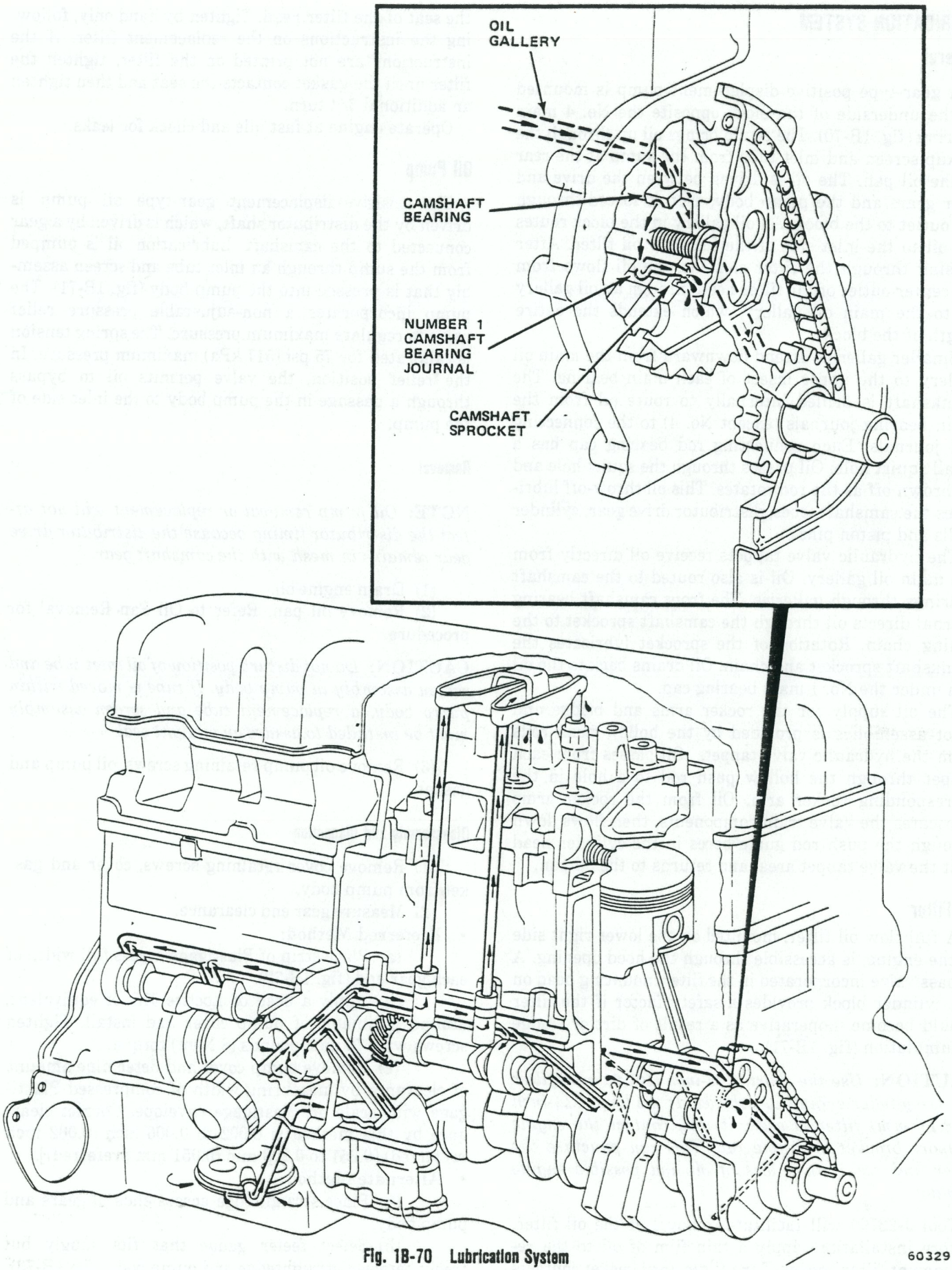


Fig. 1B-70 Lubrication System

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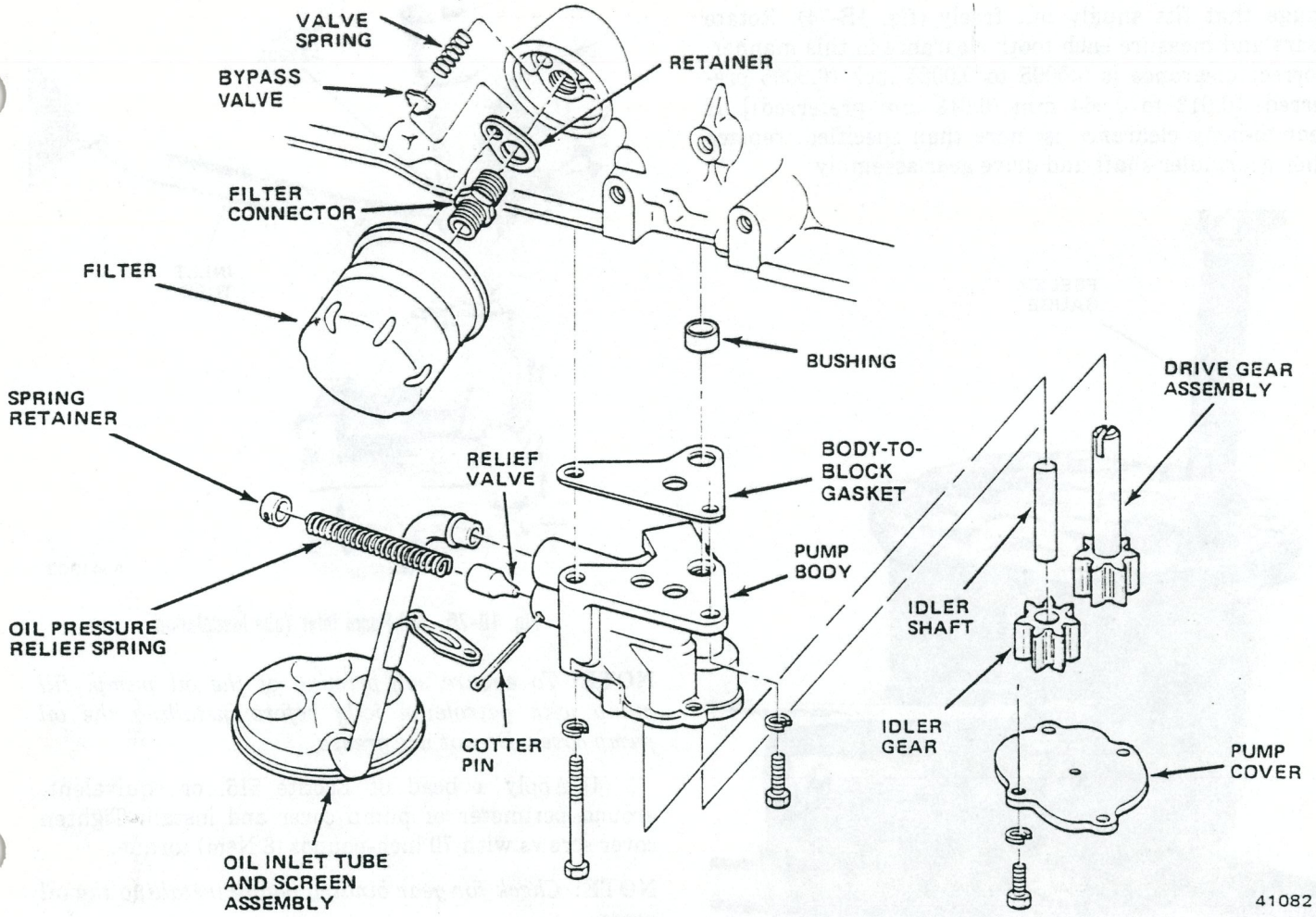

Fig. 1B-71 Oil Filter and Oil Pump Assembly

Correct clearance by this method is 0.004 to 0.008 inch (0.007 inch preferred) [0.102 to 0.203 mm (0.178 mm preferred)]. If gear end clearance is excessive, replace oil pump assembly.

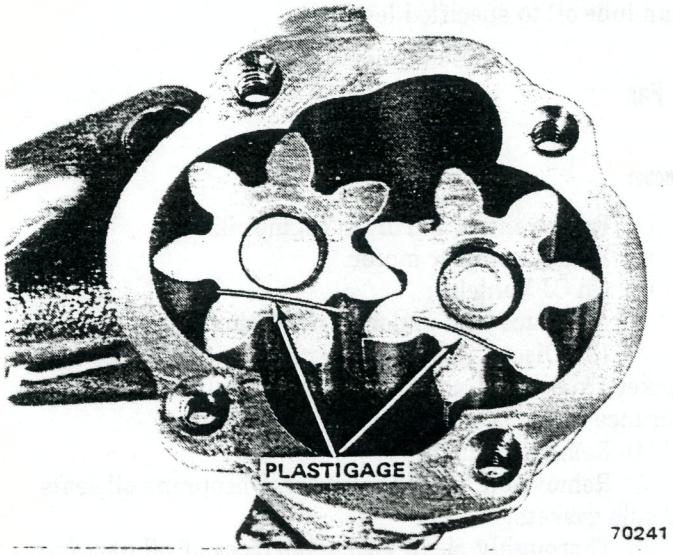

Fig. 1B-72 Oil Pump Gear End Clearance Measurement—Plastigage Method

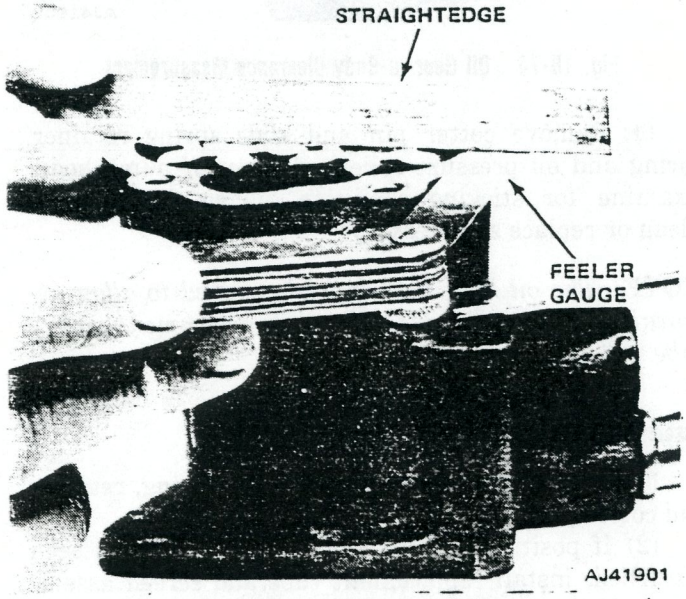

Fig. 1B-73 Oil Pump Gear End Clearance Measurement—Feeler Gauge Method

(3) Measure gear-to-body clearance by inserting feeler gauge between gear tooth and pump body inner wall directly opposite point of gear mesh. Select feeler

gauge that fits snugly but freely (fig. 1B-74). Rotate gears and measure each tooth clearance in this manner. Correct clearance is 0.0005 to 0.0025 inch (0.0005 preferred) [0.013 to 0.064 mm (0.013 mm preferred)]. If gear-to-body clearance is more than specified, replace idler gear, idler shaft and drive gear assembly.

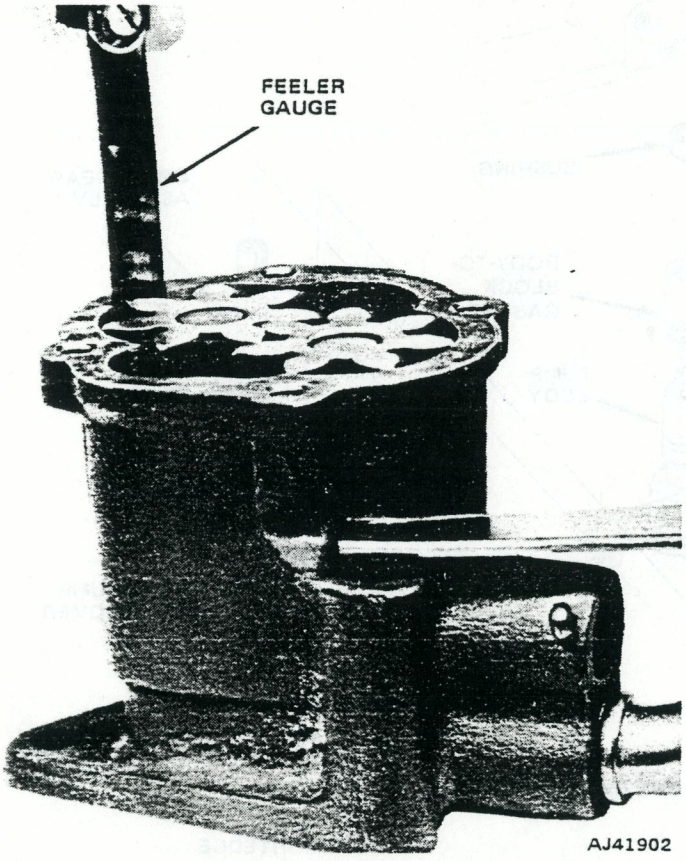

Fig. 1B-74 Oil Gear-to-Body Clearance Measurement

(4) Remove cotter pin and slide spring retainer, spring and oil pressure relief valve out of pump body. Examine for sticking condition during disassembly. Clean or replace as necessary.

NOTE: *The oil inlet tube must be moved to allow removal of the relief valve. Install a replacement pickup tube and screen assembly.*

Assembly and Installation

(1) Install oil pressure relief valve, spring, retainer and cotter pin.

(2) If position of inlet tube in pump body has been disturbed, install replacement tube and screen assembly. Apply light film of Permatex No. 2, or equivalent, around end of tube. Use Tool J-21882 to drive tube into body. Ensure support bracket is properly aligned (fig. 1B-75).

(3) Install idler shaft, idler gear and drive gear assembly.

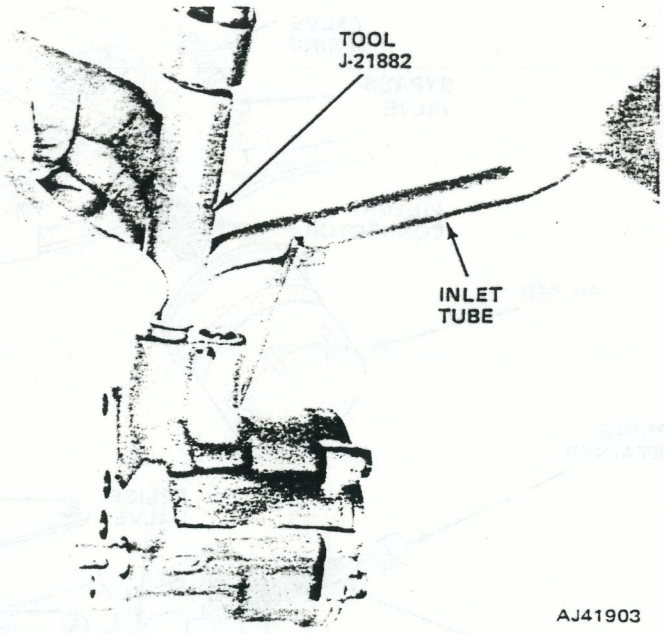

Fig. 1B-75 Oil Pump Inlet Tube Installation

NOTE: *To ensure self-priming of the oil pump, fill pump with petroleum jelly before installing the oil pump cover. Do not use grease.*

(4) Apply a bead of Loctite 515, or equivalent, around perimeter of pump cover and install. Tighten cover screws with 70 inch-pounds (8 N•m) torque.

NOTE: *Check for gear binding before installing the oil pump.*

(5) Install oil pump and replacement gasket. Tighten short screws with 10 foot-pounds (14 N•m) torque and long screws with 17 foot-pounds (23 N•m) torque.

(6) Install oil pan, using replacement gaskets and seals. Refer to Oil Pan Installation. Fill crankcase with clean lube oil to specified level.

Oil Pan

Removal

(1) Raise vehicle and drain engine oil.
(2) Remove starter motor.
(3) On CJ Vehicles:
(a) Place jack under transmission.
(b) Disconnect engine right support cushion bracket from block and raise engine to allow sufficient clearance for oil pan removal.
(4) Remove oil pan.
(5) Remove oil pan front and rear neoprene oil seals and side gaskets.
(6) Thoroughly clean gasket surfaces of oil pan and engine block. Remove all sludge and residue from oil pan sump.

Installation

(1) Install replacement oil pan front seal on timing case cover. Apply generous amount of Jeep Gasket-in-a-Tube (RTV silicone), or equivalent, to end tabs.

(2) Cement replacement oil pan side gaskets into position on engine block. Apply generous amount of Jeep Gasket-in-a-Tube (RTV silicone), or equivalent, to gasket ends.

(3) Coat inside curved surface of replacement oil pan rear seal with soap. Apply generous amount of Jeep Gasket-in-a-Tube (RTV silicone), or equivalent, to side gasket contacting surface of seal end tabs.

(4) Install seal in recess of rear main bearing cap, ensuring it is fully seated.

(5) Apply engine oil to oil pan contacting surface of front and rear oil pan seals.

(6) Install oil pan and tighten drain plug securely.

(7) Lower engine and connect right support cushion bracket to block. Remove jack.

(8) Install starter motor.

(9) Lower vehicle and fill crankcase with clean lube oil to specified level.

Oil Pressure Gauge

Refer to Chapter 1L—Power Plant Instrumentation for operation, diagnosis and replacement of oil pressure gauge.

CONNECTING ROD AND PISTON ASSEMBLIES

NOTE: *The following procedure is used to service connecting rod and piston assemblies with the engine installed in the vehicle.*

Removal

(1) Remove cylinder head.

(2) Position pistons near bottom of stroke and use ridge reamer to remove ridge from top end of cylinder walls.

(3) Drain engine oil.

(4) Remove oil pan and gaskets.

(5) Remove connecting rod bearing caps and inserts and retain in same order as removed.

NOTE: *Connecting rods and caps are stamped with the corresponding cylinder number.*

CAUTION: *Ensure that connecting rod bolts do not scratch the connecting rod journals or cylinder walls. Short pieces of rubber hose slipped over the bolts will provide protection during removal.*

(6) Remove connecting rod and piston assemblies through top of cylinder bores.

Installation

(1) Clean cylinder walls thoroughly. Apply light film of clean engine oil to walls with clean, lint-free cloth.

(2) Install piston rings on pistons. Refer to Piston Rings for procedure.

(3) Lubricate piston and rings with clean engine oil.

CAUTION: *Ensure that connecting rod screws do not scratch the connecting rod journals or cylinder walls. Short pieces of rubber hose slipped over the screws will provide protection during installation.*

(4) Use Piston Ring Compressor Tool J-5601 to install connecting rod and piston assemblies through top of cylinder bores (fig. 1B-76).

(5) Install connecting rod bearing caps and inserts in same order as removed.

NOTE: *Oil squirt holes in connecting rods must face camshaft.*

(6) Install oil pan using replacement gaskets and seals. Tighten drain plug.

(7) Install gasket and cylinder head.

(8) Fill crankcase with clean oil to specified dipstick level.

CONNECTING RODS

The connecting rods are malleable iron, balanced assemblies with bearing inserts at the crankshaft journal end. The piston pin is 2,000 pound (907.2 kg) press-fitted.

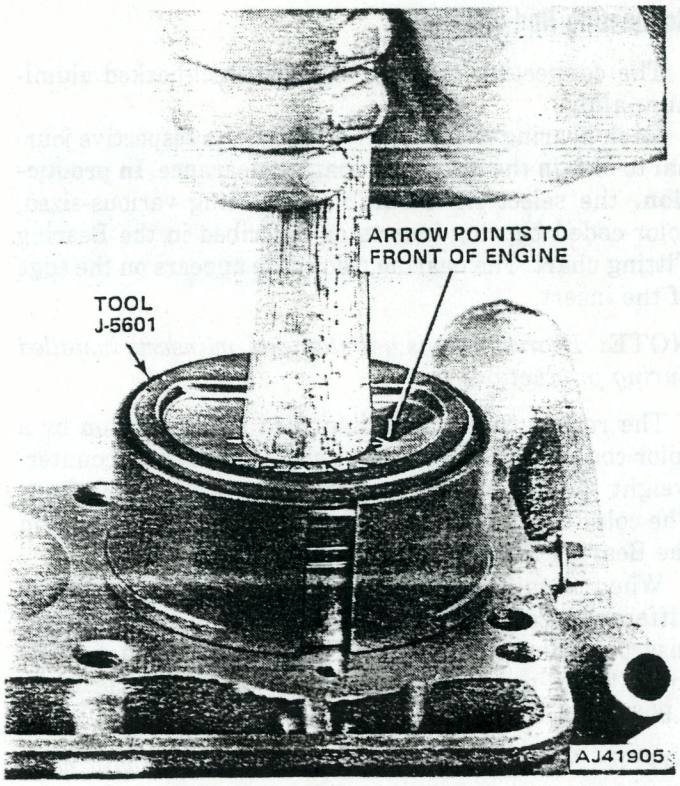

Fig. 1B-76 Piston Installation

Connecting Rod Bearing Fitting Chart

Crankshaft Connecting Rod Journal Color and Diameter in Inches (Journal Size)	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow —2.0955 to 2.0948 (53.2257-53.2079mm) (Standard)		
Orange —2.0948 to 2.0941 (53.2079-53.1901mm) (0.0007 Undersize)	Yellow —Standard Yellow —Standard	Yellow —Standard Black —0.001-inch (0.025mm) Undersize
Black —2.0941 to 2.0934 (53.1901-53.1723mm) (0.0014 Undersize)	Black —0.001-inch (0.025mm) Undersize	Black —0.001-inch (0.025mm) Undersize
Red —2.0855 to 2.0848 (53.9717-52.9539mm) (0.010 Undersize)	Red —0.010-inch (0.254mm) Undersize	Red —0.010-inch (0.254mm) Undersize

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A squirt hole in the crankshaft end of the connecting rod provides lubrication for the camshaft lobes, distributor drive gear, cylinder walls and piston pins. The squirt hole faces the camshaft when the connecting rod is installed.

Misaligned or bent connecting rods cause abnormal wear on pistons, piston rings, cylinder walls, connecting rod bearings and crankshaft connecting rod journals. If wear patterns or damage to any of these components indicate the probability of a misaligned connecting rod, check rod alignment. Replace misaligned or bent rods.

Side Clearance Measurement

Slide snug-fitting feeler gauge between connecting rod and crankshaft journal flange. Correct clearance is 0.010 to 0.019 inch (0.25 to 0.48 mm). Replace connecting rod if side clearance is not within the specification.

Connecting Rod Bearings

The connecting rod bearings are steel-backed aluminum-alloy.

Each bearing is selectively fitted to its respective journal to obtain the desired operating clearance. **In production,** the select fit is obtained by using various-sized, color-coded bearing inserts as described in the Bearing Fitting chart. The bearing color code appears on the edge of the insert.

NOTE: *Bearing size is not stamped on inserts installed during production.*

The rod journal size is identified **in production** by a color coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. The color codes used to indicate journal size are listed in the Bearing Fitting chart.

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.001-inch (0.025 mm) undersize insert to reduce clearance 0.0005 inch. (0.013 mm)

NOTE: *Never use a pair of bearing inserts with more than 0.001-inch (0.025 mm) difference in size.*

Example:

Bearing Insert Pairs

Insert	Correct	Incorrect
Upper	Standard	Standard
Lower	0.001-inch (0.025mm) undersize	0.002-inch (0.051mm) undersize

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Service replacement bearing inserts are available as pairs in the following sizes: standard, 0.001-, 0.002-, 0.010- and 0.012-inch undersize. The bearing size is stamped on the back of service replacement inserts.

NOTE: *The 0.002- and 0.012-inch undersize inserts are not used for production assembly.*

Removal

(1) Drain engine oil.
(2) Remove oil pan and gaskets.
(3) Rotate crankshaft as required to position two connecting rods at a time at bottom of stroke.
(4) Remove connecting rod bearing cap. Remove lower bearing insert.
(5) Remove upper bearing insert by rotating it out of connecting rod.

NOTE: *Do not interchange bearing caps. Each connecting rod and its matching cap is stamped with the cylinder number on a machined surface adjacent to the oil squirt hole, which faces the camshaft side of the engine block.*

Inspection

(1) Clean inserts.
(2) Inspect linings and backs of inserts for irregular wear pattern. Note any scraping, stress cracks or discoloration (fig. 1B-77). If bearing has "spun" in rod, replace bearing and connecting rod and inspect crankshaft journal for scoring.
(3) Inspect for material imbedded in linings that may indicate piston, timing sprocket, distributor gear or oil pump gear problems. Figures 1B-78 and 1B-79 depict common score patterns.

(4) Inspect fit of bearing locking tab in rod cap. If inspection indicates that insert may have been caught between rod and rod cap, replace upper and lower bearing inserts.

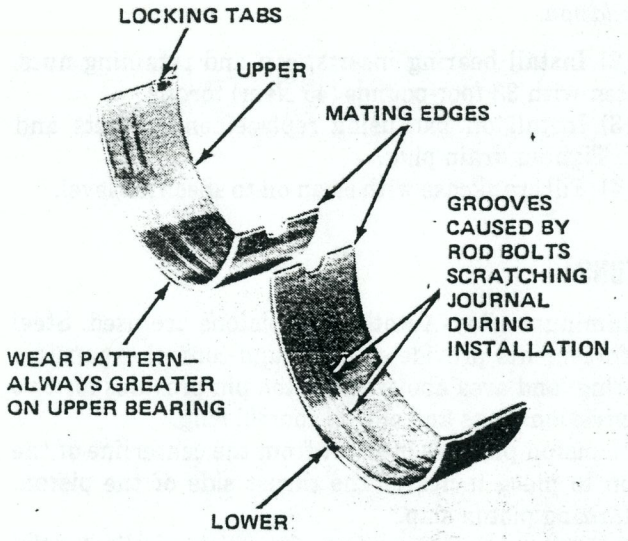

Fig. 1B-77 Connecting Rod Bearing Inspection

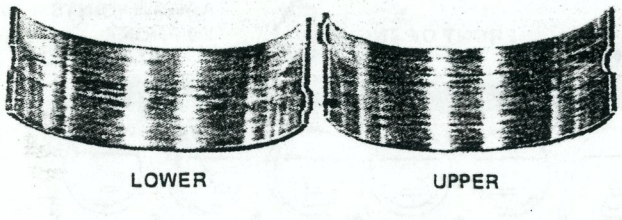

Fig. 1B-78 Scoring Caused by Insufficient Lubrication

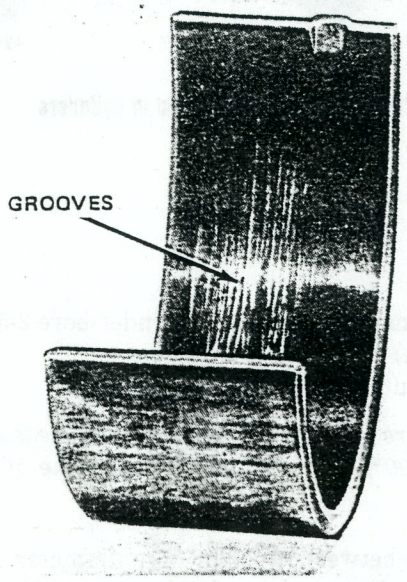

Fig. 1B-79 Scoring Caused by Imbedded Material

(5) Inspect insert in area of locking tab. Abnormal wear indicates bent tabs or improper installation of inserts (fig. 1B-80).

(6) Replace bearing inserts that are damaged or worn.

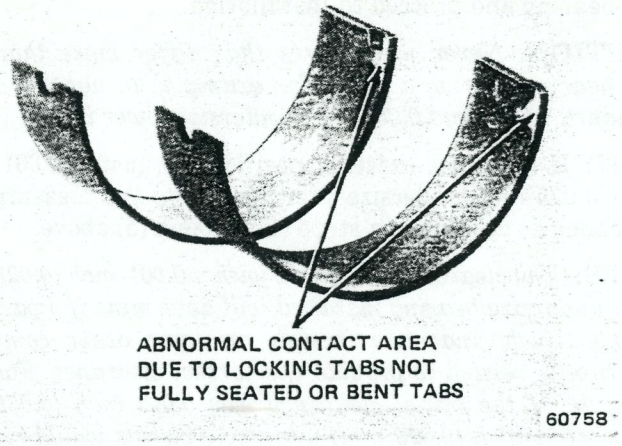

Fig. 1B-80 Locking Tab Inspection

Measuring Bearing Clearance with Plastigage

(1) Wipe journal clean.

(2) Lubricate upper insert and install in rod.

(3) Install lower insert in bearing cap. Lower insert must be dry. Place strip of Plastigage across full width of lower insert at center of bearing cap.

NOTE: *Plastigage must not crumble in use. If brittle, obtain a fresh stock.*

(4) Attach bearing cap to connecting rod and tighten nuts with 28 foot-pounds (38 N•m) torque.

NOTE: *Do not rotate crankshaft. Plastigage will shift, resulting in inaccurate clearance indication.*

(5) Remove bearing cap and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope (fig. 1B-81). Correct clearance is 0.001 to 0.0025 inch (0.025 to 0.064 mm).

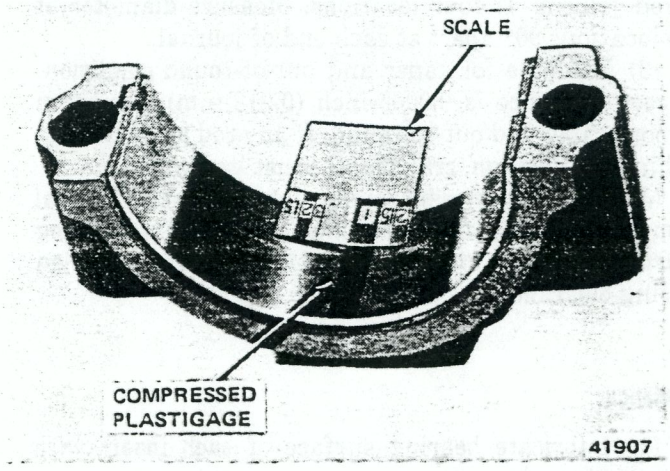

Fig. 1B-81 Rod Bearing Clearance Measurement with Plastigage

NOTE: *Plastigage should maintain the same size across the entire width of the insert. If size varies, it may indicate a tapered journal, bent connecting rod or foreign material trapped between the insert and rod.*

(6) If correct clearance is indicated, bearing fitting is not necessary. Remove Plastigage from crankshaft and bearing and proceed to Installation.

CAUTION: *Never use inserts that differ more than one bearing size as a pair. For example, do not use a standard upper and 0.002-inch undersize lower insert.*

(7) If clearance exceeds specification, install 0.001-inch (0.025 mm) undersize bearing inserts and measure clearance as described in steps (1) through (5) above.

NOTE: *The clearance indicated with a 0.001-inch (0.025 mm) undersize bearing installed will determine if a pair of 0.001-inch undersize inserts or some other combination is needed to provide the correct clearance. For example, if the initial clearance was 0.003 inch (0.076 mm), 0.001-inch (0.025 mm) undersize inserts would reduce clearance by 0.001 inch (0.025 mm). Oil clearance would be 0.002 inch (0.051 mm) and within specification. A 0.002-inch (0.051 mm) undersize insert and a 0.001-inch (0.025 mm) undersize insert would reduce this clearance an additional 0.0005 inch (0.013 mm). Oil clearance would then be 0.0015 inch (0.038 mm).*

(8) If oil clearance exceeds specification when pair of 0.002-inch (0.051 mm) undersize inserts are installed, measure connecting rod journal on crankshaft with micrometer. If journal size is correct (not less than 2.0934 inch or 53.172 mm), inside diameter of connecting rod is incorrect and rod must be replaced. If journal size is incorrect, replace crankshaft or grind journal to accept suitable undersize bearing.

Measuring Bearing Clearance with Micrometer

(1) Wipe connecting rod journal on crankshaft clean.

(2) Use micrometer to measure maximum diameter of rod journal at four locations. Measure diameter at two locations 90° apart at each end of journal.

(3) Examine for taper and out-of-round condition. Correct tolerance is 0.0005-inch (0.013 mm) maximum for both taper and out-of-round. If any rod journal is not within specification, crankshaft must be replaced.

(4) Compare measurement obtained with journal diameters listed in Connecting Rod Bearing Fitting Chart and select inserts required to obtain specified bearing clearance.

Installation

(1) Lubricate bearing surface of each insert with clean engine oil.

CAUTION: *Use care when rotating the crankshaft with bearing caps removed. Ensure the connecting rod bolts do not accidentally come in contact with the rod journals and scratch the surface. Bearing failure would result. Short pieces of rubber hose slipped over the connecting rod bolts will provide protection during installation.*

(2) Install bearing inserts, cap and retaining nuts. Tighten with 33 foot-pounds (45 N•m) torque.

(3) Install oil pan using replacement gaskets and seals. Tighten drain plug.

(4) Fill crankcase with clean oil to specified level.

PISTONS

Aluminum alloy Autothermic pistons are used. Steel reinforcements provide strength and control expansion. The ring land area above the piston pin provides for two compression rings and one oil control ring.

The piston pin boss is offset from the centerline of the piston to place it nearer the thrust side of the piston, minimizing piston slap.

An arrow on the top surface of the piston indicates the correct installation position in the bore. The arrow points toward the front of engine when installed correctly (fig. 1B-82).

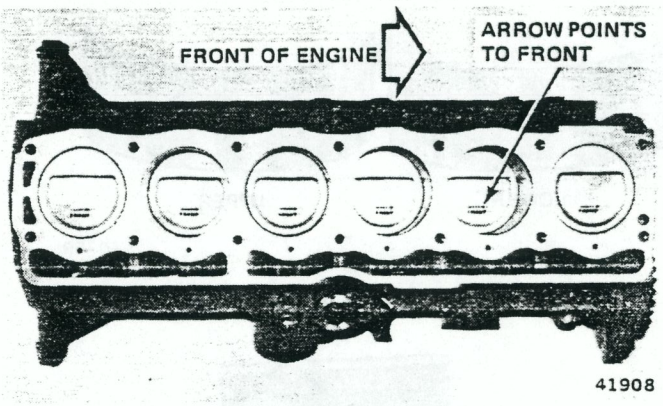

Fig. 1B-82 Pistons Correctly Positioned in Cylinders

Piston Fitting

Micrometer Method

(1) Measure inside diameter of cylinder bore 2-5/16 inches (58.725 mm) below top of cylinder.

(2) Measure outside diameter of piston.

NOTE: *Pistons are cam ground and must be measured at a right angle (90°) to piston pin at centerline of pin (fig. 1B-83).*

(3) Difference between cylinder bore diameter and piston diameter is piston-to-bore clearance.

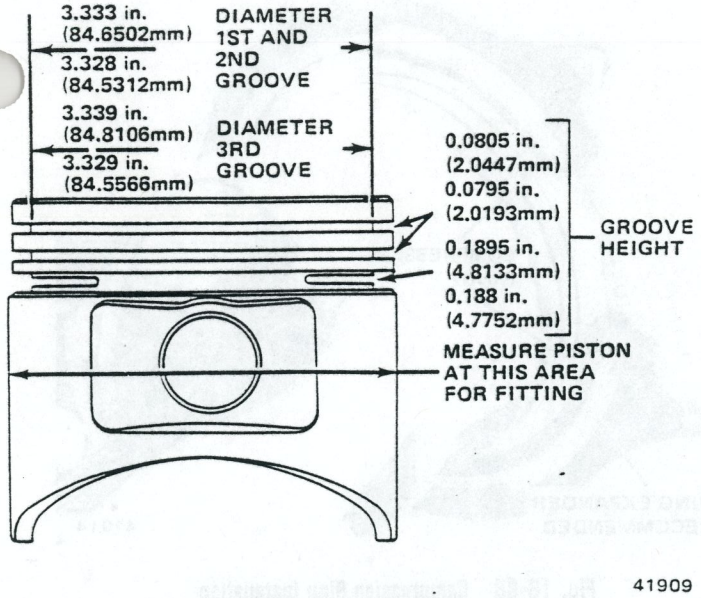

Fig. 1B-83 Piston Measurement

Feeler Gauge Method

(1) Remove rings from piston.

(2) Insert long 0.0005-inch (0.013 mm) feeler gauge into cylinder bore.

(3) Insert piston, top first, into bore alongside feeler gauge. With entire piston inserted in bore, piston should not bind against feeler gauge.

(4) Repeat steps (2) and (3) above with long 0.002-inch (0.051 mm) feeler gauge. Piston should bind.

If piston binds on 0.0005-inch (0.013 mm) gauge, piston is too large or bore is too small. If piston does not bind on 0.002-inch (0.051 mm) gauge, piston may be enlarged by knurling or shot-peening. Replace pistons that are 0.004 inch (0.102 mm) or more undersize.

Piston Rings

The two compression rings are made of cast iron. The oil control ring is a three-piece steel design.

Ring Fitting

(1) Clean carbon from all ring grooves. Oil drain openings in oil ring grooves and pin boss must be open. Do not remove metal from grooves or lands. This will change ring groove clearances and will damage ring-to-land seating.

(2) Measure ring side clearance with feeler gauge fitted snugly between ring land and ring. Rotate ring in groove. It must move freely at all points (fig. 1B-84). Refer to Specifications for correct ring side clearance.

(3) Place ring in bore and push down with inverted piston to position near lower end of ring travel. Measure ring gap (joint clearance) with feeler gauge fitting snugly in ring end gap (fig. 1B-85). Refer to Specifications for correct ring gap clearance.

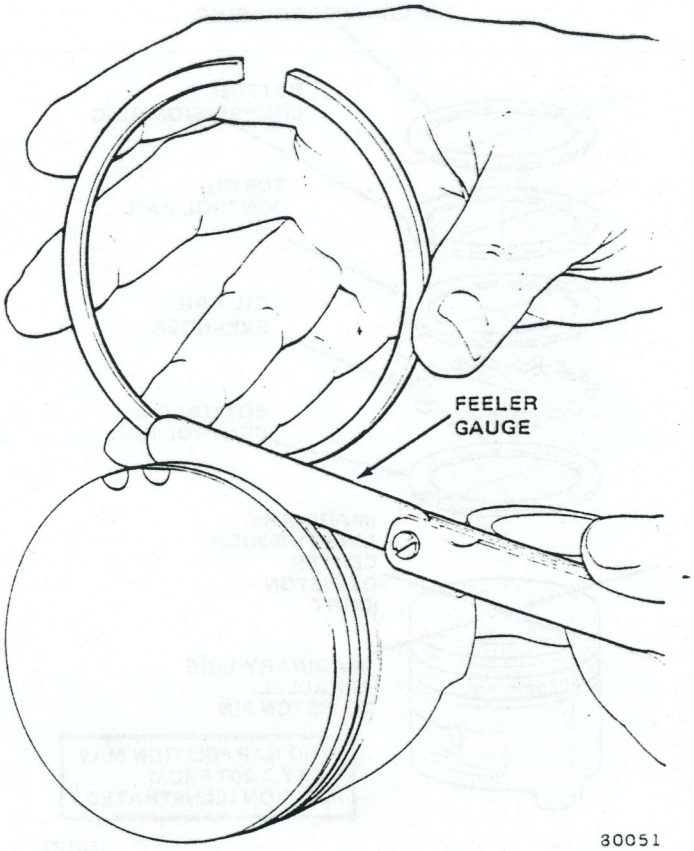

Fig. 1B-84 Ring Side Clearance

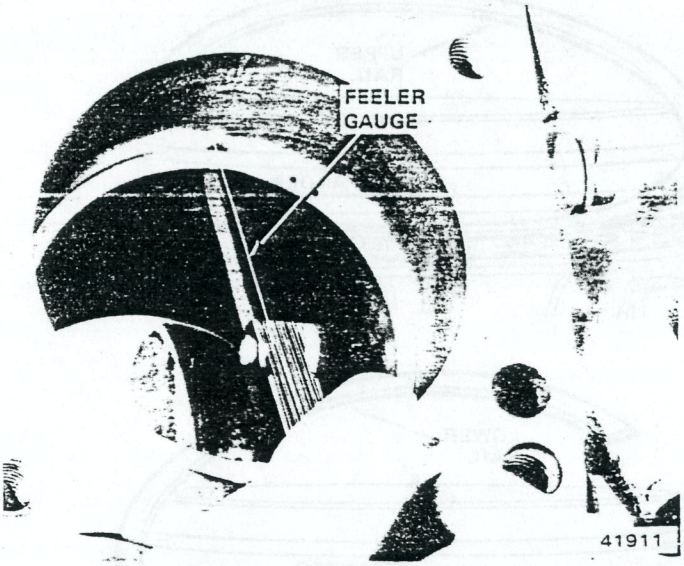

Fig. 1B-85 Ring Gap Clearance

Installation

Refer to figure 1B-86 for position of ring gaps when installing rings.

(1) Install oil control rings as indicated by instructions in package. It is not necessary to use tool to install upper and lower rails (fig. 1B-87). Insert expander ring first, then side rails.

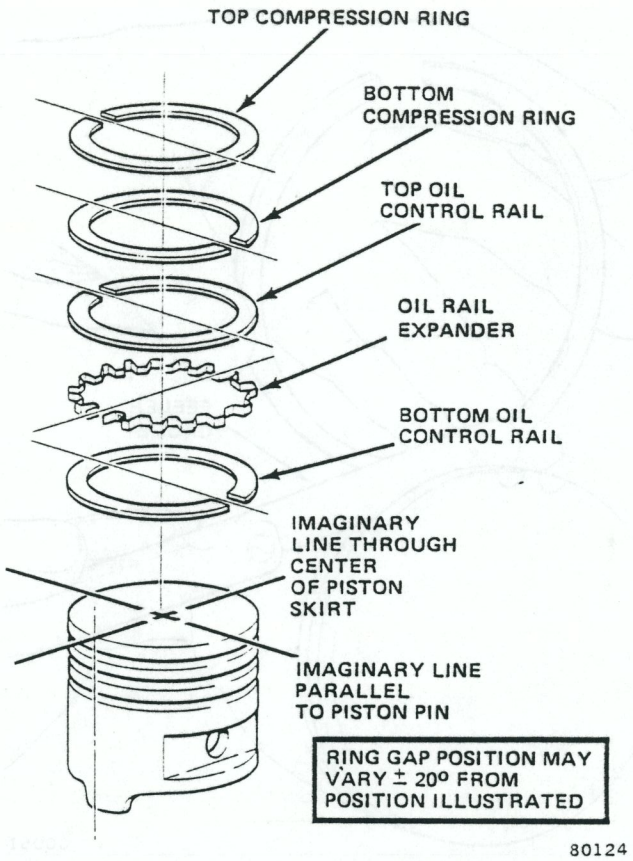

Fig. 1B-86 Piston Ring Gap Position

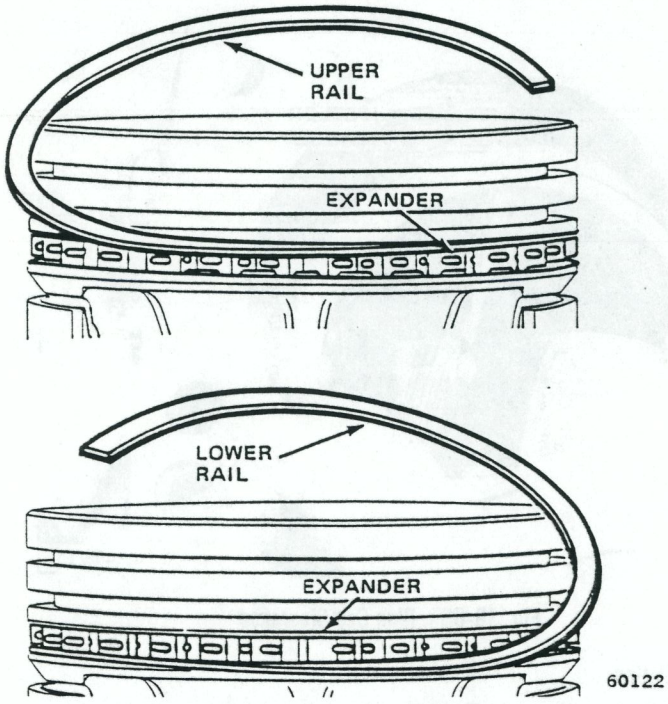

Fig. 1B-87 Oil Control Ring Rail Installation

(2) Install lower compression ring using ring installer to expand ring around piston (fig. 1B-88).

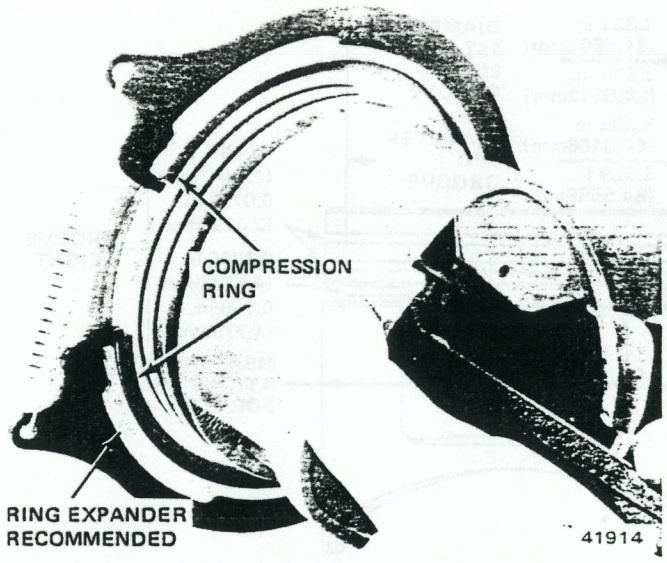

Fig. 1B-88 Compression Ring Installation

NOTE: *Ensure upper and lower compression rings are installed properly. Ideally, ring gaps should be located 180 degrees apart. Figure 1B-89 depicts typical ring markings that indicate the top side of each ring.*

(3) Install upper compression ring using ring installer to expand ring around piston (fig. 1B-88). Position ring gap 180° from lower compression ring.

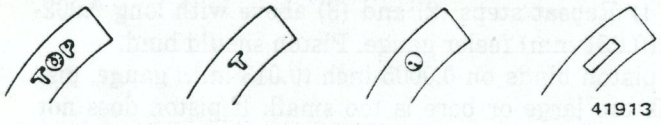

Fig. 1B-89 Typical Piston Ring Markings

Piston Pins

Piston pins are press fit into the connecting rod and require no locking device.

Removal

(1) Using Piston Pin Remover Tool J-21872 and arbor press, place piston on Remover Support Tool J-21872-1 (fig. 1B-90).

(2) Use Piloted Driver Tool J-21872-3 to press pin completely out of piston. Note position of pin through gauge window of remover support.

Pin Inspection

(1) Inspect pin and pin bore for nicks and burrs. Remove as necessary.

NOTE: *Never reuse piston pin after it has been installed in and removed from a connecting rod.*

(2) With pin removed from piston, clean and dry piston pin bore and replacement piston pin.

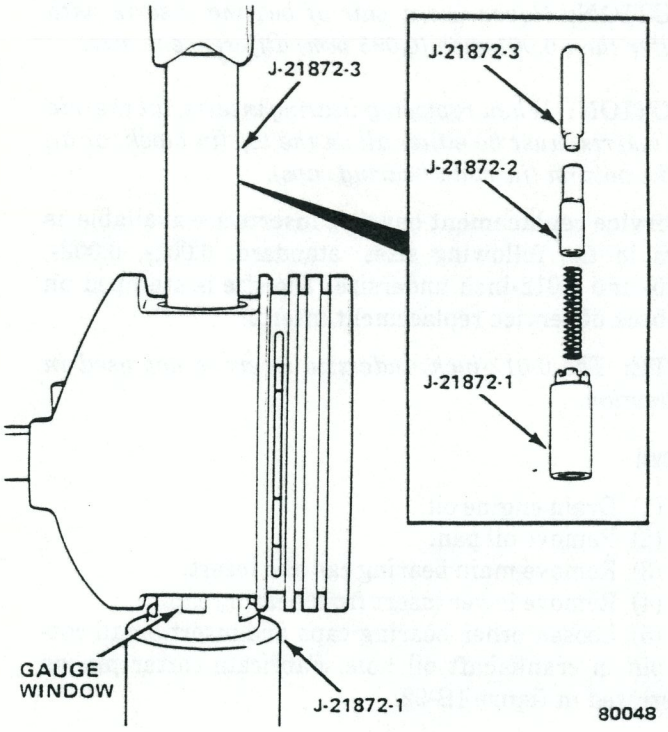

Fig. 1B-90 Piston Pin Removal or Installation

(3) Position piston so that pin bore is in vertical position. Insert pin in bore. At room temperature, the replacement pin should slide completely through pin bore without using force.

(4) Replace piston if pin jams in pin bore.

Installation

(1) Insert Pin Pilot Tool J-21872-2 through piston and connecting rod pin bores (fig. 1B-90).

(2) Position pin pilot, piston and connecting rod on Support Tool J-21872-1.

(3) Insert piston pin through upper piston pin bore and into connecting rod pin bore.

(4) Position Piloted Driver Tool J-21872-3 inside piston pin.

(5) Use arbor press to press piston pin through connecting rod and piston until pin pilot indexes with mark on support.

NOTE: *The piston pin requires a 2,000 pound (8.9 kN) press-fit. If little effort is required to install piston pin in connecting rod, or if rod moves along pin, replace connecting rod.*

(6) Remove piston and connecting rod assembly from press. Pin should be centered in rod, ±0.0312 inch (0.792 mm).

CRANKSHAFT

The nodular iron crankshaft is counterweighted and balanced. The crankshaft has four counterweights, even main bearing journals and six connecting rod journals. End thrust is controlled by the No. 3 main bearing.

An oil slinger is located at the rear main journal, inboard of the rear oil seal. The component parts and crankshaft are first individually balanced and then the complete assembly is balanced as a unit.

Service replacement vibration dampers, crankshafts, flywheels, drive plates, torque converters and clutch components are balanced individually and may be replaced as required without balancing the complete assembly.

Removal or Replacement

If the crankshaft is damaged to the extent that reconditioning is not feasible, it must be replaced. Removal and installation procedures are outlined under Cylinder Block.

Crankshaft End Play Measurement

The crankshaft end play is controlled by the No. 3 main bearing inserts, which are flanged for this purpose.

(1) Attach dial indicator to cylinder block adjacent to No. 3 main bearing (fig. 1B-91).

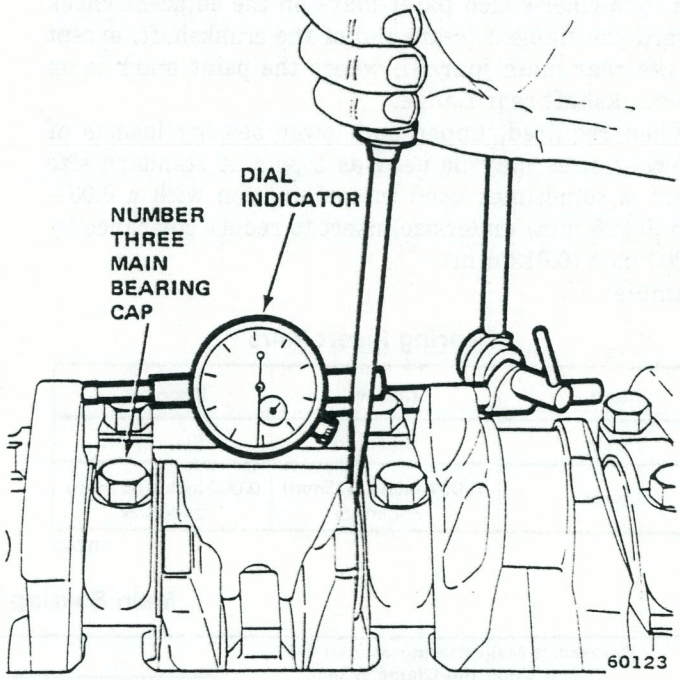

Fig. 1B-91 Measuring Crankshaft End Play

(2) Pry shaft forward with flat-bladed screwdriver and with dial indicator stem on face of crankshaft counterweight, set to zero.

(3) Pry shaft fore and aft and observe dial indicator. The end play is the difference between the high and low measurements. The correct crankshaft end play is 0.0015 to 0.0065 inch (0.0020 to 0.0025 desired) [0.038 to 0.165 mm (0.051 to 0.064 mm desired)].

(4) If end play is not within specifications, inspect crankshaft bearing thrust faces for wear. If wear is apparent, replace thrust bearing and measure end play. If end play is still not within specifications, replace crankshaft.

NOTE: *When replacing the thrust bearings, pry the crankshaft fore and aft to align the faces of the thrust bearings before the final tightening.*

Crankshaft Main Bearings

The main bearings are a steel-backed, micro-babbitt, precision type. The main bearing caps are numbered (front to rear) from 1 through 7, and an arrow indicates the forward position. The upper main bearing inserts are grooved while the lower inserts are smooth.

Each bearing is selectively fitted to its respective journal to obtain the desired operating clearance. **In production,** the select fit is obtained by using various sized color coded bearing inserts as described in the Main Bearing Fitting Chart. The bearing color code appears on the edge of the insert.

NOTE: *Bearing size is not stamped on inserts installed during production assembly.*

The main bearing journal size is identified **in production** by a color-coded paint mark on the adjacent cheek toward the flanged (rear) end of the crankshaft, except for the rear main journal, where the paint mark is on the crankshaft rear flange.

When required, upper and lower bearing inserts of different sizes may be used as a pair. A standard size insert is sometimes used in combination with a 0.001-inch (0.025 mm) undersize insert to reduce clearance by 0.0005 inch (0.013 mm).
Example:

Bearing Insert Pairs

Insert	Correct	Incorrect
Upper	Standard	Standard
Lower	0.001-inch (.025mm) undersize	0.002-inch (.051mm) undersize

70242

CAUTION: *Never use a pair of bearing inserts with greater than 0.001-inch (0.025 mm) difference in size.*

CAUTION: *When replacing bearing inserts, all the odd size inserts must be either all on the top (in block) or all on the bottom (in main bearing caps).*

Service replacement bearing inserts are available as pairs in the following sizes: standard, 0.001-, 0.002-, 0.010- and 0.012-inch undersize. The size is stamped on the back of service replacement inserts.

NOTE: *The 0.012-inch undersize insert is not used in production.*

Removal

(1) Drain engine oil.
(2) Remove oil pan.
(3) Remove main bearing cap and insert.
(4) Remove lower insert from bearing cap.
(5) Loosen other bearing caps and insert small cotter pin in crankshaft oil hole. Fabricate cotter pin as illustrated in figure 1B-92.

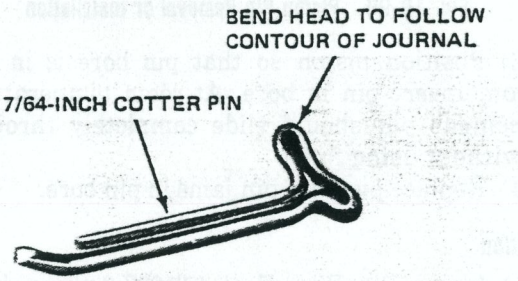

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Fig. 1B-92 Fabricated Upper Main Bearing Removal Tool

(6) With cotter pin in place, rotate crankshaft so that upper bearing insert rotates in direction of its locking tab.

Main Bearing Fitting Chart

Crankshaft Main Bearing Journal 1-6 Color Code and Diameter in Inches (Journal Size)	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow — 2.5001 to 2.4996 (Standard) (63.5025 to 63.4898 mm)	Yellow — Standard	Yellow — Standard
Orange — 2.4996 to 2.4991 (0.0005 Undersize) (63.4898 to 63.4771 mm)	Yellow — Standard	Black — 0.001-inch Undersize (0.025 mm)
Black — 2.4991 to 2.4986 (0.001 Undersize) (63.4771 to 63.4644 mm)	Black — 0.001-inch Undersize (0.025 mm)	Black — 0.001-inch Undersize (0.025 mm)
Green — 2.4986 to 2.4981 (0.0015 Undersize) (63.4644 to 63.4517 mm)	Black — 0.001-inch Undersize (0.025 mm)	Green — 0.002-inch Undersize (0.051 mm)
Red — 2.4901 to 2.4896 (0.010 Undersize) (63.2485 to 63.2358 mm)	Red — 0.010-inch Undersize (0.254 mm)	Red — 0.010-inch Undersize (0.254 mm)

60262A

Crankshaft Main Bearing Journal 7 Color Code and Diameter in Inches (Journal Size)	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow — 2.4995 to 2.4990 (Standard) (63.4873 to 63.4746 mm)	Yellow — Standard	Yellow — Standard
Orange — 2.4990 to 2.4985 (0.0005 Undersize) (63.4746 to 63.4619 mm)	Yellow — Standard	Black — 0.001-inch Undersize (0.025 mm)
Black — 2.4985 to 2.4980 (0.001 Undersize) (63.4619 to 63.4492 mm)	Black — 0.001-inch Undersize (0.025 mm)	Black — 0.001-inch Undersize (0.025 mm)
Green — 2.4980 to 2.4975 (0.0015 Undersize) (63.4492 to 63.4365 mm)	Black — 0.001-inch Undersize (0.025 mm)	Green — 0.002-inch Undersize (0.051 mm)
Red — 2.4895 to 2.4890 (0.010 Undersize) (63.2333 to 63.2206 mm)	Red — 0.010-inch Undersize (0.254 mm)	Red — 0.010-inch Undersize (0.254 mm)

60262B

NOTE: *Because there is no hole in the number 4 main journal, use a tongue depressor or similar soft-faced tool to remove the bearing (fig. 1B-93). After moving the insert approximately one inch (25.40 mm), the insert can be removed by applying pressure under the tab.*

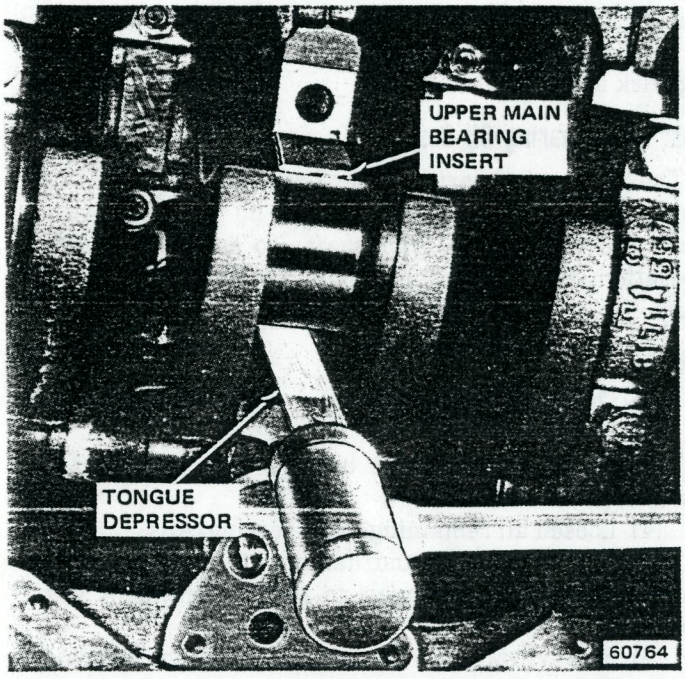

Fig. 1B-93 Removing No. 4 Main Bearing Insert

(7) In the same manner described above, remove remaining bearings one at a time for inspection.

Inspection

(1) Wipe lower insert clean and inspect for abnormal wear pattern and for metal or other foreign material imbedded in lining. Normal main bearing wear pattern is illustrated in figure 1B-94.

NOTE: *If the crankshaft journal is scored, remove the engine for crankshaft repair.*

(2) Inspect back of insert for fractures, scrapings or irregular wear pattern.

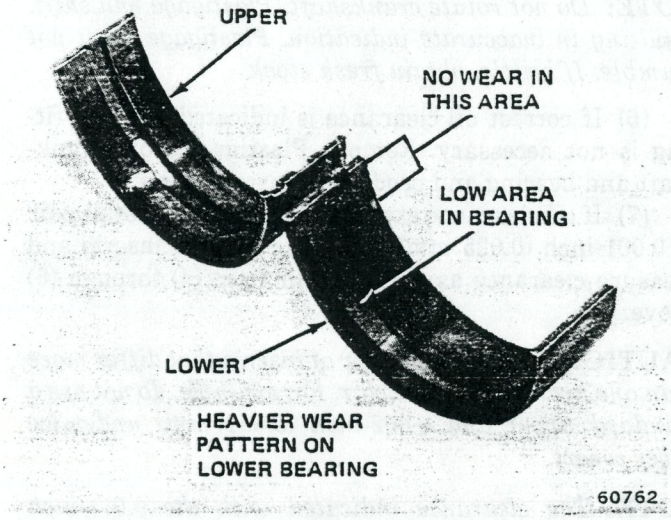

Fig. 1B-94 Normal Main Bearing Wear Pattern

(3) Inspect locking tabs for damage.

(4) Replace bearing inserts that are damaged or worn.

Measuring Bearing Clearance with Plastigage (Crankshaft Installed)

NOTE: *Measure clearance of one bearing at a time. All other bearings must remain tightened.*

(1) Remove main bearing cap and insert.

(2) Clean insert and exposed portion of crankshaft journal.

(3) Place strip of Plastigage across full width of bearing insert.

(4) Install bearing cap and tighten bolts with 80 foot-pounds (108 N•m) torque.

(5) Remove bearing cap and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope (fig. 1B-95). Correct clearance is 0.001 to 0.003 inch (0.025 to 0.076 mm) . The Plastigage should maintain same size across entire width of insert. If size varies, it may indicate tapered journal or foreign material trapped behind insert.

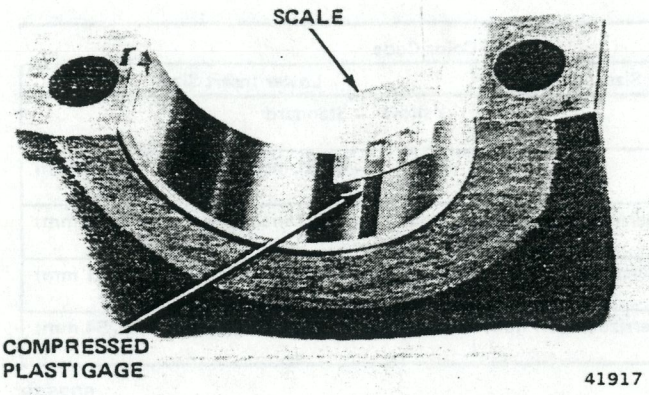

Fig. 1B-95 Measuring Main Bearing Clearance with Plastigage

NOTE: *Do not rotate crankshaft. Plastigage will shift, resulting in inaccurate indication. Plastigage must not crumble. If brittle, obtain fresh stock.*

(6) If correct oil clearance is indicated, bearing fitting is not necessary. Remove Plastigage from crankshaft and bearing and proceed to Installation.

(7) If oil clearance exceeds specification, install pair of 0.001-inch (0.025 mm) undersize bearing inserts and measure clearance as described in steps (4) through (6) above.

CAUTION: *Never use a pair of inserts that differ more than one bearing size as a pair. For example, do not use a standard upper and 0.002-inch (0.051 mm) undersize lower insert.*

NOTE: *The clearance indicated with the 0.001-inch (0.025 mm) undersize inserts installed will determine if the pair of 0.001-inch (0.025 mm) undersize inserts or some other combination will provide the correct clearance. For example, if the clearance was 0.0035 inch (0.089 mm) originally, a pair of 0.001-inch (0.025 mm) undersize inserts would reduce the clearance by 0.001 inch (0.025 mm). Oil clearance would be 0.0025 inch (0.064 mm) and within specification. A 0.002-inch (0.051 mm) undersize insert and a 0.001-inch (0.025 mm) undersize insert would reduce this clearance an additional 0.0005 inch (0.013 mm) and the oil clearance would be 0.002 inch (0.051 mm).*

(8) If oil clearance exceeds specification using 0.002-inch (0.051 mm) undersize bearing inserts, measure crankshaft journal with micrometer. If journal size is correct, crankshaft bore in cylinder block may be misaligned, which requires cylinder block replacement or machining to true bore. If journal size is less than 2.4981 inch (63.4517 mm), replace crankshaft or grind to accept suitable undersize inserts.

Measuring Main Bearing Journal with Micrometer (Crankshaft Removed)

(1) Clean main bearing journal.

(2) Measure maximum diameter of journal with micrometer. Measure at two locations 90 degrees apart at each end of journal.

(3) Compare measurements obtained with journal diameters listed in Main Bearing Fitting Chart and select inserts required to obtain specified bearing clearance.

Installation

(1) Lubricate bearing surface of each insert with clean engine oil.

(2) Loosen all main bearing caps and install main bearing upper insert(s).

(3) Install lower insert(s) and main bearing caps. Tighten bolts with 40 foot-pounds (54 N•m) torque. Then tighten with 60 foot-pounds (81 N•m) torque. Finally, tighten with 80 foot-pounds (108 N•m) torque. Rotate crankshaft after tightening each main bearing cap to ensure it rotates freely.

NOTE: *When installing a crankshaft kit (crankshaft plus bearing inserts), measure each bearing with Plastigage to determine if fit is correct.*

(4) Install oil pan, using replacement gaskets and seals. Tighten drain plug.

(5) Fill crankcase with clean lube oil to specified dipstick level.

Rear Main Bearing Oil Seal

The rear main bearing crankshaft oil seal consists of two pieces of neoprene with a single lip that effectively seals the rear of the crankshaft. To ensure leak-free operation, replace the upper and lower seal halves in pairs.

Removal

(1) Drain engine oil.

(2) Remove oil pan.

(3) Remove rear main bearing cap and discard lower seal.

(4) Loosen all remaining main bearing caps.

(5) Use brass drift and hammer to tap upper seal until seal protrudes enough to permit pulling it out completely.

(6) Remove oil pan front and rear neoprene oil seals and oil pan side gaskets.

(7) Clean gasket surfaces of oil pan and engine block. Remove all sludge and residue from oil pan sump.

(8) Clean main bearing cap thoroughly to remove all sealer.

Installation

(1) Wipe seal surface of crankshaft clean and lightly coat with engine oil.

(2) Coat lip of seal with engine oil.

(3) Install upper seal into engine block.

NOTE: *Lip of seal must face toward front of engine.*

(4) Coat both sides of lower seal end tabs with RTV silicone (Jeep Gasket-in-a-Tube, or equivalent). Use care to prevent applying sealer to lip of seal.

(5) Coat outer curved surface of lower seal with soap and lip of seal with engine oil.

(6) Install seal into cap recess and seat it firmly.

(7) Coat both chamfered edges of rear main bearing cap with RTV silicone (fig. 1B-96).

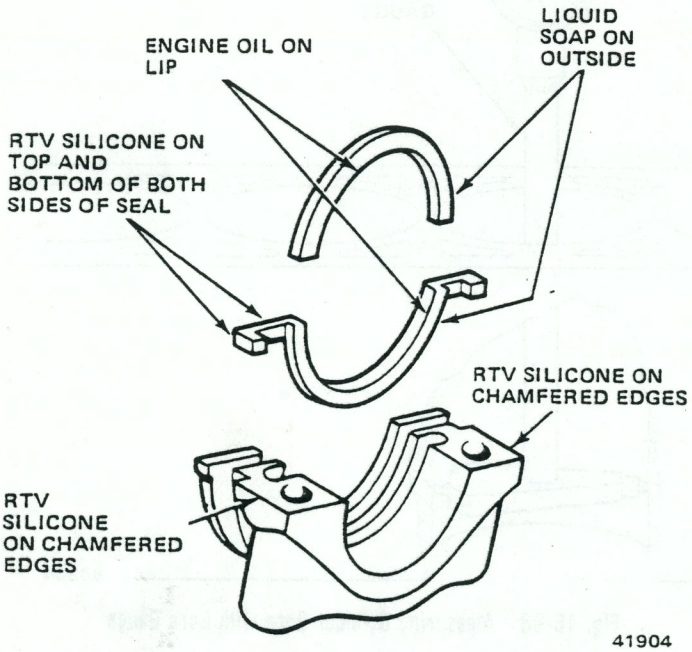

Fig. 1B-96 Rear Main Oil Seal and Cap Installation

CAUTION: *Do not apply sealer to cylinder block mating surfaces of rear main bearing cap because bearing clearance would be affected.*

(8) Install rear main bearing cap.

(9) Tighten all main bearing bolts in steps with 40, 60 and 80 foot-pounds (54, 81 and 108 N•m) torque.

(10) Install oil pan using replacement gaskets and seals. Tighten drain plug.

(11) Fill crankcase with clean oil to specified dipstick level.

Vibration Damper and Pulley

The vibration damper is balanced independently and then rebalanced as part of the complete crankshaft assembly.

Do not attempt to duplicate the vibration damper balance holes when installing a service replacement. The vibration damper is not repairable and is serviced only as a complete assembly.

Removal

(1) Remove drive belt(s).

(2) Remove three retaining bolts and separate vibration damper pulley from vibration damper.

(3) Remove vibration damper retaining screw and washer.

(4) Use Vibration Damper Remover Tool J-21791 to remove damper from crankshaft (fig. 1B-97).

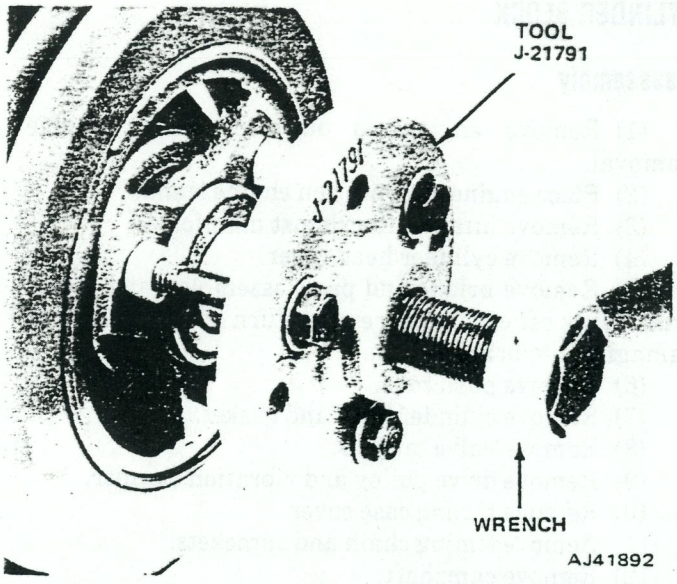

Fig. 1B-97 Vibration Damper Removal

Installation

(1) Align key way of vibration damper with crankshaft key and tap damper onto crankshaft.

(2) Install vibration damper retaining screw and washer. Tighten screw with 80 foot-pounds (108 N•m) torque.

(3) Install damper pulley with retaining bolts. Tighten bolts with 20 foot-pounds (27 N•m) torque.

(4) Install drive belt(s) and tighten to specified tension. Refer to Chapter 1C—Cooling System.

Flywheel/Drive Plate and Ring Gear Assembly

The ring gear can be replaced only for vehicles equipped with manual transmission. The ring gear is welded to and balanced as part of the converter drive plate on vehicles with automatic transmissions. The entire drive plate and ring gear assembly must be replaced on automatic transmission equipped vehicles.

Ring Gear Replacement (Manual Transmission)

(1) Position flywheel on arbor press with steel blocks equally spaced around perimeter and under ring gear.

(2) Press flywheel through ring gear.

NOTE: *Ring gear can also be removed by breaking with chisel.*

(3) Apply heat to expand inside diameter of replacement ring gear.

(4) Press flywheel into replacement ring gear.

NOTE: *On manual transmission equipped cars, the flywheel is balanced as an individual component and also as part of the crankshaft assembly. Do not attempt to duplicate original flywheel balance holes when installing a service replacement. Service flywheels are balanced during manufacture.*

CYLINDER BLOCK

Disassembly

(1) Remove engine as outlined within Engine Removal.
(2) Place engine assembly on engine stand.
(3) Remove intake and exhaust manifolds.
(4) Remove cylinder head cover.
(5) Remove bridge and pivot assemblies and rocker arms. Back off each capscrew one turn at a time to avoid damaging the bridge.
(6) Remove push rods.
(7) Remove cylinder head and gasket.
(8) Remove valve tappets.
(9) Remove drive pulley and vibration damper.
(10) Remove timing case cover.
(11) Remove timing chain and sprockets.
(12) Remove camshaft.
(13) Position pistons, one at a time, near bottom of stroke and use a ridge reamer to remove any ridge from top end of cylinder walls.
(14) Remove oil pan and gaskets.
(15) Remove oil pump.
(16) Remove connecting rod bearing caps and inserts and retain in same order as removed.

NOTE: *Connecting rods and caps are stamped with the number of the corresponding cylinder.*

(17) Remove piston and connecting rod assemblies through top of cylinder bores.

NOTE: *Ensure that the connecting rod bolts do not scratch the connecting rod journals or cylinder walls. Short pieces of rubber hose slipped over the rod bolts will prevent damage to the cylinder bores and crankshaft.*

(18) Remove main bearing caps and inserts.
(19) Remove crankshaft.

Cylinder Bore Reconditioning

Measuring Cylinder Bore

Use a bore gauge to measure the cylinder bore (fig. 1B-98). If a bore gauge is not available, use an inside micrometer.
(1) Measure cylinder bore crosswise to block near top of bore. Repeat measurement at bottom of bore.
(2) Determine taper by subtracting smaller dimension from larger dimension.
(3) Turn measuring device 120° and repeat step (1). Then turn another 120° and repeat measurements.
(4) Determine out-of-round by comparing difference between measurements taken 120° apart.
If the cylinder taper does not exceed 0.005 inch (0.013 mm) and the out-of-round does not exceed 0.003 inch (0.076 mm), the cylinder bore may be trued by honing. If

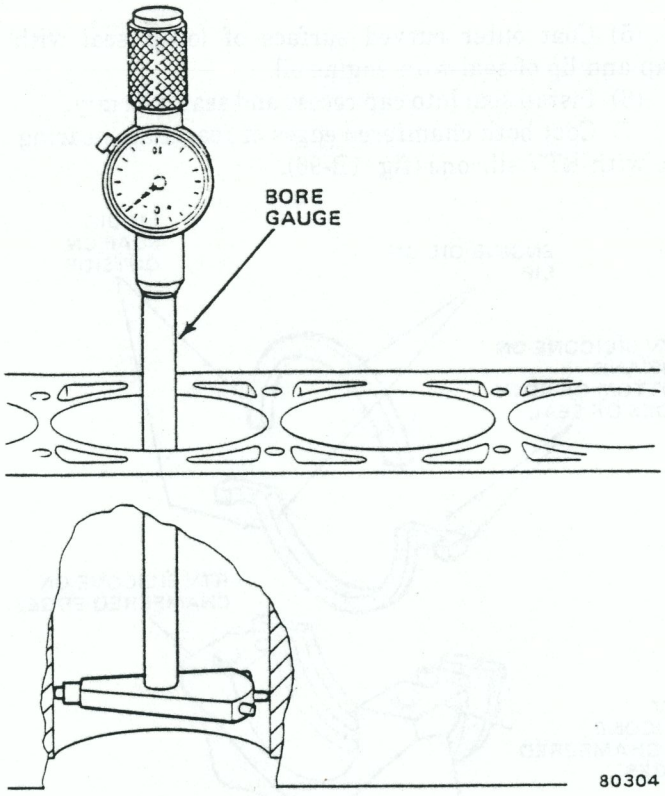

Fig. 1B-98 Measuring Cylinder Bore with Bore Gauge

the cylinder taper or out-of-round condition exceeds these limits, bore and then hone the cylinder for an oversize piston.

Resurfacing Cylinder Bore

CAUTION: *Do not use rigid type hones to remove cylinder wall glaze. A slight amount of taper always exists in cylinder walls after an engine has been in service for a period of time.*

(1) Use expanding hone to true cylinder bore and to remove glaze for faster ring seating. Move hone up and down at sufficient speed to produce uniform 60° angle crosshatch pattern on cylinder walls. Do not use more than ten strokes per cylinder (a stroke is one down and one up movement).

CAUTION: *Protect engine bearings and lubrication system from abrasives.*

(2) Scrub cylinder bores clean with solution of hot water and detergent.
(3) Immediately apply light engine oil to cylinder walls. Wipe with clean, lint-free cloth.

Assembly

(1) Install upper main bearing inserts in cylinder block.
(2) Install crankshaft.
(3) Install lower main bearing inserts and caps. Apply oil to insert before installing. Tighten bolts in steps

of 40, 60 and 80 foot-pounds torque (54, 81, 108 N•m). Plastigage all inserts if replacement inserts or crankshaft have been installed.

(4) Clean cylinder bores thorougly. Apply light film of clean engine oil to bores with clean, lint-free cloth.

(5) Install piston rings on piston. Refer to Piston Rings for procedure.

(6) Lubricate piston and rings with clean engine oil.

(7) Use Piston Ring Compressor Tool J-5601 to install connecting rod and piston assemblies through top of cylinder bores (fig. 1B-82).

NOTE: *Ensure that connecting rod bolts do not scratch the connecting rod journals or cylinder walls. Short lengths of rubber hose slipped over the connecting rod bolts will provide protection during installation.*

(8) Apply oil to inserts. Install connecting rod bearing inserts and caps in same location as removed. Tighten retaining nuts with 33 foot-pounds (45 N•m) torque.

NOTE: *Oil squirt holes in connecting rods must face camshaft.*

(9) Install oil pump with replacement pick-up tube and screen assembly.

(10) Install oil pan using replacement gaskets and seals. Tighten drain plug.

(11) Install camshaft and timing chain—sprocket assembly.

(12) Install timing case cover.

(13) Install vibration damper and drive pulley.

(14) Install valve tappets.

(15) Install gasket and cylinder head.

(16) Install push rods.

(17) Install rocker arms and bridge and pivot assemblies. Loosely install capscrews at each bridge, then tighten capscrews alternately, one turn at a time, to avoid damaging or breaking bridge.

(18) Install cylinder head cover, using silicone (RTV) rubber sealant.

(19) Install intake and exhaust manifolds.

(20) Remove engine from engine stand.

(21) Install engine assembly as outlined within Engine Installation.

SPECIFICATIONS

Six-Cylinder Engine Specifications

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Type	In Line, OHV, Six-Cylinder	
Bore	3.75	95.25
Stroke		
258	3.895	98.93
Displacement		
258	258 cubic inches	4.2 liters
Compression Ratio	8.0:1	
Compression Pressure		
258	120-150 psi	827-1034 kPa
Maximum Variation Between Cylinders	30 psi	206 kPa
Firing Order	1-5-3-6-2-4	
Taxable Horsepower	33.75 Bhp	25.2 kW
Fuel	unleaded	
Camshaft		
Fuel Pump Eccentric Diameter	1.615-1.625	41.02-41.28
Tappet Clearance	Zero Lash (Hydraulic tappets)	
End Play	Zero (engine operating)	
Bearing Clearance	0.001-0.003	0.025-0.076
Bearing Journal Diameter		
No. 1	2.029-2.030	51.54-51.56
No. 2	2.019-2.020	51.28-51.31
No. 3	2.009-2.010	51.03-51.05
No. 4	1.999-2.000	50.78-50.80
Base Circle Runout	0.001 (max)	0.03 (max)
Cam Lobe Lift	0.253	6.43
Intake Valve Timing		
Opens	9° BTDC	
Closes	73° ABDC	
Exhaust Valve Timing		
Opens	57° BBDC	
Closes	25° ATDC	
Valve Overlap	34°	
Intake Duration	262°	
Exhaust Duration	262°	

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Connecting Rods		
Total Weight (less bearings)		
258	695-703 grams	
Total Length (center-to-center)		
258	5.873-5.877	149.17-140.28
Connecting Rod Bore (less bearings)	2.2085-2.2080	56.09-56.08
Bearing Clearance	0.001-0.0025 (0.0015-0.002 preferred)	0.03-0.06 (0.044 preferred)
Side Clearance	.010-.019	.25-.48
Maximum Twist	0.001 per inch	0.025 per 25.4 mm
Maximum Bend	0.0005 per inch	0.0127 per 25.4 mm
Crankshaft		
End Play	0.0015-0.0065	0.038-0.165
Main Bearing Journal Diameter	2.4986-2.5001	63.464-63.502
Main Bearing Journal Width		
No. 1	1.086-1.098	27.58-27.89
No. 3	1.271-1.273	32.28-32.33
No. 2-4-5-6-7	1.182-1.188	30.02-30.18
Main Bearing Clearance		
No. 1 Main	.0005 to .0026 (.0015 preferred)	.013 to .066 (.04 preferred)
No. 2, 3, 4, 5, & 6 Mains	.0005 to .003 (.0017 preferred)	.013 to .076 (.045 preferred)
No. 7 Main	.0011 to .0035 (.0023 preferred)	.028 to .089 (.058 preferred)
Connecting Rod Journal Diameter	2.0934-2.0955	53.17-53.23
Connecting Rod Journal Width	1.070-1.076	27.18-27.33

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Six-Cylinder Engine Specifications (Continued)

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Maximum Out-of-Round (All Journals)	0.0005	0.013
Maximum Taper (All Journals)	0.0005	0.013
Cylinder Block		
Deck Height	9.487-9.493	240.97-241.12
Deck Clearance	0.0148 (below block)	0.376 (below block)
Cylinder Bore (standard)	3.7501-3.7533	95.253-95.334
Maximum Cylinder Taper	0.005	0.13
Maximum Cylinder (Out-of-Round)	0.003	0.08
Tappet Bore Diameter	0.9055-0.9065	23.0-23.025
Cylinder Block Flatness	0.001/1-0.002/6 (max)	0.03/25-0.05/152 0.20 (max)
Cylinder Head		
Combustion Chamber Volume	67.84-70.84cc	
Valve Arrangement	EI-IE-IE-EI-EI-IE	
Valve Guide ID (Integral)	0.3735-0.3745	9.487-9.512
Valve Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
Intake Valve Seat Angle	30°	
Exhaust Valve Seat Angle	44.5°	
Valve Seat Width	0.040-0.060	1.02-1.52
Valve Seat Runout	0.0025	0.064
Cylinder Head Flatness	0.001/1-0.002/6 0.008 (max)	0.03/25-0.05/152 0.20 (max)
Lubrication System		
Engine Oil Capacity	4 quarts (Add 1 quart with filter change)	3.8 liters (Add 0.9 liter with filter change)
Normal Operating Pressure	13psi at 600 rpm; 37-75 psi (max) at 1600+ rpm	89.6 kPa at 600 rpm; 255.1-517.1 kPa (max) at 1600+ rpm
Oil Pressure Relief	75 psi (max)	517.1 kPa (max)
Gear-to-Body Clearance Radial	.002-.004 (.002 preferred)	.051-.102 (.051 preferred)
Gear End Clearance, Plastigage	0.002-0.006 (0.002 preferred)	0.051-0.152 (0.0508 preferred)
Gear End Clearance, Feeler Gauge	0.004-0.008 (0.007 preferred)	0.1016-0.2032 (0.1778 preferred)
Pistons		
Weight (less pin)	498-502 grams	
Piston Pin Bore Centerline-to-Piston Top	1.651-1.655	41.94-42.04
Piston-to-Bore Clearance	0.0009-0.0017 (0.0012-0.0013 preferred)	0.023-0.043 (0.030-0.033 preferred)
Piston Ring Gap Clearance — Compression (both)	0.010-0.020	0.25-0.51
Piston Ring Gap Clearance — Oil Control Steel Rails	0.010-0.025	0.25-0.64
Piston Ring Side Clearance		
No. 1 Compression	0.0017-.0032 (0.0017 preferred)	0.043-0.081 (0.043 preferred)
No. 2 Compression	0.0017-.0032 (0.0017 preferred)	0.043-0.081 (0.043 preferred)
Oil Control	0.001-0.008 (0.003 preferred)	0.03-0.20 (0.08 preferred)
Piston Ring Groove Height		
Compression (both)	0.0795-0.0805	2.019-2.045
Oil Control	0.188-0.1895	4.78-4.80
Piston Ring Groove Diameter		
No. 1 and No. 2	3.324-3.329	84.43-84.56
Oil Control	3.329-3.339	84.56-84.81
Piston Pin Bore Diameter	0.9308-0.9313	23.642-23.655
Piston Pin Diameter	0.9304-0.9309	23.632-23.645
Piston Pin-to-Clearance	0.0003-0.0005 loose (0.0005 preferred)	0.008-0.013 loose (0.013 preferred)
Piston Pin-to-Connecting Rod	2000 lbf press-fit	8.900 kN press-fit
Rocker Arms, Push Rods and Tappets		
Rocker Arm Ratio	1.6:1	
Push Rod Length	9.640-9.660	244.856-245.364
Push Rod Diameter	.312-.315	7.92-8.00
Hydraulic Tappet Diameter	0.904-0.9045	22.96-22.97
Tappet-to-Bore Clearance	0.001-0.0025	0.03-0.05
Valves		
Valve Length (Tip-to-Gauge Dim. Line)	4.7895-4.8045	121.653-122.034
Valve Stem Diameter	0.3715-0.3725	9.436-9.462
Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
Intake Valve Head Diameter	1.782-1.792	45.26-45.52
Intake Valve Face Angle	29°	
Exhaust Valve Head Diameter	1.401-1.411	35.59-35.84
Exhaust Valve Face Angle	44°	
Maximum Allowable Removed for Tip Refinishing	0.010	0.25
Valve Springs, Exhaust		
Valve Open	80-88 at 1.625	
Valve Closed	210-226 at 1.188	
I.D.	1.000-1.020 in.	
Valve Springs, Intake		
Free Length	1.99 approx.	50.55 approx.
Spring Tension		
Valve Closed	64-72 lbf at 1.786	285-320 N at 45.24
Valve Open	188-202 lbf at 1.411	836-898 N at 35.84
Inside Diameter	0.948-0.968	24.08-24.59

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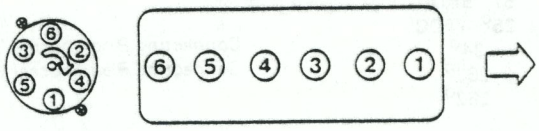
Six-Cylinder Engine Firing Order



Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Air Injection Tube-to-Manifold	20	15-20	27	20-27
Air Pump Adjusting Strap-to-Pump	20	15-22	27	20-30
Air Pump Brackets-to-Engine (A/C Compressor or Pedestals)	25	18-28	34	24-38
Air Pump-to-Bracket	20	15-22	27	20-30
Alternator Adjusting Bolt	18	15-20	24	20-27
Alternator Mounting Bracket-to-Engine	28	23-30	38	31-41
Alternator Pivot Bolt or Nut	28	20-35	38	27-47
Alternator Pivot Mounting Bolt-to-Head	33	30-35	45	41-47
Block Heater Nut	20 in-lbs	17-25 in-lbs	2	2-3
Camshaft Sprocket Screw	50	45-55	68	61-75
Carburetor Hold-Down Nuts	14	12-20	19	16-27
Clutch Housing Spacer to Block Screws	12	9-15	16	12-20
Clutch Housing-to-Block Screws (bottom)	43	37-47	58	50-64
Clutch Housing-to-Block Screws (top)	27	22-30	37	30-41
Coil Bracket-to-Cylinder Head	14	10-18	19	14-24
Connecting Rod Bolt Nuts	33	30-35	45	41-47
Crankshaft Pulley-to-Damper Bolts	20	15-25	27	20-34
Cylinder Head Capscrews	85	80-90	115	108-122
Cylinder Head Cover Nuts	28 in-lbs	25-31 in-lbs	32	2.8-3.5
Distributor Clamp Bracket Screw	13	10-18	18	14-24
EGR Valve	13	9-18	18	12-24
Exhaust Manifold Bolts	23	18-28	31	24-38
Exhaust Pipe-to-Manifold	20	15-25	27	20-34
Fan and Hub Assembly Bolts	18	12-25	24	16-34
Drive Plate-to-Converter Screw	22	20-25	30	27-34
EGR Tube Nuts	30	25-35	41	34-47
Flywheel or Drive Plate-to-Crankshaft	105	95-115	142	129-156
Front Support Bracket-to-Block Screw	35	25-40	47	34-54
Front Support Cushion-to-Bracket	33	27-38	45	36-52
Front Support Cushion-to-Bracket-to-Frame	37	30-45	50	41-61
Fuel Pump Screws	16	13-19	22	18-26
Idler Arm Bracket-to-Sill	50	35-60	68	47-81
Idler Pulley Bracket-to-Front Cover Nut	7	4-9	9	5-12
Idler Pulley Bearing Shaft-to-Bracket Nut	33	28-38	45	38-52
Intake Manifold Coolant Fittings	20	15-25	27	20-34
Intake Manifold Heater Screws	7	5-9	9	7-12
Intake Manifold Screws	23	18-28	31	24-38
Main Bearing Capscrews	80	75-85	108	101-115
Oil Filter Adapter	48	42-55	65	57-75
Oil Pan Drain Plug	30	25-35	41	34-47
Oil Pan Screws—1/4 inch—20	7	5-9	9	7-12
Oil Pan Screws—5/16 inch—18	11	9-13	15	12-18
Oil Pump Attaching Screws (Long)	17	12-20	23	16-27
Oil Pump Attaching Screws (Short)	10	8-13	14	11-18
Oil Pump Cover Screws	70 in-lbs	60-80 in-lbs	8	7-9
Oxygen Sensor	35	32-38	48	43-52
Power Steering Pump Adapter Screw	23	18-28	31	24-38
Power Steering Pump Bracket Screw	43	37-47	58	50-64
Power Steering Pump Mounting Screw	28	25-35	38	34-47
Power Steering Pump Pressure Line Nut	38	30-45	52	41-61
Power Steering Pump Pulley Nut	58	40-65	79	54-88
Rear Crossmember-to-Side Sill Nut	30	20-35	41	27-47
Rear Support Bracket-to-Transmission	33	27-38	45	37-52
Rear Support Cushion-to-Bracket	48	40-55	65	54-75
Rear Support Cushion-to-Crossmember	18	12-25	24	16-34
Rocker Arm Assembly-to-Cylinder Head	19	16-26	26	22-35
Spark Plug	11	7-15	15	10-20
Starter to Converter Housing Bolt	18	13-25	24	18-34
Thermostat Housing Screw	13	10-18	18	14-24
Timing Case Cover-to-Block Screws	5	4-8	7	5-11
Timing Case Cover-to-Block Studs	16	13-19	22	18-26
Vibration Damper Screw, Lubricated	80	70-90	108	95-122
Water Pump Screws	13	9-18	18	12-24

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.

Refer to the Standard Torque Specifications and Capscrew Markings Chart in Chapter A of this manual for any torque specifications not listed above.

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EIGHT-CYLINDER ENGINE

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GENERAL

The 304 (5 liters) and 360 (6 liters) CID engines are 90-degree V-8 cylinder designs incorporating overhead valves (figs. 1B-99 and 1B-100). The cylinders are numbered from front to rear: 1-3-5-7 on the left bank and 2-4-6-8 on the right bank. The cylinder firing order is 1-8-4-3-6-5-7-2.

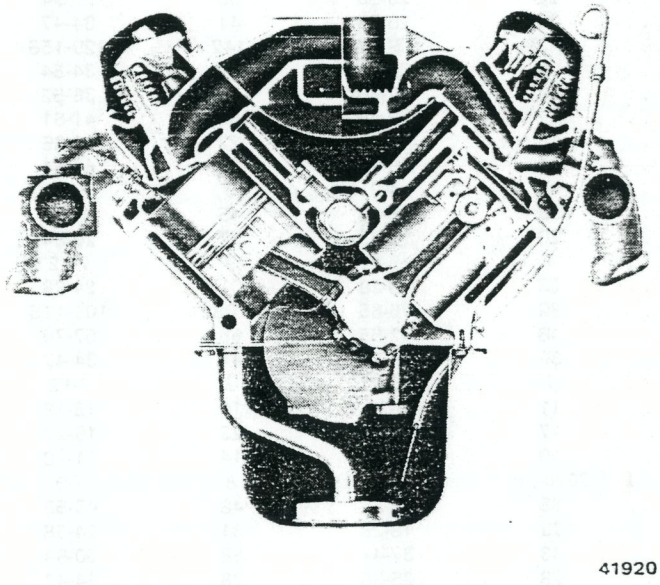

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Fig. 1B-99 Sectional View of Eight-Cylinder Engine Assembly

The crankshaft, supported by five two-piece main bearing inserts, rotates in a counterclockwise direction as viewed from the rear. The camshaft is supported by five one-piece, line-bored bearings.

Bridge and pivot assemblies control movement of intake and exhaust rocker arms and are paired by cylinder.

Because of the similarity of the two engines, service procedures have been consolidated and typical illustrations are used to represent both engines.

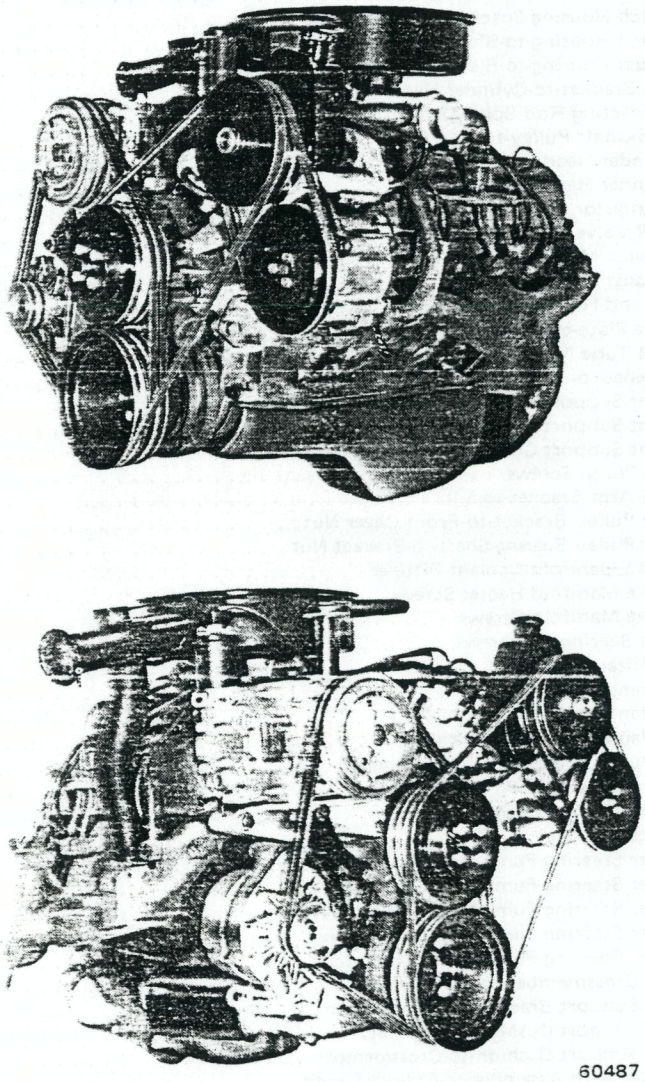

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Fig. 1B-100 Typical Eight-Cylinder Engine Assembly

Engine Identification

The cubic-inch displacement numbers are cast into both sides of the cylinder block. These numbers are located between the engine mounting bracket bosses.

Engine Type and Build Date Code

The engine Type and Build Date Code is located on a plate attached to the right bank cylinder head cover (fig. 1B-101).

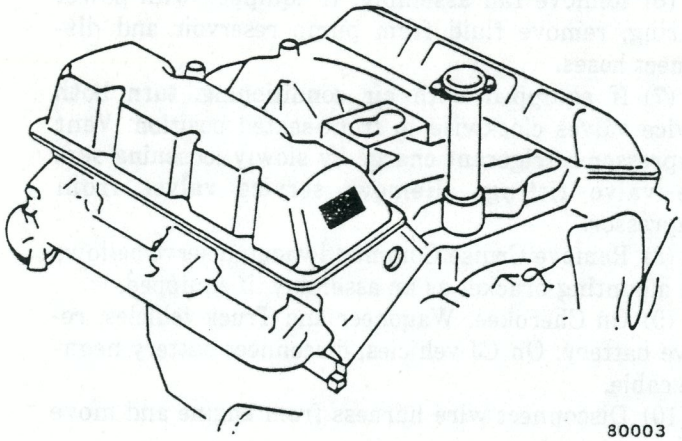

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Fig. 1B-101 Engine Type and Build Date Code Location

The code numbers identify the year, month, and day that the engine was built. The code letter identifies the cubic inch displacement, number of carburetor venturi and compression ratio.

The example code identifies a 304 CID (5 liters) engine with 2V carburetor and 8.4:1 compression ratio built on October 15, 1980.

Engine Type and Build Date Code

Letter Code	CID	Carburetor	Compression Ratio
H	304	2V	8.4:1
N	360	2V	8.25:1

1st Character (Year)	2nd and 3rd Characters (Month)	4th Character (Engine Type)	5th and 6th Characters (Day)
5-1981 4-1980	01 - 12	H or N	01 - 31

EXAMPLE: 4 10 H 15

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Oversize or Undersize Components

It is sometimes necessary to machine all cylinder bores 0.010-inch (0.254 mm) oversize, all crankshaft main bearing journals 0.010-inch (0.254 mm) undersize, all connecting rod journals 0.010-inch (0.254 mm) undersize, or all camshaft bearing bores 0.010-inch (0.254 mm) oversize. If so, the engine has a single or double letter code stamped adjacent to the Engine Type and Build Date Code on the plate attached to the right bank cylinder head cover. The code is explained in the Oversize or Undersize Components Code chart.

Oversize or Undersize Components Code

Single Letter B	cylinder bore 0.010-inch (0.254mm) oversize
Single Letter M	main bearings 0.010-inch (0.254mm) undersize
Single Letter F	connecting rod bearings 0.010-inch (0.254mm) undersize
Double Letters PM	main and connecting rod bearings 0.010-inch (0.254mm) undersize
Single Letter C	camshaft bearing bores 0.010-inch (0.254mm) oversize

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SHORT ENGINE ASSEMBLY (SHORT BLOCK)

A service replacement short engine assembly (short block) may be installed whenever the original engine block is damaged beyond feasible repair. A short engine assembly consists of an engine block, piston and connecting rod assemblies, crankshaft, camshaft, timing sprockets and chain. When installing a short engine assembly, always install a replacement oil pump pickup tube and screen assembly.

NOTE: *Short engine assemblies include a replacement engine type and build date code plate. Remove the original plate and attach the replacement plate to right cylinder head cover.*

Installation includes transfer of required component parts from the worn or damaged original engine. Follow the appropriate procedures for cleaning, inspection and tightening as outlined in this section.

ENGINE MOUNTING

Resilient rubber mounting cushions support the engine and transmission at three points. A cushion is located at each side on the centerline of the engine. The rear is supported by a cushion between the transmission extension housing and the rear support crossmember (fig. 1B-102).

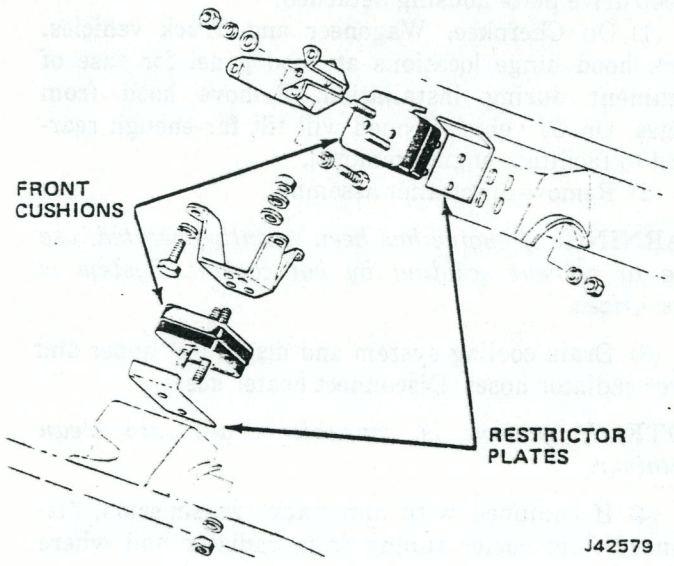

Fig. 1B-102 Typical Engine Mounting

Removal or replacement of any cushion may be accomplished by supporting the weight of the engine or transmission in the area of the cushion.

ENGINE HOLDING FIXTURE

If necessary to remove the front engine mounts to perform service such as oil pan removal, fabricate an engine holding fixture such as that illustrated in figure 1B-103.

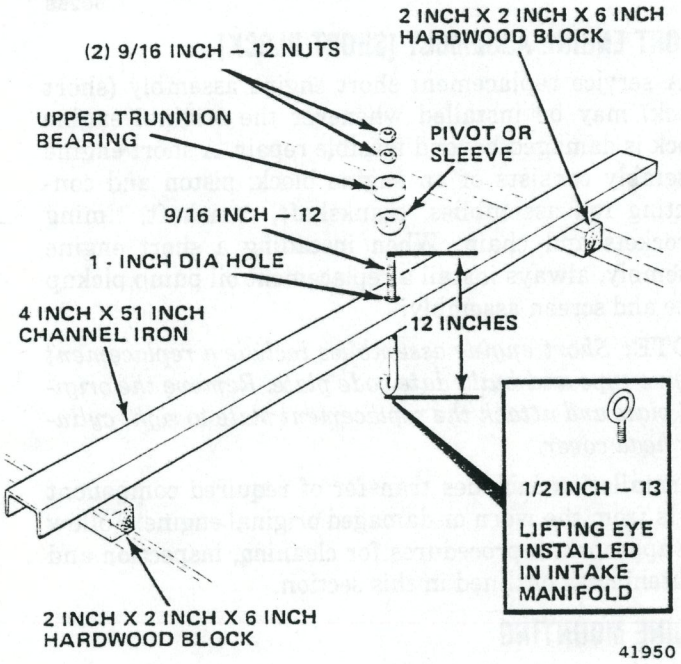

Fig. 1B-103 Engine Holding Fixture

ENGINE REMOVAL

The engine is removed with the transmission and flywheel/drive plate housing detached.

(1) On Cherokee, Wagoneer and Truck vehicles, mark hood hinge locations at hood panel for ease of alignment during installation. Remove hood from hinges. On CJ vehicles, hood will tilt far enough rearward to facilitate engine removal.

(2) Remove air cleaner assembly.

WARNING: *If engine has been recently operated, use care to prevent scalding by hot coolant. System is pressurized.*

(3) Drain cooling system and disconnect upper and lower radiator hoses. Disconnect heater hoses.

NOTE: *If coolant is reusable, drain into clean container.*

(4) If equipped with automatic transmission, disconnect fluid cooler tubing from radiator and where attached to engine.

NOTE: *If the vehicle is equipped with a radiator shroud, separate the shroud from the radiator to facilitate removal and installation of the radiator and fan assembly.*

(5) Remove radiator.

(6) Remove fan assembly. If equipped with power steering, remove fluid from pump reservoir and disconnect hoses.

(7) If equipped with air conditioning, turn both service valves clockwise to front-seated position. Vent compressor refrigerant charge by slowly loosening service valve fittings. Remove service valves from compressor.

(8) Remove Cruise Command vacuum servo bellows and mounting bracket as an assembly, if equipped.

(9) On Cherokee, Wagoneer and Truck vehicles, remove battery. On CJ vehicles, disconnect battery negative cable.

(10) Disconnect wire harness from engine and move aside.

(11) Disconnect following hoses, as applicable:

(a) Fuel supply and return hoses at chassis tubing.

(b) Vacuum hose at power brake unit.

(c) Vacuum hose for heater damper doors at intake manifold.

(12) If equipped with automatic transmission, disconnect transmission filler tube bracket from right cylinder head. Do not remove filler tube from transmission.

(13) Remove both engine front support cushion-to-frame retaining nuts.

(14) Support weight of engine with lifting device.

(15) On CJ vehicles, remove left front support cushion and bracket from cylinder block.

(16) On CJ vehicles equipped with manual transmission, remove transfer case shift lever boot, floormat (if equipped), and transmission access cover.

(17) On vehicles equipped with automatic transmission, remove upper screws securing drive plate housing to engine. If equipped with manual transmission, remove upper screws securing flywheel housing to engine.

(18) Disconnect exhaust pipe from exhaust manifolds and support bracket.

(19) Remove starter motor.

(20) Support transmission with floor jack.

(21) If equipped with automatic transmission:

(a) Remove drive plate housing inspection cover. Scribe mark to indicate assembled position of converter and drive plate and remove converter-to-drive plate bolts.

(b) Remove lower throttle valve and inner manual linkage support. Disconnect throttle valve rod at lower end of bellcrank.

(22) Remove remaining screws securing flywheel/drive plate housing to engine. If equipped with manual transmission, remove flywheel housing lower cover.

CAUTION: *If equipped with power brakes, avoid damaging the power unit while removing the engine.*

(23) Remove engine by lifting upward and forward.

ENGINE INSTALLATION

(1) Lower engine slowly into engine compartment and align with flywheel/drive plate housing. With manual transmissions, ensure clutch shaft is aligned properly with splines of clutch driven plate.

(2) Install flywheel/drive plate housing screws. Tighten screws with specified torque. Automatic transmission: 28 foot-pounds (38 N•m). Manual transmission: 27 foot-pounds (37 N•m).

(3) Remove floor jack used to support transmission.

(4) If equipped with automatic transmission, align scribe marks previously made on converter and drive plate, install converter-to-drive plate bolts and tighten with specified torque. Install throttle valve bellcrank and manual linkage support.

(5) Install inspection cover (automatic transmission) or flywheel housing lower cover (manual transmission).

(6) Install starter motor.

(7) On CJ vehicles, install left front support cushion and bracket on cylinder block. Tighten screws with 28 foot-pounds (38 N•m) torque.

(8) Lower engine onto supports. Remove lifting device.

(9) Install front support cushion retaining nuts. Tighten nuts with 33 foot-pounds (45 N•m) torque.

(10) Connect exhaust pipe to exhaust manifolds and support bracket.

(11) If equipped with automatic transmission, connect transmission filler tube bracket to right cylinder head.

(12) Install battery, if removed.

(13) Install Cruise Command vacuum servo bellows and mounting bracket, if removed.

(14) Connect all wires, tubing, linkage and hoses to engine.

(15) Connect receiver outlet to disconnect coupling. Connect condenser and evaporator lines to compressor.

CAUTION: *Both service valves must be open before the air conditioning system is operated.*

(16) Purge compressor of air.

(17) If equipped with power steering, connect hoses and fill pump reservoir to specified level.

(18) Install radiator fan assembly and tighten retaining screws with 18 foot-pounds (24 N•m) torque.

(19) Install radiator and connect upper and lower hoses. If equipped with automatic transmission, connect fluid cooler tubing.

(20) Fill cooling system to specified level.

(21) Install air cleaner assembly.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(22) Start engine. Inspect all connections for leaks. Stop engine.

(23) If removed, install and align hood assembly.

(24) If removed, install transmission access cover, floormat and transfer case shift lever boot.

VALVE TRAIN

General

All eight-cylinder engines have overhead valves operated by hydraulic tappets, push rods and rocker arms. A chain-driven camshaft is mounted in the cylinder block. The hydraulic valve tappets provide automatic valve lash adjustment.

Rocker Arm Assembly

The intake and exhaust rocker arms for each cylinder pivot on a bridge and pivot assembly that is secured to the cylinder head by two capscrews (fig. 1B-104). The bridge and pivot assembly maintains correct rocker arm-to-valve tip alignment. Each rocker arm is actuated

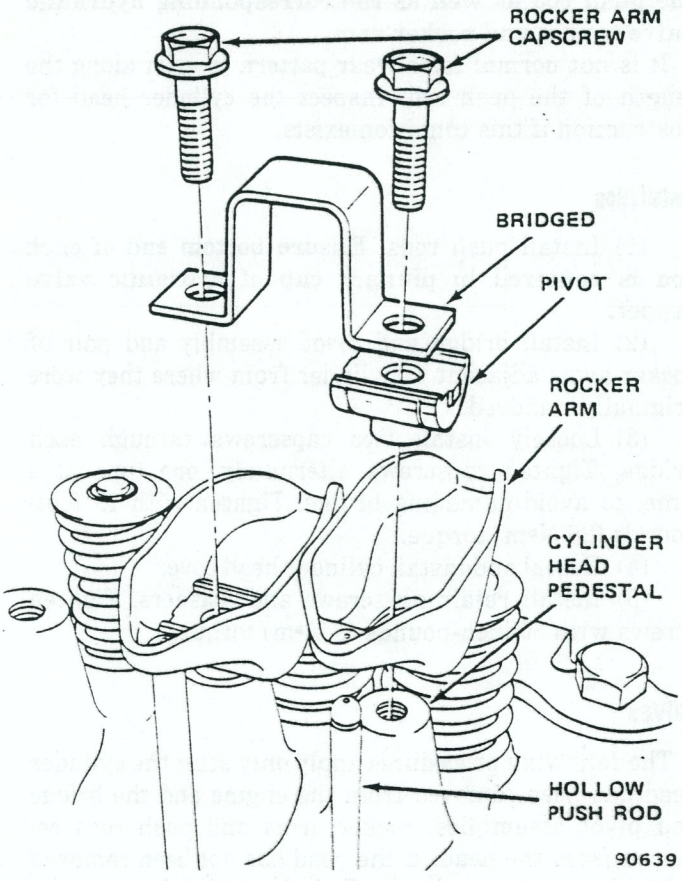

Fig. 1B-104 Rocker Arm Assembly

by a hollow steel push rod with a hardened steel ball at each end. The hollow push rods also route oil to the rocker arm assemblies.

Removal

(1) Remove cylinder head cover.
(2) Remove two capscrews at each bridge. Alternately loosen capscrews one turn at a time to avoid damaging bridge.
(3) Remove bridge and pivot assemblies and place on bench in same order as removed.
(4) Remove rocker arms and place on bench in same order as removed.
(5) Remove push rods and place on bench in same order as removed.

Cleaning and Inspection

Clean all parts with cleaning solvent. Use compressed air to clean out the oil passages in the rocker arms and push rods.

Inspect the pivot contact surface of each rocker arm and push rod. Replace parts that are scuffed, pitted or excessively worn. Inspect the valve stem contact surface of each rocker arm and replace if deeply pitted. Inspect each push rod end for scuffing or excessive wear. **If any push rod is excessively worn from lack of oil, replace the push rod as well as the corresponding hydraulic valve tappet and rocker arm.**

It is not normal for a wear pattern to exist along the length of the push rod. Inspect the cylinder head for obstruction if this condition exists.

Installation

(1) Install push rods. **Ensure bottom end of each rod is centered in plunger cap of hydraulic valve tappet.**
(2) Install bridge and pivot assembly and pair of rocker arms adjacent to cylinder from where they were originally removed.
(3) Loosely install two capscrews through each bridge. Tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten with 19 foot-pounds (26 N•m) torque.
(4) Reseal and install cylinder head cover.
(5) Install retaining screws and washers. Tighten screws with 50 inch-pounds (6 N•m) torque.

Valves

The following procedures apply only after the cylinder head has been removed from the engine and the bridge and pivot assemblies, rocker arms and push rods removed from the head. If the head has not been removed from the engine, refer to Cylinder Head for removal procedure.

Removal

(1) Compress each valve spring with C-clamp type spring compressor tool. Remove valve locks and retainers. Release compressor tool.
(2) Remove valve springs.
(3) Remove valve stem oil deflectors.
(4) Remove valves individually and place in rack in same order as installed in cylinder head.

Cleaning and Inspection

Remove all carbon deposits from the combustion chambers, valve ports, and valve stems and heads.

Remove all foreign material and gasket cement from the cylinder head gasket mating surface.

Inspect for cracks in the combustion chambers and valve ports and in the gasket surface area at each coolant passage.

Inspect for burned or cracked valve heads and scuffed valve stems. Replace any valve that is bent, warped or scuffed.

Valve Refacing

Use a valve refacing machine to reface intake and exhaust valves to specified angle. After refacing, at least 1/32-inch (0.787 mm) margin must remain. If not, replace the valve. Examples of correct and incorrect valve refacing are illustrated in figure 1B-105.

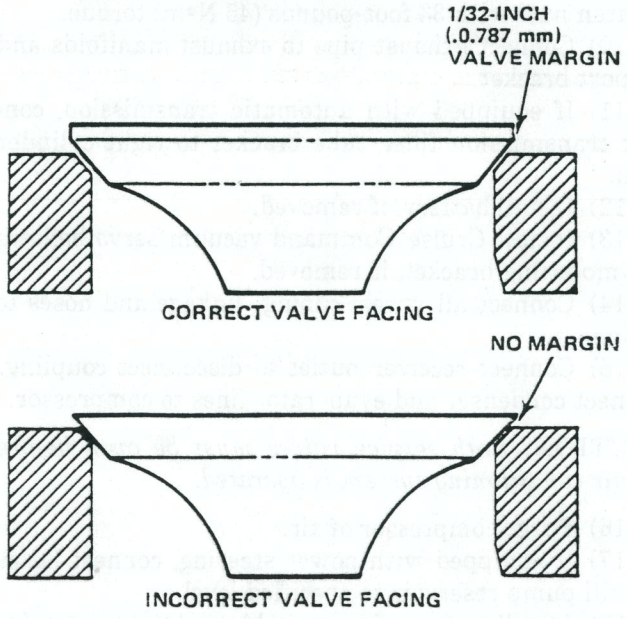

Fig. 1B-105 Valve Refacing

Resurface and rechamfer the valve stem tip when excessively worn. **Never remove more than 0.020 inch (0.508 mm).**

Valve Seat Refacing

Install a pilot of the correct size in the valve guide and reface the valve seat to the specified angle with a dressing stone in good condition. Remove only enough metal to provide a smooth finish. This is especially important on exhaust valve seats. The seat hardness varies in depth. Use tapered stones to obtain the specified seat widths when required. Maximum seat runout is 0.0025 inch (0.064 mm) (fig. 1B-106).

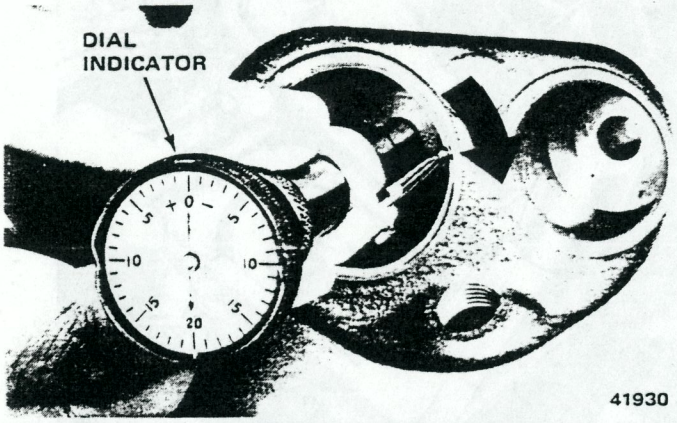

Fig. 1B-106 Valve Seat Runout Measurement

Valve Stem Oil Deflector Replacement

Nylon valve stem oil deflectors are installed on each valve stem to prevent lubrication oil from entering the combustion chamber through the valve guide bores. Replace oil deflectors whenever valve service is performed or if the deflectors have deteriorated.

Oil deflector replacement requires removal of valve springs. Refer to Valve Springs for procedure.

Valve Guides

The valve guides are an integral part of the cylinder head and are not replaceable. When the stem-to-guide clearance is excessive, ream the valve guide bores to the next larger valve stem size. Service valves are available with 0.003-inch (0.076 mm), 0.015-inch (0.127 mm) and 0.030-inch (0.760 mm) oversize stems.

Refer to the Valve Guide Reamer Size chart for listing of reamers.

Valve Guide Reamer Sizes

Reamer Tool Number	Size
J-6042-1	0.003-inch (0.076mm)
J-6042-5	0.015-inch (0.381mm)
J-6042-4	0.030-inch (0.762mm)

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NOTE: *Ream valve guide bores in steps. Start with the 0.003-inch (0.076 mm) reamer and progress to the size required.*

Valve Stem-to-Guide Clearance

Valve stem-to-guide clearance can be measured by either one of two methods:

Preferred Method

(1) Remove valve from head and clean valve guide bore with solvent and bristle brush.

(2) Insert telescoping gauge into valve guide bore approximately 3/8 inch (9.525 mm) from valve spring side of head (fig. 1B-107) with contacts crosswise to head. Measure telescoping gauge with micrometer.

(3) Repeat measurement with contacts lengthwise to cylinder head.

(4) Compare lengthwise and crosswise measurements to determine out-of-roundness. If measurements differ by more than 0.0025 inch (0.0635 mm), ream guide bore to accommodate oversize valve stem.

(5) Compare valve guide bore diameter measurement with diameter listed in Specifications. If measurement is larger by more than 0.003 inch (0.076 mm), ream guide bore to accommodate oversize valve stem.

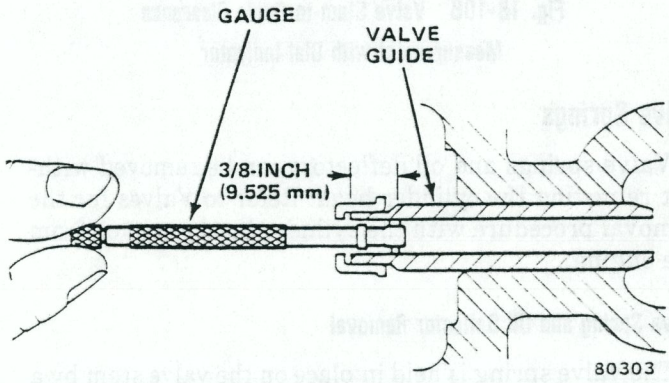

Fig. 1B-107 Measuring Valve Guide Bore with Telescoping Gauge

Alternate Method

Use a dial indicator to measure the lateral movement of the valve stem with the valve installed in its guide and barely off the valve seat (fig. 1B-108). Correct clearance is 0.001 to 0.003 inch (0.025 to 0.076 mm).

Installation

(1) Thoroughly clean valve stems and valve guide bores.

(2) Lightly lubricate stem and install valve in same valve guide bore from where it was originally removed.

(3) Install replacement valve stem oil deflector on valve stem.

(4) Position valve spring and retainer on cylinder head and compress valve spring with compressor tool. Install valve locks and release tool.

(5) Tap valve spring from side to side with light hammer to seat spring properly on cylinder head.

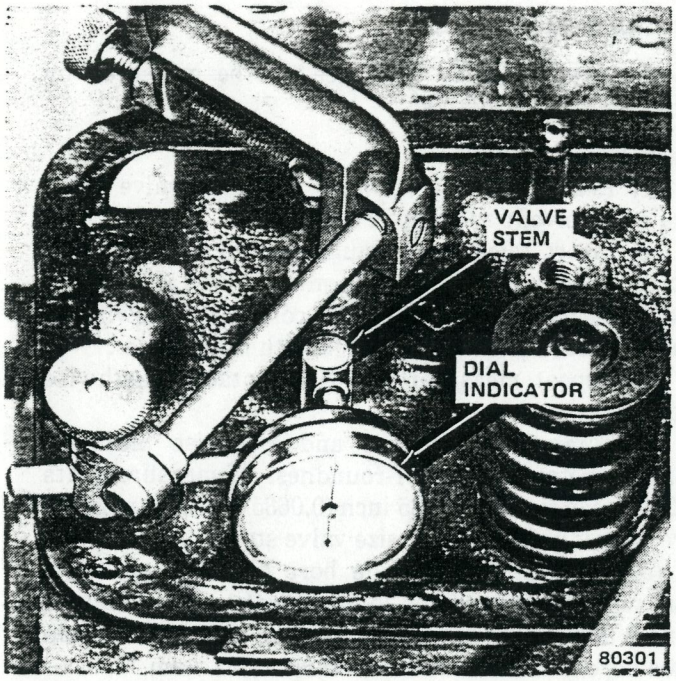

Fig. 1B-108 Valve Stem-to-Guide Clearance Measurement with Dial Indicator

Valve Springs

Valve springs and oil deflectors can be removed without removing the cylinder head. Refer to Valves for the removal procedure with the cylinder head removed from the engine.

Valve Spring and Oil Deflector Removal

The valve spring is held in place on the valve stem by a retainer and a set of valve locks. The locks can be removed only by compressing the valve spring.

(1) Remove cylinder head cover.

(2) Remove bridge and pivot assemblies and rocker arms from valves requiring valve spring or oil deflector removal. Remove two capscrews at each bridge. Alternately loosen capscrews, one turn at a time, to avoid damaging bridge.

(3) Remove push rods.

NOTE: *Retain rocker arms, bridge and pivot assemblies and push rods in the same order as removed.*

(4) Remove spark plug from cylinder that requires valve spring or oil deflector removal.

(5) Install 14 mm (thread size) air adapter in spark plug hole.

NOTE: *An adapter can be constructed by welding an air hose connection to the body of a spark plug having the porcelain removed.*

(6) Connect air hose to adapter and maintain at least 90 psi (620 kPa) in cylinder to hold valves against their seats.

(7) Use Valve Spring Remover and Installer Tools J-22534-1, J-22534-4, and J-22534-5 to compress valve spring. Remove valve locks (fig. 1B-109).

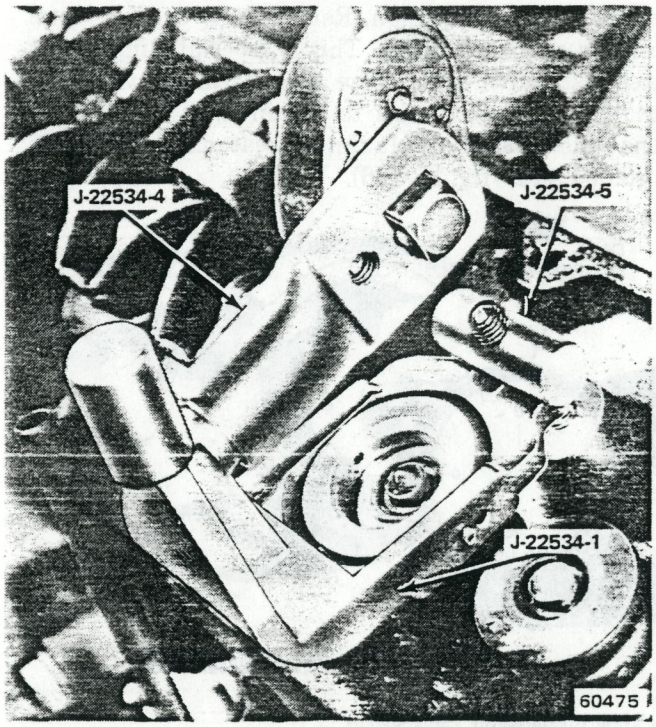

Fig. 1B-109 Valve Spring Removal

(8) Remove valve spring and retainer from cylinder head.

(9) Remove oil deflector.

Valve Spring Tension Test

Use Valve Spring Tester J-8056, or equivalent, to test each valve spring for the specified tension value (fig. 1B-110). Replace springs that are not within specification. Replace springs that bind because of warpage.

Installation

(1) Use 7/16-inch (11 mm) deep socket and hammer to gently tap oil deflector onto valve stem.

NOTE: *A close-coil valve spring is used with all valves. The close-coil end must face the cylinder head when installed.*

(2) Install valve spring and retainer.

(3) Compress valve spring with Valve Spring Remover and Installer Tools J-22534-1, J-22534-4 and J-22534-5. Insert valve locks. Release spring compression and remove tool.

(4) Tap valve spring from side to side with light hammer to ensure spring is seated properly on cylinder head.

(5) Disconnect air hose, remove air adapter from spark plug hole and install spark plug.

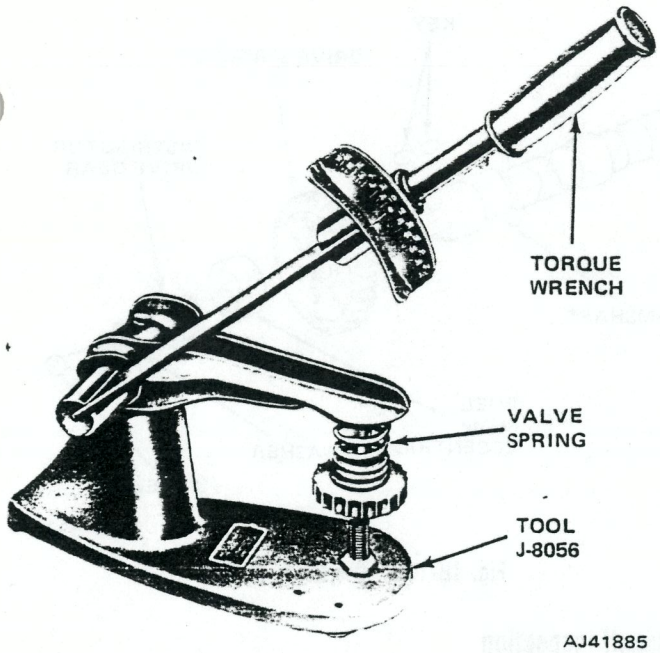

Fig. 1B-110 Valve Spring Tester

(6) Install push rods. Ensure bottom end of each rod is centered in plunger cap of hydraulic valve tappet.

(7) Install rocker arms and bridge and pivot assembly. At each bridge, tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten capscrews with 19 foot-pounds (25 N•m) torque.

(8) Reseal and install cylinder head cover.

(9) Install retaining screws and washers. Tighten screws with 50 inch-pounds (6 N•m) torque.

CAMSHAFT AND BEARINGS

General

The 304 CID (5 liter) engine uses the same camshaft as the 360 CID (6 liter) engine. The camshaft is supported by five steel-shelled, babbitt-lined bearings pressed into the block and line reamed. The step bored camshaft journals are larger at the front bearing than at the rear to permit easy removal and installation of the camshaft. All camshaft bearings are pressure lubricated.

NOTE: *Do not replace camshaft bearings unless special removal and installation tools are available.*

Camshaft end play is maintained by the load placed on the camshaft by the oil pump and distributor drive gear. The helical cut of the gear holds the camshaft sprocket thrust face against the cylinder block face to maintain zero camshaft end play during engine operation. The rear camshaft bearing journal has two holes drilled through it to relieve pressure that could develop between the journal and camshaft plug and force the camshaft forward.

Cam Lobe Lift Measurement

(1) Remove cylinder head cover and gasket.

(2) Remove bridge and pivot assemblies and rocker arms. Alternately loosen capscrews one turn at a time to avoid damaging bridge.

(3) Remove spark plugs.

(4) Use piece of rubber tubing to secure dial indicator on end of push rod (fig. 1B-111).

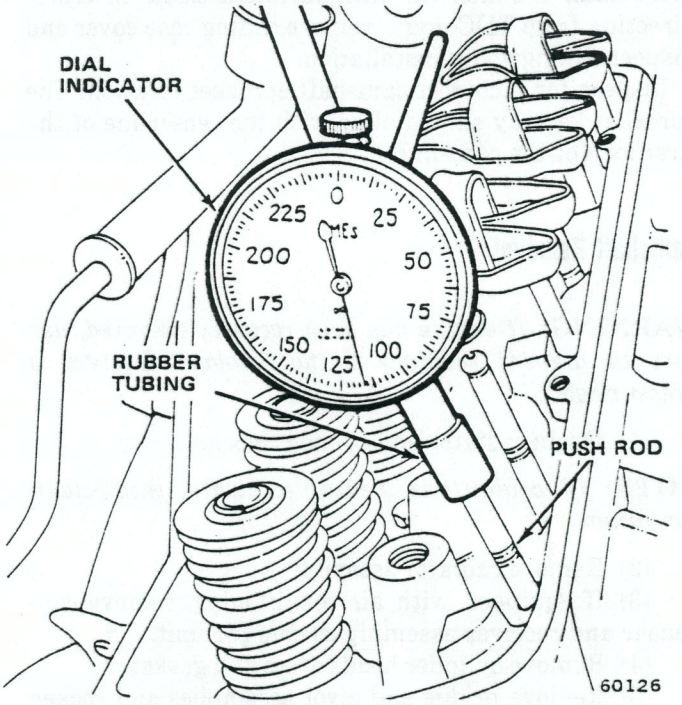

Fig. 1B-111 Cam Lobe Lift Measurement

(5) Rotate crankshaft until cam lobe base circle (push rod down) is under valve tappet.

(6) Set dial indicator to zero.

(7) Rotate crankshaft until point of maximum push rod upward movement occurs.

(8) Note travel on dial indicator. Correct lift is 0.260 to 0.270 inch (6.604 to 6.858 mm) for both 304 (5 liter) and 360 (6 liter) CID engines.

NOTE: *Rocker arm ratio is 1.6:1. Multiply cam lift by 1.6 to determine valve lift.*

Valve Timing

(1) Remove spark plugs.

(2) Remove cylinder head covers and gaskets.

(3) Remove bridge and pivot assemblies and rocker arms from No. 1 cylinder.

(4) Rotate crankshaft until No. 6 piston is at top dead center (TDC) on compression stroke. This positions No. 1 piston at TDC on exhaust stroke in valve overlap position.

(5) Rotate crankshaft counterclockwise 90° as viewed from front.

(6) Install dial indicator on No. 1 intake valve push rod end. Use rubber tubing to secure stem on push rod.

(7) Set dial indicator at zero.

(8) Rotate crankshaft slowly in direction of normal rotation (clockwise viewed from front) until dial indicator indicates 0.020 inch (0.508 mm).

(9) This should align milled timing mark on vibration damper with TDC mark on timing degree scale. If more than 1/2-inch (13 mm) variation exists in either direction from TDC mark, remove timing case cover and inspect timing chain installation.

Inspect for incorrect camshaft sprocket location. The sprocket keyway should align with the centerline of the first lobe of the camshaft.

Camshaft Removal

WARNING: *If engine has been recently operated, use care to prevent scalding by hot coolant. System is pressurized.*

(1) Drain radiator and cylinder block.

NOTE: *If coolant is reusable, drain into clean container.*

(2) Remove radiator assembly.

(3) If equipped with air conditioning, remove condenser and receiver assembly as charged unit.

(4) Remove cylinder head covers and gaskets.

(5) Remove bridge and pivot assemblies and rocker arms. Alternately loosen capscrews, one turn at a time, to avoid damaging bridge.

(6) Remove push rods.

NOTE: *Retain push rods, rocker arms, bridge and pivot assemblies and tappets in the same order as removed.*

(7) Remove intake manifold assembly.

(8) Remove tappets.

(9) Remove drive belts.

(10) Remove fan and hub assembly.

(11) Remove distributor.

(12) Remove damper pulley and vibration damper.

(13) Remove timing case cover.

(14) Install vibration damper screw with two or more flat washers to provide means of rotating crankshaft.

(15) Rotate crankshaft until timing mark on crankshaft sprocket is closest to and on centerline with timing mark on camshaft sprocket (fig. 1B-121).

(16) Remove retaining screw from camshaft. Remove retaining screw from crankshaft.

(17) Remove distributor drive gear and fuel pump eccentric from the camshaft (fig. 1B-112).

(18) Remove crankshaft sprocket, camshaft sprocket and timing chain as assembly.

(19) Remove hood latch support bracket, front bumper or grille as required and remove camshaft.

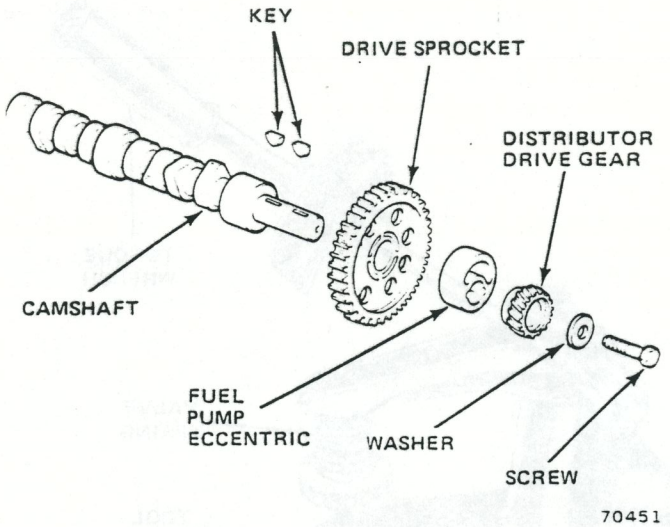

Fig. 1B-112 Camshaft Assembly

Camshaft Inspection

Inspect the camshaft bearing journals for an uneven wear pattern or rough finish. Replace camshaft if either condition exists.

Inspect the distributor drive gear for damage or excessive wear.

Inspect fuel pump eccentric for excessive wear.

Inspect each cam lobe and the associated hydraulic valve tappet for wear. If the face of the tappet(s) is worn concave and the corresponding camshaft lobe(s) is also worn, replace both camshaft and tappet(s).

Camshaft Installation

(1) Lubricate entire camshaft generously with Jeep Engine Oil Supplement (EOS), or equivalent.

(2) Carefully install camshaft into engine block.

(3) Assemble timing chain, crankshaft sprocket and camshaft sprocket with timing marks aligned. Refer to Timing Chain Installation for procedure.

(4) Install oil slinger on crankshaft.

(5) Install fuel pump eccentric and distributor drive gear on camshaft (fig. 1B-112). Tighten retaining screw with 30 foot-pounds (41 N•m) torque.

NOTE: *The fuel pump eccentric has the word "REAR" stamped on it to indicate proper installed position. The camshaft washer (fig. 1B-112) fits into the recess in the distributor drive gear.*

(6) Install replacement timing case cover gasket.

(7) Install timing case cover.

(8) Install replacement oil seal. Apply light film of engine oil to lips of seal.

(9) Install vibration damper.

(10) Install damper pulley with retaining bolts. Tighten bolts with 30 foot-pounds (41 N•m) torque.

(11) Install hydraulic valve tappets lubricated with Jeep Engine Oil Supplement (EOS), or equivalent.

NOTE: *Do not drain the EOS from the engine for at least 1,000 miles (1 609 km) or until the next scheduled oil change.*

(12) Install intake manifold assembly with replacement gasket.

(13) Install push rods.

(14) Install rocker arms and bridge and pivot assemblies. Tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten capscrews with 19 foot-pounds (26 N•m) torque.

(15) Reseal and install cylinder head covers.

(16) Install fuel pump.

(17) Rotate crankshaft until No. 1 piston is at TDC position on compression stroke.

NOTE: *After No. 1 intake valve has closed, TDC can be attained by rotating the crankshaft clockwise as viewed from the front until the timing mark on the vibration damper aligns with the TDC index on the timing degree scale.*

(18) Install distributor so that rotor is aligned with No. 1 terminal of cap when fully seated on block.

(19) Install distributor cap.

(20) Install ignition wires.

(21) If removed, install air conditioner condenser and receiver assembly.

CAUTION: *Both service valves must be open before the air conditioning system is operated.*

(22) Install hood latch support bracket, front bumper or grille, if removed.

(23) Install radiator.

(24) Install fan and hub assembly.

(25) Fill cooling system to specified level.

(26) Install and adjust drive belts to proper tension. Refer to Chapter 1C—Cooling Systems for procedures.

HYDRAULIC VALVE TAPPETS

A hydraulic valve tappet consists of a tappet body, plunger, plunger return spring, check valve assembly, metering disc, plunger cap and lockring (fig. 1B-113).

The tappet operates in a guide bore that has an oil passage drilled into the adjoining oil gallery.

The operating mode of the hydraulic tappet begins when the tappet is on the heel (base circle) of the cam lobe (engine valve closed). A groove in the tappet body aligns with the tappet oil gallery, admitting pressurized oil into the tappet (fig. 1B-114). A hole and groove arrangement admits the oil to the inside of the plunger. Oil is forced past the plunger check valve and fills the chamber between the plunger and tappet body. When the chamber is full, additional oil in the plunger body unseats the metering disc, and a spurt of oil flows up the pushrod to lubricate the rocker arm assembly. These events all take place while the tappet is on the heel of the cam lobe. As the cam turns, the lobe begins exerting force on the tappet body. This force is transferred by the trapped oil in the tappet chamber to the plunger and finally to the pushrod and rocker arm assembly. The engine valve opens. While the valve is open, the trapped oil is subjected to considerable pressure and some of it escapes between the plunger and the tappet body (leakdown). The cycle is completed as the cam lobe rotates back to the starting position and another charging cycle begins. In this way, zero valve lash is maintained and engine noise is reduced.

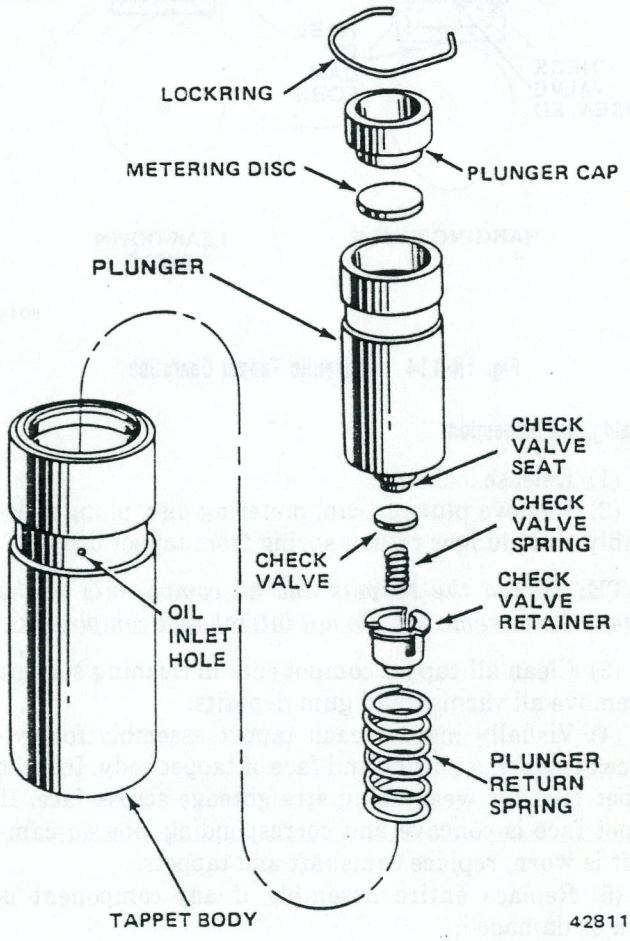

Fig. 1B-113 Hydraulic Tappet Assembly

Removal

(1) Remove cylinder head cover.

(2) Remove bridge and pivot assemblies and rocker arms. Alternately loosen capscrews, one turn at a time, to avoid damaging bridge.

(3) Remove push rods.

NOTE: *Retain bridge and pivot assemblies, rocker arms and push rods in the same order as removed.*

(4) Remove intake manifold.

(5) Remove tappet from guide bore in engine block with Tool J-21884.

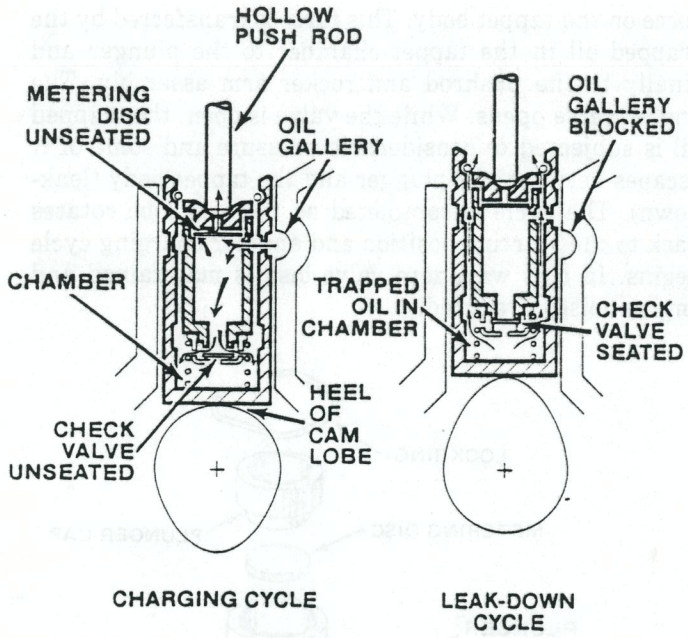

Fig. 1B-114 Hydraulic Tappet Operation

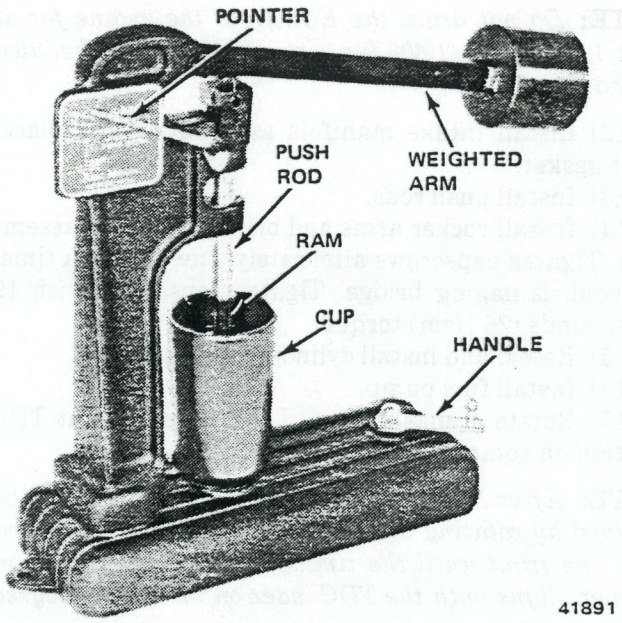

Fig. 1B-115 Hydraulic Tappet Leak-Down Rate Tester J-5790

Cleaning and Inspection

(1) Release lockring.

(2) Remove plunger cap, metering disc, plunger assembly and plunger return spring from tappet body.

NOTE: *Retain the tappets and all components in the same order as removed. Do not interchange components.*

(3) Clean all tappet components in cleaning solvent to remove all varnish and gum deposits.

(4) Visually inspect each tappet assembly for evidence of scuffing on side and face of tappet body. Inspect tappet face for wear using straightedge across face. If tappet face is concave and corresponding lobe on camshaft is worn, replace camshaft and tappets.

(5) Replace entire assembly if any component is worn or damaged.

(6) Install plunger return spring, check valve assembly, plunger, metering disc and plunger cap in tappet body.

(7) Use push rod on plunger cap to compress plunger assembly and install lockring.

Hydraulic Tappet Leak-Down Rate Test

After cleaning, inspection and assembly, use Tester J-5790 to test tappet leak-down rate and to ensure zero-lash operating condition (fig. 1B-115).

(1) Swing weighted arm of tester away from ram of tester.

(2) Place 0.312- to 0.313-inch (7.92 to 7.95 mm) diameter ball bearing on plunger cap of tappet.

(3) Lift ram and place tappet with ball bearing inside tester cup.

(4) Lower ram, then adjust nose of ram until it contacts ball bearing.

(5) Fill tester cup with valve tappet test oil J-5268, or equivalent, until tappet is completely covered.

(6) Swing weighted arm onto ram and pump up and down on tappet to remove air. When air bubbles cease, swing weighted arm away and allow plunger to rise to normal position.

(7) Adjust nose of ram to align pointer with SET mark on scale of tester and tighten hex nut.

(8) Slowly swing weighted arm onto ram. Rotate cup by turning handle at base of tester clockwise one revolution every two seconds.

(9) Time leak-down interval from instant pointer aligns with START mark on scale until pointer aligns with 0.125 mark.

(10) Acceptable tappet will require 20 to 110 seconds interval to leak down. Replace tappets with leak-down rate outside this range.

NOTE: *Do not charge the tappet assemblies with engine oil because they will charge themselves within three to eight minutes of engine operation.*

Installation

(1) Dip each tappet assembly in Jeep Engine Oil Supplement (EOS), or equivalent. Install tappet in same bore from where it was originally removed.

(2) Install push rods in same position as removed.

(3) Install rocker arm and bridge and pivot assemblies in same position as removed. Tighten capscrews alternately, one turn at a time, to avoid damaging bridge. Tighten with 19 foot-pounds (26 N•m) torque.

(4) Pour remaining EOS over entire valve train mechanism.

NOTE: *Do not drain the EOS from the engine for at least 1,000 miles (1 609 km) or until the next scheduled oil change.*

(5) Reseal and install cylinder head cover. Tighten retaining screws with 50 inch-pounds (6 N•m) torque.

(6) Install intake manifold using replacement gasket and end seals. Tighten manifold retaining screws with 43 foot-pounds (58 N•m) torque.

(7) Install all pipes, hoses, linkage and wires disconnected from intake manifold.

TIMING CASE COVER

The timing case cover is die-cast aluminum. A crankshaft oil seal is used to prevent oil leakage at the vibration damper hub (fig. 1B-116). The oil seal may be installed from either side of the timing case cover. It is not necessary to remove the cover whenever oil seal replacement is required.

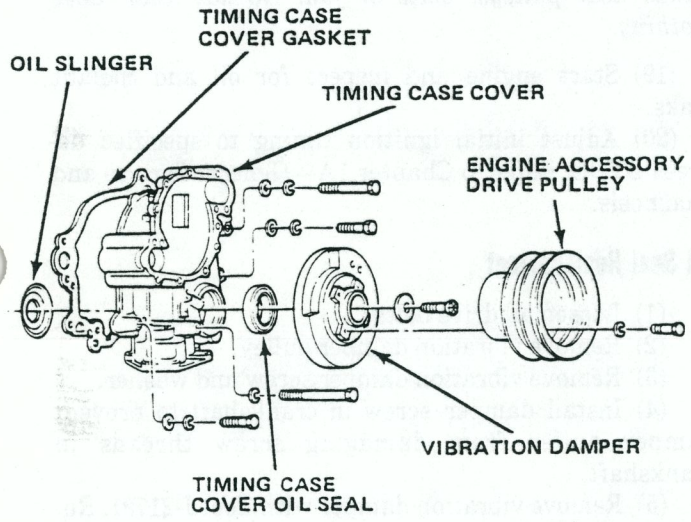

Fig. 1B-116 Timing Case Cover Assembly

A graduated timing degree scale cast in the cover is used for ignition timing. A socket is also provided for timing the ignition with a magnetic timing probe.

The engine oil pump, oil passages and coolant passages are incorporated within the timing case cover casting. The timing case cover casting is also used to mount the fuel pump, distributor and water pump.

Removal

WARNING: *If engine has been recently operated, use care to prevent scalding by hot coolant. System is pressurized.*

(1) Drain radiator and cylinder block.

NOTE: *If coolant is reusable, drain into a clean container.*

(2) Disconnect radiator hoses and bypass hose.

(3) Remove all drive belts.

(4) Remove fan and hub assembly.

(5) If equipped with air conditioner, remove compressor and bracket assembly from engine and move aside. Do not disconnect air conditioner hoses.

(6) Remove alternator, alternator mounting bracket and back idler pulley.

(7) Disconnect heater hose at water pump.

(8) Remove power steering pump and bracket assembly, if equipped. Remove air pump and mounting bracket as assembly. Do not disconnect power steering pump hoses.

(9) Remove distributor cap. Note rotor and housing position.

(10) Remove distributor.

(11) Remove fuel pump.

(12) Remove vibration damper pulley.

(13) Remove vibration damper using tool J-21791.

(14) Remove two front oil pan screws.

(15) Remove screws that secure timing case cover to engine block.

NOTE: *The cover retaining screws are of various lengths and must be installed in the same location as removed.*

(16) Remove cover by pulling forward until clear of locating dowel pins.

(17) Clean gasket contact surface of cover.

(18) Remove oil seal.

NOTE: *Always replace the oil seal whenever the timing case cover is removed. Refer to Oil Seal Replacement for procedure.*

Installation

(1) Remove lower locating dowel pin from engine block.

NOTE: *The dowel pin is required for correct cover alignment. Dowel must be installed after the cover is in position.*

(2) Use sharp knife or razor blade to cut both sides of oil pan gasket flush with engine block.

(3) Apply Permatex No. 2, or equivalent, to both sides of replacement timing case cover gasket. Install gasket on timing case cover.

(4) Install replacement front oil pan seal to bottom of timing case cover.

NOTE: *There are two methods of sealing timing case cover to oil pan where oil pan gaskets were cut off. If replacement oil pan gaskets are used, perform step (5). If room temperature vulcanizing (RTV) silicone is used, perform step (6).*

(5) If oil pan gaskets are used:

(a) Using original gasket pieces as guide, trim replacement gaskets to correspond to amount cut off in step (2) above.

(b) Align tongues of replacement oil pan gasket pieces with oil pan seal and cement into place on cover (fig. 1B-117).

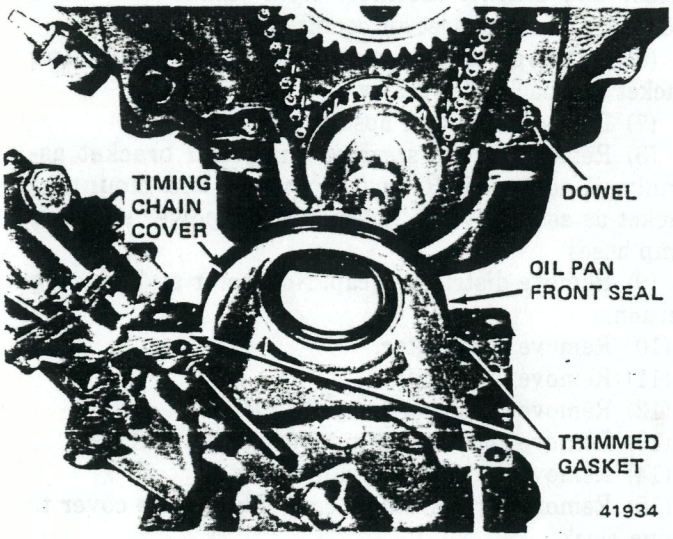

Fig. 1B-117 Oil Pan Front Seal Installation

(c) Apply Permatex No. 2, or equivalent, to cut off edges of original oil pan gaskets.

(d) Place timing case cover in position and install front oil pan screws.

(e) Tighten screws slowly and evenly until cover aligns with upper locating dowel.

(f) Insert lower dowel through cover and drive into corresponding hole in engine block.

(g) Install remaining cover retaining screws in same location as removed. Tighten all screws with 25 foot-pounds (34 N•m) torque.

(h) Proceed to step (7).

(6) If RTV is used:

(a) Apply coating of RTV silicone 1/8-inch (3.175 mm) thick on timing case cover flanges (fig. 1B-117). Use Jeep Gasket-in-a-Tube, or equivalent. Flanges must be clean and dry.

(b) Place cover in position. Align with top dowel.

(c) Loosely install front cover retaining screws in same locations as removed.

(d) Insert lower dowel through cover and drive into corresponding hole in engine block.

(e) Install remaining cover retaining screws and tighten all screws with 25 foot-pounds (34 N•m) torque.

(f) Apply small bead of RTV to joint between pan and cover and force into place with finger.

(g) Apply drop of Loctite, or equivalent, to oil pan screws and tighten until snug. *Do not over-tighten* because oil pan will distort.

(h) Proceed to step (7).

(7) Install vibration damper. Tighten retaining screw with 90 foot-pounds (122 N•m) torque.

(8) Install damper pulley. Tighten retaining bolts with 30 foot-pounds (41 N•m) torque.

(9) Install fuel pump.

(10) Install distributor with rotor and housing in same position as it was prior to removal.

(11) Install distributor cap and connect heater hose.

(12) Install power steering pump, air pump and mount bracket, if removed.

(13) Install alternator, alternator mounting bracket, and back idler pulley assembly.

(14) Install air conditioner compressor and bracket assembly, if removed.

(15) Install fan and hub assembly.

(16) Install all drive belts and adjust to specified tension. Refer to Chapter 1C—Cooling Systems.

(17) Connect radiator hoses and bypass hose.

(18) Fill cooling system to specified level.

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(19) Start engine and inspect for oil and coolant leaks.

(20) Adjust initial ignition timing to specified degrees BTDC. Refer to Chapter 1A—General Service and Diagnosis.

Oil Seal Replacement

(1) Loosen all drive belts.

(2) Remove vibration damper pulley.

(3) Remove vibration damper screw and washer.

(4) Install damper screw in crankshaft to prevent damper puller from damaging screw threads in crankshaft.

(5) Remove vibration damper with Tool J-21791. Remove damper screw.

(6) Remove oil seal using Remover J-9256 (fig. 1B-118).

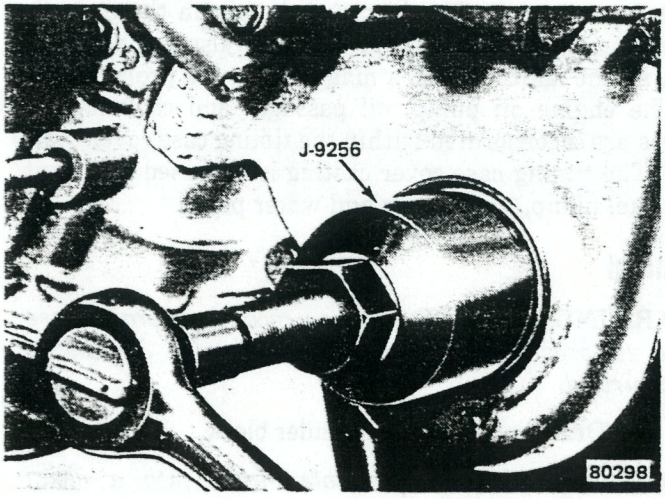

Fig. 1B-118 Removing Timing Case Cover Oil Seal

(7) Wipe crankshaft sealing area clean.

(8) Apply Permatex No. 2, or equivalent, to outer metal surface of replacement seal.

(9) Install seal using Installer Tool J-26562 (fig. 1B-119).

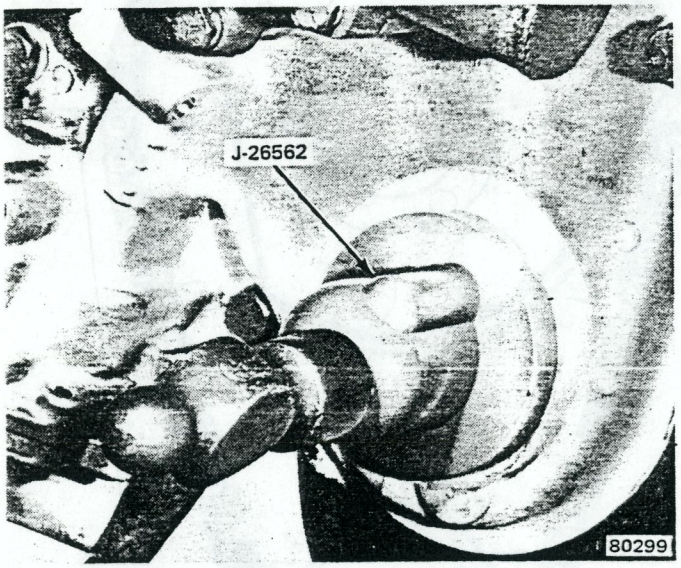

Fig. 1B-119 Installing Timing Case Cover Oil Seal

(10) Apply light coating of engine oil to seal contact surface of damper.

(11) Install damper, flat washer and screw. Tighten with 90 foot-pounds (122 N•m) torque.

(12) Install pulley and belts. Adjust belts to specifications. Refer to Chapter 1C—Cooling Systems.

TIMING CHAIN

To ensure correct valve timing, install the timing chain with the timing marks of the crankshaft and camshaft sprockets correctly positioned.

Timing Chain Wear Measurement

(1) Remove timing case cover. Refer to Timing Case Cover Removal for procedure.

(2) Rotate camshaft or crankshaft sprocket until all slack is removed from right side of chain.

(3) Determine reference point for deflection measurement according to following:

(a) Measure up from dowel on right side of engine 3/4 inch (19 mm) and mark location (fig. 1B-120).

(b) Position straightedge across timing chain from point at lowest root of camshaft sprocket to point marked in step (a) above (fig. 1B-120).

(c) Grasp chain where straightedge dissects chain and use as reference.

(d) Move chain inward toward centerline of engine and mark engine block at point of maximum inward chain deflection (fig. 1B-120).

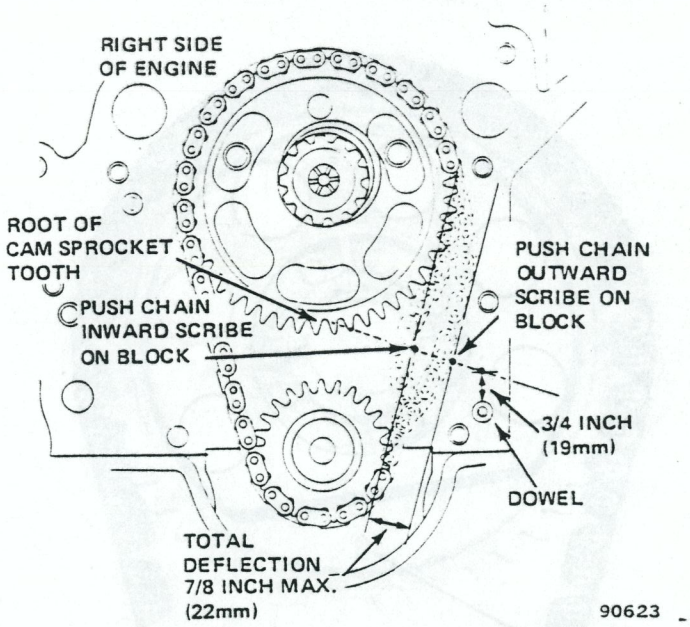

Fig. 1B-120 Timing Chain Wear Measurement

(e) Move chain outward from centerline of engine and mark engine block at point of maximum outward chain deflection (fig. 1B-120).

(f) Measure distance between two marks to determine total deflection.

(g) Replace chain assembly if deflection (wear) exceeds 7/8 inch (22 mm). Refer to Timing Chain Removal and Installation for procedure.

(h) Install timing case cover. Refer to Timing Case Cover Installation for procedure.

Removal

(1) Remove vibration damper pulley, damper, timing case cover and gasket.

(2) Remove crankshaft oil slinger.

(3) Remove camshaft sprocket retaining screw and washer.

(4) Remove distributor drive gear and fuel pump eccentric (fig. 1B-112).

(5) Rotate crankshaft until zero timing mark on crankshaft sprocket is closest to and on centerline with zero timing mark on camshaft sprocket (fig. 1B-121).

(6) Remove crankshaft sprocket, camshaft sprocket and timing chain as assembly.

Installation

(1) Assemble timing chain, crankshaft sprocket and camshaft sprocket with timing marks positioned as depicted in figure 1B-121.

(2) Install chain and sprocket assembly on crankshaft and camshaft.

NOTE: *Install the fuel pump eccentric with the stamped word REAR facing the camshaft sprocket.*

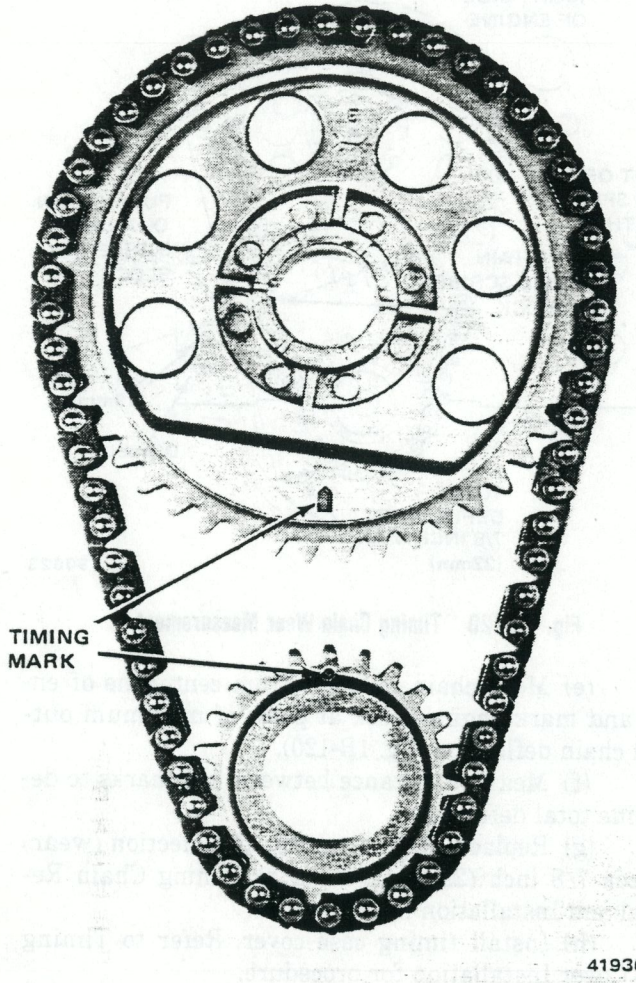

Fig. 1B-121 Timing Chain and Sprocket Alignment

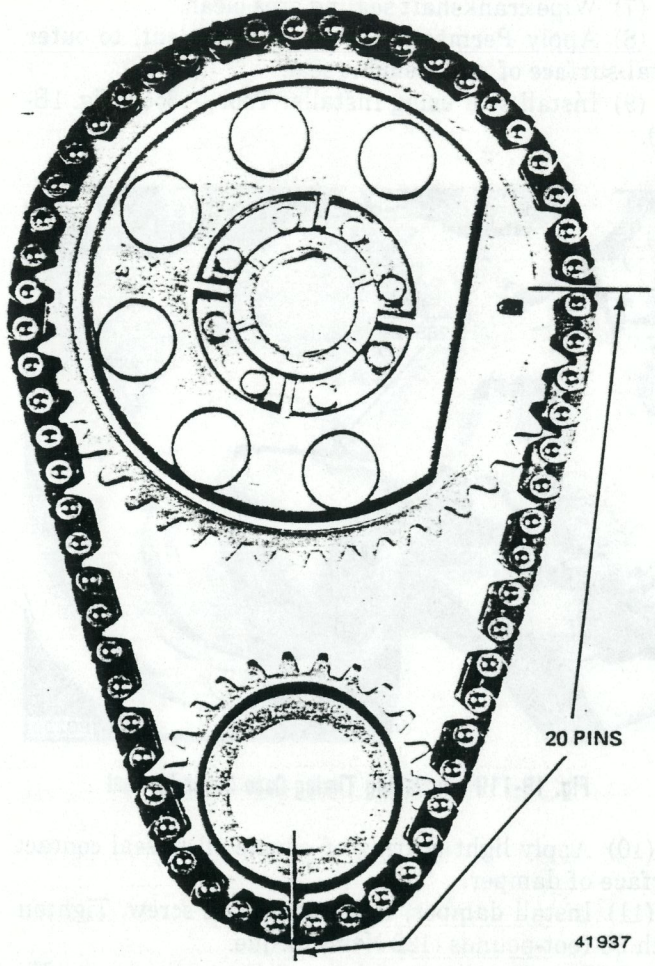

Fig. 1B-122 Correct Timing Chain Installation Verification

(3) Install fuel pump eccentric and distributor drive gear.

(4) Install camshaft washer and retaining screw. Tighten screw with 30 foot-pounds (41 N•m) torque.

(5) To verify correct installation of timing chain:

(a) Rotate crankshaft until timing mark on camshaft sprocket is on horizontal line at 3 o'clock position (fig. 1B-122).

(b) Beginning with pin directly adjacent to camshaft sprocket timing mark, count number of pins downward to timing mark on crankshaft sprocket.

(c) There must be 20 pins between these two points. **The crankshaft sprocket timing mark must be between pins 20 and 21 (fig. 1B-122).**

(6) Install crankshaft oil slinger.

(7) Remove original oil seal from timing case cover.

(8) Install replacement oil seal in timing case cover.

(9) Install timing case cover using replacement gasket. Tighten retaining screws with 25 foot-pounds (34 N•m) torque.

(10) Install vibration damper and pulley.

INTAKE AND EXHAUST MANIFOLDS

Intake Manifold

The cast iron intake manifold is designed to enclose and seal the tappet area between the cylinder heads. A one-piece metal gasket, used to seal the intake manifold to the cylinder heads and block, also serves as an oil splash baffle.

The intake manifold contains coolant passages, a crankcase ventilator passage and an exhaust crossover passage. Passages are also incorporated within the intake manifold for the Exhaust Gas Recirculation (EGR) system.

Induction system passages distribute a uniform fuel and air mixture to the combustion chamber of each cylinder. The left side of the carburetor supplies the fuel/air mixture through passages in the intake manifold to numbers 1, 7, 4 and 6 cylinder intake ports. The right side supplies numbers 3, 5, 2, and 8 cylinder intake ports.

Removal

WARNING: *If engine has been recently operated, use care to prevent scalding by hot coolant. System is pressurized.*

(1) Drain coolant from radiator and cylinder block.

NOTE: *If coolant is reusable, drain into clean container.*

(2) Remove air cleaner assembly.
(3) Disconnect ignition wires.
(4) Remove ignition wire plastic separators from cylinder head cover brackets.
(5) Disconnect radiator upper hose and bypass hose from intake manifold.
(6) Disconnect and move aside wire from coolant temperature gauge sending unit.
(7) Disconnect ignition coil bracket and move coil and bracket assembly aside.
(8) Disconnect heater hose from rear of manifold.
(9) Identify and disconnect all hoses, pipes and wire connectors from carburetor assembly.
(10) Disconnect throttle and throttle valve linkage from carburetor and intake manifold.
(11) Disconnect air hoses from air injection manifolds.
(12) Disconnect diverter valve from air pump output hose and move valve and air hoses aside.
(13) Remove carburetor.
(14) Remove intake manifold, metal gasket and end seals.
(15) Clean gasket mating surfaces of engine block, cylinder head and intake manifold.

Installation

NOTE: *When installing replacement intake manifold, transfer all components (i.e., EGR valve and back-pressure sensor, EGR CTO valve, thermostat housing and coolant temperature gauge sending unit) from original manifold. Clean and tighten as required.*

(1) Apply nonhardening sealer or RTV silicone sealant such as Jeep Gasket-in-a-Tube, or equivalent, to both sides of replacement manifold gasket.
(2) Position gasket by aligning locators at rear of cylinder head. While holding rear of gasket in place, align front locators.
(3) Install two end seals. Apply Permatex No. 2, Jeep Gasket-in-a-Tube, or equivalent, to seal ends.
(4) Install intake manifold and retaining screws. Ensure all screws are properly started before tightening. Tighten with 43 foot-pounds (58 N•m) torque.
(5) Install diverter valve and connect air pump output hose.
(6) Connect air hoses to air injection manifolds.
(7) Identify and connect all disconnected hoses, pipes, linkages and wires to intake manifold and carburetor.
(8) Install ignition coil and bracket assembly.
(9) Connect radiator upper hose and bypass hose.
(10) Install ignition wire plastic separators on cylinder head cover brackets.
(11) Connect ignition wires.
(12) Install air cleaner assembly.
(13) Add coolant as necessary.

Exhaust Manifold

The swept-flow designed cast iron manifold provides efficient removal of exhaust gases and minimizes back pressure. The mating surface of the exhaust manifold and the cylinder head are machined smooth to eliminate the need for a gasket.

All eight-cylinder engines are equipped with an air injection system and have air injection manifolds attached at number 1, 3 and 5 exhaust ports of the left exhaust manifold and numbers 2, 4, 6 and 8 of the right exhaust manifold. Refer to Chapter 1K—Exhaust Systems for description of the air injection system.

Removal

(1) Disconnect ignition wires.
(2) Disconnect air hose at injection manifold.
(3) Disconnect exhaust pipe at exhaust manifold.
(4) Remove exhaust manifold retaining screws.
(5) Separate exhaust manifold from cylinder head.
(6) Remove air injection manifold, fittings and washers.

Installation

(1) Clean mating surfaces of exhaust manifold and cylinder head. **Do not nick or scratch.**
(2) Install air injection manifold on exhaust manifold.

CAUTION: *The correct screws and washers must be used to allow the manifold to expand and prevent cracking.*

(3) Install exhaust manifold and retaining screws. Tighten two center screws with 25 foot-pounds (34 N•m) torque. Tighten four outer screws with 15 foot-pounds (20 N•m) torque.
(4) Connect exhaust pipe using replacement seal, if required. Tighten nuts with 20 foot-pounds (27 N•m) torque.
(5) Connect air hose to air injection manifold.
(6) Connect ignition wires.

CYLINDER HEADS AND COVERS

Cylinder Head Covers

The cylinder head covers are installed with a formed-in-place RTV (room temperature vulcanizing) silicone gasket.

Removal

(1) Remove air cleaner assembly.
(2) Disconnect air hose from air injection manifold.
(3) Left side:
(a) Disconnect power brake vacuum hose at intake manifold, if equipped.
(b) Disconnect throttle stop solenoid wire, if equipped.
(4) Right side:
(a) Remove thermostatically controlled air cleaner (TAC) hot air hose.
(b) Remove heater hose from choke cover clamp.
(5) Disconnect ignition wires and remove plastic wire separator from cylinder head cover bracket.
(6) Remove retaining screws and washers. Strike cover with rubber mallet to break loose from cylinder head. Remove cover and gasket.

Installation

(1) Inspect for bent or cracked cover and repair or replace as required.
(2) Remove gasket material from cylinder head cover and cylinder head gasket surface area.
(3) Apply bead of Jeep Gasket-in-a-Tube, or equivalent, to cylinder head and cylinder head cover gasket surface area.
(4) Position cylinder head cover on engine.
(5) Install retaining screws and tighten with 50 inch-pounds (6 N•m) torque.
(6) Connect ignition wires and install plastic wire separator on cylinder head cover bracket.
(7) Right side:
(a) Install heater hose on choke cover clamp.
(b) Install TAC hot air hose.
(8) Left side:
(a) Connect power brake vacuum hose at intake manifold.
(b) Connect throttle stop solenoid wire.
(9) Connect air hose to air injection manifold.
(10) Install air cleaner assembly.

Cylinder Heads

Removal

WARNING: *Use extreme caution when engine is operating. Do not stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(1) Drain cooling system and cylinder block.

NOTE: *If coolant is reuseable, drain into clean container.*

(2) Remove ignition wires and spark plugs.
(3) Remove cylinder head cover and gasket.
(4) Remove bridge and pivot assemblies and rocker arms. Alternately loosen capscrews, one turn at a time, to avoid damaging bridge.
(5) Remove push rods.

NOTE: *Retain rocker arms, bridges, pivots and push rods in the same order as removed to facilitate installation in original locations.*

(6) Remove intake manifold.
(7) Disconnect exhaust manifold from head. It is not necessary to remove exhaust pipe from manifold.
(8) Loosen all drive belts.
(9) Right side:
(a) If equipped with air conditioning, remove compressor mount bracket and battery negative cable from cylinder head.
(b) Disconnect alternator support brace from cylinder head.
(10) Left side: Disconnect air pump and power steering mount bracket, if equipped, from cylinder head.
(11) Remove cylinder head retaining screws.
(12) Remove cylinder head and gasket.

Cleaning and Inspection

Thoroughly clean the gasket surfaces of the cylinder head and block to remove all foreign material and gasket cement. Remove carbon deposits from the combustion chambers and the top of each piston.

Use a straightedge and feeler gauge to determine the flatness of the cylinder head and block mating surfaces. Refer to Specifications for tolerances.

If the cylinder head is to be replaced and the original valves reused, remove the valves and measure the stem diameters.

NOTE: *Service replacement heads have standard-size valve guide bores. If valves with oversize stems from original head are to be installed in replacement head, ream valve guide bores to appropriate oversize diameter.*

If the original valves are used, remove all carbon deposits and reface the valves as outlined within Valve Refacing. Install the valves in the cylinder head using replacement valve stem oil deflectors. If valves with oversize stems are used, oversize deflectors are also required. Transfer all components from the original head that are not included with the replacement head.

Installation

NOTE: *Wire brush the threads of screws prior to installation. Unclean threads will affect the tightening torque indications. Blow coolant from screw holes to prevent trapping coolant.*

NOTE: *The 304 CID engine uses an aluminum coated embossed steel gasket and the 360 CID engine uses an aluminum coated laminated steel and asbestos gasket. Retightening head bolts after engine has been operated is not necessary for either gasket.*

(1) Apply even coat of nonhardening sealing compound to both sides of replacement head gasket.

NOTE: *Do not apply sealing compound to head and block surfaces. Do not allow sealer to enter cylinder bores.*

(2) Position gasket flush on block with stamped word TOP facing upward.

(3) Install cylinder head over gasket.

(4) Tighten cylinder head capscrews evenly with 80 foot-pounds (108 N•m) torque following sequence outlined in figure 1B-123. Then repeat sequence and tighten screws with 110 foot-pounds (149 N•m) torque.

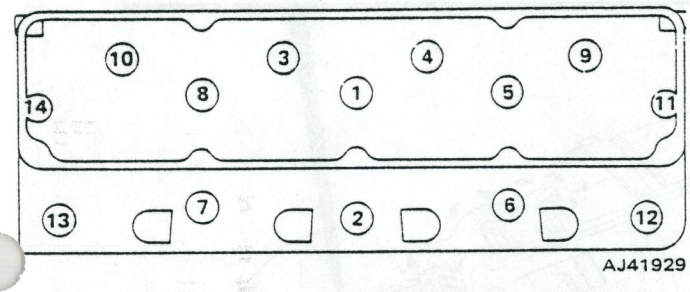

Fig. 1B-123 Cylinder Head Tightening Sequence

(5) Left side: connect air pump mount bracket and power steering pump, if removed, to cylinder head.

(6) Right side:

(a) Connect alternator support bracket to cylinder head.

(b) Install air conditioner compressor mounting bracket, if removed, and battery negative cable on cylinder head.

(7) Adjust all drive belts to specified tension. Refer to Chapter 1C—Cooling Systems.

(8) Install exhaust manifold and tighten retaining screws with 25 foot-pounds (34 N•m) torque.

(9) Install intake manifold. Tighten retaining screws with 43 foot-pounds (58 N•m) torque.

(10) Install all disconnected pipes, hoses, linkage and wires.

(11) Install push rods, rocker arms and bridge and pivot assemblies in original position. Loosely install capscrews through bridges. Tighten capscrews alternately, one turn at a time, to avoid damaging bridges. Tighten capscrews with 19 foot-pounds (26 N•m) torque.

(12) Reseal and install cylinder head cover. Tighten retaining screws with 50 inch-pounds (6 N•m) torque.

(13) Install spark plugs and connect ignition wires.

(14) Fill cooling system to specified level.

LUBRICATION SYSTEM

Oil is pumped from the sump of the oil pan through a pick-up tube and screen assembly to a horizontal oil gallery located at the lower right side of the engine block (fig. 1B-124). A passage in the timing case cover channels oil into the oil pump. Pressure is developed when oil is driven between the gears and pump body.

The oil is forced from the pump through a passage in the oil pump cover to the oil filter (fig. 1B-125).

The oil passes through the filtering element and on to an outlet passage in the oil pump cover. From the oil pump cover passage, the oil enters an adjoining passage in the timing case cover and is channeled into a gallery that extends up the left front of the cylinder block. This gallery channels oil directly to the right main oil gallery, which intersects with a short passage that channels oil to the left main oil gallery.

The left and right main oil galleries extend the length of the cylinder block. The left oil gallery channels oil to each hydraulic tappet on the left bank. The right oil gallery channels oil to each hydraulic tappet on the right bank. In addition, passages extend down from the right oil gallery to the five camshaft bearings and on to the five upper main bearing inserts. The crankshaft is drilled to allow oil to flow from each main journal to adjacent connecting rod journals. A squirt hole in each connecting rod bearing cap distributes oil to the cylinder walls, pistons and piston pins as the crankshaft rotates.

A small passage within the front camshaft bearing journal channels oil through the camshaft sprocket to the timing case cover area where the case and sprockets throw off oil to lubricate the distributor drive gear and fuel pump eccentric (see insert, fig. 1B-124). The oil returns to the oil pan by passing under the front main bearing cap.

Oil for the rocker arm assemblies is metered through the hydraulic valve tappets and routed through hollow push rods to a hole in the corresponding rocker arm. This oil lubricates the valve train, then returns to the oil pan through channels at both ends of the cylinder head.

Oil Filter

A full flow oil filter mounted on the oil pump at the lower right-hand side of the engine is accessible from below the chassis.

A bypass valve in the filter mounting base provides a safety factor in the event the filter should become inoperative as a result of restriction from sludge or foreign material accumulation (fig. 1B-126). Oil Filter Remover Tool J-22700 will facilitate removal.

Before installation, apply a thin film of oil to the filter gasket. **Do not use grease.** Rotate filter until the gasket contacts the seat of the filter base. Tighten by hand only, following instructions on replacement filter. If instructions are not printed on filter, tighten filter until gasket contacts seat and then tighten an additional 3/4 turn. Operate engine at fast idle and inspect for leaks.

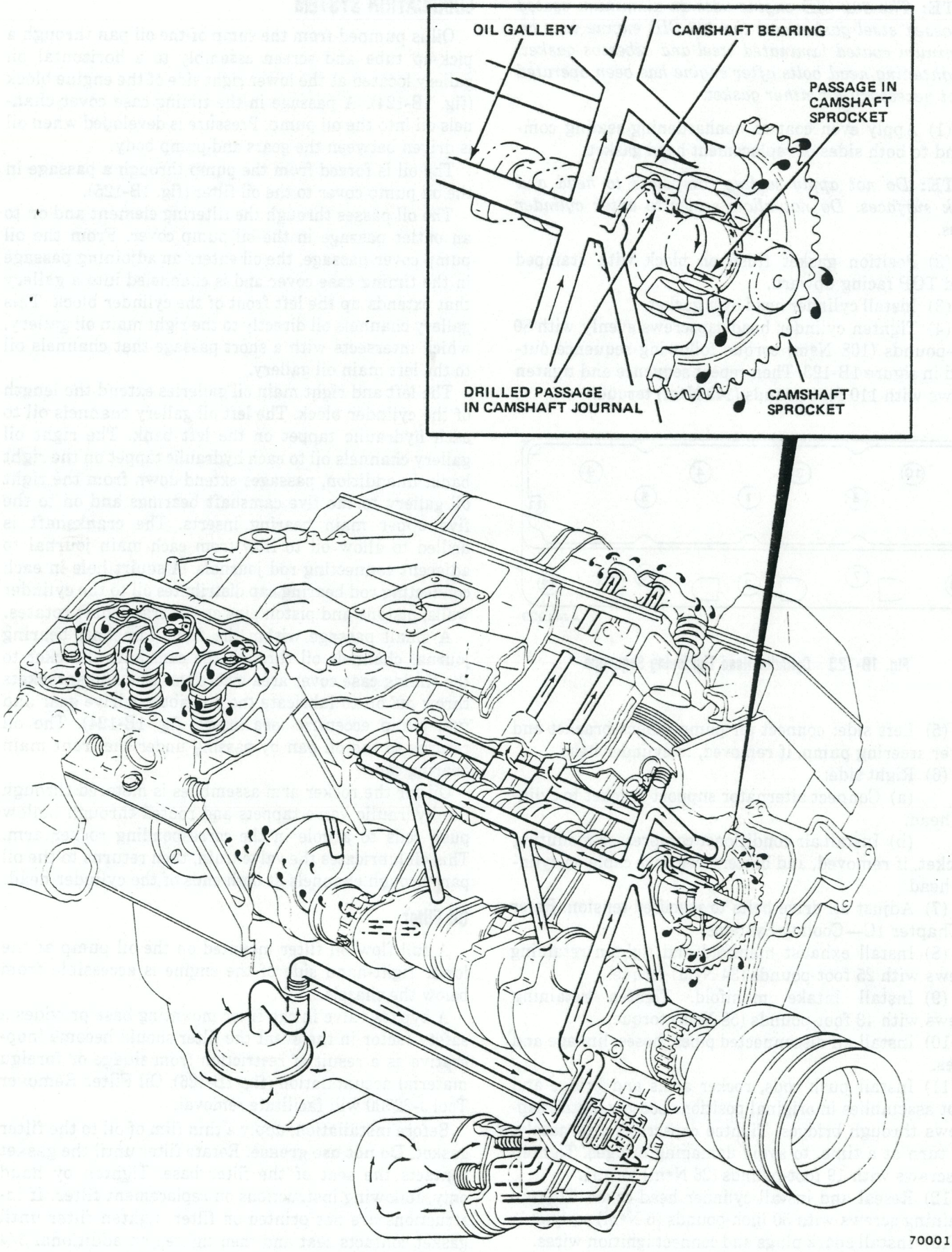

Fig. 1B-124 Lubrication System

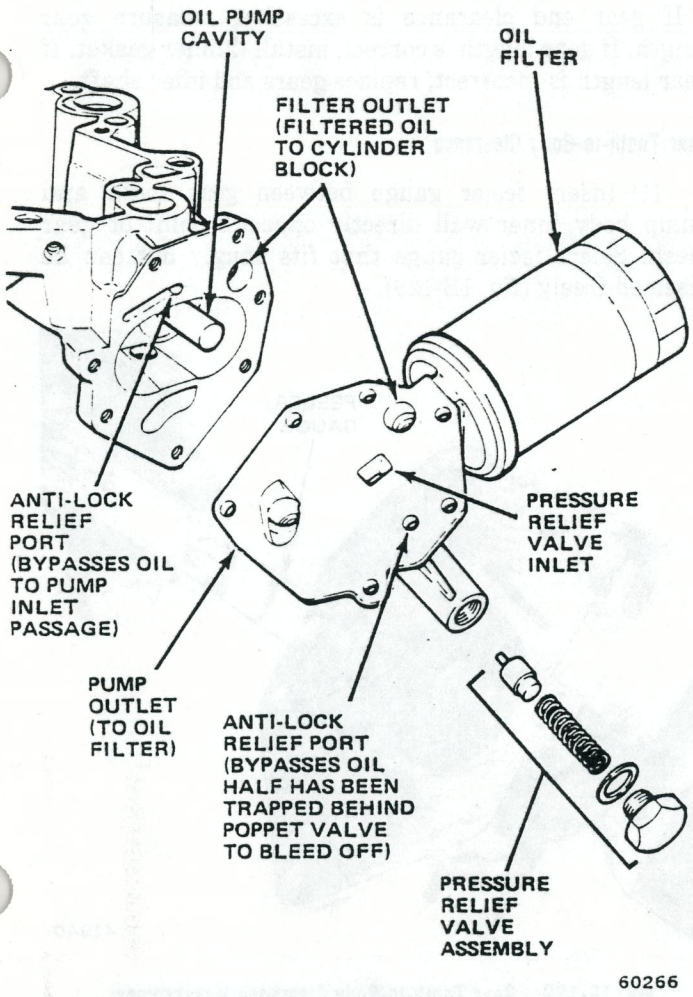

Fig. 1B-125 Oil Pump Cover

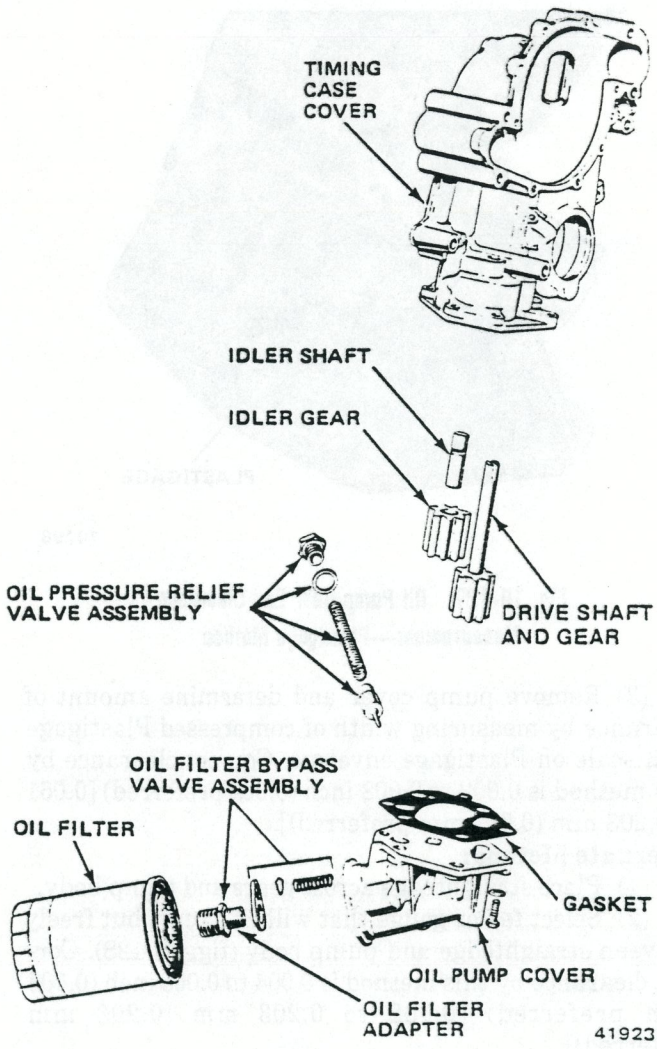

Fig. 1B-126 Oil Pump and Filter Assembly

Oil Pump

The positive-displacement gear-type oil pump is driven by the distributor shaft, which is driven by a gear on the camshaft (fig. 1B-126). The pump is integral with the timing case cover. A cavity in the cover forms the body of the pump. A pressure relief valve regulates maximum oil pressure.

Oil pump removal or replacement will not affect the distributor timing because the distributor drive gear will remain in mesh with the camshaft drive gear.

Oil Pressure Relief Valve

The oil pressure relief valve is not adjustable. The spring tension is calibrated for 75 psi (517 kPa) maximum pressure.

In the relief position, the valve permits oil to bypass through a passage in the pump cover to the inlet side of the pump (fig. 1B-126).

Removal

(1) Remove retaining screws and separate oil pump cover, gasket and oil filter as an assembly from pump body (timing case cover).

(2) Remove drive gear assembly and idler gear by sliding them out of body.

(3) Remove oil pressure relief valve from pump cover for cleaning by removing retaining cap and spring. Clean cover thoroughly. Test operation of relief valve by inserting poppet valve and determining if it slides back and forth freely. If not, replace pump cover and poppet valve.

Gear End Clearance Measurement

This measurement determines the distance between the end of the pump gear and the pump cover. The ideal clearance is as close as possible without binding gears. The pump cover gasket is 0.009- to 0.011-inch (0.229 to 0.279 mm) thick. Symptoms of excessive pump clearance are fair to good pressure when the oil is cold and low or no pressure when the oil is hot.

Preferred Method:

(1) Place strip of Plastigage across full width of each gear (fig. 1B-127).

(2) Install pump cover and gasket. Tighten screws with 55 inch-pounds (6 N•m) torque.

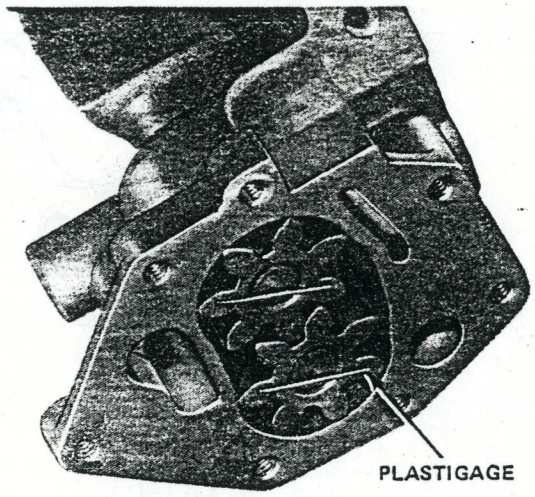

Fig. 1B-127 Oil Pump Gear End Clearance Measurement—Plastigage Method

(3) Remove pump cover and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope. Correct clearance by this method is 0.002 to 0.008 inch (0.002 preferred) [0.051 to 0.203 mm (0.051 mm preferred)].

Alternate Method:

(1) Place straightedge across gears and pump body.

(2) Select feeler gauge that will fit snugly but freely between straightedge and pump body (fig. 1B-128). Correct clearance by this method is 0.004 to 0.008 inch (0.008 inch preferred) [0.102 to 0.203 mm (0.203 mm preferred)].

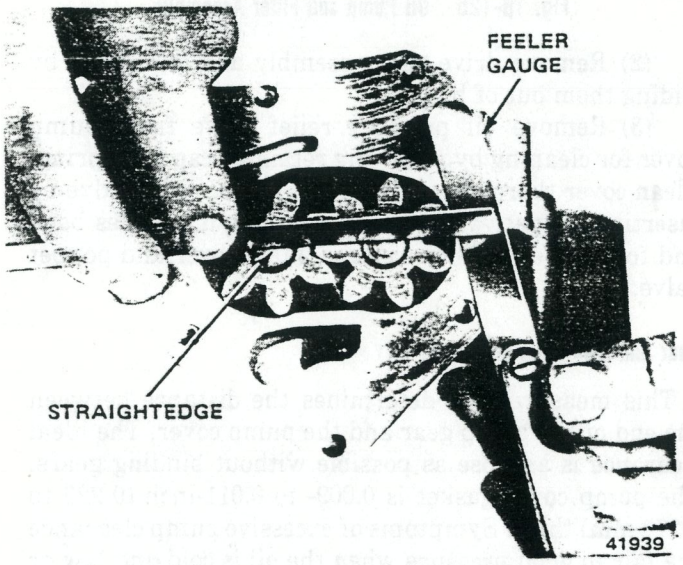

Fig. 1B-128 Oil Pump Gear End Clearance Measurement—Feeler Gauge Method

NOTE: *Ensure gears are up into body as far as possible for measurement.*

If gear end clearance is excessive, measure gear length. If gear length is correct, install thinner gasket. If gear length is incorrect, replace gears and idler shaft.

Gear Tooth-to-Body Clearance

(1) Insert feeler gauge between gear tooth and pump body inner wall directly opposite point of gear mesh. Select feeler gauge that fits snugly but can be inserted freely (fig. 1B-129).

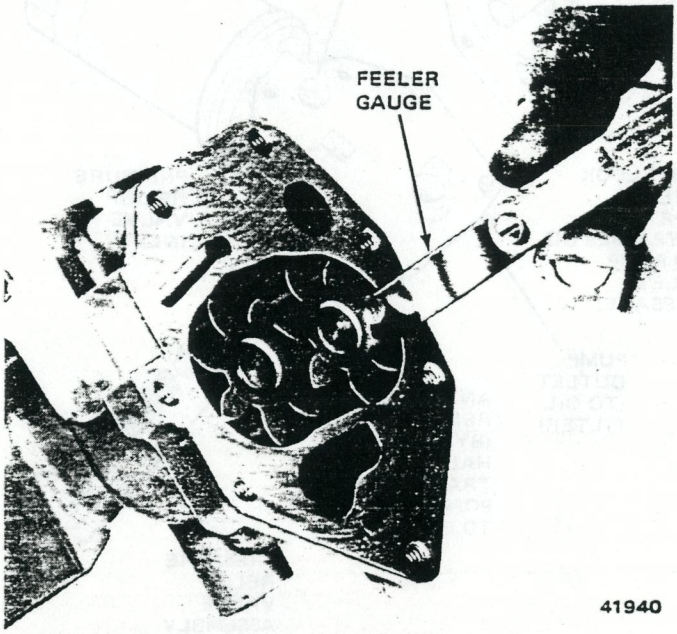

Fig. 1B-129 Gear Tooth-to-Body Clearance Measurement

(2) Rotate gears and measure clearance of each tooth and body in this manner. Correct clearance is 0.0005 to 0.0025 inch (0.0005 inch preferred) or 0.013 to 0.064 mm (0.013 mm preferred).

(3) If gear tooth-to-body clearance is more than specified, measure gear diameter with micrometer. If gear diameter is correct and gear end clearance is correct and relief valve is functioning properly, replace timing case cover. If gear diameter is incorrect, replace gears and idler shaft.

NOTE: *If the oil pump shaft or distributor drive shaft is broken, inspect for loose oil pump gear-to-shaft fit or worn front cover. Oversize pump shafts are not available.*

Installation

(1) Install oil pressure relief valve in pump cover with spring and retaining cap.

(2) Install idler shaft, idler gear and drive gear assembly.

NOTE: *To ensure self-priming of the oil pump, fill pump with petroleum jelly prior to the installation of the oil pump cover.* **Do not use grease of any type.**

(3) Install pump cover and oil filter assembly with replacement gasket. Tighten retaining screws with 55 inch-pounds (6 N•m) torque.

Oil Pan

Removal

(1) Drain engine oil.
(2) Remove starter motor.
(3) On CJ vehicles:
(a) Remove frame cross bar.
(b) Remove automatic transmission fluid cooler tubing, if equipped.
(c) Cut corner of engine mount on right side with hacksaw to provide clearance for pan removal, if required.
(4) On all vehicles, bend tabs down on dust shield, if equipped with manual transmission.
(5) Remove oil pan attaching screws. Remove oil pan.
(6) Remove oil pan front and rear neoprene oil seals.
(7) Thoroughly clean gasket surfaces of oil pan and engine block. Remove all sludge and residue from oil pan sump.

Installation

(1) Install replacement oil pan front seal for timing case cover. Apply generous amount of Jeep Gasket-in-a-Tube (RTV silicone sealant), or equivalent, to end tabs.
(2) Coat inside curved surface of replacement oil pan rear seal with soap or RTV silicone sealant. Apply generous amount of RTV silicone sealant to gasket contacting surface of seal end tabs.
(3) Install seal in recess of rear main bearing cap, ensuring it is fully seated.
(4) Apply RTV silicone sealant to oil pan contacting surface of front and rear oil pan seals.
(5) Cement replacement oil pan side gaskets into position on engine block. Apply generous amount of RTV silicone sealant to gasket ends.
(6) Install oil pan. Tighten 1/4-20 oil pan screws with 7 foot-pounds (9 N•m) torque and 5/16-18 oil pan screws with 11 foot-pounds (15 N•m) torque.
(7) Tighten drain plug securely.
(8) Install starter motor and connect cable.
(9) On CJ vehicles:
(a) Install frame cross bar.
(b) Install automatic transmission fluid cooler tubing, if removed.
(10) Fill crankcase to specified level with clean lube oil.

Oil Pressure Gauge

Refer to Chapter 1L—Power Plant Instrumentation for a description of operation, diagnosis and replacement procedure.

CONNECTING ROD AND PISTON ASSEMBLIES

Use the following procedures to service connecting rods and pistons with the engine installed in the vehicle.

Removal

(1) Remove cylinder head cover(s).
(2) Alternately loosen bridge and pivot assembly capscrews one turn at a time to avoid damaging bridges. Remove bridges, pivots and rocker arms.
(3) Remove push rods.

NOTE: *Retain bridges, pivots, rocker arms and push rods in same order as removed to facilitate installation in original locations.*

(4) Remove intake manifold assembly.
(5) Remove exhaust manifold(s). It is not necessary to disconnect exhaust pipe from manifold.
(6) Remove cylinder head(s) and gasket(s).
(7) Position pistons, one at a time, near bottom of stroke. Use ridge reamer to remove any ridge from top end of cylinder walls.
(8) Drain engine oil.
(9) Remove oil pan.
(10) Remove connecting rod bearing caps and inserts. Retain in same order as removed.

NOTE: *Connecting rods and caps are stamped with the number of the associated cylinder.*

(11) Remove connecting rod and piston assemblies through top of cylinder bores. Ensure that connecting rod bolts do not scratch connecting rod journals or cylinder walls. Short pieces of rubber hose slipped onto rod bolts will provide protection during removal.

Installation

(1) Thoroughly clean cylinder bores. Apply light film of clean engine oil to bores with clean, lint-free cloth.
(2) Arrange spacing of piston ring gaps. Refer to Piston Rings for procedure.
(3) Lubricate piston and ring surfaces with clean engine oil.
(4) Use piston ring compressor tool to install connecting rod and piston assemblies through top of cylinder bores. Ensure that connecting rod bolts do not scratch connecting rod journals or cylinder walls. Short lengths of rubber hose slipped over connecting rod bolts will provide protection during installation.

NOTE: *Squirt holes in connecting rods must face inward (fig. 1B-130).*

(5) Install connecting rod bearing caps and inserts in original positions. Tighten retaining nuts with 33 foot-pounds (45 N•m) torque.
(6) Install engine oil pan using replacement gaskets and seals.

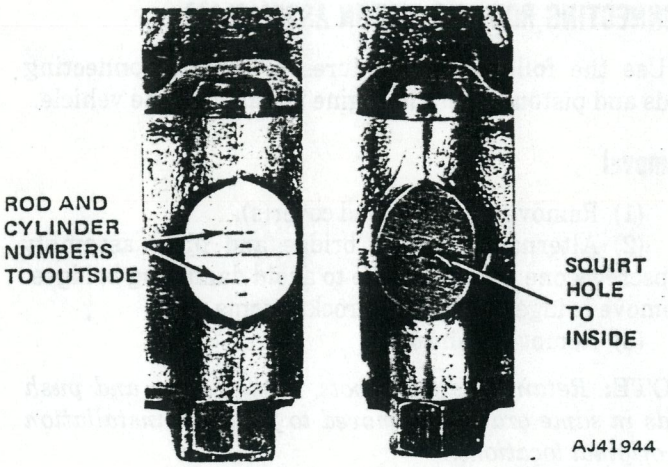

Fig. 1B-130 Rod Number and Squirt Hole Location

(7) Install cylinder head(s) and replacement gasket(s).

(8) Install push rods.

(9) Install rocker arms and bridge and pivot assemblies. Loosely install capscrews through each bridge and alternately tighten, one turn at a time, to avoid damaging bridge. Tighten capscrews with 19 foot-pounds (26 N•m) torque.

(10) Install intake manifold gasket and manifold assembly.

(11) Install exhaust manifold(s).

(12) Reseal and install cylinder head cover(s).

(13) Fill crankcase with clean oil to specified level.

WARNING: *Use extreme caution when engine is operating. Do no stand in direct line with fan. Do not put hands near pulleys, belts or fan. Do not wear loose clothing.*

(14) Start engine inspect for leaks.

CONNECTING RODS

The connecting rods are malleable iron and are independently balanced. The crankshaft end of the connecting rod incorporates a two-piece bearing insert. The number stamped onto the removeable bearing cap and onto the adjacent machined surface of the rod corresponds to the associated cylinder (fig. 1B-130). The piston end of the rod is connected to the piston with a 2000 pound (8.9 kN) press-fitted piston pin.

Have the connecting rod alignment checked by a competent machine shop whenever engine wear patterns or damage indicates probable rod misalignment. Always replace bent connecting rods.

Connecting Rod Side Clearance Measurement

(1) Rotate crankshaft to position where connecting rod journal is at bottom of stroke.

(2) Insert snug fitting feeler gauge between connecting rods (fig. 1B-131).

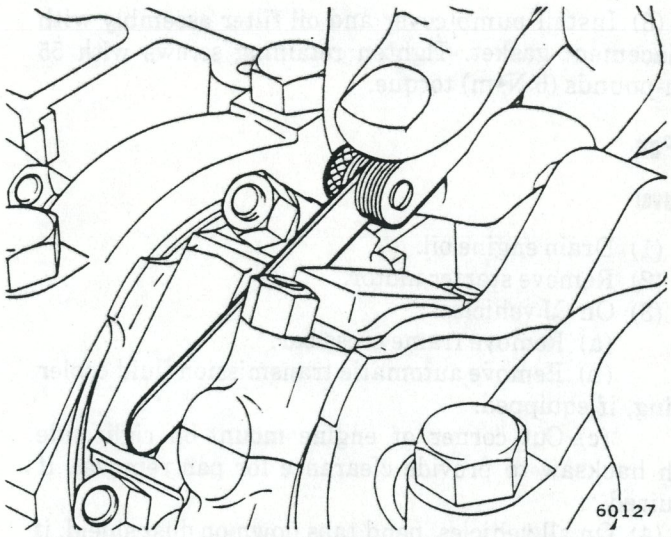

Fig. 1B-131 Connecting Rod Side Clearance Measurement

(3) Compare feeler gauge measurement to specified clearance. Replace rods that are not within specifications.

Connecting Rod Bearings

The connecting rod bearings are precision-type steel-backed aluminum alloy inserts. The connecting rod bearing inserts are selectively fitted to their respective journals to obtain the desired operating clearance. **In production,** the select fit is obtained by using various sized color coded bearing inserts as listed in the Bearing Fitting Chart. The bearing color code appears on the edge of the insert.

NOTE: *Bearing size is not stamped on production inserts.*

The rod journal size is identified **in production** by a color coded paint mark on the adjacent cheek or counterweight toward the flanged (rear) end of the crankshaft. Refer to color codes listed in the Bearing Fitting Chart to identify journal size and select the correct bearing inserts to obtain correct clearances.

CAUTION: *Never use a pair of bearing inserts that are greater than 0.001-inch (0.025 mm) difference in size.*

When required, different sized upper and lower bearing inserts may be used as a pair. A standard size insert is sometimes used in combination with a 0.001-inch (0.025 mm) undersize insert to reduce clearance by 0.0005 inch or 1/2 thousandth of an inch (0.013 mm). Example:

Insert	Correct	Incorrect
Upper	Standard	Standard
Lower	0.001-inch (0.025mm) undersize	0.002-inch (0.051mm) undersize

70242

Connecting Rod Bearing Fitting Chart

304 - 360 CID Engines

Crankshaft Connecting Rod Journal Color Code and Diameter in Inches (Journal Size)	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow —2.0955 to 2.0948 (53.2257 - 53.2079 mm) (Standard)	Yellow — Standard	Yellow — Standard
Orange —2.0948 to 2.0941 (53.2079 - 53.1901 mm) (0.0007 Undersize)	Yellow — Standard	Black —0.001-inch (0.025mm)Undersize
Black —2.0941 to 2.0934 (53.1901 - 53.1723 mm) (0.0014 Undersize)	Black —0.010-Inch (0.025mm)Undersize	Black —0.001-inch (0.025mm)Undersize
Red —2.0855 to 2.0848 (52.9717 - 52.9535 mm) (0.010 Undersize)	Red —0.010-Inch (0.254mm)Undersize	Red —0.010-inch (0.254mm)Undersize

Service replacement bearing inserts are available in pairs in the following sizes: standard, 0.001-inch (0.025 mm) undersize, 0.002-inch (0.051 mm) undersize, 0.010-inch (0.250 mm) undersize and 0.012-inch (0.305 mm) undersize. The size is stamped on the back of service replacement inserts.

NOTE: *The 0.002-inch (0.051 mm) and 0.012-inch (0.305 mm) undersize inserts are not used for production engine assembly.*

Removal

Use the following procedure to service connecting rod bearings with the engine installed in the vehicle.

(1) Drain engine oil.

(2) Remove oil pan.

(3) Rotate crankshaft as required to position two connecting rods at a time at bottom of their stroke.

(4) Remove bearing caps and lower inserts.

(5) Remove upper insert by rotating insert out of connecting rod.

NOTE: *Do not interchange bearing caps. Connecting rod and corresponding cap are stamped with the associated cylinder number (fig. 1B-130). The numbers are located on a machined surface opposite the squirt holes.*

Inspection

(1) Clean inserts

(2) Inspect linings and backs of inserts for irregular wear pattern. Note any scraping, stress cracks or distortion (fig. 1B-132). If bearing has spun in rod, replace bearing and connecting rod and inspect crankshaft journal for scoring.

(3) Inspect for material imbedded in linings that may indicate abnormal piston, timing gear, distributor gear or oil pump gear wear. Figures 1B-133 and 1B-134 depict common score problems.

(4) Inspect fit of insert locking tab in rod cap. If result of inspection indicates that insert tab may have been pinched between rod and rod cap, replace upper and lower bearing inserts.

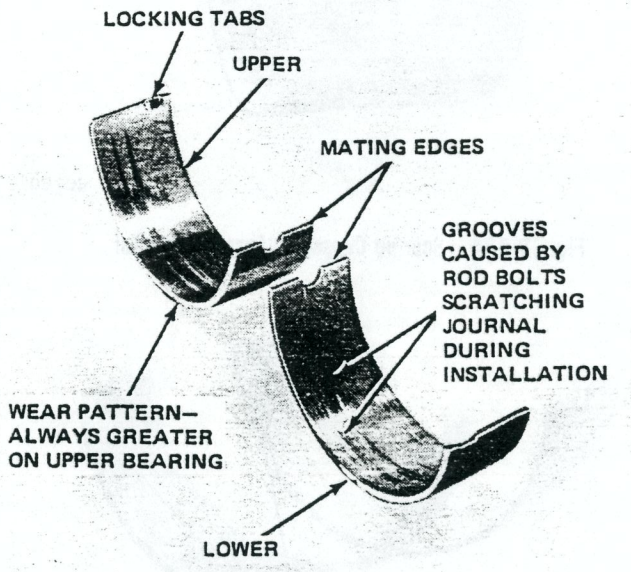

Fig. 1B-132 Connecting Rod Bearing Inspection

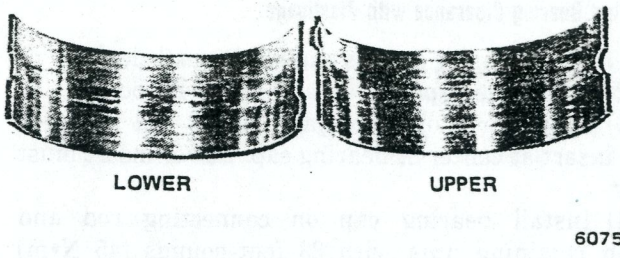

Fig. 1B-133 Scoring Caused by Insufficient Lubrication

(5) Inspect contact area of locking tab. Abnormal wear indicates bent tabs or improper installation of inserts (fig. 1B-135).

(6) Replace bearing inserts that are damaged or worn.

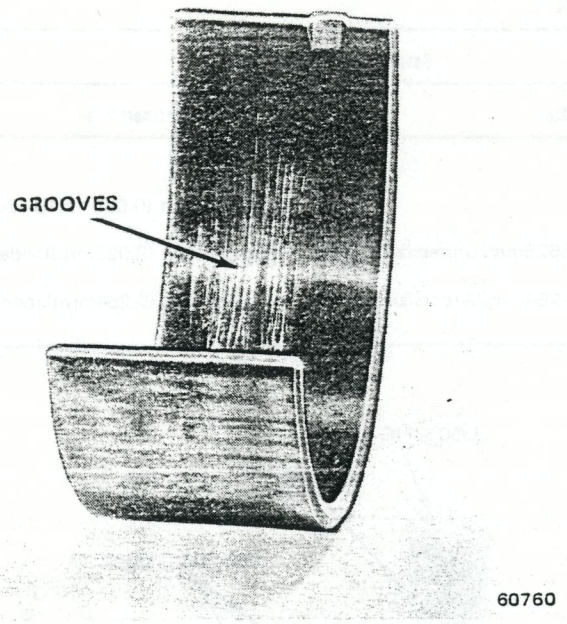

Fig. 1B-134 Scoring Caused by Foreign Material

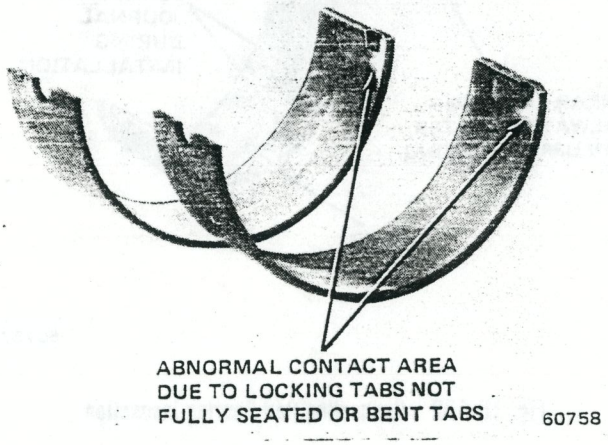

Fig. 1B-135 Locking Tab Inspection

Measuring Bearing Clearance with Plastigage

(1) Wipe bearing inserts and rod journal clean.

(2) Lubricate upper insert and install in rod.

(3) Place strip of Plastigage across full width of lower insert at center of bearing cap. Lower insert must be dry.

(4) Install bearing cap on connecting rod and tighten retaining nuts with 33 foot-pounds (45 N•m) torque.

NOTE: *Do not rotate crankshaft. Plastigage will shift, resulting in inaccurate indication. Plastigage must not crumble. If brittle, obtain fresh stock.*

(5) Remove bearing cap and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope (fig. 1B-136).

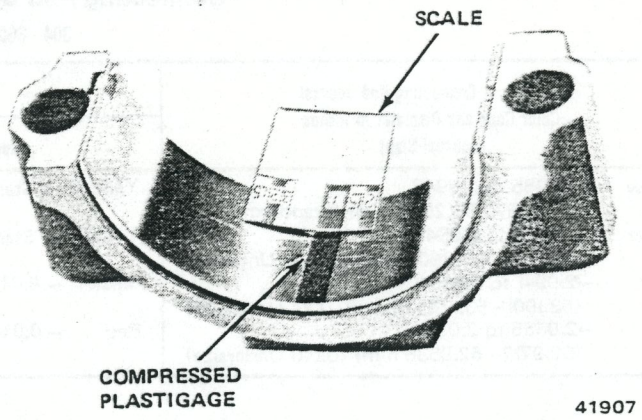

Fig. 1B-136 Connecting Rod Bearing Clearance Measurement with Plastigage

(6) If correct clearance is indicated, bearing fitting is not necessary. Remove Plastigage from crankshaft journal and bearing and proceed to Installation.

NOTE: *Traces of Plastigage left on bearing surfaces will dissolve in hot engine oil after engine is operating.*

(7) If oil clearance exceeds specification, install 0.001-inch (0.025 mm) undersize bearing inserts and measure clearance as described in steps (1) through (5) above.

NOTE: *The measured clearance with 0.001-inch (0.025 mm) undersize bearing inserts installed will determine if a pair of 0.001-inch (0.025 mm) undersize inserts or some other combination are needed to provide the correct clearance. For example, if the initial clearance was 0.003 inch (0.076 mm), 0.001-inch (0.025 mm) undersize inserts will reduce the clearance by 0.001 inch (0.025 mm). The oil clearance will be 0.002 inch (0.051 mm) and within specification. A combination of a 0.002-inch (0.051 mm) undersize insert and a 0.001-inch (0.025 mm) undersize insert will reduce the clearance an additional 0.0005 inch (0.013 mm). The oil clearance will then be 0.0015 inch (0.038 mm).*

CAUTION: *Never use a combination of inserts that differ more than one bearing size as a pair. For example, do not use a standard upper and a 0.002-inch (0.051 mm) undersize lower insert.*

(8) If oil clearance exceeds specification when 0.002-inch (0.051 mm) undersize inserts are installed, measure diameter of connecting rod journal with micrometer. If journal diameter is correct, inside diameter of connecting rod is incorrect and rod must be replaced.

Measuring Connecting Rod Journal with Micrometer

NOTE: *If the journal diameter does not conform to the specification, it may have been ground 0.010-inch (0.254 mm) or more undersize.*

If journal diameter is incorrect, replace crankshaft or grind journal to accept the appropriate undersized bearing insert pair.

(1) Wipe connecting rod journal clean.

(2) Use micrometer to measure journal diameter at two locations 90 degrees apart at each end of journal. Note difference between maximum and minimum diameters.

(3) Refer to Specifications for maximum allowable taper and out-of-roundness. If any rod journal dimension is not within specification, replace crankshaft or recondition crankshaft journals and fit with appropriate undersize bearing inserts.

(4) Compare largest diameter measurement with journal diameters listed in Bearing Fitting Chart.

(5) Select bearing insert pair required to provide specified bearing clearance.

NOTE: *Always measure clearance with Plastigage after installing replacement bearing inserts. Also, measure the clearance of each journal after installing a crankshaft kit (crankshaft supplied with bearings).*

Installation

CAUTION: *Use care when rotating the crankshaft with bearing caps removed. Ensure the connecting rod bolts do not accidentally come in contact with the rod journals and scratch the surface finish, which can cause bearing failure. Short pieces of rubber hose slipped over the rod bolts will provide protection during installation.*

(1) Rotate crankshaft to position connecting rod journal at bottom of stroke.

(2) Lubricate bearing surface of each insert with clean engine oil.

(3) Install bearing inserts, cap and retaining nuts. Tighten with 33 foot-pounds (45 N•m) torque.

(4) Install oil pan using replacement gaskets and seals. Tighten drain plug securely.

(5) Fill crankcase to specified level with clean engine lube oil.

PISTONS

The pistons used with all eight-cylinder engines are aluminum alloy Autothermic pistons. They are steel reinforced for strength and to control expansion.

The pistons are cam-ground and are elliptical in shape. The ring belt area contains three piston rings: two compression rings and one oil control ring located above the piston pin.

The piston pin boss is offset from the piston centerline so that it is nearer the thrust side of the piston. This minimizes piston slap.

To ensure correct installation of the pistons in the bore, two notches are cast in the top perimeter of the pistons for both the 304 (5 liter) and 360 (6 liter) CID engines. The notches must face forward when installed (fig. 1B-137).

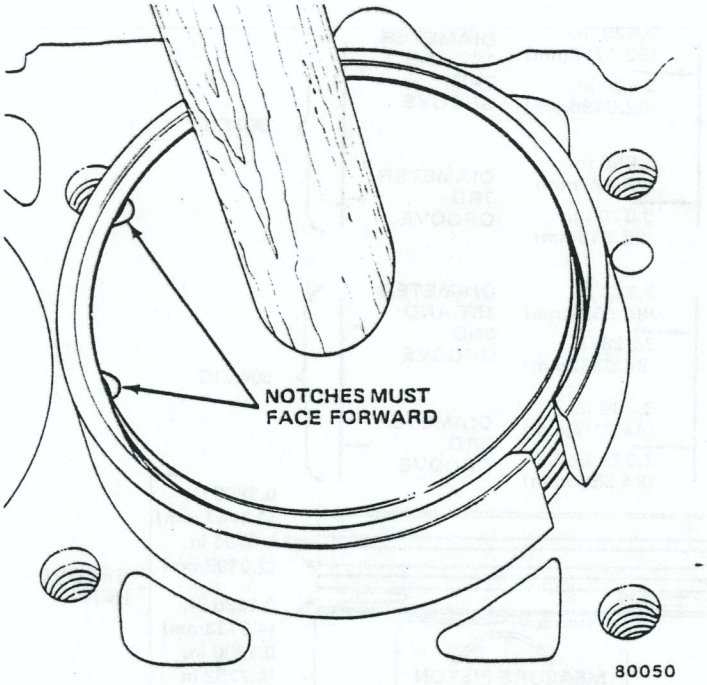

Fig. 1B-137 Installing Piston Assembly Into Cylinder Bore

Piston Measurements

Micrometer Method

(1) Use inside micrometer to measure cylinder bore inside diameter at location 2 5/16 inches (59 mm) below top of bore and crosswise to block.

(2) Measure outside diameter of piston.

NOTE: *Pistons are cam ground and must be measured at a right angle (90 degrees) to piston pin at centerline of pin (fig. 1B-138).*

(3) Difference between cylinder bore diameter and piston diameter dimensions is piston-to-bore clearance. Refer to Specifications.

Feeler Gauge Method

(1) Remove rings from piston.

(2) Insert long 0.0005-inch (0.013 mm) feeler gauge into cylinder bore.

(3) Insert piston (top first) into cylinder bore alongside feeler gauge. With entire piston inserted in cylinder bore, piston should not bind against feeler gauge.

(4) Repeat steps (2) and (3) above with long 0.002-inch (0.051 mm) feeler gauge. Piston should bind.

If the piston binds on the 0.0005-inch (0.013 mm) feeler gauge, either the piston is too large or the cylinder bore is too small. If the piston does not bind on the 0.002-inch (0.051 mm) feeler gauge, the piston may be enlarged by knurling or shot-peening. Replace any piston that is 0.004-inch (0.102 mm) or more undersize.

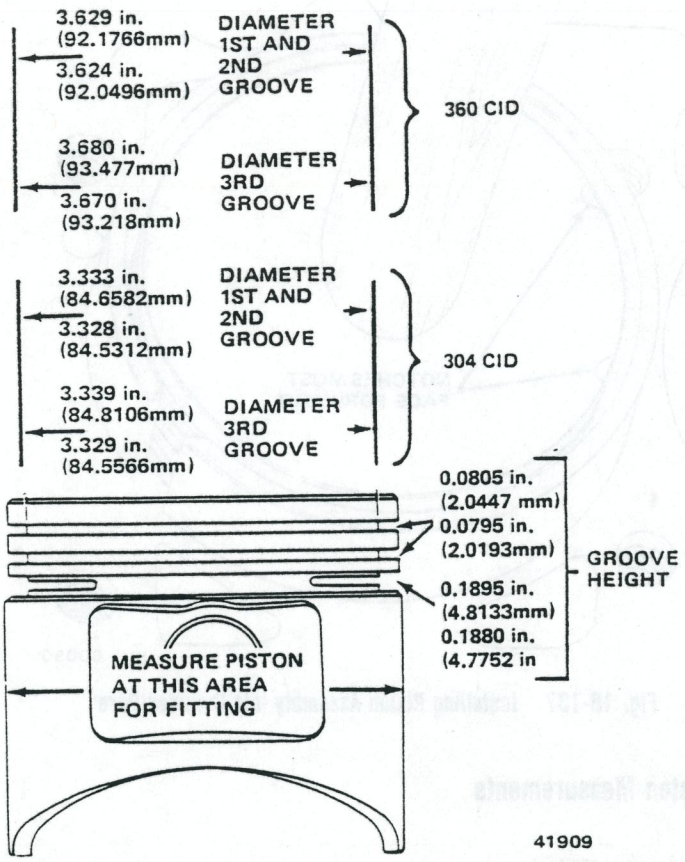

Fig. 1B-138 Piston Measurements

Piston Rings

The top compression ring is constructed of moly-filled iron. The second compression ring is constructed of cast-iron. The oil control ring has a three-piece steel design.

Ring Measurements

CAUTION: *Do not remove metal from grooves or lands. This will change ring groove clearances and will destroy ring-to-land seating.*

(1) Clean carbon deposits from all ring grooves. Ensure oil drain openings in oil ring grooves and pin boss are open.

(2) Measure ring side clearance with correct size feeler gauge that fits snugly between ring land and ring. Slide ring around groove. It must slide freely around circumference of groove (fig. 1B-139). Refer to Specifications for correct ring side clearance.

(3) Place ring in cylinder bore. Use inverted piston to push ring down near lower end of ring travel area. Measure ring gap (clearance) with feeler gauge fitted snugly in ring opening (fig. 1B-140). Refer to Specifications.

NOTE: *Insert each compression ring (not oil control rings) in its respective cylinder bore and measure end gap.*

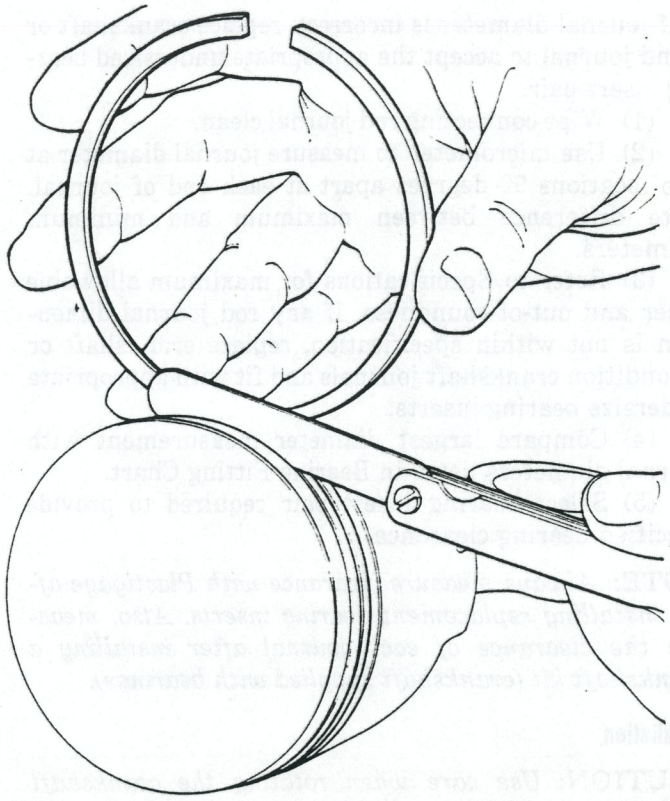

Fig. 1B-139 Ring Side Clearance Measurement

Installation

NOTE: *Ensure top and bottom compression rings are installed properly. Ideally, ring gaps should be spaced 180 degrees from each other. Correct ring gap spacing is depicted in figure 1B-141.*

(1) Install oil control rings according to instructions in package. Roll upper and lower rails into place without use of tool (fig. 1B-142).

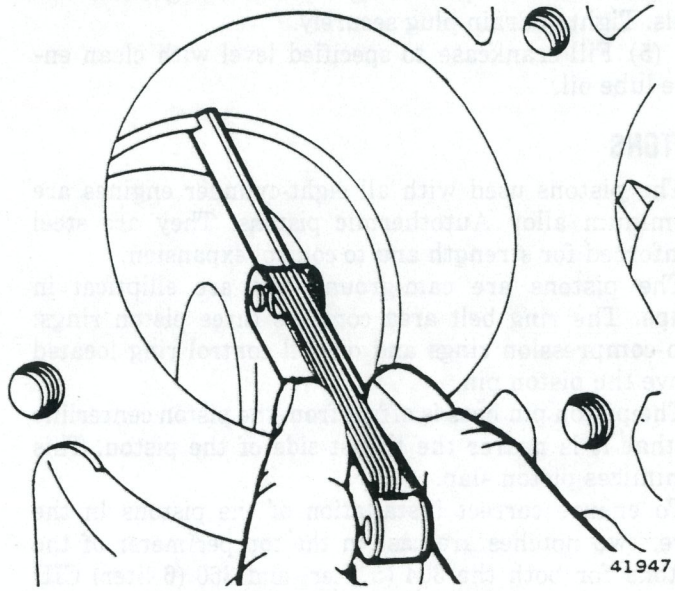

Fig. 1B-140 Compression Ring Gap Measurement

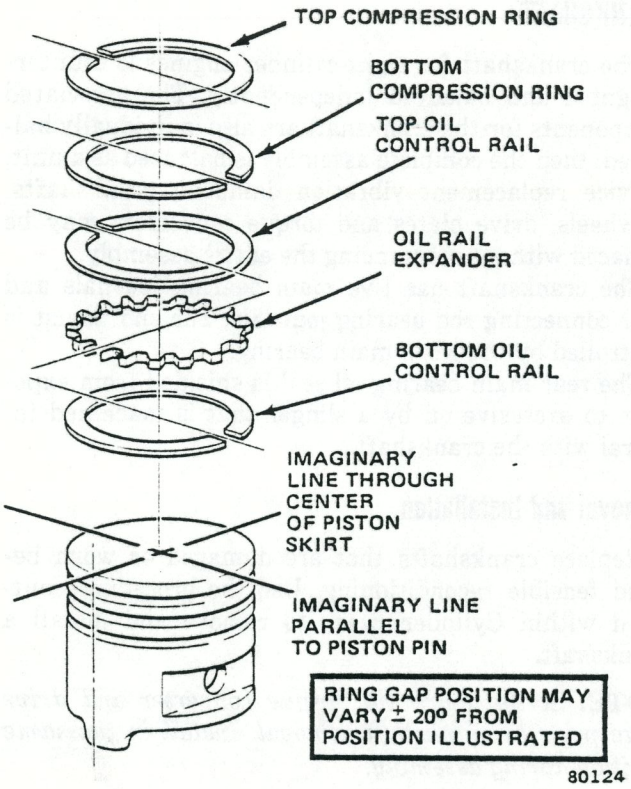

Fig. 1B-141 Ring Gap Spacing

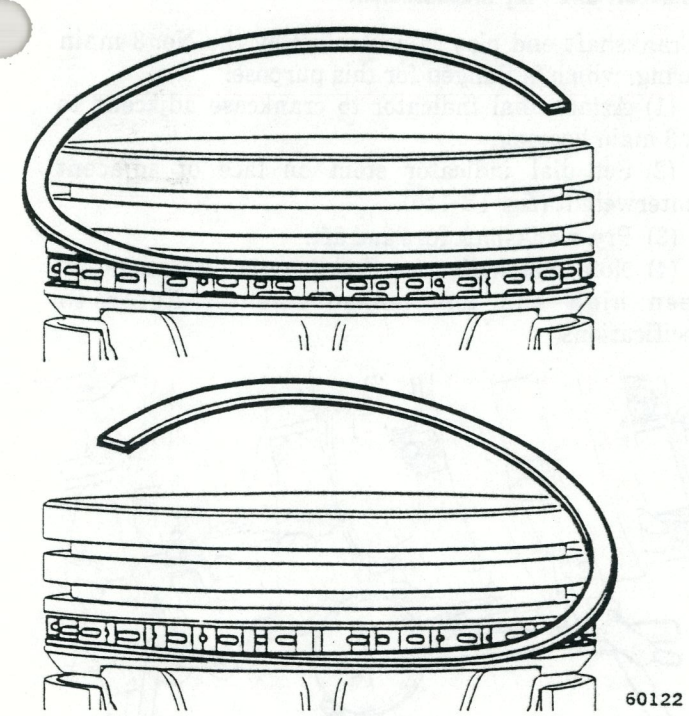

Fig. 1B-142 Installing Oil Control Ring Upper and Lower Rails

(2) Install bottom compression ring using ring installer to expand ring around piston (fig. 1B-143).

NOTE: *Ensure top and bottom compression rings are installed with* ***top*** *side up. Figure 1B-144 illustrates typical ring marks that indicate the* ***top*** *side of the ring.*

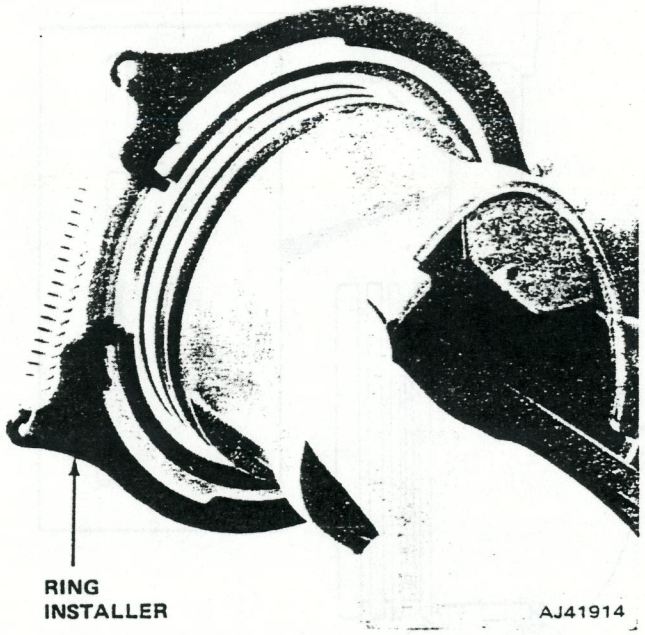

Fig. 1B-143 Compression Ring Installation

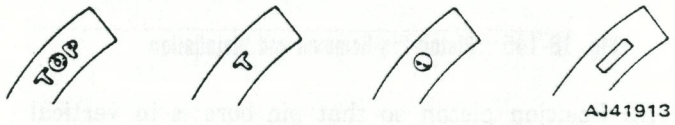

Fig. 1B-144 Typical Compression Ring Marks

(3) Install top compression ring using ring installer to expand ring around piston (fig. 1B-143).

Piston Pins

The piston pins are pressed into the rods with 2000 pounds force (8900 N) and do not require a retaining device.

Removal

(1) Using Piston Pin Remover Tool J-21872 and arbor press, place piston on Remover Support Tool J-21872-1 (fig. 1B-145).

(2) Use Piloted Driver Tool J-21872-3 to press pin completely out of piston and connecting rod. Note position of pin through gauge window of remover support tool.

Pin Fitting

(1) Inspect piston and connecting rod bores for nicks and burrs. Replace rod and piston if necessary.

NOTE: *Never reuse a piston pin after it has been pressed in and out of a connecting rod.*

(2) With pin removed from piston and connecting rod, clean and dry piston pin bores.

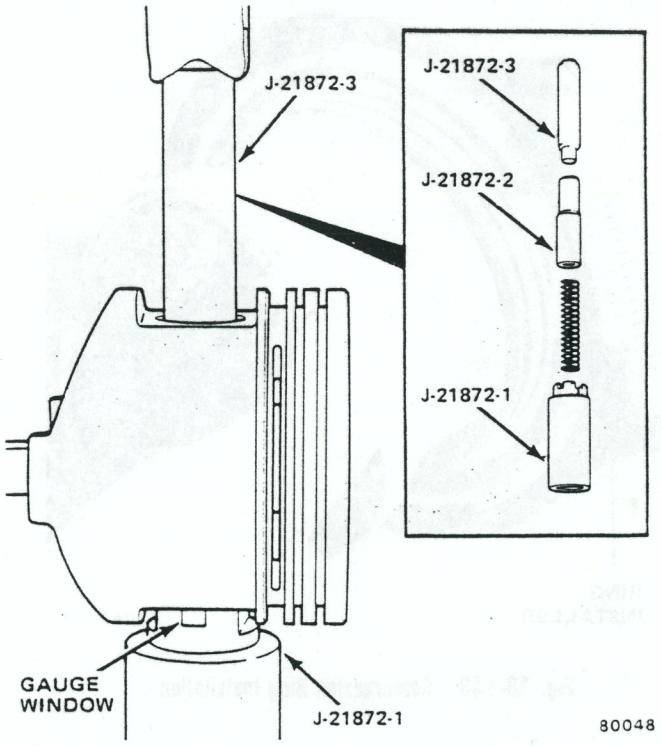

Fig. 1B-145 Piston Pin Removal and Installation

(3) Position piston so that pin bore is in vertical position. Insert replacement pin in bore. At room temperature, replacement pin should slide completely through piston bore without forcing.

(4) Replace piston if pin jams in bore.

Installation

(1) Position piston and connecting rod so that piston notches will face forward and rod squirt hole will face inward when assembly is installed in engine.

(2) Place Pin Pilot Tool J-21872-2 through piston and connecting rod pin bores (fig. 1B-145).

(3) Place pin pilot, piston and connecting rod on Support Tool J-21872-1.

(4) Insert piston pin into piston pin bore and into connecting rod pin bore.

(5) Insert Piloted Driver Tool J-21872-3 into piston pin.

(6) Use arbor press to press piston pin through connecting rod and piston bores until pin pilot indexes with mark on support.

NOTE: *The piston pin requires 2000 pounds force (8900 N) for installation. If insufficient force is required to press piston pin into connecting rod, or if rod slides along pin, replace connecting rod.*

(7) Remove piston and connecting rod assembly from press. Pin should be centered in rod ±1/32 inch (0.787 mm).

CRANKSHAFT

The crankshaft for eight-cylinder engines is counterweighted and balanced independently. The associated components for the crankshaft are also individually balanced, then the complete assembly is balanced as a unit. Service replacement vibration dampers, crankshafts, flywheels, drive plates and torque converters may be replaced without rebalancing the entire assembly.

The crankshaft has five main bearing journals and four connecting rod bearing journals. The end thrust is controlled by the No. 3 main bearing.

The rear main bearing oil seal is shielded from exposure to excessive oil by a slinger that is machined integral with the crankshaft.

Removal and Installation

Replace crankshafts that are damaged or worn beyond feasible reconditioning. Use the procedures outlined within Cylinder Block to remove and install a crankshaft.

NOTE: *Scribe mark the torque converter and drive plate prior to crankshaft removal. Install in the same position during assembly.*

Crankshaft End Play Measurement

Crankshaft end play is controlled by the No. 3 main bearing, which is flanged for this purpose.

(1) Attach dial indicator to crankcase adjacent to No. 3 main bearing.

(2) Set dial indicator stem on face of adjacent counterweight (fig. 1B-146).

(3) Pry crankshaft fore and aft.

(4) Note dial indicator. End play is difference between high and low measurements. Refer to Specifications

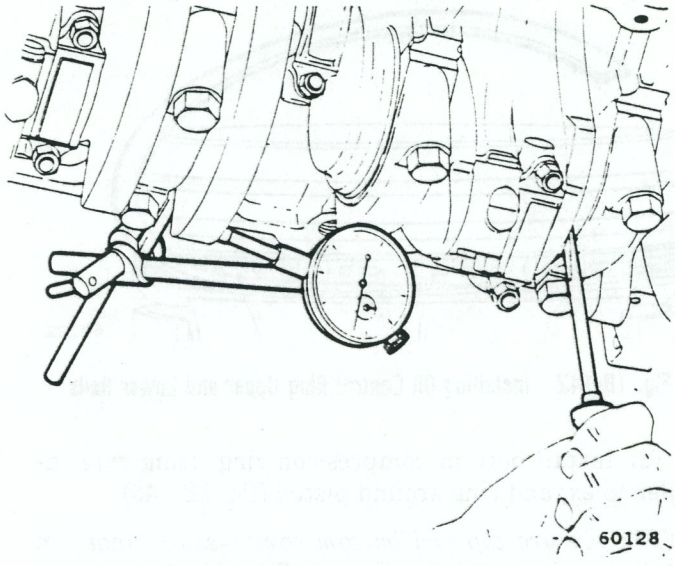

Fig. 1B-146 Crankshaft End Play Measurement

(5) If end play is not within specification, inspect crankshaft thrust faces for wear. If no wear is apparent, replace No. 3 (thrust) main bearing inserts and measure end play. If end play is not within specification, replace crankshaft.

NOTE: *When installing the No. 3 (thrust) main bearing inserts, pry the crankshaft fore and aft to align the thrust faces of the bearing inserts before final tightening.*

Crankshaft Main Bearings

The main bearing inserts are steel-backed aluminum-tin lined. Optional bearing inserts are available with overplated copper-lead linings. The main bearing caps are numbered 1 through 5, front to rear, with an arrow to indicate the forward position. The upper main bearing insert surfaces are grooved. The lower insert surfaces are smooth.

Each bearing insert pair is selectively fitted to its respective journal to obtain the desired operating oil clearance. **In production,** the select fit is obtained by using various-sized color-coded main bearing inserts as listed in the Main Bearing Fitting Chart. The bearing color code appears on the edge of the insert.

NOTE: *The bearing size is not stamped on production inserts.*

The main bearing journal diameter is identified **in production** by a color-coded paint mark on the adjacent cheek toward the flanged (rear) end of the crankshaft, except for the rear main journal. The paint mark that identifies the rear main journal diameter is on the crankshaft rear flange.

Refer to the Main Bearing Fitting Chart to select the proper bearing inserts to obtain the specified bearing clearance. The correct clearance is 0.0015 to 0.0020 inch (0.038 to 0.051 mm) for No. 1 through No. 4 main bearings and 0.0025 to 0.0030 inch (0.064 to 0.076 mm) for the rear main bearing.

When required, use different sized upper and lower bearing inserts as a pair. Use a standard size upper insert in combination with a 0.001-inch (0.025 mm) undersize lower insert to reduce the clearance by 0.0005 inch or 1/2 thousandth of an inch (0.013 mm).
Example:

Insert	Correct	Incorrect
Upper	Standard	Standard
Lower	0.002-inch (0.051 mm) undersize	0.001-inch (0.025 mm) undersize

70242

NOTE: *When installing upper and lower inserts having different sizes, install undersize inserts either all on the top (upper) or all on the bottom (lower). Never use bearing inserts in combination with greater than 0.001-inch (0.025 mm) difference in size.*

Service replacement main bearing inserts are available as pairs in the following sizes: standard, 0.001-inch (0.025 mm) undersize, 0.002-inch (0.051 mm) undersize, 0.010-inch (0.250 mm) undersize, and 0.012-inch (0.305 mm) undersize. The bearing size is stamped on the back of service replacement inserts.

NOTE: *The 0.012-inch (0.305 mm) undersize insert is not used for production engine assembly.*

Removal

The following procedure can be used when the engine is installed in the vehicle.

(1) Drain engine oil and remove oil pan.
(2) Remove main bearing cap and lower insert.
(3) Remove lower insert from bearing cap.
(4) Remove upper insert by loosening all other bearing caps and inserting tool fabricated from cotter pin approximately 1/2-inch (14 mm) into crankshaft oil hole. Fabricate cotter pin as depicted in figure 1B-147.

Main Bearing Fitting Chart

Crankshaft Main Bearing Journal Color Code and Diameter in Inches (Journal Size)	Bearing Color Code	
	Upper Insert Size	Lower Insert Size
Yellow —2.7489 to 2.7484 (69.8220-69.8093mm) (Standard)	Yellow —Standard	Yellow —Standard
Orange —2.7484 to 2.7479 (69.8093-69.7966mm) (0.0005 Undersize)	Yellow —Standard	Black 0.001-inch (0.025mm) Undersize
Black —2.7479 to 2.7474 (69.7966-69.7839mm) (0.001 Undersize)	Black 0.001-inch (.025mm) Undersize	Black 0.001-inch (0.025mm) Undersize
Green —2.7474 to 2.7469 (69.7839-69.7712mm) (0.0015 Undersize)	Black 0.001-inch (.025mm) Undersize	Green 0.002-inch (0.051mm) Undersize
Red —2.7389 to 2.7384 (69.5680-69.5553mm) (0.010 Undersize)	Red 0.010-inch (.254mm) Undersize	Red 0.010-inch (0.254mm) Undersize

60273

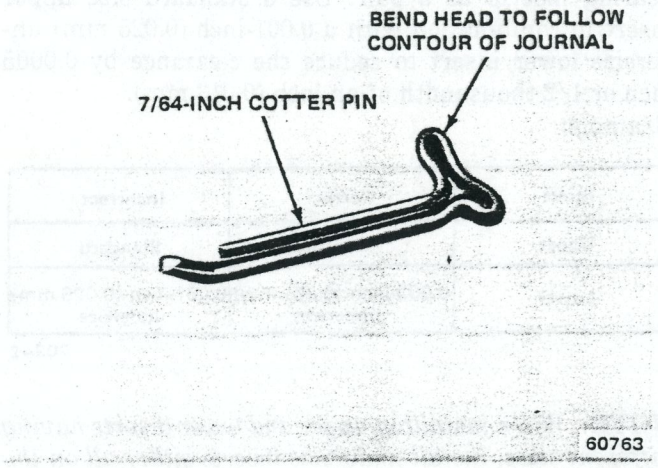

Fig. 1B-147 Fabricated Upper Main Bearing Insert Removal Tool

(5) With cotter pin in place, rotate crankshaft so that upper bearing insert is rotated in direction of its locking tab.

(6) Remove remaining bearings in same manner as outlined above.

Inspection

(1) Wipe inserts clean and inspect for abnormal wear patterns and for metal or other foreign material imbedded in lining. Normal main bearing insert wear patterns are illustrated in figure 1B-148.

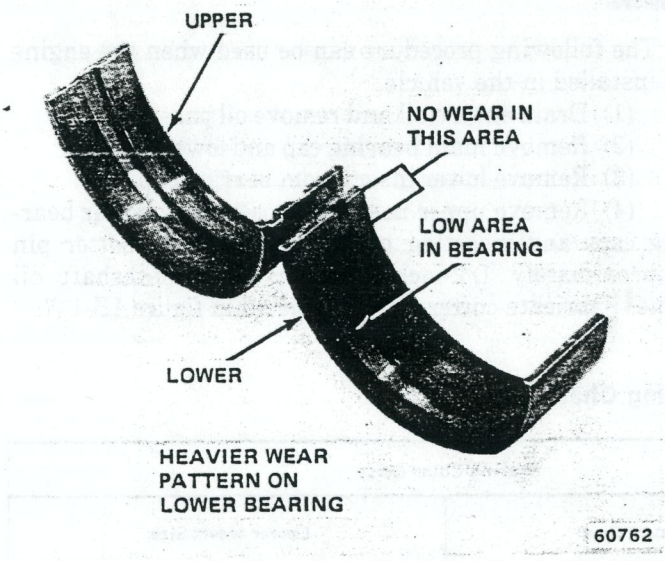

Fig. 1B-148 Normal Main Bearing Insert Wear Patterns

NOTE: *If any of the crankshaft journals are scored, remove the engine for crankshaft repair.*

(2) Inspect back of inserts for fractures, scrapings or irregular wear patterns.

(3) Inspect upper insert locking tabs for damage.

(4) Replace all damaged or worn bearing inserts.

Measuring Main Bearing Clearance with Plastigage (Crankshaft Installed)

(1) Support weight of crankshaft with jack placed under counterweight adjacent to journal being measured.

NOTE: *Measure clearance of one bearing at a time. ALL other bearing caps must remain tightened.*

(2) Remove main bearing cap and lower insert.

(3) Wipe insert and exposed portion of crankshaft journal clean.

(4) Place strip of Plastigage across full width of bearing insert.

NOTE: *Plastigage must not crumble. If brittle, obtain fresh stock.*

(5) Install bearing cap and tighten retaining screws with 100 foot-pounds (136 N•m) torque.

NOTE: *Do not rotate crankshaft. Plastigage will shift, resulting in inaccurate indication.*

(6) Remove bearing cap and determine amount of clearance by measuring width of compressed Plastigage with scale on Plastigage envelope. Correct clearance is 0.0015 to 0.0020 inch (0.038 to 0.051 mm) for No. 1 through No. 4 main bearings and 0.0025 to 0.003 inch (0.064 to 0.076 mm) for rear main bearing (fig. 1B-149).

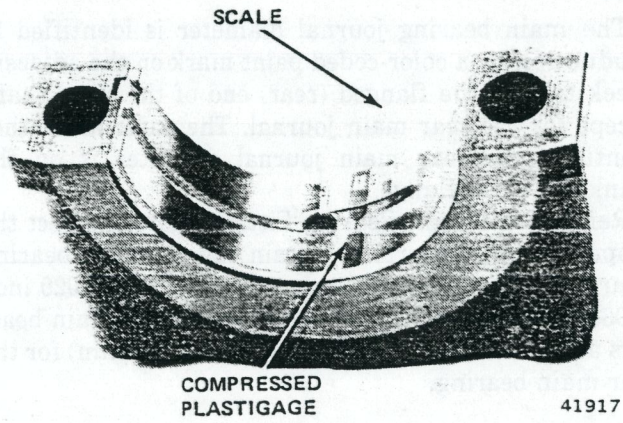

Fig. 1B-149 Measuring Main Bearing Clearance with Plastigage

NOTE: *The compressed Plastigage should maintain the same size across the entire width of the insert. If the size varies, this may indicate either a tapered journal or foreign material trapped behind the insert.*

(7) If correct clearance is indicated, bearing replacement is not necessary. Remove Plastigage from crankshaft and insert. Proceed to Installation.

NOTE: *Small pieces of Plastigage may remain on insert or journal surfaces. If so, they will dissolve in hot engine oil when the engine is operated.*

(8) If oil clearance exceeds specification, install pair of 0.001-inch (0.025 mm) undersize bearing inserts and measure clearance as described in steps (3) through (6) above.

(9) Clearance measured with 0.001-inch (0.025 mm) undersize inserts installed will determine if pair of 0.001-inch (0.025 mm) undersize inserts or some other size combination will provide correct clearance. For example, if clearance was 0.0035-inch (0.089 mm) originally, a pair of 0.001-inch (0.025 mm) undersize inserts will reduce clearance by 0.001 inch (0.025 mm). Oil clearance will be 0.0025 inch (0.064 mm) and within specification. Combination of 0.002-inch (0.051 mm) undersize insert and 0.001-inch (0.025 mm) undersize insert will reduce this clearance additional 0.0005 inch (0,013 mm) and oil clearance will be 0.002 inch (0.051 mm).

CAUTION: *Never use a combination of inserts that have a difference of more than one bearing size. For example, do not use a standard upper and 0.002-inch (0.051 mm) undersize lower insert.*

(10) If oil clearance exceeds specification with pair of 0.002-inch (0.051 mm) undersize inserts, measure crankshaft journal diameter with micrometer. Refer to Specifications. If journal diameter is correct, crankshaft bore in cylinder block may be misaligned, which requires cylinder block replacement. If journal diameter is incorrect, replace or grind crankshaft to standard undersize.

Installation

(1) Lubricate journal contact surface of each insert with clean engine oil.

(2) Loosen all main bearing caps.

(3) Install main bearing upper insert(s).

(4) Install main bearing cap(s) and lower insert(s). Tighten retaining screws evenly with 100 foot-pounds (136 N•m) torque in steps of 30, 60, 90 and 100 foot-pounds (41, 81, 122 and 136 N•m) torque. Rotate crankshaft after each tightening step to determine if it rotates freely. If it does not rotate freely, examine inserts for proper installation and size.

(5) Install oil pan using replacement gaskets and seals. Tighten drain plug securely.

(6) Fill crankcase to specified level with clean lube oil.

Measuring Main Bearing Journals with Micrometer (Crankshaft Removed)

(1) Wipe main bearing journals clean.

(2) Measure each journal diameter with micrometer. Note difference between maximum and minimum diameters of each journal.

(3) Refer to Specifications for maximum allowable taper and out-of-roundness.

(4) Compare measured largest diameter dimensions with journal diameter dimensions listed in Main Bearing Fitting Chart.

(5) Select insert pairs that will provide specified bearing clearance. Correct clearance is 0.0015 to 0.0020 inch (0.038 to 0.051 mm) for No. 1 through No. 4 main bearings and 0.0025 to 0.0030 inch (0.064 to 0.076 mm) for rear main bearing.

Rear Main Bearing Oil Seal

The rear main bearing oil seal consists of a two-piece neoprene single lip seal. Correct installation of the seal is required for leak-free engine operation.

Removal

(1) Drain engine oil.

(2) Remove starter motor.

(3) Remove oil pan.

(4) Remove oil pan front and rear neoprene oil seals.

(5) Remove oil pan side gaskets.

(6) Thoroughly clean gasket mating surfaces of oil pan and engine block. Remove all sludge and residue from oil pan sump.

(7) Remove rear main bearing cap.

(8) Remove and discard lower seal.

NOTE: *To ensure leak-free operation, always replace the upper and lower seal halves as a pair.*

(9) Clean main bearing cap thoroughly to remove all sealer.

(10) Loosen all remaining main bearing capscrews.

(11) Use brass drift and hammer to tap upper seal half until sufficient portion of seal is protruding to permit pulling seal out completely.

Installation

(1) Wipe crankshaft seal surface area clean and apply light film of oil.

(2) Coat block contact surface area of replacement upper seal half with soap and lip of seal with clean engine oil (fig. 1B-150).

(3) Insert upper seal half into engine block.

NOTE: *The lip of the seal must face the front of the engine.*

(4) Coat both sides of replacement lower seal half end tabs with Jeep Gasket-in-a-Tube (RTV silicone), or equivalent. Do not apply sealer to lip of seal.

(5) Coat outer curved surface of lower seal half with soap and lip of seal with clean engine oil.

(6) Insert seal into cap recess and seat firmly.

(7) Apply Jeep Gasket-in-a-Tube (RTV silicone), or equivalent, to both chamfered edges of rear main bearing cap.

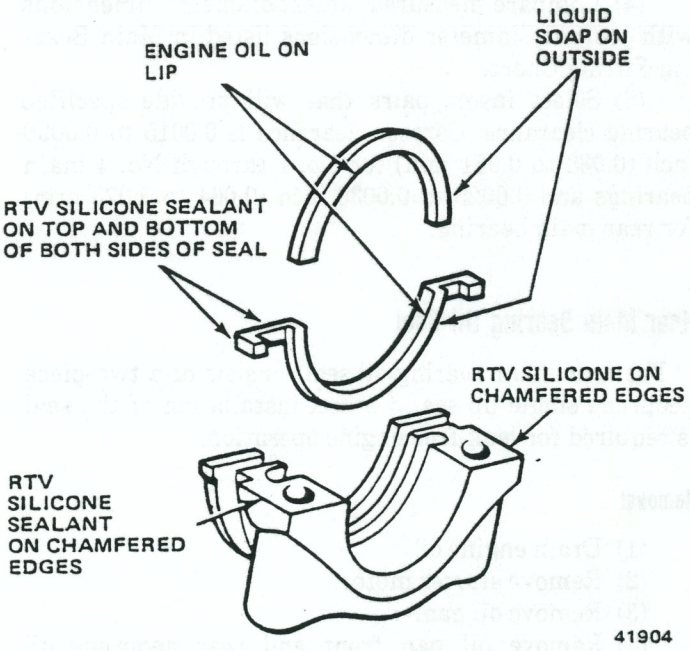

Fig. 1B-150 Rear Main Oil Seal Installation

CAUTION: *Do not apply sealer to the cylinder block mating surface of the rear main cap because bearing clearance could be affected.*

(8) Tighten all main bearing capscrews with 100 foot-pounds (136 N•m) torque.

(9) Install oil pan using replacement gaskets and seals. Tighten drain plug securely.

(10) Install starter motor.

(11) Fill crankcase to specified level with clean engine lube oil.

VIBRATION DAMPER AND PULLEY

The vibration damper is balanced independently and then rebalanced as part of the complete crankshaft assembly.

Do not attempt to duplicate original vibration damper balance holes when installing a service replacement damper. The vibration damper is not repairable and is serviced only as a complete assembly.

Removal

(1) Loosen damper retaining screw.

(2) Loosen alternator drive belt.

(3) Loosen air conditioner compressor drive belt, if equipped, and move aside.

(4) Loosen power steering pump drive belt, if equipped, and move aside.

(5) Remove damper pulley retaining bolts. Remove damper pulley from damper.

(6) Remove damper retaining screw and washer and loosely install screw to prevent damage to screw threads when removal tool is used.

(7) Use Vibration Damper Removal Tool J-21791 to remove damper from crankshaft (fig. 1B-151).

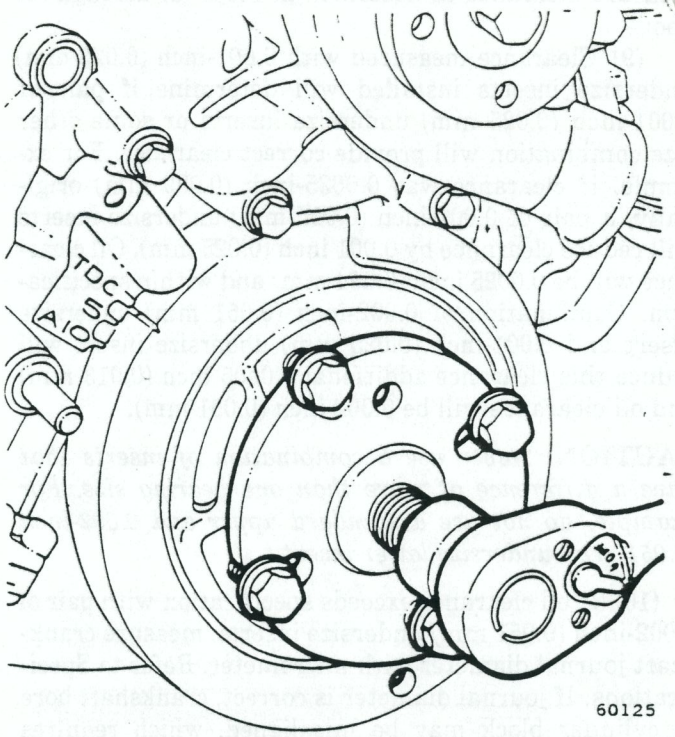

Fig. 1B-151 Vibration Damper Removal

Installation

(1) Polish damper hub with crocus cloth to prevent seal damage.

(2) Apply light film of engine oil to seal contact surface area of damper.

(3) Align key slot in damper hub with crankshaft key way.

(4) Position damper on end of crankshaft.

(5) Lubricate screw threads and washer with engine oil.

(6) Install damper retaining screw and washer and tighten with 90 foot-pounds (122 N•m) torque.

NOTE: *If crankshaft turns before specified torque is attained, proceed with belt installation. With belts installed, tighten damper retaining screw with 90 foot-pounds (122 N•m) torque.*

(7) Install damper pulley and retaining bolts. Tighten bolts with 30 foot-pounds (41 N•m) torque.

(8) Install drive belts and adjust to specified tension. Refer to Chapter 1C—Cooling Systems.

FLYWHEEL/DRIVE PLATE AND RING GEAR ASSEMBLY

The ring gear can be removed only from engines used with manual transmissions. With automatic transmissions, the ring gear is welded to and balanced as part of the drive plate and is not removeable.

Ring Gear Replacement—Manual Transmission (Flywheel Removed)

(1) Place flywheel on arbor press with steel blocks equally spaced around perimeter and under ring gear.
(2) Press flywheel down through ring gear.

NOTE: *The ring gear can also be removed by breaking it with a chisel.*

(3) Apply heat to expand inside perimeter of replacement ring gear.
(4) Press replacement ring gear onto flywheel.

NOTE: *The flywheel is balanced as an individual component and also as part of the crankshaft assembly. Do not attempt to duplicate original flywheel balance holes when installing a service replacement.*

CYLINDER BLOCK

Disassembly

(1) Drain engine oil.
(2) Remove engine assembly from vehicle as outlined in Engine Removal.
(3) Use engine stand to support engine assembly.
(4) Remove distributor.
(5) Remove cylinder head covers and gaskets.
(6) Remove bridge and pivot assemblies and rocker arms. Alternately loosen capscrews, one turn at a time, to avoid damaging bridge.
(7) Remove push rods.

NOTE: *Retain bridges, pivots, rocker arms, push rods and tappets in cylinder sets to facilitate installation in original locations.*

(8) Remove intake manifold assembly.
(9) Remove valve tappets.
(10) Remove cylinder heads and gaskets.
(11) Position pistons, one at a time, near bottom of stroke. Use ridge reamer to remove ridge, if any, from top end of cylinder walls.
(12) Loosen all drive belts. Remove power steering pump, air pump and air conditioner compressor, if equipped.
(13) Remove damper pulley and vibration damper.
(14) Remove timing case cover.
(15) Remove oil pan.
(16) Remove camshaft.
(17) Remove connecting rod bearing caps and inserts and retain in same order as removed.

NOTE: *Connecting rods and caps are stamped with the number of the associated cylinder.*

(18) Remove connecting rod and piston assemblies through top of cylinder bores. Ensure that connecting rod bolts do not scratch connecting rod journals or cylinder walls. Short pieces of rubber hose slipped over rod bolts will provide protection during removal.
(19) Remove oil pickup tube and screen assembly.
(20) Remove main bearing caps and inserts.
(21) Remove crankshaft.

Cylinder Bore Reconditioning

Cylinder Bore Measurement

Use a bore gauge to measure the cylinder bores (fig. 1B-152). If a bore gauge is not available, use an inside micrometer.

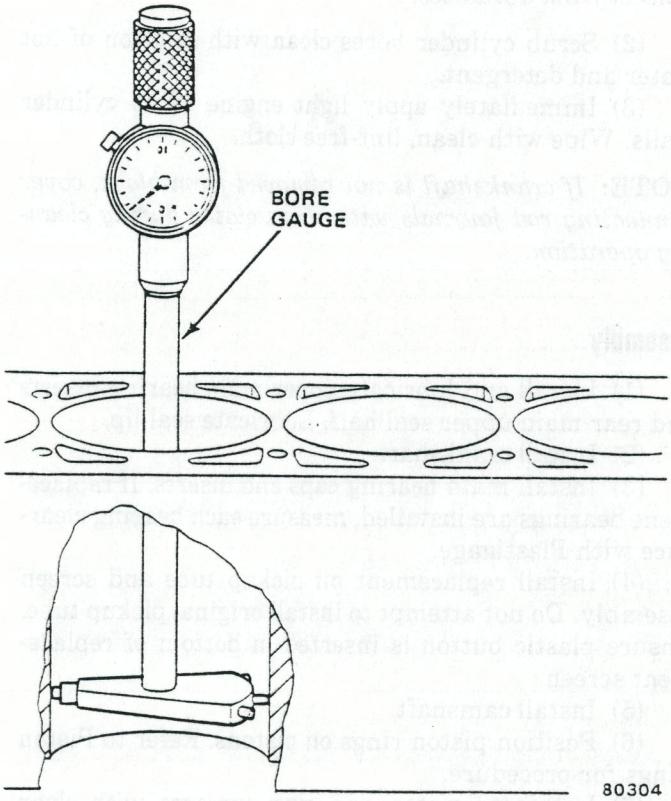

Fig. 1B-152 Measuring Cylinder Bore with Bore Gauge

(1) Measure cylinder bore crosswise to block near top of bore. Repeat measurement at bottom of bore.
(2) Determine taper by subtracting smaller dimension from larger dimension.
(3) Turn measuring device 120° and repeat step (1). Then turn another 120° and repeat measurements.
(4) Determine out-of-roundness by comparing difference between measurements taken 120° apart.

If the cylinder taper does not exceed 0.005 inch (0.127 mm) and the out-of-roundness does not exceed 0.003 inch (0.076 mm), true the cylinder bore by honing. If the cylinder taper or out-of-round condition exceeds these limits, bore and then hone cylinder for an oversize piston.

Resurfacing Cylinder Bore

CAUTION: *Do not use rigid type hones to remove cylinder glaze. A slight amount of taper always exists in cylinder walls after the engine has been in service for a period of time.*

(1) Use expanding hone to true cylinder bore and to remove glaze for faster ring seating. Move hone up and down at sufficient speed to produce uniform 60° angle crosshatch pattern on the cylinder walls. Do not use more than ten strokes per cylinder. A stroke is one down-and-up motion.

CAUTION: *Protect engine bearings and lubrication system from abrasives.*

(2) Scrub cylinder bores clean with solution of hot water and detergent.

(3) Immediately apply light engine oil to cylinder walls. Wipe with clean, lint-free cloth.

NOTE: *If crankshaft is not removed from block, cover connecting rod journals with clean cloths during cleaning operation.*

Assembly

(1) Install and lubricate upper main bearing inserts and rear main upper seal half. Lubricate seal lip.

(2) Install crankshaft.

(3) Install main bearing caps and inserts. If replacement bearings are installed, measure each bearing clearance with Plastigage.

(4) Install replacement oil pickup tube and screen assembly. Do not attempt to install original pickup tube. Ensure plastic button is inserted in bottom of replacement screen.

(5) Install camshaft.

(6) Position piston rings on pistons. Refer to Piston Rings for procedure.

(7) Lubricate piston and ring surfaces with clean engine oil.

(8) Use piston ring compressor tool to install connecting rod and piston assemblies through top of cylinder bores. Ensure that connecting rod bolts do not scratch connecting rod journals or cylinder walls. Short lengths of rubber hose slipped over connecting rod bolts will provide protection during installation.

(9) Install connecting rod bearing caps and inserts in same location as removed. Tighten nuts with 33 foot-pounds (45 N•m) torque.

(10) Install camshaft and crankshaft sprockets and timing chain as an assembly.

(11) Install timing case cover and gaskets. Refer to Timing Case Cover for procedure.

(12) Install engine oil pan using replacement gaskets and seals. Tighten drain plug securely.

(13) Install vibration damper and damper pulley.

(14) Install cylinder heads with replacement gaskets.

(15) Install valve tappets.

(16) Install intake manifold with replacement gasket.

(17) Install push rods.

(18) Install rocker arms and bridge and pivot assemblies. Loosely install capscrews through each bridge and then alternately tighten capscrews, one turn at a time, to avoid damaging bridge. Tighten capscrews with 19 foot-pounds (26 N•m) torque.

(19) Turn crankshaft to position No. 1 piston at TDC on compression stroke.

(20) Reseal and install cylinder head covers.

(21) Install power steering pump, air pump and air conditioner compressor.

(22) Install distributor.

(a) Point rotor at No. 1 spark plug firing position.

(b) Turn oil pump drive shaft with long screw driver to engage with distributor shaft.

(c) With rotor pointing at No. 1 spark plug firing position, rotate distributor housing counterclockwise until leading edge of trigger wheel segment is aligned with center of sensor. Tighten distributor hold-down clamp.

NOTE: *When engine is installed and operating, check ignition timing as outlined in Chapter 1A—General Service and Diagnosis.*

(23) Remove engine from stand.

(24) Install engine assembly as outlined in Engine Installation.

SPECIFICATIONS

Eight-Cylinder Engine Specifications

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Bore		
304	3.75	95.25
360	4.08	103.63
Stroke		
304	3.44	87.38
360	3.44	87.38
Displacement		
304	304 cu.in.	5 liter
360	360 cu.in.	6 liter
Compression Ratio		
304	8.40:1	
360	8.25:1	
Compression Pressure		
304	120 - 140 psi (min)	827-1034 kPa
360	120 - 140 psi (min)	827-1034 kPa
Maximum Variation Between Cylinders	30 psi	206 kPa
Taxable Horsepower		
304	45.00	33.56 kW
360	53.27	39.72 kW
Fuel	unleaded	
Camshaft		
Fuel Pump Eccentric Diameter	2.182-2.192	55.423-55.677
Tappet Clearance	Zero lash (hydraulic tappets)	
End Play	Zero (engine operating)	
Bearing Clearance	0.001-0.003 (0.0017-0.0020 preferred)	0.0254-0.0762 (0.0432-0.0508 preferred)
Bearing Journal Diameter		
No. 1	2.1195-2.1205	53.835-53.861
No. 2	2.0895-2.0905	53.073-53.099
No. 3	2.0595-2.0605	52.311-52.337
No. 4	2.0295-2.0305	51.549-51.575
No. 5	1.9995-2.0005	50.787-50.813
Maximum Base Circle Runout	0.001	0.0254
Cam Lobe Lift		
304/360	0.266	6.7564
Intake Valve Timing		
Opens 304/360	14.75° BTDC	
Closes 304/360	68.75° BTDC	
Exhaust Valve Timing		
Opens 304/360	56.75° BBDC	
Closes 304/360	26.75° ATDC	
Valve Overlap		
304/360	41.50°	
Intake Duration		
304/360	263.50°	
Exhaust Duration		
304/360	263.50°	

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Connecting Rods		
Total Weight (Less Bearings)		
304/360	681-689 grams	
Total Length (Center-to-Center)		
304/360	5.873-5.877	149.17-149.28
Bearing Clearance	0.001-0.003 (0.0020-0.0025 preferred)	0.03-0.08 (0.051-0.064 preferred)
Side Clearance	0.006-0.018	0.15-0.46
Maximum Twist	0.0005 per inch	0.013 per 25.4 mm
Maximum Bend	0.001 per inch	0.03 per 25.4 mm
Crankshaft		
End Play	0.003-0.008	0.08-0.20
Main Bearing Journal Diameter		
No. 1, 2, 3, 4	2.7474-2.7489	69.784-69.822
Rear Main	2.7464-2.7479	69.759-69.797
Main Bearing Journal Width		
304/360		
No. 1	1.2635-1.2695	32.093-32.25
No. 2	1.246-1.248	31.65-31.70
No. 3	1.273-1.275	32.33-32.39
No. 4	1.246-1.248	31.65-31.70
No. 5	1.215-1.217	30.86-30.91
Main Bearing Clearance		
No. 1, 2, 3, 4	0.001-0.003 (0.0017-0.0020 preferred)	0.03-0.08 (0.04-0.05 preferred)
Rear Main		
No. 5	0.002-0.004 (0.0025-0.003 preferred)	0.05-0.10 (0.06-0.08 preferred)
Connecting Rod Journal Diameter		
304/360	2.0934-2.0955	53.172-53.266
Connecting Rod Journal Width		
304/360	1.998-2.004	50.75-50.90
Connecting Rod Bearing		
Clearance	0.001-0.003 (0.0020-0.0025 preferred)	0.03-0.08 (0.051-0.064 preferred)
Maximum Taper (All Journals)	0.0005	0.013
Maximum Out-of-Round (All Journals)	0.0005	0.013
Cylinder Block		
Deck Height	9.205-9.211	233.81-233.96
Deck Clearance		
304/360	0.0145 (below block)	0.368 (below block)

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Eight-Cylinder Engine Specifications (Continued)

	(USA) Inches Unless Otherwise Specified	(METRIC) Millimeters Unless Otherwise Specified
Maximum Cylinder Taper	0.005	0.13
Maximum Cylinder Out-of-Round	0.003	0.08
Tappet Bore Diameter	0.9055-0.9065	22.999-23.025
Cylinder Block Flatness	0.001/1-0.002/6 0.008 (max)	0.03/25-0.05/152 0.20 (max)
Cylinder Head		
Combustion Chamber Volume		
304	57.42-60.42 cc	
360	58.62-61.62 cc	
Valve Arrangement	EI-IE-EI-IE	
Valve Guide ID (Integral)	0.3735-0.3745	9.487-9.512
Valve Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
Intake Valve Seat Angle	30°	
Exhaust Valve Seat Angle	44.5°	
Valve Seat Width	0.040-0.060	1.02-1.52
Valve Seat Runout	0.0025 (max)	0.064 (max)
Cylinder Head Flatness	0.001/1-0.002/6 0.008 (max)	0.03/25-0.05/152 0.20 (max)
Lubrication System		
Engine Oil Capacity	4 quarts (add 1 quart with filter change)	3.8 liters (add 0.9 liters with filter change)
Normal Operating Pressure	13 psi at 600 rpm 37-75 psi at 1600+ rpm	90 kPa at 600 rpm 255-517 kPa at 1600+ rpm
Oil Pressure Relief	75 psi (max)	517 kPa (max)
Gear-to-Body Clearance	0.0005-0.0025 (0.0005 preferred)	0.013-0.064 (0.013 preferred)
Gear End Clearance, Feeler Gauge	0.004-0.008 (0.008 preferred)	0.010-0.2 (0.10 preferred)
Gear End Clearance, Plastigage	0.002-0.008 (0.002 preferred)	
Pistons		
Weight (Less Pin)		
304	1.1-1.12 lbs	506-510 grams
360	1.32-1.33 lbs	601-605 grams
Piston Pin Bore CL-to Piston Top		
304/360	1.599-1.603	40.62-40.72
Piston-to-Bore Clearance		
304	0.0010-0.0018 (0.0014 preferred)	0.025-0.46 (0.035 preferred)
360	0.0012-0.0020 (0.0016 preferred)	0.030-0.051 (0.041 preferred)
Piston Ring Gap Clearance		
No. 1 and No. 2	0.010-0.020 (0.010-0.012 preferred)	0.25-0.51 (0.25-0.305 preferred)
Oil Control Steel Rail		
304	0.010-0.025	0.25-0.64
360	0.015-0.045 (0.010-0.020 preferred)	0.38-1.14 (0.25-0.51 preferred)
Piston Ring Side Clearance		
340		
No. 1	0.0015-0.0035 (0.0015 preferred)	0.038-0.089 (0.038 preferred)
No. 2	0.0015-0.003 (0.0015 preferred)	0.038-0.076 (0.038 preferred)
Oil Control	0.0011-0.008	0.028-0.203
360		
No. 1	0.0015-0.003 (0.0015 preferred)	0.038-0.076 (0.038 preferred)
No. 2	0.0015-0.0035 (0.0015 preferred)	0.038-0.089 (0.038 preferred)
Oil Control	0.000-0.007	0.000-0.18
Piston Ring Groove Height		
No. 1 and No. 2	0.0795-0.0805	2.019-2.045
Oil Control	0.1880-0.1895	4.775-4.813
Piston Ring Groove Diameter		
304		
No. 1 and No. 2	3.328-3.333	84.53-84.66
Oil Control	3.329-3.339	84.56-84.81
360		
No. 1 and No. 2	3.624-3.629	92.05-92.18
Oil Control	3.624-3.635	92.05-92.33
Piston Pin Diameter		
304/360	0.9308-0.9313	23.649-23.655
Piston Pin Bore Diameter		
304/360	0.9288-0.9298	23.592-23.617
Piston-to-Pin Clearance	0.0003-0.0005 (0.005 preferred) loose	0.008-0.013 (0.013 preferred) loose
Piston Pin-to-Connecting Rod Fit	2000 lbf Press-Fit	8900 N Press-Fit
Rocker Arms, Push Rods, and Tappets		
Rocker Arm Ratio	1.6:1	
Push Rod Length	7.790-7.810	197.87-198.37
Push Rod Diameter	0.312-0.315	7.93-8.00
Hydraulic Tappet Diameter	0.9040-0.9045	22.962-22.974
Tappet-to-Bore Clearance	0.001-0.0025	0.025-0.064
Valves		
Valve Length		
(Tip-to-Gauge Dim. Line)	4.7895-4.8045	121.653-122.034
Valve Stem Diameter	0.3715-0.3725	9.436-9.462
Stem-to-Guide Clearance	0.001-0.003	0.03-0.08
Intake Valve Head Diameter		
304	1.782-1.792	45.26-45.52
360	2.020-2.030	51.31-51.56
Intake Valve Face Angle	29°	
Exhaust Valve Head Diameter		
304	1.401-1.411	35.59-35.84
360	1.675-1.685	42.55-42.80
Exhaust Valve Face Angle	44°	
Valve Springs		
Free Length	1.99	50.55
Spring Tension		
Valve Closed	64-72 lbf at 1.786	282-317 N at 45.36
Valve Open	202-220 lbf at 1.356	889-968 N at 34.44
Inside Diameter (All)	0.948-0.968	24.08-24.59

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Torque Specifications

Service Set-To Torques should be used when assembling components. Service In-Use Recheck Torques should be used for checking a pre-torqued item.

	USA (ft-lbs)		Metric (N·m)	
	Service Set-To Torque	Service In-Use Recheck Torque	Service Set-To Torque	Service In-Use Recheck Torque
Air Injection Tube-to-Manifold	38	30-45	52	41-61
Air Pump-to-Bracket Pivot Screw	20	15-22	27	20-30
Air Pump Brackets-to-Engine—AC Compressor or Pedestals	25	18-28	34	24-38
Air Pump Adjusting Strap-to-Pump	20	15-22	27	20-30
Alternator Pivot Bolt or Nut	28	20-35	38	27-47
Alternator Adjusting Bolt	18	15-20	24	20-27
Alternator Mounting Bracket Bolt-to-Engine	28	23-30	38	31-41
Alternator Pivot Mounting Bolt-to-Head	33	30-35	45	41-47
Block Heater Nut, T-Screw Type	20 in-lbs	17-25 in-lbs	2	2-3
Camshaft Gear Retainer Screw	30	25-35	41	34-47
Carburetor Adapter-to-Manifold Screws—2V	14	12-15	19	16-20
Carburetor Holddown Nuts	14	12-15	19	16-20
Connecting Rod Bolt Nuts	33	30-35	45	41-47
Crankshaft Pulley-to-Damper	23	18-28	31	24-38
Cylinder Head Capscrews	110	100-120	149	136-163
Cylinder Head Cover Screws	50 in-lbs	42-58 in-lbs	6	5-7
Distributor Clamp Screw	20	18-24	18	14-24
Drive Plate-to-Converter Screw	22	20-25	30	27-34
EGR Valve-to-Manifold	13	9-18	18	12-24
Exhaust Manifold Screws				
Center (2)	25	20-30	34	27-41
Outer (4)	15	12-18	20	16-24
Exhaust Pipe-to-Manifold Nuts	20	15-25	27	20-34
Fan and Hub Assembly Bolts	18	12-25	24	16-34
Flywheel or Drive Plate-to-Crankshaft	105	95-115	142	129-156
Front Support Cushion Bracket-to-Block Screw	35	25-40	47	34-54
Front Support Cushion-to-Bracket-to-Frame	37	30-45	50	41-61
Fuel Pump Screws	16	13-19	22	18-26
Idler Pulley Bearing Shaft-to-Bracket Nut	33	28-38	45	38-52
Idler Pulley Bracket-to-Front Cover Nut	7	4-9	9	5-12
Intake Manifold Screws	43	37-47	58	50-64
Main Bearing Capscrews	100	90-105	136	122-142
Oil Pump Cover Screws	55 in-lbs	45-65 in-lbs	6	5-7
Oil Pan Screws				
1/4 inch - 20	7	5-9	9	7-12
5/16 inch - 18	11	9-13	15	12-18
Oil Relief Valve Cap	28	22-35	38	30-47
Power Steering Pump Adapter Screw	23	18-28	31	24-38
Power Steering Pump Bracket Screw	43	37-47	58	50-64
Power Steering Pump Mounting Screw	28	25-35	38	34-47
Rear Crossmember-to-Side Sill Nut	30	20-35	41	27-47
Rear Insulator Bracket-to-Trans. Screw	33	27-38	45	37-52
Rear Support Insulator-to-Bracket Nut	48	40-55	65	54-75
Rear Support Cushion-to-Crossmember Screw Nut	18	12-25	24	16-34
Rocker Arm Capscrew	19	16-26	26	22-35
Spark Plugs	28	22-33	38	30-45
Starter Motor to Converter Housing Screws	18	13-25	24	18-34
Thermostat Housing Screw	13	10-18	18	14-24
Throttle Valve Rod Adjusting Screw	40 in-lbs	30-50 in-lbs	5	3-6
Timing Case Cover-to-Block	25	18-33	34	24-45
Vibration Damper Screw (Lubricated)	90	80-100	122	108-136
Water Pump Screws	48 in-lbs	40-55 in-lbs	5	5-6

All Torque values given in foot-pounds and newton-meters with dry fits unless otherwise specified.
Refer to the Standard Torque Specifications and Capscrew Markings Chart in Chapter A of this manual for any torque specifications not listed above.

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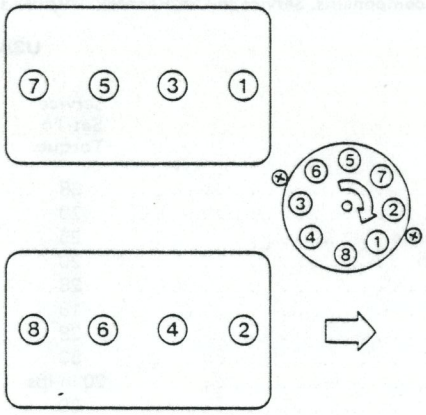
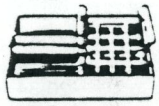
Eight-Cylinder Engine
Firing Order

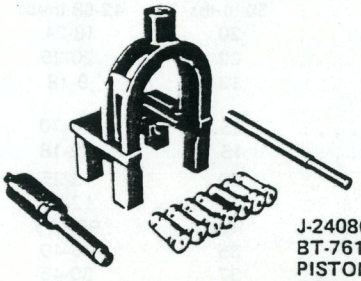


Tools

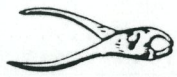
Four-Cylinder Engine



J-5821
VALVE LIFTER
CLEANING TANK



J-24086
BT-7612
PISTON PIN
TOOL

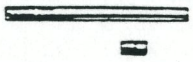


J-3049
VALVE LIFTER
REMOVER

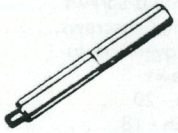
J-8087
CYLINDER BORE
CHECKING GAUGE
(RANGE 2-1/2"–9")

J-5830
VALVE GUIDE
REAMER SET

J-21473-1
CAMSHAFT BUSHING
REMOVER & INSTALLER
ADAPTER (USE WITH
J-21054-1)



J-6305-11
CONNECTING ROD
BOLT GUIDE SET



J-21054-1
HANDLE (CAMSHAFT
BUSHING REMOVER
& INSTALLER) (USE
WITH J-21473-1)

J-22330
VALVE SEAL
INSTALLER &
TESTER

J-8101
VALVE GUIDE
CLEANING TOOL

J-23042
TIME COVER
SEAL ALIGNER
& INSTALLER

J-22794
AIR LINE
ADAPTER

J-4160
HYDRAULIC VALVE
LIFTER PLUNGER
REMOVER

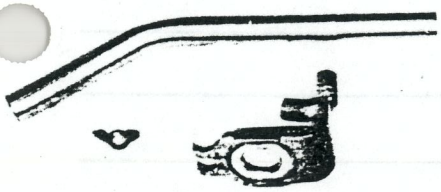
J-5569
PISTON RING
COMPRESSOR
(4")

J-5892-1
VALVE SPRING
COMPRESSOR

50428B

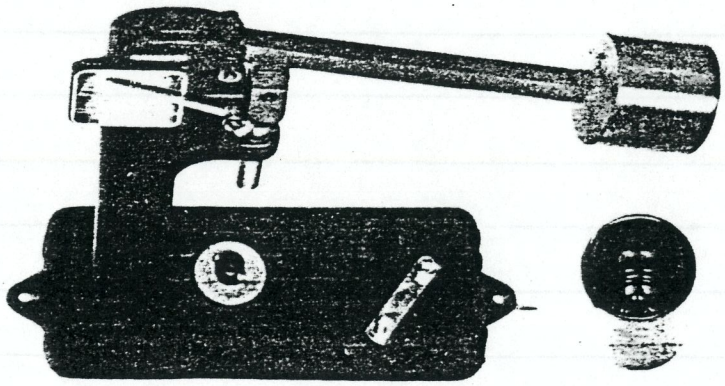
Tools

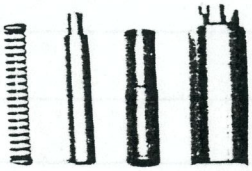
Six- and Eight-Cylinder Engine



J-22534-1
VALVE SPRING
REMOVER AND
INSTALLER

J-21791
VIBRATION DAMPER
REMOVER

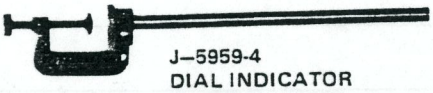




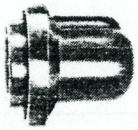
J-21872
PISTON PIN REMOVER AND INSTALLER

J-26562
TIMING CASE COVER
OIL SEAL INSTALLER

J-5790
HYDRAULIC VALVE LIFTER TESTER

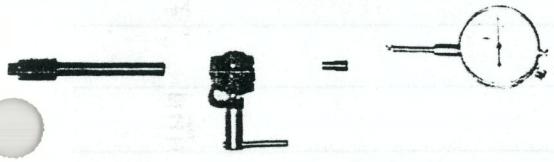


J–5959-4
DIAL INDICATOR
CLAMP AND ROD

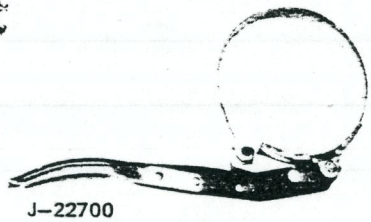


J-26562
OIL SEAL INSTALLER

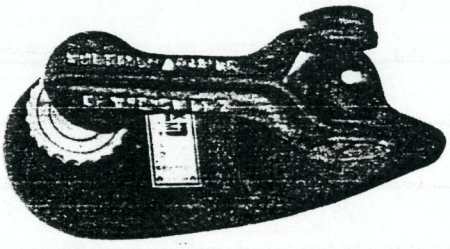
J–6042-1, 4, 5
VALVE GUIDE REAMERS



J–8520
DIAL INDICATOR SET
(0-1 INCH -.001 INCH GRADUATION)



J–22700
OIL FILTER WRENCH



J–8056
VALVE AND CLUTCH
SPRING TESTER

J-22248
TIMING CASE COVER
ALIGNMENT TOOL AND
SEAL INSTALLER

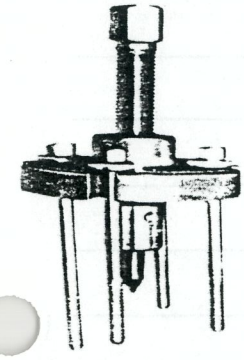
SCREW, TIMING CASE
COVER CRANKSHAFT
SEAL INSTALLER
PART OF TOOL J-9163

J-21882
OIL PUMP INLET
TUBE INSTALLER

J-9256 TIMING CASE COVER
OIL SEAL REMOVER

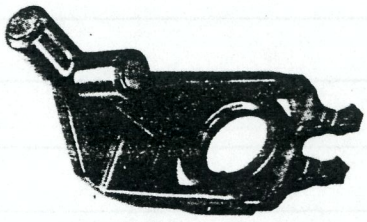
J-5601
PISTON RING
COMPRESSOR 3-3/4"

J-6042-1,4,5
VALVE GUIDE REAMERS



J-21791 VIBRATION
DAMPER REMOVER

J-21884 HYDRAULIC VALVE TAPPET
REMOVER AND INSTALLER



TOOL J-22534-1
VALVE SPRING REMOVER
AND INSTALLATION TOOL

TOOL
J-22534-4

TOOL
J-22534-5

J-22534 VALVE SPRING REMOVER AND INSTALLATION TOOL

90197

NOTES