SECTION 6A6

ISUZU ENGINE

NOTICE: When fasteners are removed, always reinstall them at the same location from which they were removed. If a fastener needs to be replaced, use the correct part number fastener for that application. If the correct part number fastener is not available, a fastener of equal size and strength (or stronger) may be used. Fasteners that are not reused, and those requiring thread locking compound will be called out. The correct torque value must be used when installing fasteners that require it. If the above conditions are not followed, parts or system damage could result.

CONTENTS

GENERAL INFORMATION

STATEMENT ON CLEANLINESS AND CARE

- An engine is a combination of many machined, honed, polished, and lapped surfaces with very fine tolerances.
- Whenever valve train components, cylinder head, cylinder, crankshaft, or connecting rod components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.
- Any time the air cleaner or hose or connection is removed, the intake opening must be covered. This will protect against the entrance of foreign material which could follow the intake passage into the cylinder and cause extensive damage when the engine is started.
- When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not specifically stated.
- Whenever the fuel injection pump or line are removed or disconnected, care must be taken to prevent the entry of dirt into the pump, lines, and injectors. The entry of even a small amount of dirt or other foreign material into the fuel injection system may cause serious damage.
- It should be kept in mind, while working on the engine, that the 12-volt electrical system is capable of violent and damaging short circuits. When performing any work where electrical terminals could possibly be grounded, the ground cable of the battery should be disconnected at the battery.
- Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to wire harness or other electrical parts.
- Cover or otherwise protect exposed electrical connections to prevent damage from oil and fuel.
- When raising or supporting the engine for any reason, do not use a jack under the oil pan. due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause it to be bent against the pump screen resulting in a damaged oil pickup unit.

DESCRIPTION

The Isuzu model 4BD2-TC engine is used in vehicles covered by this manual.

The engine is an in-line, four-fuel cylinder, four-stroke, water-cooled and in-direct-fuel-injection, turbocharged diesel. The bore is 102 mm (4.02 in); the stroke is 118 mm (4.65 in). The total displacement is 3.856 liter (235.3 cu.in.). The compression ratio is 21:1.

The forged crankshaft is supported by five precision insert main bearings. Crankshaft thrust is taken at the #4 main bearing.

The connecting rods have precision insert-type crankpin bushings (rod bearing).

The piston pins are retained by snap rings.

The pistons have two compression rings and one oil control ring. The pistons are cooled by oil jets.

Dry-type liners are used. The liners are chromefaced for long life.

The camshaft is supported by three plain bearings. The camshaft is gear driven. Motion is transferred to the overhead valves by flat-faced, cylindrical, solid valve lifters, pushrods, and shaft-type, adjustable rocker arms.

The cylinder head is rebuildable, with replaceable valve guides and seats.

LUBRICATION SYSTEM

A gear-type oil pump is used. The engine is equipped with both full-flow and bypass filters. An oil cooler is provided to help cool oil temperatures. Major moving parts are supplied with oil from a large oil gallery in the cylinder block. The lubrication schematic is shown in figure 1.

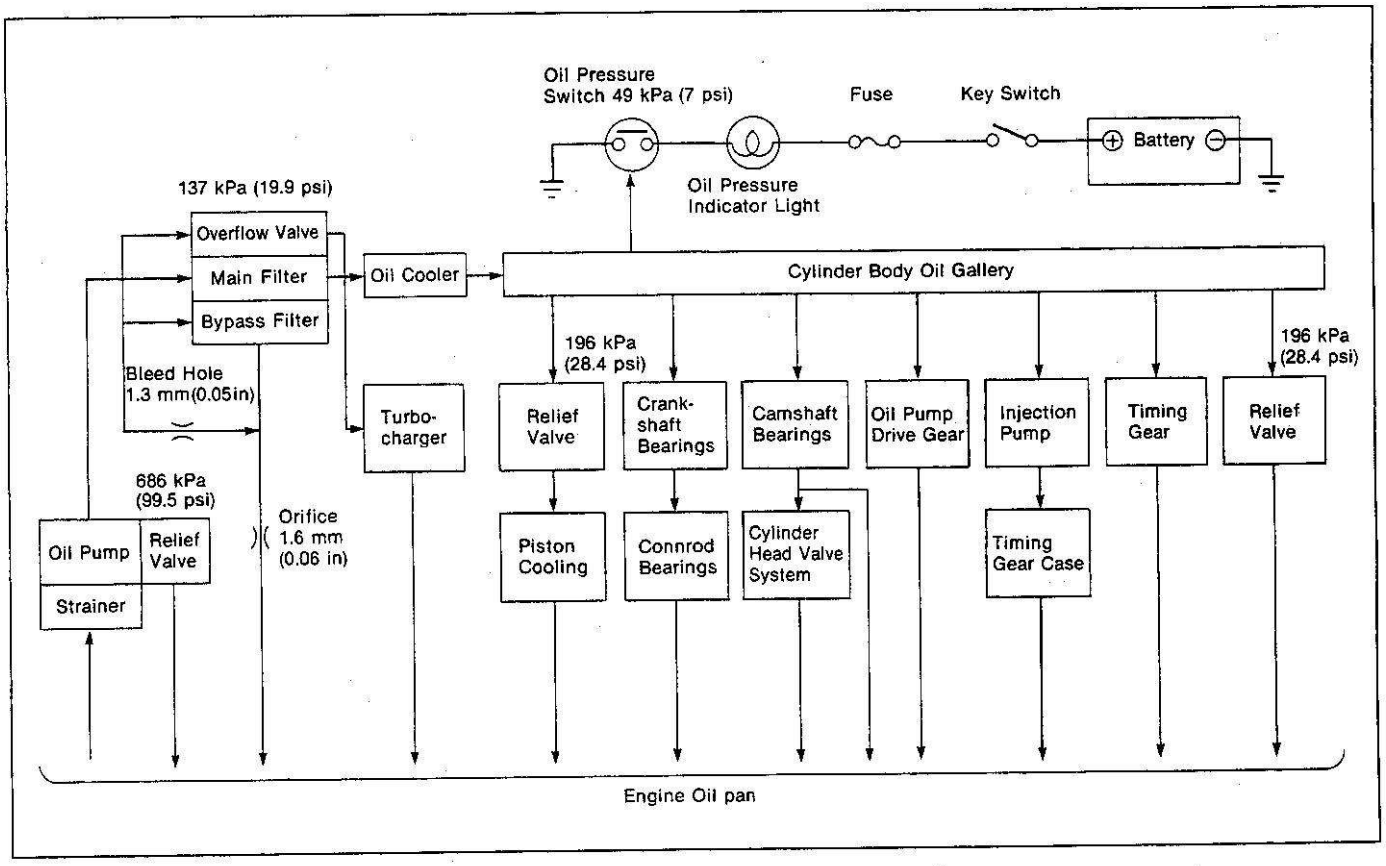


Figure 1. Lubrication System Schematic

DIAGNOSIS OF ISUZU DIESEL ENGINE

ENGINE WILL NOT TURN OVER

1. Dead or weak battery.
2. Loose or Corroded connections in starter circuit. Check battery terminals, starter motor Connections, etc.
3. Faulty starter or solenoid.
4. Faulty or broken wiring or engine control switch.
5. Hydrostatic lock (llquid in combustion chambers). Remove the injectors and check for presence of fluid.
6. Seized pistons, bearings, etc.

ENGINE TURNS OVER SLOWLY BUT DOES NOT START

1. Weak battery.
2. Corroded or poor connections in starter circuit. Check battery terminals, starter motor connections, etc.
3. Faulty starter motor.
4. Undersized battery or cable.
5. Oil viscosity too heavy.
6. Tight bearings, pistons, etc.

ENGINE CRANKS NORMALLY BUT DOES NOT START

1. Fuel tank empty.
2. Engine stopper fuse blown.
3. Check for fuel flow at the injector lines. Loosen all the fuel lines at the fuel injector. Crank the engine and observe the fuel flow.
   If there is fuel flow, bleed the lines until free of air bubbles and retighten the fittings.
   If there is no fuel flow:
   a. Fuel filter clogged. In low temperature conditions, this may be caused by fuel waxing.
      Replace the filter and bleed the system. Use winter grade fuel if necessary.
   b. Restricted or kinked fuel lines. Replace, reroute or repair as necessary.
   c. Fuel lines leaking. Check all fittings and tighten as necessary.
   d. Transfer (lift) pump faulty.
4. Air filter clogged.
5. Air inlet tube clogged.
6. No compression due to stuck valves, broken pistons, etc. Perform the "Compression Check" later in this section.
7. Engine stopper faulty.
8. Low or no voltage to glow plugs.

ENGINE CRANKS NORMALLY BUT IS DIFFICULT TO START

1. Air in the fuel system. Bleed the system as outlined in DIESEL FUEL INJECTION (SEC. 6C3) in this manual.
2. Restricted or insufficient fuel supply.
   a. Clogged fuel filter. In low temperature conditions, this may be caused by fuel waxing.
      Replace the filter and bleed the system as outlined in DIESEL FUEL INJECTION (SEC. 6C3) in this manual. Use winter grade fuel if necessary.

INCONSISTENT IDLE SPEED (ENGINE "LOPES")

1. Idle speed set too low.
2. Burned, leaking or sticking valves. Perform the "Compression Check" later in this section.
3. Incorrect valve adjustment.
4. Incorrect injection timing.
5. Restricted exhaust.
6. Camshaft lobes worn.
7. Faulty governor. Have inspected by a qualified technician.

ENGINE MISSES AT IDLE

Fuel System Problems

1. Faulty injector.
2. Poor quality fuel.
3. Dirty air cleaner.
4. Faulty injection pump.

Mechanical Problems

1. Low compression due to leaky valves, broken rings, etc. Perform the "Compression Check" later in this section.
2. Incorrect valve adjustment.
3. Exhaust restriction.
4. Leaky valve guide(s).
5. Worn camshaft lobe(s).
6. Intake restriction.

ENGINE MISSES AT HIGH SPEEDS

Fuel System Problems

1. Restricted fuel filter.
2. Plugged air cleaner.
3. Poor quality fuel.
4. Faulty fuel pump.

5. Intermittent or insufficient delivery of fuel to the injection pump caused by restricted lines, etc.
6. Faulty injectors.
7. Faulty injection pump.

Mechanical Problems

1. Restricted exhaust system.
2. Incorrect valve adjustment.
3. Sticking valves.
4. Broken or weak valve springs.

ENGINE MISSES AT ALL SPEEDS

Fuel System Problems

1. Water or dirt in fuel.
2. Dirty air filter.
3. Fuel filter plugged.
4. Poor quality fuel.
5. Faulty fuel (transfer) pump.
6. Clogged or faulty injectors.
7. Faulty fuel injection pump. Have inspected by a qualified technician.

Mechanical Problems

1. Low compression. Perform the "Compression Check" later in this section. Some causes of low compression are:
   a. Sticking valves.
   b. Broken valve spring.
   c. Valve held open by improper adjustment or binding valve train.
2. Restricted exhaust.
3. Engine brake exhaust valve stuck shut.
4. Worn camshaft lobes.

ENGINE MISSES ON ONE CYLINDER

1. Faulty or plugged injector.
2. Stuck valve.
3. Broken valve spring.
4. Broken or faulty rings or piston. Perform the "Compression Check" later in this section.

LACK OF POWER OR PERFORMANCE

If applicable, also refer to "Excessive Exhaust Smoke" later in this section.

Fuel System Problems

1. Dirty air cleaner.
2. Accelerator linkage binding, loose or improperly adjusted. This may not allow full fuel delivery from injection pump.
3. Fuel supply not sufficient. Replace the fuel filter and bleed the fuel system. Tighten fuel line connections.
4. Fuel lines restricted.
5. Faulty fuel (transfer) pump.
6. Poor quality fuel.
7. Improper injection pump timing.
8. Pressure relief valve on injection pump not working properly. Replace.
9. Faulty fuel injectors, or injection pump. Have inspected by a qualified technician.

Mechanical Problems

1. Poor engine compression. Perform the "Compression Check" later in this section.
2. Exhaust brake valve stuck shut.
3. Burned or sticking valves. Weak valve springs.
4. Incorrect valve adjustment.
5. Incorrect valve timing.
6. Worn camshaft lobes.
7. Faulty turbocharger.
8. Air leaks at turbocharger turbine housing or intake manifold.
9. Air filter plugged.
10. Restricted exhaust system.

Miscellaneous Problems

1. Engine overheating.
2. Preignition.
3. Clutch slippage.
4. Excessive rolling resistance due to dragging brakes, tight wheel bearings, underinflated tires, etc.
5. Incorrect rear axle ratio.
6. Oversize tires.
7. Inaccurate speedometer (gives impression of lack of performance).
8. Overloaded vehicle.
9. Excessive exhaust back pressure.

EXCESSIVE EXHAUST SMOKE

Black or Gray Smoke

1. Improper or poor fuel.
2. Excess or irregular fuel delivery. Have the injection pump inspected by a qualified technician.
3. Air filter clogged.
4. Valve clearance incorrect. Adjust as outlined later in this section.
5. Fuel injection pump aneroid improperly adjusted, or damaged (California and high-altitude certified engines only). Have inspected by a qualified technician.
6. Fuel injection nozzle restricted.
7. Injection pump improperly timed.
8. Malfunctioning turbocharger.

Blue Smoke

Generally caused by the presence of lube oil in the combustion chambers resulting from:

1. Too much lube oil in crankcase.
2. Air cleaner restriction.
3. Valve guide seals faulty.
4. Excessive crankcase pressure due to clogged breather or breather tube.
5. Worn pistons or rings. Perform the "Compression Check" later in this section.
6. Connecting rod (big end) bearing clearance excessive.
7. Internal turbocharger seal leakage.

White Smoke

1. Improper fuel.
2. Leakage between cylinder and head.
3. Low compression (usually a valve problem).
4. Incorrect injection and pump timing.

ENGINE FAILS TO REACH OPERATING TEMPERATURE

1. Faulty engine coolant temperature gage or sending unit.
2. Faulty cooling system thermostat.

ENGINE OVERHEATS

1. Low oil level. Improper grade or type of oil used.
2. Cooling fan belts broken.
3. Use of a winter front.
4. Faulty engine coolant temperature gage or sending unit.
5. Faulty cooling system thermostat.
6. Excessive exhaust back pressure.
7. Excessive rolling friction due to dragging brakes, low tire pressure, etc.
8. Excessive engine friction due to tight pistons, bearings, etc.
9. Exhaust brake valve stuck shut.
10. Plugged radiator or deposits on water jacket walls.

LOW OIL PRESSURE

Shut The Engine Down Immediately

1. Low oil level.
2. Improper oil type or viscosity.
3. Overheated engine.
4. Loose connections in oil lines.
5. Oil pump screen or pickup tube clogged.
6. Air leak in oil pump. May be caused by improper assembly, loose oil pickup tube, or loose cover.
7. Faulty pressure sending unit.
8. Excessive main bearing clearance.
9. Malfunctioning oil pump. Replace.
10. Oil gallery plug missing.
11. Relief valve stuck open.

HIGH OIL PRESSURE

1. Oil too heavy.
2. Main oil galleries on the pump pressure side plugged.
3. Oil pressure relief valve clogged. Relief valve spring too strong.
4. Sending unit or gage faulty.

BURNED, STICKING OR BROKEN VALVES

1. Overspeeding of the engine.
2. Improper valve adjustment.
3. Excessive exhaust back pressure.
4. Weak valve springs.
5. Improper valve face width.
6. Incorrect valve seat width.
7. Out-of-round valve seats.
8. Deposits on valve seats, valve guides, or valve stems.
9. Warped valves.
10. Broken valve guide.

EXCESSIVE FUEL CONSUMPTION

There are a number of factors that will contribute to excessive fuel consumption. One of the most important of these is the driving habits of the operator.

When the operator habitually makes "jack-rabbit" starts and stops, "rides" the brake (or clutch) pedal, overloads the vehicle, drives at excessively high speed for prolonged periods, fails to hold a consistent throttle position (continuously accelerates, then coasts) and/or operates the vehicle under short run conditions (cold engine) the majority of the time, this could be the problem.

Vehicle air resistance at high speeds has a major effect on fuel consumption. Head winds, excessively high speeds, or added frontal area will cause an increase in fuel consumption.

When it has been determined that the operator is not at fault, make a fuel consumption test using a calibrated fuel measuring device. The amount of fuel used to drive the vehicle a measured distance should be recorded.

Then record the amount of fuel used to return to the starting point. An average of the two readings should be used in determining the fuel consumption. The vehicle odometer should be checked over a measured mile for proper calibration.

If it has been determined that a problem does exist, refer to the following:

Fuel System Problems

1. Loose fittings or leaking hoses.
2. Fuel tank cap missing.
3. Clogged air cleaner.
4. Faulty fuel injection nozzle or injection pump.

Mechanical Problems

1. Clutch slippage.
2. Excessive rolling resistance (low tires, dragging brakes, etc.).
3. Incorrect valve adjustment.
4. Excessive exhaust back pressure.
5. Loss of compression, due to worn rings, pistons, burned valves, etc. Perform the "Compression Check" later in this section.
6. Improper rear axle ratio.
7. Wrong speedometer gear.
8. Improper tire size.

EXCESSIVE OIL CONSUMPTION

Internal Leakage

1. Poor quality oil. A poor quality oil may become too thin when the engine is hot.
2. Improper oil viscosity.
3. Oil dilution due to faulty fuel injection pump or fuel pump.
4. Excessive crankcase pressure.
5. Excessive valve-to-valve guide clearance and/or faulty valve guide seals.
6. Worn pistons or piston rings. Piston rings stuck in their grooves.
7. Excessive connecting rod bearing clearance.
8. Internal turbocharger leaks:
   a. Internal turbocharger seal leakage on the turbine (exhaust) side. Check the oil drain line for blockage. If none is found, check the crankcase breather and tube for clogging or other obstruction. If none is found, check for excessive ring blow-by. If these items are satisfactory, the turbocharger internal seals are faulty. Replace the turbocharger.
   b. Internal turbocharger seal leakage on the compressor (intake) side. Check for a plugged air filter or obstruction in the air inlet pipe. If not found, the turbocharger internal seals are faulty. Replace the turbocharger.

External Leakage

Recurring external oil leaks from gaskets or seals may be caused by excessive crankcase pressure due to blocked crankcase breather or vent hose. It is a good practice to check the oil level, breather and hose whenever a seal or gasket leakage problem occurs.

Check gasket and seal areas to determine the point of leakage. Replace parts as necessary.

ENGINE NOISES

When diagnosing engine noise problems, be careful that noises caused by accessories are not mistaken for engine noise. Removal of accessory drive belts will eliminate any noises caused by these units.

In general, engine noises are either synchronized to engine speed or one-half engine speed. Those that are timed to engine speed are sounds that have to do with the crankshaft, rods, pistons, and wrist pins.

The sounds emitted at one-half engine speed are valve train noises.

The use of a stethoscope will often aid in locating an engine noise. Caution must be exercised, however, because noise will travel to other metal parts not involved in the problem.

No definite rule or test can be listed that will positively determine the source of a noise complaint.

Fuel pumps, flywheels, drive belts, or carbon built up in the combustion chamber may contribute to noisy engine operation. The following information can therefore be used only as a general guide to noise diagnosis. There is no substitute for experience.

Noisy Main Bearing

A loose main bearing is indicated by a powerful, but dull, thud or knock when the engine is under load. If all main bearings are loose, a noticeable chatter will be audible.

The thud occurs regularly every other revolution. The noise is loudest when the engine is "lugging" or under heavy load. The sound is heavier and duller than a connecting rod noise. Low oil pressure also accompanies this condition. If a bearing is not quite loose enough to produce a knock by itself, the bearing may knock if oil is too thin or if there is no oil at the bearing.

Regular noise—worn bearings, irregular—worn endthrust bearings.

Crankshaft end play—intermittent rap or knock that is sharper than a loose main bearing. Repeated disengagements of the clutch may cause a change in the rap.

Causes of Noisy Main Bearings

1. Insufficient oil supply.
2. Low oil pump pressure.
3. Thin or diluted oil.
4. Excessive bearing clearance.
5. Excessive crankshaft end play.

6. Out-of-round crankshaft journals.
7. Sprung crankshaft.
8. Excessive belt tension.
9. Loose crankshaft pulley.
10. Loose flywheel or torque converter.

Noisy Rod Bearings

Rods with excessive clearance knock under all speeds and under both idle and load conditions. At the early stage of looseness, rod noise may easily be confused with piston slap or loose pins. Rod knock noise increases in intensity with engine speed. Low oil pressure also accompanies this condition.

Causes of Noisy Rod Bearings

1. Excessive bearing clearance.
2. Worn crankpin.
3. Lack of oil (thin or diluted).
4. Low oil pressure.
5. Journals out-of-round.
6. Misaligned rod.
7. Connecting rod bolts not tightened correctly.

Noisy Timing Gears

A high frequency light knock that is difficult to isolate without a sound detecting device. It is about the same intensity whether the engine is idling, at high speeds or under load.

Causes of Noisy Gears

1. Gears misaligned.
2. Excessive backlash.
3. Chipped tooth.
4. Gears loose on hubs or shafts.
5. Teeth meshed too tight (new oversized gear).
6. Too much end play in the camshaft or crankshaft.
7. Front camshaft bearing clearance excessive.

Noisy Pistons

Piston pin, piston, and connecting rod noises are difficult to tell apart. A loose piston pin causes a sharp double knock that is usually heard when the engine is idling. However, on some engines the knock becomes more noticeable at 25 to 35 mph (40 to 56 km/h) on the road.

Cause of Piston Noise

1. Worn or loose piston pin or bushing.
2. Improper fit of pin. (Listen for a light ticking or tapping noise. More noticeable with no load on engine. May disappear completely under load. Generally piston pin noise can be noticed on deceleration of the engine.)
3. Piston-to-cylinder bore clearance excessive (sounds very similar to tappet noise). One indication of piston slap is a decrease in noise as the engine warms up. Piston slap is always louder when the engine is cold.
4. Lack of lubrication.
5. Carbon deposits on top of piston strike cylinder head.
6. Worn or broken piston ring land (most noticeable during acceleration).
7. Broken or cranked piston.
8. Engine overheating.
9. Poor fuel.
10. Excessive rod bearing clearance.
11. Misaligned connecting rods.
12. Worn rings, cylinder walls, low ring tension, broken rings, out-of-round or tapered bores.
13. Excessive side clearance of rings in groove, clearance between rings and groove and/or ring gap.
14. Undersize piston installed.
15. Wrong type and/or size rings installed.
16. Cylinder bores tapered or eccentric.
17. Insufficient ring gap clearance.
18. Piston 180 degrees out of position.

Noisy Valve Michanism

1. Sticking or warped valves.
2. Bent pushrods.
3. Dirty worn, or scored parts (rocker arms, etc.).
4. Damaged valve lifter and/or camshaft lobes.
5. Insufficient or poor oil supply to valve mechanism (thin, foaming, or diluted).
6. Excessive valve stem-to-guide clearance.
7. Valve lifter incorrectly fitted to bore size.

Noisy Fan Belt

1. Belt worn or burned.
2. Wrong belt. Does not fit pulley grooves properly.
3. Belt or pulley dirty or sticky with gummy oil.
4. Pulley bent, cracked or broken.
5. Belt pulleys misaligned.

Miscellaneous Noises

Loose Flywheel

A thud or click that is usually irregular. To test, run the engine at about 20 mph (32 km/h) and shut off the engine. If thud is heard, the flywheel may be loose.

Excessive Crankshaft End Play

A rather sharp rap that occurs at idling speed, but may be heard at higher speeds also. The noise should disappear when clutch is disengaged.

Engine Vibration

1. Unequal compression in cylinders.
2. Missing at high speed.

3. Damaged engine mounts.
4. Faulty front engine pulley.
5. Engine support loose on frame or cylinder block.
6. Unbalanced or sprung crankshaft.
7. Excessive engine friction due to tight pistons, etc.

COMPRESSION CHECK

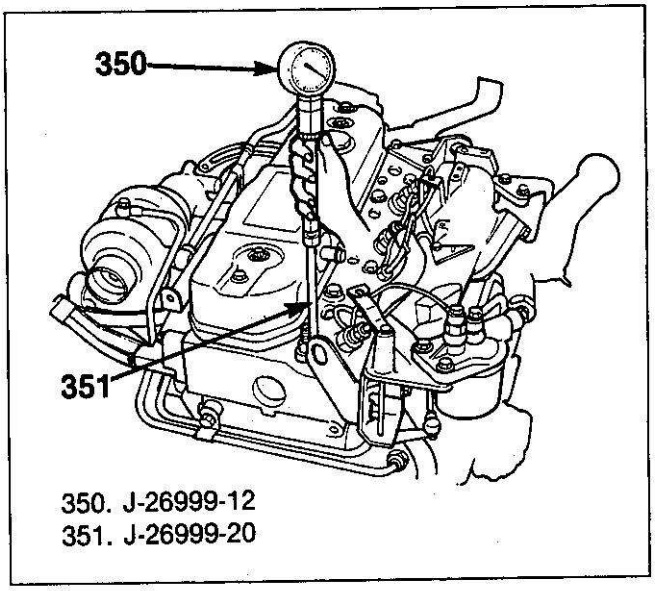
1. Be sure the batteries are fully charged.
2. Start the engine. Run the engine until it is at operating engine coolant temperature. Stop the engine.
3. Remove the four glow plugs, as outlined later in this section.
4. Be sure the injection pump is in the "No Fuel" position. To do this remove the "Engine Stop" fuse from the fuse box before cranking the engine. The fuse is number 11.
5. Install Adapter J-26999-20 into a glow plug hole, as shown in figure 2.
6. Connect Compression Gage J-26999-12 to the adapter.
7. Crank the engine and record the reading. Allow six compression strokes per cylinder.

Normal—compression builds up quickly and evenly to specified compression on each cylinder.

Piston rings leaking—compression low on first stroke. Tends to build up on following strokes but does not reach normal.

NOTICE: Do not add oil to any cylinder to compression test, as extensive damage may result.

8. The correct production pressure reading is 3043 kPa (441 psi). The reading should not fall below 2160 kPa (313 psi). These readings require a cranking speed of 200 rpm.
9. Perform the test on the remaining cylinders.
10. Install the glow plugs, as outlined later in this section.
11. Install the "Engine Stop" fuse.



350. J-26999-12
351. J-26999-20

Figure 2. Checking Engine Compression

MAINTENANCE

Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual for service intervals and recommended lubricants.

VALVE ADJUSTMENT

1. The adjustment is to be made with the engine stopped and cold.
2. Remove the cylinder head cover as outlined later in this section.
3. Turn the crankshaft in the direction of normal rotation until both rocker arms on the number one (front) cylinder are loose, and the TDC (Top Dead Center) timing notch on the vibration damper is aligned with the "T" mark (figure 3).
4. With the crankshaft in this position, the valves indicated in figure 4 can be adjusted.
   If the timing marks are aligned at "T" mark and the number one cylinder valves have no clearance, then the number four cylinder is in the compression-firing position. Adjust the valves as shown in figure 6.
5. Refer to figure 5. Use a 0.4 mm (0.016 in) feeler gage for both intake and exhaust valves.
   a. Loosen the jam nut.
   b. Turn the adjusting screw until the feeler gage can be inserted with a light drag between the rocker arm and valve.

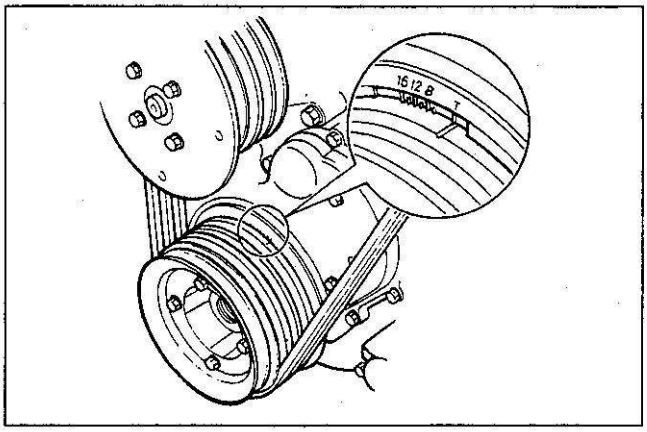


Figure 3. Timing Mark at Top Dead Center

c. Hold the adjusting screw in this position and tighten the jam nut. Correct torque is 25 N·m (19 lb·ft).
d. Recheck the clearance.

6. Turn the crankshaft one full turn in the direction of normal rotation. Align the "T" mark with the timing notch (figure 3). With the crankshaft in this position, the valves indicated in figure 6 can be adjusted. Adjust as outlined in step 5.
7. Install the cylinder head cover as outlined later in this section.

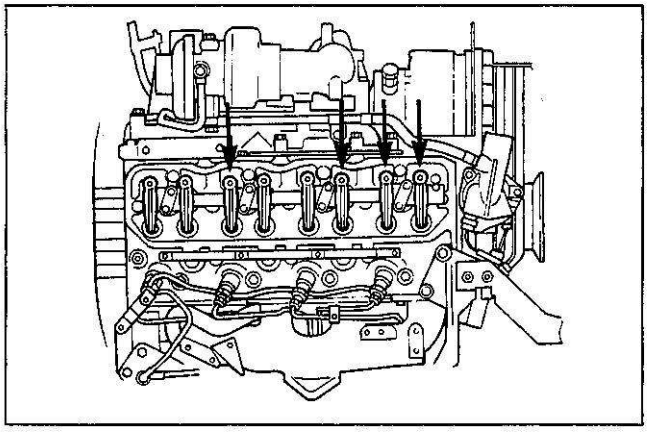


Figure 4. Valve Adjustment–Sequence (1)

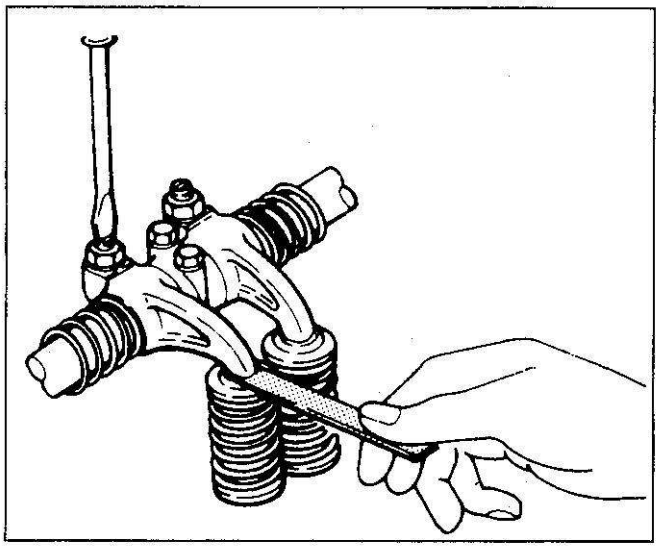


Figure 5. Adjusting Valve Clearance

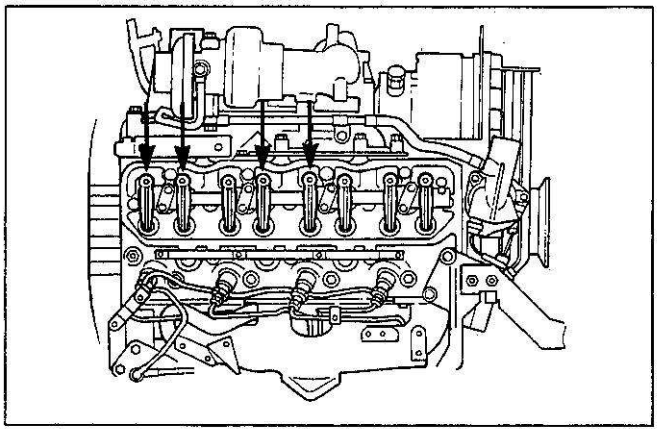


Figure 6. Valve Adjustment–Sequence (2)

TURBOCHARGER MAINTENANCE

The following items should be checked at the intervals outlined in MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

Inspect (Figure 7)

— Turbocharger to exhaust manifold connection (A) for leakage and mounting nut torque (figure 7a).
— Turbocharger oil drain pipe(B) for damage and connection for leakage (figure 7a).
— Turbocharger to adapter connection (C) for leakage (figure 7b).
— Oil feed pipe (D) for damage and connection for leakage (figure 7b).
— Water feed pipes (E) for kinks or damage and connection for leakage (figure 7b).
— Air inlet hose and pipe (F) for damage and connection for looseness or leakage (figure 7b).

— Charge air hoses and pipe between the turbocharger and the charge air cooler (G) for kinks or damage and connection for looseness or leakage (figure 7b).
— Charge air hose and pipe between the charge air cooler and intake manifold (H) for kinks or damage and connection looseness or leakage (figure 7c).
— Charge air cooler assembly for damage and mounting nut tightness (figure 7d).
— Turbocharger for vibration or abnormal noises during engine operation.
— Exhaust smoke. Blue smoke may indicate, among other things, oil leakage past internal turbocharger seals. Refer to "Excessive Oil Consumption" under "Diagnosis of Isuzu Diesel Engine" previously in this manual.

Important

- If the engine has not been running for a long period of time, it is recommended that the turbocharger bearings be lubricated BEFORE starting the engine. Proceed as follows:
  1. Clean around the turbocharger oil feed line (item D, figure 7b).
  2. Disconnect the turbocharger oil feed line. Take care not to allow dirt into the oil passage.
  3. Pour about 125 ml (4 oz) of clean engine oil into the turbocharger oil passage.
  4. Disconnect the air inlet pipe. Turn the turbocharger compressor wheel by hand to distribute the oil. Reconnect the air inlet pipe.

Important

- Any time the intake air pipe, charge air pipe, or turbocharger are removed, the intake opening must be covered. This will protect against the entrance of foreign material that could seriously damage the turbocharger or follow the intake passage into the cylinder and cause extensive engine damage when started.

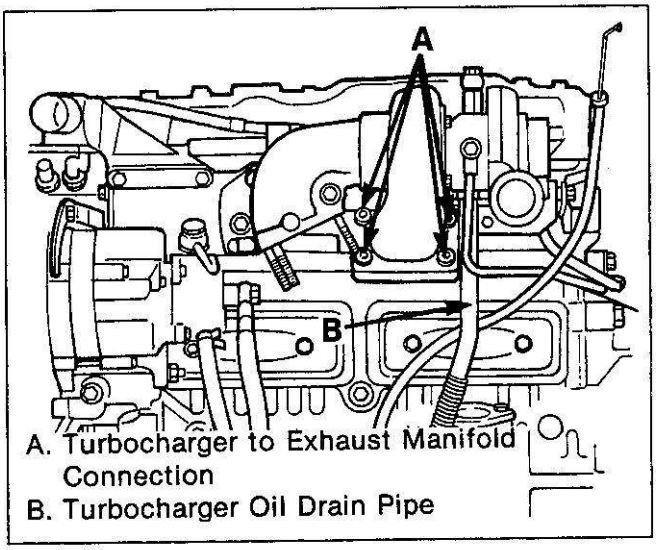


Figure 7a. Turbocharger Attachments Inspection (1)

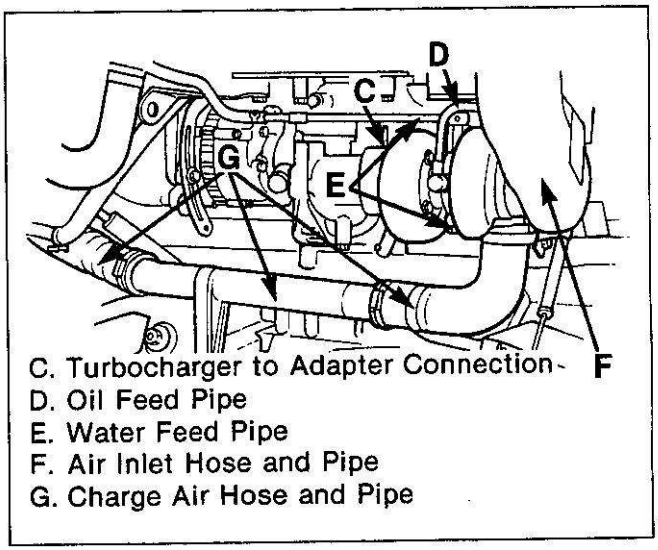


Figure 7b. Turbocharger Attachments Inspection (2)

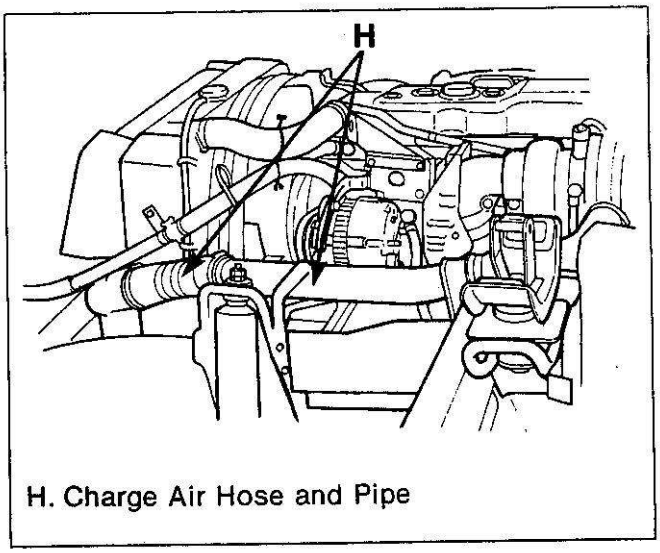


Figure 7c. Turbocharger Attachments Inspection (3)

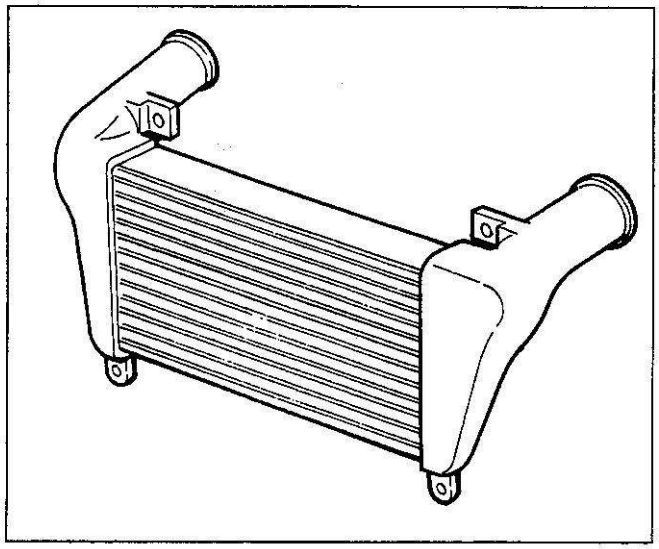
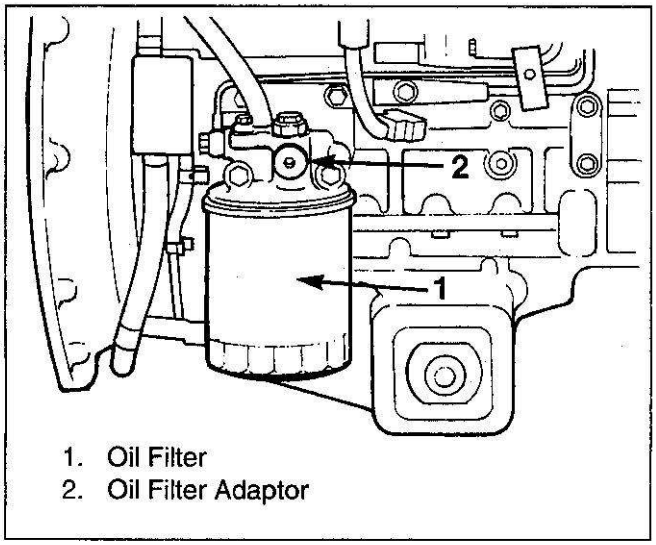


Figure 7d. Charge Air Cooler Assembly



1. Oil Filter
2. Oil Filter Adaptor

Figure 8. Oil Filter Location

CHANGING THE CRANKCASE OIL AND OIL FILTER

- The oil filter is located at the right rear of the engine (figure 8).
- It is recommended that the oil filter be changed at each oil change.
- The oil filter is a spin-on type.

Remove or Disconnect (Figure 8)

- Drain the crankcase oil.
- Oil filter (1). Use a strap wrench.

Clean (Figure 8)

- Oil filter gasket surface on the oil filter adaptor (2).

Install or Connect (Figure 8)

1. Apply engine oil to the filter gasket face.
2. Oil filter (1).
3. Hand tighten filter until filter gasket contacts face of adaptor (2).
4. Turn filter an additional 2/3 turn.
5. Oil pan drain plug.
   - Fill the crankcase with the proper quality and grade of oil. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.

Inspect

- Crankcase oil level. Add oil as needed.

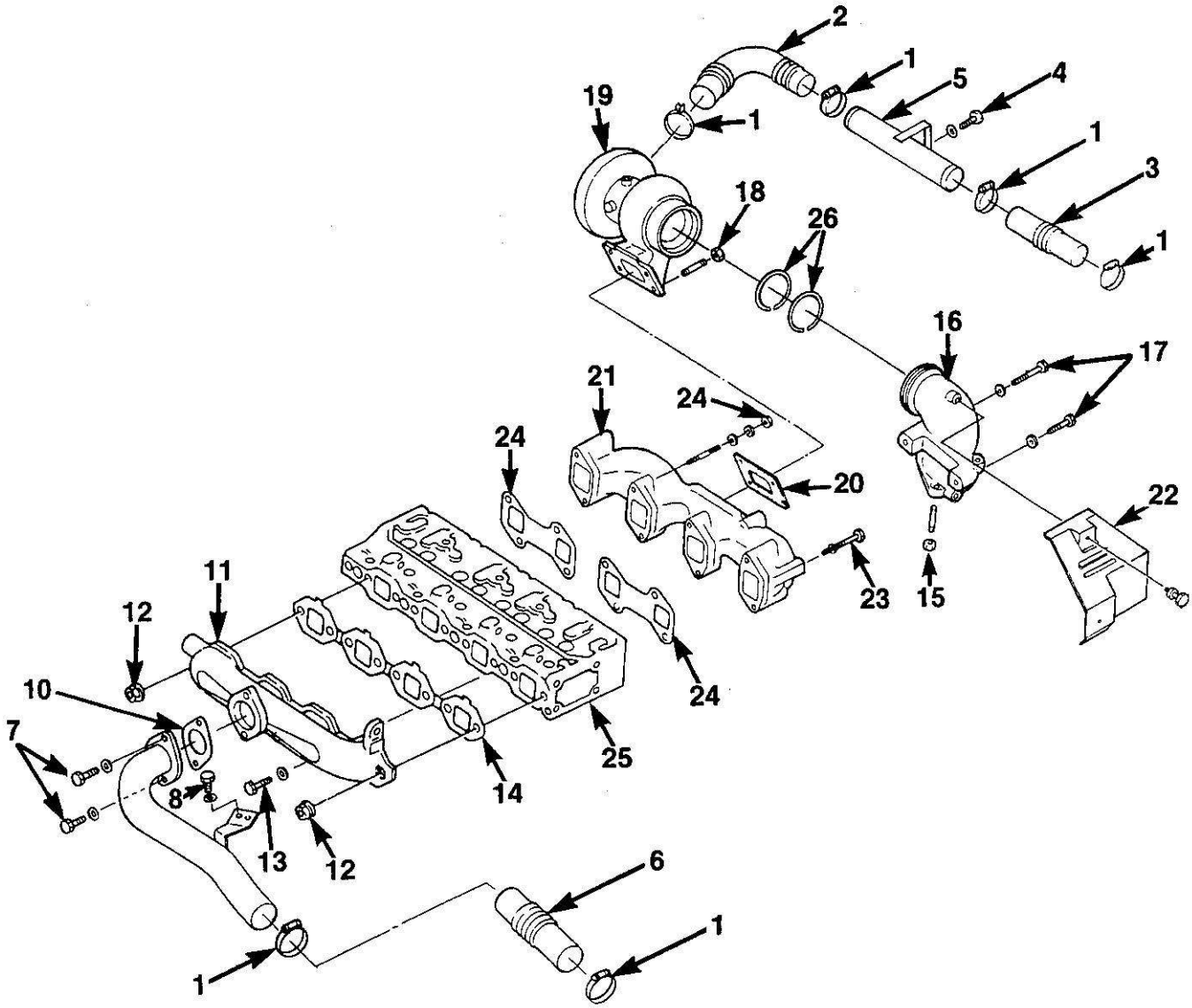
ISUZU ENGINE ON-VEHICLE SERVICE

STATEMENT ON CLEANLINESS AND CARE

- An engine is a combination of many machined, honed, polished, and lapped surfaces with very fine tolerances.
- Whenever valve train components, cylinder head, cylinder, crankshaft, or connecting rod components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.
- Any time the intake air pipe, charge air pipe, or turbocharger is removed, the intake opening must be covered. This will protect against the entrance of foreign material that could seriously damage the turbocharger, or follow the intake passage into the cylinder and cause extensive damage when the engine is started.
- When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces on initial operation. Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice even if not

specifically stated.

- Whenever the fuel injection pump or lines are removed or disconnected, care must be taken to prevent the entry of dirt into the pump, lines, and injection nozzle. The entry of even small amounts of dirt or other foreign material into the fuel injection system may cause serious damage.
- It should be kept in mind, while working on the engine, that the 12-volt electrical system is capable of violent and damaging short circuits. When performing any work where electrical terminals could possibly be grounded, the ground cable of the battery should be disconnected at the battery.
- Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect cables may result in damage to the wire harness or other electrical parts.
- Cover or otherwise protect exposed electrical connections to prevent damage from oil and fuel.
- The cylinder head and connecting rod cap bolts must be tightened using the angle method, as instructed. NEVER attempt to convert the angle torque figures to torque wrench figures.



1. Clamp
2. Connecting Hose
3. Connecting Hose
4. Bolt
5. Charge Air Pipe
6. Connecting Hose
7. Bolt
8. Bolt
9. Nut
10. Gasket
11. Intake Manifold
12. Nut
13. Bolt
14. Gasket
15. Nut
16. Exhaust Adapter
17. Bolt
18. Nut
19. Turbocharger
20. Gasket
21. Exhaust Manifold
22. Heat Shield
23. Bolt
24. Nut
25. Cylinder Head
26. Seal Ring

Figure 9. Manifolds, Turbocharger and Components

CHARGE AIR PIPE REPLACEMENT

Refer to "Statement on Cleanliness and Care" previously in this section.

Remove or Disconnect (Figure 9)

1. Clamps (1).
2. Connecting hoses (2) and (3).
3. Bracket bolts (4) and washers and charge air pipe(5).
4. Clamps (1).
5. Connecting hose (6).
6. Charge air pipe bolts (7).
7. Bracket bolts (8).
8. Charge air pipe (9).
9. Gasket (10).

Inspect (Figure 9)

- Hoses (2), (3) and (6) for deterioration, or damage.
- Charge air pipes (5) and (9) for damage.

Install or Connect (Figure 9)

1. Gasket (10) to the intake manifold (11).
2. Charge air pipe (9).
3. Bolts (7) and washer.

Tighten

- Bolts (7) to 26 N·m (20 lb·ft).

4. Bracket bolts (8).
5. Connecting hose (6).
6. Clamps (1).
7. Charge air pipe (5) and bracket bolts (4).
8. Connecting hoses (2) and (3).
9. Clamps (1).

INTAKE MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 9)

1. Charge air pipe (9) as outlined in "Charge Air Pipe Replacement" previously in this section.
2. Engine control cable bracket from the intake manifold (11).
3. Fuel injector lines from the fuel injectors and injection pump.
4. Nuts (12) and bolts (13).
5. Intake manifold (11).
6. Gasket (14) and discard.

Inspect (Figure 9)

- Intake manifold (11) for cracks or damage to gasket surfaces.

Install or Connect (Figures 9 and 10)

1. Gasket (14) as shown in figure 10.
2. Intake manifold (11).
3. Nuts (12) and bolts (13).

Tighten

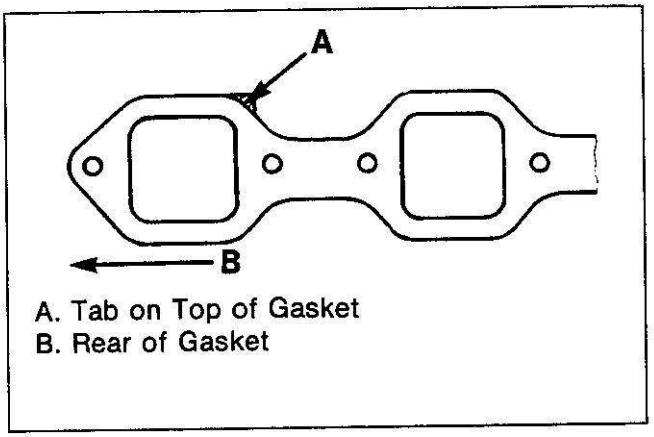
- Nuts (12) and bolt, a little at a time, to 19 N·m (14 lb·ft).

4. Fuel injector lines to the fuel injectors.

Tighten

- Fuel injector line nuts to 26 N·m (20 lb·ft).

5. Engine control cable bracket to the intake manifold.
6. Engine stop cable brackets to the intake manifold.
7. Charge air pipe (5) as outlined previously in this section.



A. Tab on Top of Gasket
B. Rear of Gasket

Figure 10. Intake Manifold Gasket Installed Postion

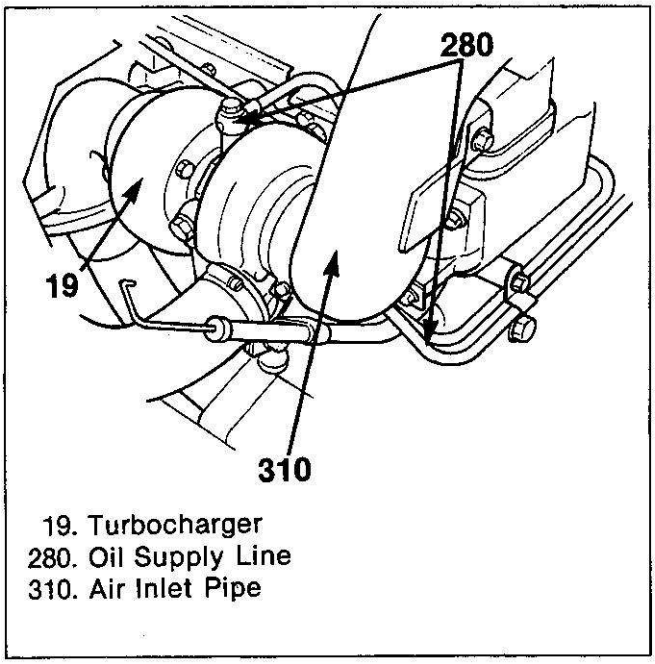
TURBOCHARGER REPLACEMENT

Refer to "Statement on Cleanliness and Care" previously in this section.

Remove or Disconnect (Figures 9, 11, 12 and 13)

1. Heat shield (22) bolt (figure 9).
2. Exhaust pipe to exhaust adapter Nuts (15) (figure 9).
3. Exhaust adapter (16) to exhaust manifold bolts (17) (figures 9 and 13).
4. Turbocharger air inlet pipe (310) (figure 11).
5. Oil feed line (280) (figure 11).
6. Charge air pipe clamps (1) (figure 9).
7. Water feed and drain lines (300) (figure 12).

8. Oil drain line (290) (figure 12).
9. Turbocharger to exhaust manifold nuts (18) (figures 9 and 13).
10. Turbocharger (19) (figure 9).
11. Exhaust adapter (16) (figures 9 and 13).



19. Turbocharger
280. Oil Supply Line
310. Air Inlet Pipe

Figure 11. Turbocharger Oil Feed Line Attachment

Inspect (Figure 9)

— Turbocharger (19) housing for cracks or damage.
— Gasket surfaces for damage.
— Seals and gaskets for damage.
— Turbine and compressor blades for damage or carbon buildup.
— Air and exhaust exit openings for oil or wetness.
— For grinding or roughness when spinning turbine and compressor wheels by hand.
— For evidence of turbine or compressor blades contacting the shroud or housing. If any of the above conditions exist, the turbocharger must be replaced or repaired by an authorized repair facility.

Measure

Play in radial clearance.
Moving the rotor in the radial clearance, measure the play by a dial gage.

- Measure the play at several points while letting the rotor revolve.
- Use only the flat dial gage attachment. Do not use the pointed one.
- Attach the turbocharger and dial gage firmly. Service limit is 0.140 mm (0.0055 in). If excessive, replace the turbocharger.

Measure

Play in axial clearance.
Moving the rotor in the axial clearance, measure the play by a dial gage.

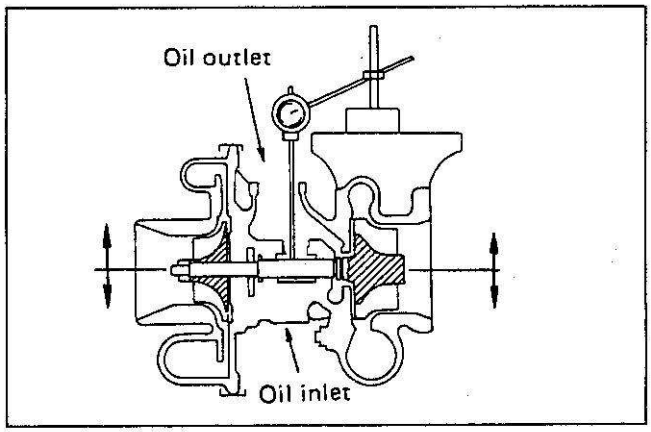


Figure 11a. Radial Clearance Measurement

- Measure the play at several points while letting the rotor revolve.
- Attach the turbocharger and dial gage firmly. Service limit is 0.097 mm (0.0038 in). If excessive, replace the turbocharger.

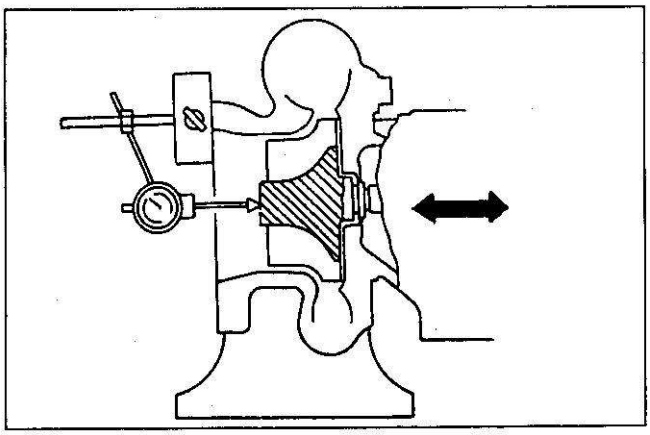


Figure 11b. Axial Clearance Measurement

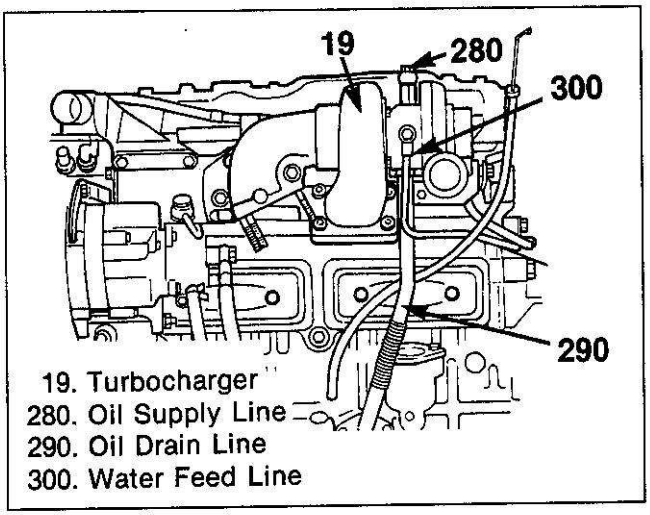


Figure 12. Turbochager Oil Drain Attachment

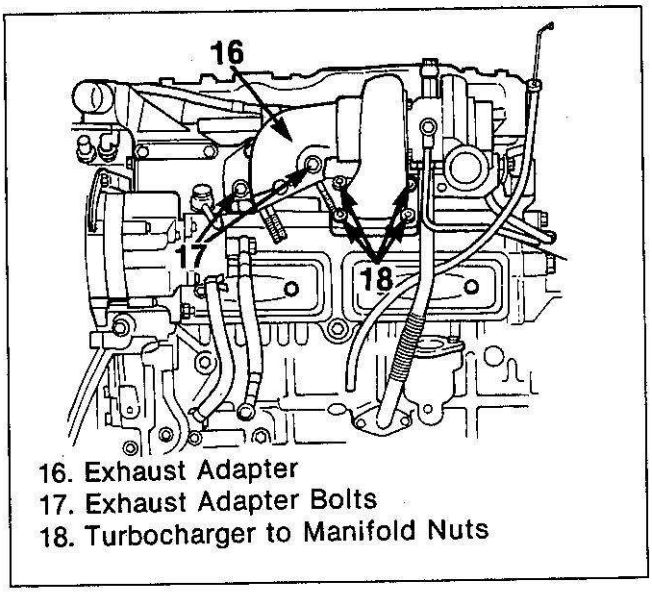


Figure 13. Turbocharger Mounting Attachment

Install or Connect (Figures 9, 11, 12 and 13)

1. Exhaust adapter (16) to turbocharger (19).
2. New gasket (20) and turbocharger (19) to exhaust manifold (21) (figure 9).

Tighten

- Nuts (18) to 26 N·m (20 lb·ft).(figure 13)

3. Turbocharger oil drain line (290) (figure 12).

Tighten

- Bolts (290) to 19 N·m (14 lb·ft).

4. Water supply and drain lines (300) (figure 12)

Tighten

- Fitting (300) to 21 N·m (15 lb·ft).

5. Charge air pipe connecting hoses (6) and clamps (1) to turbocharger (19) (figure 9).
6. Turbocharger oil supply line (280) to turbocharger (19) (figure 12).

Tighten

- Fitting (280) to 14 N·m (122 lb·in).

7. Air inlet pipe (310) to turbocharger (19) (figure 11).
8. Exhaust adapter (16) to exhaust manifold (21)(figure 9).

Tighten

- Bolts (17) to 21 N·m (15 lb·ft).

9. New gasket and exhaust pipe to exhaust adapter (16) (figure 9).

Tighten

- Nuts (15) to 37 N·m (27 lb·ft)

10. Heat shield (23) to exhaust adapter (16) (figure 9).

EXHAUST MANIFOLD REPLACEMENT

Remove or Disconnect (Figure 9)

1. Turbocharger (19) as outlined previously in this section.
2. Heat shield (22).
3. Bolts (23), nuts (24) and washers. Loosen bolts as shown in figure 14.
4. Exhaust manifold (21).
5. Gaskets (24).

Inspect (Figure 9)

- Exhaust manifold (21) and cylinder head (25) for cracks or damage to gasket surfaces.

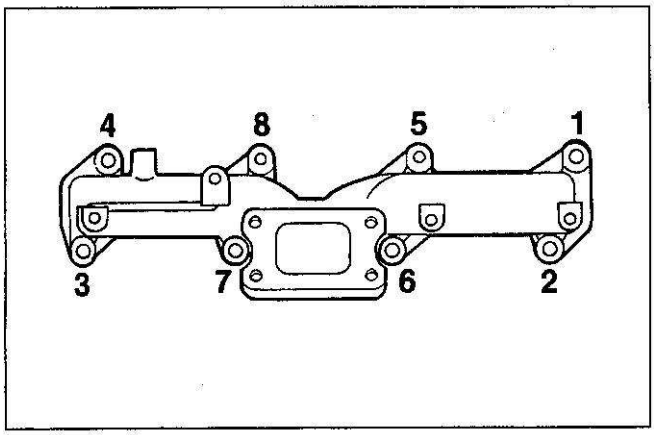


Figure 14. Exhaust Manifold Bolt Loosening Sequence

Install or Connect (Figures 9, 14 and 15)

1. Gaskets (24) as shown in figures 9 and 15.
2. Exhaust manifold (21).
3. Washers nuts (24) and bolts (23) as shown in figure 9.

Tighten

- Nuts and bolts, a little at a time, in the sequence shown in figure 17, to 19 N·m (14 lb·ft).

4. Heat shield (22).
5. Turbocharger (19) as outlined previously in this section.

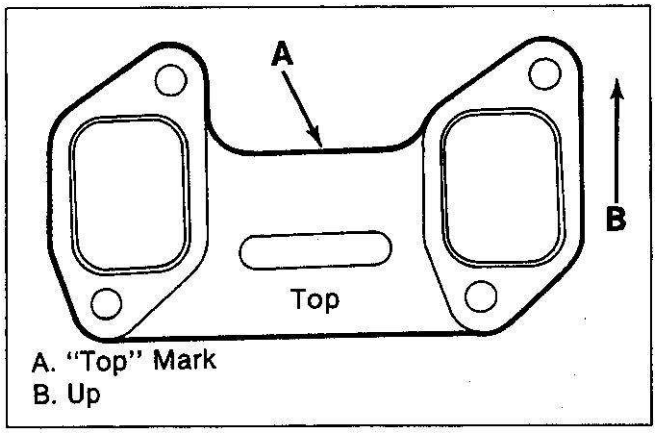


Figure 15. Exhaust Manifold Gasket Position

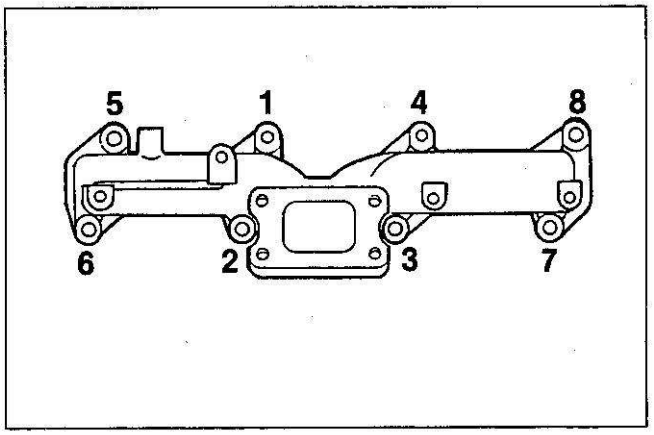


Figure 16. Exhaust Manifold Bolt Torquing Sequence

CYLINDER HEAD COVER REPLACEMENT

Remove or Disconnect (Figures 9 and 17)

1. Nuts (33), washers (34) and seals (35) (figure 17).
   Remove nuts in [1], [2], [3] sequence.
2. Cylinder head cover (36).
3. Gasket (37).

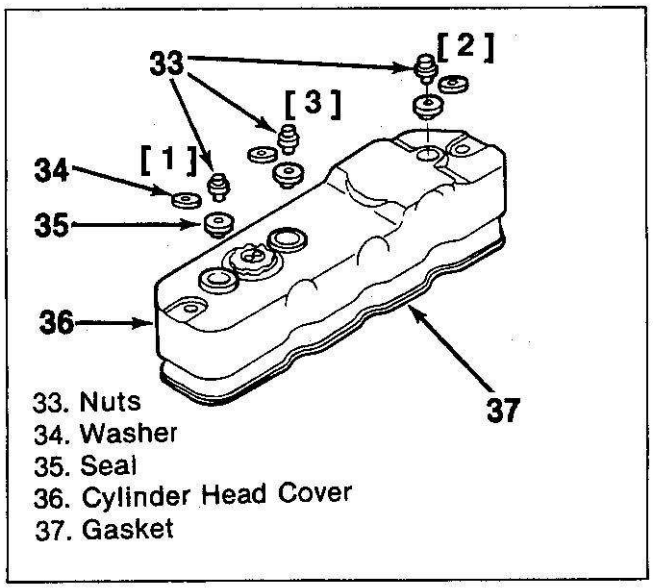


Figure 17. Cylinder Head Cover Assembly

Clean (Figure 17)

- All sludge and dirt from rocker arm cover (36).
- All pieces of old gasket (37) from rocker arm cover (36) and cylinder head.

Inspect (Figure 17)

- Cylinder head cover (36) for damage.

Install or Connect (Figure 17)

1. Gasket (37).
2. Cylinder head cover (36) to cylinder head.
3. Seals (35).
4. Washer (34) and nuts (33).

Tighten

- Nuts (33), a little at a time, to 10 N·m (87 lb·in).

VALVE SEAL AND COMPONENTS REPLACEMENT

Remove or Disconnect (Figure 18)

Tools Required:
J-26513-A Valve Spring Compressor

The valve to piston clearance is extremely small when the piston is at the top dead center and the valve remains in place when freed. The valve seal and components can be replaced easily in this condition.

Important

- When the valve spring is removed and the valve is freed, never turn the crankshaft as the valve will fall in the cylinder.

1. Remove the cylinder head cover. Refer to "Cylinder Head Cover Replacement" earlier in this section.
2. All glow plugs. Refer to "Glow Plug Replacement" later in this section.
3. Rocker arm shaft. Refer to "Valve Train Component Replacement" later in this section.
4. Turn the crankshaft in the direction of normal rotation until the TDC timing notch on the vibration damper is aligned with the "T" mark (figure 3).
5. With the crankshaft in this position the No. 1 and No. 4 pistons are top dead center position and these cylinder can be replaced the valve seals and components.
6. Install Valve Spring Compressor Tool J-26513-A (352) onto the valve spring assembly and compress the valve spring.
7. Split collars, spring upper seat (retainer) springs, and valve guide seal from valve guide.
8. nstall removed parts as outlined later in this section then turn the crankshaft 180 degrees in the direction of normal rotation.

Important

- When the valve spring is removed and the valve is freed, never turn the crankshaft as the valve will fall in the cylinder

9. With the crankshaft in this position the No. 2 and No. 3 pistons are top dead center position and these cylinders can be replaced the valve seals and components. Replace as outlined in step 6 and 7.

Install or Connect (Figure 18)

Tool Required:
J-34545 Valve Stem Seal Installer

1. Valve stem seal using J-34545.

Important

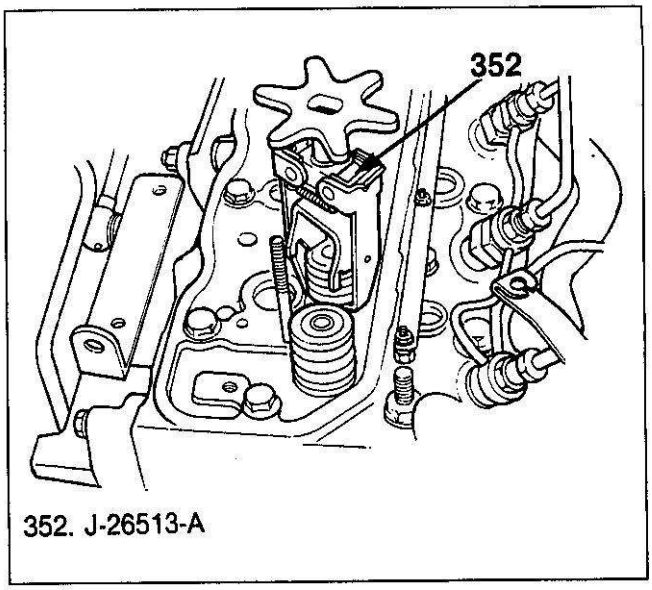
- It may be necessary to remove the garter spring before installing the valve seal.

2. Valve springs.

Important

- Install springs with the close wrapped coils toward the cylinder head.

3. Spring seat (retainer).
4. Compress springs using J-26513-A (352) and install split collars.
5. Rocker arm assembly, glow plugs and remaining engine parts as described under "Cylinder Head" later in this section.
6. Adjust valves as described under "Valve Adjustment" earlier in this section.
7. Cylinder head cover as outlined in "Cylinder Head Cover Replacement" earlier in this section.
8. Start engine and check for proper operation.



352. J-26513-A

Figure 18. Valve Spring Replacement

VALVE TRAIN COMPONENT REPLACEMENT

Refer to "Statement on Cleanliness and Care" mentioned previously in this section.

Remove or Disconnect (Figures 19 and 20)

1. Cylinder head cover, as outlined in "Cylinder Head Cover Replacement" previously in this section.
2. Bolts (43), nuts (52) and washers (51).

Important

- Loosen the bolts and nut a little at a time in the sequence shown in figure 20.

3. Rocker arm shaft (38) and components.
4. Pushrods (45).

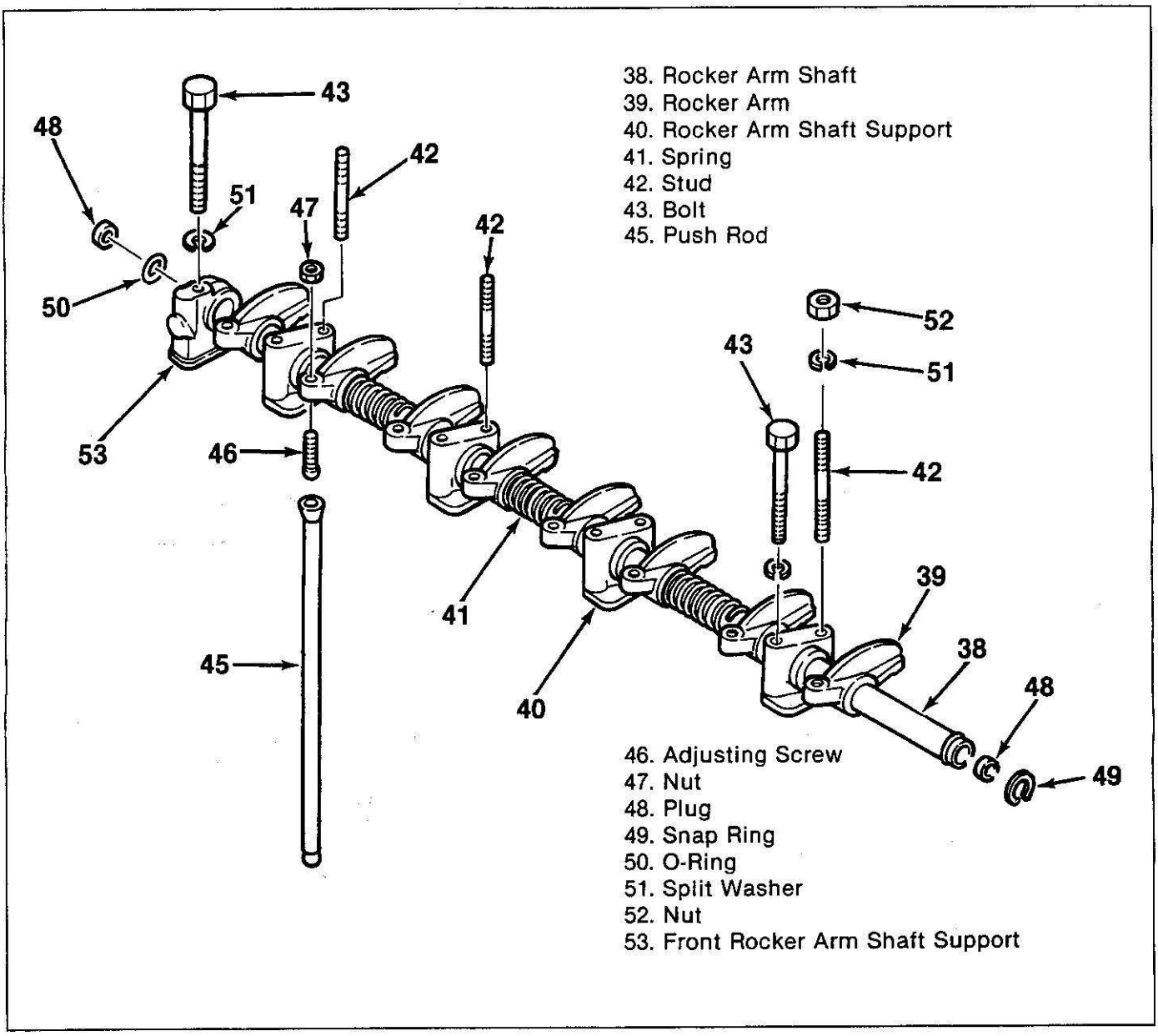


Figure 19. Rocker Arm Assembly

- In order to replace the tappets, the camshaft must be removed. Refer to"Camshaft and Bearings" later in this section.

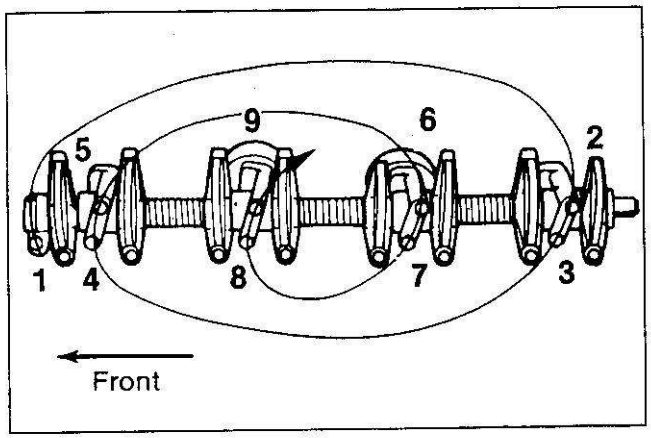


Figure 20. Rocker Arm Assembly Bolt Loosening Sequence

Disassemble (Figure 19)

- O-ring (50), rocker arms (39), rocker arm shaft supports (40) and springs (41) from the rocker arm shaft (38).

Clean

- All parts in solvent.

Inspect (Figures 19 and 21)

— Pushrod (45) for bent condition. Use a feeler gage and surface plate as shown in figure 21. Maximum runout of 0.3 mm (0.012 in).
— Rocker arm shaft supports (40 and 53) for cracks or damage (figure 19).
— Rocker arm shaft (38) for scoring or wear.
— Rocker arm (39) inside diameter for scoring or wear.
— Rocker arm (39) at the area where it contacts the valve stem. The surface should not be grooved or pitted.
— Plugs (48) for looseness. Replace the plug(s) if loose.

Measure (Figures 19 and 22)

- Rocker arm (39) inside diameter (figure 22), using an inside micrometer. Production diameter is 19.01–19.03 mm (0.7489–0.7497 in). Replace the rocker arm if the diameter is more than 19.05 mm (0.75 in).
- Rocker arm shaft diameter, using a micrometer. Measure at the rocker arm mating areas. Production diameter is 18.98–19.00 mm (0.7478 – 0.7486 in). Replace the rocker arm shaft if the diameter is less than 18.85 mm (0.743 in).

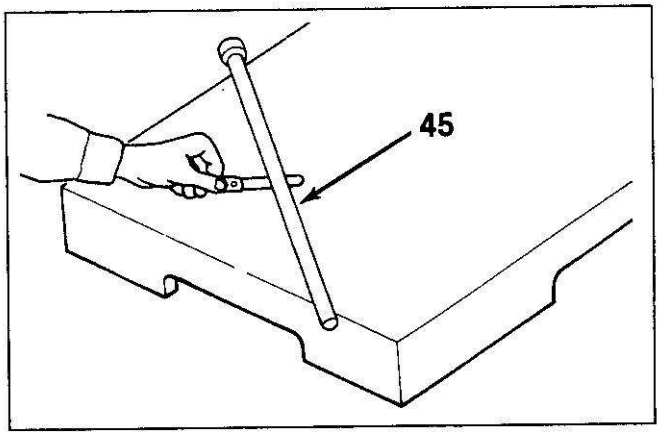


Figure 21. Measuring Pushrod Runout

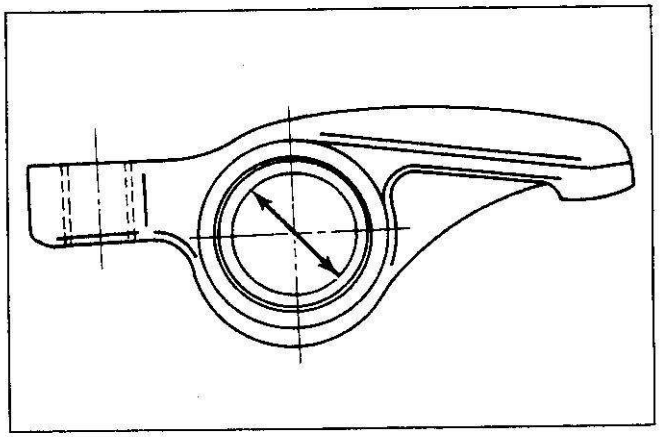


Figure 22. Measuring Rocker Arm Inside Diameter

- Subtract the rocker arm shaft diameter from the rocker arm diameter to obtain the rocker arm to shaft clearance. Production clearance is 0.014–0.062mm (0.00055 – 0.0024 in). If the clearance is more than 0.2 mm (0.008 in), replace the worn component.

Assemble (Figures 19 and 23)

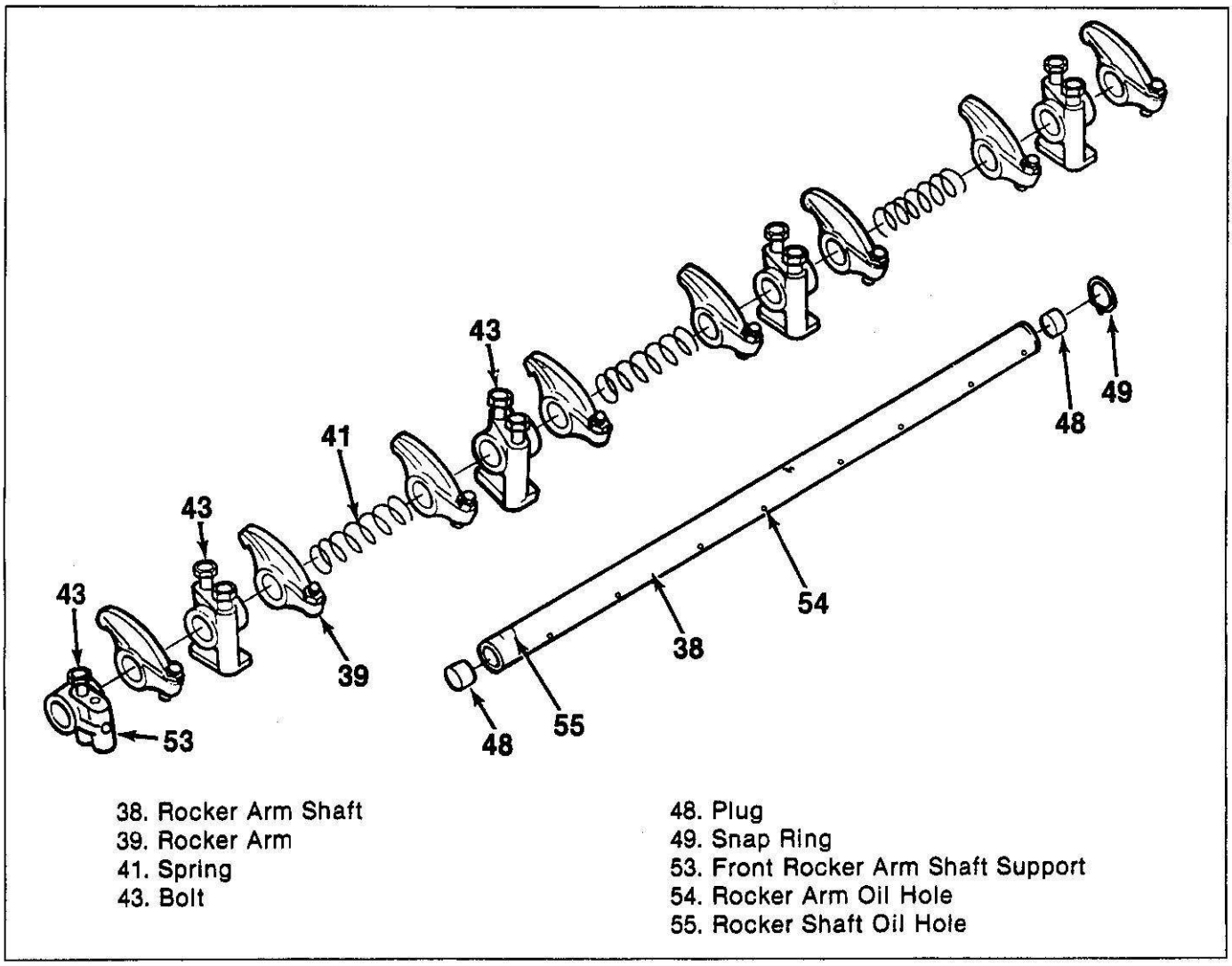
- Apply engine oil to the rocker arm shaft (38).
- O-ring (50), rocker arm shaft supports (40 and 53), rocker arms (39), and springs (41).

Important

- The parts must be assembled so that the rocker arm shaft (38) oil holes (54) face down (toward the cylinder head) (figure 23).

Install or Connect (Figures 19 and 23)

1. Pushrods (45).
2. Rocker arms (39), springs (41), rocker arm shaft (38), and rocker arm shaft supports (40 and 53) as an assembly.
3. Bolts (43), nuts (52) and washers (51).



38. Rocker Arm Shaft
39. Rocker Arm
41. Spring
43. Bolt
48. Plug
49. Snap Ring
53. Front Rocker Arm Shaft Support
54. Rocker Arm Oil Hole
55. Rocker Shaft Oil Hole

Figure 23. Assembling Rocker Arm Shaft

Tighten

- Bolts (43) and nuts (52) to 23 N·m (17 lb·ft), using the sequence shown in figure 24.

4. Rocker arm cover as outlined in "Cylinder Head Cover Replacement" previously in this section.

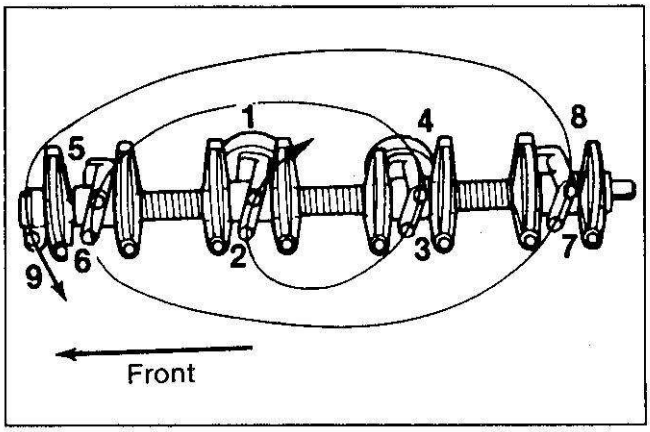


Figure 24. Rocker Arm Assembly Torque Sequence

GLOW PLUG REPLACEMENT

Remove or Disconnect (Figure 25)

1. Battery negative cable.
2. Glow plug wire (58).
3. Buss bar nuts.
4. Glow plug buss bars (57).
5. Glow plug (56). Use a deep socket.

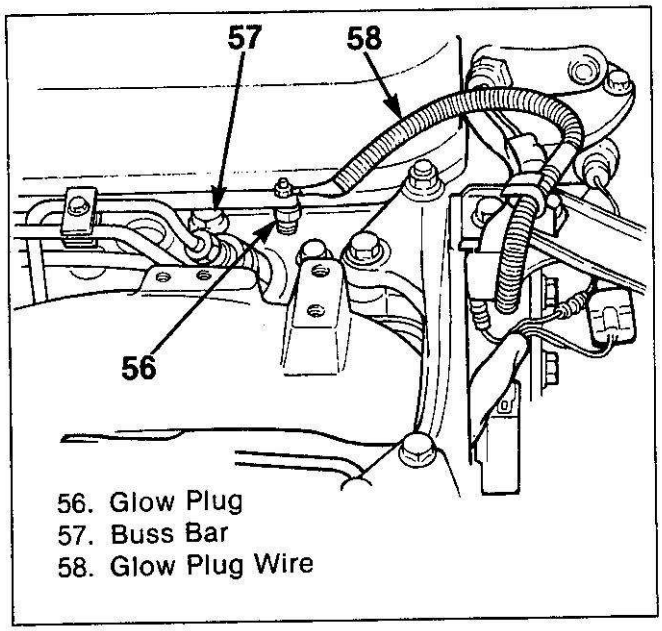
Install or Connect (Figure 25)

1. Glow plug (56).

Tighten

- Glow plug (56) to 23 N·m (17 lb-ft).

2. Glow plug buss bars (57).
3. Buss bar nuts.
4. Glow plug wire (58).
5. Battery negative cable.



56. Glow Plug
57. Buss Bar
58. Glow Plug Wire

Figure 25. Glow Plug Replacement

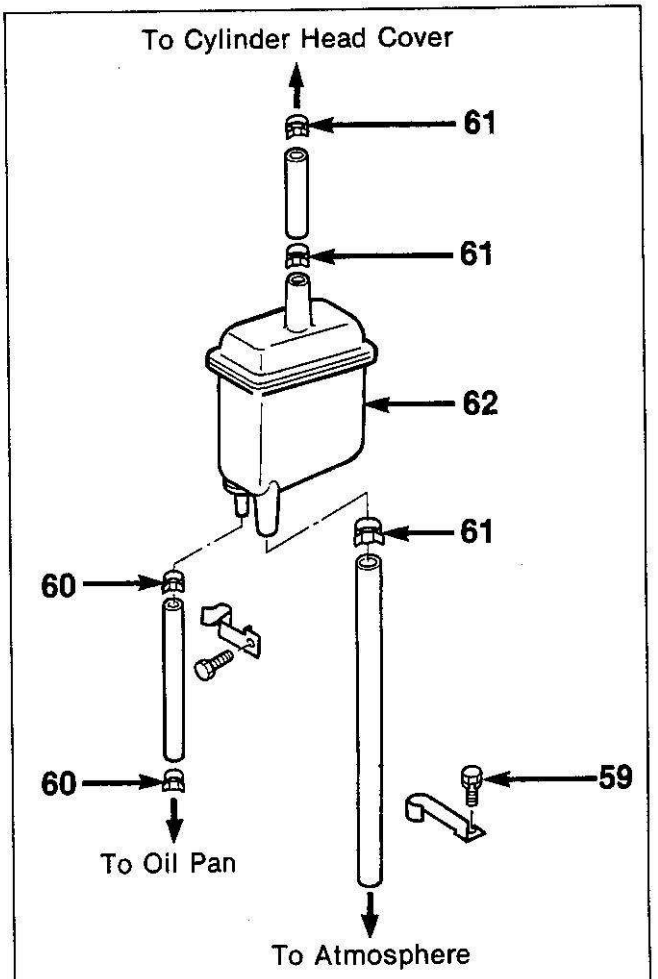
CRANKCASE BREATHER REPLACEMENT

Remove or Disconnect (Figure 26)

1. Clamp bolt (59).
2. Clamps (60 and 61) and crankcase breather (62).

Install or Connect (Figure 26)

1. Crankcase breather (62) and clamps (60 and 61).
2. Clamp bolt (59).



59. Bolt and Washer (2)
60. Clamp
61. Clamp
62. Crankcase Breather

Figure 26. Crankcase Breather System

CYLINDER HEAD

Refer to "Statement on Cleanliness and Care" in this section.

Remove or Disconnect (Figures 27 and 28)

1. Battery ground cable. Refer to ENGINE (SEC.6A).
2. Drain engine coolant at lower rear of radiator through drain valve. Refer to RADIATOR (SEC. 6B2).
3. Thermostat housing. Refer to COOLING SYSTEM (SEC. 6B1).
4. Exhaust brake bracket from clutch housing bolts. Refer to ENGINE (SEC. 6A).
5. Exhaust pipe at exhaust manifold. Refer to EXHAUST (SEC. 6F).

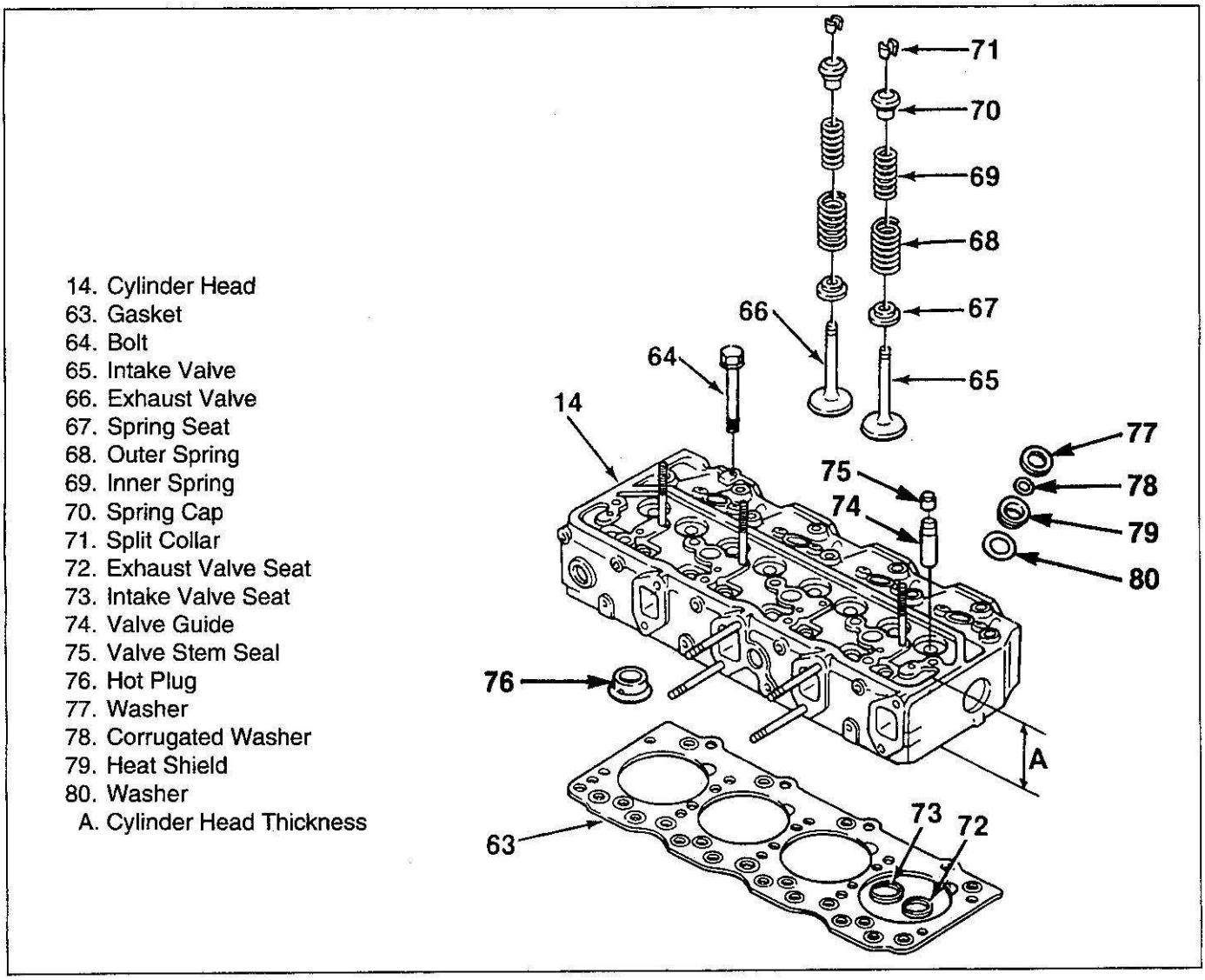


Figure 27. Cylinder Head and Components

6. Turbocharger air inlet and charge air pipes at turbocharger. Refer to "Turbocharger Maintenance" earlier in this section.
7. Turbocharger oil feed and drain pipes at turbocharger. Refer to "Turbocharger Maintenance" earlier in this section.
8. Exhaust manifold bolts and nuts at cylinder head. Refer to "Exhaust Manifold Replacement" earlier in this section.
9. Turbocharger and exhaust manifold assembly.
10. Generator upper adjusting bracket at generator and at cylinder head. Refer to ENGINE ELECTRICAL (SEC. 6D).
11. Heat shield and oil dipstick bracket upper bolts from left side of cylinder head.
12. Deflector.
13. Heater hose and upper radiator hose clamps at thermostat housing and remove hoses.
14. Injection nozzle leak-off pipes.
15. Fuel, pipes at fuel filter.
16. Fuel filter from intake manifold.
17. Crankcase breather.
18. Fuel injection pipes.
19. Injection nozzles.
20. Cylinder head cover.
21. Rocker arm shaft assembly (figure 20).
22. Glow plug wire connector, buss bar, and plugs (figure 25).
23. Valve push rods (figure 19).
24. Cylinder head bolts (figure 28).
25. Cylinder head.

Important

- If the hot plugs fell off, mark their fitting positions each hot plug with the cylinder number from which it was removed.

Disassemble (Figures 27 and 29)

1. Intake manifold nuts and bolts. Refer to "Intake Manifold Replacement" earlier in this section.
2. Intake manifold. Refer to "Intake Manifold Replacement" earlier in this section.
3. Thermostat housing from front of cylinder head. Refer to ON-VEHICLE SERVICE: COOLING SYSTEM COMPONENTS (SEC. 6B1).
4. Compress valve spring with spring compressor tool (figure 29) and remove split collars (71).
5. Valve spring (68,69) and valve seats (70).
6. Spring seat (67).
7. Valves (65,66).
8. Valve seal (75). Seal fits over valve guide and is retained with a spring (74).

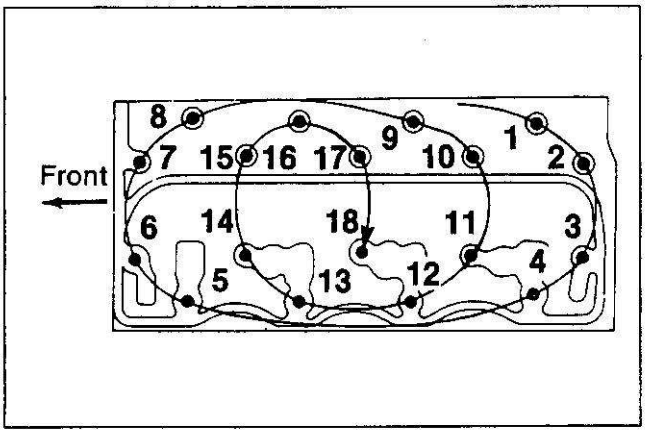


Figure 28. Cylinder Head Bolt Loosening Sequence

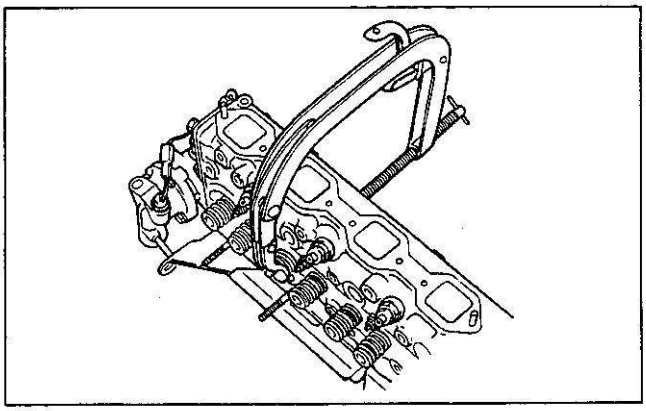


Figure 29. Compressing Valve Spring

Clean (Figure 27)

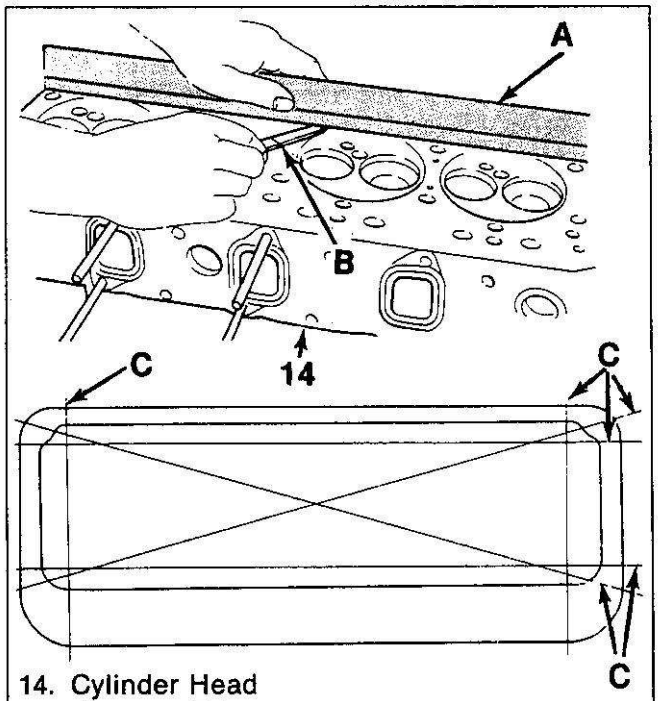
- All carbon from valve ports and combustion chambers.
- Valve guide bore of dirt and carbon.
- Valve stems and heads. Do not use a wire wheel.
- All traces of old gaskets from cylinder head (14) and block.

Inspect (Figure 27)

- Cylinder head (14) for cracks, damaged threaded parts, etc.
- Cylinder head (14) gasket surface for damage.
- Valves (65 and 66) for warping, pitting, etc.
- Valve seats (72 and 73) for burning and pitting.
- Hot plug (76) for cracks. Replace with new parts if four or more cracks exist or if a crack extends outside of the cylinder bore (figure 30a).

Measure (Figures 27 and 30-37)

- Cylinder head gasket surface for distortion. Use a straightedge and feeler gage as shown in figure 30. Check in six different directions, as shown. If the cylinder head is distorted more than 0.2 mm (0.008 in), it must be replaced or resurfaced. The minimum allowable thickness of the cylinder head (item A, figure 27) after resurfacing is 89.75 mm (3.533 in).
- Hot plugs for depression. Check the amount of depression of hot plugs on No. 1 through No. 4 cylinders using a feeler gage with a straightedge held against the hot plug face. If the hot plug is depressed more than 0.02 mm (0.0008 in), it must be replaced.
- Valve installed depth (figure 31). Production depth is 0.65–1.10 mm (0.026–0.043 in). If more than 2.5 mm (0.100 in), replace the valve (65 or 66) or valve seat (72 or 73) as required.



14. Cylinder Head
A. Straight Edge
B. Feeler Gage
C. Check in Six Directions

Figure 30. Checking Cylinder Head Distortion

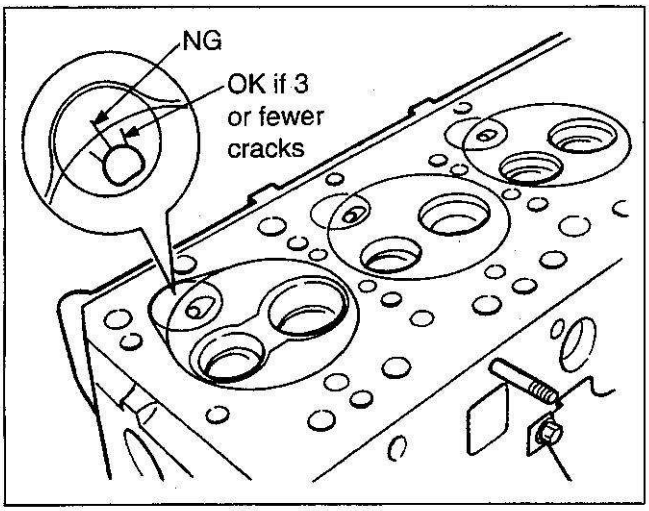


Figure 30a. Checking Hot Plug Crack

— Valve stem diameter, as shown in figure 32. Check in three places, as shown. Check against "Specifications" at the end of this section.
— Valve guide (74) inside diameter, using an inside micrometer. Check against "Specifications" at the end of this section.

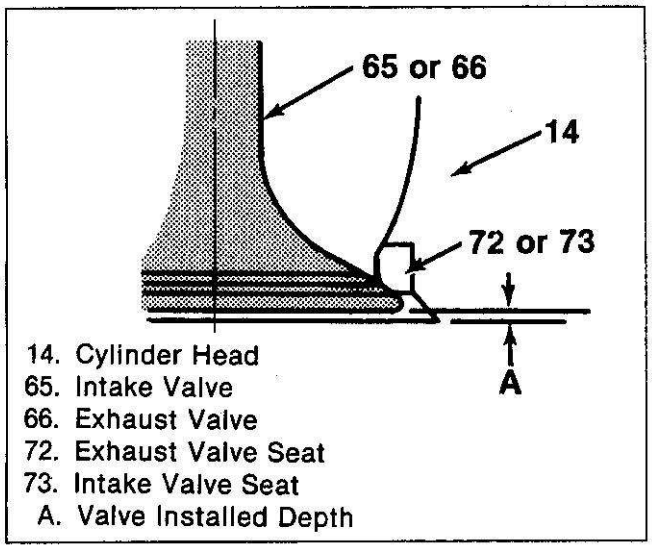


Figure 31. Measuring Valve Installed Depth

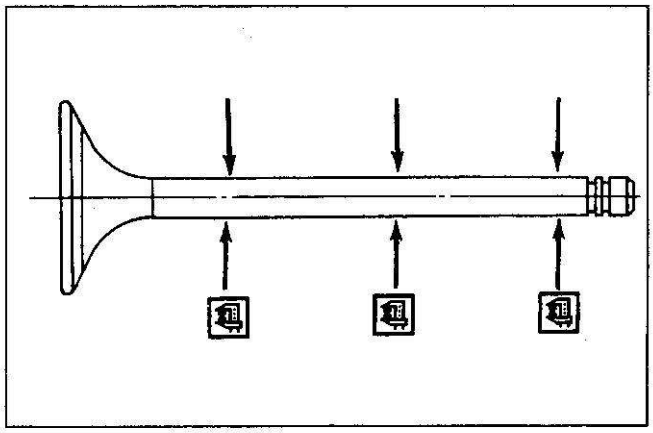


Figure 32. Measuring Valve Stem Diameter

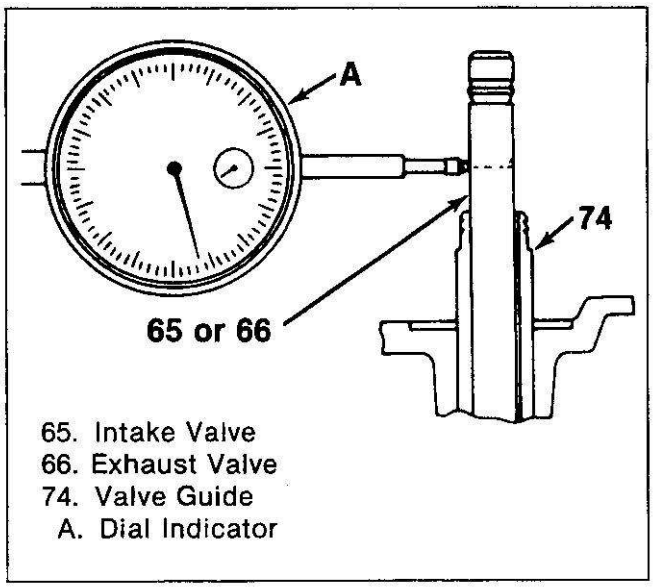


Figure 33. Measuring Valve Stem to Guide Clearance

— Valve guide to valve stem clearance (figure 33).
  • Locate a dial indicator as shown.
  • Hold the valve on its seat.
  • Move the valve stem from side to side to obtain the clearance reading. Check against "Specifications" at the end of this section.
— Valve springs (68 and 69) for length and straightness. Check against "Specifications" at the end of this section.
  • Check length with vernier calipers (figure 34).
  • Check amount of inclination from vertical with a square on a surface plate, as sown in figure 35.
— Valve spring tension (figure 36). Check the spring at the specified length.

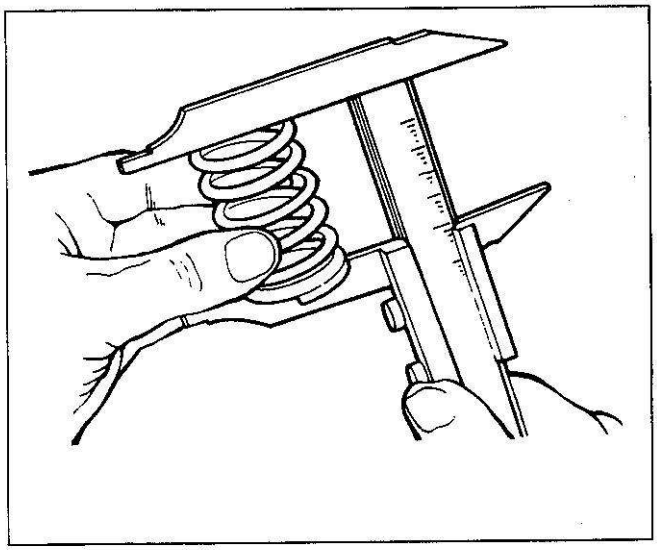


Figure 34. Measuring Valve Spring Length

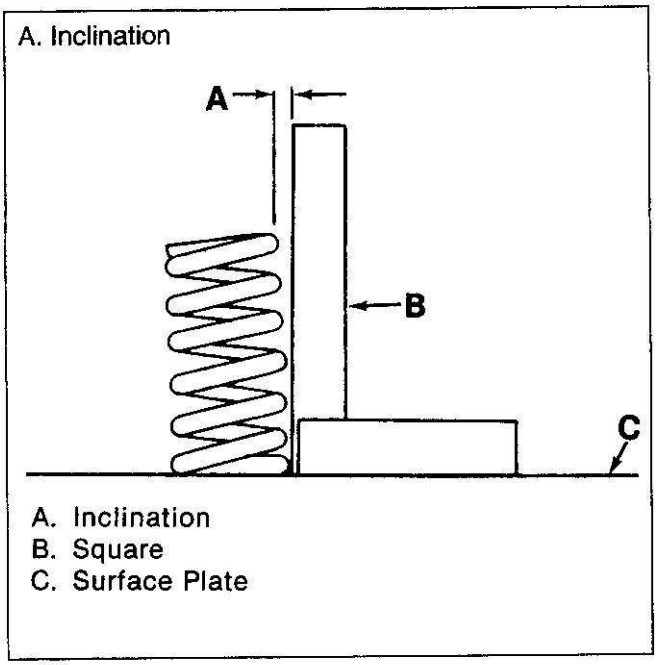


Figure 35. Checking Valve Spring Squareness

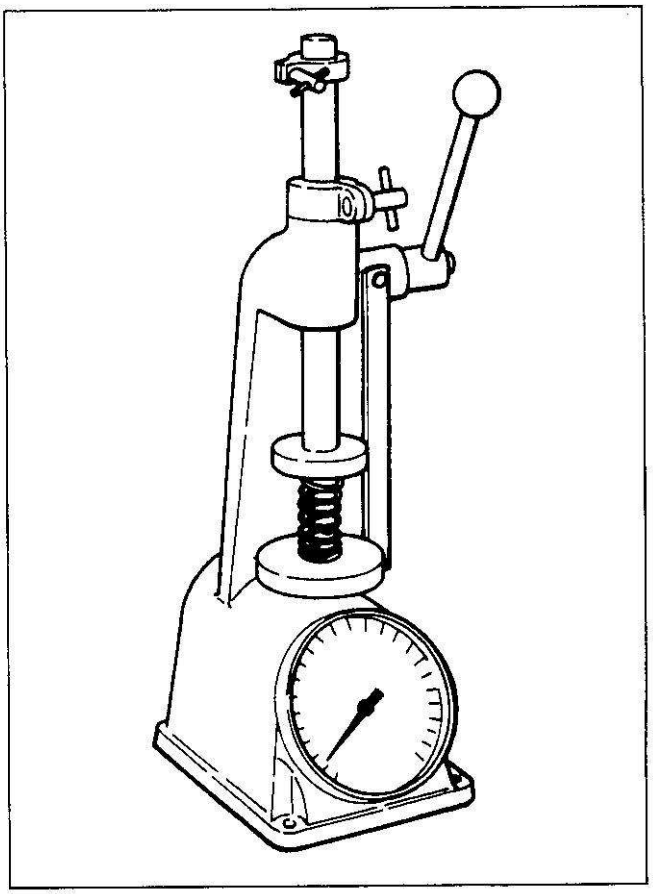


Figure 36. Measuring Valve Spring Tension

Valve Seat Grinding

Reconditioning the valve seats is very important because the seating of the valves must be perfect for the engine to deliver the power and performance built into it.

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

Several different types of equipment are available for grinding valve seats. The recommendations of the manufacturer of the equipment being used should be carefully followed to attain proper results.

Regardless of what type of equipment is used, however, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the pilot in the guide. The correct seat angle is 45 degrees.

If too much material is removed from the valve seat, the valve installed depth (figure 31) may become excessive (more than 2.5 mm/0.100 in). If this is the case, the valve seat must be replaced, as outlined later in this section.

Valve Grinding

- Valves that are pitted must be refaced to the proper angle. Valve stems that show excessive wear, or valves that are warped excessively should be replaced. When a valve head that is warped excessively is replaced, a knife edge will be ground on part or all of the valve head due to the amount of metal that must be removed to completely reface. A knife edge leads to breakage or burning due to heat localizing on this knife edge.
- The minimum valve margin thickness after grinding is 0.7 mm (0.028 in) (figure 37).
- The correct valve face angle is 45 degrees.
- Several different types of equipment are available for refacing valves. The recommendation of the manufacturer of the equipment being used should be carefully followed to attain proper results.

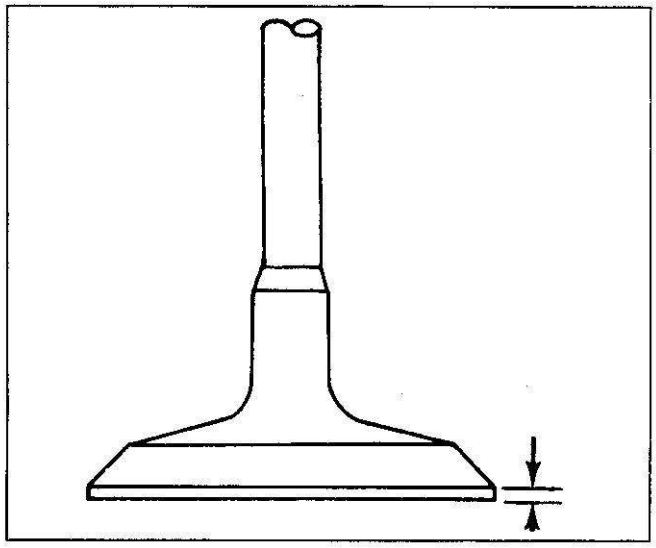


Figure 37. Valve Margin Thickness

Valve Guide Replacement

(Figures 27, 38 and 39)

Tool Required:

J-34535 Valve Guide Remover and Installer

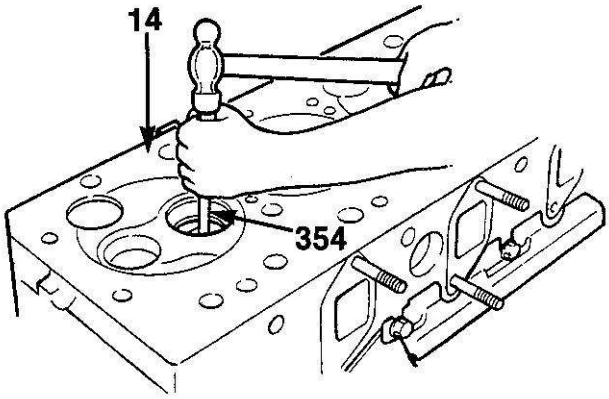
1. Place the cylinder head (14) on wooden blocks, combustion chamber side up.
2. Drive out the old valve guide (74), using tool J-34535 (figure 38).
3. Thoroughly clean the valve guide bore in the cylinder head (14).
4. Drive in the new valve guide (74) using tool J-34535 (figure 38a). After installation, the top surface of the valve guide MUST be 14.1 mm (0.550 in) above the cylinder head surface.

Valve Seat Replacement

(Figures 27, 31 and 39)

NOTICE: Do not attempt to heat the cylinder head to remove the valve seats. This may damage the cylinder head.

1. Grind the valve seat (72 or 73) until the seat is 0.5–1.0 mm (0.020–0.040 in) thick (figure 39).
2. Pry the valve seat (72 or 73) out, using a pry tool.
3. Thoroughly clean the valve seat counterbore in the cylinder head (14).
4. Press the new valve seat (72 or 73) into place.
5. Grind the valve seat (72 or 73) as outlined in "Valve Seat Grinding" previously in this section. Reface the valve seat until the valve installed depth (figure 31) is correct. When a new valve seat and new valve (65 or 66) are used together, the installed depth should be 0.65–1.10 mm (0.026–0.042 in). In no case should the installed depth be greater than 2.5 mm (0.100 in).



14. Cylinder Head
354. J-34535

Figure 38. Removing the Valve Guide

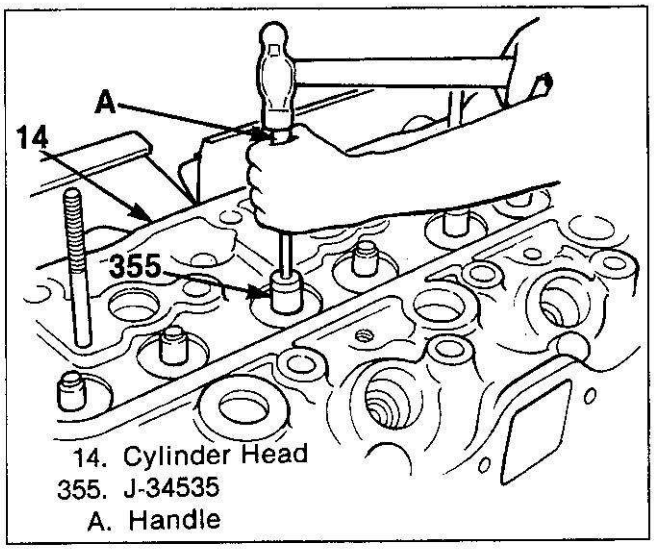


Figure 38a. Installing the Valve Guide

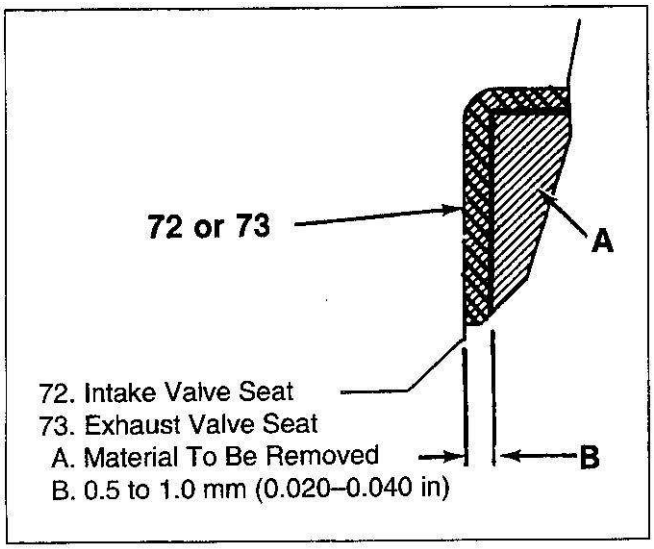


Figure 39. Grinding the Valve Seat to Allow Removal

Valve Lapping

(Figures 27 and 41)

The valves should be lapped before final assembly to ensure a good valve seal.

1. Apply Prussian blue, or equivalent, to a valve seat (72 or 73).
2. Insert the valve (65 or 66) into the proper port.
3. Rotate the valve (65 or 66) lightly, then remove.
4. Inspect the valve face. The valve seat width should be 1.5 mm (0.059 in), as indicated by the mark on the valve face. The contact area should be centered on the valve face (figure 41). If not, the valve seat (72 or 73) requires grinding, as outlined in "Valve Seat Replacement" previously in this section.
5. Repeat steps 1 through 4 on the remaining valves (65 or 66) as required.
6. Clean all Prussian blue from the valves (65 and 66) and valve seats (72 and 73).
7. Apply a medium valve lapping compound to the valves. Lap until a gray ring appears all the way around the valve face.
8. Thoroughly clean all lapping compound from the valves and cylinder head.

Hot Plug and Heat Shield Replacement

(Figures 27, 40, 40a and 40c)

Important

- Do not remove if no fault is apparent.

1. Place the cylinder head (14) on wooden blocks.
2. Remove the fuel injection nozzle holder assembly, washer (77) and corrugated washer (78).
3. Insert a suitable round rod sizing 3 to 5 mm (0.1 to 0.2 in) in diameter into nozzle holder fitting hole to touch the hot plug (76), then drive out the hot plugs using a hammer (figure 40).
4. Insert a suitable round rod sizing 3 to 5 mm (0.1 to 0.2 in) in diameter into hot plug fitting hole and drive out the heat shield (79) (figure 40a).
5. Remove the washer (80).
6. Thoroughly clean the hot plugs (76) and combustion chamber.
7. Check hot plug (76) for crack or damage.
8. Check washer for damage.
9. Drive the hot plug (76) into cylinder head by aligning lock ball in hot plug with groove in cylinder head.

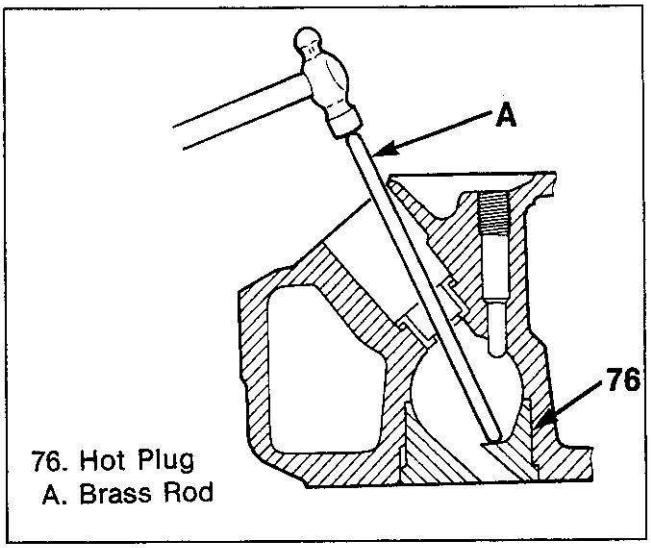
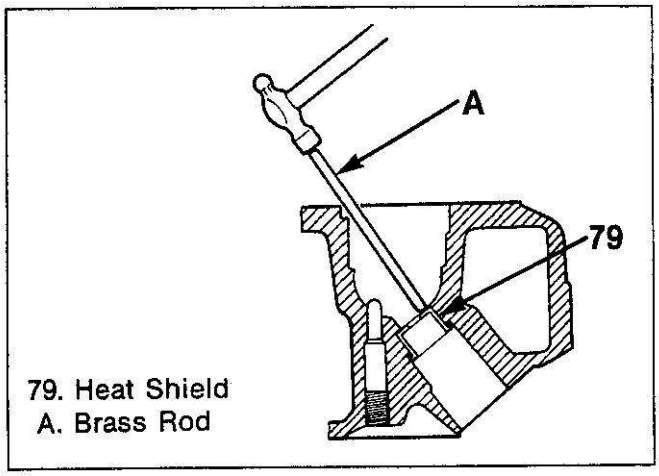


Figure 40. Removing the Hot Plug



79. Heat Shield
A. Brass Rod

Figure 40a. Removing the Heat Shield

In case of new hot plug

Press the hot plug into position by applying 44,000–49,000 N (9,900 – 11,000 lb) pressure using press with a piece of metal fitted against the hot plug face for protection. After installation, use a surface grinder to grind off any hot plug surface protrusions.

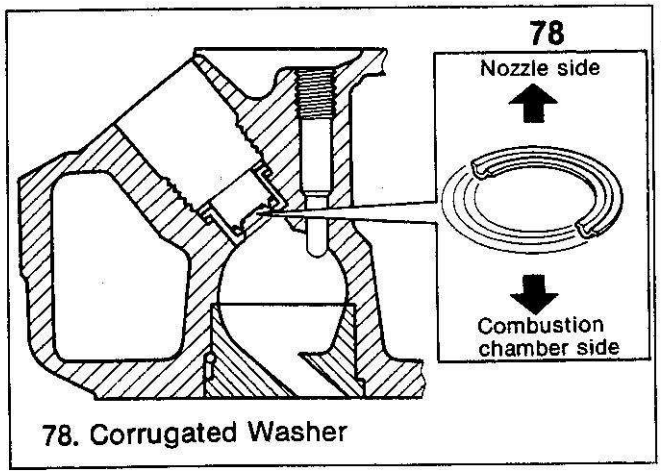
Important

- Do not apply pressure greater than that specified. Damage to the cylinder head will result.

10. Install washer (80), new heat shield (79) with the flanged up on the cylinder head by tapping on the flange lightly with a brass bar.
11. Install new corrugated washer (78). The corrugated washer should be installed with blue color painted side turned to the nozzle (figure 40b).
12. Washer (77) and nozzle holder.

Tighten

- Nozzle holder assembly to 64 N·m (47 lb·ft).



78. Corrugated Washer

Figure 40b. Installing the Corrugated Washer

Assemble (Figures 27, 29 and 42)

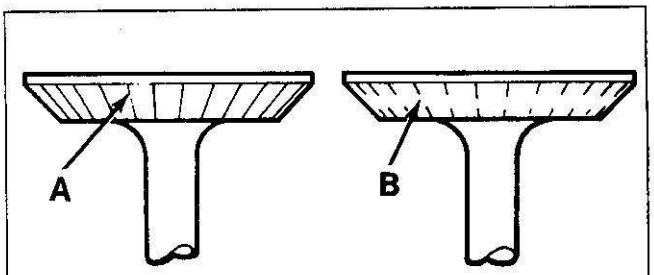
- Lubricate the valve stem seals (75) with engine oil.

1. Valve stem seals (75) using tool J-34545 (figure 42).

Important

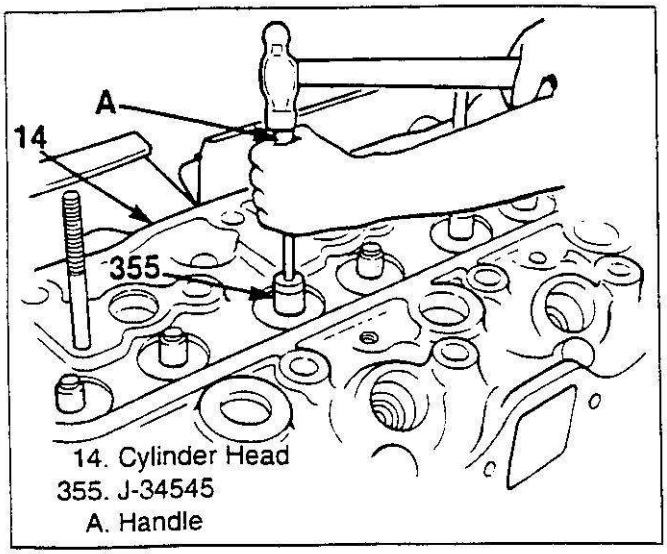
- It may be necessary to remove the garter spring before installing the valve seal.
- Lubricate the valve stems with engine oil.

2. Valves (65 and 66) into the proper port.
3. Valve spring seats (67).
4. Valve springs (68 and 69). The close-spaced coils face toward the cylinder head.
5. Valve spring cap (70).
   - Compress the valve springs using spring compressor tool (figure 29).
6. Valve keys (71). Slowly release the compressor tool after the valve keys (71) are in place.
7. Thermostat housing and gasket. Refer to ON-VEHICLE SERVICE: COOLING SYSTEM COMPONENTS (SEC. 6B1).
8. Intake manifold and gasket. Refer to "Intake Manifold Replacement" earlier in this section.



A. Pencil Marks Before Contact
B. Pencil Marks After Proper Contact

Figure 41. Valve Face Contact Pattern

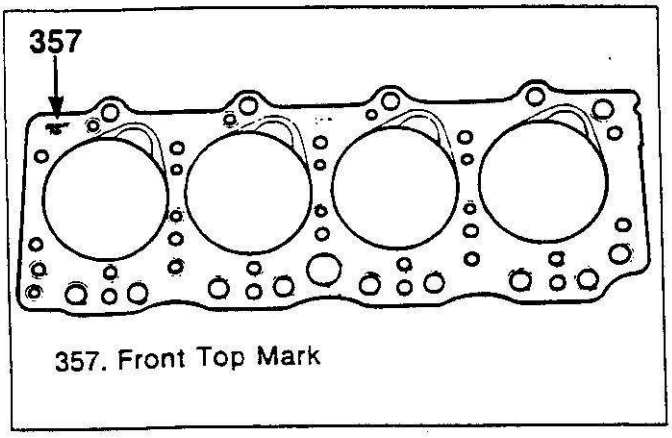


14. Cylinder Head
355. J-34545
A. Handle

Figure 42. Installing the Valve Seal

Install or Connect (Figures 27 and 43-45)

1. Head gasket (63) to the block. The "FRONT-TOP" mark on the gasket must be right side up, at the front of the block (figure 43).
2. Cylinder head (14).
   - If hot plug fell out, apply grease to the hot plug, and install it to the cylinder head.
   - Apply grease containing molybdenum disulfide to all head bolts (64).
3. Head bolts (64). The stud bolts are used on the right side (injection pump side) of the cylinder head (figure 44).



357. Front Top Mark

Figure 43. Head Gasket Marking

Tighten (Figures 27, 44 and 45)

Head bolts (64) in three stages, as outlined below:

- Stage 1: Tighten all head bolts to 68 N·m (50 lb-ft) using the tightening sequence shown in figure 44.
- Stage 2: Tighten all head bolts to 88 N·m (65 lb-ft) using the tightening sequence shown in figure 44.
- Stage 3: Refer to figure 45. Make punch mark on the bolt heads, as shown.
  Then, make a second punch mark on the head, 120–150 degrees clockwise from the first mark, as shown. Then, tighten all head bolts 120–150 degrees, using the tightening sequence shown in figure 44.

4. Valve train components as outlined in "Valve Train Component Replacement" previously in this section.

Adjust

- Refer to VALVE ADJUSTMENT (SEC. 6A) in this manual.

5. Cylinder head cover (36) as outlined in "Cylinder Head Cover Replacement" previously in this section.
6. Exhaust manifold (16) as outlined in "Exhaust Manifold Replacement" previously in this section.
7. Turbocharger (22) as outlined in "Turbocharger Replacement" previously in this section.
8. Injection nozzles and injection pipes. Refer to DIESEL FUEL INJECTION (SEC. 6C3) in this manual.
9. Glow plugs (56) as outlined in "Glow Plug Replacement" previously in this section.
10. Fuel filter and lines as outlined in FUEL SYSTEM (SEC. 6C1).
11. Engine stop cable. Refer to FUEL INJECTION PUMP REPLACEMENT (SEC. 6B3).
12. Water pump bypass hose. Refer to ON-VEHICLE SERVICE: COOLING SYSTEM COMPONENTS (SEC. 6B1).
13. Heater hose. Refer to COOLING SYSTEM (SEC. 6B1).
14. Crankcase breather as outlined in "Crankcase Breather Replacement" previously in this section.
15. Upper radiator hose. Refer to COOLING SYSTEM (SEC. 6B1).
    — Fill the radiator with the proper quantity and grade of coolant. Refer to MAINTENANCE AND LUBRICATION (SEC. 0B) in this manual.
16. Battery cables.
    - Bleed the fuel system. Refer to DIESEL FUEL INJECTION (SEC. 6C3) in this manual.

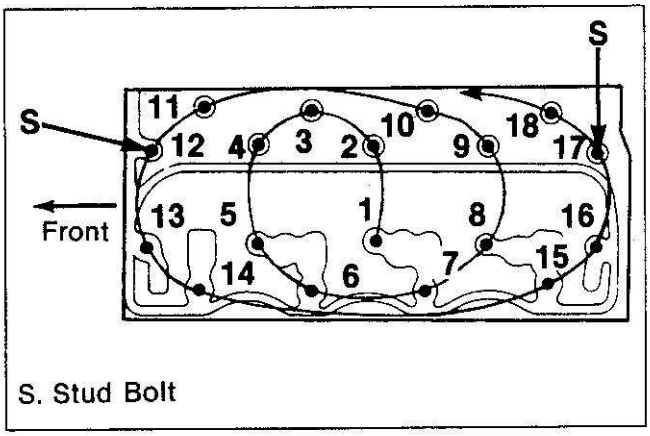


Figure 44. Head Bolt Tightening Sequence

PISTON, CONNECTING ROD AND LINER

Refer to " Statement on Cleanliness and Care" previously mentioned in this section.

Remove or Disconnect (Figures 46 and 47)

1. Battery cables.
2. Cylinder head (14) as outlined in "Cylinder Head" previously in this section.
3. Oil pan (134) as outlined in "Oil Pan Replacement" later in this section.
4. Bolts (83).
5. Connecting rod cap (82).
6. Piston (80) and connecting rod (81) as an assembly. If the piston is to be reused, mark the cylinder number on it so it can be returned to the proper cylinder as assembly. Be sure to keep the connecting rod cap (82), connecting rod (81) and connecting rod bearing inserts (86 and 87) together as a matched set. Numbers are stamped on the connecting rod and cap to help keep the parts together (figure 47).

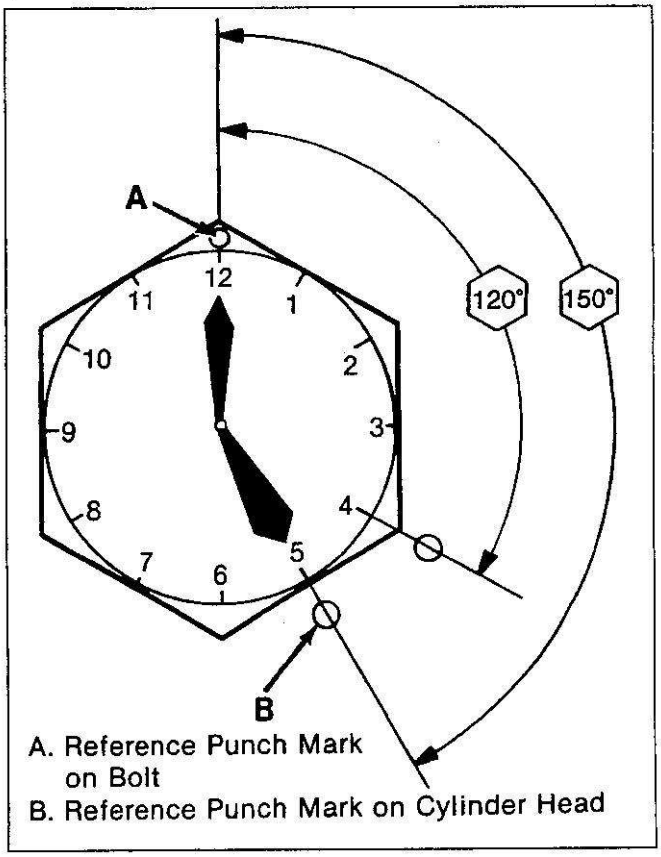


Figure 45. Angle Torquing Method for Cylinder Head Bolts

Disassemble (Figures 46, 48 and 59)

1. Rings (76, 77 and 78), using a ring expander (figure 48).
2. Snap rings (79).
3. Piston pin (84). Heat the piston (80), if required, to aid in piston pin removal. Do not drive the piston pin out.

Clean (Figure 46)

— Piston (80) and rings (76, 77 and 78) in solvent. Do not wire brush the piston.
— Liner (89) bore with a solvent soaked cloth (figure 59).
— Piston (80) ring grooves with a ring groove cleaning tool.

76. Upper Compression Ring
77. Lower Compression Ring
78. Oil Control Ring
79. Snap Ring
80. Piston
81. Connecting Rod
82. Connecting Rod Cap
83. Bolt
84. Piston Pin
85. Piston Pin Bushing
86. Upper Connecting Bearing Insert
87. Lower Connecting Rod Bearing Insert
88. Connecting Rod Bearing

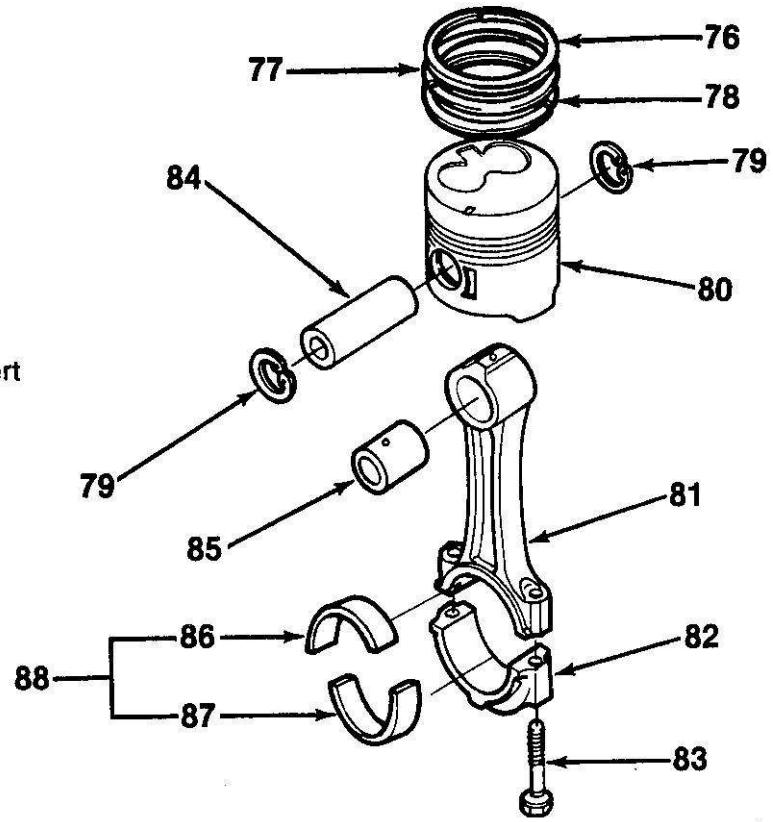
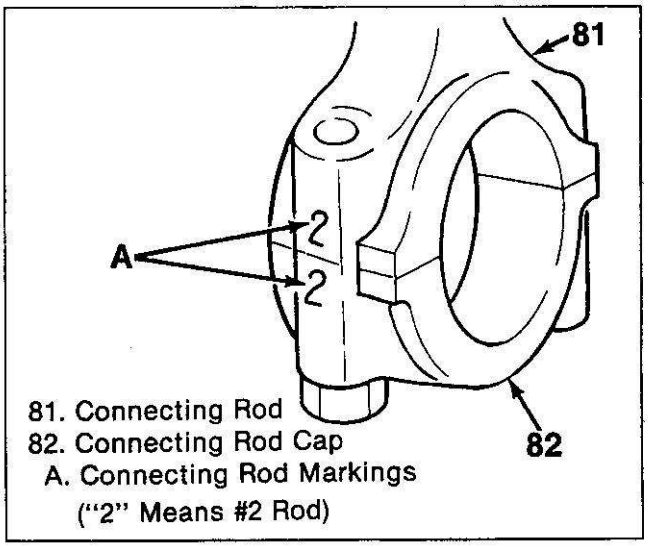


Figure 46. Piston, Connecting Rod and Components

Inspect (Figure 46)

- Piston (80) for cracks and scoring.
- Liner (89) for scratches, cracks and scoring (figure 59).
- Connecting rod (81) and connecting rod cap (82) for cracks, damage etc.
- Piston pin bushing (85) for scoring.
- Connecting rod bearing inserts (86 and 87) for scoring.
- Connecting rod bearing insert (86 and 87) tension (figure 53). Moderate finger pressure should be needed to push the bearing inserts into place. If the inserts fit loosely, they should be replaced.
- Connecting rod journal on the crankshaft for scoring or other damage.



81. Connecting Rod
82. Connecting Rod Cap
A. Connecting Rod Markings ("2" Means #2 Rod)

Figure 47. Connecting Rod Markings