2.5L VM DIESEL

INDEX

GENERAL INFORMATION

GENERAL SPECIFICATION

Type	425CLIEE (36B)
Displacement	2.5L (2499 cc)
Bore	92.00 mm
Stroke	94.00 mm
Compression Ratio	20.95:1
Vacuum at Idle	600 mm/Hg (23.6 In/Hg)
Thermostat Opening	80°C±2°C
Generator Rating	Bosch 50/120 Amp
Cooling System Capacity	9.5 Liter
Power Steering Capacity	0.75 Liter
Type	425CLIEE (36B)
Engine Oil Capacity	6.5 Liters With Oil Filter Change
Timing System	Pushrod Operated Overhead valves, With Gear-Driven Camshaft.
Air Intake	Dry Filter
Fuel Feed	Vacuum Pump Incorporated in Injection Pump.
Fuel System	Indirect Fuel Injection (Precombustion Chamber)
Combustion Cycle	4 Stroke
Cooling System	Water Cooled
Injection Pump	Rotary Pump Electronically Controlled.

GENERAL INFORMATION (Continued)

Type 425CLIEE (36B)
Lubrication . Pressure Lubrication by Rotary Pump, Full-Flow Filtration
Engine Rotation . . . . Clockwise Viewed From Front Cover

ENGINE IDENTIFICATION

The engine model code (3-digit number/letter code) and serial number are stamped on the forward facing side of the engine block (Fig. 1).

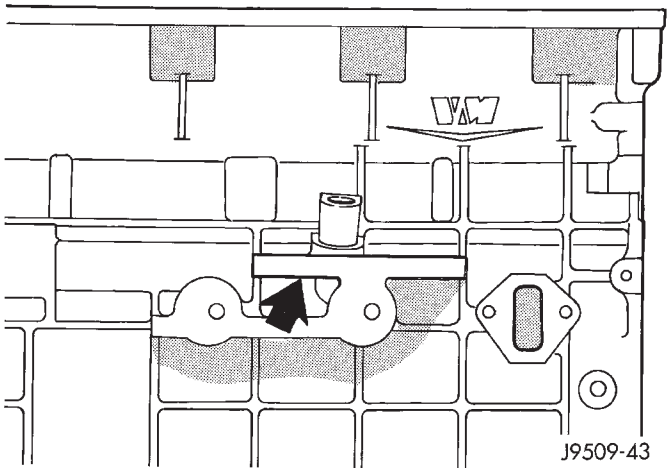


Fig. 1 Engine Code Location

DESCRIPTION AND OPERATION

LUBRICATION SYSTEM

The pressurized system (Fig. 2) uses a rotary pump (3) located in the front of the engine block, driven by a gear which meshes directly with the crankshaft gear. All the oil sent to every lubricated part is filtered. The pump sends the oil through a pressure relief valve (2) to the filter (7) and through galleries in the crankcase to the crankshaft bearings (8), camshaft bearings (11) and turbocharger (10). The piston pins, connecting rod small ends and insides of the pistons are lubricated and cooled by oil sprayed out from jets (9) in the crankshaft mounting blocks. The lubricating oil is sent to the rockers (12) through an external pipe (Fig. 3). A valve in the filter cartridge enables the oil to be circulated even when the cartridge is clogged.

Sump inlet (1). Pressure relief valve (2). Oil pump (3). Oil cooler (6). Filter cartridge (7). Crankshaft bearings (8). Jet valve (9). Turbocharger bearings (10). Camshaft bearings (11). Rockers (12).

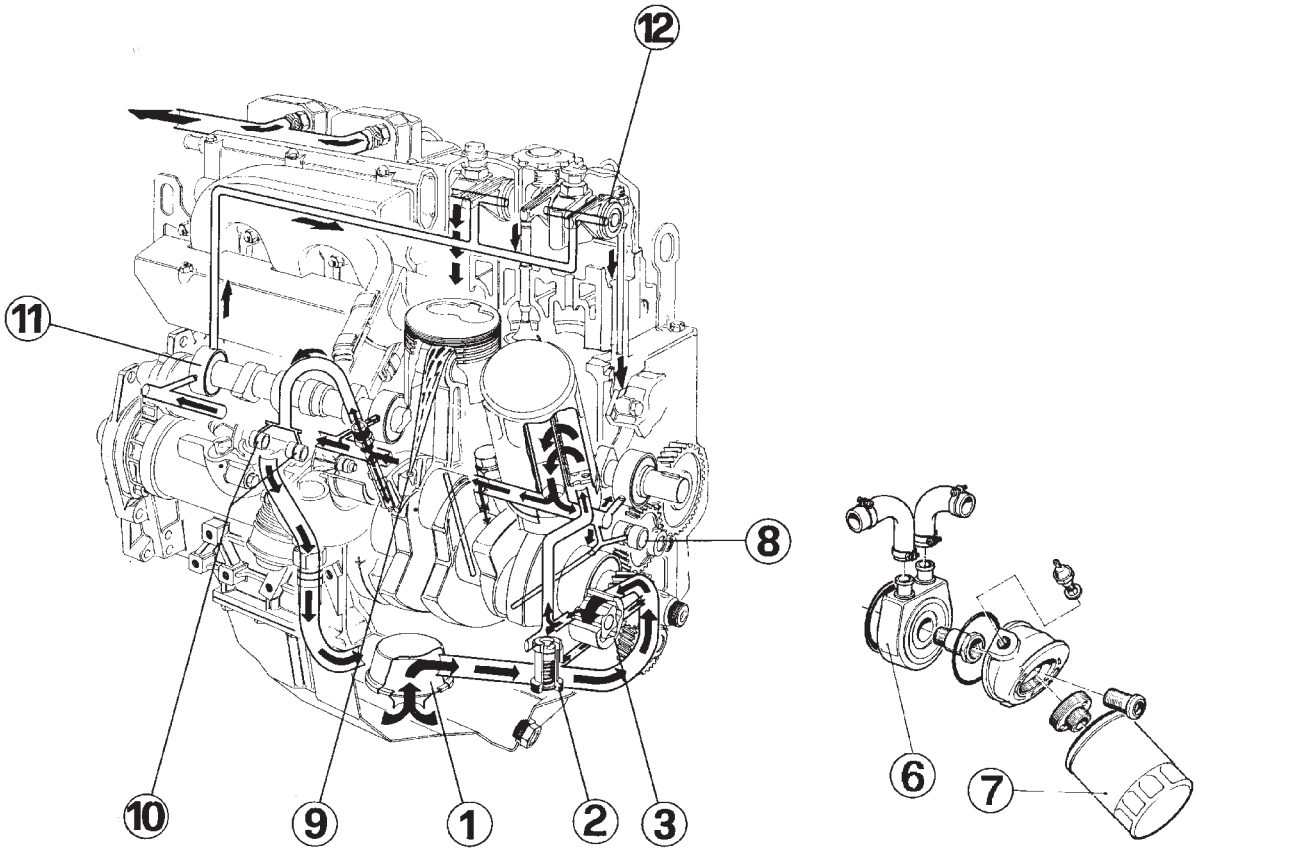


Fig. 2 Lubrication System

DESCRIPTION AND OPERATION (Continued)

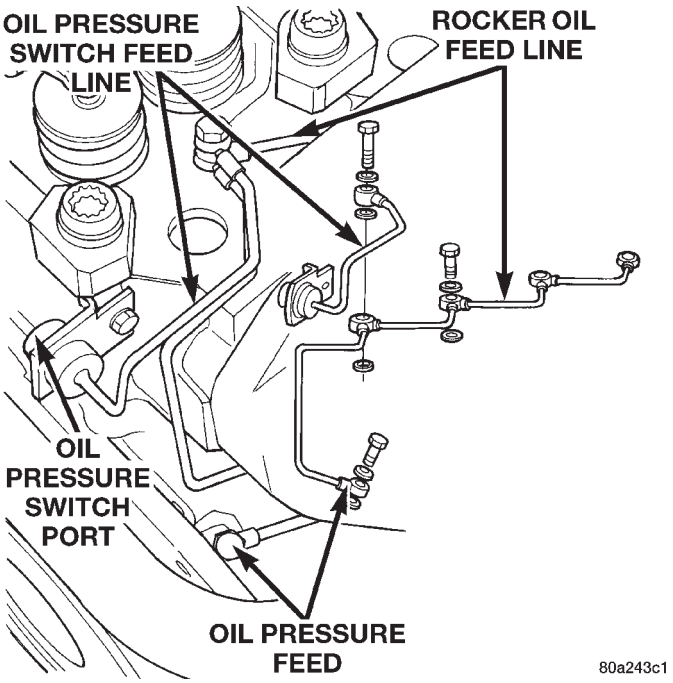


Fig. 3 Lubrication Lines

DIAGNOSIS AND TESTING

ENGINE DIAGNOSIS—PERFORMANCE

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE WILL NOT CRANK OR CRANKS SLOWLY	1. Starting motor operating, but not cranking the engine.	1. Remove the starter motor. Check for broken flywheel teeth or a broken starter motor spring.
	2. Crankshaft rotation restricted.	2. Rotate the engine to check for rotational resistance.
	3. Starting circuit connections loose or corroded.	3. Clean and tighten connections.
	4. Neutral safety or starter relay inoperative.	4. Check starter relay supply voltage and proper operation of neutral safety switch (if equipped). Replace defective parts.
	5. Battery charge low.	5. Check Battery voltage. Replace battery if a charge cannot be held.
	6. No voltage to starter solenoid.	6. Check voltage to solenoid. If necessary, replace the solenoid.
	7. Solenoid or starter motor inoperative.	7. Replace starter motor.
ENGINE CRANKS, BUT WILL NOT START, NO SMOKE	1. No fuel in supply tank.	1. Fill fuel supply.
	2. Electrical fuel shutdown solenoid not operating.	2. Check for loose wires and verify that the fuel shutdown solenoid is functioning. Check for fault codes in the ECU.
	3. Fuel injection system defective: Cranking speed sensor. Loose connection between ECU and harness. No power supply to the ECU. Loose connection between injection pump and harness.	3. Check for fault codes at ECU. Refer to Group 14, Fuel System for repairs procedures.
	4. Air intake or exhaust plugged.	4. Remove the obstruction.
	5. Fuel filter plugged.	5. Drain fuel/water separator and replace fuel filter.
	6. Excessive fuel inlet restriction.	6. Check for restriction. Correct cause.
	7. Injection pump not getting fuel or fuel is aerated.	7. Check fuel flow/bleed fuel system.
	8. One or more injectors worn or not operating properly.	8. Check/replace bad or improperly operating injectors.
	9. Camshaft out of time.	9. Check/correct timing chain sprocket alignment.
ENGINE HARD TO START, OR WILL NOT START, SMOKE FROM EXHAUST	1. Incorrect starting procedure.	1. The fuel shutoff solenoid control must be in the run position. Ensure the proper procedure is being used.
	2. Cranking speed to slow.	2. Check the battery, starter motor and look for loose or corroded wiring connections.
	3. Cylinder head heater plugs defective.	3. Verify system is working. Verify connection between heater plug relay and ECU. Repair/replace inoperative parts.
	4. Insufficient intake air	4. Inspect or replace air filter and check for obstruction in air supply.
	5. Air in fuel system or the fuel supply is inadequate.	5. Check the fuel flow through the filter and bleed system. Locate and eliminate the air source.
	6. Contaminated fuel.	6. Verify by operating the engine with clean fuel from a temporary tank. Check for the presence of gasoline. Drain and flush fuel supply tank. Replace fuel/water separator filter.
	7. Fuel screen plugged.	7. Check fuel screen.
	8. One or more injectors worn or not operating properly.	8. Check/replace improperly operating injectors.
	9. Injector pump out of time.	9. Check pump timing. Refer to Group 14, Fuel System for procedure.
	10. Engine compression low.	10. Check compression to identify the problem.
	11. Fuel injection system defective.	11. Vacuum modulator defective causing EGR to open in cold condition. Check for fault codes in the ECU.

DIAGNOSIS AND TESTING (Continued)

ENGINE DIAGNOSIS—MECHANICAL

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL PRESSURE LOW	1. Low oil level.	1a. Check and fill with clean engine oil. 1b. Check for severe external oil leaks that could reduce the pressure.
	2. Oil viscosity thin, diluted, or wrong specification.	2. Verify the correct oil is being used. Check for oil dilution.
	3. Improperly operating pressure switch/gauge	3. Verify the pressure switch is functioning correctly. If not, replace switch/gauge.
	4. Relief valve stuck open.	4. Check/replace valve.
	5. Plugged oil filter.	5. Change oil filter. Oil filter change interval may need to be revised.
	6. Oil cooler was replaced, shipping plugs left in cooler.	6. Check/removed shipping plugs.
	7. Worn oil pump.	7. Check/replace oil pump.
	8. Suction tube loose or seal leaking.	8. Check and replace seal.
	9. Worn bearing or wrong bearing installed.	9. Inspect and replace connecting rod or main bearings. check and replace piston cooling oil jet.
	10. Oil jets under piston loose or bad fit.	10. Check oil jets position.
LUBRICATING OIL LOSS	1. External oil leaks.	1. Visually inspect for oil leaks. Repair as required.
	2. Crankcase being overfilled.	2. Verify that the correct dipstick is being used.
	3. Incorrect oil specification or viscosity.	3a. Make sure the correct oil is being used. 3b. Look for reduced viscosity from dilution with fuel. 3c. Review/reduce the oil change intervals.
	4. Oil cooler leak.	4. Check and replace the oil cooler.
	5. High blow-by forcing oil out the breather.	5. Check the breather tube area for signs of oil loss.

DIAGNOSIS AND TESTING (Continued)

ENGINE DIAGNOSIS—MECHANICAL CONT.

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL LOSS (CONT.)	6. Turbocharger leaking oil into the air intake. 7. Piston rings not sealing (oil being consumed by the engine).	6. Inspect air duct for evidence of oil transfer. 7. Perform blow-by check. Repair as required.
COMPRESSION KNOCKS	1. Air in fuel system. 2. Poor quality fuel or water/gasoline contaminated fuel. 3. Engine Overloaded. 4. Improperly operating injectors. 5. Fuel injection system defective.	1. Bleed the fuel system (refer to Group 14, Fuel System). 2. Verify by operating from a temporary tank with good fuel. Clean and flush the fuel supply tank. Replace fuel/water separator. 3. Verify the engine load rating is not being exceeded. 4. Check and replace injectors. 5a. Instrumented injection. 5b. Timing solenoid of the fuel pump. 5c. Pre and post heat time of the glow plugs. Check the fault codes in the ECU.
EXCESSIVE ENGINE NOISES	1. Drive belt squeal, insufficient tension or abnormally high loading. 2. Intake air and exhaust leak. 3. Excessive valve lash. 4. Turbocharger noise. 5. Power function knock. 6. Fuel injection system defective.	1. Inspect the drive belts. Make sure water pump pulley, generator and power steering all turn freely. 2. Refer to excessive exhaust smoke. (Engine Diagnosis and Testing) 3. Make sure the rocker arms are not bent. Defective hydraulic lash adjuster. 4. Check turbocharger impeller and turbine wheel for housing contact. 5. Check and replace rod and main bearings. 6a. Instrumented injection. 6b. Timing solenoid of the fuel pump. 6c. Pre and post heat time of the glow plugs. Check the fault codes in the ECU.

DIAGNOSIS AND TESTING (Continued)

ENGINE DIAGNOSIS—MECHANICAL CONT.

CONDITION	POSSIBLE CAUSES	CORRECTION
GENERATOR NOT CHARGING OR INSUFFICIENT CHARGING	1. Loose or corroded battery. 2. Generator belt slipping. 3. Generator pulley loose on shaft. 4. Improperly operating generator.	1. Clean/tighten battery connection. 2. Check/replace automatic belt tensioner. Check/replace and adjust belt. 3. Tighten pulley. 4. Check/replace generator.

DIAGNOSIS AND TESTING (Continued)

HYDRAULIC TAPPETS

Before disassembling any part of the engine to correct tappet noise, check the oil pressure. If vehicle has no oil pressure gauge, install a reliable gauge at the pressure sending unit. The pressure should be between 3.5 bars to 5.0 bars at 4000 RPM.

Check the oil level after the engine reaches normal operating temperature. Allow 5 minutes to stabilize oil level, check dipstick. The oil level in the pan should never be above the FULL mark or below the ADD OIL mark on dipstick. Either of these 2 conditions could be responsible for noisy tappets.

OIL LEVEL HIGH

If oil level is above the FULL mark, it is possible for the connecting rods to dip into the oil. With the engine running, this condition could create foam in the oil pan. Foam in oil pan would be fed to the hydraulic tappets by the oil pump causing them to lose length and allow valves to seat noisily.

OIL LEVEL LOW

Low oil level may allow oil pump to take in air. When air is fed to the tappets, they lose length which allows valves to seat noisily. Any leaks on intake side of oil pump through which air can be drawn will create the same tappet action. Check the lubrication system from the intake strainer to the pump cover, including the relief valve retainer cap. When tappet noise is due to aeration, it may be intermittent or constant, and usually more than 1 tappet will be noisy. When oil level and leaks have been corrected, operate the engine at fast idle. Run engine for a sufficient time to allow all of the air inside the tappets to be bled out.

TAPPET NOISE DIAGNOSIS

(1) To determine source of tappet noise, operate engine at idle with cylinder head covers removed.

(2) Feel each valve spring or rocker arm to detect noisy tappet. The noisy tappet will cause the affected spring and/or rocker arm to vibrate or feel rough in operation.

NOTE: Worn valve guides or cocked springs are sometimes mistaken for noisy tappets. If such is the case, noise may be dampened by applying side thrust on the valve spring. If noise is not appreciably reduced, it can be assumed the noise is in the tappet. Inspect the rocker arm push rod sockets and push rod ends for wear.

(3) Valve tappet noise ranges from light noise to a heavy click. A light noise is usually caused by excessive leak down around the unit plunger or by the plunger partially sticking in the tappet body cylinder. The tappet should be replaced. A heavy click is caused by a tappet check valve not seating or by foreign particles becoming wedged between the plunger and the tappet body. This will cause the plunger to stick in the down position. This heavy click will be accompanied by excessive clearance between the valve stem and rocker arm as valve closes. In either case, tappet assembly should be removed for inspection and cleaning.

(4) The valve train generates a noise very much like a light tappet noise during normal operation. Care must be taken to ensure that tappets are making the noise. In general, if more than one tappet seems to be noisy, its probably not the tappets.

SERVICE PROCEDURES

CHECKING OIL LEVEL

To assure proper engine lubrication, the engine oil must be maintained at the correct level. Check the oil level at regular intervals, such as every fuel stop.

The best time to check the oil level is about 5 minutes after a fully warmed-up engine is shut off, or before starting the vehicle after it has sat overnight.

Checking the oil while the vehicle is on level ground, will improve the accuracy of the oil level readings (Fig. 4).

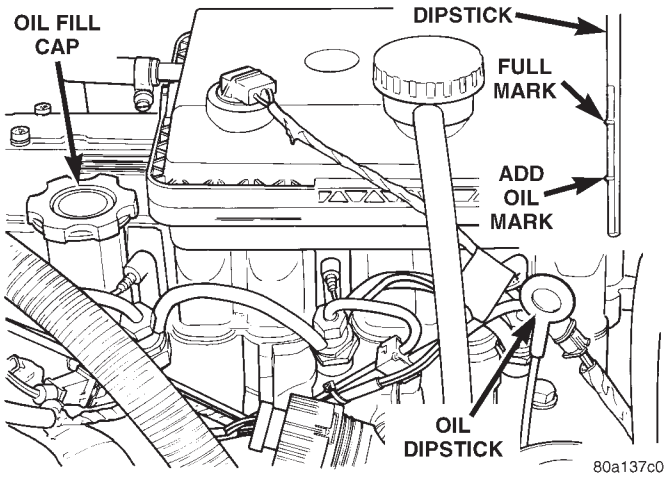


Fig. 4 Checking Engine Oil

CHANGING ENGINE OIL AND FILTER

Change engine oil and filter at mileage and time intervals described in the Maintenance Schedule.

SERVICE PROCEDURES (Continued)

ENGINE OIL CHANGE

WARNING: NEW OR USED ENGINE OIL CAN BE IRRITATING TO THE SKIN. AVOID PROLONGED OR REPEATED SKIN CONTACT WITH ENGINE OIL. CONTAMINANTS IN USED ENGINE OIL, CAUSED BY INTERNAL COMBUSTION, CAN BE HAZARDOUS TO YOUR HEALTH. THOROUGHLY WASH EXPOSED SKIN WITH SOAP AND WATER. DO NOT WASH SKIN WITH GASOLINE, DIESEL FUEL, THINNER, OR SOLVENTS, HEALTH PROBLEMS CAN RESULT. DO NOT POLLUTE, DISPOSE OF USED ENGINE OIL PROPERLY. CONTACT YOUR DEALER OR GOVERNMENT AGENCY FOR LOCATION OF COLLECTION CENTER IN YOUR AREA.

Run engine until achieving normal operating temperature.

(1) Position the vehicle on a level surface and turn engine off.

(2) Remove oil fill cap.

(3) Hoist vehicle. Refer to Hoisting and Jacking Recommendations.

(4) Place a suitable drain pan under crankcase drain.

(5) Remove drain plug from crankcase and allow oil to drain into pan (Fig. 5). Inspect drain plug threads for stretching or other damage. Replace drain plug if damaged.

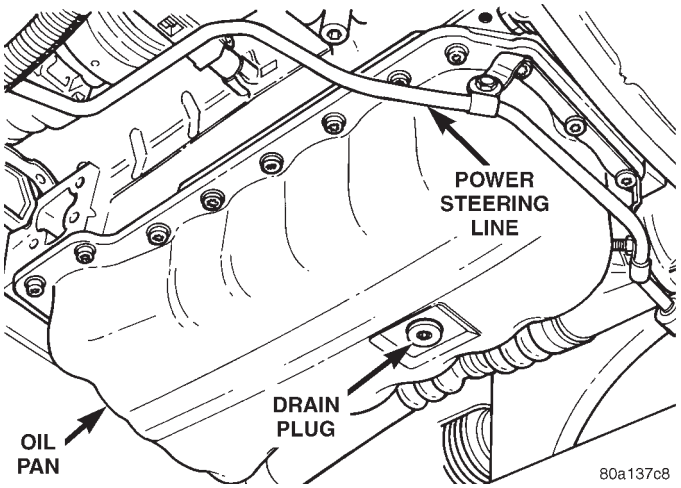


Fig. 5 Oil Drain Plug

(6) Install drain plug in crankcase.

(7) Lower vehicle and fill crankcase with specified type and amount of engine oil.

(8) Install oil fill cap.

(9) Start engine and inspect for leaks.

(10) Stop engine and inspect oil level.

ENGINE OIL

ENGINE OIL QUALITY

Use only oils conforming to API (American Petroleum Institute) quality SG/CD, or CCMC G4. Use only Diesel engine oil meeting standard **MIL-2104C** or API service classification **SG/CD or CCMM PD1** .

OIL VISCOSITY

Grade 15W-40 is recommended for temperatures between +35°C to –10°C (95°F to 14°F). Low viscosity oils must have the proper API quality or the CCMC G5 designation. Low viscosity oils are preferred when minimum temperatures consistently fall below –12°C (10°F).

ENGINE OIL FILTER CHANGE

(1) Position a drain pan under the oil filter.

(2) Using a suitable oil filter wrench loosen filter.

(3) Rotate the oil filter counterclockwise to remove it from the oil filter base (Fig. 6).

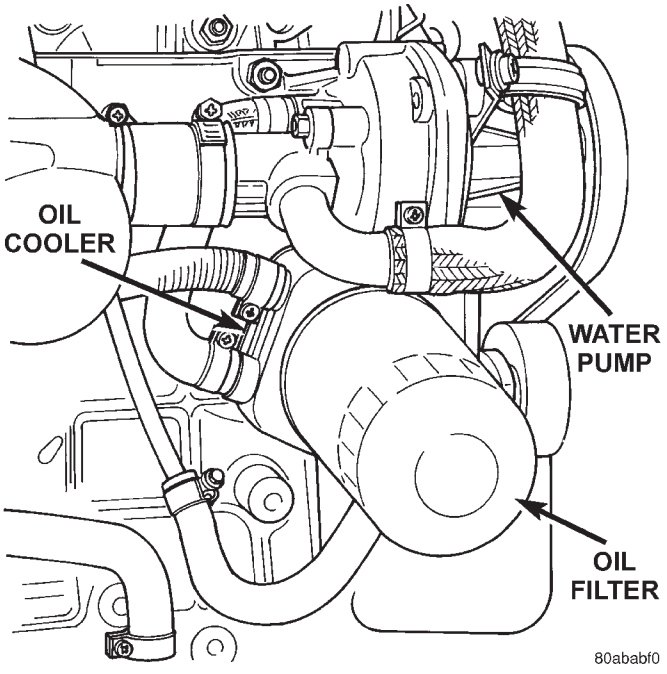


Fig. 6 Oil Filter

(4) When filter separates from base, tip gasket end upward to minimize oil spill. Remove filter from vehicle.

(5) With a cloth, wipe clean the gasket sealing surface of oil and grime.

OIL FILTER INSTALLATION

(1) Lightly lubricate oil filter gasket with engine oil.

(2) Thread filter onto the base. When gasket makes contact with sealing surface, hand tighten filter one full turn, do not over tighten.

SERVICE PROCEDURES (Continued)

(3) Add oil, verify crankcase oil level and start engine. Inspect filter area for oil leaks.

TIMING PROCEDURE

CAUTION: If a timing gear is removed you must loosen the rocker arm supports before rotating the crankshaft or camshaft. This will prevent the valves hitting the pistons.

For the engine components to be in proper timing order, the timing gear marks (dots) must be aligned as shown in (Fig. 7). To facilitate reassembly, align the timing marks as shown in (Fig. 7), or mark the timing gear positions before removal of any marked gears or gear driven component(s).

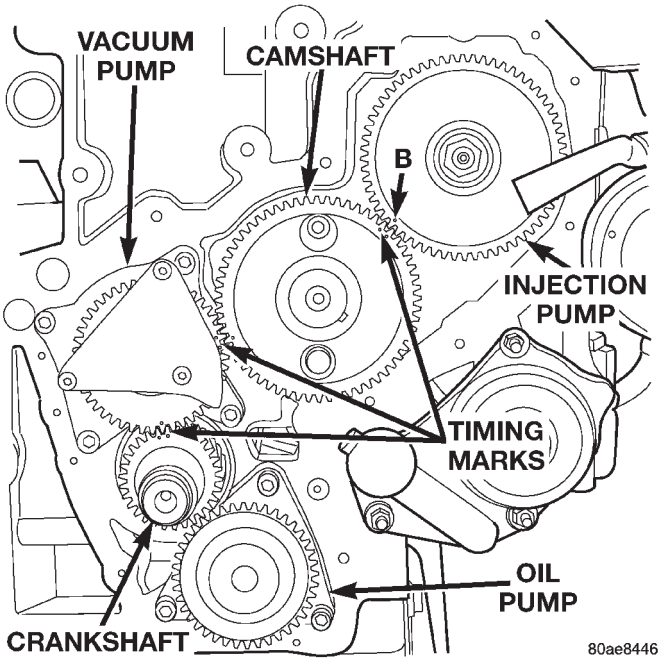


Fig. 7 Aligning Timing Marks

VALVE AND SEAT REFACING

VALVE REFACING

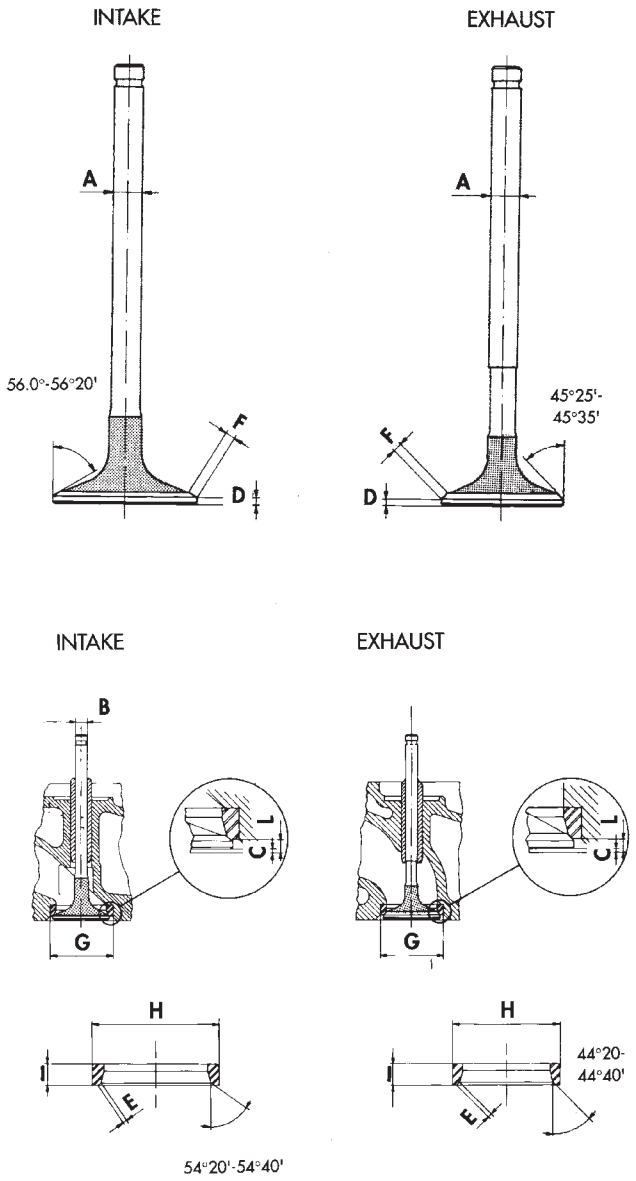
(1) Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.

(2) After refacing, a margin of at least 4.52-4.49 mm (.178-.177 inch) must remain (Fig. 8). If the margin is less than 4.49 mm (.177 inch), the valve must be replaced.

VALVE SEAT REFACING

(1) Install a pilot of the correct size in the valve guide bore. Reface the valve seat to the specified angle with a good dressing stone. Remove only enough metal to provide a smooth finish.

(2) Use tapered stones to obtain the specified seat width when required.



MEASUREMENT	INTAKE	EXHAUST
A	7.940-7.960	7.922-7.940
B	8.00-8.015	8.000-8.015
C	0.880-1.140	0.990-1.250
D	2.2±0.08	2.09 $^{+0.07}_{-0.09}$
E	1.80-2.20	1.65-2.05
F	2.73-3.44	2.45-3.02
G	41.962-41.985	35.964-35.987
H	42.070-42.086	36.050-36.066
I	7.14-7.19	7.00-7.05
L	3.11-3.26	3.10-3.25

Fig. 8 Valve Specification

SERVICE PROCEDURES (Continued)

VALVE STAND DOWN

Valve stand down is to maintain the adequate compression ratio.

(1) Invert cylinder head.

(2) Fit each valve to its respective valve guide.

(3) Using a straight edge and feeler gauge (Fig. 9), check valve head stand down: Inlet valve head stand down .80 to 1.2 mm (.031 to .047 in.) and exhaust valve stand down .79 to 1.19 mm (.031 to .047 in).

(4) If valve head stand down is not in accordance with above, discard original valves, check stand down with new valves and recut valve seat inserts to obtain correct stand down.

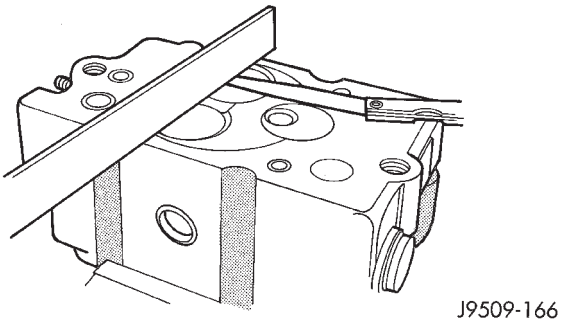


Fig. 9 Checking Valve Stand Down

VALVE GUIDE HEIGHT

(1) Valve Guides height requirement.

(2) Measurement A (Fig. 10): 13.50 - 14.00 mm.

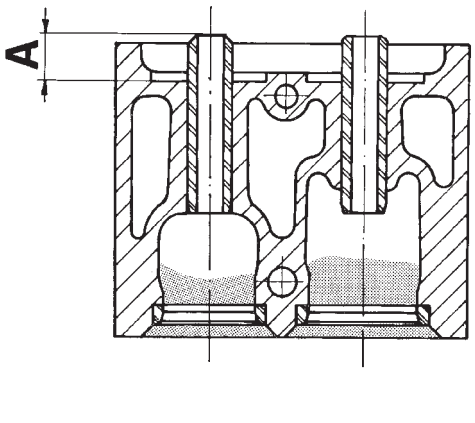


Fig. 10 Valve Guide Height

VALVE STEM-TO-GUIDE CLEARANCE MEASUREMENT

(1) Measure and record internal diameter of valve guides. Valve guide internal diameter is 8.0 to 8.015 mm (.3149 to .3155 in.).

(2) Measure valve stems and record diameters. Intake valve stem diameter 7.94 to 7.96 mm (.3125 to .3133 in). Exhaust valve stem diameter 7.92 to 7.94 mm (.3118 to .31215 in).

(3) Subtract diameter of valve stem from internal diameter of its respective valve guide to obtain valve stem clearance in valve guide. Clearance of inlet valve stem in valve guide is .040 to .075 mm (.0015 to .0029 in). Clearance of exhaust valve stem in valve guide is .060 to .095 mm (.0023 to .0037 in).

(4) If valve stem clearance in valve guide exceeds tolerances, new valve guides must be installed.

FITTING PISTON RING

(1) Wipe cylinder bore clean. Insert ring and push down with piston to ensure it is square in bore. The ring gap measurement must be made with the ring positioning at least 12 mm (0.50 in.) from bottom of cylinder bore (Fig. 11). Check gap with feeler gauge. Top compression ring gap .25 to .50mm (.0098 to .0196 in.). Second compression ring gap .25 to .35mm (.0098 to .0137 in.). Oil control ring gap .25 to .58mm (.0098 to .0228 in.).

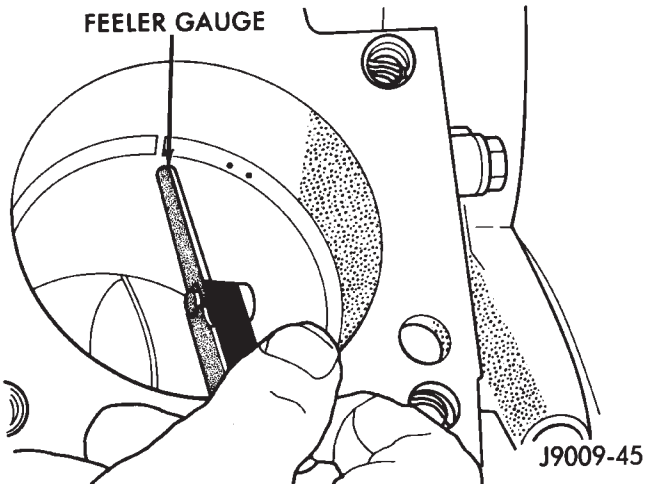


Fig. 11 Ring Gap Measurement

(2) If ring gaps exceed dimension given, new rings or cylinder liners must be fitted. Keep piston rings in piston sets.

(3) Check piston ring to groove clearance (Fig. 12). Top compression ring gap .08 to .130mm (.0031 to .0051 in.). Second compression ring gap .070 to .102mm (.0027 to .0040 in.). Oil control ring gap .040 to .072mm (.0015 to .0028 in.).

CRANKSHAFT END PLAY

(1) Attach dial indicator to engine block (Fig. 13).

(2) Move crankshaft toward front of engine and zero indicator.

(3) Move crankshaft toward the rear of engine and record measurement.

(4) Subtract specified crankshaft end float from figure obtained. Crankshaft end float 0.08 to 0.21mm.

(5) Select thrust washer which will give correct end float.

SERVICE PROCEDURES (Continued)

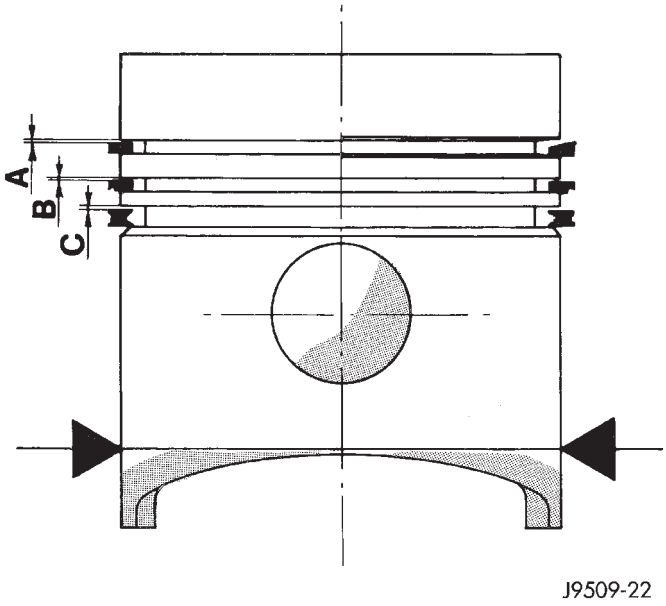


Fig. 12 Piston Ring Side Clearance

(6) Refer to crankshaft main bearing Installation if not in specification.

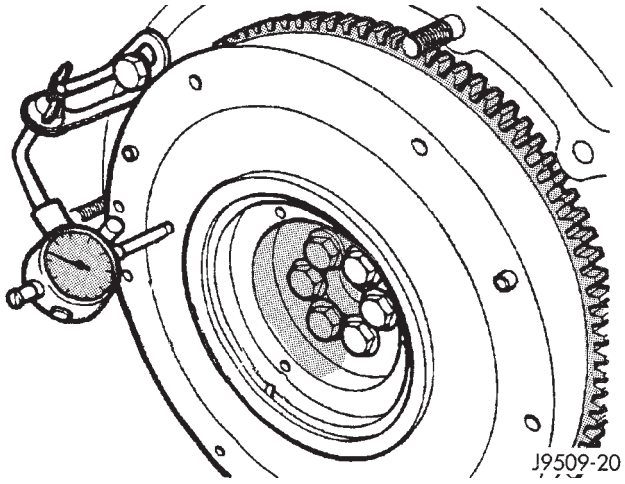


Fig. 13 Measuring Crankshaft End Play

NOTE: If engine is disassembled refer to Crankshaft Main Bearing Removal and Installation for this procedure.

REMOVAL AND INSTALLATION

ENGINE MOUNT—FRONT

(1) Disconnect battery.

(2) Remove lower air dam at front fascia.

(3) Remove the bolts holding tow bracket and front mount to the lower crossmember.

(4) Remove thru bolt in engine mount (Fig. 14). Remove mount.

(5) Reverse removal procedure for installation.

(6) Torque engine mount thru bolt to 65 N·m (48 ft. lbs.)

(7) Torque crossmember bolts for tow bracket and engine mount to 54 N·m (40 ft. lbs.)

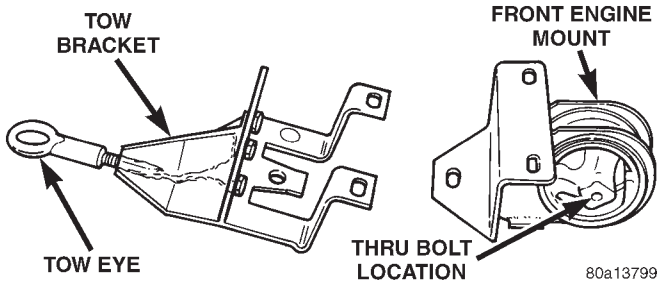


Fig. 14 Front Engine Mount and Tow Bracket

ENGINE MOUNT—RIGHT

(1) Remove the right engine mount top support bracket bolt (Fig. 15).

(2) Remove the load on the engine motor mounts by carefully supporting the engine and transmission assembly with a floor jack.

(3) Remove the engine mount to frame bolts.

(4) Remove the thru bolt from the mount assembly. Remove insulator

(5) If replaceing or removing right engine mount bracket the torque on the mounting bolts is 40 N·m (30 ft. lbs.)

(6) Reverse removal procedure for installation.

(7) Torque engine mount top bolt (Vertical) to 101 N·m (75 ft. lbs.)

(8) Torque engine mount thru bolt (Horizontal) to 145 N·m (107 ft. lbs.)

(9) Torque engine mount to frame bolts to 68 N·m (50 ft. lbs.)

MOUNT—LEFT SIDE

(1) Raise vehicle on hoist and remove left front wheel.

(2) Remove inner splash shield.

(3) Support the transmission with a transmission jack.

(4) Remove the insulator thru bolt from the mount (Fig. 16).

(5) Remove the transmission mount bolts and remove mount. It may be necessary to lower transmission slightly to remove mount.

(6) Reverse removal procedure for installation.

(7) Install mount. Torque transmission mount bolts to 54 N·m (40 ft. lbs.).

(8) Align mount into frame bracket with transmission jack, install thru bolt. Torque thru bolt to 71 N·m (53 ft. lbs.).

REMOVAL AND INSTALLATION (Continued)

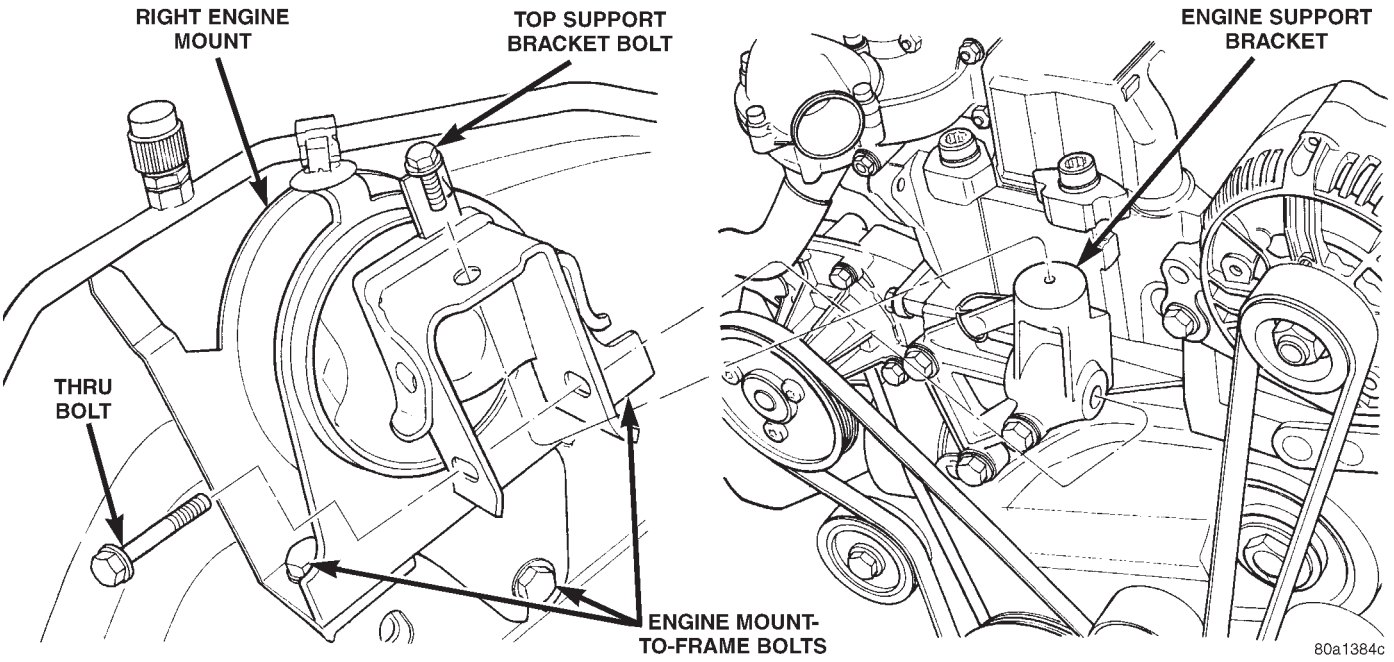


Fig. 15 Right Engine Mount—VM Diesel

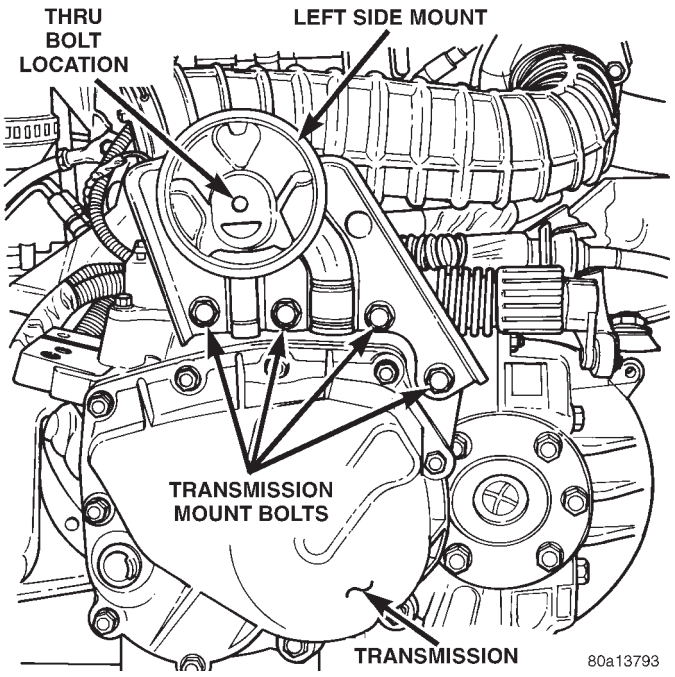


Fig. 16 Left Side Mount—VM Diesel

ENGINE MOUNT—REAR

(1) Raise vehicle on hoist.

(2) Support the engine and transmission assembly with a transmission jack so it will not rotate.

(3) Remove the thru bolt from the insulator at crossmember connection (Fig. 17).

(4) Remove the bolts holding the mount to the engine and transmission.

(5) Disconnect both shifter cables at transmission. Remove the retainers holding the cables to the mount (Fig. 18).

(6) Remove the mount assembly.

(7) Reverse removal procedure for installation.

(8) Install mount assembly. Torque bolts at engine and transmission to 101 N·m (75 ft. lbs.).

(9) Align insulator at crossmember and install thru bolt. Torque to 68 N·m (50 ft. lbs.).

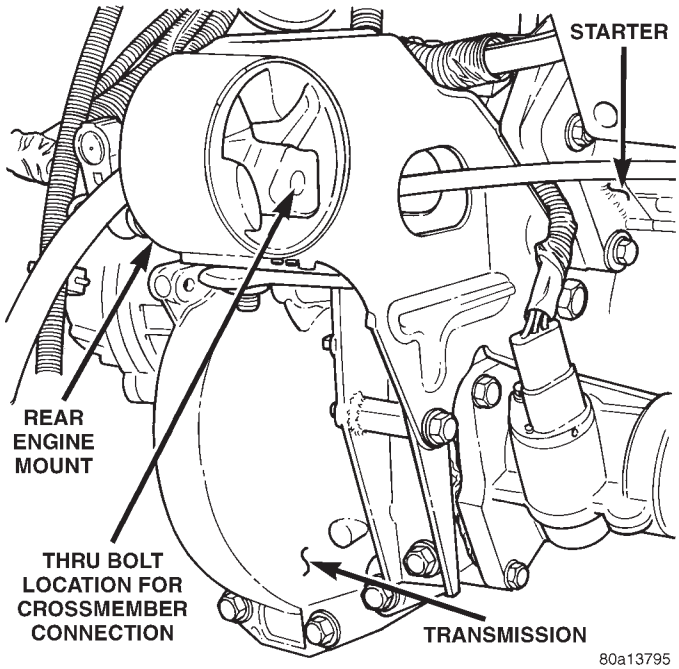


Fig. 17 Rear Engine Mount—VM Diesel

REMOVAL AND INSTALLATION (Continued)

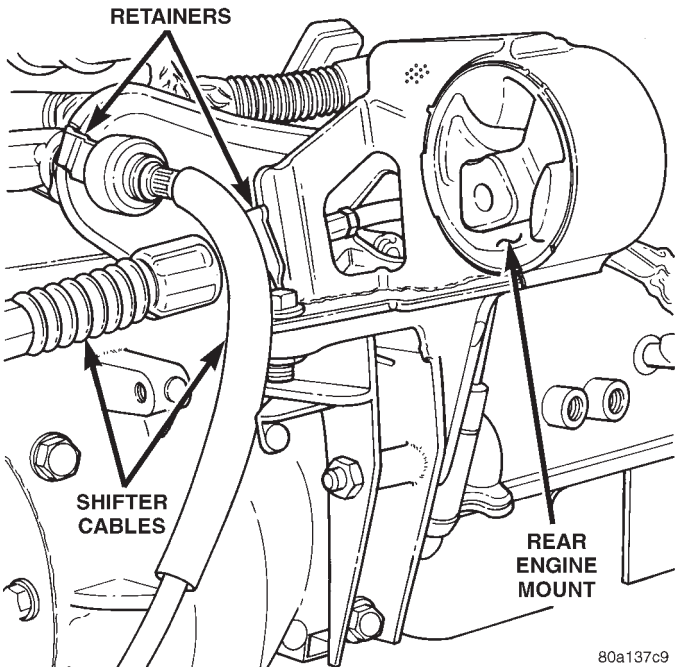


Fig. 18 Shift Cables at Rear Mount

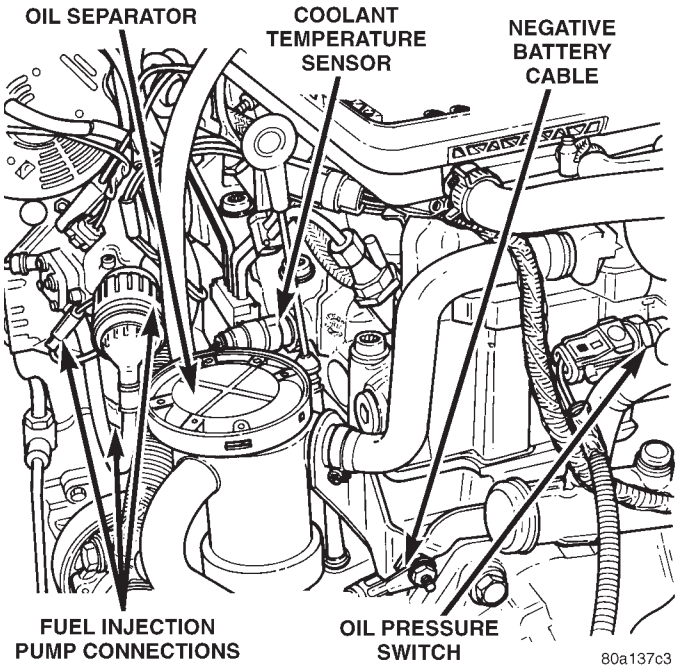


Fig. 19 Component Locations

ENGINE ASSEMBLY

REMOVAL

(1) Disconnect the battery.
(2) Remove the air cleaner assembly and inlet hose.
(3) Remove both hoses at intercooler and engine.
(4) Disconnect EGR vacuum hose.
(5) Disconnect brake booster vacuum hose.
(6) Disconnect oil pressure switch connector (Fig. 19).
(7) Disconnect Wiring harness bracket at transaxle shift tower.
(8) Disconnect transaxle wiring at speed sensor, crank sensor, and backup light switch.
(9) Remove both transmission shift cables at transmission.
(10) Remove negative battery cable at cylinder block (Fig. 19).
(11) Remove oil separator.
(12) Remove connectors at coolant temperature sensor and A/C compressor.
(13) Disconnect fuel injection pump wiring connectors (Fig. 19).
(14) Disconnect glow plug connectors.
(15) Disconnect electrical connector at number 1 fuel injector.
(16) Raise vehicle on hoist.
(17) Remove right side splash shield (Fig. 20).

WARNING: THE COOLANT IN A RECENTLY OPERATED ENGINE IS HOT AND PRESSURIZED. USE CARE TO PREVENT SCALDING BY HOT COOLANT.

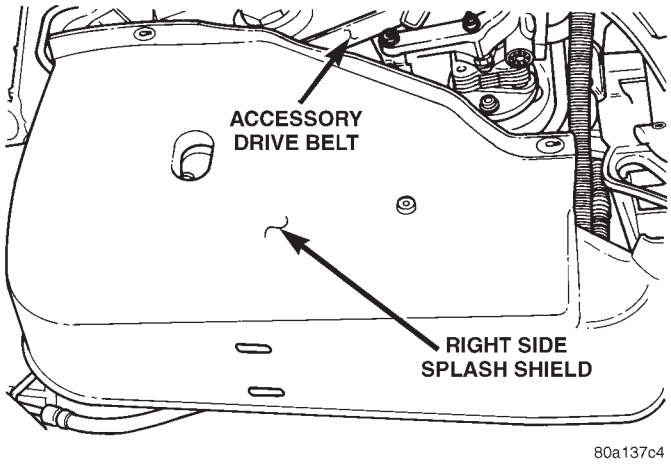


Fig. 20 Right Side Splash Shield

CAREFULLY RELEASE THE PRESSURE BEFORE REMOVING THE RADIATOR DRAIN COCK AND CAP.

(18) Drain the cooling system (refer to Group 7, Cooling).
(19) Lower vehicle.
(20) Remove Coolant pressure bottle and disconnect low coolant level sensor.
(21) Disconnect both heater hoses.
(22) Remove the lower radiator hose.
(23) Remove the upper radiator hose.
(24) Remove fuel line at injector pump and cap.
(25) Remove power steering reservoir and reposition.
(26) Remove upper radiator crossmember.
(27) Disconnect cooling fan module connector.

REMOVAL AND INSTALLATION (Continued)

(28) Remove radiator support bolts. **It is necessary to loosen the receiver/dryer to gain access to the radiator bolts.**

(29) Remove radiator and fans as an assembly.

(30) Remove accessory drive belt generator/power steering. Refer to Group 7, for procedure.

(31) Remove both power steering lines at pump, and cap both lines.

NOTE: It is not necessary to discharge A/C system for engine removal.

(32) Remove A/C compressor. Secure compressor away from engine for clearance during engine removal.

(33) Remove Generator and adjusting bracket.

NOTE: Do not remove the mounting base from the generator. It is aligned at the factory and cannot be realigned in the field.

(34) Hoist vehicle.

(35) Remove exhaust pipe at turbo outlet.

(36) Remove connections at starter.

(37) Remove power steering high pressure line bracket at rear of oil pan.

(38) Remove both driveshafts from transaxle. Refer to Group 2, Suspension and Driveshafts.

(39) Disconnect clutch cable at transaxle.

(40) Remove reinforcement plate on lower crossmember.

(41) Remove front and rear engine mounts. Refer to procedure outlined in this section.

(42) Drain engine oil and remove oil filter if necessary.

(43) Mount both special tool, engine support brackets VM-1026 to cylinder block (Fig. 21).

(44) Using engine dolly and cradle assembly with 4 adjustable posts align posts with holes in the engine support brackets.

(45) Lower vehicle so weight of **only the engine and transmission** is on the dolly and cradle assembly.

(46) Remove left side splash shield to gain access to thru bolt for left side mount.

(47) Remove right engine mount and left side mount. Refer to procedure outlined in this section.

(48) Raise vehicle slowly. It may be necessary to move the engine/transmission assembly on the dolly to allow for removal around body.

(49) Reverse removal procedure for installation.

CYLINDER HEAD COVER

REMOVAL

(1) Disconnect the battery cables.

(2) Remove generator bracket.

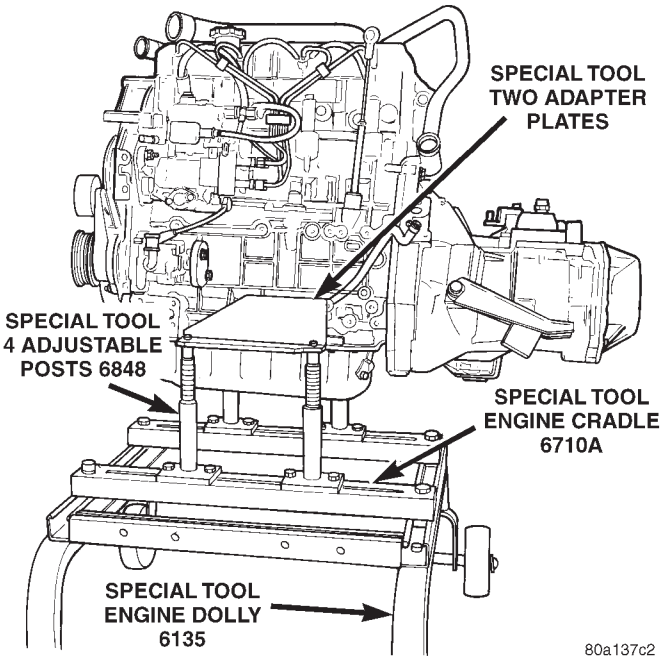


Fig. 21 Engine Removal

(3) Remove breather hose.

(4) Remove coolant pressure tank.

(5) Remove cylinder head cover.

INSTALLATION

(1) Install cylinder head cover, torque nuts to 23.5 N·m (208 in. lbs.).

(2) Install coolant pressure tank.

(3) Install breather hose.

(4) Install generator bracket, tighten bolts to 7 N·m (4 ft. lbs.).

(5) Connect battery cable.

ROCKER ARMS AND PUSH RODS

REMOVAL

(1) Disconnect the battery cables.

(2) Remove generator bracket.

(3) Remove breather hose.

(4) Remove coolant pressure tank.

(5) Remove cylinder head cover.

(6) Remove rocker retaining nuts (Fig. 22).

(7) Remove rocker assembly. Place them on a bench in the same order as removed.

(8) Remove the push rods and place them on a bench in the same order as removed.

INSTALLATION

(1) Install the push rods in the same order as removed.

(2) Install rocker arm assemblies in the same order as removed. Tighten the rocker arm nuts to 29.4 N·m (264 in. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

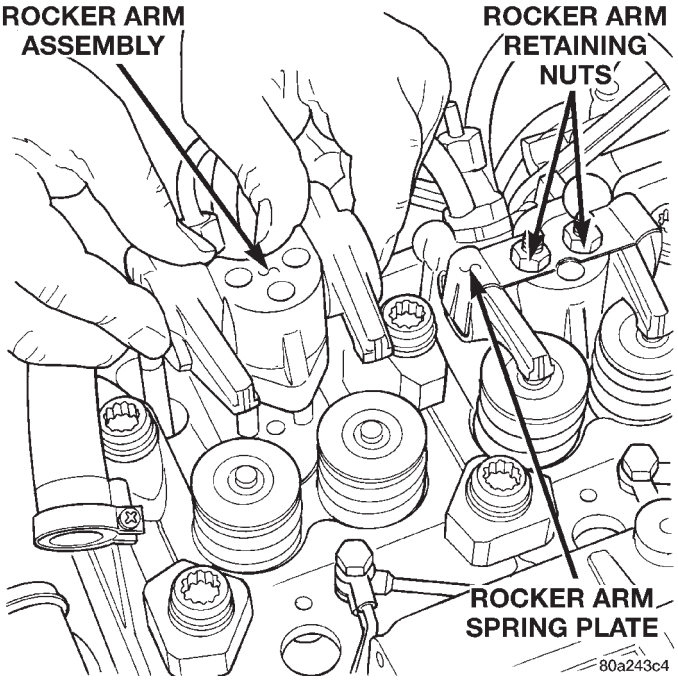


Fig. 22 Rocker Arm Retaining Nut

(3) Install cylinder head cover, torque nuts to 14.7 N·m (132 in. lbs.).

(4) Install coolant pressure tank.

(5) Install breather hose.

(6) Install generator bracket, tighten bolts to 7 N·m (4 ft. lbs.).

(7) Connect the service valves to the A/C compressor ports, if equipped with air conditioning.

(8) Connect battery cable.

VALVE SPRINGS—CYLINDER HEAD NOT REMOVED

This procedure can be done with the engine cylinder head installed on the block.

REMOVAL

Each valve spring is held in place by a retainer and a set of conical valve locks. The locks can be removed only by compressing the valve spring.

(1) Remove the engine cylinder head cover, refer to cylinder head cover removal in this section.

(2) Remove rocker arms assemblies for access to each valve spring to be removed.

(3) Remove push rods. Retain the push rods, and rocker arms assemblies in the same order and position as removed.

(4) Inspect the springs and retainer for cracks and possible signs of weakening.

(5) Install an air hose adaptor in the fuel injector hole.

(6) Connect an air hose to the adapter and apply air pressure slowly. Maintain at least 621 kPa (90 psi) of air pressure in the cylinder to hold the valves against their seats.

(7) Tap the retainer or tip with a rawhide hammer to loosen the lock from the retainer. Use Valve Spring Compressor Tool to compress the spring and remove the locks.

(8) Remove valve spring and retainer.

Inspect the valve stems, especially the grooves. An Arkansas smooth stone should be used to remove nicks and high spots.

INSTALLATION

(1) Install valve spring and retainer.

(2) Compress the valve spring with Valve Spring Compressor Tool and insert the valve locks. Release the spring tension and remove the tool. Tap the spring from side-to-side to ensure that the spring is seated properly on the engine cylinder head.

(3) Disconnect the air hose. Remove the adaptor from the fuel injector hole and install the fuel injector.

(4) Repeat the procedures for each remaining valve spring to be removed.

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

(6) Install the rocker arm assemblies, at their original location.

(7) Tighten the rocker arm assembly nut to 106 N·m (78 ft. lbs.) torque.

(8) Install the engine cylinder head cover, refer to cylinder head cover installation in this section.

CYLINDER HEAD

REMOVAL

(1) Disconnect the battery cable.

WARNING: DO NOT REMOVE THE CYLINDER BLOCK DRAIN PLUGS OR LOOSEN THE RADIATOR DRAIN COCK WITH THE SYSTEM HOT AND PRESSURIZED BECAUSE SERIOUS BURNS FROM THE COOLANT CAN OCCUR.

(2) Drain the cooling system. Refer to Group 7, Cooling.

(3) Remove wiper module. Refer to Group 8K, Windshield Wiper Unit Removal for procedure.

(4) Remove coolant pressure bottle.

(5) Remove intercooler hose at intake manifold (Fig. 23).

(6) Remove intercooler hose at turbocharger intercooler tube.

(7) Remove the upper radiator hose.

(8) Remove water manifold.

(9) Disconnect the heater hoses and coolant pressure bottle hoses.

REMOVAL AND INSTALLATION (Continued)

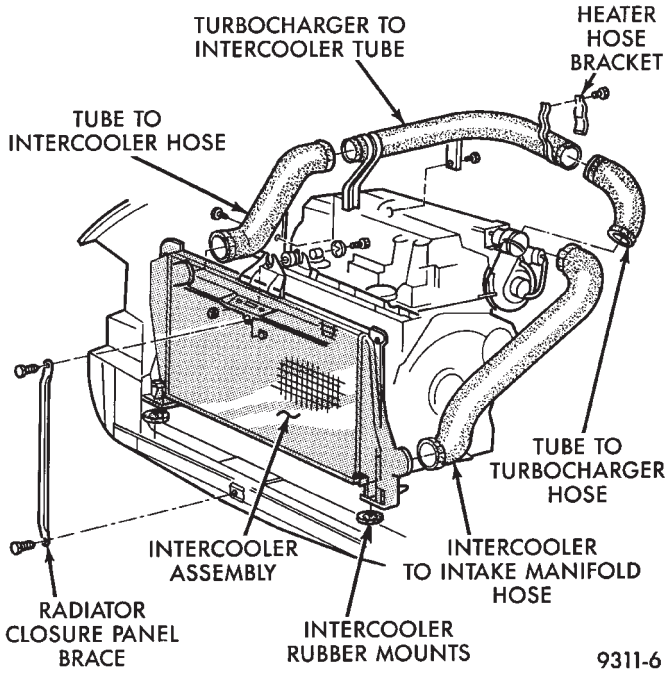


Fig. 23 Intercooler Assembly

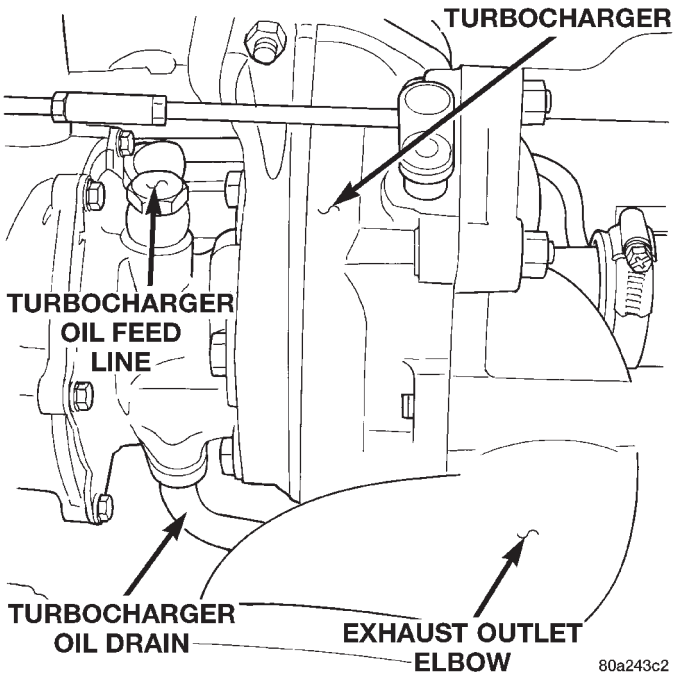


Fig. 24 Turbocharger

(10) Disconnect EGR tube from EGR valve (Fig. 25).

(11) Remove exhaust pipe from turbocharger elbow and.

(12) Disconnect oil feed line from turbo (Fig. 24).

(13) Disconnect oil drain line from turbo.

(14) Remove Intake manifold. Refer to Group 11, Exhaust System and Intake Manifold.

(15) Remove lift eye and brake vacuum tube at rear of exhaust manifold.

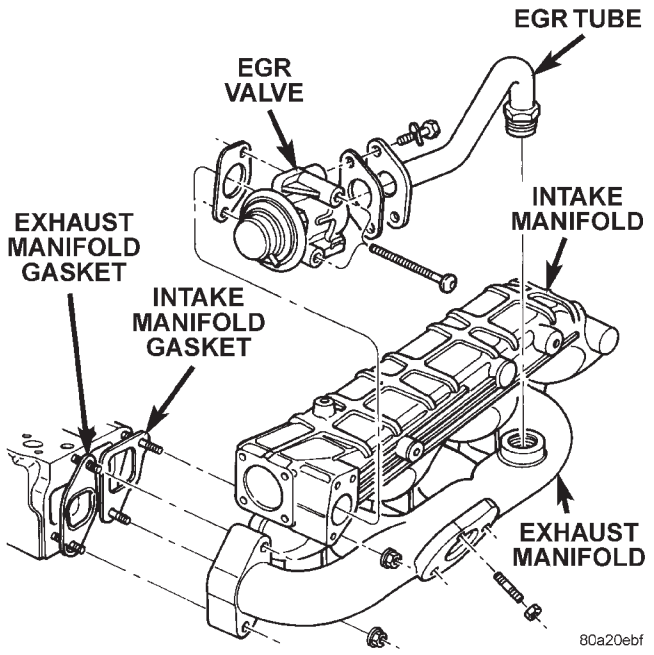


Fig. 25 EGR Valve and Tube

(16) Remove the support strut from block to turbocharger exhaust elbow.

(17) Remove Exhaust manifold. Refer to Group 11, Exhaust System and Intake Manifold.

(18) Remove oil line at pressure switch.

(19) Remove oil feed line for rocker arm assemblies (Fig. 26).

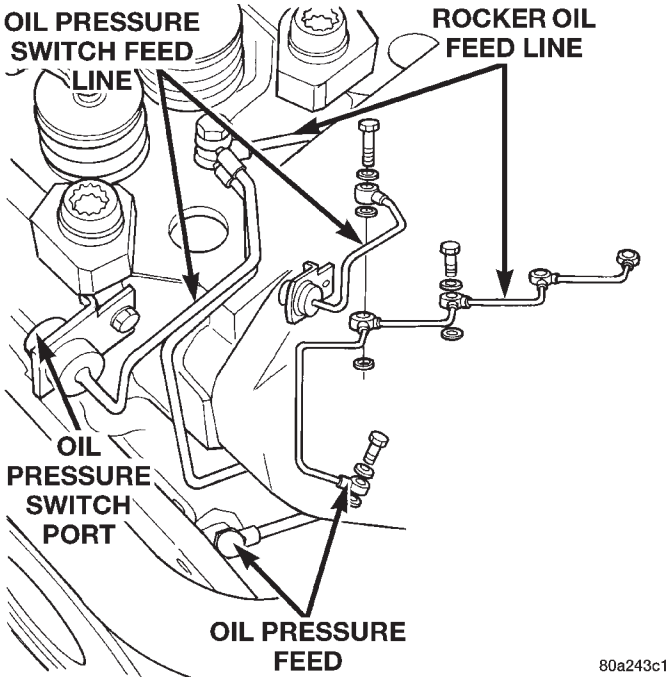


Fig. 26 Rocker Arm Oil Feed Lines

(20) Remove Crankcase breather hose from valve cover

(21) Remove the engine cylinder head cover.

REMOVAL AND INSTALLATION (Continued)

(22) Remove the injector sensor wire at the connector, and glow plug Connectors.

NOTE: The attachment point for the injector sensor wire at the injector is not a connector. The connector is located in the wire 4 to 6 inches away from the injector.

(23) Remove injector fuel lines from injectors to pump.

(24) Remove fuel injectors with tool VM-1012A (Fig. 27) and (Fig. 28) Refer to Group 14, Fuel System.

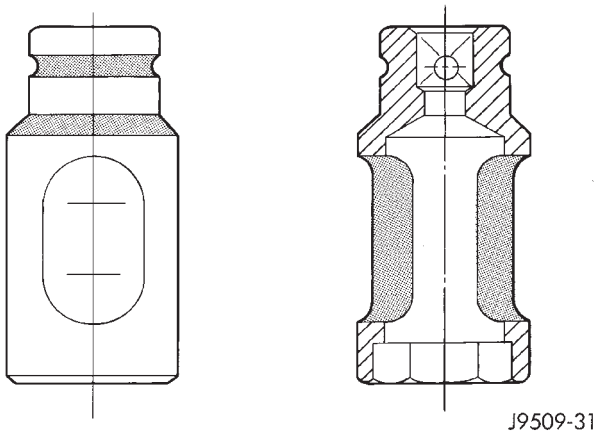


Fig. 27 Fuel Injector Tool VM-1012A

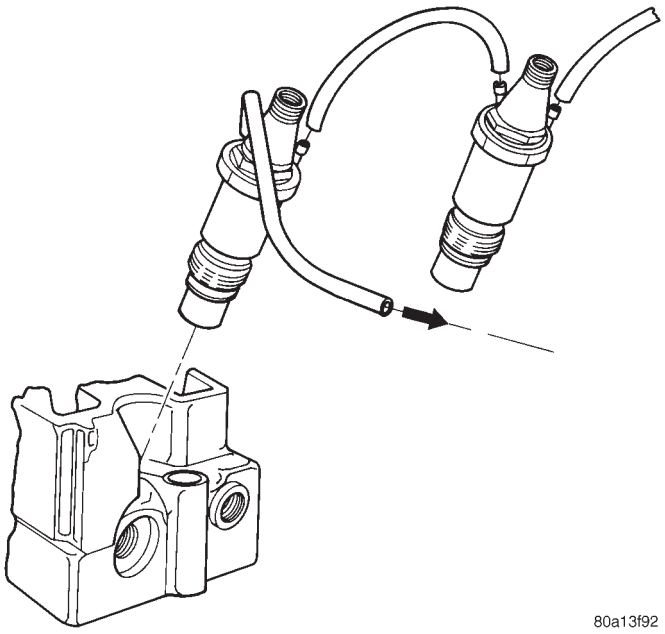


Fig. 28 Fuel Injector

(25) Remove rocker retaining nuts (Fig. 29).

(26) Remove rocker assemblies. Place them on a bench in the same order as removed.

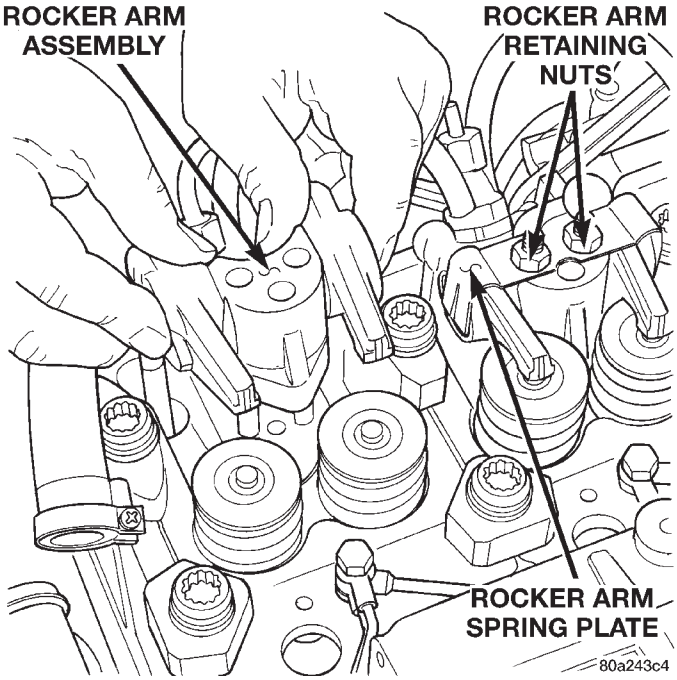


Fig. 29 Rocker Arm Retaining Nut

(27) Remove the push rods and place them on a bench in the same order as removed.

(28) Mark cylinder heads to ensure installation in there original position.

(29) Remove the engine cylinder head bolts with special tool VM-1018 and VM-1019.

(30) Remove the engine cylinder heads and gasket.

NOTE: A single steel head gasket is used for 4 cylinder heads (Fig. 32).

(31) Stuff clean lint free shop towels into the cylinder bores.

CYLINDER HEAD GASKET

NOTE: If cylinder wall liners have not been removed; the same thickness head gasket removed, may be used.

CAUTION: Piston protrusion must be measured, to determine cylinder head gasket thickness, if one or more cylinder wall liners have been replaced.

Cylinder head gaskets are available in three thickness. The different thicknesses are marked with identification holes (one, two or none) (Fig. 32). The gasket is to be installed DRY. **DO NOT use a gasket sealing compound on the gasket.**

(1) Use special tool VM-1010 with dial indicator special tool VM- 1013 (Fig. 30).

(2) Bring the piston of cylinder no. 1 exactly to top dead center.

REMOVAL AND INSTALLATION (Continued)

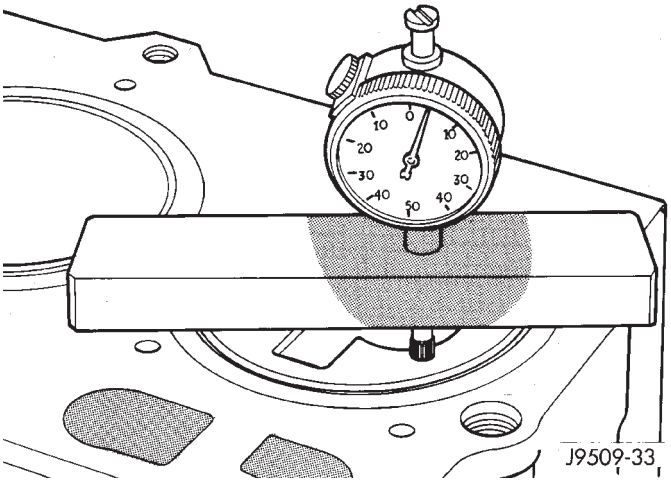


Fig. 30 Measuring Piston Protrusion

(3) Zero the dial indicator on the cylinder block mating surface.

(4) Setup the dial indicator on the piston crown (above the center of the piston pin) 5mm (1/8 in.) from the edge of the piston and note the measurement (Fig. 31).

(5) Repeat the procedure with the rest of the cylinders.

(6) Establish the thickness of the gasket for all four cylinder heads on the basis of the greatest piston protrusion (Fig. 32).

Measured dimension (mm)	0.53 - 0.62
Cyl. head gasket thickness (mm)	1.42
Piston clearance (mm)	0.80 - 0.89
Measured dimension (mm)	0.63 - 0.72
Cyl. head gasket thickness (mm)	1.52
Piston clearance (mm)	0.80 - 0.89
Measured dimension (mm)	0.73 - 0.82
Cyl. head gasket thickness (mm)	1.62
Piston clearance (mm)	0.80 - 0.89

J9509-164

Fig. 31 Piston Protrusion Chart

INSTALLATION CYLINDER HEAD

(1) Remove the shop towels from the cylinder bores. Coat the bores with clean engine oil.

(2) Install cylinder head alignment studs (VM-1009).

(3) After determining the correct head gasket thickness, clean the block and head mating surfaces, place the engine cylinder head gasket over the dowels.

(4) Place the engine cylinder head over the dowels.

CAUTION: Engine cylinder head bolts can be reused up to three times.

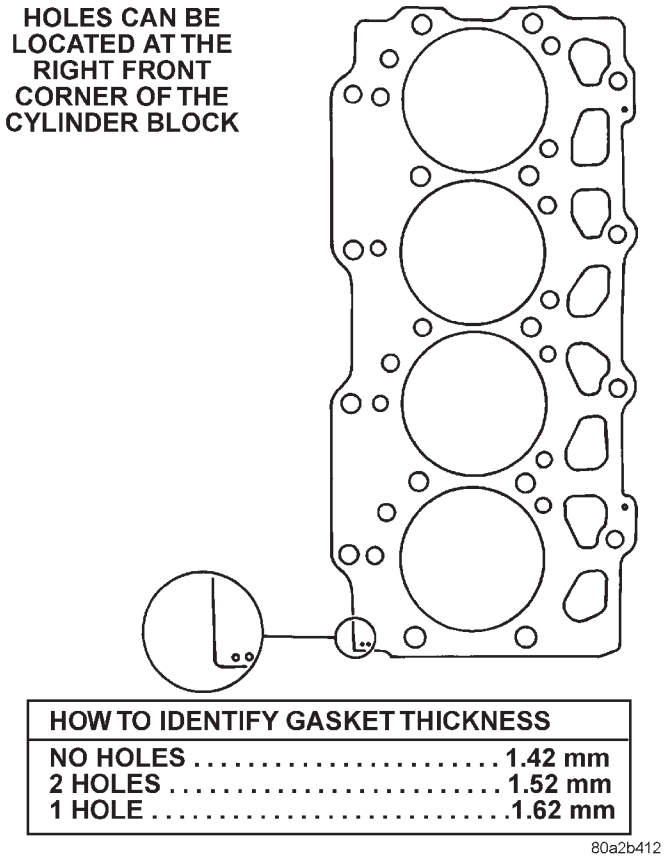


Fig. 32 Head Gasket Identification

(5) Tighten the engine cylinder head bolts in sequence according to the following procedure (Fig. 33):

a. The threads and underside heads of the bolts should be lubricated. Use the cylinder head alignment studs tool number VM-1009. Position the heads on the block and secure with the ten large center bolts and spacers (clamps), finger tight only.

b. Ensure that the various clamps are installed correctly and the head gasket remain in their proper position, completely covered. Then, lubricate and install the eight small bolts, also finger tight.

(6) Loosen assembly oil feed line for rocker arm assemblies

(7) Install the intake and exhaust manifolds with new gaskets, partially tightening the nuts to a maximum of 5 N·m (44 in. lbs.). This will align the heads (refer to Group 11, Exhaust System and Intake Manifold for the proper procedures). Install lift eye and brake vacuum tube at this time.

(8) Then, tighten the 12mm bolts with special tool VM-1019 in the following manner:

(9) **1st Phase:** Tightening Head Bolts (Fig. 33). Central bolts (A-L): Tighten all bolts, starting with bolt A then B-C-D-E-F-G-H-I-L, to 30 N·m. Repeat the operation with the same torque. Following the same sequence rotate each bolt through an angle of

REMOVAL AND INSTALLATION (Continued)

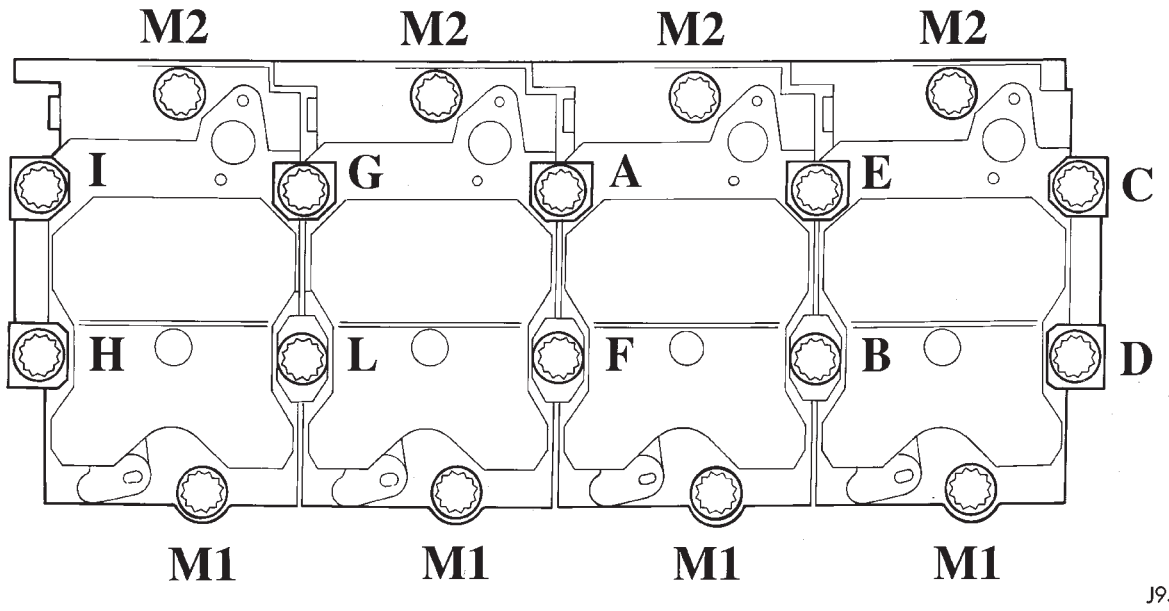


Fig. 33 Engine Cylinder Head Bolt Tightening Sequence

70° using angle torque tool. Then rotate the bolts an additional 70° following tightening sequence.

(10) Then, tighten the 14mm bolts with special tool VM-1018 in the following manner:

(11) Side bolts (M1-M2): Tighten M1 bolts to 30 N·m, then rotate them 85° (±5). Tighten M2 bolts to 30 N·m, then rotate them 85° (±5).

(12) **2nd Phase:** After 20 minutes of engine operation at operating temperature, allow engine to cool down completely. Then retorque the head bolts as follows:

(13) Central bolts A-L: Starting from bolt A, slacken and retorque it immediately to 30 N·m + 65°. Rotate the bolt an additional 65°. Then proceed in the same way, bolt by bolt, following alphabetical order, as indicated.

(14) Side bolts M1-M2: **Without slackening** , torque bolts M1 then bolts M2 to 90 N·m (66 ft. lbs.).

(15) Tighten intake nuts to 30 N·m (22 ft. lbs.) and exhaust manifolds nuts to 30 N·m (22 ft. lbs.) specified torque after completing Phase 2.

(16) If the engine cylinder head is to be replaced and the original valves used, measure the valve stem diameter. Only standard size valves can be used with a service replacement engine cylinder head unless the replacement head valve stem guide bores are reamed to accommodate oversize valve stems. Remove all carbon buildup and reface the valves.

(17) Tighten oil feed lines for rocker arm assemblies and oil pressure switch to 13 N·m (112 in. lbs.).

(18) Install push rods and rocker arm assemblies, tighten nut to 29.4 N·m (264 in. lbs.).

(19) Install fuel injectors use tool VM-1012 (refer to Group 14, Fuel System).

(20) Install valve cover, tighten nuts to 14.7 N·m (132 in. lbs.).

(21) Connect crankcase breather hose.

(22) Connect the injector sensor wire connector, and the glow plug connectors.

(23) Install oil feed line, tighten banjo bolts to 12.7 N·m (108 in. lbs), and oil drain line to turbo.

(24) Install water manifold tighten bolts to 12 N·m (106 in. lbs.).

(25) Install exhaust pipe to turbo elbow, tighten bolts to 28 N·m (250 in. lbs.).

(26) Install the support strut from block to turbocharger exhaust elbow.

(27) Install EGR tube to EGR valve, tighten bolts to 26 N·m (19 ft. lbs.).

(28) Install intercooler hoses at intake manifold.

(29) Install coolant pressure bottle and hoses.

(30) Install wiper module. Refer to Group 8K, Windshield Wiper Unit Installation for procedure.

(31) Install intercooler hose at turbocharger tube.

(32) Install fuel injector lines from the pump to injectors, tighten nuts to 17.6 N·m (156. lbs.).

(33) Connect the upper radiator hose.

(34) Connect negative cable to battery.

(35) Fill the cooling system. Check for leaks.

WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN DIRECT LINE WITH THE FAN. DO NOT PUT HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.

REMOVAL AND INSTALLATION (Continued)

(36) Operate the engine with the radiator cap off. Inspect for leaks and continue operating the engine until the thermostat opens. Add coolant, if required.

VALVES AND VALVE SPRINGS—HEAD OFF

This procedure is done with the engine cylinder head removed from the block.

REMOVAL

(1) Remove the engine cylinder head from the cylinder block. Refer to cylinder head removal in this section.

(2) Use Valve Spring Compressor Tool and compress each valve spring.

(3) Remove the valve locks, retainers, and springs.

(4) Use an Arkansas smooth stone or a jewelers file to remove any burrs on the top of the valve stem, especially around the groove for the locks.

(5) Remove the valves, and place them in a rack in the same order as removed.

INSTALLATION

(1) Fit each valve to its respective valve guide.

NOTE: If valves and valve seats have been refaced refer to Service Procedures in this section. Follow The Valve Stand Down procedure.

(2) Install lower, washer and spring.

(3) Install upper spring collar, and compress valve spring with spring compressor tool. Install split cone retainers.

HYDRAULIC TAPPETS

REMOVAL

(1) Remove coolant pressure bottle.

(2) Remove cylinder head cover. Refer to cylinder head cover removal in this section.

(3) Remove rocker assembly and push rods. Identify push rods to ensure installation in original location (Fig. 34).

(4) Remove cylinder head, intake manifold, and exhaust manifold. Refer to cylinder head removal in this section.

(5) Remove yoke retainer and aligning yokes (Fig. 35).

(6) Slide Hydraulic Tappet Remover/Installer Tool through opening in block and seat tool firmly in the head of tappet.

(7) Pull tappet out of bore with a twisting motion. If all tappets are to be removed, identify tappets to ensure installation in original location.

(8) If the tappet or bore in cylinder block is scored, scuffed, or shows signs of sticking, ream the bore to next oversize. Replace with oversize tappet.

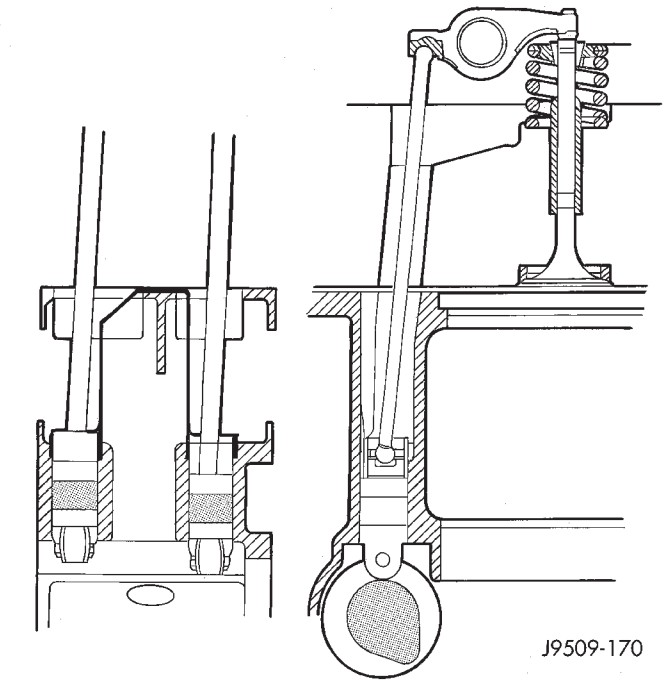


Fig. 34 Tappet and Rocker Arm Assembly

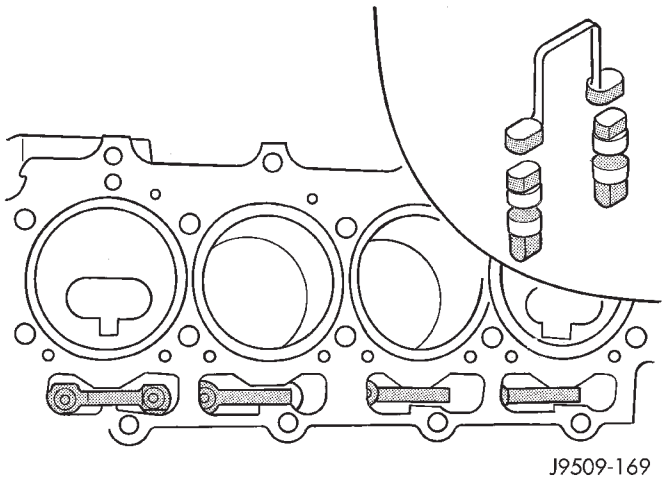


Fig. 35 Tappet and Yoke

CAUTION: The plunger and tappet bodies are not interchangeable. The plunger and valve must always be fitted to the original body. It is advisable to work on one tappet at a time to avoid mixing of parts. Mixed parts are not compatible. DO NOT disassemble a tappet on a dirty work bench.

INSTALLATION

(1) Lubricate tappets.

(2) Install tappets and yoke retainers in their original positions. Ensure that the oil feed hole in the side of the tappet body faces up (away from the crankshaft).

REMOVAL AND INSTALLATION (Continued)

(3) Install cylinder head, intake manifold, and exhaust manifold. Refer to cylinder head installation in this section.
(4) Install push rods in original positions.
(5) Install rocker arms in original positions.
(6) Install cylinder head cover. Refer to cylinder valve cover installation in this section.
(7) Start and operate engine. Warm up to normal operating temperature.

CAUTION: To prevent damage to valve mechanism, engine must not be run above fast idle until all hydraulic tappets have filled with oil and have become quiet.

VIBRATION DAMPER

REMOVAL

(1) Disconnect the battery cable.
(2) Raise vehicle on hoist.
(3) Remove right side lower splash shield.
(4) Remove generator, power steering belt. Refer to Group 7, Cooling.
(5) Remove water pump belt. Refer to Group 7, Cooling.
(6) Remove engine starter. Refer to Group, 8B for procedure
(7) Install flywheel locking tool VM.1014 to prevent engine rotation.

NOTE: Crankshaft damper nut is left handed thread.

(8) Remove vibration damper nut.
(9) Remove vibration damper. No special tool is needed for removal.

CAUTION: If thread sealant is used it is important to remove all the old thread sealant from the threads on the crankshaft.

INSTALLATION

NOTE: Before installing damper be sure the O-ring inside the center of the damper is in its grove.

(1) Install vibration damper.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(2) Install vibration damper nut and tighten to 441 N·m (325 ft. lbs.).
(3) Remove flywheel locking tool, and install engine starter.
(4) Install both accessary drive belts. Refer to Group 7, Cooling.
(5) Install right splash shield.
(6) Lower vehicle.
(7) Connect the battery cable.

TIMING GEAR COVER OIL SEAL

REMOVAL

(1) Disconnect the battery cable.
(2) Remove vibration damper. Refer to vibration damper removal in this section.
(3) Pry out seal (Fig. 36).

INSTALLATION

Remove the oil seal ring. The seating diameter must be 68.000 - 68.030 mm.
(1) Install new seal using special tool VM-1015.
(2) Install vibration damper. Refer to vibration damper installation in this section.
(3) Connect the battery cable.

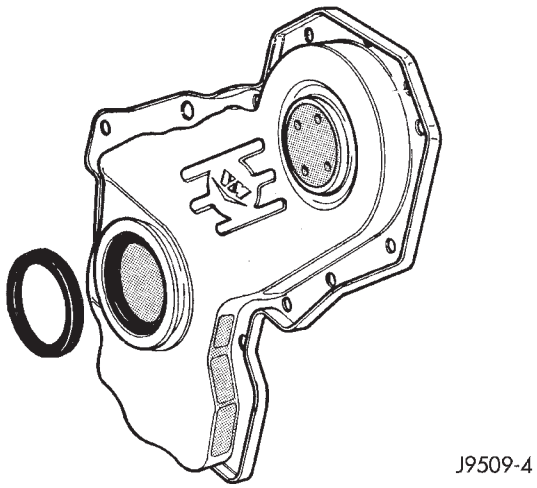


Fig. 36 Front Cover Seal

INJECTION PUMP

For removal and installation of injection pump refer to Group 14, Fuel.

TIMING GEAR COVER

REMOVAL

(1) Disconnect the battery cable.
(2) Raise vehicle on hoist.
(3) Remove right splash shield.
(4) Remove accessary drive belts. Refer to Group 7, Cooling.
(5) Remove vibration damper nut.

NOTE: Crankshaft damper nut is left handed thread.

(6) Remove vibration damper.

REMOVAL AND INSTALLATION (Continued)

(7) Remove power steering/air conditioning pulley nut. Remove pulley.

CAUTION: Remove old loctite from threads on pump.

(8) Remove pump shaft support bracket assembly.
(9) Disconnect the water drain pipe hose at the timing cover.

CAUTION: When separating the timing geat cover from the block take care not to damage the mating surface of the timing gear cover or block. Also take care not to damage the timing gears or components located inside the timing gear cover near the edge.
(10) Remove timing gear cover.

INSTALLATION

(1) Apply a continuous 3 mm bead of Silicone Sealer to timing cover, install within 10 minutes, tighten Torx bolts to 11 N·m (96 in. lbs) (Fig. 37).

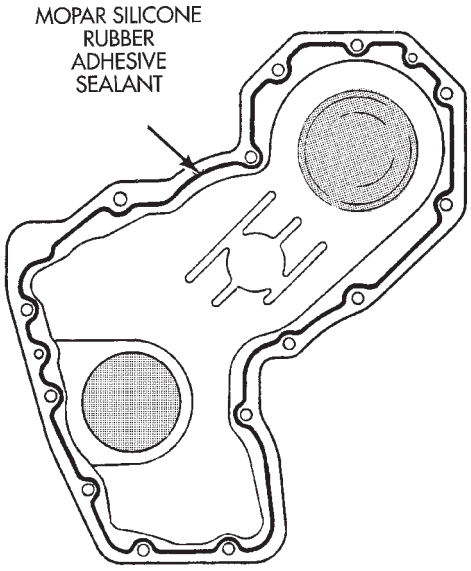


Fig. 37 Front Cover Sealer Location

(2) Install pump shaft support bracket assembly, tighten nuts to 24.5 N·m (216 in. lbs.).
(3) Install Power steering/air conditioning pulley, tighten to 170 N·m (125 ft. lbs.).

CAUTION: Correct torque on the power steering/air conditioning pulley nut is important or engine damage can occur.

(4) Connect water drain pipe hose at the timing cover.

NOTE: Before installing damper be sure O-ring on inside center of damper is in place.

(5) Install vibration damper.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(6) Tighten vibration damper nut to 441 N·m (325 ft. lbs.).
(7) Install accessary drive belts. Refer to Group 7, cooling for procedure.
(8) Install splash shield.
(9) Lower vehicle.
(10) Connect battery cable.

CAMSHAFT

REMOVAL

(1) To service the camshaft (Fig. 38) the engine must be removed from the vehicle.

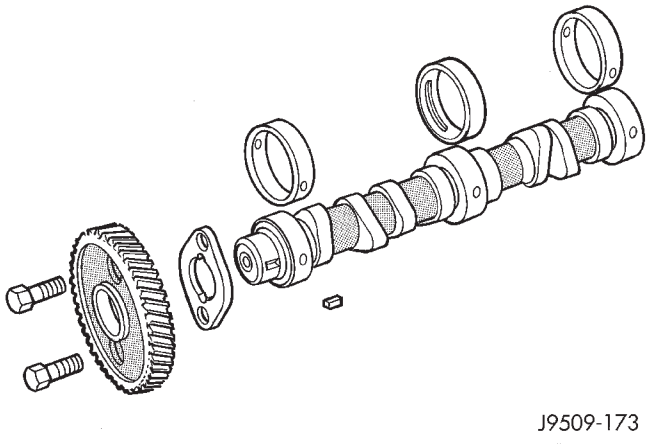


Fig. 38 Camshaft Assembly

(2) Remove valve cover. Refer to valve cover removal in this section.
(3) Remove rocker arms and push rods. Identify push rods to ensure installation in there original location.
(4) Remove cylinder head. Refer to cylinder head removal in this section.
(5) Remove hydraulic tappets. Refer to tappet removal in this section.
(6) Remove vibration damper. Refer to vibration damper removal in this section.
(7) Remove power steering pulley.
(8) Remove pump shaft support bracket.
(9) Remove timing gear cover. Refer to timing gear cover removal in this section.
(10) Remove camshaft.

REMOVAL AND INSTALLATION (Continued)

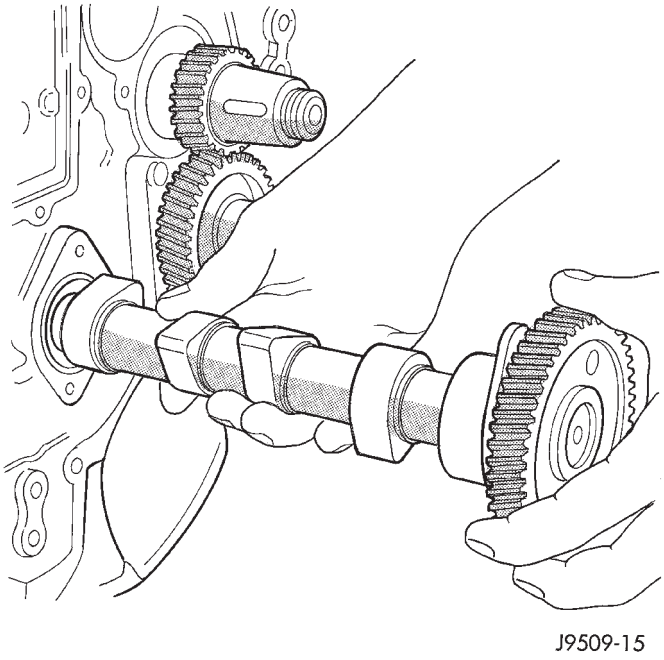


Fig. 39 Camshaft Removal

THRUST PLATE INSPECTION

Check the thickness (Fig. 40) of the plate at points a-b-c-d. If the measurement is not between 3.950 - 4.050 it must be changed.

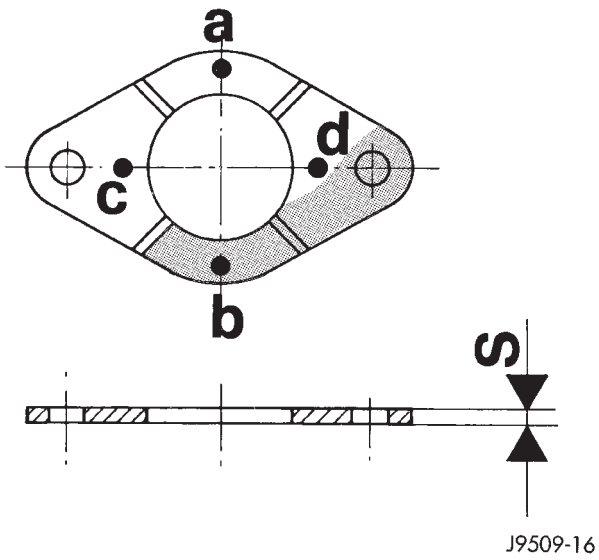


Fig. 40 Camshaft Thrust Plate

INSTALLATION

(1) Coat the camshaft journals with clean engine oil and carefully install the camshaft complete with thrust plate and gear. Tighten the retaining bolts to 24 N·m. Be sure to align the timing marks as shown.

(2) Install hydraulic tappets and retaining yokes.

(3) Install cylinder heads.

(4) Push rods, and rocker arm assemblies. In there original location.

(5) Install valve cover.

(6) Install Timing case cover.

(7) Install Vibration damper.

(8) Reinstall Engine.

CAMSHAFT BEARINGS

This procedure requires that the engine is removed from the vehicle.

REMOVAL

(1) With engine completely disassembled, drive out rear cam bearing core hole plug.

(2) Install proper size adapters and horseshoe washers (part of Camshaft Bearing Remover/Installer Tool) at back of each bearing shell. Drive out bearing shells.

INSTALLATION

(1) Install new camshaft bearings with Camshaft Bearing Remover/Installer Tool by sliding the new camshaft bearing shell over proper adapter.

(2) Position rear bearing in the tool. Install horseshoe lock and by reversing removal procedure, carefully drive bearing shell into place.

(3) Install remaining bearings in the same manner. Bearings must be carefully aligned to bring oil holes into full register with oil passages from the main bearing. If the camshaft bearing shell oil holes are not in exact alignment, remove and install them correctly. Install a new core hole plug at the rear of camshaft. **Be sure this plug does not leak.**

CRANKSHAFT MAIN BEARINGS

REMOVAL

(1) Disconnect battery cable.

(2) Remove engine from vehicle, refer to engine removal in this section.

(3) Install engine to engine stand.

(4) Remove accessary drive system.

(5) Remove cylinder head cover, refer to cylinder head cover removal in this section.

(6) Remove rocker arm and push rods, refer to rocker arm and push rod section in this section.

(7) Remove intake, exhaust manifold and turbocharger, refer to Group 11, Exhaust System and Intake Manifold.

(8) Remove water manifold.

(9) Remove oil feed lines to rocker arms.

(10) Remove cylinder heads.

(11) Remove oil pan and oil pick-up.

(12) Remove piston and connecting rods from crankshaft journals.

REMOVAL AND INSTALLATION (Continued)

(13) Remove pistons and connecting rods from block.

(14) Remove vibration damper. Refer to procedure in this section.

(15) Remove front cover. Refer to procedure in this section.

(16) Remove oil pump drive gear.

(17) Install special tool VM-1004 onto crankshaft over gear (Fig. 41).

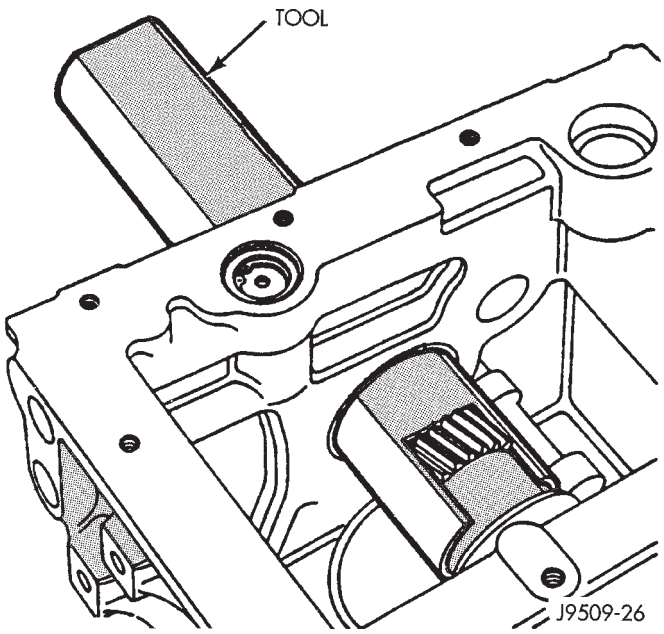


Fig. 41 Crankshaft Special Tool VM.1004

(18) Remove main bearing oil feed and carrier locators from block.

(19) Remove flywheel and adaptor plate from engine block.

(20) Remove thrust bearings from rear main bearing carrier (Fig. 42).

(21) Slide crankshaft and bearing carriers rearward to rear of block. If you encounter difficulty in removing the complete assembly as previously described, slide the assembly rearward sufficiently to gain access to the main bearing carrier bolts. Mark the carriers for assembly and remove the bolts, two for each carrier (Fig. 43).

(22) Separate the two halves of each carrier, remove from the crankshaft and temporarily re-assemble the carriers (Fig. 44). Withdraw the crankshaft through the rear of the crankcase.

INSTALLATION

NOTE: Assemble engine according to sequence described, thus saving time and preventing damages to engine components. Clean parts with a suitable solvent and dry them with compressed air before assembly. Use new gaskets where applicable and torque wrenches for correct tightening of components.

(1) Thoroughly clean crankcase and oil passages, and blow dry with compressed air.

(2) Install new main bearing shells in each of the carrier halves. Assemble the carriers to the crankshaft journals, ensuring that the carriers are installed in their original locations. Secure each carrier with the two bolts tightening evenly to 42 N·m (31 ft. lbs.) (Fig. 44).

(3) Slide special tool (VM-1002) over the crankshaft gear and, insert the crankshaft and carrier assembly into the crankcase in the same manner used for removal.

(4) Align the holes in the lower carriers, with the center of the crankcase webs (Fig. 45).

(5) Secure each carrier assembly to the crankcase with the main bearing oil feed and carrier locators and tighten them to 54 N·m (40 ft. lbs).

(6) Install rear main bearing carrier onto crankshaft ensuring arrow on bearing carrier aligns with vertical web in center of crankcase.

(7) Install rear oil seal.

(8) Install new O-rings in adaptor plate.

(9) Install adaptor plate and tighten bolts to 47 N·m (35 ft. lbs.).

(10) Install bolts to main bearing carrier and tighten to 26.5 N·m (20 ft. lbs.).

(11) Position flywheel and O-ring on crankshaft and align bolt holes.

NOTE: For purposes of checking crankshaft end play used flywheel bolts may be used. Final assembly requires new flywheel bolts.

(12) Install 2 flywheel bolts, 180° apart, and tighten bolts to 20 N·m plus 60° (15 ft. lbs.) plus 60°.

(13) Attach dial indicator to engine block.

(14) Move crankshaft toward front of engine and zero indicator.

(15) Move crankshaft toward the rear of engine and record measurement.

(16) Subtract specified crankshaft end play from figure obtained. Crankshaft end play 0.08 to 0.21 mm (0.0032 to 0.0083 in.).

(17) Select thrust washers which will give correct end play.

(18) Remove tools and flywheel.

(19) Lubricate thrust washer halves and fit them into the rear main bearing carrier.

(20) To verify correct end play, install 2 flywheel bolts 180° apart, and tighten bolts to 20 N·m plus 60° (15 ft. lbs. plus 60°).

(21) Measure crankshaft end play with a dial gauge. Crankshaft end play should not exceed 0.08-

REMOVAL AND INSTALLATION (Continued)

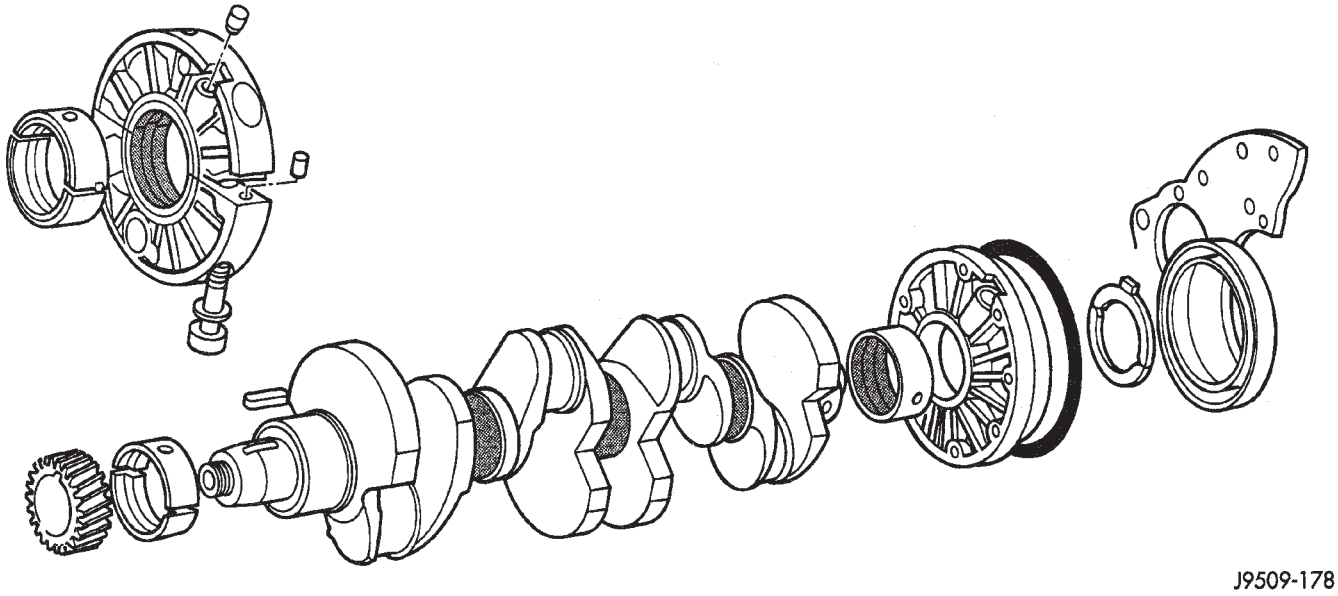


Fig. 42 Crankshaft and Bearings

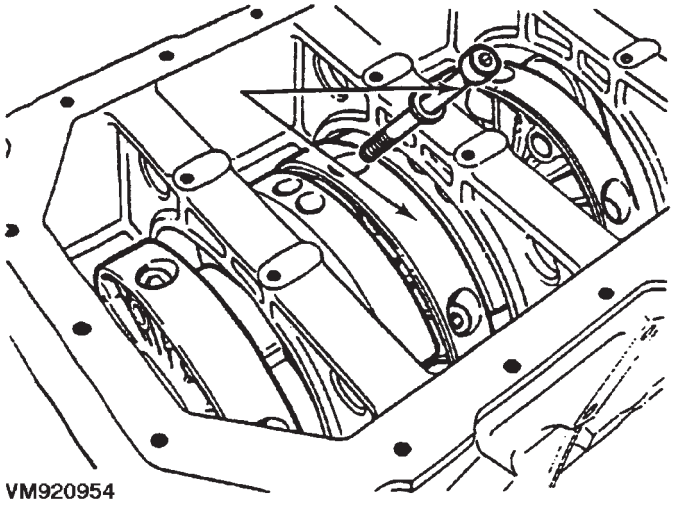


Fig. 43 Carrier Bolts

0.21 mm (0.0032 to 0.0083 in.) (Fig. 46). If end clearance exceeds these values install oversize thrust washer.

CAUTION: Use NEW flywheel bolt for the following procedure.

(22) Install new O-ring on flywheel. Install flywheel. The 6 flywheel bolts must be tightened as follows:

a. Torque the 6 flywheel bolts to 60 N·m (44 ft. lbs.).

b. Loosen 2 of the 6 bolts, 180° apart. Torque the 2 bolts to 20 N·m (180 in. lbs.). Then using a torque angle gauge rotate the 2 bolts 65° additional.

c. Loosen the next 2 bolts, 180° apart and follow the same procedure.

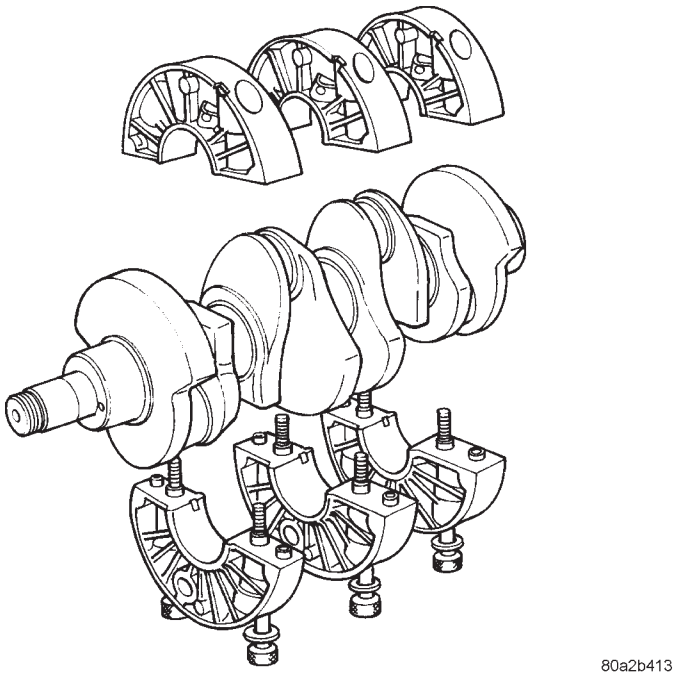


Fig. 44 Crankshaft and Carrier Bearing Assembly

d. Loosen the last 2 bolts, 180° apart and follow the same procedure.

(23) Install Transmission. Refer to procedure in Group 21, Transmission.

(24) Install pistons and connecting rod assemblies, refer to piston and connecting rods in this section.

(25) Install oil pick up tube and tighten bolts to 25 N·m (18 ft. lbs.).

(26) Install oil pan, refer to oil pan installation in this section.

(27) Install vacuum pump. Tighten retaining screws to 20 N·m (15 ft. lbs.).

REMOVAL AND INSTALLATION (Continued)

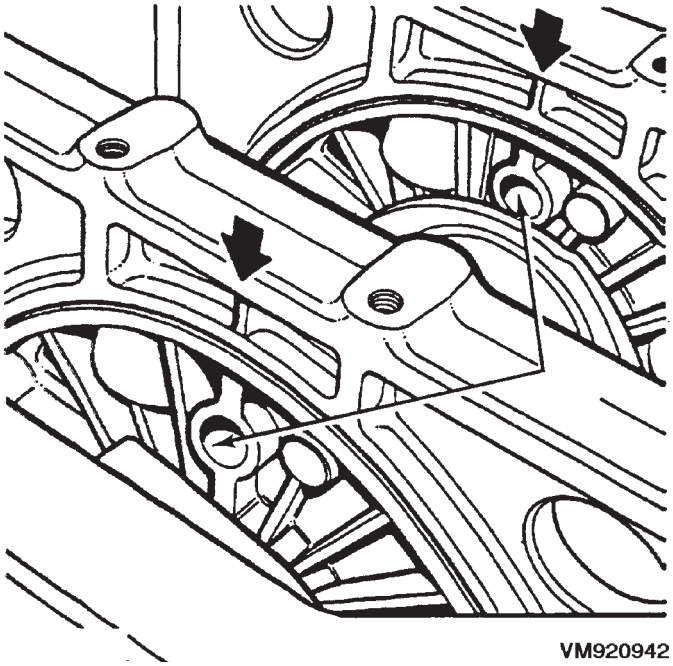


Fig. 45 Main Bearing Carrier Alignment

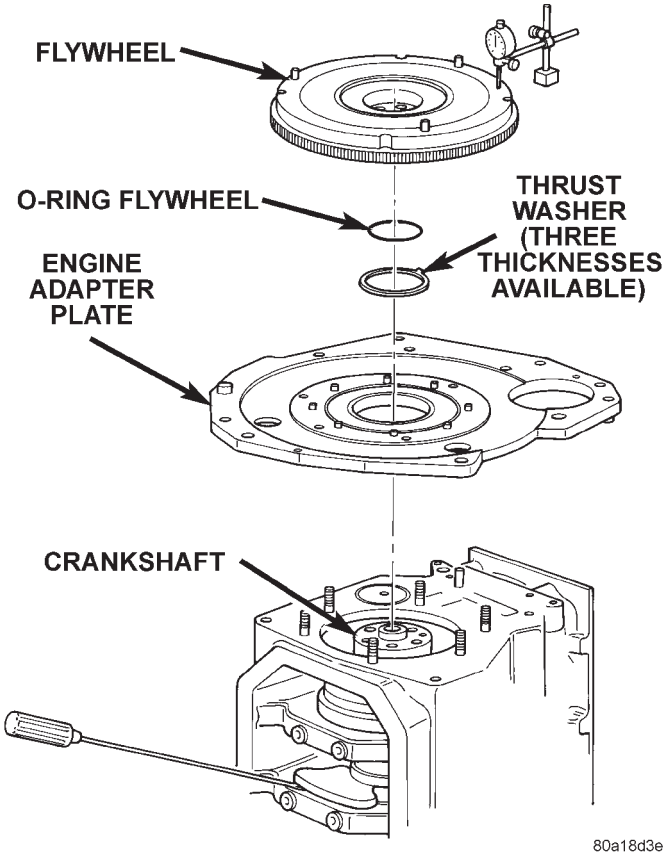


Fig. 46 Measuring Crankshaft End Play

CAUTION: The vacuum pump must be centered in the block and tighten with two bolts. Ensure that the pump spins freely. If vacuum pump drags or does not spin freely loosen bolts and perform procedures again.

(28) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 47). Difference between A and B should be 0.020-0.082 mm (.0007 to 0032 in.).

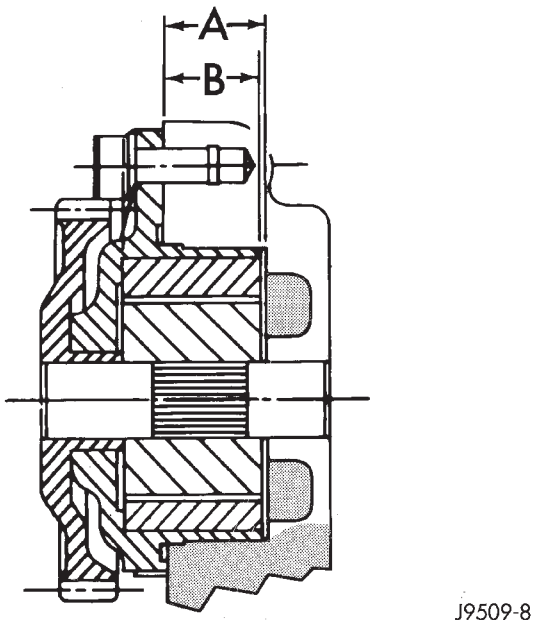


Fig. 47 Oil Pump Bore Depth

(29) Install oil pump and tighten retaining screws to 27 N·m (20 ft. lbs.). Check for normal backlash between pump and crankshaft gears.

(30) Install oil pump drive Gear.

(31) Install front cover. Refer to procedure in this section.

(32) Install vibration damper. Refer to procedure in this section.

(33) Install cylinder heads. Refer to procedure in this section.

(34) Install rocker arms and push rods. Refer to procedure in this section.

(35) Install cylinder head cover. Refer to procedure in this section.

(36) Install accessary drive system.

(37) Install engine in vehicle. Refer to procedure in this section.

(38) Fill engine with the correct amount of fluids specified.

(39) Connect battery cable.

OIL PAN

REMOVAL

(1) Disconnect battery cable.

(2) Raise vehicle on hoist.

REMOVAL AND INSTALLATION (Continued)

(3) Drain oil.
(4) Remove oil pan bolts (Fig. 48).
(5) Remove oil pan.

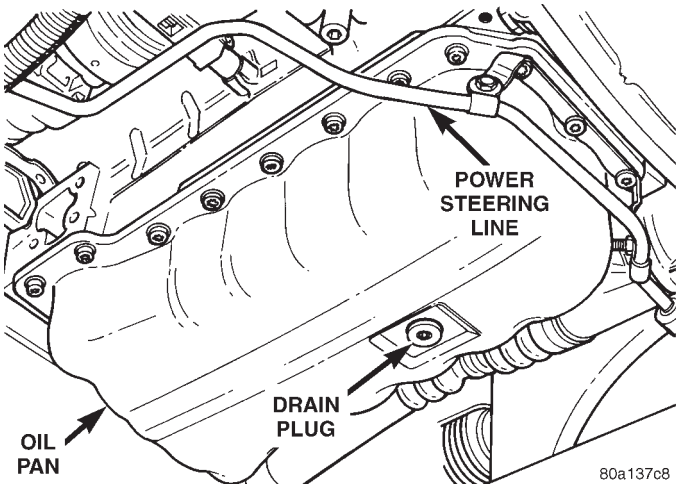


Fig. 48 Oil Pan

INSTALLATION

(1) Install oil pan. Apply a continuous 3 mm bead of Silicone Sealer to oil pan, install within 10 minutes.
(2) Install oil pan bolts and torque bolts to 11 N·m (8 ft. lbs.).
(3) Install oil drain plug tighten to 79 N·m (58 ft. lbs).
(4) Lower vehicle.
(5) Fill engine with proper amount of oil.
(6) Connect battery cable.

OIL PUMP

REMOVAL

(1) Raise vehicle on hoist.
(2) Remove right splash shield.
(3) Remove both accessory drive belts. Refer to Group 7, Cooling.
(4) Remove pump shaft support bracket assembly.
(5) Remove vibration damper. Refer to Vibration Damper Removal in this section.

NOTE: Crankshaft damper nut is left handed thread.

(6) Remove front cover. Refer to Timing Gear Cover Removal in this section.
(7) Remove oil pump.

INSTALLATION

(1) Install new O-ring and lubricate with clean engine oil.
(2) Install oil pump and tighten retaining screws to 27.5 N·m (240 in. lbs.).

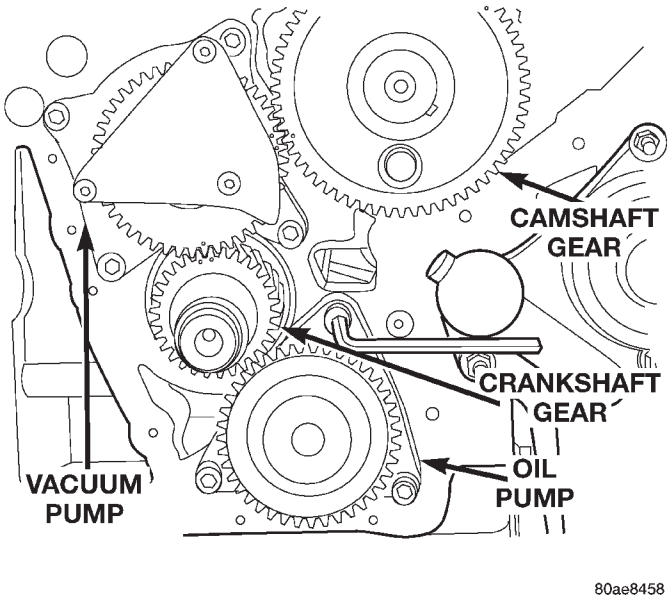


Fig. 49 Oil Pump Drive Gear

(3) Install front cover. Refer to Timing Gear Cover Installation in this section.
(4) Install pump shaft support bracket assembly.

CAUTION: Correct torque on the vibration damper nut is important or engine damage can occur.

(5) Install vibration damper. Torque nut to 441 N·m (325 ft. lbs.)
(6) Install both accessory drive belts. Refer to Group 7, Cooling.
(7) Install right splash shield.

OIL PUMP PRESSURE RELIEF VALVE

REMOVAL

(1) Remove oil pan.
(2) Remove clip retaining relief valve.
(3) Remove relief valve cap, spring, and plunger (Fig. 50).
(4) Check relief valve spring length. Relief valve spring free length is 57.5mm (2.263 in.). If spring length is less or spring is distorted it must be replaced.
(5) Check plunger for scoring, replace if necessary.

INSTALLATION

(1) Thoroughly clean all components and relief valve pocket in cylinder block.
(2) Fit plunger, spring and cap into block.
(3) Compress spring and install retaining clip. Ensure clip is completely seated in groove.

REMOVAL AND INSTALLATION (Continued)

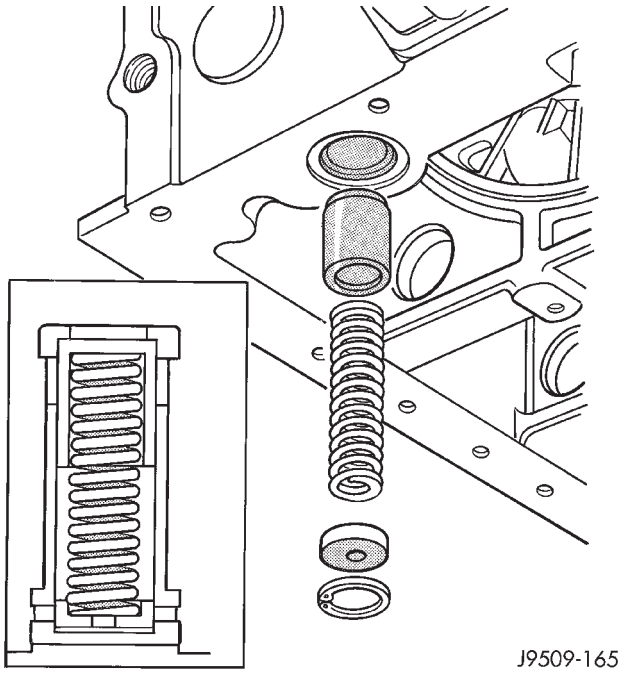


Fig. 50 Oil Pressure Relief Valve

OIL FILTER ADAPTER AND OIL COOLER

REMOVAL

(1) Remove oil filter.
(2) Remove oil cooler adapter bolt.
(3) Remove oil cooler (Fig. 51).

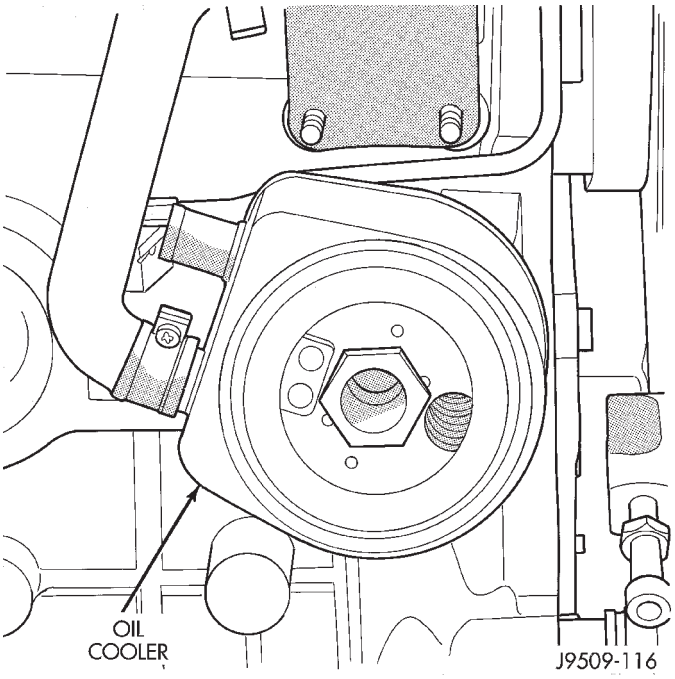


Fig. 51 Oil Cooler

INSTALLATION

(1) Install oil cooler with new gasket, tighten oil cooler adapter bolt to 60 N·m (44 ft. lbs.).
(2) Install oil filter adapter to oil cooler and tighten to 49 N·m (36. lbs.).
(3) Install oil filter and tighten to 9.8 N·m (85 in. lbs.) and add oil.

VACUUM PUMP

REMOVAL

(1) Remove the front cover refer to front cover removal in this section.
(2) Remove 4 bolts.

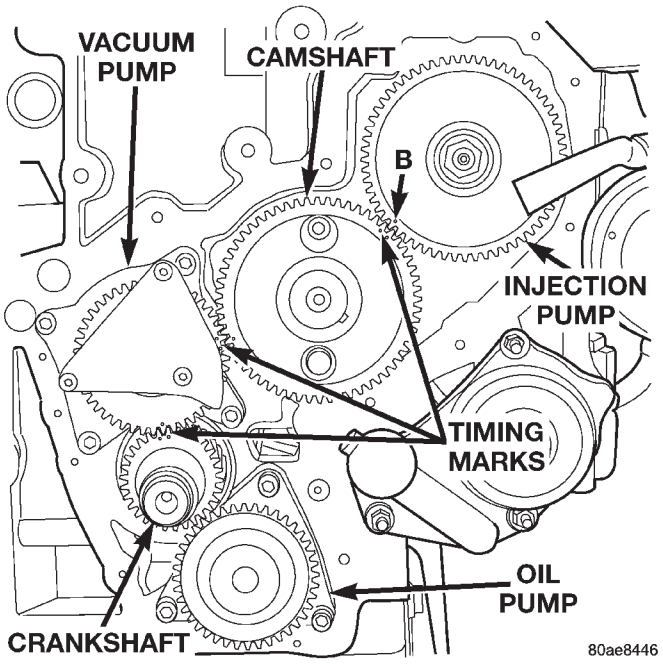


Fig. 52 Vacuum Pump

(3) Remove vacuum pump.

INSTALLATION

(1) To install the vacuum pump, align the outer part of the gear with the inner part using a screwdriver or similar tool, align with timing marks on gear set and install.
(2) Install bolts and tighten to 20 N·m (15 ft. lbs.).
(3) Install front cover.

PISTONS AND CONNECTING ROD

REMOVAL

(1) Disconnect the battery cable.
(2) Remove cylinder heads, refer to cylinder head removal in this section.
(3) Raise vehicle on host.
(4) Remove oil pan, refer to oil pan removal in this section.
(5) Remove top carbon ridge of cylinder bores with a reliable ridge reamer before removing pistons from cylinder block. **Be sure to keep tops of pistons**

REMOVAL AND INSTALLATION (Continued)

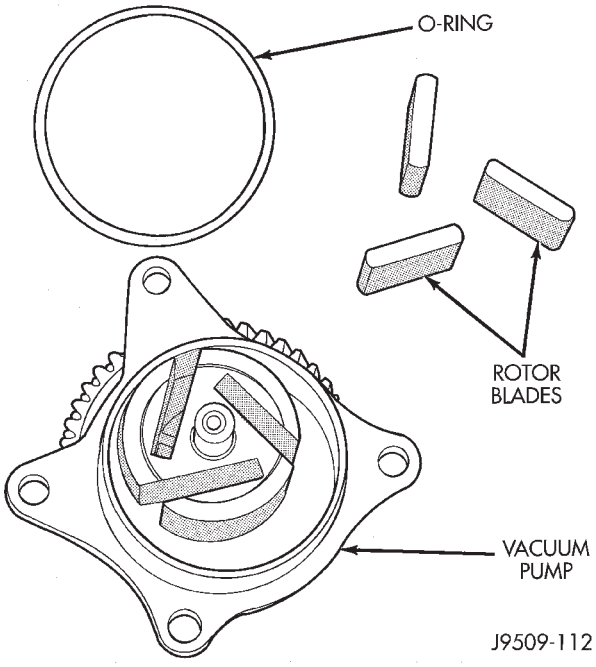


Fig. 53 Vacuum Pump Parts

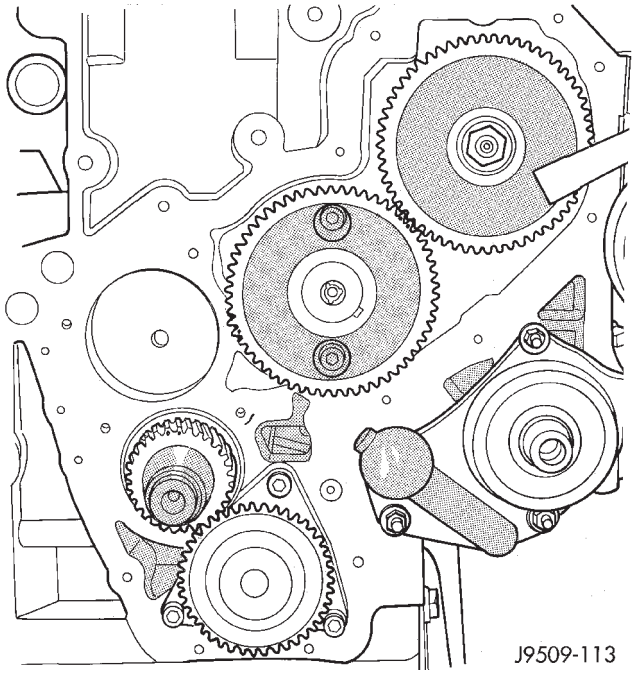


Fig. 54 Vacuum Pump Mounting Hole

covered during this operation. Mark piston with matching cylinder number.

(6) Pistons and connecting rods must be removed from top of cylinder block. Rotate crankshaft so that each connecting rod is centered in cylinder bore.

(7) Remove connecting rod cap. Push each piston and rod assembly out of cylinder bore.

CAUTION: During piston and rod removal. DO NOT rotate piston and connecting rod or damage to the

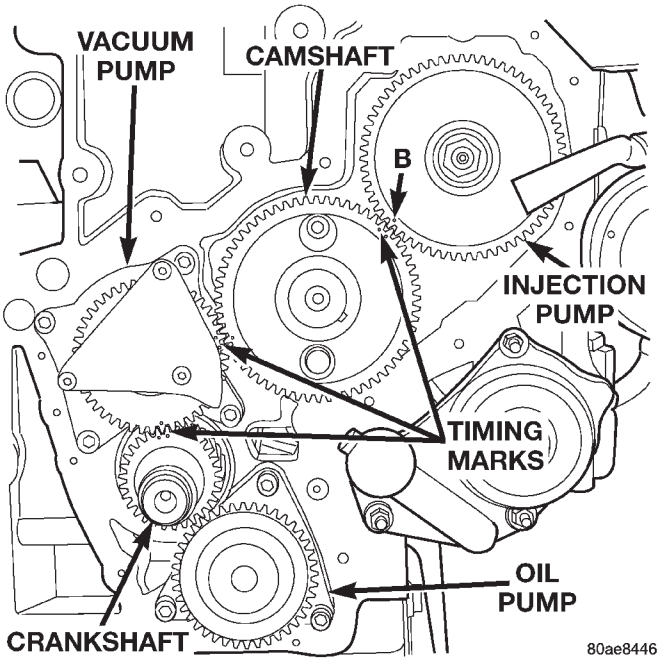


Fig. 55 Timing Marks

oil jets extending out into the cylinder bore will occur (Fig. 56).

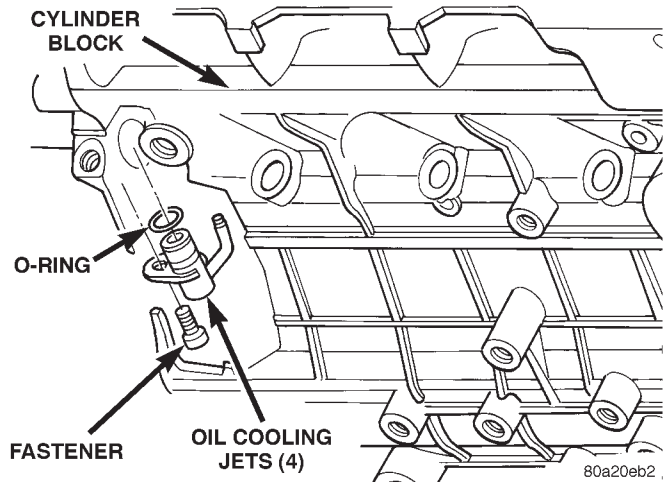


Fig. 56 Oil Jets

NOTE: Be careful not to nick crankshaft journals.

(8) After removal, install bearing cap on the mating rod.

PISTON PIN—REMOVAL

(1) Secure connecting rod in a soft jawed vice.

(2) Remove 2 clips securing piston pin (Fig. 57).

(3) Push piston pin out of piston and connecting rod.

REMOVAL AND INSTALLATION (Continued)

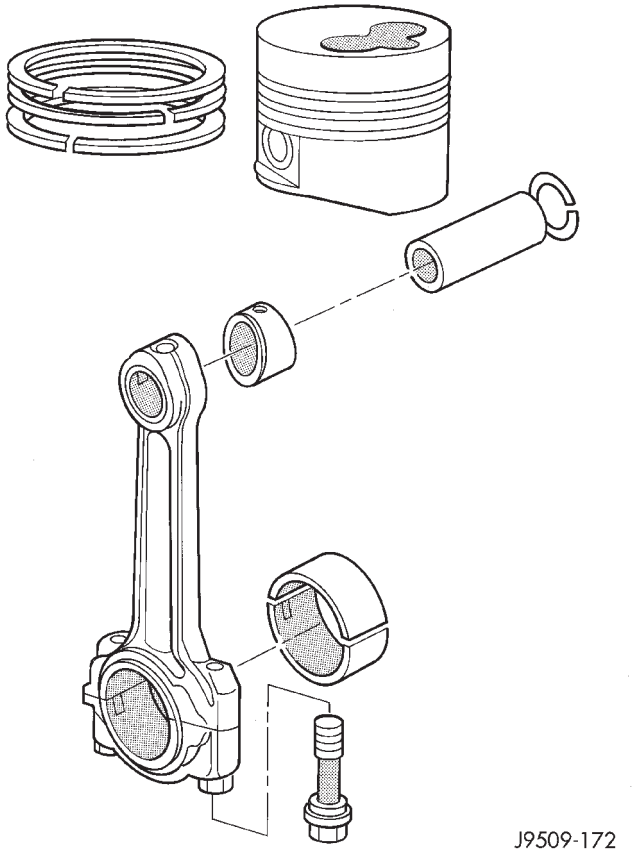


Fig. 57 Piston Assembly

PISTON RING—REMOVAL

(1) Identification (ID) mark on face of upper and intermediate piston rings must point toward piston crown.

(2) Using a suitable ring expander, remove upper and intermediate piston rings (Fig. 58).

(3) Remove the upper oil ring side rail, lower oil ring side rail and then oil ring expander from piston.

(4) Carefully clean carbon from piston crowns, skirts and ring grooves ensuring the 4 oil holes in the oil control ring groove are clear.

FITTING PISTON RINGS

(1) Wipe cylinder bore clean. Insert ring and push down with piston to ensure it is square in bore. The ring gap measurement must be made with the ring positioning at least 12 mm (0.50 in.) from bottom of cylinder bore. Check gap with feeler gauge (Fig. 59). Top compression ring gap .25 to .50 mm (.0098 to .0196 in.). Second compression ring gap .25 to .35 mm (.0098 to .0137 in.). Oil control ring gap .25 to .58 mm (.0098 to .0228 in.).

(2) If ring gaps exceed dimension given, new rings or cylinder liners must be fitted. Keep piston rings in piston sets.

(3) Check piston ring to groove clearance (Fig. 60). Top compression ring gap .08 to .130 mm (.0031 to .0051 in.). Second compression ring gap .070 to .102 mm (.0027 to .0040 in.). Oil control ring gap .040 to .072 mm (.0015 to .0028 in.).

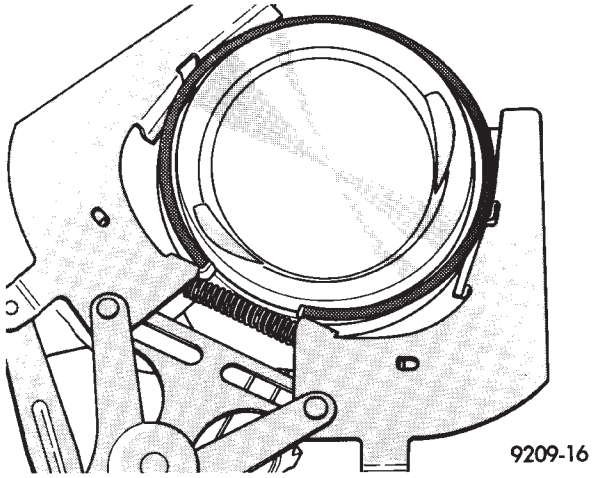


Fig. 58 Piston Rings—Removing and Installing

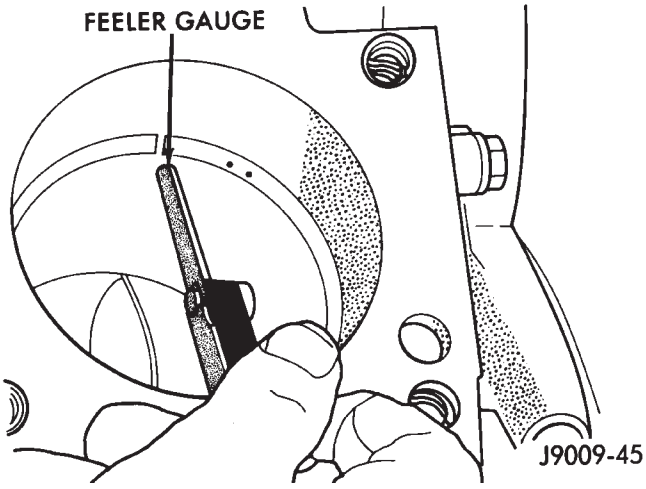


Fig. 59 Ring Gap Measurement

PISTON RINGS—INSTALLATION

(1) Install rings on the pistons using a suitable ring expander (Fig. 58).

(2) Top compression ring is tapered and chromium plated. The second ring is of the scraper type and must be installed with scraping edge facing bottom of the piston. The third is an oil control ring (Fig. 61). Ring gaps must be positioned, before inserting piston into the liners, as follows (Fig. 62).

(3) Top ring gap must be positioned at 30 degrees to the right of the combustion chamber recess (looking at the piston crown from above).

(4) Second piston ring gap should be positioned on the opposite side of the combustion chamber recess.

(5) Oil control ring gap to be located 30 degrees to the left of combustion chamber recess.

(6) When assembling pistons check that components are installed in the same position as before dis-

REMOVAL AND INSTALLATION (Continued)

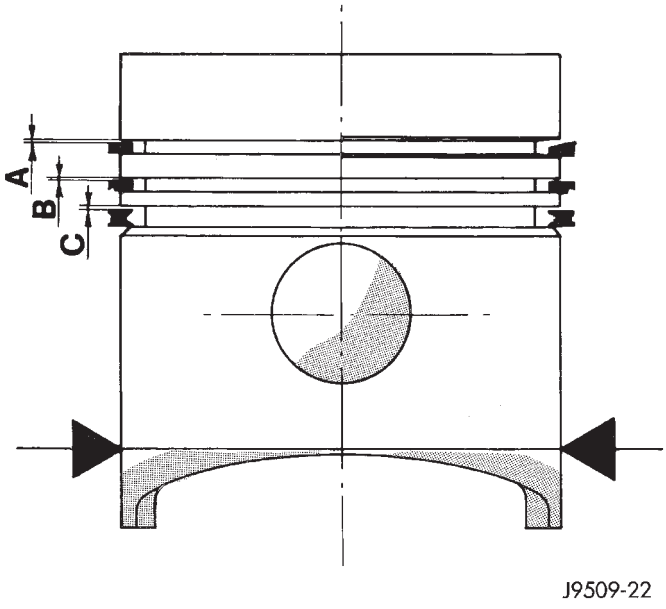


Fig. 60 Piston Ring Side Clearance

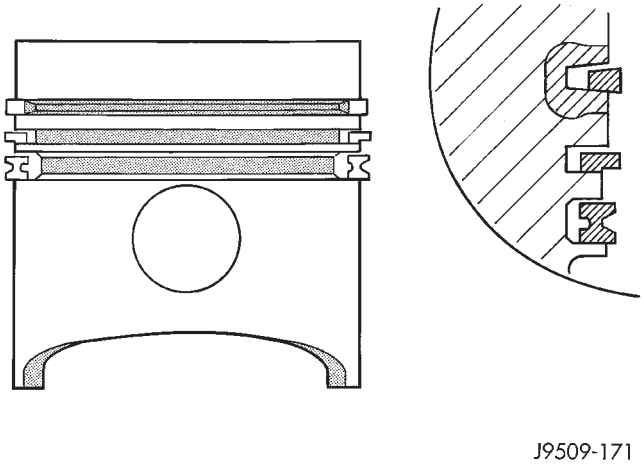


Fig. 61 Piston Ring Identification

assembly, determined by the numbers stamped on the crown of individual pistons. Engine cylinders are numbered starting from gear train end of the engine. **Face chamber recess side of piston towards camshaft**. Therefore, the numbers stamped on con rod big end should also face in the same direction. To insert piston into cylinder, use a ring compressor as shown in (Fig. 63).

PISTON PIN—INSTALLATION

(1) Secure connecting rod in soft jawed vice.
(2) Lubricate piston pin and piston with clean oil.
(3) Position piston on connecting rod.

CAUTION: Ensure combustion recess in piston crown and the bearing cap numbers on the connecting rod are on the same side.

(4) Install piston pin.
(5) Install clips in piston to retain piston pin.
(6) Remove connecting rod from vice.

PISTON—INSTALLATION

(1) Before installing pistons, and connecting rod assemblies into the bore, be sure that compression ring gaps are staggered so that neither is in line with oil ring rail gap (Fig. 62).

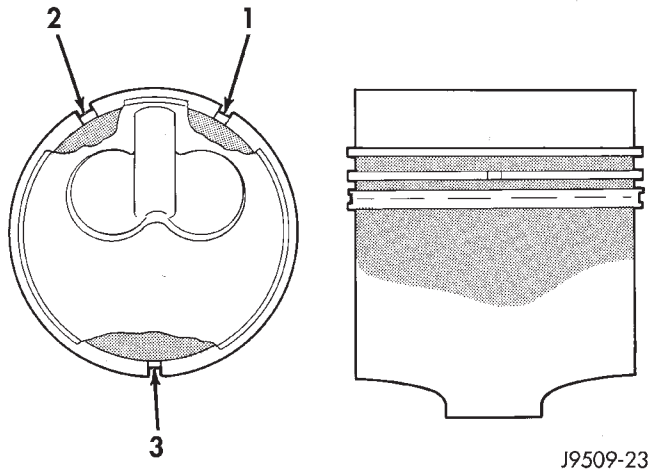


Fig. 62 Piston Ring Gap Location

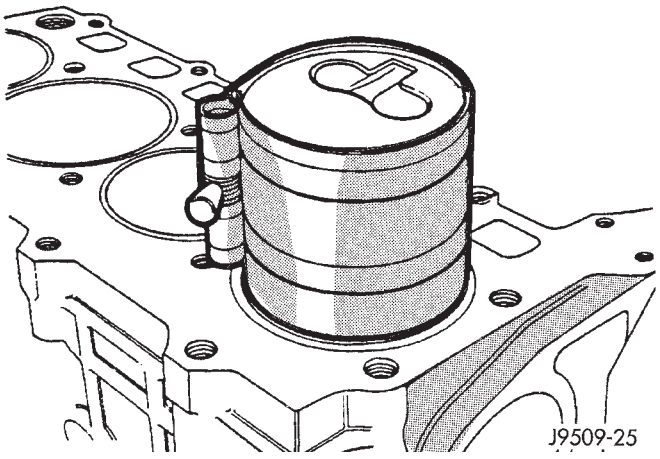


Fig. 63 Installing Piston

(2) Before installing the ring compressor, make sure the oil ring expander ends are butted and the rail gaps located as shown in (Fig. 62).

(3) Immerse the piston head and rings in clean engine oil, slide the ring compressor, over the piston and tighten with the special wrench (Fig. 63). **Ensure position of rings does not change during this operation**.

REMOVAL AND INSTALLATION (Continued)

(4) Face chamber recess side of piston towards camshaft.

(5) Install connecting rod bolt protectors on rod bolts.

(6) Rotate crankshaft so that the connecting rod journal is on the center of the cylinder bore. Insert rod and piston into cylinder bore and guide rod over the crankshaft journal.

CAUTION: During piston and rod installation. DO NOT rotate piston and connecting rod or damage to the oil jets extending out into the cylinder bore will occur (Fig. 56).

(7) Tap the piston down in cylinder bore, using a hammer handle. At the same time, guide connecting rod into position on connecting rod journal.

(8) Install rod caps. Install nuts on cleaned and oiled rod bolts and tighten nuts to 29.5 N·m (22 ft. lb.) plus 60°.

CYLINDER LINER

REMOVAL

(1) Remove cylinder heads (refer to cylinder head removal in this section).

(2) Remove Oil pan (refer to oil pan removal in this section).

(3) Remove pistons (refer to piston removal in this section).

(4) Use tool VM-1001 to remove liners (Fig. 64).

(5) Remove shims from cylinder liner or cylinder block recess. Keep shims with each cylinder liner.

INSTALLATION

(1) Carefully clean residual **sealer** from liner and crankcase, and degrease the crankcase where it comes into contact with the liners. Referring to (Fig. 65), install the liners in the crankcase as shown (A), rotating them back and forth by 45° in order to guarantee correct positioning.

(2) Measure the liner recess relative to block deck with a dial indicator mounted on a special tool VM-1010 A. **All the measurements must be taken on camshaft side**. Zero dial gauge on block deck.

(3) Move dial gauge to cylinder liner record reading on dial gauge.

(4) Remove liner and special tool.

(5) Then select the correct shim thickness to give proper protrusion (0.01 - 0.06 mm).

(6) Fit the shim and the O-rings onto the liner.

(7) Lubricate the lower liner location in the block. Apply LOCTITE 275 to the corner of the liner seat. Apply LOCTITE 275 uniformly to the upper part of the liner at area.

(8) Fit the liners in the crankcase making sure that the shim is positioned correctly in the seat. Lock

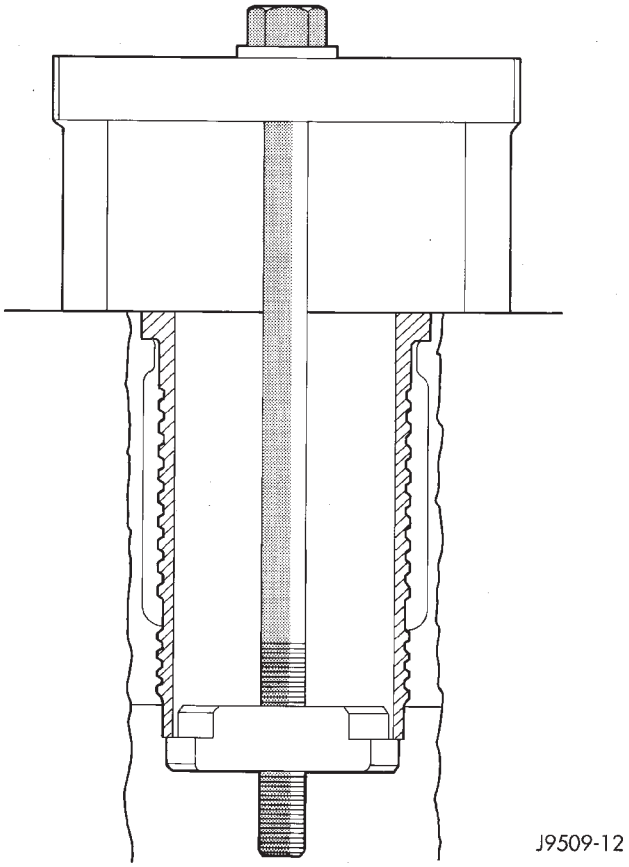


Fig. 64 Cylinder Liner—Removal

the liners in position using special tool (VM-1016) and bolts (Fig. 66). Clean the residual LOCTITE on the upper surface of the block deck.

(9) Recheck the liner protrusion. It should be 0.01 - 0.06 mm.

NOTE: A period of six hours must elapse between the liners being installed and engine start-up. If engine assembly is not continued after liner installation, the liners need to be clamped for twelve hours minimum.

(10) Refer to Cylinder Head Removal and Installation procedure in this section. To measure piston protrusion for installation of proper head gasket thickness.

CRANKSHAFT—REMOVAL

Refer to CRANKSHAFT MAIN BEARING REMOVAL in this section.

REAR CRANKSHAFT OIL SEAL

REMOVAL

(1) Remove transmission. Refer to Group 21, Transmission for removal procedure.

(2) Remove flywheel.

REMOVAL AND INSTALLATION (Continued)

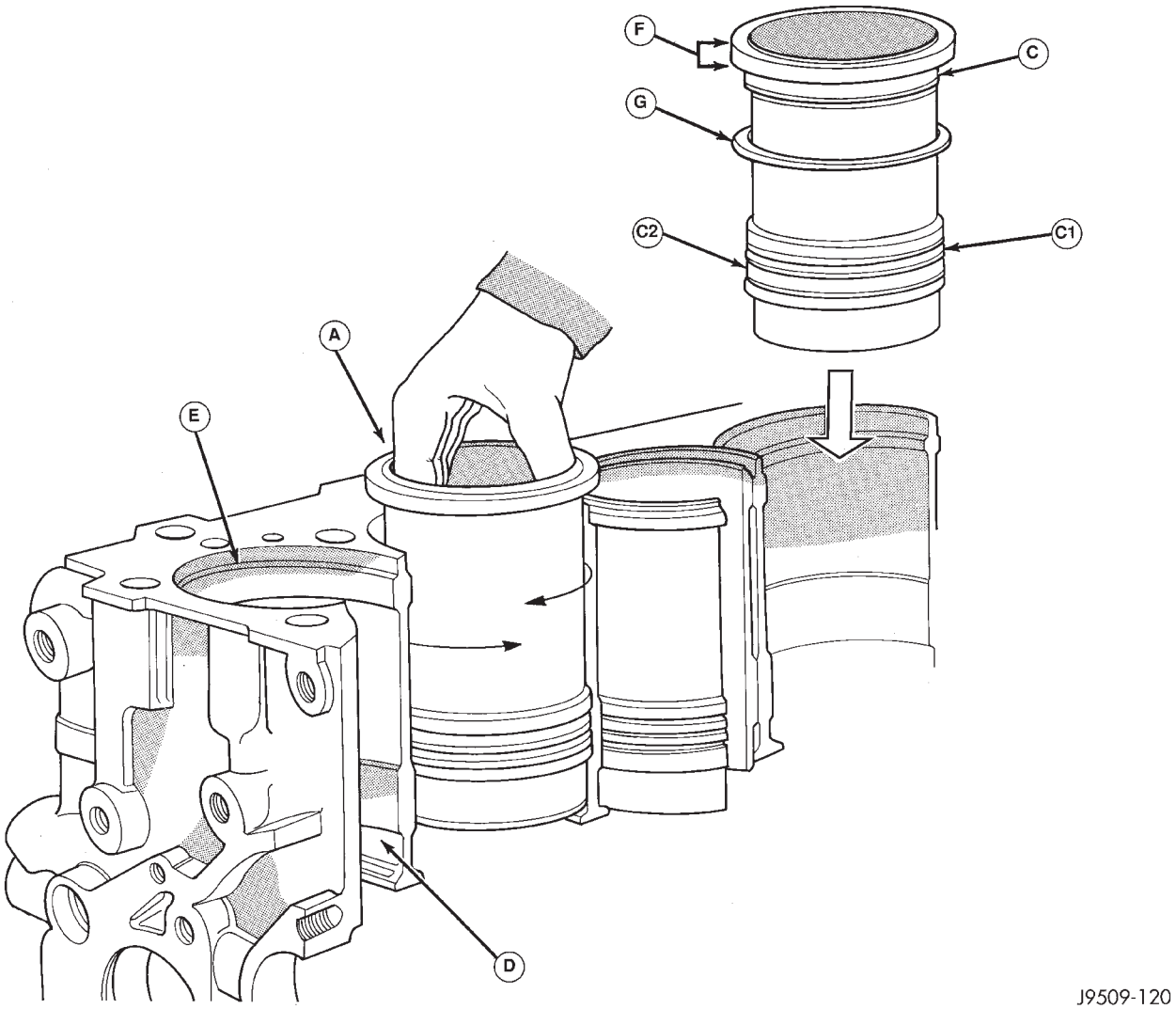


Fig. 65 Cylinder Liner—Installation

NOTE: Inspect O-ring in flywheel (Fig. 67).

(3) Remove rear crankshaft oil seal from retainer (Fig. 68).

CAUTION: When removing seal from retainer take care not to damage retainer.

INSTALLATION

(1) Install crankshaft oil seal.

CAUTION: Use NEW flywheel bolt for the following procedure.

(2) Install new O-ring on flywheel. Install flywheel. The 6 flywheel bolts must be tightened as follows:

a. Torque the 6 flywheel bolts to 60 N·m (44 ft. lbs.).

b. Loosen 2 of the 6 bolts, 180° apart. Torque the 2 bolts to 20 N·m (180 in. lbs.). Then using a torque angle gauge rotate the 2 bolts 65° additional.

c. Loosen the next 2 bolts, 180° apart and follow the same procedure.

d. Loosen the last 2 bolts, 180° apart and follow the same procedure.

(3) Install Transmission. Refer to procedure in Group 21, Transmission.

DISASSEMBLY AND ASSEMBLY

HYDRAULIC TAPPETS

DISASSEMBLE AND ASSEMBLE

(1) Pry out plunger retainer spring clip.

(2) Clean varnish deposits from inside of tappet body above plunger cap.

(3) Invert tappet body and remove plunger cap, plunger, check valve, check valve spring, check valve

DISASSEMBLY AND ASSEMBLY (Continued)

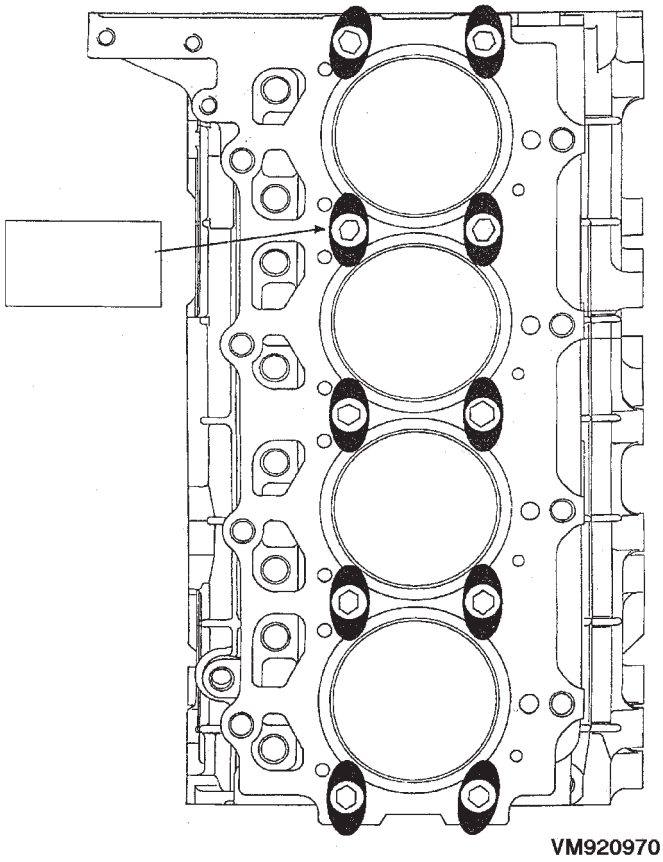


Fig. 66 Liner Clamp Location

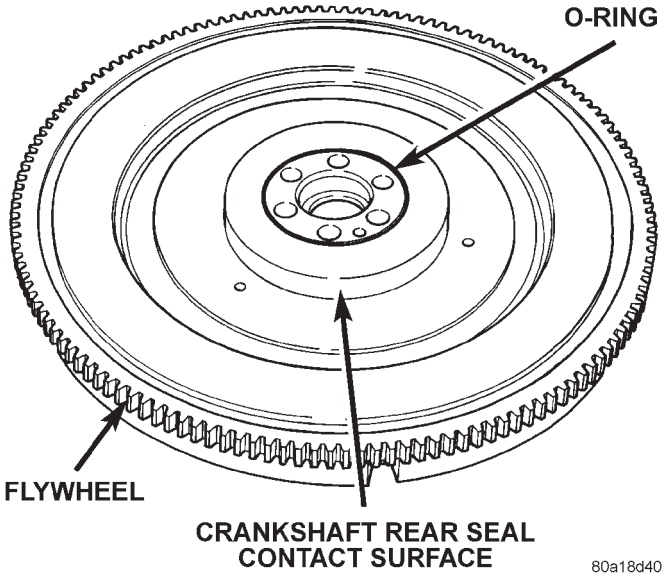


Fig. 67 Flywheel

retainer and plunger spring. Check valve could be flat or ball.

Assemble tappets in reverse order.

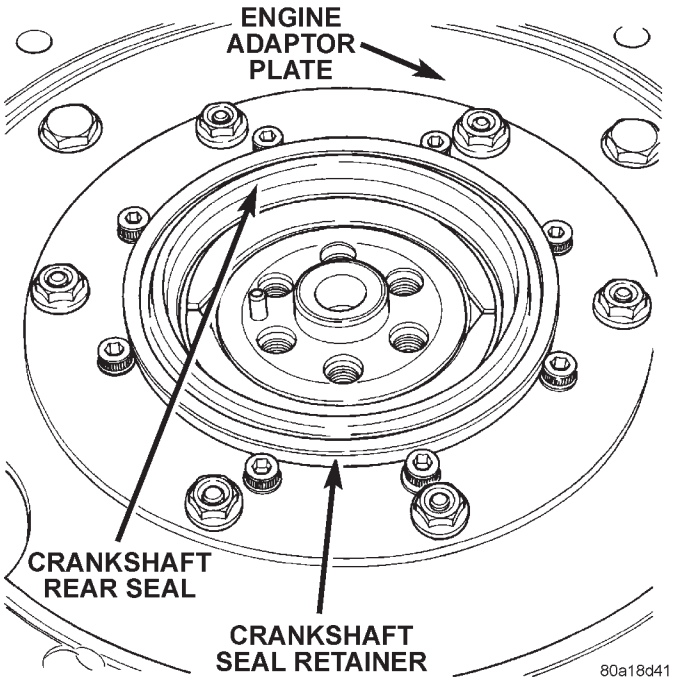


Fig. 68 Crankshaft Seal

CLEANING AND INSPECTION

CYLINDER HEAD COVERS

Remove any original sealer from the cover sealing surface of the engine cylinder head.

Remove all residue from the sealing surface using a clean, dry cloth.

ROCKER ARMS AND PUSH RODS

CLEANING

Clean all the components (Fig. 69) with cleaning solvent.

Use compressed air to blow out the oil passages in the rocker arms and push rods.

INSPECTION

Inspect the pivot surface area of each rocker arm. Replace any that are scuffed, pitted, cracked or excessively worn.

Inspect the 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 it and inspect the corresponding hydraulic tappet for excessive wear.

Inspect the push rods for straightness by rolling them on a flat surface or by shining a light between the push rod and the flat surface.

A wear pattern along the length of the push rod is not normal. Inspect the engine cylinder head for obstruction if this condition exists.

CLEANING AND INSPECTION (Continued)

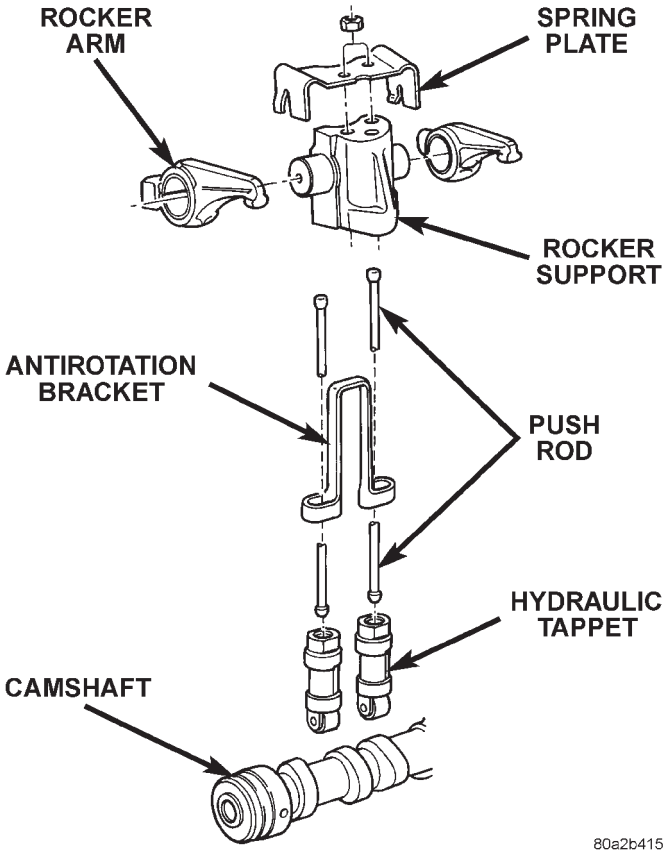


Fig. 69 Rocker Arm Components

CYLINDER HEAD

CLEANING

Thoroughly clean the engine cylinder head and cylinder block mating surfaces. Clean the intake and exhaust manifold and engine cylinder head mating surfaces. Remove all gasket material and carbon.

Check to ensure that no coolant or foreign material has fallen into the tappet bore area.

Remove the carbon deposits from the combustion chambers and top of the pistons.

INSPECTION

Use a straightedge and feeler gauge to check the flatness of the engine cylinder head and block mating surfaces (Fig. 70).

Minimum cylinder head thickness 89.95mm (3.541 in.)

CAUTION: If only one cylinder head is found to be distorted and requires machining, it will also be necessary to machine the remaining cylinders heads and end plates by a corresponding amount to maintain correct cylinder alignment.

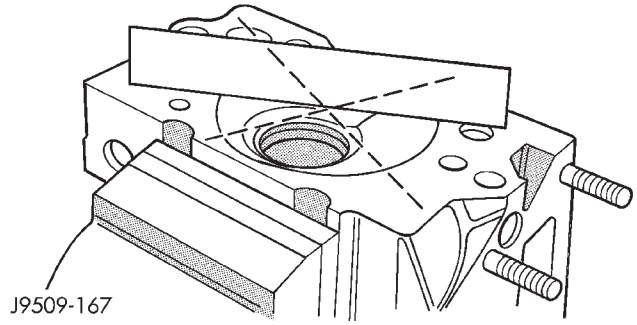


Fig. 70 Checking Cylinder Head Flatness

VALVE GUIDE HEIGHT

(1) Valve Guides height requirement.

(2) Measurement A (Fig. 71): 13.50 - 14.00 mm.

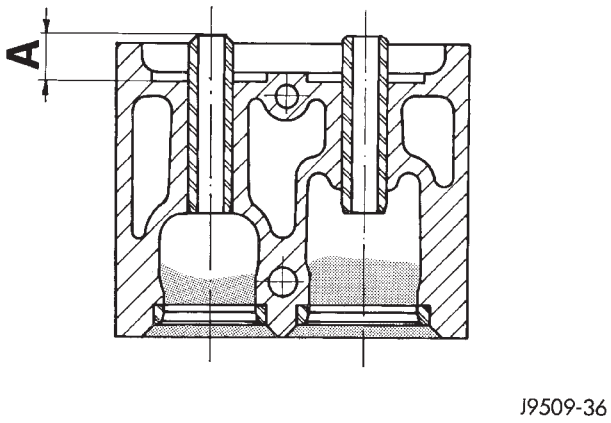


Fig. 71 Valve Guide Height

VALVE STEM-TO-GUIDE CLEARANCE MEASUREMENT

(1) Measure and record internal diameter of valve guides. Valve guide internal diameter is 8.0 to 8.015 mm (.3149 to .3155 in.).

(2) Measure valve stems and record diameters. Intake valve stem diameter 7.94 to 7.96 mm (.3125 to .3133 in). Exhaust valve stem diameter 7.92 to 7.94 mm (.3118 to .31215 in).

(3) Subtract diameter of valve stem from internal diameter of its respective valve guide to obtain valve stem clearance in valve guide. Clearance of inlet valve stem in valve guide is .040 to .075 mm (.0015 to .0029 in). Clearance of exhaust valve stem in valve guide is .060 to .095 mm (.0023 to .0037 in).

(4) If valve stem clearance in valve guide exceeds tolerances, new valve guides must be installed.

TIMING GEAR COVER

Be sure mating surfaces of timing gear cover and cylinder block are clean and free from burrs.

CLEANING AND INSPECTION (Continued)

VALVES AND VALVE SPRINGS

VALVE CLEANING

Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and heads.

Clean all grime and gasket material from the engine cylinder head machined gasket surfaces.

INSPECTION

Inspect for cracks in the combustion chambers and valve ports.

Inspect for cracks on the exhaust seat.

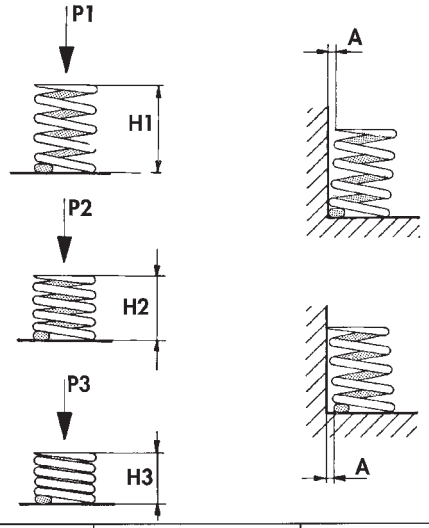
Inspect for cracks in the gasket surface at each coolant passage.

Inspect valves for burned, cracked or warped heads.

Inspect for scuffed or bent valve stems.

Replace valves displaying any damage.

Check valve spring height. (Fig. 72).



LOAD Kg		HEIGHT mm		STATE
P1	0.00	H1	44.65	FREE LENGTH
P2	33-35	H2	38.60	VALVE CLOSED
P3	90-95	H3	28.20	VALVE OPEN

J9509-38

Fig. 72 Valve Spring Chart

HYDRAULIC TAPPETS

(1) Clean all tappet parts in a solvent that will remove all varnish and carbon.

(2) Replace tappets that are unfit for further service with new assemblies.

(3) If plunger shows signs of scoring or wear, install a new tappet assembly. If valve is pitted, or valve seat on end of plunger is prevented from seating, install a new tappet assembly.

OIL PUMP

CLEANING

Wash all parts in a suitable solvent and inspect carefully for damage or wear (Fig. 74).

INSPECTION

(1) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 73). Difference between A and B should be 0.020-0.082 mm.

(2) Check clearance between rotors (Fig. 75).

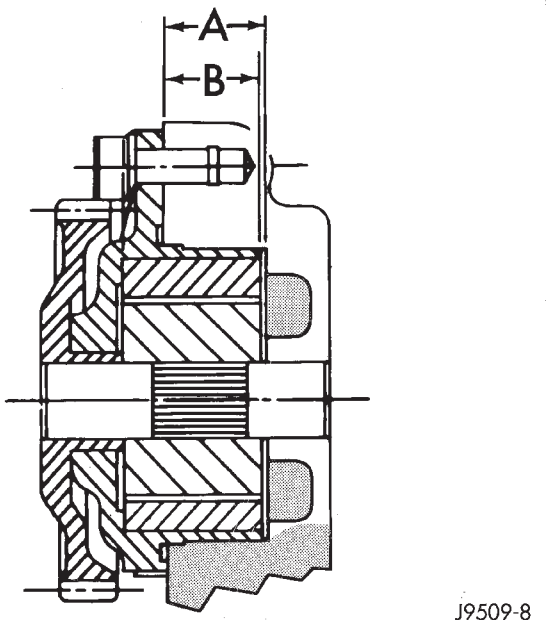


Fig. 73 Oil Pump Bore Depth

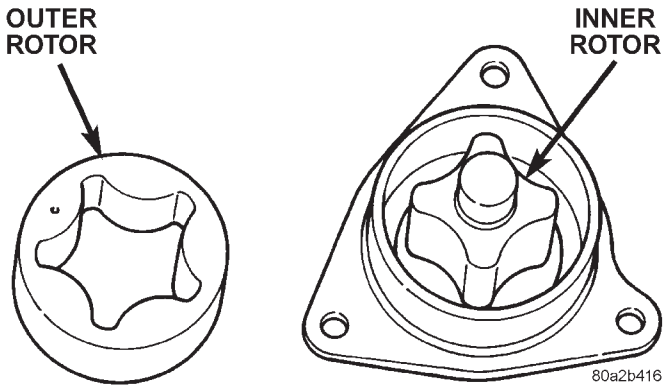


Fig. 74 Oil Pump Inner and Outer Rotors

PISTON AND CONNECTING ROD

PISTONS

(1) Piston Diameter: Size Group A: 91.93-91.94mm (3.6191-3.6196 in.) Size Group B: 91.94-91.95mm

CLEANING AND INSPECTION (Continued)

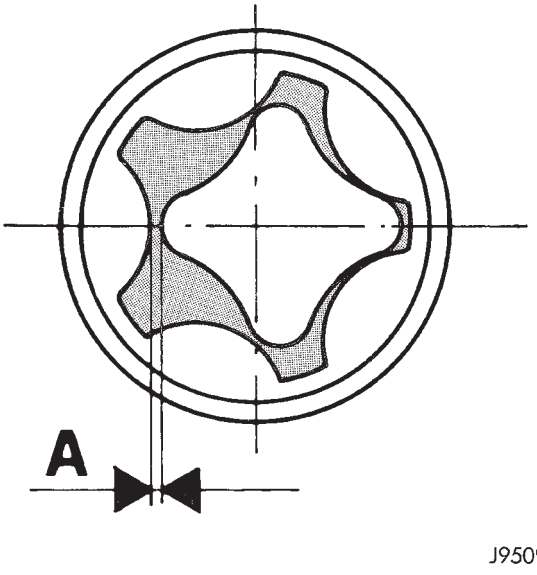


Fig. 75 Checking Rotor Clearance

(3.6196-3.6200 in.). Maximum wear limit .05mm (.0019 in.).

(2) Check piston pin bores in piston for roundness. Make 3 checks at 120° intervals. Maximum out of roundness .05mm (.0019in.).

(3) The piston diameter should be measured approximately 15 mm (.590 in.) up from the base.

(4) Skirt wear should not exceed 0.1 mm (.00039 in.).

(5) The clearance between the cylinder liner and piston should not exceed 0.25 mm (.0009 in.).

(6) Make sure the weight of the pistons does not differ by more than 5 g.

CONNECTING ROD

(1) Assemble bearing shells and bearing caps to their respective connecting rods ensuring that the serrations on the cap and reference marks are aligned.

(2) Tighten bearing cap bolts to 29 N·m (21 ft. lbs.) plus 60°.

(3) Check and record internal diameter of crank end of connecting rod.

Note: When changing connecting rods, all four must have the same weight and be stamped with the same number. **Replacement connecting rods will only be supplied in sets of four.**

(4) Connecting rods are supplied in sets of four since they all must be of the same weight category. Max allowable weight difference is 18 gr. **NOTE:** On one side of the big end of the con-rod there is a two-digit number which refers to the weight category. On the other side of the big end there is a four digit number on both the rod and the cap. These numbers must both face the camshaft as well as the recess on the piston crown (Fig. 76). Lightly heat the piston in oven. Insert piston pin in position and secure it with provided snap rings. **The Four digit numbers marked on con rod big end and rod cap must be on the same side as the camshaft (Fig. 76).** After having coated threads with Molyguard, tighten con rod bolts to 29 N·m (21 ft. lbs.) plus 60°.

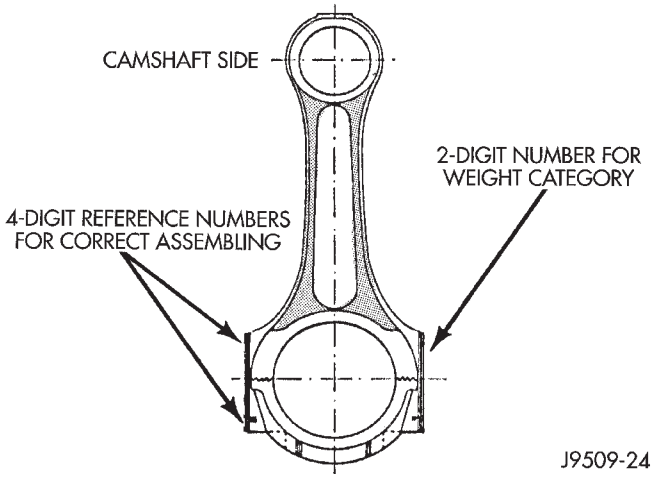


Fig. 76 Connecting Rod Identification

PISTON PIN

(1) Measure the diameter of piston pin in the center and both ends (Fig. 77).

(2) Piston pin diameter is 29.990 to 29.996mm (1.1807 to 1.1809 in.).

CRANKSHAFT

CRANKSHAFT JOURNALS

(1) Using a micrometer, measure and record crankshaft connecting rod journals, take reading of each journal 120° apart. Crankshaft journal diameter is 53.84 to 53.955mm (2.1196 to 2.1242 in.).

(2) Crankshaft journals worn beyond limits or show signs of out of roundness must be reground or replaced. Minimum reground diameter is 53.69mm (2.1137 in.).

BEARING-TO-JOURNAL CLEARANCE

Compare internal diameters of connecting rod with crankshaft journal diameter. Maximum clearance between connecting rod and crankshaft journals .022 to .076mm (.0008 to .0029 in.) (Fig. 78).

CRANKSHAFT MAIN BEARING

INSPECTION

(1) Fit main bearing carriers together and torque to 42 N·m (31 ft. lbs.)

(2) Check internal diameter of bearings.

CLEANING AND INSPECTION (Continued)

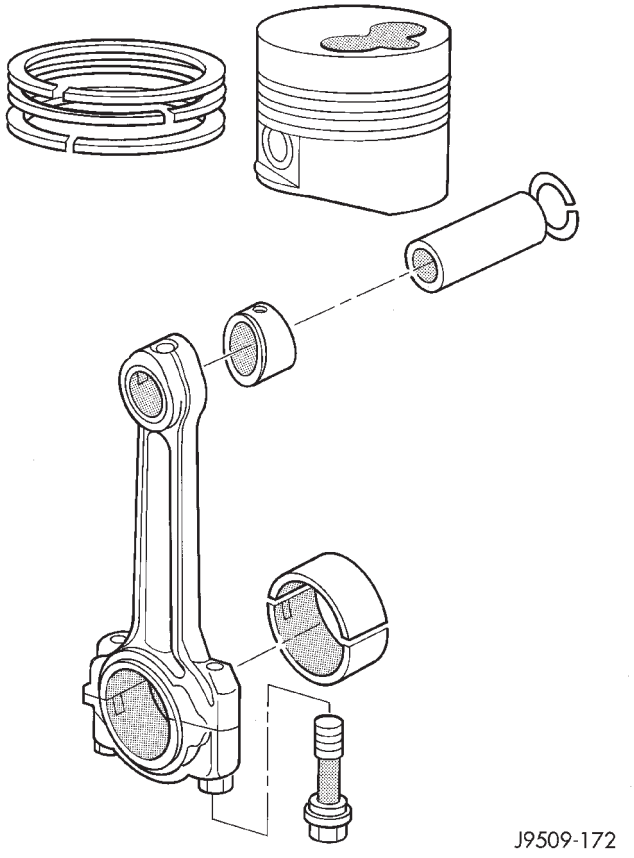


Fig. 77 Piston, Connecting Rod and Pin

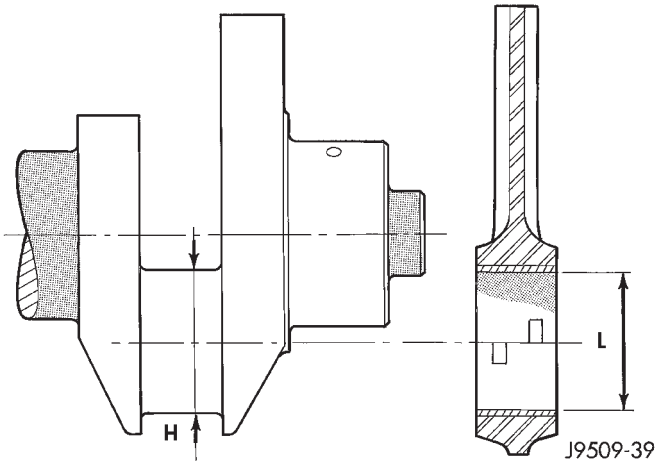


Fig. 78 Bearing Clearance

(3) If internal diameter of original bearing is being checked and figures are not within specifications, new bearings must be used.

(4) Check crankshaft main bearing journals to bearing clearances. Clearances of main bearings is .03 to .088mm (.0011 to .0035 in.).

OIL PAN

Remove all gasket material from cylinder block. Be careful not gouge pan sealing surface.

CYLINDER LINER

INSPECTION

The cylinder walls should be checked for out-of-round and taper with dail bore gauge. The cylinder bore out-of-round is 0.100 mm (.0039 inch) maximum and cylinder bore taper is 0.100 mm (0.0039 inch) maximum. If the cylinder walls are badly scuffed or scored, new liners should be installed and honed, and new pistons and rings fitted.

Measure the cylinder bore at three levels in directions A and B (Fig. 79). Top measurement should be 10 mm (3/8 inch) down and bottom measurement should be 10 mm (3/8 inch.) up from bottom of bore.

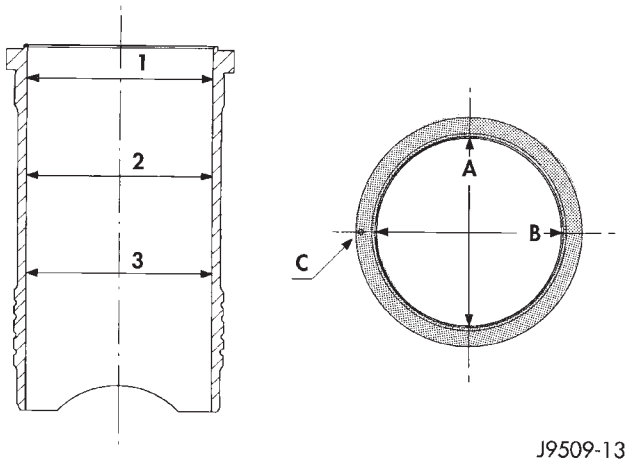


Fig. 79 Liner Inspection

SPECIFICATIONS

2.5L VM DIESEL

DESCRIPTION	SPECIFICATIONS
Type	425CLIEE (36B)
Number of Cylinder	4
Bore	92 mm
Stroke	94 mm
Capacity	2499.5 cm3
Injection Order	1-3-4-2
Compression Ratio	21:1 (± 0.5)
Crankshaft	
Front Journal Diameter	
Nominal	62.985–63.000 mm
–0.25	62.735–62.750 mm
–0.125	62.860–62.875 mm
Front Bearing Diameter	
Nominal	63.043–63.088 mm
–0.25	62.793–62.838 mm
–0.125	62.918–62.963 mm
Clearance Between Journal and Bearing:	
0.043–0.103 mm	
Center Journal Diameter	

SPECIFICATIONS (Continued)

DESCRIPTION	SPECIFICATIONS
Nominal	63.005–63.020 mm
–0.25	62.755–62.770 mm
–0.125	62.880–62.895 mm
Center Bearing Diameter	
Nominal	63.050–63.093 mm
–0.25	62.800–62.843 mm
–0.125	62.925–62.968 mm
Clearance Between Journal and Bearing: 0.030–0.088 mm	
Rear Journal Diameter	
Nominal	79.980–80.000 mm
–0.25	79.730–79.750 mm
–0.125	79.855–79.875 mm
Rear Bearing Diameter	
Nominal	80.045–80.070 mm
–0.25	79.795–79.820 mm
–0.125	79.920–79.945 mm
Clearance Between Journal and Bearing: 0.045–0.090 mm (Wear Limit: 0.200 mm)	
Connecting Rod Journal	
Nominal	53.940–53.955 mm
–0.25	53.690–53.705 mm
–0.125	53.815–53.830 mm
Connecting Rod Bearing	
Nominal	53.977–54.016 mm
–0.25	53.727–53.766 mm
–0.125	53.852–53.891 mm
Clearance Between Journal and Bearing: 0.022–0.076 mm (Wear Limit: 0.200 mm)	
Crankshaft End Play	
End Play	0.08–0.21 mm
Adjustment	Thrust Washers
Thrust Washers Available	2.31–2.36 mm
Thrust Washers Available	2.41–2.46 mm
Thrust Washers Available	2.51–2.56 mm
Main Bearing Carriers	
Front	67.025–67.050 mm
Center	66.670–66.690 mm
Rear	85.985–86.005 mm
Liners	
Internal Diameter	92.000–92.010 mm
Protrusion	0.01–0.06 mm
Adjustment	Shims
Available Shims:	0.15 mm
Available Shims:	0.17 mm
Available Shims:	0.20 mm
Available Shims:	0.23 mm
Available Shims:	0.25 mm
Cylinder Head	
Minimum Thickness	89.95–90.05 mm
Gasket	Steel
Gasket thickness:	1.42 ± 0.1 mm 0 Holes
Gasket thickness:	1.62 ± 0.1 mm 1 Holes
Gasket thickness:	1.52 ± 0.1 mm 2 Holes
End Plates	
Height	89.02–90.00 mm
Connecting Rods	
Weight (Without the crank bearing)	1129–1195 grams
Small End Bearing Internal Diameter	
Minimum	30.035 mm
Maximum	30.050 mm
Crankshaft Bearings Standard Internal Diameter	53.997–54.016 mm
Pistons	
Skirt Diameter	91.935–91.945 mm
(Measured at approximately 15 mm above the bottom of the skirt)	
Piston Clearance	0.055–0.075 mm
Top of Piston to Cylinder Head	0.80–0.89 mm
Piston Protrusion	0.53–0.62 mm Fit Gasket (1.42), 0 Holes
Piston Protrusion	0.73–0.82 mm Fit Gasket (1.62), 1 Hole
Piston Protrusion	0.63–0.72 mm Fit Gasket (1.52), 2 Holes
Piston Pins	
Type	Full Floating
Pin Diameter	29.990–29.996 mm
Clearance	0.004–0.014 mm
Piston Rings (Clearance in Groove)	
Top	0.080–0.130 mm
Second	0.070–0.102 mm
Oil Control	0.040–0.072 mm
Piston Rings (Fitted Gap)	
Top	0.25–0.50 mm
Second	0.20–0.35 mm
Oil Control	0.25–0.58 mm
Camshaft	
Journal Diameter Front	53.460–53.480 mm
Bearing Clearance	0.06–0.13 mm
Journal Diameter Center	53.460–53.480 mm
Bearing Clearance	0.06–0.13 mm
Journal Diameter Rear	53.460–53.480 mm
Bearing Clearance	0.06–0.13 mm
Tappets	
Outside Diameter	22.195–22.212 mm
Rocker Gear	
Shaft Diameter	21.979–22.00 mm
Bushing internal diameter	22.020–22.041 mm
Assembly Clearance	0.020–0.062 mm
Valves (Intake)	
Opens	26° B.T.D.C.
Closes	58° A.B.D.C.
Valves (Exhaust)	
Opens	64° B.B.D.C.
Closes	38° A.T.D.C.

SPECIFICATIONS (Continued)

DESCRIPTION	SPECIFICATIONS
Valve Face Angle	
Intake	55°30'– 55°50'
Exhaust	45°25'– 45°35'
Valve Head Diameter	
Intake	40.05–40.25 mm
Exhaust	33.8–34.0 mm
Valve Head Stand Down	
Intake	1.08–1.34 mm
Exhaust	1.99–1.25 mm
Valve Stem Diameter	
Intake	7.940–7.960 mm
Exhaust	7.922–7.940 mm
Valve Clearance in Guide	
Intake	0.040–0.075 mm
Exhaust	0.060–0.093 mm
Valve Guide	
Inside Diameter	8.0–8.015 mm
Fitted Height	13.5–14.0 mm
Valve Spring	
Free Length	44.65 mm
Fitted Length	38.6 mm
Load at Fitted Length	34 ± 6% Kg
Load at Top of Lift	92.5 ± 4% Kg
Number of Coils	5.33 Valve Timing
Oil Pressure	
at 4000 rpm	3.0 to 4.5 bar (Oil at 90–100°C)
Pressure Relief Valve Opens	6.38 bar
Pressure Relief Valve–Free Length	57.5 mm
Oil Pump	
Outer Rotor End Float	0.03–0.09 mm
Inner Rotor End Float	0.03–0.09 mm
Outer Rotor to Body Diameter Clearance	0.130–0.230 mm
Rotor Body to Drive Gear Clearance (Pump Not Fitted)	3.27–3.73 mm

TORQUE

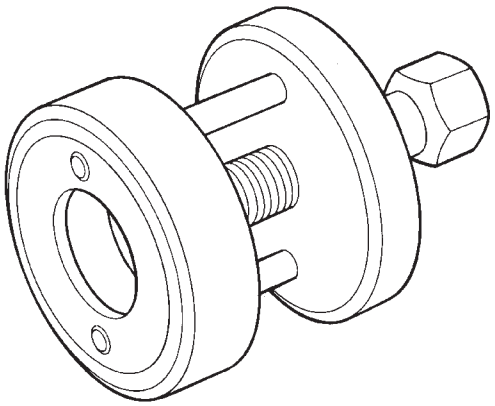
DESCRIPTION	TORQUE
Generator Mounting Bracket	
Bolts	47 N·m (35 ft. lbs.)
Camshaft Thrust Plate Retaining Bolts	
Bolt	24 N·m (18 ft. lbs.)
Cylinder Head	
Bolts	See Cylinder Head Installation Procedure
Connecting Rod	
Bolts	29.5 N·m +60° (22 ft. lbs. +60°)
Crankshaft Bearing Carrier	
Bolts	44 N·m (32 ft. lbs.)
Crankshaft damper (Pulley)	
Nut	441 N·m (325 ft. lbs.)
EGR Valve to Intake Manifold	
Tube	26 N·m (19 ft. lbs.)
EGR Tube to EGR Valve	
Bolts	26 N·m (19 ft. lbs.)
Engine Mount—Front	
Support Bracket Engine Bolts	68 N·m (50 ft. lbs.)
Support Bracket Transmission Bolts	101 N·m (75 ft. lbs.)
Support Cushion Crossmember Bolts	54 N·m (40 ft. lbs.)
Support Cushion Thru Bolt	65 N·m (48 ft. lbs.)
Engine Mount—Rear	
Support Bracket Transmission Bolts	101 N·m (75 ft. lbs.)
Support Bracket to Engine Bracket	101 N·m (75 ft. lbs.)
Support Cushion Thru Bolt	68 N·m (50 ft. lbs.)
Engine Mount—Left	
Transmission Mounting Bolts	54 N·m (40 ft. lbs.)
Support Cushion Thru Bolt	71 N·m (53 ft. lbs.)
Engine Mount—Right	
Mount to Frame Rail Bolts	68 N·m (50 ft. lbs.)
Mount Bolt (Horizontal)	145 N·m (107 ft. lbs.)
Mount Bolt (Vertical)	101 N·m (75 ft. lbs.)
Right Engine Mount Bracket	
Bolts	40 N·m (30 ft. lbs.)
Exhaust Pipe to Turbocharger	
Bolts	28 N·m (250 in. lbs.)
Exhaust Manifold Outlet to Turbo	
Nuts	32 N·m (24 ft. lbs.)
Exhaust Elbow to Turbo	
Bolts	30 N·m (22 ft. lbs.)
Exhaust Manifold Mounting	
Nuts	30 N·m (22 ft. lbs.)
Flywheel	
Bolts	See Rear Crankshaft Seal Installation Procedure
Engine Adaptor Plate	
Bolts	47 N·m (35 ft. lbs.)
Front Timing Gear Cover	
Bolts	11 N·m (96 in. lbs.)
Fuel Filter	
Nuts	28 N·m (250 in. lbs.)
Glow Plugs	
Plugs	14 N·m (120 in. lbs.)
Idler Pulley Pump Support Bracket	
Nuts	26 N·m (228 in. lbs.)
Idler Pulleys (left handed threads)	
Bolts	47 N·m (35 ft. lbs.)
Injector Pump fuel lines	
Nuts	17.6 N·m (156 in. lbs.)
Injector Pump Gear	
Lock Nut	86 N·m
Injector Pump Mounting	
Nuts	27.5 N·m (240 in. lbs.)

SPECIFICATIONS (Continued)

DESCRIPTION	TORQUE
Injector	
Tighten to	65 N·m (48 ft. lbs.)
Intake Manifold Mounting	
Nuts	30 N·m (264 in. lbs.)
Main Bearing Oil Delivery Union	
Bolts	54 N·m (40 ft. lbs.)
Oil Feed Line To Rocker Arms	
Bolts	12.7 N·m (108 in. lbs.)
Oil Feed Line to Block	
Bolts	12.7 N·m (108 in. lbs.)
Oil Feel Line to Vacuum Pump	
Bolts	16.7 N·m (145 in. lbs.)
Oil Filter	
Tighten to	9.8 N·m (85 in. lbs.)
Oil Filter Adaptor	
Fastener	49 N·m (36 ft. lbs.)
Oil Filter Base	
Fastener	49 N·m (36 ft. lbs.)
Oil Pan Mounting	
Bolts	12 N·m (108 in. lbs.)
Oil Pickup Tube	
Bolts	11.3 N·m (100 in. lbs.)
Oil Pump Mounting	
Bolts	27.5 N·m (240 in. lbs.)
Oil Pan Drain	
Plug	54 N·m (40 ft. lbs.)
Power Steering Pressure Hose	
Fastener	28 N·m (240 in. lbs.)
Power Steering Pulley	
Nut	170 N·m (125 ft. lbs.)
Rear Crankshaft Bearing Carrier	
Bolts	10.8 N·m (95 in. lbs.)
Rocker Arm Cover	
Bolts	14.7 N·m (132 in. lbs.)
Rocker Arm Mounting	
Nuts	29.4 N·m (264 in. lbs.)
Power Steering Pump Mounting	
Nuts	24.5 N·m (216 in. lbs.)
Turbocharger Mounting	
Nuts	32 N·m (288 in. lbs.)
Turbocharger Oil Delivery	
Bolt	27.5 N·m (240 in. lbs.)
Turbocharger Oil Drain	
Bolts	10.8 N·m (95 in. lbs.)
Vacuum Pump Mounting	
Bolts	10.8 N·m (95 in. lbs.)
Water Manifold Mounting	
Bolts	11.8 N·m (108 in. lbs.)
Water Pump Pulley	
Bolts	27.5 N·m (240 in. lbs.)

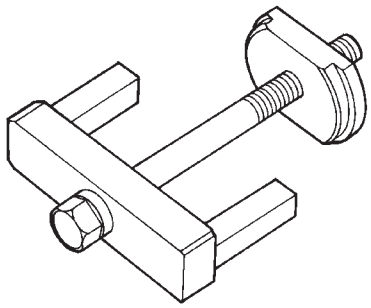
SPECIAL TOOLS

2.5L VM DIESEL



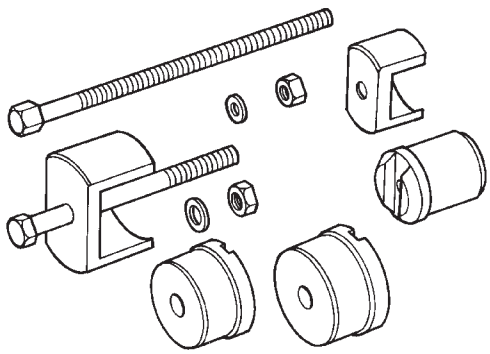
803fd6a1

Crankshaft Pulley and Gear Remover VM.1000A



803fd6a2

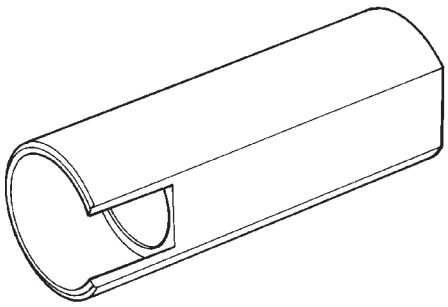
Cylinder Liner Puller VM.1001



803fd6a3

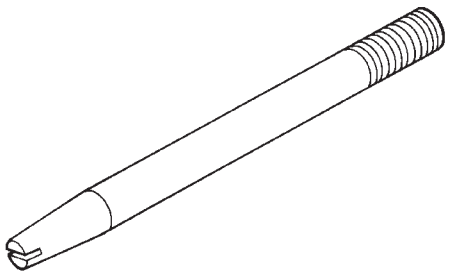
Crankshaft Bearing Remover/Installer VM.1002

SPECIAL TOOLS (Continued)



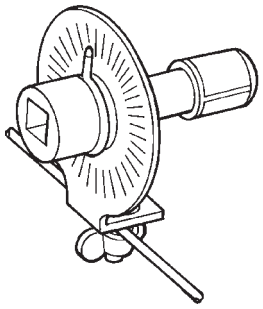
803fd6a5

Crankshaft Remover/Installer Sleeve VM.1004



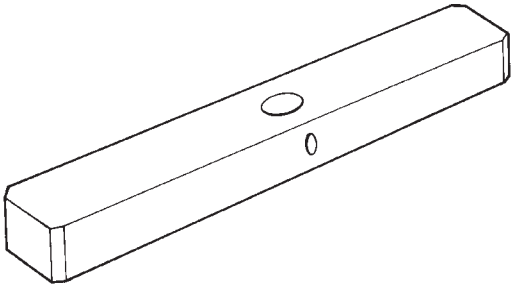
803fd6a9

Cylinder Head Guide Studs VM.1009



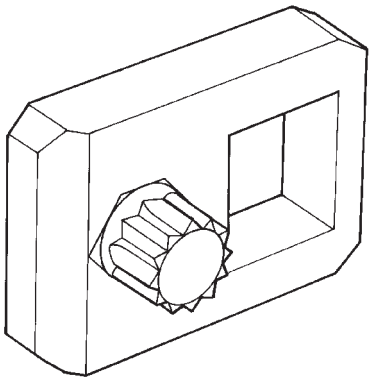
803fd6a6

Torque Angle Gauge VM.1005



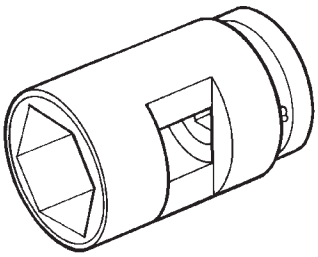
80a1aa43

Cylinder Liner Protrusion Tool VM.1010



803fd6a7

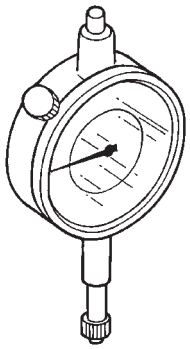
Cylinder Head Bolt Wrench VM.1006A



80a1aa45

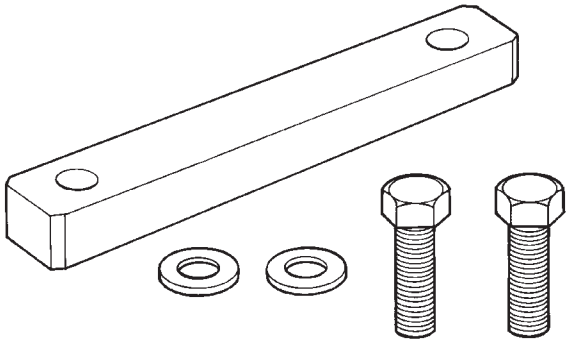
Injector Socket Remover/Installer VM.1012A

SPECIAL TOOLS (Continued)



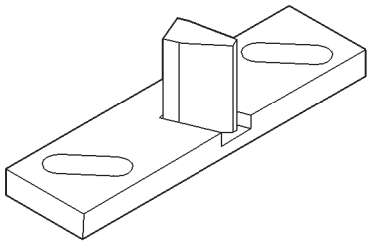
80a1aa46

Dial Indicator Gauge VM.1013

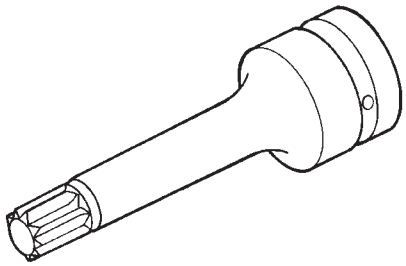


80a1aa49

Cylinder Retainers VM.1016

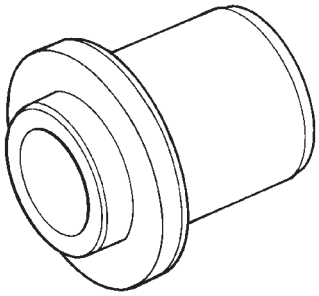


Flywheel Locking Tool VM.1014



80a1aa4b

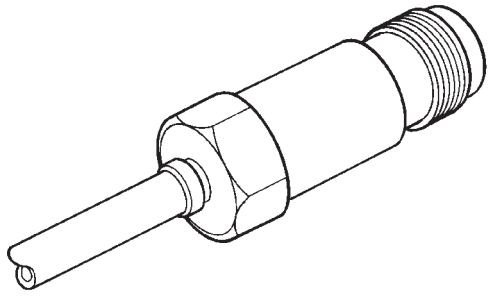
Cylinder Head Bolt Wrench M12 VM.1018



80a1aa48

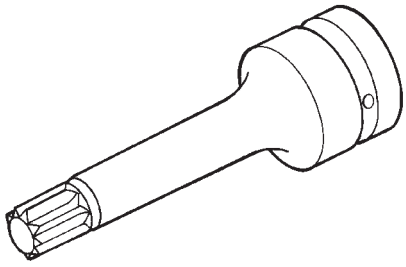
Timing Cover Oil Seal Installer VM.1015

SPECIAL TOOLS (Continued)



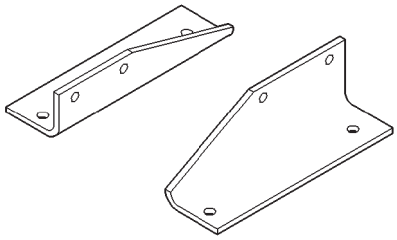
80a1aa4e

Adapter Cylinder Leakage Tester VM.1021



80a1aa4c

Cylinder Head Bolt Wrench M14 VM.1019



Support Brackets Engine Removal/Installation VM.1026