

ENGINE

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GENERAL INFORMATION

ENGINE IDENTIFICATION

The engine model code and serial number are stamped on the left side of the engine block, just below the oil dipstick tube (Fig. 1).

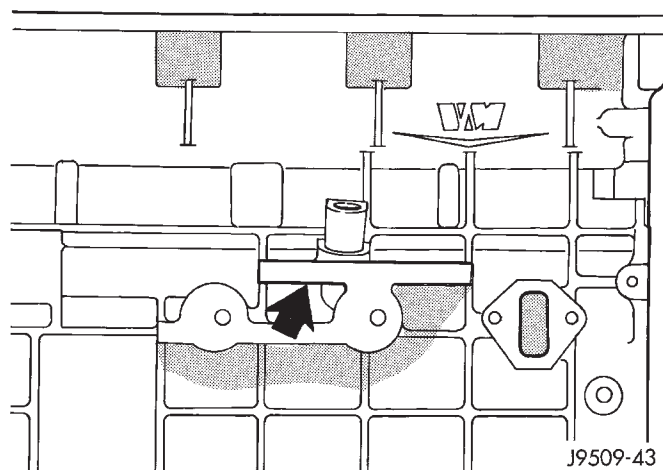


Fig. 1 Engine Code Location

GENERAL INFORMATION (Continued)

Displacement	2.5L (2499 cc)
Bore	92.00
Stroke	94.00
Compression Ratio	20.95:1
Vacuum at idle	600 mm/Hg (23.6 In/Hg)
Belt Tension	53 DaN - New 30 DaN - Used
Thermostat Opening	80°C ± 2°C
Generator Rating	Bosch 50/120 Amp
Cooling System Capacity	9.5 Liter
P/S Capacity	0.75 Liter
Engine Oil Capacity	6.8 Liter w/filter change
Timing System	Pushrod operated overhead valves, with gear-driven camshaft in crankcase.
Air Intake	Dry filter.
Fuel Feed	Vane pump incorporated in injection pump.
Fuel System	Indirect fuel injection (precombustion chamber).
Combustion Cycle	4 stroke.
Cooling System	Water cooling.
Injection Pump	Rotary pump with built-in mechanical regulator.
Lubrication	Pressure lubrication by rotary pump, full-flow filtration.
Engine Rotation	Clockwise viewed from front cover.

J9509-174

*Engine Description***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 4 bars (50 psi) at 3000 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 cre-

ate 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.

DIAGNOSIS AND TESTING**SERVICE DIAGNOSIS—DIESEL—
PERFORMANCE****SERVICE DIAGNOSIS—DIESEL—MECHANICAL****TAPPET NOISE**

(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.

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.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE WILL NOT CRANK OR CRANKS SLOWLY	<ol style="list-style-type: none"> 1. Starting motor operating, but not cranking the engine. 2. Crankshaft rotation restricted. 3. Starting circuit connections loose or corroded. 4. Neutral safety switch or starter relay inoperative. 5. Battery charge low. 6. No voltage to starter solenoid. 7. Solenoid or starter motor inoperative. 	<ol style="list-style-type: none"> 1. Remove the starter motor. Check for broken flywheel teeth or a broken starting motor spring. 2. Rotate the engine to check for rotational resistance. 3. Clean and tighten connections. 4. Check starter relay supply voltage and proper operation of neutral safety switch (if equipped). Replace defective parts. 5. Check battery voltage. Replace battery if a charge cannot be held. 6. Check voltage to solenoid. If necessary, replace the solenoid. 7. Replace starter motor.
ENGINE CRANKS, BUT WILL NOT START NO SMOKE	<ol style="list-style-type: none"> 1. No fuel in supply tank. 2. Electrical fuel shutdown solenoid not operating. 3. Air intake or exhaust plugged. 4. Fuel filter plugged. 5. Excessive fuel inlet restriction. 6. Injection pump not getting fuel or fuel is aerated. 7. One or more injectors worn or not operating properly. 8. Worn or inoperative injection pump. 9. Camshaft out of time. 	<ol style="list-style-type: none"> 1. Fill fuel supply. 2. Check for loose wires and verify that the fuel shutdown solenoid and fuel shutdown solenoid relay is functioning. 3. Remove the obstruction. 4. Drain fuel/water separator and replace fuel filter. 5. Check fuel inlet restriction. Correct cause. 6. Check fuel flow/bleed fuel system. 7. Check/replace bad or improperly operating injectors. 8. Visually check delivery with externally connected injector to one of the pump outlets. Repair or replace the pump if fuel is not being delivered. 9. Check/correct gear train timing alignment.
ENGINE HARD TO START, OR WILL NOT START SMOKE FROM EXHAUST	<ol style="list-style-type: none"> 1. Incorrect starting procedure. 2. Cranking speed too slow. 3. Cylinder heads heater plugs relay defective. 4. One or more cylinder head heater plugs defective. 5. Insufficient intake air. 	<ol style="list-style-type: none"> 1. The fuel shutoff solenoid control must be in the run position. Ensure proper procedure is being used. 2. (A) Verify that the transmission is not engaged. (B) Check the battery, starting motor and look for loose or corroded wiring connections. 3. Verify system is working. Repair/replace inoperative parts. 4. Verify system is working. Repair/replace inoperative parts. 5. Inspect or replace filter and check for obstruction to the air supply tube.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
<p>ENGINE HARD TO START, OR WILL NOT START SMOKE FROM EXHAUST (CONT.)</p>	<p>6. Air in fuel system or the fuel supply is inadequate.</p> <p>7. Contaminated fuel.</p> <p>8. Fuel screen plugged.</p> <p>9. One or more injectors worn or not operating properly.</p> <p>10. Worn or inoperative injection pump.</p> <p>11. Injection pump out of time.</p> <p>12. Engine compression low.</p>	<p>6. Check the flow through the filter and bleed the system. Locate and eliminate the air source.</p> <p>7. Verify by operating the engine with clean fuel from a temporary tank. Check for presence of gasoline. Drain and flush fuel supply tank. Replace fuel/water separator filter.</p> <p>8. Check fuel screen.</p> <p>9. Check/replace improperly operating injectors.</p> <p>10. Visually check fuel delivery with an externally connected injector to one of the pump outlets. Repair or replace the pump if fuel is not being delivered.</p> <p>11. Check/Time the pump (refer to Group 14, Fuel System).</p> <p>12. Check compression to identify the problem.</p>
<p>ENGINE STARTS, BUT WILL NOT KEEP RUNNING</p>	<p>1. Cylinder heads heater plugs relay defective.</p> <p>2. One or more cylinder head heater plugs defective.</p> <p>3. Intake air or exhaust system restricted.</p> <p>4. Air in the fuel system or the fuel supply is inadequate.</p> <p>5. Fuel waxing due to extremely cold weather.</p> <p>6. Contaminated fuel.</p>	<p>1. Verify system is working. Repair/replace inoperative parts.</p> <p>2. Verify system is working. Repair/replace inoperative parts.</p> <p>3. Visually check for exhaust restriction and inspect the air intake. Repair/replace restricting parts.</p> <p>4. Check flow through the filter and bleed the system. Locate and eliminate the air source.</p> <p>5. Verify by inspecting the fuel filter. Clean the system and use climatized fuel. Replace fuel/water separator filter. Check fuel heater for proper operation.</p> <p>6. Verify by operating the engine with clean fuel from a temporary supply tank. Check for presence of gasoline. Replace fuel/water separator filter.</p>
<p>SURGING (SPEED CHANGE)</p>	<p>1. If the condition occurs at idle, the idle speed is set too low for the accessories.</p> <p>2. High pressure fuel leak.</p> <p>3. One or more injectors worn or not operating properly.</p> <p>4. Improperly operating injection pump.</p>	<p>1. Adjust the idle speed.</p> <p>2. Inspect/correct leaks in the high pressure lines. Fittings and delivery valve sealing washers.</p> <p>3. Check/replace the inoperative injectors.</p> <p>4. Replace the injector pump.</p>

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
<p>ROUGH IDLE (IRREGULARLY FIRING OR ENGINE SHAKING)</p>	<ol style="list-style-type: none"> 1. If engine is cold, glow plug relay on glow plug(s) defective. 2. Engine mounts damaged or lose. 3. High pressure fuel leaks. 4. Air in the fuel system. 5. Sticking needle valve in an injector. 	<ol style="list-style-type: none"> 1. Refer to troubleshooting for cylinder head heater plugs (see Group 14, Fuel System). 2. Repair or replace mounts. 3. Correct leaks in the high pressure lines, fittings or delivery valves. 4. Bleed the fuel system and eliminate the source of the air. 5. Check and replace the injector with the sticking needle valve.
<p>ENGINE RUNS ROUGH</p>	<ol style="list-style-type: none"> 1. Fuel injection lines leaking. 2. Air in the fuel or the fuel supply is inadequate. 3. Contaminated fuel. 4. Incorrect valve operation. 5. Injection pump timing incorrect. 6. Improperly operating injectors. 7. Defective injection pump (delivery valve). 8. Camshaft out of time. 9. Damaged camshaft or tappets. 10. Automatic timing advance not operating. 	<ol style="list-style-type: none"> 1. Correct leaks in the high pressure lines, fittings, injectors sealing washers or delivery valves. 2. Check the flow through the filter and bleed the system. Locate and eliminate the air source. 3. Verify by operating the engine with clean fuel from a temporary supply tank. Check for presence of gasoline. Replace fuel/water separator filter. 4. Check for a bent push rod and adjust valves. Replace push rod, if necessary. 5. Check/time pump (refer to Group 14, Fuel System). 6. Replace inoperative injectors. 7. Repair or replace injection pump. 8. Check/correct gear train timing alignment. 9. Inspect camshaft valve lift. Replace camshaft and tappets. 10. Check injection pump. Check fuel injector sensor at number 1 cylinder injector.
<p>ENGINE RPM WILL NOT REACH RATED SPEED</p>	<ol style="list-style-type: none"> 1. Engine overload. 2. Improperly operating tachometer. 3. Inadequate fuel supply. 4. Air/fuel controls leak. 	<ol style="list-style-type: none"> 1. Verify high idle speed without load. Investigate operation to be sure correct gear is being used. 2. Verify engine speed with hand tachometer, correct as required. 3. Check the fuel flow through the system to locate the reason for inadequate fuel supply, correct as required. 4. Check and repair leak. Check AFC tubing for obstruction.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
ENGINE RPM WILL NOT REACH RATED SPEED (CONT.)	6. Improperly operating injection pump.	6. Repair or replace injection pump.
LOW POWER	<ol style="list-style-type: none"> 1. Fuel control lever not moving to full throttle. 2. High oil level. 3. Engine overloaded. 4. Slow throttle response caused by leaking or obstructed air control tube or improperly operating control in the pump. 5. Inadequate intake air flow. 6. Inadequate fuel supply. Air in the fuel. 7. Excessive exhaust restriction. 8. High fuel temperature. 9. Poor quality fuel or fuel contaminated with gasoline. 10. Air leak between the turbocharger and the intake manifold. 11. Exhaust leak at the manifold or turbocharger. 12. Improperly operating turbocharger. 13. Wastegate operation. 14. Valve not operating. 15. Worn or improperly operating injectors. 16. Incorrect injection pump timing. 17. Improperly operating injection pump. 	<ol style="list-style-type: none"> 1. Check/correct for stop-to-stop travel. 2. Check/correct oil level. 3. Check for added loading from accessories or driven units, brakes dragging and other changes in vehicle loading. Repair/replace as needed. 4. Check for leaks and obstructions. Tighten the fittings. Repair or replace the pump if the controls are not functioning. 5. Inspect/replace air cleaner element. Look for other restrictions. 6. Check the flow through the filter to locate the source of the restriction. Check fuel pressure and inlet restriction. 7. Check/correct the restriction in the exhaust system. 8. Verify that fuel heater is off when engine is warm. Check for restricted fuel drain tubes. Repair/replace as needed. 9. Verify by operating from a temporary tank with good fuel. Check for presence of gasoline. Replace fuel/water separator filter. 10. Check/correct leaks in hoses, gaskets, charge air cooler and around mounting capscrews or through holes in the manifold cover. 11. Check/correct leaks in the manifold or turbocharger gaskets. If manifold is cracked, replace manifold. 12. Inspect/replace turbocharger. 13. Check wastegate operation. 14. Check for bent push rod, replace if necessary. 15. Check/replace injectors. 16. Verify injection pump timing (see Group 14, Fuel System). 17. Repair or replace injection pump.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
<p>EXCESSIVE EXHAUST SMOKE</p>	<ol style="list-style-type: none"> 1. Engine running too cold (white smoke). 2. Improper starting procedure (white smoke). 3. Fuel supply inadequate. 4. Injection pump timing. 5. Inadequate intake air. 6. Air leak between turbocharger and intake manifold. 7. Exhaust leak at the manifold or turbocharger. 8. Improperly operating turbocharger. 9. Improperly operating injectors. 10. Improperly operating or overfueled injector pump. 11. Piston rings not sealing (blue smoke). 	<ol style="list-style-type: none"> 1. Refer to troubleshooting for coolant temperature below normal (refer to Group 7, Cooling System). Inspect cylinder head heater plugs for proper operation. 2. Use proper starting procedures. 3. Check fuel supply pressure and inlet restriction. 4. Check and time pump (refer to Group 14, Fuel System). 5. Inspect/change air filter. Look for other restriction. Check charge air cooler for obstructions. 6. Check/correct leaks in the air crossover tube, hoses, gaskets, mounting capscrews or through holes in the manifold cover. 7. Check/correct leaks in the manifold or turbocharger gaskets. If cracked replace manifold. 8. Inspect/replace turbocharger. 9. Check and replace inoperative injectors. 10. Repair or replace injection pump. 11. Perform blow-by check. Correct as required.
<p>ENGINE WILL NOT SHUT-OFF</p>	<ol style="list-style-type: none"> 1. Fuel shutoff solenoid inoperative. 2. Engine running on fumes drawn into the air intake. 3. Fuel injection pump malfunction. 	<ol style="list-style-type: none"> 1. Check/replace fuel shutoff solenoid. 2. Check the air intake ducts for the source of fumes. WARNING: In case of engine runaway due to flammable fumes from gasoline spills or turbocharger oil leaks being sucked into the engine, shut off engine ignition switch first then use a CO2 fire extinguisher and direct the spray under the front bumper to remove oxygen supply. The engine air intake is on the passenger side behind the bumper. The fire extinguisher must be directed at this location for emergency shutdown conditions. 3. Repair or replace fuel injection pump.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
COOLANT TEMPERATURE ABOVE NORMAL	<ol style="list-style-type: none"> 1. Low coolant level. 2. Incorrect/improperly operating pressure cap. 3. Loose drive belt on water pump/fan. 4. Inadequate air flow to the radiator. 5. Radiator fins plugged. 6. Collapsed radiator hose. 7. Improperly operating temperature sensor/gauge. 8. Improperly operating, incorrect or no thermostat. 9. Air in the cooling system. 10. Inoperative water pump. 11. Incorrect injection pump timing. 12. Overfueled injection pump. 13. Plugged cooling passages in radiator, head, head gasket or block. 14. Engine overloaded. 	<ol style="list-style-type: none"> 1. Check coolant level. Add coolant, if necessary. Locate and correct the source of the coolant loss, (refer to Group 7, Cooling). 2. Replace cap with the correct rating for the system. 3. Check/replace belt or belt tensioner. 4. Check/repair radiator core, fan shroud and viscous fan drive as required. 5. Blow debris from fins. 6. Replace the hose. Check coolant tank cap operation, (refer to Group 7, Cooling Tanks). 7. Verify that the gauge and temperature sensor are accurate. Replace gauge/sensor, if bad. 8. Check and replace the thermostat. 9. (A) make sure the fill rate is not being exceeded and the correct vented thermostat is installed. (B) Check for loose hose clamps. Tighten if loose. (C) If aeration continued, check for a compression leak through the head gasket. 10. Check and replace the water pump. 11. Verify pump timing marks are aligned. Check/time the injector pump (refer to Group 14, Fuel System). 12. Repair or replace the injection pump. 13. Flush the system and fill with clean coolant. 14. Verify that the engine load rating is not being exceeded.
COOLANT TEMPERATURE BELOW NORMAL	<ol style="list-style-type: none"> 1. Too much air flow across the radiator. 2. Incorrect thermostat or contamination in thermostat. 3. Temperature sensor or gauge inoperative. 4. Coolant not flowing by temperature sensor. 	<ol style="list-style-type: none"> 1. Check/repair viscous fan drive as required. 2. Check and replace thermostat. 3. Verify that the gauge and sensor are accurate. If not, replace gauge/sensor. 4. Check and clean coolant passages.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL PRESSURE LOW	<ol style="list-style-type: none"> 1. Low oil level. 2. Oil viscosity thin, diluted or wrong specification. 3. Improperly operating pressure switch/gauge. 4. Relief valve stuck open. 5. Plugged oil filter. 6. If cooler was replaced, shipping plugs left in cooler. 7. Worn oil pump. 8. Suction tube loose or seal leaking. 9. Loose main bearing cap. 10. Worn bearings or wrong bearings installed. 11. Oil jet under piston bad fit into main carrier. 	<ol style="list-style-type: none"> 1. (A) Check and fill with clean engine oil. (B) Check for a severe external oil leak that could reduce the pressure. 2. Verify the correct oil is being used. Check for oil dilution. Refer to Contaminated Lube Oil (Engine Diagnosis Mechanical). 3. Verify the pressure switch is functioning correctly. If not, replace switch/gauge. 4. Check/replace valve. 5. Change oil filter. Oil filter change interval may need to be revised. 6. Check/remove shipping plugs. 7. Check and replace oil pump. 8. Check and replace seal. 9. Check and install new bearing and tighten cap to proper torque. 10. Inspect and replace connecting rod or main bearings. Check and replace piston cooling nozzles. 11. Check oil jet position.
LUBRICATING OIL PRESSURE TOO HIGH	<ol style="list-style-type: none"> 1. Pressure switch/gauge not operating properly. 2. Engine running to cold. 3. Oil viscosity too thick. 4. Oil pressure relief valve stuck closed or binding. 	<ol style="list-style-type: none"> 1. Verify the pressure switch is functioning correctly. If not, replace switch/gauge. 2. Refer to Coolant Temperature Below Normal (Engine Diagnosis Performance). 3. Make sure the correct oil being used, (Refer to Group 0, Lubrication and Maintenance). 4. Check and replace valve.
LUBRICATING OIL LOSS	<ol style="list-style-type: none"> 1. External leaks. 2. Crankcase being overfilled. 3. Incorrect oil specification or viscosity. 4. Oil cooler leak. 5. High blow-by forcing oil out the breather. 	<ol style="list-style-type: none"> 1. Visually inspect for oil leaks. Repair as required. 2. Verify that the correct dipstick is being used. 3. (A) Make sure the correct oil is being used. (B) Look for reduced viscosity from dilution with fuel. (C) Review/reduce the oil change intervals. 4. Check and replace the oil cooler. 5. Check the breather tube area for signs of oil loss. Perform the required repairs.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
LUBRICATING OIL LOSS (CONT.)	<ol style="list-style-type: none"> 6. Turbocharger leaking oil to the air intake. 7. Piston rings not sealing (oil being consumed by the engine). 	<ol style="list-style-type: none"> 6. Inspect the air ducts for evidence of oil transfer. Repair as required. 7. Perform blow-by check. Repair as required.
COMPRESSION KNOCKS	<ol style="list-style-type: none"> 1. Air in the fuel system. 2. Poor quality fuel or water/gasoline contaminated fuel. 3. Engine overloaded. 4. Incorrect injection pump timing. 5. Improperly operating injectors. 	<ol style="list-style-type: none"> 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 tanks. Replace fuel/water separator. 3. Verify the engine load rating is not being exceeded. 4. Check and time injection pump (refer to Group 14, Fuel System). 5. Check and replace inoperative injectors.
EXCESSIVE VIBRATION	<ol style="list-style-type: none"> 1. Loose or broken engine mounts. 2. Damaged fan or improperly operating accessories. 3. Improperly operating vibration damper. 4. Improperly operating viscous fan drive. 5. Worn or damaged generator bearing. 6. Flywheel housing misaligned. 7. Loose or broken power component. 8. Worn or unbalanced driveline components. 	<ol style="list-style-type: none"> 1. Replace engine mounts. 2. Check and replace the vibrating components. 3. Inspect/replace the vibration damper. 4. Inspect/replace the fan drive. 5. Check/replace the generator. 6. Check/correct flywheel alignment. 7. Inspect the crankshaft and rods for damage that causes an unbalance. Repair/replace as required. 8. Check/repair driveline components.
EXCESSIVE ENGINE NOISES	<ol style="list-style-type: none"> 1. Drive belt squeal, insufficient tension or abnormally high loading. 2. Intake air or exhaust leaks. 3. Turbocharger noise. 4. Gear train noise. 5. Power function knock. 	<ol style="list-style-type: none"> 1. Check the automatic tensioner and inspect the drive belt. Make sure water pump, tensioner pulley, fan hub and generator turn freely. 2. Refer to Excessive Exhaust smoke (Engine Diagnosis Performance). 3. Check turbocharger impeller and turbine wheel for housing contact. Repair/replace as required. 4. Visually inspect and measure gear backlash. Replace gears as required. 5. Check/replace rod and main bearings.

DIAGNOSIS AND TESTING (Continued)

CONDITION	POSSIBLE CAUSES	CORRECTION
GENERATOR NOT CHARGING OR INSUFFICIENT CHARGING	<ol style="list-style-type: none">1. Loose or corroded battery.2. Generator belt slipping.3. Generator pulley loose on shaft.4. Improperly operating generator.	<ol style="list-style-type: none">1. Clean/tighten battery connection.2. Check/replace automatic belt tensioner. Check/replace and adjust belt.3. Tighten pulley.4. Check/replace generator.

SERVICE PROCEDURES

VALVE SERVICE

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

DISASSEMBLY

(1) Remove the engine cylinder head from the cylinder block. Refer to cylinder head removal and installation 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.

VALVE CLEANING

(1) Clean all carbon deposits from the combustion chambers, valve ports, valve stems, valve stem guides and head.

(2) Clean all grime and gasket material from the engine cylinder head machined gasket surface.

INSPECTION

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

(2) Inspect for cracks on the exhaust seat.

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

(4) Inspect valves for burned, cracked or warped heads.

(5) Inspect for scuffed or bent valve stems.

(6) Replace valves displaying any damage.

(7) Check valve spring height (Fig. 2).

VALVE REFACING

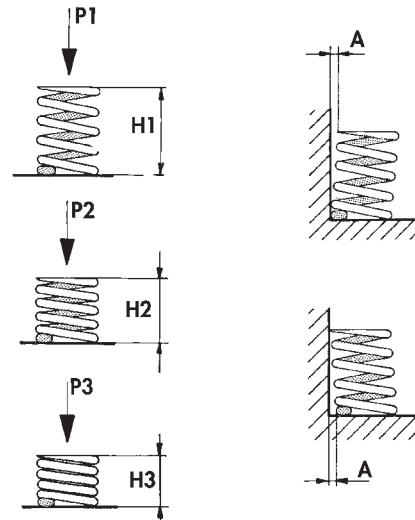
(1) Use a valve refacing machine to reface the intake and exhaust valves to the specified angle.

(2) After refacing, a margin of at least 4.52-4.49 mm (.178-.177 inch) must remain (Fig. 3). 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.



	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

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Fig. 2 Valve Spring Chart

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. 4), 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.

VALVE GUIDES

(1) Valve Guides height requirement.

(2) Measurement A (Fig. 5): 13.50 - 14.00 mm.

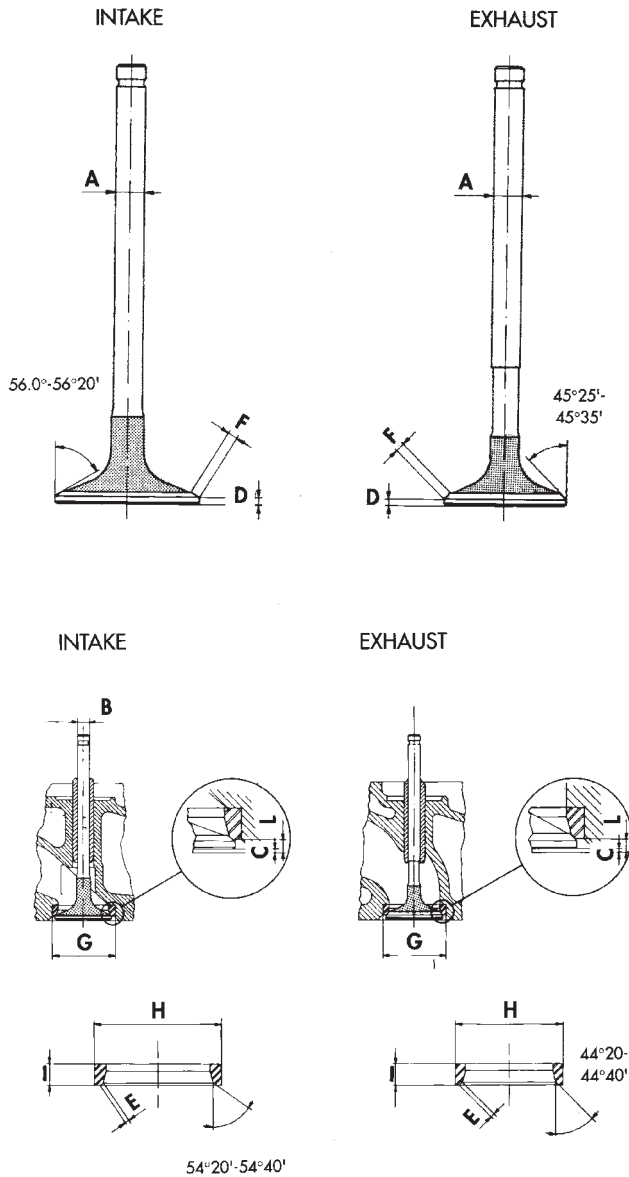
VALVE STEM-TO-GUIDE CLEARANCE MEASUREMENT

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

(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).

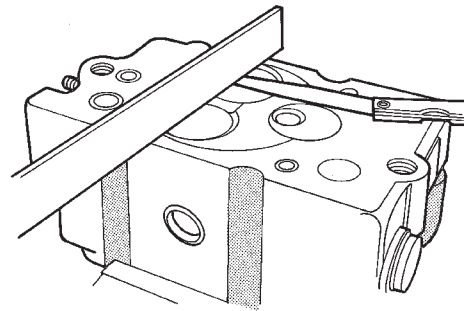
SERVICE PROCEDURES (Continued)



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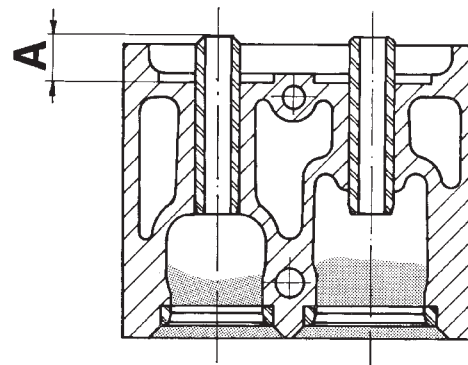
Fig. 3 Valve Specification

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



J9509-166

Fig. 4 Checking Valve Stand Down



J9509-36

Fig. 5 Valve Guide Height

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

REMOVAL AND INSTALLATION

ENGINE MOUNTS — LHD DIESEL

The engine mounts support the engine at each side. These supports are made of resilient rubber.

REMOVAL—RIGHT SIDE

- (1) Disconnect the negative battery cable.
- (2) Remove the innercooler inlet hose from the turbocharger and position it out of the way (Fig. 6).
- (3) Remove the right engine mount upper sill plate nuts.
- (4) Raise the vehicle on a hoist.
- (5) Remove the oil filter and adaptor from the engine.
- (6) Remove the engine mount throughbolt nut only. Do not remove the bolt at this time.
- (7) Position a jack stand and raise the weight off the right engine mount.
- (8) Remove the (2) engine mount lower sill plate bolts.
- (9) Remove the (4) engine mount bracket bolts from the engine block.

REMOVAL AND INSTALLATION (Continued)

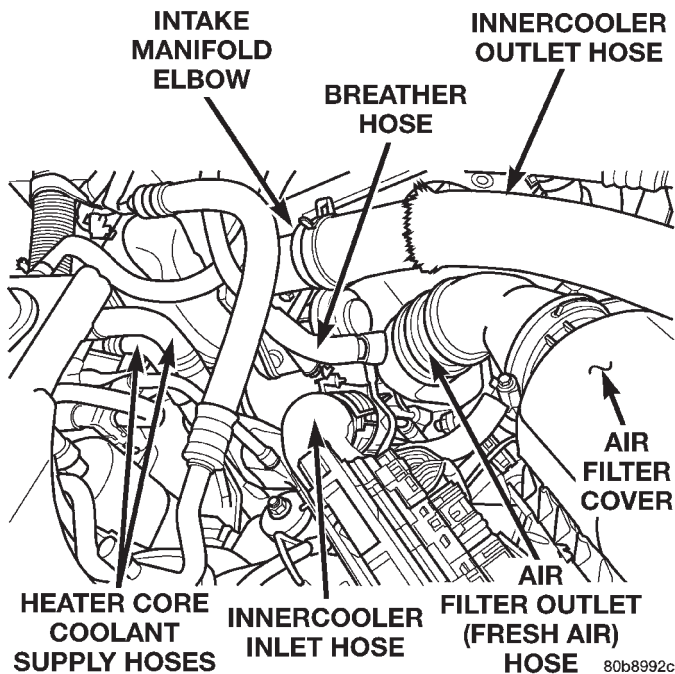


Fig. 6 Engine Compartment View — Diesel

- (10) Remove the engine mount throughbolt.
- (11) Remove the right engine mount from the vehicle.

INSTALLATION—RIGHT SIDE

- (1) Position the engine mount and bracket and install the engine mount throughbolt and nut, leaving them loose at this time.
- (2) Install, but do not torque the engine mount lower sill plate bolts.
- (3) Install the (4) engine mount bracket to engine block retaining bolts and torque to 61 N·m (45 ft. lbs.).
- (4) Torque the engine mount lower sill plate bolts to 41 N·m (30 ft. lbs.).
- (5) Remove the jack stand.
- (6) Torque the engine mount throughbolt nut to 65 N·m (48 ft. lbs.).
- (7) Install the oil filter and adaptor on the engine. Torque the adaptor retaining bolt to 50 N·m (37 ft. lbs.).
- (8) Lower the vehicle from the hoist.
- (9) Install the engine mount upper sill plate nuts. Torque to 41 N·m (30 ft. lbs.).
- (10) Install the innercooler inlet hose on the turbocharger (Fig. 7).
- (11) Connect the negative battery cable.

REMOVAL—LEFT SIDE

- (1) Disconnect the negative battery cable.
- (2) Remove the refrigerant line support bracket from the rear of the rocker cover.

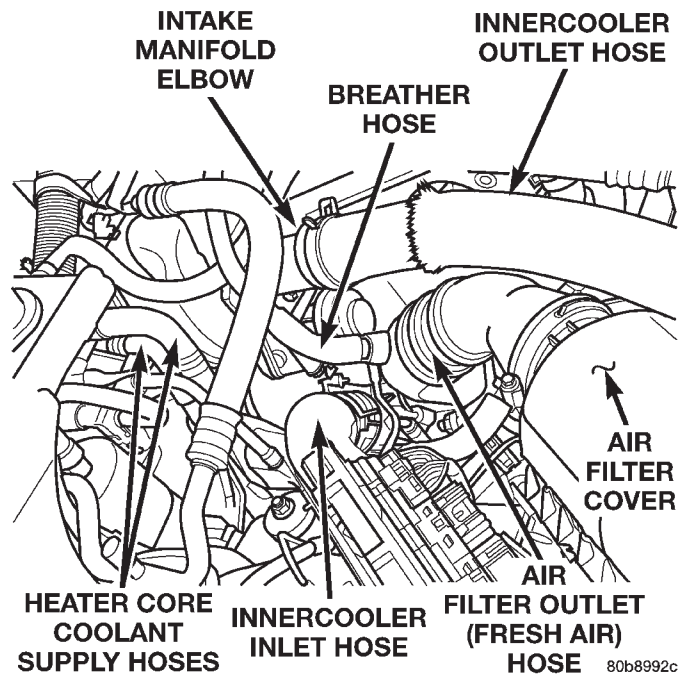
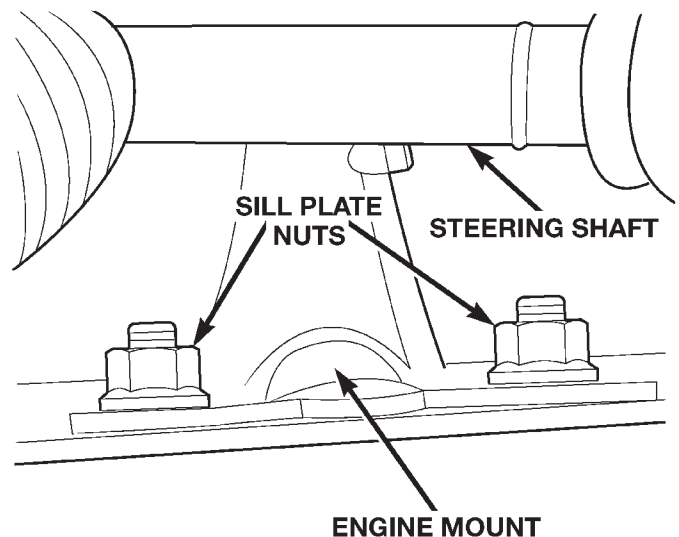


Fig. 7 Engine Compartment View — Diesel

- (3) Disconnect the A/C compressor electrical connector.
- (4) Remove the (2) engine mount upper sill plate nuts (Fig. 8).



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Fig. 8 Left Engine Mount Sill Plate Nuts

- (5) Make sure the steering shaft is in the unlocked position. Raise the vehicle on a hoist.
- (6) Remove the steering shaft pinchbolt. Remove the shaft from the gearbox by sliding it straight off the gearbox input shaft.

REMOVAL AND INSTALLATION (Continued)

CAUTION: Do not rotate the steering shaft while removed from the gearbox input shaft. Damage to the steering column clockspring will occur.

(7) Remove the left engine mount throughbolt nut only (Fig. 9). Do not remove the bolt at this time.

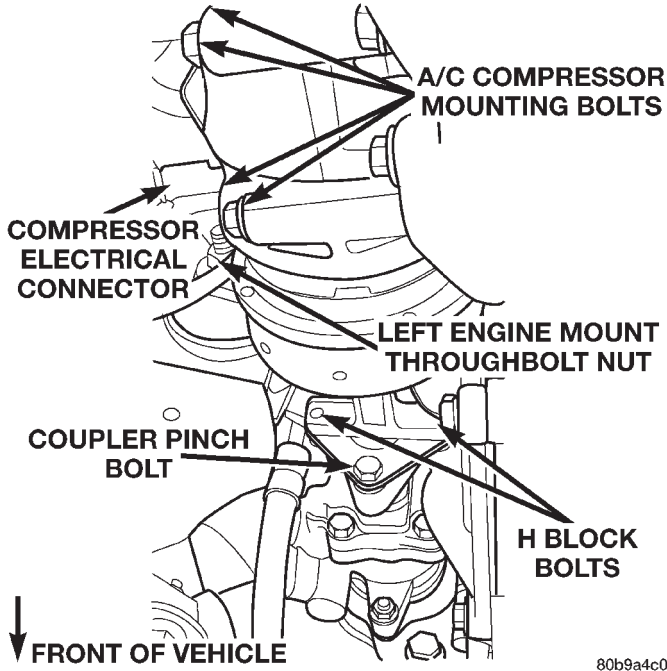


Fig. 9 A/C Compressor Position & Orientation

(8) Loosen the (4) H-Block retaining bolts, Do not remove the bolts at this time.

NOTE: Mark the position of the H-Block in relation to the power steering pump and the A/C Compressor so it may be installed in its original position.

(9) Remove the (2) H-Block retaining bolts from the power steering pump side of the block (Fig. 9).

(10) Support the A/C Compressor with mechanics wire before proceeding to the next step.

(11) Remove the (4) A/C Compressor retaining bolts (Fig. 9).

(12) Remove the remaining (2) bolts from the H-Block and remove the H-Block from the compressor.

(13) Position a jack stand and raise the weight off the left engine mount.

(14) Remove the (4) engine mount bracket bolts from the engine block.

(15) Remove the (4) trackbar support bracket bolts and remove the bracket (Fig. 10).

(16) Remove the remaining engine mount lower sill plate bolt (Fig. 10).

(17) Remove the engine mount throughbolt.

(18) Remove the left engine mount from the vehicle.

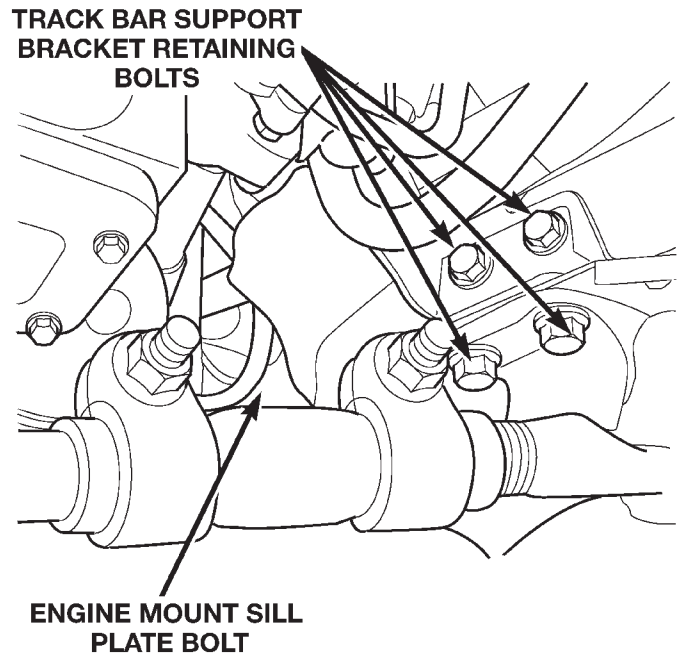


Fig. 10 Left Engine Mount Retaining Bolts

INSTALLATION—LEFT SIDE

(1) Position the engine mount and bracket and install the engine mount through bolt and nut, leaving them loose at this time.

(2) Install, but do not torque the engine mount lower sill plate bolt and the trackbar support bracket bolts (Fig. 11).

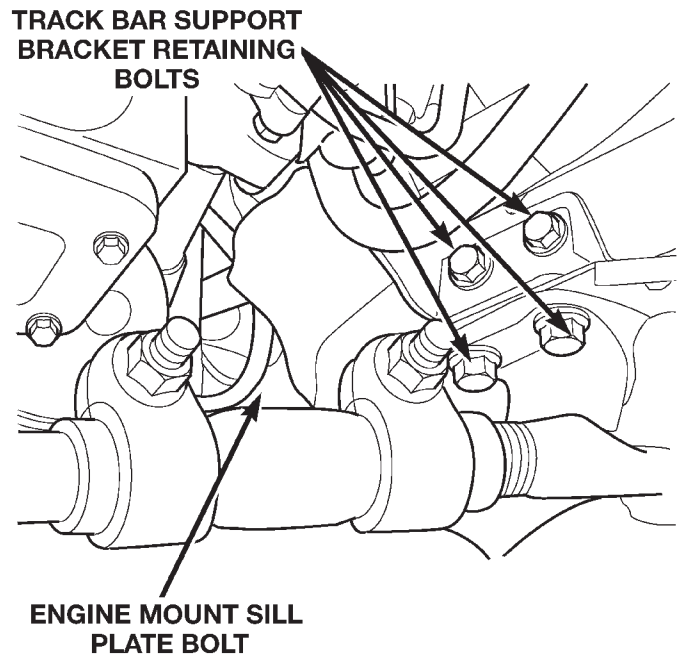


Fig. 11 Left Engine Mount Retaining Bolts

(3) Install the (4) engine mount bracket bolts. Torque to 61 N·m (45 ft. lbs.).

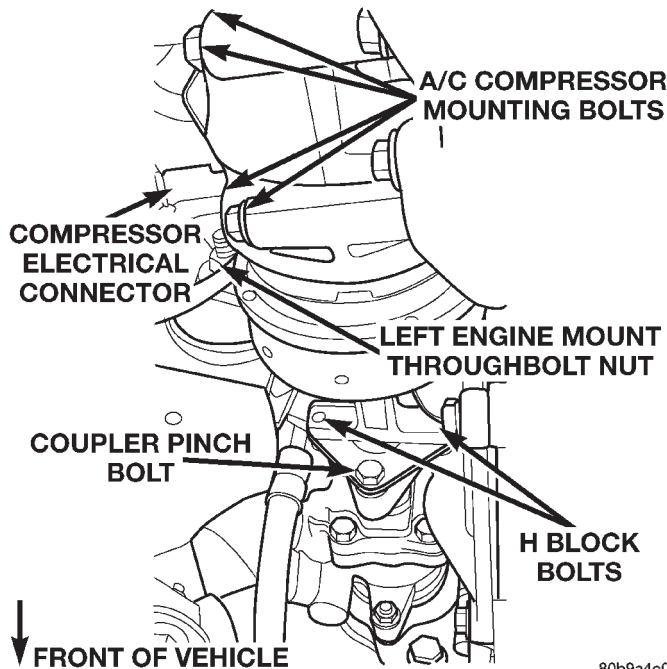
REMOVAL AND INSTALLATION (Continued)

(4) Torque the lower engine mount sill plate bolts to 41 N·m (30 ft. lbs.) (Fig. 11).

(5) Torque the larger trackbar support bracket bolts to 125 N·m (92 ft. lbs.) (Fig. 11).

(6) Remove the jack stand.

(7) Position the H-Block and the A/C Compressor in their original positions and install the retaining bolts (Fig. 12).



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Fig. 12 A/C Compressor Position & Orientation

(8) Torque the A/C Compressor mounting bolts to 41 N·m (30 ft. lbs.) (Fig. 12).

(9) Torque all the H-Block retaining bolts to 18 N·m (159 in. lbs.).

(10) Torque the engine mount throughbolt nut to 65 N·m (48 ft. lbs.) (Fig. 12).

(11) Install the steering shaft. Torque the pinchbolt to 49 N·m (36 ft. lbs.).

(12) Lower the vehicle from the hoist.

(13) Install the engine mount upper sill plate nuts. Torque to 41 N·m (30 ft. lbs.) (Fig. 13).

(14) Install the refrigerant line support bracket on the rear of the rocker cover.

(15) Connect the A/C compressor electrical connector.

(16) Connect the negative battery cable.

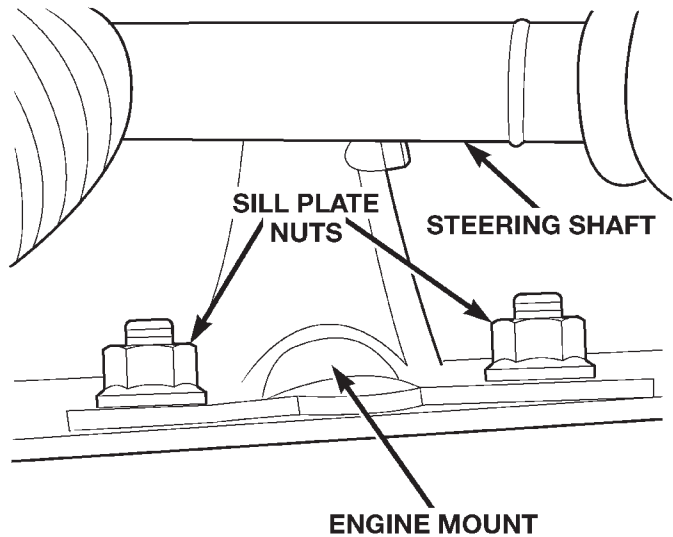
ENGINE MOUNTS — RHD DIESEL

The engine mounts support the engine at each side. These supports are made of resilient rubber.

REMOVAL—RIGHT SIDE

(1) Disconnect the negative battery cable.

(2) Make sure the steering wheel is in the unlocked position. Raise the vehicle on a hoist.



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Fig. 13 Left Engine Mount Sill Plate Nuts

(3) Remove the steering shaft pinchbolt and slide the steering shaft straight off the gearbox input shaft.

CAUTION: Do not rotate the steering shaft while removed from the gearbox input shaft. Damage to the steering column clockspring will occur.

(4) Remove the oil filter adaptor retaining bolt and remove oil filter and adaptor from the vehicle.

(5) Remove the engine mount upper sill plate nuts (Fig. 14).

(6) Remove the engine mount throughbolt nut only. Leave the bolt installed at this time.

(7) Position a jack stand and raise the weight off the right engine mount.

(8) Remove the (4) trackbar support bracket retaining bolts and remove the bracket.

(9) Remove the (4) engine mount bracket bolts from the engine block.

(10) Remove the remaining engine mount lower sill plate bolt.

(11) Remove the engine mount through bolt.

(12) Remove the right engine mount from the vehicle.

INSTALLATION—RIGHT SIDE

(1) Position the engine mount and bracket in position and install the engine mount through bolt and nut, leaving them loose at this time.

(2) Install, but do not torque the engine mount lower sill plate bolts and the trackbar support bracket bolts.

REMOVAL AND INSTALLATION (Continued)

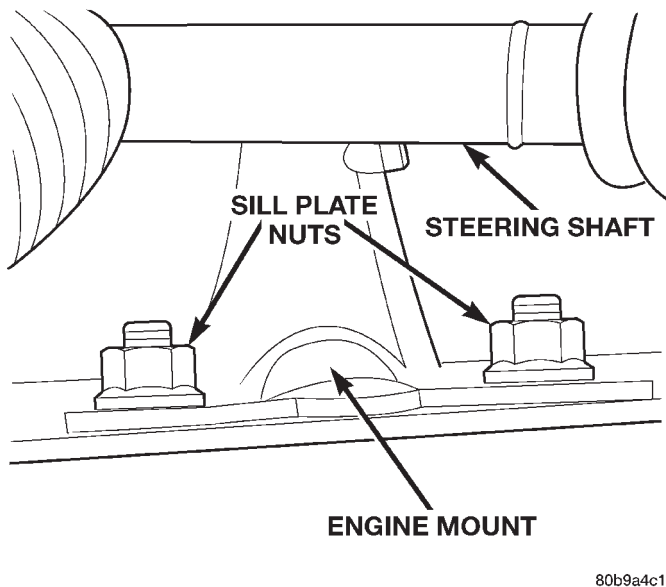


Fig. 14 Right Engine Mount Sill Plate Nuts

- (3) Install the (4) engine mount bracket to engine block retaining bolts. Torque bolts to 61 N·m (45 ft. lbs.).
- (4) Torque the engine mount lower sill plate bolts to 41 N·m (30 ft. lbs.).
- (5) Torque the larger trackbar support bracket bolts to 125 N·m (92 ft. lbs.).
- (6) Install the oil filter and adaptor on the engine. Torque oil filter adaptor retaining bolt to 50 N·m (75 ft. lbs.).
- (7) Remove the jack stand.
- (8) Install the engine mount upper sill plate nuts. Torque to 41 N·m (30 ft. lbs.).
- (9) Torque the engine mount throughbolt nut to 65 N·m (48 ft. lbs.).
- (10) Install the steering shaft and torque the pinchbolt to 49 N·m (36 ft. lbs.).
- (11) Lower the vehicle from the hoist.
- (12) Connect the negative battery cable.

REMOVAL—LEFT SIDE

- (1) Disconnect the negative battery cable.
- (2) Remove the refrigerant line support bracket bolt from the upper radiator support crossmember..
- (3) Remove the A/C filter-drier assembly support bracket nuts from the left fenderwell.
- (4) Disconnect A/C compressor electrical connector (Fig. 15).
- (5) Raise the vehicle on a hoist.
- (6) Remove the engine mount throughbolt nut only (Fig. 15). Leave the bolt installed at this time.
- (7) Loosen the (4) H-Block retaining bolts. Do not remove the bolts at this time.

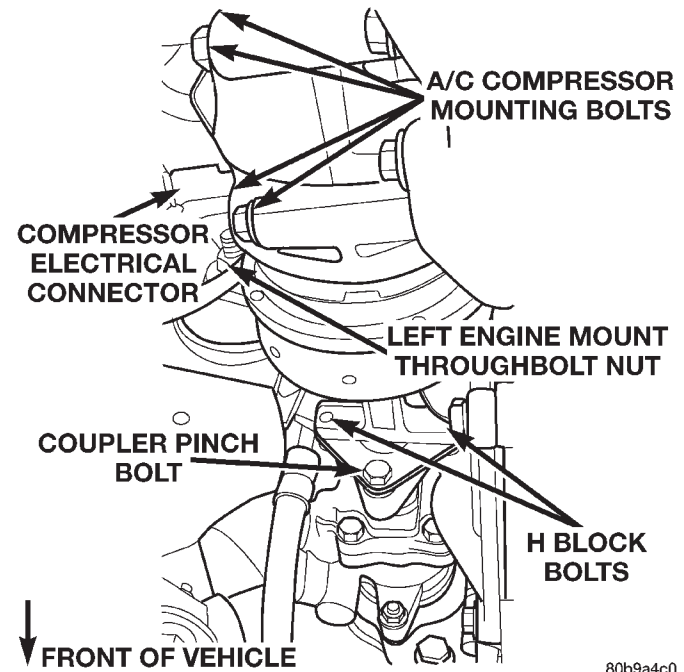


Fig. 15 A/C Compressor Position & Orientation

NOTE: Mark the position of the H-Block in relation to the power steering pump and A/C Compressor so it may be installed in its original position.

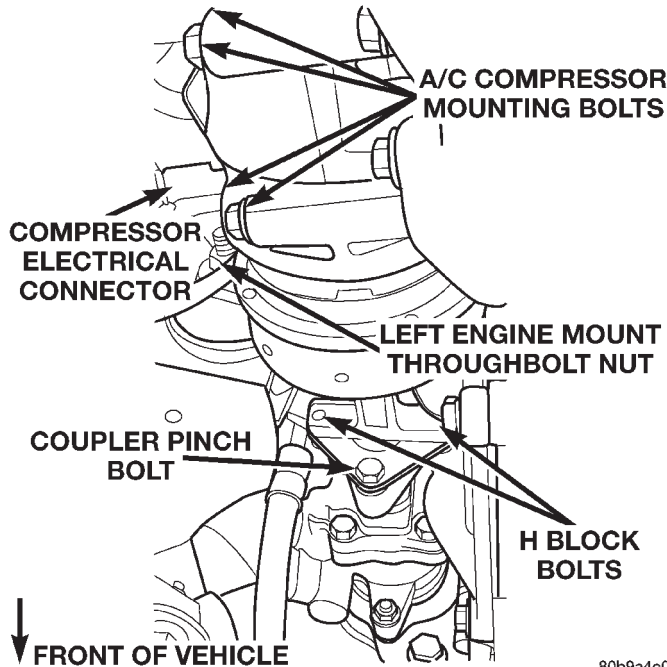
- (8) Remove the (2) H-Block retaining bolts from the power steering pump side of the block (Fig. 15).
- (9) Support the A/C Compressor with mechanics wire before proceeding to the next step.
- (10) Remove the (4) A/C Compressor mounting bolts (Fig. 15).
- (11) Remove the remaining (2) bolts from H-Block and remove the H-Block from the compressor.
- (12) Position a jack stand and raise the weight off the left engine mount.
- (13) Remove the (2) engine mount upper sill plate nuts.
- (14) Remove the (4) engine mount bracket bolts from the engine block.
- (15) Remove the (2) engine mount lower sill plate bolts.
- (16) Remove the engine mount troughbolt.
- (17) Remove the left engine mount from the vehicle.

INSTALLATION—LEFT SIDE

- (1) Position the engine mount and bracket in position and install the engine mount through bolt and nut, leaving them loose at this time.
- (2) Install, but do not torque engine mount lower sill plate bolts.
- (3) Install the (4) engine mount bracket to engine block retaining bolts. Torque to 61 N·m (45 ft. lbs.).

REMOVAL AND INSTALLATION (Continued)

- (4) Torque the (2) lower engine mount sill plate bolts to 41 N·m (30 ft. lbs.).
- (5) Install the (2) engine mount upper sill plate nuts. Torque to 41 N·m (30 ft. lbs.).
- (6) Remove the jack stand.



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Fig. 16 A/C Compressor Position & Orientation

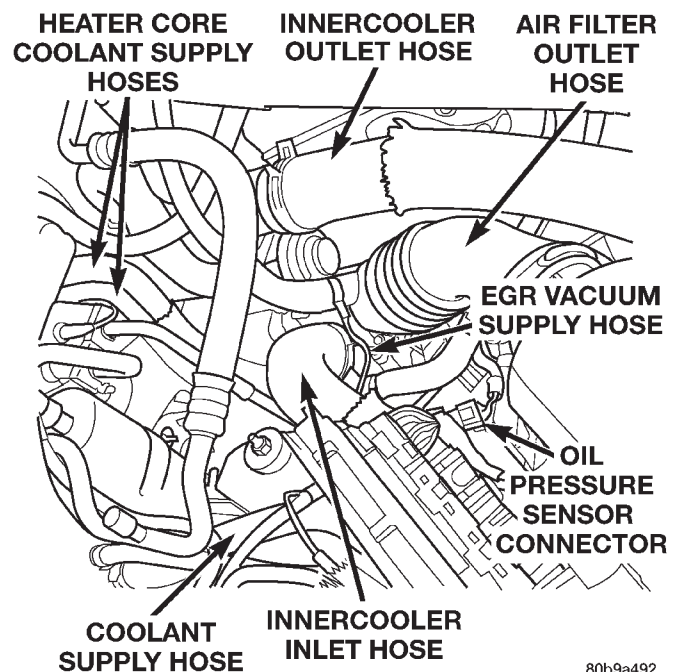
- (7) Position the H-Block and the A/C Compressor in their original positions and install the retaining bolts (Fig. 16).
- (8) Torque the A/C Compressor mounting bolts to 41 N·m (30 ft. lbs.) (Fig. 16).
- (9) Torque all the H-Block bolts to 18 N·m (159 in. lbs.) (Fig. 16).
- (10) Torque the engine mount throughbolt nut to 65 N·m (48 ft. lbs.) (Fig. 16).
- (11) Lower the vehicle from the hoist.
- (12) Install the refrigerant line support bracket.
- (13) Install the A/C filter-drier support bracket.
- (14) Connect the negative battery cable.

2.5L DIESEL ENGINE**REMOVAL**

- (1) Disconnect both of the battery cables and remove the battery.
- (2) Mark the hinge locations on the hood for alignment reference during installation.

CAUTION: Wrap the appropriate size drillbit with masking tape 1/4 inch from tip. This will prevent damaging the hood outer panel when drilling out the rivets retaining the hood latch cable control assembly.

- (3) Drill out the rivets retaining the hood latch cable control assembly.
- (4) Remove the hood latch assemblies from the hood.
- (5) Disconnect and remove the engine compartment lamp.
- (6) With assistance from another person, remove the hood.
- (7) Cover both of the fenders and the grill opening panel to prevent paint damage.
- (8) Remove the battery tray.
- (9) Disconnect the radiator cooling fan electrical.
- (10) Remove the manual cooling fan and let set inside of the fan shroud.
- (11) If equipped, recover the refrigerant. Refer to Group 24, Heating and Air Conditioning for the procedure.
- (12) Disconnect the suction and discharge lines and remove the lines from the vehicle.
- (13) Disconnect the breather hose and remove the air filter outlet hose from the vehicle (Fig. 17).



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Fig. 17 LHD Engine Compartment — Diesel

- (14) Disconnect the oil pressure sensor electrical connector (Fig. 17).
- (15) Disconnect the EGR vacuum supply hose from the engine (Fig. 17).
- (16) Remove the coolant reservoir cap.
- (17) Drain the cooling system. Refer to Group 7, Cooling System for the procedure.
- (18) Remove the upper and lower radiator hoses from the engine.
- (19) Remove the innercooler inlet and outlet hoses from the engine (Fig. 17).

REMOVAL AND INSTALLATION (Continued)

(20) Remove the coolant reservoir supply hose from the engine (Fig. 17).

(21) On L.H.D. vehicles, disconnect the heater core coolant supply and the brake vacuum supply hoses from the engine.

(22) On R.H.D. vehicles, disconnect the heater core coolant supply and the brake vacuum supply hoses from the right side of the engine compartment. Remove the line assembly retaining bolt and bracket from the rear of the rocker cover and position the assembly out of the way.

(23) Working inside of the vehicle, remove the center console. Refer to Group 23, Body for the procedure.

(24) Remove the shifter boot seal.

(25) Disconnect the shifter from the transmission

(26) Raise the vehicle on a hoist.

(27) Remove the lower fan shroud retaining bolts and remove the lower fan shroud panel.

(28) Remove the engine ground wire (Fig. 18).

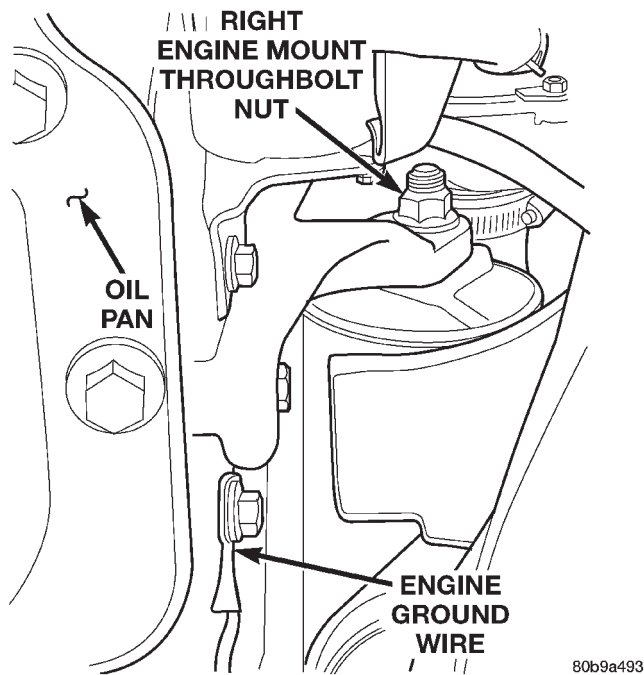


Fig. 18 Engine Ground Wire Location

(29) Remove the right and left engine mount throughbolt nuts only. Do not remove the bolts at this time (Fig. 18).

(30) Drain the transmission fluid. Refer to Group 21, Transmission and Transfer Case for the procedure.

(31) Mark the position of the front and rear driveshafts in relation to their companion flanges.

(32) Remove the front driveshaft. Refer to Group 3, Differential and Driveline for the procedure.

(33) Remove the rear driveshaft. Refer to Group 3, Differential and Driveline for the procedure.

(34) Disconnect the exhaust system at the (3) bolt flange (Fig. 19).

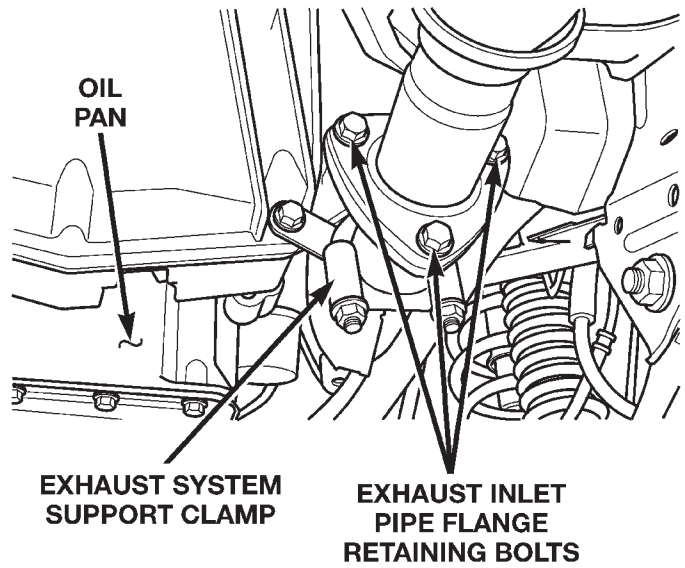


Fig. 19 Exhaust System Inlet Pipe Connection

(35) Remove the exhaust system support clamp (Fig. 19).

(36) Remove the clutch slave cylinder from the clutch housing (Fig. 20).

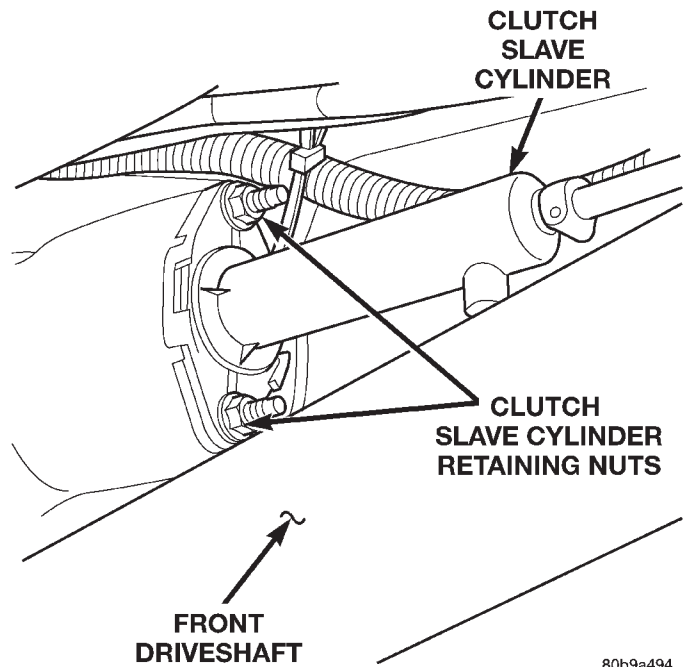


Fig. 20 Clutch Slave Cylinder

(37) Remove the (3) nuts retaining the transfer case shift linkage and position the linkage aside (Fig. 21).

REMOVAL AND INSTALLATION (Continued)

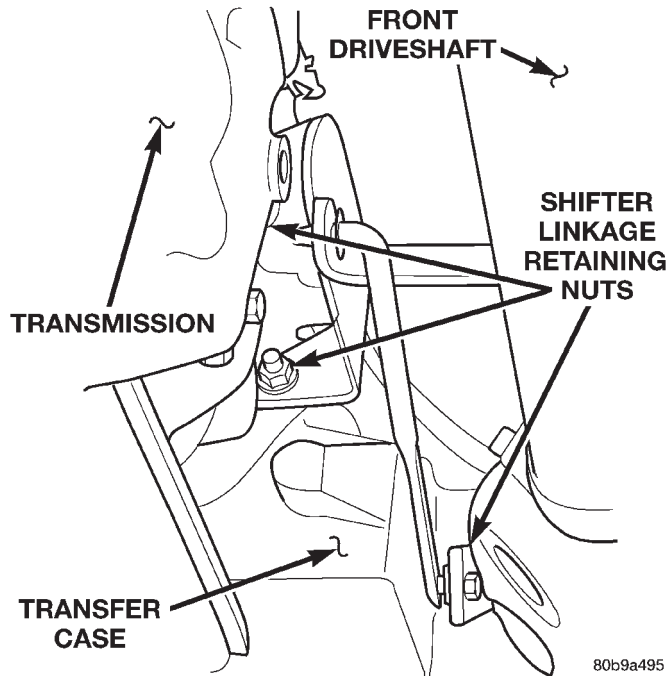


Fig. 21 Transfer Case Shift Linkage — 4x4

(38) Disconnect the electrical connectors and the vent hose and from the transfer case and transmission.

(39) Support the rear of the transmission with a jack.

(40) Remove the transmission support crossmember.

(41) Lower the transmission to gain access to the transmission to engine retaining bolts.

(42) Remove all the bolts securing the transmission to the engine assembly. Remove the transmission and the transfer case assembly from the vehicle.

(43) Lower the vehicle from the hoist.

(44) Remove the fan shroud and both cooling fans as an assembly.

(45) Remove the oil filter and adaptor from the vehicle as an assembly.

(46) Remove the power steering fluid pressure line from the steering gear.

(47) Disconnect the electrical connectors from the bottom of the fuel / water separator.

(48) Drain the fuel / water separator. Refer to Group 9, Fuel System for the procedure.

(49) Remove the fuel lines from the fuel / water separator and cap.

(50) Remove the fuel / water separator and mounting bracket assembly from the bulkhead.

(51) Remove all the remaining wiring from the engine assembly and position it out of the way.

(52) Attach a lifting device to the engine lifting brackets and slightly raise the weight off the engine mounts.

(53) Remove the right and left engine mount throughbolts.

(54) Carefully lift the engine out of the engine compartment.

INSTALLATION

(1) Carefully place the engine assembly into the engine compartment..

(2) Install the engine mount throughbolts and nuts in there original position. Leaving them loose at this time.

(3) Install the fuel / water separator and mounting bracket on the bulkhead.

(4) Install the fuel lines on the fuel / water separator.

(5) Connect the electrical connectors to the bottom of the fuel/water separator.

(6) Install the power steering fluid pressure line on the steering gear.

(7) Install the oil filter and adaptor on the engine. Torque adaptor retaining bolt to 50 N-m (37 ft. lbs.). Fill the oil filter prior to installation.

(8) Install the fan shroud and both cooling fans as an assembly in the vehicle.

(9) Raise the vehicle on a hoist.

(10) Install the transmission and transfer case assembly in the vehicle.

(11) Install the bolts securing the transmission to the engine assembly. Torque to 74.6 N-m (55 ft. lbs.).

(12) Position, connect and secure all electrical connectors and vent hoses on the transfer case and transmission in there original positions.

(13) Install the transmission support crossmember. Torque bolts to 50 N-m (37 ft. lbs.).

(14) Install the (3) nuts retaining the transfer case shift linkage (Fig. 22).

(15) Install the clutch slave cylinder on the clutch housing, making sure the cylinder pushrod is properly aligned with the clutch fork (Fig. 23).

(16) Connect the exhaust system at the (3) bolt flange (Fig. 24).

(17) Install the exhaust system support clamp (Fig. 24).

(18) Install the rear driveshaft in its original position.

(19) Install the front driveshaft in its original position.

(20) Install the lower fan shroud panel and retaining bolt.

(21) Install the engine ground wire (Fig. 25).

(22) Lower the vehicle from the hoist.

(23) Working inside the vehicle, install the shifter on the transmission

(24) Install the shifter boot seal.

REMOVAL AND INSTALLATION (Continued)

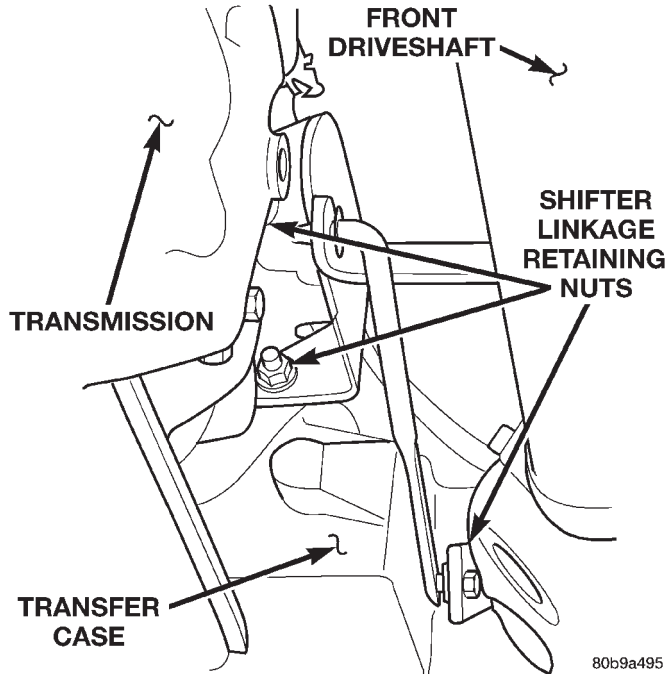


Fig. 22 Transfer Case Shift Linkage — 4x4

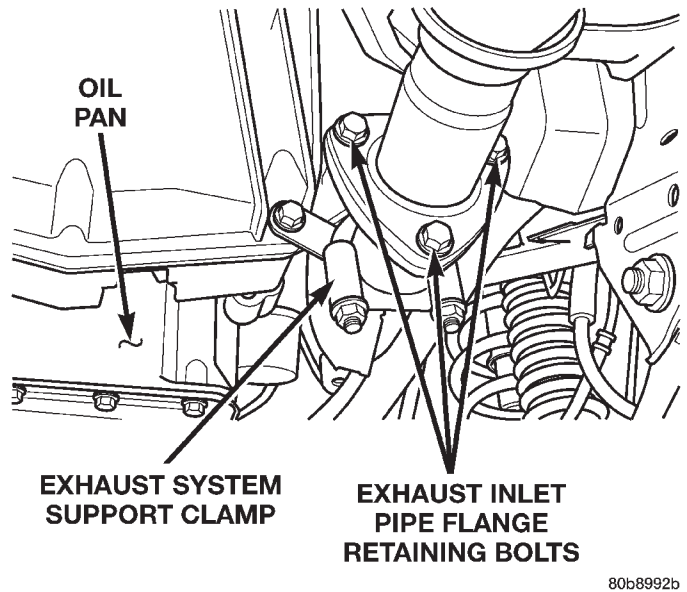


Fig. 24 Exhaust System Inlet Pipe Connection

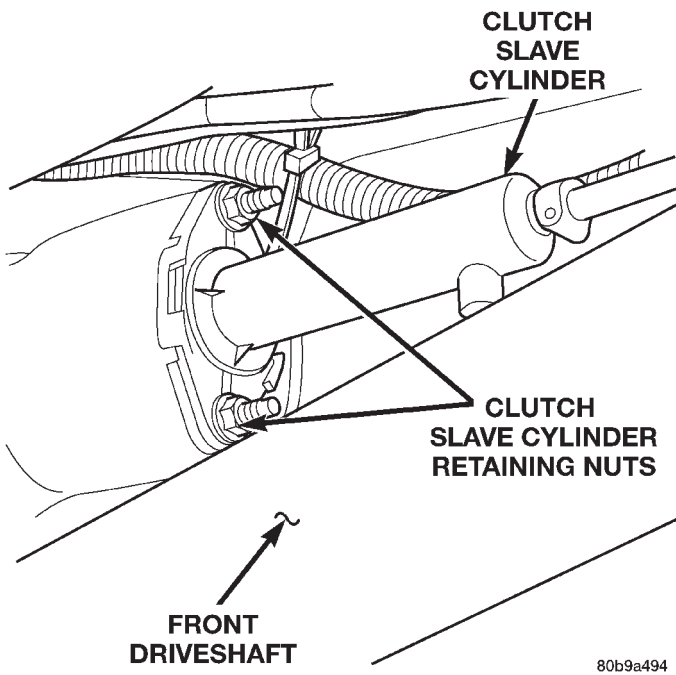


Fig. 23 Clutch Slave Cylinder

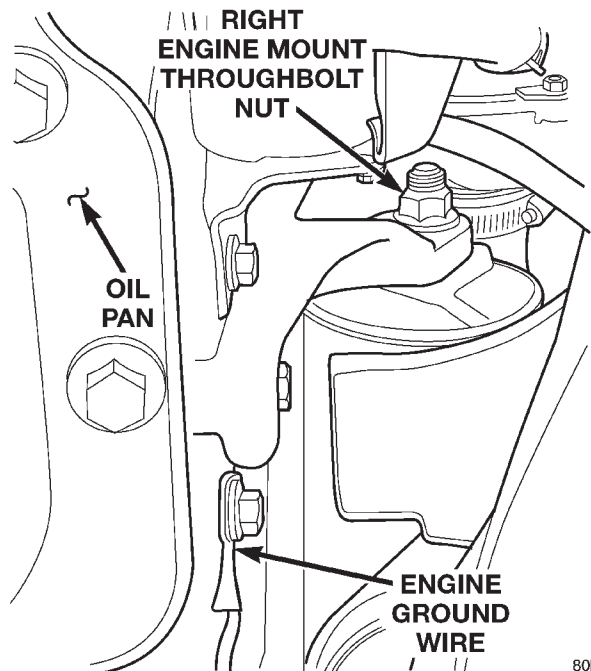


Fig. 25 Engine Ground Wire Location

- (25) Install the center console. Refer to Group 23, Body for the procedure.
- (26) Position, connect and secure all engine wiring in its original position
- (27) On L.H.D. vehicles, connect the heater core coolant supply and brake vacuum supply hoses on the engine.
- (28) On R.H.D. vehicles, position the steel line assembly and connect the heater core coolant supply and the brake vacuum supply hoses on the engine.

- (29) Install the coolant reservoir supply hose on the engine (Fig. 26).
- (30) Install the innercooler inlet and outlet hoses on the engine (Fig. 26).
- (31) Install the upper and lower radiator hoses on the engine.
- (32) Fill the cooling system. Refer to Group 7, Cooling System, for the procedure.
- (33) Connect the oil pressure sensor electrical connector (Fig. 26).

REMOVAL AND INSTALLATION (Continued)

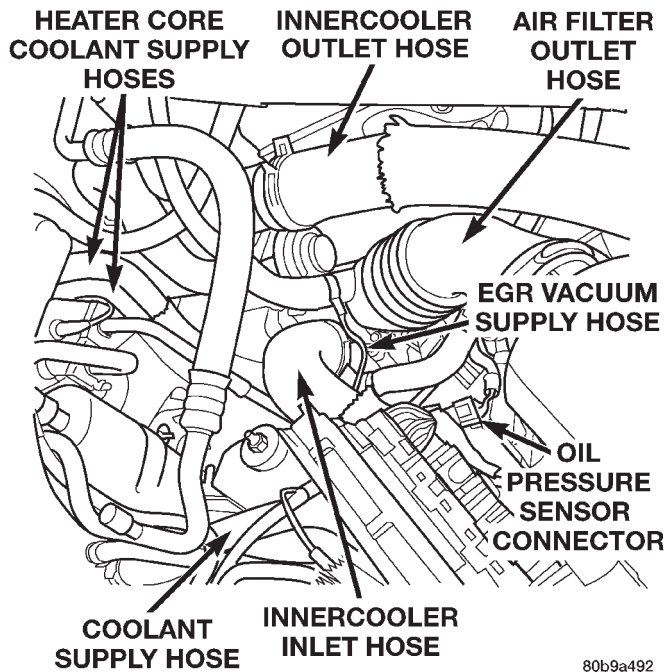


Fig. 26 LHD Engine Compartment — Diesel

(34) Connect the EGR vacuum supply hose on the engine (Fig. 26).

(35) Install the air filter outlet hose and connect the breather hose on the engine (Fig. 26).

(36) Install the refrigerant suction and discharge lines. Torque the retaining bolts on the A/C compressor to 22 N·m (200 in. lbs.). Make sure the O-Rings are well lubricated and free of tears.

(37) Charge the refrigerant system. Refer to Group 24, Heating and Air Conditioning for the procedure.

(38) Install the manual cooling fan.

(39) Connect the electric cooling fan electrical connector.

(40) Install the battery tray.

(41) With assistance from another person, install the hood.

NOTE: Use the previously marked hinge locations for alignment reference.

(42) Install the hood retaining bolts.

(43) Install the rivets on the hood latch cable control assembly.

(44) Install the hood latch assemblies on the hood.

(45) Install and connect the engine compartment lamp.

(46) Install the battery and connect both of the battery cables.

(47) Fill the power steering fluid. Refer to Group 19, Steering — Power Steering Pump-Initial operation for the procedure.

(48) Fill the transmission fluid. Refer to Group 21, Transmission and Transfer Case for the procedure.

(49) Check the engine oil level before engine start up.

CYLINDER HEAD COVER

REMOVAL

(1) Disconnect the negative 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) On right hand drive vehicles, drain the cooling system. Refer to Group 7, Cooling System for the procedure.

(3) Recover the air conditioning system, if equipped. Refer to Group 24, Heating and Air Conditioning for the procedure.

(4) Remove the A/C lines at the compressor and cap all openings. Refer to Group 24, Heating and Air Conditioning for the procedure. Remove the A/C line support bracket attached to cylinder head cover, and move the A/C, vacuum lines away from the cylinder head.

(5) Remove the generator support brace.

(6) Remove the Crankcase breather hose from the rear of the valve cover

(7) Remove the cylinder head cover bolts.

(8) Remove the cylinder head cover.

INSTALLATION

(1) Install the cylinder head cover. Torque the bolts to 15 N·m (133 in. lbs.).

(2) Connect the crankcase breather hose.

(3) Install the generator support brace. Torque bolts to 7 N·m (62 in. lbs.).

(4) Install the A/C lines on the compressor and install the support bracket on the cylinder head cover. Torque bolt to 7 N·m (62 in. lbs.).

(5) Connect the negative battery cable.

(6) If equipped with A/C, evacuate and charge the air conditioning system. Refer to Group 24, Heater and Air Conditioning.

(7) On right hand drive vehicles, 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.

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

REMOVAL AND INSTALLATION (Continued)

HYDRAULIC TAPPETS

REMOVAL

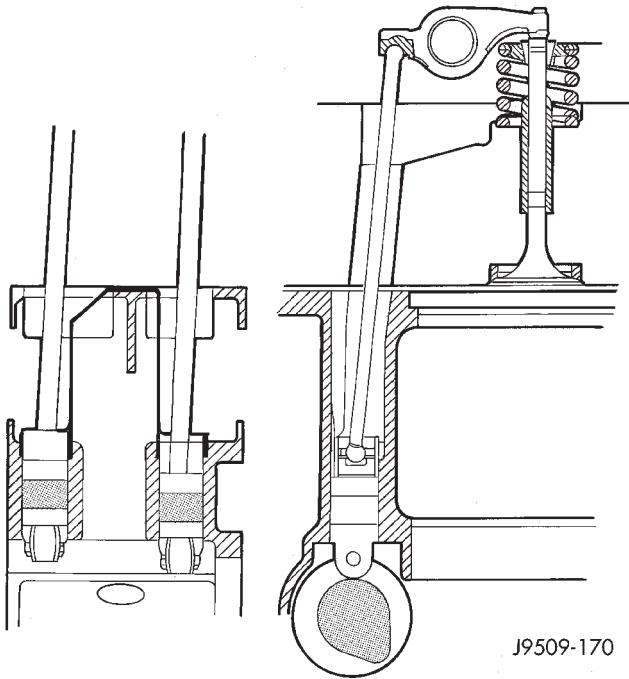


Fig. 27 Tappet And Rocker Arm Assembly

- (1) Disconnect the negative battery cable.
- (2) Discharge the air conditioning system, if equipped. Refer to Group 24, Heating and Air Conditioning for procedure.
- (3) If equipped with air conditioning, remove the A/C lines at the compressor and cap.
- (4) Remove the A/C line bracket attached to the cylinder head cover and move the lines away from the cylinder head.
- (5) Remove cylinder head cover. Refer to cylinder head cover removal and installation procedure in this section.
- (6) Remove the rocker assemblies and push rods. Refer to rocker arms and push rod removal and installation procedure in this section. Identify push rods to ensure installation in original location.
- (7) Remove cylinder head, intake manifold, and exhaust manifold. Refer to cylinder head removal and installation in this section.
- (8) Remove the tappet retainers (Fig. 28).
- (9) Slide Hydraulic Tappet Remover/Installer Tool through opening in block and seat tool firmly in the head of tappet.
- (10) Pull the tappet out of the bore with a twisting motion. If all tappets are to be removed, identify tappets to ensure installation in original location.

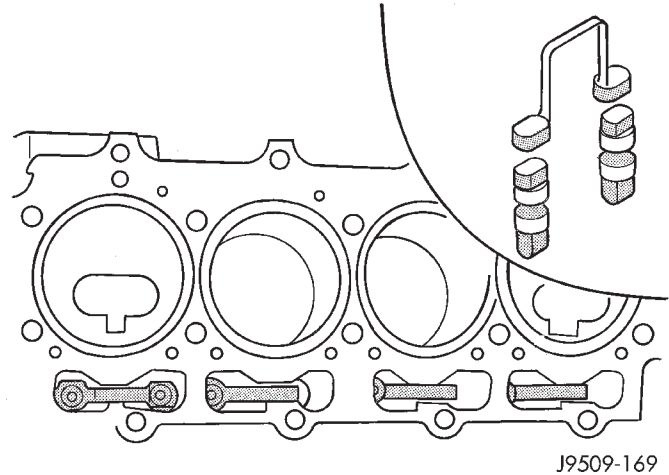


Fig. 28 Tappet And Retainer

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 the tappets.
- (2) Install the tappets and retainers in their original positions. Ensure that the oil feed hole in the side of the tappet body faces up (away from the crankshaft).
- (3) Install the cylinder head, intake manifold, and exhaust manifold. Refer to cylinder head removal and installation in this section.
- (4) Install the push rods.
- (5) Install the rocker arms. Refer to rocker arms and push rod removal and installation in this section.
- (6) Install the cylinder head cover. Refer to cylinder head cover removal and installation in this section.
- (7) Connect the negative battery cable.

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.

- (8) Start and operate engine. Warm up to normal operating temperature.

REMOVAL AND INSTALLATION (Continued)

ROCKER ARMS AND PUSH RODS

REMOVAL

- (1) Disconnect the negative battery cable.
- (2) Discharge the air conditioning system, if equipped. Refer to Group 24, Heating and Air Conditioning for procedure.
- (3) If equipped with air conditioning, remove the service valves and cap the compressor ports. Refer to Group 24, Heating and Air Conditioning.
- (4) Remove the generator bracket.
- (5) Remove the cylinder head cover. Refer to cylinder head cover removal and installation in this section.
- (6) Remove the rocker arm retaining nut (Fig. 29).

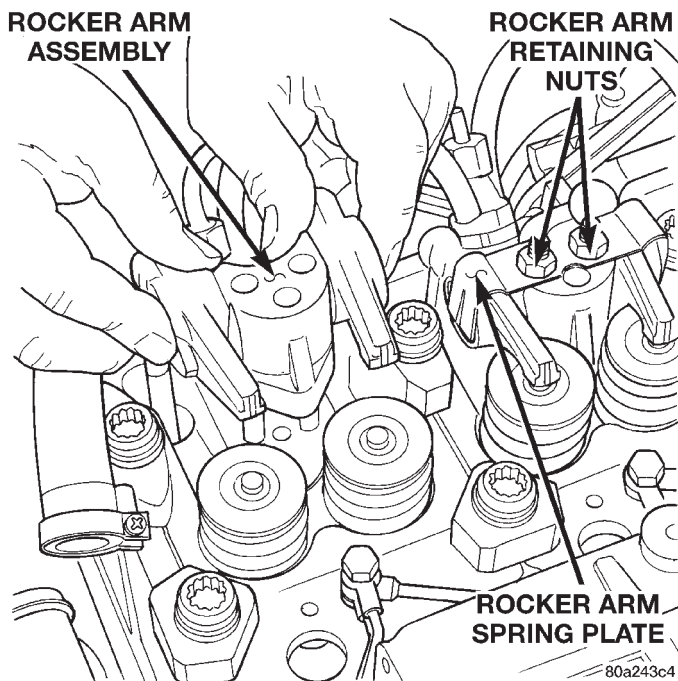


Fig. 29 Rocker Arm Retaining Nut

- (7) Remove the 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) Rotate the crankshaft until the mark lines up with the TDC mark on the timing cover.
- (2) Install the push rods in the same order as removed.
- (3) Install the rocker arm assemblies in the same order as removed. Torque nuts to 29.4 N·m (264 in. lbs.).
- (4) Install the cylinder head cover. Refer to cylinder head cover removal and installation in this group.

- (5) Install the generator bracket. Torque bolts to 7 N·m (4 ft. lbs.).

- (6) If equipped, evacuate and charge the air conditioning system. Refer to Group 24, Heater and Air Conditioning.

- (7) Connect the negative battery cable.

VALVE SPRINGS

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

REMOVAL

- (1) Disconnect the negative battery cable. 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.
- (2) Remove the cylinder head cover. Refer to cylinder head cover removal and installation in this section.
- (3) Remove the rocker arms assemblies and push rods. Refer to rocker arm and push rod removal and installation in this section. 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 the valve spring and retainer.
- (9) Inspect the valve stems, especially the grooves. An Arkansas smooth stone should be used to remove nicks and high spots.

INSTALLATION

- (1) Install the 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.

REMOVAL AND INSTALLATION (Continued)

(6) Install the rocker arm assemblies, in their original locations. Torque nuts to 29.4 N·m (264 in. lbs.).

(7) Install the cylinder head cover. Refer to cylinder head cover removal and installation in this section.

(8) Connect the negative battery cable.

ENGINE CYLINDER HEAD

REMOVAL

(1) Disconnect the negative 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 System for procedure.

(3) Discharge the air conditioning system, if equipped. Refer to Group 24, Heating and Air Conditioning for procedure.

(4) If equipped with air conditioning, remove the A/C lines at the compressor and cap. Refer to Group 24, Heating and Air Conditioning. Remove A/C line bracket attached to cylinder head cover, and move A/C lines away from cylinder head.

(5) Remove the air cleaner hose from turbocharger and breather hose.

(6) Remove the air cleaner assembly and breather hose.

(7) Remove the generator support bracket.

(8) Remove the upper radiator hose and coolant recovery hose.

(9) Remove the water manifold and recovery hose.

(10) Disconnect the heater hoses and coolant recover bottle hose.

(11) Disconnect the EGR tube from EGR valve.

(12) Remove the EGR valve

(13) Remove the exhaust heat shield from exhaust manifold.

(14) Remove the exhaust heat shield from down pipe.

(15) Remove the exhaust down pipe from turbocharger (Fig. 30).

(16) Disconnect the oil feed line from turbocharger.

(17) Disconnect the oil drain line from turbocharger.

(18) Remove the Exhaust manifold. Refer to Group 11, Exhaust System and Turbocharger.

(19) Remove the Intake manifold. Refer to intake manifold removal and installation procedure in this section.

(20) Remove the oil feed line for rocker arm assemblies (Fig. 31).

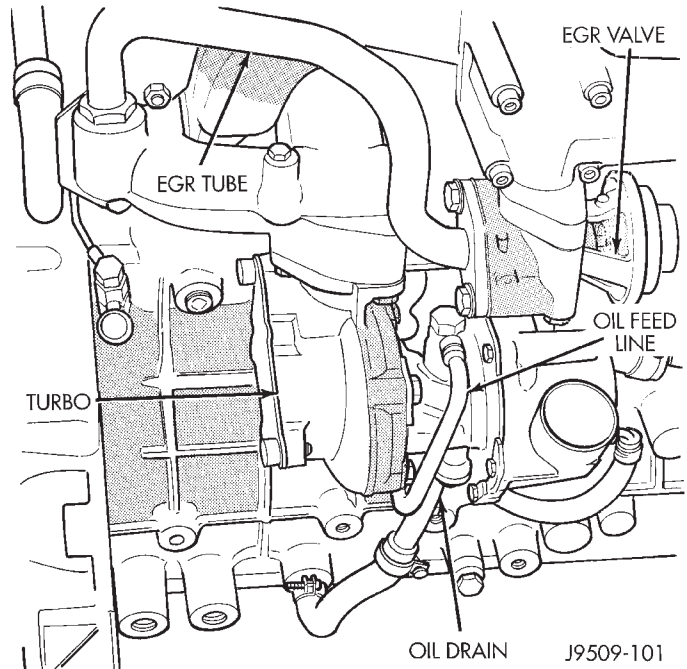


Fig. 30 Turbocharger

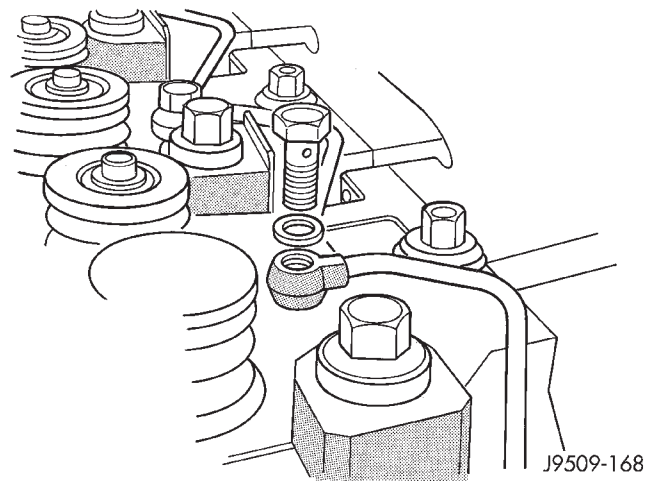


Fig. 31 Rocker Arm Oil Feed Lines

(21) Remove the Crankcase breather hose from rear of the valve cover

(22) Remove the injector sensor wire and the glow plug hot lead.

(23) Remove the fuel lines and fuel filter. Refer to Group 14, Fuel Systems for procedure.

(24) Remove the injector fuel lines from injectors to pump.

(25) Remove the fuel injectors with tool VM.1012 (Fig. 32). Refer to Group 14, Fuel System for procedure.

(26) Remove the engine cylinder head cover.

(27) Remove the rocker retaining nuts (Fig. 34).

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

REMOVAL AND INSTALLATION (Continued)

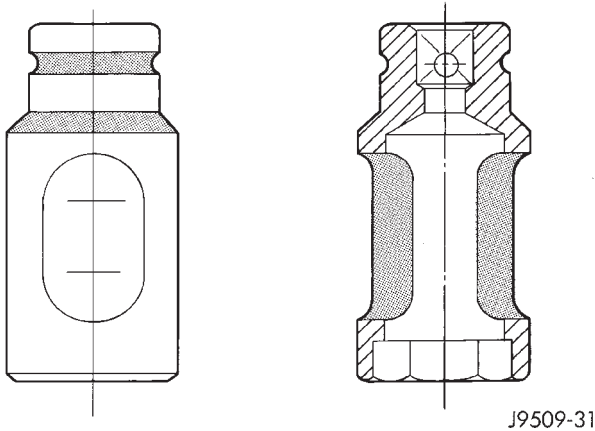


Fig. 32 Fuel Injector Tool VM.1012

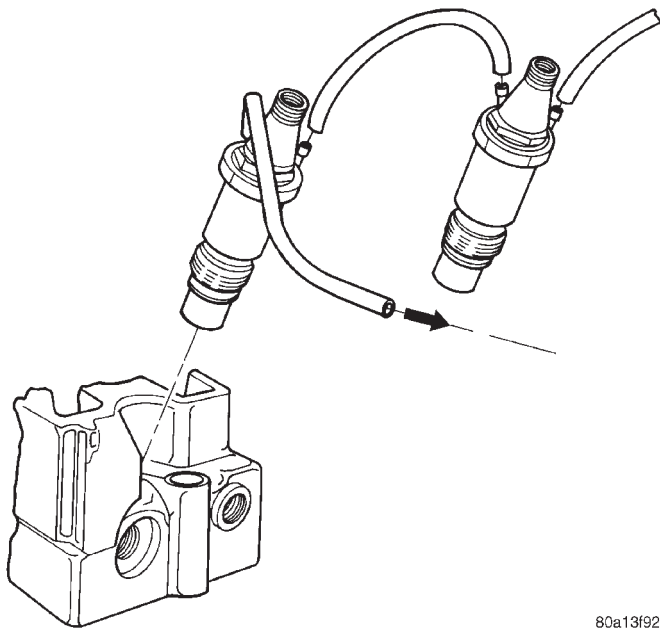


Fig. 33 Fuel Injector

- (29) Remove the push rods and place them on a bench in the same order as removed.
- (30) Mark the cylinder head positions.
- (31) Remove the engine cylinder head bolts with special tool VM.1018 and VM.1019.
- (32) Remove the engine cylinder head and gasket.
- (33) Stuff clean lint free shop towels into the cylinder bores.

CYLINDER HEAD GASKETS

A steel cylinder head gasket is used for all four cylinder heads.

Cylinder head gaskets are available in three thicknesses. Identification holes in the right front corner of the gasket indicate the thickness of the gasket (Fig. 35).

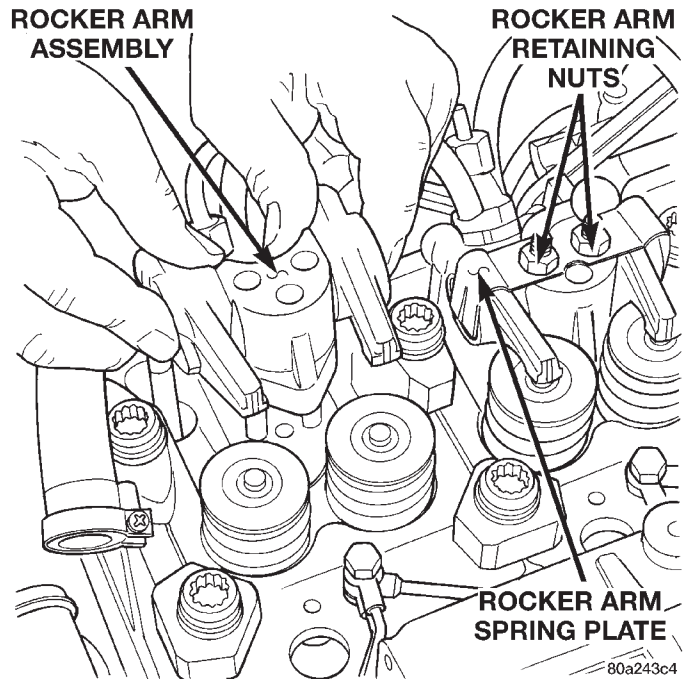
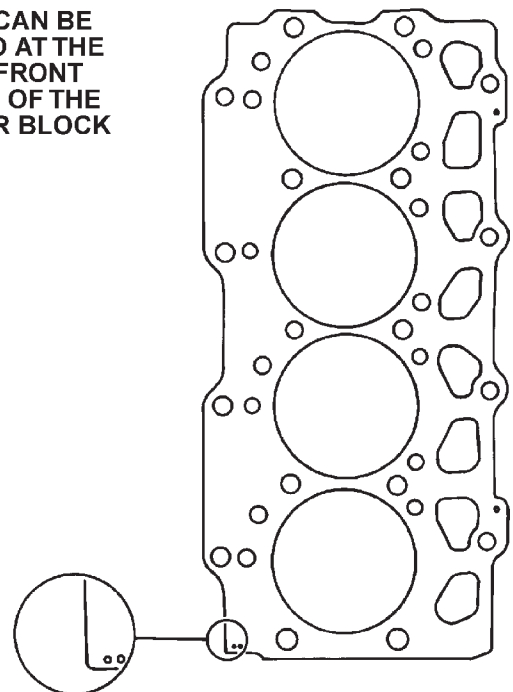


Fig. 34 Rocker Arm Retaining Nuts

HOLES CAN BE LOCATED AT THE RIGHT FRONT CORNER OF THE CYLINDER BLOCK



HOW TO IDENTIFY GASKET THICKNESS

NO HOLES	1.42 mm
2 HOLES	1.52 mm
1 HOLE	1.62 mm

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Fig. 35 Steel Type Cylinder Head Gasket—identification

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

REMOVAL AND INSTALLATION (Continued)

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

MEASURING PISTON PROTRUSION

(1) Use special tool VM.1010 with dial indicator special tool VM.1013 (Fig. 36).

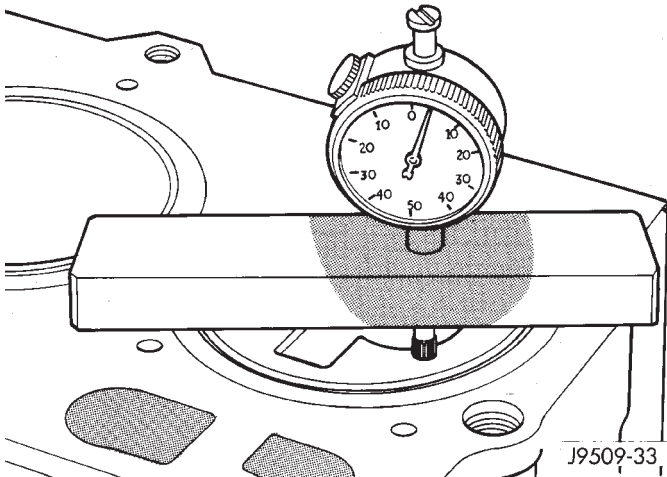


Fig. 36 Measuring Piston Protrusion

- (2) Bring the piston of cylinder no. 1 exactly to top dead center.
- (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. 37).
- (5) Repeat the procedure with the rest of the cylinders.
- (6) Establish the thickness of the steel gasket for all four cylinder heads on the basis of the greatest piston protrusion (Fig. 35).

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

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Fig. 37 Piston Protrusion Chart

CAUTION: Gaskets are to be installed DRY. DO NOT use a gasket sealing compound on the gasket.

INSTALLATION

- (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 alignment studs.
- (4) Place the engine cylinder head over the alignment studs.

CAUTION: New cylinder head bolts should be used.

(5) Tighten the engine cylinder head bolts in sequence according to the following procedure (Fig. 38):

- 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 remains in it's proper position, completely covered. Then, lubricate and install the eight small bolts, also finger tight.

(6) Install the intake and exhaust manifolds with a new gasket, 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 Turbo-charger for the proper procedure. Install lift eye and brake vacuum tube at this time.

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

(8) **1st Phase:** Tightening Head Bolts (Fig. 38). Central bolts (A-L): Tighten all bolts, starting with bolt H then G-F-E-D-C-B-A-L-I, to 30 N·m. Tighten all bolts an additional 70°, starting with bolt A and continuing in alphabetical order. Finally, tighten all bolts an additional 70°, starting again with bolt A and continuing in alphabetical order.

(9) Tighten the 14mm bolts in the following manner:

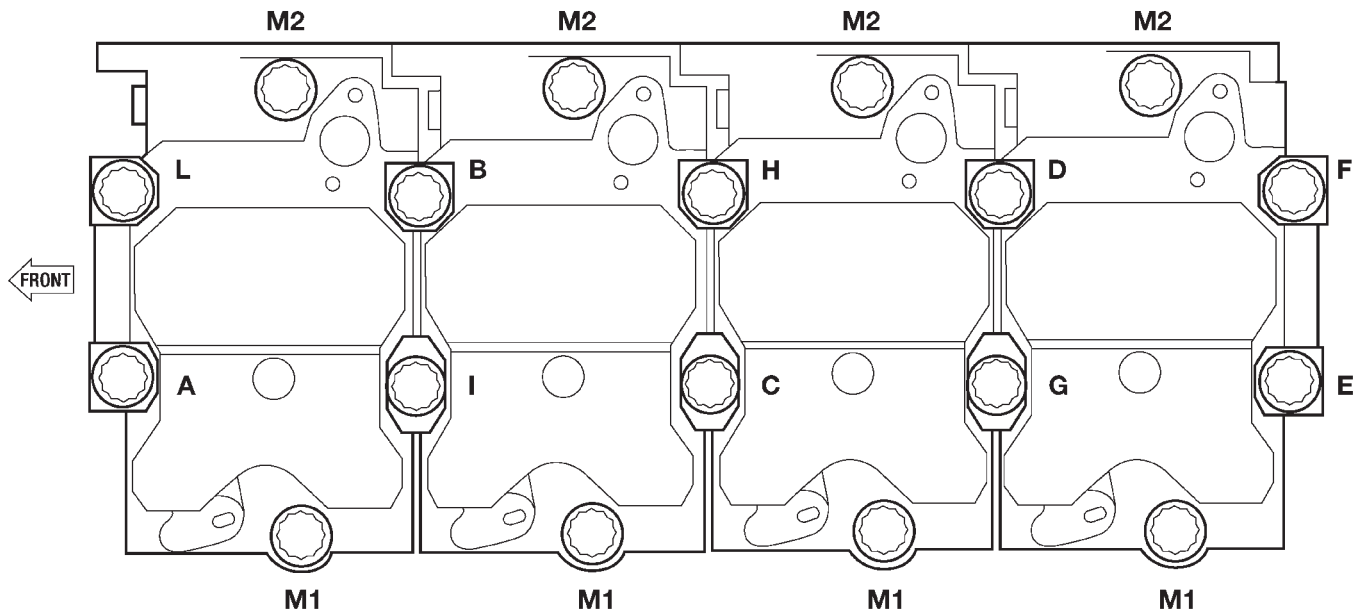
(10) Side bolts (M1-M2): Tighten M1 bolts to 30 N·m, then rotate them 85° (±5). Tighten M2 bolts to 30 N·m, then rotate them 85° (±5).

NOTE: If vehicle is equipped with A/C do not install A/C lines to compressor and charge A/C till Phase 2 is complete.

(11) **2nd Phase:** After 20 minutes of engine operation at operating temperature, allow engine to cool down completely. Then retorquer the head bolts as follows:

(12) Central bolts A-L: Completely back off bolts one-by-one and then retighten to 30 N·m plus 130° (±5°). Then proceed in the same way, bolt by bolt, following alphabetical order, as indicated.

REMOVAL AND INSTALLATION (Continued)



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Fig. 38 Engine Cylinder Head Bolt Tightening Sequence

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

(14) Torque intake nuts to 32 N·m (24 ft. lbs.) and exhaust manifolds nuts to 32 N·m (24 ft. lbs.) after completing the cylinder head torquing procedure.

NOTE: 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.

(15) Install the oil feed lines for the rocker arm assemblies and oil pressure switch. Torque oil feed lines to 13 N·m (115 in. lbs.).

(16) Install the push rods and rocker arm assemblies, tighten nuts to 29 N·m (22 ft. lbs.).

(17) Install the cylinder head cover. Torque bolts to 15 N·m (133 in. lbs.).

(18) Connect the crankcase breather hose.

(19) Connect the injector sensor wire and the glow plug hot lead.

(20) Install the turbocharger oil feed line. Torque banjo bolts to 27 N·m (20 ft. lbs.).

(21) Install the turbocharger oil drain line. Torque bolts to 11 N·m (97 in. lbs.).

(22) Install the water manifold. Torque bolts to 12 N·m (106 in. lbs.).

(23) Install the generator support bracket.

(24) Raise the vehicle on hoist.

(25) Install the exhaust down pipe to turbocharger, tighten bolts to 22 N·m (16 ft. lbs.).

(26) Install the exhaust down pipe heat shield.

(27) Install the exhaust heat shield, Tighten bolts to 11 N·m (8 ft. lbs.).

(28) Install the EGR valve to intake manifold, tighten bolts to 26 N·m (19 ft. lbs.).

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

(30) Install the lower Charge air cooler hose to turbocharger.

(31) Install the air cleaner assembly and hose.

(32) Install the oil breather hose to air cleaner hose.

(33) Install the upper charge cooler hose to turbocharger.

(34) Connect the recover bottle hose to water manifold.

(35) Install the fuel injectors using special tool VM.1012. Refer to Group 14, Fuel System for procedures.

(36) Install the fuel injector lines from the pump to injectors. Torque nuts to 23 N·m (17 ft. lbs.).

(37) Connect the A/C lines to compressor and install bracket on cylinder head cover, if equipped with air conditioning.

REMOVAL AND INSTALLATION (Continued)

- (38) Install the fuel filter, Tighten bolts to 28 N·m (250 in. lbs.)
- (39) Connect the fuel supply and return lines
- (40) Connect the upper radiator hose.
- (41) Connect the negative cable battery.
- (42) If equipped with A/C, evacuate and charge the air conditioning system. Refer to Group 24, Heater and Air Conditioning.
- (43) 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.

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

CAUTION: After rebuild or cylinder head gasket replacement, the cylinder head must be retorqued within the first 20,000km. If individual fiber type head gaskets were used.

NOTE: The one piece steel type head gasket does not require, the above mentioned, retorquing procedure.

CYLINDER HEAD RE-TORQUE

Within the first 20,000 km (12,000 miles) after rebuild, retorquing the cylinder head bolts as follows: (Fig. 38) Central bolts A-L: Without slackening the bolts, following alphabetical order tighten the bolts through an angle of 15°. Side bolts M1-M2: Without slackening, tighten M1 then M2 bolts through an angle of 15°.

VIBRATION DAMPER

REMOVAL

- (1) Disconnect the negative battery cable.
- (2) Remove the fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.
- (3) Remove the accessory drive belt. Refer to Group 7, Cooling System for procedure.
- (4) Remove the vibration damper nut.
- (5) Install special tool VM.1000-A to remove vibration damper.

INSTALLATION

- (1) Install the vibration damper and align with key way.
- (2) Install the vibration damper nut. Torque nut to 196 N·m (147 ft. lbs.).

- (3) Install the accessory drive belt. Refer to Group 7, Cooling System for procedure.
- (4) Connect the negative battery cable.

TIMING GEAR COVER OIL SEAL

REMOVAL

- (1) Disconnect the negative battery cable.
- (2) Remove the vibration damper. Refer to vibration damper removal and installation in this section.

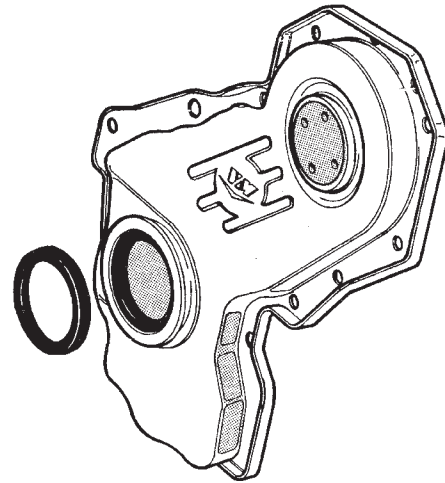
CAUTION: Use care when removing the old seal. Be sure not to damage the timing gear cover.

- (3) Pry out the old seal.

INSTALLATION

Remove the oil seal ring. The seating diameter must be 68.000 - 68.030 mm.

- (1) Install the new seal using special tool VM.1015A.
- (2) Install the vibration damper. Refer to vibration damper removal and installation in this section.
- (3) Connect the negative battery cable.



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Fig. 39 Timing Gear Cover Oil Seal

TIMING GEAR COVER

REMOVAL

- (1) Disconnect the negative battery cable.
- (2) Remove the fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.
- (3) Remove the accessory drive belt. Refer to Group 7, Cooling System for procedure.
- (4) Remove the vibration damper nut.
- (5) Install special tool VM.1000-A to remove the vibration damper.
- (6) Remove the fan pulley.

NOTE: The idler pulley bolt has left hand thread.

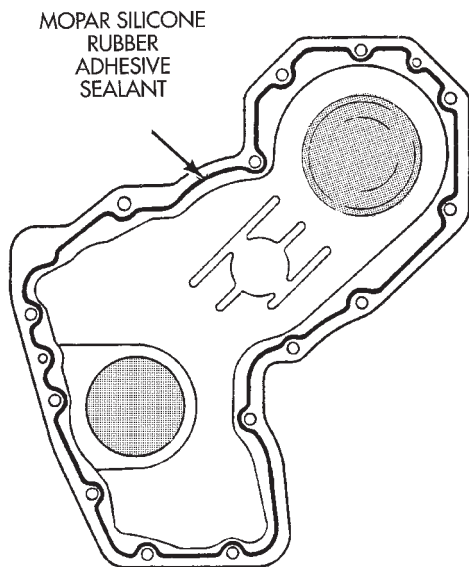
REMOVAL AND INSTALLATION (Continued)

- (7) Remove the idler pulley and bracket.
- (8) Remove the automatic belt tensioner.
- (9) Remove the Power steering pump pulley.
- (10) Remove the timing gear cover.

INSTALLATION

(1) Be sure the mating surfaces of the gear case cover and the cylinder block are clean and free from burrs.

(2) Apply a continuous 3 mm bead of Silicone Sealer (Fig. 40) to timing cover, install within 10 minutes, tighten 6mm bolts to 10.3 N·m (91 in. lbs) and tighten 8mm bolts to 26.2 N·m (19 ft. lbs.).



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Fig. 40 Front Cover Sealer Location

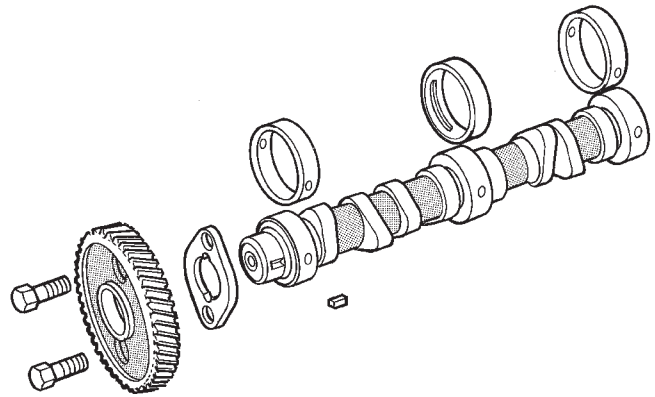
- (3) Install Power steering pump pulley. Torque nut to 130 N·m (96 ft. lbs.).
- (4) Install the automatic belt tensioner.
- (5) Install the idler pulley bracket. Torque bolts to 40 N·m (29 ft. lbs.).

NOTE: The idler pulley has left hand thread.

- (6) Install the idler pulley. Torque nut to 48 N·m (35 ft. lbs.).
- (7) Install the fan pulley. Torque bolts to 56 N·m (41 ft. lbs.).
- (8) Install the vibration damper. torque nut to 196 N·m (147 ft. lbs.).
- (9) Install the accessory drive belt. Refer to Group 7, Cooling System for procedure).
- (10) Install the fan and fan shroud.
- (11) Connect the negative battery cable.

CAMSHAFT

REMOVAL



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Fig. 41 Camshaft Assembly

- (1) Disconnect the negative battery cable.
- (2) Remove the cylinder head cover. Refer to cylinder head cover removal and installation in this section.
- (3) Remove the cylinder heads. Refer to cylinder head removal and installation in this section.
- (4) Remove the rocker arm assemblies, push rods, and hydraulic tappets. Refer to the respective groups in this section.
- (5) Remove the fan and set fan inside fan shroud then remove fan shroud and fan as an assembly.
- (6) Remove the accessory drive belt. Refer to Group 7, Cooling System for procedure.
- (7) Remove the radiator. Refer to Group 7, Cooling System for procedure.
- (8) Remove the A/C condenser. Refer to Group 24, Heating and Air Conditioning for procedure.
- (9) Remove the vibration damper. Refer to vibration damper removal and installation in this section.
- (10) Remove the power steering pump pulley.
- (11) Remove timing gear cover. Refer to timing gear cover removal and installation in this section.
- (12) Rotate the engine to align the timing marks as shown (Fig. 42).
- (13) Unscrew the flange bolts and remove camshaft (Fig. 43).

THRUST PLATE INSPECTION

Check the thickness (Fig. 44) of the plate at points a-b-c-d. If the measurement is not between 3.950 - 4.050 it must be changed.

INSTALLATION

(1) Coat the camshaft journals with clean engine oil and carefully install the camshaft complete with

REMOVAL AND INSTALLATION (Continued)

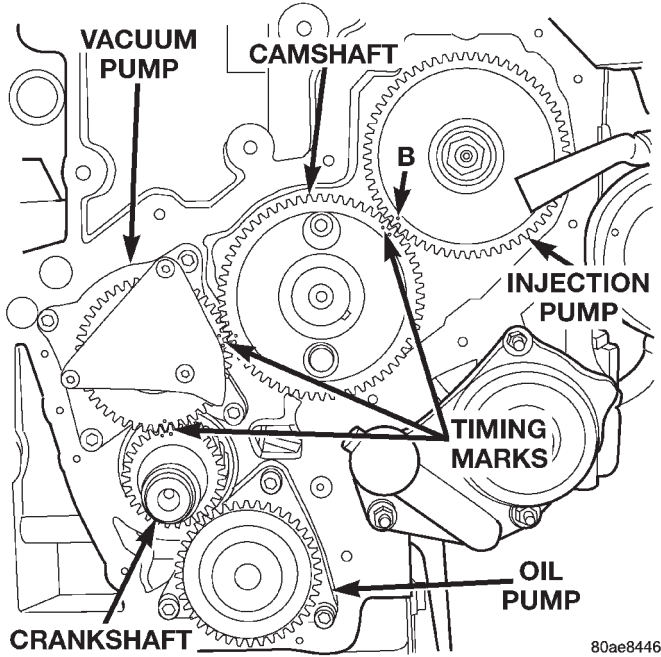


Fig. 42 Timing Marks

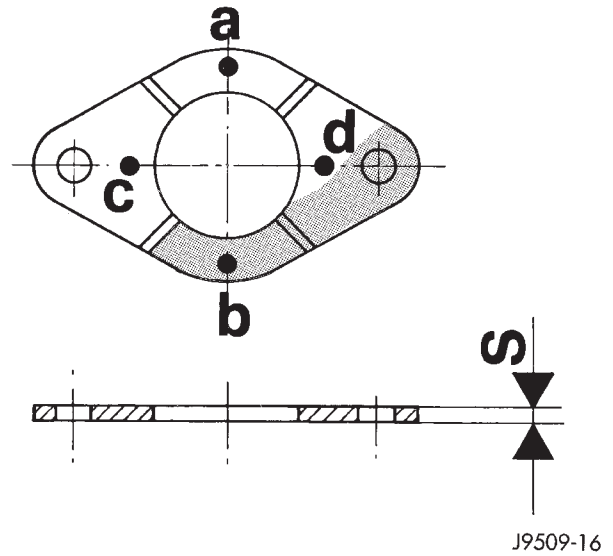


Fig. 44 Camshaft Thrust Plate

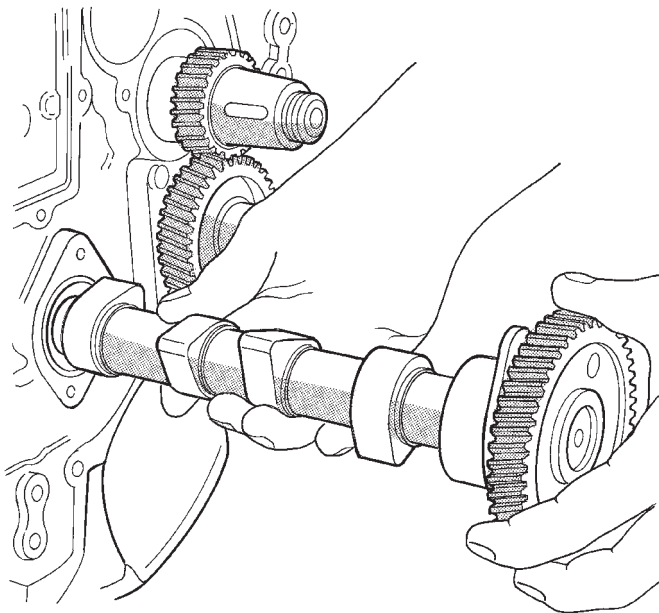


Fig. 43 Camshaft Removal

thrust plate and gear. Tighten retaining bolts to 24 N·m (18 ft. lbs.) torque. Be sure to align the timing marks as shown (Fig. 45).

(2) Install the hydraulic tappets and retainers. Refer to hydraulic tappet removal and installation in this section.

(3) Install the cylinder heads. Refer to cylinder head removal and installation in this section.

(4) Install the push rods and rocker arm assemblies. Refer to the respective sections.

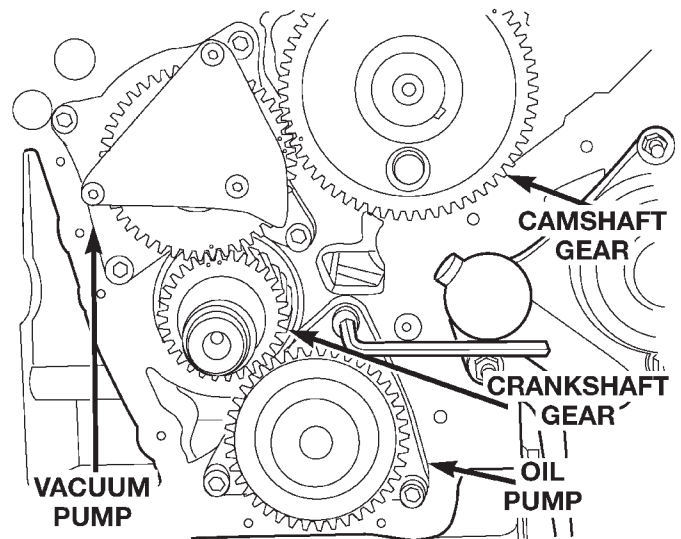


Fig. 45 Timing Marks

(5) Install the cylinder head cover. Refer to cylinder head cover removal and installation in this section.

(6) Install the timing gear cover. Refer to timing gear cover removal and installation in this section.

(7) Install the vibration damper. Refer to the vibration damper removal and installation in this section.

(8) Install the A/C condenser. Refer to Group 24, Heating and Air Conditioning for procedure.

REMOVAL AND INSTALLATION (Continued)

(9) Install the radiator. Refer to Group 7, Cooling System for procedure.

(10) Install the fan and fan shroud. Torque fan to 56 N·m (41 ft. lbs.).

(11) If equipped, evacuate and charge the air conditioning system. Refer to Group 24, Heater and Air Conditioning for procedure.

(12) Connect the negative battery cable.

(13) 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.

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

CAMSHAFT BEARINGS

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

REMOVAL

(1) With the engine completely disassembled, remove camshaft rear plate and o-ring.

(2) Install the proper size adapters and horseshoe washers (part of Camshaft Bearing Remover/Installer Tool C-3132-A) at back of each bearing shell. Drive out the bearing shells.

INSTALLATION

(1) Install the new camshaft bearings with Camshaft Bearing Remover/Installer Tool C3131-A by sliding the new camshaft bearing shell over proper adapter.

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

(3) Install the remaining bearings in the same manner. The 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 rear plate o-ring at the rear of camshaft. **Be sure this seal does not leak.**

OIL PAN

REMOVAL

(1) Disconnect the negative battery cable.

(2) Raise the vehicle on hoist.

(3) Drain the oil.

(4) Remove the oil pan lower cover (Fig. 46).

(5) Remove the bolts from oil pan. Remove the 6 bolts that are on the inside of the oil pan.

(6) Remove the oil pan.

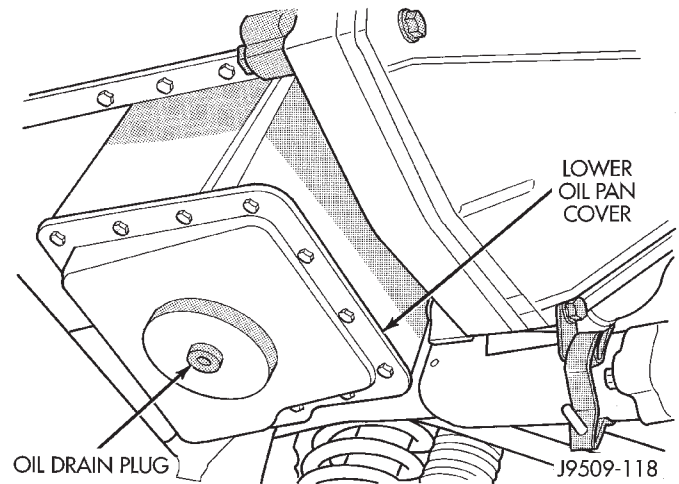


Fig. 46 Oil Pan

INSTALLATION

(1) Remove all gasket material from cylinder block. Be careful not gouge or scratch aluminum pan sealing surface.

(2) Apply a continuous 3 mm bead of Silicone Sealer to oil pan, install within 10 minutes. Install the oil pan.

(3) Install the inside oil pan bolts. Torque bolts to 11 N·m (8 ft. lbs.).

(4) Torque the smaller oil pan bolts to 11 N·m (8 ft. lbs.). Torque the larger oil pan bolts to 25 N·m (18 ft. lbs.).

(5) Install the oil drain plug. Torque to 79 N·m (58 ft. lbs.).

(6) Lower the vehicle from hoist.

(7) Fill engine with proper amount of oil.

(8) Connect the negative battery cable.

OIL PUMP

REMOVAL

(1) Disconnect the negative battery cable.

(2) Remove the timing gear cover. Refer to timing gear cover removal and installation in this section).

(3) Remove the oil pump (Fig. 47).

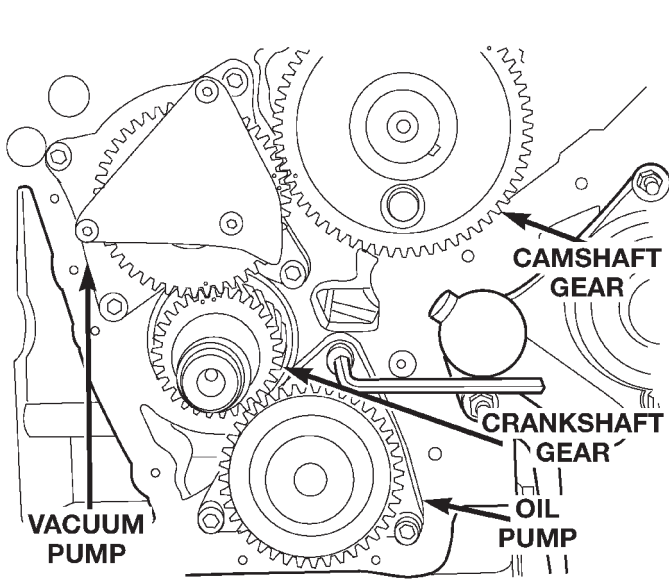
INSTALLATION

(1) Install new O-ring and lubricate with clean engine oil.

(2) Install the oil pump. Torque screws to 24.5-29.9 N·m (22.7-28.3 ft. lbs.). Check for normal backlash between pump and crankshaft gears.

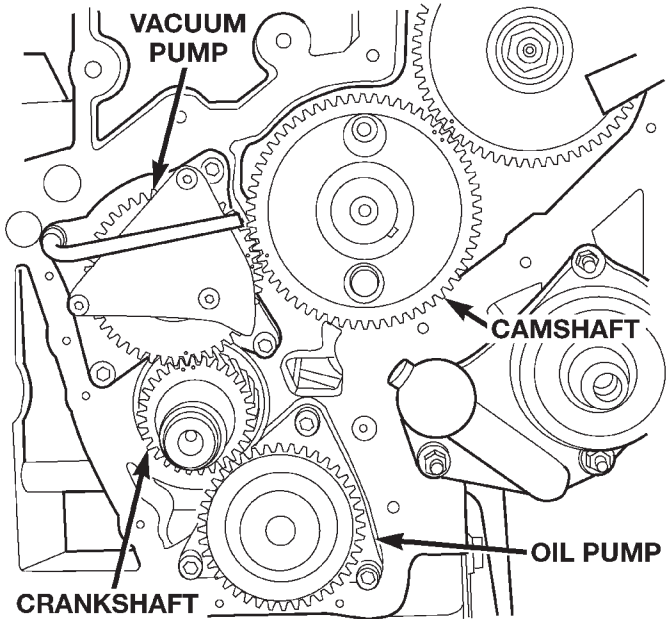
(3) Install the timing gear cover. Refer to timing gear cover removal and installation in this section.

REMOVAL AND INSTALLATION (Continued)



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Fig. 47 Oil Pump Removal



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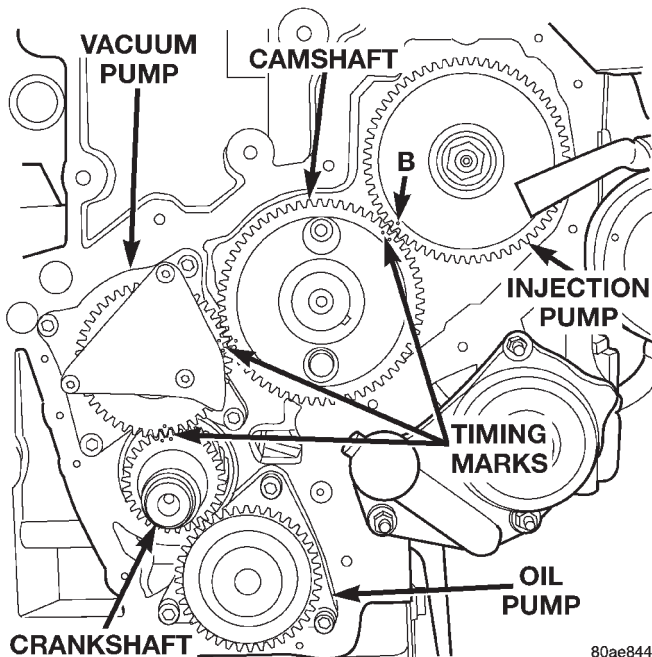
Fig. 49 Vacuum Pump

INTERNAL VACUUM PUMP

REMOVAL

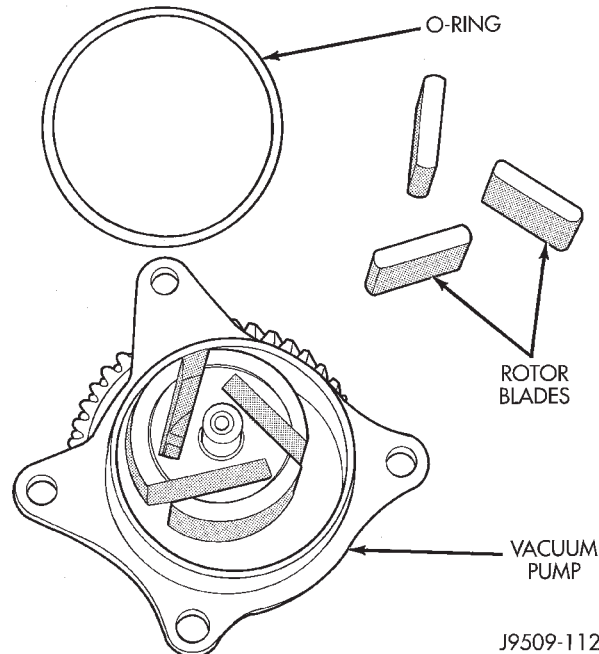
- (1) Disconnect the negative battery cable.
- (2) Remove the timing gear cover. Refer to timing gear cover removal in this section.
- (3) Align all the timing marks before removing the vacuum pump (Fig. 48).
- (4) Remove the vacuum pump retaining bolts..

- (5) Remove the internal vacuum pump.



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Fig. 48 Timing Marks



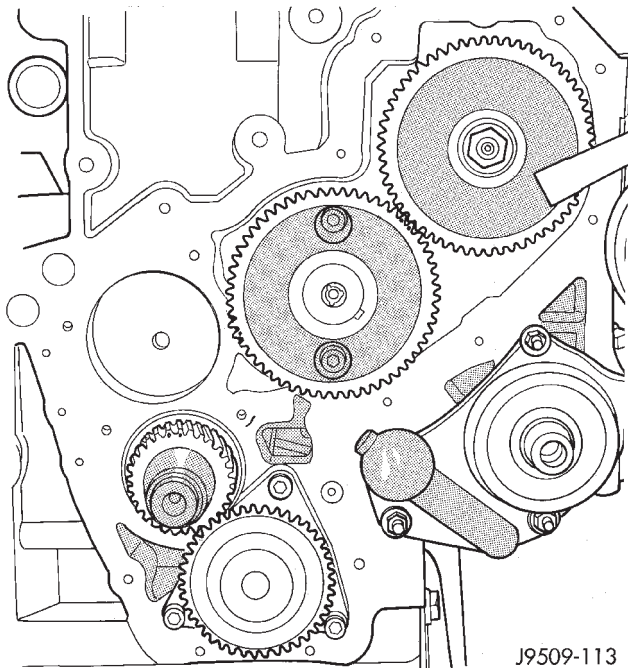
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Fig. 50 Vacuum Pump Parts

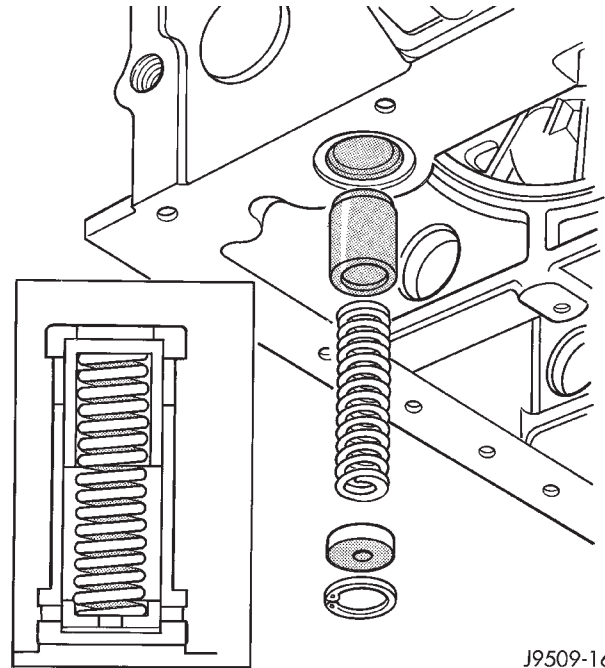
INSTALLATION

- (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 (Fig. 48). Torque bolts to 20 N·m (15 ft. lbs.).
- (2) Install the timing gear cover. Refer to timing gear cover removal in this section.
- (3) Connect the negative battery cable.

REMOVAL AND INSTALLATION (Continued)



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Fig. 51 Vacuum Pump Mounting Hole

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Fig. 52 Oil Pressure Relief Valve**OIL PUMP PRESSURE RELIEF VALVE****REMOVAL**

- (1) Disconnect the negative battery cable
- (2) Remove the oil pan. Refer to oil pan removal and installation procedure in this section.
- (3) Remove the relief valve snap ring.
- (4) Remove the relief valve cap, spring, and plunger (Fig. 52).
- (5) Check the 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.
- (6) Check the plunger for scoring, replace if necessary.

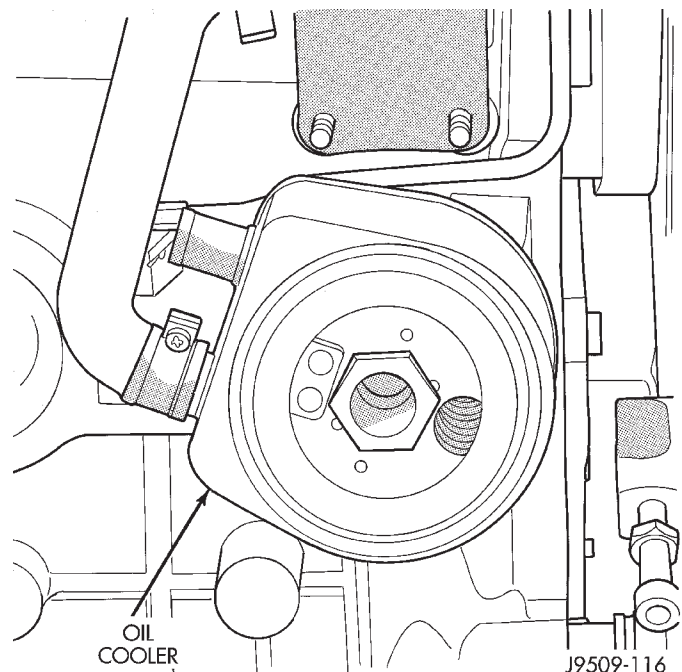
INSTALLATION

- (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 the snap ring. Ensure the snap ring is completely seated in groove.
- (4) Install the oil pan. Refer to oil pan removal and installation procedure in this section.
- (5) Connect the negative battery cable.

OIL FILTER ADAPTER**REMOVAL**

- (1) Disconnect the negative battery cable.
- (2) Remove the oil filter.
- (3) Remove the oil filter adapter.

- (4) Remove the oil filter base, allen bolt in center of adapter.
- (5) Remove the oil cooler adapter bolt.
- (6) Remove the oil cooler (Fig. 53).



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Fig. 53 Oil Cooler**INSTALLATION**

- (1) Install the oil cooler with new gasket. Torque the oil cooler adapter bolt to 60 N·m (44 ft. lbs.).
- (2) Install the oil filter base with new o-ring. Torque bolt to 46.6 N·m (34 ft. lbs.).

REMOVAL AND INSTALLATION (Continued)

- (3) Install the oil filter adapter to oil filter base. Torque to 46.6 N·m (34 ft. lbs.).
- (4) Install the oil filter. Torque to 18 N·m (13 ft. lbs.) and add oil.
- (5) Connect the negative battery cable.

PISTONS AND CONNECTING ROD ASSEMBLY

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 ridge of cylinder bores with a reliable ridge reamer before removing pistons from cylinder block. **Be sure to keep tops of pistons 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. Install connecting rod bolt protectors on connecting rod bolts. Push each piston and rod assembly out of cylinder bore.

NOTE: Be careful not to nick crankshaft journals.

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

PISTON PIN—REMOVAL

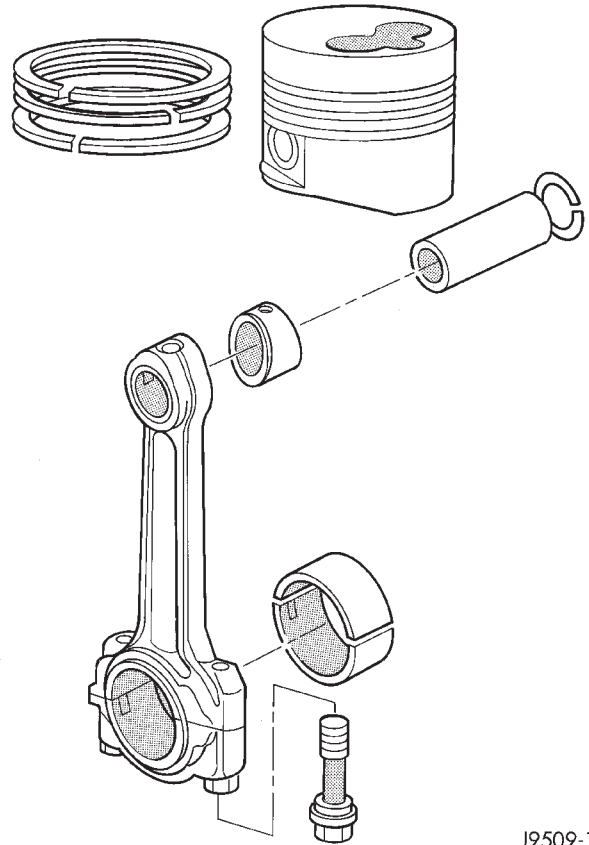
- (1) Secure connecting rod in a soft jawed vice.
- (2) Remove 2 clips securing piston pin.
- (3) Push piston pin out of piston and connecting rod.

PISTON RING—REMOVAL

- (1) 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. 55).
- (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.

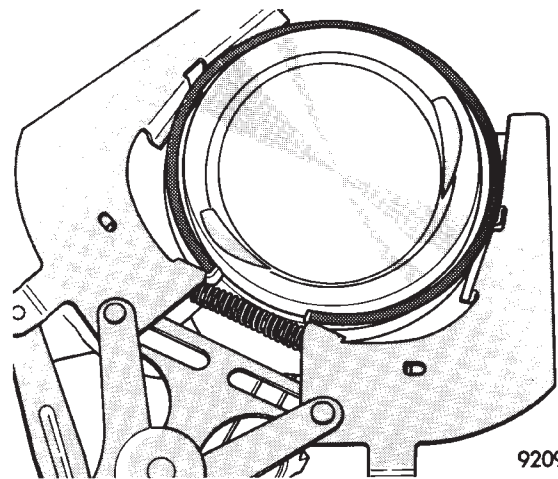
PISTON RING FITTING

- (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. Top compression ring gap .25 to .50mm (.0098 to .0196 in.). Second compression ring gap .25 to .35mm (.0098 to



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Fig. 54 Piston Assembly



9209-16

Fig. 55 Piston Rings—Removing and Installing

.0137 in.). Oil control ring gap .25 to .58mm (.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. 57). Top compression ring gap .08 to .130mm (.0031 to .0051 in.). Second compression ring gap .070 to

REMOVAL AND INSTALLATION (Continued)

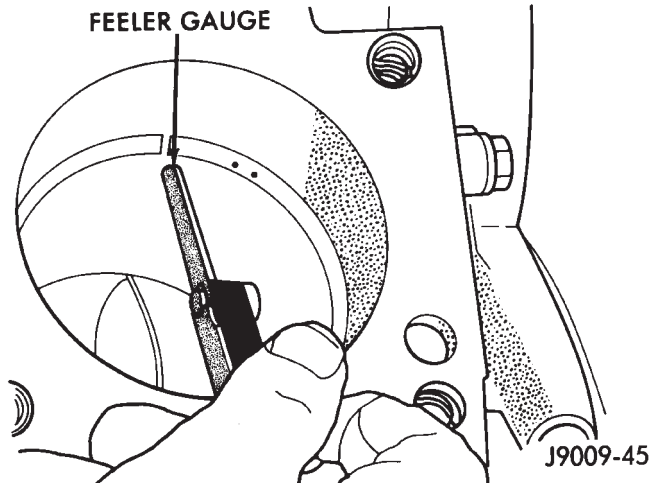


Fig. 56 Ring Gap Measurement

.102mm (.0027 to .0040 in.). Oil control ring gap .040 to .072mm (.0015 to .0028 in.).

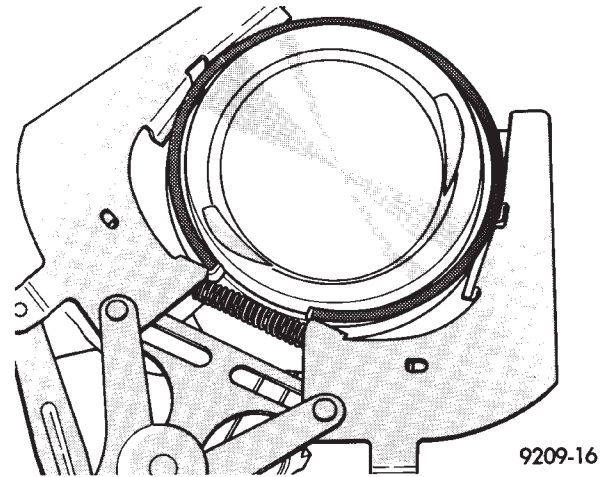


Fig. 58 Piston Rings—Removing and Installing

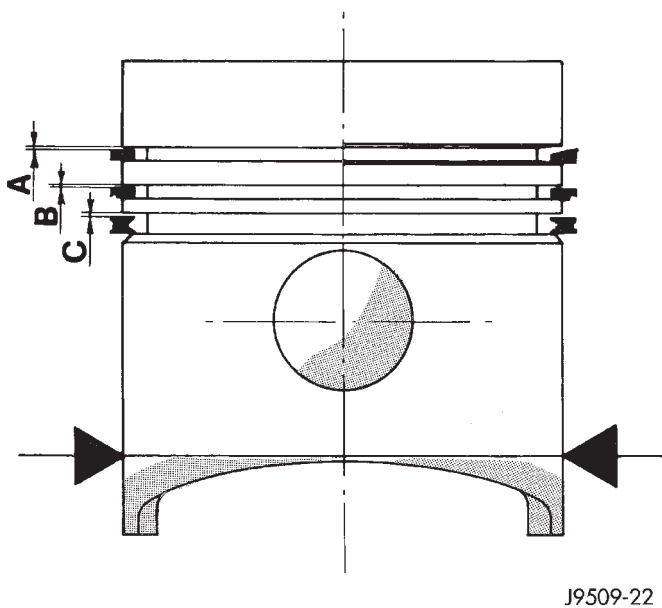


Fig. 57 Piston Ring to Groove Clearance

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. Ring gaps must be positioned, before inserting piston into the liners, as follows (Fig. 60).

(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).

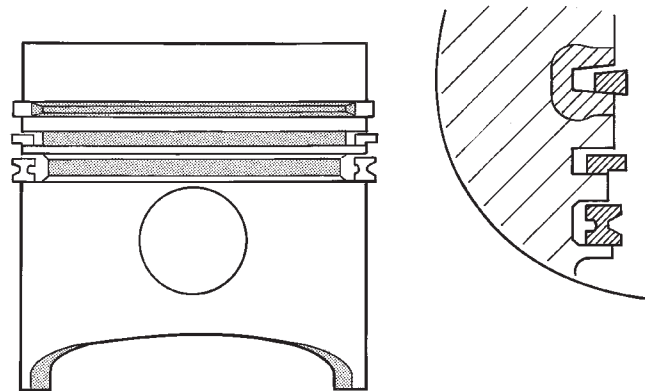


Fig. 59 Piston Ring Identification

(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 disassembly, 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. 58).

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.

REMOVAL AND INSTALLATION (Continued)

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.

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. 60).

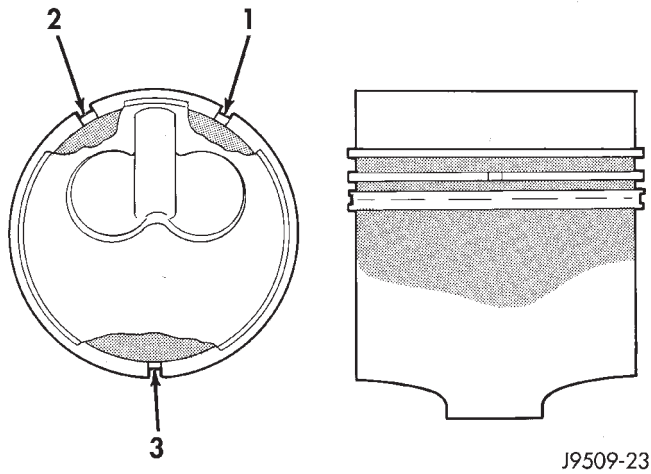


Fig. 60 Piston Ring Gap Location

(2) Before installing the ring compressor, make sure the oil ring expander ends are butted and the rail gaps located as shown in (Fig. 60).

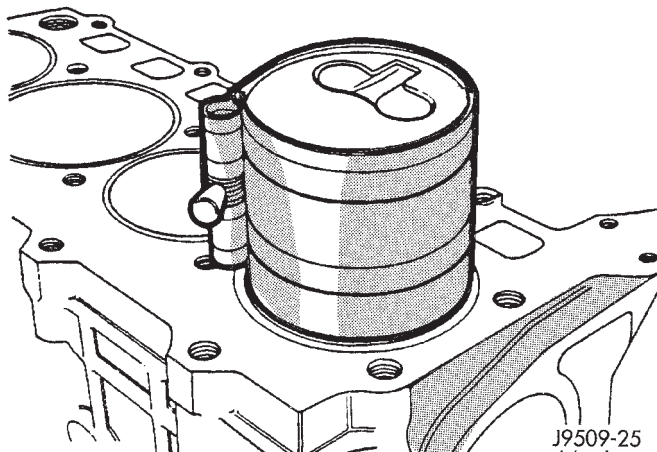


Fig. 61 Installing Piston

(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. 61). **Ensure position of rings does not change during this operation.**

(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.

(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 WALL LINER ASSEMBLY

REMOVAL

- (1) Remove cylinder heads.
- (2) Remove Oil pan.
- (3) Remove pistons.
- (4) Use tool VM-1001 to remove liners (Fig. 62).

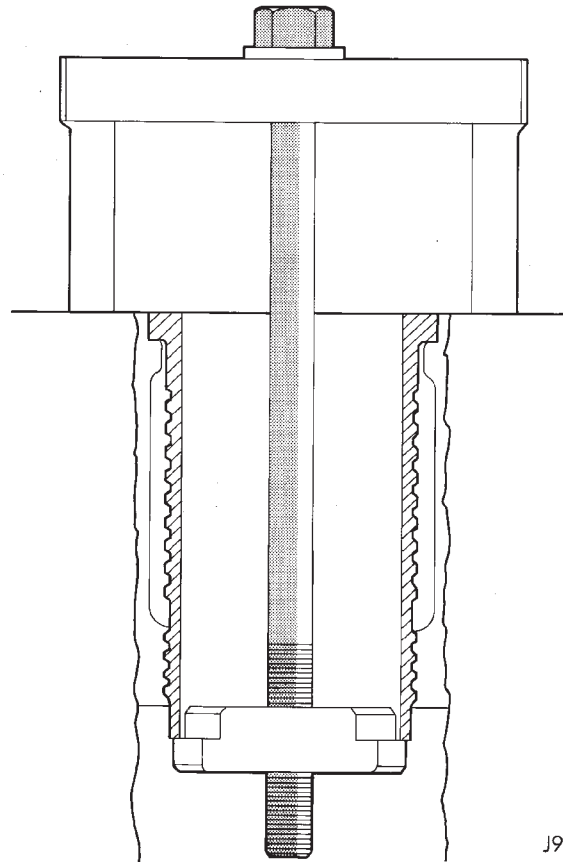
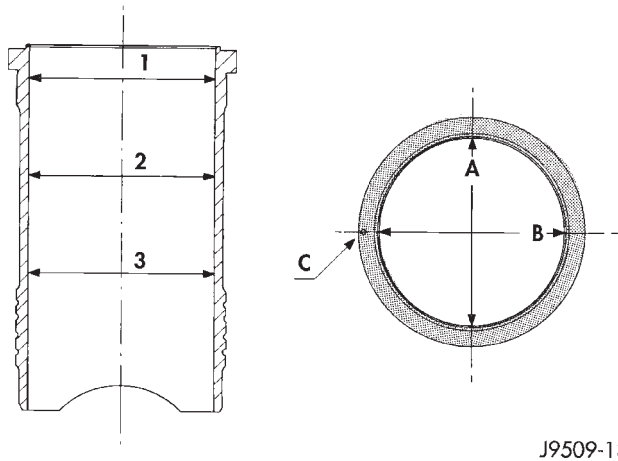


Fig. 62 Liner Removal Tool

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

REMOVAL AND INSTALLATION (Continued)



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Fig. 63 Liner Inspection**INSTALLATION**

(1) Carefully clean residual LOCTITE from liner and crankcase, and degrease the crankcase where it

comes into contact with the liners. Install the liners in the crankcase as shown (A), rotating them back and forth by 45° in order to guarantee correct positioning (Fig. 64).

(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.

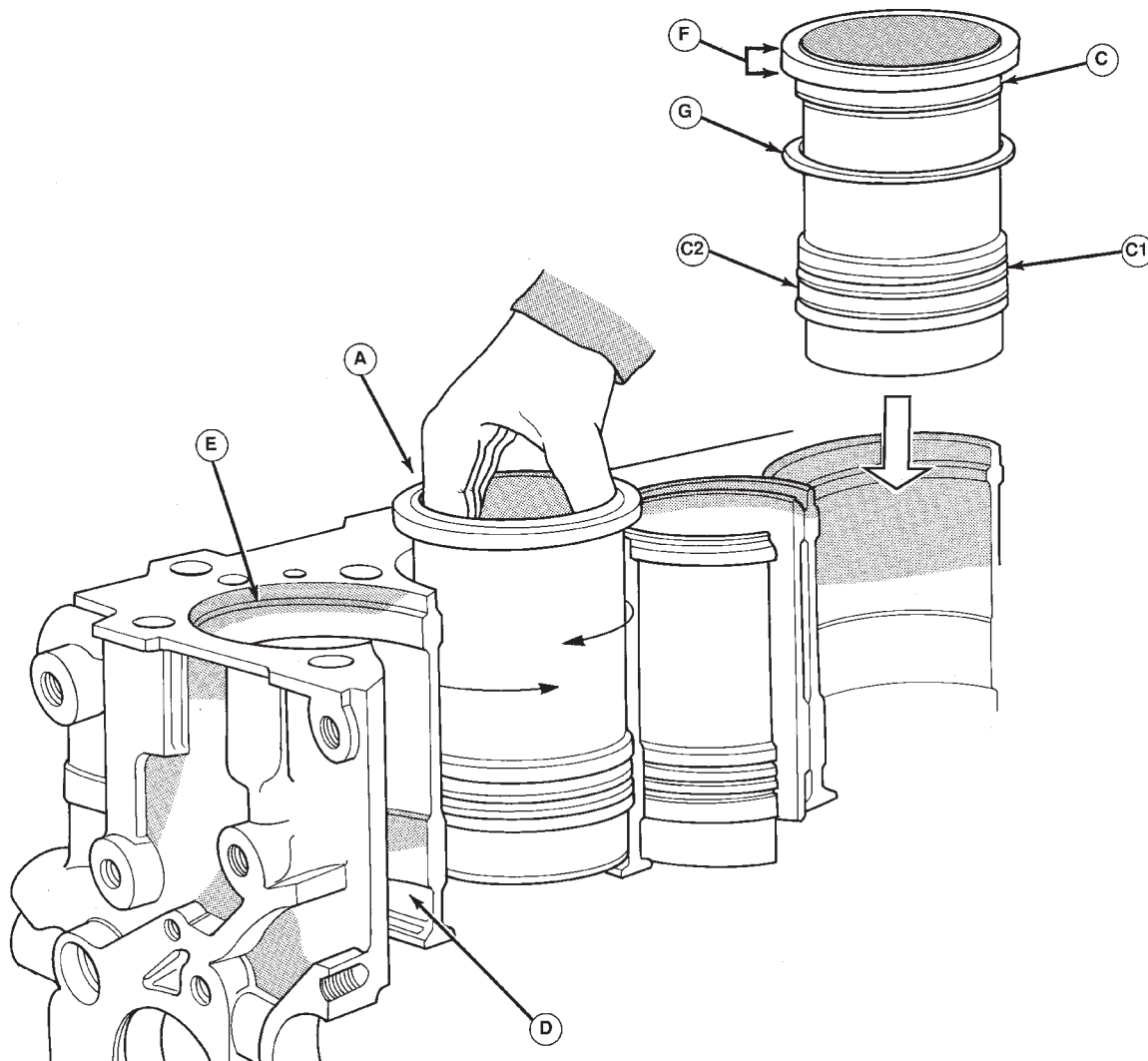
(4) Remove liner and special tool.

(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 AVX to the corner of the liner seat. Apply LOCTITE AVX 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



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Fig. 64 Liner Installation

REMOVAL AND INSTALLATION (Continued)

the liners in position using special tool (VM-1016) and bolts (Fig. 65). Clean the residual LOCTITE on the upper surface of the block deck.

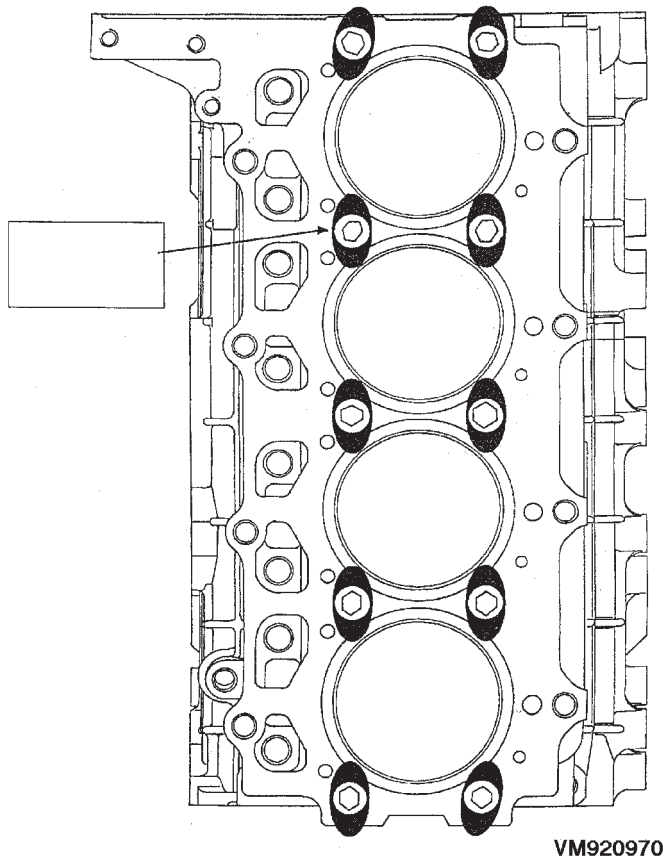


Fig. 65 Liner Clamp Location

(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.

CRANKSHAFT MAIN BEARINGS

REMOVAL

- (1) Disconnect the negative battery cable.
- (2) Remove the engine from vehicle. Refer to engine removal and installation in this section.
- (3) Install the engine on an engine stand.
- (4) Remove the accessory drive system.
- (5) Remove the cylinder head cover. Refer to cylinder head cover removal and installation in this section.
- (6) Remove the rocker arm assemblies and push rods. Refer to rocker arm and push rod removal and installation in this section.

(7) Remove the intake manifold, exhaust manifold and turbocharger. Refer to Group 11, Exhaust System and Turbocharger.

- (8) Remove the water manifold.
- (9) Remove the oil feed lines to rocker arms.
- (10) Remove the cylinder heads. Refer to cylinder head removal and installation in this section.
- (11) Remove the oil pan and oil pick-up.
- (12) Remove the pistons and connecting rods.
- (13) Remove the vibration damper. Refer to vibration damper removal and installation in this section.
- (14) Remove the timing gear cover. Refer to timing gear cover removal and installation in this section.
- (15) Remove the oil pump and vacuum pump from block.
- (16) Install special tool VM.1004 onto crankshaft over gear (Fig. 67).
- (17) Remove the main bearing oil feed and crankshaft support locators from block.
- (18) Remove the flywheel and adaptor plate from engine block.
- (19) Remove the thrust bearings from rear main bearing carrier.
- (20) Slide the 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. 68).
- (21) Separate the two halves of each carrier, remove from the crankshaft and temporarily re-assemble the carriers (Fig. 69). Withdraw the crankshaft through the rear of the crankcase.

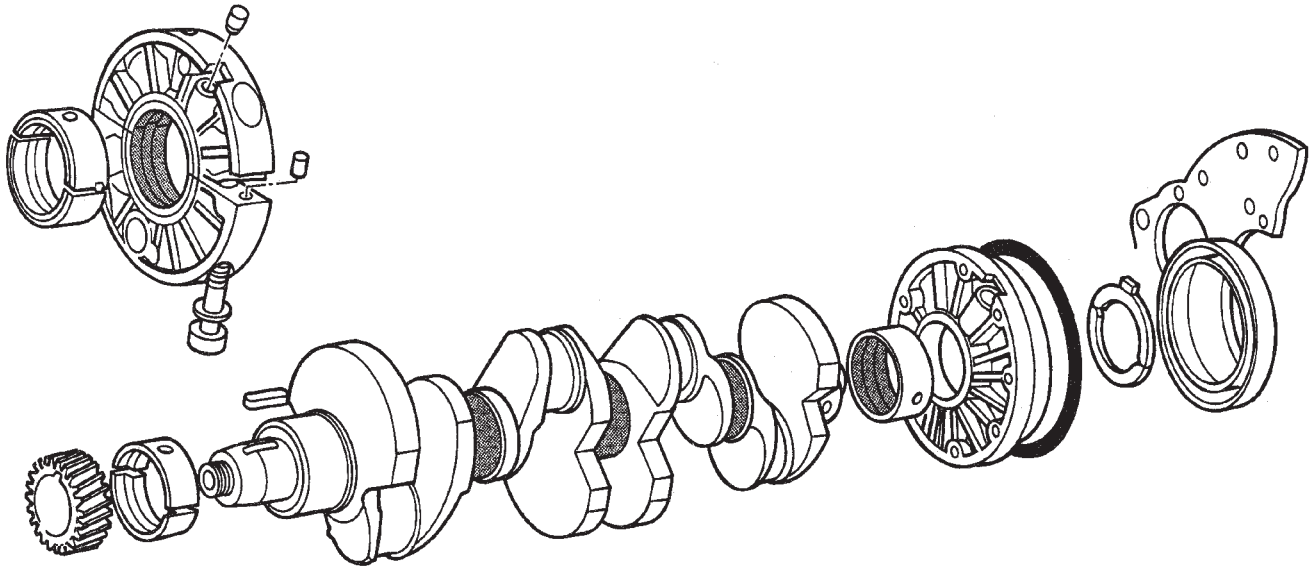
INSTALLATION

NOTE: Be sure the oil jets are facing the front of the engine.

- (1) Fit the main bearing supports together. Torque to 42 N·m (31 ft. lbs.)
- (2) Check internal diameter of bearings.
- (3) If internal diameter of original bearing is being checked and figures are not within specifications, new bearings must be used.
- (4) Check the crankshaft main bearing journals to bearing clearances. Clearances of main bearings is .03 to .088mm (.0011 to .0035 in.).

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.

REMOVAL AND INSTALLATION (Continued)



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Fig. 66 Crankshaft and Bearing Assembly

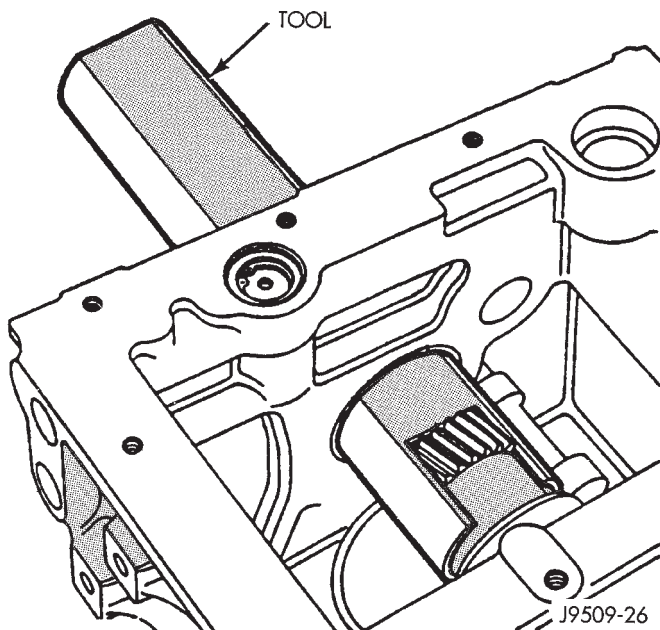


Fig. 67 Crankshaft Special Tool VM.1004

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

(6) 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 and that the **piston jet notch is towards the front of the crankshaft**. Secure each carrier with the two bolts tightening evenly to 42 N·m (31 ft. lbs.). Check that the oil jet is in position (Fig. 69).

(7) Slide special tool VM.1004 over the crankshaft gear and, insert the crankshaft and support assembly

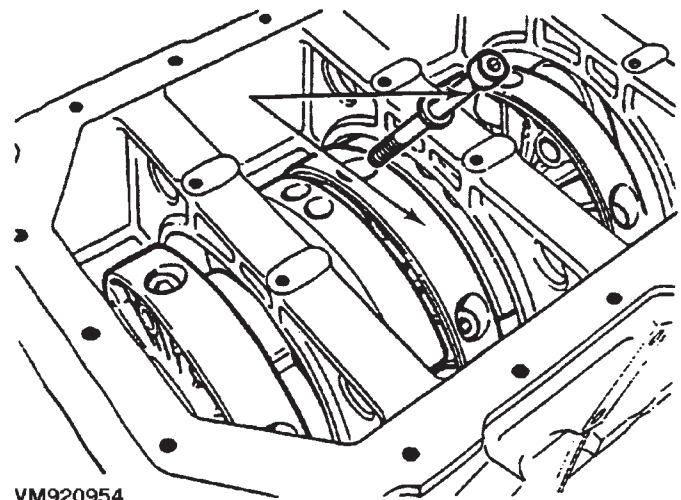


Fig. 68 Crankshaft Support Locator Bolts

into the crankcase in the same manner used for removal.

(8) Align the holes in the lower supports, with the center of the crankcase webs (Fig. 70).

(9) Secure each support assembly to the crankcase with the main bearing oil feed and support locators. Torque to 54 N·m (40 ft. lbs).

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

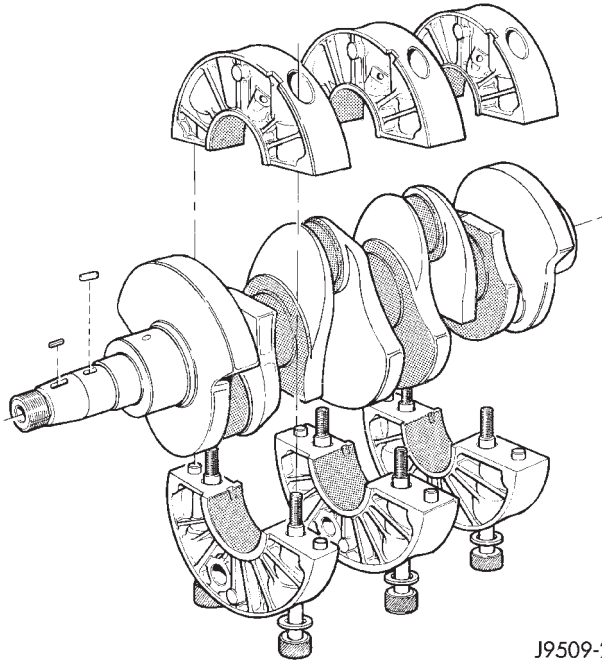
(11) Install the rear oil seal.

(12) Install the new O-rings in adaptor plate.

(13) Install the adaptor plate to block. Torque nuts to 26.5 N·m (20 ft. lbs.).

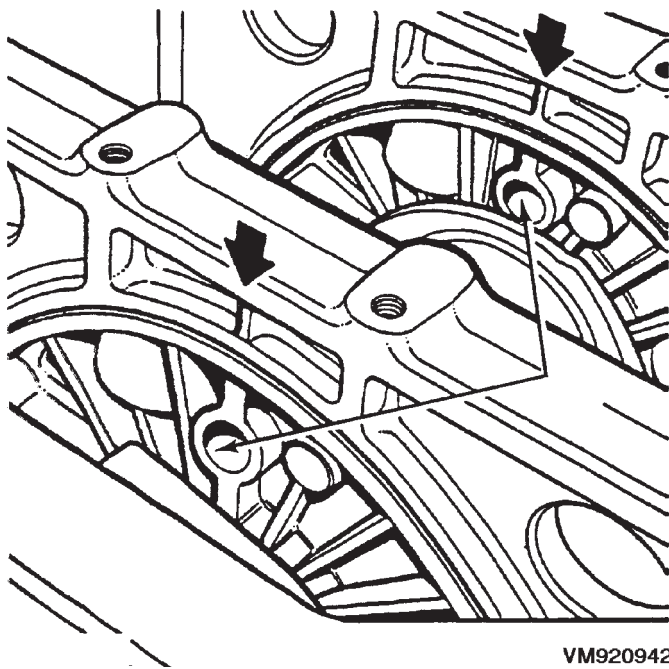
(14) Install the Allen bolts through adaptor plate to rear main bearing support. Torque to 11 N·m (97 in. lbs.).

REMOVAL AND INSTALLATION (Continued)



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Fig. 69 Crankshaft and Carrier Bearing Assembly



VM920942

Fig. 70 Main Bearing Support Alignment

(15) Position the 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.

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

(17) Attach dial indicator to engine block.

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

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

(20) Subtract specified crankshaft end play from figure obtained. Crankshaft end play .153 to .304mm (.0060 to .0119 in.).

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

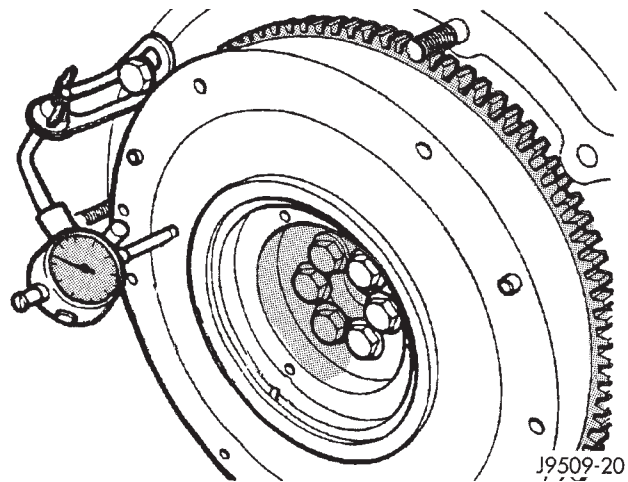
(22) Remove tools and flywheel.

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

(24) Ensure that crankshaft end and flywheel mating surfaces are clean and dry. Install "O" ring in flywheel groove.

(25) 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°).

(26) Measure crankshaft end play with a dial gauge. Crankshaft end play should not exceed .153 to .304mm (.0060 to .0119 in.) (Fig. 71).



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Fig. 71 Measuring Crankshaft End Play

CAUTION: Use NEW flywheel bolts for the following procedure.

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

- a. Lubricate and install the 6 new flywheel bolts.
- b. Torque the 6 flywheel bolts to 49 N·m (36 ft. lbs.) starting one bolt and following with the opposite one (cross tightening) until completion, in a clockwise direction..

c. Loosen one bolt at a time and tighten to 19.6 N·m (14 ft. lbs.) plus 75° using the cross tightening method.

(28) Install the pistons and connecting rod assemblies. Refer to piston and connecting rods removal and installation in this section.

REMOVAL AND INSTALLATION (Continued)

(29) Install the oil pick up tube. Torque bolts to 25 N·m (18 ft. lbs.).

(30) Install the oil pan. Refer to oil pan removal and installation in this section.

(31) Install the vacuum pump, being careful to align the gear timing marks with those on the crankshaft gear. Torque screws to 20 N·m (15 ft. lbs.).

(32) Before installing the oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 72). Difference between A and B should be 0.020-0.082 mm (.0007 to 0032 in.).

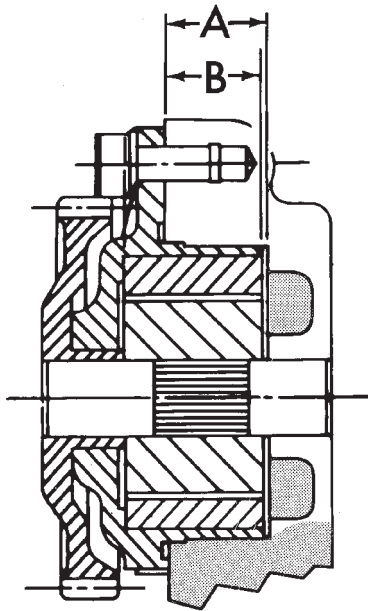


Fig. 72 Oil Pump Bore Depth

(33) Install the oil pump. Torque screws to 27 N·M (20 ft. lbs.). Check for normal backlash between pump and crankshaft gears.

(34) Install the timing gear cover. Refer to timing gear cover removal and installation in this section.

(35) Install the vibration damper. Refer to vibration damper removal and installation in this section.

(36) Install the cylinder heads. Refer to cylinder head removal and installation in this section.

(37) Install the rocker arms and push rods. Refer to rocker arm and push rod removal and installation in this section.

(38) Install the cylinder head cover. Refer to cylinder head cover removal and installation in this section.

(39) Install the accessory drive system.

(40) Install the engine in vehicle. Refer to engine removal and installation in this section.

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

(42) Connect the negative battery cable.

DISASSEMBLY AND ASSEMBLY

HYDRAULIC TAPPETS

DISASSEMBLE

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

ASSEMBLE

- (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.
- (4) Assemble tappets.

CLEANING AND INSPECTION

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. 73).

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 cylinder heads and end plates by a corresponding amount to maintain correct cylinder alignment.

CLEANING AND INSPECTION (Continued)

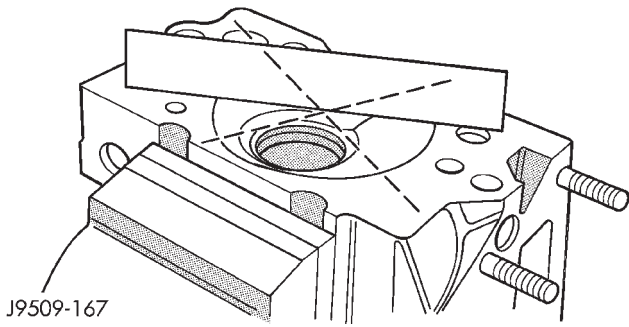


Fig. 73 Checking Cylinder Head Flatness

ROCKER ARMS AND PUSH RODS

CLEANING

Clean all the components (Fig. 74) with cleaning solvent.

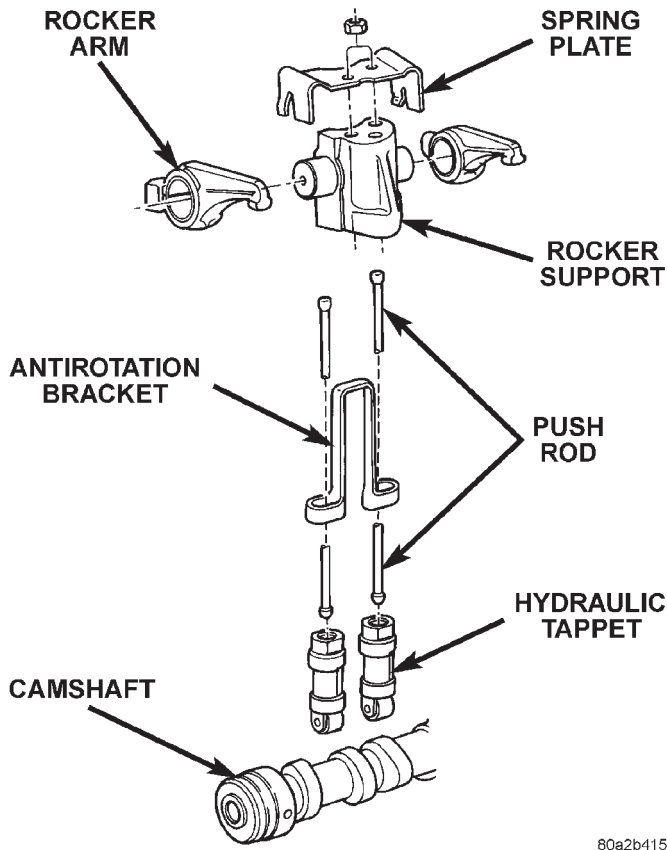


Fig. 74 Rocker Arm Components

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.

PISTONS AND CONNECTING ROD ASSEMBLY

INSPECTION—PISTONS

(1) Piston Diameter: Size Group A: 91.93-91.94mm (3.6191-3.6196 in.) Size Group B: 91.94-91.95mm (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 (.0019 in.).

(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.

INSPECTION—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 29N·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.

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.

CLEANING AND INSPECTION (Continued)

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°.

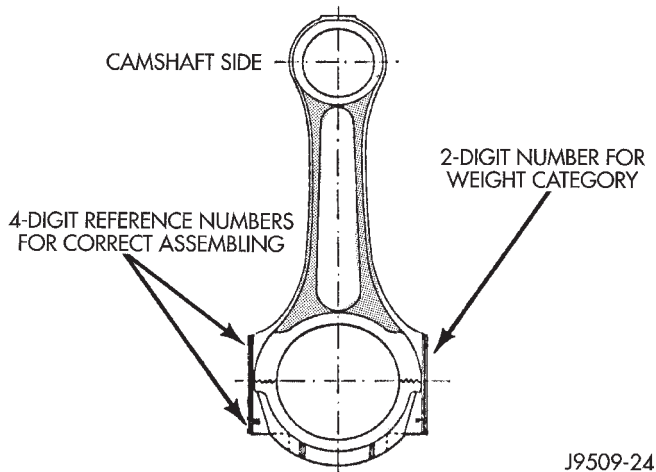


Fig. 75 Connecting Rod Identification

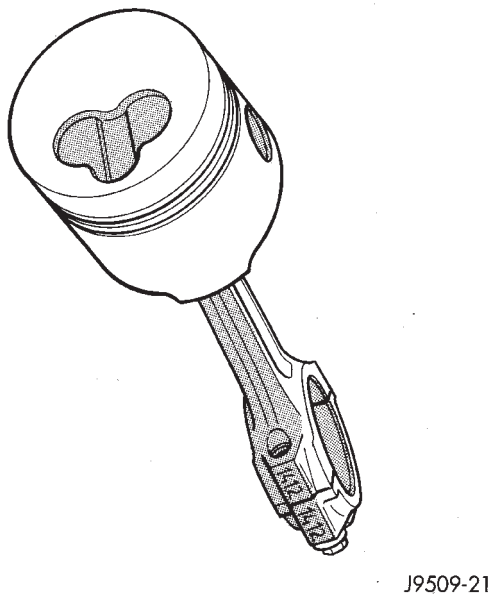


Fig. 76 Piston and Connecting Rod Assembly

INSPECTION—PISTON PIN

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

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

INSPECTION—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.).

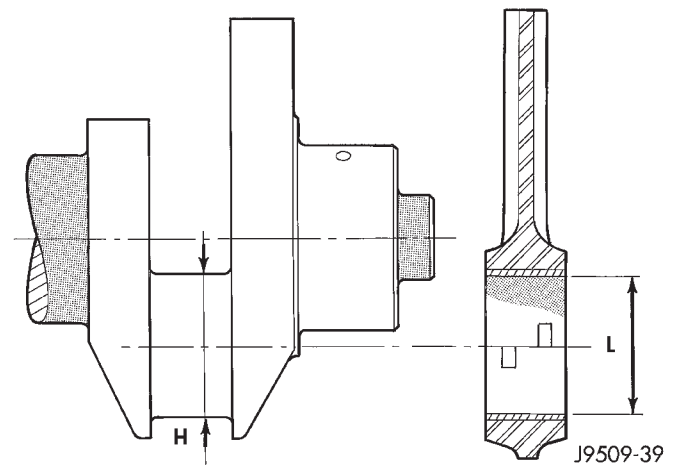


Fig. 77 Bearing Clearance

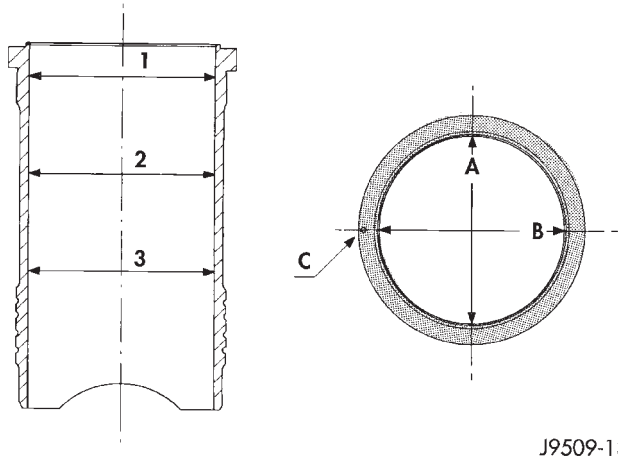
CYLINDER WALL LINER ASSEMBLY

INSPECTION

The cylinder walls should be checked for out-of-round and taper with dial 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.

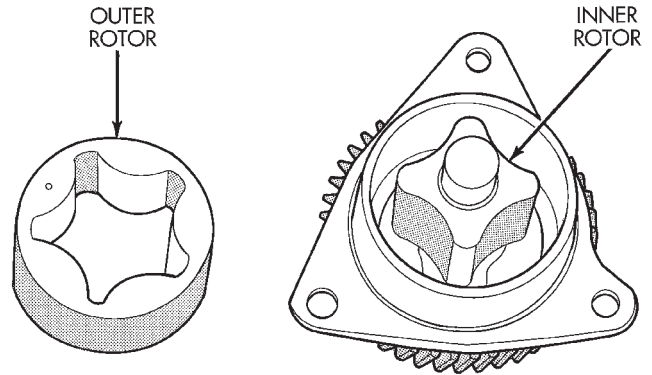
Measure the cylinder bore at three levels in directions A and B (Fig. 78). Top measurement should be 10 mm (3/8 inch) down and bottom measurement should be 10 mm (3/8 inch.) up from bottom of bore.

CLEANING AND INSPECTION (Continued)



J9509-13

Fig. 78 Liner Inspection



J9509-109

Fig. 80 Oil Pump Inner and Outer Rotors

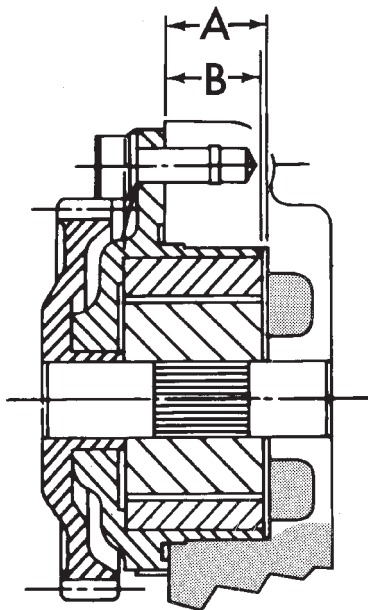
OIL PUMP

CLEANING

Wash all parts in a suitable solvent and inspect carefully for damage or wear.

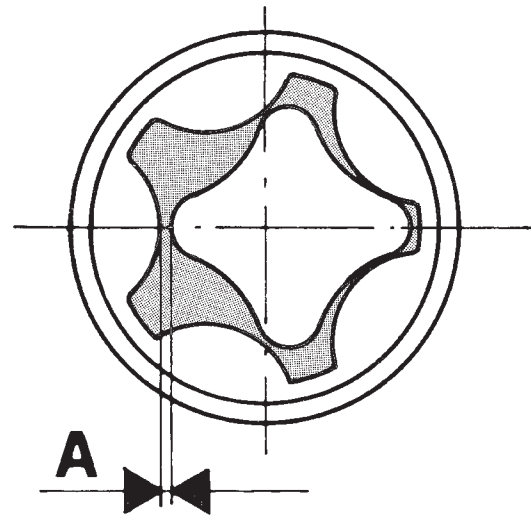
INSPECTION

(1) Before installing oil pump check pump bore depth in block (A) and pump body height (B) (Fig. 79). Difference between A and B should be 0.020-0.082 mm.



J9509-8

Fig. 79 Oil Pump Bore Depth



J9509-10

Fig. 81 Checking Rotor Clearance

(2) Check clearance between rotors (Fig. 81).

SPECIFICATIONS

ENGINE SPECIFICATIONS

Description	Specifications
Type	425CLIRX (23B)
Number of cylinders.....	4
Bore	92 mm
Stroke	94 mm
Capacity	2499.5 cm ³
Injection order.....	1-3-4-2
Compression ratio.....	21 : 1 (+/- 0.5)
Gasket.....	Asbestos free

Crankshaft

Front journal diameter	
Nominal	62.985-63.000 mm
-0.25	62.745-62.760 mm
-0.125.....	62.860-62.875 mm
Front bearing diameter	
Nominal	63.043-63.088 mm
-0.25	62.810-62.860 mm
-0.125.....	62.918-62.963 mm
Clearance between journal and bearing:	0.043-0.103
Center journal diameter	
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.....	63.550-62.968 mm
Clearance between journal and bearing:	0.030-0.088
Rear journal diameter	
Nominal	69.980-70.000 mm
-0.25	69.735-69.750 mm
-0.125.....	69.855-69.875 mm
Rear bearing diameter	
Nominal	70.030-70.055 mm
-0.25	69.780-69.805 mm
-0.125.....	69.905-69.980 mm
Clearance between journal and bearing:	0.030-0.075
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
Wear limit:	0.200 mm

Description	Specifications
Crankshaft end play	
End play	0.153-0.304 mm
Adjustment.....	Thrust washers
Thrust washers available:	
	2.311-2.362 mm
	2.411-2.462 mm
	2.511-2.562 mm

Main bearing carriers

Internal diameter	
Front	67.025-67.050 mm
Center	66.670-66.687 mm
Rear	75.005-75.030 mm

Liners

Internal diameter	92.000-92.010 mm
Protrusion	0.01-0.06 mm
Adjustment.....	Shims
Available shims:	
	0.15 mm
	0.17 mm
	0.20 mm
	0.23 mm
	0.25 mm

Cylinder head

Minimum thickness	89.95-90.05 mm
Gaskets thickness:	
	1.42 mm +/- 0.04, 0 notches
	1.62 mm +/- 0.04, 1 notches
	1.52 mm +/- 0.04, 2 notches
End plates:	
Height	91.26-91.34 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	53.977-54.016 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 Fit gasket
	Number (1.42),0 notches
	0.73 - 0.82 Fit gasket
	Number (1.62),1 notches
	0.63 - 0.72 Fit gasket
	Number (1.52),2 notches

SPECIFICATIONS (Continued)

Description	Specifications
-------------	----------------

Piston pins
 Type.....Fully floating
 Pin diameter.....29.990-29.996 mm
 Clearance.....0.039-0.060 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
 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.....53.495-53.51 mm
 Bearing clearance.....0.030-0.095 mm
 Center.....53.45-53.47 mm
 Bearing clearance.....0.07-0.14 mm
 Rear.....53.48-53.50 mm
 Bearing clearance.....0.04-0.11 mm

Tappets
 Outside diameter.....14.965-14.985 mm

Rocker gear
 Shaft diameter.....21.979-22.00 mm
 Bush internal diameter.....22.020-22.041 mm
 Assembly clearance.....0.020-0.062 mm

Valves
 Intake valve:
 Opens.....22° B.T.D.C.
 Closes.....46° A.B.D.C.
 Exhaust valve:
 Opens.....60° B.B.D.C.
 Closes.....24° A.T.D.C.

Description	Specifications
-------------	----------------

Face angle:
 Intake.....56° - 56° 20`
 Exhaust.....45° 25` - 45° 35`
 Head diameter:
 Intake.....40.05-40.25 mm
 Exhaust.....33.8-34.0 mm
 Head stand down:
 Intake.....0.88-1.14 mm
 Exhaust.....0.99-1.25 mm
 Stem diameter:
 Intake.....7.940-7.960 mm
 Exhaust.....7.922-7.940 mm
 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 mm

Valve springs
 Free length.....44.65 mm
 Fitted length.....38.6 mm
 Load at fitted length.....34 +/- 3% Kg
 Load at top of lift.....92.5 +/- 3% Kg
 Number of coils.....5.33 Valve timing

Lubrication
 System pressure
 at 4000 rev/min.....3.5 to 5.0 bar (oil at 90-100°C)
 Pressure relief valve opens.....6.38 bar
 Pressure relief valve spring - free length.....57.5 mm

Oil pump:
 Outer rotor end float.....0.02-0.08 mm
 Inner rotor end float.....0.02-0.08 mm
 Outer rotor to body diam. clearance.....0.130-0.230 mm
 Rotor body to drive gear clearance
 (pump not fitted).....0.30 - 0.56 mm

SPECIFICATIONS (Continued)

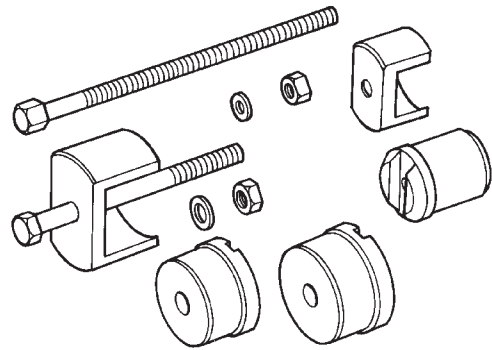
TORQUE SPECIFICATIONS

DESCRIPTION	TORQUE
Adaptor Plate to Block	
Nuts (6)	26.5 N·m (20 ft. lbs.)
Automatic Belt Tensioner to Block	
Bolts (2)	121 N·m
Automatic Belt Tensioner to Mounting Bracket	
Bolt (1)	75 N·m
Generator belt	
Tensioner	79 N·m
Generator bracket	
Mounting bolts (6 mm)	10 N·m
Mounting bolts (8 mm)	24.4 N·m
Generator	
Mounting bolt	47 N·m
Camshaft thrust plate	
Bolts	24 N·m
Connecting rod	
Mounting bolt	29.5 N·m +60°
Crankshaft bearing	
Carrier screw	42 N·m
Crankshaft pulley	
Locknut	160 N·m
Crossmember	
Bolts	42 N·m
Diesel delivery	
Union nut	18.5 N·m
EGR valve	
To intake manifold	26 N·m
EGR tube	
To EGR valve	26 N·m
Engine mount—Front	
Engine support bracket	61 N·m
Support Cushion	47 N·m
Support cushion bracket bolts	54 N·m
Support cushion bracket stud nuts	41 N·m
Support Cushion through bolt	65 N·m
Engine mount—Rear	
Transmission support bracket	46 N·m
Support Cushion nuts	75 N·m
Support Cushion through bolt	65 N·m
Exhaust down pipe	
To turbocharger	22 N·m
Exhaust heat shield	
Screws	11 N·m
Exhaust manifold collar	
Mounting nut	24.5 to 29.5 N·m
Exhaust manifold	
Mounting nut	32.5 N·m
Fan drive	
To fan hub	56 N·m
Flywheel	
Lock bolt	20 N·m +60°

DESCRIPTION	TORQUE
Front timing cover	
6 mm bolts	10 N·m
8 mm bolts	26 N·m
Fuel filter	
Nuts	28 N·m
Glow plug	
Torque	13.0 N·m
Idler pulley bracket	
Bolts	40 N·m
Idler pulley	
Bolt (left hand thread)	47 N·m
Injection pump fuel lines	
Nut	23 N·m
Injection pump gear	
Lock nut	86 N·m
Injection pump	
Mounting nut	27.5 N·m
Injector	
Torque	68.5 N·m
Intake manifold	
Mounting nut	32.5 N·m
Main bearing oil delivery	
Union	54 N·m
Water hose to cylinder head	
Nut	8 to 10 N·m
Oil cooler adaptor	
Bolt	60 N·m
Oil feed line	
For rocker arms	12 N·m
To block	27 N·m
To vacuum pump	15 N·m
Oil filter	
Torque	18 N·m
Oil filter adapter	
Torque	46.6 N·m
Oil filter base	
Torque	46.6 N·m
Oil pan	
Mounting bolts	13 N·m
Oil pickup tube	
Torque	25 N·m
Oil pump	
Mounting screw	27 N·m
Oil sump drain plug	
Torque	54 N·m
Power steering pressure hose	
Nut	28 N·m
Power steering pulley	
Nut	130 N·m
Rear crankshaft bearing carrier Allen Bolts	
Torque	11 N·m
Rocker cover	
Bolts	19 N·m

SPECIFICATIONS (Continued)

DESCRIPTION	TORQUE
Rocker mounting	
Lock Nut	35 N·m
Steering pump	
Bolts	28 N·m
Turbocharger	
Mounting nuts	32.5 N·m
Turbocharger	
Oil delivery fitting	27.5 N·m
Turbocharger oil drain	
Plug	10.8 N·m
Vacuum pump	
Torque	27 N·m
Water manifold	
Bolts	12 N·m
Water pump pulley	
Nut	27 N·m

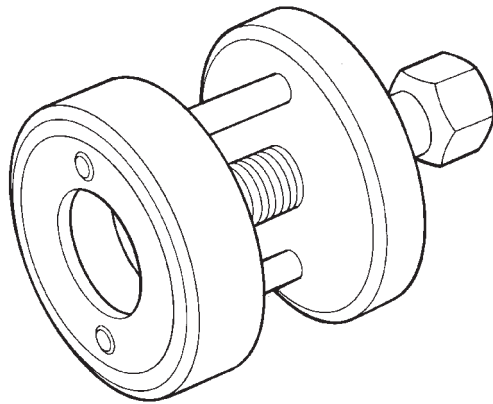


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Crankshaft Bearing Remover/Replacer VM. 1002

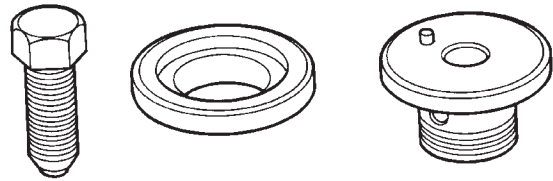
SPECIAL TOOLS

SPECIAL TOOLS



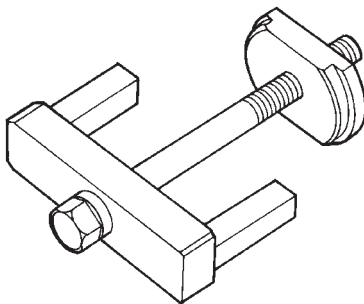
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Crankshaft Pulley and Gear Remover VM. 1000A



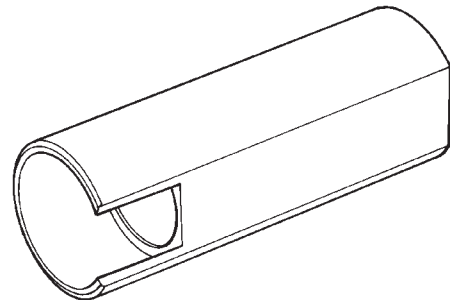
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Injection Pump Puller and Gear Retainer VM. 1003



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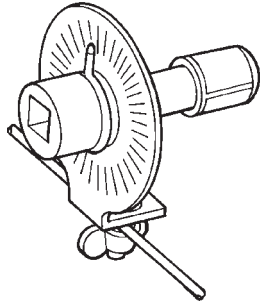
Cylinder Liner Puller VM, 1001



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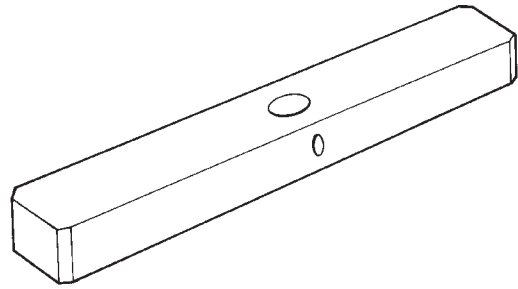
Crankshaft Remover/Replacer Sleeve VM. 1004

SPECIAL TOOLS (Continued)



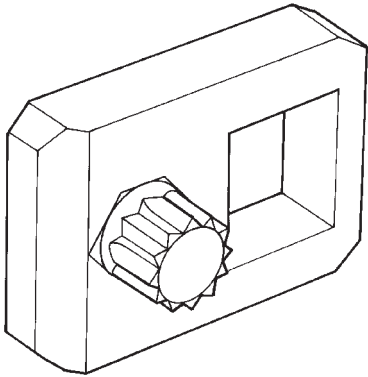
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Torque Angle Gauge VM. 1005



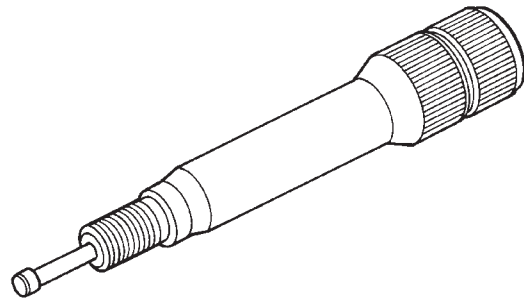
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Cylinder Liner Protrusion Tool VM. 1010



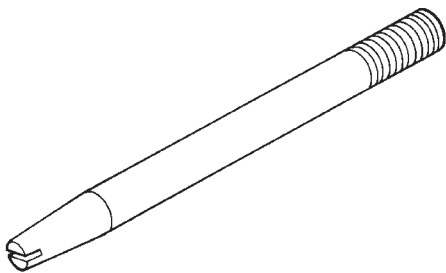
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Cylinder Head Bolt Wrench VM. 1006A



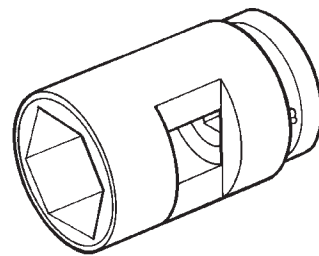
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Bosch Pump Timing Adapter VM. 1011



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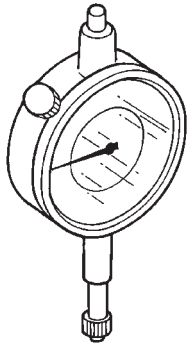
Cylinder Head Guide Studs VM. 1009



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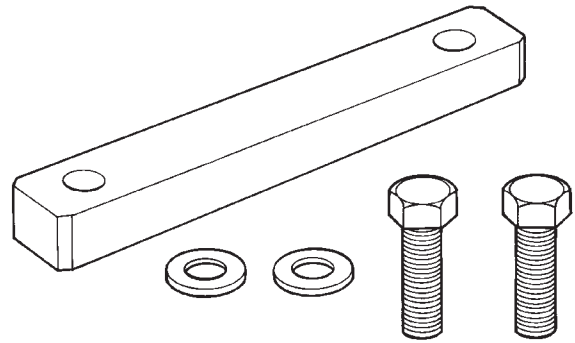
Injector Remover/Replacer Socket VM. 1012

SPECIAL TOOLS (Continued)



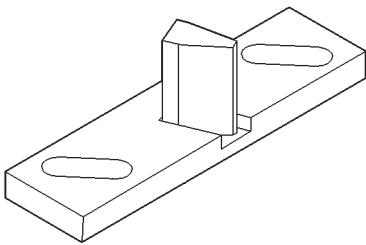
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Dial Indicator Gauge VM. 1013

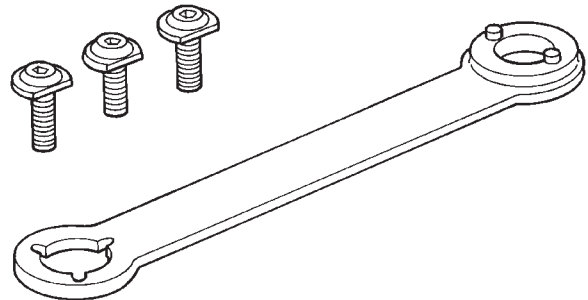


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Cylinder Retainer VM. 1016

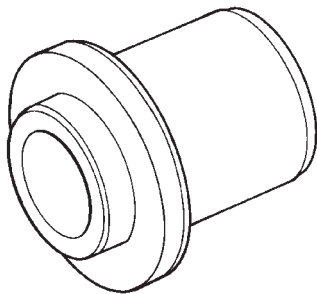


Flywheel Locking Tool VM. 1014



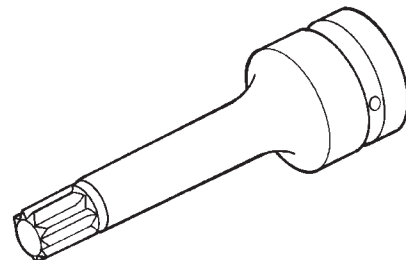
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Crankshaft and Water Pump Pulley Holder VM. 1017



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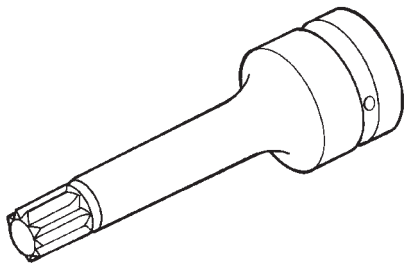
Timing Cover Oil Seal Replacer VM. 1015



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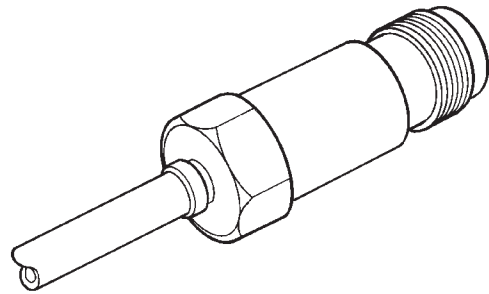
Cylinder Head Bolt Wrench M12 VM. 1018

SPECIAL TOOLS (Continued)



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Cylinder Head Bolt Wrench M14 VM. 1019



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Cylinder Leakage Tester Adapter VM. 1021