

SECTION 6A1-1 - ENGINE MECHANICAL – V6 ENGINE

IMPORTANT

Before performing any Service Operation or other procedure described in this Section, refer to Section 00 CAUTIONS AND NOTES for correct workshop practices with regard to safety and/or property damage.

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1. GENERAL DESCRIPTION

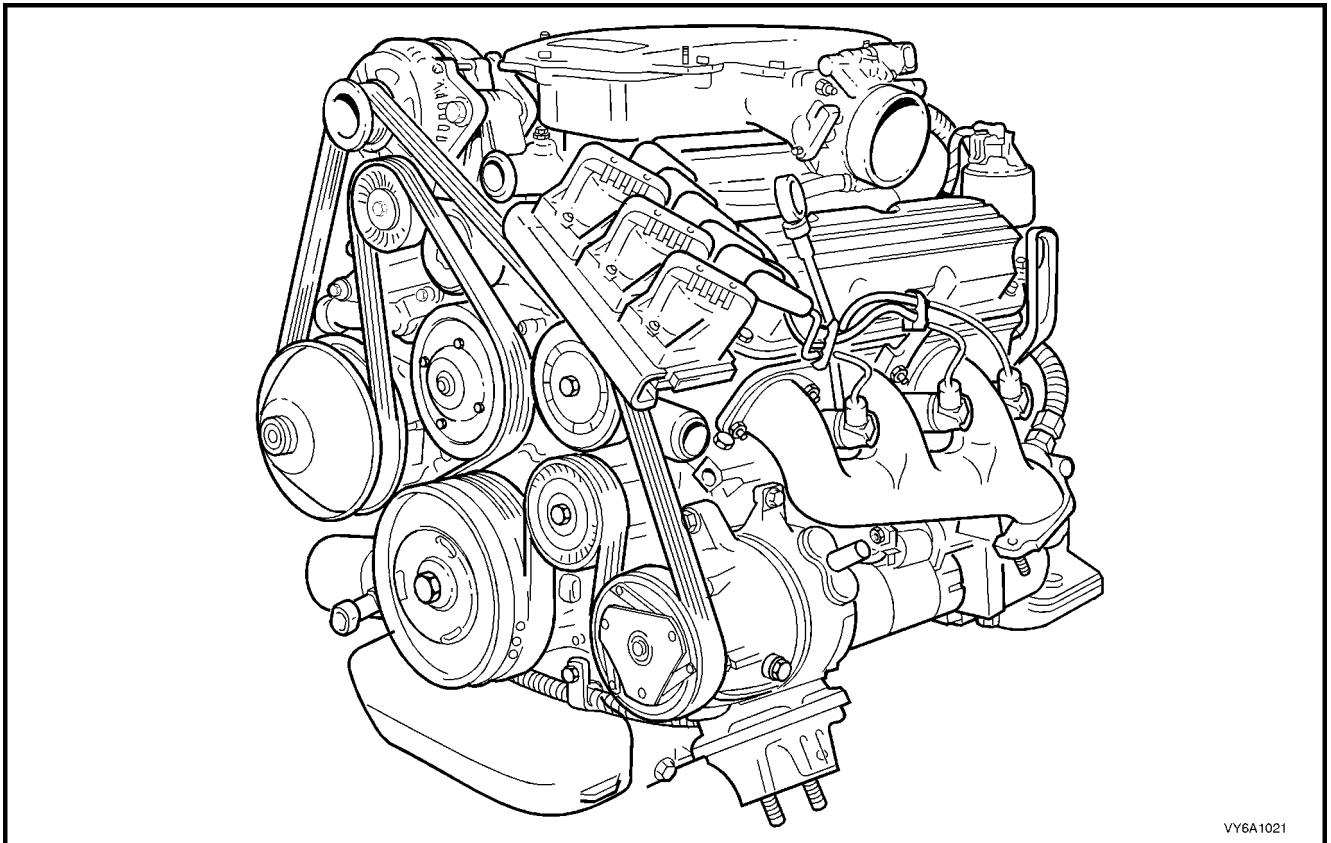
The 3.8 litre, 3800 engine (production option LN3) for MY 2003 VY and V2 Series Models, is a 90 degree, V6, overhead valve unit with a 96.52 mm bore and 86.36 mm stroke, displacing 3791 cm³ with a compression ratio of 9.35:1.

Engine features include, light weight, increased torque and horsepower, and a rigid valve train incorporating beehive shaped valve springs for greater valve control. All combustion chambers and intake/exhaust ports are symmetrical for more even firing pressures, reduced emissions.

An EGR valve is fitted, to control engine exhaust emissions.

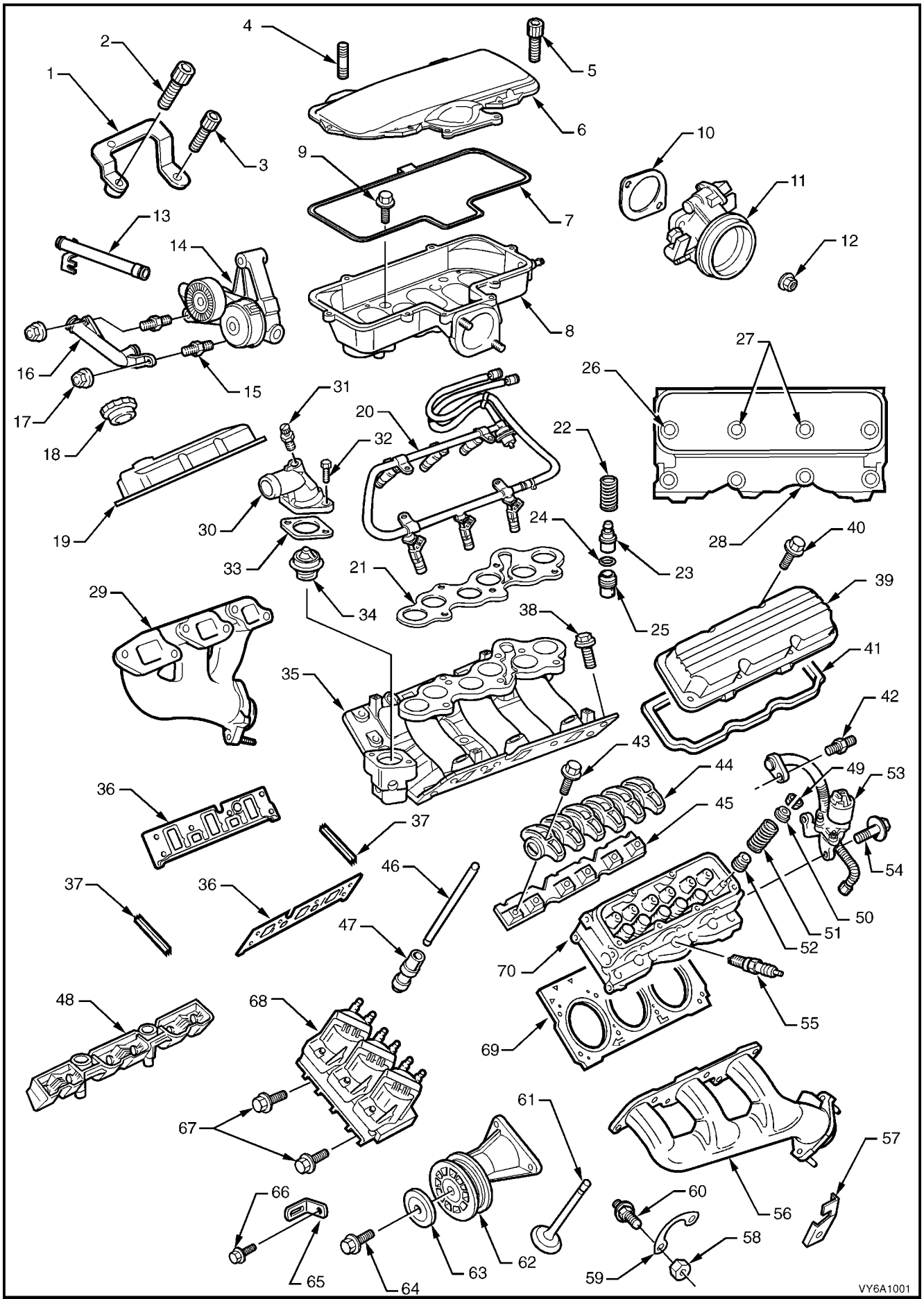
Fuel injection is sequential with an upper and lower intake manifold, the upper manifold supporting a plenum chamber with the throttle body mounted on the left hand side

A stiffened engine block and side bolted main bearing caps along with an insulated engine dress cover contribute to engine quietness.



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Figure 6A1-1-1

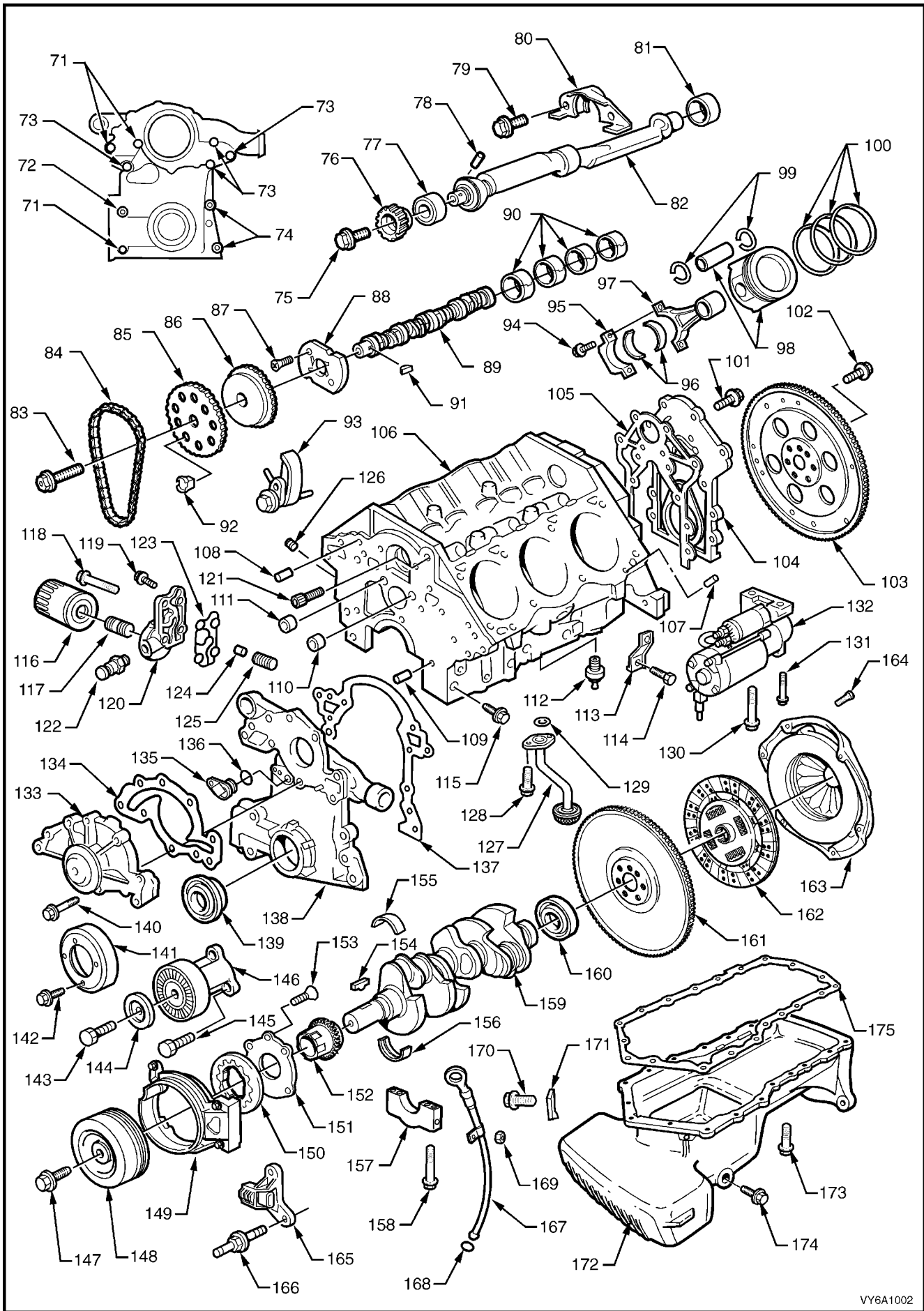


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Figure 6A1-1-2

Legend

1. Generator Brace Bracket
2. Bolt
3. Bolt
4. Double Ended Stud
5. Cover Bolt
6. Upper Intake Manifold Cover
7. Upper Intake Manifold Cover O-Ring Seal
8. Upper Intake Manifold
9. Bolt
10. Throttle Body to Intake Manifold Gasket
11. Throttle Body
12. Nut
13. Heater Outlet Pipe
14. Drive Belt Tensioner Assembly
15. Stud
16. Coolant Intake Tube
17. Nut
18. Oil Filler Cap
19. Right Hand Rocker Cover
20. Injector and Fuel Rail Assembly
21. Gasket
22. Crankcase Vent Valve Spring
23. Crankcase Vent Valve
24. Crankcase Vent Valve O-ring
25. Oil separation Baffle
26. Cylinder Head Upper Outer Bolt
27. Cylinder Head Upper Inner Bolt
28. Cylinder Head Lower Bolt
29. Right Hand Exhaust Manifold
30. Coolant Outlet
31. Air Vent Valve
32. Bolt
33. Thermostat Gasket
34. Thermostat
35. Lower Intake Manifold
36. Intake Manifold to Cylinder Head Gasket
37. Intake Manifold Seal
38. Bolt
39. Left Hand Rocker Cover
40. Rocker Cover Fastener
41. Rocker Cover Seal
42. Stud – EGR Pipe to Throttle Body
43. Rocker Arm Pedestal Bolt
44. Rocker Arm Assembly
45. Rocker Arm Retainer
46. Rocker Arm Pushrod
47. Lifter
48. Lifter Guide
49. Valve Collet
50. Valve Spring Cap
51. Valve Spring
52. Valve Stem Seal
53. Exhaust Gas Recirculation (EGR) Valve
54. Bolt
55. Spark Plug
56. Left Hand Exhaust Manifold
57. Spark Plug Lead Support Bracket
58. Nut
59. Bolt Lock Plate
60. Stud – Exhaust Manifold
61. Valve
62. Idler Pulley and Support
63. Idler Pulley Retaining Plate
64. Pulley to Housing Bolt
65. Engine Harness Retaining Bracket
66. Idler Pulley Housing Bolt
67. Bolts – DIS Module to Cylinder Head
68. DIS Ignition Coil/Module Assembly.
69. Cylinder Head Gasket
70. Cylinder Head



VY6A1002

Figure 6A1-1-3

Legend

- 71. Bolts
- 72. Stud
- 73. Bolts
- 74. Studs
- 75. Bolt
- 76. Balance Shaft Driven Gear
- 77. Balance Shaft Front Ball Bearing
- 78. Pin
- 79. Bolt
- 80. Balance Shaft Retainer
- 81. Balance Shaft Rear Bearing
- 82. Balance Shaft
- 83. Bolt
- 84. Timing Chain
- 85. Camshaft Sprocket
- 86. Balance Shaft Drive Gear
- 87. Screw
- 88. Camshaft Thrust Plate
- 89. Camshaft
- 90. Camshaft Bearings
- 91. Key
- 92. Camshaft Position Sensor Magnet
- 93. Timing Chain Dampener
- 94. Cap Bolt
- 95. Connecting Rod Cap
- 96. Connecting Rod Bearings
- 97. Connecting Rod
- 98. Piston and Pin Assembly
- 99. Circlips
- 100. Piston Rings
- 101. Bolt
- 102. Bolt
- 103. Flexplate
- 104. Crankshaft Rear Oil Seal Housing
- 105. Crankshaft Rear Oil Seal Housing Gasket
- 106. Cylinder Block
- 107. Cylinder Head Locater Pin
- 108. Engine Front Cover Locater Pin
- 109. Engine Front Cover Locater Pin
- 110. Cup Plug
- 111. Cup Plug
- 112. Knock Sensor
- 113. Knock Sensor Shield Support Bracket
- 114. Bolt
- 115. Main Bearing Cap Bolt - Side
- 116. Oil Filter
- 117. Oil Filter Adaptor Stud
- 118. Bolt
- 119. Screw
- 120. Oil Filter Adaptor
- 121. Special Torque Axis Screw
- 122. Oil pressure Switch
- 123. Oil Filter Adaptor Seal
- 124. Pressure Regulator Valve
- 125. Pressure Regulator Spring
- 126. Plug
- 127. Oil Suction Pipe and Screen
- 128. Bolt
- 129. O-Ring
- 130. Bolt Long
- 131. Bolt Short
- 132. Starter Motor
- 133. Coolant Pump
- 134. Coolant Pump Gasket
- 135. Camshaft Position Sensor
- 136. O-Ring
- 137. Front Cover Gasket
- 138. Front Cover
- 139. Crankshaft Front Seal
- 140. Bolt
- 141. Coolant Pump Pulley
- 142. Bolt
- 143. Bolt
- 144. Idler Pulley Plate
- 145. Bolt
- 146. Idler Pulley (with Air Conditioning)
- 147. Bolt
- 148. Harmonic Balancer
- 149. Shield
- 150. Oil Pump Gears
- 151. Oil Pump Cover
- 152. Crankshaft Sprocket
- 153. Screw
- 154. Sprocket Key
- 155. Main Bearing Upper Shell
- 156. Main Bearing Lower Shell
- 157. Main Bearing Cap
- 158. Main cap Bolt
- 159. Crankshaft
- 160. Rear Main Oil Seal
- 161. Flywheel
- 162. Clutch Driven Plate
- 163. Pressure Plate and Cover Assembly
- 164. Bolt
- 165. Crankshaft Position Sensor
- 166. Crankshaft Position Sensor Stud
- 167. Dipstick and Tube Assembly
- 168. O-Ring
- 169. Nut
- 170. Bolt
- 171. Wiring Harness Support Bracket
- 172. Oil pan
- 173. Bolt
- 174. Drain Plug
- 175. Oil Pan Gasket

1.1 ENGINE SERIAL NUMBER

The engine serial number is stamped on the engine block front left hand face.

The engine number is prefixed by a two letter code: VH.

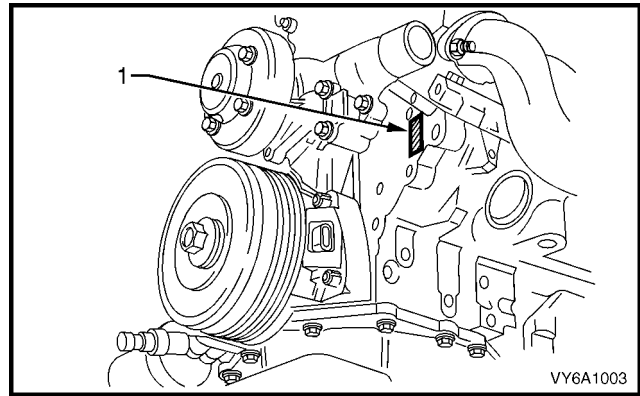


Figure 6A1-1-4

1.2 ENGINE CONSTRUCTION

CYLINDER BLOCK

The cylinder block is made of cast iron. It has six cylinders arranged in a 90 degree V-shape with three cylinders in each bank.

The cylinder numbering is as shown in Figure 6A1-1-5.

Firing order is 1-6-5-4-3-2.

Four main bearings support the crankshaft which is retained by bearing caps that are machined with the block for proper alignment and clearances. The three front main bearing caps are side bolted for increased stiffness. Cylinders are completely encircled by coolant jackets.

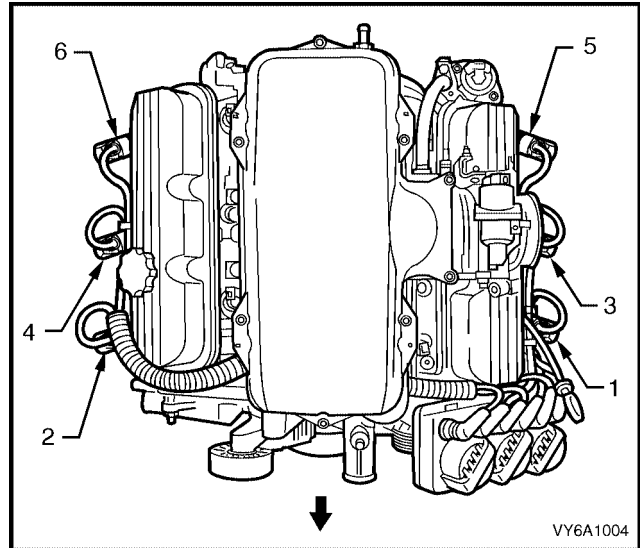


Figure 6A1-1-5

CYLINDER HEADS

Each cylinder head (3) is cast iron and incorporates integral valve guides and individual exhaust and intake ports for each cylinder. The cylinder head features symmetrical ports and combustion chambers

Right and left hand cylinder heads are identical and interchangeable, although in service, it is good practice to reinstall cylinder heads on the side from which they were removed.

Legend:

1. Intake Valve
2. Exhaust Valve
3. Cylinder Head

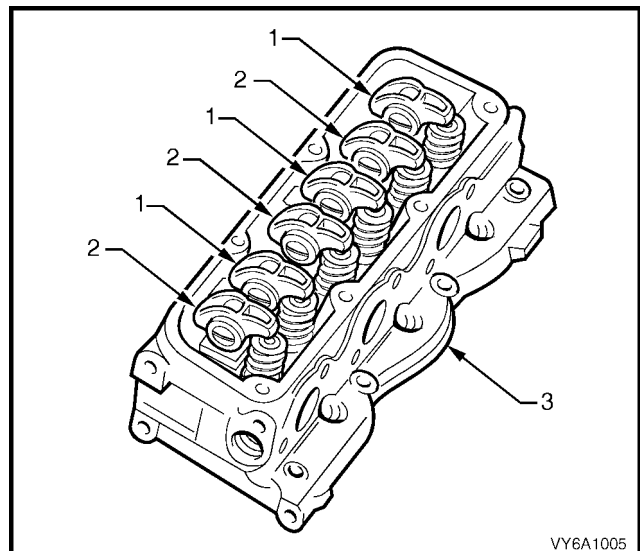


Figure 6A1-1-6

CRANKSHAFT

The crankshaft (1) is cast nodular iron with rolled fillets. It is supported by four main bearings, with each bearing being specific (except No. 1 and No. 4 upper bearing shells having the same design), with No. 2 main bearing taking crankshaft end thrust.

The crankshaft is counter balanced by weights cast integral with the crankshaft. Additional counter balancing is obtained from the flywheel, crankshaft balancer and a balance shaft (2) which is located in the cylinder block, above the camshaft (3). The balance shaft (2) is gear driven by the camshaft (3).

The 3800 V6 engine is even-firing, i.e. the cylinder firing is at equal 120 degree intervals of crankshaft rotation. The location of the crankpins are displaced by an included angle of 30 degrees (1) in order to fire the cylinders at equal 120 degree intervals of crankshaft rotation.

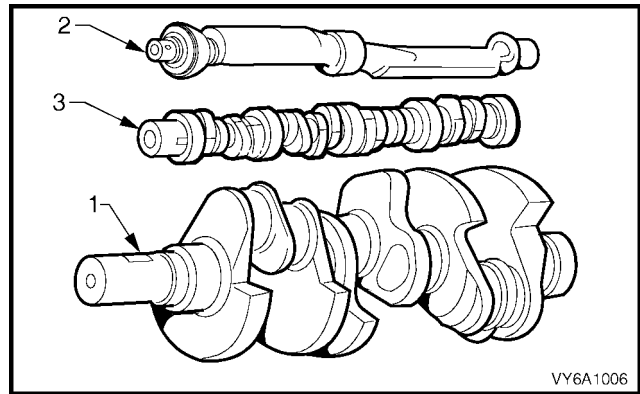


Figure 6A1-1-7

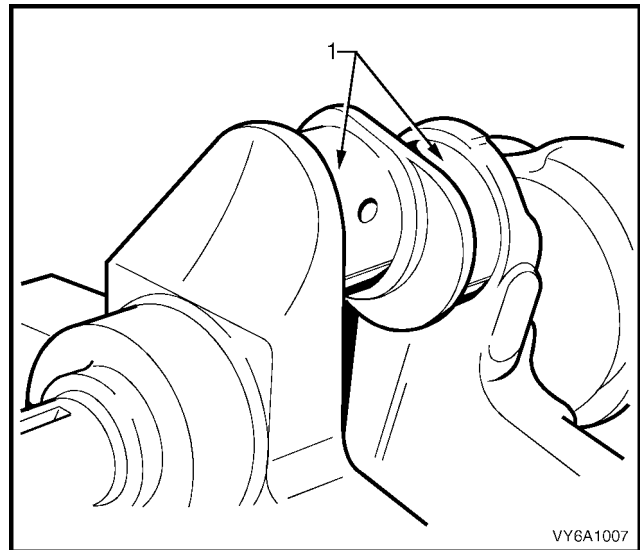


Figure 6A1-1-8

The crankshaft is common for both automatic and manual transmissions. A spigot bearing (1) and flywheel locating dowel pins are installed into the rear of the crankshaft when manual transmission is used.

One of the bolt holes in the crankshaft and flywheel/ flexplate is offset to allow assembly to the crankshaft in one position only.

The flywheel/flexplate is held to the crankshaft by eight bolts ('2' and '3'). The attaching bolts are to be used only once, and if removed, must be replaced.

Where required, engine balance weights (4) are fitted in the location shown.

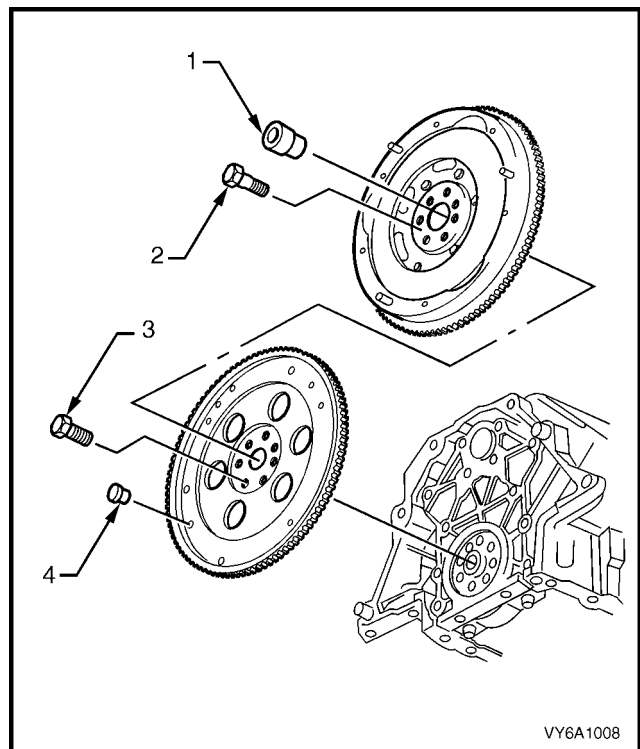


Figure 6A1-1-9

PISTONS AND CONNECTING RODS

Pistons (3) are of a lightweight, low friction short skirt design with floating pins (1), dished crowns and are cast from aluminium alloy and machined.

Each piston has two compression rings and one oil control ring. Two transverse slots in the piston wall and permit drain back of oil collected by the oil ring.

Piston pins (1) are offset toward the major thrust side of the piston (left hand side, as viewed from the front of the engine) to provide a gradual change in thrust pressure against the cylinder wall as the piston travels its path.

Pistons pins (1) are case-hardened and have a floating fit in the piston (3) and the connecting rod (4).

Connecting rods (4) are cast malleable iron with a bushed small end for the floating piston pin. Bearing caps are held in place on the connecting rods by attaching bolts.

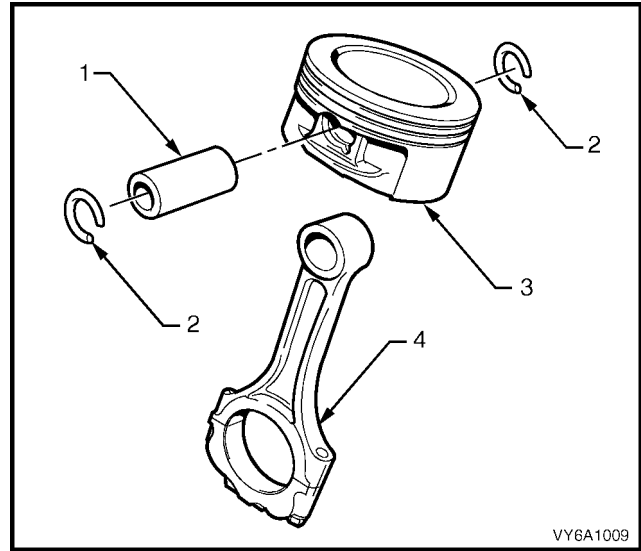


Figure 6A1-1-10

CAMSHAFT AND DRIVE

The camshaft (5) is steel and supported by four aluminium lead bearings.

It is driven by the crankshaft sprocket (8), keyed (7) to the nose of the crankshaft and chain (1) at the front of the engine. Both the crankshaft (8) and camshaft (3) sprockets have timing marks to set the correct valve timing.

A magnet, fitted to the camshaft (3) sprocket, is used by the camshaft sensor, located in the front cover, to detect the position of the camshaft.

The Powertrain Control Module (PCM) uses this information to control the fuel injectors. Refer to [Section 6C1 POWERTRAIN MANAGEMENT - V6 ENGINE](#).

The balance shaft is driven by the drive gear (4), that is keyed (6) to the camshaft (5).

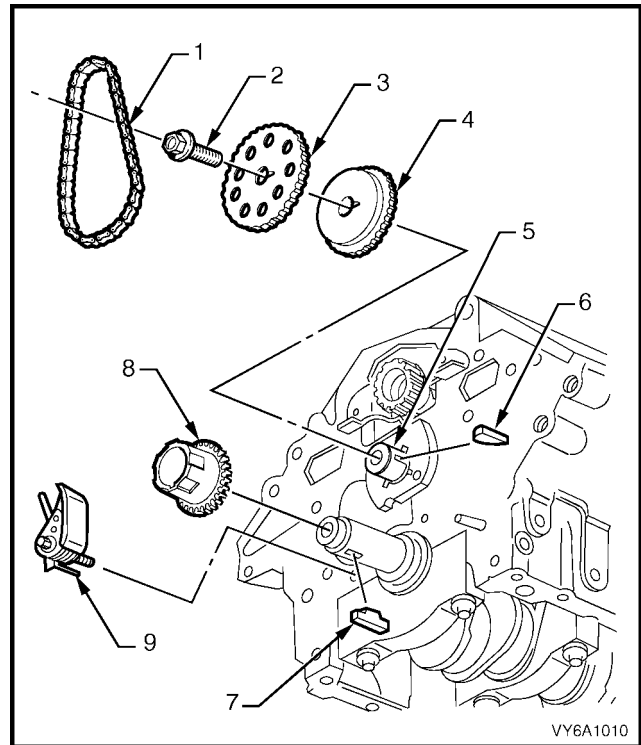


Figure 6A1-1-11

BALANCE SHAFT

A counter rotating cast iron balance shaft is installed in the cylinder block. It is located in the lifter valley of the cylinder block above, and parallel to, the camshaft. The balance shaft is gear driven by the camshaft, at crankshaft speed, and resolves primary rotational imbalance for improved engine smoothness. The shaft has a ball bearing at the front and plain rear bearing journal at the rear.

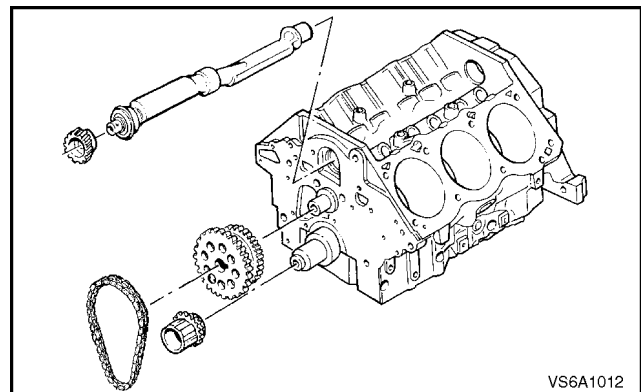


Figure 6A1-1-12

INTAKE MANIFOLD

The intake manifold is a three piece aluminium construction and is bolted to the inner faces of both cylinder heads so that it connects with all intake ports.

Provision is made for the mounting of the fuel injectors and fuel rail assembly, throttle body, thermostat and coolant outlet.

Legend:

1. Upper Intake Manifold Cover
2. Upper Intake Manifold Cover O-Ring Seal
3. Upper Intake Manifold
4. Throttle Body to Intake Manifold Gasket
5. Throttle Body
6. Injector and Fuel Rail Assembly
7. PCV Valve Components
8. Upper to Lower Intake Manifold Gasket
9. Coolant Outlet
10. Thermostat
11. Lower Intake Manifold

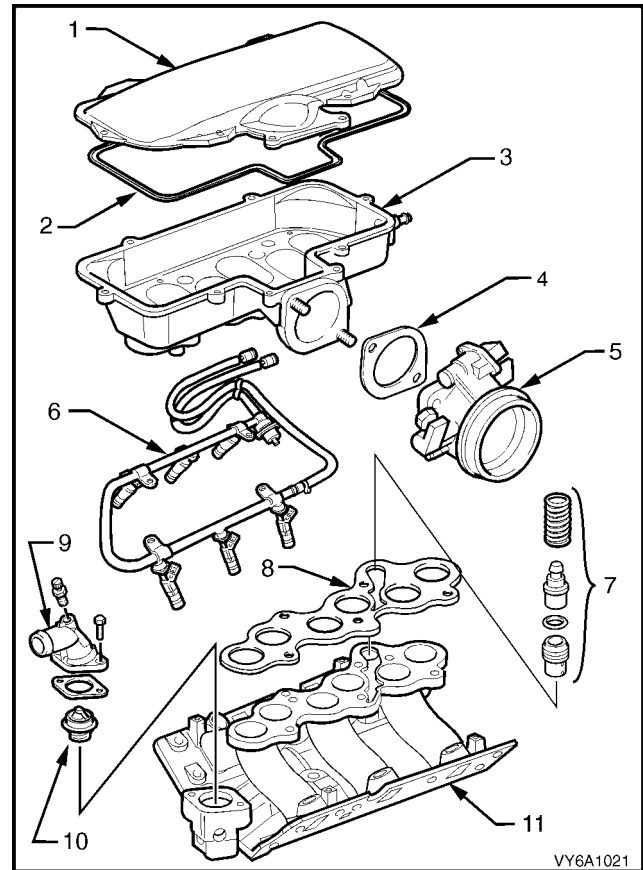


Figure 6A1-1-13

VALVE TRAIN

The valve rocker arms for each bank of cylinders, pivot on roller bearings. The rocker arms are kept in alignment by a single retainer (1) on each cylinder head.

Hydraulic, roller valve lifters and tubular push rods are used to operate overhead rocker arms and valves for both banks of cylinders from a single camshaft. This system requires no lash adjustment at time of assembly or in service.

Intake and exhaust valves feature "beehive" shaped valve springs for greater valve control.

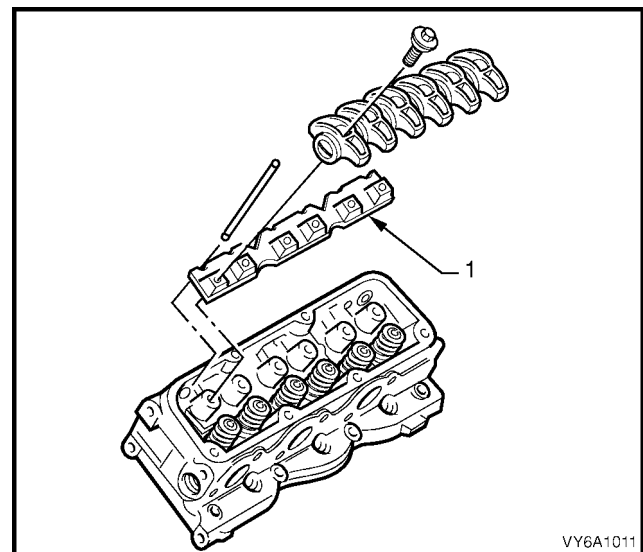


Figure 6A1-1-14

HYDRAULIC VALVE LIFTER OPERATION

In addition to its normal function of a cam follower, each hydraulic valve lifter also serves as an automatic adjuster which maintains zero lash in the valve train under all operating conditions. By eliminating all lash in the valve train and also providing a cushion of oil to absorb operating shocks, the hydraulic valve lifter promotes quiet valve operation. It also eliminates the need for periodic valve adjustment to compensate for wear of parts.

Oil is supplied to the lifter through a hole in the side of the lifter body which indexes with a groove and hole in the lifter plunger. Oil is then metered past the metering valve in the lifter, through the push rods to the rocker arms.

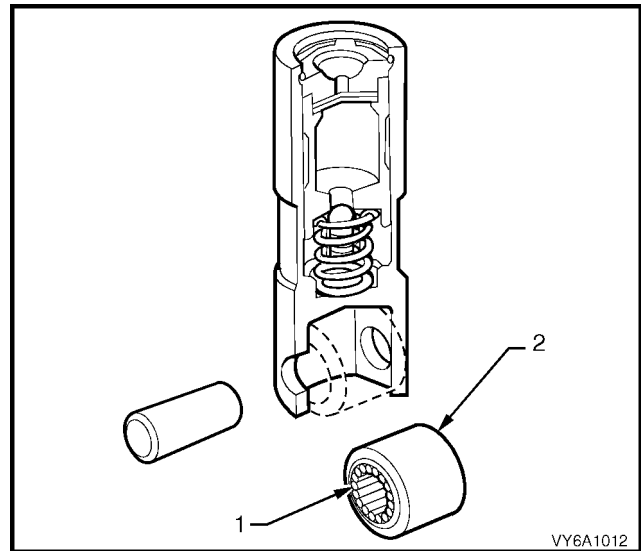


Figure 6A1-1-15

When the lifter begins to ride up the cam lobe, the check ball is held against its seat in the plunger by the check ball spring. The check ball traps the oil in the base of the lifter body below the plunger. The plunger and the lifter body then rise as a unit, pushing up the push rod to open the valve.

The force of the valve spring, which is exerted on the plunger through the rocker arm and push rod, causes a slight amount of leakage between the plunger and lifter body. This 'leak down' allows a slow escape of trapped oil in the base of the lifter body.

As the lifter rides down the other side of the cam lobe and reaches the base circle, or 'valve closed' position, the plunger spring quickly moves the plunger back (up) to its original position. This movement causes the check ball to open against the ball spring, and oil from within the plunger is drawn into the base of the lifter. This restores the lifter to zero lash.

For hydraulic valve lifter diagnosis, refer to [4.5 HYDRAULIC VALVE LIFTERS](#) in this Section.

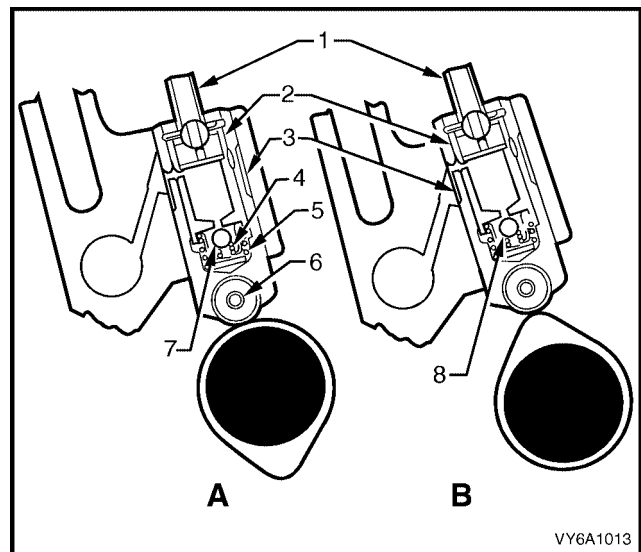


Figure 6A1-1-16

Legend

- A:** Engine Valve Closed
- B:** Engine Valve Open
- 1. Push Rod
- 2. Plunger
- 3. Lifter Body
- 4. Check Ball Spring
- 5. Plunger Return Spring
- 6. Roller
- 7. Check Ball Open
- 8. Check Ball Closed

EXHAUST MANIFOLDS

Two nodular cast iron exhaust manifolds (10) are used to direct exhaust gases from the combustion chambers to the exhaust system.

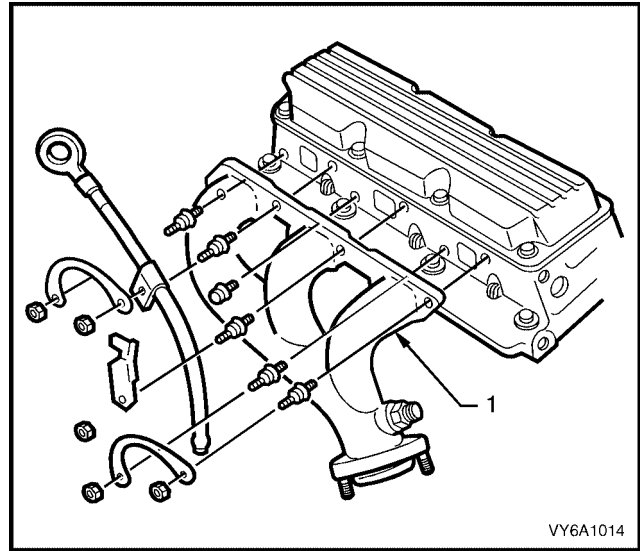


Figure 6A1-1-17

OIL PUMP

The oil pump assembly is integrated with the front cover assembly and retained there by the pump cover (1). The oil pump has "Gerotor" design gears (2) and is driven by the front end of the crankshaft sprocket. For details of oil pump operation, refer to [1.3 LUBRICATION](#) in this Section.

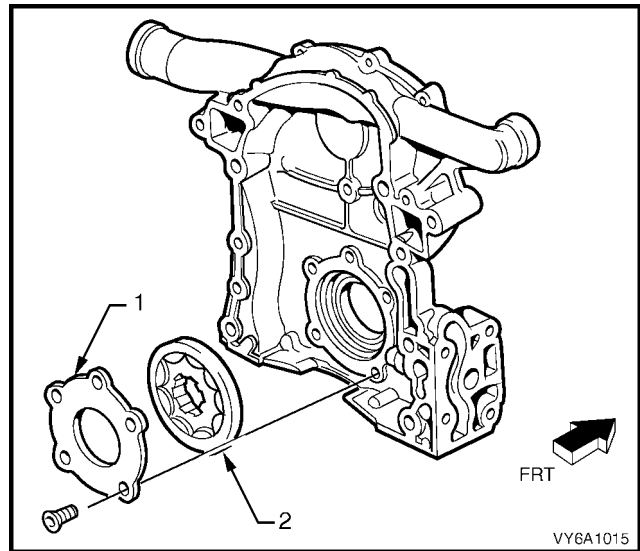


Figure 6A1-1-18

ACCESSORY DRIVE

The 3800 V6 engine employs a single serpentine belt (1) which drives each of the engine mounted accessories i.e. coolant pump, generator, power steering pump and if fitted, air conditioning compressor (as shown).

Each accessory drive pulley has six grooves which mate with the contours of the belt inner surface. The exception to this is the coolant pump pulley which is driven off the outer surface of the belt and, consequently, does not require grooves.

Drive belt tension is provided by a tensioner assembly (2). The tensioner is an idler pulley mounted on a spring-loaded arm that maintains the drive belt at the proper tension, without imposing undue loads on the various components.

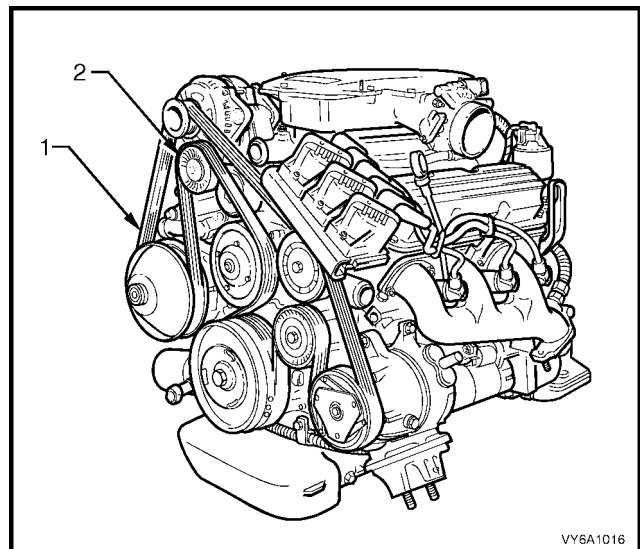


Figure 6A1-1-19

Throughout its functional travel, the tensioner mechanism will maintain correct belt tension, using a pulley (1) mounted to a spring loaded arm (6), that compensating for increases in belt wear and stretch.

When the indicator pointer (5) on the tensioner has reached minimum tension range (3), the tensioner has reached the full extent of its travel and replacement of the belt (2) is necessary.

The maximum tension range is shown as (4).

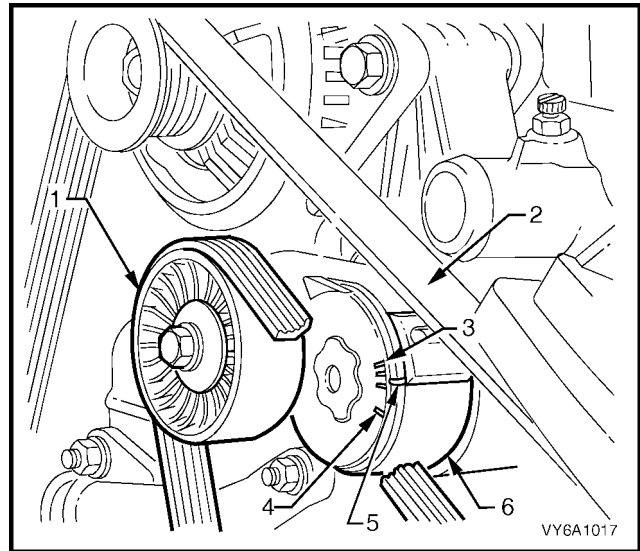


Figure 6A1-1-20

POWERTRAIN MOUNTING

Engine front mounts (1) are a hydraulic design which incorporate a rubber body and two connected, oil filled cavities (2). These mounts provide engine vibration damping by allowing oil transfer from one cavity to another via controlled orifices, similar in principle to a hydraulic shock absorber.

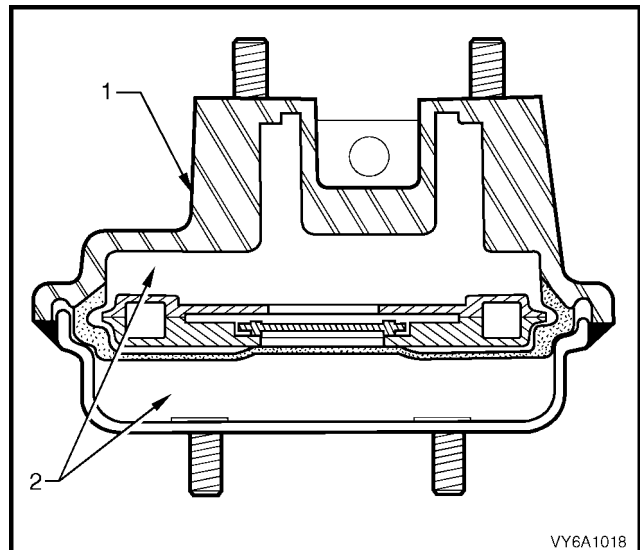


Figure 6A1-1-21

MANUAL TRANSMISSION

For vehicles fitted with manual transmission, the rear transmission mounting has changed to two round rubber mounts (5) that are attached to the two lugs (4) on the rear transmission case and the rear crossmember (1), by nuts (3 and 6).

The re-designed rear crossmember (1) is secured to the underbody side rails by four bolts (2).

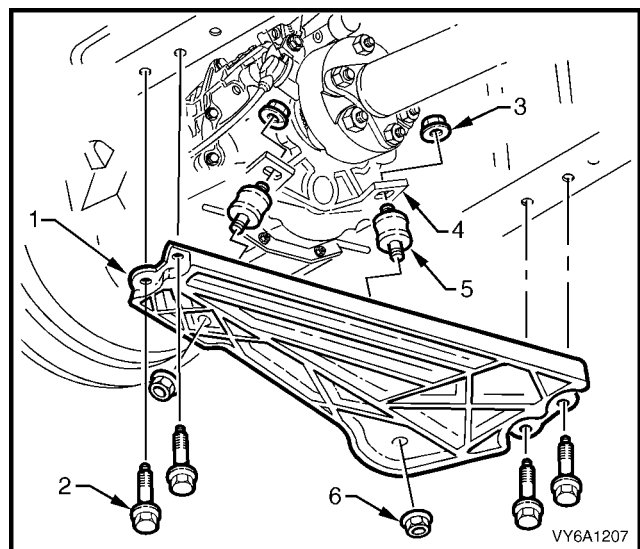


Figure 6A1-1-22

AUTOMATIC TRANSMISSION

For vehicles fitted with automatic transmission, the engine rear rubber mounting (1) is attached to the transmission rear extension by two bolts (2). The rubber mounting is also attached to the rear crossmember (3) by two attaching nuts (5).

The rear crossmember (5) is then secured to the underbody side rails by four bolts (4).

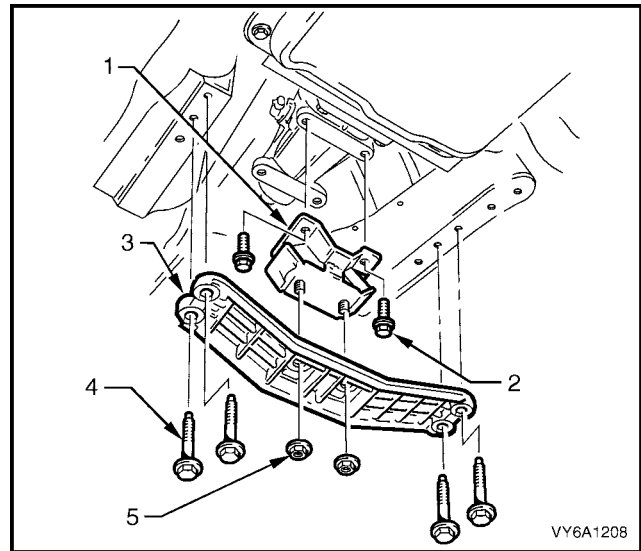


Figure 6A1-1-23

1.3 LUBRICATION

The engine lubrication system is of the force-feed type in which oil is supplied under full pressure to the crankshaft, connecting rods, camshaft bearings, valve lifters and a controlled volume is supplied to the rocker arms and push rods. The engine has a pressure fed rear balance shaft bearing. Oil is fed from the rear of the right oil gallery through a rear seal housing. The housing also includes the cross over passage for oil supply to the left bank. All other moving parts are lubricated by gravity flow or splash.

The supply of oil is carried in the oil pan which is filled through a filler opening in the right hand rocker cover (as viewed from the drivers seat). An oil level indicator (dip stick), located on the front left hand side of the crankcase, (as viewed from the drivers seat) is provided to check oil level.

The oil pump is located in the engine front cover and is driven by the crankshaft. It is a 'Gerotor' type pump which is a combination of gear and rotor pumps. It is connected by a passage in the cylinder crankcase to an oil suction pipe and screen. The screen is submerged in the oil supply.

Oil is drawn into the pump through the screen and pipe assembly and the passage in the crankcase which connects to passages in the front cover. All oil is discharged from the pump to the oil filter adaptor assembly which consists of a full flow oil filter and by-pass valve.

The spring loaded oil pressure regulator valve, located in the front cover, limits the oil pressure to approximately 414 kPa. The oil filter by-pass valve opens when the filter has become clogged. When approximately 69 kPa pressure difference exists between the filter intake and discharge, oil by-passes the oil filter and channels unfiltered directly into the main galleries of the engine.

The main oil galleries run the full length of the crankcase and connect into the valve lifter guide holes to supply oil at full pressure to the lifters. Holes drilled from the crankshaft main bearings to the main gallery, intersect the camshaft bearing bores which supply oil to the camshaft bearings.

Holes drilled in the crankshaft, carry oil from the crankshaft main bearings to the connecting rod bearings. Pistons and cylinder walls are lubricated by oil thrown off the crankshaft and by connecting rod splash. Piston pins are lubricated by splash.

Each rocker arm and valve is supplied with oil through the tubular push rod. This oil comes from the inside of the lifter, passing around the metering valve, up the inside of the push rod and through a hole in the rocker arm push rod seat.

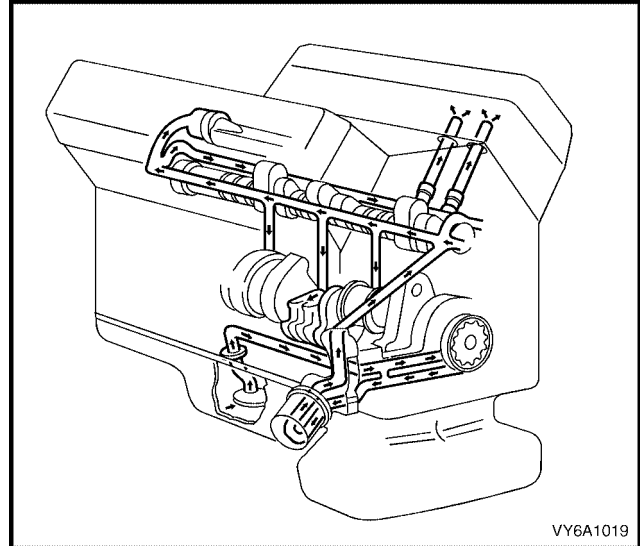


Figure 6A1-1-24

1.4 SERVICE NOTES

CLEANLINESS AND CARE

A motor vehicle engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in thousandths of a millimetre. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly to protect and lubricate the surfaces on initial operation. Throughout this Section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard workshop practice even if not specifically stated.

Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when removed.

Battery terminals should be disconnected before any major work is performed on the engine. Failure to disconnect terminals may result in damage to wiring harnesses or other electrical components.

THE FOLLOWING INFORMATION ON ENGINE SERVICE SHOULD BE NOTED CAREFULLY, AS IT IS IMPORTANT IN PREVENTING DAMAGE AND IN CONTRIBUTING TO RELIABLE ENGINE PERFORMANCE.

When raising or supporting the engine for any reason, do not use a jack under the oil pan. The oil pan is of cast aluminium construction and could be damaged.

Refer to **Section 0A GENERAL INFORMATION** in the MY 2003 VY and V2 Series Service Information, for location of jacking points, also refer to **Section 3 FRONT SUSPENSION** in the MY 2003 VY and V2 Series Service Information for jacking precautions.

Any time the air flow ducting is removed or disconnected, the intake opening should be covered. This will protect against accidental entrance of foreign material which could follow the intake passage into a cylinder and cause extensive damage when the engine is started.

CAUTION: Do not start engine with engine intake manifold top cover or throttle body removed, as engine will run at wide open throttle.

2. MINOR SERVICE OPERATIONS

2.1 OIL LEVEL CHECK

1. Engine must be at normal operating temperature (idle for 10 minutes or equivalent).
2. Park vehicle on level surface (as this will affect the accuracy indicated on dipstick, this is a critical requirement).
3. Do not check oil level for at least 10 minutes after shut down to allow oil to drain back into the oil pan.
4. Remove dipstick and wipe clean.
5. Reinstall dipstick with FULL/ADD marks facing towards centre line of engine. This aspect is very important due to the angle that the dipstick enters the oil in the oil pan.
6. Ensure dipstick is fully seated and slowly remove to avoid smearing. Hold horizontally or with lower end slightly down to avoid oil running along dipstick.
7. Observe the oil level where it passes over the centre line of the dipstick.
8. When topping up the engine oil, allow approximately 10 minutes for the oil added to fully drain into the oil pan. Alternatively, add 50 ml of oil for each millimetre below the "FULL" mark on the dipstick.

2.2 ENGINE OIL CHANGE

NOTE 1: Quicker and more complete draining will occur if the engine oil is at operating temperature. However, care must be taken to avoid scalding from the hot oil.

NOTE 2: It is also recommended that the oil filter is changed at each engine oil change, refer **2.3 OIL FILTER**, in this Section.

1. Raise the engine hood and remove the oil fill cap.
2. Raise the vehicle front and rear to maintain a level attitude and support with safety stands. This is to ensure complete draining. Refer **Section 0A GENERAL INFORMATION**.
3. Clean any foreign material from around the oil drain plug and place a suitable, clean drain tray under the engine.
4. Using a suitable sized ring spanner, remove the drain plug, taking care to avoid scalding with the hot, waste oil.
5. While waiting for the oil to drain sufficiently, clean and inspect the drain plug threads for damage. If not damaged the drain plug seal can be re-used.
6. Reinstall the drain plug, tightening to the correct torques specification.

OIL PAN DRAIN PLUG TORQUE SPECIFICATION	45 Nm
--	-------

7. Lower the vehicle to the ground and fill with the necessary amount of 10W-30 SJ ILSAC GF2 engine oil (all V6 engines except LPG) or 15W/40 SH/CG4 engine oil (LPG engines) as required. Reinstall the oil fill cap.

ENGINE OIL CAPACITY	
WITHOUT OIL FILTER CHANGE	5.2 litres
WITH OIL FILTER CHANGE	5.6 litres

NOTE: For V6 or V6 Supercharged engines (except LPG), use of the preferred engine lubricant (10W-30 SJ ILSAC GF2) will yield a fuel economy benefit, an alternative recommended oil such as 20W-50 SJ or 15W/40 SJ engine oil can be used but will not yield the same fuel benefits.

8. Start the engine and check for leaks.

2.3 OIL FILTER

NOTE: The oil filter should be replaced at the time or distance intervals specified in the MY 2003 VY and V2 Series, Owner's Handbook or whenever the engine oil is contaminated by foreign material.

REPLACE

1. Place an oil drain tray beneath engine.
2. Using a suitable oil filter wrench, unscrew oil filter ('1' in Figure 6A1-1-25), remove and discard.
3. Ensure seal is installed correctly in recess of new filter.
4. Pour some clean engine oil into filter until level remains at approximately 2 cm below top of filter.
5. Smear some engine oil over filter seal. Screw filter (1) into place until seal contacts mating surface of adaptor. Tighten filter through a further 2/3 of a turn.
6. Clean any excess oil from filter (1) and adaptor.
7. Check oil level. Start engine and check for oil leaks. Repair as necessary.

NOTE: The oil level must be rechecked and oil added as necessary, after running the engine, to compensate for oil used to refill the oil filter.

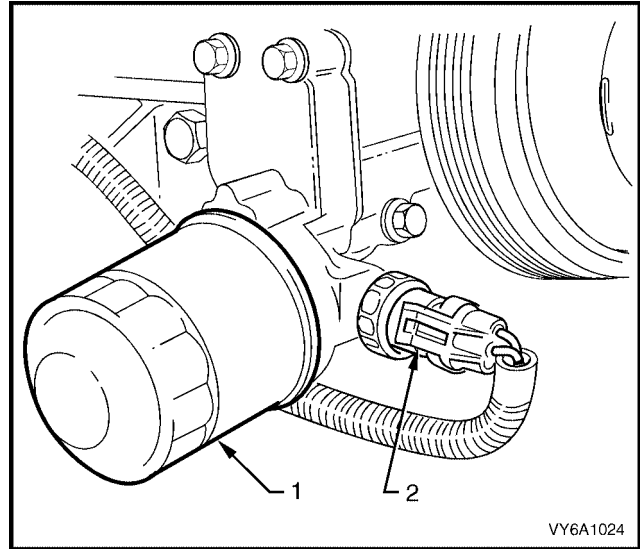


Figure 6A1-1-25

2.4 OIL FILTER ADAPTOR AND/OR OIL COOLER

REMOVE

1. Place an oil drain tray beneath engine.
2. Disconnect battery ground lead.
3. Remove oil filter (1), refer to **2.3 OIL FILTER** in this Section.
4. Pull out retaining tang on engine harness connector (2) at oil pressure sender unit and pull connector from sender unit.
If necessary, loosen and remove oil pressure sender unit.

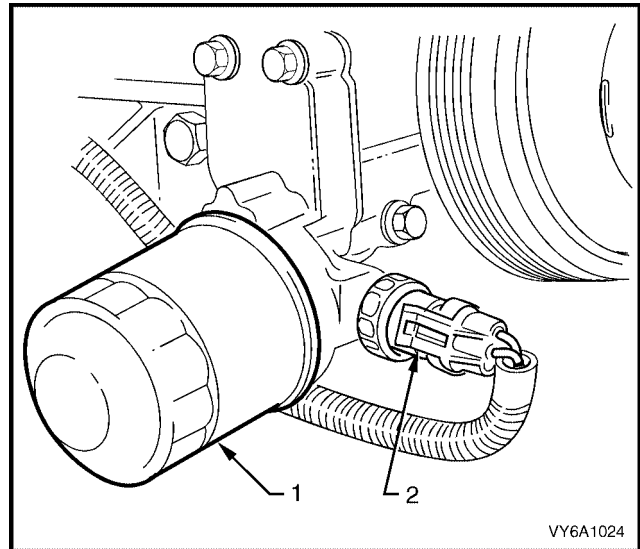


Figure 6A1-1-26

Engines Without Oil Cooler (View 'A')

5. Remove oil filter adaptor (7) to front cover (7) attaching bolts ('3' and '5'), remove adaptor (7).
6. Remove oil filter adaptor gasket (2) and discard.
7. Remove oil pressure regulator valve (8) and spring (9).

Engines With Oil Cooler (View 'B')

8. Remove both coolant hose connections to the oil cooler (10), collecting drained coolant in a clean container.
9. Remove the oil cooler connector shaft (11), then the oil cooler (10) from the oil filter adaptor (7).
10. Remove oil filter adaptor (7) to front cover (1) attaching bolts ('3' and '5'), remove adaptor (7).
11. Remove oil filter adaptor gasket (2) and discard.
12. Remove oil pressure regulator valve (8) and spring (9).

NOTE: Figure 6A1-1-27 shows the conventional arrangement in View 'A', while view 'B' shows the arrangement when an oil cooler is fitted to the engine.

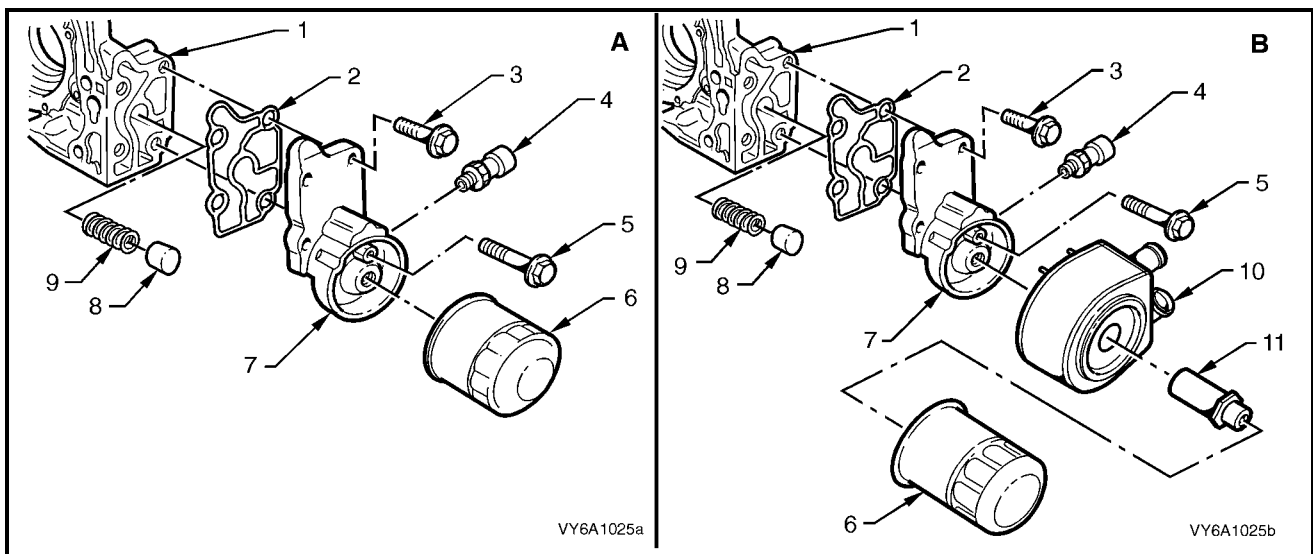


Figure 6A1-1-27

Legend

- | | | |
|--|-----------------------------------|------------------------------------|
| A Engines Without an Oil Cooler | 4. Oil Pressure Sender Assembly | 9. Spring – Oil Pressure Regulator |
| B Engines With and Oil Cooler | 5. Bolt - Long | 10. Oil Cooler Assembly |
| 1. Front Cover Assembly | 6. Oil Filter | 11. Oil Cooler Connector Shaft |
| 2. Gasket | 7. Oil Filter Adaptor Cover | |
| 3. Bolt – Short | 8. Valve – Oil Pressure Regulator | |

REINSTALL

1. Using a suitable size thread tap, clean adaptor 'long' attaching bolt threads in front cover (1). Clean attaching bolt threads ('6' and '7').
2. Ensure that oil filter adaptor (5) and front cover (1) mating surfaces are clean and free of foreign matter.
3. Inspect oil pressure regulator valve bore in front cover (1) for scoring or burrs. Inspect the red, regulator valve spring (2) for tension loss or bending. If in any doubt, replace spring.

OIL PRESSURE REGULATOR VALVE FREE LENGTH SPECIFICATION	66.3 mm
---	---------

4. Install regulator valve spring (2) and valve (3).
5. Install adaptor (5) with a new gasket (4) to front cover (1). Install attaching bolts ('6' and '7') and tighten to the correct torque specification.

NOTE: Before installing 'long' adaptor attaching bolt (7), apply Loctite 242 sealant or equivalent to the cleaned bolt threads.

OIL FILTER ADAPTOR TO FRONT COVER ATTACHING BOLT TORQUE SPECIFICATION	30 Nm
---	-------

6. If the oil pressure sender unit was removed, apply Loctite 242 sealant (or equivalent) to the cleaned sender unit threads. Reinstall sender unit and tighten to the correct torque specification.

OIL PRESSURE SENDER UNIT TORQUE SPECIFICATION	13 Nm
--	-------

For Engines With Oil Cooler (refer 'B' in Figure 6A1-1-27)

7. Wipe, then apply clean engine oil to the oil cooler O-ring seal.
8. Reinstall oil cooler (10), securing with the oil cooler connector shaft (11), then tighten to the correct torque specification.

OIL COOLER CONNECTOR SHAFT TORQUE SPECIFICATION	50 Nm
--	-------

9. Check service records to determine when the engine coolant was last changed. If there is more than six months life left before the next coolant change, then refill the engine cooling system with the coolant collected when the oil cooler hoses were disconnected. Check the coolant concentration, refer [Section 6B1 ENGINE COOLING – V6 ENGINE](#) for more information.

All V6 Engines

10. Install new oil filter, refer [2.3 OIL FILTER](#) in this Section.
11. Check oil level. Start engine and check for oil leaks. Repair as necessary.

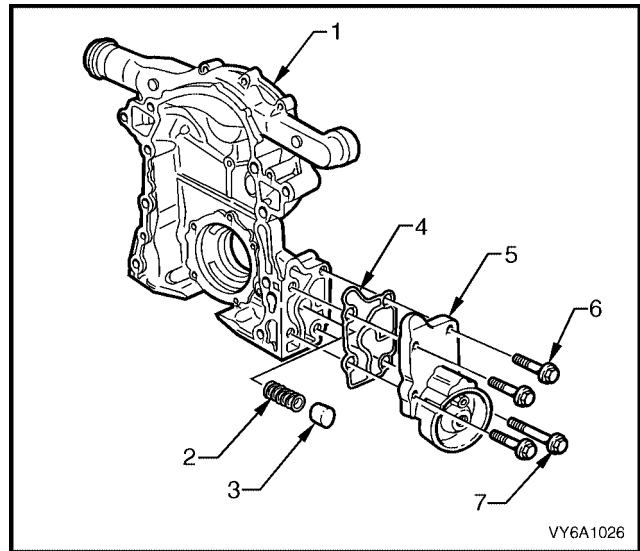


Figure 6A1-1-28

2.5 ENGINE OIL PRESSURE CHECK

1. Check engine oil level and add oil as required.
2. Ensure that engine is at operating temperature.
3. Pull out retaining tang on engine harness connector (1) at oil pressure sender unit (2) and pull connector (1) from sender unit.
4. Place an oil drain tray beneath engine.
5. Loosen and remove oil pressure sender unit from oil filter adaptor, using Tool J 41712.
6. Install a suitable oil pressure gauge assembly into oil filter adaptor oil pressure sender unit hole.
7. Start engine and check oil pressure reading with engine running under no load.

OIL PRESSURE SPECIFICATION	
ENGINE SPEED	OIL PRESSURE READING
1,850 and Above	375 kPa Minimum

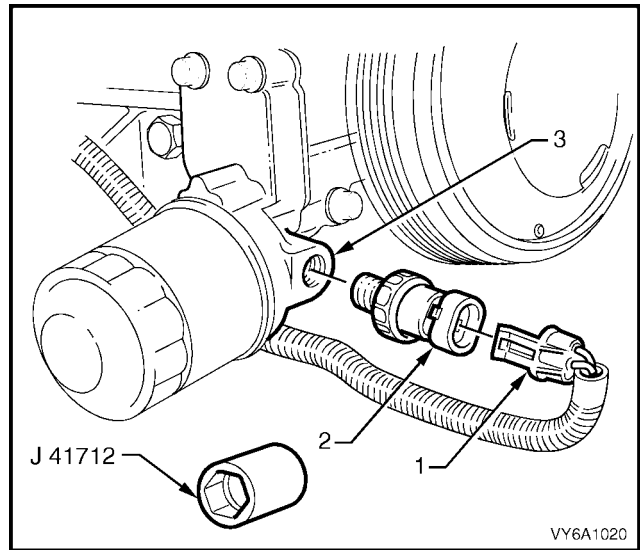


Figure 6C1-1-29

8. After completion of the pressure test, apply Loctite 242 sealant or equivalent, to the sender unit threads. Install sender unit and tighten to the correct torque specification.

OIL PRESSURE SENDER UNIT TORQUE SPECIFICATION	13 Nm
--	-------

9. Reinstall wiring harness connector to sender unit, start engine and check for oil leaks and oil pressure warning display in the instruments.

2.6 COMPRESSION CHECK

1. When conducting this check, ensure:
 - a. Engine is at operating temperature.
 - b. Battery is at or near full charge.
 - c. All spark plugs removed.
 - d. Remove the engine control (EFI) relay 'X4' (1) and fuel pump relay 'X16' (2) from the underhood electrical centre.

Removal of relay 'X4' isolates the fuel injectors and ignition system, while relay 'X16' isolates the fuel pump, during engine cranking.

2. Install a suitable compression tester.
3. Crank engine. Record compression gauge reading.

NOTE: It is important to open the throttle when conducting a compression test to ensure cylinder filling.

4. Check remaining cylinders.

NOTE: The lowest reading of any cylinder should not be less than 70% of the highest and no cylinder reading should be less than 689 kPa.

5. If cylinder compression in one or more cylinders is low, pour a small amount of engine oil into the cylinders through the spark plug holes and retest compression.

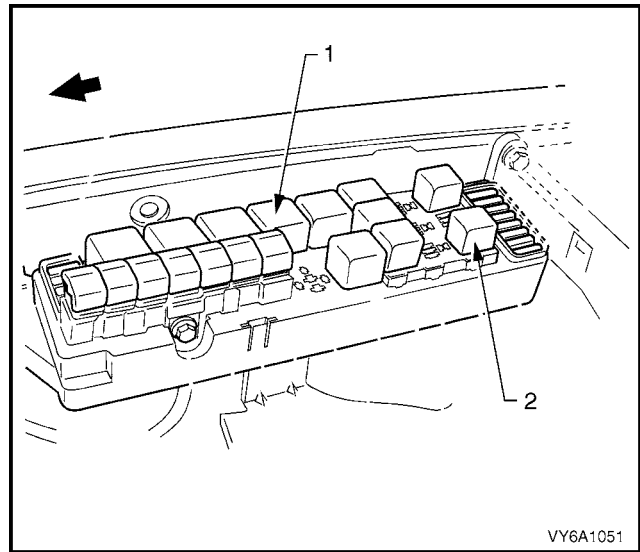


Figure 6A1-1-30

INTERPRETATION OF COMPRESSION READINGS

NORMAL - Compression builds up quickly and evenly on each cylinder.

PISTON RINGS - Compression low on first stroke tending to build up on following strokes, but does not reach normal. Improves considerably with addition of oil.

VALVES - Low on first stroke and does not tend to build up on following strokes. Does not improve much with addition of oil.

HEAD GASKET - If cylinder compression in any two adjacent cylinders is low, and if adding oil does not help compression, cylinder head gasket has blown.

2.7 DRIVE BELT

TENSION CHECK

NOTE: A belt squeak when the engine is started or stopped is normal and has no effect on drive belt durability.

1. Inspect tensioner markings to see if belt is within operating limits. Replace belt (2) if excessively worn or the minimum tension indicator (3) is aligned with the pointer (5) on the pulley spring loaded arm (6), indicating that the belt tension is on the low side of the tensioner operating range.

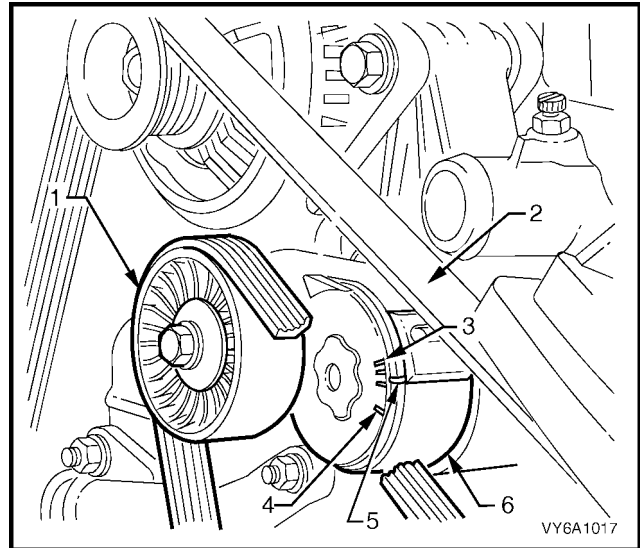


Figure 6A1-1-31

2. If fitted, switch the air conditioning off and run the engine until warmed up. Switch engine off and read belt tension with Tool BT3373-F placed between the generator (1) and air-conditioning compressor pulleys (8). For vehicles without air-conditioning, read tension between power steering pump (4) and crankshaft pulley (7). Remove tension gauge.

NOTE: Before carrying out drive belt tension, check the calibration of Tool No. BT3373-F.

3. If fitted, switch the air conditioning off and run the engine again, allowing the drive belt to stabilise for 15 seconds. Turn engine off. Then, using a 15 mm ring spanner, apply clockwise force (tighten) to tensioner pulley (2) bolt. Remove ring spanner and immediately take a tension reading with Tool No. BT3373-F without disturbing the belt tensioner assembly.
4. Using a 15 mm ring spanner, apply an anti-clockwise force to tensioner pulley (2) bolt and raise pulley to 'belt install' position. Slowly lower pulley to 'at rest' position and take a tension reading without disturbing belt tensioner position. Record reading and remove tool.
5. Average the three readings (add them together, then divide by three). If the average of the three readings is lower than 250 N and the belt is within tensioner operating range, replace belt tensioner.

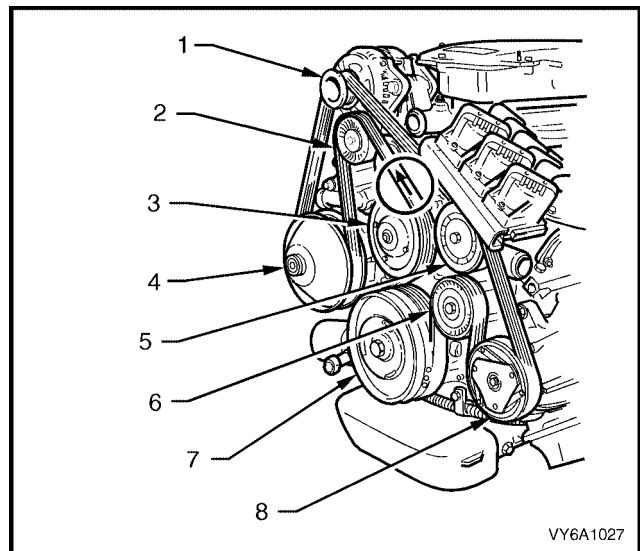


Figure 6A1-1-32

INSPECT

Figure 6A1-1-33 illustrates the various stages of belt wear to aid in belt replacement decisions. Condition of the belt ribs is best judged where the belt is bent over the coolant pump pulley.

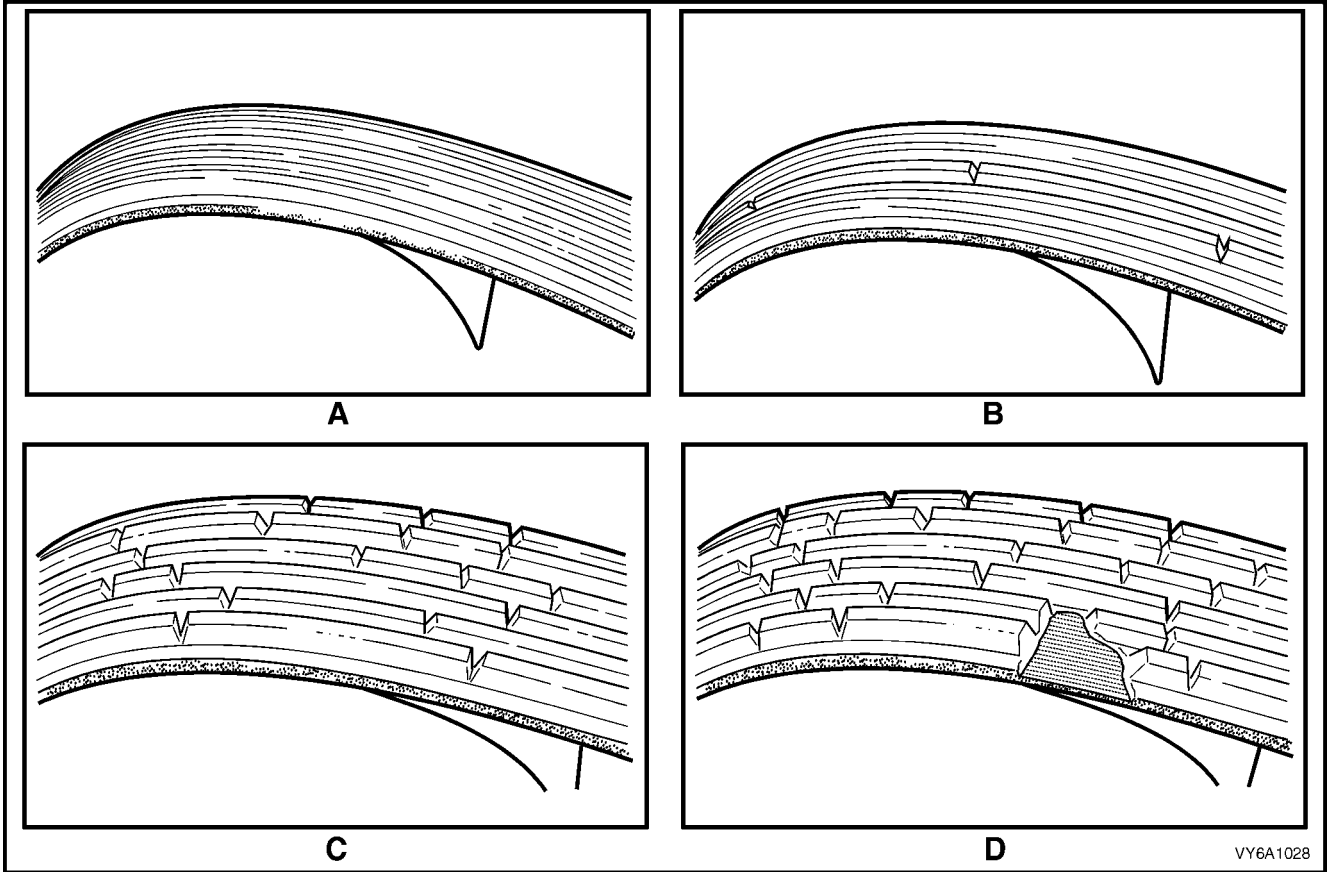


Figure 6A1-1-33

Legend

- A. A New Belt – No Cracks or 'Chunks'.
- B. Moderately Used Belt – Few Cracks, Some Wear on Ribs and in Grooves. Replacement is Not Required.
- C. Severely Used Belt – Several cracks per 30 mm. Should be Replaced Before 'Chunking' Occurs.
- D. Failed Belt – Separation of Rib Material from the Backing ('Chunking'). Replace Belt Immediately.

REMOVE

1. Disconnect battery ground lead.
2. Remove four nuts securing engine dress cover.

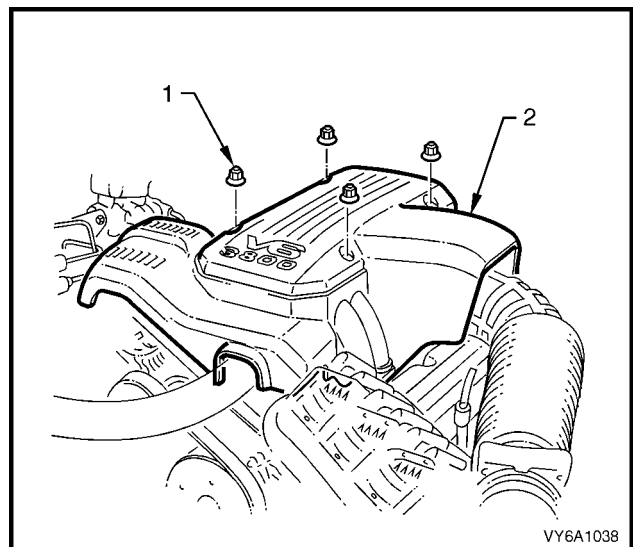


Figure 6A1-1-34

- Using a 15 mm ring spanner on drive belt tensioner pulley pivot bolt, rotate tensioner pulley assembly anti-clockwise, hold in that position and slip the drive belt from coolant pump pulley. Release tensioner pulley assembly and remove drive belt from the remaining drive pulleys.

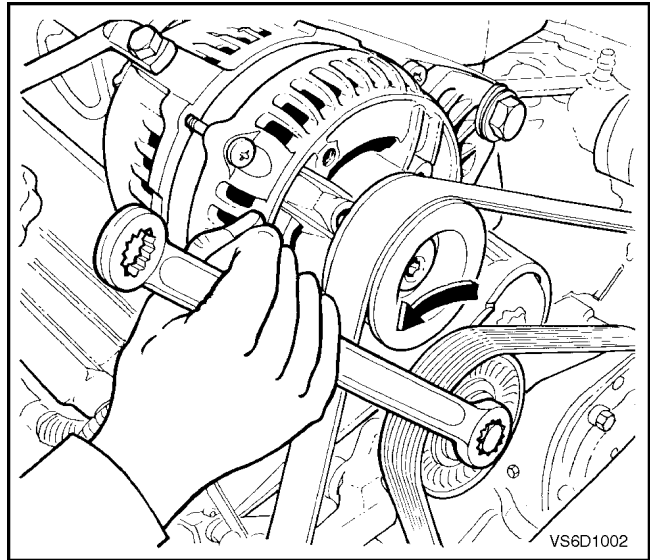


Figure 6A1-1-35

REINSTALL

- Inspect drive belt condition, refer to [Figure 6A1-1-33](#).
- Install drive belt onto accessory drive pulleys refer to [Figure 6A1-1-36](#).
NOTE: Ensure that drive belt ribs are aligned into all accessory pulleys and crankshaft balancer drive belt grooves.
- Using a 15 mm ring spanner, rotate tensioner pulley anti-clockwise and, while holding in that position install the drive belt over coolant pump pulley. Slowly return the tensioner to its normal position.
- Reconnect battery ground lead, start engine and check drive belt operation.

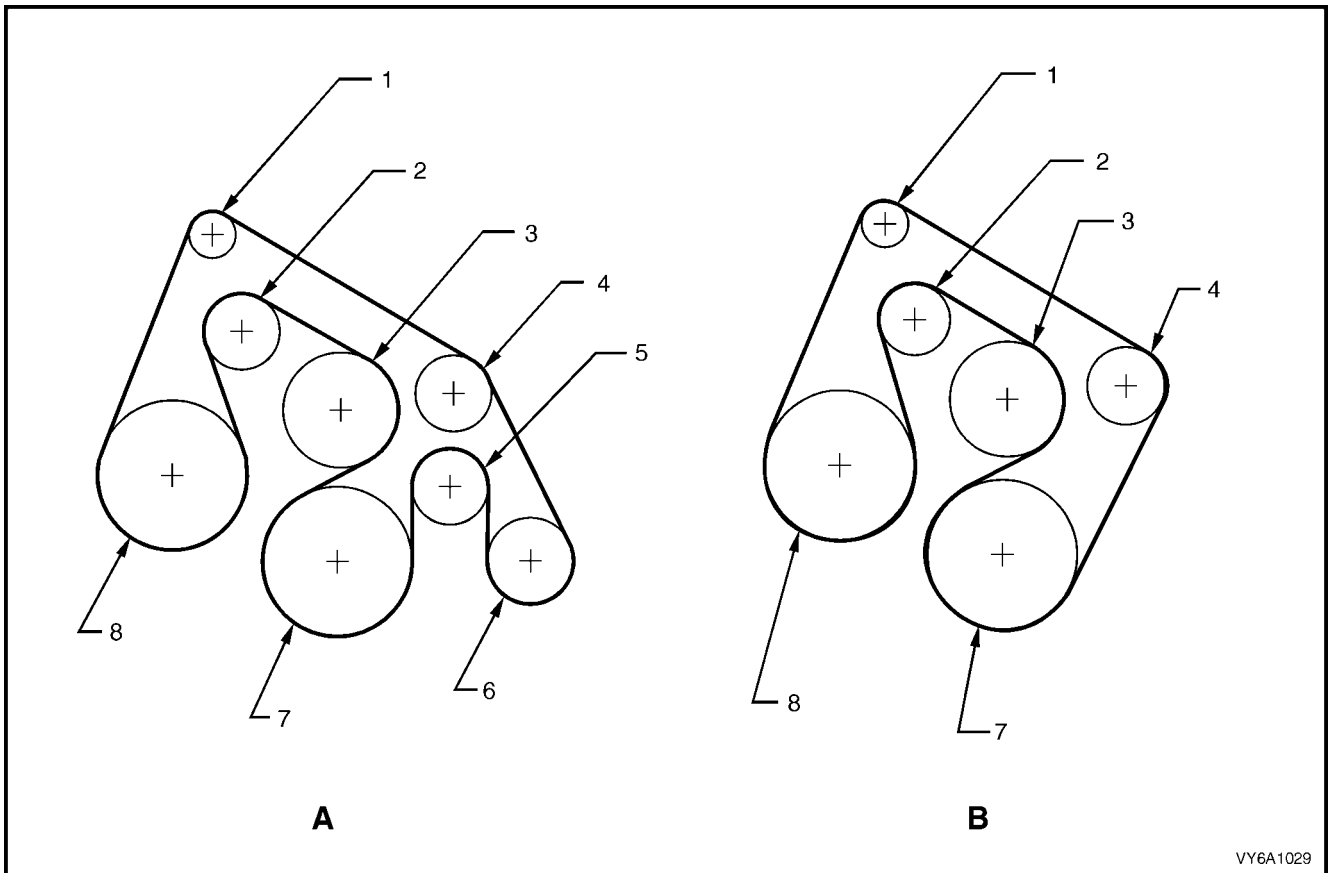


Figure 6A1-1-36

Legend

- | | |
|--|--------------------------------|
| A. Vehicle With Air Conditioning – Long Belt. | 4. Idler |
| B. Vehicle Without Air Conditioning – Short Belt. | 5. Idler |
| 1. Generator | 6. Air Conditioning Compressor |
| 2. Tensioner | 7. Crankshaft |
| 3. Coolant Pump | 8. Power Steering Pump |

2.8 DRIVE BELT TENSIONER PULLEY

REPLACE

1. Remove the engine drive belt, refer [2.7 DRIVE BELT, Remove](#), in this Section.

NOTE: The bolt securing the drive belt tensioner pulley is a left hand thread.

2. Using a 15 mm ring spanner or socket and bar, loosen then remove the retaining bolt, by turning in the direction indicated.
3. Remove the pulley from the tensioner assembly.
4. Install a new pulley and bearing assembly, then reinstall the retaining bolt, remembering that it has a left hand thread.
5. Tighten the retaining bolt to the correct torque specification.

DRIVE BELT TENSIONER PULLEY RETAINING BOLT TORQUE SPECIFICATION	45 Nm
---	-------

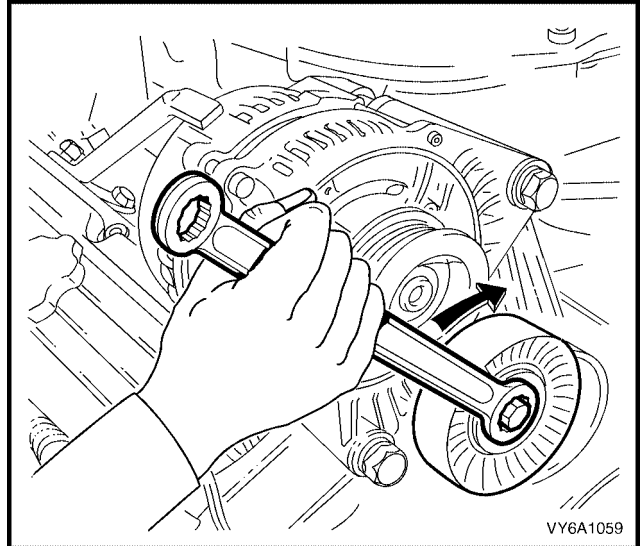


Figure 6A1-37

6. Reinstall the drive belt after carrying out a belt inspection to determine serviceability, refer [2.7 DRIVE BELT, Inspect and Reinstall](#), in this Section.

2.9 DRIVE BELT TENSIONER ASSEMBLY

REMOVE

1. Disconnect battery ground lead.
2. Remove four nuts securing engine dress cover.

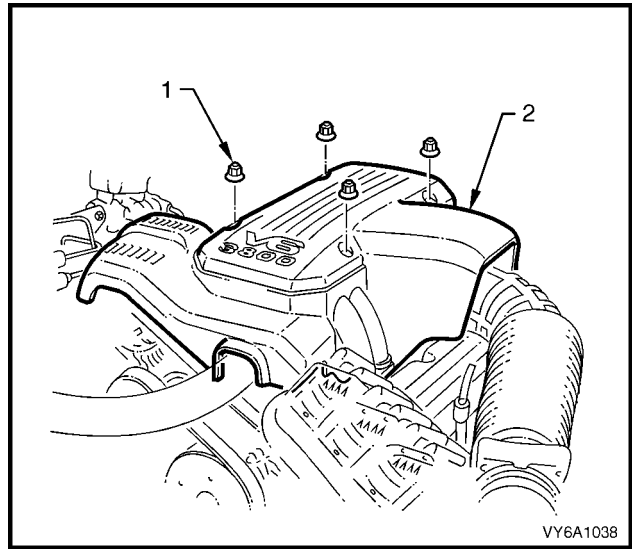


Figure 6A1-1-38

3. Using a 15 mm ring spanner on drive belt tensioner pulley pivot bolt, rotate tensioner pulley assembly anti-clockwise, hold in that position and slide drive belt from the coolant pump pulley. Release tensioner pulley assembly and remove drive belt from remaining drive pulleys.

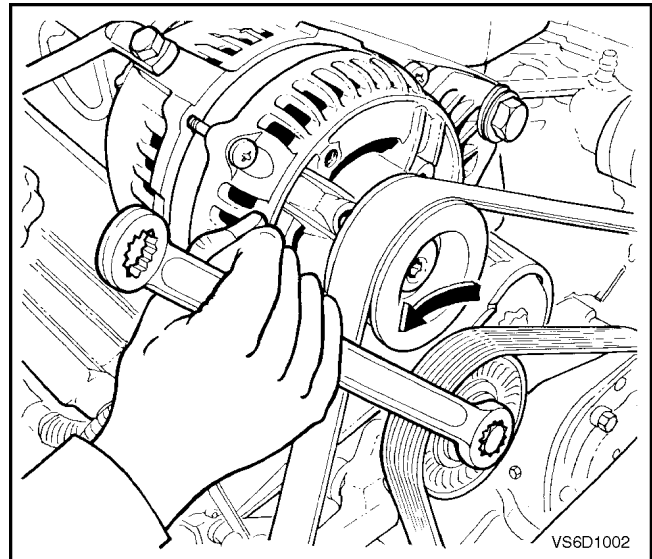


Figure 6A1-1-39

4. Remove radiator cap to release any cooling system pressure.

CAUTION: To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of the cooling system pressure is a very dangerous and could result in personal injury.

5. Place a clean container (of at least 12 litres capacity) under the engine for the engine coolant to drain into.

NOTE: To reduce the impact on the environment and the maintenance cost, whenever the coolant is drained from the engine, the service records are to be checked to determine when the coolant was last changed. If more than six months life is left before the next coolant change, then the drained coolant can be re-used. For further information, refer to [Section 6B1 ENGINE COOLING – V6 ENGINE](#).

6. Loosen hose clamp (2) and remove heater outlet hose (1) from heater outlet pipe connection.
7. Loosen hose clamp (3) and remove coolant inlet hose (4) from the coolant inlet tube.
8. Capture as much coolant as possible in the container placed under the engine.

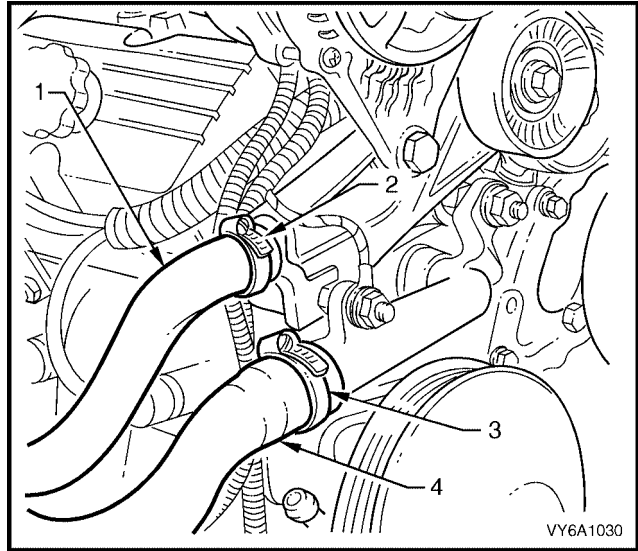


Figure 6A1-1-40

9. Remove generator assembly, refer [Section 6D1-1 CHARGING SYSTEM – V6 ENGINE](#).
10. Remove the two nuts (2 and 3), then the powertrain wiring harness ground lead (1) from the tensioner bracket, lower attaching studs.

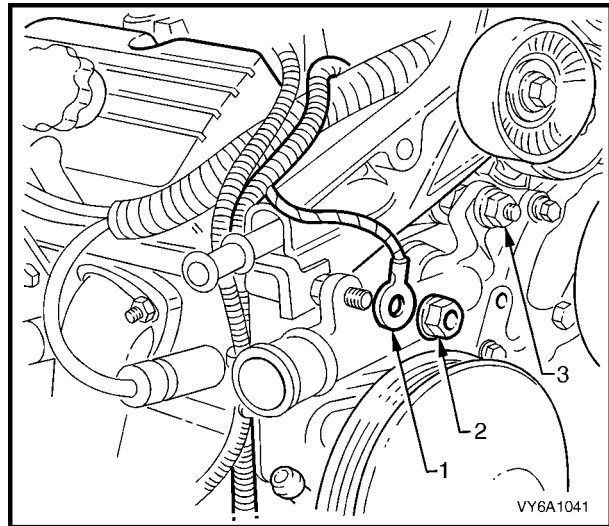
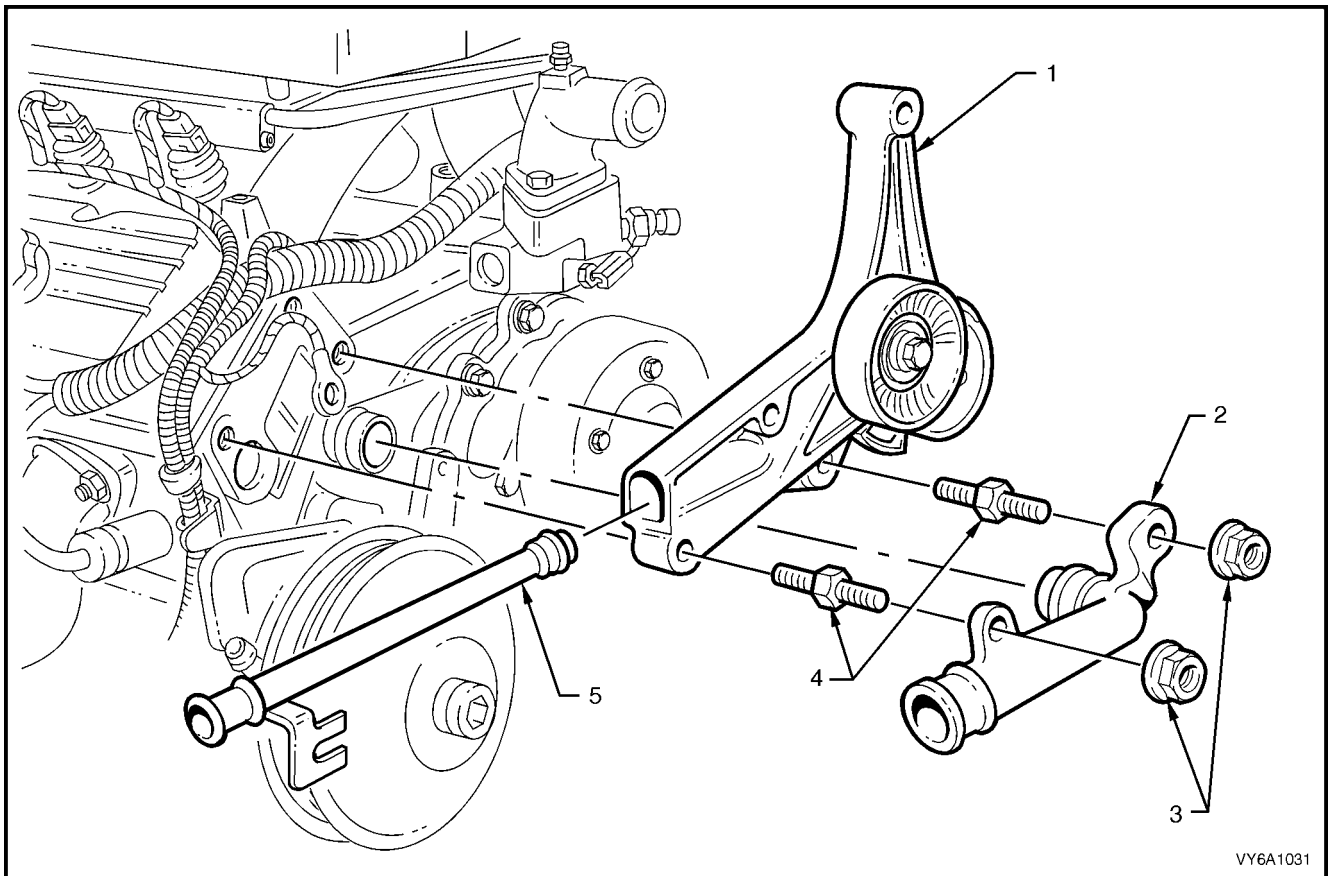


Figure 6A1-1-41



VY6A1031

Figure 6A1-1-42

Legend

- | | |
|----------------------------------|-----------------------|
| 1. Drive Belt Tensioner Assembly | 4. Studs |
| 2. Coolant Inlet Tube | 5. Heater Outlet Pipe |
| 3. Nuts | |

11. Remove coolant intake tube nuts (3) and the coolant inlet tube (2).
12. Remove studs (4) securing heater outlet pipe (5) and drive belt tensioner assembly (1), pull heater outlet pipe (5) out from intake manifold connection and remove drive belt tensioner assembly (1).

REINSTALL

Installation of the drive belt tensioner assembly is the reverse of removal procedures, noting the following points:

1. Ensure that all fasteners are tightened to the correct torque specification.

DRIVE BELT TENSIONER STUD TORQUE SPECIFICATION	50 Nm
COOLANT INLET TUBE TO BELT TENSIONER STUD NUT TORQUE SPECIFICATION	22 Nm

2. Check and inspect O-rings on end of heater outlet pipe and coolant intake tube, replace if necessary. Lubricate O-rings with petroleum jelly, prior to reassembly.
3. Refill cooling system with the correct concentration of coolant and check for leaks, refer to [Section 6B1 ENGINE COOLING – V6 ENGINE](#).
4. Start engine and check drive belt operation and leaks from the power steering and cooling systems.

2.10 UPPER INTAKE MANIFOLD

REMOVE

1. Depressurise fuel system, as follows:
 - a. Remove the fuel pump relay (1) from the underhood electrical centre.
 - b. With the throttle closed, crank the engine. The engine may start and idle until any pressurised fuel in the delivery system is exhausted.
 - c. When the engine stops, crank for approximately 10 seconds to ensure that all built-up pressure has been exhausted.
 - d. Replace the fuel pump relay.
2. Disconnect battery ground lead.
3. Remove four nuts securing engine dress cover.

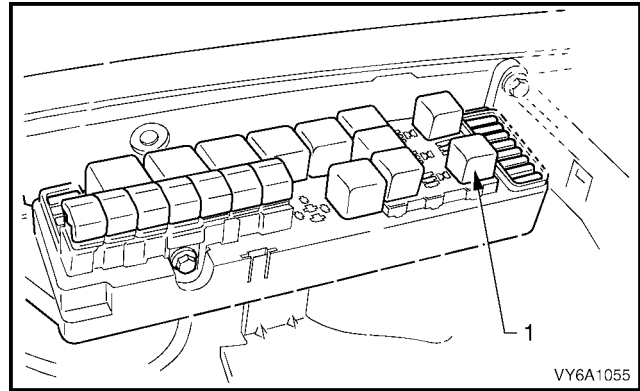


Figure 6A1-1-43

4. Disconnect mass air flow sensor wiring harness connector (4), loosen air flow duct rubber boot clamps (1) at throttle body and air cleaner (5). Remove the air flow duct (2) and mass air flow sensor (3) as an assembly and carefully place to one side.

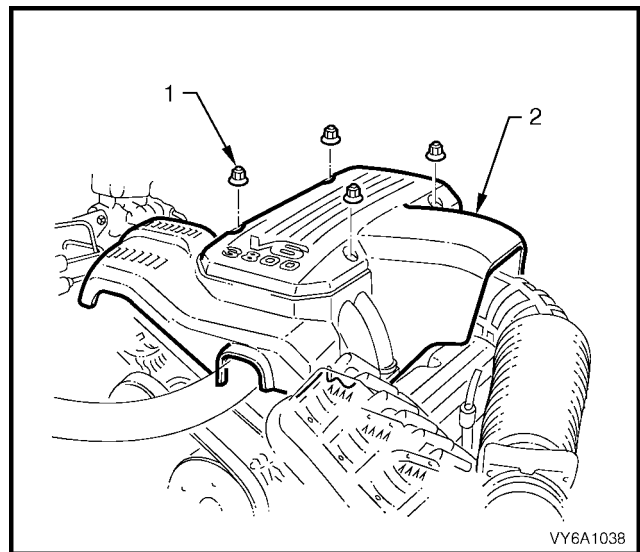


Figure 6A1-1-44

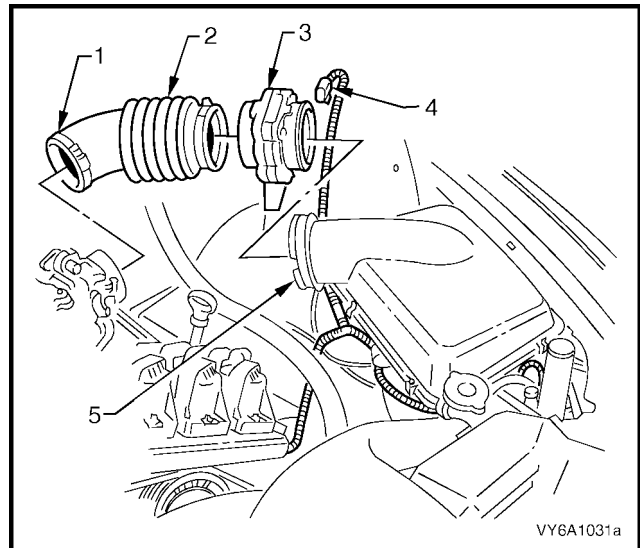


Figure 6A1-1-45

5. Using quick connect release tool No. 7370 open tool and install over fuel line.
6. Close 7370 and pull into fuel line quick connect to release it from fuel feed line, then pull back on quick connect to disconnect. Repeat this for the fuel return (2) and fuel evaporative canister hose (3). Plug all openings to prevent foreign matter entry.

NOTE 1: Do not attempt to remove hoses from fuel rail connections. Once removed from fuel rail connection, hoses require replacement.

NOTE 2: The white tape on the fuel return pipe (5) and hose (6) is to ensure that the correct connections are made on reassembly.

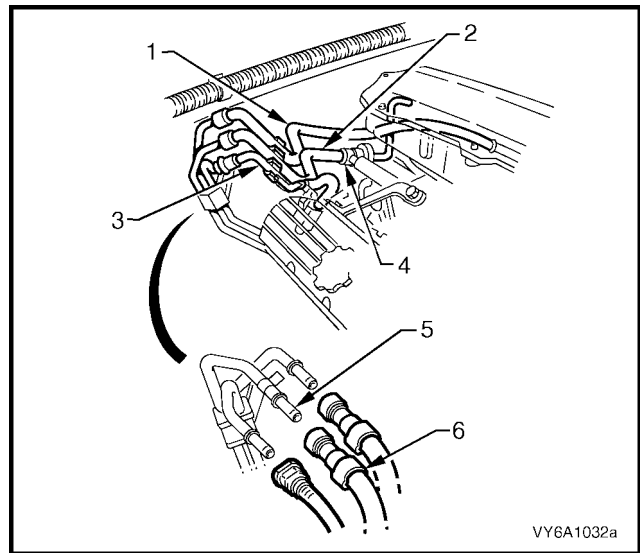


Figure 6A1-1-46

7. Disconnect emission control purge hose (3) from throttle body connection.
8. Loosen both hose clamps (1) securing the crankcase ventilation hose (2), then remove the hose and clamps from the engine.

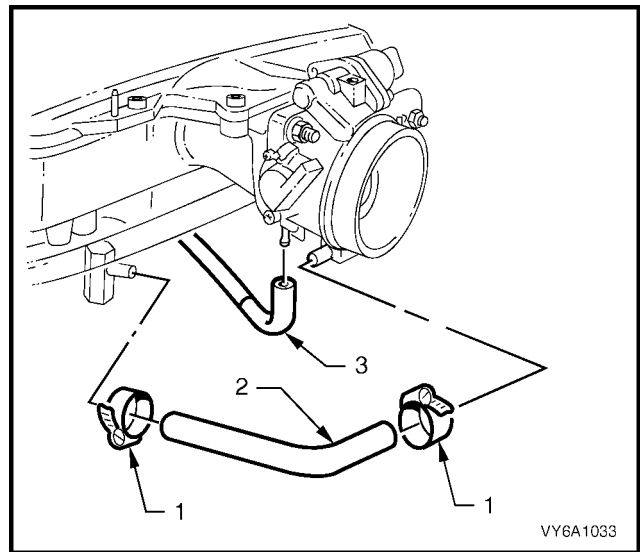


Figure 6A1-1-47

9. Remove the retaining double ended stud (2), then disconnect EGR outlet pipe (1) from upper intake manifold.

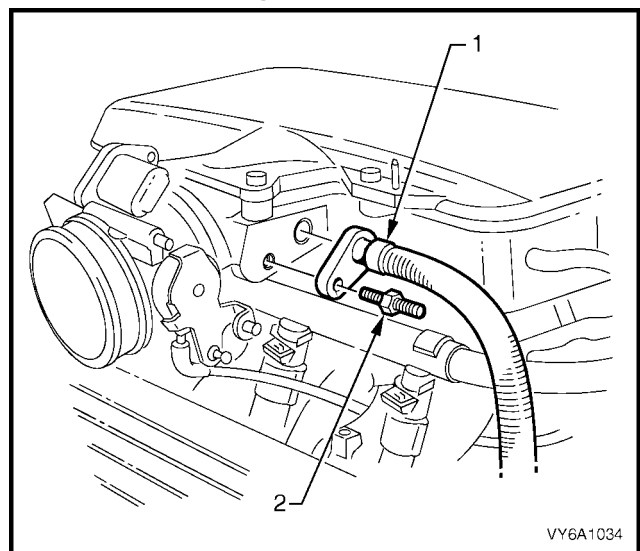


Figure 6A1-1-48

10. Disconnect the brake booster (1), fuel pressure regulator (2) and heater vacuum control (3) hoses from the upper manifold vacuum connections.

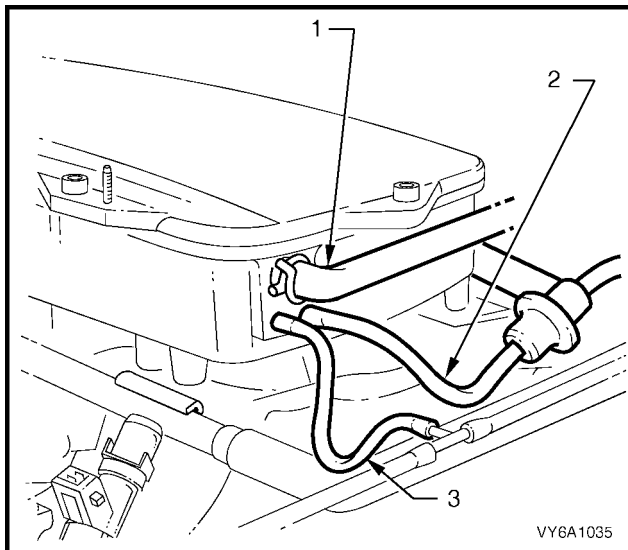


Figure 6A1-1-49

11. Remove generator assembly, refer to [Section 6D1-1 CHARGING SYSTEM V6 – ENGINE](#).
12. Disconnect throttle inner cable (1) from throttle body linkage (2). Loosen throttle outer cable lock nuts (3) at mounting bracket (5) and lay cable away from engine.
13. If vehicle is fitted with cruise control, disconnect cruise control outer cable (4) from mounting bracket (5) and push inner cable forward off throttle body linkage (2).
14. If required, remove the mounting bracket (5) retaining nuts (6) and remove bracket from the throttle body.

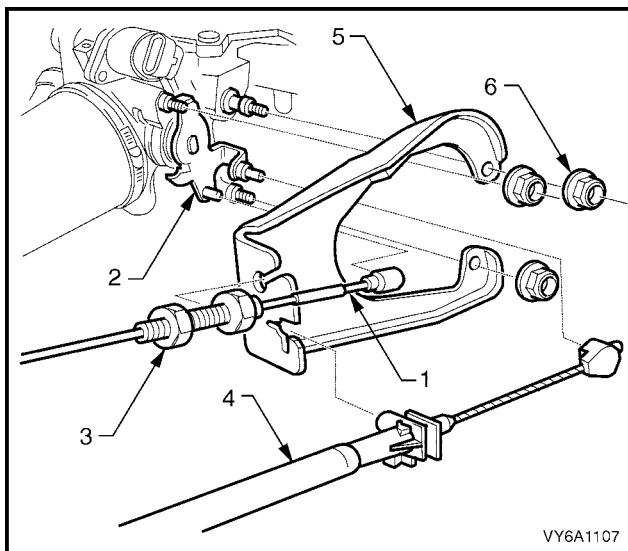


Figure 6A1-1-50

15. Disconnect powertrain wiring harness connectors from:
 1. Throttle Position Switch (TPS).
 2. Idle Air Control (IAC) Valve.
 3. EGR valve.
 4. Injectors.

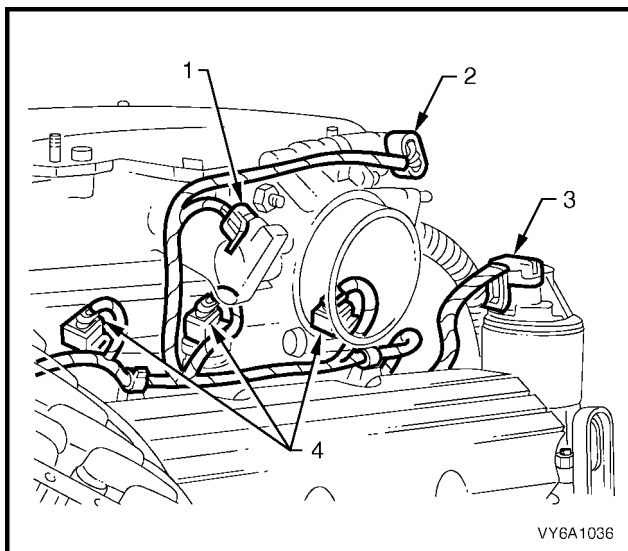


Figure 6A1-1-51

16. Remove four bolts (2) securing the fuel rail (1) to the upper intake manifold.

NOTE: This step is recommended to overcome the potential damage to the injector tips when the upper intake manifold is lifted from the lower section.

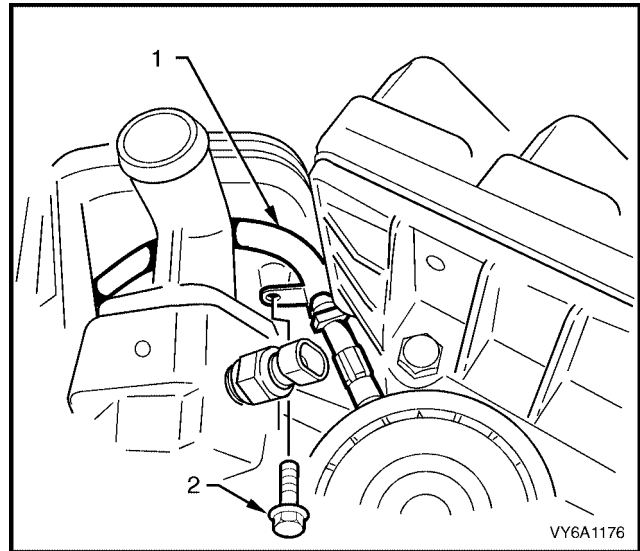


Figure 6A1-1-52

17. Remove the eight intake manifold cover attaching screws (1) and remove cover (2). Remove and discard the O-ring seal (3).

18. Using a suitable cloth or plug temporarily block off the passages in the lower intake manifold (4).

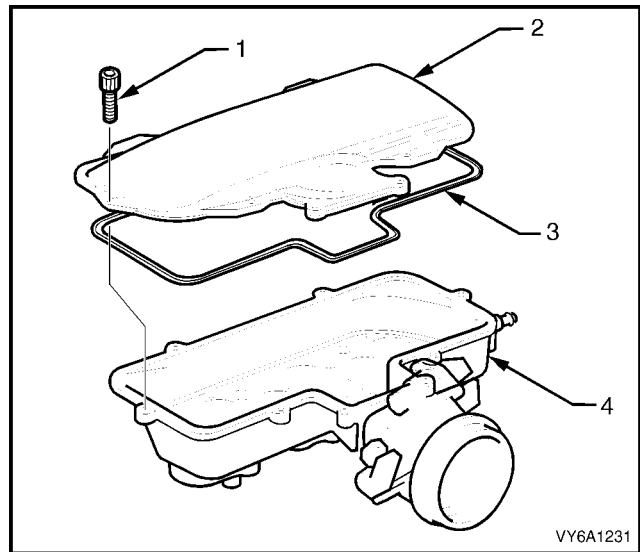


Figure 6A1-1-53

19. Completely loosen the five bolts securing upper intake manifold assembly (1) to lower intake manifold assembly, then remove the upper intake manifold (1).

NOTE: The upper intake manifold assembly to lower intake manifold bolts are captive on a secondary thread in the upper intake manifold. Do not screw bolt past this captive feature.

20. Carefully remove the fuel rail and injector assembly (3) from the lower intake manifold.

21. Remove and discard the gasket (2).

22. Remove the crankcase ventilation valve assembly and O-ring seal from the lower intake manifold.

IMPORTANT: While there is no specific servicing interval for the PCV valve, it is recommended that, whenever the upper intake manifold is separated from the lower, then the PCV valve is removed and cleaned, together with the PCV valve vapour passage in the lower intake manifold.

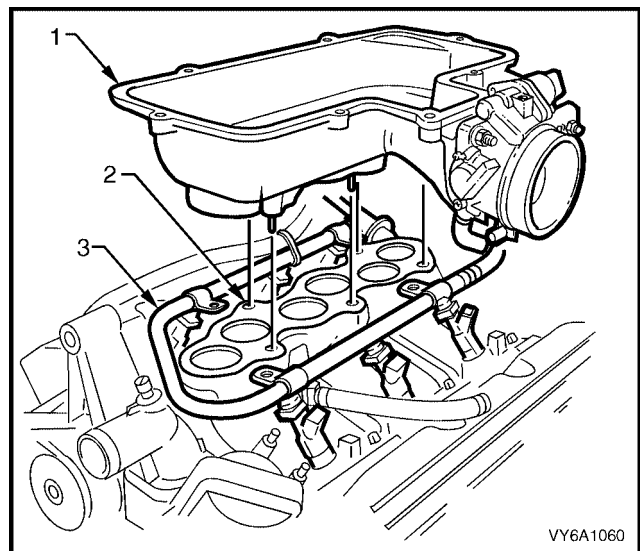


Figure 6A1-1-54

NOTE: The following operations need only be performed if necessary.

23. Disconnect crankcase ventilation hose from intake manifold connection at the rear of the upper manifold (1). Remove throttle body to manifold attaching nuts, remove throttle body (2). Discard the gasket (3).
24. Remove vacuum connectors (4) from manifold.

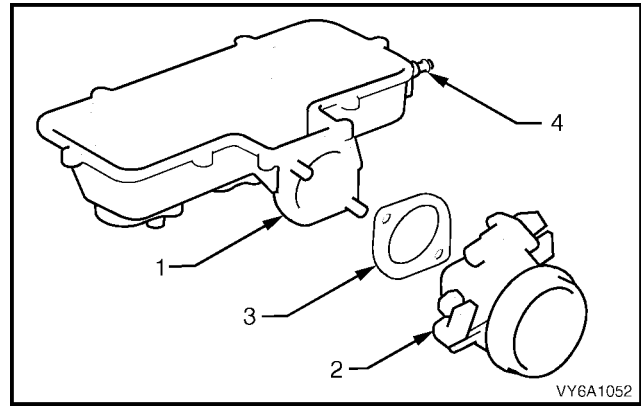


Figure 6A1-1-55

CLEAN AND INSPECT

1. Use a suitable cleaning agent to clean all parts, taking particular care to ensure that no sludge remains in the Positive Crankcase Ventilation (PCV) Valve passage in the lower intake manifold.
2. Inspect all components for damage and manifold machined surfaces for warpage or other damage.
3. Replace any components that are warped or damaged as re-surfacing of manifold machined surfaces is not recommended.

REINSTALL

Installation of the upper intake manifold is the reverse of removal procedures, noting the following points:

1. Install PCV valve with O-ring and spring, refer to [2.11 LOWER INTAKE MANIFOLD – Reinstall](#), in this Section.
2. Reinstall fuel rail with injectors to the lower manifold, using new O-ring seals, lubricated with petroleum jelly.
3. Reinstall the upper to the lower intake manifold, using a new gasket.
4. Tighten the retaining bolts to the correct torque specification.

UPPER TO LOWER INTAKE MANIFOLD BOLT TORQUE SPECIFICATION	18 Nm
--	-------

5. If removed, reinstall the throttle body assembly, using a new gasket. Tighten the retaining nuts to the correct torque specification.

THROTTLE BODY ATTACHING NUT TORQUE SPECIFICATION	18 Nm
--	-------

6. Reinstall the four fuel rail to upper manifold retaining bolts, tightening to the correct torque specification.

FUEL RAIL TO UPPER INTAKE MANIFOLD BOLT TORQUE SPECIFICATION	10 Nm
--	-------

7. Reinstall the upper intake manifold cover, using a new gasket. Reinstall the retaining bolts and tighten to the correct torque specification.

UPPER INTAKE MANIFOLD COVER SCREW TORQUE SPECIFICATION	10 Nm
--	-------

2.11 LOWER INTAKE MANIFOLD

REMOVE

1. Depressurise fuel system, as follows:
 - a. Remove the fuel pump relay (1) from the underhood electrical centre.
 - b. With the throttle closed, crank the engine. The engine may start and idle until any pressurised fuel in the delivery system is exhausted.
 - c. When the engine stops, crank for approximately 10 seconds to ensure that all built-up pressure has been exhausted.
 - d. Replace the fuel pump relay.

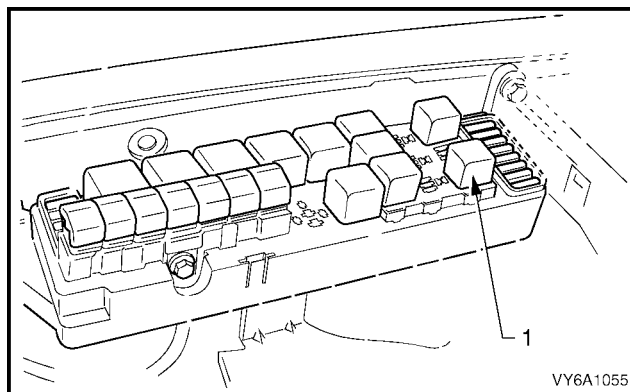


Figure 6A1-1-56

2. Disconnect battery ground lead.
3. Remove four nuts (1) securing engine dress cover (2).

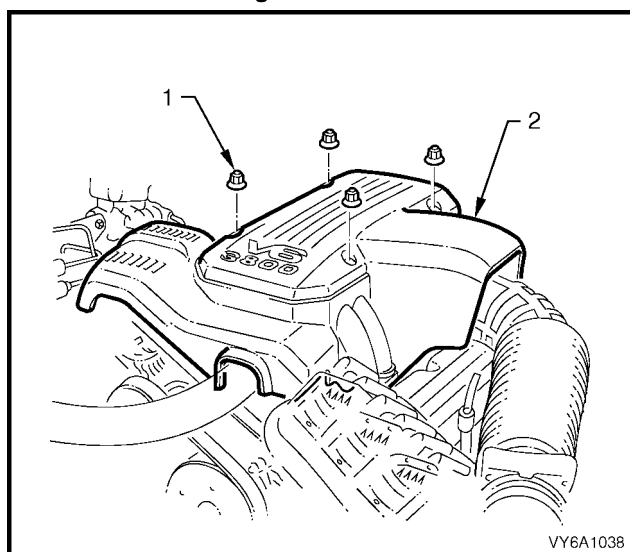


Figure 6A1-1-57

4. Disconnect mass air flow sensor wiring harness connector (4), loosen air flow duct rubber boot clamps (1) at throttle body and air cleaner (5). Remove the air flow duct (2) and mass air flow sensor (3) as an assembly and carefully place to one side.

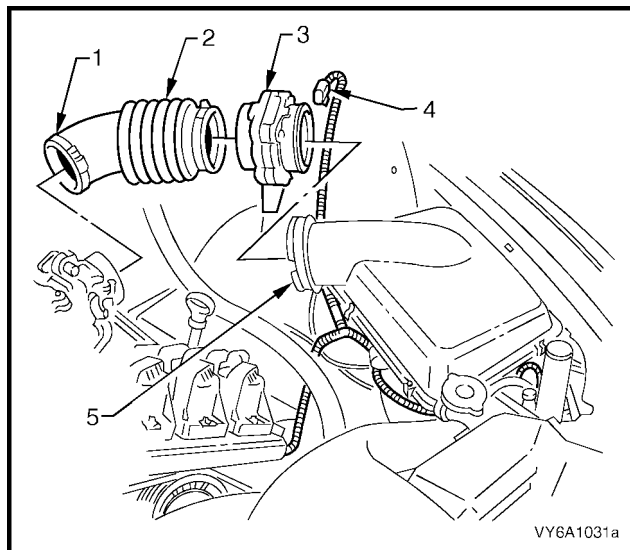


Figure 6A1-1-58

5. Using quick connect release tool No. 7370 open tool and install over fuel line.
6. Close 7370 and pull into fuel line quick connect to release it from fuel feed line, then pull back on quick connect to disconnect. Repeat this for the fuel return (2) and fuel evaporative canister hose (3). Plug all openings to prevent foreign matter entry.

NOTE 1: Do not attempt to remove hoses from fuel rail connections. Once removed from fuel rail connection, hoses require replacement.

NOTE 2: The white tape on the fuel return pipe (5) and hose (6) is to ensure that the correct connections are made on reassembly.

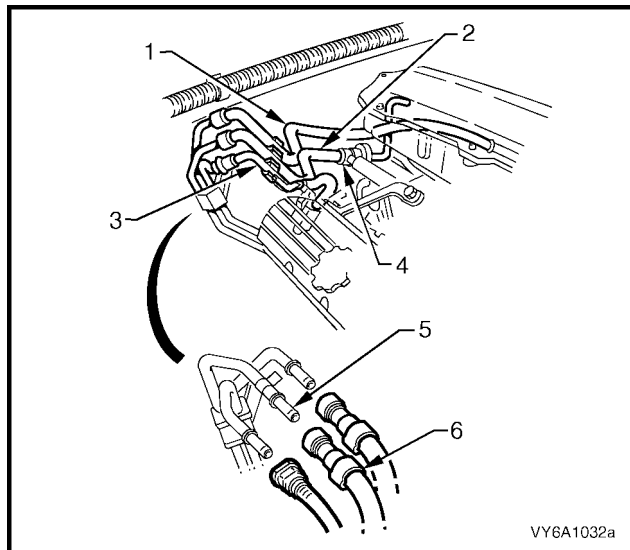


Figure 6A1-1-59

7. Remove radiator cap to release any cooling system pressure.

CAUTION: To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of cooling system pressure is very dangerous and could cause personal injury.

8. Place a clean container (of at least 12 litres capacity) under the engine for the engine coolant to drain into.

NOTE: To reduce the impact on the environment and the maintenance cost, whenever the coolant is drained from the engine, the service records are to be checked to determine when the coolant was last changed. If more than six months life is left before the next coolant change, then the drained coolant can be re-used. For further information, refer to [Section 6B1 ENGINE COOLING – V6 ENGINE](#).

9. Drain engine coolant into drain tray by disconnecting radiator lower hose (1) from the front cover connection.
10. Disconnect emission control purge hose (3) from throttle body connection.
11. Loosen both hose clamps (1) securing the crankcase ventilation hose (2), then remove the hose and clamps from the engine.

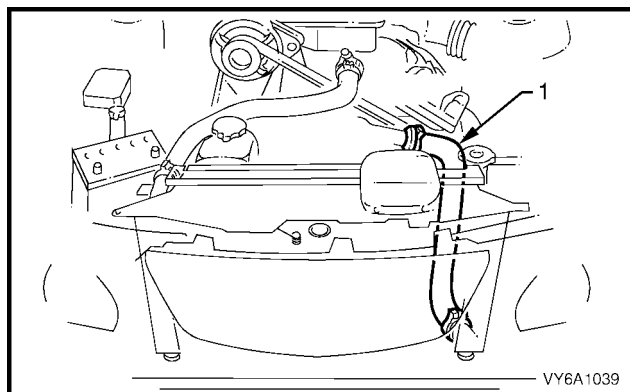


Figure 6A1-1-60

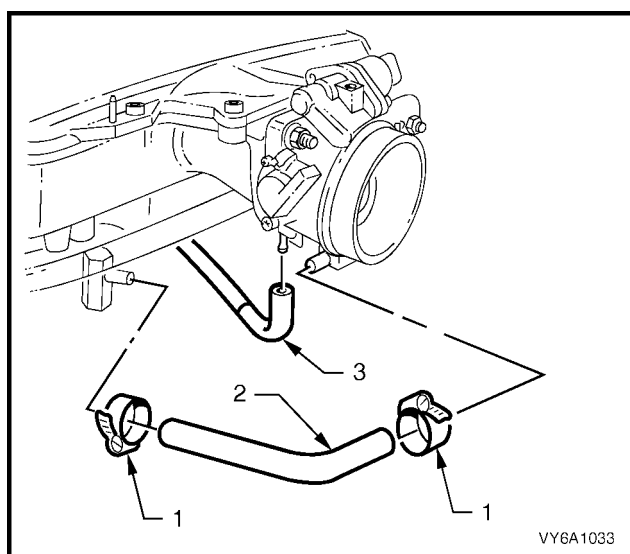


Figure 6A1-1-61

12. Remove the retaining double ended stud (2), then disconnect EGR outlet pipe (1) from upper intake manifold.

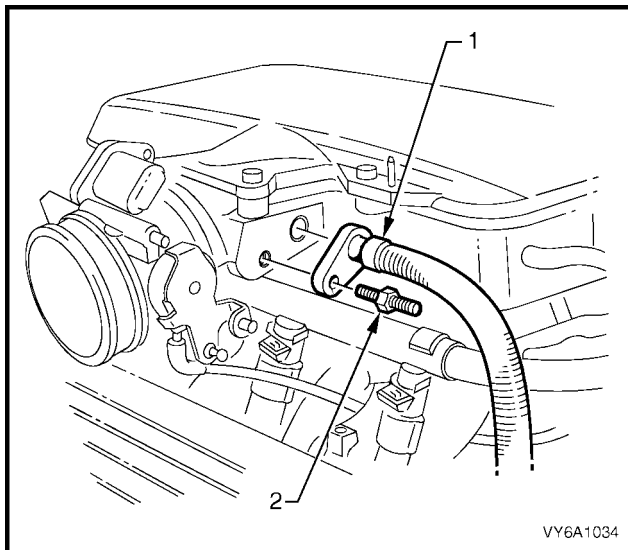


Figure 6A1-1-62

13. Remove right hand side spark plug leads from spark plug terminals by twisting the boot to first break the seal, then pulling on the boot only. After removing the leads from retainer supports at side of cylinder head, lay spark plug lead conduit away from the intake manifold.

NOTE: All spark plug leads and coil terminals are numbered to correspond to cylinder numbering.

If cylinder numbering does not appear on top of any coil assembly, refer to cylinder numbering on the module (refer to [Section 6C1-3 SERVICE OPERATIONS, IGNITION SYSTEM - V6 ENGINE](#)).

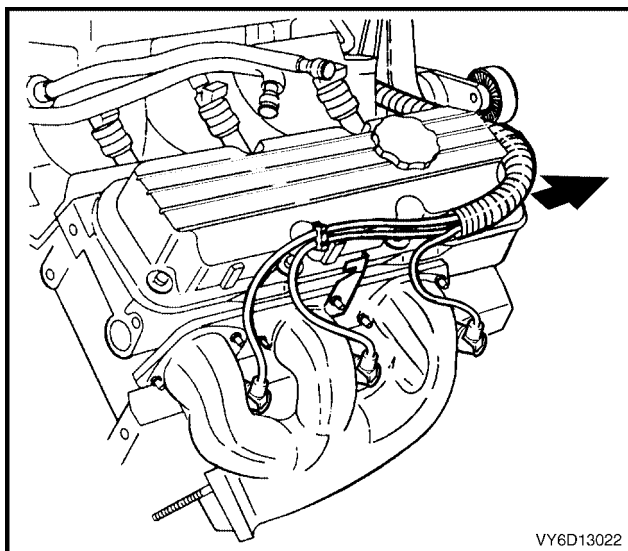


Figure 6A1-1-63

14. Disconnect the brake booster (1), fuel pressure regulator (2) and heater vacuum control (3) hoses from the upper manifold vacuum connections.

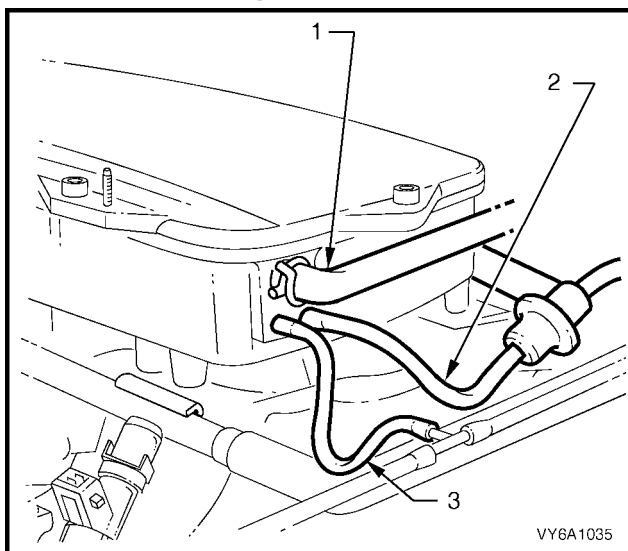


Figure 6A1-1-64

15. Disconnect radiator upper hose (1) from coolant outlet, lay hose away from engine.

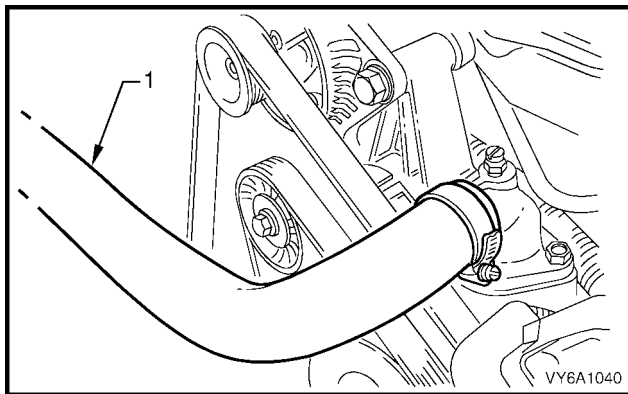


Figure 6A1-1-65

16. Remove generator assembly, refer to [Section 6D1-1 CHARGING SYSTEM - V6 ENGINE](#).
17. Remove powertrain wiring harness ground lead retaining nut (2) from tensioner bracket lower attaching studs. Remove the ground lead (1).

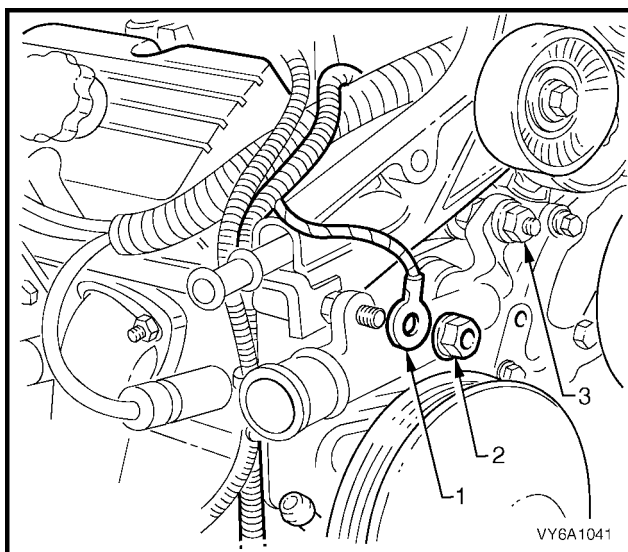


Figure 6A1-1-66

18. Remove remaining nut (1) retaining the coolant intake tube (2). Remove the coolant intake tube (2) from the engine.
19. Remove front stud (3) retaining the heater outlet pipe (4) and drive belt tensioner assembly. Pull heater outlet pipe (4) from the intake manifold and belt tensioner assembly.
20. Remove the remaining stud (6), then remove the tensioner assembly from the right hand cylinder head.

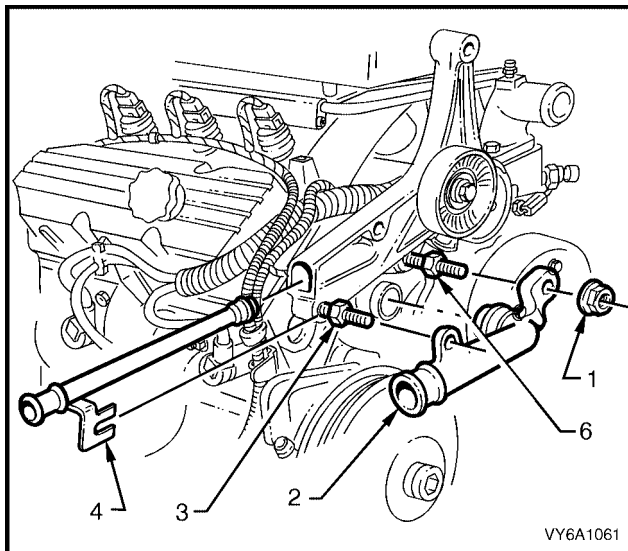


Figure 6A1-1-67

21. Disconnect throttle inner cable (1) from throttle body linkage (2). Loosen throttle outer cable lock nuts (3) at mounting bracket (5) and lay cable away from engine.
22. If vehicle is fitted with cruise control, disconnect cruise control outer cable (4) from mounting bracket (5) and push inner cable forward off throttle body linkage (2).
23. If required, remove the mounting bracket (5) retaining nuts (6) and remove bracket from the throttle body.

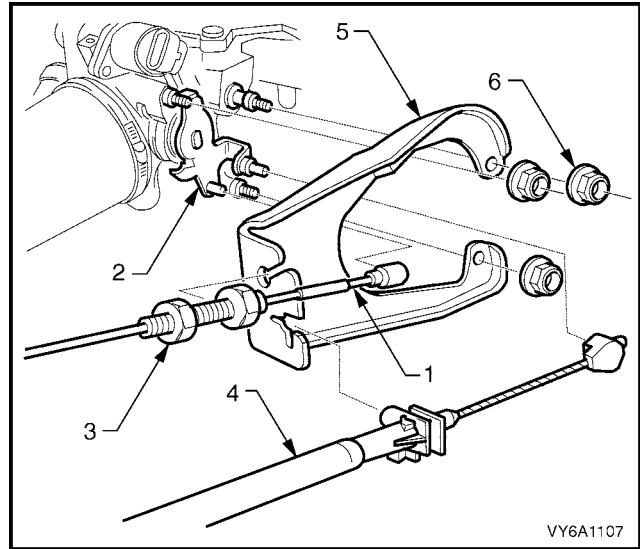


Figure 6A1-1-68

24. Disconnect powertrain wiring harness connectors from:
 - a. Throttle Position Switch (TPS) – 1.
 - a. Idle Air Control (IAC) Valve – 2.
 - b. EGR valve – 3.
 - c. Injectors – 4.

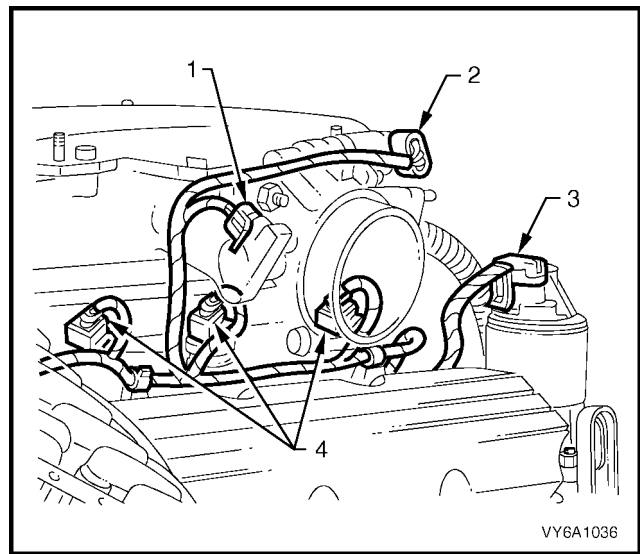


Figure 6A1-1-69

- e. Engine Coolant Temperature (ECT) Sensor (1). Lift the locking tang and pull the wiring harness connector (3) from the sensor (1).

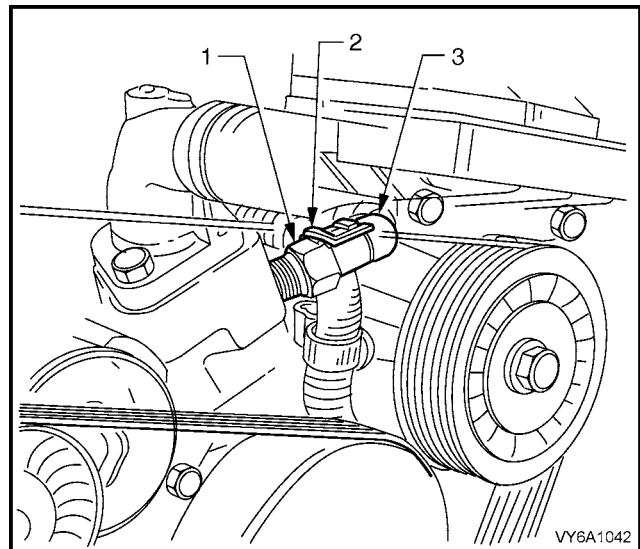


Figure 6A1-1-70

25. Pull out wiring harness retainers from the intake manifold posts near the injector mountings and from the boss at the rear of the manifold. Position the harness away from the intake manifold.

26. Unscrew and remove the engine coolant temperature (ECT) sensor (1) from the thermostat housing.

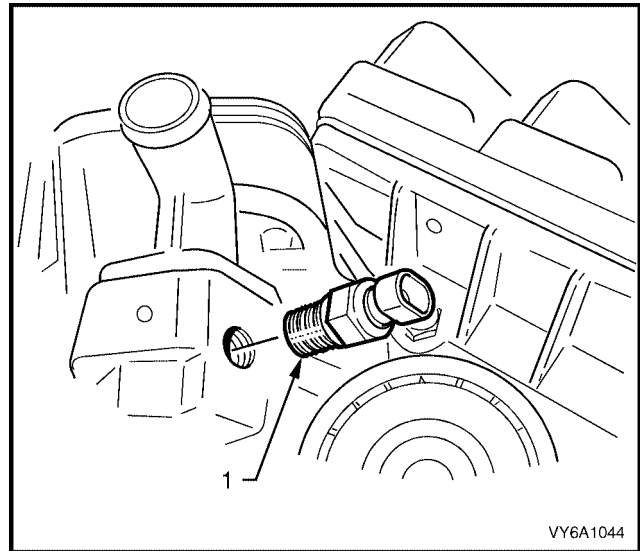


Figure 6A1-1-71

27. Remove 12 lower intake manifold to cylinder head attaching bolts (2), then lift the lower intake manifold (1) from the engine.
28. Remove and discard intake manifold gaskets (3) and seals (4/5).

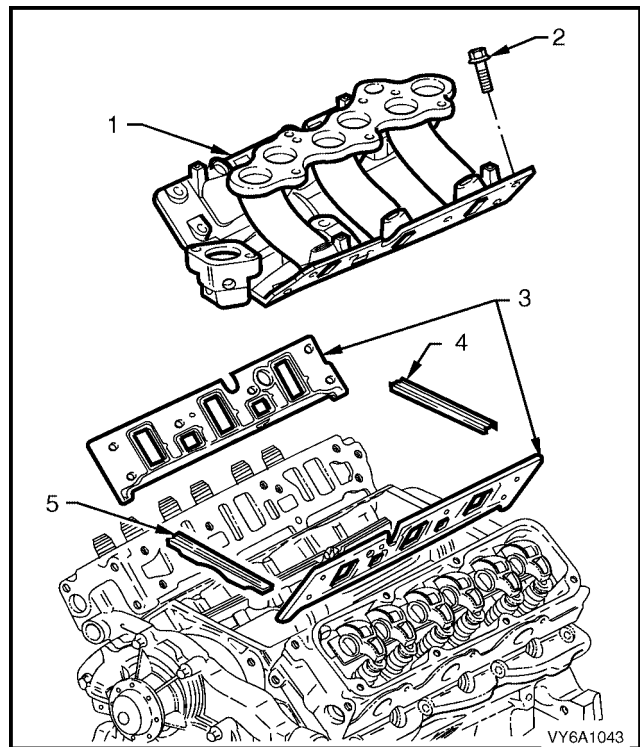


Figure 6A1-1-72

DISMANTLE

NOTE: Remove any or all of the following, as required:

1. Loosen both crankcase ventilation hose clamps (1), then remove the hose (2) from intake manifold and throttle body connections. Remove throttle body to manifold attaching nuts (3), then remove the throttle body (4) and gasket (5). Discard the removed gasket (5).

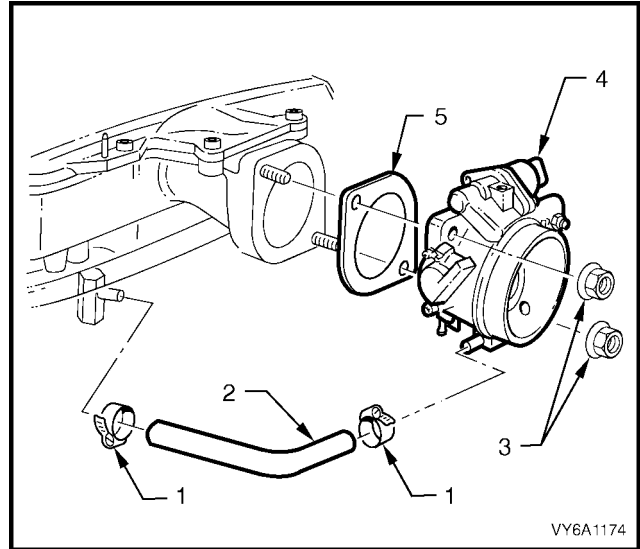


Figure 6A1-1-73

2. Remove the eight intake manifold cover attaching bolts, then remove the cover (1). Remove and discard the gasket (2).
3. Remove the four bolts securing the injectors and fuel rail (4) to the upper intake manifold (3).
4. Loosen then remove all five bolts securing upper intake manifold assembly (3) to lower intake manifold assembly (6). Remove the upper manifold assembly
5. Separate the fuel rail and injector assembly from the intake manifold.
6. Remove and discard the upper to lower intake manifold gasket (5).

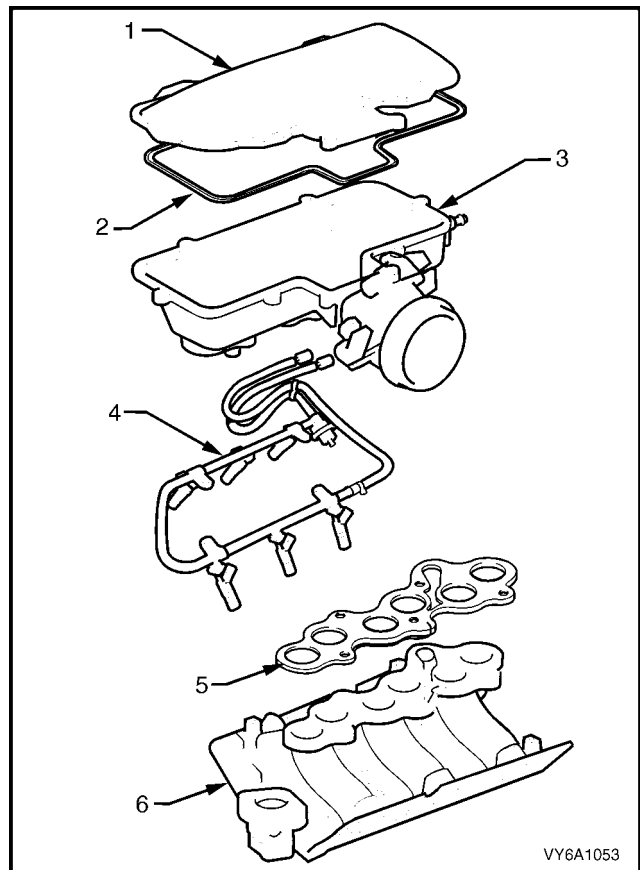


Figure 6A1-1-74

7. Remove spring (1), PCV valve (2), O-ring seal (3) and baffle (4) from lower intake manifold (5). Discard the O-ring seal (3).

NOTE: For PCV valve testing procedures, refer to **Section 6E1 EMISSION CONTROL – V6 ENGINE.**

8. Remove coolant outlet and vent valve (6), then the gasket (7) and thermostat (8). Discard the gasket.

NOTE: For thermostat testing procedures, refer to **Section 6B1 ENGINE COOLING – V6 ENGINE.**

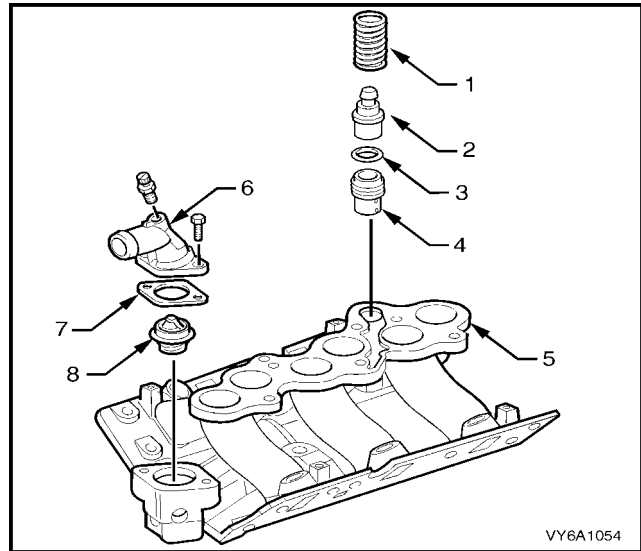


Figure 6A1-1-75

REASSEMBLE

1. Reinstall PCV valve components, noting:
 - a. When reinstalling the baffle (1), ensure that the holes ('A') are aligned across the manifold, as shown.
 - b. Use a new O-ring seal (2) that has been lubricated with petroleum jelly.
 - c. The PCV Valve (3) and spring (4) are installed in the direction shown.

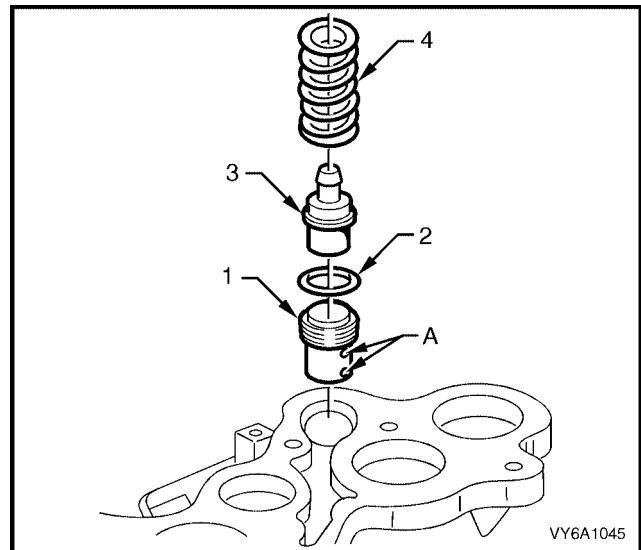


Figure 6A1-1-76

2. Clean the mating surfaces of the intake manifold and the coolant outlet machined surfaces, If the coolant outlet shows signs of excessive corrosion, replace it.
3. Reinstall the thermostat into the intake manifold in the direction shown.
4. Install a new gasket (3), reinstall the coolant outlet (2) and secure with the two retaining bolts. Tighten to the correct torque specification.

COOLANT OUTLET TO INTAKE MANIFOLD BOLT TORQUE SPECIFICATION	28 Nm
---	-------

5. Reinstall the bleeder screw but do not tighten the lock nut at this stage.

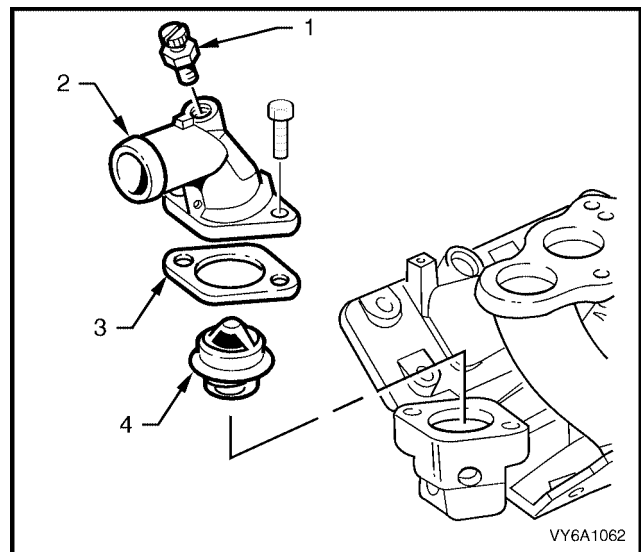


Figure 6A1-1-77

REINSTALL

1. Clean gasket and seal surfaces on cylinder block, cylinder heads and intake manifold. Take care not to scratch or gouge machined surfaces. Ensure that all gasket sealing surfaces are clean and dry.
2. Ensure that manifold attaching bolts and cylinder head threads are clean and free of sealant. Use a suitable size thread tap to clean out threads in cylinder head.

3. While the general arrangement of the gaskets are as shown in Figure 6A1-1-78, the gaskets are to be installed, following these next four steps. Also refer to Figure 6A1-1-79 for more detail:

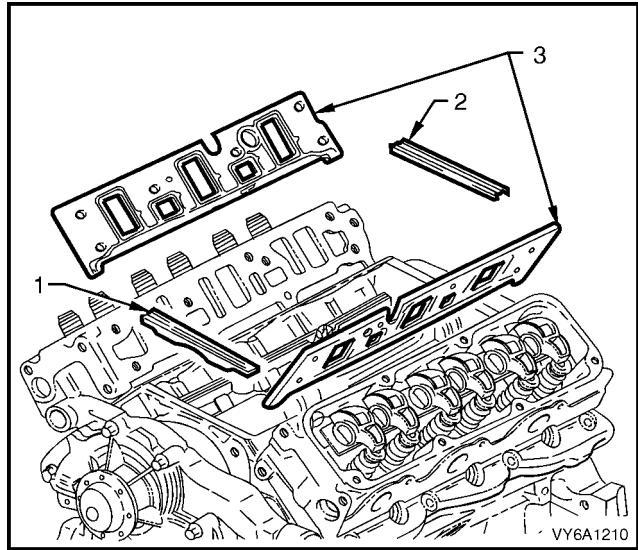


Figure 6A1-1-78

- a. Apply RTV 732 sealant or equivalent in a 2 – 3 mm bead to cylinder head to block joints across edge of head gaskets (four places).
- b. Lay new front (1) and rear (2) manifold seals in place, pushing sealant out towards the cylinder heads at seal and manifold gasket join.

NOTE: Ensure seals are installed with cut out sections facing to outside of the cylinder block.

- c. Slide manifold gaskets (3) into place, ensuring that dowels on each gasket fit into corresponding holes in cylinder head ventilation system hole in each cylinder head.

NOTE: Both gaskets are identical.

- d. Apply a further 2 – 3 mm diameter bead of intake manifold gaskets to seals.

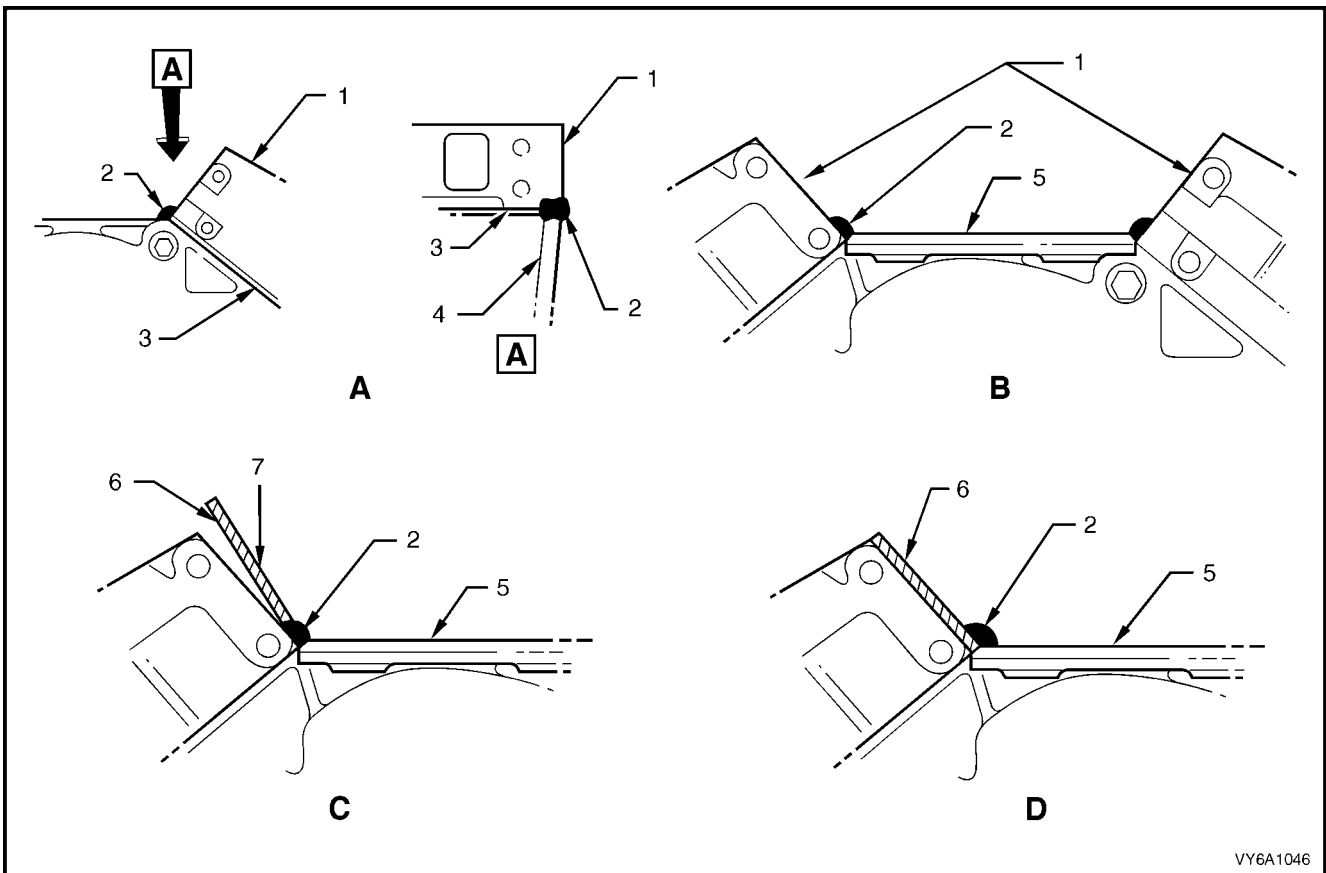


Figure 6A1-1-79

Legend

- | | |
|--|---------------------|
| A, B, C, D Relate to the procedure in step 3, above. | 4. Cylinder Block |
| 1. Cylinder Heads | 5. Seal |
| 2. Sealant Bead | 6. Gasket |
| 3. Cylinder Head Gasket | 7. Push Gasket Down |

8. Apply Loctite 242 sealant or equivalent to the cleaned, lower intake manifold to cylinder head attaching bolt threads.
9. Reinstall lower intake manifold and attaching bolts. Seat bolts by tightening to an initial torque of 5 Nm in the numbered sequence shown.
10. Re-torque bolts to specification, again in the numbered sequence shown.

LOWER INTAKE MANIFOLD ATTACHING BOLT TORQUE SPECIFICATION	15 Nm In the Specified Sequence
---	------------------------------------

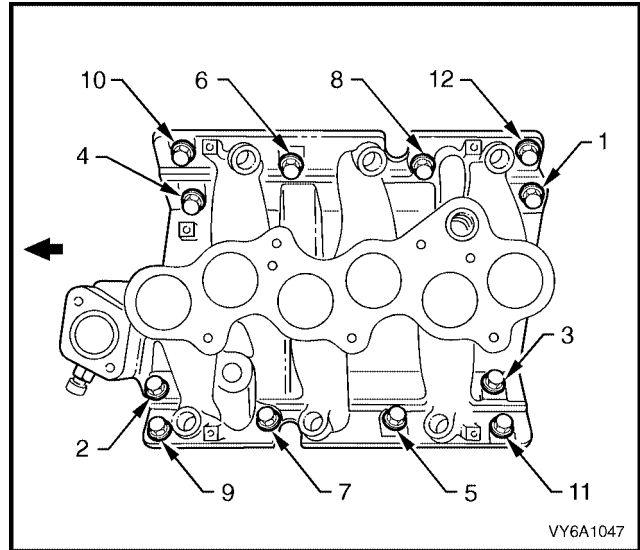


Figure 6A1-1-80

11. Carefully reinstall fuel rail with injectors to the lower manifold, using new O-ring seals, lubricated with petroleum jelly.
12. Reinstall the upper to the lower intake manifold, using a new gasket.
13. Reinstall and tighten the retaining bolts to the correct torque specification.

UPPER TO LOWER INTAKE MANIFOLD BOLT TORQUE SPECIFICATION	18 Nm
--	-------

14. Reinstall the four fuel rail to upper manifold retaining bolts, tightening to the correct torque specification.

FUEL RAIL TO UPPER INTAKE MANIFOLD BOLT TORQUE SPECIFICATION	10 Nm
--	-------

15. If removed, reinstall the throttle body assembly, using a new gasket. Tighten the retaining nuts to the correct torque specification.

THROTTLE BODY ATTACHING NUT TORQUE SPECIFICATION	18 Nm
--	-------

16. Reinstall the upper intake manifold cover, using a new gasket. Reinstall the eight retaining screws and tighten to the correct torque specification.

UPPER INTAKE COVER TO UPPER INTAKE MANIFOLD SCREW TORQUE SPECIFICATION	10 Nm
--	-------

17. Reinstall the drive belt tensioner, securing with the two studs but do not tighten at this stage.
18. After fitting a new O-ring to the heater outlet pipe, lubricate with commercially available petroleum jelly and reinstall through the drive belt tensioner into the intake manifold. Locate the heater outlet pipe securing lug under the outer drive belt tensioner stud, then tighten both studs to the correct torque specification.

DRIVE BELT TENSIONER STUD TORQUE SPECIFICATION	50 Nm
---	-------

19. Inspect sealing O-ring on coolant intake tube; replace if necessary.
20. Smear O-ring with petroleum jelly, reinstall coolant intake tube into the coolant pump body, secure with two nuts and tighten to the correct torque specification.

COOLANT INLET TUBE TO BELT TENSIONER STUD NUT TORQUE SPECIFICATION	22 Nm
--	-------

21. Apply Loctite 242 sealant or equivalent to coolant temperature sensor threads. Reinstall coolant sensor and tighten to the correct torque specification.

COOLANT TEMPERATURE SENSOR TORQUE SPECIFICATION	25 Nm
--	-------

22. Reinstall alternator, refer to **3.1 GENERATOR**, in Section 6D1-1 CHARGING SYSTEM – V6 ENGINE.

23. Reinstall remaining components in reverse order of removal procedures. Ensure that all fasteners are tightened to the correct torque specification.

24. Adjust throttle cable, refer to **3 SERVICE OPERATIONS**, in Section 6C1 POWERTRAIN MANAGEMENT – V6 ENGINE. For cruise control cable, refer to **Section 12E CRUISE CONTROL**.

25. Reinstall air flow duct, reconnect mass air flow sensor electrical connector.

26. Refill cooling system with specified coolant, refer to **Section 6B1 ENGINE COOLING - V6 ENGINE**.

27. Reconnect battery ground lead, start engine and check for air, fuel, oil and coolant leaks. Repair as necessary.

2.12 EXHAUST MANIFOLDS

REMOVE

Left Hand Exhaust Manifold

1. Disconnect battery ground lead.
2. Disconnect spark plug leads from spark plugs, pull lead retainers from support brackets (2) and ignition coils lay leads on top of engine.

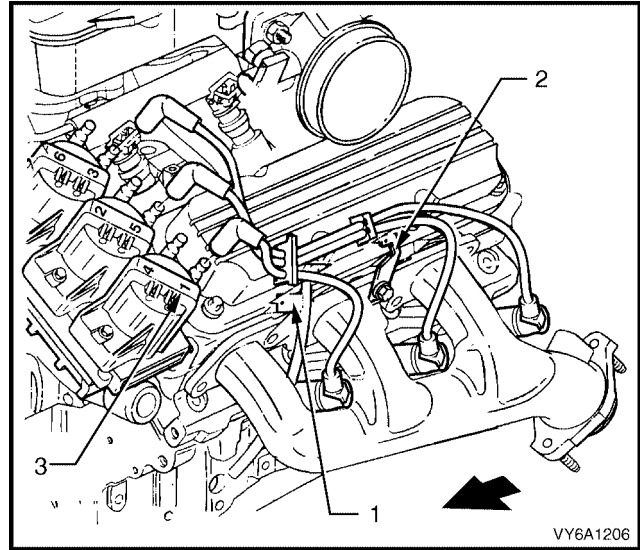


Figure 6A1-1-81

3. Disconnect mass air flow sensor wiring harness connector (4), loosen air flow duct rubber boot clamps (1) at throttle body and air cleaner (5). Remove the air flow duct (2) and mass air flow sensor (3) as an assembly and carefully place to one side.

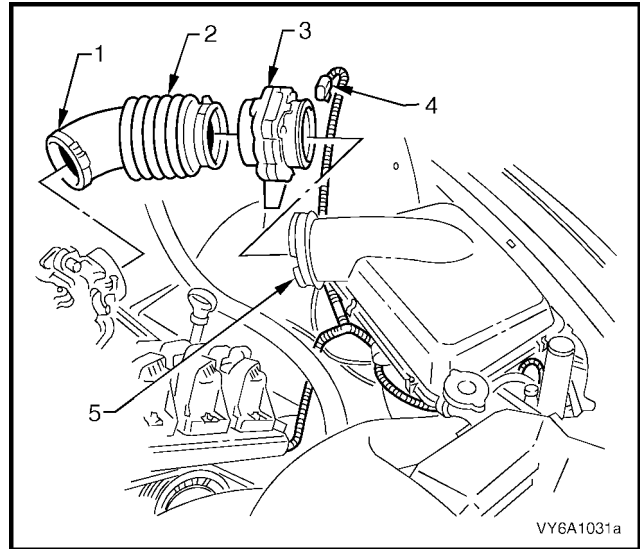


Figure 6A1-1-82

4. Raise front of vehicle and support on safety stands. Refer to [Section 0A GENERAL INFORMATION](#) for location of jacking points.
5. Remove engine pipe to manifold stud attaching nuts.

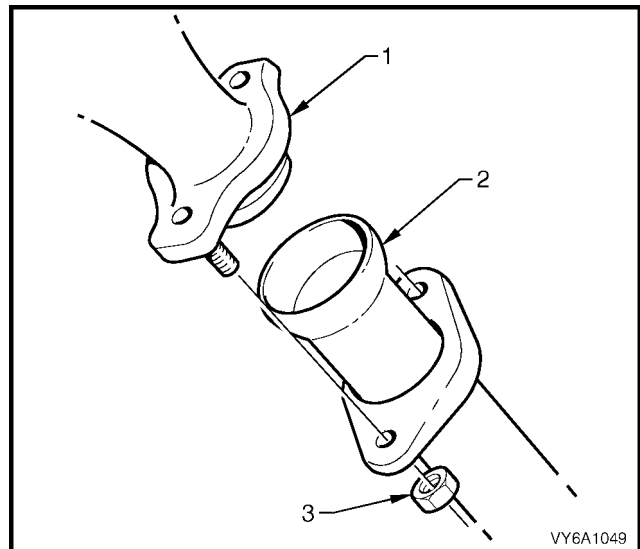


Figure 6A1-1-83

6. Fold up/down locking tabs to release nuts (4).
7. Remove the nut (4) securing the dipstick (1) to the exhaust manifold stud (6). Disconnect dipstick tube from stud and pull assembly from oil pan. Plug the hole in the oil pan to prevent the ingress of foreign matter.
8. Disconnect EGR outlet pipe (8) from exhaust manifold (7).
9. Remove remaining lock nuts (4), lock plates (5) and bolt (2).
10. Remove manifold to cylinder head attaching studs (6), then and remove exhaust manifold (7) from the cylinder head.

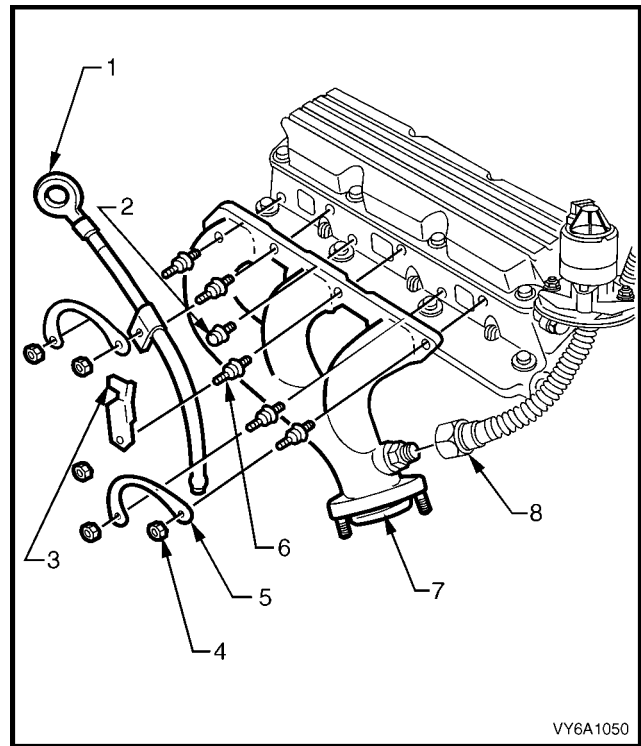


Figure 6A1-1-84

Right Hand Exhaust Manifold

Removal operations are the same as for the left side exhaust manifold, except for steps 7 and 8, that are not required.

REINSTALL

Installation of the exhaust manifold/s is the reverse of removal procedures, noting the following points:

1. Ensure that manifold, cylinder head and engine pipe surfaces are clean.
2. Apply anti-seize compound such as Kopr-Kote (Caltex) or equivalent to exhaust manifold to cylinder head and engine pipe to manifold attaching studs.
3. Install manifold into position and install attaching studs.
4. Connect manifold and engine pipe together and install attaching nuts.
5. Tighten manifold to cylinder head attaching studs to the correct torque specification.

EXHAUST MANIFOLD TO CYLINDER HEAD STUD TORQUE SPECIFICATION	30 Nm
---	-------

6. Tighten engine pipe to manifold stud attaching nuts to the correct torque specification.

ENGINE PIPE TO MANIFOLD ATTACHING NUT TORQUE SPECIFICATION	27 Nm
--	-------

7. Reinstall lock plates, dip stick tube, spark plug lead bracket and lock nuts. Tighten lock nuts to the correct torque specifications. Fold tabs to retain nuts.

NOTE: Install dipstick tube bracket behind lock plate.

EXHAUST MANIFOLD STUD LOCK NUT TORQUE SPECIFICATION	24 Nm
---	-------

8. Reconnect spark plug lead retainers to support brackets and leads to spark plugs.
9. Reinstall air flow duct, reconnect mass air flow sensor electrical connector.
10. Reconnect battery ground lead, start engine and check for exhaust leaks. Repair as necessary.

2.13 ROCKER COVERS AND/OR SEALS

REMOVE

1. Disconnect battery ground lead.

Left Hand Rocker Cover

2. Disconnect spark plug leads from coil terminals.
3. Disconnect mass air flow sensor wiring, loosen air flow duct rubber boot clamps at throttle body and air cleaner and remove air flow duct. Carefully place air flow duct and mass air flow sensor assembly to one side.
4. Fold up/down locking tabs and remove the nut securing the dipstick tube (1) to the exhaust manifold stud. Disconnect dipstick tube from stud and pull assembly from oil pan. Plug hole in oil pan to prevent foreign matter ingress.
5. Disconnect spark plug lead retainers from spark plug lead support (2).

NOTE: All spark plug leads and coil terminals are numbered (3) to correspond to the cylinder numbering. If cylinder numbering does not appear on top of any coil assembly, refer to cylinder numbering on the module (refer to **3 SERVICE OPERATIONS**, in Section 6C1 POWERTRAIN MANAGEMENT – V6 ENGINE.

6. Unscrew rocker cover to cylinder head fasteners and remove rocker cover (1) from cylinder head.
7. If replacing rocker cover seal, remove seal from cylinder head flange recess in rocker cover.
8. If necessary, push out fastener and seal assemblies from rocker cover.

Right Hand Rocker Cover

Proceed as for the left hand rocker cover with the exception of steps '2', '3' and '4' that are not required.

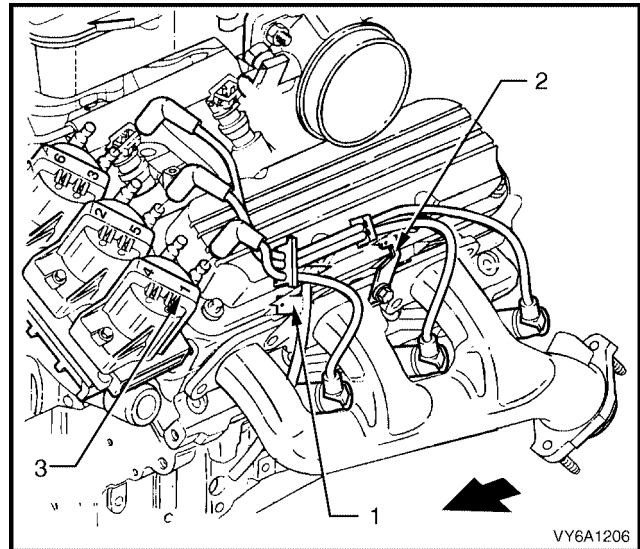


Figure 6A1-1-85

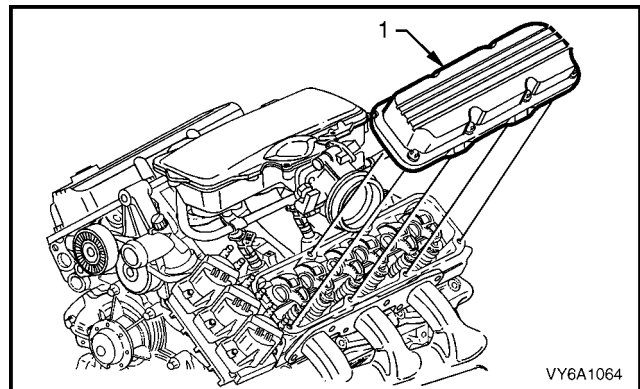


Figure 6A1-1-86

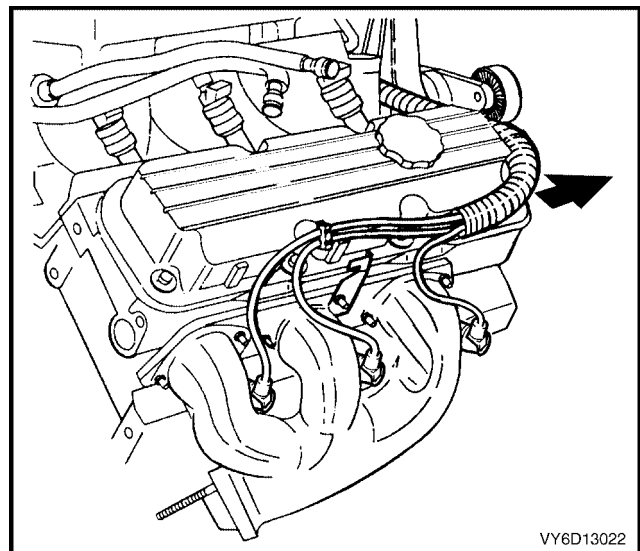


Figure 6A1-1-87

REINSTALL

1. If necessary, install seal in rocker cover recess. Install rocker cover fastener and seal assemblies.

NOTE: Ensure that seal (1) is correctly installed in rocker cover.

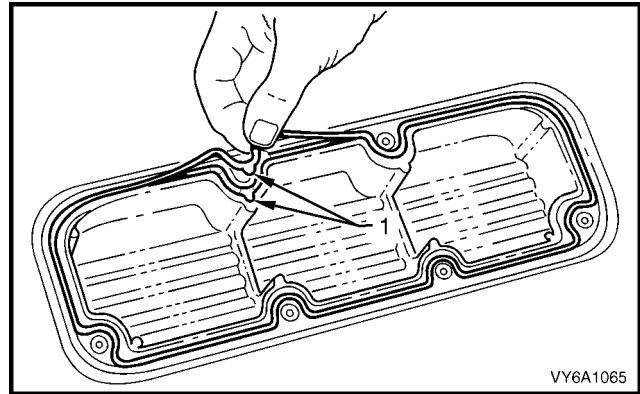


Figure 6A1-1-88

2. Inspect fastener seals and replace any assembly if damaged.
3. Install rocker cover to cylinder head and tighten fasteners to the correct torque specification.

ROCKER COVER FASTENER TORQUE SPECIFICATION	10 Nm
---	-------

4. Refit spark plug lead retainers to support and leads to spark plugs.
5. If removed, reinstall spark plug leads to coil terminals, ensuring correct lead orientation with coil terminal numbering.
6. For the left hand rocker cover, reinstall dip stick tube and air flow duct, reconnect mass air flow sensor electrical connector.
7. Reconnect battery ground lead, start engine and check for oil leaks. Repair as necessary.

2.14 ROCKER ARMS AND PUSHRODS

REMOVE

1. Disconnect battery ground lead.
2. Remove rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section.
3. Remove rocker arm bolts (1), rocker arms (2) and retainers (3).

NOTE: Once removed, discard rocker arm pedestal bolts. New bolts must be used on reassembly.

4. Remove pushrods (4).

NOTE: It is important that the original location of all removed components is retained during reassembly. For this reason, place all components on a suitable rack.

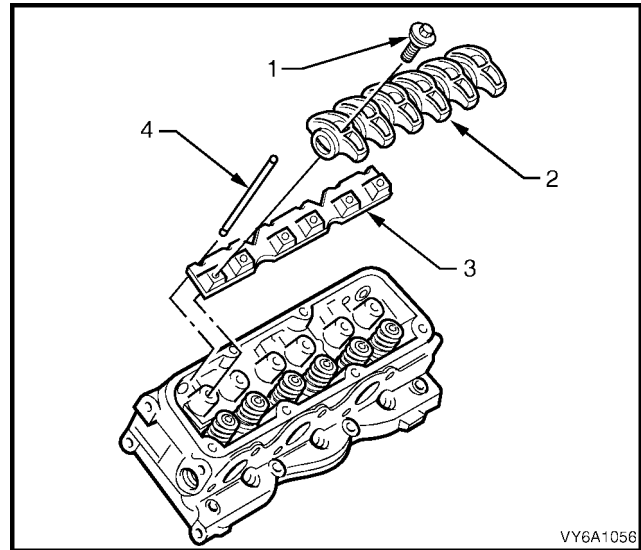


Figure 6A1-1-89

CLEAN AND INSPECT

Clean all components in a suitable cleaning solvent and blow dry with clean dry compressed air.

Inspect all components for wear, check rocker arm pedestal bearings for freedom of movement; replace as necessary.

If there is excessive wear on spherical surfaces of pushrod, refer to [4. ENGINE MECHANICAL DIAGNOSIS - Valve Train Noise](#) in this Section.

REINSTALL

1. Lubricate pushrod contact surfaces with Molybdenum Disulphide, either as a 10% grease or aerosol spray (or equivalent) and install pushrods.
2. Install pedestal retainers onto cylinder heads.
3. Lubricate rocker arm pedestal bearings with clean engine oil.
4. Assemble new rocker arm bolts and rocker arms in their original positions on each cylinder head.
5. Tighten pedestal bolts to the correct torque specification and, at the same time, ensure that each pedestal base engages into the retainer squares and that pushrods remain in contact with each lifter and rocker arm.

ROCKER ARM PEDESTAL BOLT TORQUE SPECIFICATION	15 Nm, then 90° turn angle
--	-------------------------------

6. Reinstall rocker covers, refer to [2.13 ROCKER COVERS AND OR/SEALS](#) in this Section.
7. Reconnect battery ground lead, start engine and check for oil leaks or valve train noise. Repair as necessary.

2.15 VALVE STEM OIL SEALS

REPLACE

1. Disconnect battery ground lead.
2. Remove rocker cover/s, refer to **2.13 ROCKER COVERS AND/OR SEALS** in this Section.
3. Remove rocker arms, refer to **2.14 ROCKER ARMS AND PUSHRODS** in this Section.
4. Remove the spark plug from relevant cylinder.
5. Insert a suitable piece of wire into the spark plug hole and turn the crankshaft balancer bolt until the piston is at or near Top Dead Centre (TDC).
6. Screw air adaptor, Tool No. E1178B into spark plug hole. Apply air pressure to hold valves in closed position.

CAUTION: When air pressure is applied to cylinder, take care, as the pressure may cause the crankshaft to rotate, if the piston is not at TDC or BDC.

7. Using Tool No. J38606 (previously released as KD2078), compress the valve spring and remove valve collets. Repeat for as many valves as required.

NOTE 1: It is important that only spring compressor Tool No. J38606 (or KD2078) is used, as other tools may cause damage to the valve stem collet 'contact' area.

NOTE 2: It may be necessary to tap top of valve cap with a soft faced hammer after the spring compressor has been applied to overcome the binding of the valve collets in the valve spring cap.

8. Remove spring, cap and spring compressor tool as an assembly from cylinder head.

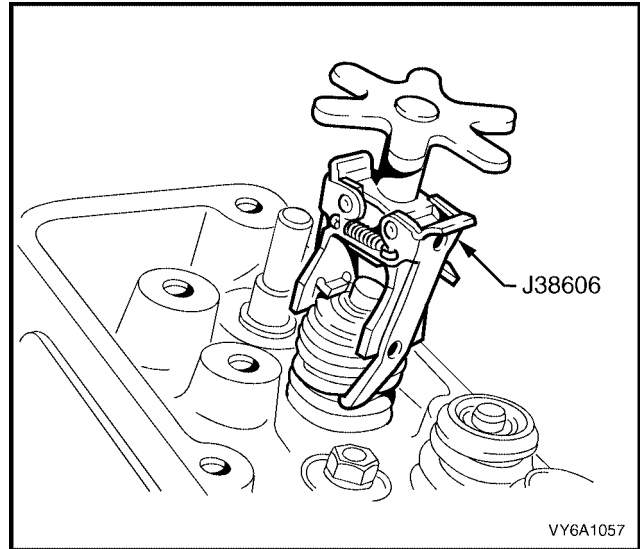


Figure 6A1-1-90

9. Using a screwdriver, lever valve stem oil seal from valve guide. Remove and discard seal.

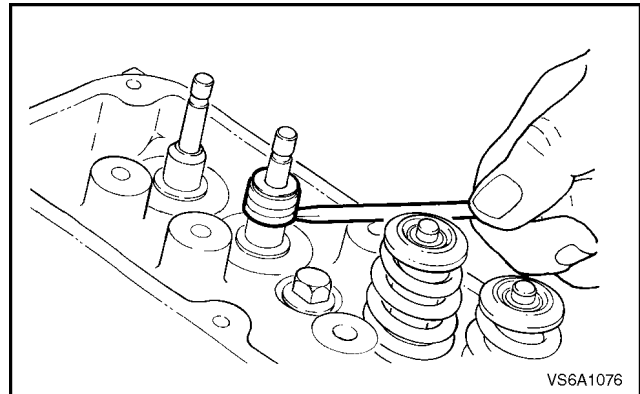


Figure 6A1-1-91

NOTE 1: There are specific valve stem seals for intake (1) and exhaust (2) valves.

- a. The colour of the replacement seal may not be the same colour as the original seal.
- b. Ensure the correct type of seal is fitted to the appropriate valve, based on part number and package description.

NOTE 2: Top views of the valve stem oil seals are shown.

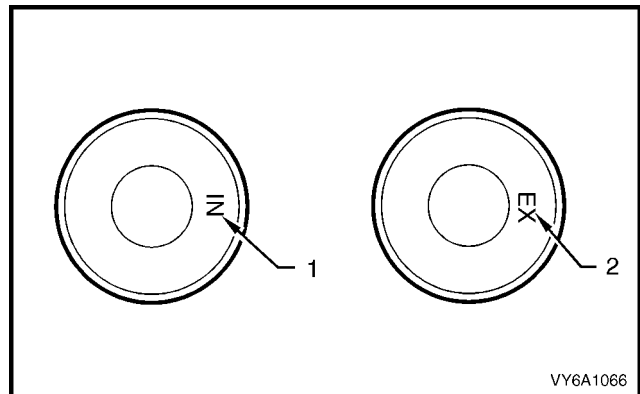


Figure 6A1-1-92

10. Thoroughly clean and dry all components.
11. Lubricate valve stems and valve guides thoroughly with clean engine oil.
12. Lubricate new seal with engine oil and install over valve with a twisting motion and push the seal down until the rubber jacket touches the top of guide.
13. Place the valve stem installation tool J41512 over the valve stem seal (flat surfaced end toward the seal).
14. Lightly tap the top (tapered end of Tool J41512) lightly with a plastic hammer until the valve stem seal is resting flush with the top of the valve guide.

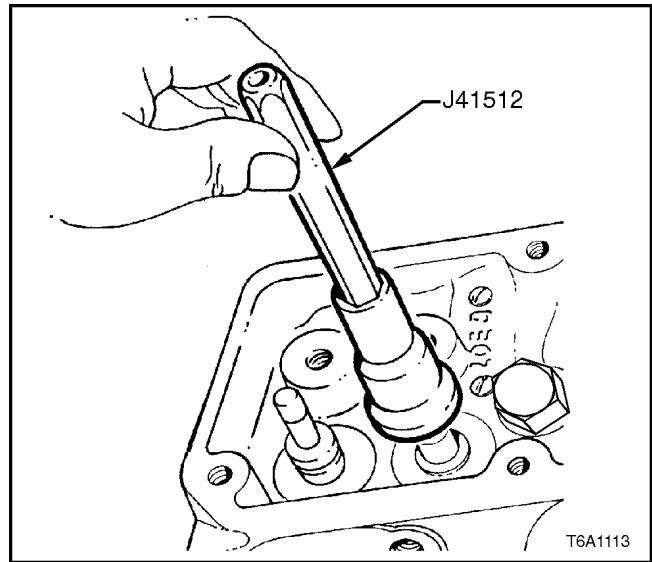


Figure 6A1-1-93

15. Install spring with the larger diameter coils towards the cylinder head spring seat. Install cap and compressor as an assembly on to the valve stem.
16. Install valve collets, ensuring that they locate correctly in groove in top end of valve stem. Slowly release valve spring compressor, checking that collets seat correctly. A sharp tap on cap with a soft faced hammer will ensure correct seating of collets. Chassis grease or petroleum jelly may be used to hold collets in place.
17. Disconnect air line to Tool No. E1178B.
18. Repeat procedure for remaining seals that are to be replaced.
19. Reinstall rocker arms, refer to **2.14 ROCKER ARMS AND PUSHRODS** in this Section.
20. Reinstall rocker cover/s, refer to **2.13 ROCKER COVERS AND/OR SEALS** in this Section.
21. Remove Tool No. E1178B, reinstall spark plugs and tighten to the correct torque specification.

SPARK PLUG TORQUE SPECIFICATION	25 Nm
------------------------------------	-------

22. Reinstall spark plug leads and battery ground lead.
23. Start engine and check for oil leaks and valve train noise. Repair as necessary.

2.16 VALVE LIFTERS

REMOVE

1. Depressurise fuel system, as follows:
 - a. Remove the fuel pump relay (1) from the underhood electrical centre.
 - b. With the throttle closed, crank the engine. The engine may start and idle until any pressurised fuel in the delivery system is exhausted.
 - c. When the engine stops, crank for approximately 10 seconds to ensure that all built-up pressure has been exhausted.
 - d. Replace the fuel pump relay.

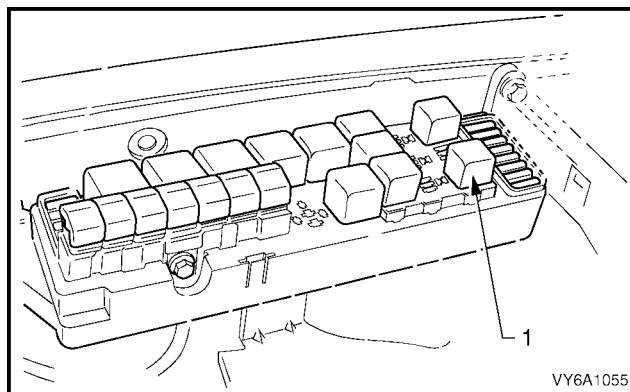


Figure 6A1-1-94

2. Disconnect battery ground lead.
3. Remove rocker covers, refer to **2.13 ROCKER COVERS AND/OR SEALS** in this Section.
4. Remove rocker arms and pushrods, refer to **2.14 ROCKER ARMS AND PUSHRODS** in this Section.
5. Remove lower intake manifold, refer to **2.11 LOWER INTAKE MANIFOLD** in this Section.
6. From valley in cylinder block, remove two valve lifter guide attaching bolts (3). Remove lifter guides (2) with the two encapsulated bolts (3).
7. Remove lifters (1) from cylinder block bores and place in order on rack.

NOTE: Ensure that **all** valve train components are kept in order so they can be reinstalled (if required), in their original locations.

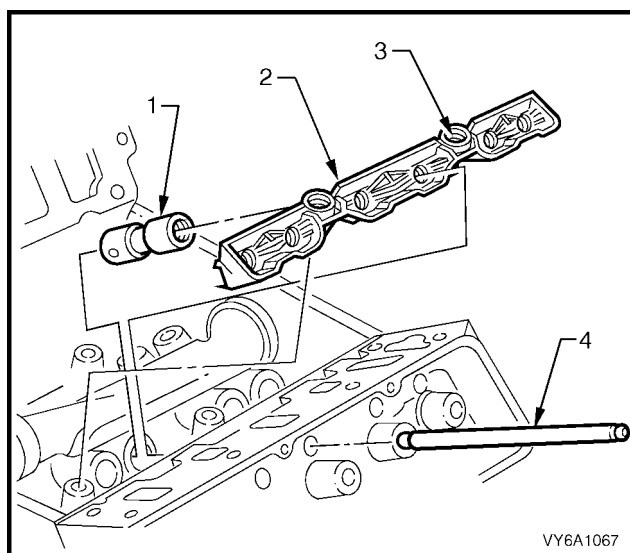


Figure 6A1-1-95

DISASSEMBLE

1. Using a small, fine bladed screwdriver, remove push rod seat retainer clip (10).
2. Remove push rod seat (9), oil metering valve (8), plunger assembly (7, 6, 5 and 4) and plunger spring (3) from the lifter body (2).

NOTE: If the plunger is stuck in the lifter body, turn lifter body upside down and tap lifter body on a block of wood. If the plunger cannot be moved in this way, soak lifter assembly in a suitable cleaning fluid.

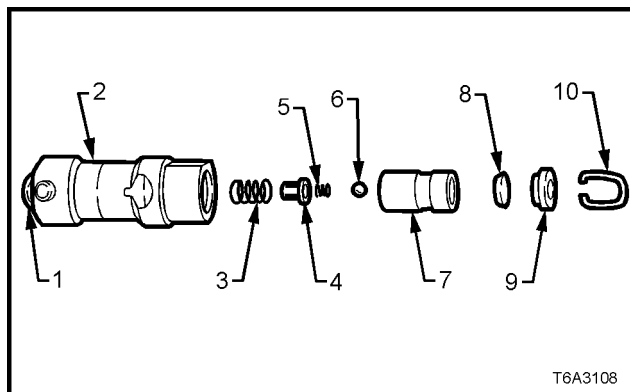


Figure 6A1-1-96

3. Remove check valve retainer, ball check spring and ball from plunger assembly with a small, fine bladed screwdriver.

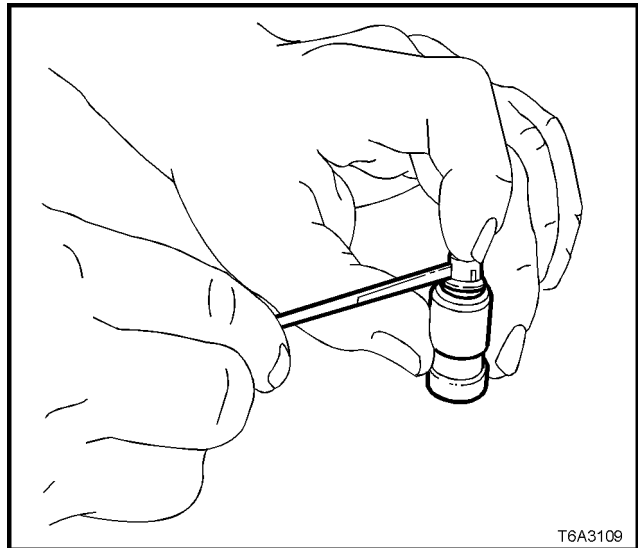


Figure 6A1-1-97

CLEAN AND INSPECT

1. Thoroughly clean all parts in a suitable cleaning fluid. Blow all parts dry with compressed air.

CAUTION: Wear safety glasses to avoid eye injury.

2. Inspect valve lifters for:
 - a. Bent or broken clip (1).
 - b. Worn pushrod socket (2). If the seat is worn, inspect the matching push rod. Replace the push rod if worn.
 - c. Scuffed or worn lifter body (3). Also inspect lifter bore in the cylinder block.
 - d. Flat spots on roller (4). Replace lifter if the roller is worn.
 - e. Loose or damaged pin (5).
 - f. Partially blocked oil hole (6).
 - g. Worn or damaged roller bearing. Replace lifter if roller binds or roughness can be felt.
3. Inspect valve lifter guides for;
 - a. Cracks or damage.
 - b. Excessive wear in the lifter mounting bores.

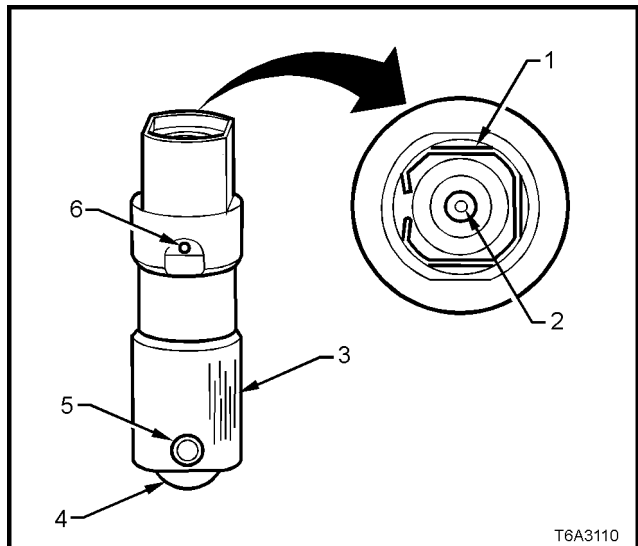


Figure 6A1-1-98

REASSEMBLE

1. Carefully place check ball spring and retainer over ball and press retainer into position in the plunger with a small bladed screwdriver.
2. Half fill valve lifter body with test fluid No. E1151.

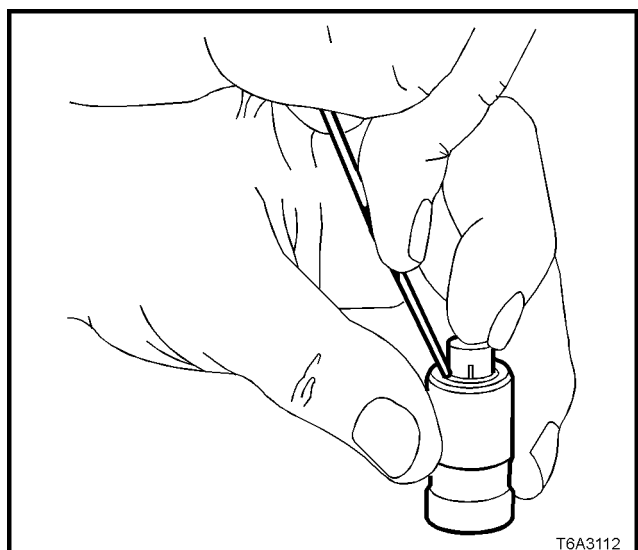


Figure 6A1-1-99

3. Reinstall plunger spring into the lifter body.
4. Install plunger assembly in body, taking care to align oil feed holes
5. Using a 1 mm diameter pin punch or similar, unseat the check ball (2) in the plunger, then push plunger down to the full extent of its travel.
6. Use Tool E1152 (also released as 6A24) (or a suitable sized pin punch) to align the oil feed holes (1) in the body and plunger.
7. Fill the lifter with test fluid.
8. Reinstall the oil metering valve, push rod seat (cup side facing out) and the retaining clip.

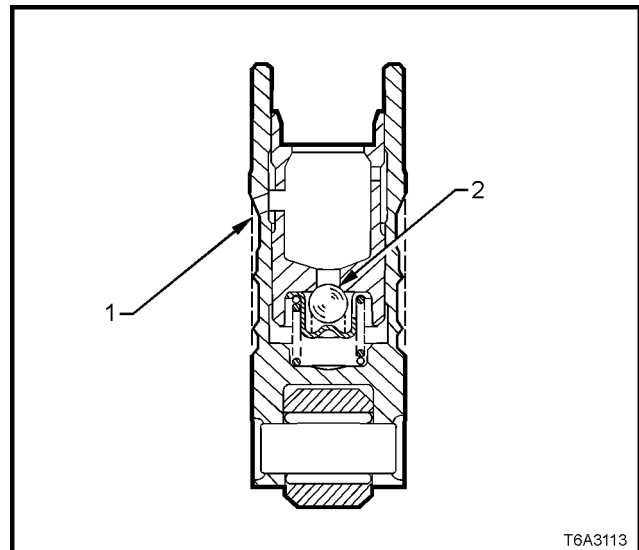


Figure 6A1-1-100

TESTING LIFTER LEAKDOWN RATE

After an hydraulic lifter has been cleaned, inspected and reassembled, it must be tested before being reinstalled. Lifter test fixture, Tool No. 49 U012 005 (also released as 6A23) has been designed to test the leakdown rate of the lifter, to ensure that the lifter will operate as intended, when reinstalled.

1. Ensure the test cup is clean. Install the cup on the fixture and place the lifter in the cup.

NOTE: Some versions of Tool No. 49 U012 005 (or 6A23) may require modification to hold the base of the lifter inside the tester cup.

2. Add test fluid, No. E1151 to completely cover the lifter.
3. Place ball bearing supplied with test fixture in the push rod seat of the lifter.
4. Lower test fixture ram to rest on ball bearing.
5. Operate lifter plunger through its maximum travel to force all air out of lifter by using a vigorous pumping action on test fixture weight arm. Continue pumping action until considerable resistance is built up in lifter and lifter becomes solid.
6. Raise weight arm to allow lifter plunger to come up to its retainer, then lower arm to rest on ram.
7. Use a stop watch to measure the time required for the indicator needle on the tester to travel from 'START' to the 0.125" position on the scale.
8. The leak down rate (time between 'Start' and the 0.125" position) must be between 10 to 30 seconds to assure satisfactory lifter operation.

NOTE 1: A doubtful lifter should be tested several times before being discarded.

NOTE 2: Clean cup and refill with fresh test fluid after several lifters have been tested.

9. Stand tested lifters upright so that fluid does not drain from oil holes.
10. After all lifters have been thoroughly tested, place a cover over the test fixture to keep dirt and dust from the cup.
11. Support all lifters in an upright position, so that fluid does not drain from the oil holes.

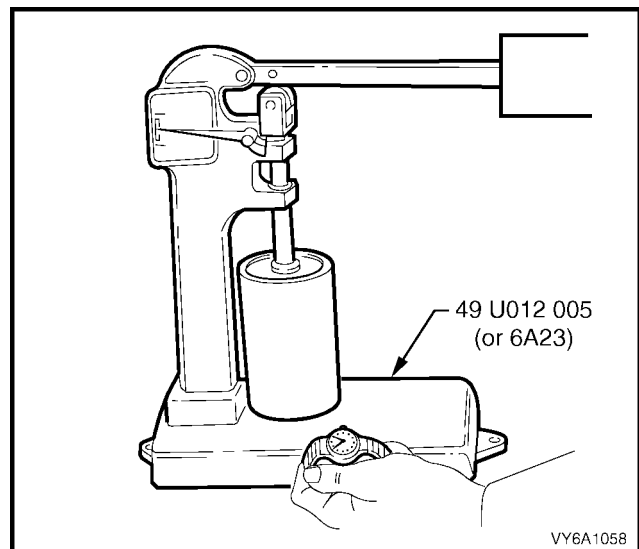


Figure 6A1-1-101

REINSTALL

1. Ensure that lifter bodies, rollers and lifter bores are clean.
2. Lubricate lifter bodies and bores with Molybdenum Disulphide either as a 10% grease or an aerosol spray (or equivalent) and install lifters.
3. Reinstall lifter guides, aligning flats on lifter body with flats in guide.
4. Install valve lifter guide retainer and attaching bolts. Tighten bolts to the correct torque specification.

VALVE LIFTER GUIDE RETAINER BOLT TORQUE SPECIFICATION	30 Nm
---	-------

5. Install rocker arms and pushrods, refer to [2.14 ROCKER ARMS AND PUSHRODS](#) in this Section.
6. Install rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section.
7. Reinstall lower intake manifold, refer to [2.11 LOWER INTAKE MANIFOLD](#) in this Section.
8. Reconnect battery ground lead, start engine and check for oil or fuel leaks and valve train noise. Repair as necessary.

2.17 CYLINDER HEADS

REMOVE

1. Depressurise fuel system, as follows:
 - e. Remove the fuel pump relay (1) from the underhood electrical centre.
 - f. With the throttle closed, crank the engine. The engine may start and idle until any pressurised fuel in the delivery system is exhausted.
 - g. When the engine stops, crank for approximately 10 seconds to ensure that all built-up pressure has been exhausted.
 - h. Replace the fuel pump relay.
2. Disconnect battery ground lead.
3. Disconnect spark plug leads from spark plugs on the right (1) and left (2) banks. Remove spark plug leads from retainers.

NOTE: All spark plug leads and coil terminals are numbered to correspond with the cylinder numbering.

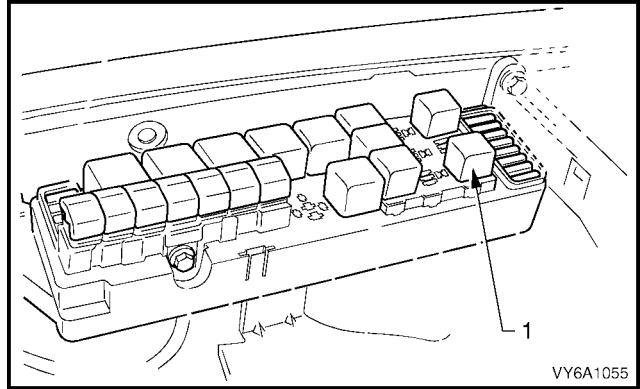


Figure 6A1-1-102

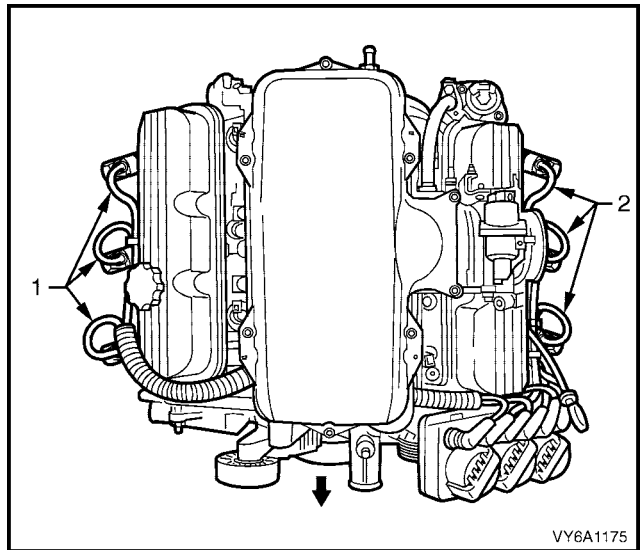


Figure 6A1-1-103

4. Remove drive belt, refer to [2.7 DRIVE BELT - REMOVE](#) in this Section.
5. Remove radiator cap to release any cooling system pressure.
- CAUTION:** To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of cooling system pressure is very dangerous and could cause personal injury.
6. Remove lower intake manifold, refer to [2.11 LOWER INTAKE MANIFOLD](#) in this Section.
7. Remove exhaust manifolds, refer to [2.12 EXHAUST MANIFOLDS](#) in this Section.
8. Remove rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section.
9. Remove rocker arms and pushrods, refer to [2.14 ROCKER ARMS AND PUSHRODS](#) in this Section.
10. **For left hand side cylinder head:**

- a. Disconnect wiring harness connector (1) to ignition coil module assembly (3), remove bolts (2) securing ignition coil and module assembly (3) to left hand cylinder head.
- b. Remove remaining bolt (4) and bracket (5) securing idler pulley assembly (6), removing assembly from the engine.

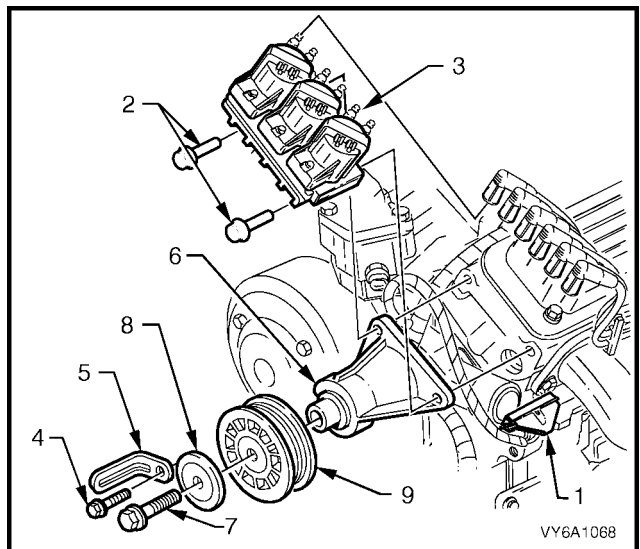


Figure 6A1-1-104

- c. Remove powertrain harness ground connector (3) at rear of cylinder head, after removing the retaining bolt (2).
- d. Remove the wiring harness connector (1) from EGR valve.
- e. Disconnect the EGR pipes from the exhaust manifold and the upper intake manifold.
- f. Remove the EGR valve from the cylinder head.

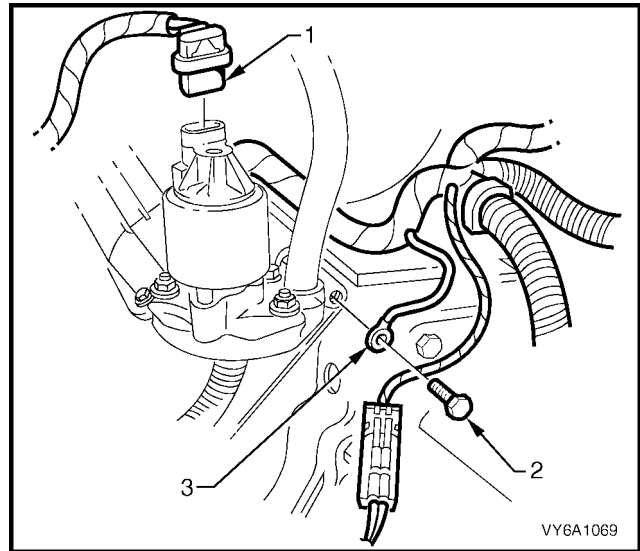


Figure 6A1-1-105

- g. Remove bolt (1) securing starter motor heat shield (2) to rear of cylinder head.

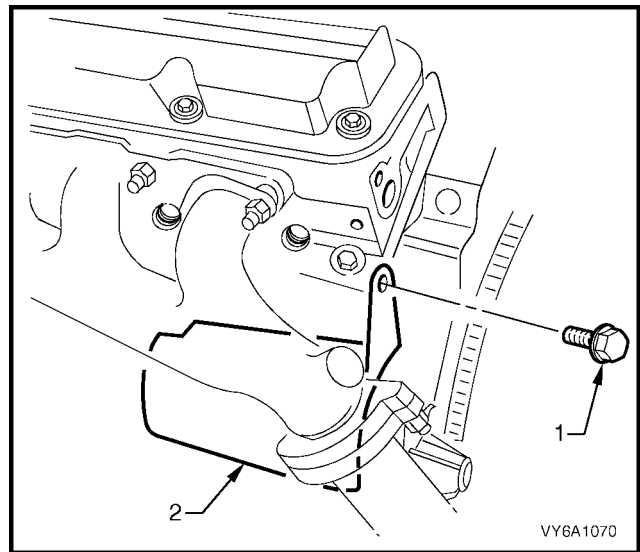


Figure 6A1-1-106

11. For the Right Hand Cylinder Head:

- a. Disconnect evaporative canister purge solenoid vacuum lines (1 and 4) and electrical connector (2), from the evaporative canister purge solenoid valve (3), at rear of cylinder head.

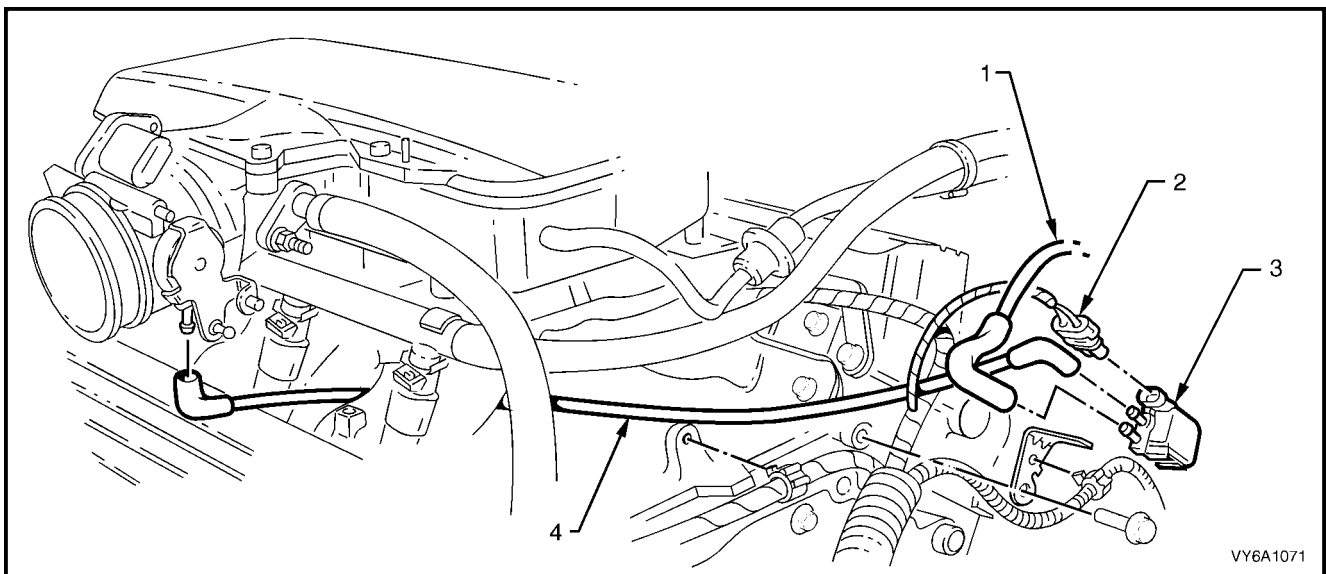


Figure 6A1-1-107

Legend

- | | |
|--|--|
| 1. Hose – Purge Solenoid to Evaporative Canister | 3. Evaporative Canister Purge Solenoid |
| 2. Purge Solenoid Electrical Connector | 4. Hose – Evaporative Canister Purge Solenoid to Throttle Body |

- b. Remove the drive belt tensioner assembly refer to **2.9 DRIVE BELT TENSIONER ASSEMBLY** in this Section.
 - a. Remove generator brace to cylinder head bracket bolt (1) and generator brace bracket to cylinder head bolt (4).
 - b. Remove brace to generator bolt (3), then remove the brace and bracket assembly (2).

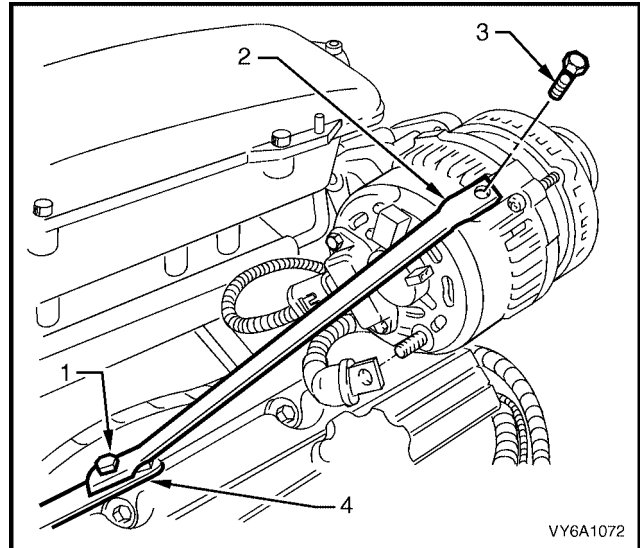


Figure 6A1-1-108

- 5. Gradually and progressively loosen cylinder head bolts in the sequence shown.

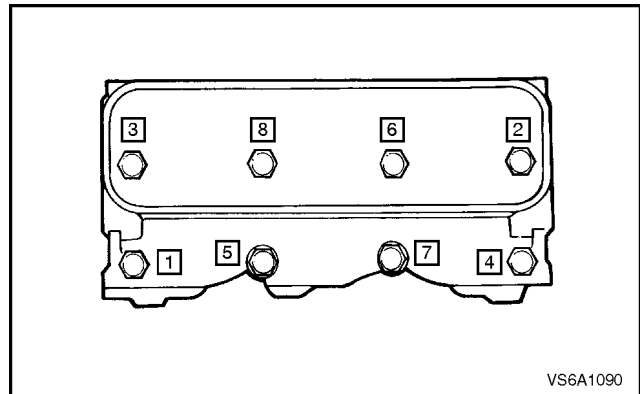


Figure 6A1-1-109

- 6. Remove cylinder head bolts (1), remove cylinder head/s (2) and gasket/s (3).

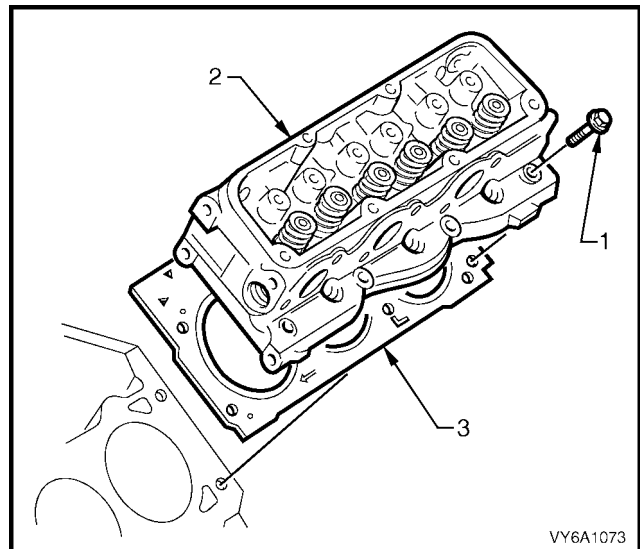


Figure 6A1-1-110

CLEAN AND INSPECT

1. Clean mating surfaces of cylinder head and cylinder block, taking care not to scratch machined surfaces.

NOTE: Do not use a motorised wire brush on any gasket sealing surface.

2. Check cylinder head deck, intake and exhaust manifold mating surfaces for distortion. These surfaces may be refaced by parallel grinding. If more than 0.25 mm must be removed from any surface, replace cylinder head.

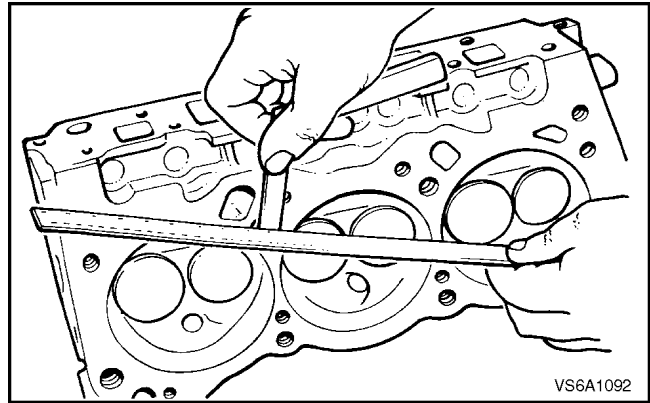


Figure 6A1-1-111

NOTE 1: To determine if cylinder head has sufficient deck surface thickness for resurfacing, measure head height from machined head deck surface to cast pads (arrows), in the three places shown, using a depth micrometer.

NOTE 2: New cylinder heads measure from 1.37 mm to 1.67 mm. The minimum dimension allowed after resurfacing is 1.12 mm

NOTE 3: If the cylinder head does not meet the minimum thickness after resurfacing, the cylinder head must be replaced.

NOTE 4: Do not reduce combustion chamber volume below 60 cm³. Machining 0.15 mm off deck face will reduce combustion chamber volume by 1.00 cm³.

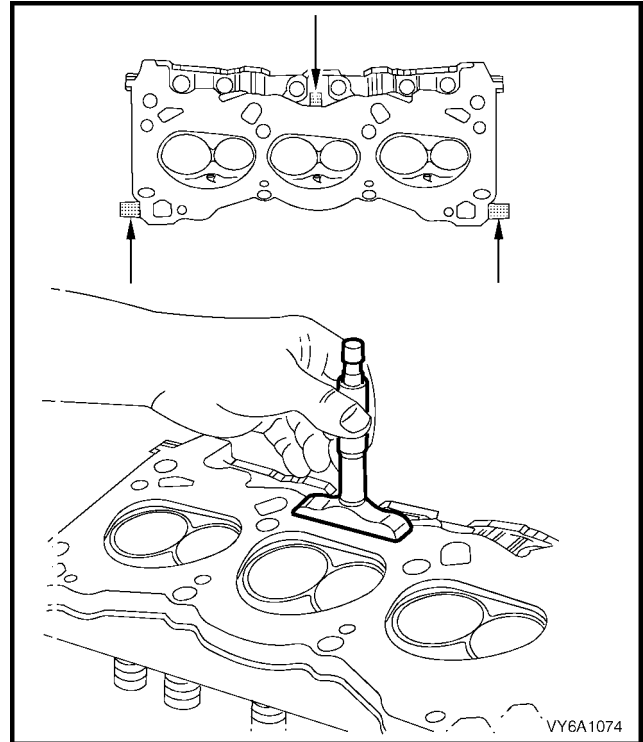


Figure 6A1-1-112

3. Inspect all threaded holes for damage, repair as required.
4. Inspect coolant jacket welch plugs for signs of corrosion, replace plugs as necessary.
If replacing welch plugs, apply a coating of Loctite 242 or equivalent, around plug sealing surface before installation.
5. Inspect cylinder head for cracks, especially between valve seats or exhaust ports.
6. Inspect cylinder head deck surface for corrosion, casting sand inclusions or blow holes.
7. Inspect cylinder block deck surface for distortion, refer to **3.15 CYLINDER BLOCK** in this Section.
8. Clean cylinder head bolt hole threads in cylinder block using a 7/16 UNC thread, bottoming tap. Threads may be reconditioned if necessary, using suitable thread inserts. Clean out bolt holes with an air hose.

CAUTION: Wear eye protection during this operation.

9. Clean cylinder head bolts, replace any bolt that has suspect threads, stretched or damaged heads caused by improper use of tools.

REINSTALL

Reinstallation of the cylinder heads is the reverse of removal procedures, noting the following points:

1. Place head gaskets (1 and 2) in position over dowel pins on cylinder block.

NOTE 1: Ensure that the 'arrow' marking (3) on the gaskets is facing towards the front of the engine

NOTE 2: Head gaskets have a special coating on both sides and care must be taken when installing head gaskets, that the coating is not damaged.

NOTE 3: The left hand cylinder head gasket is identified by a 'L' shaped cut out (4) and the right hand gasket by a 5.0 mm hole. Both are visible on final engine assembly, as a validity check.

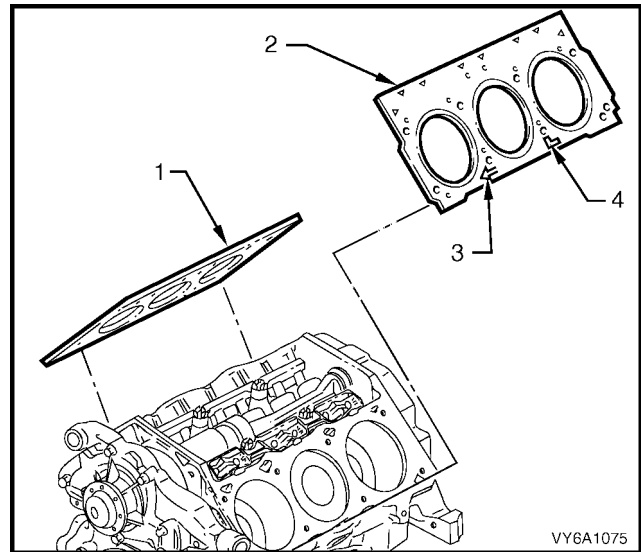


Figure 6A1-1-113

2. Carefully guide cylinder head into place over dowel pins and onto gasket.
3. Coat threads of cylinder head bolts with Loctite 242 sealant or equivalent and install finger tight.

NOTE: Different length head bolts are used; '1' are the longer and '2', the shorter.

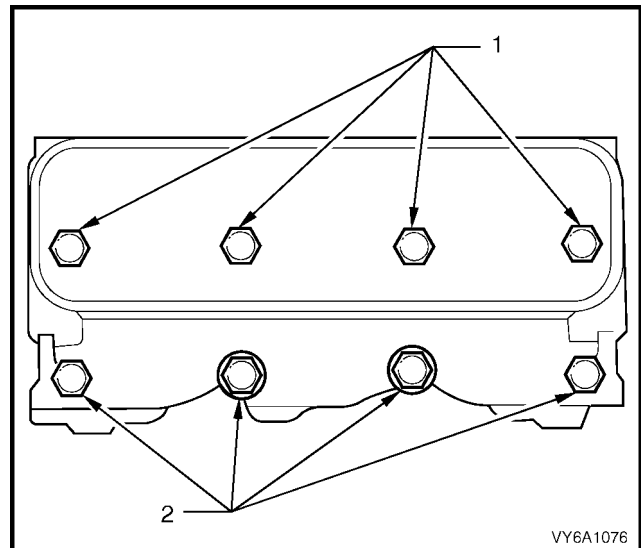


Figure 6A1-1-114

- Tighten cylinder head bolts using the next procedure and in the order shown.

NOTE: Following the stated procedure will avoid head gasket failure and possible engine damage.

- Initially, tighten all cylinder head bolts to 34 Nm.

The next step requires the use of with the torque wrench.

- Tighten each bolt 90 degrees in the order shown, using Tool No. E7115 and an accurate torque wrench.
- Further tighten all bolts in the specified order to 90 Nm.

In summary, the tightening sequence is:

CYLINDER HEAD BOLT TORQUE SPECIFICATION (IN SEQUENCE)		
Step 1.		34 Nm
Step 2.	Turn through 90°	
Step 3.		90 Nm

- The remaining reinstallation of components is the reverse of removal procedures.
- Start engine, check for oil, coolant, fuel and exhaust leaks. Repair as necessary.

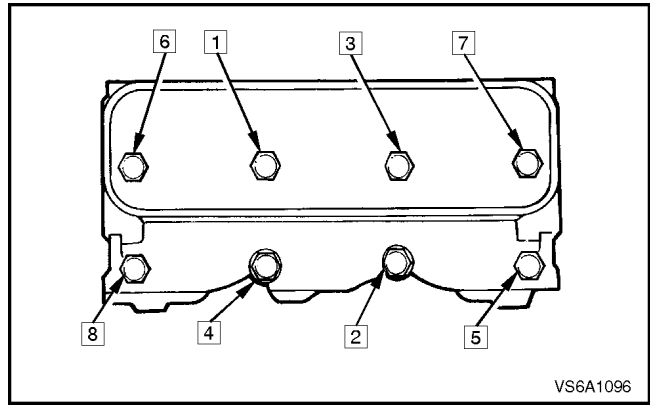


Figure 6A1-1-115

2.18 CYLINDER HEAD RECONDITIONING

NOTE: Ensure that all valve train components are kept together and identified so that they can be reinstalled in their original locations.

DISASSEMBLE

1. Using spring compressor tool No. KD2078, compress each valve spring in turn and remove valve collets.

NOTE: It is important that only spring compressor Tool No. J38606 (or KD2078) be used as other tools may cause damage to valve stem collet 'contact' area. It may be necessary to tap top of valve caps with a soft faced hammer after spring compressor has been installed to overcome the binding of the valve collets in the valve spring caps.

2. Remove valve spring caps, springs and valve stem oil seals.
3. Remove valves from cylinder head.

IMPORTANT: Do not force valves out of guides, as mushroomed valve ends due to rocker arm wear, burred valve collet groove or dirt in the guides, will damage the guides. Remove burrs by chamfering the affected area of valve stem with an oil stone only. During the stoning process, protect the valve stem/guide area with rags or grease to prevent any possible ingress of foreign material.

CLEAN AND INSPECT

1. Clean all carbon from combustion chambers, valve ports etc., using a rotary type carbon removing wire brush.

NOTE: Do not wire brush on any gasket sealing surface.

2. Clean cylinder head gasket surface of cylinder head.
3. Thoroughly clean valve guides with a suitable cleaning solvent or a wire brush.
4. Clean valve heads with a buffing wheel.

NOTE: Do not scratch the valve stem with the buffing wheel.

5. Thoroughly wash all components in a suitable cleaning solvent and blow dry with dry compressed air.
6. Clean cylinder head bolt hole threads in cylinder block using a 7/16 UNC thread, bottoming tap. Threads may be reconditioned if necessary, using suitable thread inserts. Clean out bolt holes with an air hose.

CAUTION: Wear eye protection during this operation.

7. Inspect cylinder heads for cracks in valve seats and combustion chambers, and for external cracks to coolant jackets.
8. Check cylinder head deck surface for corrosion.

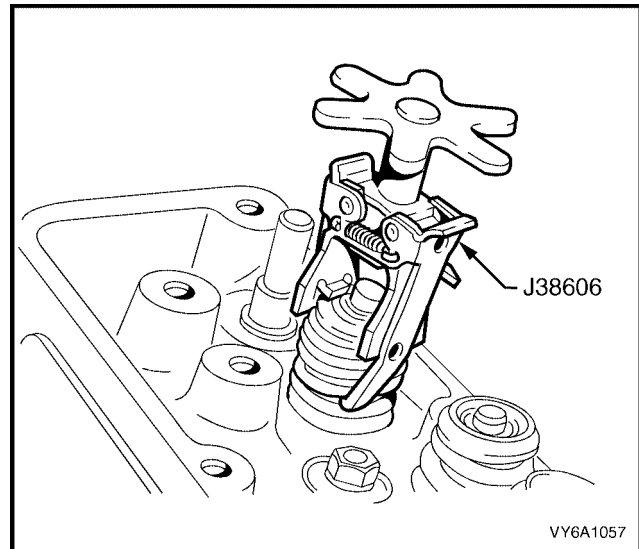


Figure 6A1-1-116

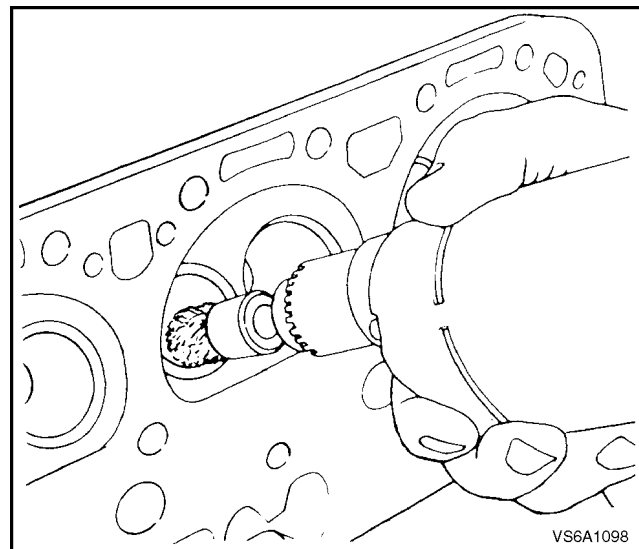


Figure 6A1-1-117

- Using a straight edge and feeler gauge. Check cylinder head deck intake and exhaust manifold surfaces for distortion.

Check cylinder head deck surface diagonally, longitudinally and transversely.

These surfaces may be refaced by parallel grinding. If more than 0.25 mm must be removed from any surface, replace cylinder head.

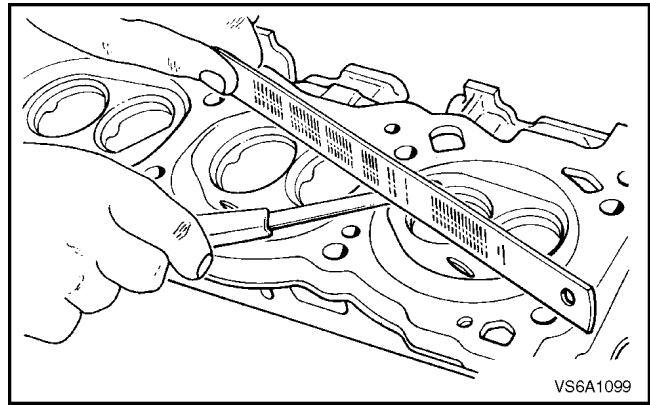


Figure 6A1-1-118

NOTE 1: To determine if cylinder head has sufficient deck surface thickness for resurfacing, measure head height from deck surface to cast pads, in the three places shown by arrows, using a depth micrometer.

NOTE 2 New cylinder heads measure from 1.37 mm to 1.67 mm. The minimum dimension allowed after resurfacing is 1.12 mm

NOTE 3: If the cylinder head does not meet the minimum thickness after resurfacing, the cylinder head must be replaced.

NOTE 4: Do not reduce combustion chamber volume below 60 cm³. Machining 0.15 mm off deck face will reduce combustion chamber volume by 1.00 cm³.

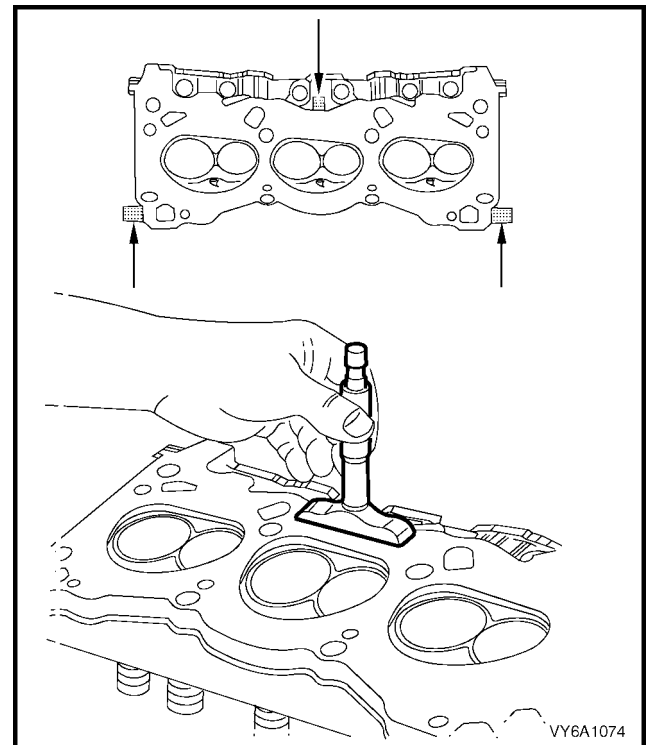


Figure 6A1-1-119

- Inspect all threaded holes for damage, repair as required.
- Inspect coolant jacket welch plugs for signs of corrosion, replace plugs as necessary.
If replacing welch plugs, apply a coating of Loctite 242 or equivalent, around plug sealing surface before installation.
- Inspect cylinder head for cracks, especially between valve seats or exhaust ports.
- Inspect cylinder head deck surface for corrosion, casting sand inclusions or blow holes.
- Inspect cylinder block deck surface for distortion, refer to **3.15 CYLINDER BLOCK** in this Section.

VALVE GUIDES

Clearance Checking

Excessive valve stem to guide bore clearance will cause lack of power, rough idling and noisy valve operation. Insufficient clearance will result in noisy and sticking functioning of the valve and will disturb engine smoothness of operation.

Measure clearance as outlined in the following steps:

1. Insert valve into its guide.
2. Clamp a dial indicator (1) on one side of cylinder head rocker cover seating rail, locating the indicator so that movement of the valve stem from side to side (crosswise to the head) will cause a direct movement to the indicator stem.

The indicator stem must contact the side of the valve stem, 8 - 12 mm above top of valve guide.

3. With the valve head dropped approximately 2 mm from its seat, move the stem of the valve side to side using light force to obtain a clearance reading.

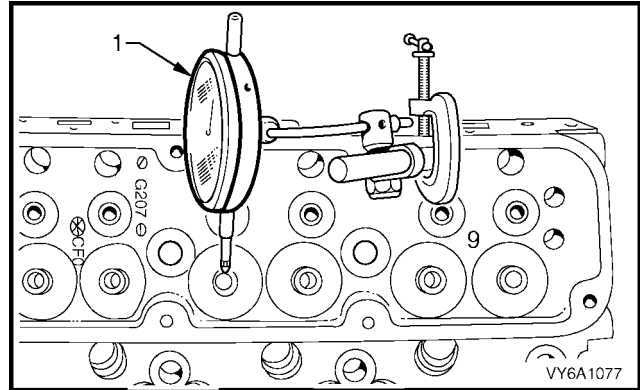


Figure 6A1-1-120

VALVE STEM TO VALVE GUIDE CLEARANCE SPECIFICATION – ALL

0.43 – 0.25 mm Total Indicated Reading
--

NOTE: It is important to check the clearance with a new, standard valve before attempting to ream any valve guide.

An alternative method of measuring valve stem to guide wear, is to subtract the valve stem measurement from the valve guide bore diameter. In this situation, the following specifications apply.

VALVE STEM TO VALVE GUIDE CLEARANCE SPECIFICATION			
New Parts	Intake Valve	0.033 – 0.066 mm	
	Exhaust Valve	0.036 – 0.074 mm	
Worn Parts	All Valves Maximum	0.18 mm	

New Parts	Intake Valve	0.033 – 0.066 mm
	Exhaust Valve	0.036 – 0.074 mm
Worn Parts	All Valves Maximum	0.18 mm

If valve stem to valve guide clearance is within specification when using a new valve, check original valve stem diameter (refer to **VALVES** in this Section) and replace any worn valves as necessary.

Valve guides may be reamed to accept an oversize of 0.254 mm (0.010") or 0.381 (0.015").

Valves with oversize stems are identified by a marking (1), just above the valve stem collet groove (2), as shown.

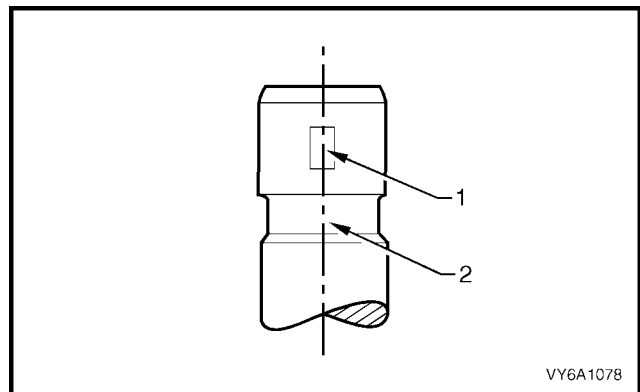


Figure 6A1-1-121

NOTE: Avoid breaking reamer flutes or jamming the reamer into the valve guide due to the packing of chips or carbon. Clean the valve guides before reaming. Do not push down on the reamer, and clean and lubricate the reamer often during use.

VALVE SEATS

Reconditioning the valve seats is very important because the seating of the valves must be precise for the engine to deliver its designed power and performance.

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

Several different types of equipment are available for reconditioning valve seats with an oscillating type valve seat grinder being preferred. The recommendations of the manufacturer of the equipment being used should be carefully followed to attain proper results.

Check valve seats for any evidence of pitting or damage at valve contact surface. If pitting is evident, the valve seats will need to be reconditioned.

NOTE: Since the valve guide serves to support and centre the valve seat grinder, it is essential that the valve guide is serviced before reconditioning the valve seats.

Valve seat angles are to be as indicated next. If, after grinding, the seat is too wide, it may be narrowed by using a 25 degree or 60 degree grinding stone. The 25 degree stone will lower the seat and the 60 degree stone will raise the seat.

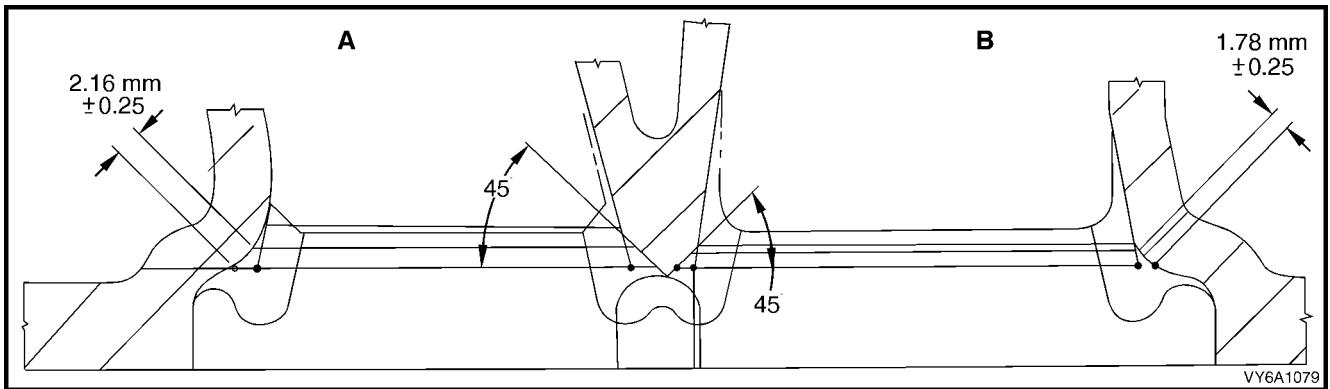


Figure 6A1-1-122

Legend

A. Exhaust Valve

B. Intake Valve

If the valve seats are reconditioned, the valves must also be reconditioned (refer to **VALVES** in this Section) or replace valves as necessary.

VALVE SPRINGS

1. Inspect valve spring surfaces on cylinder head and valve cap for wear or gouging. Replace components as needed.
2. Check spring ends, if they are not parallel, the spring is bent, as indicated by a variance of more than 1.6 mm (dimension '1').

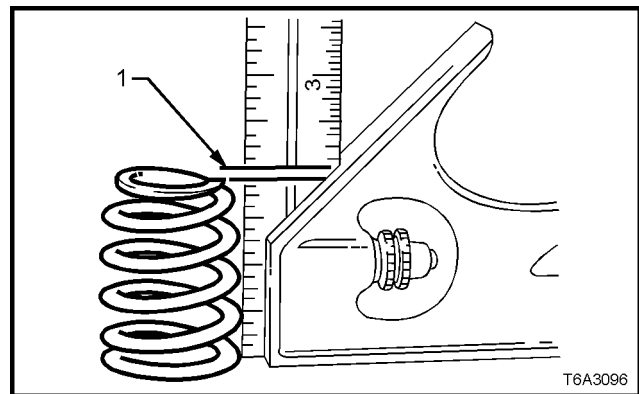


Figure 6A1-1-123

3. Check valve spring load with a commercially available spring tester.

Springs should be compressed to the specified height and checked against specifications.

Replace any valve spring, not to specification.

VALVE SPRING LOAD / HEIGHT SPECIFICATION	
VALVE OPENED HEIGHT	970 – 1059 N at 32.4 mm
ASSEMBLED HEIGHT	316 – 351 N at 43.7 mm

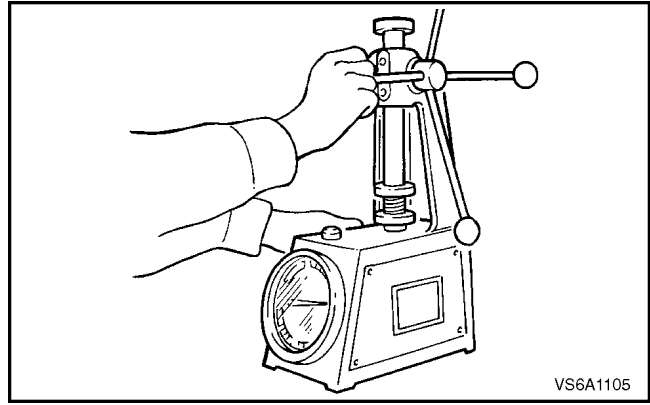


Figure 6A1-1-124

VALVES

1. Inspect valve stem for burrs and scratches. Burrs and minor scratching may be removed with an oil stone.

Valves with excessive stem wear (4) or that are warped should be replaced.

Inspect valve stem end (1) for wear. The valve end may be reconditioned by grinding. Follow the grinder manufacturer's instructions and ensure that new tip surface is at right angles to the valve stem.

2. Inspect valve stem collet groove (2) for damage.

3. Check valve face (5) for burning or cracking.

If pieces have broken off, inspect corresponding piston and cylinder head area for damage.

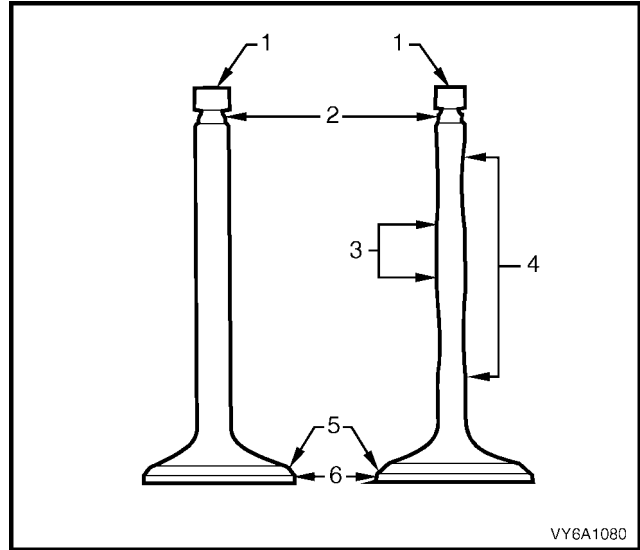


Figure 6A1-1-125

Legend:

1. Valve Stem End
2. Collet Groove
3. Minimum Stem Wear
4. Excessive Stem Wear
5. Valve Face
6. Margin

4. Inspect valve stem for straightness and valve head for bending or distortion. Use V – blocks. Bent or distorted valves must be replaced.

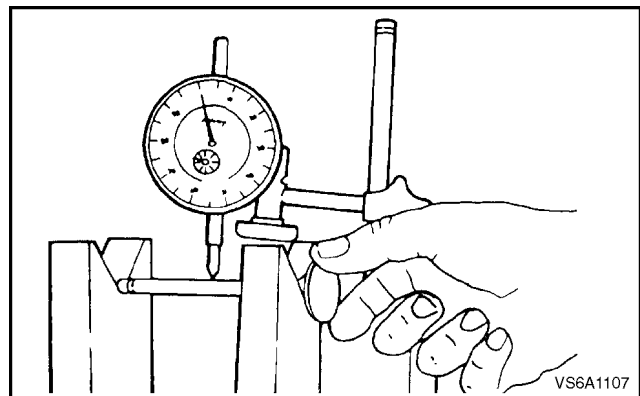


Figure 6A1-1-126

5. Valves with pitted or grooved faces can be reconditioned with a valve refacing machine, ensuring correct relationship between head and stem.

VALVE FACE ANGLE	45 Degrees
------------------	------------

NOTE If pitting or grooving is so deep that refacing would result in a 'knife' edge at the valve head, the valve must be replaced. Measure valve margin after refacing valves. If margin is less than minimum specified, the valve must be replaced.

MINIMUM VALVE HEAD MARGIN THICKNESS	0.63 mm
-------------------------------------	---------

6. Lightly lap reconditioned valves into valve seat.

NOTE: New valves must not be lapped. Lapping destroys the protective coating on the valve face.

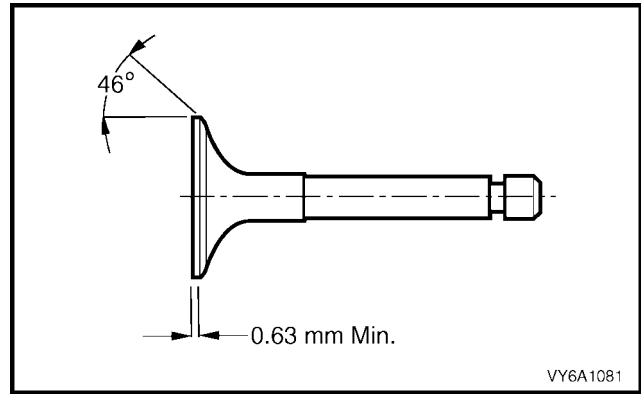


Figure 6A1-1-127

7. After refacing an existing valve or installing a new valve, check for correct seating as follows:
- Lightly coat valve face with bearing blue.
 - Insert valve and rotate about 1/6th of a revolution.
 - Remove valve and check its contact with the seat.
 - If full contact is indicated, valve and seat are acceptable. However, if partial contact is indicated, reinsert valve and turn through a full revolution. If blue on seat indicates full contact, reface valve. If blue on the seat indicates partial contact, regrind cylinder head valve seat.
 - Clean all traces of bearing blue from valves and seats.

MEASURING VALVE STEM HEIGHT

After reconditioning valves or valve seats or when a new valve is installed, the valve stem height must be checked to ensure correct hydraulic valve lifter operation.

1. Place valve in its guide and hold it in the closed position.
2. Using a vernier caliper (1), measure from machined valve spring seat (3) to valve stem end (2).

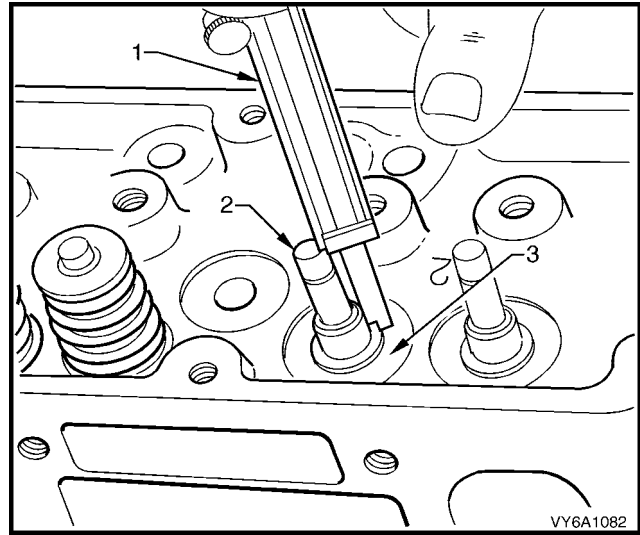


Figure 6A1-1-128

3. Measurement should be as specified.

INSTALLED VALVE STEM HEIGHT SPECIFICATION – “A”	49.22 – 50.49 mm
--	------------------

If measurement is greater than specified, remove valve and grind end of valve stem to achieve specified dimension.

NOTE: Do not grind off any more than is necessary.

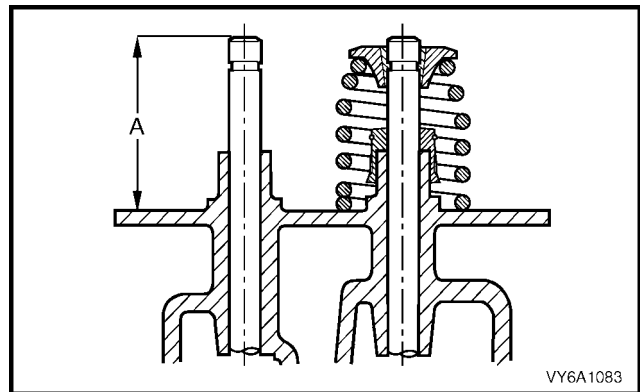


Figure 6A1-1-129

VALVE SPRING INSTALLED HEIGHT

Excessive valve spring installed height, caused by valve seat wear or valve and seat reconditioning, must be compensated for by adding shims under the valve springs.

1. Place valve in its guide.
2. Install valve spring cap and collets.
3. Pull up on valve spring cap to seat collet and valve.
4. Use a vernier caliper (1) to measure from the machined spring seat to the underside of the valve spring cap, see Figure 6A1-1-128.

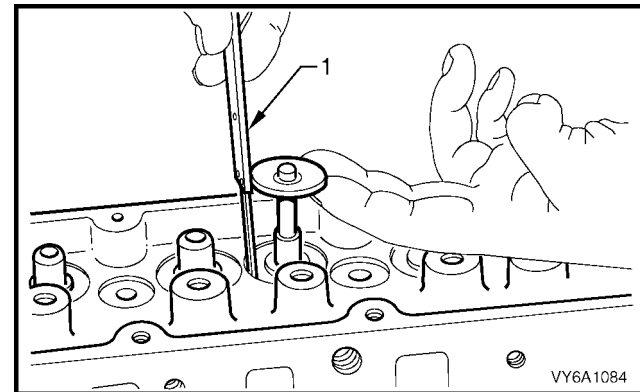


Figure 6A1-1-130

5. Valve spring installed height ‘A’ should be as specified.

VALVE SPRING INSTALLED HEIGHT	43.7 ± 0.5 mm
----------------------------------	-------------------

If any measurement is not as specified, shim the valve spring seat as required.

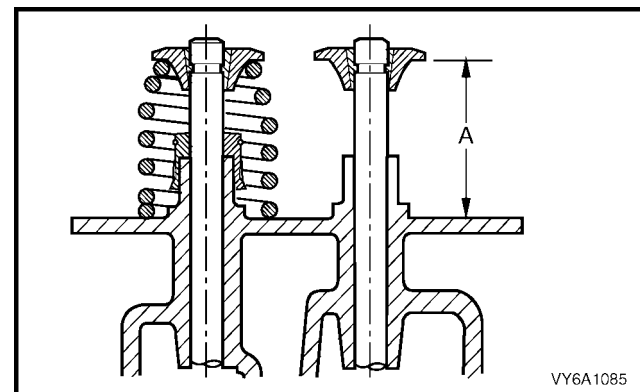


Figure 6A1-1-131

REASSEMBLE

1. Thoroughly clean and dry all components.
2. Lubricate valve stems and valve guides thoroughly with clean engine oil. Install valves in corresponding guides.
3. Lubricate new seal with engine oil and install over valve with a twisting motion and push the seal down until the rubber jacket touches the top of guide.
4. Place the valve stem installation tool over the valve stem seal (flat surfaced end toward the seal).
5. Lightly tap the top (tapered end of the tool) lightly with a plastic mallet until the valve stem seal is resting flush with the top of the valve guide.

NOTE: Install seals using valve stem installation Tool No. J41512.

NOTE 1: There are specific valve stem seals for intake and exhaust valves. Ensure the correct type is fitted to the appropriate valve based on part number and package description.

NOTE 2: The colour of the replacement seals may not be the same colour as the original seals.

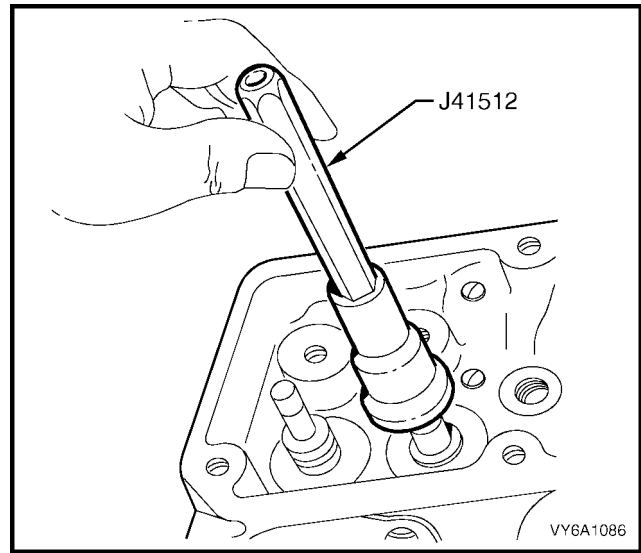


Figure 6A1-1-132

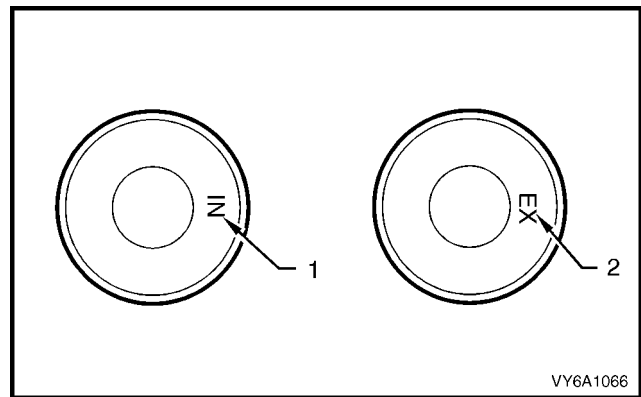


Figure 6A1-1-133

6. Place valve spring and cap over valve stem.
 7. Compress valve spring with tool No. KD2078.
- NOTE:** Compress valve spring only enough to install valve collets. Excess compression can cause valve spring cap to damage valve stem oil seal.
8. Install valve collets, ensuring that they locate correctly in groove in top end of valve stem. Slowly release valve spring compressor, checking that collets seat correctly. A sharp tap on cap with a soft faced hammer will ensure correct seating of collets. Grease may be used to hold collets in place.
 9. Repeat procedure to install all valve springs, caps and collets.

2.19 CRANKSHAFT BALANCER

REMOVE

1. Disconnect battery ground lead.
2. Remove drive belt, refer to [2.7 DRIVE BELT](#) in this Section.
3. Disconnect the wiring harness connector from the oil pressure switch.
4. Lock crankshaft against rotation by inserting the lugs of the crankshaft balancer holding Tool No. AU320 (also released as AU448) into two of the slots in the face of the crankshaft balancer (1). Rotate balancer and locking tool by hand resting the arm of the tool on the R/H side rail.
5. Using a suitable size socket and 'breaker' bar loosen and remove balancer retaining bolt.
6. Remove crankshaft balancer holding tool from crankshaft balancer.

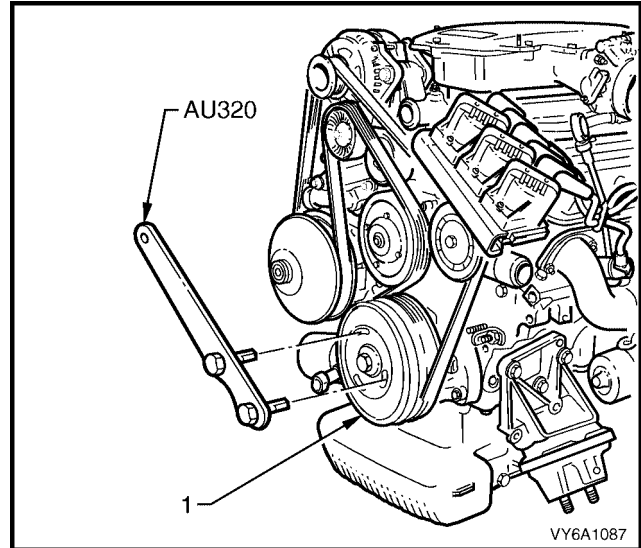


Figure 6A1-1-134

7. Install puller, Tool No. AU424 with three bolts, to front of balancer, then turn the forcing screw to remove balancer from crankshaft.

NOTE 1: Before installing the puller to the balancer, lubricate threads and end of puller forcing screw with grease.

NOTE 2: When installing the puller to the balancer, ensure that the locating pin in the front face of the puller aligns with the indentation between two of the slots in the front face of the balancer. This is to ensure correct alignment of the bolt holes in the balancer and puller.

NOTE 3: The three puller attaching bolts, need to be 10 mm longer than those originally supplied with Tool No. AU 424.

NOTE 4: A series of holes are drilled in the perimeter of the puller plate to enable the installation of a bar to hold the puller from rotating while turning the forcing screw.

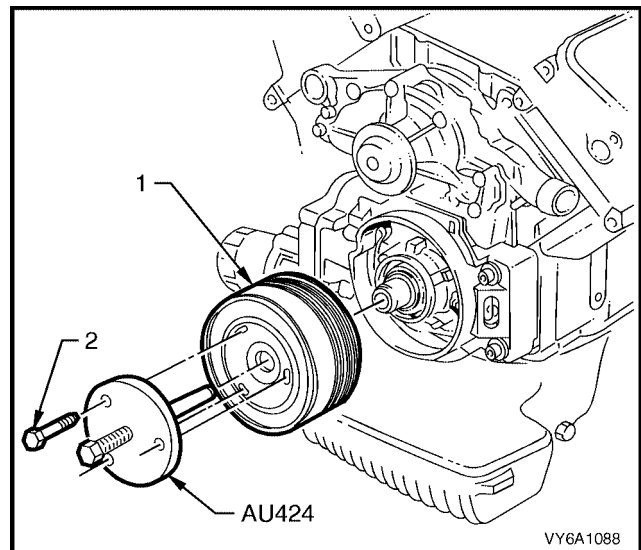


Figure 6A1-1-135

REINSTALL

Installation is the reverse of removal procedures, noting the following points:

NOTE: The balancer is serviced only as an assembly.

1. Visually inspect interrupter rings, on rear of balancer, for any damage or distortion.
2. Lubricate front seal and seal contact surface of balancer with engine oil. Install balancer, engaging key on crankshaft with slot in balancer.
3. Pull crankshaft balancer into position by tightening retaining bolt. Once balancer has seated onto front end of crankshaft, lock crankshaft against rotation by inserting lugs of crankshaft balancer locking tool No. AU448 into two of the slots on the face of crankshaft balancer. Rotate balancer and locking tool by hand so that the arm of the tool rests against the L/H side rail. Continue to tighten balancer retaining bolt to the correct torque specification.

CRANKSHAFT BALANCER RETAINING BOLT TORQUE SPECIFICATION	300 Nm
---	--------

4. Rotate Crankshaft and ensure that interrupter rings do not make contact with crank sensor. If any part of the interrupter rings touch the crank sensor then the crank shaft balancer must be replaced, refer to [Section 6C1-3 IGNITION SYSTEM – V6 ENGINE](#).
5. Check drive belt operation.

2.20 CRANKSHAFT FRONT SEAL

REPLACE

1. Remove crankshaft balancer, refer to **2.19 CRANKSHAFT BALANCER** in this Section.
2. Using Tool No. E308 or commercial equivalent, remove seal (1) from the front cover.

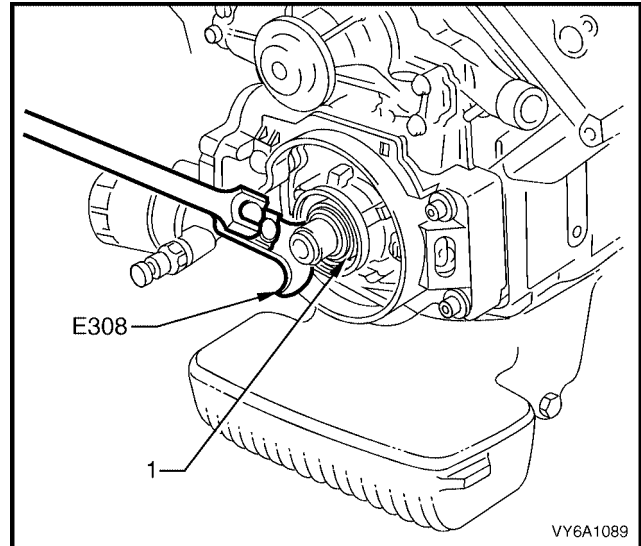


Figure 6A1-1-136

3. Using Tool No. J28540-A install new seal.

NOTE: The crankshaft balancer key will need to be removed from the nose of the crankshaft, before using Tool No. J28540-A.

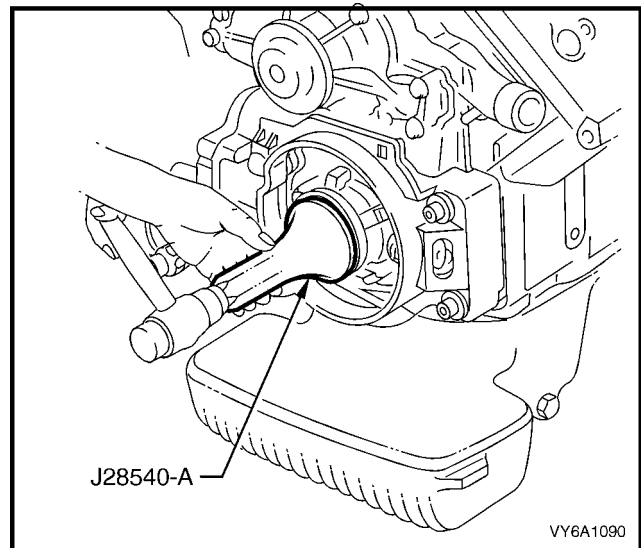


Figure 6A1-1-137

4. Inspect seal surface on crankshaft balancer, if grooved or damaged, replace balancer.
5. Reinstall crankshaft balancer, refer to **2.19 CRANKSHAFT BALANCER** in this Section.

2.21 FRONT COVER AND GASKET

REMOVE

1. Disconnect battery ground lead.
2. Remove radiator cap to release any cooling system pressure.

CAUTION: To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of cooling system pressure is very dangerous and could cause personal injury.

3. With the drive belt still installed, loosen the four coolant pump pulley retaining bolts.
4. Loosen power steering pump drive pulley (2) to power steering pump (1), bolts (3).

NOTE: If necessary, a suitable Allen key may need to be inserted in front of power steering pump shaft to prevent shaft from turning.

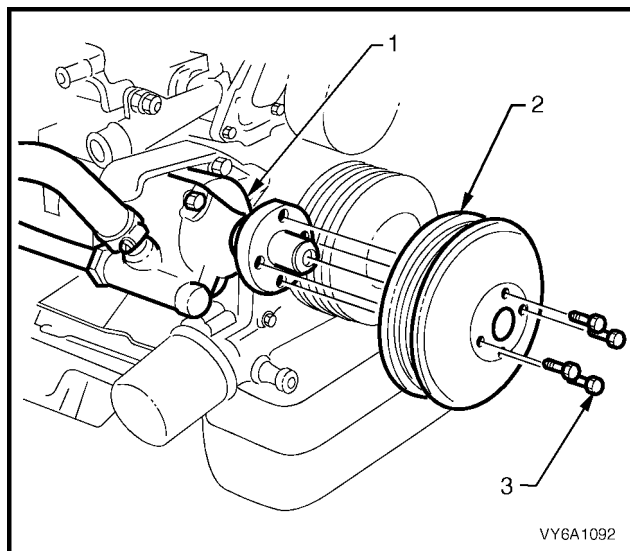


Figure 6A1-1-138

5. Remove the drive belt, refer to [2.7 DRIVE BELT](#), in this Section.
6. Remove crankshaft balancer, refer to [2.19 CRANKSHAFT BALANCER](#) in this Section.
7. Remove the coolant pump (1) to pump pulley (2) attaching bolts (3). Remove pulley.

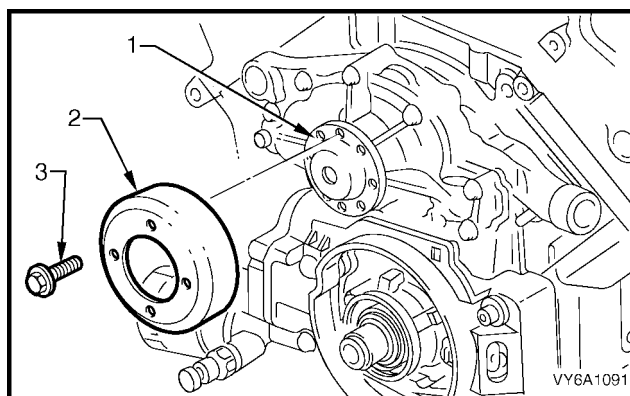


Figure 6A1-1-139

8. Place a clean container (of at least 12 litres capacity) under the engine for the engine coolant to drain into.

NOTE: To reduce the impact on the environment and the maintenance cost, whenever the coolant is drained from the engine, the service records are to be checked to determine when the coolant was last changed. If more than six months life is left before the next coolant change, then the drained coolant can be re-used. For further information, refer to [Section 6B1 ENGINE COOLING – V6 ENGINE](#).

9. Drain engine coolant into drain tray by disconnecting radiator lower hose (1) from the front cover connection.

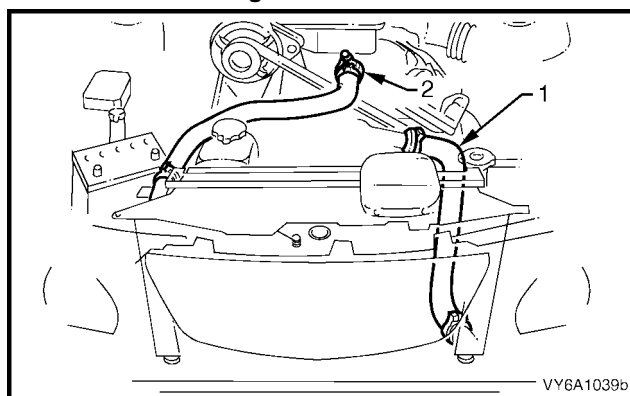


Figure 6A1-1-140

10. Remove two nuts from belt tensioner lower mounting studs and remove coolant intake tube from front cover.

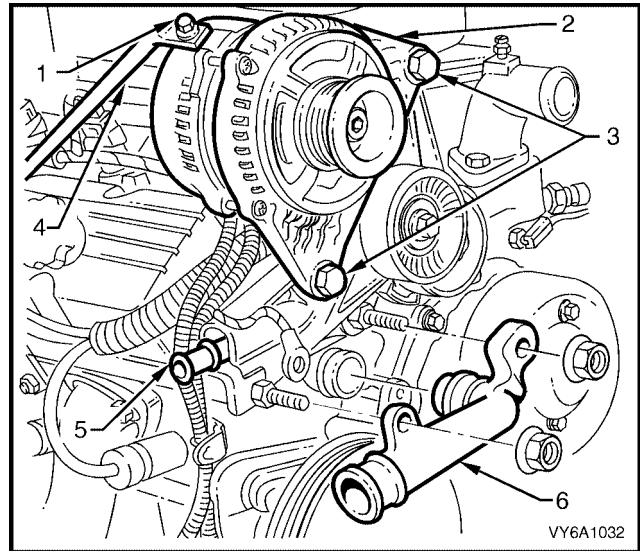


Figure 6A1-1-141

11. Loosen hose clamp (2) and remove heater outlet hose (1) from heater outlet pipe connection.
12. Loosen hose clamp (3) and remove coolant inlet hose (4) from the coolant inlet tube.

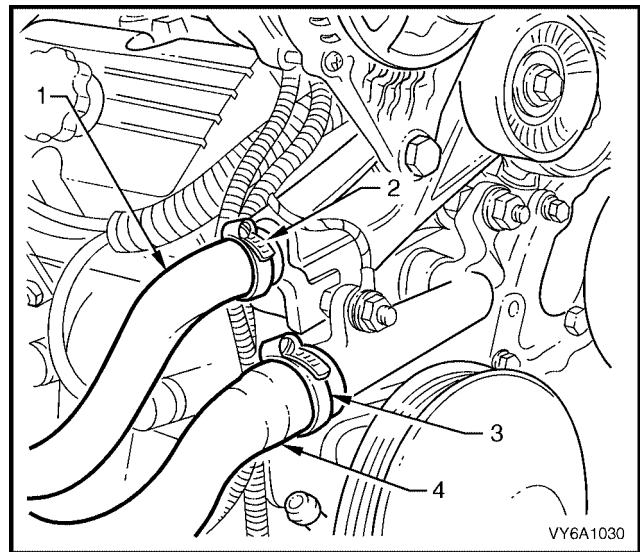


Figure 6A1-1-142

13. Remove generator assembly, refer [Section 6D1-1 CHARGING SYSTEM – V6 ENGINE](#).
14. Remove the nut (2) securing the powertrain wiring harness ground lead (1) from the tensioner bracket, lower attaching stud. Remove the ground lead.
15. Remove the remaining nut (3), then remove the coolant inlet tube from the front cover.

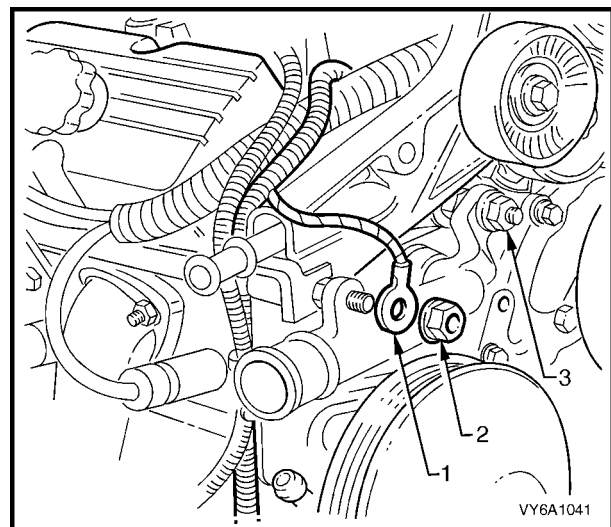


Figure 6A1-1-143

16. Remove spark plug leads from their sockets in coil pack (1) and disconnect electrical connector (4) from Direct Ignition System (DIS) module on the coil pack by first removing the connector securing bolt (3).
17. Remove the harness cover (2) to release the wiring harness.

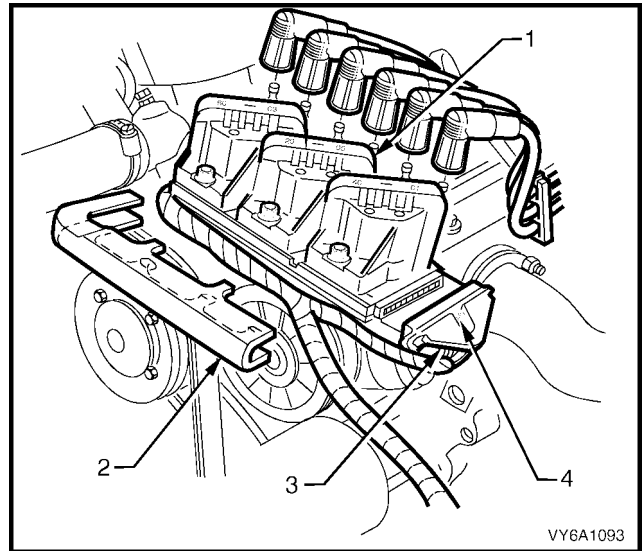


Figure 6A1-1-144

18. Remove bolts (2) securing idler pulley (6) and coil pack assembly (3) to cylinder head, then remove the coil pack and idler bracket assemblies from the engine.

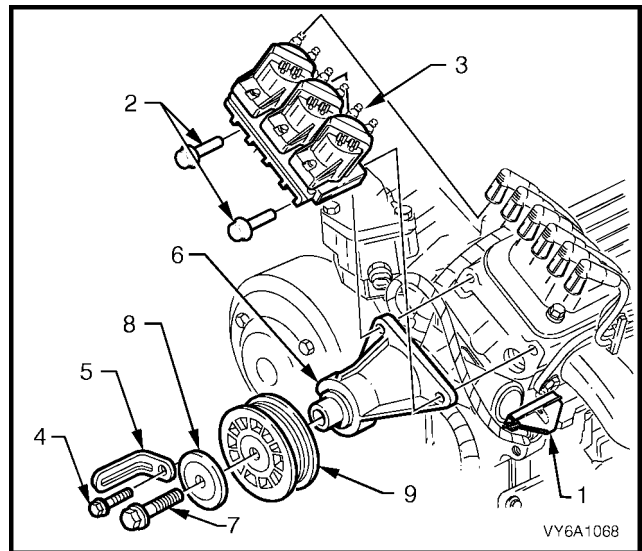


Figure 6A1-1-145

19. Remove screws securing battery harness and transmission cooler pipes refer view 'B', next, then move the harness to one side.
20. Bend back tabs securing power train harness.

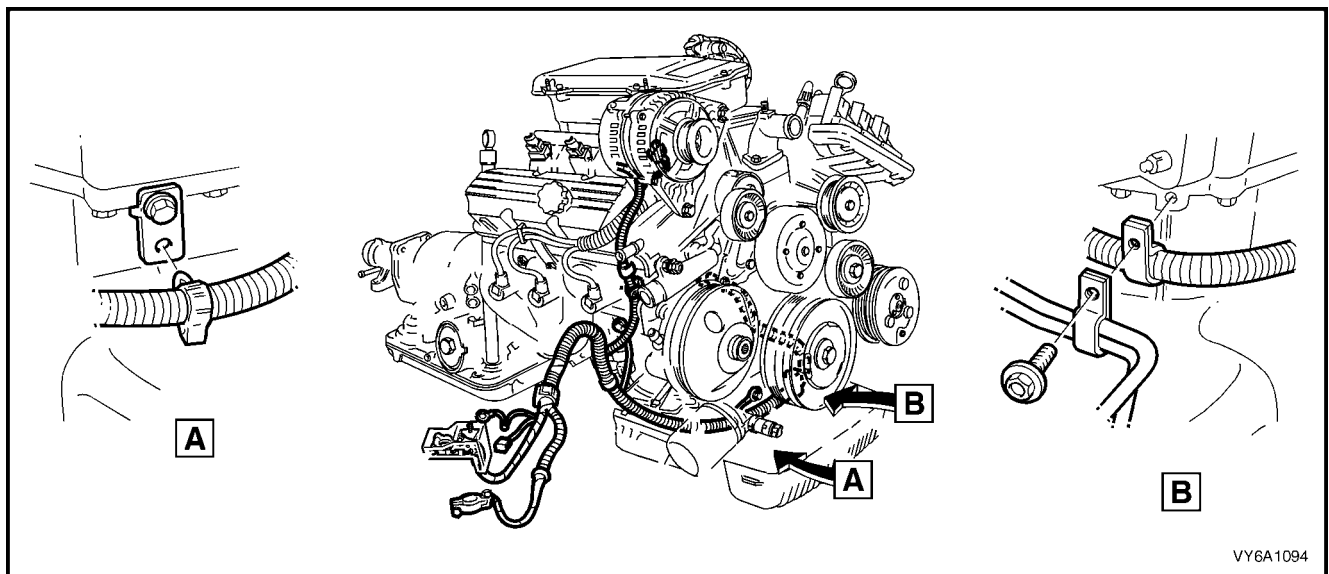


Figure 6A1-1-146

Legend

A. Battery Harness Securing Bracket.

B. Automatic Transmission Cooler Pipe Bracket and Screw.

21. Using a fine bladed screwdriver, lever back the powertrain harness connector retaining tang from crankshaft position sensor (2) and camshaft position sensor (1), pull connector from sensors and move harness to one side.

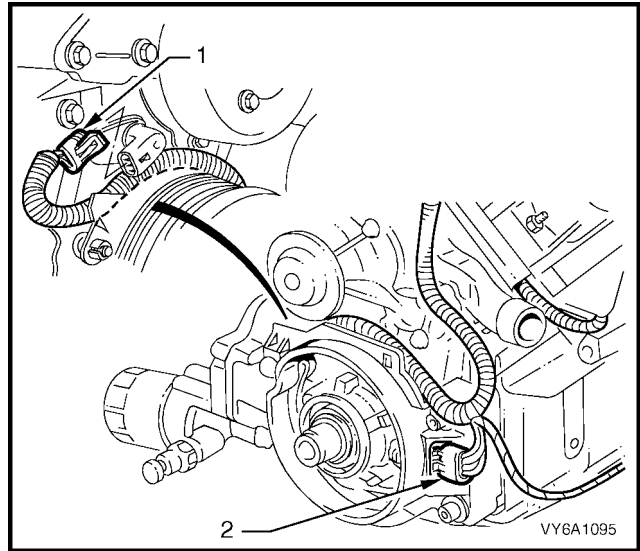


Figure 6A1-1-147

22. Using a screwdriver behind crankshaft position sensor shield (1), lever each corner of shield from front cover studs, remove shield.

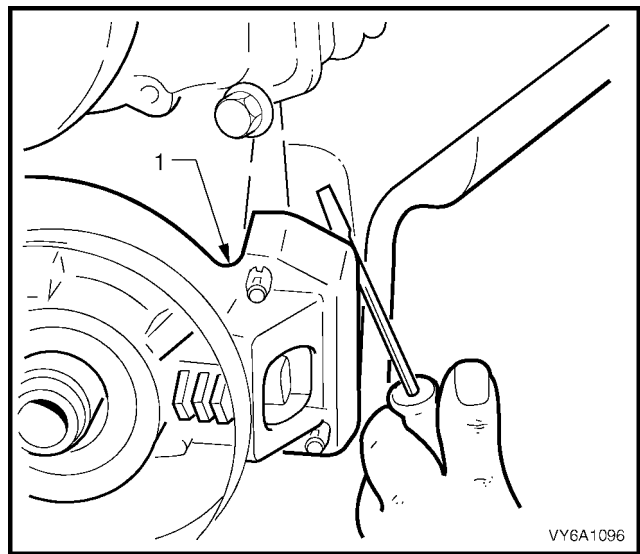


Figure 6A1-1-148

23. Remove crank angle sensor bracket to front cover attaching studs (1) and remove sensor assembly (2) from the front cover (3).

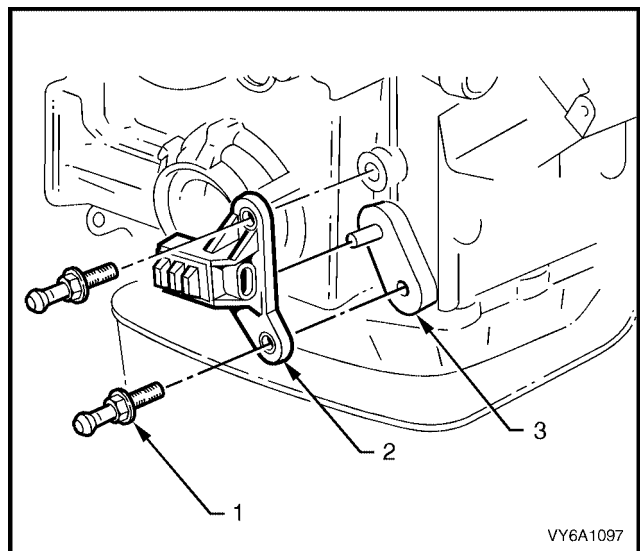


Figure 6A1-1-149

24. Pull out tang (3) on oil pressure sender unit wiring harness connector (2) and pull connector from sender unit.

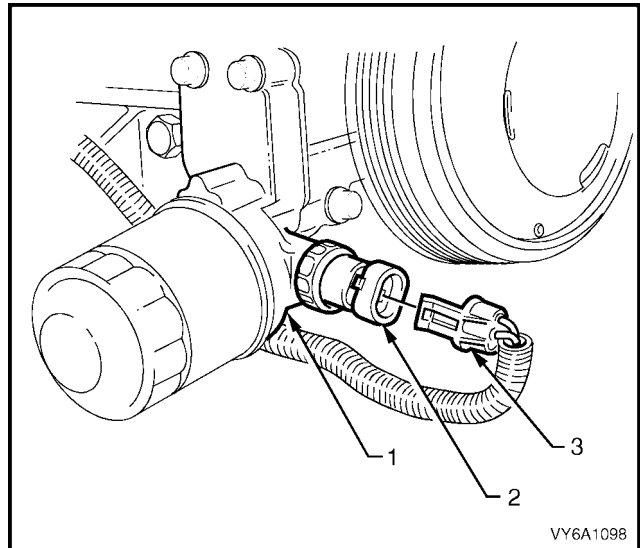


Figure 6A1-1-150

25. Raise front of vehicle and support on safety stands. For location of jacking points refer to **Section 0A GENERAL INFORMATION**.
26. Remove oil pan. Refer **2.26 OIL PAN**, in this Section.
27. Remove front cover to cylinder block attaching bolts/studs and remove cover. Remove and discard front cover gasket.

Legend:

- 1. Long Bolts (78 mm)
- 2. Short Bolts (35 mm)
- 3. Shield Stud

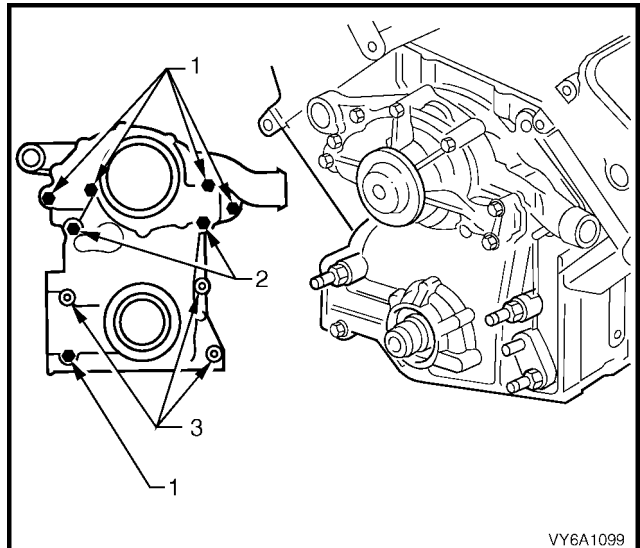


Figure 6A1-1-151

28. If required, remove coolant pump to front cover attaching bolts (3) and separate pump (1) from front cover. Remove and discard coolant pump gasket (2).

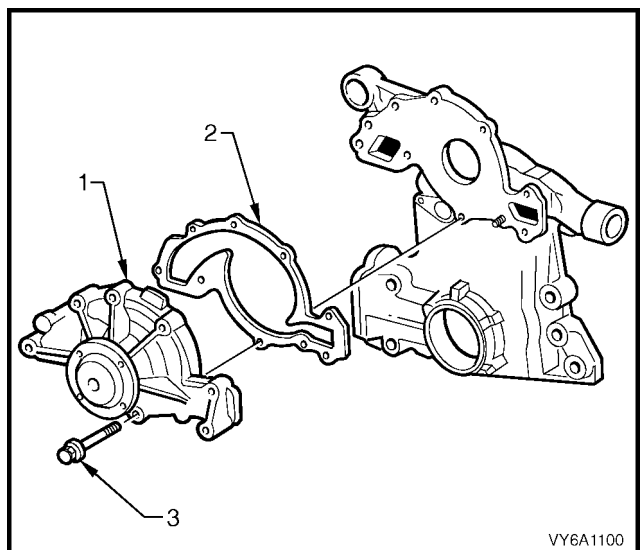


Figure 6A1-1-152

29. If required, remove camshaft position sensor to front cover attaching bolt and remove sensor from front cover.

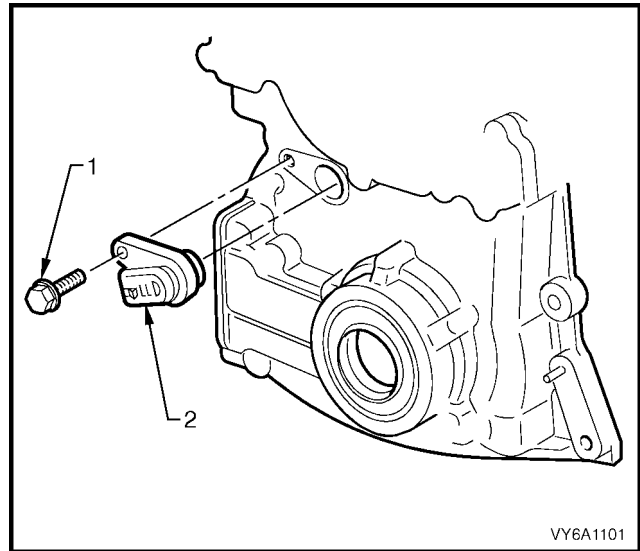


Figure 6A1-1-153

30. If required, remove oil pressure sender unit, oil filter adaptor and pressure regulator valve and spring. Refer to [2.4 OIL FILTER ADAPTOR](#) in this Section. Remove and discard oil filter adaptor gasket.

REINSTALL

Installation is the reverse of removal procedures, noting the following points:

1. Clean threads on all front cover to cylinder block attaching bolts/studs.
2. Using a suitable sized bottoming thread tap, clean front cover attaching bolt/stud threaded holes in cylinder block.
3. Ensure that front cover and cylinder block surfaces are clean and free of foreign matter.
4. If coolant pump was removed during disassembly, ensure that coolant pump to front cover mating surfaces are clean and free of foreign matter.
5. If removed on disassembly, reinstall oil pressure regulator valve spring and valve, oil filter adaptor, refer to [2.4 OIL FILTER ADAPTOR](#) in this Section.
6. Check timing chain wear as follows:
 - a. Use a socket and bar to turn the camshaft in a clockwise direction to take up the tensioner load.
 - b. Check the total 'in and out' movement to ensure that the total movement ('A') is no more than specified.

TIMING CHAIN MAXIMUM MOVEMENT	25.5 mm
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7. Also check the condition of timing chain sprockets, refer to [2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS](#) in this Section.

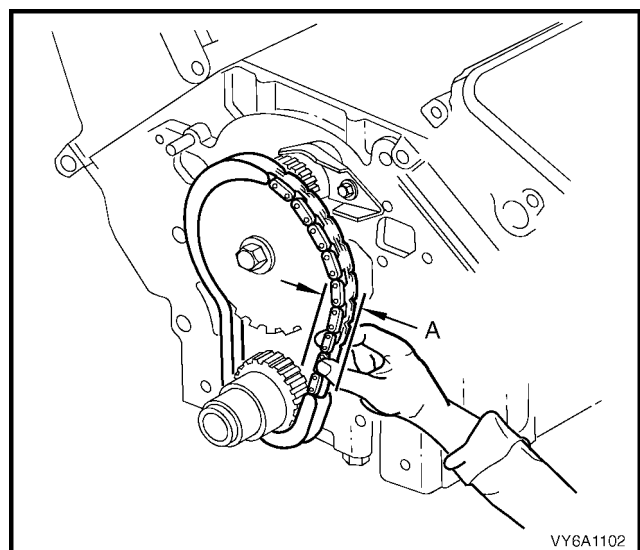


Figure 6A1-1-154

- If necessary, install coolant pump with new gasket to front cover. Install and tighten coolant pump to front cover attaching bolts to the correct torque specification.

COOLANT PUMP TO FRONT COVER BOLT TORQUE SPECIFICATION	10 Nm
---	-------

NOTE: The top three coolant pump attaching bolts engage with the cylinder block and have a different torque specification.

- If necessary, install camshaft position sensor with new O-ring to front cover. Lubricate O-ring with petroleum jelly. Install and tighten camshaft position sensor attaching bolt to the correct torque specification.

CAMSHAFT POSITION SENSOR TO FRONT COVER ATTACHING BOLT TORQUE SPECIFICATION	10 Nm
---	-------

- Using a dummy stud (3) made from a 90 mm long bolt with a thread of 5/16-18 UNC-2A thread, and with the head cut off, install into bolt hole in the location shown.

NOTE: This step is important to ensure that, when the front cover gasket is installed, the oil feed hole in the cylinder block aligns with the appropriate gasket hole and is not partially blocked.

- Reinstall new front cover gasket (1) onto cylinder block to front cover dowel pins.

NOTE: Ensure ends of gasket are level to 0.15 mm proud of the cylinder block oil pan face. The front cover oil pan face, must be aligned with the cylinder block oil pan rail to within ± 0.2 mm.

- Reinstall front cover (2), aligning spline on nose of crankshaft sprocket gear with spline on oil pump inner gear.

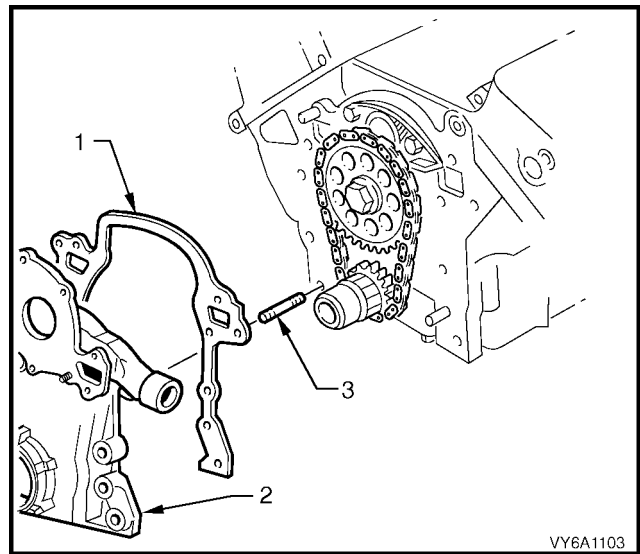


Figure 6A1-1-155

- Coat threads of front cover to cylinder block attaching bolts with Loctite 242 sealant or equivalent. With front cover firmly in place, remove dummy stud installed at step 10. Install bolts and tighten to the correct torque specification.

FRONT COVER ATTACHING BOLT/STUD TORQUE SPECIFICATION	30 Nm
--	-------

Legend

- Long Bolts (78 mm)
- Short Bolts (35 mm)
- Short Shield Studs
- Long Shield Studs

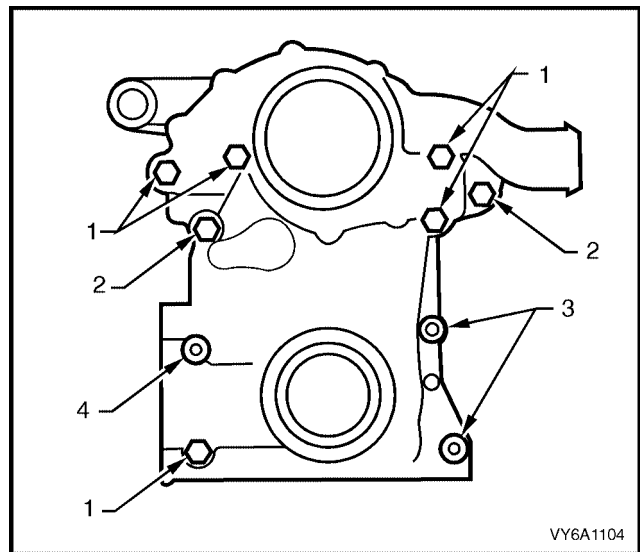


Figure 6A1-1-156

14. Ensure that interrupter rings on crankshaft balancer do not contact crankshaft position sensor at any point during crankshaft rotation, refer to **3 SERVICE OPERATIONS, IGNITION SYSTEM**, in Section 6C1 POWERTRAIN MANAGEMENT – V6 ENGINE.
15. Smear approx. 6.0 mm wide and 0.2 mm thick film of Loctite 5900 or equivalent to GM Specification 9985990, or equivalent centrally across the oil pan rail at front cover to cylinder block joint both sides, refer to **2.26 ENGINE OIL PAN** in this Section. Install oil pan to front cover attaching bolts and tighten all oil pan bolts to the correct torque specification.

NOTE: Front cover and oil pan/cylinder block faces must be aligned to within 0.20 mm.

OIL PAN ATTACHING BOLT TORQUE SPECIFICATION	14 Nm
--	-------

16. Install the top three coolant pump to cylinder block bolts and tighten to the correct torque specification.

COOLANT PUMP TO CYLINDER BLOCK BOLT TORQUE SPECIFICATION	30 Nm
--	-------

17. Check and inspect O-ring on end of coolant intake tube and replace if necessary. Lubricate O-ring with commercially available, petroleum jelly.
18. Install tube into front cover, engaging tube onto belt tensioner bracket attaching studs. Install nuts to studs and tighten to the correct torque specification.

COOLANT INLET TUBE TO BELT TENSIONER STUD NUT TORQUE SPECIFICATION	22 m
--	------

19. Ensure that all remaining component fasteners are tightened to the correct torque specifications as nominated at the end of this Section.
20. Fill cooling system with the correct concentration of coolant, refer to **Section 6B1 ENGINE COOLING – V6 ENGINE**.
21. Start engine and check for oil or coolant leaks. Repair as necessary.

2.22 OIL PUMP

REMOVE

The oil pump is integrated into the front cover assembly. To gain access to the oil pump, it is necessary to remove the front cover, refer to **2.21 FRONT COVER AND GASKET** in this Section.

DISASSEMBLE

1. Using a suitable oil filter wrench, remove oil filter and drain oil from pump.
2. Remove oil filter adaptor to front cover attaching bolts (5), then remove adaptor (4) and seal (3).
3. Remove oil pressure regulator valve (2) and spring (1) from front cover bore.

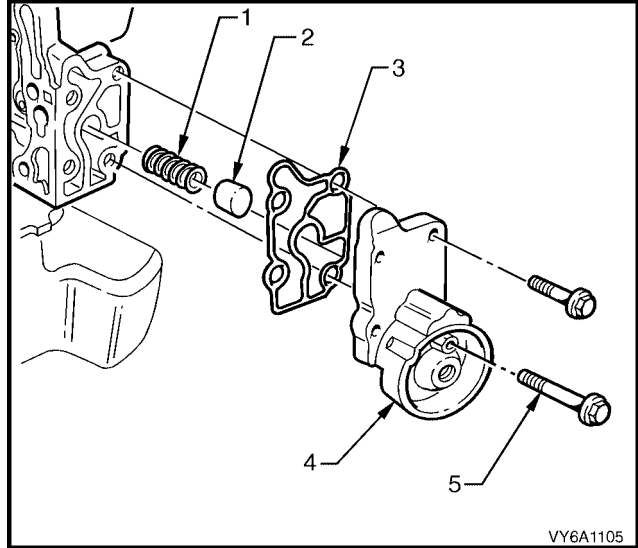


Figure 6A1-1-157

4. Remove oil pump cover screws, using Tool No. J25359-4 (or commercially available Torx bit T30) and a suitable adaptor. Remove cover (1) and gears (2).

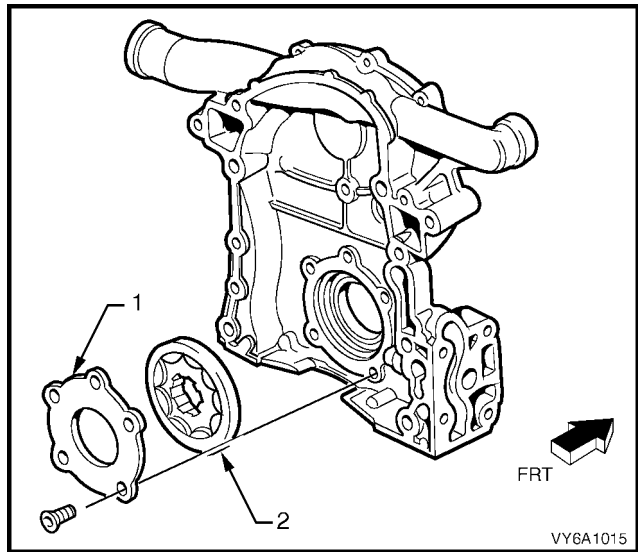


Figure 6A1-1-158

5. Using Tool No. E308 (or a commercial equivalent), remove crankshaft front seal (1) from front cover.
6. Clean all mating surfaces.

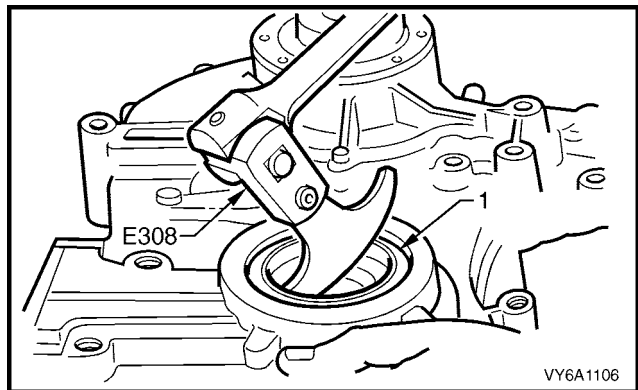


Figure 6A1-1-159

INSPECT

1. Clean all components in a suitable cleaning solvent and blow dry with clean dry compressed air.
2. Using a suitable size thread tap, clean adaptor 'long' attaching bolt threads in front cover. Clean bolt attaching threads.
3. Inspect front cover and oil pump cover for cracks, scoring, porous or damaged casting, damaged threads or excessive wear or scoring.
4. Check pressure regulator valve for scoring, sticking in valve bore or burrs in bore. Inspect regulator valve spring for tension loss (compare with new spring) or bending. If in any doubt, replace spring.
5. Inspect oil pump gears for chipping, scoring or excessive wear.
6. Install gears into front cover and check that the following clearances are to specification.
 - a. Tip of the inner gear (2) to outer gear (1) clearance.

INNER GEAR TIP TO OUTER GEAR CLEARANCE SPECIFICATION	0.152 mm Maximum
--	------------------

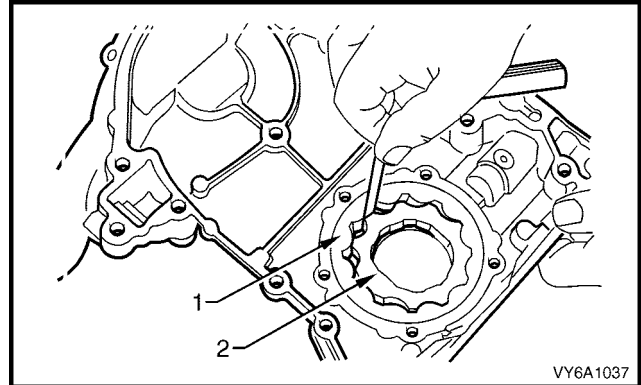


Figure 6A1-1-160

- b. Outer gear (1) to housing clearance.

OUTER GEAR TO HOUSING CLEARANCE SPECIFICATION	0.203 – 0.381 mm
--	------------------

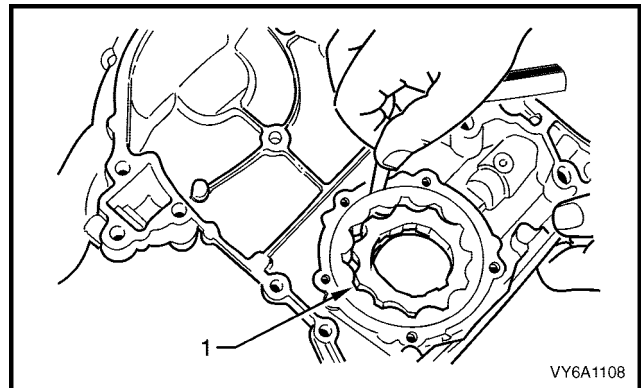


Figure 6A1-1-161

- c. Inner and outer gear end to housing clearance, using a depth micrometer (1).

INNER AND OUTER GEAR END TO HOUSING SPECIFICATION	0.025 – 0.089 mm
--	------------------

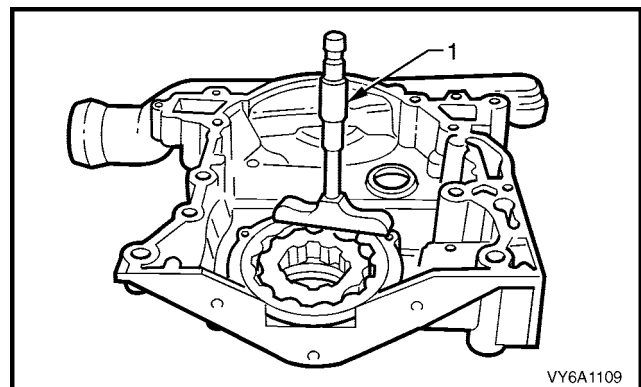


Figure 6A1-1-162

If any component is excessively worn or damaged, replace front cover and oil pump as an assembly.

7. Check pressure regulator valve to bore clearance by measuring valve and bore diameters and then subtracting the valve from bore diameters.

PRESSURE REGULATOR VALVE TO BORE CLEARANCE	0.038 - 0.076 mm
---	------------------

If any clearance specification is not as specified, replace front cover and oil pump assembly.

REASSEMBLE AND REINSTALL

1. Using Tool No. J28540-A, install new seal into front cover (1).

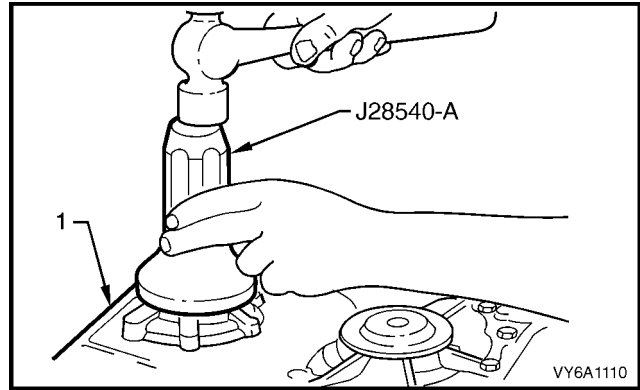


Figure 6A1-1-163

2. Lubricate oil pump gears with petroleum jelly. Install gears into housing.

NOTE 1: Ensure that the inner gear is installed with the chamfered (or raised) inner edge facing away from the housing.

NOTE 2: The outer gear can be installed into the housing either way.

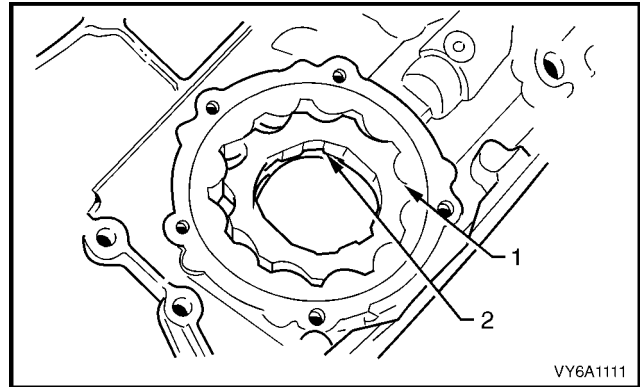


Figure 6A1-1-164

3. Completely fill oil pump gear cavity with petroleum jelly (1) (commercially available).

NOTE: This is an important step, as the oil pump may not begin to pump oil as soon as the engine is started.

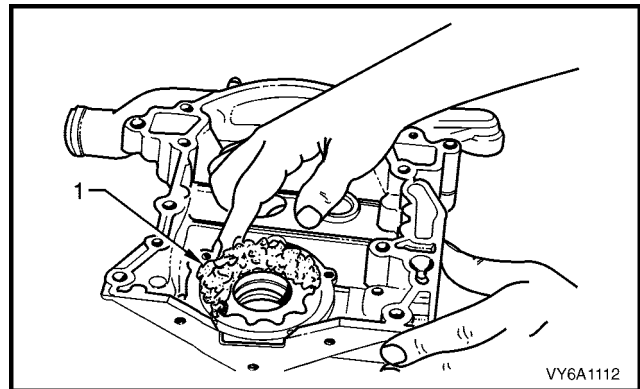


Figure 6A1-1-165

4. Reinstall oil pump cover screws. Tighten screws to the correct torque specification.

OIL PUMP COVER SCREW TORQUE SPECIFICATION	11 Nm
--	-------

5. Reinstall pressure regulator valve spring and valve.

6. Reinstall oil filter adaptor and new gasket to front cover. Install adaptor attaching bolts and tighten to the correct torque specification.

NOTE: Before installing 'long' adaptor attaching bolt, apply Loctite 242 sealant or equivalent to the cleaned bolt threads, refer to '7' in [Figure 6A1-1-28](#) in this Section.

OIL FILTER ADAPTOR TO FRONT COVER ATTACHING BOLT TORQUE SPECIFICATION	30 Nm
---	-------

7. Reinstall front cover, refer to [2.21 FRONT COVER AND GASKET](#) in this Section.

8. Reinstall new oil filter, refer to [2.3 OIL FILTER](#) in this Section.

9. Reconnect battery ground lead.

10. Check engine oil level and add as required. Start engine and check for oil or coolant leaks. Repair as necessary.

NOTE: The oil level must be checked and oil added as necessary, after running the engine, to compensate for oil used to refill the oil filter.

2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS

REMOVE

1. Disconnect battery ground lead.
2. Remove front cover, refer to **2.21 FRONT COVER AND GASKET** in this Section.
3. Check timing chain wear as follows:
 - a. Use a socket and bar to turn the camshaft in a clockwise direction to take up the tensioner load.
 - b. Check the total 'in and out' movement to ensure that the total movement ('A') is no more than specified.

TIMING CHAIN MAXIMUM MOVEMENT	25.5 mm
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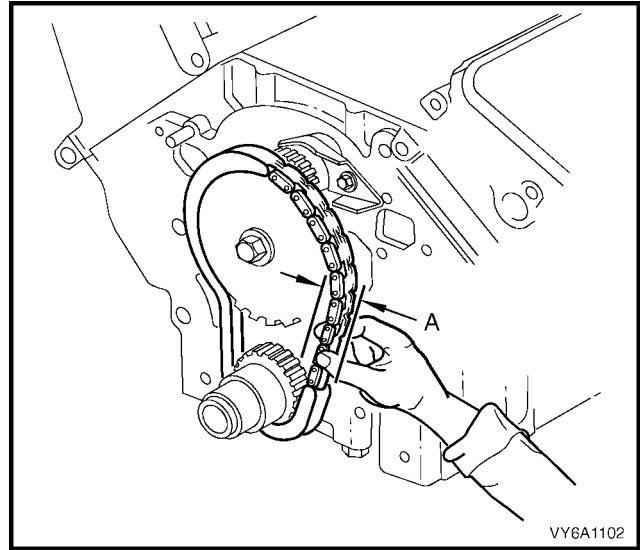


Figure 6A1-1-166

4. Loosen camshaft sprocket bolt (2).

NOTE: On vehicles with automatic transmission, prevent camshaft and crankshaft from rotating while loosening bolt by temporarily replacing crankshaft balancer and retaining bolt. Tighten bolt until balancer is fully seated against crankshaft sprocket then install crankshaft balancer holding tool No. AU448. Rotate crankshaft and tool by hand so the arm of the tool rests on the R/H side rail.

After loosening the camshaft sprocket bolt, remove crankshaft balancer with crankshaft balancer puller tool No. AU424. Refer to **2.19 CRANKSHAFT BALANCER** in this Section.

On vehicles with manual transmission, to prevent camshaft and crankshaft from rotating, pull park brake fully 'ON', transmission in gear and chock rear wheels.

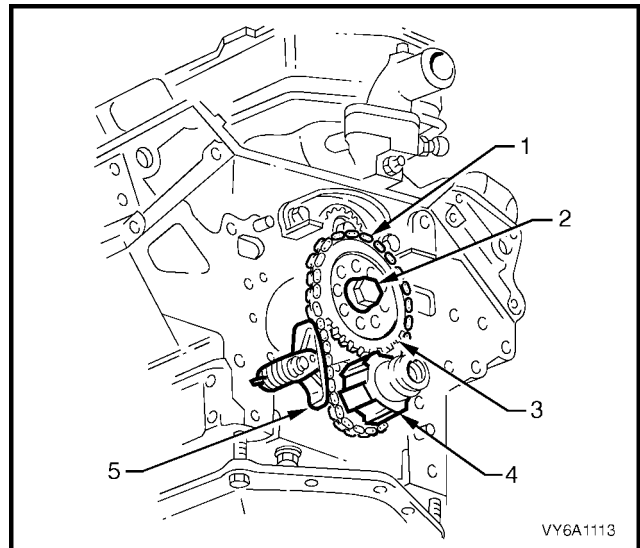


Figure 6A1-1-167

Legend

1. Timing Chain
2. Camshaft Sprocket Retaining Bolt
3. Camshaft Sprocket
4. Oil Pump Drive and Crankshaft Sprocket
5. Timing Chain Dampener

NOTE 2: Grinding chamfer (1) from top of socket, as shown in '2', will help in ensuring full engagement over bolt head and assist in removal and re-tightening of camshaft sprocket bolt.

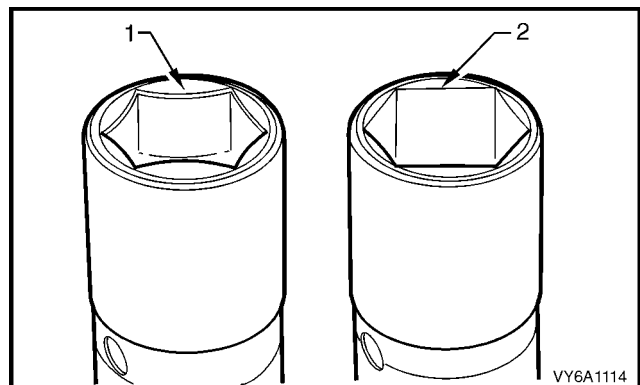


Figure 6A1-1-168

NOTE 3: If carrying out this operation with the engine removed from the vehicle, remove oil pan and prevent camshaft and crankshaft from rotating by positioning a suitable piece of wood (1) (e.g. 50 mm x 75 mm, 150 mm long) between the right hand inside of the cylinder block (2) and the crankshaft front counterweights (3).

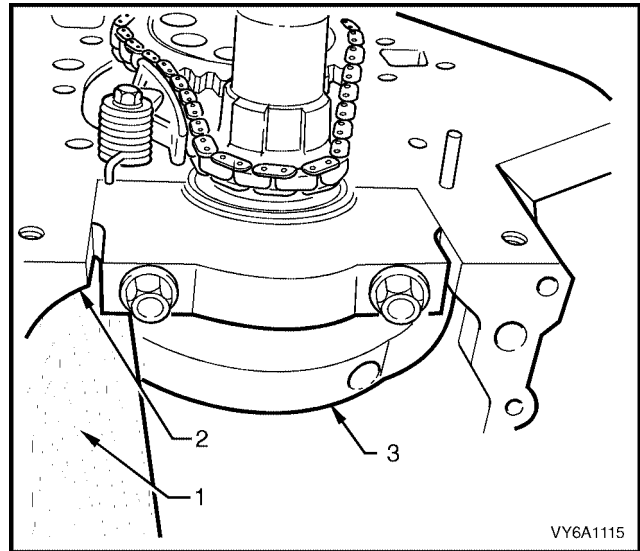


Figure 6A1-1-169

5. Rotate crankshaft so that timing marks (2) on crankshaft (3) and camshaft (1) sprockets are adjacent to each other, which will be when piston No. 1 is in the Top Dead Centre (TDC) position.

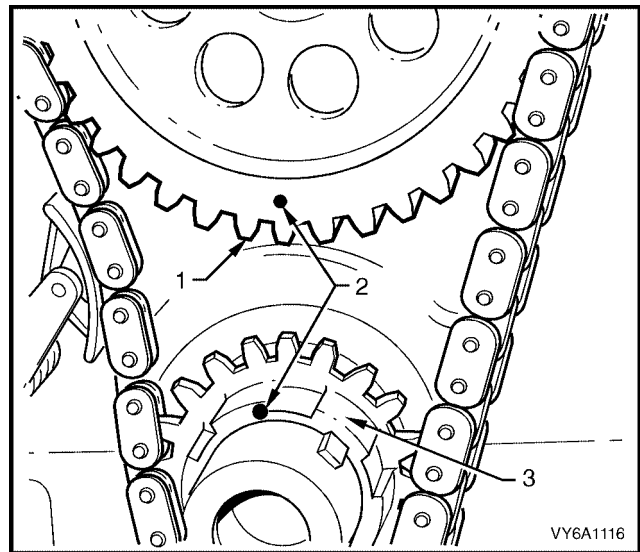


Figure 6A1-1-170

6. Remove camshaft sprocket retaining bolt (2).
7. Pull dampener (5) away from timing chain (1) and remove camshaft sprocket (3) and timing chain (1) taking care not to lose camshaft sensor magnet due to its loose fit in the camshaft sprocket.
8. Remove crankshaft sprocket (4) from crankshaft.
9. If necessary, remove dampener attaching bolt and dampener assembly (5).

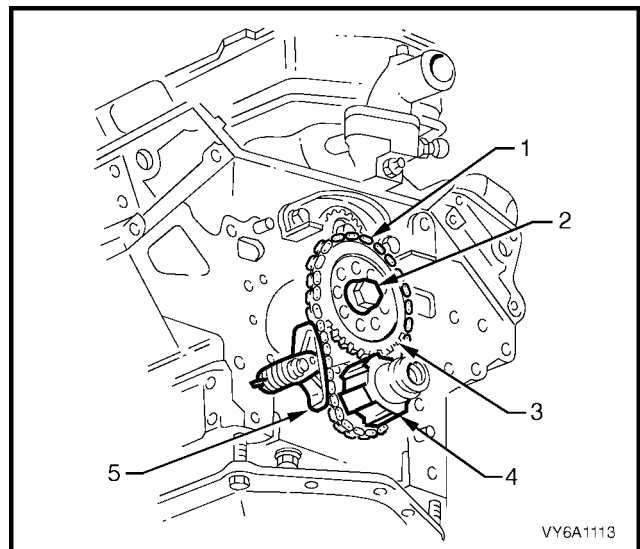


Figure 6A1-1-171

10. If removing balance shaft gears, proceed as follows:

- a. Remove balance shaft drive gear (2) and sprocket key (1) from camshaft.
- b. Remove balance shaft (1), refer to **3.9 BALANCE SHAFT AND BEARINGS** in this Section.

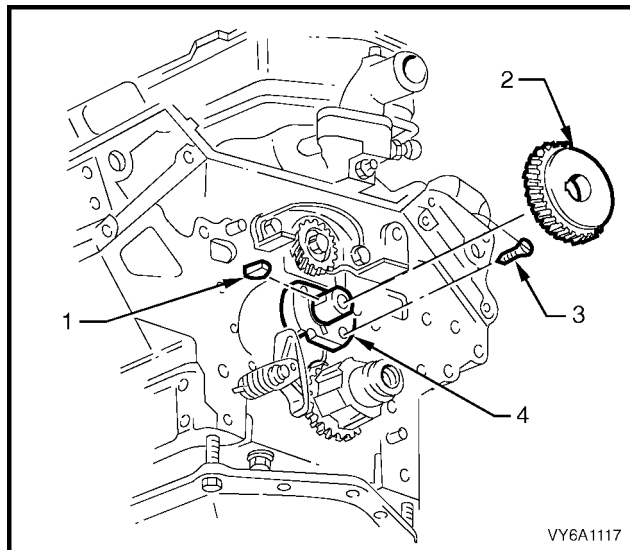


Figure 6A1-1-172

- c. Hold balance shaft (1) in a vice using soft jaws (2), taking care to ensure that balance shaft front bearing and rear bearing journal surface are not damaged, during this process.
- d. Remove balance shaft driven gear retaining bolt and driven gear (3).

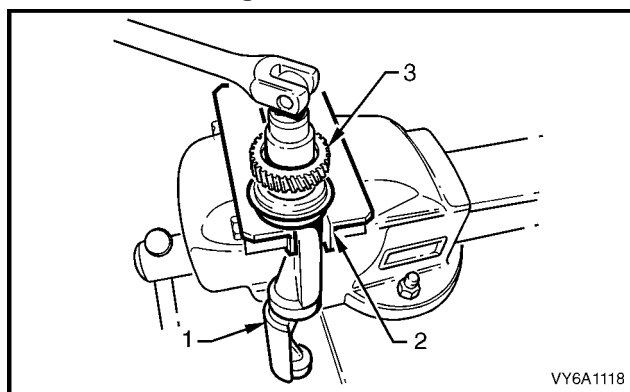


Figure 6A1-1-173

INSPECT

1. Clean all components in a suitable cleaning solvent and blow dry with clean dry compressed air.
2. Using a suitable size thread tap, clean sprocket retaining bolt threads in front end of camshaft. Clean retaining bolt threads.
3. If removed, clean balance shaft driven gear retaining bolt threads in front end of balance shaft. Clean retaining bolt threads.
4. Inspect all components for wear or damage. Check chain for excessive wear or stretch at roller links.

REINSTALL

1. If removed, reinstall driven gear (2), aligning slot on the inside of gear with pin at front of balance shaft.
2. Coat threads of balance shaft driven gear retaining bolt with Loctite 242 sealant or commercial equivalent. Reinstall driven gear retaining bolt to balance shaft.
3. Tighten balance shaft driven gear retaining bolt to the correct torque specification.

BALANCE SHAFT DRIVEN GEAR RETAINING BOLT TORQUE SPECIFICATION	22 Nm, plus 70° turn angle
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NOTE: Use Tool No. E7115 (also released as BT8653-A) angle wrench with a suitable sized socket (1) and bar, to achieve the correct turn angle.

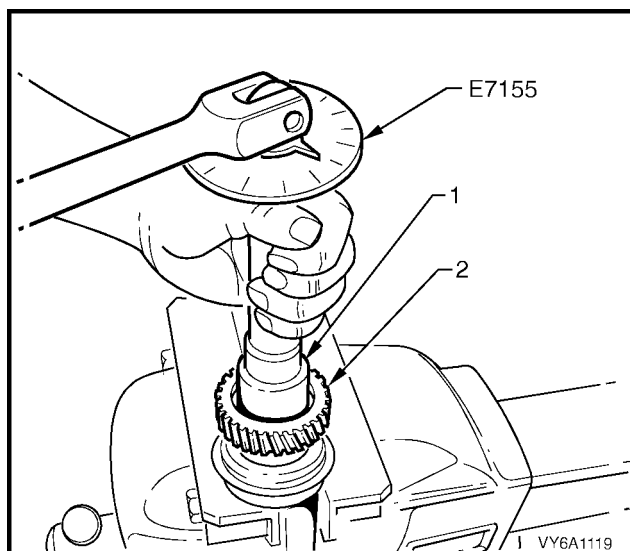


Figure 6A1-1-174

4. Reinstall sprocket key to front end of camshaft.
Reinstall balance shaft drive gear (2) to camshaft, aligning sprocket key with gear slot and ensuring that timing marks (4) on each of the balance shaft gears (3 and 4) face together.

NOTE: It may be necessary to rotate balance shaft slightly to ensure that balance shaft timing marks align.

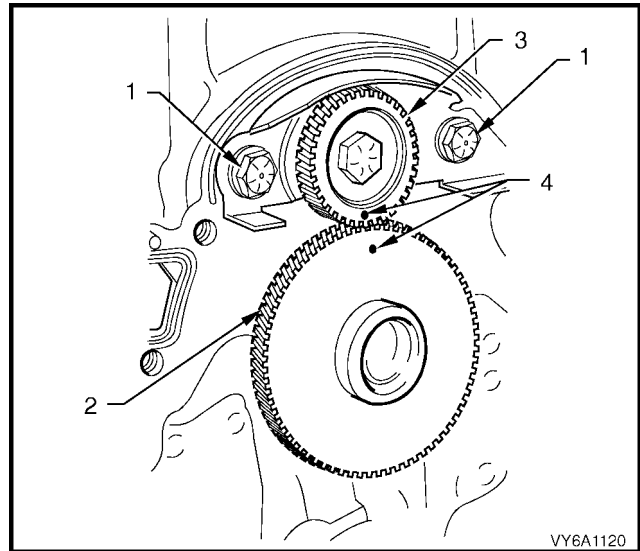


Figure 6A1-1-175

5. Reinstall crankshaft sprocket onto crankshaft, aligning key slot in sprocket with sprocket key.
With sprocket installed on crankshaft, timing mark should be facing upward. If not facing upward, remove piece of wood between crankshaft and cylinder block (if fitted), rotate crankshaft until correct position is reached (No. 1 piston at TDC).
6. Temporarily install camshaft sprocket to camshaft. Turn camshaft so that sprocket timing mark is facing crankshaft sprocket timing mark. Remove camshaft sprocket.
7. Reinstall timing chain dampener locating spring end (1) into cylinder block hole. Install and tighten dampener attaching bolt (2) to the correct torque specification.

TIMING CHAIN DAMPENER ATTACHING BOLT TORQUE SPECIFICATION	22 Nm
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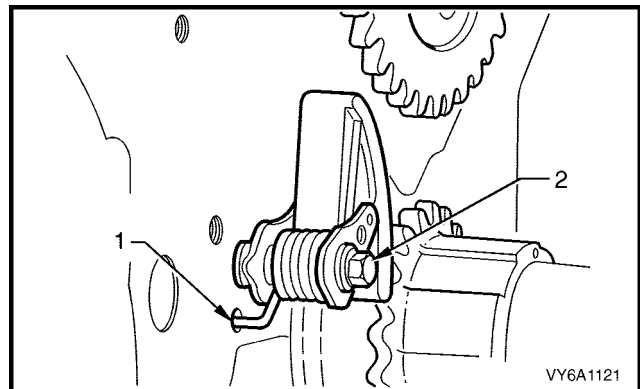


Figure 6A1-1-176

8. Lubricate timing chain and sprockets with engine oil.
9. Ensure that front cover and cylinder block mating surfaces are clean and free of foreign matter. Install front cover, refer to [2.21 FRONT COVER AND GASKET](#) in this Section.

10. Reinstall timing chain and camshaft sprocket (1) together ensuring that the camshaft position sensor magnet is in position in the camshaft sprocket. Pull back timing chain dampener and install chain around crankshaft sprocket (3) and fit camshaft sprocket to camshaft, aligning key slot in sprocket with sprocket key. Release dampener and ensure that timing marks (2) on sprockets are aligned.
11. Apply Loctite 242 sealant or commercial equivalent to the cleaned threads of the camshaft sprocket retaining bolt. Install and tighten bolt to the correct torque specification.

CAMSHAFT SPROCKET	
RETAINING BOLT	
TORQUE SPECIFICATION	100 Nm, plus 90° turn angle

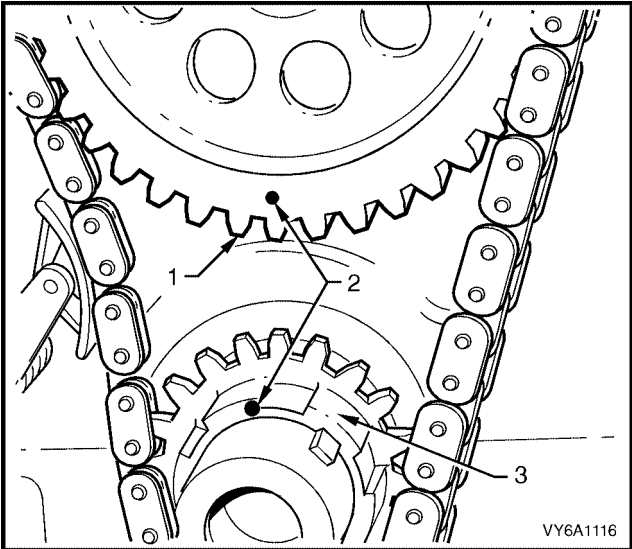


Figure 6A1-1-177

12. Reconnect battery ground lead. Start engine and check for oil or coolant leaks. Repair as necessary.

2.24 CAMSHAFT

MEASURING CAMSHAFT LOBE LIFT

1. Remove rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section. Remove rocker arms, refer to [2.14 ROCKER ARMS AND PUSHRODS](#) in this Section.
2. Remove spark plugs.
3. Mount a dial indicator so that its stylus is resting on the top end of a pushrod.
4. Rotate crankshaft and measure camshaft lobe lift.

CAMSHAFT LOBE LIFT SPECIFICATION	
INTAKE	6.56 mm
EXHAUST	6.56 mm

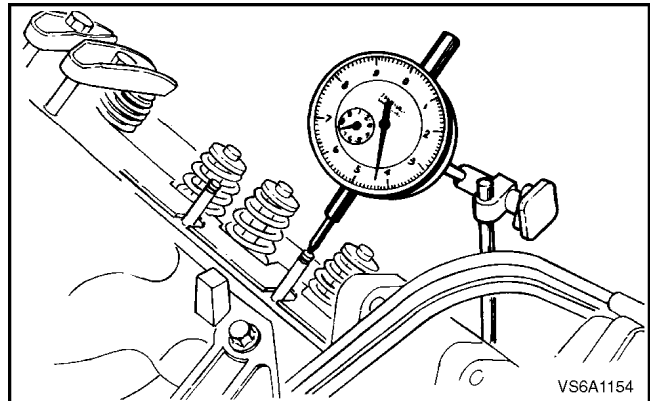


Figure 6A1-1-178

5. Repeat steps 3 and 4, above, for the remaining eleven pushrods. If any lobe lift is not to specification, remove and replace camshaft, refer to 2.24 CAMSHAFT in this Section.
6. If camshaft lobe lift is satisfactory, reassemble rocker arms, refer to [2.14 ROCKER ARMS AND PUSHRODS](#) in this Section. Reinstall rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section.
7. Reinstall spark plugs and tighten to the correct torque specification.

SPARK PLUG TORQUE SPECIFICATION	25 Nm
------------------------------------	-------

REMOVE

1. Disconnect battery ground lead.
 2. Remove radiator cap to release any cooling system pressure.
- CAUTION:** To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of cooling system pressure is very dangerous and could cause personal injury.
3. Remove cooling fan shroud, cooling fan and radiator, refer to [Section 6B1 ENGINE COOLING - V6 ENGINE](#).
 4. Remove crankshaft balancer, refer to [2.19 CRANKSHAFT BALANCER](#) in this Section.
 5. Remove front cover, refer to [2.21 FRONT COVER AND GASKET](#) in this Section.
 6. Remove timing chain, camshaft sprocket and balance shaft drive gear, refer to [2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS](#) in this Section.
 7. Remove rocker covers, refer to [2.13 ROCKER COVERS AND/OR SEALS](#) in this Section.
 8. Remove lower intake manifold, refer to [2.11 LOWER INTAKE MANIFOLD](#) in this Section.
 9. Remove rocker arms and pushrods, refer to [2.13 ROCKER ARMS AND PUSHRODS](#) in this Section.
 10. Remove valve lifters, refer to [2.16 VALVE LIFTERS](#) in this Section.
 11. Remove sprocket key (1) from front end of camshaft.
 12. Using Tool No. J25359-4 (or a commercially available, T30 Torx bit), remove camshaft thrust plate to cylinder block attaching screws (2), remove thrust plate (3).

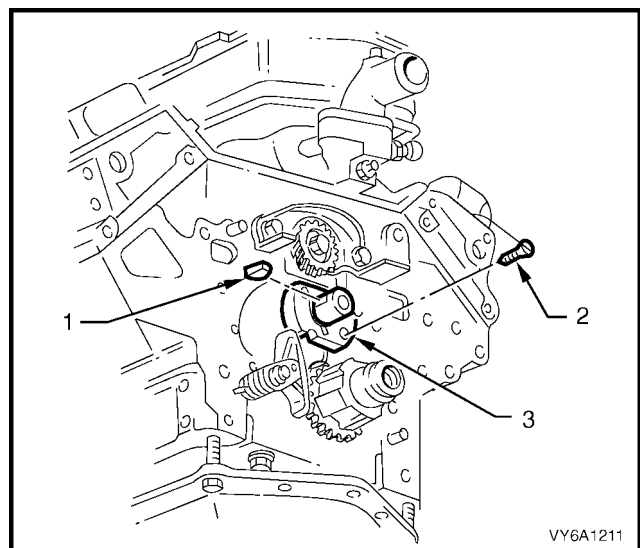


Figure 6A1-1-179

- Carefully withdraw camshaft (1) from front of engine, avoiding damage to any of the camshaft bearing surfaces.

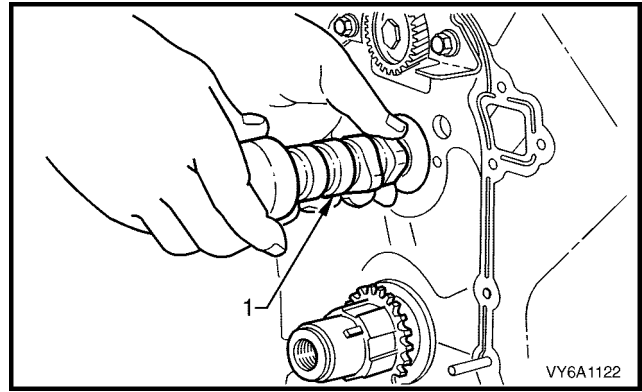


Figure 6A1-1-180

INSPECT

- Inspect camshaft bearing journals and lobes for wear, damage or overheating (discolouration).
- Check camshaft journal diameter and run-out with suitable measuring equipment.

CAMSHAFT JOURNAL DIAMETER	46.858 – 46.893 mm
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If journals are not to specification, replace camshaft.

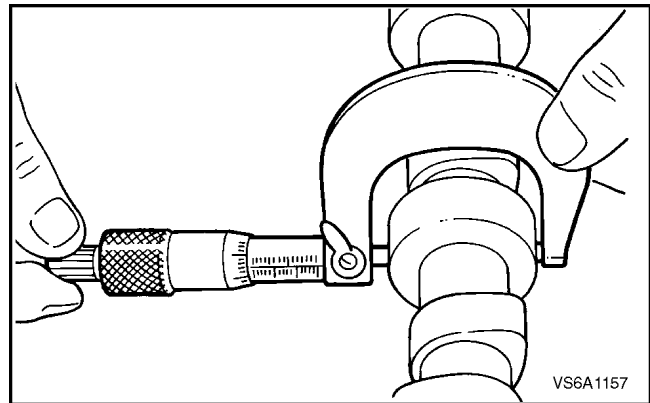


Figure 6A1-1-181

- Position camshaft on V-blocks and check each camshaft lobe lift.

CAMSHAFT LOBE LIFT SPECIFICATION	
INTAKE	6.56 mm
EXHAUST	6.56 mm

If any lobe is not to specification, replace camshaft.

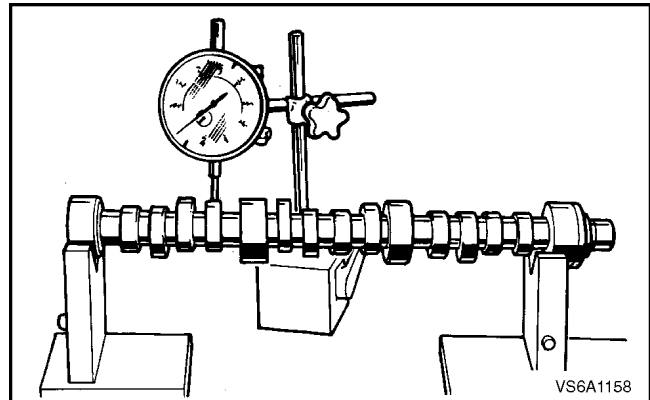


Figure 6A1-1-182

CAMSHAFT BEARING SERVICE

Slightly scored camshaft bearings will be satisfactory if the surfaces of camshaft journals are polished and bearings are cleaned up to remove burrs, and the fit of the camshaft in bearings is free and within specification.

Should the bearings be badly damaged or worn, the engine assembly must be removed from the vehicle and the bearings replaced, refer to [3.8 CAMSHAFT BEARINGS](#) in this Section.

REINSTALL

Reinstallation of the camshaft is the reverse of removal procedures, noting the following points:

1. Clean threads of camshaft thrust plate attaching screws and mating threads in cylinder block.
2. Lubricate camshaft bearing journals with clean engine oil and all lobes with Molybdenum Disulphide grease or aerosol spray, then install camshaft.
3. When installing camshaft, take care not to disturb lubricant film on camshaft lobes.
4. Apply engine oil to camshaft and thrust plate contact surfaces.
5. Apply Loctite 242 or equivalent to the cleaned threads of the thrust plate attaching screws. Install screws and tighten to the correct torque specification.

CAMSHAFT THRUST PLATE TO CYLINDER BLOCK ATTACHING BOLT TORQUE SPECIFICATION	15 Nm
---	-------

6. Lubricate all lifters and lifter bores with Molybdenum Disulphide grease or aerosol spray before installing.
7. Start engine, check for oil or coolant leaks. Check for valve train noise. Repair as necessary.

2.25 ENGINE MOUNTS

FRONT MOUNTS

Check

1. Check in the area of the mounts for signs of oil leakage. If oil leakage from a mount is present, the mount is defective and must be replaced.
2. Using a suitable engine lifting crane, raise engine to remove weight from mounts and to place rubber in slight tension. Check that mounting rubber has not deteriorated, split or separated from metal plates. Replace the mount if found to be defective.

Remove

1. Disconnect battery ground lead.
2. Disconnect mass air flow sensor wiring, loosen air flow duct rubber boot clamps at throttle body and air cleaner and remove air flow duct. Carefully place air flow duct and mass air flow sensor assembly to one side.

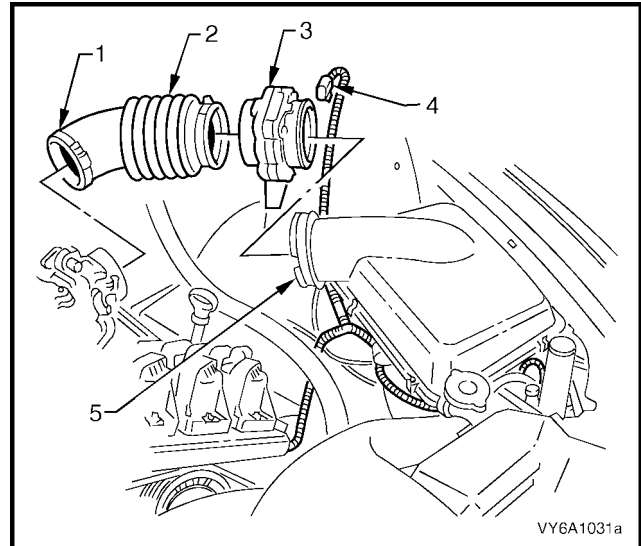


Figure 6A1-1-183

3. Remove engine front mount to front crossmember attaching nuts.
4. Remove right hand mount as follows:
 - a. Remove mount to mounting bracket attaching nuts.
 - b. Raise engine slightly with a suitable engine lifting crane to remove weight from mounts.
 - c. Remove mounting bracket to cylinder block attaching bolts, remove bracket and mount.

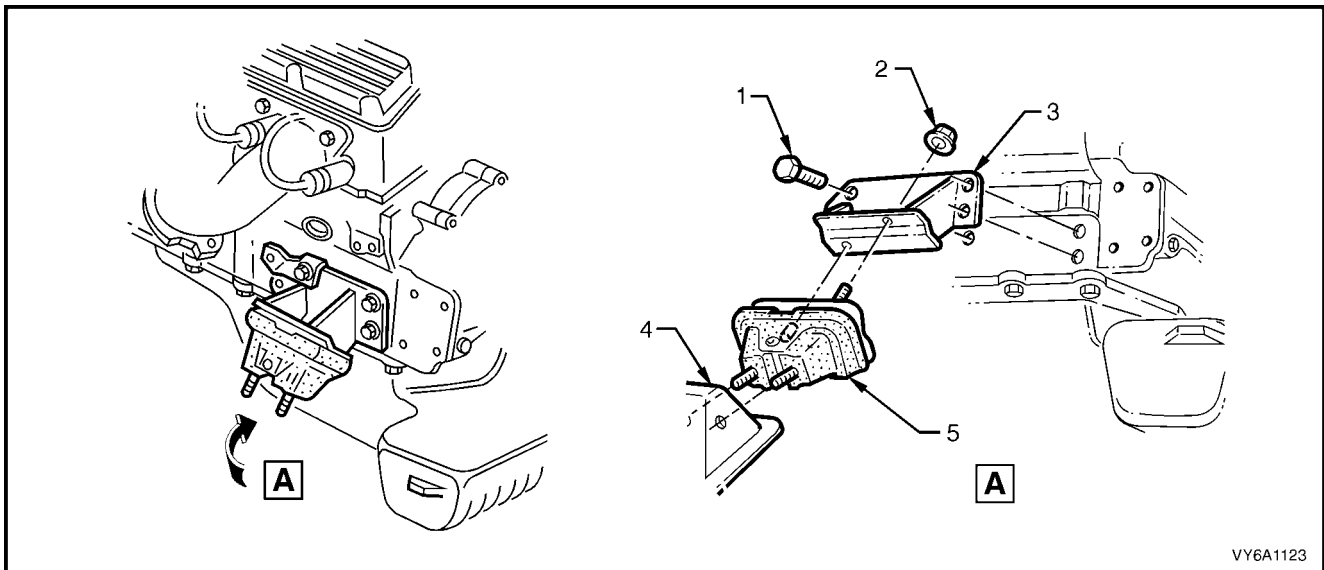


Figure 6C1-1-184

Legend

- | | |
|---------------------|----------------------|
| 1. Bolt – 3 places | 4. Front Crossmember |
| 2. Nut | 5. Engine Mount |
| 3. Mounting Bracket | |

5. Remove left hand mount as follows:
 - a. Raise engine slightly with a suitable engine lifting crane to remove weight from mounts and gain access to air conditioning compressor (if fitted) attaching bolts.
 - b. If fitted, remove air conditioning compressor to left hand engine mounting bracket attaching bolts. Use tie wire to support compressor away from the engine block.

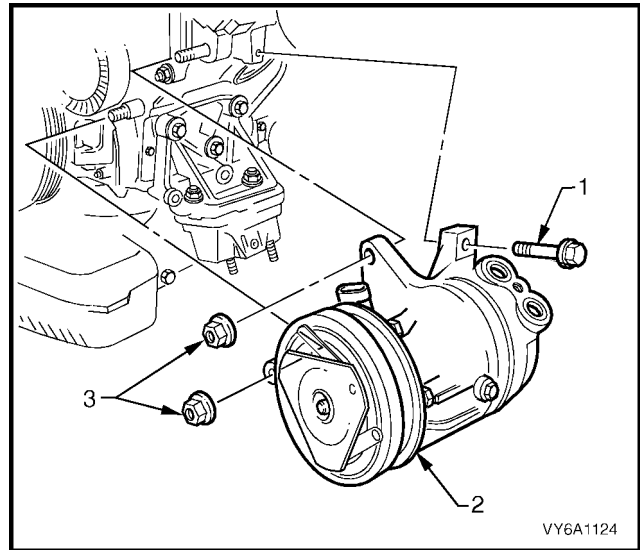


Figure 6A1-1-185

- c. Remove nuts (1) securing mount to the mounting bracket and front crossmember.
- d. Remove mount bracket to cylinder block attaching bolts (3), remove bracket (5), knock sensor heatshield (2) and mount (4).

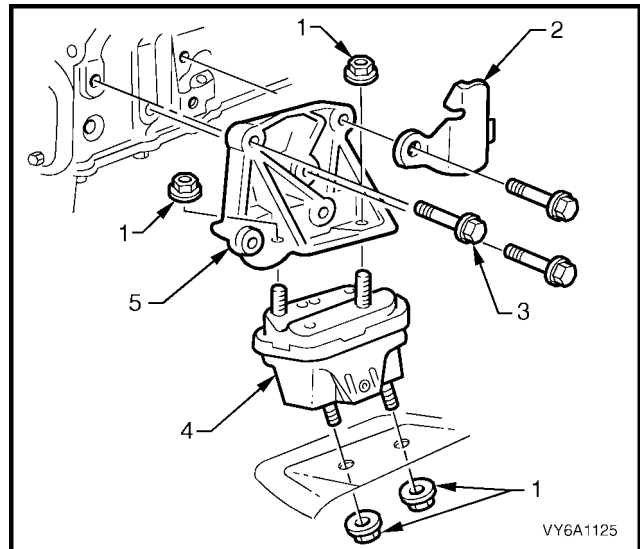


Figure 6A1-1-186

Reinstall

Installation of the engine front mounts is the reverse to removal procedures, ensuring that all fasteners are tightened to the correct torque specifications.

FRONT ENGINE MOUNT TO MOUNTING BRACKET AND FRONT CROSSMEMBER ATTACHING NUT TORQUE SPECIFICATION	50 Nm
FRONT MOUNTING BRACKET TO CYLINDER BLOCK ATTACHING BOLT TORQUE SPECIFICATION	50 Nm
AIR CONDITIONING COMPRESSOR TO MOUNTING BRACKET ATTACHING BOLT TORQUE SPECIFICATION	50 Nm

REAR MOUNT/S

Remove

1. Raise vehicle front and rear and place on safety stands. For location of jacking points, refer to **Section 0A GENERAL INFORMATION**.
2. Support rear of transmission with a jack, using a block of wood between transmission and jack.

Manual Transmission (View 'A')

3. Mark the relationship of each mount upper stud to the transmission case lug, before disturbing the mount to transmission attaching nuts.

IMPORTANT: The transmission lug holes are oval in shape and, to reduce the possibility of inducing a driveline vibration on reassembly, it is important that the mount is reassembled in the same position.

4. Scribe a line around the outer ends of the crossmember (7), to mark the location to the side rails, then remove the four bolts (8) attaching the crossmember to the side rails.
5. Lower the crossmember (7) and mounts, to clear the upper studs from the transmission case lugs.

NOTE: With the mounting angle and the close tolerance of the crossmember holes, the crossmember will not come free without the mounts being disconnected at the transmission first.

6. Remove nuts attaching rear mounts to crossmember, then remove each of the mounts.

Automatic Transmission (View 'B')

7. Scribe a line around the outer ends of the crossmember (15) to mark the location to the side rails, then remove the four bolts (14) attaching the crossmember (15) to the side rails.
8. Remove nuts (13) attaching rear mount (11) to the crossmember (15).
9. Remove crossmember to frame bolts (14), then remove crossmember from the vehicle.
10. Remove rear mount to transmission rear extension attaching bolts (12), then remove the rear mount (11).

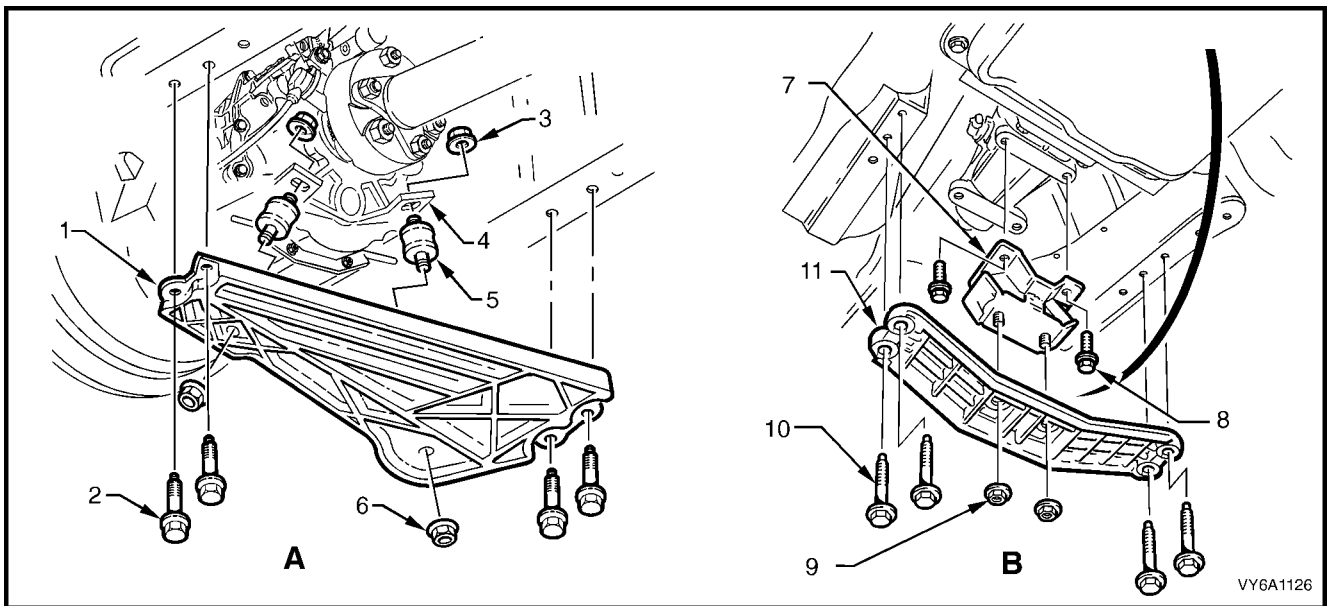


Figure 6A1-1-187

Legend

- | | |
|----------------------------------|----------------------------------|
| A. Manual Transmission. | B. Automatic Transmission |
| 1. Rear Crossmember | 7. Transmission Mount Assembly |
| 2. Bolt – 4 places | 8. Bolt – 2 Places |
| 3. Nut – 2 places | 9. Nut – 2 Places |
| 4. Transmission Mounting Lug | 10. Bolt – 4 Places |
| 5. Transmission Mount – 2 places | 11. Rear Crossmember |
| 6. Nut – 2 Places | |

Reinstall

Manual Transmission

1. For each of the manual transmission, round mounts (5), reinstall to the crossmember (7), aligning the flats with those in the crossmember.
2. Reinstall a retaining nut (6) to each mount stud, protruding through the crossmember and tighten to the correct torque specification.

REAR MOUNT TO CROSSMEMBER ATTACHING NUT TORQUE SPECIFICATION	25 Nm
--	-------

3. Reinstall the mount and crossmember assembly to the transmission case, then reinstall the mount nuts and crossmember bolts. Before tightening fasteners to the correct torque specification, align the marks made to the transmission case lugs and the side rails.

REAR MOUNT TO TRANSMISSION CASE LUG RETAINING NUT TORQUE SPECIFICATION	50 Nm
CROSSMEMBER TO SIDE FRAME BOLT TORQUE SPECIFICATION	55 Nm

Automatic Transmission

4. Reinstall rear mount and attaching bolts to the automatic transmission rear extension. Tighten bolts to correct torque specification.

REAR MOUNT TO AUTOMATIC TRANSMISSION EXTENSION HOUSING BOLT TORQUE SPECIFICATION	55 Nm
--	-------

5. Install crossmember to side frame bolts, aligning the marks made before removal. Tighten bolts to correct torque specification.

CROSSMEMBER TO SIDE FRAME BOLT TORQUE SPECIFICATION	55 Nm
--	-------

6. Lower jack and block of wood supporting transmission, centralising the studs in the crossmember holes.
7. Tighten crossmember to rear mount attaching nuts to correct torque specification.

REAR MOUNT TO CROSSMEMBER NUT TORQUE SPECIFICATION	25 Nm
---	-------

8. Remove safety stands and lower vehicle to ground.

2.26 ENGINE OIL PAN & GASKET (ENGINE INSTALLED)

REMOVE

1. Disconnect the battery ground lead.

IMPORTANT: Disconnection of the battery affects certain vehicle electronic systems. Refer to **SECTION 00 CAUTIONS, 5. BATTERY DISCONNECTION PROCEDURES** before disconnecting the battery.

2. Raise front of vehicle and support on safety stands. For location of jacking points, refer **Section 0A GENERAL INFORMATION**.
3. Drain engine oil into a suitable container, then reinstall the drain plug, tightening to the correct torque specification.

OIL PAN DRAIN PLUG TORQUE SPECIFICATION	45 Nm
--	-------

4. Remove nut securing the dipstick tube to the left hand exhaust manifold stud. Disconnect the dipstick tube from the stud and pull assembly from the oil pan. Plug the dipstick tube hole in the oil pan to prevent the entry of foreign mater.
5. Remove the two steering rack to front crossmember retaining bolts and nuts, then lower rack to provide clearance for the oil pan removal.
6. On each side, remove the stabiliser bar link (1), ball joint retaining nut (4) from the stabiliser bar (2), as follows:
 - a. With a backing set spanner holding the stabiliser bar link inner stud hexagon (3), use a second spanner to loosen then remove the retaining nut (4).
 - b. Separate the stabiliser bar link (1) from the stabiliser bar (2).
 - c. Repeat for the other side.
7. Remove engine mounting nuts, refer **2.25 ENGINE MOUNTS**, in this Section.
8. Raise the engine 45 mm, then place a 40 mm spacer block under each front engine mount to support the engine. Lower the engine onto the blocks.

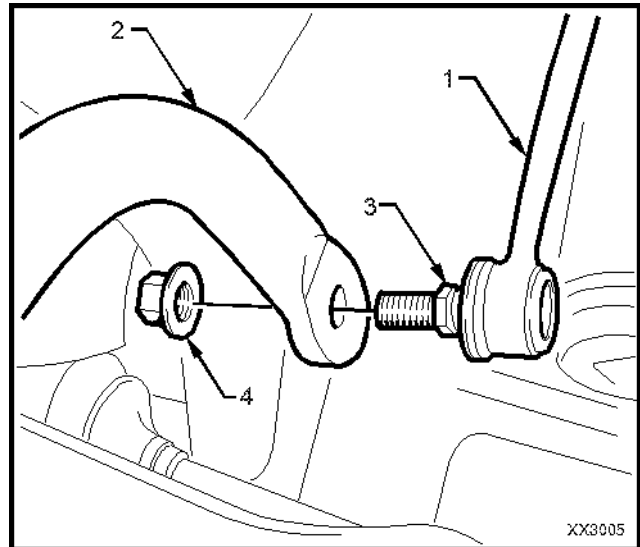


Figure 6A1-1-188

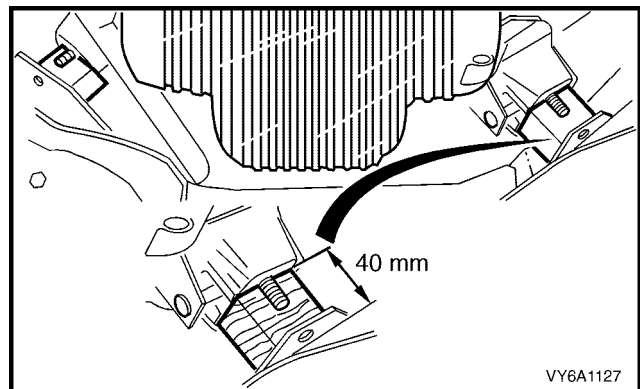


Figure 6A1-1-189

9. Remove the battery harness and (if fitted) automatic transmission oil cooler lines retaining bracket screw from the front of the engine, refer views 'A' and 'B', next.

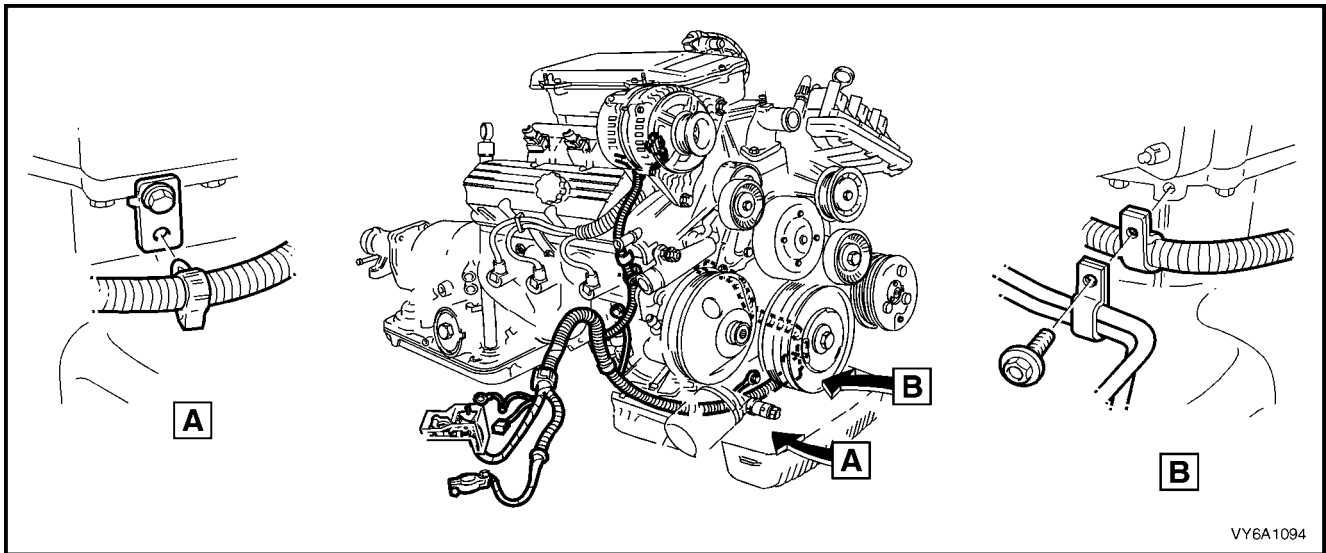


Figure 6A1-1-190

VY6A1094

Legend

- A. Battery Harness Securing Bracket. B. Automatic Transmission Cooler Pipe Bracket and Screw.

10. Remove a retaining screw from each of the transmission close-out covers.
11. Remove the two transmission to oil pan bolts.
12. Remove the oil pan retaining bolts, lower the oil pan and gasket, then remove from the vehicle. Discard the removed oil pan gasket.

REINSTALL

1. Thoroughly clean mating surfaces of the oil pan, front cover, rear oil seal housing, the cylinder block and the exposed section of the transmission housing. Use a suitable solvent to thoroughly clean all traces of engine oil from all mating surfaces. Ensure all oil pan retaining bolt threads are clean and free from dirt or sealant residue.

IMPORTANT: Ensure old sealant is removed from the oil pan surfaces and cylinder block surfaces.

2. Apply Loctite 5900 or equivalent to GM Specification 9985990, as a bead 10 mm long, 3mm wide and 1 mm thick to the cylinder block in the area of the rear oil seal housing and the front cover joints

IMPORTANT: Do not apply excess sealer. The thickness can be controlled by first applying a 1 mm thick adhesive strip, on each side of the appropriate joint. Use a scraper to fill the gap, then remove the strips.

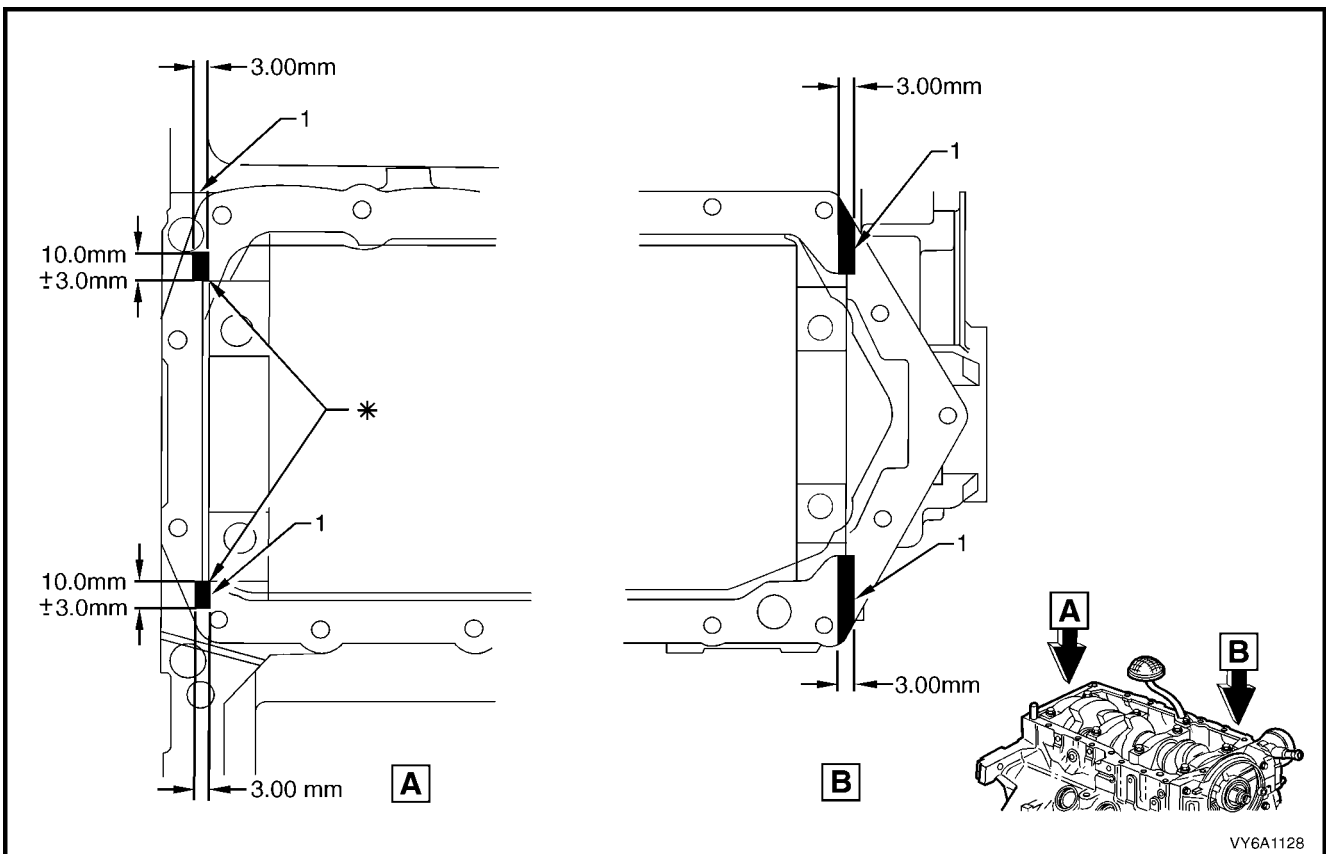


Figure 6A1-1-191

VY6A1128

NOTE: When applying sealer to the areas marked (*), to avoid filling these corners, stop short of the edges.

3. Make up two temporary studs as guide pins (1) and install to the cylinder block in two locations. This is required to overcome smearing the sealer during the oil pan installation process.

NOTE: To make installation of the oil pan easier, turn the engine over (using a socket on the harmonic balancer retaining bolt), until the front four connecting rod big ends are not protruding below the cylinder block oil pan rails.

4. Install a new oil pan gasket (2) to the oil pan and offer both up to the cylinder block, retaining with sixteen of the eighteen retaining bolts (3).

NOTE 1: Coat the cleaned threads of all oil pan bolts with Loctite 243 or equivalent, prior to reinstallation.

NOTE 2: Only tighten the oil pan retaining bolts finger tight at this stage.

NOTE 3: The oil pan fastening bolts must be tightened within 5 minutes of the sealer application to the cylinder block.

5. Reinstall the two transmission to oil pan bolts, tightening to the correct torque specification.

OIL PAN TO TRANSMISSION HOUSING BOLT TORQUE SPECIFICATION	55 Nm
---	-------

6. Remove the two guide pins and install the two remaining oil pan bolts.
7. Tighten the oil pan retaining bolts to the correct torque specification, in the sequence shown.

OIL PAN ATTACHING BOLT TORQUE SPECIFICATION	14 Nm
---	-------

8. Reinstall the transmission dust covers and tighten dust cover retaining bolts to the correct torque specification.

TRANSMISSION CLOSE-OUT COVER SCREW TORQUE SPECIFICATION	8 Nm
---	------

9. Ensure that the oil pan drain plug has been installed and tightened to the correct torque specification.

OIL PAN DRAIN PLUG TORQUE SPECIFICATION	45 Nm
---	-------

10. Reinstall the battery harness and automatic transmission (if fitted) oil cooler line retainer bracket screws to the front of the engine and tighten to the correct torque specification.

HARNESS AND OIL COOLER LINE SCREWS TORQUE SPECIFICATION	10 Nm
---	-------

11. Raise the engine, remove the spacer blocks, then reinstall the engine mount retaining nuts. Refer [2.25 ENGINE MOUNTS](#), in this Section.

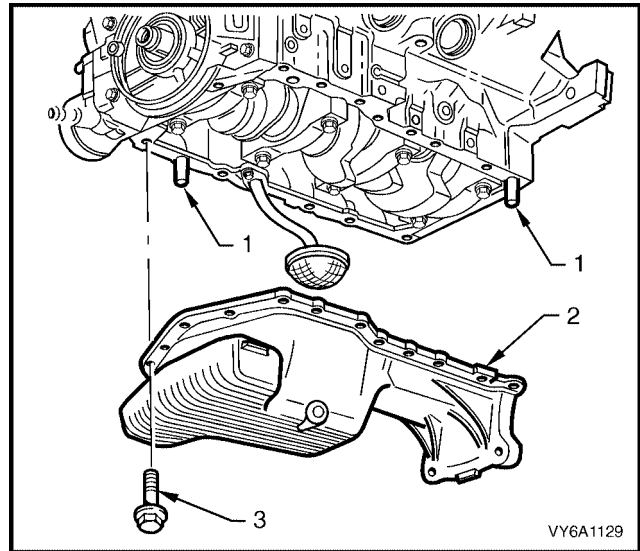


Figure 6A1-1-192

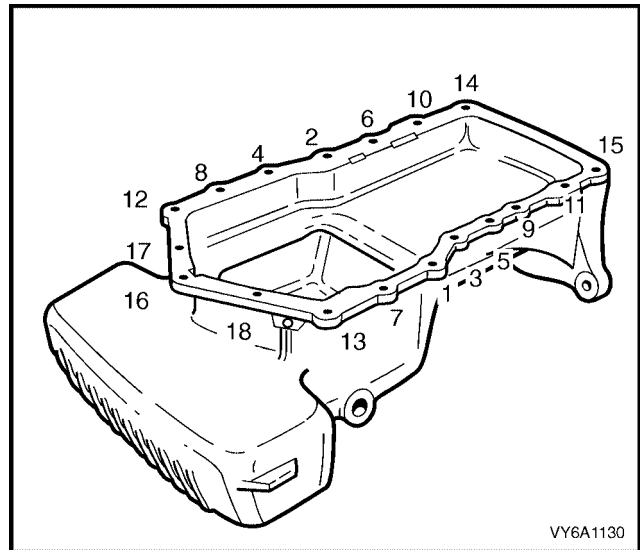


Figure 6A1-1-193

12. Reinstall the steering gear housing and secure with the two bolts and nuts, tightening to the correct torque specification.

STEERING GEAR HOUSING TO CROSSMEMBER MOUNTING NUT TORQUE SPECIFICATION	80 Nm
--	-------

13. Reinstall the stabiliser bar link ball joint stud to the stabiliser bar, reinstall and tighten the retaining nut to the correct torque specification, while holding the inner stud hexagon with a backing spanner.

STABILISER BAR LINK BALL JOINT STUD RETAINING NUT TORQUE SPECIFICATION	50 Nm
--	-------

14. Remove the plugging material from the cylinder block, then reinstall the dipstick tube after fitting a new O-ring. Locate the tube bracket over the exhaust manifold stud under the locking tab, reinstall the exhaust manifold to bracket nut and tighten to the correct torque specification.

EXHAUST MANIFOLD STUD, LOCK NUT TORQUE SPECIFICATION	24 Nm
---	-------

15. For all V6 engines except those using LPG, fill the oil pan to the correct level, using 10W-30 SJ GF2 engine oil. Refer [2.1 OIL LEVEL CHECK](#), in this Section.

16. Start engine and check for oil leaks. Rectify as required.

2.27 IDLER ASSEMBLY

REMOVE

1. Disconnect battery ground lead.

IMPORTANT: Disconnection of the battery affects certain vehicle electronic systems. Refer to **Section 00 CAUTIONS, 5. Battery Disconnection Procedures** before disconnecting the battery.

2. Remove drive belt, refer to **2.7 DRIVE BELT** in this Section.
3. Remove all spark plug leads from the ignition coils.
4. Remove the screw securing the ignition module wiring harness connector, then remove the connector (1) from the DIS ignition module.
5. Remove ignition coil and module mounting bolts (2), then remove the ignition coil and module assembly (3).
6. Loosen, then remove the bolt (7) and washer (8) securing the idler pulley (9).
7. Remove the idler pulley (9).
8. Remove the bolt (4) and bracket (5), then remove the idler assembly housing from the engine.

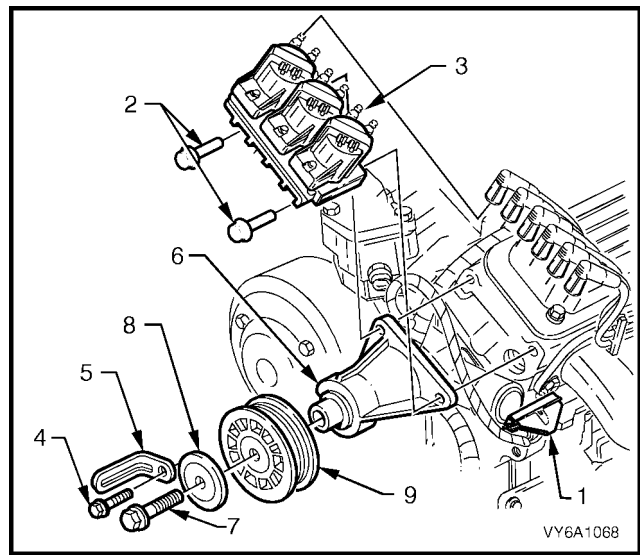


Figure 6A1-1-194

REINSTALL

1. Installation is the reverse of removal operations noting the following points.
2. Tighten all fasteners to the correct torque specification.

IDLER ASSEMBLY HOUSING MOUNTING BOLT TORQUE SPECIFICATION	45 Nm
IDLER ASSEMBLY PULLEY ATTACHING BOLT TORQUE TORQUE SPECIFICATION	45 Nm

3. Start engine and check drive belt operation.

3. MAJOR SERVICE OPERATIONS

3.1 ENGINE ASSEMBLY

REMOVE

1. Depressurise fuel lines, refer to **2.10 UPPER INTAKE MANIFOLD**, in this Section, for the procedure.
2. Disconnect battery leads from battery terminals.
3. Remove radiator cap to release any cooling system pressure.

CAUTION: To avoid serious personal injury, never remove the radiator cap when the engine is hot. Sudden release of cooling system pressure is very dangerous and could cause personal injury.

4. Place a clean container (of at least 12 litres capacity) under the engine for the engine coolant to drain into.

NOTE: To reduce the impact on the environment and the maintenance cost, whenever the coolant is to be drained from the engine, the service records are to be checked to determine when the coolant was last changed. If more than six months life is left before the next coolant change, then the drained coolant can be re-used. For further information, refer to **Section 6B1 ENGINE COOLING – V6 ENGINE**.

5. Drain engine coolant into drain tray by disconnecting radiator lower hose (1) from the front cover connection.
6. Loosen hose clamp and disconnect upper radiator hose (2) from engine.
7. Remove cooling fan and radiator assembly, together with the two radiator hoses, refer to **Section 6B1 ENGINE COOLING - V6 ENGINE**.
8. Place an oil drain tray beneath engine.
9. Remove engine oil pan drain plug and allow engine oil to drain into a clean container. Refit drain plug once oil has drained.
10. Disconnect windshield washer hose at the in-line connector located at the rear LH side of hood.

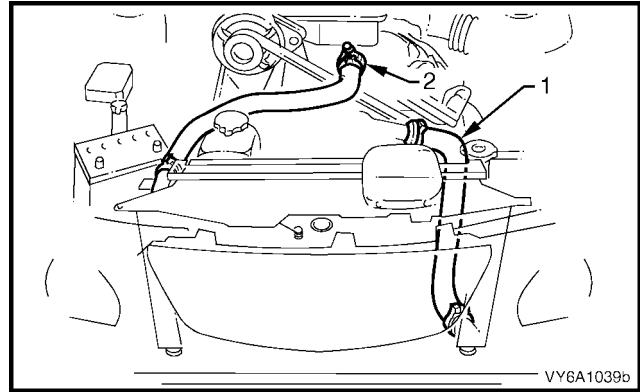


Figure 6A1-1-195

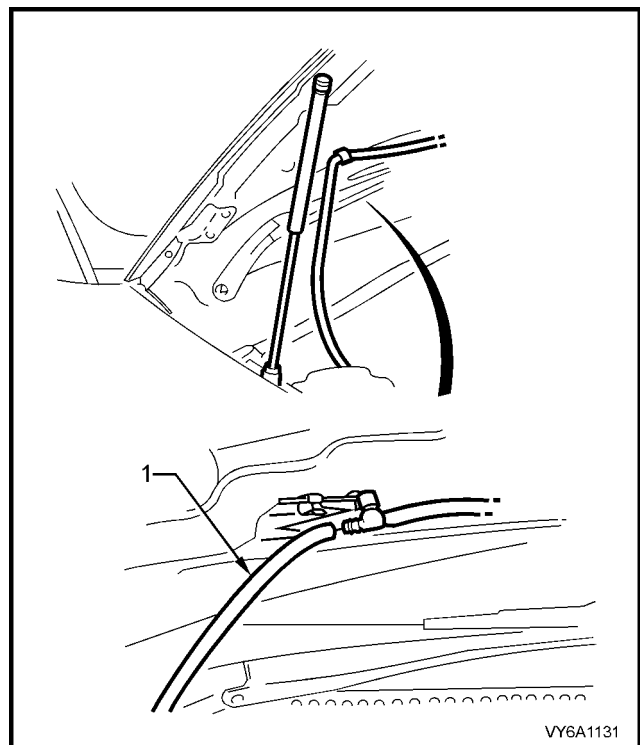


Figure 6A1-1-196

11. With engine hood adequately supported, remove clips securing upper end of struts to hood pivots. Disengage struts from hood pivots and lay strut down on fender inner panel. With the aid of an assistant hold hood assembly, remove engine hood bracket to hinge attaching bolts, then remove the hood.

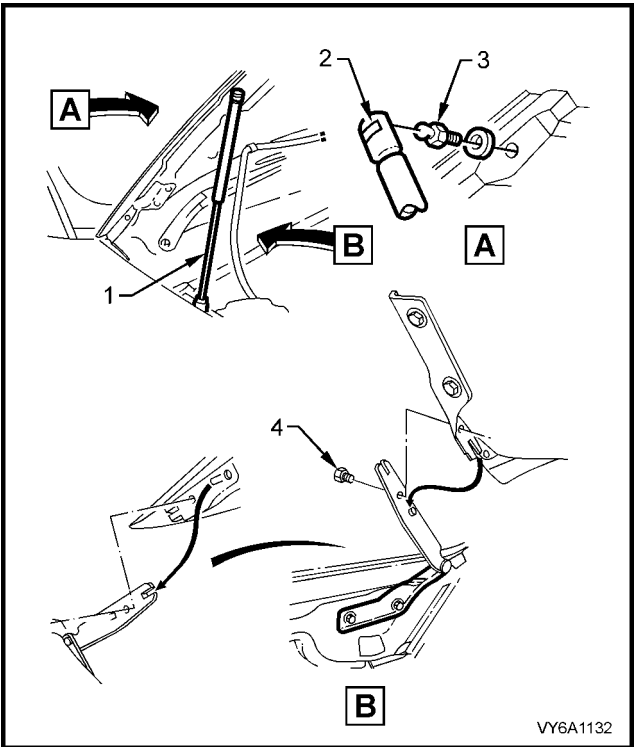


Figure 6A1-1-197

12. Remove the four nuts securing engine dress cover.

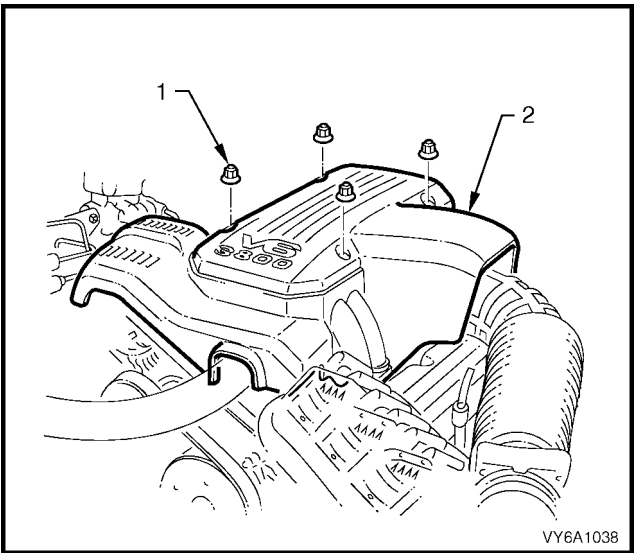


Figure 6A1-1-198

13. Loosen clamps (2) and (3) on the heater outlet hose (1) and coolant inlet hose (4), then disconnect hoses from heater outlet pipe and coolant inlet tube.

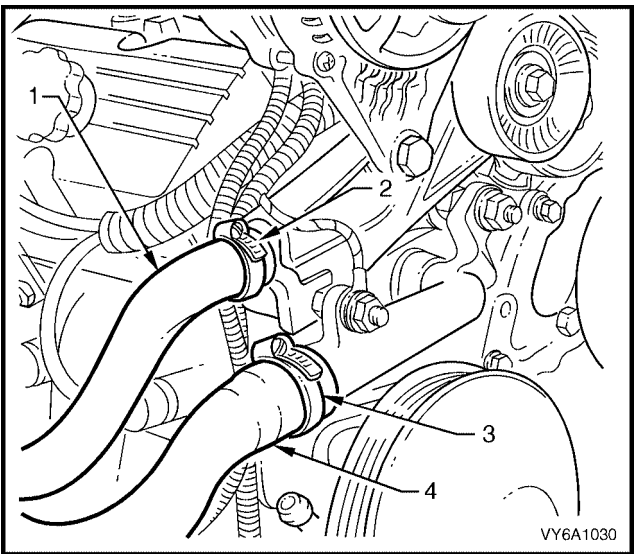


Figure 6A1-1-199

14. Disconnect the ground lead from the engine block (1) and from the right hand engine mount bracket (2), both in view 'A', next.
15. Remove nut (3) securing battery harness earth terminal to the ABS/CRUISE CONTROL bracket stud (4).

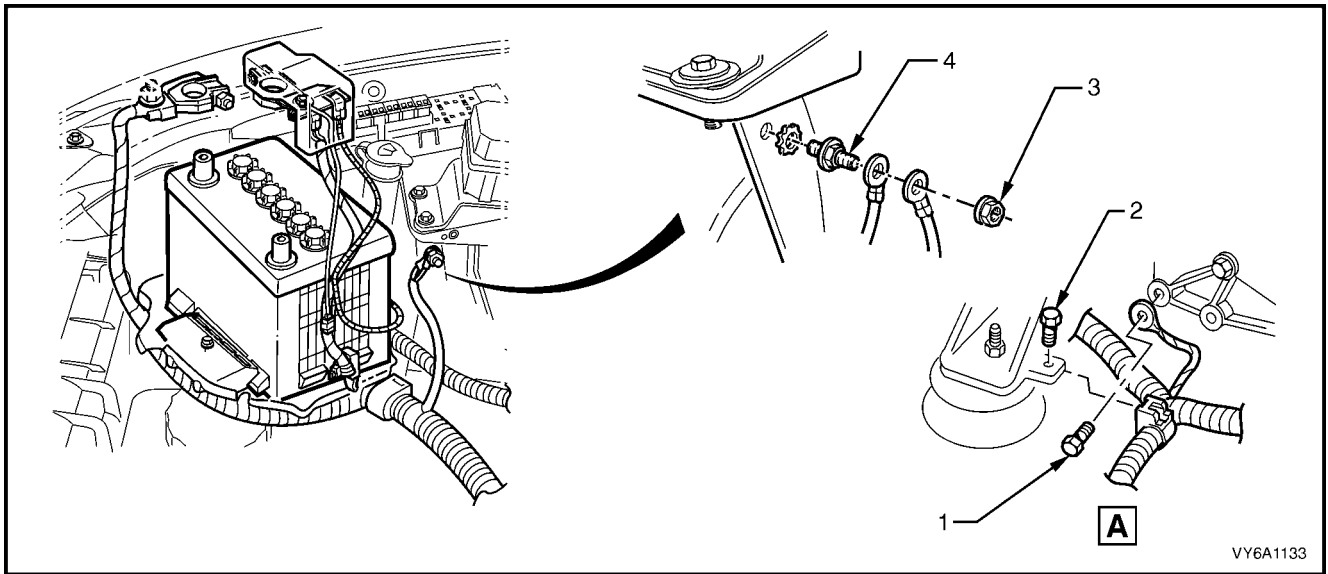


Figure 6A1-1-200

16. Remove the high pressure pipe clamp bolt (2), then the high pressure pipe (1) from rear of power steering pump.
17. Place a clean container beneath the fluid reservoir, then loosen the low pressure hose clamp at pump reservoir connection (4) and disconnect hose (3) from reservoir.

NOTE: While the RHD arrangement is shown, the LHD power steering pump connections are the same.

Plug all openings to prevent foreign matter entry.

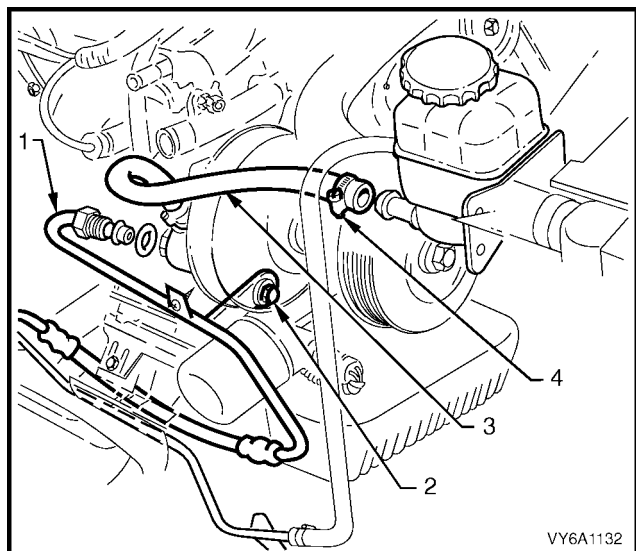


Figure 6A1-1-201

18. Disconnect throttle inner cable (1) from throttle body linkage (2). Loosen throttle outer cable lock nuts (3) at mounting bracket (5) and lay cable (1) away from engine.
19. If vehicle is fitted with cruise control, disconnect cruise control outer cable (4) from mounting bracket (5) and push inner cable forward off throttle body linkage (2).

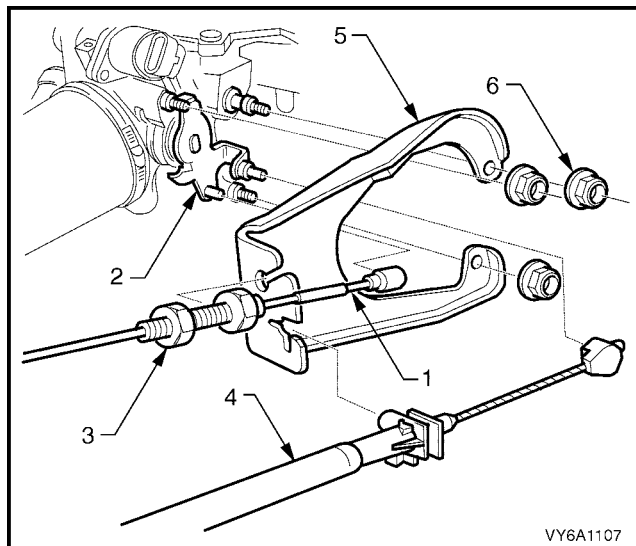


Figure 6A1-1-202

20. Using quick connect release tool No. 7370 open tool and install over fuel line.
21. Close 7370 and pull into fuel line quick connect to release it from fuel feed line, then pull back on quick connect to disconnect. Repeat this for the fuel return (2) and fuel evaporative canister hose (3). Plug all openings to prevent foreign matter entry.

NOTE 1: Do not attempt to remove hoses from fuel rail connections. Once removed from fuel rail connection, hoses require replacement.

NOTE 2: The white tape on the fuel return pipe (5) and hose (6) is to ensure that the correct connections are made on reassembly.

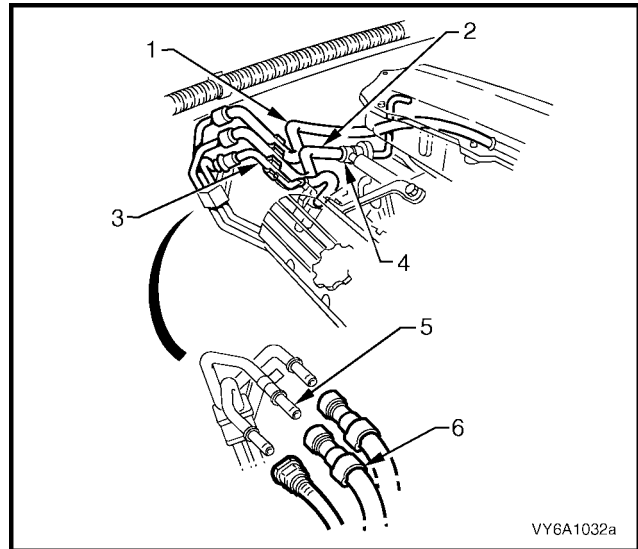


Figure 6A1-1-203

22. From inside vehicle, remove left hand shroud panel trim, glove box assembly. Remove the screw beneath the rocker panel cover, before removing the lower left hand side trim assembly, refer to [Section 1A1 BODY](#).
23. Disconnect engine wiring harness connectors (2) from Powertrain Control Module (PCM) (3). Also disconnect wiring harness connector X206 (6).
24. Remove PCM (3) and mounting bracket (4). Refer [2.1 POWERTRAIN CONTROL MODULE](#) in Section 6C1-3 SERVICE OPERATIONS for the procedure.
25. Compress lugs on engine harness plug (1) at dash panel and push engine harness and connectors out into engine compartment.

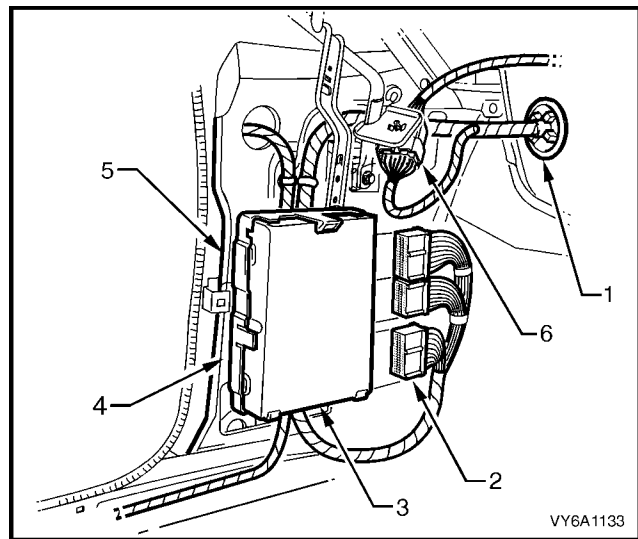


Figure 6A1-1-204

26. Disconnect mass air flow sensor wiring harness connector (4), loosen air flow duct rubber boot clamps at throttle body (1) and air cleaner (5) and remove air flow duct. Carefully place air flow duct (2) and mass air flow sensor assembly (3) to one side.
27. Lay engine harness on top of engine.

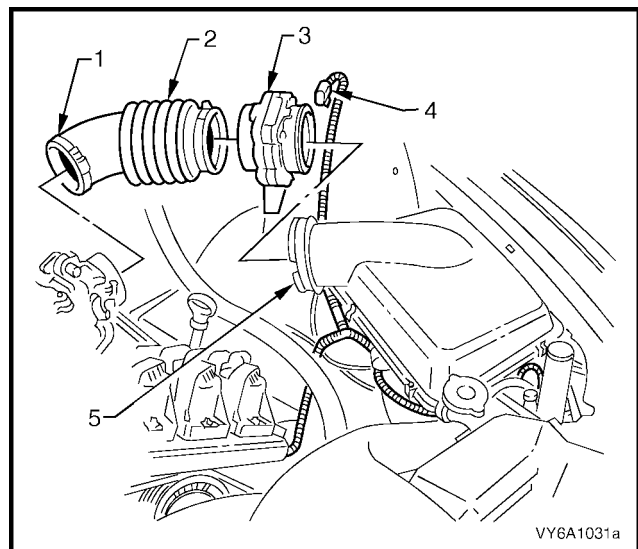


Figure 6A1-1-205

28. From the engine compartment, release powertrain harness to dash panel retaining clips (1 and 2), remove the harness connector from the intake air temperature sensor at air duct (4), the mass air flow sensor (5) and air conditioning pressure transducer connector (6) at air conditioning condenser.

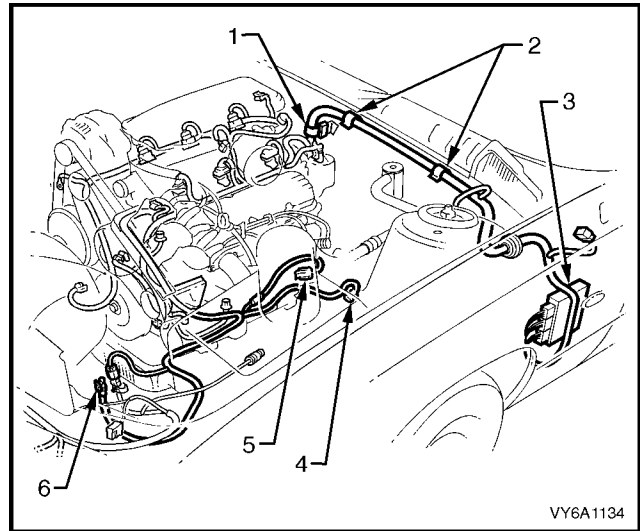


Figure 6A1-1-206

29. Disconnect the brake booster (1), fuel pressure regulator (2) and heater vacuum control (3) hoses from the upper manifold vacuum connections.

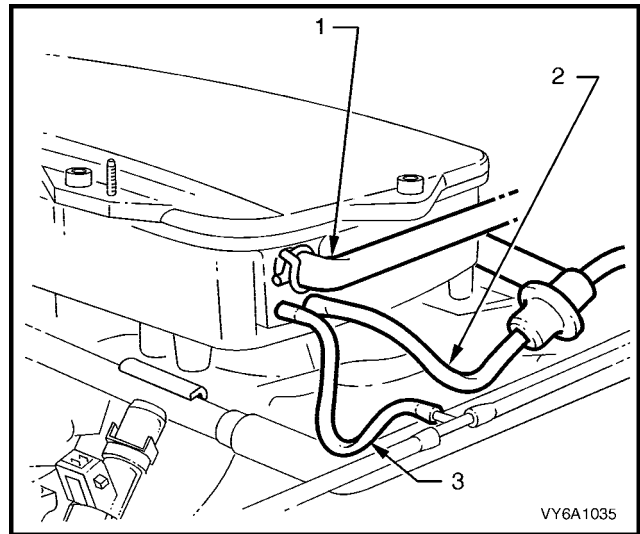


Figure 6A1-1-207

30. Raise vehicle front and rear and place on safety stands. For location of jacking points, refer to **Section 0A GENERAL INFORMATION**.
31. Remove propeller shaft, refer to **Section 4C PROPELLER SHAFTS AND UNIVERSAL JOINTS**. Install a suitable plug in end of automatic transmission.
32. Disconnect oxygen sensor connectors (1) from powertrain harness.

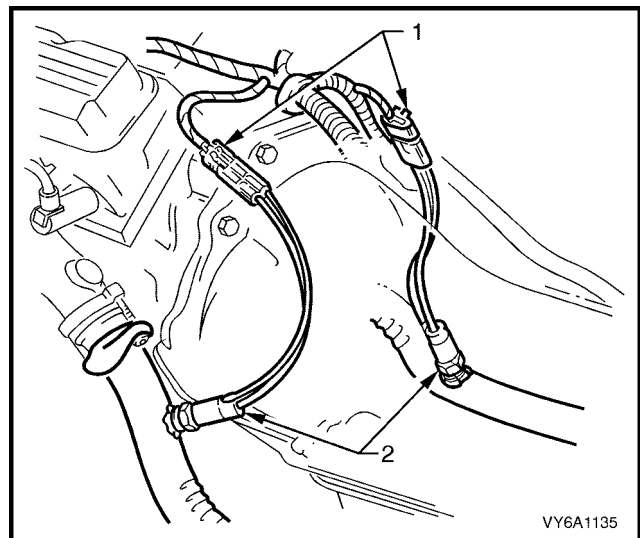


Figure 6A1-1-208

- 33. Remove engine pipe to exhaust manifold retaining nuts (3) on both the left and right hand engine pipes (2). Remove engine pipes from both exhaust manifold assemblies (1).

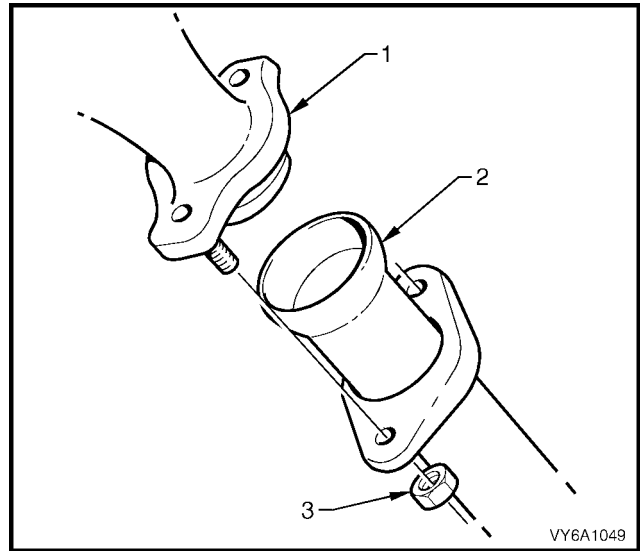


Figure 6A1-1-209

- 34. Disconnect gear shift control from transmission. Refer to either [Section 7B1 MANUAL TRANSMISSION - V6 ENGINE](#) or to [Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING](#).
- 35. On vehicles with manual transmission, disconnect the hydraulic line to the clutch actuating cylinder, refer to [3.6 CLUTCH ACTUATING CYLINDER](#) in Section 7A1 CLUTCH. Plug open hydraulic fittings, to prevent fluid loss and/or dirt entry.
- 36. Attach suitable lifting brackets (2) (position at driver's side front and passenger side rear of engine), lifting hook and chain (1) to engine, raise engine slightly to take weight off mounts.

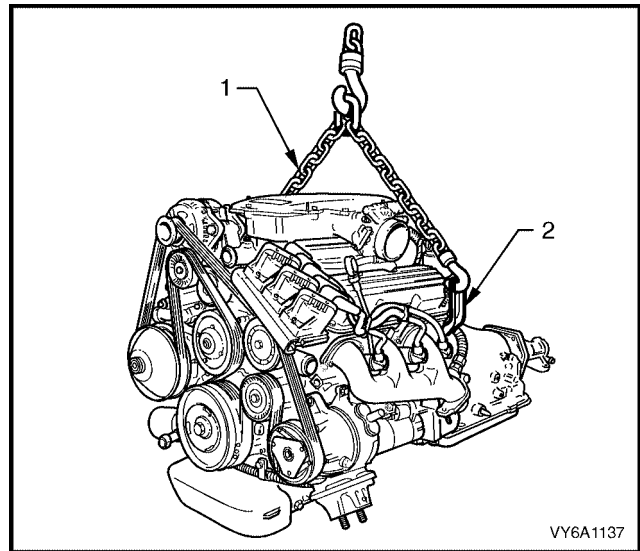


Figure 6A1-1-210

- 37. Remove engine front mounting (2) to front suspension crossmember attaching nuts (3).

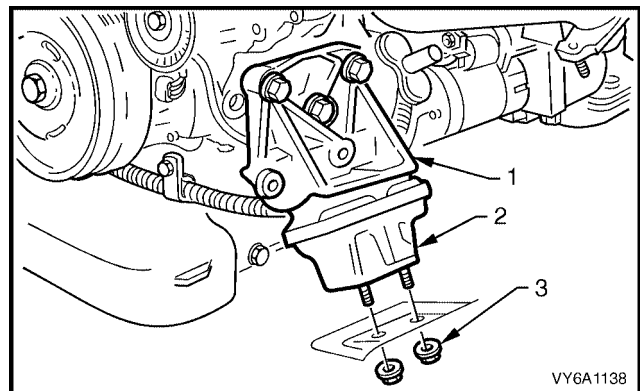


Figure 6A1-1-211

Vehicles Fitted with Manual Transmission:

38. Mark the relationship of the rear crossmember to the side frames, then remove engine rear crossmember to frame bolts (2).
39. Lower the rear of the transmission and mark the alignment relationship of the upper mounting studs to the transmission lug (4).
40. Remove mount to transmission attaching nuts (3). Remove crossmember and both mounts from vehicle.

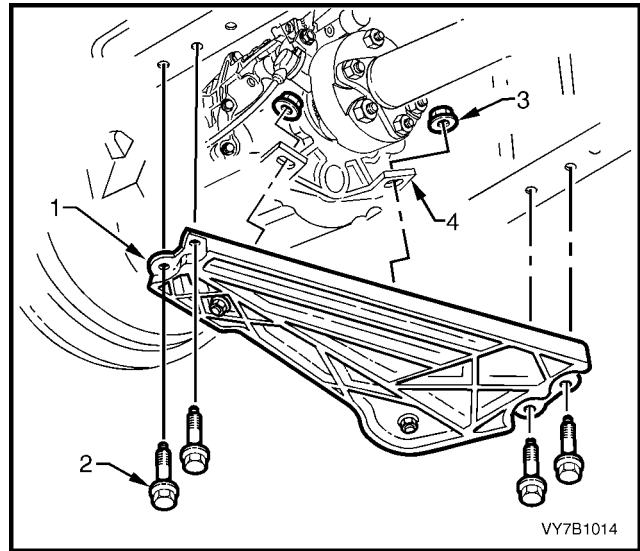


Figure 6A1-1-212

Vehicles Fitted with Automatic Transmission:

41. Mark the relationship of the rear crossmember to the side frames, then remove engine rear crossmember (3) to frame bolts (4). Remove crossmember to rear mounting (1) attaching nuts (5) and remove crossmember (3) from vehicle.

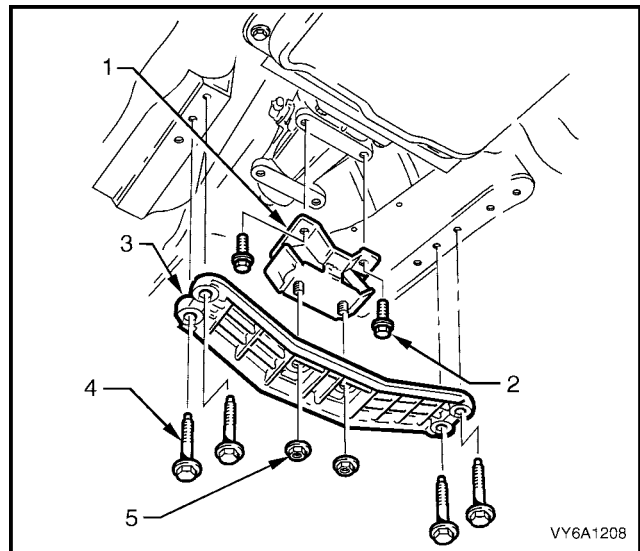


Figure 6A1-1-213

42. On vehicles with air conditioning, disconnect wiring harness connector from compressor clutch connector.
43. Raise engine slightly and remove compressor to left hand engine mount bracket mounting bolts (1) and nuts (3). Tie compressor (2) back away from the engine.

NOTE: While the refrigerant pipes are shown removed from the A/C compressor, this is not required for engine removal.

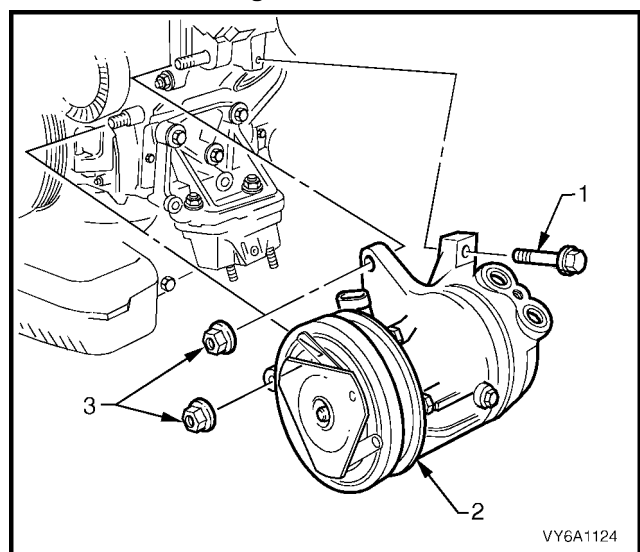


Figure 6A1-1-214

44. Raise engine with front tilted upwards and a floor jack supporting rear of transmission assembly, ensure that engine exhaust manifolds, transmission or starter motor do not rest on steering gear.

NOTE: On vehicles with air conditioning, do not allow engine to swing forward and damage air conditioning condenser.

45. If required, separate engine and transmission assemblies. Refer to either **4.2 TRANSMISSION ASSEMBLY – Remove** in Section 7B1 MANUAL TRANSMISSION - V6 ENGINE or to **3.14 TRANSMISSION ASSEMBLY – Remove** in Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING.

DISASSEMBLE

1. Mount engine assembly in a suitable engine stand.
2. Drain remaining coolant from engine block, by removing both knock sensor heat shields (2 and 5), followed by the knock sensors (1 and 6) themselves.

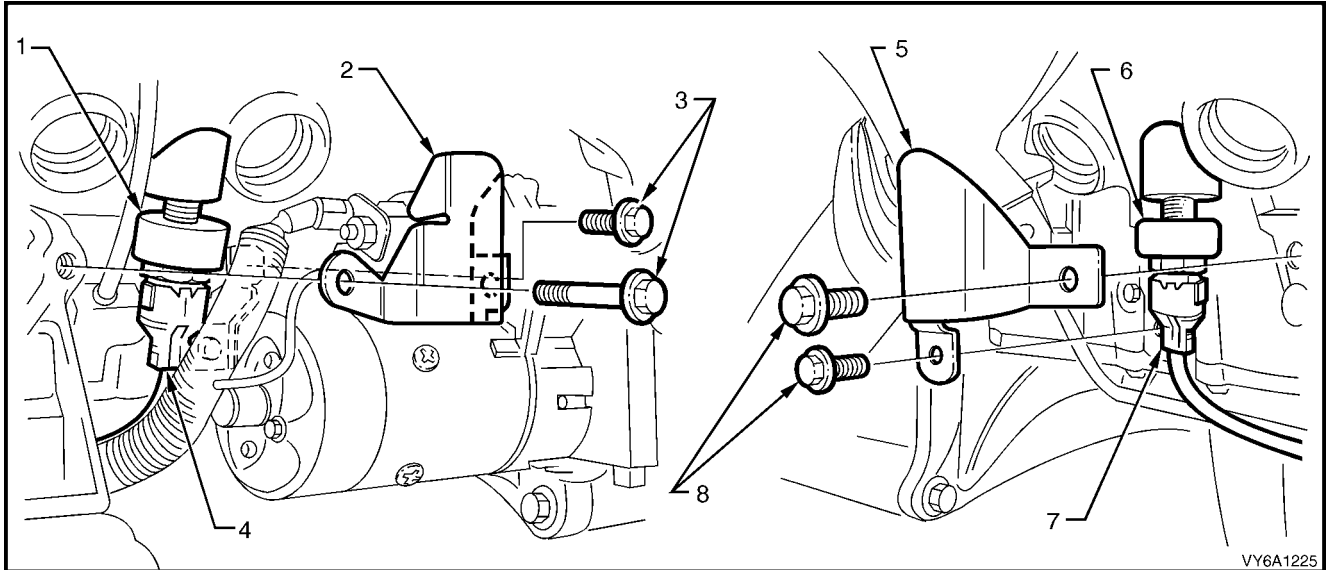


Figure 6C2-1-215 – Knock Sensor Locations

Legend

- | | |
|-----------------------------|-----------------------------|
| 1. Left Hand Knock Sensor | 5. Knock Sensor Shield RHS. |
| 2. Knock Sensor Shield LHS | 6. Right Hand Knock Sensor |
| 3. Attaching Bolts | 7. Wiring Harness Connector |
| 4. Wiring Harness Connector | 8. Attaching Bolts |
9. Remove the following items as described in the references provided:
 - a. Generator and brackets, refer to **Section 6D1-1 CHARGING SYSTEM - V6 ENGINE.**
 - b. Starter motor, refer to **Section 6D1-2 STARTING SYSTEM - V6 ENGINE.**
 - c. Ignition coils, DIS Ignition Module and mounting bracket, high tension leads and spark plugs, refer to **Section 6C1-3 SERVICE OPERATIONS, POWERTRAIN MANAGEMENT – V6 ENGINE.**
 - d. EGR Valve assembly, refer to **Section 6E1 EMISSION CONTROL - V6 ENGINE.**

10. Remove the following components as described in this Section:
 - a. Oil filter and adaptor, refer to [2.3](#) and [2.4](#).
 - b. Drive belt, refer to [2.7](#).
 - c. Drive belt tensioner, refer to [2.9](#).
 - d. Exhaust manifolds, refer to [2.12](#).
 - e. Intake manifold assembly, refer to [2.11](#).
 - f. Rocker covers, rocker arms and pushrods, refer to [2.13](#) and [2.14](#).
 - g. Valve lifters, refer to [2.16](#).
 - h. Crankshaft balancer, refer to [2.19](#).
 - i. Flywheel/flexplate, refer to [3.4](#).
 - j. Front cover, refer to [2.21](#).
 - k. Timing chain, tensioner, sprockets and balance shaft gears, refer to [2.23](#).
 - l. Camshaft, refer to [2.24](#).
 - m. Balance shaft, refer to [3.9](#).
 - n. Cylinder heads, refer to [2.17](#).
 - o. Oil pan, refer to [3.2](#).
 - p. Oil pump suction pipe and screen, refer to [3.3](#).
 - q. Piston and connecting rod assemblies, refer to [3.10](#).
 - r. Crankshaft, refer to [3.12](#).
11. Discard all gaskets and seals.
12. For inspection procedures for each component, refer to the relevant component descriptions listed under step 4.

REASSEMBLE

Reassembly is the reverse of disassembly procedure for each component as outlined in this Section. The relevant reassembly instructions for each component is listed in step 4 of the DISASSEMBLE procedure, above.

REINSTALL

Installation is the reverse of removal procedures, noting the following points:

1. Ensure that all fasteners are tightened to the specified torque provided at the end of this Section.
2. Use specified engine lubricant and coolant when refilling lubrication and cooling systems.
3. Check transmission fluid level, add lubricant as required.
4. Check for oil, fuel, coolant and exhaust leaks. Repair as necessary.
5. Check engine hood alignment.

3.2 ENGINE OIL PAN & GASKET (ENGINE REMOVED)

REMOVE

NOTE 1: This procedure assumes that the engine has been removed from the vehicle. For the same procedure with the engine installed, refer to **2.26 ENGINE OIL PAN AND GASKET**, in this Section.

NOTE 2: If this operation is to be carried out on an engine where it is supported from the rear block surface, longer spacers and bolts may be required, to gain at least 30 – 40 mm clearance. This is necessary to allow for a straight edge to be used for alignment during the oil pan reinstallation process.

1. If not already done, remove the flywheel/flexplate from the crankshaft. Refer **3.4 FLYWHEEL/FLEXPLATE, Remove**, in this Section.
2. Remove oil pan attaching bolts (1), then remove oil pan (2) and gasket (3). Discard the removed gasket (3).

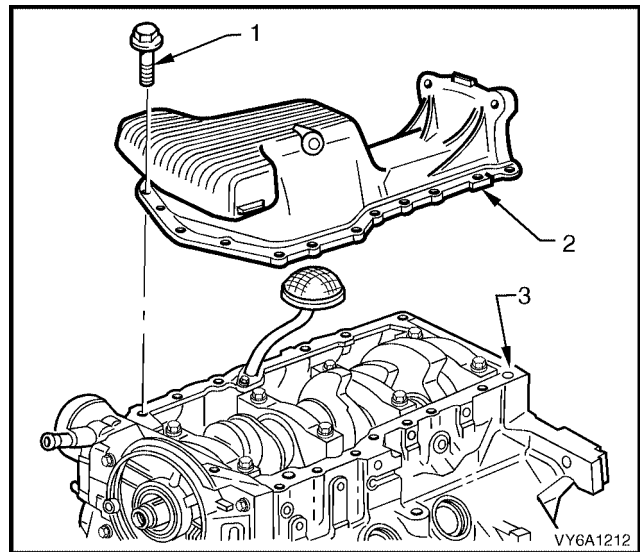


Figure 6A1-1-216

CLEAN AND INSPECT

1. Clean oil pan with suitable cleaning solvent and blow dry with compressed air.

CAUTION: Wear safety glasses to avoid eye injury.

2. Carefully inspect oil pan machined surfaces for flatness, scratching or other damage that may inhibit proper sealing. Replace the oil pan if any damage is found.

REINSTALL

1. Thoroughly clean mating surfaces of the oil pan, front cover, rear oil seal housing, the cylinder block and the exposed section of the transmission housing, using a suitable solvent. Ensure that all oil pan retaining bolt threads are clean and free from dirt or sealant residue.

IMPORTANT: Ensure old sealant is removed from the oil pan surfaces and cylinder block surfaces.

2. Apply Loctite 5900 or equivalent to GM Specification 9985990, as a bead 10 mm long, 3mm wide and 1 mm thick to the cylinder block in the area of the rear oil seal housing and the front cover joints, shown next.

IMPORTANT: Do not apply excess sealer. The thickness can be controlled by first applying a 1 mm thick adhesive strip, on each side of the appropriate joint. Use a scraper to fill the gap, then remove the strips.

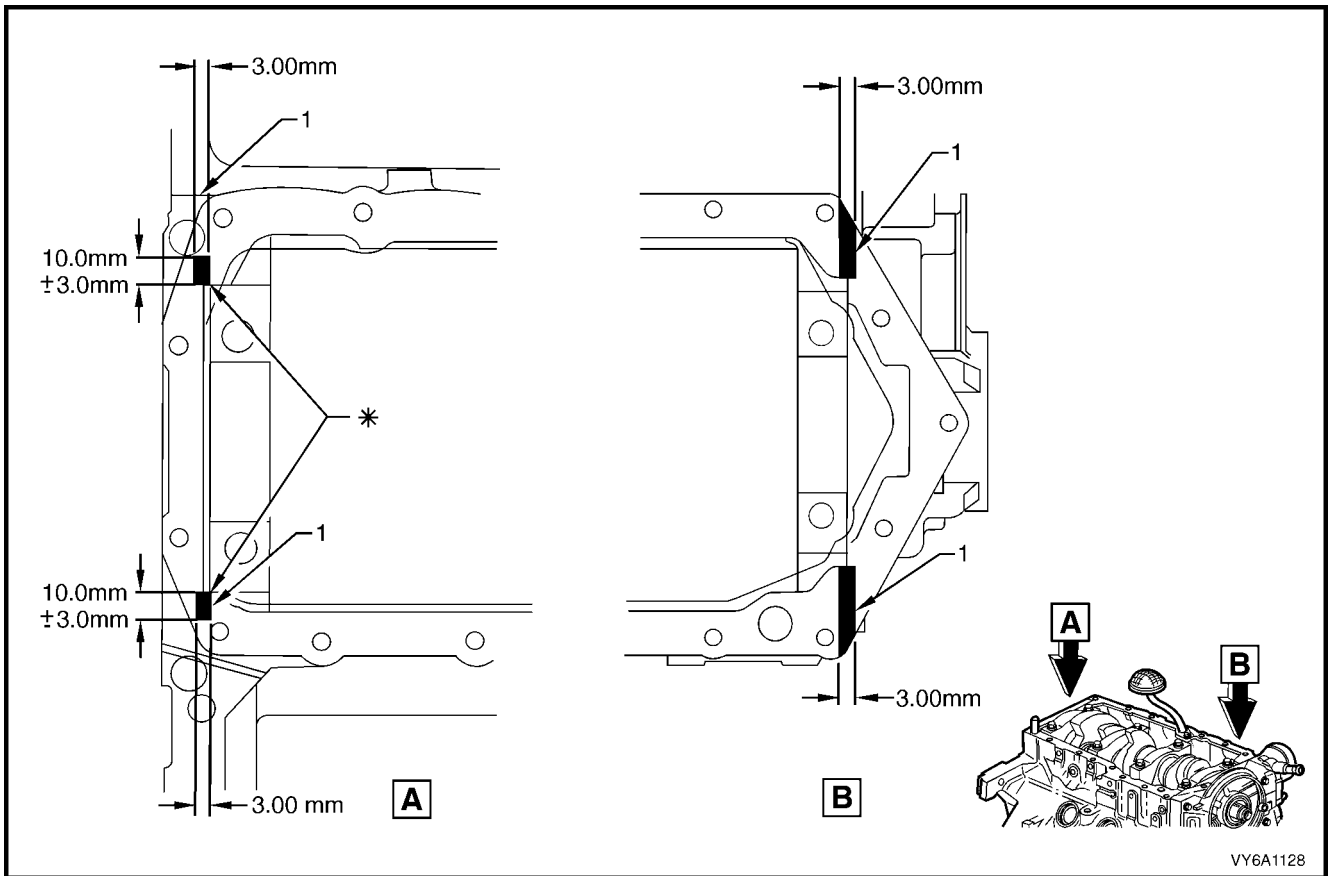


Figure 6A1-1-217

NOTE: When applying sealer to the areas marked (*), to avoid filling these corners, stop short of the edges.

3. Make up two temporary studs (1) as guide pins and install to the cylinder block. This is required to overcome smearing the sealer during the oil pan installation process.
4. Install a new oil pan gasket over the guide pins.
5. Reinstall the oil pan (2) to the engine block locating with the two guide pins (1).
6. Loosely install all but two of the oil pan fastening bolts (3), after coating the cleaned threads of each bolt with Loctite 243 or equivalent, prior to reinstallation.
7. Remove the two guide pins, then reinstall the remaining two oil pan fastening bolts, also with Loctite 243 or equivalent applied to the threads.

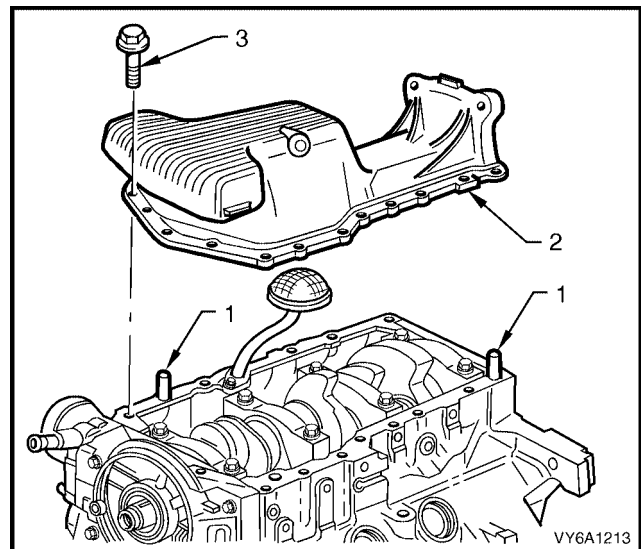


Figure 6A1-1-218

IMPORTANT: Correct alignment of the structural oil pan to the rear of the engine block is important for powertrain durability.

8. Align the rear, machined surface of the oil pan with the machined rear surface of the engine block, using a straight edge (or flat plate) clamped to the cylinder block on each side, to assist.

9. Tighten the oil pan retaining bolts to the correct torque specification and, in the sequence shown.

OIL PAN ATTACHING BOLT TORQUE SPECIFICATION	14 Nm
--	-------

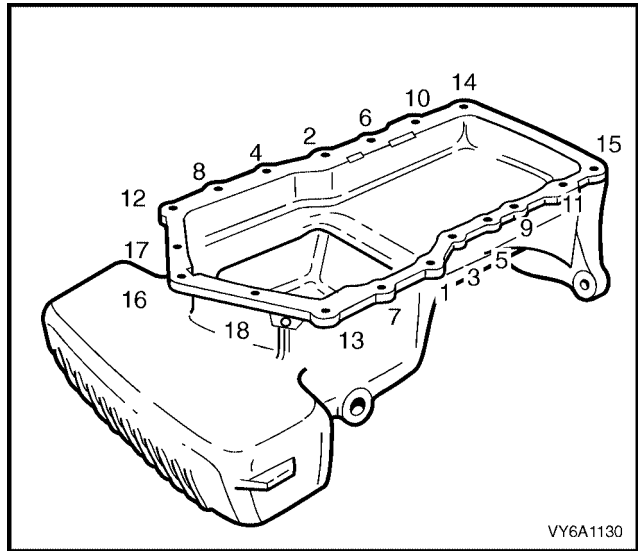


Figure 6A1-1-219

10. With the straight edge still clamped to the machined rear surface of the cylinder block (2), check that the transmission mounting flange of the oil pan (1) is from 0.1 mm over-flush to 0.2 mm under-flush to the cylinder block, as indicated. Use an appropriate thickness feeler gauge to assess.

11. If the specified alignment is not attained, then the oil pan attaching bolts must be loosened and a soft faced hammer used to align the oil pan to achieve the alignment result required, refer to steps 8 – 10 above.

NOTE: This whole process must be carried out quickly as the oil pan fastening bolts must be tightened within 5 minutes of the sealer application to the cylinder block.

12. Ensure that the oil pan drain plug has been installed and tightened to the correct torque specification.

OIL PAN DRAIN PLUG TORQUE SPECIFICATION	45 Nm
--	-------

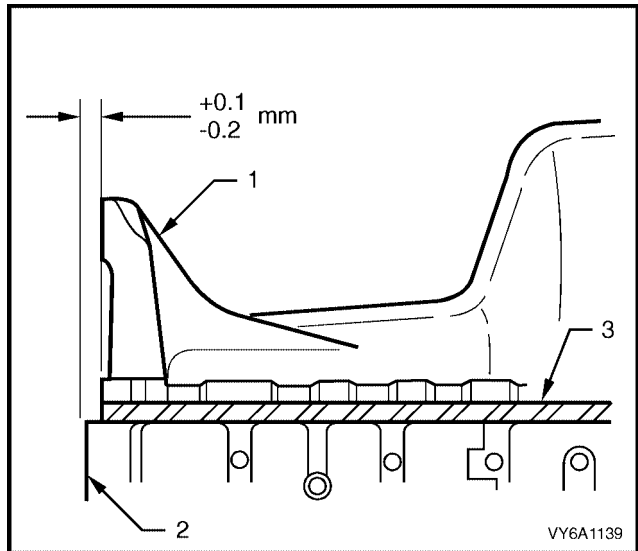


Figure 6A1-1-220

3.3 OIL PUMP SUCTION PIPE & SCREEN

REMOVE

1. Remove oil pan, refer to **3.2 ENGINE OIL PAN AND GASKET**, in this Section.
2. Remove two bolts (1) securing suction pipe flange to cylinder block and remove pipe and screen assembly (2).
3. Remove suction pipe to cylinder block O-ring (3) and discard.

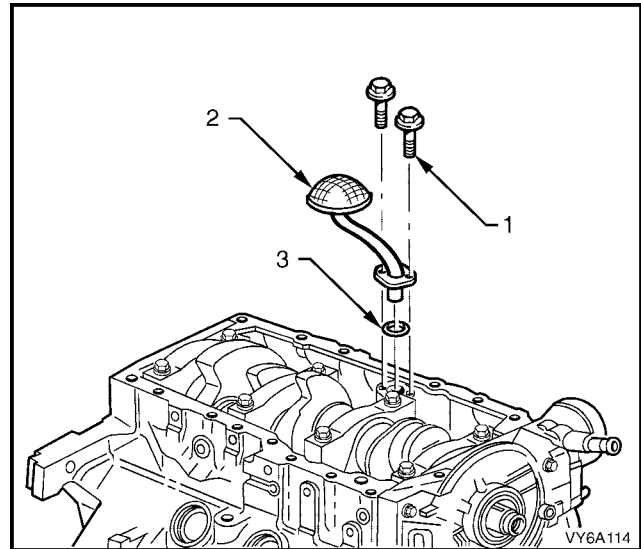


Figure 6A1-1-221

REINSTALL

Installation is the reverse of removal procedures, noting the following points:

1. Ensure that the screen is cleaned of any foreign matter.
2. Clean suction pipe flange and cylinder block mating surfaces.
3. Clean threads of suction pipe securing bolts and mating threads in cylinder block with a suitable size thread tap.
4. Apply Loctite 242 or equivalent to bolt threads.
5. Install a new O-ring between suction pipe flange and cylinder block. Install the suction pipe to the cylinder block and secure with the two bolts, tightened to the correct torque specification.

OIL PUMP SUCTION PIPE FLANGE TO TORQUE SPECIFICATION	10 Nm
--	-------

6. Ensure that the oil pan drain plug has been installed and tightened to the correct torque specification.

OIL PAN DRAIN PLUG TORQUE SPECIFICATION	45 Nm
--	-------

3.4 FLYWHEEL/FLEXPLATE

REMOVE

Manual Transmission Equipped Vehicles

- 1a. Remove the transmission and clutch assembly. Refer **3.9 CLUTCH DRIVEN PLATE, PRESSURE PLATE AND/OR THROWOUT BEARING, Remove**, in Section 7A1 CLUTCH.

Automatic Transmission Equipped Vehicles

- 1b. Remove the automatic transmission. Refer **3.14 TRANSMISSION ASSEMBLY, Remove**, in Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING.

Legend:

- A. Manual Transmission
- B. Automatic Transmission
- 1. Clutch Pressure Plate
- 2. Dual Mass Flywheel
- 3. Clutch Driven Plate
- 4. Pressure Plate Attaching Bolt
- 5. Painted Balance Marks
- 6. Spigot

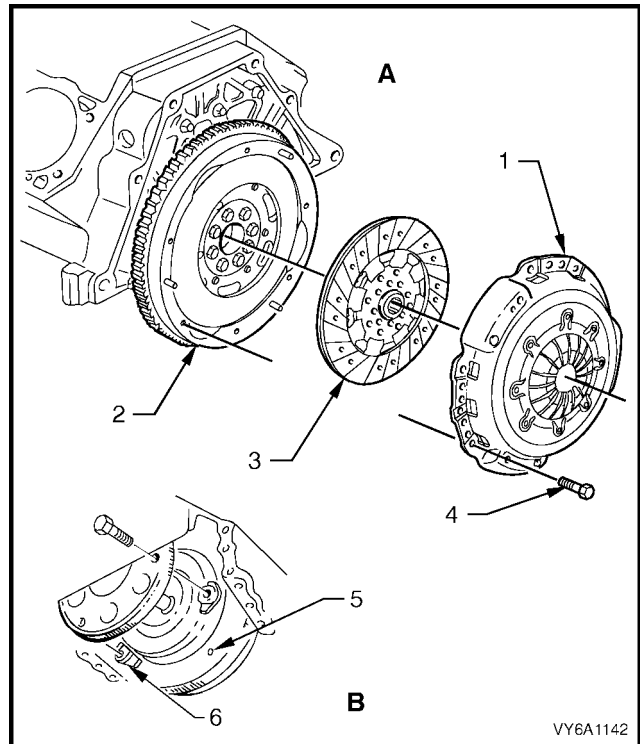


Figure 6A1-1 222

2. Using a screwdriver or suitable locking tool, block flywheel/flexplate from rotating. Gradually loosen, then remove the attaching bolts, working from opposite sides. Remove flywheel/flexplate to crankshaft attaching bolts and discard, as the bolts must be replaced on reassembly. Remove flywheel/flexplate from the crankshaft.

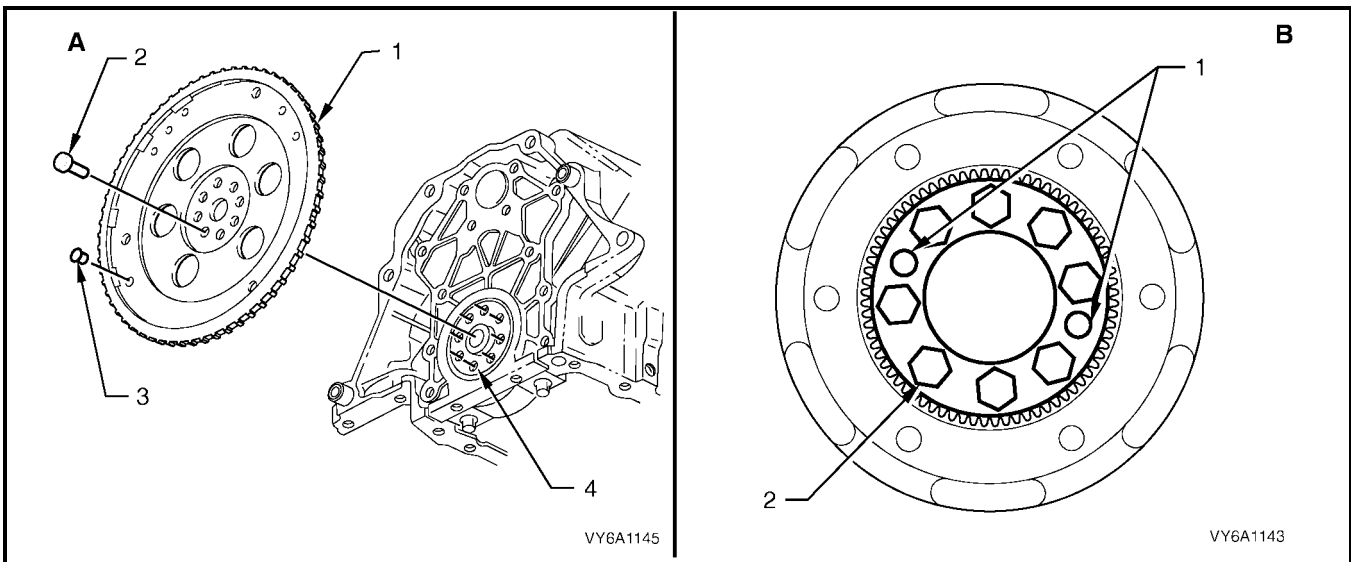


Figure 6A1-1-223

Legend

- A** Flexplate Arrangement
 - 1. Flexplate
 - 2. Attaching Bolt
 - 3. Balance Weight (If Required)
 - 4. Crankshaft
- B** Flywheel Arrangement
 - 1. Flywheel Locating Dowel Pins
 - 2. Flywheel Attaching Bolts

NOTE: There are specific bolts for flywheel and flexplate attachment to the crankshaft. Bolt 'A' is used to secure the flywheel, while bolt 'B' is used to secure the flexplate. Both bolts have the same thread i.e. 18 UNC 3A.

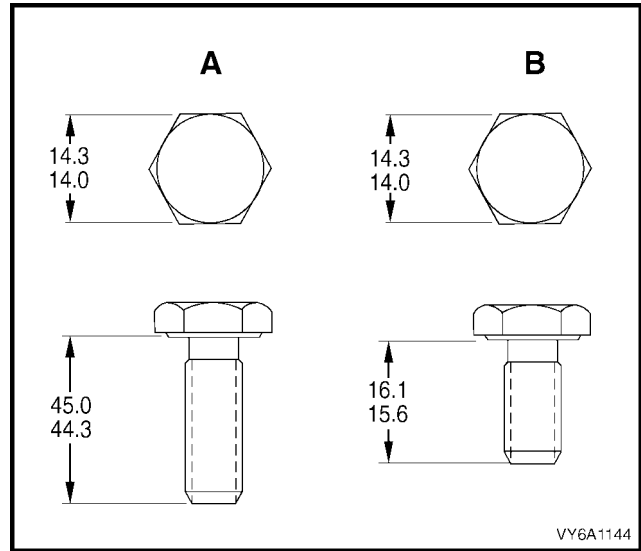


Figure 6A1-1-224

INSPECT

1. Inspect flywheel/flexplate ring gear for cracked, badly worn or damaged teeth. If the ring gear is damaged, it will be necessary to replace flywheel or flexplate as a complete assembly . If ring gear teeth are found to be damaged, also inspect starter motor pinion gear for damage. Refer to [Section 6D1-2 STARTING SYSTEM - V6 ENGINE](#).
2. Check flexplate retainer plate for any damage, such as cracking or excessive warpage.
3. Check crankshaft and flywheel/flexplate mating surfaces for burrs. Remove burrs, if present, with a fine mill file.

NOTE: No attempt should be made to re-balance the flywheel or flexplate, as these are non serviceable units.

4. Using a 5/16 UNC thread tap, clean flywheel/flexplate attaching bolt threads in rear of crankshaft.
5. Inspect the clutch driven plate face of the dual mass flywheel for scoring or excessive heat damage. While some evidence of heat cracks can be ignored, should the surface be considered unserviceable, then the flywheel **MUST** be replaced as an assembly.
6. Check the rotational free play between the engine and transmission sides of the dual mass flywheel. Should the amount of travel exceed specification ('A' = 27 mm or 11°), then the flywheel assembly **MUST** be replaced as an assembly.

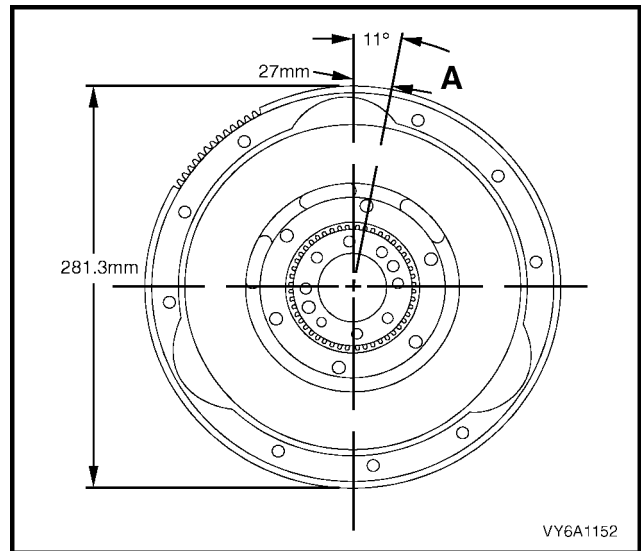


Figure 7A-225

REINSTALL

Installation is the reverse of removal procedures, noting the following points:

1. Vehicles with manual transmission align flywheel dowel pin holes with crankshaft flange dowel pins and reinstall flywheel onto crankshaft flange. Install and tighten new attaching bolts to the correct torque specification.

NOTE: Bolt holes are unevenly spaced so all flywheel/flexplate bolts can only be installed with the flywheel/flexplate in the correct position.

2. Vehicles with automatic transmission reinstall flexplate to crankshaft flange. Install and tighten new attaching bolts to the correct torque specification.

FLYWHEEL BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 85°
FLEXPLATE BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 50°

3. On those vehicles with a flexplate (i.e. automatic transmission), mount a dial indicator to the rear of cylinder block.
4. Check flexplate run-out at the three torque converter mounting bolt holes. Run-out should not exceed specification.

FLEXPLATE RUN-OUT SPECIFICATION	0.38 mm Maximum
------------------------------------	-----------------

5. If runout exceeds specification, an attempt to correct the runout can be made by tapping the high side with a rubber mallet (1). If the runout condition cannot be corrected, replace flexplate.
6. Reinstall clutch assembly and transmission, refer **3.9 CLUTCH DRIVEN PLATE, PRESSURE PLATE AND/OR THROWOUT BEARING, Reinstall**, in Section 7A1 CLUTCH.
7. Reconnect battery ground lead and check starter motor operation.
8. Start engine and check clutch operation.

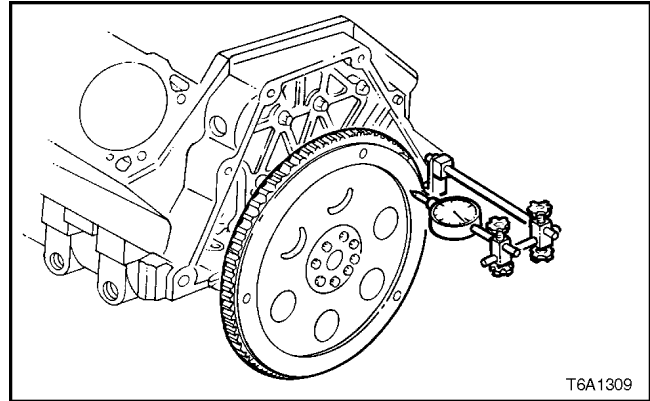


Figure 6A1-1-226

3.5 RING GEAR

REPLACE

The ring gear is welded to the flexplate/flywheel and as such, in each case, the assembly is only serviced as a complete assembly.

3.6 SPIGOT BEARING

REPLACE

1. Disconnect battery earth lead.
2. Remove the transmission and clutch assembly.
Refer **3.9 CLUTCH DRIVEN PLATE, PRESSURE PLATE AND/OR THROWOUT BEARING, Remove**, in Section 7A1 CLUTCH.
3. Using suitable spigot bearing removal tools, such as Tool No. J 23907 with slide hammer J 26125-B, remove spigot bearing.

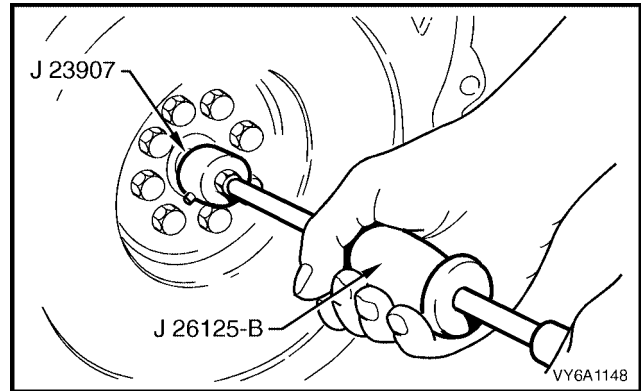


Figure 6A1-1-227

4. In replacing spigot bearing, use a piloted driver (1). Place new bearing on pilot of bearing next to shoulder on tool. Drive bearing into crankshaft until bearing shoulder contacts crankshaft boss.

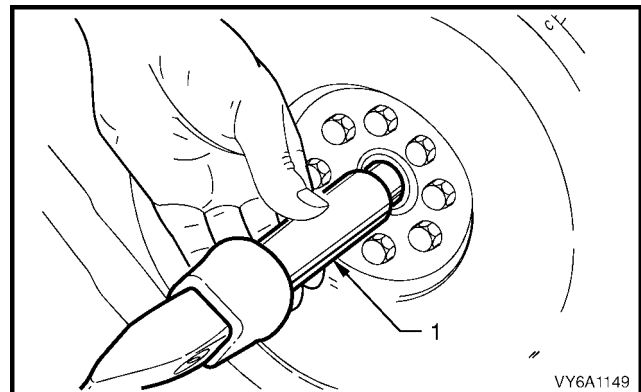


Figure 6A1-1-228

5. Lubricate bearing with several drops of SAE 90 Gear Oil.
6. Reinstall clutch assembly and transmission, refer **3.9 CLUTCH DRIVEN PLATE, PRESSURE PLATE AND/OR THROWOUT BEARING, Reinstall**, in Section 7A1 CLUTCH.
7. Reconnect battery ground lead, start engine and check clutch operation.

3.7 MAIN AND CONNECTING ROD BEARINGS

Each crankshaft main bearing journal has two bearing halves or shells which are dissimilar and not interchangeable in the bearing cap nor the cylinder block, (except No. 1 and No. 4 upper bearing shells). The upper (cylinder block) shell (1) has two oil feed holes (3) and is grooved to supply oil to the connecting rod bearing, with the lower bearing shells (2) having a continuation of this groove (4) in each end of the shell. The two bearing shells on each journal must not be interchanged. The No. 2 bearing shells are flanged to take end thrust.

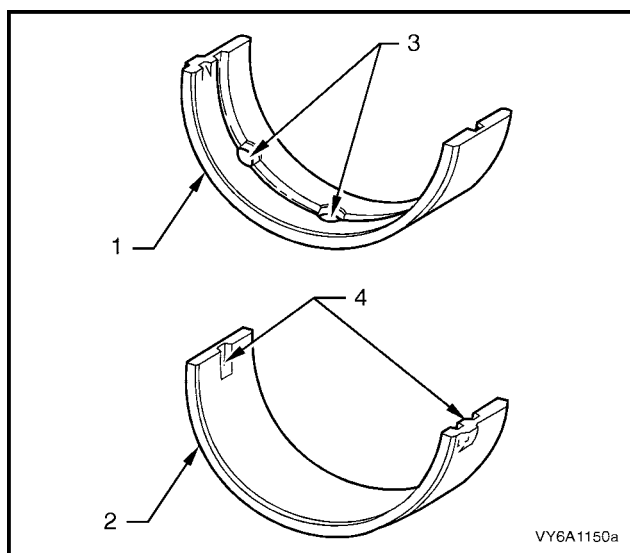


Figure 6A1-1-229

Each connecting rod bearing ('B') consists of two bearing halves or shells which are interchangeable in the rod and cap.

Both sets of bearing shells are of the precision insert type and do not require reaming to size or utilise shims for adjustment.

When shells are placed in the cylinder block or connecting rod and bearing cap, the ends extend slightly beyond the parting surfaces so that when the cap bolts are tightened, the shells clamp tightly in place to ensure positive seating and to prevent turning.

Therefore, the ends of the bearing shells must NEVER be filed flush with the parting surfaces of the cylinder block, connecting rod or bearing cap.

Service replacement main bearings are available in standard and 0.0254 mm undersize. Each bearing shell has identification markings on the back of the shell. 'A' shows the location of the marking (1) while 'B' shows the location for the connecting rod shells.

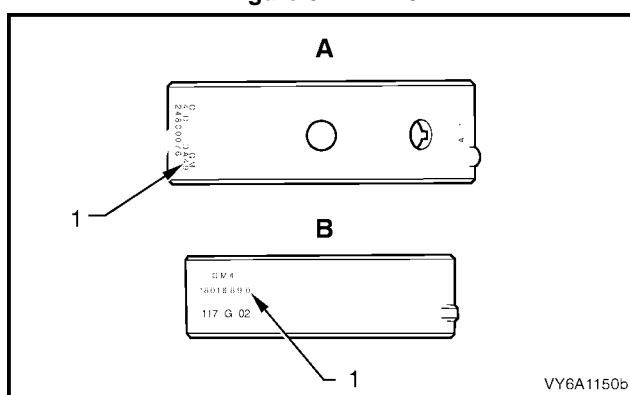


Figure 6A1-1-230

MAIN BEARINGS - INSPECT

1. With engine removed from vehicle refer to **3.1 ENGINE ASSEMBLY** in this Section, mount in a suitable stand and invert engine assembly.
2. Remove oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
3. Remove oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.

4. Remove main bearing cap bolts and main bearing cap side bolts. Discard the side bolts as they must be replaced on reassembly. Observe the following procedure:

NOTE 1: Main bearing caps are a press fit and special care is required when removing the caps. J41348 has been designed to work in conjunction with J6125-B in order to prevent damage to bearing and/or cap. J41348 must be installed correctly into bolt holes of caps and J6125-B attached in order to properly remove main bearing cap without damage to the cap and/or bearing. Deviation from this procedure may cause damage to the cap and/or bearing resulting in engine damage.

- a. Install J41348 into main bearing cap bolt holes.
 - b. Tighten bolts to 11 Nm.
 - c. Reinstall J6125-B to J41348.
 - d. Using the slide hammer motion of J6125-B remove main bearing cap.
5. Inspect lower bearing shells and crankshaft journals. If journal surface is heavily scored or ridged, replace crankshaft, refer to **3.12 CRANKSHAFT** in this Section.
 6. To ensure satisfactory engine operation, new bearing shells must be installed, refer to **Main Bearings** and if necessary, **Connecting Rod Bearings** in this Section.
 7. Check inner surface of bearing shells for wear, gouges or embedded foreign material. If foreign material is found, determine its nature and source. Inspect outer surface of bearing shells for surface wear (indicates movement of shell or high spot in surrounding material), overheating (discolouration) or looseness or rotation (flattened tangs and wear grooves).
 8. Inspect thrust surfaces of thrust bearing shell for wear or grooving. Grooves are caused by irregularities in the crankshaft thrust surfaces or dirt refer to **3.12 CRANKSHAFT** in this Section.
 9. If condition of lower bearing shells and crankshaft journals is satisfactory, check bearing clearance as follows:

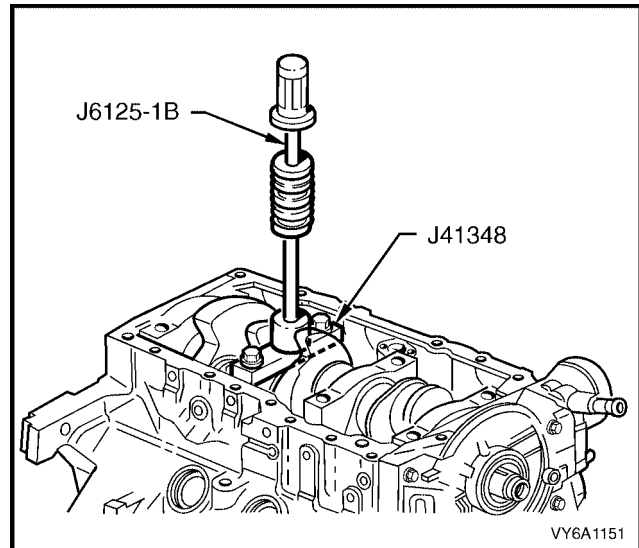


Figure 6A1-1-231

- a. Wipe oil from crankshaft journal and inner and outer surfaces of lower bearing shell.
- b. Reinstall bearing shell in original position in bearing cap.
- c. Place a piece of Plastigage (1) across full width of crankshaft journal, parallel to crankshaft centreline.

NOTE: Ensure Plastigage is not placed across the journal oil hole.

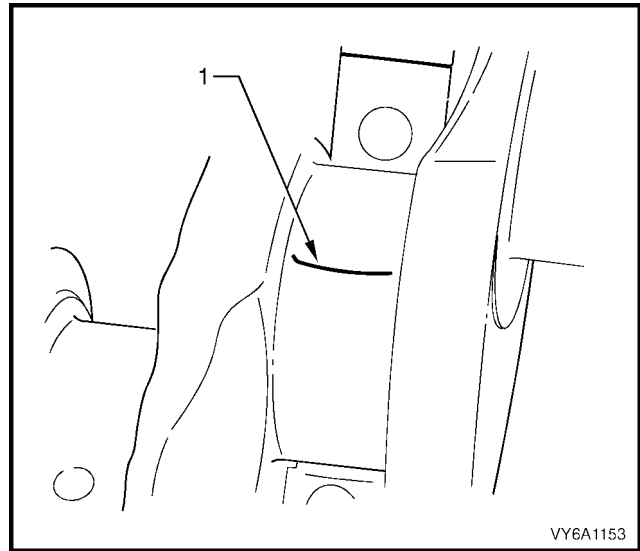


Figure 6A1-1-232

- d. Reinstall bearing cap and bolts into cylinder block.

NOTE 1: Ensure that the bearing caps are installed into the crankcase with the correct orientation (1) and in the correct order (2).

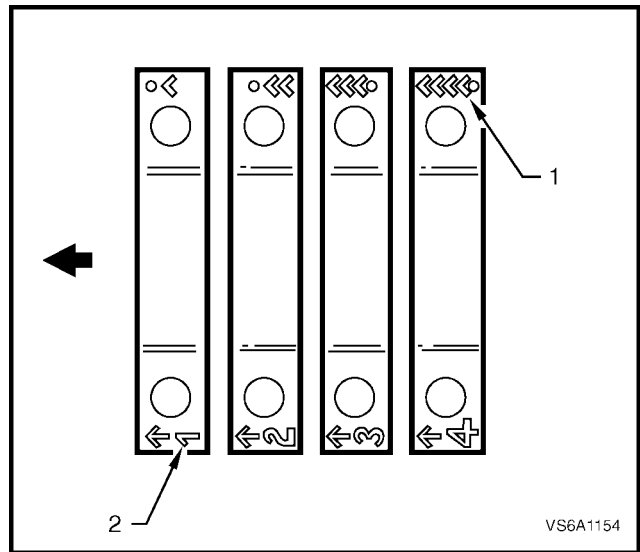


Figure 6A1-1-233

10. Before final installation of cap bolts, determine if bolts have stretched by comparing with a new bolt. Replace bolt/s as necessary.
11. Reinstall main bearing caps, hand start main bearing cap bolts, on each bearing cap in turn, tighten cap bolts half a turn at a time to carefully seat cap.

NOTE: Do not tighten one cap completely at a time but progressively tighten all four caps to one step of procedure, before moving to next stage of torque.

MAIN BEARING CAP BOLT TORQUE SPECIFICATION PROCEDURE	
TO FULLY SEAT EACH CAP, TIGHTEN TO	70 Nm, then Loosen All 360°.
RE-TIGHTEN EACH BOLT TO	20 Nm, then 40 Nm. Finally,
TURN EACH CAP BOLT THROUGH	35°, three times (= 105° Total).
TIGHTEN EACH BEARING CAP SIDE BOLT	15 Nm, then turn through 45°

IMPORTANT: In order to prevent the possibility of cylinder block or bearing cap damage, do not install bearing cap using a soft faced hammer. Use cap bolts to pull bearing cap into position. Failure to observe this procedure may damage cylinder block or bearing cap.

NOTE 1: Ensure that crankshaft does not turn with Plastigage installed.

NOTE 2: Use an angle wrench such as E7115 to ensure accurate turn angle.

12. Remove bearing cap bolts, remove cap. Look for flattened Plastigage adhering to either crankshaft or bearing shell in bearing cap.

13. Determine bearing clearance by comparing width of flattened Plastigage (1) at the widest point, with the graduations on Plastigage packaging. The number within the graduation on the envelope indicates the clearance.

Clearance between each main bearing and crankshaft journal should not exceed specification.

MAIN BEARING CLEARANCE	0.023 – 0.053 mm
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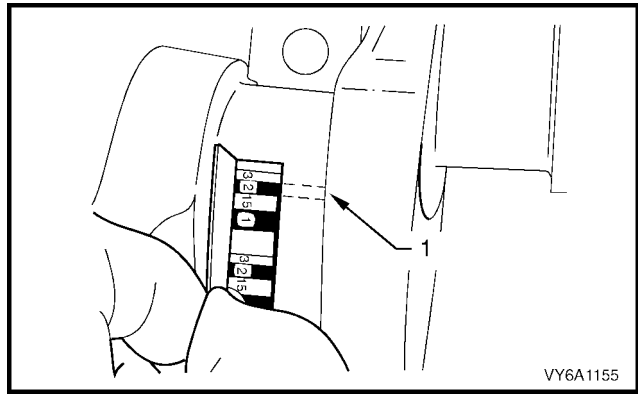


Figure 6A1-1-234

NOTE: This method of checking main bearing clearance does not give any indication of crankshaft journal taper or out-of-round.

To measure taper, undersize or out-of-round, the crankshaft must be removed from the cylinder block, refer to **3.12 CRANKSHAFT** in this Section.

14. If bearing clearance exceeds specification, it is advisable to install new bearing shells and recheck clearance as previously described.

NOTE: If lower bearing shell is a standard size, install a 0.0254 mm undersize shell and recheck clearance.

If clearance is still not to specification, remove crankshaft, and measure crankshaft journals, refer to **3.12 CRANKSHAFT** in this Section.

15. Ensure that main bearing cap bolt threads and cylinder block threads are clean and dry. Then apply some clean engine oil to the cap bolt threads.

NOTE: Before final installation of cap bolts, determine if bolts have stretched by comparing with a new bolt. Replace bolt/s as necessary.

16. With main bearing caps installed, reinstall and tighten cap bolts to the correct torque specification, as detailed in Step 11, above.

17. If the thrust bearing shell is disturbed or replaced, apply engine oil to thrust surfaces.

Also, it is necessary to line up the thrust surfaces of the bearing shells before the cap bolts are tightened.

To do this, move the crankshaft forward and rearward the length of its travel several times (last movement forward), with the thrust bearing cap bolts finger tight.

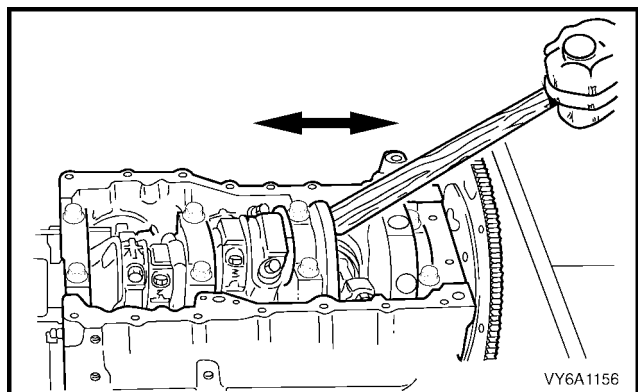


Figure 6A1-1-235

18. Push crankshaft forward and measure crankshaft end float between front of No. 2 main bearing (2) and crankshaft thrust faces with a feeler gauge (1).

CRANKSHAFT END FLOAT SPECIFICATION	0.08 – 0.28 mm
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If clearance is excessive, replace No. 2 main bearing shells, refer to the following replacement procedures.

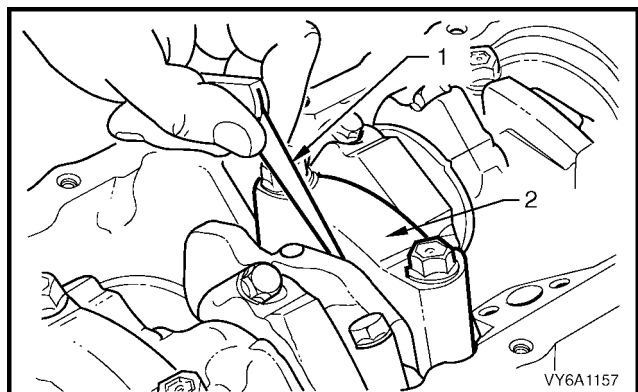


Figure 6A1-1-236

MAIN BEARINGS - REPLACE

The main bearing shells can be replaced with or without the crankshaft installed.

With Crankshaft Installed

1. With engine removed from vehicle refer to **3.1 ENGINE ASSEMBLY** in this Section, mount in a suitable engine stand and invert engine assembly.
2. Remove oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
3. Remove oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
4. Remove spark plugs.
5. Remove main bearing cap bolts and main bearing cap side bolts.

NOTE 1: New main bearing cap side bolts must be used to ensure bolts remain oil tight to cylinder block.

NOTE 2: Main bearing caps are press fit and special care is required when removing the caps. J41348 has been designed to work in conjunction with J6125-B in order to prevent damage to bearing and/or cap. J41348 must be installed correctly into bolt holes of caps and J6125-B attached in order to properly remove main bearing cap without damage to the cap and/or bearing. Deviation from this procedure may cause damage to the cap and/or bearing resulting in engine damage.

- a Install J41348 into main bearing cap bolt holes.
- b Tighten puller bolts to 11 Nm.
- c Install J6125-B to J41348.
- d Using the slide hammer motion of J6125-B remove main bearing cap.
- e Remove bearing shell from bearing cap.

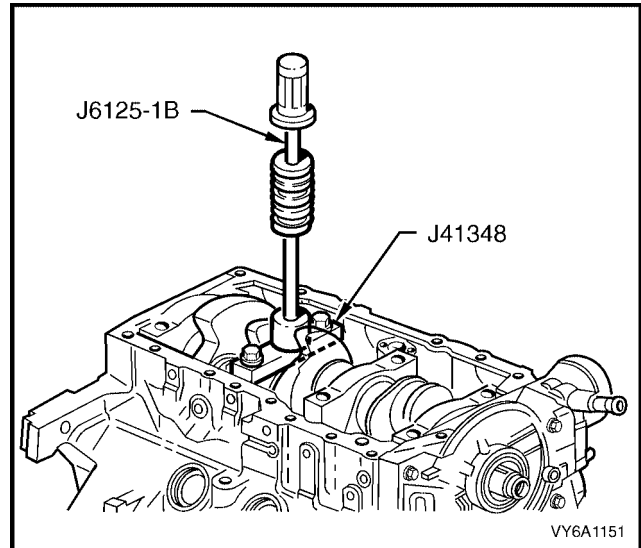


Figure 6A1-1-237

6. Remove upper bearing shell as follows:
 - a. Install Tool No. J8080 in the oil hole of the crankshaft journal.

NOTE: As an alternative to J8080, use a cotter pin.
 - b. Rotate crankshaft anti-clockwise as viewed from front of engine. This will roll upper shell (1) out of cylinder block. Remove Tool No. J8080 (or cotter pin).
7. Thoroughly clean crankshaft journal, cylinder block bearing seat and bearing cap.
8. Lubricate new selected upper bearing.

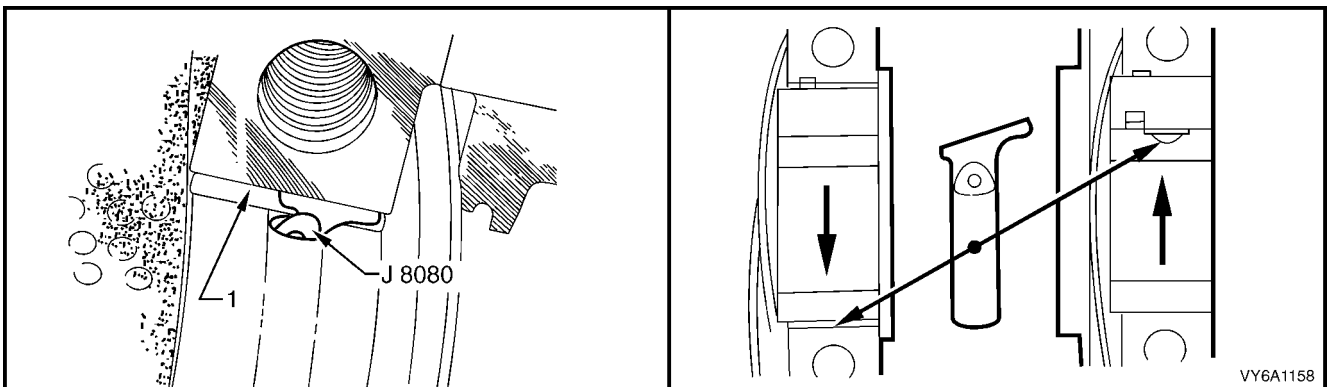


Figure 6A1-1-238

9. Insert plain end of shell between crankshaft journal and notched side (1) of the cylinder block.

NOTE: Ensure that the correct bearing shell is fitted between the crankshaft journal and cylinder block (refer to Figures 6A1-1-231/232 for bearing shell identification details).

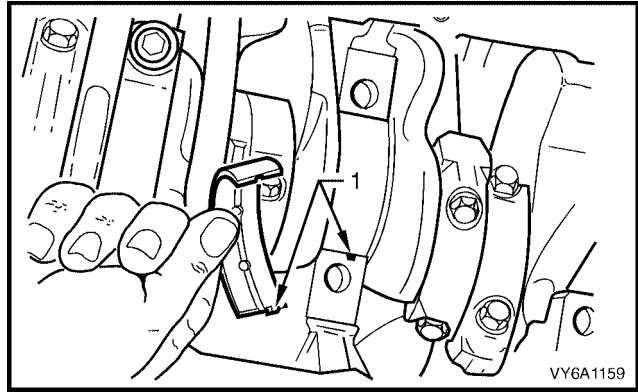


Figure 6A1-1-239

10. Rotate bearing shell into place using crankshaft and J8080 (or cotter pin).

11. Remove J8080 (or cotter pin) from crankshaft.

12. Check bearing to crankshaft clearance with Plastigage as outlined in **MAIN BEARINGS - INSPECT** in this Section.

13. Lubricate journal and bearing shells with engine oil.

NOTE: If replacing No. 2 main bearing shells, lubricate thrust surfaces with engine oil.

14. Ensure that main bearing cap bolt threads and cylinder block threads are clean and dry, then apply some clean engine oil to the cap bolt threads.

15. Reinstall bearing cap and tighten all bearing cap bolts to the correct torque specification.

NOTE: Ensure that each bearing cap is installed into the crankcase in the correct order (2), orientation (1) and is parallel to bottom of channel.

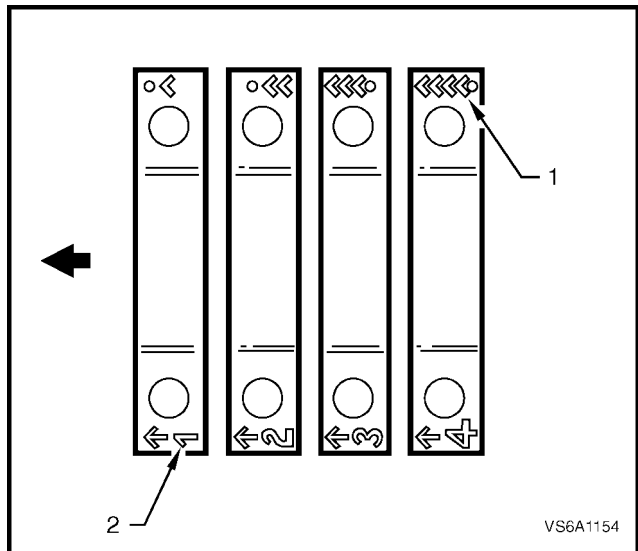


Figure 6A1-1-240

16. Before final installation of cap bolts, determine if bolts have stretched by comparing with a new bolt. Replace bolt/s as necessary.

Reinstall main bearing caps, hand start main bearing cap bolts, on each bearing cap in turn, tighten cap bolts half a turn at a time to carefully seat cap.

Hand start main bearing cap side bolts.

Due to the thrust bearing shells being disturbed, it is necessary to line up the thrust surfaces of the bearing shells before the cap bolts are tightened. To do this, move the crankshaft fore and aft the length of its travel several times (last movement forward).

NOTE 1: Do not tighten one cap completely at a time but progressively tighten all four caps to each stage of the following tightening procedure, before moving to next stage of torque.

NOTE 2: New main bearing cap side bolts must be used to ensure bolts remain oil tight to cylinder block.

NOTE 3: Use an angle wrench such as E7115 to ensure accurate turn angle.

MAIN BEARING CAP BOLT TORQUE SPECIFICATION PROCEDURE	
TO FULLY SEAT EACH CAP, TIGHTEN TO	70 Nm, then Loosen All 360°.
RE-TIGHTEN EACH BOLT TO	20 Nm, then 40 Nm. Finally,
TURN EACH CAP BOLT THROUGH	35°, three times (= 105° Total).
TIGHTEN EACH BEARING CAP SIDE BOLT	15 Nm, then turn through 45°

17. If the thrust bearing shell is disturbed or replaced, it is necessary to line up the thrust surfaces of the bearing shells before the cap bolts are tightened. To do this, move the crankshaft fore and aft the length of its travel several times (last movement forward) with the thrust bearing cap bolts finger tight.

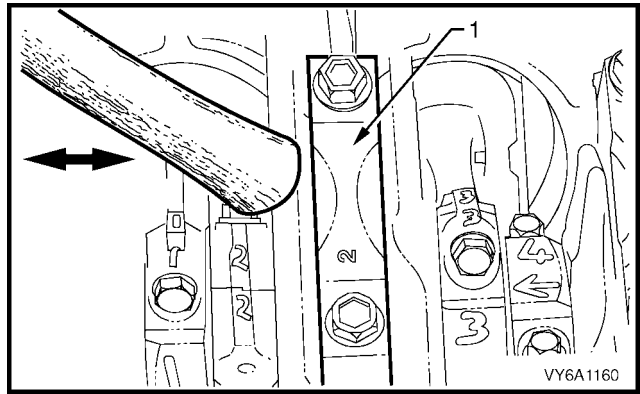


Figure 6A1-1-241

With Crankshaft Removed

1. With the crankshaft removed, remove all bearing shells from cylinder block and bearing caps.
2. Thoroughly clean crankshaft journals, bearing caps and cylinder block bearing shell seats.
3. Install new bearing upper shells in cylinder block, ensuring notches in bearing shells align with recesses in cylinder block (1).

NOTE: Ensure the correct bearing shells are fitted into the appropriate cylinder block bearing seat (refer to Figures 6A1-1-230/231 in this Section for bearing shell identification details).

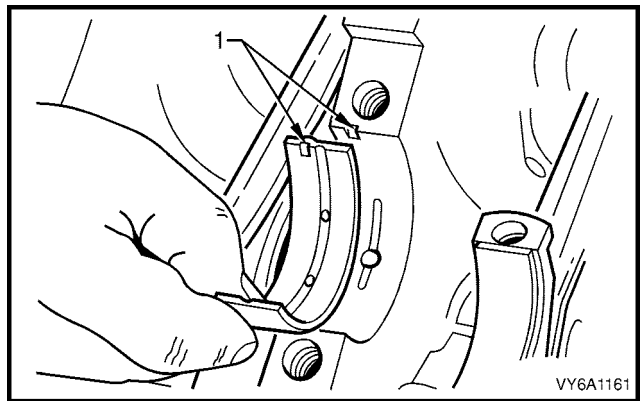


Figure 6A1-1-242

4. Lubricate No. 2 main bearing shell thrust surfaces with engine oil.
5. Lay crankshaft in upper bearing shells, taking care not to damage crankshaft thrust flange and No. 2 main bearing thrust faces. Also take care not to contact connecting rod journals with connecting rods.
6. Install lower bearing shells in bearing caps, ensuring the notches in the shells align with the recesses in the caps and the correct bearing shell is installed in the appropriate cap.
7. Measure bearing to crankshaft clearances as outlined in **MAIN BEARINGS** in this Section.

NOTE: Ensure that bearing cap is installed into the cylinder block in the correct order (2) and orientation (1).

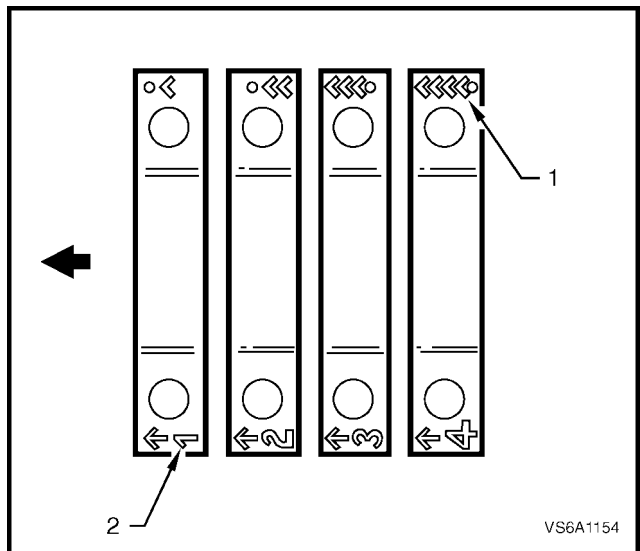


Figure 6A1-1-243

8. If clearances are satisfactory, continue reassembly of crankshaft, refer to **3.12 CRANKSHAFT** in this Section.

CONNECTING ROD BEARINGS - INSPECT AND REPLACE

Connecting rod bearings can be replaced without removing the rod and piston assembly from the engine.

1. With engine removed from vehicle refer to **3.1 ENGINE ASSEMBLY** in this Section, mount in a suitable engine stand and invert engine assembly.
2. Remove oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
3. Remove oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
4. Remove spark plugs.
5. Mark connecting rods and caps with an etching marker or felt tipped pen to indicate cylinder number (1) and orientation (2) of cap.

NOTE: Marking cap orientation is most important as there re no other identifying marks on the connecting rod.

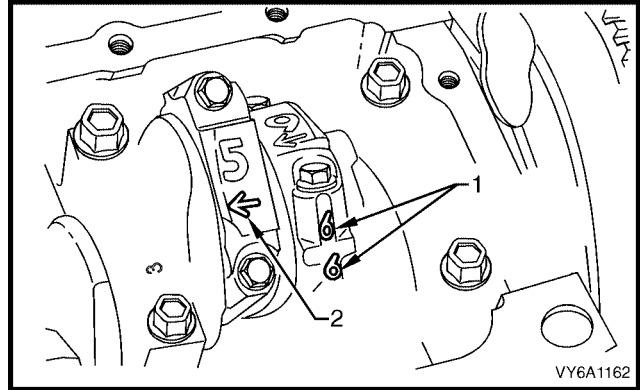


Figure 6A1-1-244

6. Remove connecting rod cap securing bolts and remove cap and lower bearing shell (1).
7. Push piston and connecting rod up cylinder bore, so that connecting rod is free from crankshaft journal. Remove bearing shell from connecting rod.

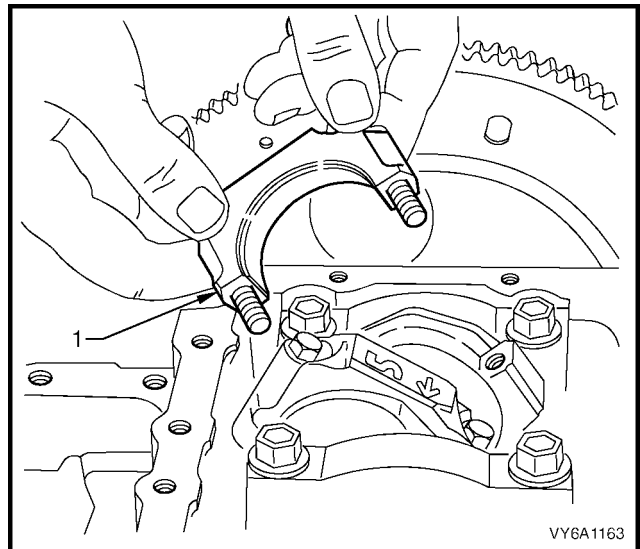


Figure 6A1-1-245

8. Clean crankshaft journal (2) and measure for out-of-round or taper, using a micrometer (1).
If not to specification, replace crankshaft, refer to **3.12 CRANKSHAFT** in this Section.

CRANKSHAFT CONNECTING ROD BEARING JOURNAL DIAMETER	57.117 – 57.147 mm
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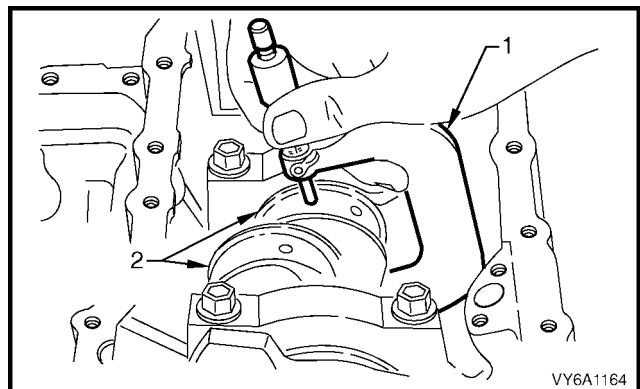


Figure 6A1-1-246

9. Wipe oil from both inner and outer surfaces of bearing shells.

10. Check inner surface of bearing shells for wear, gouges or embedded foreign material.

If foreign material is found, determine its nature and source.

Inspect outer surface of bearing shell for surface wear (indicates movement of shell or high spot in surrounding material), overheating (discolouration) or looseness or rotation (flattened tangs and wear grooves).

If uneven side to side wear is found, the crankshaft may be bent or have tapered bearing journals. If necessary, remove crankshaft, refer to **3.12 CRANKSHAFT - REMOVE** in this Section and check crankshaft for bend or journal taper.

IMPORTANT: Bearing failure, other than normal wear, must be investigated carefully. With crankshaft removed, inspect all connecting rod and crankshaft bearing bores.

To inspect the bearing bores:

- a. Install bearing caps without bearing shells installed. Tighten cap bolts to the specified torque.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
--	-------------------------------

- b. Measure bearing bores for taper and out-of-round.

Replace any component if not to specification, refer to the relevant component description in this Section.

CONNECTING ROD BEARING BORE	
DIAMETER	60.295 – 60.312 mm
MAXIMUM OUT-OF-ROUND	0.008 mm
MAXIMUM TAPER	0.008 mm

11. If inspection reveals that crankshaft is OK, reinstall bearing shells in original positions in connecting rod and cap.

12. Pull connecting rod onto crankshaft so that upper bearing is seated against crankshaft journal.

13. Place a piece of Plastigage (1) across width of bearing journal, parallel to crankshaft centreline.

NOTE: Ensure Plastigage is not placed across oil hole in journal.

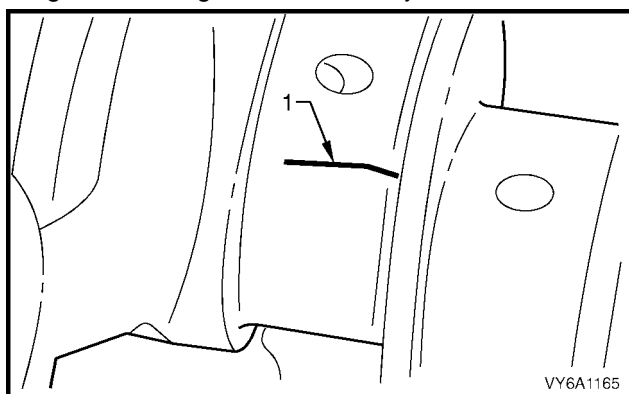


Figure 6A1-1-247

14. Reinstall connecting rod cap in original position as noted in step 5. Tighten bolts to the correct torque specification.

NOTE: Ensure that crankshaft does not turn with Plastigage installed.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
--	-------------------------------

NOTE: Use an angle wrench such as E7115 to ensure accurate turn angle.

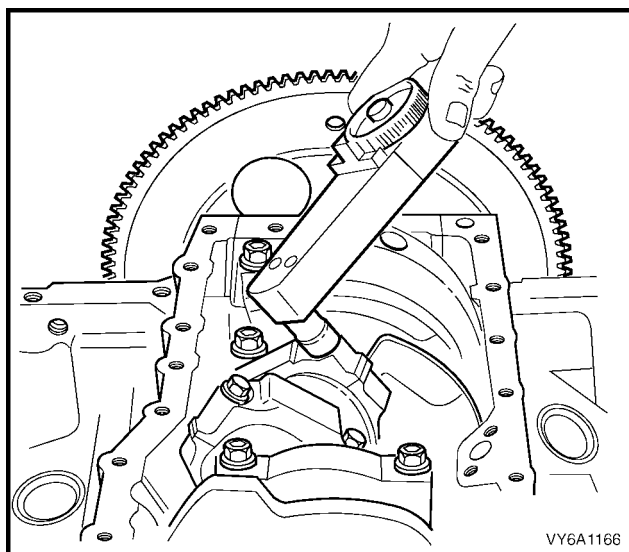


Figure 6A1-1-248

15. Remove connecting rod cap bolts, remove cap. Look for flattened Plastigage adhering to either crankshaft or bearing shell in cap.
16. Determine bearing clearance by comparing width of flattened Plastigage (1) at widest point with graduation on Plastigage packaging. The number within the graduation on the envelope indicates the clearance.

Clearance between connecting rod bearings and crankshaft should not exceed specification.

NOTE: If a bearing is being fitted to an out-of-round journal, be sure to fit Plastigage to the maximum diameter of the journal. If the bearing is fitted to the minimum diameter, and the journal is out-of-round 0.008 mm, interference between the bearing and journal will result in rapid bearing failure.

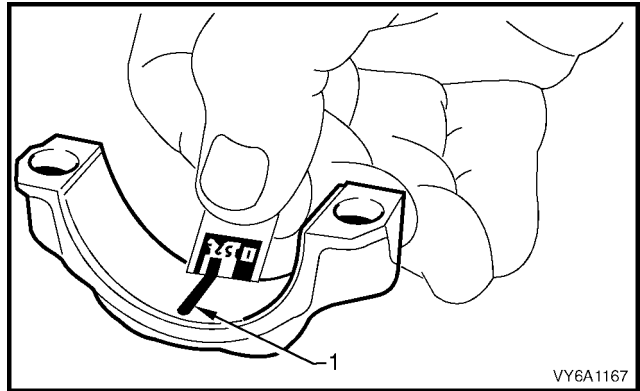


Figure 6A1-1-249

CONNECTING ROD BEARING CLEARANCE	0.023 – 0.053 mm
----------------------------------	------------------

17. Ensure that connecting rod cap bolt threads and connecting rod threads are clean and dry. Apply some engine oil to the cap bolt threads.

NOTE: Before final installation of cap bolts, determine if bolts have stretched by comparing with a new bolt. Replace bolt/s as necessary.

18. Install bearing shells in connecting rod and cap, ensuring notches in shells match up with recesses in connecting rod and cap.

Check clearance of new bearing with Plastigage as previously described.

19. Remove all traces of Plastigage after measuring.
20. Lubricate bearing shells and journal with clean engine oil. Reinstall connecting rod cap in original position as noted in step 5. Tighten bolts and then loosen one full turn. Finally tighten cap bolts to the correct torque specification.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
--	----------------------------

NOTE: Use an angle wrench such as E7115 to ensure accurate turn angle.

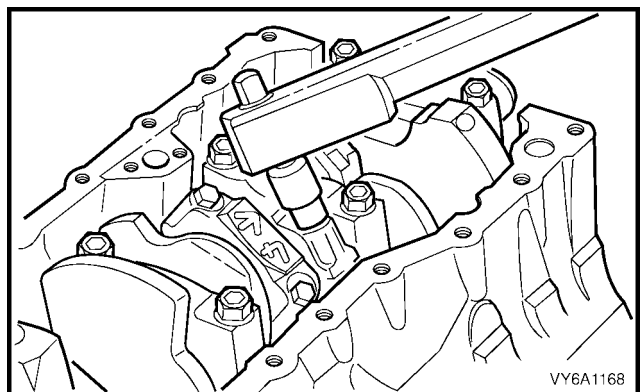


Figure 6A1-1-250

21. With bearing shells installed and cap bolts tightened, it should be possible to move connecting rod back and forth on crankshaft journal as allowed by end clearance. Also, the crankshaft should rotate without binding.

If connecting rod binds on crankshaft journal, loosen and re-tighten bearing cap bolts.

If rod still cannot be moved or crankshaft binds, check bearing cap to rod orientation, bearing clearance or connecting rod alignment.

22. Measure clearance between connecting rods and crankshaft journal flanges with a feeler gauge.

CONNECTING ROD SIDE CLEARANCE	0.10 – 0.50 mm
-------------------------------	----------------

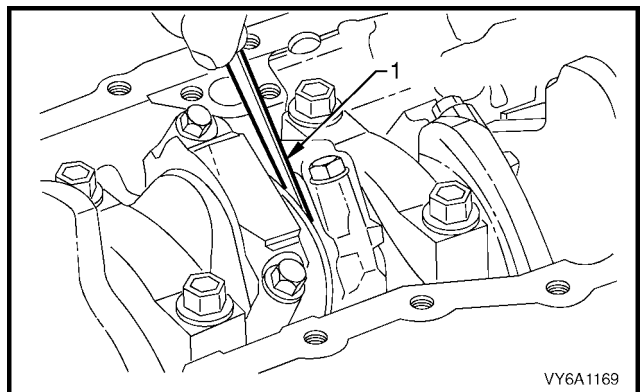


Figure 6A1-1-251

23. Reinstall oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
24. Reinstall oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
25. Reinstall rear main oil seal, refer to **3.13 REAR MAIN OIL SEAL** in this Section.
26. Reinstall spark plugs and tighten to the correct torque specification.

SPARK PLUG TORQUE SPECIFICATION	25 Nm
------------------------------------	-------

27. Refill oil pan with the correct amount of engine oil, refer to **Section 0B LUBRICATION** in the MY 2003 VY and V2 Series Service Information.
28. Reinstall engine assembly. Start engine and check for oil leaks. Repair as necessary.
29. Check engine oil pressure, refer to **2.2 CHECKING ENGINE OIL PRESSURE** in this Section.

3.8 CAMSHAFT BEARINGS

REPLACE

Care must be exercised during bearing removal and installation, not to damage bearings that are not being replaced.

The following operations involve the use of Tool No. AU384-B and finished sized camshaft bearings. If installing unfinished sized bearings, installation must be carried out by a specialist machine shop and then line bored to correct final size.

1. With engine removed from vehicle, refer to **3.1 ENGINE ASSEMBLY** in this Section and mounted in a suitable stand, remove camshaft, refer to **2.24 CAMSHAFT** in this Section.

Inspect camshaft and lifters for contact damage.

2. Remove crankshaft, refer to **3.12 CRANKSHAFT** in this Section.

3. For all camshaft bearings except No. 1, install;

- a. The forcing nut onto the threaded length of Tool No. AU384-1, followed by the flat washer.
- b. Slide the aligning adaptor, Tool No. AU384-2 over the threaded length of AU384-1.
- c. Working from the front of the engine, install Tool No. AU384-7 into the bearing to be removed, then thread Tool No. AU384-1 into AU384-7 until the thread is fully installed into AU384-7.

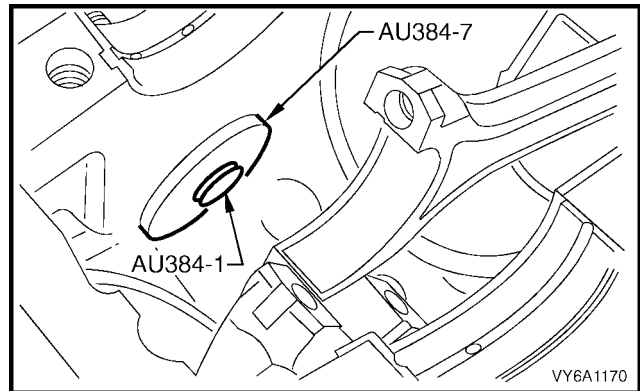


Figure 6A1-1-252

- d. Locate the flanged portion of the aligning adaptor, AU384-2 into the front bearing bore, then tighten nut on the forcing screw of AU384-1, while holding the end of the forcing screw with a suitable spanner and pull bearing from bore.

NOTE: The washer, nut and forcing screw, all form part of AU384-1.

4. For the front camshaft bearing;
 - a. Remove the forcing screw from AU384-7, then remove aligning adaptor AU384-2.
 - b. Install receiving sleeve AU384-6A onto the forcing screw of AU 384-1.

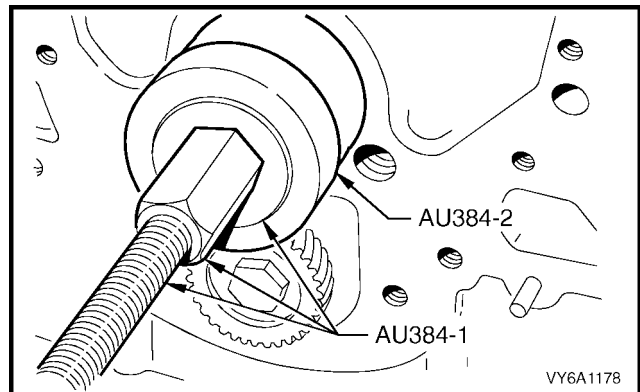


Figure 6A1-1-253

Tighten the nut on the forcing screw AU384-1, while holding the end with a suitable spanner and pull the bearing from its bore and into the receiving sleeve, AU384-6A.

5. With bearing released from its bore, disassemble remover tool, remove the bearing and discard.

NOTE: To install Tool No. AU384-7 to remove camshaft bearing number 2, turn the tool 90° to the normal attitude. Then, when installed to the space adjacent to the lower end of the cylinders, rotate the tool back and install into the bearing. Proceed as detailed in step 3 above.

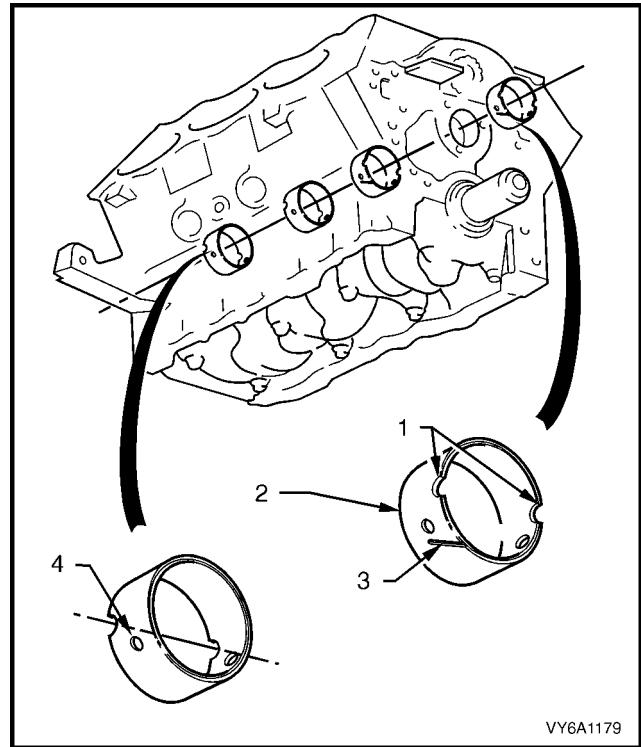
6. Install new bearing onto AU384-7 and install into cylinder block, aligning oil hole/s in bearing with holes in cylinder block.

NOTE 1: The new bearing is a loose fit on Tool No. AU384-7. As the bearing is installed into its bore, the bearing will be reduced to the correct installed size by the interference fit. The bearing must be installed with the notches (1) in the horizontal position as shown, to ensure correct oil gallery alignment with the bearing oil feed holes (4).

NOTE 2: The camshaft bearings (2) for journals 1 and 4 are a common pair, with 2 and 3 also being common.

NOTE 3: The bearings for journals 1 and 4 are identified by having an oil feed slot (3) on the outer surface.

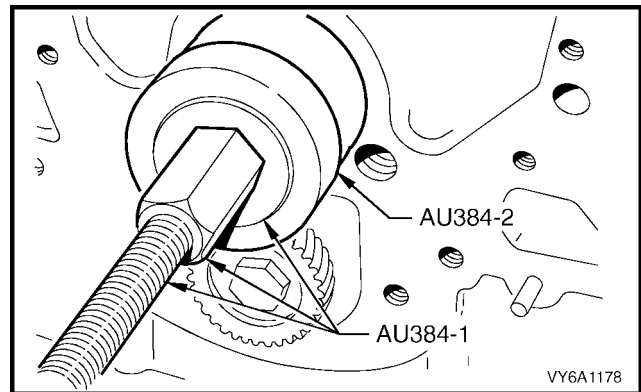
NOTE 4: Ensure that when installing No. 1 camshaft bearing, the oil feed slot (3) faces the front of the engine, as shown.



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Figure 6A1-1-254

7. Working from the front of the engine, for camshaft bearings 2 to 4, first install the aligning sleeve, Tool No. AU384-2 onto the forcing screw, AU384-1 after installing the forcing nut and flat washer.
8. Feed the screw through the camshaft bearing bores, taking care not to damage any installed bearing/s in the process. Thread the screw of AU384-1 into the adaptor AU384-7 until full thread depth is reached.
9. Tighten nut of AU384-1 until bearing is installed into the correct position.



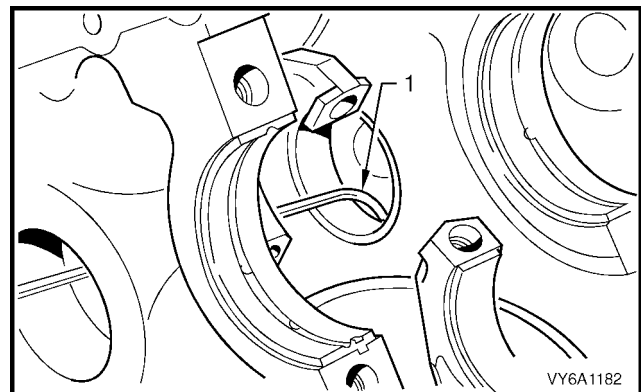
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Figure 6A1-1-255

NOTE: It may be necessary to hold the end of the forcing screw with a suitable spanner during the installation process.

10. For the front camshaft bearing, remove the aligning sleeve, AU384-2 and replace with the receiving sleeve AU384-6A, Then proceed as described in steps 7 to 9.
11. With a piece of 2.4 mm diameter brass rod (1) with a 90° bend at the end, probe the camshaft bearing oil holes to verify that they are properly aligned with oil feed holes in cylinder block.

IMPORTANT: Proper alignment of the oil holes is critical. Restriction of the oil flow will cause severe engine damage.



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Figure 6A1-1-256

12. Lubricate camshaft bearings and journals with clean engine oil. Temporarily install camshaft. Ensure camshaft rotates without binding.

If camshaft binds, remove camshaft, inspect bearings for high spots or incorrect installation. Remove any burrs if present. Check camshaft journal to bearing clearance.

If camshaft bearing journals are not within specification, replace camshaft.

CAMSHAFT SPECIFICATIONS	
JOURNAL DIAMETER	46.858 - 46.893 mm
BEARING DIAMETER (INSTALLED)	
NUMBERS 1 AND 4	46.934 – 46.970 mm
NUMBERS 2 AND 3	46.942 – 46.977 mm
BEARING TO JOURNAL CLEARANCE	0.041 – 0.119 mm

13. Reinstall camshaft and valve train components, refer to [2.24 CAMSHAFT](#) in this Section.

3.9 BALANCE SHAFT AND BEARINGS

REMOVE

1. With the engine removed from the vehicle, refer to **3.1 ENGINE ASSEMBLY** in this Section, mount it in a suitable engine stand.
2. Remove lower Intake manifold, refer to **2.11 LOWER INTAKE MANIFOLD** in this Section.
3. Remove front cover, refer to **2.21 FRONT COVER AND GASKET** in this Section.
4. Remove rear main oil seal and housing, refer to **3.13 REAR MAIN OIL SEAL** in this Section.
5. Remove timing chain, sprockets and camshaft gear, refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section.
6. Remove balance shaft retainer attaching bolts (1), remove retainer (2).

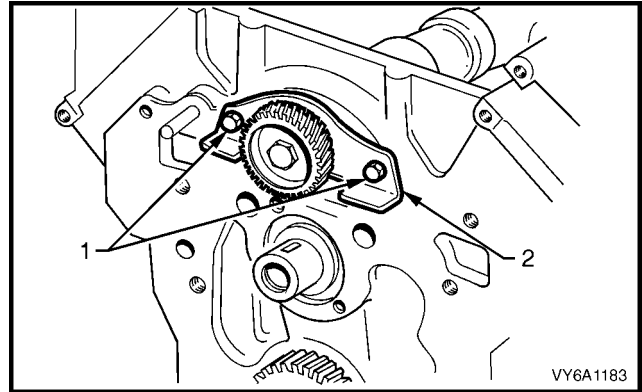


Figure 6A1-1-257

7. Using two screwdrivers, positioned behind balance shaft driven gear (1), lever balance shaft out, until the front bearing area is free from its bore.

NOTE 1: Ensure that screwdrivers lever behind the step on the gear, behind the gear teeth. Do not lever against the gear teeth.

NOTE 2: If the balance shaft cannot be removed from cylinder block using this method, remove driven gear retaining bolt and gear. Install slide hammer, Tool No. AU354, into balance shaft gear bolt hole and remove balance shaft.

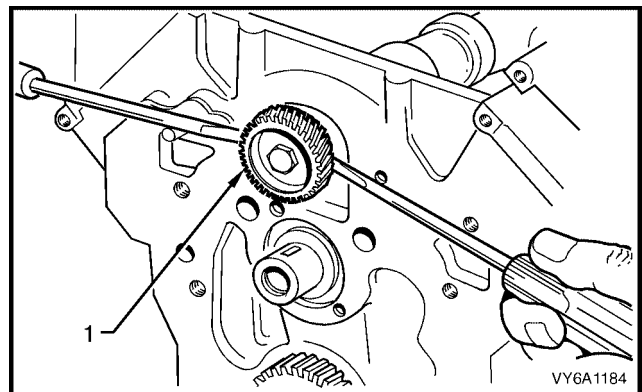


Figure 6A1-1-258

8. Remove balance shaft from cylinder block.
9. Remove balance shaft driven gear, refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section.
10. Install receiving adaptor AU384-6A onto the forcing screw AU384-1, after installing the forcing nut and flat washer.
11. Working from the front of the engine, feed the screw of AU384-1 through the front bearing aperture, then thread into the adaptor AU384-4, previously installed into the rear bearing.

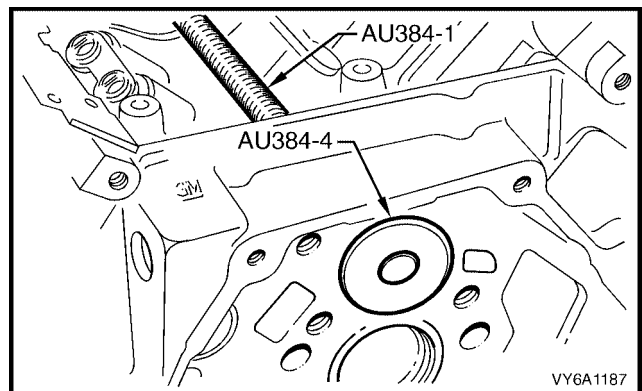


Figure 6A1-1-259

- With the receiving adaptor AU384-6A located in the machined recess at the front of the engine, tighten the forcing nut of AU384-1 to remove the balance shaft rear bearing.

NOTE: It may be necessary to hold the hexagonal end of the forcing screw AU384-1 with a suitable spanner, during this procedure.

- With bearing released from its bore, disassemble remover tools and discard the removed bearing.

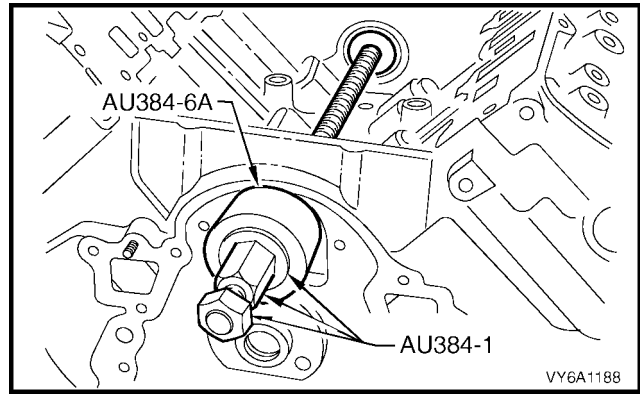


Figure 6A1-1-260

REINSTALL

- Dip new rear bearing in clean engine oil.
- Install new rear bearing onto AU384-4 and offer up to the bearing bore.
- Pre-assemble receiving adaptor AU384-6A onto the forcing screw of AU384-1 (refer Figure 6A1-1-261), then thread into adaptor AU384-4.
- Tighten nut to draw bearing into bore. Continue to tighten the nut of AU384-1, until the flange of AU384-4 is flush with the rear of the engine block.
- Remove bearing installation tools and check that bearing (1) is installed to the specified depth from the rear of the cylinder block (2).

BALANCE SHAFT REAR BEARING INSTALLED DEPTH SPECIFICATION	0.99 – 1.49 mm
--	----------------

NOTE: The bearing depth is important, as lubrication feed must align with the groove around the bearing.

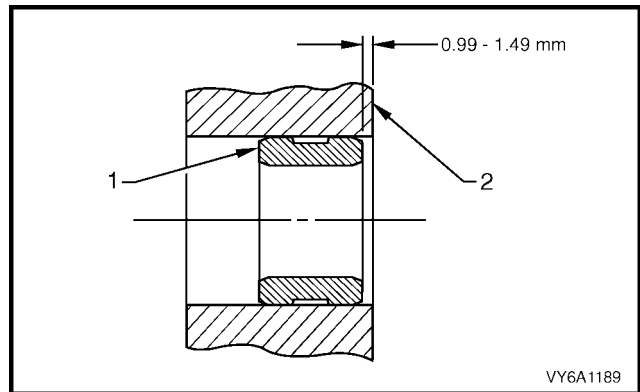


Figure 6A1-1-261

- Check balance shaft (1) rear bush clearance specification by measuring the rear balance shaft journal diameter using a micrometer and comparing that dimension to the measured inside diameter of the installed bearing.

Subtracting the journal measurement from that of the bearing will provide the oil clearance.

REAR BUSH CLEARANCE SPECIFICATION	0.012 – 0.109 mm
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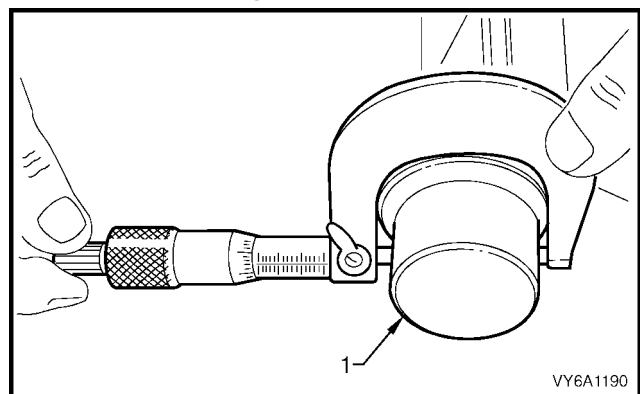


Figure 6A1-1-262

7. Lubricate balance shaft front and rear bearings and rear bearing journal with clean engine oil.
8. Reinstall balance shaft driven gear (refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section).
9. Reinstall balance shaft into bearing bores. Using a brass drift (2) and a soft faced hammer, lightly tap on balance shaft front bearing outer race (1) until front bearing is fully installed in bore (bearing outer snap ring seated against cylinder block).

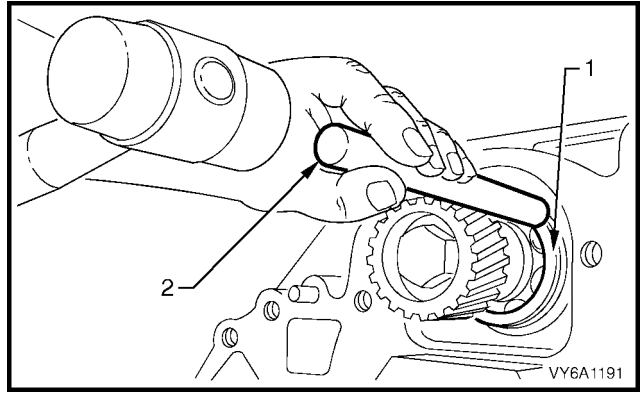


Figure 6A1-1-263

10. Install balance shaft retainer and attaching bolts (1).
Tighten retainer attaching bolts to the correct torque specification.

BALANCE SHAFT RETAINER ATTACHING BOLT TORQUE SPECIFICATION	30 Nm
--	-------

11. Rotate balance shaft (3) by hand and ensure that it spins freely.
12. Reinstall sprocket key to front end of camshaft.
Reinstall balance shaft drive gear (2) to camshaft, aligning sprocket key with gear slot and ensuring that timing marks (4) on each of the balance shaft gears face together.
It may be necessary to rotate balance shaft slightly to ensure that balance shaft timing marks align.

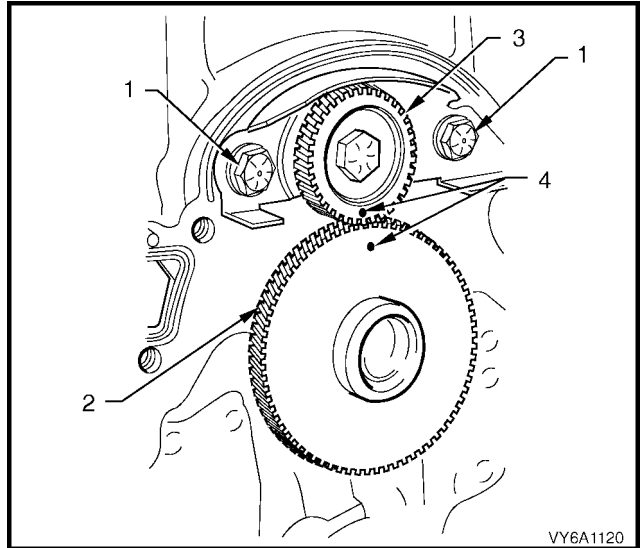


Figure 6A1-1-264

13. With balance shaft installed, carry out the following balance shaft checks.
 - a. Measure balance shaft end play, using a dial indicator, set up as shown.

BALANCE SHAFT END PLAY SPECIFICATION	0 – 0.171 mm
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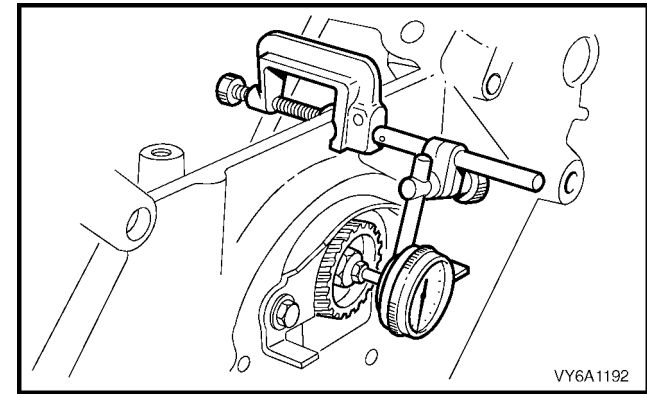


Figure 6A1-1-265

- b. Measure balance shaft front bearing, radial play.

FRONT BEARING RADIAL PLAY	0 – 0.026 mm
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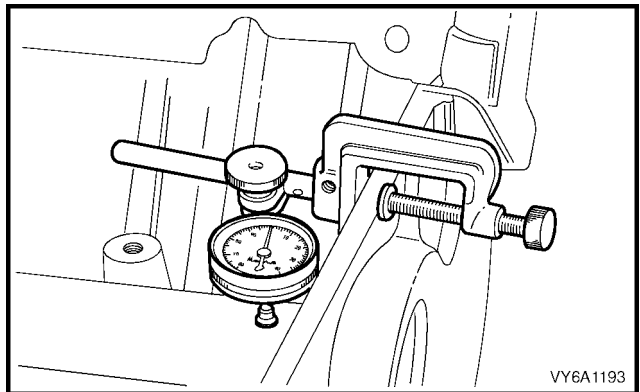


Figure 6A1-1-266

14. Carry out the following procedure to measure balance shaft drive gear lash:

a. Measure balance shaft gear lash at four locations (every 1/4 turn).

BALANCE SHAFT GEAR LASH TORQUE SPECIFICATION	0.050 – 0.125 mm
---	------------------

b. If gear lash exceeds specifications, replace drive gears.

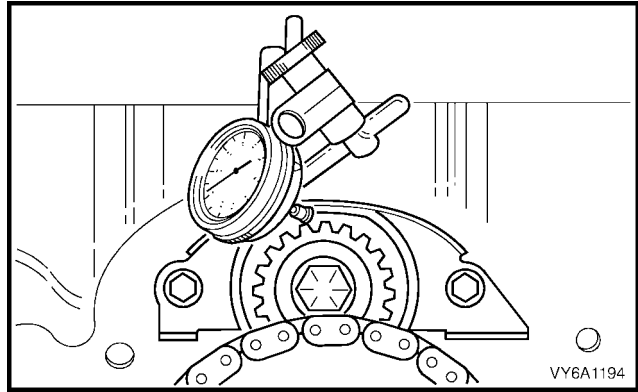


Figure 6A1-1-267

15. Reinstall balance shaft drive gear, timing chain and camshaft sprocket, refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section.

16. Reinstall lower Intake manifold, refer to **2.11 LOWER INTAKE MANIFOLD** in this Section.

17. Reinstall front cover, refer to **2.21 FRONT COVER AND GASKET** in this Section.

18. Reinstall rear main oil seal and housing, refer to **3.13 REAR MAIN OIL SEAL** in this Section.

19. Start engine and check for oil, fuel or coolant leaks. Repair as necessary.

3.10 PISTON AND CONNECTING ROD ASSEMBLY

The piston and connecting rod assemblies can be removed without the engine being removed.

If the cylinder bore requires machining, remove the engine assembly, refer to **3.1 ENGINE ASSEMBLY** in this Section, and remove piston and connecting rod assemblies.

Piston and pin assemblies/piston ring sets are available in std. and 0.508 mm oversizes.

When fitting pistons, both piston and cylinder bore condition must be considered together. Production and service pistons have the same nominal weight and can be intermixed without affecting engine balance. If necessary, used pistons may be fitted selectively to any cylinder of the engine, providing they are in good condition.

NOTE: Do not machine oversize pistons down or engine balance will be affected.

REMOVE

1. Disconnect battery earth lead.
2. Remove cylinder heads, refer to **2.16 CYLINDER HEADS** in this Section.
3. Remove oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
4. Remove oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
5. Examine cylinder bores above piston ring travel. If bores are worn so that a shoulder or ridge exists, remove using a ridge remover.

IMPORTANT: For each cylinder, rotate crankshaft so that piston is at bottom of stroke and cover piston with a cloth to collect cuttings.

6. Mark all pistons and connecting rods caps with an etching marker or felt tipped pen to indicate cylinder numbering and orientation.

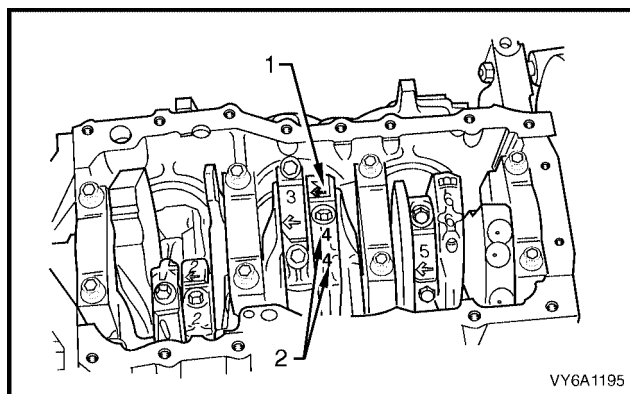


Figure 6A1-1-268

7. Remove piston and rod assemblies as follows:
 - a. With connecting rod crankshaft journal at bottom of its travel (Bottom Dead Centre), remove connecting rod cap bolts and remove cap with bearing shell (1).

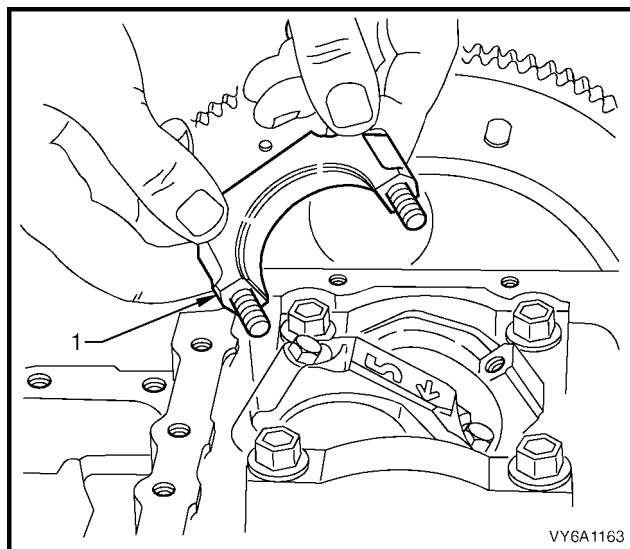


Figure 6A1-1-269

- b. Install the 'short' connecting rod guide tool AU388-2, into connecting rod inner bolt hole.
- c. Install 'long' connecting rod guide AU388-1, into opposite bolt hole.
Turn guides down fully to hold upper bearing shell in place.
- d. Using a hammer handle, push on long guide to remove piston and connecting rod from cylinder. Remove guides and reinstall cap and bolts to connecting rod.

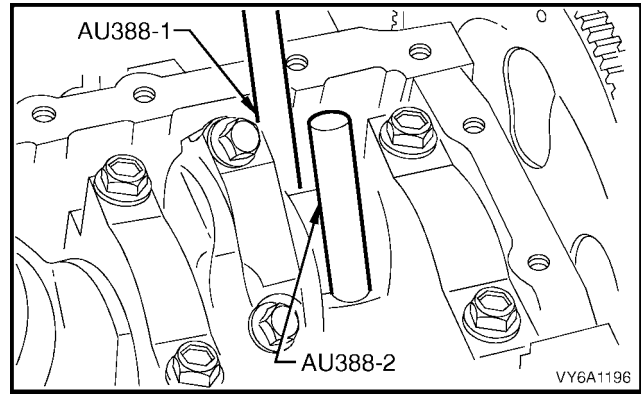


Figure 6A1-1-270

8. Remove all other piston and connecting rod assemblies in the same manner.

DISASSEMBLE

1. Remove piston rings by expanding them and sliding them off pistons, and then discarding.

NOTE: Take care when removing piston rings as worn rings may have sharp edges.

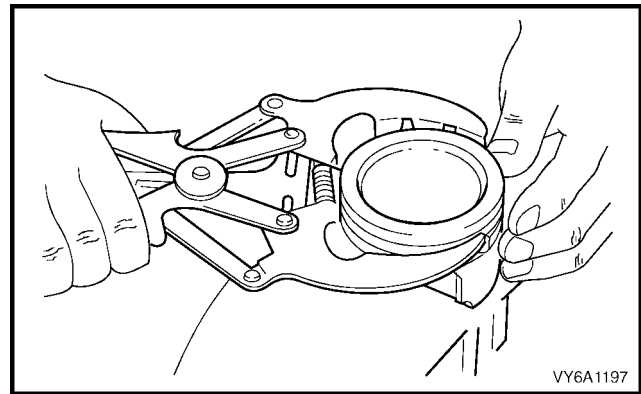


Figure 6A1-1-271

2. Remove two piston pin retainers (2).

NOTE: Piston pin retainers may be reused if not damaged.

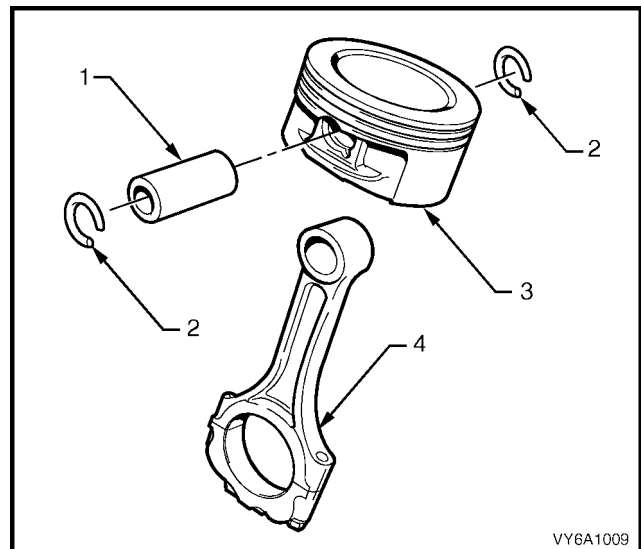


Figure 6A1-1-272

INSPECT

1. Inspect cylinder walls for scoring, roughness, or ridges which indicate excessive wear. Check cylinder bores for taper and out-of-round with an accurate cylinder gauge at top, middle and bottom of bore, both parallel and at right angles to centreline of engine. Refer to **3.15 CYLINDER BLOCK** in this Section.
2. Clean carbon from piston heads. Clean carbon from ring grooves with suitable tool or a piece of piston ring and remove any gum or varnish from piston skirts with suitable cleaning solvent.

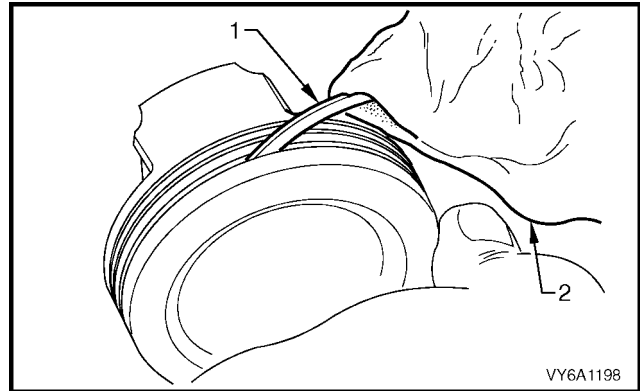


Figure 6A1-1-273

3. Carefully examine piston skirt for rough or scored surfaces, cracks in skirt or crown, broken ring lands, chipping or uneven wear which would cause rings to seat improperly or have excessive clearance in ring grooves. Damaged or faulty pistons should be replaced.

The pistons are cam ground, which means that the diameter at right angles to the piston pin is greater than the diameter parallel to the piston pin. When a piston is checked for size, it must be done at a point 90° to the piston pin bore, 41 mm from top of piston.

PISTON SIZE SPECIFICATIONS	
STANDARD	96.482 - 96.497 mm
AVAILABLE OVERSIZE	0.508 mm

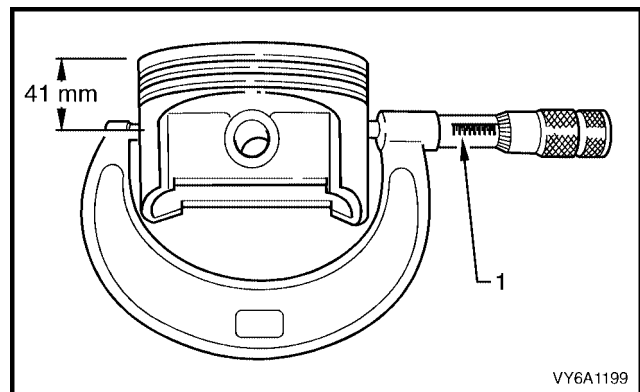


Figure 6A1-1-274

4. Inspect piston pin bores and piston pins/bushes for wear. Piston pin bores and piston pins must be free of varnish or scuffing when being measured. The piston pin should be measured with a micrometer and piston pin bore should be measured with a dial bore gauge or an inside micrometer. If clearance is not to specification, piston and pin should be replaced.

If piston pin bush requires replacement remove and install using suitable press and plates. Honing of the bush prior to pin installation may be necessary.

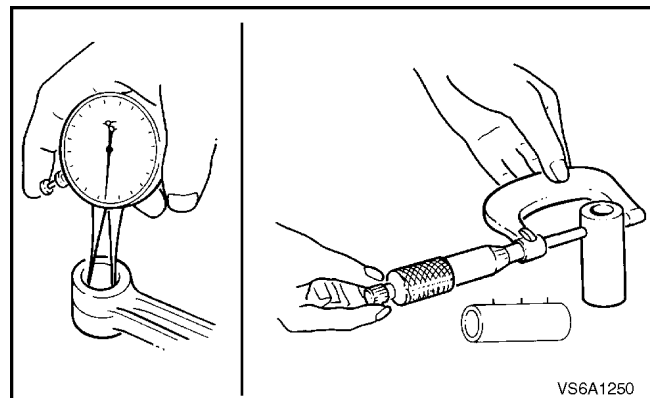


Figure 6A1-1-275

PISTON PIN SPECIFICATIONS

DIAMETER	21.995 – 22.000 mm
CLEARANCE IN PISTON	0.002 – 0.013 mm
CLEARANCE IN CONNECTING ROD	0.007 – 0.022 mm

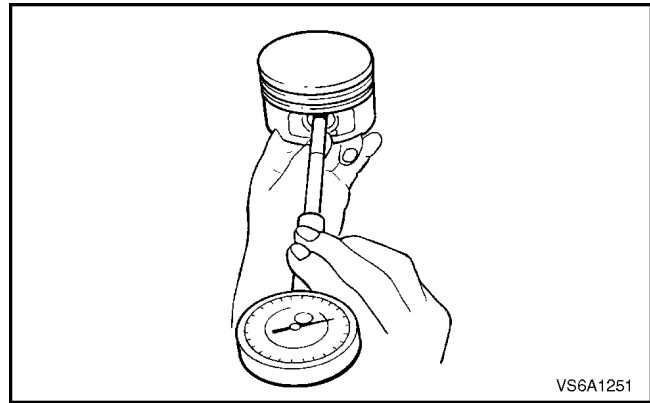


Figure 6A1-1-276

- Remove bearing shells from connecting rod, install cap and bolts. Tighten bolts to the correct torque specification.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
--	-------------------------------

- Place connecting rod assembly on a checking fixture and check rod for bend or twist.
Do not attempt to straighten rod if bent or twisted, replace it.
Check new connecting rods in the same manner before using them.

CONNECTING ROD ALIGNMENT SPECIFICATIONS

BEND	0.020 mm per 25.4 mm
TWIST	0.038 mm per 25.4 mm

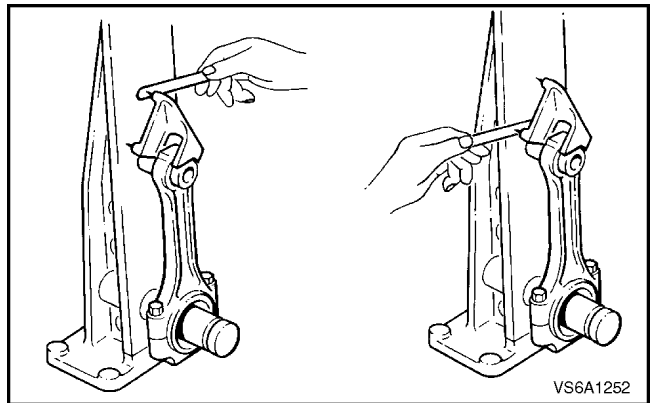


Figure 6A1-1-277

- Inspect outside of connecting rod bearing shells and internal diameter of connecting rod big end for wear indicating high spots in rod big end.
- Remove cap bolts and check bolts for stretching by comparing them with a new bolt.
Replace bolt/s if stretched.

REASSEMBLE AND REINSTALL

NOTE: The connecting rod can be assembled to the piston either way. Therefore the orientation and marking, detailed in Step 6 of the Remove procedure of **3.10 PISTON AND CONNECTING ROD ASSEMBLY**, is critical to the correct reassembly process.

As a guide, the connecting rod bearing locating notches in each half should be assembled on the same sides to each other and face the right hand bank of cylinders.

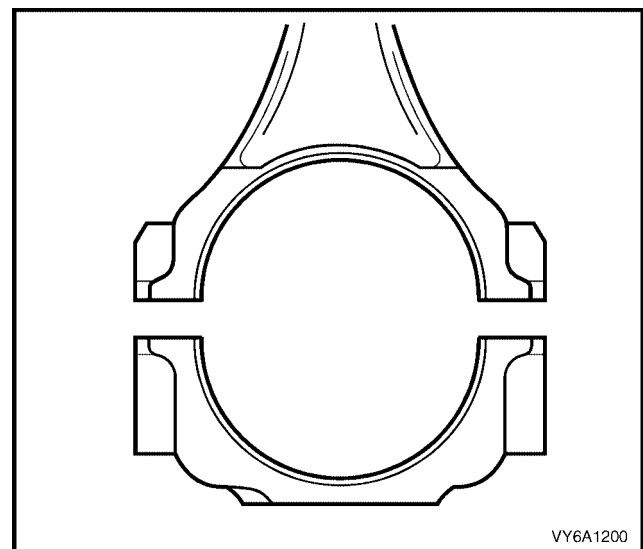


Figure 6A1-1-278

1. Lubricate piston pin bore and piston pin (3) with engine oil.
2. Install one piston pin retainer (2) by starting one side of retainer in retaining groove (1) and rotating retainer until fully seated in groove.
3. Push the piston pin (3) through the piston (5), aligning the small end of the connecting rod (4). Continue installing the piston pin until it bottoms on installed retainer (2).
4. Install remaining retainer (2), using procedure detailed in step 2.

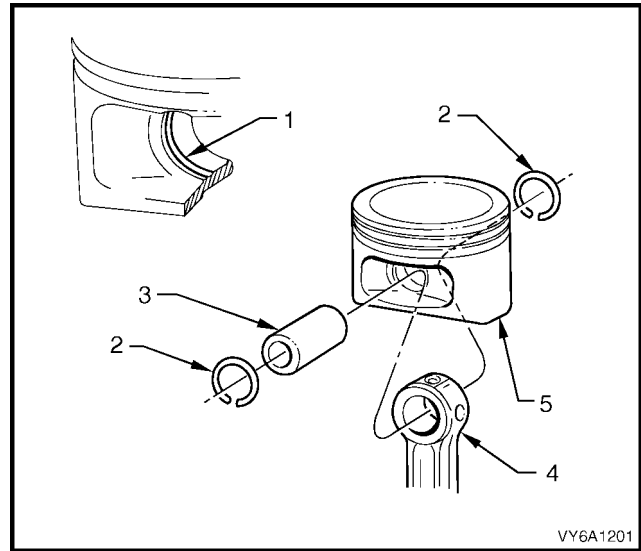


Figure 6A1-1-279

5. Install piston rings, refer to **3.11 PISTON RINGS** in this Section.
6. Ensure cylinder bores, pistons, connecting rod bearing shells and crankshaft journals are absolutely clean, then coat cylinder bores and all bearing surfaces with clean engine oil.
7. Before installation of a piston and rod assembly in its bore, position the crankpin straight down.
8. Remove cap, and with bearing upper shell seated in connecting rod, install the 'short' guide tool into inner bolt hole. Install 'long' guide tool in the other bolt hole. These guides hold upper bearing shell in place and protect crankshaft journal from damage during installation of connecting rod and piston assembly.
9. Ensure piston ring gaps are separated as detailed in **3.11 PISTON RINGS** in this Section.
10. Lubricate piston and rings with clean engine oil. Using a suitable ring compressor to compress rings, install each piston and connecting rod assembly into its cylinder bore.

NOTE: Ensure the lug (1) on the underside of the piston crown is facing forward.

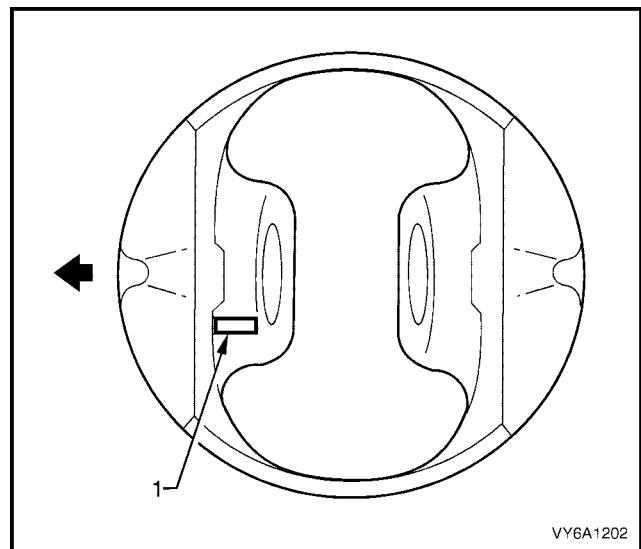


Figure 6A1-1-280

11. Using a hammer handle, lightly tap piston into its bore while holding ring compressor firmly against cylinder block until all pistons rings have entered bore.
12. Push piston down bore until connecting rod seats against crankshaft journal.

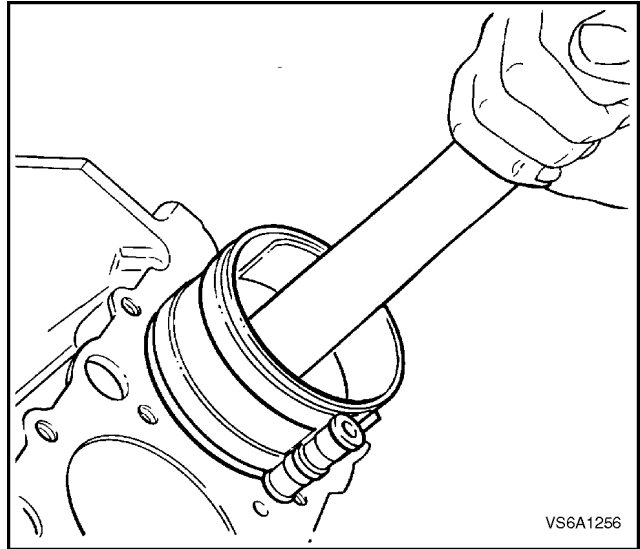


Figure 6A1-1-281

13. Remove connecting rod guides. Install bearing cap and lower bearing shell assembly. Install cap bolts and tighten and then loosen one full turn. Finally tighten the cap bolts to the correct specification.

NOTE: Ensure correct orientation of cap with connecting rod.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
--	-------------------------------

NOTE: Use an angle wrench such as E7115 to ensure accurate turn angle.

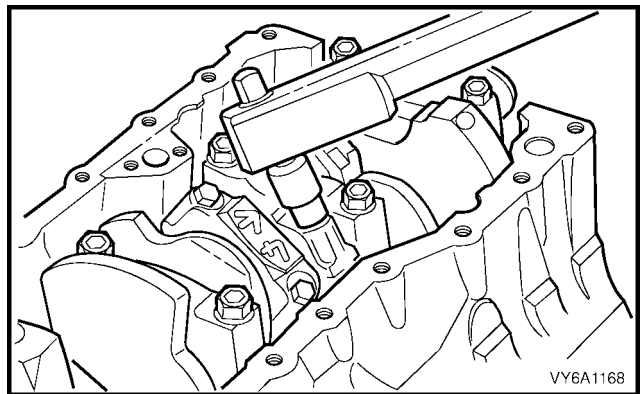


Figure 6A1-1-282

14. Rotate crankshaft to ensure free movement of crankshaft and connecting rod. If crankshaft binds, recheck bearing cap to rod orientation, bearing clearance or connecting rod alignment.
15. Measure side clearance between connecting rod and crankshaft journal using a feeler gauge (1), as shown.

If clearance is insufficient, check bearing clearance, refer to **3.7 MAIN AND CONNECTING ROD BEARINGS** in this Section, or connecting rod alignment.

CONNECTING ROD SIDE CLEARANCE	0.10 – 0.50 mm
-------------------------------	----------------

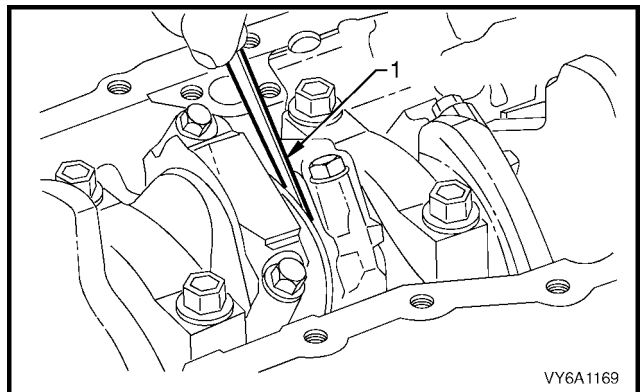


Figure 6A1-1-283

16. Reinstall remaining piston and connecting rod assemblies in the same manner.
17. Reinstall cylinder heads, refer to **2.17 CYLINDER HEADS** in this Section.
18. Reinstall oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
19. Reinstall oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
20. Start engine and check for oil leaks. Repair as necessary.

3.11 PISTON RINGS

INSTALL

NOTE: The pistons have three rings (two compression rings and one oil ring). The top ring is a steel, molybdenum filled, balanced section, barrel lapped type. The second ring is a inverted torsional taper faced type. The oil ring is of three piece design, comprising two segments and a spacer.

1. Select a set of rings comparable in size to the piston being used.
2. Install compression ring in relevant cylinder bore, then using the head of a piston (without rings fitted), press ring down into bore approximately 50 mm.

NOTE 1: Using a piston in this way will place ring square with cylinder wall.

NOTE 2: Be careful not to distort the ring during this operation, or it may bind in the piston ring groove. Fit each ring separately to the cylinder in which it is going to be installed.

3. Measure gap between ends of ring with a feeler gauge.

If the gap between the ends of a compression ring is below specification, remove ring and try another for size.

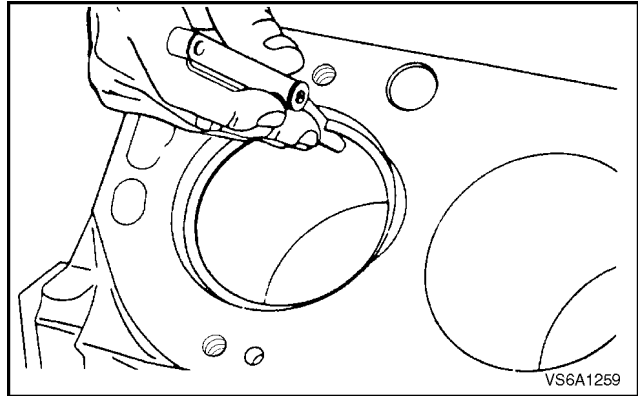


Figure 6A1-1-284

COMPRESSION RING END GAP SPECIFICATIONS	
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TOP RING	0.305 - 0.559 mm
----------	------------------

SECOND RING	0.762 - 1.016 mm
-------------	------------------

4. Check gap between ends of each oil control ring rail.

OIL RING RAIL END GAP SPECIFICATION	0.254 - 0.762 mm
-------------------------------------	------------------

5. When fitting rings to a piston that has been in service, carefully remove all traces of carbon from ring grooves in piston and inspect grooves for any burrs or chips that might cause ring to bind.
6. Slip outer surface of each compression ring in respective piston ring groove and roll ring entirely around groove to check that ring is free.

Also measure ring to piston groove side clearance.

If the ring is too tight, try another ring.

NOTE: Do not attempt to cut the piston ring groove, although high spots in the ring groove may be cleaned up by careful use of a fine file.

PISTON RING TO GROOVE CLEARANCE	
---------------------------------	--

TOP RING	0.039 - 0.079 mm
----------	------------------

SECOND RING	0.039 - 0.079 mm
-------------	------------------

OIL CONTROL RING	0.023 - 0.201 mm
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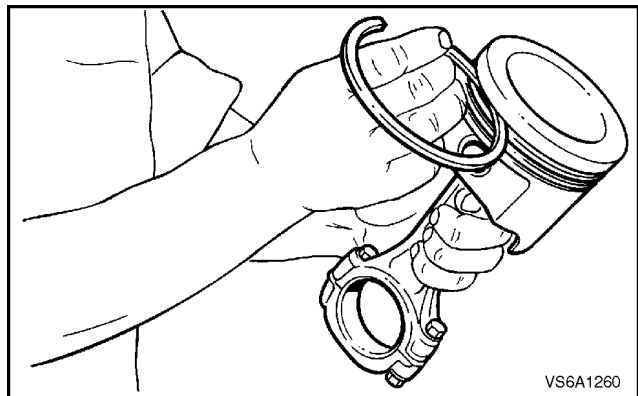


Figure 6A1-1-285

7. Install oil ring spacer (1) in bottom piston ring groove.

NOTE: The ends of the spacer butt against each other, as shown (2).

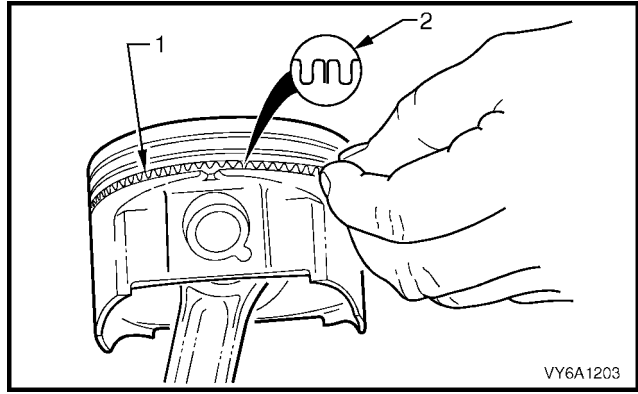


Figure 6A1-1-286

8. Install one steel rail from top of piston downward into oil ring groove.

9. Install remaining steel rail from bottom of piston skirt upwards into the oil ring groove.

10. Install compression rings in second and first grooves of each piston.

NOTE: Ensure the correct compression rings are installed in the first and second grooves, with both compression rings (3) fitted the correct way up by having the laser print identification mark, relative to the ring gap (2).

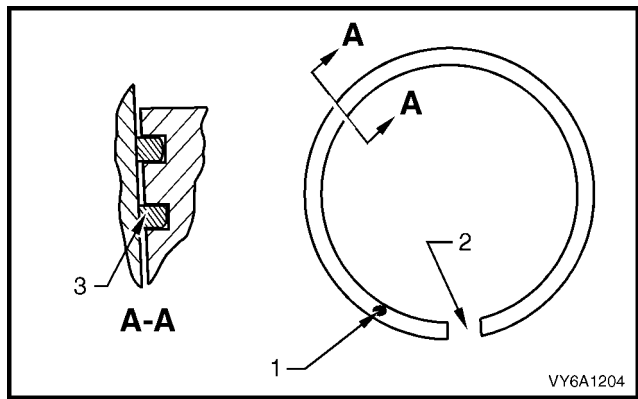


Figure 6A1-1-287

11. Make a final test of ring fit in piston grooves. Separate ends as shown.

NOTE: Never install piston with ring gaps in line, as this will allow compression leakage at this point.

Legend:

Piston Ring Positioning:

- 1. Oil Ring Spacer Gap
- 2. Oil Ring, Rail Gaps
- 3. Second Compression Ring Gap
- 4. Top Compression Ring Gap

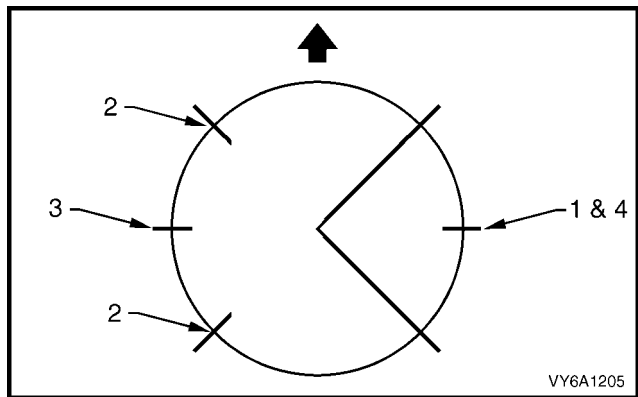


Figure 6A1-1-288

3.12 CRANKSHAFT

REMOVE

NOTE 1: It is recommended that bearing clearance be checked before removing crankshaft from cylinder block, refer to **3.7 MAIN AND CONNECTING ROD BEARINGS** in this Section.

NOTE 2: The crankshaft in this engine has rolled fillets and the journals can be repolished up to 0.025 mm undersize. If any more is required for refinishing, the crankshaft must be replaced.

1. With engine removed from vehicle and mounted in a suitable stand, remove oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.
2. Remove oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
3. Remove rear main oil seal housing refer to **3.14 REAR MAIN OIL SEAL HOUSING** in this Section.
4. Remove crankshaft balancer, refer **2.19 CRANKSHAFT BALANCER** in this Section.
5. Remove spark plugs.
6. Remove timing chain and crankshaft sprocket, refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section.
7. Mark connecting rod caps with an etching marker or felt tipped pen to indicate cylinder number (1) and orientation of cap (2).

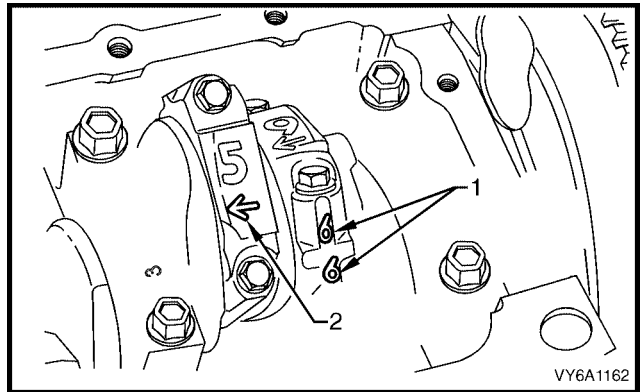


Figure 6A1-1-289

8. Remove connecting rod cap bolts and remove caps and lower bearing shells (1). Push connecting rods away from crankshaft.

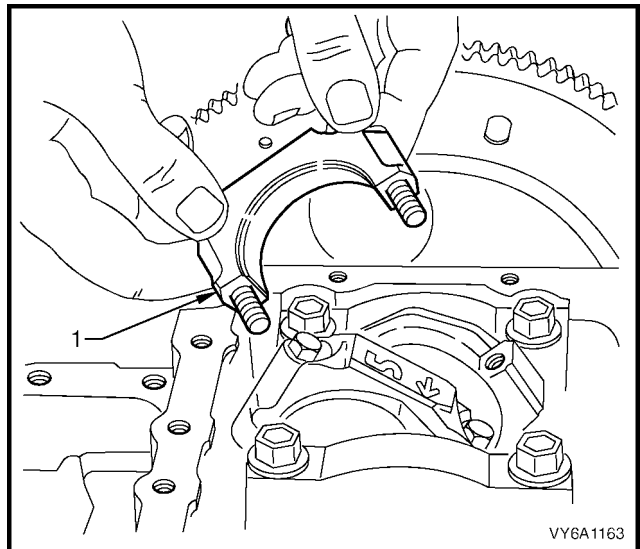


Figure 6A1-1-290

9. Remove main bearing cap bolts and main bearing cap side bolts.

NOTE 1: New main bearing cap side bolts must be used to ensure bolts remain oil tight to cylinder block.

NOTE 2: Main bearing caps are press fit and special care is required when removing the caps. J41348 has been designed to work in conjunction with J6125-B in order to prevent damage to bearing and/or cap. J41348 must be installed correctly into bolt holes of caps and J6125-B attached in order to properly remove main bearing cap without damage to the cap and/or bearing. Deviation from this procedure may cause damage to the cap and/or bearing resulting in engine damage.

- a. Install J41348 into main bearing cap bolt holes.
- b. Tighten bolts to 11 Nm.
- c. Install J6125-B to J41348.
- d. Using the slide hammer motion of J6125-B remove main bearing cap.

10. Lift crankshaft from cylinder block.

11. Remove flywheel/flexplate to crankshaft attaching bolts, remove flywheel/flexplate and discard bolts.

12. If necessary, remove sprocket key from front end of crankshaft using a suitable punch and hammer.

13. If necessary, remove crankshaft to flywheel dowel pins from crankshaft rear flange using a suitable removal tool.

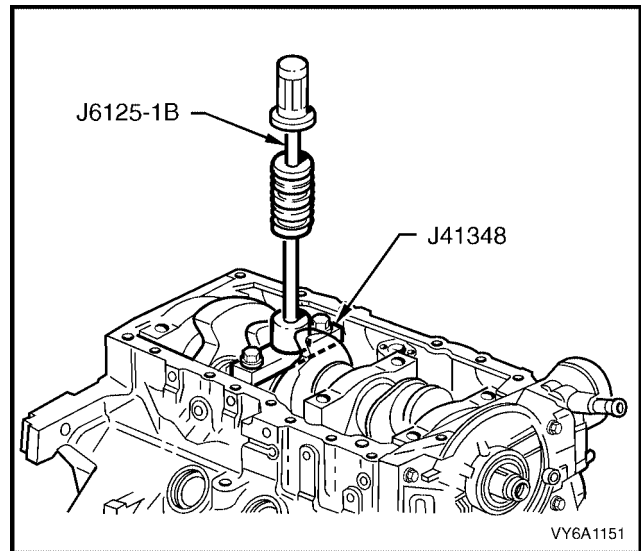


Figure 6A1-1-291

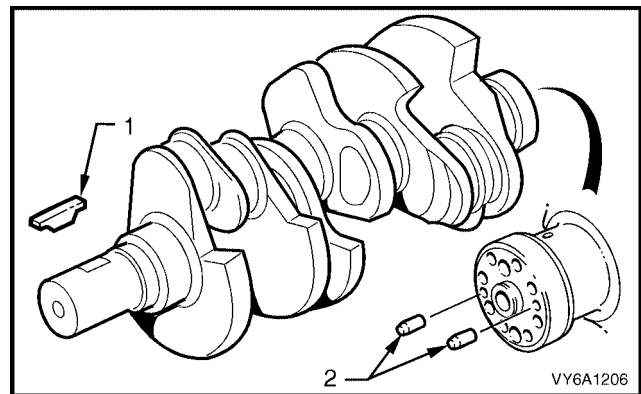


Figure 6A1-1-292

INSPECT

1. Wash crankshaft in suitable cleaning solvent and dry with compressed air.
2. Inspect crankshaft oil passages for obstructions.
3. Inspect all bearing journals, thrust surfaces and rear main oil seal contact surfaces for;
 - a. Cracks
 - b. Chips
 - c. Gouges
 - d. Roughness
 - e. Grooving
 - f. Overheating (Discolouration)

If crankshaft has any cracks, severe gouging or burned spots, the crankshaft must be replaced. Slight roughness may be removed with fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

4. Inspect connecting rod and main bearing shells for embedded foreign material and determine its source.

5. Measure bearing journals with a micrometer, checking for taper, out-of round or excessive wear.

MAIN BEARING JOURNAL DIAMETER	
STANDARD	63.470 - 63.495 mm
TAPER	0.008 mm Maximum
OUT-OF-ROUND	0.008 mm Maximum
CONNECTING ROD JOURNAL DIAMETER	
STANDARD	57.117 - 57.147 mm
TAPER	0.008 mm Maximum
OUT-OF-ROUND	0.008 mm Maximum

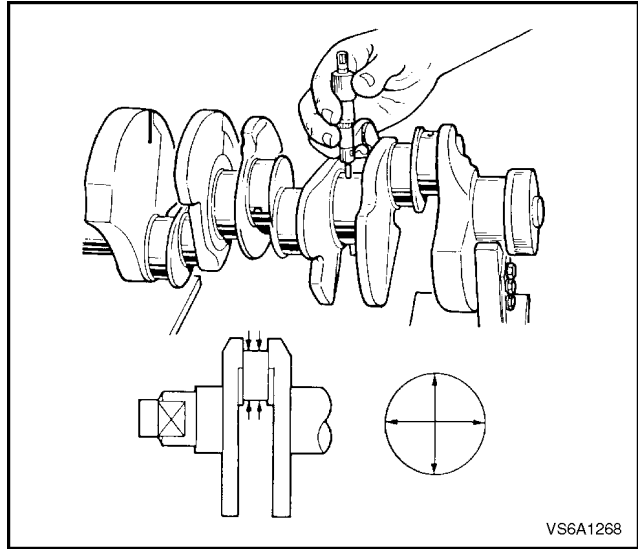


Figure 6A1-1-293

6. Check crankshaft for run-out by supporting front and rear main bearing journals in V-blocks and checking No. 2 and No. 3 journals with a dial gauge, while rotating the crankshaft by hand.

CRANKSHAFT RUNOUT SPECIFICATION	0.008 mm
---------------------------------	----------

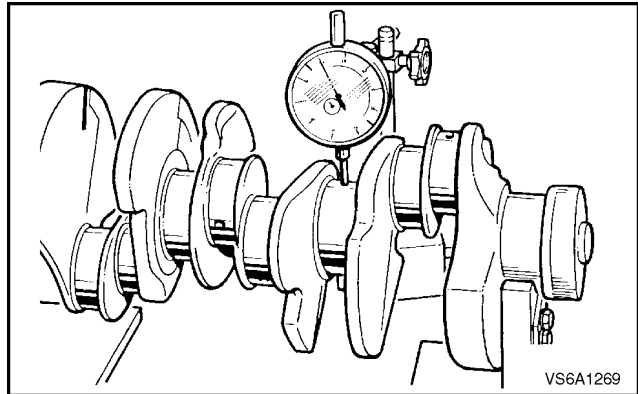


Figure 6A1-1-294

7. Position a dial gauge at the crankshaft rear flange and check the rear flange runout, while slowly rotating the crankshaft by hand.
During this check, ensure that the crankshaft is thrust forward on the V-blocks to prevent the crankshaft moving forward and falsifying the runout reading.

CRANKSHAFT REAR FLANGE RUNOUT	0.05 Max.
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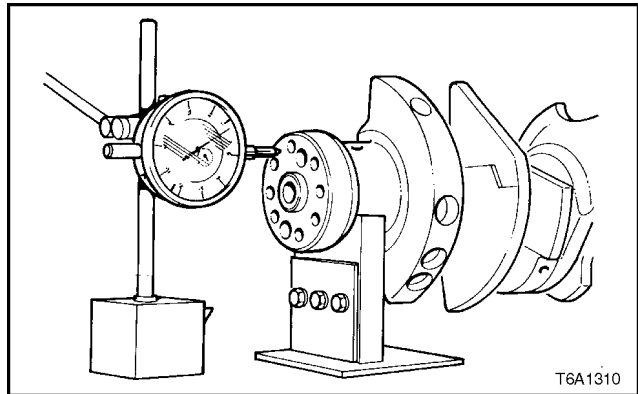


Figure 6A1-1-295

8. Replace crankshaft if not within specifications.
9. Using a 5/16" thread tap, clean flywheel/flexplate attaching bolt thread holes in rear of crankshaft.
10. Clean all traces of sealant from cylinder block.

REINSTALL

1. If necessary, install sprocket key to front end of crankshaft.
2. Lubricate all crankshaft journals and main bearing upper shells in cylinder block with clean engine oil.
3. Lay crankshaft in place in main bearing upper shells in cylinder block. Take care not to damage crankshaft thrust flange and No. 2 main bearing thrust faces. Also take care not to contact connecting rod journals with connecting rods.
4. If necessary, check main bearing clearance, refer to **3.7 MAIN AND CONNECTING ROD BEARINGS** in this Section.
5. Ensure that main bearing cap bolt threads and cylinder block threads are clean and dry. Apply some engine oil to the cap bolt threads.

NOTE: Ensure that the bearing caps are installed into the crankcase in the correct order (2) and orientation (1).

6. Before final installation of cap bolts, determine if bolts have stretched by comparing with a new bolt. Replace bolt/s as necessary.

Reinstall main bearing caps, hand start main bearing cap bolts, on each bearing cap in turn, tighten cap bolts half a turn at a time to carefully seat cap.

Hand start main bearing cap side bolts.

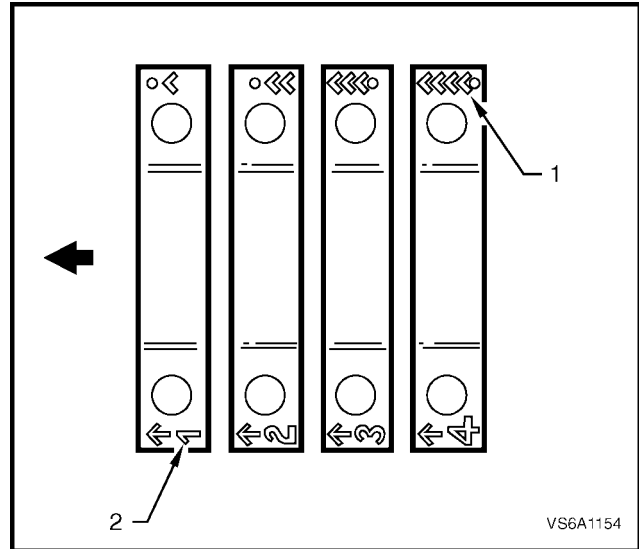


Figure 6A1-1-296

Due to the thrust bearing shells being disturbed, it is necessary to line up the thrust surfaces of the bearing shells before the cap bolts are tightened. To do this, move the crankshaft fore and aft the length of its travel several times (last movement forward).

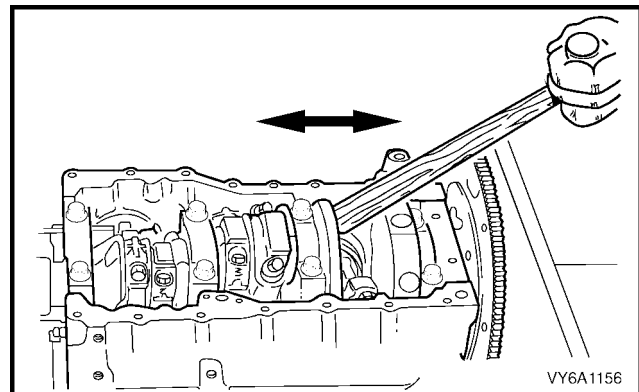


Figure 6A1-1-297

NOTE 1: Do not tighten one cap completely at a time, progressively tighten all four caps to one step of procedure before moving to next stage of torque.

NOTE 2: New main bearing cap side bolts must be used to ensure bolts remain oil tight to cylinder block.

MAIN BEARING CAP BOLT TORQUE SPECIFICATION PROCEDURE	
TO FULLY SEAT EACH CAP, TIGHTEN TO	70 Nm, then Loosen All 360°.
RE-TIGHTEN EACH BOLT TO	20 Nm, then 40 Nm. Finally,
TURN EACH CAP BOLT THROUGH	35°, three times (= 105° Total).
TIGHTEN EACH BEARING CAP SIDE BOLT	15 Nm, then turn through 45°

NOTE 3: In order to prevent the possibility of cylinder block or bearing cap damage, do not install bearing cap using a soft faced hammer. Use cap bolts to pull bearing cap into position. Failure to observe this procedure may damage cylinder block or bearing cap.

NOTE 4: Use an angle wrench such as E7115 to ensure accurate turn angle.

- Force crankshaft forward and measure crankshaft end float between front of No. 2 main bearing shell (2) crankshaft thrust faces with a feeler gauge (1).

If clearance is excessive, replace No. 2 main bearing shells.

CRANKSHAFT END FLOAT SPECIFICATION	0.08 - 0.28 mm
------------------------------------	----------------

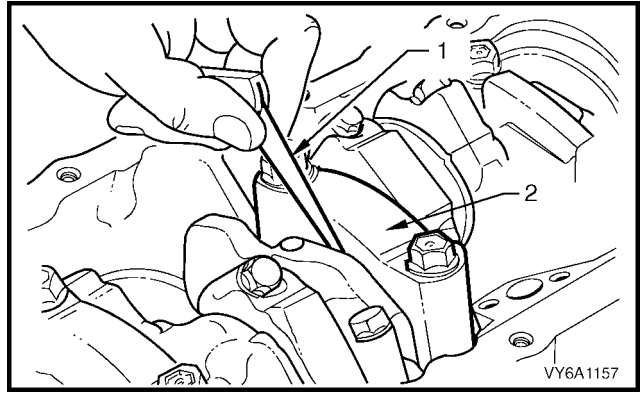


Figure 6A1-1-298

- Install new rear main oil seal, refer to [3.13 REAR MAIN OIL SEAL](#) in this Section.
- Reinstall flywheel/flexplate (1) to crankshaft and install new attaching bolts (2).

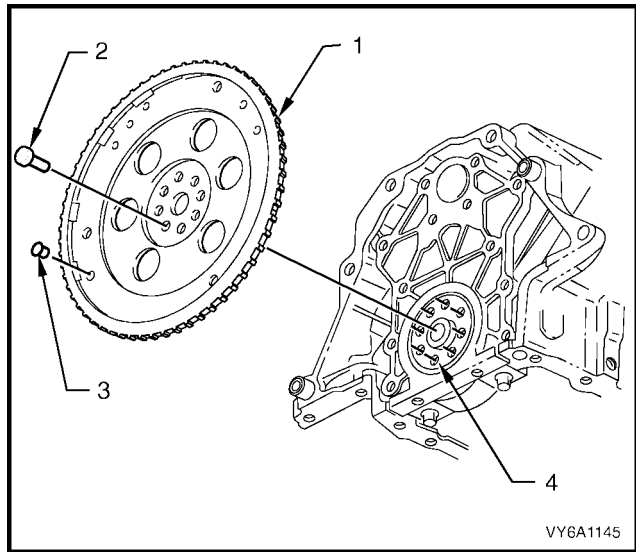


Figure 6A1-1-299

NOTE: There are specific bolts for flywheel and flexplate attachment to the crankshaft. 'A' is used for retaining the flywheel, while 'B' are used for the flexplate. Both have the same thread, 18 TPI, UNC 3A.

- Tighten retaining bolts to the correct torque specification.

FLYWHEEL BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 85°
FLEXPLATE BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 50°

- For vehicles with manual transmission, reinstall clutch pressure plate and driven plate, refer to [Section 7A1 CLUTCH – V6 ENGINE](#).

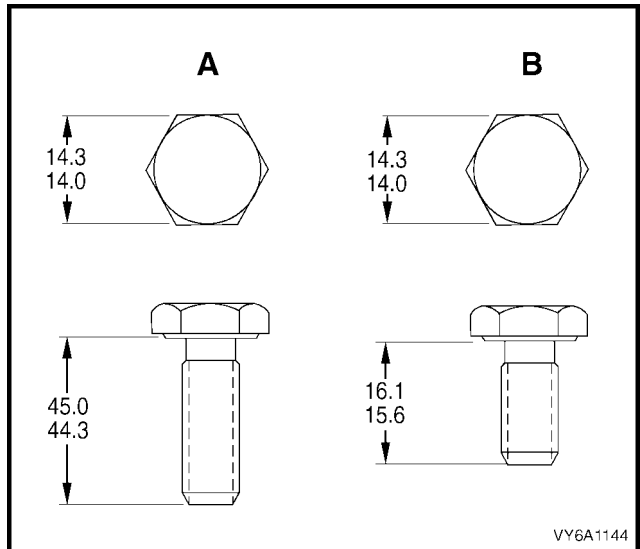


Figure 6A1-1-300

- Using guide pin tools, (AU388) pull connecting rods up to crankshaft journals.

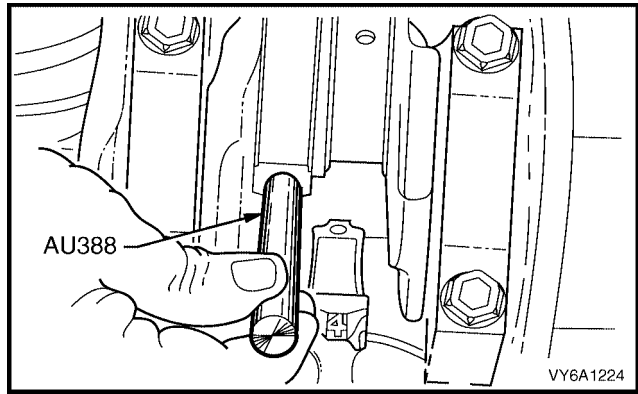


Figure 6A1-1-301

- Lubricate crankshaft connecting rod journals and bearings, install connecting rod caps and bolts.
- Tighten connecting rod cap bolts and then loosen one full turn. Tighten bolts to the correct torque specification.

CONNECTING ROD CAP BOLT TORQUE SPECIFICATION	28 Nm, plus 50° Turn Angle
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NOTE: Use an angle wrench such as E7115 to ensure accurate turn angle.

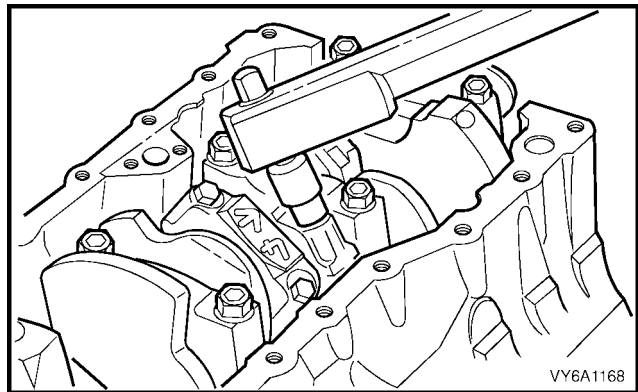


Figure 6A1-1-302

- If necessary, check connecting rod bearing clearances, refer to **3.7 MAIN AND CONNECTING ROD BEARINGS** in this Section.
- Measure clearance between connecting rods and crankshaft journal flanges with a feeler gauge (1).

CONNECTING ROD SIDE CLEARANCE	0.10 - 0.50 mm
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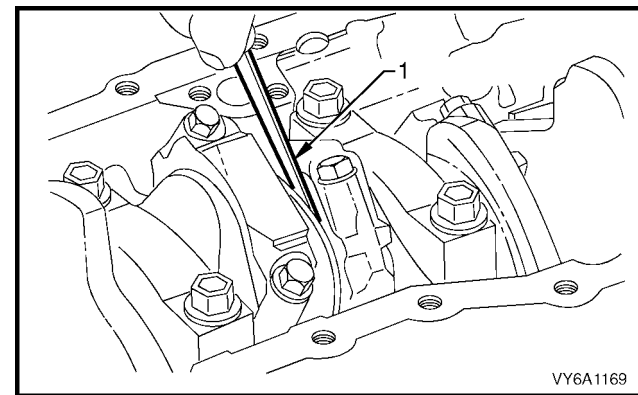


Figure 6A1-1-303

- Rotate crankshaft to ensure free movement of crankshaft and connecting rods. If crankshaft binds, check orientation of bearing caps, correct fitting of bearing caps (mains and connecting rods) or fitting of bearing shells or bearing clearance.
- Reinstall crankshaft sprocket, timing chain, and front cover, refer to **2.23 TIMING CHAIN, TENSIONER, SPROCKETS AND BALANCE SHAFT GEARS** in this Section.
- Reinstall crankshaft balancer, refer to **2.19 CRANKSHAFT BALANCER** in this Section.
- Reinstall spark plugs and tighten to the correct torque specification.

SPARK PLUG TORQUE TORQUE SPECIFICATION	25 Nm
--	-------

- Reinstall oil pump suction pipe and screen, refer to **3.3 OIL PUMP SUCTION PIPE AND SCREEN** in this Section.
- Reinstall oil pan, refer to **3.2 OIL PAN AND SEAL** in this Section.

3.13 REAR MAIN OIL SEAL

ORIGINAL OIL SEAL ONLY

IMPORTANT: IF THE ORIGINAL DESIGN OIL SEAL IS TO BE FITTED, THESE INSTRUCTIONS ARE VALID. HOWEVER, IF THE REVISED DESIGN OIL SEAL (REFER TO [PAGE 6A1-1-158](#)) IS TO BE USED, THEN A NEW REAR MAIN OIL SEAL HOUSING, SEAL AND GASKET MUST BE FITTED.

REPLACE

1. Disconnect battery earth lead.
2. Remove transmission, refer to [Section 7B1 MANUAL TRANSMISSION – V6 ENGINE](#), or [Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING](#).
3. Remove flywheel/flexplate, refer to [3.4 FLYWHEEL/FLEXPLATE](#) in this Section.
4. On vehicles with manual transmission, remove spigot bearing, refer to [3.6 SPIGOT BEARING](#) in this Section.
5. Position a piece of shim brass (1) between seal lips and crankshaft. This is necessary to protect the crankshaft seal surface.
6. Using a suitable lever, pry out seal (2), levering against shim brass strip and remove seal.
7. Check seal bore in rear main oil seal housing for nicks or burrs, correct as required.

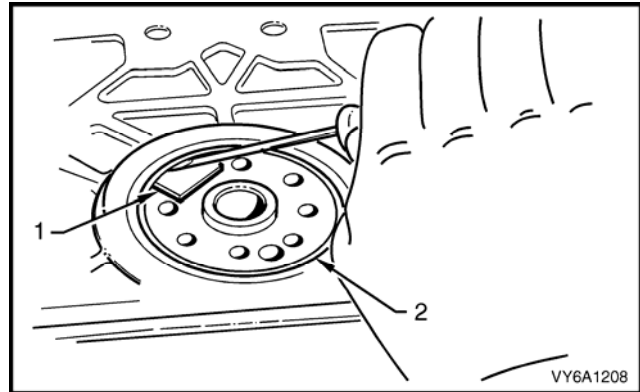


Figure 6A1-1-304

8. Wipe the crank sealing surface carefully and inspect for signs of damage. In addition check the area at the rear of the crankshaft that the seal will slide past during installation to ensure that there are no defects that will damage the seal during installation. Repair or replace the crankshaft as necessary.
9. Lubricate rear main oil seal housing and crankshaft flange plus ID and OD of J41349. Install rear main seal housing aligning tool J41349 tapered end first to crankshaft flange and rotate tool. Tool should turn evenly without binding or tight spots if housing is correctly aligned.

IMPORTANT: If the rear main oil seal aligning tool binds or does not turn evenly when rotated, then a new rear main oil seal housing, oil seal (new design) and gasket must be fitted. If this action is required.

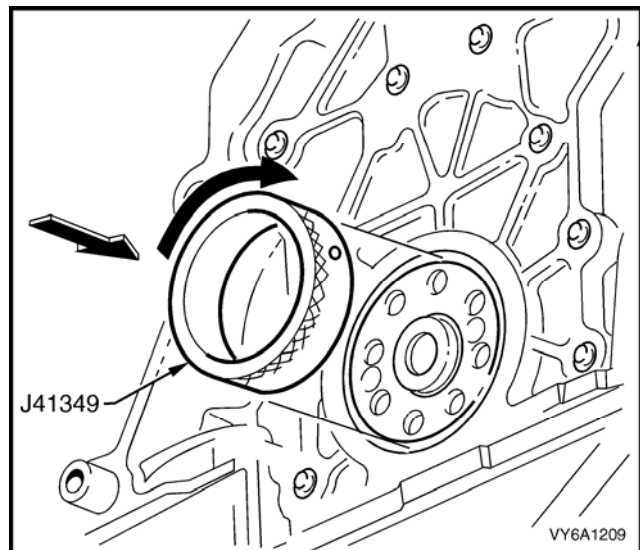


Figure 6A1-1-305

10. Apply engine oil to new seal inner and outer diameter.

Apply a thin film of clean engine oil to the surface of the crankshaft over which the seal will slide during installation.

NOTE 1: Do not apply petroleum jelly or grease to seal lip. These substances can prevent correct seal operation.

NOTE 2: Install seal, using Tool No. J38196. Ensure that the forcing nut of Tool No. J38196 is loosened right off. Slide seal over mandrel of Tool No. J38196 until it bottoms squarely against outer collar of tool.

IMPORTANT: Before use, inspect tool J38196 for damage to the seal lip area. If damage is evident, the tool should be replaced.

11. Attach tool to rear of crankshaft by tightening the two knurled attaching screws until tight.

It is important when using the seal installation tool that the correct holes in the crankshaft are used.

One of the holes in the crankshaft is offset, if this hole is one of the pair used then it can result in the seal being installed incorrectly.

12. Turn T-handle of tool so that outer collar pushes seal into its bore and continue to turn handle until additional resistance is felt. Do not over tighten T-handle otherwise damage to the tool may result.

NOTE: Seal installation using Tool No. J38196-AUS-A:

Separate tool by removing nut, and place mandrel collar to one side.

IMPORTANT: Before use, inspect the finely machined flange of Tool No. J38196-AUS-A for damage. If damage is evident, the tool should be replaced.

13. Attach seal retaining mandrel to rear of crankshaft by fitting two attaching screws (1) until tight, taking note of the following:

- a. It is important when using the seal installation tool (J38196-AUS-A) that the correct holes in the crankshaft are used.
- a. Clearance holes are provided to avoid interference with crankshaft dowel pins (if fitted).

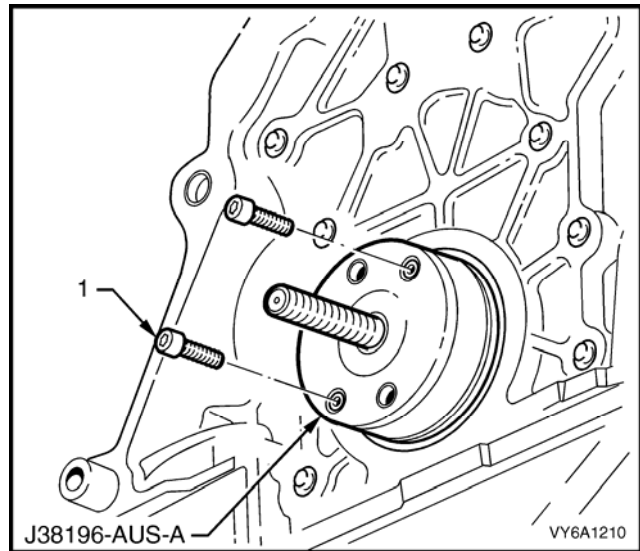


Figure 6A1-1-306

14. Install seal (1) onto seal retaining mandrel, noting that seal lips are facing in. Refer Figure 6A1-1-310 for a sectioned view.

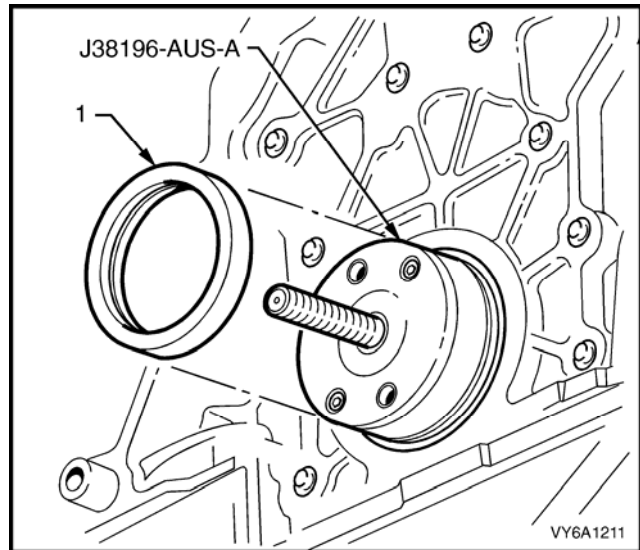


Figure 6A1-1-307

15. Install mandrel collar of Tool No. J38196-AUS-A over seal retaining mandrel.

16. Install nut onto seal retaining mandrill and tighten nut until seal is seated into rear main oil seal housing.

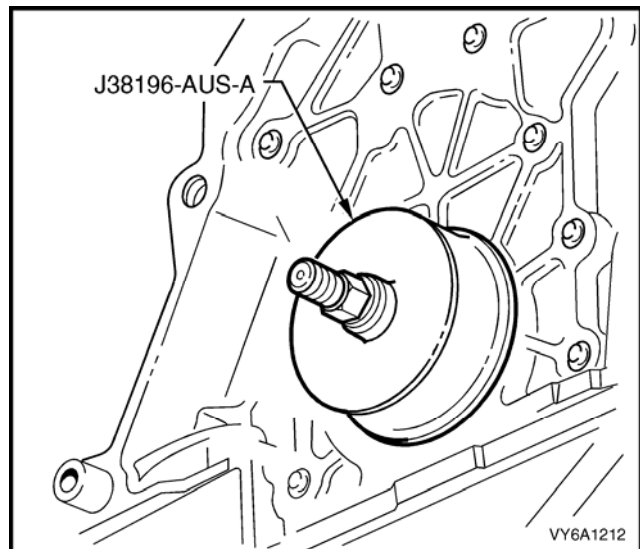


Figure 6A1-1-308

The seal must be installed parallel to the crankshaft rear flange (3).

The installed seal (1) to crankshaft rear face runout (dimension 'A') must not vary more than 0.25 mm when measured at different points around the circumference of the crankshaft rear flange.

NOTE: Dimension is shown with crankshaft in fully rearward position.

IMPORTANT: If the above dimension varies more than 0.25 mm, reattach tool J38196-AUS-A to rear of crankshaft and tighten nut until resistance is felt. With tool in this position, remove spark plugs and rotate engine slowly for two full revolutions. Remove tool and recheck that the seal is now parallel to crankshaft flange.

If the crankshaft rear flange to seal runout still varies more than 0.25 mm, replace Tool No. J38196-AUS-A.

17. Remove seal installation Tool No. J38196-AUS-A from crankshaft.

18. If necessary, reinstall spigot bearing, refer to **3.6 SPIGOT BEARING** in this Section.

19. Clean flywheel/flexplate (1) attaching bolt threads in rear of crankshaft (4) using a 5/16 UNC thread tap.

Reinstall flywheel/flexplate using new bolts (2). Refer **3.4 FLYWHEEL/FLEXPLATE** in this Section.

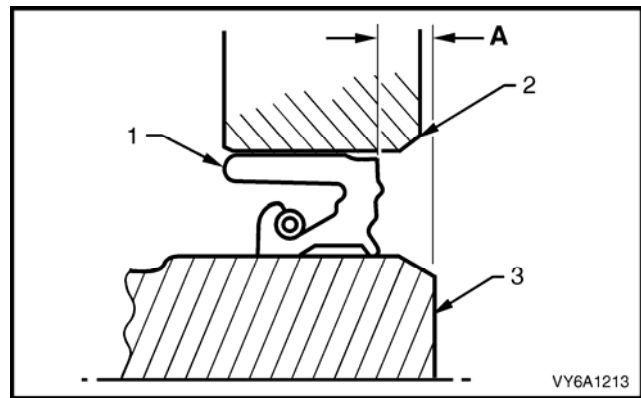


Figure 6A1-1-309

19. Clean flywheel/flexplate (1) attaching bolt threads in rear of crankshaft (4) using a 5/16 UNC thread tap.

Reinstall flywheel/flexplate using new bolts (2). Refer **3.4 FLYWHEEL/FLEXPLATE** in this Section.

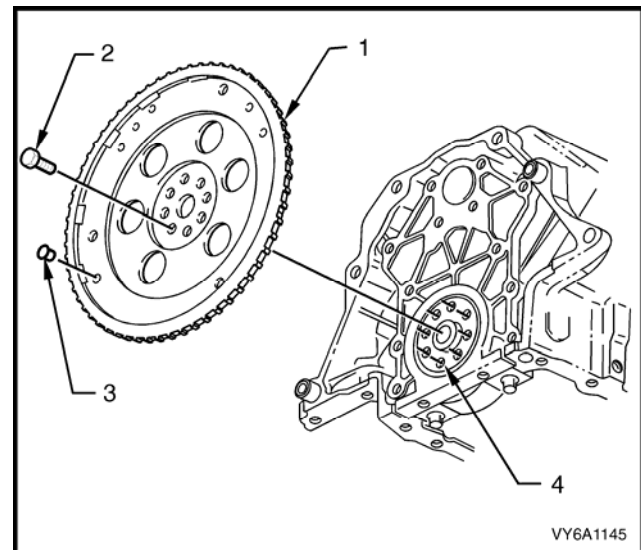


Figure 6A1-1-310

NOTE: There are specific bolts for flywheel and flexplate attachment to the crankshaft. 'A' is used for retaining the flywheel, while 'B' are used for the flexplate. Both have the same thread, 18 TPI, UNC 3A.

20. Tighten retaining bolts to the correct torque specification.

FLYWHEEL BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 85°
FLEXPLATE BOLT TORQUE SPECIFICATION	20 Nm, then turn a further 50°

21. For vehicles with manual transmission, reinstall clutch pressure plate and driven plate, refer to **Section 7A1 CLUTCH – V6 ENGINE**.

22. If fitted, reinstall the automatic transmission. Refer **Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING**.

23. Road test vehicle and check for lubricant leaks.

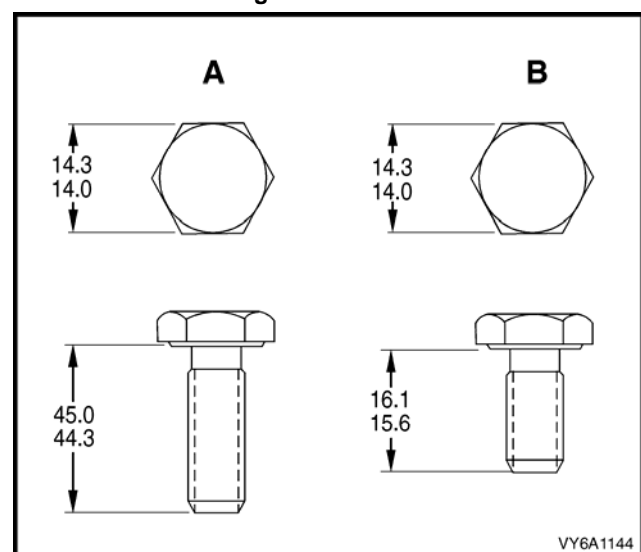


Figure 6A1-1-311

3.14 REAR MAIN OIL SEAL HOUSING

REMOVE

ORIGINAL DESIGN HOUSING & SEAL

NOTE: If this service operation is to be carried out on an engine already removed from the vehicle, commence from Step 18.

1. Disconnect battery ground lead.
2. Remove the four nuts (1) securing engine dress cover (2), then remove the cover from the engine and set to one side.

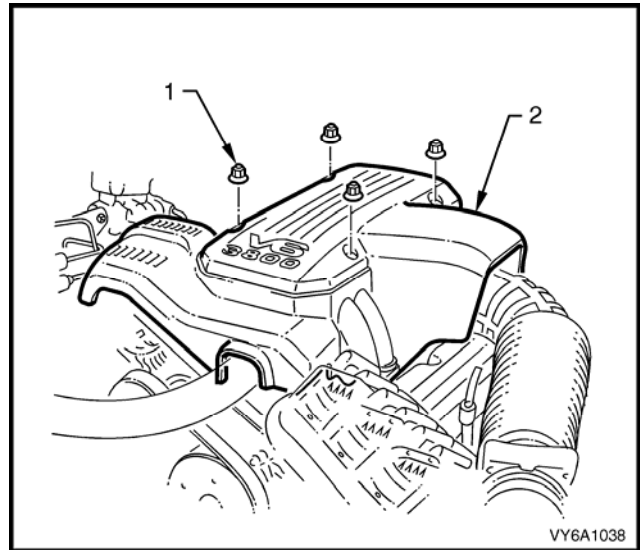


Figure 6A1-1-312

3. Place a clean container (of at least 12 litres capacity) under the engine for the engine coolant to drain into.

NOTE: To reduce the impact on the environment and the maintenance cost, whenever the coolant is drained from the engine, the service records are to be checked to determine when the coolant was last changed. If more than six months life is left before the next coolant change, then the drained coolant can be re-used. For further information, refer to [Section 6B1 ENGINE COOLING – V6 ENGINE](#).

4. Drain engine coolant into clean drain tray by disconnecting radiator lower hose (1) from the front cover connection.

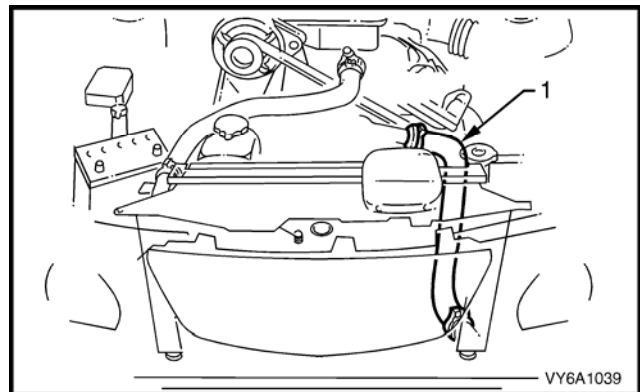


Figure 6A1-1-313

5. Remove bolts '1' and '3' securing generator brace (2).

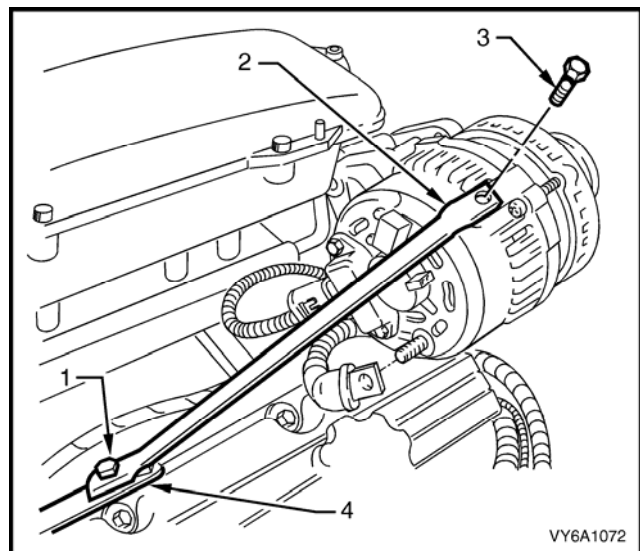


Figure 6A1-1-314

6. Disconnect mass air flow sensor wiring harness connector (4), loosen air flow duct rubber boot clamps at throttle body (1) and air cleaner (5). Remove the air flow duct (2) and mass air flow sensor (3) assembly from the vehicle and carefully set to one side.

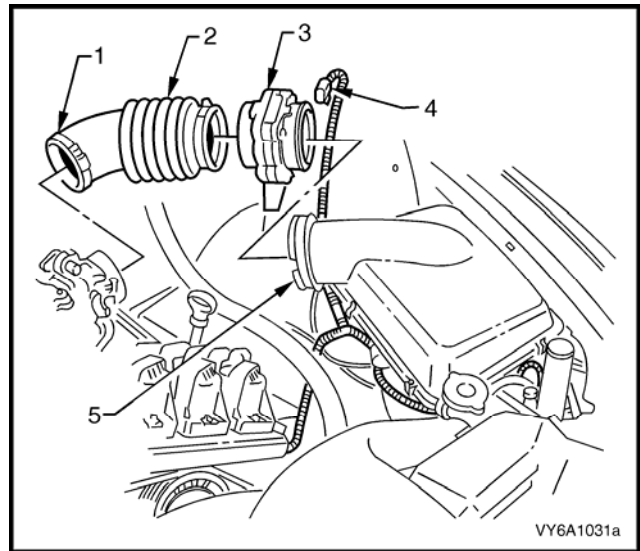


Figure 6A1-1-315

7. Remove the engine hood assembly, refer to **3.1 ENGINE ASSEMBLY, Remove**, in this Section.
8. Install engine lifting brackets (1) and engine lifting frame (2) to engine.

NOTE: Ensure adequate clearance between lifting equipment and engine components.

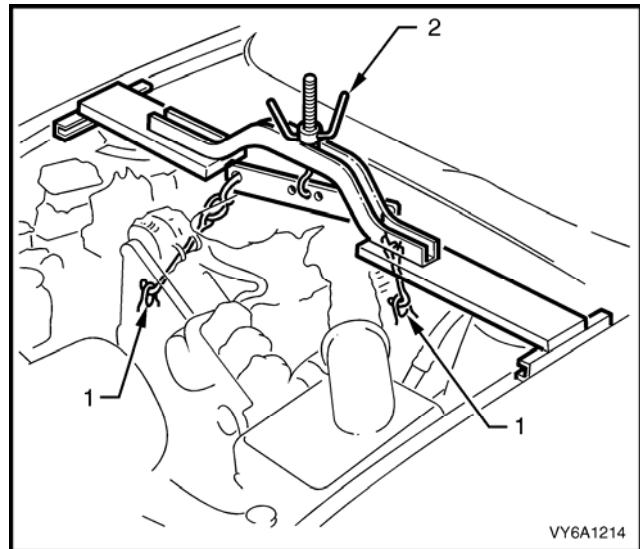


Figure 6A1-1-316

9. On each side, remove the stabiliser bar link (1), ball joint retaining nut (4) from the stabiliser bar (2), as follows:
- With a backing set spanner holding the stabiliser bar link inner stud hexagon (3), use a second spanner to loosen then remove the retaining nut (4).
 - Separate the stabiliser bar link (1) from the stabiliser bar (2).
 - Repeat for the other side.

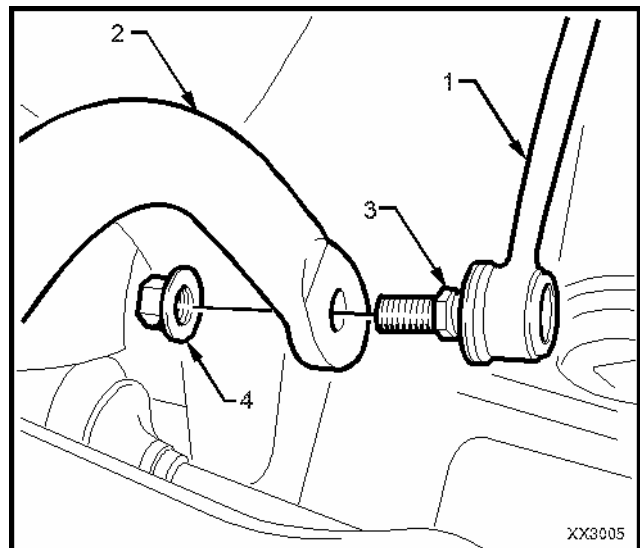


Figure 6A1-1-317

10. Remove transmission, refer to **Section 7B1 MANUAL TRANSMISSION – V6 ENGINE**, or **Section 7C4 AUTOMATIC TRANSMISSION – ON-VEHICLE SERVICING**.
11. Remove flywheel/flexplate, refer to **3.4 FLYWHEEL/FLEXPLATE** in this Section.

12. Remove steering rack mounting nuts (1) and bolts (4) (2 places) from the crossmember (3), then lower the steering rack (2) to improve access.

NOTE: While the Right Drive version is shown, the Left Drive procedure is similar.

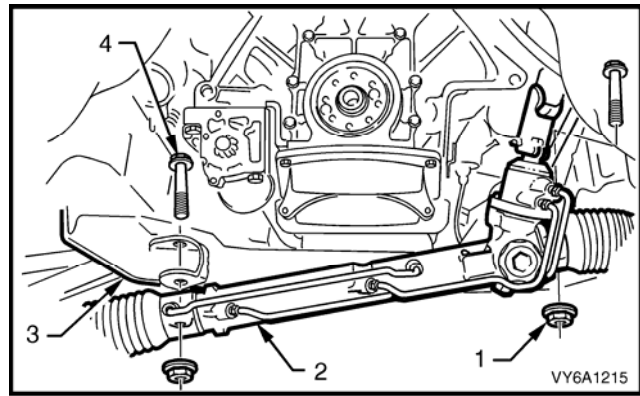


Figure 6A1-1-318

13. Remove nut securing the dipstick tube to the left hand exhaust manifold stud. Disconnect the dipstick tube from the stud and pull assembly from the oil pan. Plug the dipstick tube hole in the oil pan to prevent foreign matter ingress.

14. Remove engine mounting to front crossmember attaching nuts, refer **2.25 ENGINE MOUNTS**, in this Section.

15. Raise engine slightly more than 40 mm.

16. Fit 40 mm spacers between engine mounts and crossmember to support engine. Lower the engine onto the blocks.

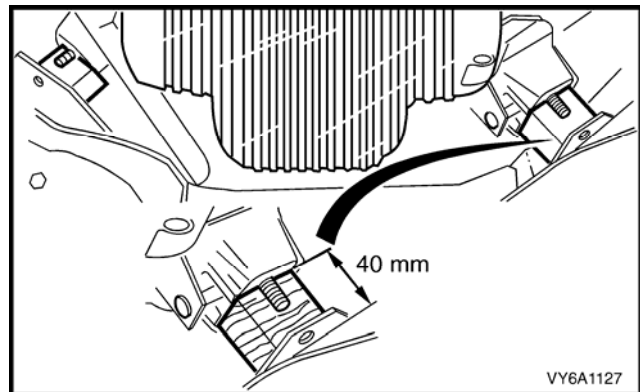


Figure 6A1-1-319

17. Remove the battery harness and (if fitted) automatic transmission oil cooler lines retaining bracket screw from the front of the engine, refer views 'A' and 'B', next.

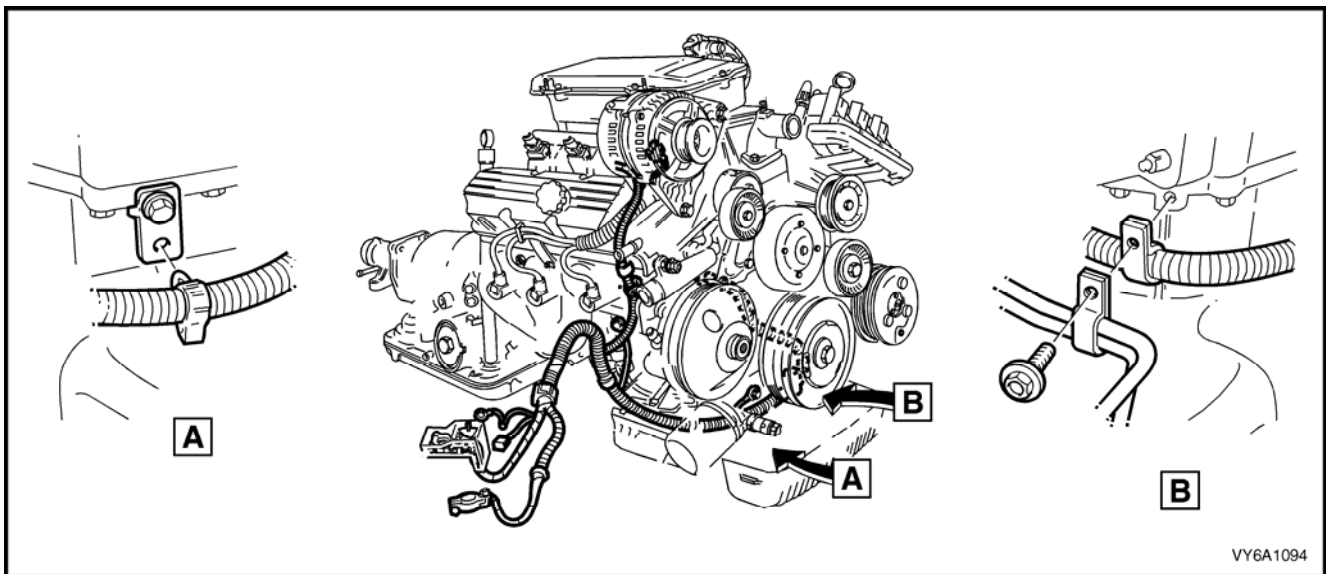


Figure 6A1-1-320

Legend

A. Battery Harness Securing Bracket.

B. Automatic Transmission Cooler Pipe Bracket and Screw.

18. Remove the two bolts securing the rear of the oil pan to the transmission.
19. Remove the oil pan retaining bolts, lower the oil pan and gasket, then remove from the vehicle. Discard the removed oil pan gasket.
20. Disconnect wiring harness to knock sensors.
21. Drain remaining coolant from engine block, by removing both knock sensor heat shields (2 and 5), followed by the knock sensors (1 and 6) themselves.

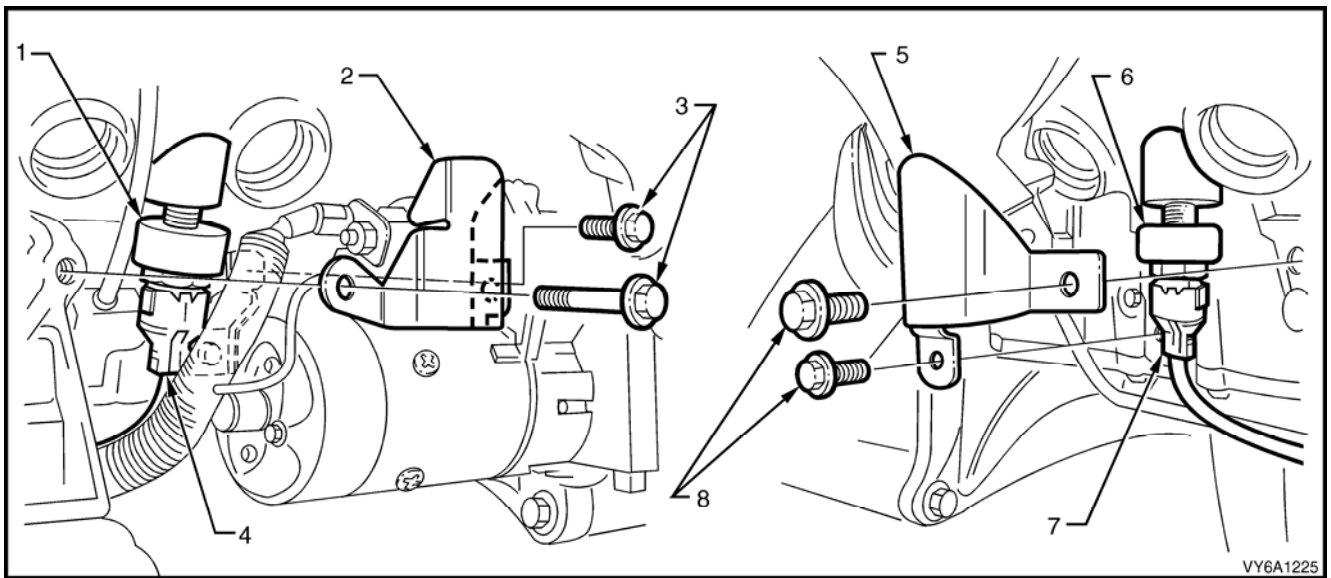


Figure 6C2-1-321 – Knock Sensor Locations

Legend

- | | |
|-----------------------------|-----------------------------|
| 1. Left Hand Knock Sensor | 5. Knock Sensor Shield RHS. |
| 2. Knock Sensor Shield LHS | 6. Right Hand Knock Sensor |
| 3. Attaching Bolts | 7. Wiring Harness Connector |
| 4. Wiring Harness Connector | 8. Attaching Bolts |

22. Remove rear main oil seal housing to cylinder block bolts (3), remove housing (2), seal and gasket (1) from the rear of the engine block.

23. Thoroughly clean all mating surfaces using a plastic scraper and solvent.

IMPORTANT: Take care not to scratch the rear of the cylinder block during the cleaning process.

24. Discard the removed gasket and rear plate as these two parts must only be replaced as a pair.

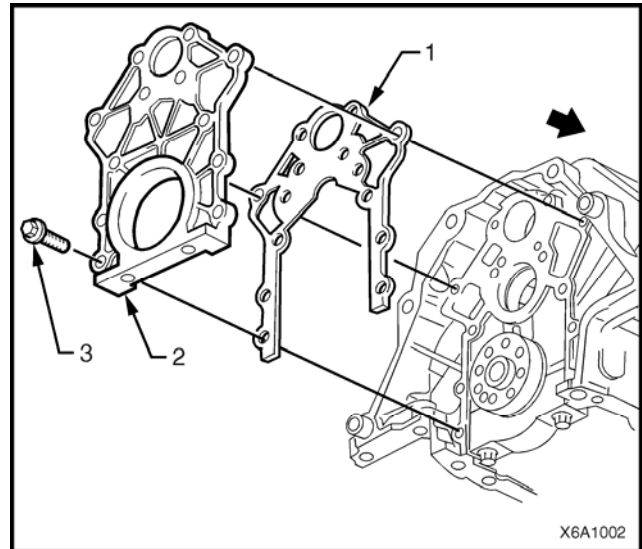


Figure 6A1-1-322

REVISED DESIGN HOUSING & SEAL

IMPORTANT: THESE REVISED COMPONENTS REQUIRE THAT A TOTALLY DIFFERENT APPROACH IS TO BE TAKEN WHEN REPLACING THE OIL SEAL AND/OR REAR MAIN OIL SEAL HOUSING.

1. Perform steps 1 to 21 inclusive of the previous procedure.
2. Remove rear main oil seal housing to cylinder block bolts, remove housing, seal and gasket from the rear of the engine block.
3. Thoroughly clean all mating surfaces using a plastic scraper and solvent.

IMPORTANT: Take care not to scratch the rear of the cylinder block during the cleaning process.

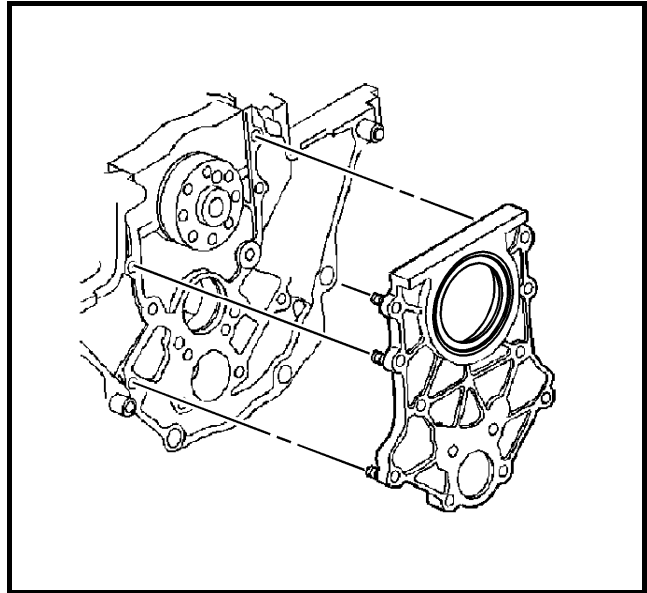


Figure 6A1-1 323

4. Place the crankshaft rear main oil seal housing face down and support with wooden blocks.
5. Using a suitable driving tool (e.g. pin punch) and hammer, lightly tap around the outer edge of the oil seal to remove it.
6. Clean and inspect all mating surfaces of the rear main oil seal housing to ensure the cover is free of any foreign material and damage.

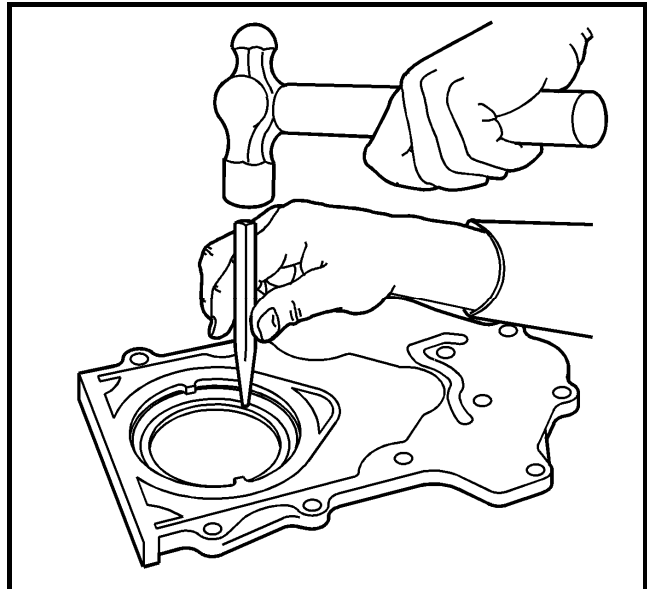


Figure 6A1-1 324

REINSTALL

ORIGINAL DESIGN HOUSING & SEAL

Installation is the reverse of removal procedures noting the following points.

NOTE: Ensure block face is clean of oil and coolant before reinstalling housing. Approximately 15 minutes is required for oil to drain sufficiently to achieve an oil free surface.

1. Prior to reinstallation of rear main oil seal housing, check thickness of the new housing as shown (dimension 'A'), between the two machined surfaces. If dimension 'A' is not within specification of 7.24 – 7.29 mm, select another rear main oil seal housing that does meet this specification.

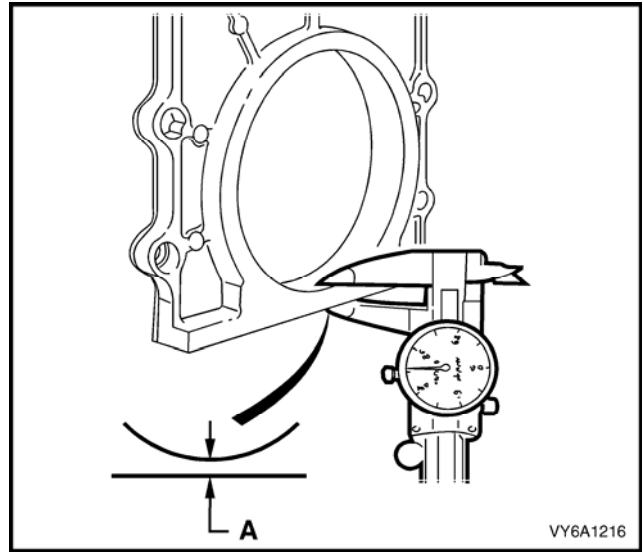


Figure 6A1-1-325

2. Fit rear main seal housing aligning tool E1409/11 to oil pan rail.
3. Loosely reinstall rear main oil seal housing and gasket to rear of cylinder block.

NOTE: Rear main oil seal housing to block bolts are torque-to-yield bolts and must not be reused.

4. Lubricate rear main oil seal housing and crankshaft flange plus ID and OD of J41349. Install rear main seal housing aligning tool J41349 tapered end first to crankshaft flange and rotate tool. Tool should turn evenly without binding or tight spots if housing is correctly aligned.

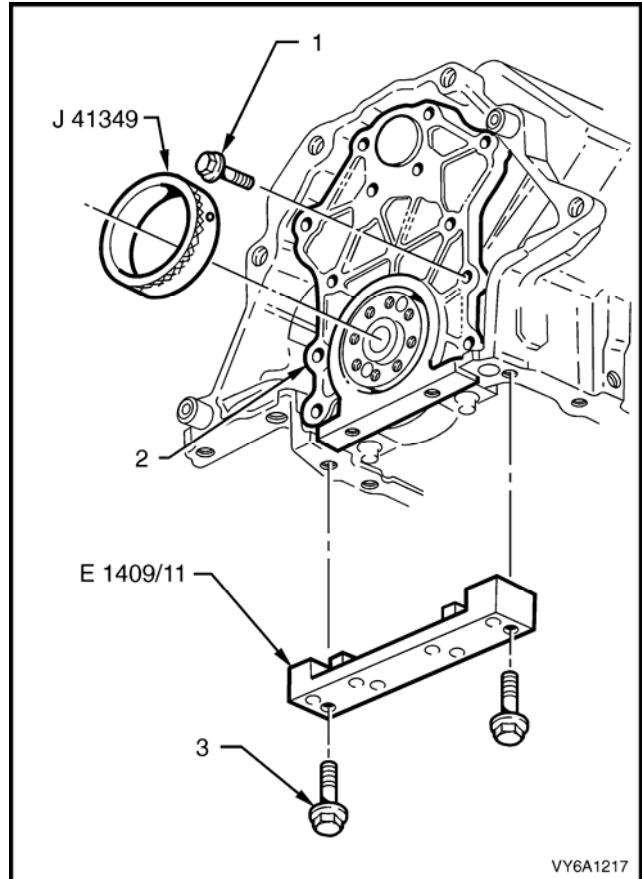


Figure 6A1-1-326

- Torque all bolts in the sequence shown and to the correct torque specification.

CRANKSHAFT REAR MAIN OIL SEAL HOUSING BOLT TORQUE SPECIFICATION	
STEP 1 Tighten bolts, in sequence	15 Nm
STEP 2. Turn through a further	50°

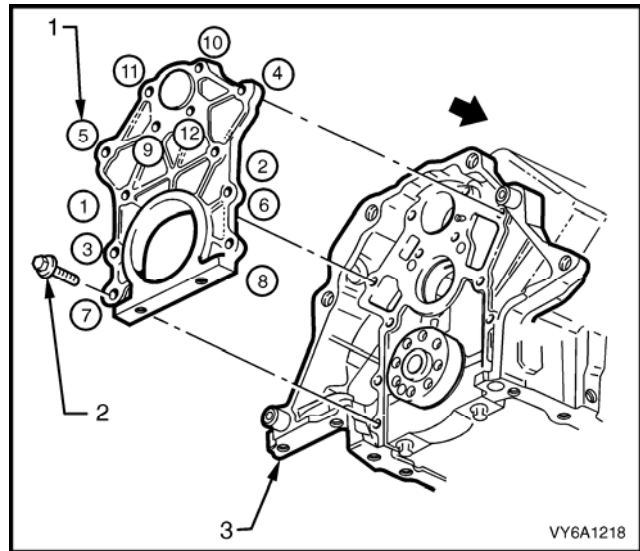


Figure 6A1-1-327

- Recheck location of housing by rotating tool J41349 on crankshaft. The tool should turn evenly without binding or tight spots.

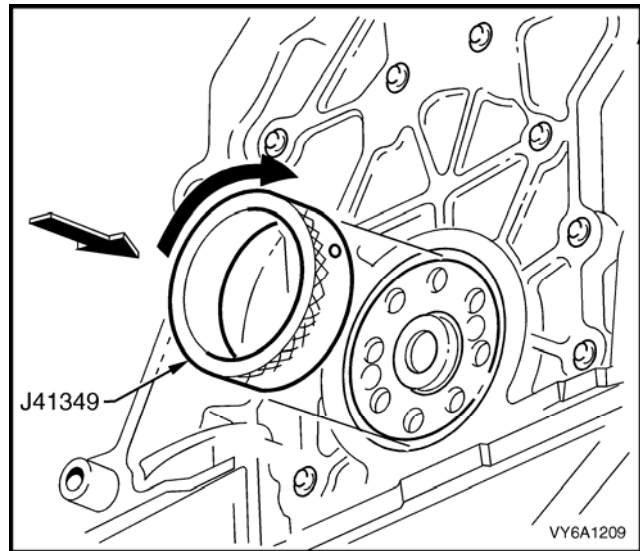


Figure 6A1-1-328

- Using feeler gauge and E1409/11, check height of rear main oil seal housing to oil pan rail. Housing must be even to -0.10 mm to oil pan rail. If not, replace rear main oil seal housing assembly and install as from step 1. Above.
- Remove tools J41349 and E1409/11.

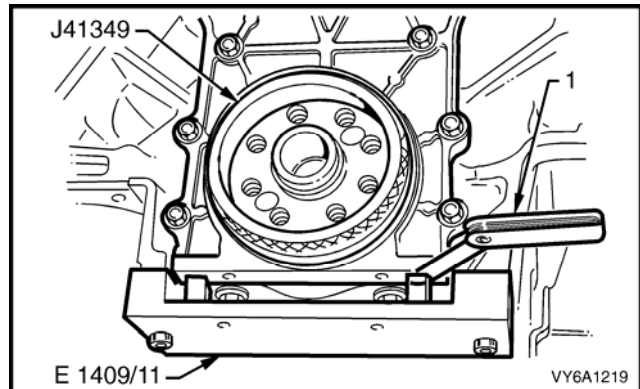


Figure 6A1-1-329

- Reinstall rear main oil seal refer to [3.13 REAR MAIN OIL SEAL](#) in this Section.
- Reinstall flywheel/flexplate using new bolts refer to [3.4 FLYWHEEL/FLEXPLATE](#) in this Section.
- Fill and bleed cooling system refer to [Section 6B1-1 ENGINE COOLING - V6 ENGINE](#).
- Refill engine with oil.
- Road test vehicle and check for oil leaks.

REVISED DESIGN HOUSING & SEAL

IMPORTANT NOTES:

- These revised components require that a totally different approach is to be taken when replacing the oil seal and/or rear main oil seal housing.
 - Do not apply or use any oil lubrication on the rear main oil seal, rear main oil seal housing or the rear main oil seal installer Tool No. EN 47623.
 - Do not touch the sealing lip of the rear main oil seal, once the protection sleeve is removed. Doing so will damage/destroy the seal.
1. Clean the crankshaft sealing surface with a clean, lint free shop cloth.
 2. Inspect the lead-in edge of the crankshaft for burrs/sharp edges that could damage the rear main oil seal. Remove any burrs/sharp edges before proceeding.
 3. Carefully remove the protection sleeve from the rear main oil seal assembly.

IMPORTANT: Notice the direction of the rear main oil seal. The new design seal is a reverse style compared to the earlier design. "THIS SIDE OUT" has been stamped into the seal as shown.

4. Install the oil seal onto EN 47623 by placing the seal on an angle and using a twisting motion until it is fully seated.

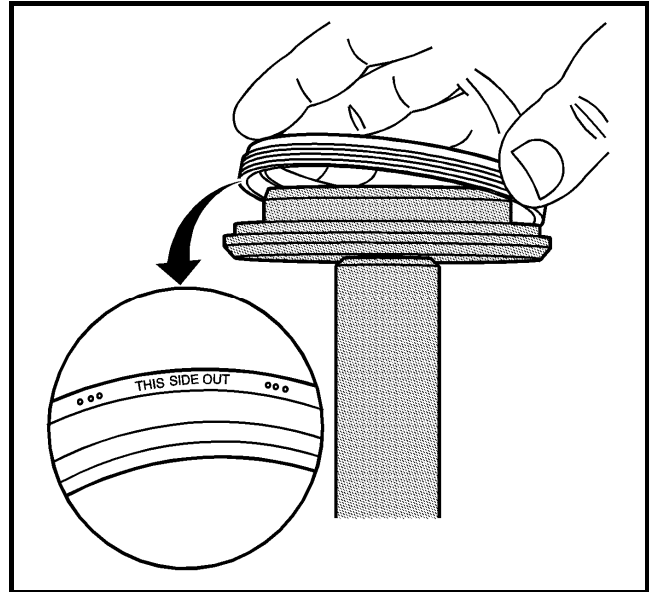


Figure 6A1-1 330

5. Install the driver handle, Tool No. J 8092 to the seal installer.
6. With the oil seal housing machined side down on a clean flat surface, apply a constant downward force on the tool, until the seal is fully installed.

NOTE: Do not use any sealant nor adhesive when installing the seal. Use of any sealant or adhesive can cause improper sealing. Not complying with this statement will cause a leak, with the possibility of causing extensive engine damage.

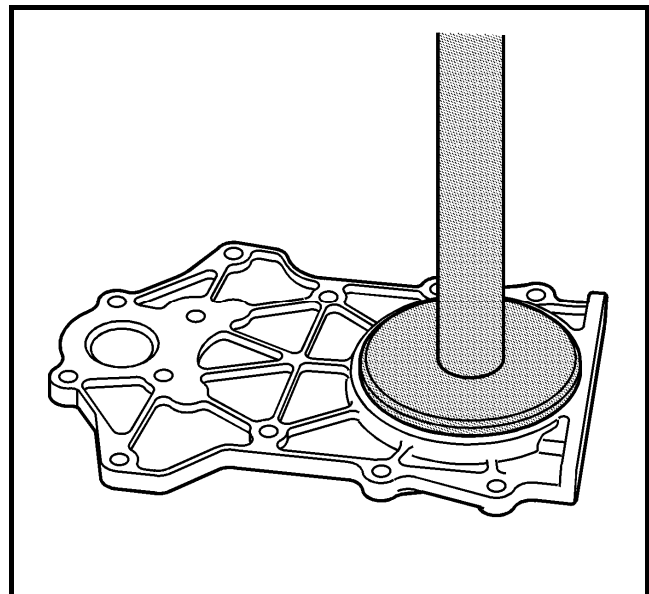


Figure 6A1-1 331

7. Using a new rear main oil seal housing gasket, install the gasket, housing and oil seal to the rear of the engine block.

NOTE: The plastic inserts in the rear main oil seal housing bolt holes are used to assist assembly only. The inserts are not required for service.

8. Install the rear main oil seal housing bolts and finger tighten only.

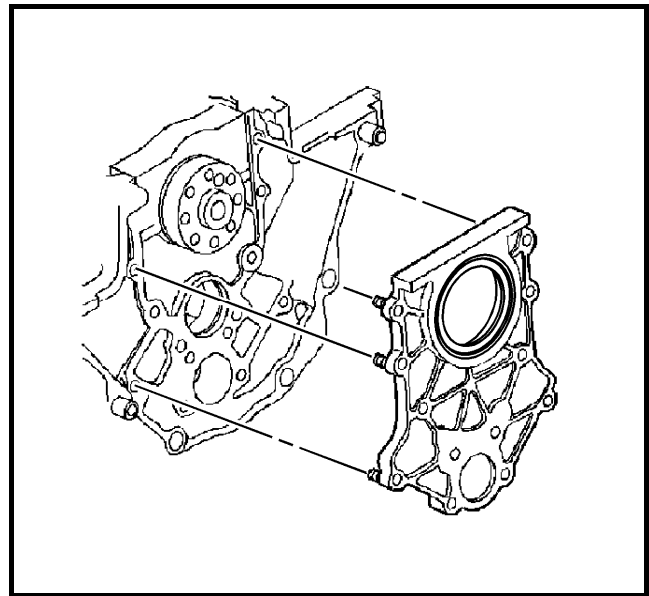


Figure 6A1-1 332

9. Place a straight edge (such as a combination square) onto the engine block oil pan flange and the rear main oil seal housing flange.
10. Use a feeler gauge to check that there is no more than 0.10 mm step on each side. If necessary, gently rotate the rear main oil seal housing assembly to make the step equal on each side.
11. When the flange is correctly aligned, tighten the rear main oil seal housing bolts to the correct torque specification.

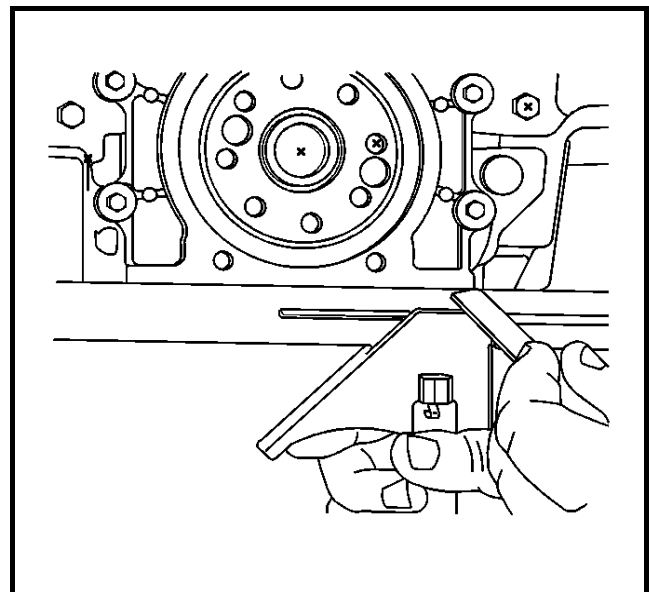


Figure 6A1-1 333

CRANKSHAFT REAR MAIN OIL SEAL HOUSING BOLTS TORQUE SPECIFICATION	
Step 1	15 Nm
Step 2	Turn through an additional 50°

12. Re-check the step height on each side of the rear main oil seal housing assembly to check that the housing did not move during the bolt tightening operation.

If the step height is not within specification, reinstall the rear main oil seal housing and measure the gap again. Replace the rear main oil seal housing if the clearance is still outside the specification.

The remainder of the installation process is the reverse to removal, noting the following:

13. Reinstall flywheel/flexplate using new bolts refer to **3.4 FLYWHEEL/FLEXPLATE** in this Section.
14. Fill and bleed cooling system refer to **Section 6B1-1 ENGINE COOLING - V6 ENGINE**.
15. Refill engine with oil.
16. Road test vehicle and check for oil leaks.

3.15 CYLINDER BLOCK

INSPECT

1. With engine removed from vehicle refer to **3.1 ENGINE ASSEMBLY** in this Section and mounted in a suitable engine stand, remove all components as outlined under the appropriate component heading in this Section.
2. Clean all cylinder block gasket surfaces.
3. If necessary, remove all coolant jacket welsh plugs, oil gallery screw plugs, knock sensors, refer to Figure 6A1-1-334 and camshaft bearings, refer to **3.8 CAMSHAFT BEARINGS** in this Section.
4. Thoroughly clean cylinder block in a suitable cleaning solution. Flush with clean coolant or steam. Spray or wipe cylinder bores and machined surfaces with engine oil.

NOTE: Caustic cleaning solutions destroy all bearing and alloy materials. All bearing and alloy components if not removed before cleaning, must be replaced. Do not clean bearing material or alloy parts with caustic solutions.

5. Check cylinder block deck surface for flatness using a straight edge and feeler gauge.

Cylinder block deck surface may be machined if any irregularity or distortion is less than specified.

If irregularity or distortion exceeds specifications, replace cylinder block.

CYLINDER BLOCK DECK SURFACE FLATNESS	
SPECIFICATION	0.013 mm per 25.4 mm OR 0.08 mm Overall

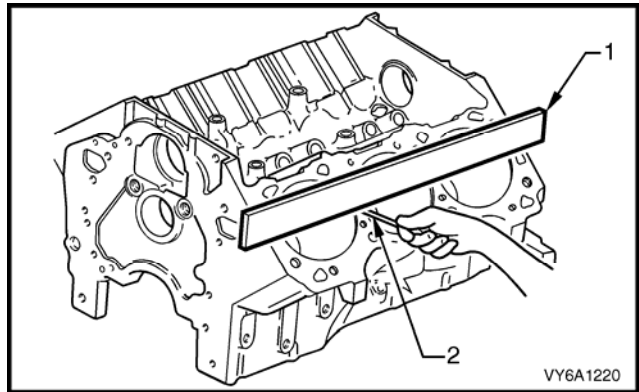


Figure 6A1-1-334

6. Inspect all oil passages for restriction.
7. Inspect oil pan and front cover attaching area for damage or burrs. Minor irregularities may be cleaned up with a fine mill file.
8. Inspect all threaded holes. If necessary clean with a suitable threaded tap or drill out and install thread insert.

The following cylinder block inspections require the main bearing caps to be installed and bolts tightened to the correct torque specification. Refer to **3.12 CRANKSHAFT** in this Section.

NOTE 1: Use an angle wrench such as E7115 to ensure accurate turn angle.

NOTE 2: Ensure that the main bearing caps are installed into the crankcase with the correct orientation and order.

NOTE 3: In order to prevent the possibility of cylinder block or bearing cap damage, do not install bearing caps using a soft faced hammer. Instead, use cap bolts to pull bearing cap into position. Failure to observe this procedure may damage the cylinder block and/or bearing cap.

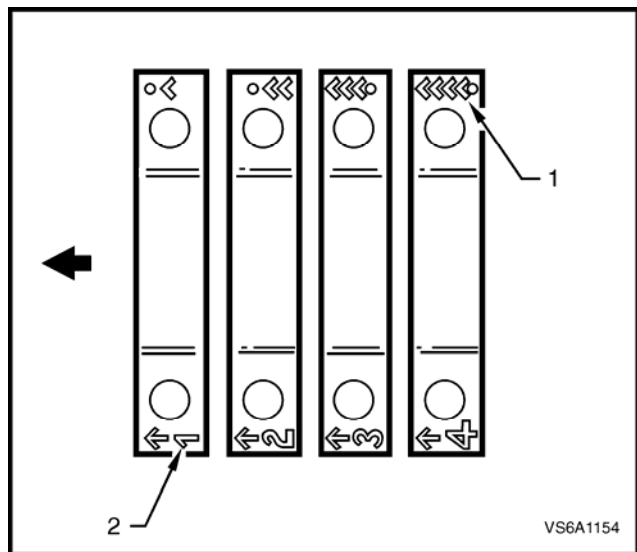


Figure 6A1-1-335

9. Measure crankshaft and camshaft bearing bores, check for concentricity and alignment.

CRANKSHAFT BEARING BORE MAXIMUM OUT-OF-ROUND	0.008 mm
CAMSHAFT BEARING BORE MAXIMUM OUT-OF-ROUND	0.013 mm

If outside specification, replace cylinder block. If examination of the outside of the bearing shells indicates minor high spots, remove high spots from bearing seats with a fine mill file.

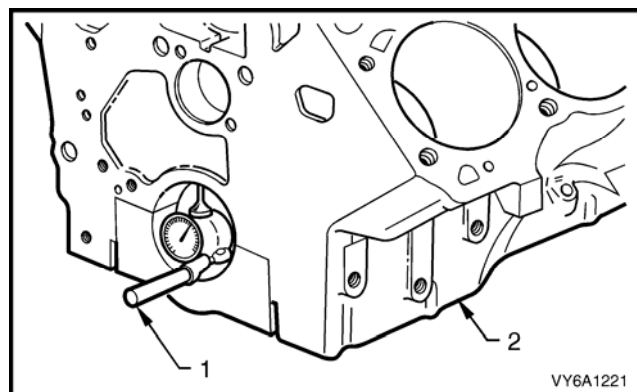


Figure 6A1-1-336

10. Measure cylinder bore walls for taper, out-of-round, oversize and excessive ridging using a commercially available bore gauge (1). If bore is worn beyond limits, it may be rebored, honed and fitted with oversize pistons.

The smallest available oversize piston should be selected, refer to Cylinder Reconditioning and Piston Fitting in this Section.

CYLINDER BLOCK DECK SURFACE FLATNESS	
STANDARD BORE DIAMETER	96.507 - 96.533 mm
MAXIMUM TAPER	0.013 mm
MAXIMUM OUT-OF-ROUND	0.010 mm

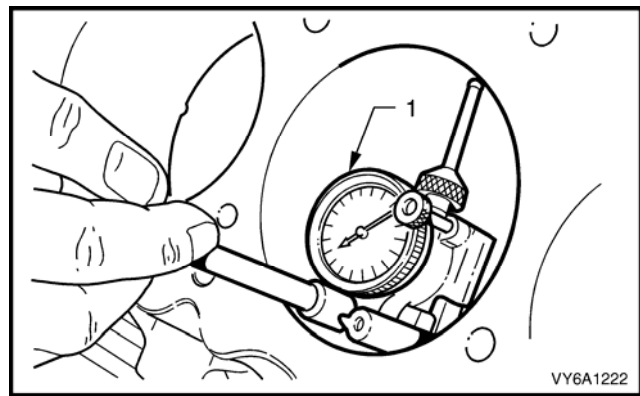


Figure 6A1-1-337

CYLINDER RECONDITIONING AND PISTON FITTING

If one or more cylinder bores are rough, scored, or worn beyond limits, it will be necessary to smooth or true up such bores to fit new pistons.

If relatively few bores require correction it will not be necessary to rebore all cylinders to the same oversize in order to maintain engine balance, since all oversize service pistons are held to the same weight as standard size pistons.

No attempt should be made to machine oversize pistons to fit cylinder bores, as this will destroy the surface treatment and affect the weight. The smallest possible oversize service pistons should be used and the cylinder bores should be honed to size for proper clearances.

Before the honing or reboring operation is started, Use an outside micrometer (1) to measure all new pistons at right angles to the piston pin bore and at 41 mm from top of piston.

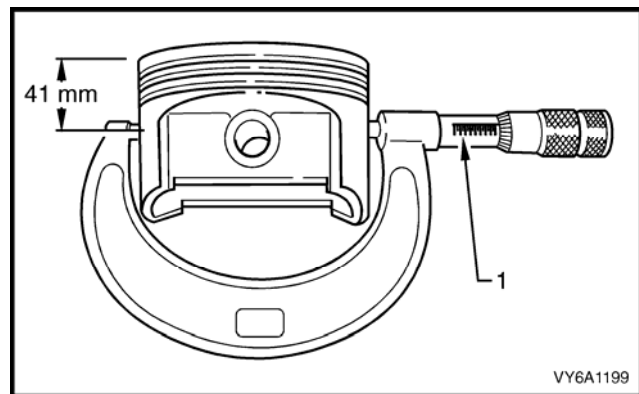


Figure 6A1-1-338

If cylinder bore wear does not exceed specification, honing is recommended for truing the bore. If wear or out-of-round exceeds specification, the bore should be trued up by boring and then hone finished.

When reboring cylinder bores, all crankshaft bearing caps must be in place and tightened to specified torque to prevent distortion of bores in final assembly.

When taking the final cut with boring bar, leave 0.025 mm on the diameter for final honing to give the specified clearance.

When cylinders are to be honed, follow the Hone Manufacturer's recommendations for the use of the hone, cleaning and lubrication during honing.

When finish honing, pass the hone through the entire length of cylinder bore at the rate of approximately 60 cycles per minute. This should produce the desired 45 degrees cross hatch pattern on cylinder walls which will ensure maximum ring life and minimum oil consumption.

During the final honing, each piston must be fitted individually to the bore in which it will be installed and marked to ensure correct assembly. After the final honing and before the piston is checked for fit, each cylinder bore must be washed and dried thoroughly to remove all traces of abrasive and then allowed to cool. Apply clean engine oil to cylinder bores. The pistons and cylinder block must be at a common temperature before checking.

When new piston rings are installed without reboring cylinders, the glazed cylinder walls should be slightly dulled, but without increasing the bore diameter, by means of the finest grade of stone in a cylinder hone.

To check piston to cylinder bore clearance, proceed as follows:

1. Wipe cylinder walls and pistons with a clean cloth. Apply clean engine oil to cylinder bores.
2. Accurately measure the bore with an inside micrometer.
3. Measure piston diameter.
4. Subtract piston diameter from cylinder bore diameter to determine piston-to-bore clearance.

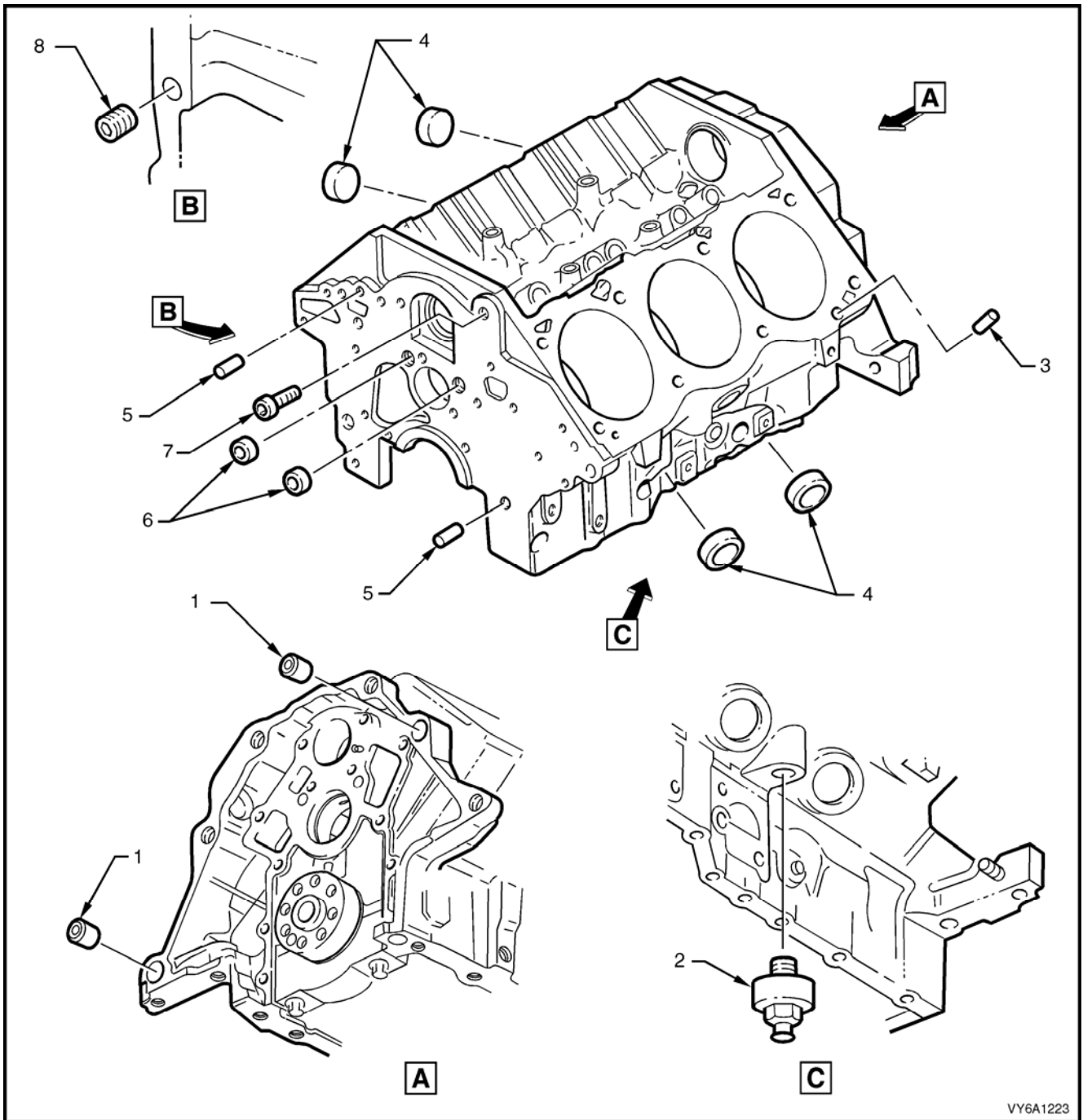
PISTON TO CYLINDER BORE CLEARANCE SPECIFICATION	0.010 - 0.051 mm
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5. Mark each piston with cylinder number to which it will be fitted and proceed to hone cylinders and fit pistons.

IMPORTANT: Handle the pistons with care and do not attempt to force them through the cylinder until cylinder has been honed to correct size, as pistons can be distorted through careless handling.

Reassemble components as outlined under the appropriate component heading in this Section.

If coolant and oil gallery plugs were removed on disassembly, coat new plugs with sealant (or its equivalent) as specified next, then install.



VY6A1223

Figure 6A1-1-339

Legend

- | | |
|--|--|
| <ul style="list-style-type: none"> 1. Clutch/Torque Converter Housing Locating Pins 2. Knock Sensor * 3. Cylinder Head Locating Pins * 4. Cylinder Block Coolant Welch Plugs * | <ul style="list-style-type: none"> 5. Front Cover to Cylinder Block Locating Pins * 6. Front Oil Gallery Welch Plugs 7. Upper LHS Screw Plug (Cylinder Block Front Face) 8. Oil Gallery Side Plug * Apply Loctite 242 (or equivalent) at these Locations. |
|--|--|

4. ENGINE MECHANICAL DIAGNOSIS

The following diagnostic information covers common problems and possible causes. When the proper diagnosis is made, the problem should be corrected by adjustment, repair or part replacement as required. Refer to the appropriate section of the Service Information for these procedures.

In the mechanical procedures described in this section, generally no references will be made to the removal of optional equipment such as power steering pump, air conditioning compressor, etc.

Should it become necessary to remove any such item to perform other service, refer to the appropriate section of the Service Information.

4.1 EXCESSIVE OIL LOSS

Excessive oil consumption (not due to leaks) is the use of 2 litres or more of engine oil within 10,000 km after the engine has completed at least 10,000 km.

Excessive oil loss may result from one or more of the following conditions:

1. External oil leaks. Tighten bolts and/or replace gaskets and seals as necessary.
2. Improper reading of oil indicator (dipstick). Check oil with car on a level surface and allow adequate drain-down time.
3. Continuous high speed driving, and/or severe usage such as towing, will normally cause increased oil consumption.
4. PCV system malfunctioning.
5. Improper oil viscosity. Use recommended SAE viscosity for prevailing temperatures. Refer to [2.2 ENGINE OIL CHANGE](#), in this Section.
6. Valve guides and/or valve stem seals worn, or seals omitted. Ream guides and install oversize service valves and/or new valve stem seals.
7. Piston rings improperly installed, broken, worn, or not seated. Allow adequate time for rings to seat. Replace broken or worn rings as necessary.
8. Piston incorrectly installed or badly fitted.

OIL LEAK DIAGNOSIS

Most oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions, an oil leak may be difficult to locate or repair. The following procedure may help in locating and repairing most leaks.

Finding The Leak

1. Identify the fluid, determine whether it is engine oil, transmission lubricant, power steering fluid, etc.
2. To determine where the fluid is leaking, run the car at normal operating temperature, park the car over a large sheet of paper. After a few minutes, the approximate location of the leak should be able to be found by observing the oil spots on the paper.
3. Visually check around the suspected component. Check all gasket mating surfaces. A mirror may be used to find leaks in hard to reach areas.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam or spray solvent. Operate the car for several kilometres at normal operating temperature and varying speed. After operating the car, visually check the suspected component. If the location of the leak still cannot be found, try using the following powder or black light and dye method.

Powder Method

1. Clean the suspected area.
2. Apply an aerosol-type powder (such as foot powder) to the suspected area.
3. Operate the car under normal conditions.
4. Visually inspect the suspected component. Trace the leak path over the white powder surface to the source.

Black Light And Dye Method

Various dye and light kits are available for finding leaks. Refer to the kit manufacturer's directions when using the kit.

1. Pour specified amount of dye into leaking component.
2. Operate the car under normal operating conditions as directed in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing The Leak

Once the leak has been pinpointed and traced back to its source, the cause of the leak must be determined in order for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check to be sure that the following conditions are correct as they may cause a leak.

Gaskets-Inspect

1. Fluid level/pressure is too high.
2. Plugged ventilation filter or valve.
3. Improperly tightened fasteners or dirty/damaged threads.
4. Scratches, burrs or other damage to the sealing surface.
5. Warped flanges or sealing surfaces.
6. Damaged or worn gasket.
7. Cracking or porosity of the component.
8. Improper sealant used (where applicable).

Seals-Inspect

1. Fluid level/pressure is too high.
2. Plugged ventilation filters, or valve.
3. Damaged seal bore (scratched, burred or nicked).
4. Damaged or worn seal.
5. Improper installation.
6. Cracks in component.
7. Shaft surface scratched, nicked or damaged.
8. Loose or worn bearing causing excess seal wear.

4.2 LOW OIL PRESSURE

Oil pressure that is below 375 kPa at engine speeds above 1,850 rpm is considered low and may result from one or more of the following conditions:

1. Low oil level. Fill to mark on oil level indicator.
2. Incorrect or malfunctioning oil pressure sender or gauge.
3. Improper oil viscosity for expected temperature, or oil diluted with moisture or unburned fuel mixtures.
4. Oil pump worn or dirty.
5. Blocked oil filter.
6. Oil pump suction pipe screen blocked.
7. Hole in oil pump suction pipe.
8. Excessive bearing clearance.
9. Cracked, porous or blocked oil galleries. Repair or replace block.
10. Gallery plugs missing or badly installed. Reinstall plugs or repair as necessary.
11. Sticking pressure regulator (idle).

4.3 ENGINE NOISE DIAGNOSIS

There are four steps to diagnosing engine noise.

The following should be determined:

1. Type of noise.
2. Under which operating conditions the noise exists.
3. At what rate, and at what location in the engine.
4. Is the noise due to normal operation. Compare the sounds to that in other V6 engines to make sure you are not trying to correct a normal condition.

Identify the **type** of noise, for example, a light rattle or low rumble. Determine the exact operating conditions under which the noise appears.

Engine noises are generally synchronised to either engine speed (caused by the crankshaft, connecting rods or pistons) or one half the engine speed (valve train noises). Try to determine the rate at which the noise is occurring.

MAIN BEARING NOISE

Damaged or worn main bearing noise is revealed by dull thuds or knocks which happen on every engine revolution, and this noise is loudest when the engine is under heavy load.

Excessive crankshaft end play is indicated by an intermittent rap or knock sharper than a worn main bearing.

Causes of main bearing noises include:

1. Low oil pump pressure.
2. Thin diluted or dirty oil and/or oil filter.
3. Excessive main bearing clearance.
4. Excessive crankshaft end play.
5. Out-of-round crankshaft journals.
6. Excessive belt tension.
7. Loose crankshaft pulley.
8. Loose flywheel or torque converter.
9. Loose main bearing cap.

CONNECTING ROD BEARING NOISE

A damaged or worn connecting rod bearing will produce a knock under all speeds. During the early stages of wear, connecting rod noise may be confused with piston slap or loose piston pins. Connecting rod knock noise increase in volume with engine speed and is at its loudest on deceleration.

Causes of connecting rod bearing noise include:

1. Excessive bearing clearance.
2. Worn crankshaft connecting rod journal.
3. Thin, diluted or dirty oil and/or oil filter.
4. Low oil pressure.
5. Crankshaft connecting rod journals out of round.
6. Misaligned connecting rod.
7. Connecting rod bolts not correctly torqued.
8. Wrong bearing inserts or misaligned bearing half.

TIMING CHAIN AND SPROCKETS

The most common noise caused by a timing chain and sprockets is a high frequency, light knocking sound. This sound will generally be the same in intensity whether the engine is idling, operating at high speeds, or under load.

Causes of timing chain and sprocket noises include:

1. Worn timing chain and/or sprockets.
2. Misaligned sprockets.
3. Stretched or damaged timing chain.
4. Worn or faulty timing chain damper.
5. Sprocket loose or improperly seated on shaft.
6. Damaged sprocket.
7. Too much end play in camshaft or crankshaft.

PISTON NOISES

Piston pin, piston and connecting rod noises are difficult to separate. A loose piston pin, for example, causes a sharp double knock usually heard when the engine is idling, or during sudden acceleration then deceleration of the engine. A piston pin that has been improperly fitted will emit a light ticking noise that is more noticeable with no load on the engine.

Excessive piston to cylinder bore clearance will cause piston slap noise. The noise is similar to a metallic knock, as if the piston were "slapping" the cylinder wall during its stroke. As with most engine noises, understanding the cause of the noise will help you imagine what the noise sounds like. An indication of piston slap is a decrease in noise as the engine warms up. When the engine is cold, the piston to bore clearance is greater and piston slap will be louder.

Causes of piston noises include:

1. Worn or loose piston pin or bushing.
2. Improper fit of pin.
3. Excessive piston to cylinder bore clearance.
4. Lack of lubrication.
5. Carbon deposits on top of piston striking cylinder head.
6. Worn or broken piston ring land.
7. Broken or cracked piston.
8. Misaligned connecting rods.
9. Worn or damaged rings.
10. Worn or out-of-round cylinder walls.
11. Excessive ring land clearance.
12. Insufficient ring end gap clearance.
13. Piston 180° out of position.
14. Incorrect piston cam grind.

VALVE TRAIN

A light tapping at one half engine speed, or any varying frequency, can indicate a valve train problem. These tapping noises increase with engine speed.

Before attempting to judge valve train noises, thoroughly warm up engine. By doing this you will bring all engine components to a normal state of expansion. Also run the engine at various speeds and listen for engine noise with the hood closed while sitting in the drivers seat.

If the valve mechanism is abnormally noisy, remove rocker arm covers and use a stethoscope to determine which valves or valve train parts are causing the noise.

Valve train noises may be caused by one or more of the following:

1. Broken or weak valve springs.
2. Sticking or warped valves.
3. Bent push rods.
4. Dirty, stuck or worn valve lifters.
5. Damaged or improperly machined camshaft lobes.
6. Insufficient or poor oil supply to valve train (low oil pressure).
7. Excessive valve stem to guide clearance.
8. Worn valve guides.
9. Worn push rods.
10. Worn rocker arms.
11. Broken rocker arm stud.
12. Loose or worn rocker arm attachments.
13. Missing or mis-positioned lifter guides.

4.4 ENGINE KNOCK DIAGNOSIS

KNOCKS WHEN ENGINE COLD AND CONTINUES FOR TWO OR THREE MINUTES

Cold engine piston knock usually disappears when the cylinder is grounded out. Cold engine piston knock that disappears in 1.5 minutes should be considered acceptable.

Increases with torque:

1. Loose or broken balancer or drive pulleys. Tighten or replace as necessary.
2. Excessive piston to bore clearance. Replace piston.
3. Bent connecting rod.
4. Rod bearing; oil supply at start-up.

HEAVY KNOCK WHEN HOT AND WITH TORQUE APPLIED

This condition may be caused by one or more of the following:

1. Broken balancer or pulley hub. Replace parts as necessary.
2. Loose torque converter to flexplate attaching bolts.
3. Exhaust system contacting underbody. Reposition as necessary.
4. Flywheel/flexplate cracked.
5. Excessive main bearing clearance.
6. Excessive connecting rod bearing clearance.
7. Low fuel quality.

LIGHT KNOCK WHEN HOT

This condition may be caused by one or more of the following:

1. Detonation or spark knock. Check fuel quality.
2. Loose torque converter to flexplate attaching bolts.
3. Exhaust leak at manifold.
4. Excessive connecting rod bearing clearance.

KNOCKS ON INITIAL START-UP BUT ONLY LASTS A FEW SECONDS

This condition may be caused by one or more of the following:

1. Improper oil viscosity. Use proper oil viscosity for expected temperatures. Refer to [2.2 ENGINE OIL CHANGE](#), in this Section.
2. Hydraulic lifter bleed down. When the engine is stopped, some valves will be open. Spring force against lifters will tend to bleed lifter down. Attempts to repair should be made only if the problem is consistent.
3. Excessive crankshaft end float. Replace crankshaft thrust bearing shells.
4. Excessive front main bearing clearance. Replace worn parts.
5. Excessive piston or rod clearance. Replace worn parts.
6. Timing chain tensioner malfunction. Clean, inspect and replace if required.

KNOCKS AT IDLE, ENGINE HOT

This condition may be caused by one or more of the following:

1. Loose or worn drive belt. Check drive belt condition and tension. Replace as necessary.
2. Air conditioning compressor or generator bearing noisy. Replace as necessary.
3. Worn valve train components. Replace parts as necessary.
4. Improper oil viscosity. Use proper viscosity oil for expected temperature. Refer to [2.2 ENGINE OIL CHANGE](#), in this Section.
5. Excessive piston pin clearance. Replace piston and pin.
6. Connecting rod alignment. Check and replace rods as necessary.
7. Insufficient piston to bore clearance. Hone bore and fit new piston.
8. Loose crankshaft balancer. Torque retaining bolt and/or replace worn balancer.
9. Piston pin offset to wrong side. Install piston correctly.

VALVE TRAIN NOISE

This condition may be caused by one or more of the following:

1. Low oil pressure. Repair as necessary (refer to diagnosis for low oil pressure).
2. Loose rocker arm attachments. Inspect and repair as necessary.
3. Worn rocker arm, pivot, and/or pushrod.
4. Broken valve spring.
5. Sticking valves.
6. Lifters worn, dirty, or defective.
7. Camshaft worn, or faulty machining. Replace camshaft.
8. Worn valve guides.

4.5 HYDRAULIC VALVE LIFTERS

Hydraulic valve lifters seldom require attention. The lifters are extremely simple in design, readjustments are not necessary and servicing of the lifters requires only that care and cleanliness be exercised in the handling of parts. The easiest method for locating a noisy valve lifter is by use of a piece of garden hose near the end of each Intake and exhaust valve with the other end of the hose to the ear.

In this manner, the sound is localised, making it easy to determine which lifter is at fault.

Another method is to place a finger on the face of the valve spring retainer. If the lifter is not functioning properly, a distinct shock will be felt when the valve returns to its seat.

The general types of valve lifter noise are as follows:

1. Momentary noise when car is started. This condition is normal. Oil drains from the lifters which are holding the valves open when the engine is not running. It will take a few seconds for the lifter to fill after the engine has started.

2. Intermittent noise at idle only, disappearing when engine speed is increased. Intermittent clicking may be an indication of a flat or pitted ball, or it may be caused by dirt.

Correction: Clean the lifter and inspect. If ball is defective, replace lifter.

3. Noisy at slow idle or with hot oil, quiet with cold oil or as engine speed is increased. Insert a 0.375 mm feeler gauge between the rocker arm and valve stem. If noise momentarily disappears and then re-appears after a few seconds, the lifter leak-down rate is too fast.

Correction: The lifter must be replaced.

4. Noisy at high car speeds and quiet at low speeds.

a. High oil level. Oil level above the FULL mark allows crankshaft counterweights to churn the oil into foam. When foam is pumped into the lifters, they will become noisy since a solid column of oil is required for proper operation.

Correction: Drain oil until proper level is obtained.

b. Low oil level. Oil level below the ADD mark allows the pump to pump air at high speeds which results in noisy lifters.

Correction: Fill until proper oil level is obtained.

c. Oil suction screen and pipe loose. Repair or replace as necessary.

5. Noisy at idle becoming louder as engine speed is increased to 1500 rpm.

This noise is not connected with lifter malfunction and is caused by one or more of the following:

- Badly worn or scuffed valve tip and rocker arm pad.
- Excessive valve stem to guide clearance.
- Excessive valve seat run-out.
- Off-square valve spring.
- Off-square rocker arm pad.
- Excessive valve face run-out.
- Valves noisy regardless of engine speed.

This condition can be caused by foreign particles or valve lash.

Check for lash by turning engine so the piston in that cylinder is on top dead centre of firing stroke. If valve lash is present, the pushrod can be freely moved up and down a certain amount with rocker arm held against valve. If this occurs, replace suspected valve lifters

Valve lash indicates one of the following:

- a. Worn pushrod.
- b. Worn rocker arm.
- c. Lifter plunger stuck in down position due to dirt or carbon.
- d. Faulty lifter.

When checking the above items

1. Look at the upper end of pushrod. Excessive wear of the spherical surface indicates one of the following conditions:

a. Improper hardness of pushrod ball. The pushrod and rocker arm must be replaced.

b. Improper lubrication of pushrod and rocker arm. The oiling system to the pushrod should be checked.

2. If pushrod appears in good condition and has been properly lubricated, replace rocker arm and recheck for valve lash.

3. If valve lash exists and pushrod and rocker arm are OK, trouble is in the lifter. Lifter should be replaced.

5. SPECIFICATIONS

GENERAL

Engine Model Year	2003
Type	90° V6, OHV
Displacement	3791 cm ³
Compression ratio.....	9.35:1
Number of cylinders.....	6
Firing order.....	1-6-5-4-3-2
Cylinder numbering-front to rear	
Left bank.....	1-3-5
Right bank.....	2-4-6
Taxable horsepower (RAC or SAE).....	34.6
Power.....	152 kW @ 5200 rpm
Torque.....	305 Nm @ 3600 rpm
Bore and stroke (nominal)	96.52 x 86.36 mm
Fuel research octane rating.....	91
Fuel requirement.....	Unleaded

CYLINDER BLOCK

Bore diameter	96.507 – 96.533 mm
Bore out-of-round.....	0.010 mm max.
Bore taper	0.013 mm max.
Cylinder block to cylinder head surface flatness	0.08 mm max. overall or 0.13 mm per 25.4 mm
Crankshaft bearing bore maximum out-of-round.....	0.08 mm
Camshaft bearing bore maximum out-of-round.....	0.013 mm

CRANKSHAFT

Material	Cast Nodular Iron
Main bearing journals	
Diameter	63.470 – 63.495 mm
Out-of-round	0.06 mm max.
Taper.....	0.08 mm max.
Cylinder block bore.....	68.250 – 68.270 mm
Crankshaft end clearance.....	0.08 – 0.28 mm
Bearing clearance #1.....	0.0178 – 0.0406 mm
#2, 3 and 4.....	0.0229 – 0.0457 mm
End thrust.....	Against main bearing No. 2
Connecting rod journals	
Diameter	57.117 – 57.147 mm
Out-of-round	0.005 mm max.
Taper.....	0.08 mm max.
Connecting rod bore	60.295 – 60.312 mm
Bearing clearance.....	0.023 – 0.053 mm
Side clearance	0.10 – 0.50 mm
Crankshaft rear flange run-out.....	0.05 mm max.

CONNECTING RODS

Type	Malleable Cast Iron 'I' Section
Length (centre to centre)	145.90 – 145.80 mm
Alignment.....	Bend 0.020/25.4 mm, Twist 0.038/25.4 mm

PISTONS

Material	Cast Aluminium Alloy
Piston diameter (41 mm from top of piston)	96.482 – 96.497 mm
Piston to bore clearance	0.010 – 0.051 mm
Piston pin bore offset and direction	0.25 – 0.55 mm, Major thrust side
Piston and pin assemblies serviced	Std and 0.508 Oversize
Ring groove widths	
Compression ring upper	1.230 – 1.255 mm
Compression ring lower	1.530 – 1.555 mm
Oil control ring.....	2.030 – 2.055 mm

PISTON PINS

Material	Steel – Case Hardened and Tempered
Length	65.0 – 65.5 mm
Diameter	21.995 – 22.000 mm
Pin to piston clearance	0.002 – 0.013 mm
Pin to rod clearance.....	0.007 – 0.022 mm

PISTON RINGS

Compression ring upper	
Type	Steel, Balanced Section Molybdenum Filled, Barrel Lapped.
Width.....	1.176 – 1.191 mm
Gap	0.305 – 0.559 mm
Piston ring to groove clearance	0.039 – 0.079 mm
Compression ring lower	
Type	Inverted Torsional Taper Faced Type
Width.....	1.476 – 1.491 mm
Gap	0.762 – 1.016 mm
Piston ring to groove clearance	0.039 – 0.079 mm
Oil control ring type.....	Segmented with Circumferential Expander Type Spacer
Width (ring assembly).....	1.854 – 2.007 mm
Ring assembly to groove clearance	0.023 – 0.201 mm
Rail gap.....	0.254 – 0.762 mm

CAMSHAFT

Material	5150 Steel
Bearing journal	
Diameter	46.858 – 46.893 mm
Number	4
Bearing diameter (installed) Numbers 1 and 4.....	46.934 – 46.970 mm
Numbers 2 and 3.....	46.942 – 46.977 mm
Clearance in bearings – All.....	0.041 – 0.119 mm
Camshaft end float (gear and bolt installed).....	0.04 – 0.26 mm
Camshaft lobe lift	
Intake	6.56 mm
Exhaust.....	6.56 mm
Valve timing (with 0.004" valve lift)	
Intake	
Opens – BTDC	8.4 degrees
Closes – ABDC.....	70.6 degrees
Duration	324 degrees
Exhaust	
Opens – BBDC	63.6 degrees
Closes – ATDC.....	28.4 degrees
Duration	334 degrees

CYLINDER HEAD

Thickness (refer [Figure 6A1-1-112](#) in this Section) .. 1.12 mm minimum

Minimum combustion chamber volume (with valves
and spark plugs installed) 60 cm³

VALVE - INTAKE

Material High Manganese Medium Carbon Steel

Diameter head 46.37 – 46.63 mm

Diameter stem..... 7.950 – 7.970 mm

Angle valve face..... 46 degrees

Angle valve seat (in head) 45 degrees

Width valve seat (in head) 1.78 mm

Valve seat run-out..... 0.05 mm

Clearance in guide 0.04 – 0.25 mm

Valve installed height (from valve tip to spring seat) . 49.22 – 50.49 mm

Valve head margin thickness..... 0.63 mm minimum

Valve oversize available 0.25 mm

VALVE - EXHAUST

Material High Alloy Exhaust Valve Steel

Diameter head 38.48 – 38.74 mm

Diameter stem..... 7.948 – 7.965 mm

Angle valve face..... 46 degrees

Angle valve seat (in head) 45 degrees

Width valve seat (in head) 2.16 mm

Valve seat run-out..... 0.05 mm

Clearance in guide 0.04 – 0.25 mm

Valve installed height (from valve tip to spring seat) . 49.22 – 50.49 mm

Valve head margin thickness..... 0.63 mm minimum

Valve oversize available 0.25 mm

VALVE SPRINGS

Valve spring force

At assembled height 316 – 351 N @ 43.7 mm

At valve opened height 970 – 1059 N @ 32.4 mm

Valve spring at installed height..... 43.7 ± .5 mm

Valve spring allowable variance in spring end length 1.6 mm

BALANCE SHAFT

End play 0 – 0.171 mm

Front bearing, radial play 0 – 0.026 mm

Front bearing bore diameter 51.973 – 51.999 mm

Rear journal diameter 38.085 – 38.105

Rear bearing inside diameter..... 38.118 – 38.194 mm

Rear bush clearance..... 0.012 – 0.109 mm

Drive gear backlash 0.050 – 0.125 mm

Installation depth of rear bearing from rear seal
cover mounting face 0.99 – 1.49 mm

FLEXPLATE

Flexplate Run-out 0.38 mm

TIMING CHAIN

Timing chain movement..... 25.4 mm max.

LUBRICATION SYSTEM

Type of lubrication

Main bearings	Pressure
Connecting rod bearings.....	Pressure
Piston pins	Splash
Camshaft bearings.....	Pressure
Timing chain	Splash
Balance shaft front bearing.....	Splash
Balance shaft rear bearing.....	Pressure
Cylinder walls.....	Splash

OIL PUMP

Oil pump type.....	Gerotor
Oil pressure regulator	Approx 414 kPa
Oil pressure hot	375 kPa minimum @ 1850 RPM and above
Oil filter by-pass valve.....	Unseats at approx. 69 kPa pressure differential

Oil pump gears

Inner gear tip to outer gear clearance	0.152 mm max.
Outer gear to housing clearance	0.203 – 0.381 mm max.
Inner and outer gear end to housing clearance.....	0.025 – 0.089 mm

Gear Pocket

Depth	11.71 – 11.75 mm
Diameter	89.10 – 89.20 mm

Pressure regulator valve to bore clearance.....	0.038 – 0.076 mm
---	------------------

Oil pressure warning switch setting

contacts open (light off)	Less than 41.4 kPa (pressure increasing)
contacts close (light on).....	More than 13.8 kPa (pressure decreasing)

Oil pan capacity (less filter).....	5.2 litres
-------------------------------------	------------

Oil filter

Type.....	Full flow disposable canister
Capacity	0.4 litres

SEALANTS

Intake manifold front and rear seal corners	RTV 732 or equivalent
Cylinder block coolant welch plugs.....	Loctite 242 or equivalent
Right and left hand knock sensors to cylinder block..	Loctite 242 or equivalent
Oil gallery plug at lower front right hand side of cylinder block	Loctite 242 or equivalent
Two oil gallery welch plugs at front face of cylinder block	Loctite 242 or equivalent
Three idler pulley mounting studs into front left hand side of cylinder block	Loctite 242 or equivalent
Oil pressure switch into oil filter adaptor.....	Loctite 242 or equivalent
Coolant temperature sender units to lower Intake manifold.....	Loctite 242 or equivalent
Brake booster vacuum fitting to upper intake manifold	Loctite 242 or equivalent
Front cover to cylinder block attaching bolt threads ..	Loctite 242 or equivalent
Cylinder head bolt threads.....	Loctite 242 or equivalent
Alternator brace bracket front bolt into right hand cylinder head.....	Loctite 242 or equivalent
Plug into left hand cylinder head on Intake manifold mounting face.....	Loctite 242 or equivalent
Intake manifold to cylinder head bolts	Loctite 242 or equivalent
Oil suction pipe attaching bolt threads.....	Loctite 242 or equivalent
Oil filter adaptor long bolt threads.....	Loctite 242 or equivalent
Main bearing cap side bolts	Recommend replacement with new bolts, to ensure bolt under-head sealing to cylinder block
Four corners of oil pan to cylinder block.....	Loctite 5900 or equivalent to GM Specification 9985990.

LUBRICANTS

Engine internal components during overhaul
(unless specified)
Camshaft lobes
Hydraulic valve lifters and bores.....
Pushrod contact surfaces
Oil pump gears and pump cavity

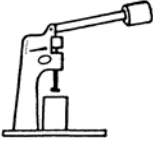

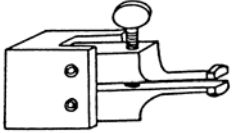
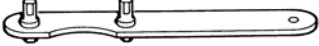
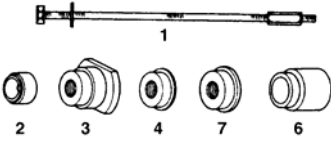

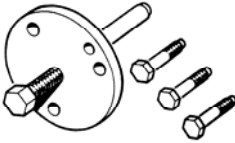

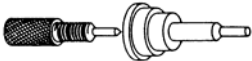
SJ GF2 10W-30 Quality Engine Oil
Molybdenum HE50 as a grease or an aerosol spray
Molybdenum HE50 as a grease or an aerosol spray
Molybdenum HE50 as a grease or an aerosol spray
Petroleum Jelly


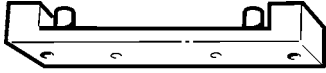
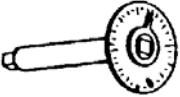
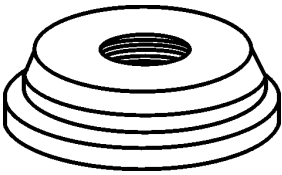
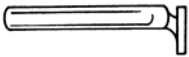
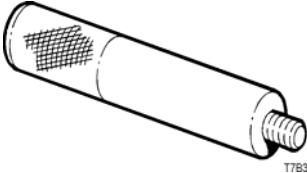
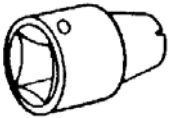
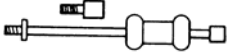
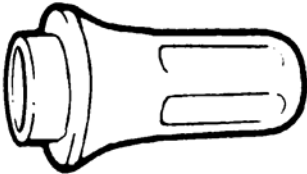
6. TORQUE WRENCH SPECIFICATIONS

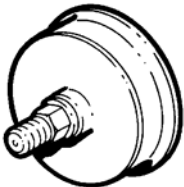
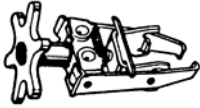
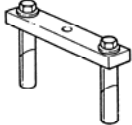
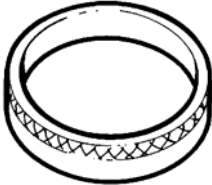
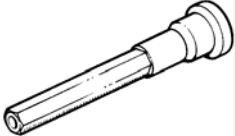
	Nm
Air Conditioning Compressor to Mounting Bracket Bolts	50
Auto. Trans. Fluid Cooler Line Retainer to Oil Pan Screw.....	10
Balance Shaft Retainer Bolts	30
Balance Shaft Driven Gear Retaining Bolt	22 plus 70° turn angle
Battery Harness Retaining Bracket to Oil Pan Bolt.....	10
Brake Booster Vacuum Fitting to Upper Intake Manifold.....	13
Camshaft Sprocket Bolt.....	100 Nm plus 90° turn angle
Camshaft Thrust Plate to Cylinder Block Attaching Bolt	15
Camshaft Position Sensor to Front Cover Attaching Bolt	10
Canister Purge Solenoid Bracket Attaching Bolt.....	35
Clutch Pressure Plate to Flywheel Bolts	32
Connecting Rod Cap Bolts	28 Nm plus 50° turn angle
Coolant Inlet Tube to Belt Tensioner Stud Nut	22
Coolant Pump Pulley Bolts.....	15
Coolant Pump to Cylinder Block Attaching Bolts	30
Coolant Pump to Front Cover Attaching Bolts	10
Coolant Temperature Sensor.....	25
Coolant Outlet to Intake Manifold Bolts.....	28
Crank Angle Sensor to Front Cover Attaching Studs.....	30
Crankshaft Balancer Attaching Bolt	300
Cylinder Head Bolts (In Sequence) Step 1.....	34 Nm
Step 2.....	Turn through 90°
Step 3.....	90 Nm
Drive Belt Tensioner Retaining Studs	50
Drive Belt Tensioner Pulley Retaining Bolt	45
EGR Valve Adaptor to Head Bolts	50
EGR Valve Adaptor to Exhaust Manifold Nut.....	25
EGR Pipe Outlet to Adaptor Attaching Bolt.....	30
EGR Valve to Adaptor Attaching Nuts	30
Engine Dress Cover Decorative Nut	5
Engine Pipe to Manifold Nuts.....	27
Exhaust Manifold to Cylinder Head Studs and one bolt.....	30
Exhaust Manifold Stud Lock Nuts	24
Front Cover Attaching Bolts/Studs	30
Front Engine Mount to Mounting Bracket and Crossmember Nut	50
Front Mounting Bracket to Cylinder Block Attaching Bolts.....	50
Flywheel Attaching Bolts	20 Nm plus 85° turn angle
Flexplate Attaching Bolts.....	20 Nm, plus 50° turn angle
Fuel Rail to Intake Manifold Bolts.....	10
Generator Brace Bracket to Cylinder Head Bolt	50
Harness mounting bracket to lower manifold bolt	8
Ignition Coil Securing Screws.....	5
Idler Pulley Housing/Coil Mounting Bolts to Cylinder Head	45
Idler Pulley Bolt.....	45
Intake Manifold Cover Bolts	10
Knock Sensor	20
Knock Sensor Shield to Cylinder Block Bolt Right Side.....	30
Lower Drive Belt Idler Housing Mounting Nuts (A/C only)	25
Lower Idler Pulley Bolt (A/C only).....	45
Lower Intake Manifold Attaching Bolts (In sequence).....	15

Main Bearing Cap Bolt Tightening Sequence:	
To Fully Seat Each Cap, Tighten to	70 Nm, then loosen each, 360°
Re-Tighten Each Bolt to	20 Nm, then 40 Nm
Finally	35 ° three times = 105° total
Main Bearing Cap Side Bolts	15 Nm plus 45° turn angle.
Oil Cooler Connector Shaft (Where Fitted)	50
Oil Filter Adaptor to Front Cover Attaching Bolts	30
Oil Gallery Screw Plug (Front right hand side cylinder block	25
Oil Pressure Sender Unit.....	13
Oil Pan Attaching Bolts.....	14
Oil Pan Drain Plug.....	45
Oil Pan to Transmission Housing Bolt.....	55
Oil Pump Cover Screws	11
Oil Pump Suction Pipe Flange to Cylinder Block Bolts	10
Rear Mounting to Crossmember Nuts – All Transmissions	25
Rear Crossmember to Side Frame Bolts	55
Rear Main Oil Seal Housing Bolts (In Sequence)	15 Nm plus 50° turn angle.
Rear Mounting to Rear Transmission Case (Man. Trans)	50
Rear Mounting to Rear Extension Bolts (A/Trans).....	55
Rocker Cover Fasteners	10
Rocker Arm Pedestal Bolts	15 Nm plus 90° turn angle.
Spark Plugs	25
Stabiliser Bar Ball Joint Stud Retaining Nut.....	50
Starter Motor Attaching Bolts	43
Steering Gear Housing to Crossmember Nut	80
Valve Lifter Guide Retaining Bolts	30
Throttle Body Attaching Nuts.....	18
Throttle Cable Support Bracket Stud into Manifold.....	23
Throttle Cable Support Mounting Nuts.....	10
Timing Chain Dampener Attaching Bolt.....	22
Transmission Dust Cover Screw	8
Upper Left Hand Side Screw Plug (Cylinder Block Front Face)	30
Upper to Lower Intake Manifold Bolts	18

7. SPECIAL TOOLS

TOOL NUMBER	ILLUSTRATION	DESCRIPTION	CLASSIFICATION
49 U012 005		<p>VALVE LIFTER TESTER Used in conjunction with testing fluid Kent More No. E1151 (previously 6A23)</p>	Unique
7370		<p>QUICK CONNECT RELEASE TOOL Used for releasing the fuel return hose quick connects at the dash panel and fuel rail connections once the fuel system has been depressurised</p>	Mandatory
6A22-2		<p>SPIGOT BEARING REMOVER Alternatively, use J23907 or E6668 which includes its own slide hammer</p>	Desirable
AU320		<p>CRANKSHAFT BALANCER HOLDING TOOL</p>	Desirable
AU384-B		<p>PULLER SCREW Used in conjunction with AU384-2, AU384-3, AU384-4, AU384-7 and AU384-6A to remove/install camshaft and rear balance shaft bearings.</p>	Desirable
AU388		<p>CONNECTING ROD GUIDE TOOLS Used in conjunction with AU388-1 and AU388-2</p>	Unique
AU424		<p>CRANKSHAFT BALANCER PULLER Previously released Puller bolts must be 70 mm x 1/4" NF</p>	Mandatory
E308		<p>SEAL REMOVER</p>	Desirable
E1152		<p>HYDRAULIC VALVE LIFTER ASSEMBLY TOOLS Previously released as 6A24</p>	Unique

TOOL NUMBER	ILLUSTRATION	DESCRIPTION	CLASSIFICATION
E1178B		AIR LINE ADAPTOR - 14mm (CYLINDER INFLATOR) 6A40A	Desirable
E1409/11		REAR MAIN SEAL HOUSING ALIGNING TOOL (Original Design Oil Seal)	Desirable
E7115		ANGLE WRENCH Also released as BT8653-A. Used to tighten component fasteners when angle torque is required.	Desirable
EN 47623		REAR MAIN OIL SEAL INSTALLER (Later Design Oil Seal)	Unique
J8080		BEARING REMOVER AND INSTALLER	Unique
J 8092	 T783103	DRIVER HANDLE	Desirable
J25359-8		TORX BIT HOLDER Used with ETX30H Torx bit	Unique
J26125-B		SLIDE HAMMER Also released as AU354. Used in conjunction with 6A22-2 to remove spigot bearing in rear of crankshaft.	Desirable
J28540-A		SEAL INSTALLER	Unique

TOOL NUMBER	ILLUSTRATION	DESCRIPTION	CLASSIFICATION
J38196-AUS-A		<p>MANDREL COLLAR Used to install the rear crankshaft seal to the rear plate. (Original Design Oil Seal)</p>	Desirable
J38606		<p>VALVE SPRING COMPRESSOR Also released as KD2078. Used to compress valve spring with cylinder head installed.</p>	Desirable
J41348		<p>MAIN BEARING CAP PULLER Used in conjunction with slide hammer 7374 (or J6125-B)</p>	Unique
J41349		<p>REAR MAIN HOUSING ALIGNING TOOL (Original Design Oil Seal)</p>	Desirable
J41512		<p>VALVE STEM INSTALLATION TOOL Alternative tool number is J42863.</p>	Desirable