

SECTION 6A2B

3.4 LITER V-6 VIN CODE S UNIT REPAIR

CAUTION: To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle at the opposite end from which components are being removed. This will reduce the possibility of the vehicle falling off of the hoist.

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

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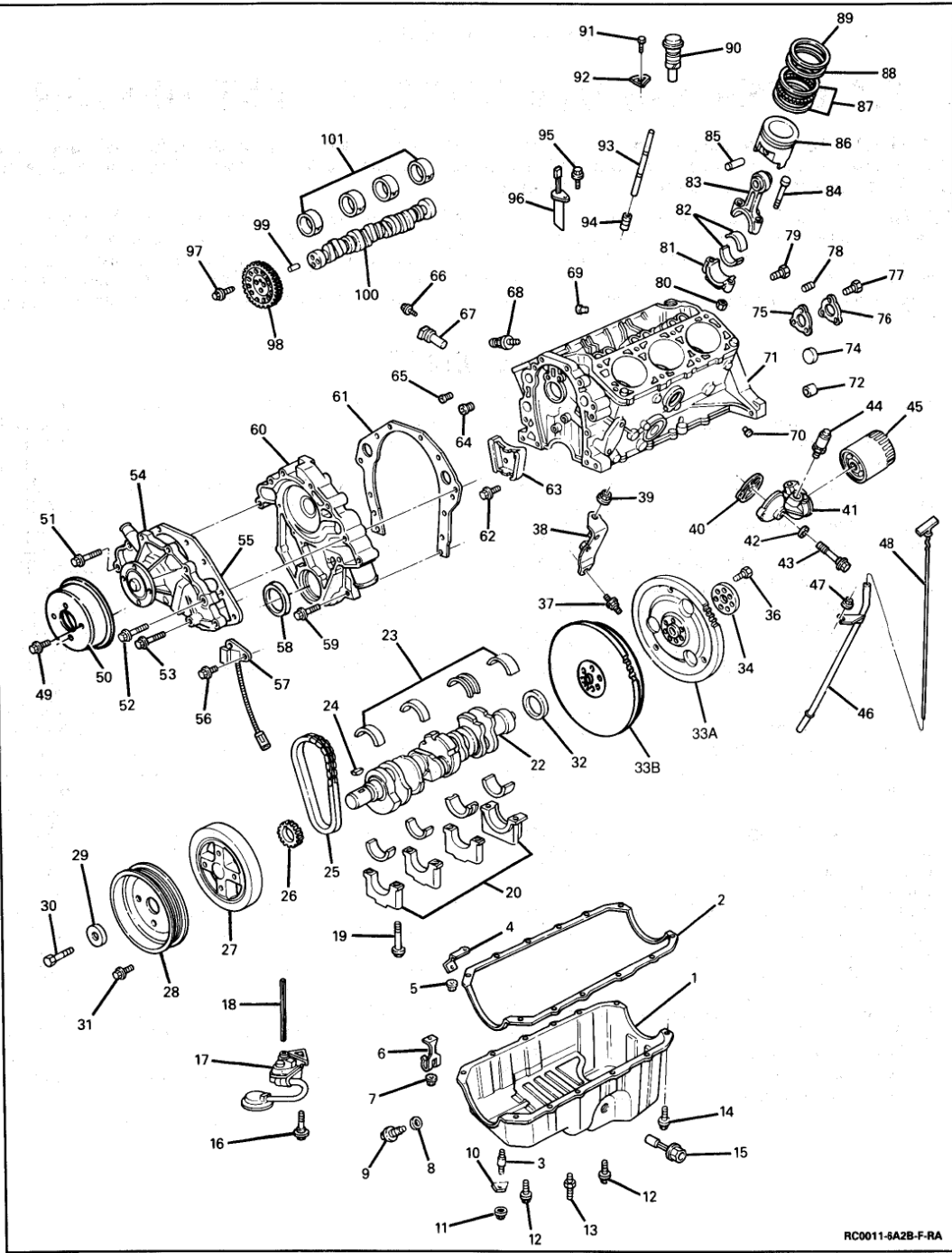


Figure 1 Engine Disassembled View 1 of 2

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1	PAN, OIL	54	PUMP, COOLANT
2	GASKET, OIL PAN	55	GASKET, COOLANT PUMP
3	STUD, OIL PAN	56	BOLT, CRANKSHAFT POSITION SENSOR
4	CLIP, WIRING HARNESS	57	SENSOR, CRANKSHAFT POSITION
5	NUT, OIL PAN	58	SEAL, FRONT COVER OIL
6	CLIP, OIL COOLER PIPE	59	BOLT, ENGINE FRONT COVER
7	NUT, OIL PAN	60	COVER, ENGINE FRONT
8	WASHER, OIL DRAIN PLUG	61	GASKET, ENGINE FRONT COVER
9	PLUG, OIL DRAIN	62	BOLT, TIMING CHAIN DAMPER
10	REINFORCEMENT, OIL PAN	63	DAMPER, TIMING CHAIN
11	NUT, OIL PAN	64	PLUG, OIL GALLERY - 1/8"
12	BOLT, OIL PAN - SMALL	65	PLUG, OIL GALLERY - 1/4"
13	STUD, OIL PAN	66	BOLT, IGNITION TIMING SENSOR
14	BOLT, OIL PAN - LARGE	67	SENSOR, IGNITION TIMING
15	SENSOR, OIL LEVEL	68	SENSOR, KNOCK
16	BOLT, OIL PUMP	69	PLUG, COOLANT JACKET
17	PUMP ASSEMBLY, OIL	70	PLUG, COOLANT JACKET
18	ROD, OIL PUMP DRIVE	71	BLOCK, ENGINE
19	BOLT, MAIN BEARING CAP	72	DOWEL
20	CAP, MAIN BEARING	74	PLUG, COOLANT JACKET
21	O-RING	75	GASKET, REAR CAMSHAFT COVER
22	CRANKSHAFT	76	COVER, REAR CAMSHAFT
23	BEARING, MAIN	77	BOLT, REAR CAMSHAFT COVER
24	KEY, CRANKSHAFT	78	PLUG, OIL GALLERY - 1/4"
25	CHAIN, TIMING	79	PLUG, OIL GALLERY - 3/8"
26	SPROCKET, CRANKSHAFT	80	NUT, CONNECTING ROD
27	DAMPER, TORSIONAL	81	CAP, CONNECTING ROD
28	PULLEY, CRANKSHAFT	82	BEARING, CONNECTING ROD
29	WASHER, TORSIONAL DAMPER	83	ROD, CONNECTING
30	BOLT, TORSIONAL DAMPER	84	BOLT, CONNECTING ROD
31	BOLT, COOLANT PUMP PULLEY	85	PIN, PISTON
32	SEAL, REAR MAIN	86	PISTON
33A	FLYWHEEL, AUTOMATIC TRANSMISSION	87	RINGS, OIL CONTROL
33B	FLYWHEEL, MANUAL TRANSMISSION	88	RING, LOWER COMPRESSION
34	REINFORCEMENT, FLYWHEEL	89	RING, UPPER COMPRESSION
36	BOLT, FLYWHEEL	90	DRIVE ASSEMBLY, OIL PUMP
37	STUD, BRACE	91	BOLT, DRIVE ASSEMBLY CLAMP
38	BRACE, POWER STEERING PUMP	92	CLAMP, OIL PUMP DRIVE ASSEMBLY
39	NUT, BRACE	93	PUSHROD
40	GASKET, OIL FILTER ADAPTER	94	LIFTER
41	ADAPTER, OIL FILTER	95	BOLT, CAMSHAFT POSITION SENSOR
42	O-RING	96	SENSOR, CAMSHAFT POSITION
43	BOLT, OIL FILTER ADAPTER	97	BOLT, CAMSHAFT SPROCKET
44	SENSOR, OIL PRESSURE	98	SPROCKET, CAMSHAFT
45	FILTER, OIL	99	PIN, DOWEL
46	TUBE, OIL LEVEL INDICATOR	100	CAMSHAFT
47	NUT, OIL LEVEL INDICATOR TUBE	101	BEARING, CAMSHAFT
48	INDICATOR, OIL LEVEL		
49	BOLT, COOLANT PUMP PULLEY		
50	PULLEY, COOLANT PUMP		
51	BOLT, COOLANT PUMP - SMALL		
52	BOLT, COOLANT PUMP - LARGE		
53	BOLT, COOLANT PUMP - MEDIUM		

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Figure 2 Legend View 1

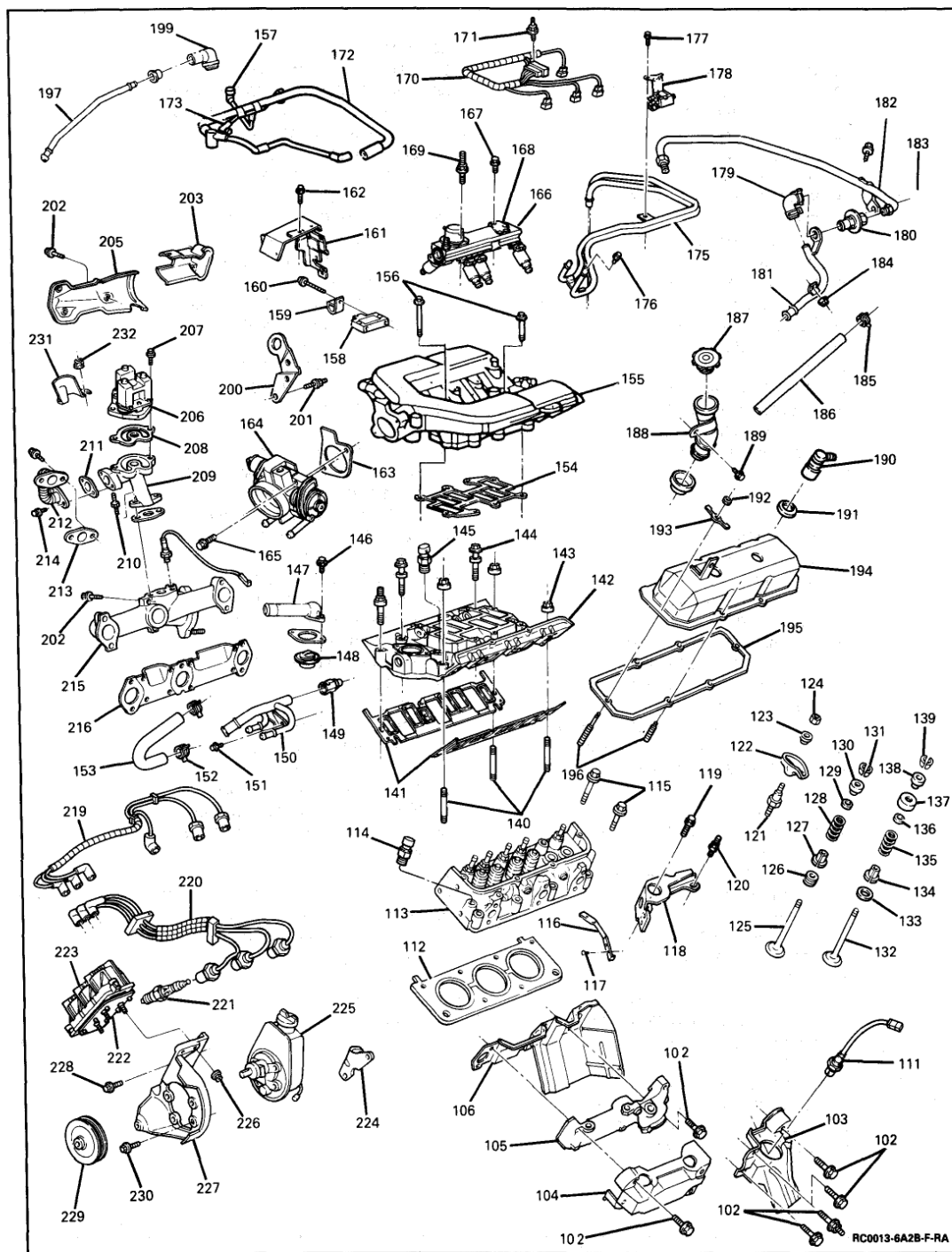


Figure 3 Engine Disassembled View 2 of 2

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102 BOLT, EXHAUST MANIFOLD	150 PIPE, HEATER INLET	194 COVER, VALVE ROCKER
103 SHIELD, EXHAUST MANIFOLD HEAT	151 SCREW, HEATER INLET PIPE	195 GASKET, VALVE ROCKER COVER
104 SHIELD, EXHAUST MANIFOLD HEAT	152 CLAMP, HOSE	196 STUD, VALVE ROCKER COVER
105 MANIFOLD, EXHAUST - LEFT	153 HOSE, HEATER INLET	197 TUBE, CRANKCASE VENT
106 GASKET, EXHAUST MANIFOLD	154 GASKET, UPPER INTAKE MANIFOLD	199 FITTING, TUBE
111 SENSOR, OXYGEN	155 MANIFOLD, UPPER INTAKE	200 BRACKET, REAR ENGINE LIFT
112 GASKET, CYLINDER HEAD	156 BOLT, UPPER INTAKE MANIFOLD	201 STUD, REAR ENGINE LIFT BRACKET
113 HEAD, CYLINDER	157 TUBE, VACUUM	202 BOLT, EXHAUST MANIFOLD
114 SENSOR, COOLANT TEMPERA- TURE GAGE	158 SENSOR, MAP	203 SHIELD, EXHAUST MANIFOLD HEAT
115 BOLT, CYLINDER HEAD	159 CLIP, ENGINE WIRING HARNESS	205 SHIELD, EXHAUST MANIFOLD HEAT
116 BRACE, FUEL LINE	160 SCREW, MAP SENSOR	206 VALVE, EGR
117 BOLT, FUEL LINE BRACE	161 BRACKET, ACCELERATOR CABLE	207 BOLT, EGR VALVE
118 BRACKET, FRONT ENGINE LIFT	162 BOLT, ACCELERATOR CABLE BRACKET	208 GASKET, EGR VALVE
119 BOLT, FRONT ENGINE LIFT BRACKET	163 GASKET, THROTTLE BODY	209 PIPE, EGR ADAPTER
120 STUD, FRONT ENGINE LIFT BRACKET	164 BODY, THROTTLE	210 BOLT, EGR ADAPTER PIPE
121 STUD, ROCKER ARM	165 BOLT, THROTTLE BODY	211 GASKET, EGR ADAPTER PIPE
122 ARM, ROCKER	166 RAIL ASSEMBLY, FUEL INJEC- TOR	212 PIPE, FLEXIBLE ADAPTER
123 BALL, ROCKER ARM	167 BOLT, FUEL LINE HOLD DOWN PLATE	213 GASKET, FLEXIBLE ADAPTER PIPE
124 NUT, ROCKER ARM	168 PLATE, FUEL LINE HOLD DOWN	214 BOLT, FLEXIBLE ADAPTER PIPE
125 VALVE, INTAKE	169 STUD, FUEL RAIL ASSEMBLY	215 MANIFOLD, EXHAUST - RIGHT
126 SEAL, INTAKE VALVE STEM	170 HARNESS, FUEL INJECTOR RAIL	216 GASKET, EXHAUST MANIFOLD
127 DAMPER, SPRING	171 STUD, FUEL RAIL HARNESS	217 SENSOR, OXYGEN
128 SPRING, VALVE	172 HARNESS, VACUUM	219 WIRES, SPARK PLUG - RIGHT
129 O-RING	173 HOSE, FUEL PRESSURE REGULATOR VACUUM	220 WIRES, SPARK PLUG - LEFT
130 CAP, SPRING	175 LINE, FUEL	221 PLUG, SPARK
131 KEY	176 SCREW, FUEL LINE RETAINING	222 SYSTEM, ELECTRONIC IGNITION
132 VALVE, EXHAUST	177 SCREW, EVAP CANISTER PURGE	223 COIL, ELECTRONIC IGNITION
133 SHIM - SELECTIVE	178 CANISTER PURGE, EVAP	224 BRACKET, REAR POWER STEERING PUMP
134 DAMPER, SPRING	179 HOSE, SECONDARY AIR INJECTION	225 PUMP, POWER STEERING
135 SPRING, VALVE	180 VALVE, AIR CHECK	226 NUT, ELECTRONIC IGNITION SYSTEM
136 O-RING	181 PIPE, SECONDARY AIR INJECTION	227 BRACKET, POWER STEERING PUMP
137 SHEDDER, OIL	182 PIPE, SECONDARY AIR INJECTION	228 BOLT, POWER STEERING PUMP BRACKET
138 CAP, SPRING	183 BOLT, AIR PIPE	229 PULLEY, POWER STEERING PUMP
139 KEY	184 NUT, AIR PIPE	230 BOLT, POWER STEERING PUMP
140 STUD, LOWER INTAKE MANIFOLD	185 CLAMP, AIR HOSE	231 SHIELD, SPARK PLUG WIRING
141 GASKET, LOWER INTAKE MANIFOLD	186 HOSE, SECONDARY AIR INJECTION	232 NUT, SPARK PLUG WIRING SHIELD
142 MANIFOLD, LOWER INTAKE	187 CAP, OIL FILL	
143 NUT, LOWER INTAKE MANIFOLD	188 TUBE, OIL FILL	
144 BOLT, LOWER INTAKE MANI- FOLD	189 SCREW, OIL FILL TUBE	
145 SENSOR, COOLANT TEMPERATURE	190 VALVE, PCV	
146 BOLT, THERMOSTAT HOUSING	191 GROMMET	
147 HOUSING, THERMOSTAT	192 NUT, VALVE ROCKER COVER	
148 THERMOSTAT	193 REINFORCEMENT, VALVE ROCKER COVER	
149 NIPPLE, HEATER INLET		

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Figure 4 Legend View 2

GENERAL DESCRIPTION

ENGINE CONSTRUCTION

Figures 1 through 4

Cylinder Block

The cylinder block is made of cast alloy iron and has six cylinders arranged in a "V" shape with three cylinders in each bank. The cylinder banks are set at a 60° angle from each other.

The right bank cylinders are (1,3,5) and the left bank cylinders are (2,4,6).

Four main bearings support the crankshaft which is retained by bearing caps that are machined with the block for proper alignment and clearances.

Cylinder Head

The cast iron cylinder heads have individual intake and exhaust ports for each cylinder. Valve guides are integral, and rocker arms are retained on individual threaded studs with locking nuts.

Crankshaft and Bearings

The crankshaft is cast nodular iron with deep rolled fillets on all six crankpins and all four main journals. Four steel-backed aluminum bearings are used, with the #3 bearing being the end-thrust bearing.

Camshaft and Drive

The camshaft is cast alloy iron with tapered 13.2 mm wide lobes, offset from the lifters and tapered to provide positive valve lifter rotation. The camshaft is supported by four journals and includes an oil pump drive gear.

Pistons and Connecting Rods

The pistons are cast aluminum with steel struts using two compression rings and one oil control ring. The piston pin is offset 0.8 mm towards the major thrust side. This allows a gradual change in thrust pressure against the cylinder wall as the piston travels its path. Pins are chromium steel and have a floating fit in the pistons. They are retained in the connecting rods by a press fit.

Connecting rods are made of forged steel. Full pressure lubrication is directed to the connecting rods by drilled oil passages from the adjacent main bearing journal.

Valve Train

A very simple ball-pivot and rocker type valve train is used. Motion is transmitted from the camshaft through the hydraulic lifter and pushrod to the rocker arm. The rocker arm pivots on its ball and transmits the camshaft motion to the valve. The rocker arm ball locates on a stud, threaded into the head, and is retained by a nut. The pushrod is located by a guide

plate held under the rocker arm stud, assuring that the rocker arm operates in the plane of the valve.

Intake Manifold

The intake manifold is a two-piece cast aluminum unit. It centrally supports a fuel rail with six fuel injectors.

Exhaust Manifolds

The exhaust manifolds are cast nodular iron.

ENGINE LUBRICATION

Figures 5 through 8

Full pressure lubrication, through a full flow oil filter is furnished by a gear type oil pump. Oil is drawn up through the pickup screen and tube, and passed through the pump to the oil filter.

The oil filter is a full flow paper element unit. An oil filter bypass is used to ensure adequate oil supply, should the filter become plugged or develop excessive pressure drop. The bypass is designed to open at 69-83 kPa (10-12 psi).

A new priority oil delivery system supplies oil first to the crankshaft journals. The passages supplying oil to the crankshaft main bearings also supply oil to the camshaft bearings through intersecting vertical drilled holes. Oil from the crankshaft main bearings is supplied to the connecting rod bearings by means of intersecting passages drilled in the crankshaft. The front cam bearing has a 0.25 mm deep slot on its outside diameter to supply oil to the cam sprocket thrust face, and oil passages from the camshaft journals supply oil to the hydraulic lifters.

The hydraulic lifters pump oil up through the pushrods to the rocker arms. Oil draining back from the rocker arms is directed by cast dams in the crankcase casting to supply the camshaft lobes. Oil also drains past specific hydraulic lifter flats to oil camshaft lobes directly.

DISASSEMBLY

FLYWHEEL

Figure 9

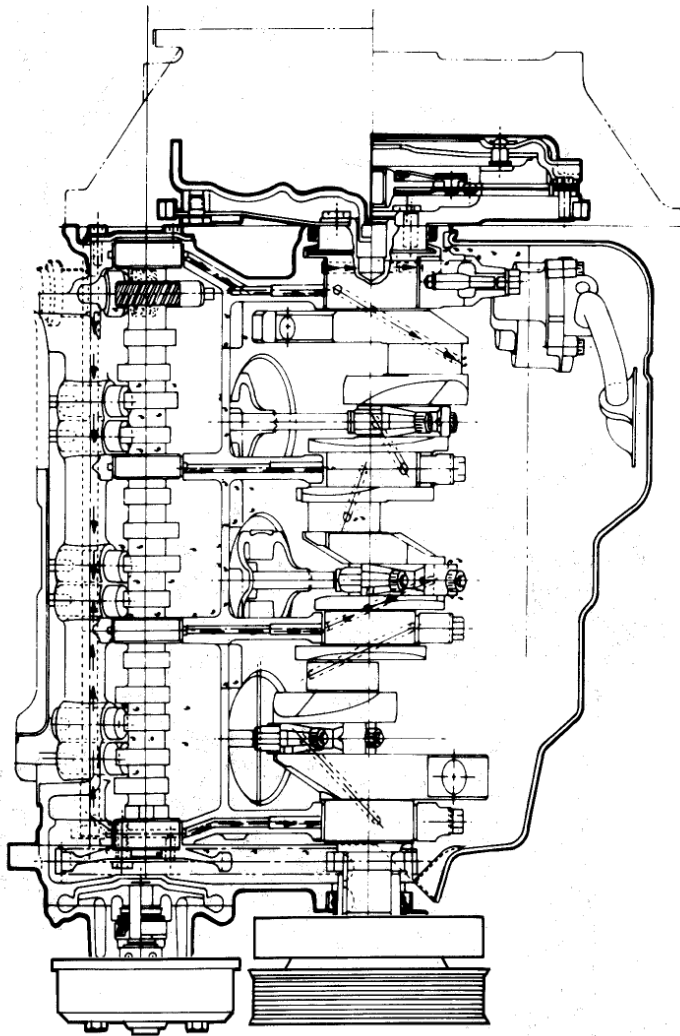
➡ Remove or Disconnect

1. Retainer bolts (36) and retainer.
2. Flywheel (33).

DRAINING THE ENGINE

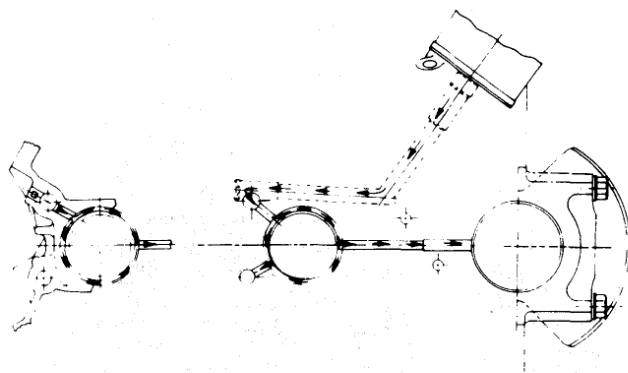
➡ Remove or Disconnect

1. Oil drain plug (9) and drain engine oil.
2. Oil filter (45).
3. Coolant drain plugs (69 and 70) and drain coolant.

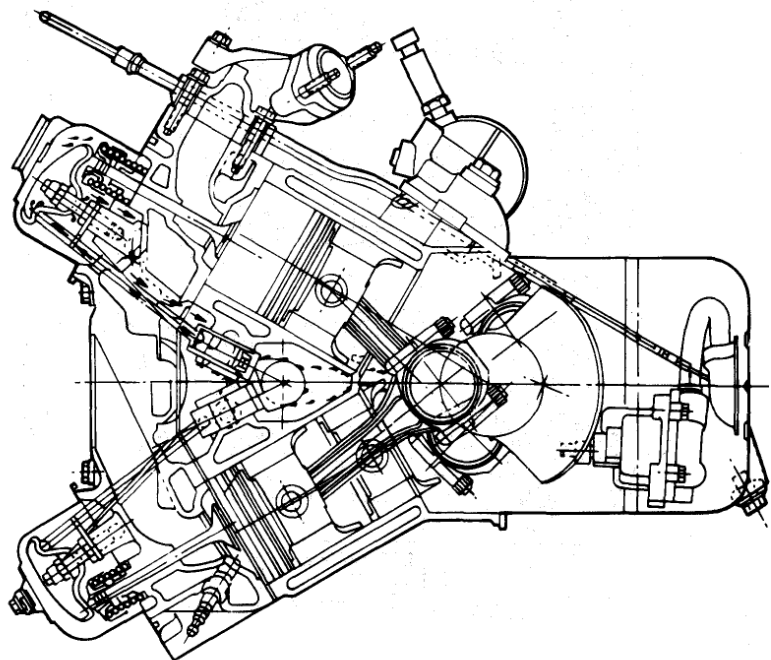


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Figure 5 Engine Lubrication View 1 of 4

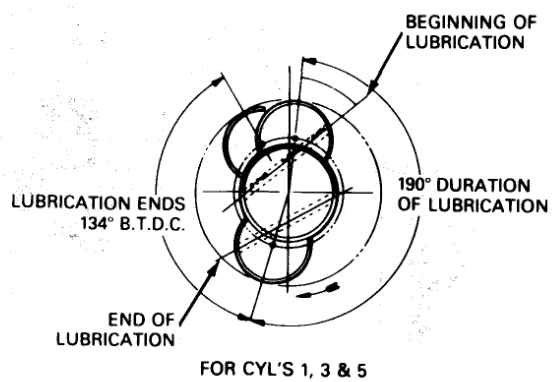
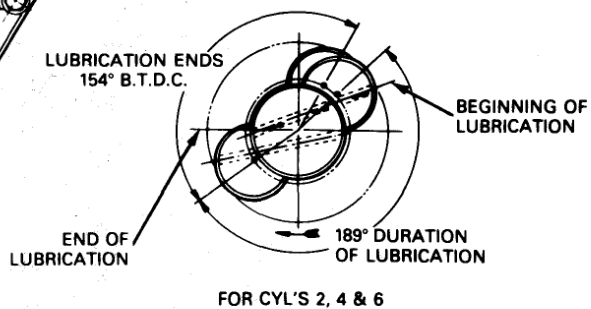
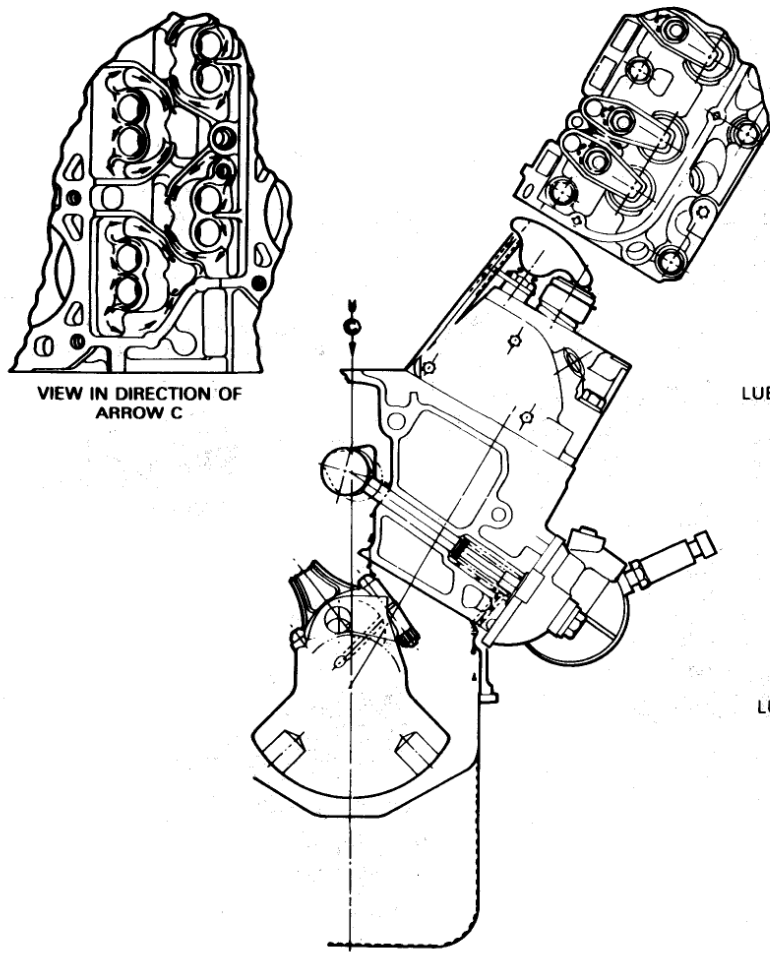


TYPICAL FOR FRONT & REAR OILING
FROM LEFT BANK TO RIGHT BANK



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Figure 6 Engine Lubrication View 2 of 4



VIEWS SHOWING INTERMITTENT OILING OF
CONNECTING ROD BEARING THROUGH GROOVE
ON UPPER HALF OF MAIN BEARINGS.

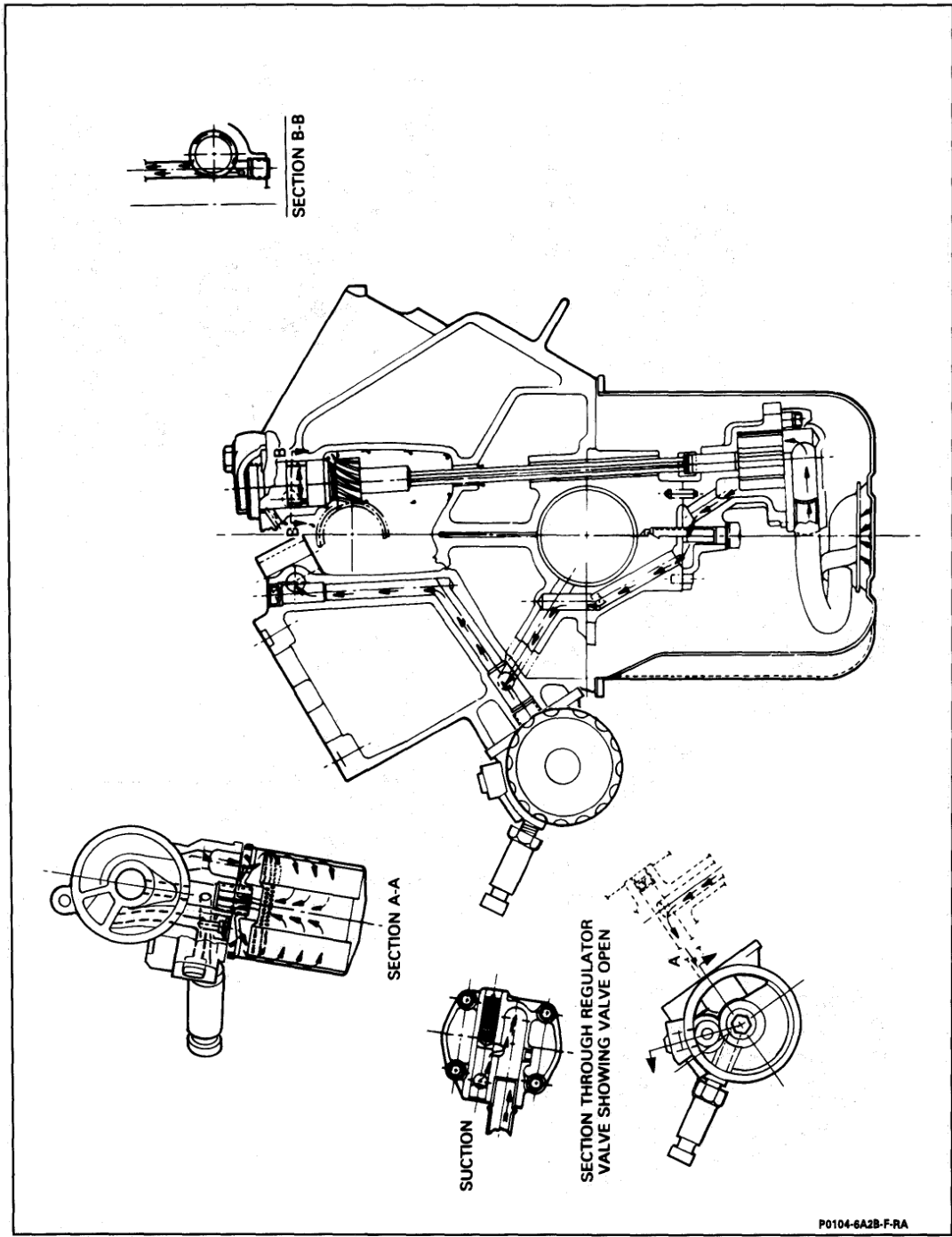


Figure 8 Engine Lubrication View 4 of 4

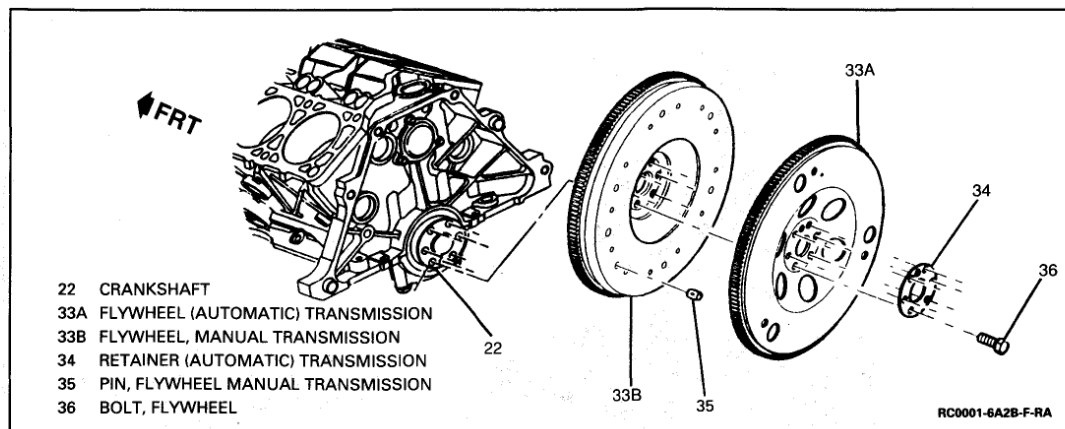


Figure 9 Flywheel

UPPER INTAKE MANIFOLD

Figure 10 and 11

Remove or Disconnect

1. Throttle body heater hose clamps (152) and hoses (153).
2. Fuel line clamp bolts (176 and 177).

Important

- The fuel line hold down plate and pivot bolt are part of the fuel rail assembly. Do not remove the pivot bolt.
3. Fuel line hold down plate bolt (167).
 - Rotate fuel line hold down plate (168) counter-clockwise.
 4. Fuel lines (175).
 5. Fuel injector rail wiring harness retaining nut.
 6. Fuel rail stud (169).
 7. Fuel pressure regulator vacuum hose (173).
 8. Coolant sensor electrical connector.
 9. Blow dirt out of injector bores with compressed air.
 10. Fuel injector rail assembly (166).
 - Pry carefully on injector rail (166). Remove injectors one side at a time.

11. PCV valve (190).
12. EGR flexible tube bolts at upper intake manifold (155).
13. MAP sensor electrical connector.
14. Upper intake manifold bolts (156).
15. Upper intake manifold (155) and gasket (154).

VALVE ROCKER COVER

Figure 12

Remove or Disconnect

1. Nuts (192) and reinforcements (193).
2. Valve rocker cover (194) and gasket (195).

VALVE ROCKER ARM AND PUSHROD

Figure 13

Remove or Disconnect

1. Rocker arm nuts (124).
 - Place valve train parts in a rack so that they can be installed in the same location which they were removed.
2. Rocker arms (122) and balls (123).
3. Pushrods (93).

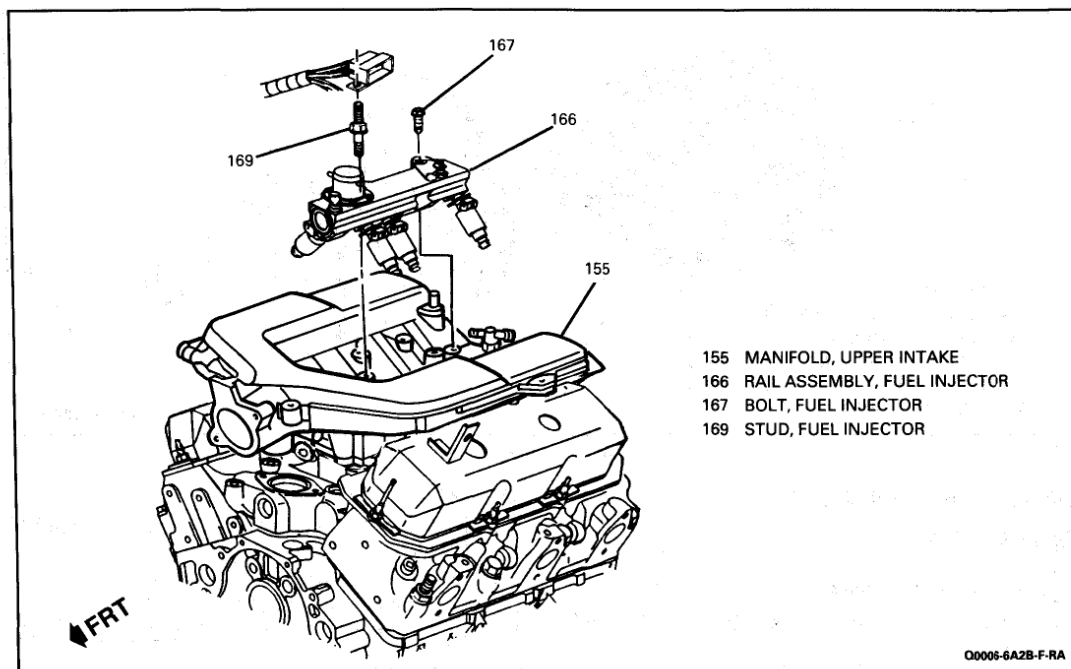


Figure 10 Fuel Injector Rail

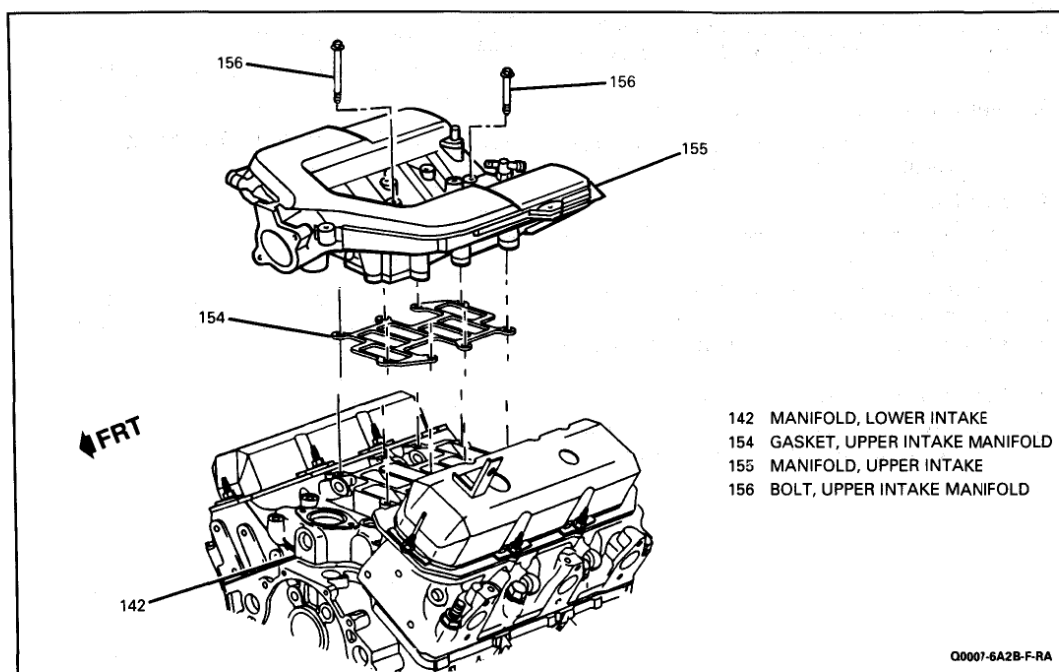


Figure 11 Upper Intake Manifold

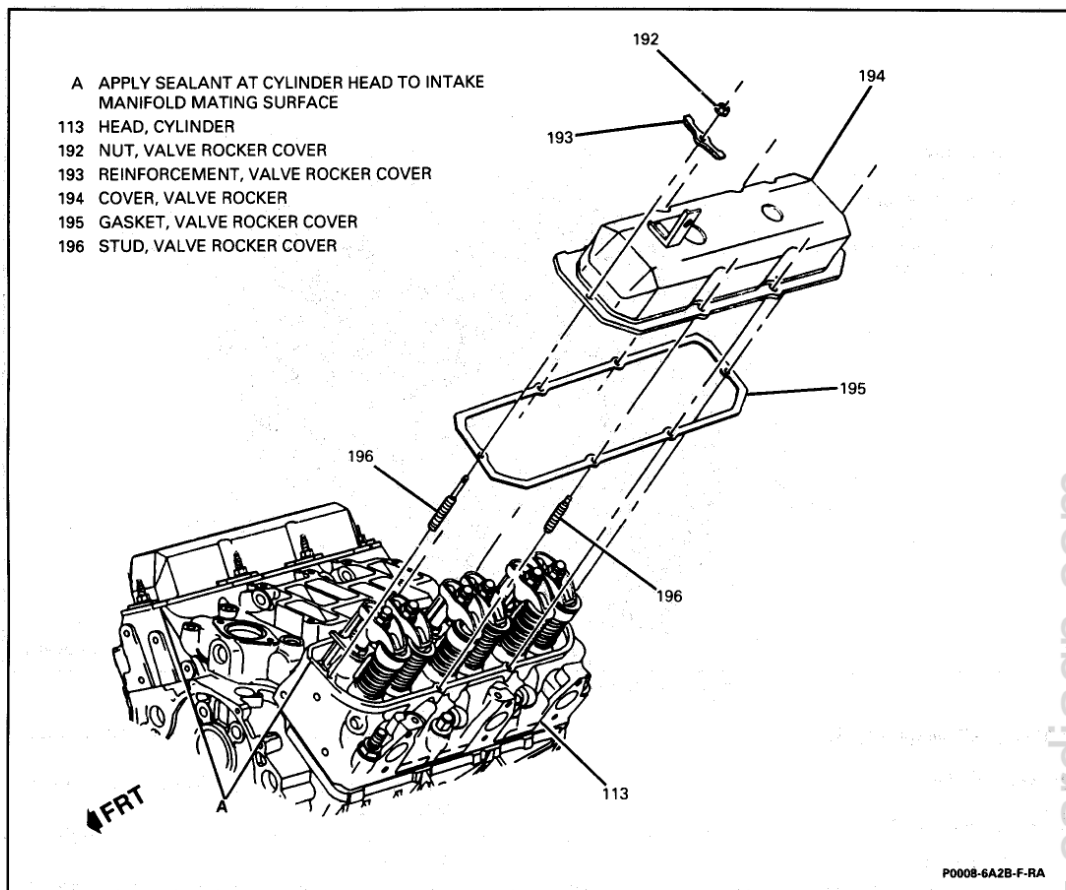


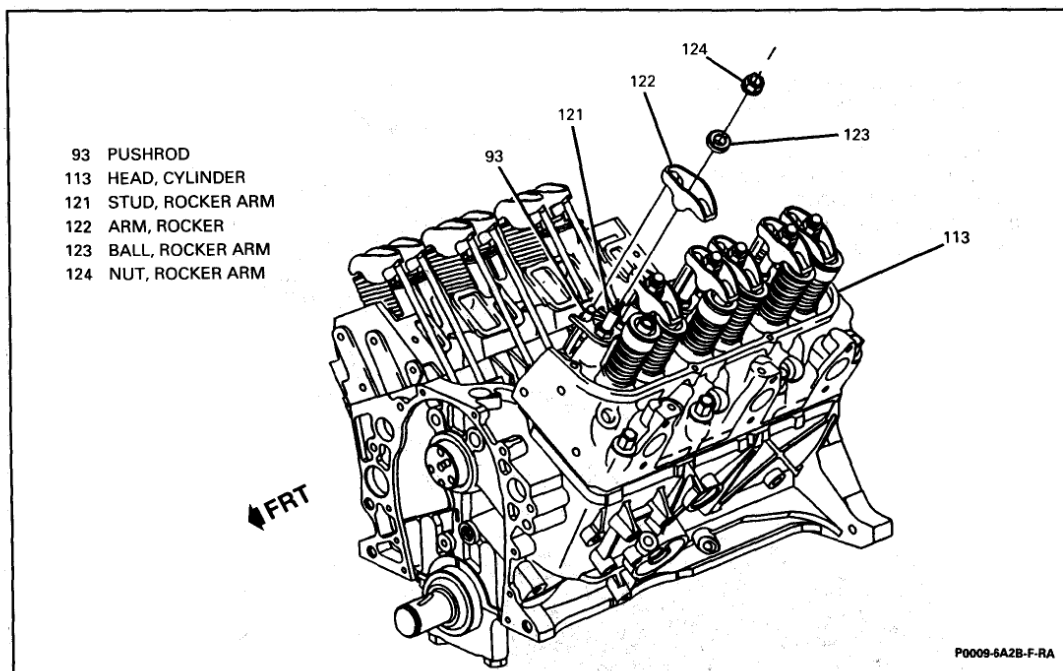
Figure 12 Valve Rocker Cover

LOWER INTAKE MANIFOLD**Figure 14****➡➡ Remove or Disconnect**

1. Retaining bolts (144) and nuts (143).
2. Lower intake manifold (142) and gaskets (141).

VALVE LIFTERS**Figure 13****➡➡ Remove or Disconnect**

1. Valve lifters (94).



EXHAUST MANIFOLD

Figures 15 and 16



Remove or Disconnect

1. Serpentine drive belt.
2. Rear A/C compressor bracket mounting bolts and bracket.
3. Generator pencil brace bolts and braces.
4. A/C compressor and generator mounting bracket bolts.
5. A/C compressor and generator mounting bracket.
6. AIR pipe fitting from right exhaust manifold, if equipped.
7. AIR pipe retaining nut (184) and bolt (183), if equipped.
8. Secondary air injection pipe assembly, if equipped.
9. Exhaust manifold retaining bolts (102 and 202).
10. Exhaust manifolds (105 and 215) and heat shields (103, 104, 203 and 205).
11. Exhaust manifold gaskets (106 and 216).

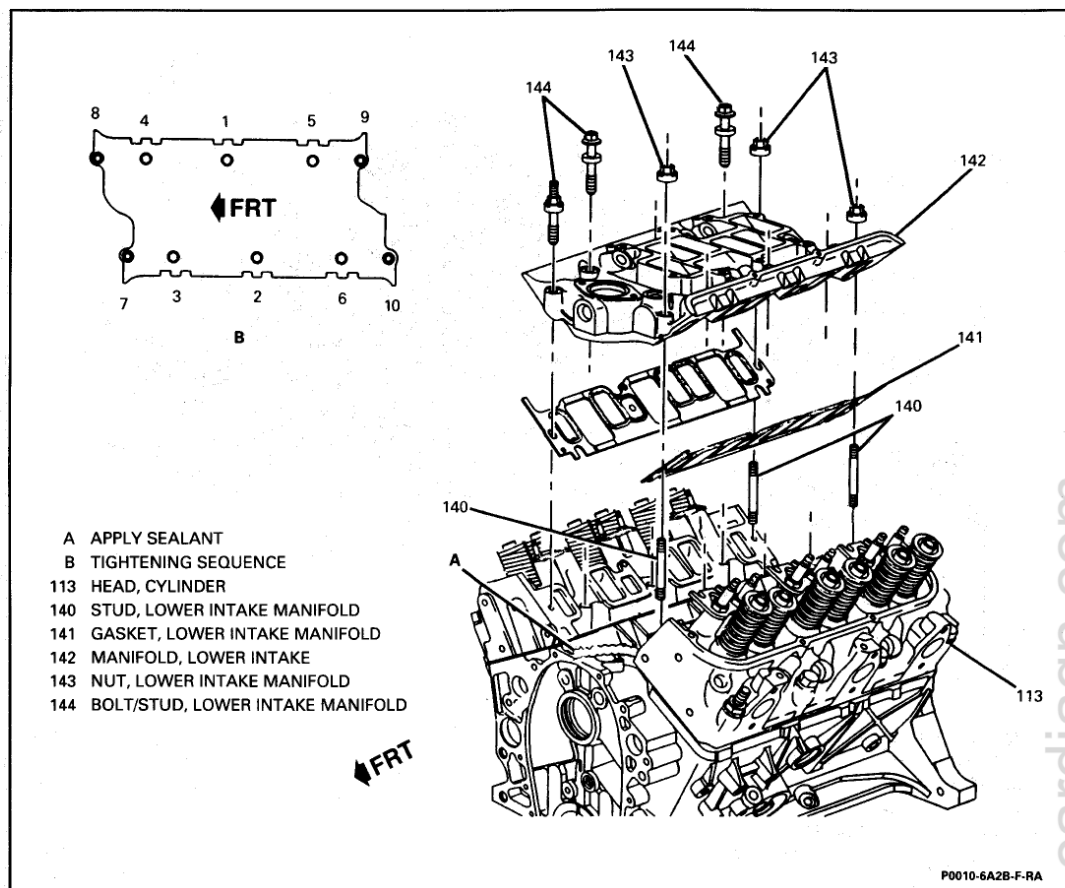


Figure 14 Lower Intake Manifold

OIL PAN**Figure 17****➡➡ Remove or Disconnect**

1. Oil pan nuts (11) and reinforcements (10).
2. Oil pan bolts (12) and studs (13).
3. Oil pan (1) and gasket (2).

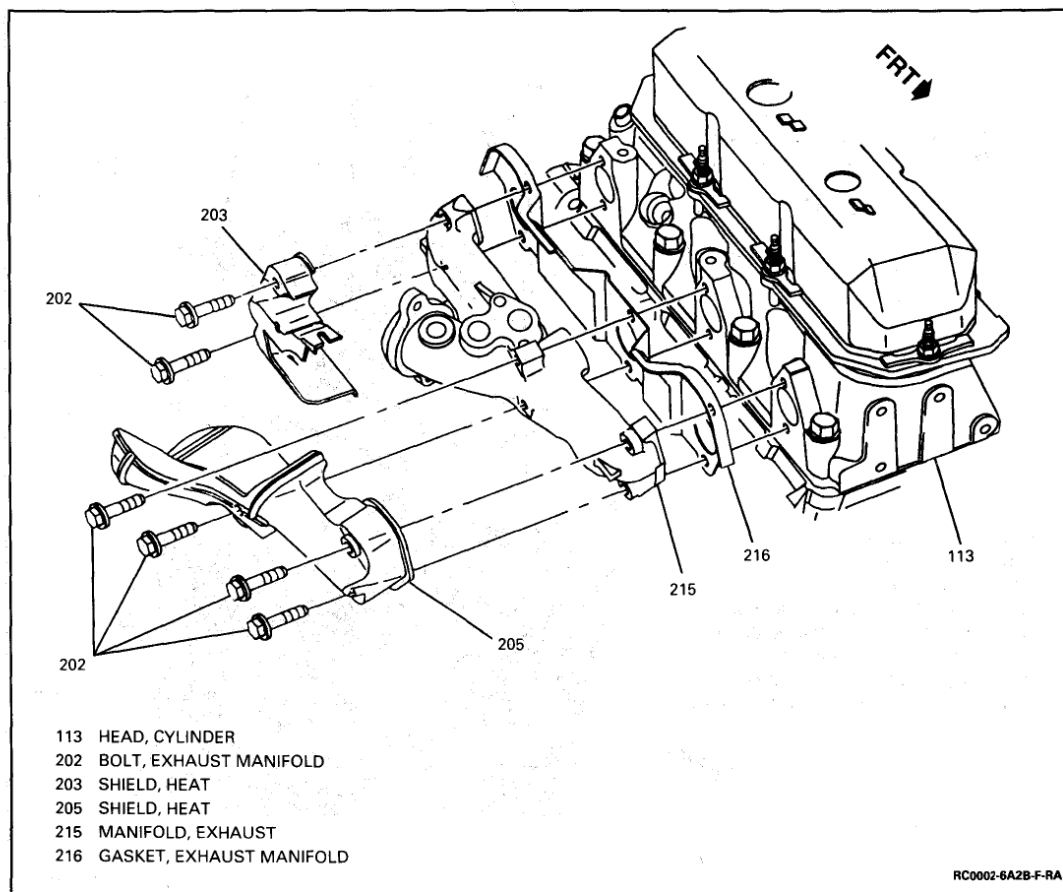


Figure 15 Exhaust Manifold - Right

ELECTRONIC IGNITION MODULE**Figure 18****Tools Required:**

- J 25034-B Power Steering Pump Pulley Remover
- J 25034-5 Adapter

**Remove or Disconnect**

1. Power steering pump pulley (229) using J 25034-B and J 25034-5.
2. Power steering pump bracket retaining bolts.
3. Power steering pump bolts (228) and pump (225).
4. Electronic ignition module nuts (226) and electronic ignition module (223).

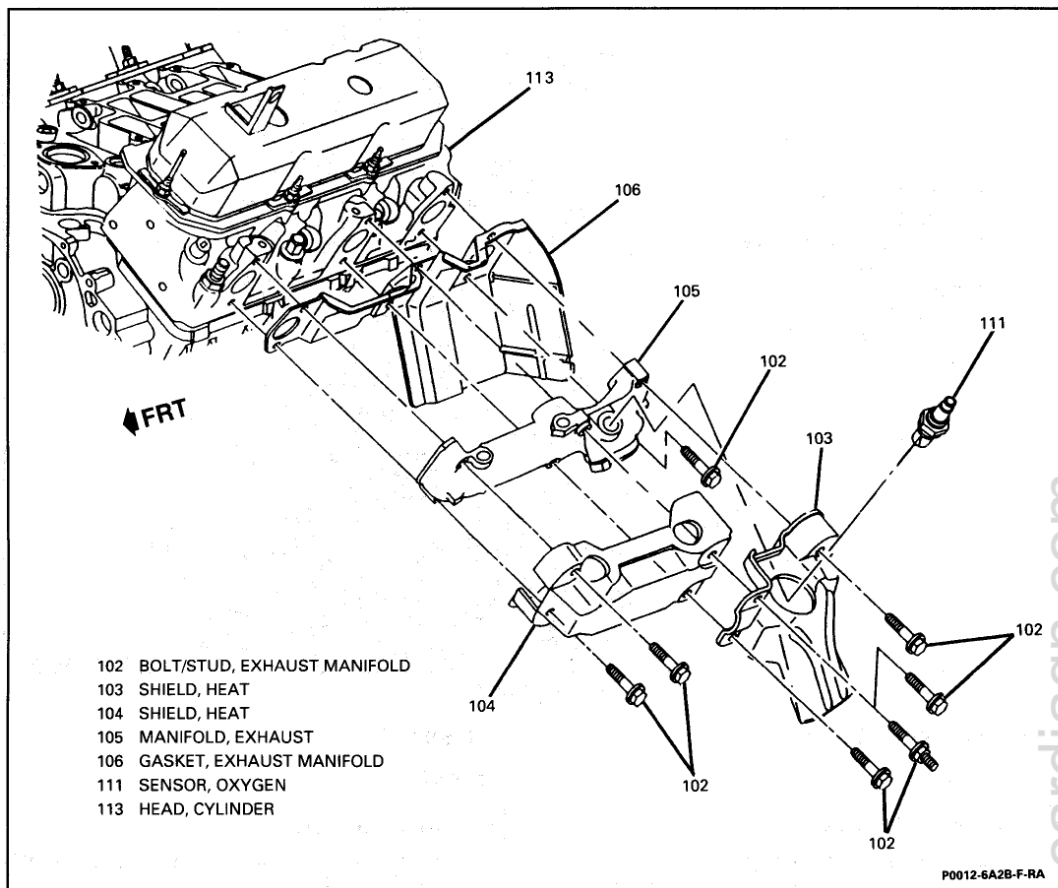


Figure 16 Exhaust Manifold - Left

COOLANT PUMP**Figure 76****➡➡ Remove or Disconnect**

1. Power steering pump mounting bracket bolts (230) and bracket (227).
2. Coolant pump pulley bolts (49) and pulley (50).
3. Coolant pump bolts (51, 52 and 53).
4. Coolant pump (54) and gasket (55).

TORSIONAL DAMPER**Figure 19**

Tool Required:

J 24420-B Torsional Damper Remover

➡➡ Remove or Disconnect

1. Torsional damper bolt (30) and washer (29).
2. Crankshaft pulley bolts (31) and pulley (28).
3. Torsional damper (27) using J 24420-B.

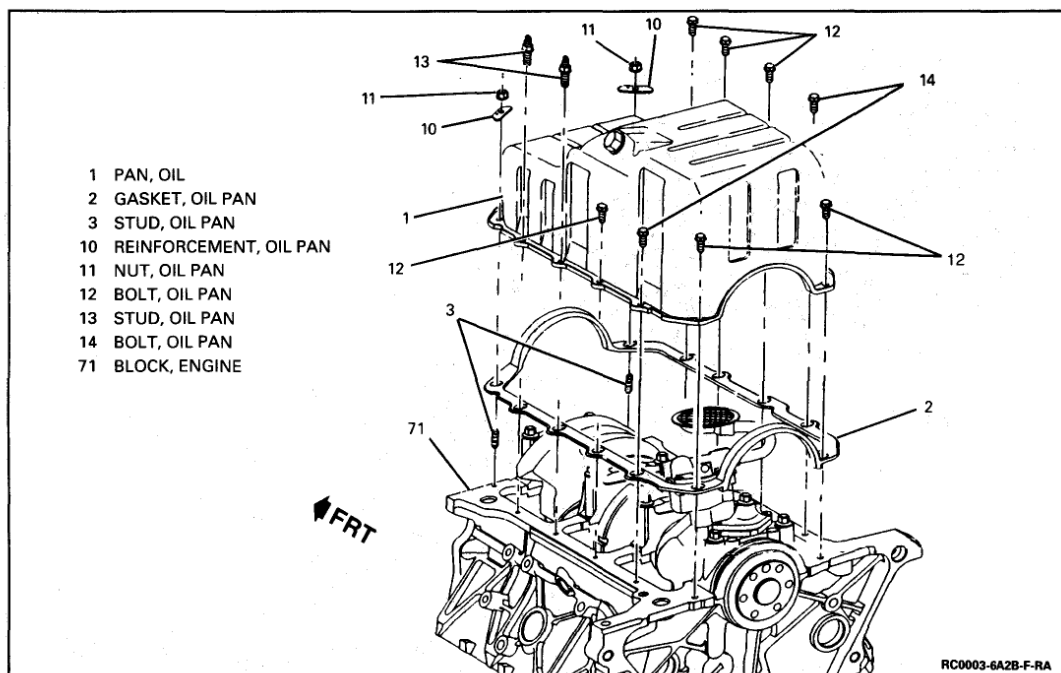


Figure 17 Oil Pan

ENGINE FRONT COVER**Figure 73****Remove or Disconnect**

1. Engine front cover bolts (59).
2. Engine front cover (60) and gasket (61).

TIMING CHAIN AND SPROCKETS**Figure 20**

Tool Required:

J 5825-A Crankshaft Sprocket Remover

**Remove or Disconnect**

1. Cam sprocket bolts (97).
2. Cam sprocket (98) and timing chain (25).
3. Crankshaft sprocket (26) using J 5825-A.
4. Timing chain damper bolts (62) and damper (63).

CAMSHAFT**Figure 69****Remove or Disconnect**

1. Oil pump driven gear hold down clamp bolt (91) and clamp (92).
2. Oil pump driven gear assembly (90).
3. Camshaft (100).

NOTICE: Camshaft journals are all the same diameter so care must be used when removing the camshaft to avoid bearing damage.

- Install three 4-inch bolts in the camshaft bolt holes.
- Carefully rotate and pull the camshaft (100) out of the camshaft bearings.

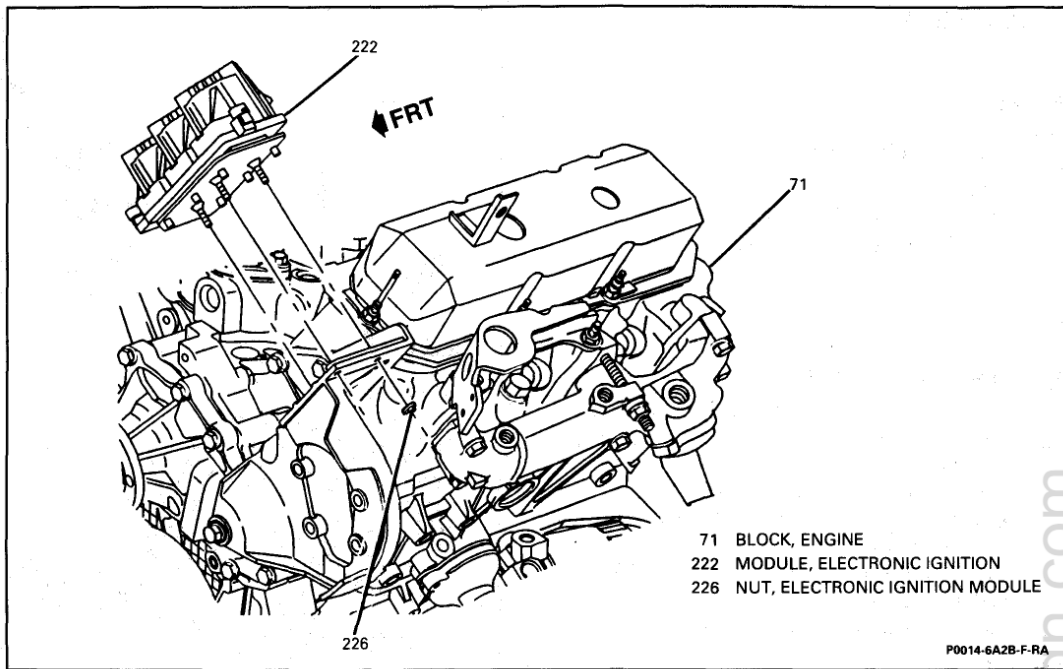


Figure 18 Electronic Ignition Module

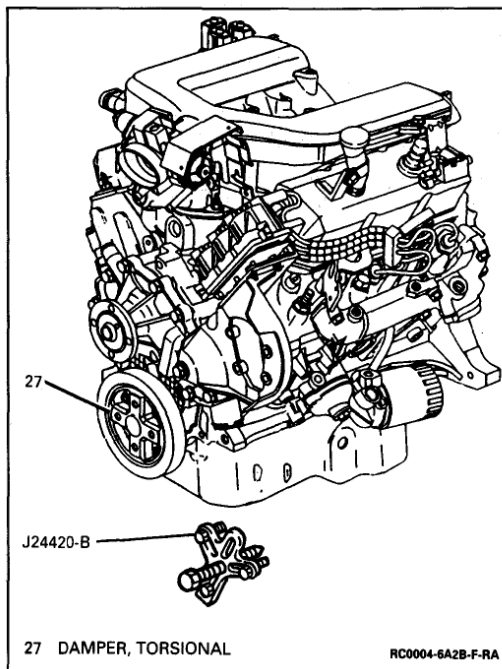


Figure 19 Torsional Damper Removal

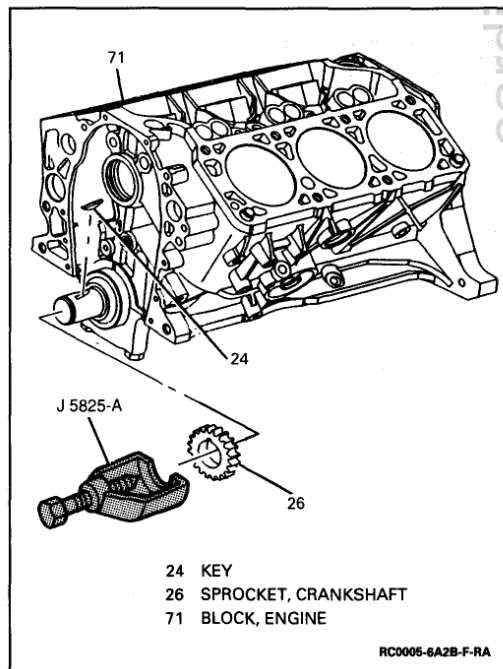


Figure 20 Crankshaft Sprocket Removal

Right

Figure 68

 Remove or Disconnect

1. Pencil brace bracket bolts.
2. Cylinder head bolts (115).
3. Cylinder head (113) and gasket (112).

Left

Figure 68

 Remove or Disconnect

1. Power steering pump stud and bracket (224).
2. Power steering pump brace nut (39), stud (37) and brace (38).
3. Oil level indicator tube nut (47).
4. Engine lift bracket bolts (119 and 120) and bracket (118).
5. Engine coolant temperature sensor (114).
6. Cylinder head bolts (115).
7. Cylinder head (113) and gasket (112).

OIL PUMP

Figure 21

 Remove or Disconnect

1. Oil pump bolt (16).
2. Oil pump (17) and drive rod (18).

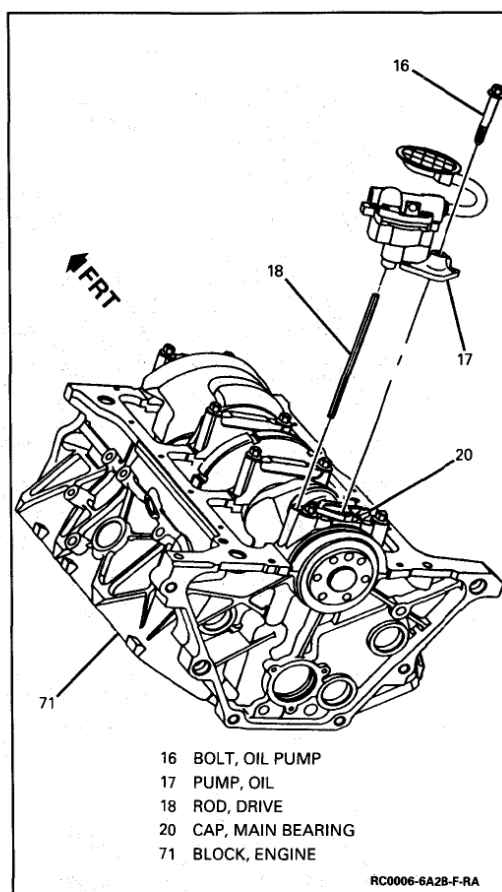


Figure 21 Oil Pump

PISTON AND CONNECTING ROD

Figure 22

Remove or Disconnect

1. Mark the piston (86) with the number of the cylinder from which it is being removed.
2. Mark the connecting rod (83) and the rod cap (81) so that they can be assembled correctly.
3. Turn the crankshaft (22) to bottom dead center.

Clean

- Carbon from the top end of the cylinder.

4. Connecting rod nut (80) and cap (81).

NOTICE: If there is a pronounced ridge at the top of the piston travel, this ridge must be removed with a ridge reamer before removing piston and connecting rod assembly. Do not use force. Avoid breaking piston rings and damaging the piston.

NOTICE: Install thread protector to avoid damage to the crankshaft journal.

5. Connecting rod (83) and piston assembly (86). Push out with a suitable tool.

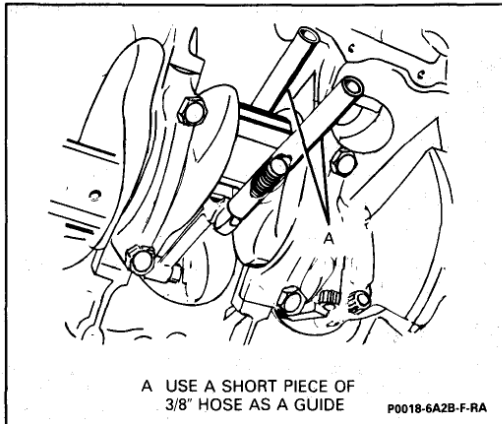


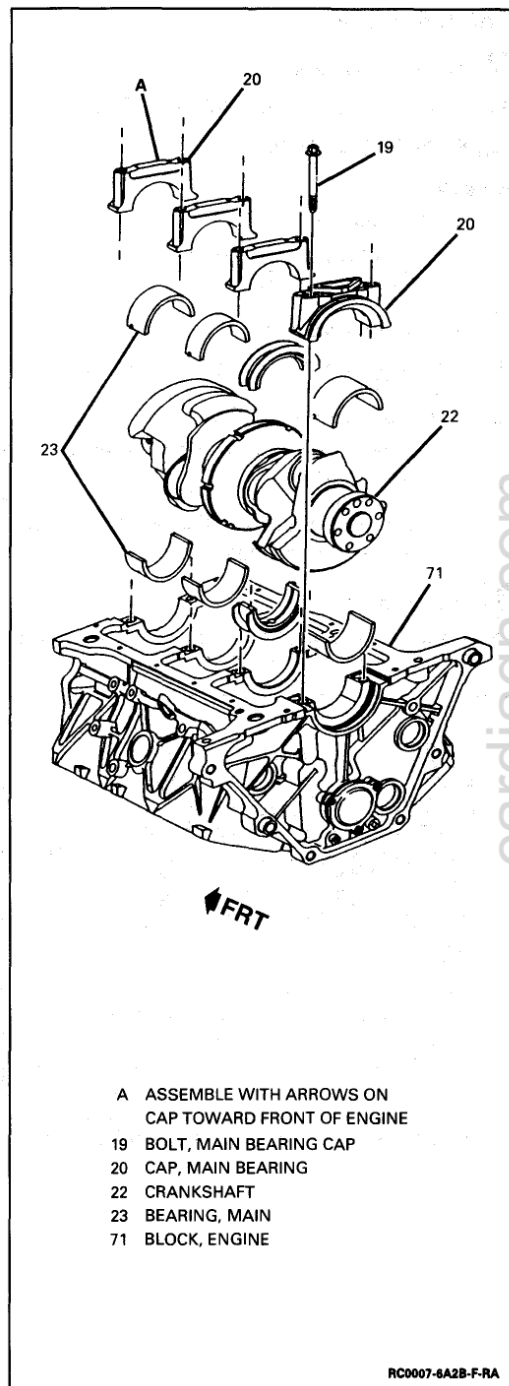
Figure 22 Connecting Rod Protector

CRANKSHAFT

Figure 23

Remove or Disconnect

1. Main bearing cap bolts (19).
2. Main bearing caps (20) and lower bearing halves (23).
3. Crankshaft (22).
4. Upper bearing halves (23).



- A ASSEMBLY WITH ARROWS ON CAP TOWARD FRONT OF ENGINE
- 19 BOLT, MAIN BEARING CAP
- 20 CAP, MAIN BEARING
- 22 CRANKSHAFT
- 23 BEARING, MAIN
- 71 BLOCK, ENGINE

Figure 23 Crankshaft

REAR MAIN SEAL

Remove or Disconnect

1. Rear main seal from crankshaft (32).

CAMSHAFT BEARINGS

Figure 24

Tool Required:

J 33049 Camshaft Bearing
Remover/Installer

Remove or Disconnect

1. Camshaft cover bolts (77), cover (76) and gasket (75).
2. Camshaft bearings (101).
 - A. Select the proper expander assembly and driving washer.
 - B. Assemble J 33049. Tighten the expander assembly snug with the camshaft bearing.
 - C. Drive out bearings.

Important

- Camshaft bearings (101) must not be re-used after they have been removed.

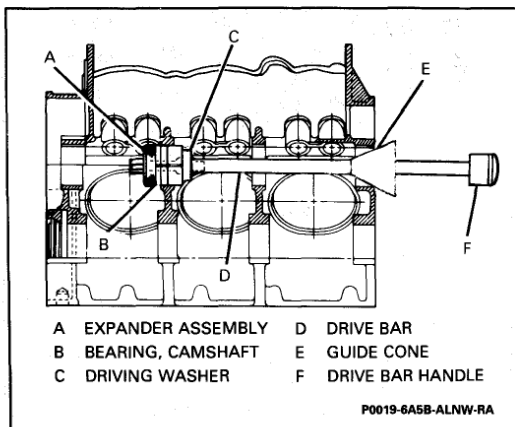


Figure 24 Removing/Installing Camshaft Bearings

CLEANING, INSPECTION AND REPAIR CYLINDER BLOCK

Figures 25 through 30

Tool Required:

J 8087 Cylinder Bore Checking Gage

Disassemble

1. Oil filter adapter bolt (43).
2. Oil filter adapter (41) and gasket (40).
3. Knock sensor.
4. Ignition timing sensor retaining bolt (66) and sensor (67).
5. Camshaft sensor retaining bolt (95).
6. Camshaft sensor (96).
7. Coolant jacket plugs (74).
8. Coolant jacket threaded plugs (69 and 70).
9. Oil gallery plugs (64, 65, 78 and 79).

Important

- Caustic cleaning solution destroys the bearing material. All bearings must be replaced after cleaning with a caustic solution. Do not clean bearing material or aluminum parts with caustic solutions.

Clean

- Sealing material from mating surfaces.
- Boil in caustic solution.
 - Flush with clean water or steam.
- Oil passages.
- All blind holes.
- Spray or wipe cylinder bores and machined surfaces with engine oil.

Inspect

- Check surface for flatness. Use a straight edge and a feeler gage (Figure 26). If the cylinder head deck flatness exceeds 0.1mm (0.004 inch), the surface should be machined flat. If more than 0.25 mm (0.010 inch) must be removed, replace the block.
- Oil pan rail and timing cover attaching area for nicks. **Minor** irregularities may be cleaned up with a flat mill file.
- Head bolt tapped holes.
- Transaxle case mating surface.

NOTICE: If this surface is not flat, a broken flywheel may result.

- Temporarily install the crankshaft. Measure crankshaft flange run-out. Refer to "Crankshaft" in Cleaning, Inspection and Repair of this section.

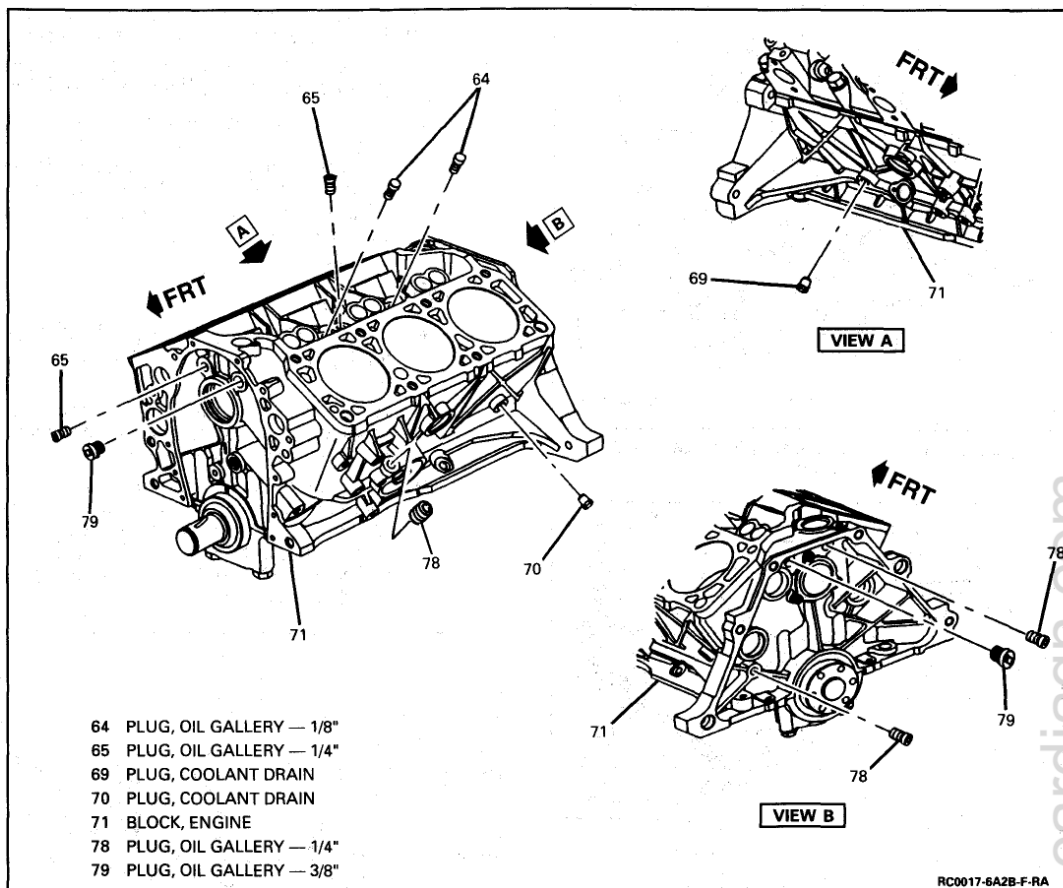


Figure 25 Engine Block

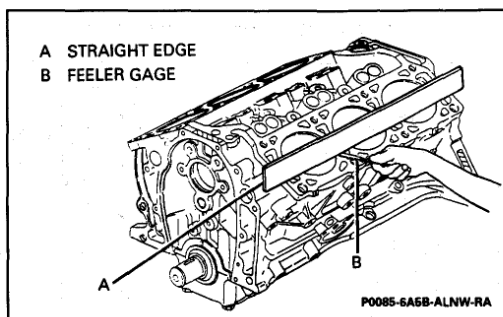


Figure 26 Measuring Cylinder Block for Flatness

Measure

- Cylinder block flange surface runout at six mounting hole bosses (Figure 27).
1. Hold gage plate flat against the crankshaft flange (Figure 27).
 2. Place dial indicator stem on the transaxle mounting bolt hole boss (Figure 28) and set indicator to 0.
 3. Take and record the readings obtained on the remaining transaxle mounting bolt hole bosses (Items A-F, Figure 27). Measurements should not vary more than 0.25 mm (0.010 inch).
 4. If the readings vary more than 0.25 mm (0.010 inch), recheck crankshaft flange run-out. If the run-out is excessive, replace the crankshaft.

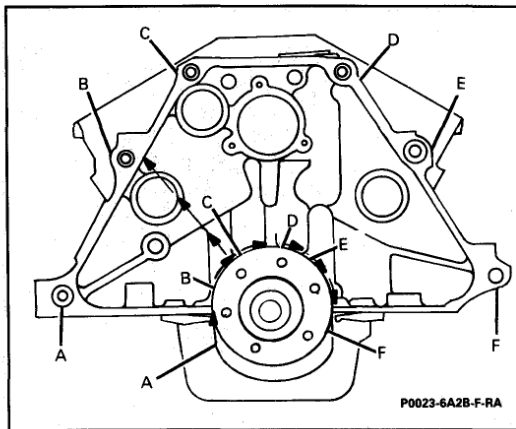


Figure 27 Transaxle Mounting Surface Checking Points

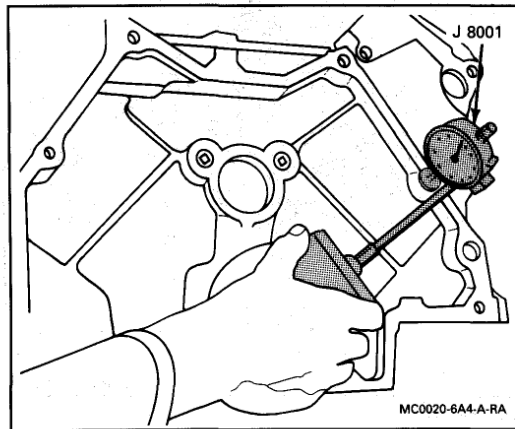


Figure 28 Measuring Transaxle Mounting Surface

**Inspect**

1. Threaded holes. If necessary, clean with a tap or drill out and install thread inserts. Refer to "Thread Repair" in Cleaning, Inspection and Repair of this section.

**Important**

- The following inspections as well as reconditioning, if necessary, must be carried out with the main bearing caps installed and tightened to specification.
- Make sure main bearing caps are installed correctly, with the arrows pointing toward the front of the engine.

2. Camshaft and Crankshaft bearing bores, using J 8087, measure concentricity and alignment.
3. Cylinder bore, with J 8087 measure for wear, taper, run-out and ridging (Figures 29 and 30).

- If the bore is worn out of specifications, it may be rebored, honed and fitted with oversize pistons. The smallest available oversize should be selected. Refer to "Pistons and Connecting Rods" in Cleaning, Inspection and Repair of this section.

**Important**

- Leave sufficient material to allow finish honing in conjunction with fitting the piston.
- If the bore is glazed but otherwise serviceable, break the glaze lightly with a hone and replace the piston rings.
- Make sure the honing stones are clean, sharp and straight. Move the hone slowly up and down to produce a cross-hatch pattern. Clean bore thoroughly with soap and water. Dry and rub in clean engine oil; then measure.

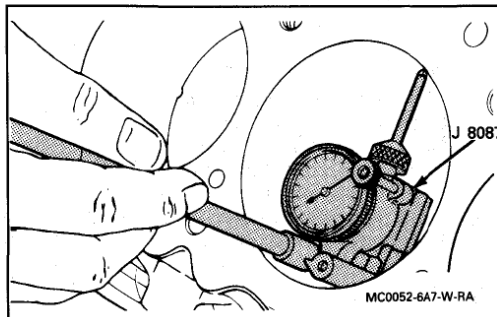


Figure 29 Measuring Cylinder Bore

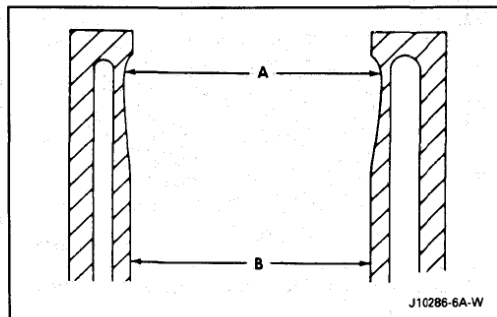


Figure 30 Cylinder Wear Pattern

THREAD REPAIR**Figure 31**

Damaged threads may be reconditioned by drilling out, rethreading and installing a suitable thread insert.

CAUTION: Wear safety glasses to avoid eye damage.

1. Determine size, pitch and depth of damaged thread. If necessary, adjust stop collars on cutting tool and tap to the required depth.

**Important**

- Refer to the kit manufacturer's instructions regarding the size of the drill and tap to be used.

2. Drill out damaged thread. Clean out chips. Refer to Figure 31-A.
3. Tap hole. Lubricate tap with light engine oil. Clean the thread. Refer to Figure 31-B.

**Important**

- Avoid build-up of chips. Back out the tap every few turns and remove chips.

4. Thread the thread insert onto the mandrel of the installer (Figure 31-C). Engage the tang of the insert onto the end of the mandrel.
5. Lubricate the insert with light engine oil (except when installing in aluminum) and install. Refer to Figure 31-D.

**Important**

- When correctly installed, the insert should be flush to one turn below the surface.

6. If the tang of the insert does not break off when backing out the installer, break the tang off with a drift pin.

CRANKSHAFT**Figure 23****Clean**

- Oil, sludge and carbon.
- Probe oil passages for obstructions.

**Inspect**

- Keyway.
- Threads.
- Bearing journals and thrust surfaces for:
 - Cracks.
 - Chips.
 - Gouges.
 - Roughness.
 - Grooves.
 - Overheating (discoloration).
- Corresponding bearing inserts for embedded foreign material and determine its source.

**Important**

- If cracks, severe gouges or burned spots are found, the crankshaft must be replaced. **Slight** roughness may be removed with a fine polishing cloth soaked in clean engine oil. Burrs may be removed with a fine oil stone.

**Measure**

- Crankshaft journals. With a micrometer measure taper and run-out. If the readings are within specifications. Refer to "Engine Specifications" in this section, note results for later selection of bearing inserts. If not within limits, the crankshaft must be replaced.

**Important**

- Note the location of main bearing high spots. If they are not in line, the crankshaft is bent and must be replaced.

PISTONS AND CONNECTING RODS**Figures 32 through 39**

Tool Required:

J 24086-C Piston Pin Remover/Installer

**Disassemble**

CAUTION: Use care when handling the piston. Worn piston rings are sharp and may cause bodily injury.

1. Piston rings (87, 88 and 89). Use a suitable tool to expand the rings. Piston rings must not be re-used.
2. Place the piston (86) and connecting rod (83) assembly into J 24086-C and press out the piston pin. Refer to Figure 32. Be sure the flat side or inside of piston is up when installing piston and rod assembly into fork.

**Important**

- Make sure no load is put on piston (86) during disassembly.

CAUTION: Avoid inhaling fumes or exposure of the skin to carburetor cleaning fluid, as bodily injury may result.

**Clean**

- Piston (86), piston pin (85) and connecting rod (83) of:
 - Sludge.
 - Carbon.
 - It is essential that the piston ring grooves are cleaned of carbon to the bare metal.
 - Varnish from the piston pin (85) by soaking in carburetor cleaning solution.
 - Do not scrape the piston skirt.

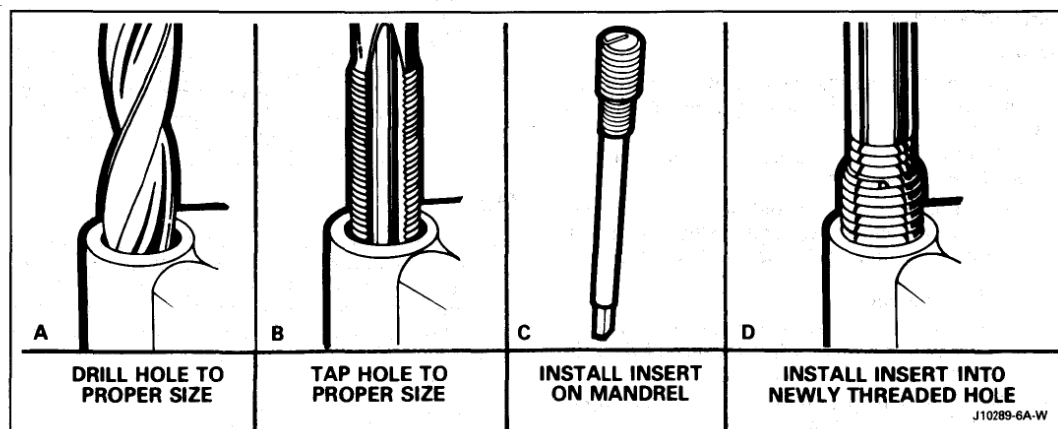


Figure 31 Repairing Threaded Holes

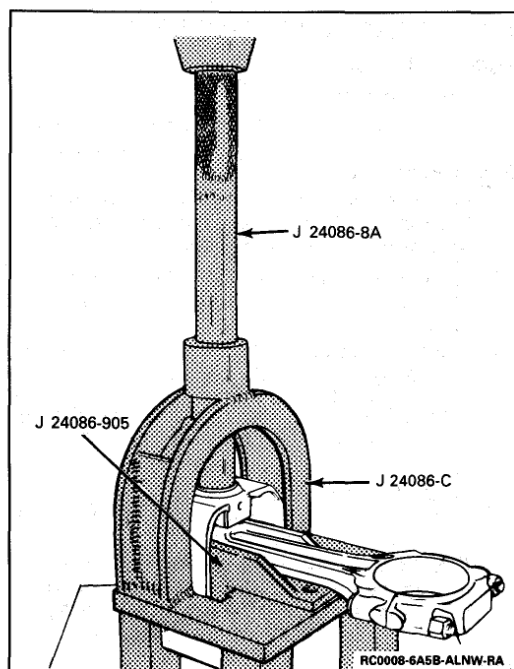


Figure 32 Removing Piston Pin

**Inspect**

1. Connecting rod (83) for:
 - Bending or twisting.
 - A. Install the connecting rod cap (81).
 - B. Place the connecting rod assembly (83) on a checking fixture and check for bending or twisting.
 - Do not attempt to straighten the connecting rod.

- The connecting rods should not be bent more than 0.007 inch for every three inches of rod length.
- The connecting rods should not be twisted more than 0.0015 inch for every inch of rod length. If bent or twisted, replace.
- Check new connecting rods before using them.

- Outside of the connecting rod bearing and the ID of the connecting rod lower end for wear indicating high spots in the connecting rod lower end.
 - Upper end for scoring.
2. Piston pin (85) for:
 - Scoring.
 - Galling caused by improper installation.
 - Fit in connecting rod and piston.
 3. Piston (86) for:
 - Scoring of the skirt.
 - Cracks.
 - Broken ring groove lands.
 - Wear.

Piston to Bore Clearance**Important**

- 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
 - Carbon can be removed with a wire brush of the engine, providing they are in good condition and the same weight.
- Do not cut oversize pistons down or engine balance will be affected.

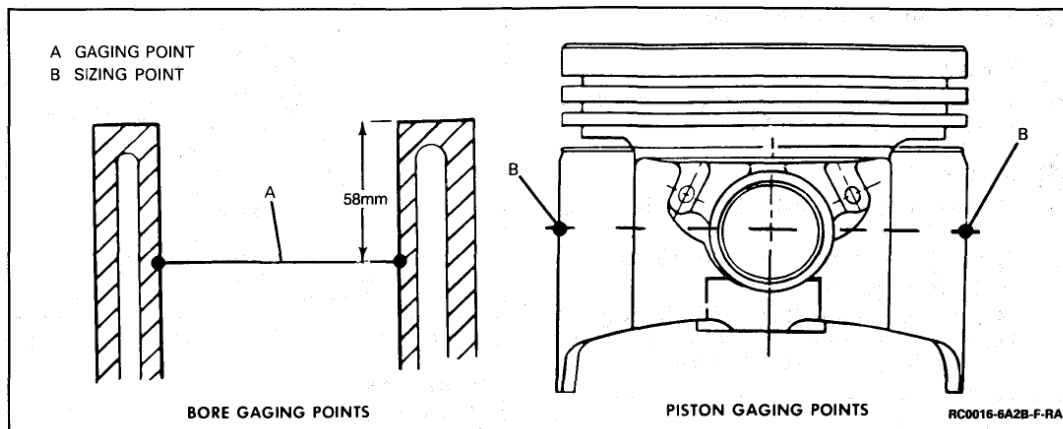


Figure 33 Cylinder Bore and Piston Gaging Points

Measure

1. Piston diameter. When measuring piston for size or taper, measurement must be made as shown with the piston pin removed (Figure 34). If worn or damaged, replace with a standard or oversize piston.

Important

- Finish hone when selecting piston.
2. Cylinder bore (Figure 33), with a telescoping gage. If worn beyond specifications, rebore and hone to size.
 3. Subtract piston diameter from cylinder bore diameter to determine piston-to-bore clearance.
 4. Compare piston-to-bore clearance with specifications in "Engine Specifications" of this section to determine if clearance is in acceptable range.
 5. If used piston is not acceptable, check service piston sizes and determine if a new piston can be selected. (Service pistons are available in standard, and several oversizes.)
 6. If cylinder bore must be reconditioned, measure new piston diameter then hone cylinder bore to correct clearance.
 7. Select new piston and mark piston to identify the cylinder for which it was fitted.

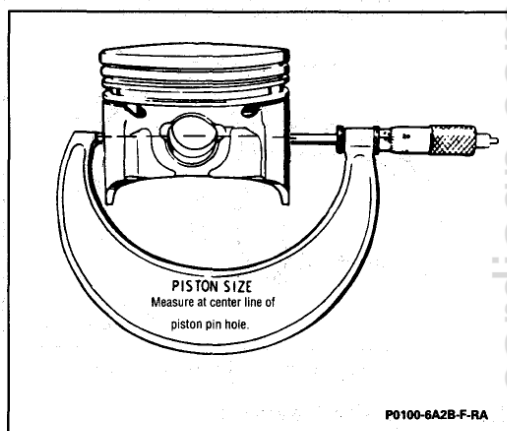


Figure 34 Measuring Piston

Piston Pin Bore-to-Piston Pin Clearance

Measure

1. Measure the piston pin bore diameter with an inside micrometer.
2. Measure the piston pin diameter with a micrometer.
3. Subtract piston pin bore diameter from piston pin diameter to determine clearance.
4. Compare clearance with Specifications in "Engine Specifications" of this section to determine if clearance is in acceptable range.
5. If it is not acceptable, replace piston assembly.

Piston Compression Ring End Gap



Important

- Do not reuse piston rings. Fit rings to match the cylinder they will be used in.



Measure

- Place piston into the cylinder at the bottom of the ring travel.
- Place a piston ring on top of the piston.
- Back off the piston.
- Measure the ring gap (Figure 35). If the gap is below specification, increase the gap by carefully filing off excess material.

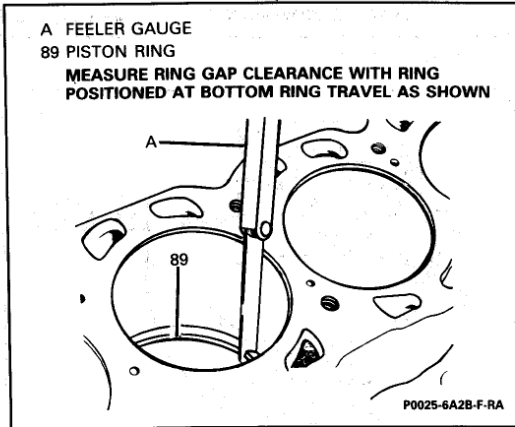


Figure 35 Measuring Piston Ring Gap

Piston Ring Side Clearance



Important

- Do not attempt to cut the ring groove, although high spots in the ring groove may be cleaned up by careful use of a point file.



Measure

- Piston compression ring side clearance.
- Roll the piston ring around the groove in which it is to be installed and measure the side clearance (Figure 36). If the ring is too thick, try another ring. Refer to "Engine Specifications" in this section for specifications.

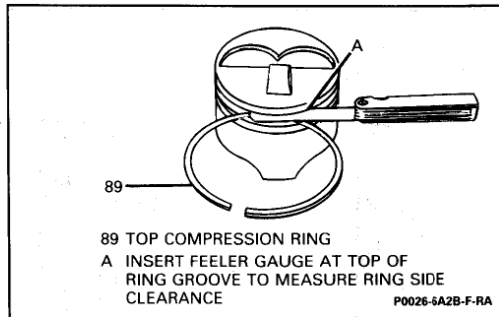


Figure 36 Measuring Piston Ring Side Clearance



Assemble

Important

- Make sure that the arrow on top of the piston faces towards the front of the engine.
- Place piston (86) and connecting rod (83) into J 24086-B (Figure 37).
 - Coat the piston pin (85) with clean engine oil.
 - Press the piston pin (85) into place.



Inspect

- Piston (86) for freedom of movement.

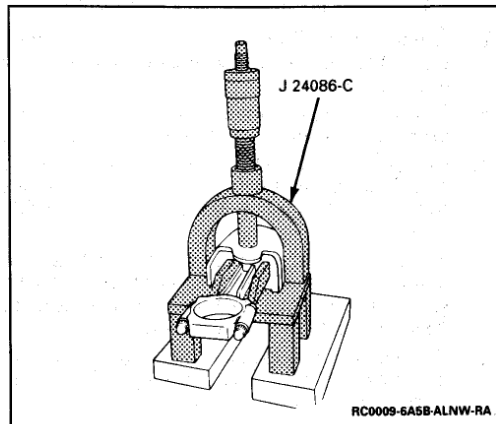


Figure 37 Installing Piston Pin

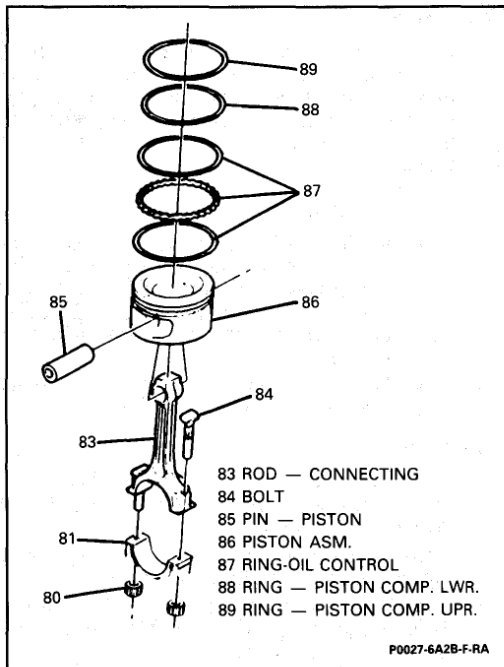


Figure 38 Piston and Rod Assembly

4. Oil control ring assembly (87).

- Expander.
- Lower oil control ring.
- Upper oil control ring.

NOTICE: Use a piston ring expander to install the rings. Avoid expanding the rings more than necessary, which may cause ring damage.

5. Upper and lower compression ring (88 and 89). Manufacturer's mark facing up.

! Important

- In order to provide an effective compression seal, the ring gaps must be staggered (Figure 39).

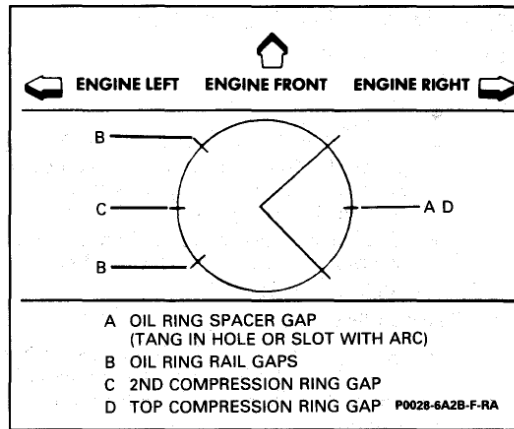


Figure 39 Piston Ring Gap Locations

MAIN BEARING AND ROD BEARING SELECTION

Figures 40 through 42

Evaluate bearings as specified in this section. If the engine is out of the vehicle and upside down, the crankshaft will rest on the upper bearings and the total clearance can be measured between the lower bearing and journal. If the engine is to remain in the vehicle, the crankshaft must be supported upward to remove any clearance from the upper bearing. The total clearance can then be measured between the lower bearing and journal.

Engine bearings are of the precision insert type. They are available for service use in standard and various undersizes (Figure 40).

NOTICE: Bearing inserts must not be shimmed, scraped or filed. Do not touch the bearing surface of the insert with bare fingers. Skin oil and acids will etch the bearing surface.

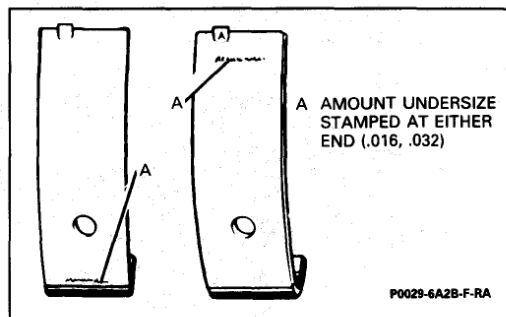


Figure 40 Main Bearing Insert Markings

**Inspect**

1. Bearing surfaces for:
 - Wear.
 - Gouges.
 - Embedded foreign material. If foreign material is found, determine its nature and source. Inspect oil pan sludge and residue.
 - Uneven side-to-side wear. If uneven wear is found, check for a bent crankshaft or tapered bearing journals.
 2. Outer surfaces for:
 - Wear. Surface wear indicates either movement of the insert or high spots in the surrounding material (spot wear).
 - Overheating (discoloration).
 - Looseness or rotation (flattened tangs and wear grooves).
 3. Thrust surfaces (main thrust bearing) for:
 - Wear.
 - Grooving. Grooves are caused by irregularities of the crankshaft thrust surface. Refer to "Crankshaft" in Cleaning, Inspection and Repair of this section.
- Important**
- Bearing failure, other than normal wear, must be investigated carefully. Inspect the crankshaft or connecting rod and the bearing bores.
4. Connecting rods or main bearing bores as follows:
 - A. Tighten the bearing cap to specifications.
 - B. Measure the bore for taper and out of round (Figure 41).
 - C. No taper or out of round should exist.

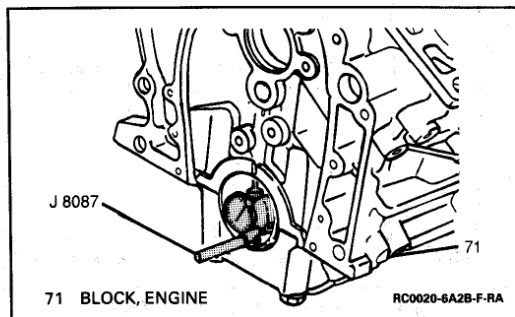


Figure 41 Measuring Bearing Bore

**Measure**

- Bearing clearance. To determine the correct replacement insert size, the bearing clearance must be measured accurately. Either of the following two methods may be used, however, method "A" gives more reliable results and is preferred.

**Important**

- Method "A" yields measurement from which the bearing clearance can be **computed**. Method "B" yields the bearing clearance **directly**. Method "B" does **not** give any indication of bearing run-out.
- Do not mix inserts of different nominal size in the same bearing bore.

Method "A"

1. Measure the journal diameter with a micrometer in several places, approximately 90° apart, and average the measurements.
2. Measure taper and run-out. Refer to "Engine Specifications" for allowable limits.
3. Install bearing inserts and tighten bearing cap bolts or nuts to specification. Measure ID with an inside micrometer.

**Important**

- The bearing cap must be tightened to specification when the measurement is taken.
 - Measure the connecting rod ID in the same direction as the length of the rod.
4. Select a set of bearing inserts that will produce the desired clearance, refer to "Engine Specifications" in this section. If the specified clearances cannot be met, the crankshaft journal must be re-conditioned and undersized bearing inserts installed. **Replace both bearing shells as a set.**

Method "B"

Tool Required:

J 36660 Torque Angle Meter

1. Clean and install the used bearing inserts.
2. Place a piece of gaging plastic across the **entire** bearing width.

NOTICE: In order to prevent the possibility of cylinder block and/or main bearing cap damage, the main bearing caps are to be tapped into their cylinder block cavity using a brass or leather mallet before attaching bolts are installed. Do not use attaching bolts to pull main bearing caps into their seats. Failure to observe this information may damage a cylinder block or bearing cap.

3. Seat the bearing cap carefully by tapping it lightly with a suitable tool.
4. Bearing cap bolts or nuts.

Tighten

- Main bearing cap bolts (19) evenly to 50 N·m (37 lb. ft.).
- Turn main bearing cap bolts (19) evenly an additional 77° using J 36660.
- Rod cap nuts (80) evenly to 50 N·m (37 lb. ft.).

Important

- Do not rotate the crankshaft.

5. Remove the bearing cap, leaving the gaging plastic in place. It does **not** matter whether the gaging plastic adheres to the journal or to the bearing cap.
6. Measure the gaging plastic at its **widest point** with the scale printed on the gaging plastic package (Figure 42).
7. Remove all traces of the gaging plastic after measuring.
8. Select a set of bearing inserts that will produce the desired clearance refer to "Engine Specifications" in this section. **Replace both bearing shells as a set.**

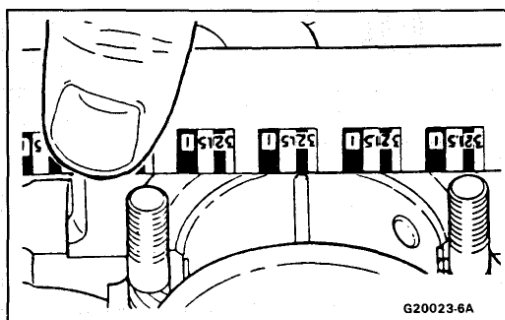


Figure 42 Measuring Bearing Clearance

OIL PUMP UNIT REPAIR

Figure 43 through 48

Tool Required:

J 21882 Oil Suction Tube Installer

Disassemble

1. Drain oil from pump.
2. Drive shaft (18).

Important

- Do not remove pickup tube from cover unless loose or broken.

3. Pump cover bolts and cover.
4. Pump gears.

CAUTION: The pressure regulator valve spring in some models is under pressure. Exercise caution when removing the retaining pin, as bodily injury may result.

5. Pressure regulator valve.
 - Cotter pin.
 - Spring.
 - Valve. If the valve is stuck, soak the pump housing in carburetor cleaning solvent.

CAUTION: Avoid breathing of fumes or exposure of the skin to the cleaning solvent, as bodily injury may result.

Clean

- All parts of sludge, oil and varnish.
- Varnish may be removed by soaking in carburetor or cleaning solvent.

Inspect

- For foreign material and determine source.
- Pump housing and cover for:
 - Cracks.
 - Scoring.
 - Casting imperfections.
 - Damaged threads.
 - Do not attempt to repair the pump housing.
 - If in doubt, replace the spring.
- Idler gear shaft. If loose in the housing, replace the pump.
- Pressure regulator valve for:
 - Scoring.
 - Sticking. Burrs may be removed with a fine oil stone.
- Pressure regulator valve spring for:
 - Loss of tension.
 - Bending.
- Suction pipe and screen assembly for:
 - Looseness, if permanently pressed into the pump body. If the suction pipe is loose, bent or has been removed, the pump body cover and suction pipe must be replaced.
 - Broken wire mesh or screen.
- Gears for:
 - Chipping.
 - Galling.
 - Wear.

- Drive shaft and drive shaft extension for:
 - Looseness.
 - Wear.

Measure

Figures 44 through 48

- Refer to "Engine Specifications" in this section for Specifications.
- Gear lash. Install gears, and measure in several places (Figure 44).
- Pump housing gear pocket (Figure 45).
- Gears (Figure 46).
- Gear side clearance (Figure 47).
- Gear end clearance (Figure 48).

Important

- When deciding pump serviceability based on end clearance, consider depth of wear pattern in the pump cover.

Assemble

1. Lubricate all internal parts with engine oil during assembly.
2. Pump gears.

NOTICE: To avoid engine damage, use **only** original equipment gaskets. The gasket thickness is **critical** to proper functioning of the pump.

3. Cover and gasket.

Tighten

- Pump cover bolts to 10 N·m (89 lb. in.).
4. Pressure regulator valve and spring.

Important

- Make sure the cotter pin is properly secured.
5. Cotter pin.
 6. Apply sealer GM p/n 1050026 (or equivalent), to a new pipe, and tap into place with a plastic hammer, using J 21882.

Important

- Whenever the oil pump is overhauled, clean the oil pan of oil and sludge; replace the oil filter; and fill crankcase with clean oil.

Inspect

1. Oil pressure as follows:

- A. Prime engine oil galleries by removing engine oil pump drive unit and rotate oil pump drive shaft using drill motor and appropriate socket and extension.
- B. Remove the oil pressure sending unit and install a pressure gage.

NOTICE: If the oil pressure does not build up almost immediately, remove the oil pan and check oil pump suction pipe attachment to the pump. Running the engine without measurable oil pressure will cause extensive damage.

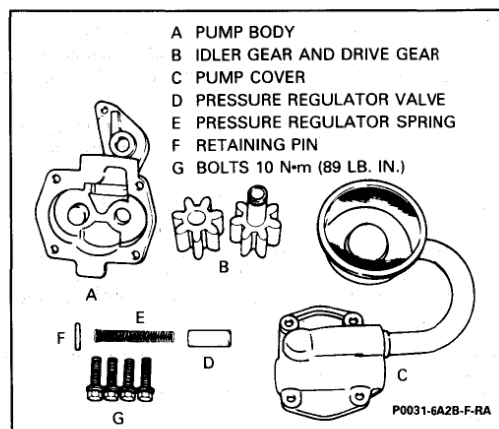


Figure 43 Oil Pump

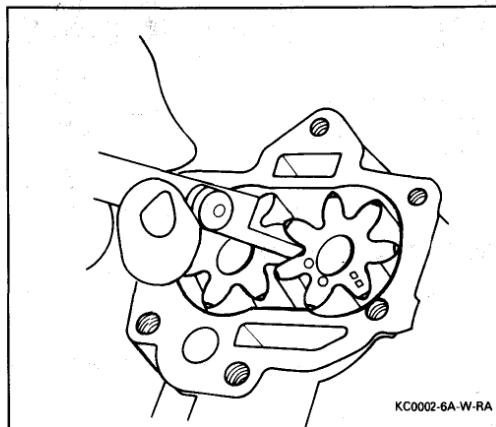


Figure 44 Measuring Oil Pump Gear Lash

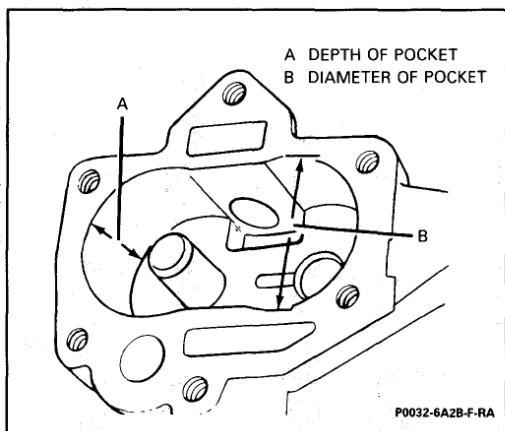


Figure 45 Measuring Oil Pump Gear Pocket

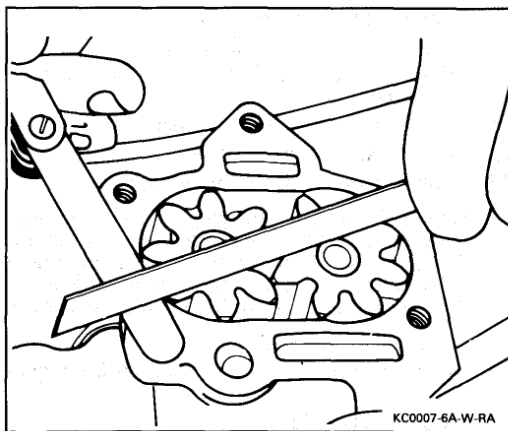


Figure 48 Measuring Oil Pump End Clearance

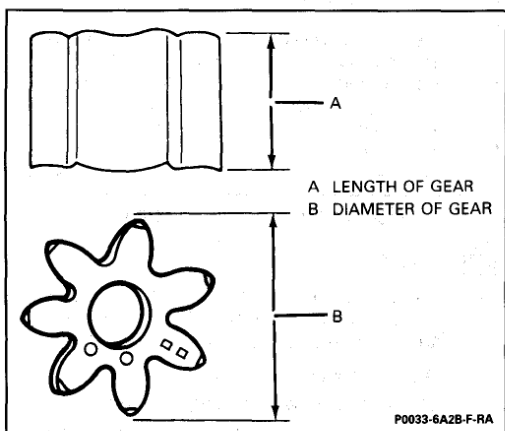


Figure 46 Measuring Oil Pump Gears

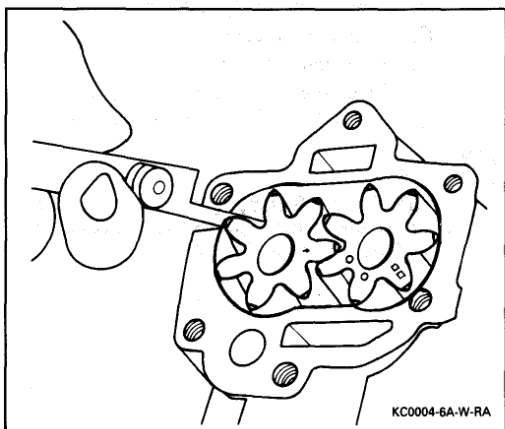


Figure 47 Measuring Gear Side Clearance

CYLINDER HEAD RECONDITIONING

Figures 49 through 56

Tools Required:

- J 8001 Dial Indicator Set
- J 8062 Valve Spring Compressor.
- J 8101 Valve Guide Cleaner
- J 9666 Valve Spring Tester
- J 37377 Valve Guide Reamer 0.089 mm (0.003 inch) OS.
- J 37378 Valve Guide Reamer 0.394 mm (0.015 inch) OS.
- J 37379 Valve Guide Reamer 0.775 mm (0.030 inch) OS.



Important

- Before removing the cylinder head(s) from the engine and before disassembling the valve mechanism, perform a compression test and note the results.
- During disassembly of the cylinder head, be sure that the valve train components are kept together and identified so that they can be installed in their original locations.



Disassemble

1. Spark plugs (221).
2. Right cylinder head engine lift hook bolts (201).
3. Engine lift hook (200).
4. Intake manifold mounting stud (140).
5. Rocker cover studs (196).
6. Compress the valve springs (128 and 135) using J 8062.
7. Valve locks (131 and 139).

8. Valve caps (130 and 138).
9. Exhaust valve oil shedders (137).
10. Valve springs (128 and 135) and dampers (127 and 134).
11. Spring shims (133), if equipped.
12. Intake valve stem oil seals (126).
13. Valve stem O-rings (129 and 136).

NOTICE: Avoid damaging the valve guide. If the valve stem has mushroomed due to wear from the rocker arm, remove burrs by chamfering the valve stem with an oil stone. Do not remove the valve from the guide with a hammer and punch.

14. Valves (125 and 132).
15. Rocker arm studs (121) and pushrod guide plates.
16. Water jacket plugs.

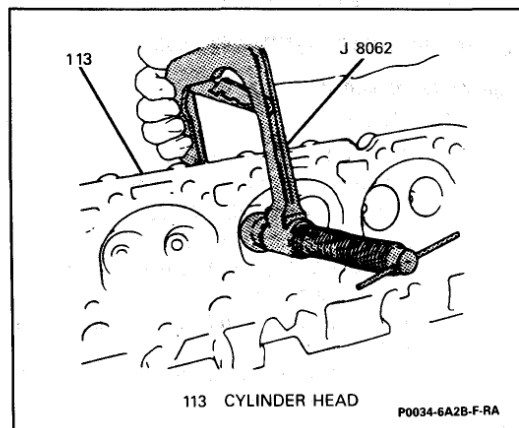


Figure 49 Compressing Valve Spring

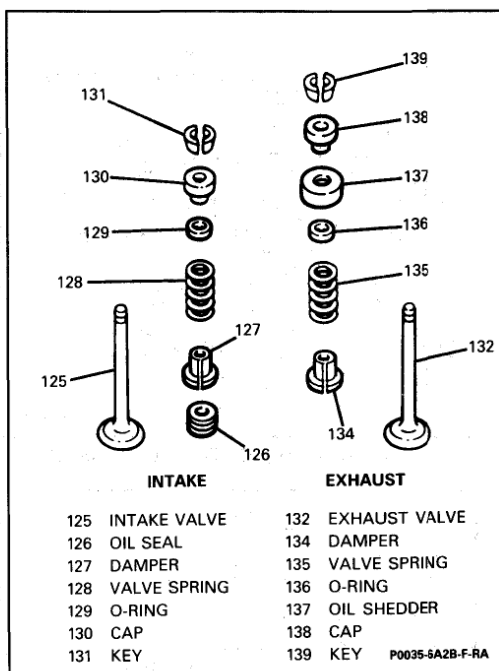


Figure 50 Valves and Components



Inspect

- Cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, determine the cause:
 - A. Improper installation.
 - B. Loose or warped cylinder head.
 - C. Missing, off location or not fully seated dowel pins.
 - D. Low torque on cylinder head bolts.
 - E. Warped case (block) surface.
 - F. Scratched surfaces.
 - G. Excessive inlet manifold torque.
 - H. Cracked engine block tapped holes.



Clean

CAUTION: Safety glasses must be worn when using a power wire brush to avoid damage to the eyes.

1. Cylinder head bolts (115).
2. Cylinder head (113). Carefully remove all varnish, soot and carbon to the bare metal. **DO NOT** use a motorized wire brush on any gasket sealing surface.
3. Valve guides as shown in Figure 51.
4. Valves (125 and 132) of carbon, oil and varnish.
 - Remove varnish by soaking in carburetor cleaning fluid.
 - Do not scratch the valve stem with the wire brush.
5. Threaded holes.
6. Remains of sealer from plug holes.
4. Cylinder head deck, intake and exhaust manifold mating surfaces for flatness as shown in Figure 52. These surfaces may be re-conditioned by milling. If the surfaces are "out of flat" by more than 0.1mm (0.004 inch), the surface should be milled. If more than 0.25 mm (0.010 inch) of metal must be removed from the head, it should be replaced.
5. All threaded holes for damage. Threads may be reconditioned with thread inserts. Refer to "Thread Repair" in this section.
6. Cooling jacket plugs seating surfaces.
7. Valve seats for excessive wear and burned spots.
 - Since the valve guide serves to support and center the valve grinder, it is essential that the valve guide is cleaned properly. If the valve guide requires reaming, measure valve guide clearance to determine if an oversized valve will be required. **This procedure must be performed before valve seats can be reconditioned.**
 - If a burnt valve condition exists, it may be necessary to recondition the valve seat. At no time should there be less than 4 mm of valve seat material remaining after reconditioning.
 - Valve seats may be reconditioned by grinding. Follow the grinder manufacturer's instructions. Refer to "Engine Specifications" in this section for seat angles. If, after grinding, the new seat is too wide, it may be narrowed by using a 70° stone. The 70° stone will raise the seat.

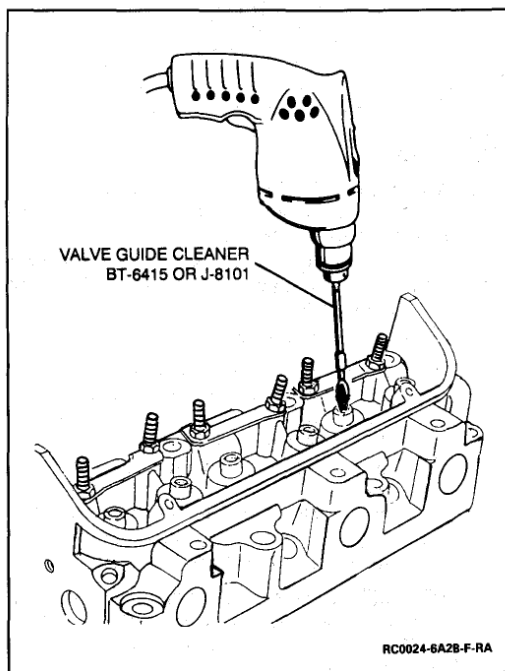


Figure 51 Cleaning Valve Guide

**Inspect**

1. Cylinder head bolts (115) for damaged threads or stretching, and damaged heads caused by improper use of tools.

**Important**

- Suspect bolts must be replaced.
2. Cylinder head (113) for cracks, especially between valve seats and in the exhaust ports.
 3. Cylinder head deck for corrosion, sand particles in head, and porosity.

**Important**

- Do not attempt to weld the cylinder head, replace it.

8. Valve stem tip for wear.
9. Valve lock (131 and 139) and oil seal grooves for chipped or worn lands. Replace the valve if chipped or worn.
10. Valve face for burning or cracking. If pieces are broken off, inspect the corresponding piston and cylinder head area for damage.
11. Valve stem for burrs and scratches. Burrs and **minor** scratches may be removed with an oil stone.
12. Valve stem for straightness and valve head for bending or distortion. Use "V" blocks. Bent or distorted valves must be replaced.
13. Valve face for grooving. If the groove is so deep that refacing would result in a knife edge, the valve must be replaced.
14. The valve face may be ground to specifications if it is otherwise in good condition. If the valve face cannot be grounded within the limits given, it must be replaced. Refer to "Engine Specifications" in this section.
15. Valve spring dampers (127 and 134) for broken pieces or cracks. Replace if damaged.

16. Valve springs (128 and 135).
- Free length.
 - Spring ends. If they are not parallel, the spring is bent and must be replaced.
 - Spring tension (load open and load closed). If below specification, replace.
 - For cracks or breaks.
17. Valve spring seating surface of the spring caps for wear, cracks or gouging. Replace as required.

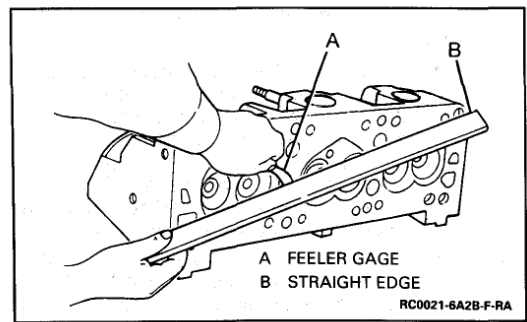


Figure 52 Checking Cylinder Head Flatness

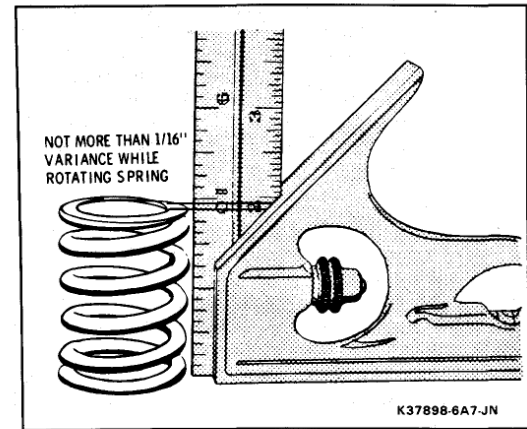


Figure 53 Checking Valve Springs

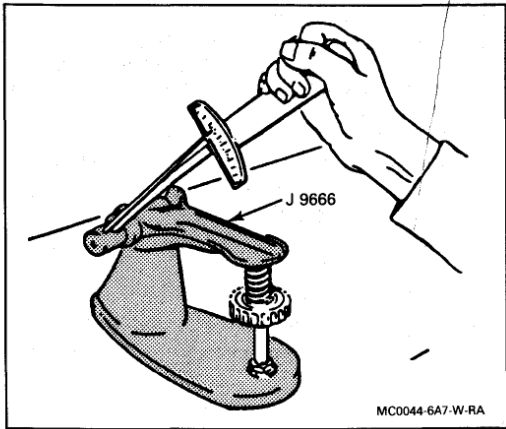


Figure 54 Checking Valve Spring Tension



Measure

1. Valve margin after grinding valves. If the margin is less than the minimum recommended margin, replace the valve.
2. Valve seat margin and runout. If the margin is less than the minimum recommended margin, replace the cylinder head.
3. Valve guide clearance.
 - Insert the valve into its guide. Lift it 2 mm (1/8 inch) off the seat and move it side to side, measuring the amount of movement with a dial indicator, or
 - With a hole gage, measure the valve guide ID, then measure the valve stem with a micrometer and compare the clearance.
 - Refer to "Engine Specifications" in this section for allowable clearances.

NOTICE: Avoid breaking reamer flutes or jamming the reamer into the valve guide due to packing of chips or carbon. Clean the valve guides before reaming.

- The valve guides may be reamed oversize and an oversized valve installed (Figure 56).

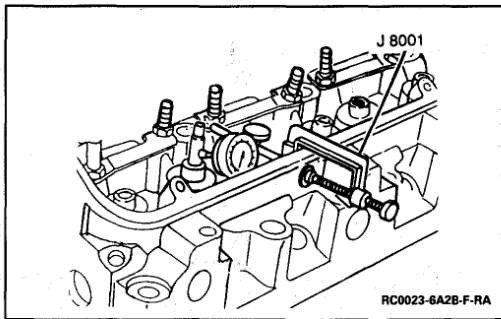


Figure 55 Measuring Valve Guide Clearance

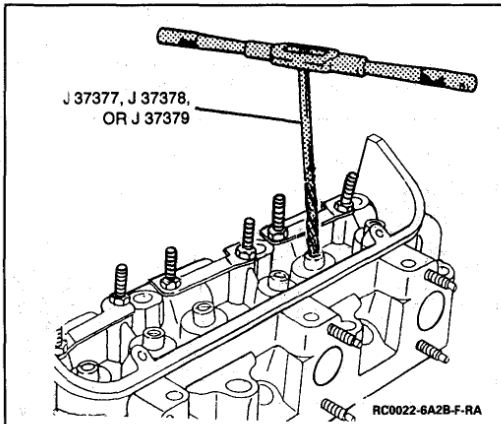


Figure 56 Reaming Valve Guide

Assemble

1. Lightly lap the reconditioned valves into the valve seat.
2. Cooling jacket plugs. Coat plugs with sealer GM p/n 1050026 (or equivalent).

Tighten

- Plug to 21 N·m (15 lb. ft.).

3. Pushrod guide plates and rocker arm studs (121).

Tighten

- Studs (121) to 46 N·m (35 lb. ft.).

4. Valves (125 and 132).

Measure

- Valve run-out. Lift the valve off its seat and apply a dab of Prussian blue on the valve face. Seat the valve and carefully rotate it. The Prussian blue traces transferred to the valve seat are an indication of concentricity of the valve seat.

- Clean all traces of Prussian blue. Apply a dab of Prussian blue on the valve seat and repeat the check. The traces of Prussian blue transferred to the valve indicates valve run-out. Recondition valve seat/face or replace valves as required.

5. Intake valve stem oil seals (126).



Important

- Push the valve stem seals down as far as possible. If oversize valves have been installed, oversized valve stem must be used.

A. Use plastic sleeve provided.

B. Press over valve guide boss.

6. Spring shim (133), if required.
7. Valve stem O-rings (129 and 136).
8. Valve spring dampers (127 and 134) and springs (128 and 135).
9. Exhaust valve oil shedders (137).
10. Valve caps (123 and 138).
11. Compress the valve springs (128 and 135) using J 38606.
12. Valve locks (131 and 139).
 - If necessary, hold valve locks in place with grease.

13. Release valve springs (128 and 135).



Inspect

- Make sure valve locks are seated.

14. Rocker cover studs (196).



Tighten

- Studs (196) to 6 N·m (106 lb. in.).

15. Intake manifold mounting studs (140).



Tighten

- Studs (140) to 10 N·m (89 lb. in.).

16. Right cylinder head engine lift hook (200) and bolts (201).



Tighten

- Bolts (201) to 32 N·m (24 lb. ft.).

NOTICE: To avoid damage, install spark plugs (221) after the cylinder head has been installed on the engine block assembly.

CAMSHAFT INSPECTION

Figure 57 and 58

Tool Required:

- J 26900-12 Dial Indicator
- J 26900-13 Magnetic Base



Inspect

- Sprocket.
- Keyway and threads.
- Bearing surfaces and lobes for:
 - Wear.
 - Galling.
 - Gouges.
 - Overheating (Discoloration).



Important

- Do not attempt to repair the camshaft, replace it if damaged.
- If a new camshaft is installed, all valve lifters must be replaced.



Measure

1. Bearing journals.
 - With a micrometer, measure diameter and run-out. If out of specification, replace the camshaft.
2. Camshaft lift.
 - A. Lubricate the camshaft bearings with GM Camshaft and Lifter Prelube p/n 1052365 (or equivalent).
 - B. Carefully set the camshaft on "V" blocks or between camshaft centers.
 - C. Install J 26900-12 and J 26900-13.
 - D. Measure camshaft journal runout and lobe lift (Figure 57 and 58). If out of specification, replace the camshaft.



Important

- If a new camshaft is being installed, add Camshaft and Lifter Prelube GM p/n 1052365 (or equivalent) to the engine oil.
- Coat cam lobes with Camshaft and Lifter Prelube GM p/n 1052365 (or equivalent).

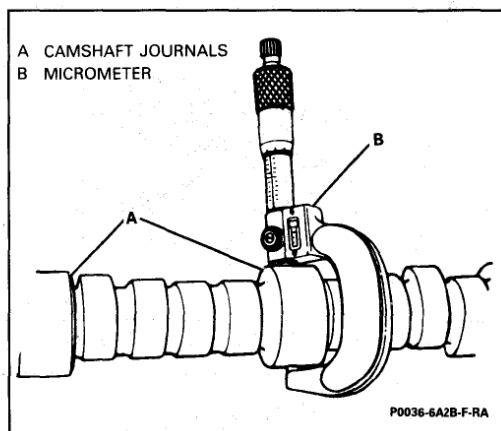


Figure 57 Measuring Camshaft Journals

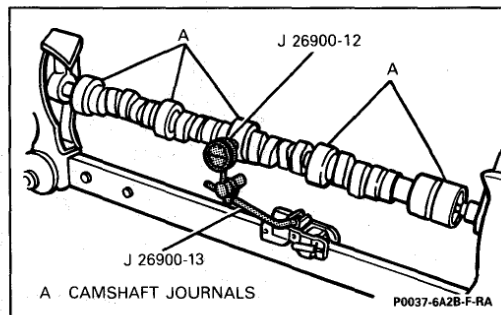


Figure 58 Measuring Cam Lift and Journal Runout

TIMING CHAIN AND SPROCKETS

Figure 71



Inspect

- Camshaft and crankshaft sprockets (98 and 26) for wear or knicks.
- Key and crankshaft keyway for wear or knicks.
- Timing chain (25) for wear or binding.

ENGINE FRONT COVER

Figure 73

Tool Required:

- J 34995 Oil Seal Installer



Disassemble

1. Crankshaft position sensor screws (56).
2. Crankshaft position sensor (57).
3. Front cover oil seal (58).
 - Pry out carefully with a suitable tool.

**Clean**

- Engine front cover mating surfaces.

**Inspect**

- Front cover oil seal (58) for damage.
- Cracks or knicks.

**Assemble**

1. Front cover oil seal (58) using J 34995.
2. Crankshaft position sensor (57).
3. Crankshaft position sensor screws (56).

**Tighten**

- Sensor screws (56) to 9 N·m (89 lb. in.).

OIL PAN**Figure 17****Disassemble**

1. Low oil level indicator (15).

**Clean**

- Oil pan (1) in solvent. Remove all sludge and varnish.
- Gasket surfaces.

**Inspect**

- Gasket flanges for bending or damage.
- Oil pan (1) for cracks or dents.

**Assemble**

1. Low oil level indicator (sensor) (15).

**Tighten**

- Indicator (sensor) (15) to 22 N·m (16 lb. ft.).

2. Oil drain plug (9) and washer (8).

**Tighten**

- Oil drain plug (9) to 25 N·m (18 lb. ft.).

COOLANT PUMP**Figure 74****Clean**

- Coolant pump (54) mating surface.

**Inspect**

- Coolant pump shaft for looseness.

VALVE LIFTERS**Figure 59**

Valve lifters should be kept in order so they may be installed in their original position.

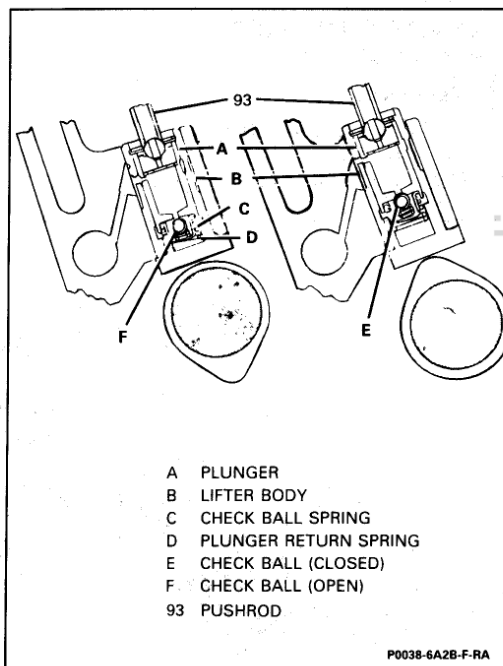
If the lifters are removed, they must be installed in their original location. If replacement is necessary, use lifters with a narrow flat ground along the lower 3/4 of lifter. These flats provide additional oil to the cam lobe and lifter surfaces.

**Inspect**

- Lifter body for wear and scuffing.
- Lifter bore for wear.
- Lifter pushrod seat for wear.

**Important**

- Whenever new valve lifters are being installed, coat foot of valve lifters with camshaft and lifter prelube GM p/n 1052365 (or equivalent).

**Figure 59 Valve Lifter Operation****VALVE ROCKER ARMS AND PUSHRODS****Figure 13****Inspect**

- Rocker arms (122) and balls (123) for wear at rotation surfaces.
- Pushrod (93) ends for wear.
- Pushrod (93) for bends.

VALVE ROCKER COVERS**Figure 12****Disassemble**

1. Oil fill tube bolt (189) and oil fill tube (188).
2. Rubber grommets.

**Clean**

- Valve rocker cover gasket surfaces.

**Inspect**

- Gasket flanges for damage.
- Rubber grommets for deterioration.

**Assemble**

1. Rubber grommets.
2. Oil fill tube (188) and bolt (189).

**Tighten**

- Oil fill tube bolt (189) to 8 N·m (71 lb. in.).

3. Canister purge solenoid (178).
4. Emission control vacuum harness assembly (172).
5. Vacuum tee.

**Clean**

- Gasket surfaces.
- Manifold bolts and studs.

**Assemble**

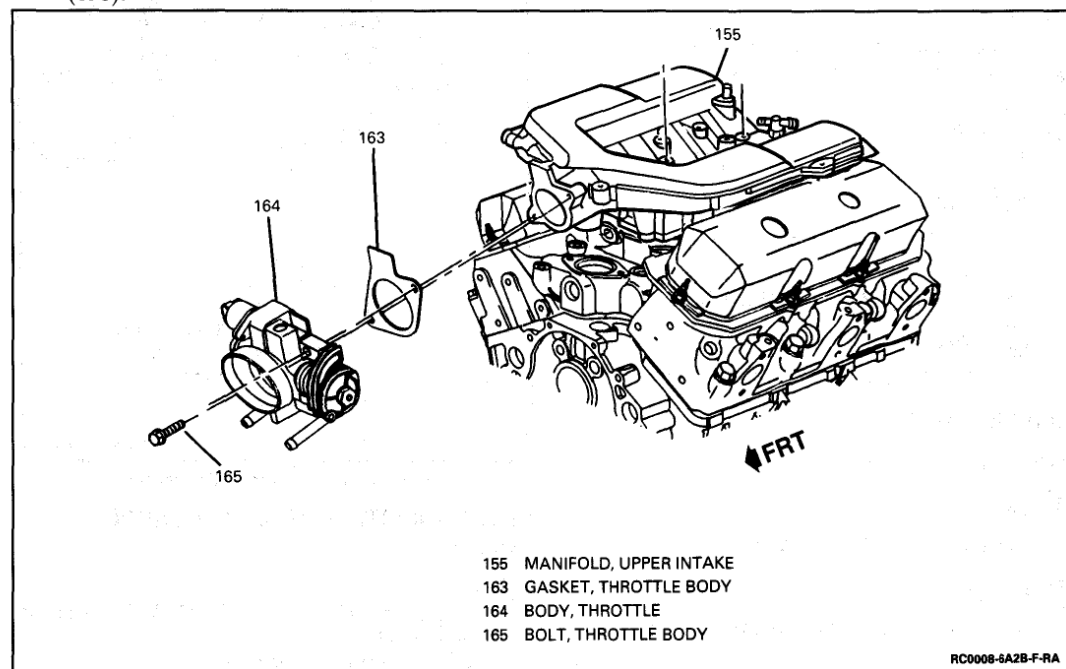
1. Vacuum tee.
2. Emission control vacuum harness assembly (172).
3. Canister purge solenoid (178).
4. MAP sensor screws (160) and MAP sensor (158).
5. Throttle body gasket (163), throttle body (164) and bolts (165).

**Tighten**

- Apply sealer GM p/n 1052080 to threads of throttle body bolts.
- Throttle body bolts (165) to 25 N·m (18 lb. ft.).

UPPER INTAKE MANIFOLD**Figures 11 and 60****Disassemble**

1. Throttle body bolts (165), throttle body (164) and gasket (163).
2. MAP sensor screws (160) and MAP sensor (158).

**Figure 60 Throttle Body**

LOWER INTAKE MANIFOLD**Figure 14****Disassemble**

1. Rocker cover studs (196).
2. Thermostat housing bolts (146).
3. Thermostat housing (147) and gasket.
4. Thermostat (148).
5. Engine coolant temperature sensor (145).
6. Heater inlet hose nipple (149).

**Clean**

- Intake manifold gasket surfaces.
- Injector bores.
- Intake manifold bolts and studs.

**Assemble**

1. Heater inlet hose nipple (149).

**Tighten**

- Apply teflon sealant to threads of pipe nipple (149).
- Pipe nipple (149) to 30 N·m (22 lb. ft.).

2. Engine coolant temperature sensor (145).

**Tighten**

- Apply teflon sealant GM p/n 1052080 to threads of sensor (145).
- Sensor (145) to 16 N·m (12 lb. ft.).

3. Thermostat (148).

4. Thermostat housing gasket and housing (147).

5. Thermostat housing bolts (146).

**Tighten**

- Thermostat housing bolts (146) to 21 N·m (15 lb. ft.).

6. Rocker cover studs (196).

**Tighten**

- Studs (196) to 6 N·m (106 lb. in.).

ASSEMBLY**CYLINDER BLOCK****Figure 1****Install or Connect**

1. Oil gallery plugs (64 and 65).

**Tighten**

- Apply teflon sealant GM p/n 1052080 to threads of plugs.
- Front and rear oil gallery plugs (79) to 33 N·m (24 lb. ft.).
- Front and rear oil gallery plugs (65 and 78) to 19 N·m (14 lb. ft.).

- Lifter valley oil gallery plugs (64) to 15 N·m (11 lb. ft.).

2. Coolant drain plugs (69 and 70).

**Tighten**

- Apply teflon sealant GM p/n 1052080 to threads of plugs.
- Coolant drain plugs to 19 N·m (14 lb. ft.).

3. Coolant plugs (74).

- Apply sealant GM p/n 12345493 to outside edge of coolant expansion plugs (74).

4. Camshaft position sensor (96).

5. Camshaft position sensor retaining bolt (95).

**Tighten**

- Bolt (95) to 10 N·m (89 lb. in.).

6. Ignition timing sensor (67) and retaining bolt (66).

**Tighten**

- Bolt (66) to 9 N·m (89 lb. in.).

7. Knock sensor (68).

**Tighten**

- Apply sealer GM p/n 1052080 to threads of knock sensor.
- Knock sensor (68) to 19 N·m (14 lb. ft.).

8. Oil filter adapter (41) and gasket (40).

9. Oil filter adapter bolt (43).

**Tighten**

- Bolt (43) to 68 N·m (50 lb. ft.).

10. Oil filter (45).

**Tighten**

- Filter (45) to 13 N·m (115 lb. in.) or 1-1/2 turns past seal contact.

CAMSHAFT BEARINGS**Figure 61**

Tool Required:

J 33049 Camshaft Bearing
Remover/Installer**Install or Connect**

1. New camshaft bearings (101).

A. Select front, rear and intermediate camshaft bearings.

B. Select the proper expander assembly and driving washer.

C. Assemble J 33049.

- D. Place intermediate camshaft bearing onto J 33049 and index the oil hole at 4 o'clock when looking from the front of the engine block. Drive the intermediate camshaft bearings into place.
- E. Install #4 camshaft bearing with the oil hole indexed at 4 o'clock when looking from the front of the engine block, using J 33049.
- F. Install #1 camshaft bearing with the oil hole indexed at 4 and 7 o'clock when looking from the front of the engine block, using J 33049.

**Inspect**

- With a piece of 3/32 inch brass rod with a 90° bend at the end, probe the bearing oil holes and verify that they are properly aligned (Figure 61).

NOTICE: Proper alignment of the oil holes is critical. Restriction of the oil flow will cause severe engine damage.

- 2. Camshaft cover gasket (75), cover (76) and bolts (77).

**Tighten**

- Bolts (77) to 10 N·m (89 lb. in.).

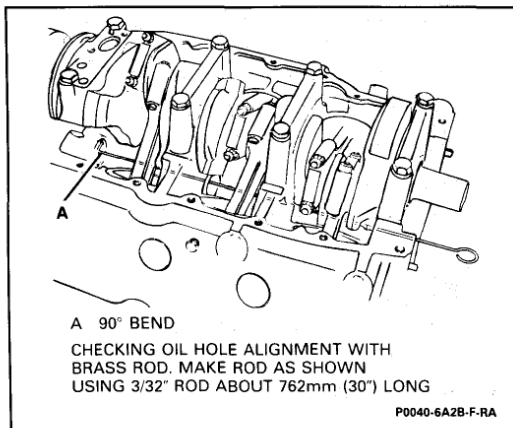


Figure 61 Checking Camshaft Bearing Oil Hole Alignment

CRANKSHAFT

Figure 62 and 63

**Install or Connect**

NOTICE: Bearing inserts must not be shimmed, scraped or filed. Do not touch the bearing surface of the insert with the bare fingers. Skin oil and acids will etch the bearing surface.

**Important**

- Make sure the bearing cap bolt holes and the cap mating surfaces are clean and dry.

- 1. Dip bearing cap bolts (19) in clean engine oil.

NOTICE: Upper and lower inserts may be different. Do not obstruct any oil passages.

- 2. Place bearing inserts (23) into the bearing cap (20) and into the engine block (71). Refer to "Main Bearing and Connecting Rod Bearing Selection" in this section.

**Important**

- The inserts will project slightly when put into place. Make sure they project an equal distance on both sides. Make sure the insert tangs are engaged.

- 3. In the case of a thrust bearing type main bearing insert, coat the thrust surface with GM EOS p/n 1052368 (or equivalent).
- 4. Lubricate the bearing surface with clean engine oil.
- 5. Crankshaft (22).

NOTICE: In order to prevent the possibility of cylinder block and/or main bearing cap damage, the main bearing caps are to be tapped into their cylinder block cavity using a brass or leather mallet before attaching bolts are installed. Do not use attaching bolts to pull main bearing caps into their seats. Failure to observe this information may damage a cylinder block or bearing cap.

- 6. Bearing cap (20). Tap gently into place with a suitable tool.
 - Apply a small amount of sealer GM p/n 1052942 to the rear of rear bearing cap sealing surface.
- 7. With crankshaft bearing and bearing caps installed and cap bolts started, thrust crankshaft rearward to set and align bearing caps, then thrust crankshaft forward to align rear face of thrust main bearing (Figure 62).
- 8. Main bearing cap bolts (19).

**Tighten**

- Main bearing cap bolts (19) evenly to 50 N·m (37 lb. ft.).
- Turn main bearing cap bolts (19) evenly an additional 77° using J 36660.

**Measure**

- Crankshaft end play (Figure 63).

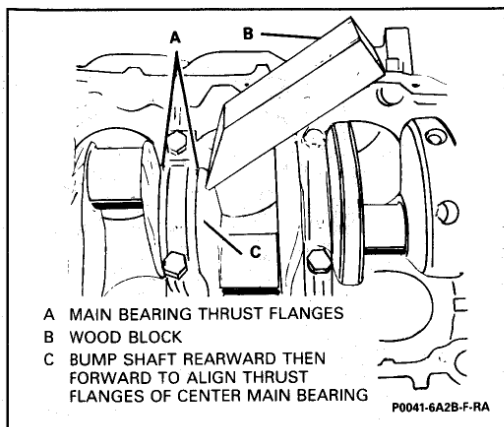


Figure 62 Seating the Crankshaft Thrust Bearing

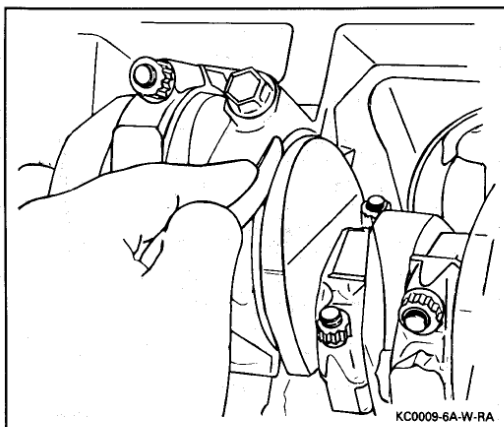


Figure 63 Measuring Crankshaft End Play

REAR MAIN OIL SEAL

Tool Required:

J 34686 Rear Main Oil Seal Installer

Figures 64 and 65

Install or Connect

1. Apply engine oil to ID and OD of new seal. Slide seal over mandrel until back of seal bottoms squarely against collar of tool (Figures 64 and 65).
2. Rear main oil seal (32).
 - A. Align dowel pin of J 34686 with dowel pin in crankshaft and attach J 34686 to crankshaft by hand or tighten attaching screws to 5 N·m (44 lb. in.).

- B. Turn "T" handle of J 34686 so the collar pushes the seal into the bore. Turn handle until the collar is tight against the cylinder case, this will ensure the seal is seated properly.
- C. Loosen the "T" handle of J 34686 until it comes to a stop.
- D. Remove J 34686 attaching screws.

**Inspect**

- Check to ensure seal is seated squarely in bore.

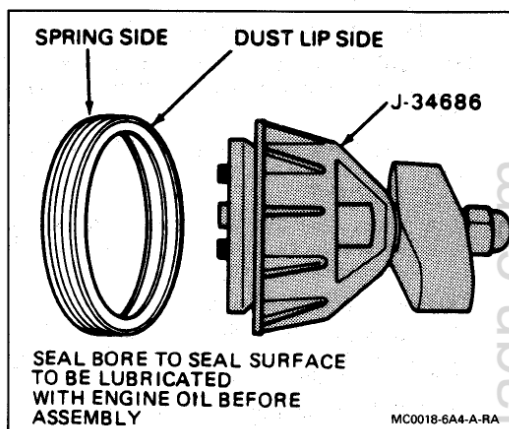


Figure 64 Rear Main Seal and Tool

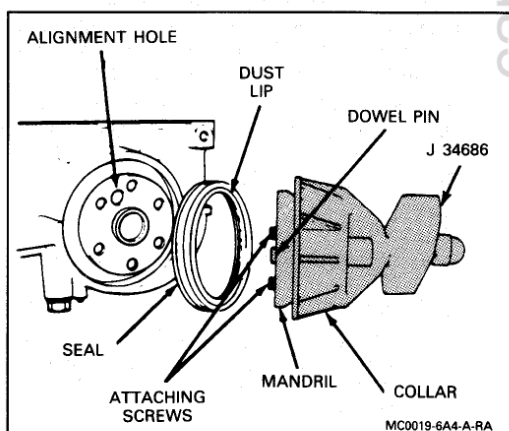


Figure 65 Installing Rear Main Seal

PISTONS AND CONNECTING RODS

Figures 66 and 67

Tool Required:

J 8037 Piston Ring Compressor

Install or Connect

1. Lubricate cylinder wall and piston rings with clean engine oil.
2. Turn crankshaft to bottom dead center.
3. Connecting rod stud thread protector (Figure 22).
4. J 8037 Piston ring compressor (Figure 66).

NOTICE: Guide the lower connecting rod end carefully to avoid damaging the crankshaft journal.

5. Piston (86) and connecting rod (83) assembly.

Important

- Make sure that the arrow on top of the piston faces towards the front of the engine (Figure 66).

6. Remove thread protectors.
7. Connecting rod bearings (82). Refer to "Main Bearing and Connecting Rod Bearing Selection" in this section.

NOTICE: In order to prevent the possibility of rod bolt or bearing cap damage, the bearing caps may need to be tapped into position with a brass or leather mallet before attaching nuts are installed. Do not use attaching nuts to pull bearing caps onto rod. Failure to observe this information may damage a rod bolt or bearing cap.

8. Seat the bearing caps (81) by pushing on by hand or by carefully tapping it lightly with a suitable tool.
9. Bearing cap nuts (80).

Tighten

- Cap nuts (80) to 50 N·m (38 lb. ft.).

Inspect

- Pry the connecting rod back and forth with a suitable tool and check for binding. If necessary, loosen and retighten the bearing cap.

Measure

- Connecting rod side clearance (Figure 67).

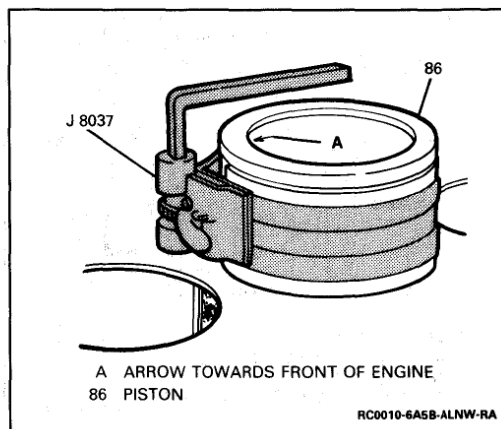


Figure 66 Piston Ring Compressor

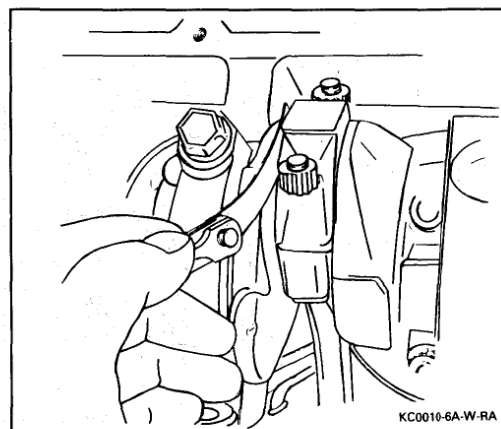


Figure 67 Measuring Connecting Rod Side Clearance

OIL PUMP

Figure 21

Install or Connect

1. Oil pump (17) and drive rod (18).
2. Oil pump bolt (16).

Tighten

- Bolt (16) to 41 N·m (30 lb. ft.).

CYLINDER HEAD

Tool Required:

J 36660 Torque Angle Meter

Right**Figure 68****Install or Connect**

1. Cylinder head gasket (112).
2. Cylinder head (113).
3. Cylinder head bolts (115).

Tighten

- Bolts (115) in sequence to 45 N·m (41 lb. ft.). Figure 68.
- Turn bolts (115) in sequence an additional 90° using J 36660. Figure 68.

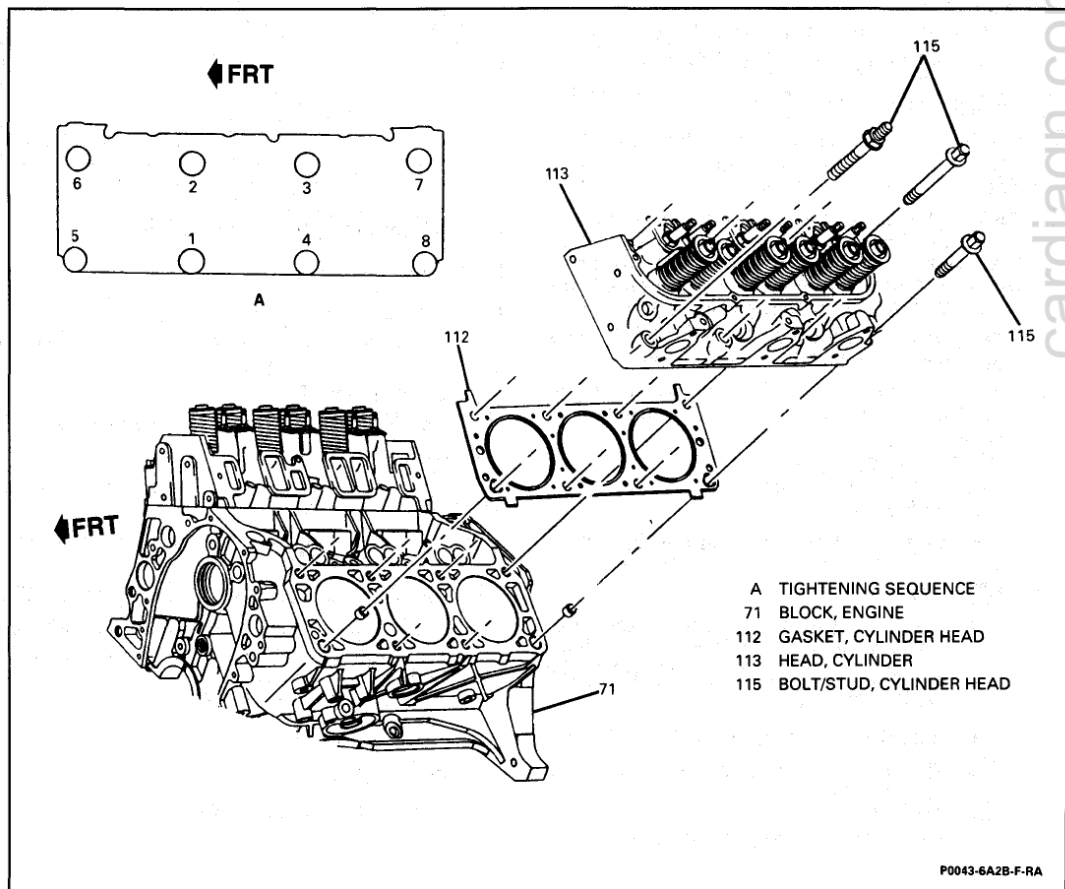
4. Pencil brace bracket bolts.

Left**Figure 68****Install or Connect**

1. Cylinder head gasket (112).
2. Cylinder head (113).
3. Cylinder head bolts (115).

Tighten

- Bolts (115) in sequence to 45 N·m (41 lb. ft.). Figure 68.
- Turn bolts (115) in sequence an additional 90° using J 36660. Figure 68.

**Figure 68 Cylinder Head Installation**

4. Engine coolant temperature sensor (114).

Tighten

- Apply teflon sealant GM p/n 1052080 to threads of sensor (114).
- Coolant temperature sensor (114) to 16 N·m (12 lb. ft.).

5. Engine lift bracket (200) and bolts (201).

Tighten

- Bolts (201) to 50 N·m (37 lb. ft.).

6. Oil level indicator tube nut (47).

Tighten

- Nut (47) to 21 N·m (15 lb. ft.).

7. Power steering pump brace (38), nut (39) and stud (37).

Tighten

- Stud (37) to 25 N·m (18 lb. ft.).
- Nut (39) to 50 N·m (37 lb. ft.).

8. Power steering pump bracket (224) and stud.

CAMSHAFT

Figure 69

Install or Connect

NOTICE: Camshaft journals are all the same diameter so care must be used when installing the camshaft to avoid bearing damage.

- Coat camshaft journals with engine oil or its equivalent.
- Coat camshaft lobes with prelube GM p/n 1052365.

1. Camshaft (100).

- Install three 4-inch bolts in the camshaft bolt holes.
- Carefully rotate and install the camshaft (100) into the camshaft bearings.

2. Oil pump driven gear assembly (90).

- Lubricate driven gear with prelube GM p/n 1052365.
- Lubricate assembly with engine oil for ease of installation.

3. Oil pump driven gear hold down clamp (92) and bolt (91).

Tighten

- Bolt (91) to 34 N·m (25 lb. ft.).

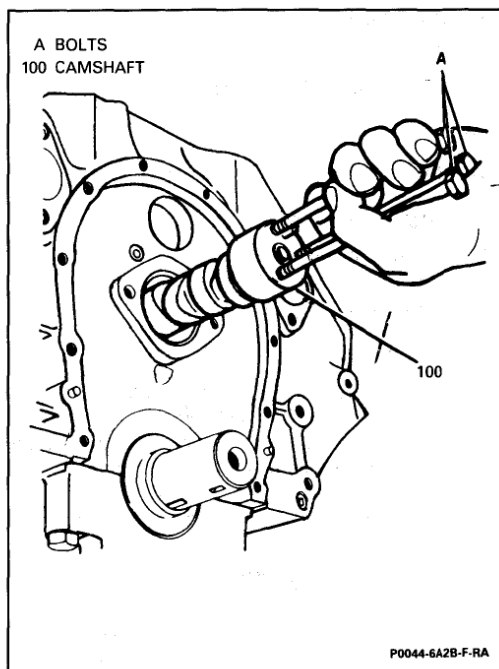


Figure 69 Installing Camshaft

TIMING CHAIN AND SPROCKETS

Figure 70 through 72

Tool Required:

J 38612 Crankshaft Sprocket Installer

Install or Connect

1. Crankshaft sprocket (26) using J 38612.
2. Remove J 38612.

- Coat crankshaft and camshaft sprocket teeth with engine oil.
- Coat rear face of camshaft sprocket with engine oil.

3. Camshaft sprocket (98) and timing chain (25).

- Align timing marks on crankshaft and camshaft sprockets with cast timing marks on engine block or timing marks on timing chain damper.

4. Camshaft sprocket bolts (97).

Tighten

- Bolts (97) to 24 N·m (18 lb. ft.).

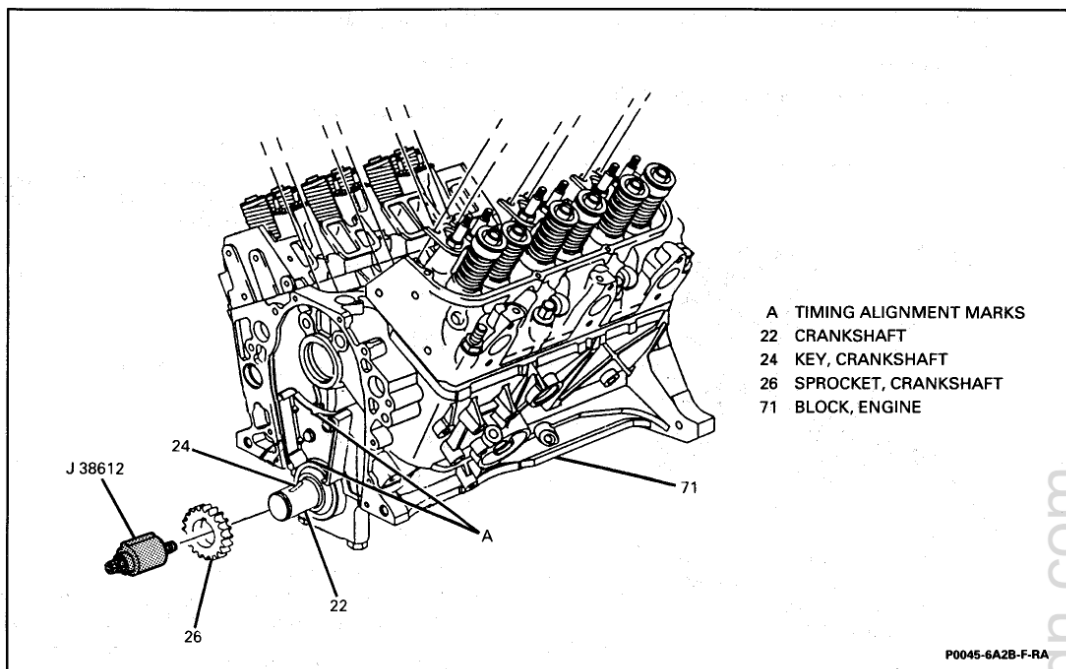


Figure 70 Crankshaft Sprocket Installation

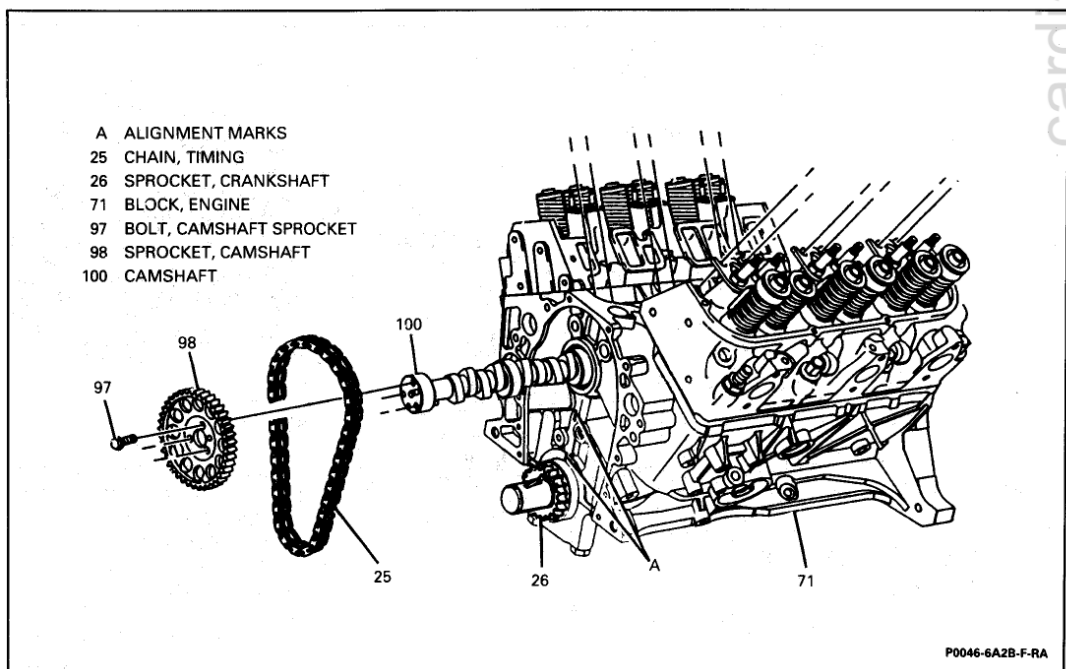


Figure 71 Camshaft Sprocket and Timing Chain Installation

5. Timing chain damper (63) and bolts (62).



Tighten

- Bolts (62) to 21 N·m (18 lb. ft.).

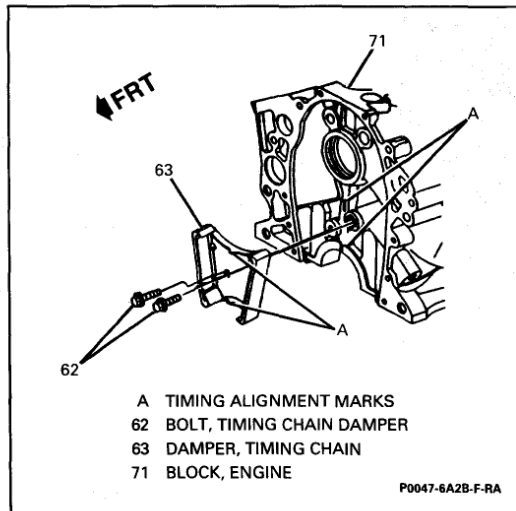


Figure 72 Timing Chain Damper

ENGINE FRONT COVER

Figure 73



Install or Connect

1. Front cover gasket (61).
 - Uniformly coat both sides of the lower tabs of the front cover gasket (61) with sealer GM p/n 1052080.
2. Front cover (60).
3. Front cover bolts (59).



Tighten

- Bolts (59) to 21 N·m (15 lb. ft.).

COOLANT PUMP

Figure 74



Install or Connect

1. Coolant pump gasket (55).
 - Apply sealer GM p/n 1052080 to the threads of the coolant pump retaining bolts (51, 52 and 53).
2. Coolant pump (54) and retaining bolts (51, 52 and 53).

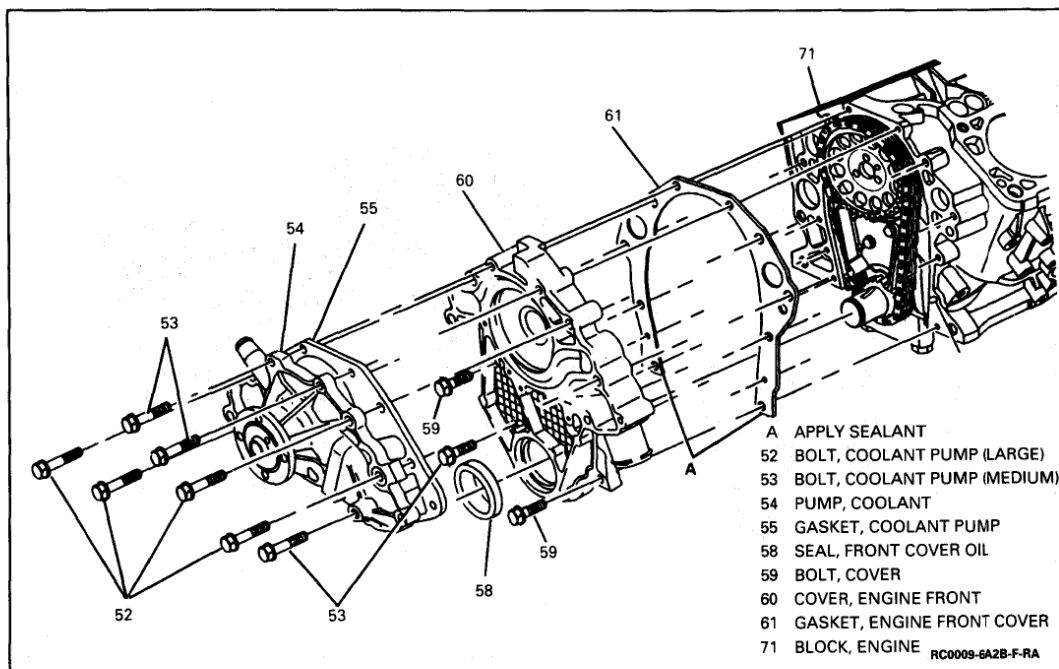


Figure 73 Engine Front Cover

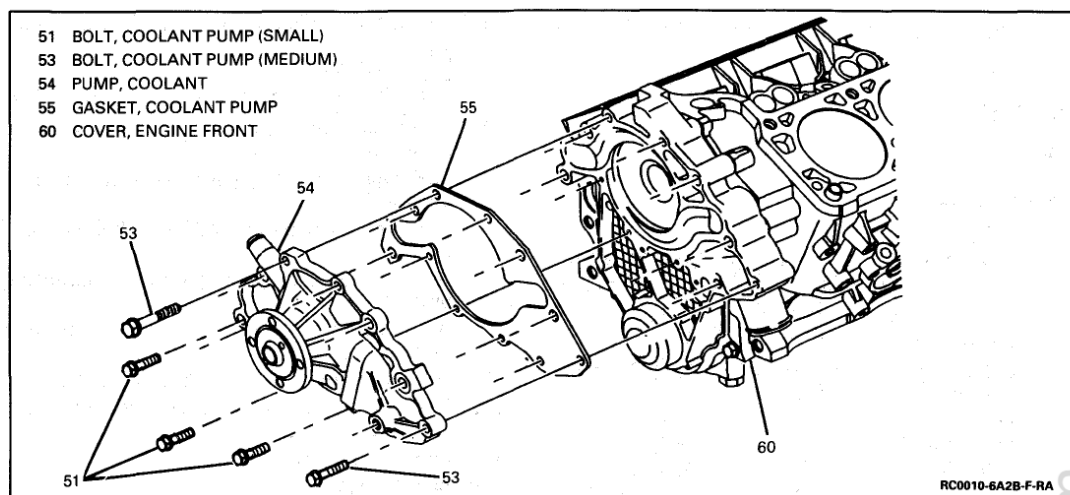


Figure 74 Coolant Pump

Tighten

- Large bolts (52) to 47 N·m (35 lb. ft.).
- Medium bolts (53) to 21 N·m (15 lb. ft.).
- Small bolts (51) to 10 N·m (89 lb. in.).

3. Coolant pump pulley (50) and retaining bolts (49).

Tighten

- Bolts (49) to 25 N·m (18 lb. ft.).

4. Power steering pump mounting bracket (227) and bolts (228).

TORSIONAL DAMPER

Figure 75

Tool Required:

J 29113 Torsional Damper Installer

Install or Connect

1. Torsional damper (27) using J 29113.
 - Apply sealant GM p/n 12345739 to keyway of damper prior to installation.
2. Remove J 29113.
3. Crankshaft pulley (28) and retaining bolts (31).

Tighten

- Bolts (31) to 50 N·m (37 lb. ft.).

4. Torsional damper washer (29) and bolt (30).

Tighten

- Bolt (30) to 79 N·m (58 lb. ft.).

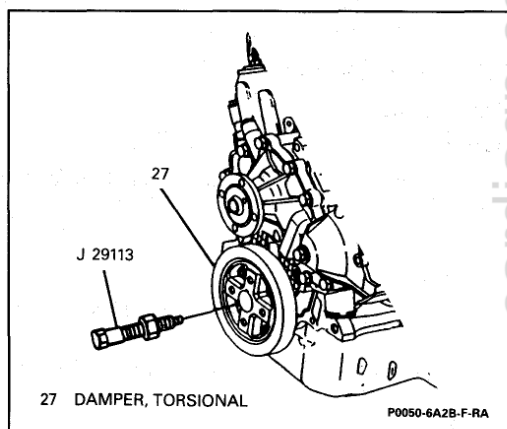


Figure 75 Torsional Damper Installation

ELECTRONIC IGNITION MODULE

Figure 18

Tool Required:

J 25033-B Power Steering Pump Pulley Installer

Install or Connect

1. Electronic ignition module (222) and retaining nuts (226).

Tighten

- Nuts (226) to 10 N·m (89 lb. in.)
2. Power steering pump (225) and retaining bolts (228).
 3. Power steering pump to rear bracket retaining bolts.

4. Power steering pump pulley (229) using J 25033-B.
 - Install pulley (229) until fully seated.

OIL PAN**Figure 17** **Install or Connect**

1. Oil pan gasket (1).
 - Apply sealant GM p/n 12345739 where the oil pan gasket tabs seat on rear main bearing cap groove.
2. Oil pan (1).
3. Oil pan reinforcements (10), nuts (11), bolts (12 and 14) and studs (13).

 Tighten

- Nuts (11) to 10 N·m (89 lb. in.).
- Two rear bolts (14) to 25 N·m (18 lb. ft.).
- Remaining bolts (12) to 10 N·m (89 lb. in.).
- Studs (13) to 6 N·m.

EXHAUST MANIFOLD**Figures 15 and 16****Transfer Parts**

If replacing an exhaust manifold, transfer the following:

1. Oxygen sensor (111 and 217).

 Tighten

- Oxygen sensor (110 and 218) to 42 N·m (31 lb. ft.).

2. Right manifold EGR adapter pipe (209) and studs (210).

 Tighten

- Studs (210) to 26 N·m (23 lb. ft.).

3. Right manifold EGR gasket (208), EGR (206) and bolts (207).

 Tighten

- Bolts (207) to 35 N·m (22 lb. ft.).

4. Right manifold EGR flexible adapter pipe gasket (211), EGR flexible adapter pipe (212) and bolts (214).

 Tighten

- Bolts (214) to 26 N·m (19 lb. ft.).

 Install or Connect

1. Exhaust manifold gasket (106 and 216).
2. Exhaust manifold (105 and 215) and heat shields (103, 104 and 205).

3. Exhaust manifold retaining bolts (102 and 202).

 Tighten

- Bolts (102 and 202) to 25 N·m (18 lb. ft.).

4. Secondary air injection pipe assembly, if equipped.
5. AIR pipe fitting to right exhaust manifold, if equipped.
6. AIR pipe retaining nut (184) and bolt (183), if equipped.
7. A/C compressor and generator mounting bracket.
8. A/C compressor and generator mounting bracket bolts.
9. Generator pencil brace bolts and braces.
10. Rear A/C compressor bracket mounting bolts and bracket.
11. Serpentine drive belt.

VALVE LIFTERS**Figure 13** **Install or Connect**

- Install lifters in their original locations.
1. Coat lifters with prelube, GM p/n 1052365.
 2. Valve lifters (94).

VALVE ROCKER ARM AND PUSHROD**Figure 13** **Install or Connect**

1. Pushrods (93).
 - Install pushrods in their original location.
 - Coat the ends of the pushrods with prelube GM p/n 1052365.
2. Rocker arms (122) and balls (123).
 - Install rocker arms and balls in their original location.
 - Coat rocker arm balls and friction surfaces of rocker arms with prelube GM p/n 1052365.
3. Rocker arm nuts (124).

 Adjust

- Valves when lifter is on base circle of camshaft lobe:
 - A. The engine should be in the #1 firing position. This may be determined by placing fingers on the #1 rocker arms as the engine assembly timing mark on the torsional damper aligns with the crankshaft position sensor bolt located on the front cover. If the valves are not moving, the engine is in the #1 firing position. If the valves move the engine is in #4 firing position and should be rotated one revolution to reach the #1 position.

- B. With the engine in the #1 firing position, the following valves should be adjusted:
 Exhaust — 1, 2, 3
 Intake — 1, 5, 6
- C. Tighten the adjusting nut until there is zero lash + 1-1/2 turns.
 (This can be determined by rotating pushrod while turning adjusting nut). When lash has been removed, turn adjusting nut in 1-1/2 additional turns (to center lifter plunger).
- D. Crank the engine one crankshaft revolution. This is the #4 firing position. With the engine in this position, the following valves should be adjusted to zero lash + 1-1/2 turns:
 Exhaust — 4, 5, 6
 Intake — 2, 3, 4

LOWER INTAKE MANIFOLD

Figure 14

Install or Connect

- Cut lower manifold gasket where it says "Cut Out".
 - This will allow you to put the manifold gasket on with pushrods already installed.
- Lower intake manifold gasket (141).
- Apply sealant GM p/n 12345739 at both ends where the intake manifold mates the engine block. Bead should be 2.0-3.0 mm wide and 3.0-5.0 mm thick.
- Lower intake manifold (142).
- Retaining bolts (144) and nuts (143).

Tighten

- Bolts (144) and nuts (143) in sequence, refer to Figure 14.
- First, bolts (144) and nuts (143) in sequence, to 5 N·m (44 lb. in.).
- Then, bolts (144) and nuts (143) in sequence, to 20 N·m (15 lb. ft.).
- Finally, bolts (144) and nuts (143) in sequence, to 30 N·m (22 lb. ft.).

VALVE ROCKER COVER

Figure 12

Install or Connect

- Valve rocker cover gasket (195) and cover (194).
 - Apply sealant GM p/n 12345739 at cylinder head to lower manifold joint.

- Reinforcement (193) and nuts (192).

Tighten

- Nuts (192) to 9 N·m (89 lb. in.).

UPPER INTAKE MANIFOLD

Figure 10 and 11

Install or Connect

- Upper intake manifold gasket (154) and manifold (155).
- Upper intake manifold bolts (156).

Tighten

- Upper intake manifold bolts (156) to 25 N·m (18 lb. ft.).
- MAP sensor electrical connector.
 - EGR flexible adapter pipe gasket (213), pipe and bolts (212) at upper manifold (155).

Tighten

- Apply teflon sealant GM p/n 1052080 to threads of bolts (212).
 - Gasket must be installed with text "tube side" facing the pipe.
 - EGR flexible adapter pipe bolts to 26 N·m (19 lb. ft.).
- PCV valve (190).

Important

- Do not press on the regulator cover or piedmont valve when installing fuel injector rail assembly.
- Fuel injector rail assembly (166).
 - Lightly lubricate fuel injector O-rings with engine oil.
 - Install injectors of fuel rail assembly into bores of manifold.
 - Carefully press on injector rail (166) with palms of both hands until injectors are fully seated.
 - Fuel rail stud (169).

Tighten

- Fuel rail stud (169) to 25 N·m (18 lb. ft.).
- Coolant sensor electrical connector.
 - Fuel pressure regulator vacuum hose (173).
 - Fuel injection harness retaining nut.
 - Fuel lines (175) to fuel injection rail (166).
 - Slide fuel line hold down plate (168) over fuel lines.

12. Fuel line hold down plate bolt (167).



Tighten

- Apply teflon sealant GM p/n 1052080 to threads of bolt (167).
- Bolt (167) to 25 N·m (18 lb. ft.).

13. Fuel line clamp bolts (176 and 177).

FLYWHEEL

Figure 9



Install or Connect

1. Flywheel (33).
2. Retainer bolts (36).



Tighten

- Bolts (36) to 83 N·m (61 lb. ft.).

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

AIR Check Valve Assembly	19 N·m (14 lb. ft.)
AIR Pipe Fitting to Manifold	25 N·m (18 lb. ft.)
AIR Pipe Assembly Nut	25 N·m (18 lb. ft.)
AIR Pipe Assembly to Cylinder Head Screw	50 N·m (37 lb. ft.)
Camshaft Rear Cover Bolts	10 N·m (89 lb. in.)
Camshaft Position Sensor Screw	10 N·m (89 lb. in.)
Camshaft Sprocket Bolt	24 N·m (18 lb. ft.)
Cannister Purge Solenoid Valve Bolt/Screw	10 N·m (89 lb. in.)
Connecting Rod Cap Nut	50 N·m (37 lb. ft.)
Coolant Drain Plug	19 N·m (14 lb. ft.)
Coolant Pump Bolt - Large	47 N·m (35 lb. ft.)
Coolant Pump Bolt - Medium	21 N·m (15 lb. ft.)
Coolant Pump Bolt - Small	10 N·m (89 lb. in.)
Coolant Pump Pulley Bolt	25 N·m (18 lb. ft.)
Coolant Temperature Sensor	16 N·m (12 lb. ft.)
Coolant Temperature Gage Sensor	13 N·m (115 lb. in.)
Crankshaft Pulley Bolt	50 N·m (37 lb. ft.)
Crankshaft Position Sensor Screw	9 N·m (80 lb. in.)
Cylinder Head Bolt	45 N·m + 90° (33 lb. ft. + 90°)
Cylinder Head Bolt Tightening Sequence	Refer to A
Cylinder Head Coolant Plug	23 N·m (17 lb. ft.)
Electronic Ignition Module Nut	10 N·m (89 lb. in.)
EGR Adapter Pipe to Exhaust Manifold Bolt	35 N·m (26 lb. ft.)
EGR Flexible Adapter Pipe to EGR Adapter Pipe Bolt	26 N·m (19 lb. ft.)
EGR Flexible Adapter Pipe to Upper Intake Manifold Bolt	26 N·m (19 lb. ft.)
EGR Stud	26 N·m (19 lb. ft.)
EGR to Adapter Pipe Bolt	35 N·m (26 lb. ft.)
Engine Front Cover Bolt	21 N·m (15 lb. ft.)
Exhaust Manifold Bolt	25 N·m (18 lb. ft.)
Exhaust Manifold Heat Shield Nut	8 N·m (71 lb. in.)
Exhaust Manifold Pipe Stud	35 N·m (26 lb. ft.)
Flywheel Bolt	83 N·m (61 lb. ft.)
Front Engine Lift Bracket Bolt	50 N·m (37 lb. ft.)
Fuel Injector Rail Stud	25 N·m (18 lb. ft.)
Fuel Line Hold Down Plate Bolt	25 N·m (18 lb. ft.)
Generator Rear Support Bolt	50 N·m (37 lb. ft.)
Heater Inlet Hose Nipple	30 N·m (22 lb. ft.)
Heater Inlet Pipe Assembly Bolt/Screw	10 N·m (89 lb. in.)
Ignition Timing Sensor Screw	9 N·m (80 lb. ft.)
Knock Sensor	19 N·m (14 lb. ft.)
Lower Intake Manifold Stud	10 N·m (89 lb. in.)

Lower Intake Manifold Bolt	30 N·m (22 lb. ft.)
Lower Intake Manifold Tightening Sequence	Refer to B
Lower Intake Manifold Nut	30 N·m (22 lb. ft.)
Main Bearing Cap Bolts	50 N·m + 77° (37 lb. ft. + 77°)
MAP Sensor Bolt/Screw	4 N·m (35 lb. in.)
Oil Drain Plug	25 N·m (18 lb. ft.)
Oil Gallery Plug - 1/8"	15 N·m (11 lb. ft.)
Oil Gallery Plug - 1/4"	19 N·m (14 lb. ft.)
Oil Gallery Plug - 3/8"	33 N·m (24 lb. ft.)
Oil Fill Tube Retaining Screw	8 N·m (71 lb. in.)
Oil Filter	13 N·m (115 lb. in.)
Oil Filter Adapter Bolt	68 N·m (50 lb. ft.)
Oil Level Indicator Nut	21 N·m (15 lb. ft.)
Oil Level Sensor	22 N·m (16 lb. ft.)
Oil Pan Bolt (2 Rear)	25 N·m (18 lb. ft.)
Oil Pan Bolt	10 N·m (89 lb. in.)
Oil Pan Nut	10 N·m (89 lb. in.)
Oil Pan Stud	6 N·m (53 lb. in.)
Oil Pressure Sensor	13 N·m (115 lb. in.)
Oil Pump Bolt	41 N·m (30 lb. ft.)
Oil Pump Cover Bolt	10 N·m (89 lb. in.)
Oil Pump Drive Assembly Bolt	34 N·m (25 lb. ft.)
Oxygen Sensor	42 N·m (31 lb. ft.)
Power Steering Pump Bracket Assembly Bolt	50 N·m (37 lb. ft.)
Power Steering Pump Rear Brace Nut	50 N·m (37 lb. ft.)
Power Steering Pump Rear Brace Stud	25 N·m (18 lb. ft.)
Pressure Plate Bolt	20 N·m + 45° (15 lb. ft. + 45°)
Rear Engine Lift Bracket Bolt	50 N·m (37 lb. ft.)
Rocker Cover Stud	6 N·m (53 lb. in.)
Rocker Cover Nut	9 N·m (80 lb. in.)
Rocker Arm Nut	25 N·m (18 lb. ft.)
Rocker Arm Stud	46 N·m (35 lb. ft.)
Spark Plug	31 N·m (23 lb. ft.)
Thermostat Housing Bolt	21 N·m (15 lb. ft.)
Throttle Body Retaining Bolt	25 N·m (18 lb. ft.)
Timing Chain Damper Bolt	21 N·m (15 lb. ft.)
Torsional Damper Bolt	79 N·m (58 lb. ft.)
Upper Intake Manifold Bolt	25 N·m (18 lb. ft.)

(A) Refer to "Cylinder Head" under Assembly in this section.

(B) Refer to "Lower Intake Manifold" under Assembly in this section.

ENGINE SPECIFICATIONS

General Specifications

Type	60°V-6
Displacement	204 Cu. In.
Liter (VIN)	3.4 (S)
RPO	L32
Bore	92 mm (3.622 inch)
Stroke	84 mm (3.3122 inch)
Compression Ratio	9.0:1
Firing Order	1-2-3-4-5-6
Oil Pressure @ Operating Temperature	103 kPa (15 psi) @ 1100 rpm - minimum

Cylinder Bore

Diameter.....92.020 mm-92.038 mm (3.6228"-3.6235")
 Out-of-Round - Max 0.014 mm (0.0006 ")

Piston

Diameter.....91.977 mm-91.992 mm (3.6211"-3.6217")
 Clearance 0.028 mm-0.061 mm (0.0011"-0.0024")

Piston Ring

Compression
 Groove Clearance
 1st.....0.05 mm-0.09 mm (0.002"-0.0035")
 2nd.....0.05 mm-0.09 mm (0.002"-0.0035")
 Gap (at gage dia.)
 1st.....0.18 mm-0.41 mm (0.007"-0.016")
 2nd.....0.48 mm-0.74 mm (0.019"-0.029")
 Oil Groove Clearance - Max. 0.20 mm (0.008")
 Gap (Segment at gage dia.) 0.25 mm-0.76 mm (0.010"-0.030")

Piston Pin

Diameter.....22.9915 mm-22.9964 mm (.9052"-.9054")
 Clearance 0.0116 mm-0.0218 mm (0.0005"-0.0009")
 Fit in Rod - Press 0.0165 mm-0.0464 mm (0.00065"-0.0018")

Crankshaft

Main Journal
 Diameter - All 67.239 mm-67.257 mm (2.6473"-2.6483")
 Taper - Max. 0.005 mm (0.0002")
 Out-of-Round - Max. 0.005 mm (0.0002")
 Main Bearing Clearance.....0.032 mm-0.077 mm (0.0012"-0.0030")
 Main Thrust Bearing
 Clearance 0.032 mm-0.077 mm (0.0012"-0.0030")
 Crankshaft End Play 0.06 mm-0.21 mm (0.0024"-0.0083")

Crankpin

Diameter.....50.768 mm-50.784 mm (1.9987"-1.9994")
 Taper - Max 0.005 mm (0.0002")
 Out-of-Round - Max. 0.005 mm (0.0002")
 Rod Bearing Clearance 0.028 mm-0.082 mm (0.0011"-0.0032")
 Rod Side Clearance 0.18 mm-0.44 mm (0.007"-0.017")

Camshaft

Lobe Lift
 Intake 6.67 mm (0.2626")
 Exhaust.....6.94 mm (0.2732")
 Journal Diameter.....47.44 mm-47.52 mm (1.868"-1.871")
 Bearing Inside
 Diameter 47.523 mm-47.549 mm (1.871"-1.872")
 Journal Clearance 0.026 mm-0.101 mm (0.001"-0.004")

Valve System

Lifter	Hydraulic
Rocker Arm Ratio	1.50:1
Face Angle	45°
Seat Angle	46°
Seat Runout - Max.	0.025 mm (0.001")
Seat Width	
Intake	1.55 mm-1.85 mm (0.061"-0.073")
Exhaust	1.70 mm-2.0 mm (0.067"-0.079")
Stem Clearance	
Intake	0.0356 mm-0.0686 mm (0.0014"-0.0027")
Exhaust	0.0381 mm-0.0737 mm (0.0015"-0.0029")

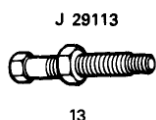
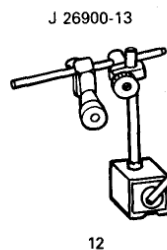
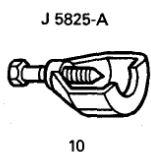
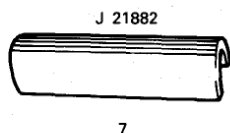
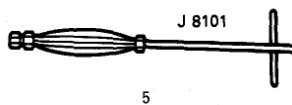
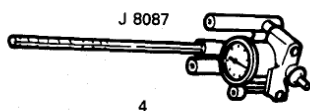
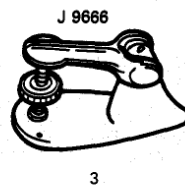
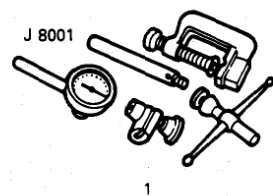
Valve Spring

Free Length	48.5 mm (1.91")
Load - Closed	356 N @ 40.9 mm (80 Lbs. @ 1.61")
Load - Open	841 N @ 30.5 mm (190 Lbs. @ 1.20")
Installed Height	40.9 mm (1.61")
Approx. # of Coils	4

Oil Pump

Gear Lash	0.094 mm-0.195 mm (0.0037"-0.0077")
Gear Pocket	
Depth	30.53 mm-30.61 mm (1.202"-1.205")
Diameter	38.202 mm-38.252 mm (1.504"-1.506")
Gear	
Length	30.45 mm-30.48 mm (1.199"-1.200")
Diameter	38.05 mm-38.10 mm (1.498"-1.500")
Side Clearance	0.08 mm-0.10 mm (0.003"-0.004")
End Clearance	0.05 mm-0.152 mm (0.002"-0.006")
Valve to Bore Clearance	0.038 mm-0.089 mm (0.0015"-0.0035")

SPECIAL TOOLS



- | | |
|-------------------------------|--|
| 1 DIAL INDICATOR SET | 8 PISTON PIN REMOVER AND INSTALLER SET |
| 2 PISTON RING COMPRESSOR | 9 TORSIONAL DAMPER REMOVER |
| 3 VALVE SPRING TESTER | 10 CRANKSHAFT SPROCKET REMOVER |
| 4 CYLINDER BORE CHECKING GAGE | 11 DIAL INDICATOR |
| 5 VALVE GUIDE CLEANER | 12 MAGNETIC BASE |
| 6 VALVE SPRING COMPRESSOR | 13 TORSIONAL DAMPER INSTALLER |
| 7 OIL SUCTION PIPE INSTALLER | |

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SPECIAL TOOLS (CONT.)

