

3.8L V6 - VINS [K & 1]

1998 Pontiac Bonneville

1998-99 ENGINES
3.8L V6
GM

Bonneville, Camaro, Eighty Eight, Firebird, Grand Prix,
Intrigue, LeSabre, Lumina, Monte Carlo, LSS, Park Avenue, Regal,
Regency, Riviera

MODEL IDENTIFICATION

MODEL IDENTIFICATION - CARS

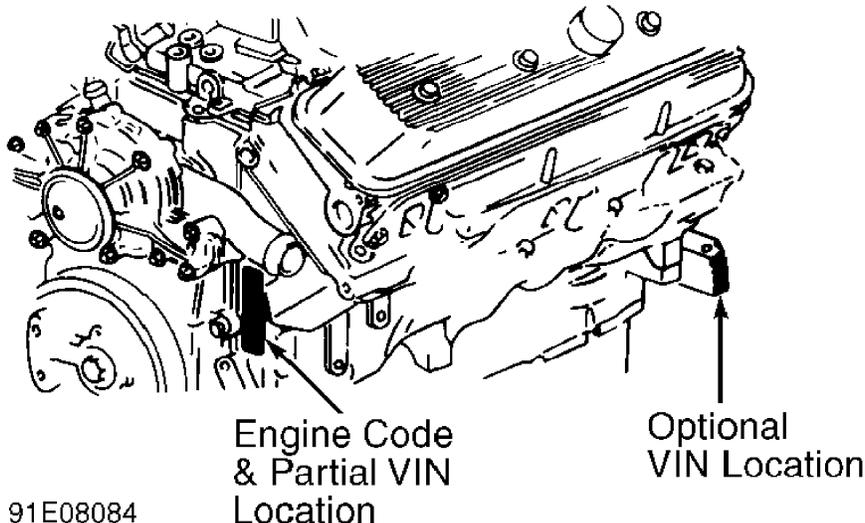
Body Code (1)	Model
"C"	Park Avenue
"F"	Camaro & Firebird
"G"	Aurora & Riviera
"H"	Bonneville, Eighty Eight, LeSabre, LSS & Regency
"W"	Century, Grand Prix, Intrigue, Lumina, Monte Carlo & Regal

(1) - Vehicle body code is fourth character of VIN.

ENGINE IDENTIFICATION

Engine can be identified by eighth character of Vehicle Identification Number (VIN) which is stamped on a metal pad located near lower left corner of windshield. See ENGINE IDENTIFICATION CODES table. "W" in the tenth character of the VIN indicates 1998 model year, and "X" indicates 1999 model year.

Engine can also be identified by a 3-character engine code (RPO code). See ENGINE IDENTIFICATION CODES table. This code may be stamped on engine. See Fig. 1.



91E08084
Fig. 1: Locating Engine Codes
Courtesy of General Motors Corp.

ENGINE IDENTIFICATION CODES

Engine	Code
3.8L SFI	
8th Character Of Dash VIN	K
Engine Code (RPO Code)	L36
3.8L SFI Supercharged	
8th Character Of Dash VIN	1
Engine Code (RPO Code)	L67

ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

Hydraulic valve lifters are used. No valve adjustment is required.

TROUBLE SHOOTING

NOTE: To trouble shoot mechanical engine components, see appropriate table in TROUBLE SHOOTING article in GENERAL INFORMATION.

REMOVAL & INSTALLATION

* PLEASE READ THIS FIRST *

CAUTION: When battery is disconnected, vehicle computer and memory systems may lose memory data. Driveability problems may exist until computer systems have completed a relearn cycle. See COMPUTER RELEARN PROCEDURES article in GENERAL INFORMATION before disconnecting battery.

NOTE: For reassembly reference, label all electrical connectors, vacuum hoses and fuel lines before removal. Also place mating marks on engine hood and other major assemblies before removal.

FUEL PRESSURE RELEASE

Disconnect negative battery cable. Loosen fuel tank filler cap. Connect Fuel Pressure Gauge (J 34730-1) to fuel line fitting (wrap shop towel around fitting to absorb leakage). Place gauge bleed hose into container. Open bleed valve to release pressure.

COOLING SYSTEM BLEEDING

Except "W" Body

1) Fill radiator to base of filler neck. Start engine. Place A/C-heater control in any position except MAX. Select highest temperature setting. Idle engine until lower radiator hose is hot.

2) Increase engine speed to 3000 RPM and then back to idle. Do this 5 times to expel any air trapped in system. Fill radiator as necessary. Install radiator cap. Allow engine to cool. Fill coolant recovery reservoir as necessary.

"W" Body

Open air bleed valve on thermostat housing. Fill radiator until coolant level is even with filler neck and no air bubbles are coming out of air bleed valve. Close air bleed valve. Install radiator

cap. Fill coolant reservoir. Warm engine. Allow engine to cool. Fill radiator and coolant reservoir.

POWER STEERING BLEEDING

CAUTION: If air was introduced into hydraulic system during servicing, bleed system. Aerated fluid, which appears Light Tan in color, results in poor steering performance and will cause pump damage.

1) Turn ignition off. Raise and support vehicle with front wheels off ground. Turn wheels fully to left. Add power steering fluid to FULL COLD mark on dipstick. Turn wheels from side to side at least 20 times, but DO NOT touch steering stops. Add fluid as necessary to maintain level at FULL COLD mark.

2) Start engine. With engine idling, check fluid level. Add fluid as necessary to bring fluid level to FULL COLD mark. Return wheels to center position. Lower vehicle. Continue to run engine for 2 to 3 minutes to raise temperature of fluid and eliminate trapped air. Turn steering wheel in both directions.

3) Road test vehicle. Check for leaks. Ensure fluid level is at FULL HOT mark when fluid is stabilized at operating temperature.

ENGINE

NOTE: Remove engine (without transaxle) through top.

Removal & Installation (Except "W" & "F" Bodies)

1) Remove hood. Disconnect battery cables. Release fuel pressure. See FUEL PRESSURE RELEASE. Drain cooling system. Drain engine oil. Remove strut tower cross brace (if equipped). Remove windshield washer, radiator and heater supply hoses.

2) Disconnect electrical connectors as necessary. Remove serpentine belt. Remove power steering pump (leave hoses attached). Remove airflow duct and air cleaner. Disconnect cables and hoses from throttle body. Remove ignition coil ground strap.

3) Disconnect fuel lines and vacuum hoses. Disconnect upper engine strut. Raise and support vehicle. Disconnect exhaust pipe. Disconnect engine mount bolts. Attach a suitable lifting hook and chain to engine lifting brackets. Raise engine slightly to take weight off mounts.

4) Remove A/C compressor (leave hoses attached). Disconnect engine oil cooler lines (if equipped). Remove front engine mount and right front engine-to-transaxle bracket. Support transaxle. Remove bolts securing transaxle to engine.

5) Remove flexplate cover. Mark flexplate in relation to torque converter for reassembly reference. Remove torque converter bolts. Remove starter. Separate transaxle from engine. Lift engine out of vehicle.

6) To install, reverse removal procedure. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING. Fill and bleed power steering system. See POWER STEERING BLEEDING. Tighten bolts to specification. See TORQUE SPECIFICATIONS table.

Removal & Installation ("F" Body)

1) Disconnect negative and positive battery cables. Discharge A/C system using approved refrigerant recovery/recycling equipment. Relieve fuel pressure. See FUEL PRESSURE RELEASE. Disconnect A/C compressor and condenser hose from accumulator. Plug openings. Raise and support vehicle. Remove front tires. Drain coolant and engine oil.

2) Remove heated oxygen sensors. Remove catalytic converter bolts. Remove exhaust pipe clamp bolt at catalytic converter and catalytic converter. Remove front fascia lower deflectors and

stabilizer bar bushing bolts. Remove radiator inlet hose.

3) On A/T models, remove torque converter bolts. Disconnect transmission fluid oil cooler lines. Disconnect transmission range selector lever cable from transmission. Remove left and right transmission support brackets.

4) On M/T models, disconnect transmission control lever handle. Remove clutch actuator cylinder line from actuator. On all models, remove driveshaft. Remove torque arm from transmission.

5) Remove steering gear coupling shaft from rack and pinion. Remove ground strap. Remove starter. Disconnect A/C compressor and condenser hose from compressor and condenser. Remove negative battery cable from rear compressor bracket mounting stud.

6) Lower vehicle. Remove heater hoses from drive belt tensioner. Remove air cleaner. Disconnect fuel lines at fuel rail. Disconnect cruise control cable from throttle body. Disconnect accelerator control cable from throttle body. Remove radiator outlet hose from thermostat housing.

WARNING: To avoid personal injury, gear tension relief function of scan tool must be performed prior to disconnecting ABS hydraulic modulator. See appropriate ANTI-LOCK article in BRAKES section.

7) Disconnect brake booster vacuum hose. Using scan tool, perform gear tension relief sequence. See appropriate ANTI-LOCK article in BRAKES section. Disconnect BRAKELINES and clips from ABS hydraulic modulator. Remove right-hand body hinge pillar trim panel. Disconnect engine wiring harness connectors. Disconnect forward lamp wiring harness connectors.

8) Disconnect Powertrain Control Module (PCM) and harness, and place on top of engine. Pull engine wiring harness through front dash. Place harness on top of engine. Disconnect positive lead at generator. Remove lower shock attachment nuts and bolts from lower control arms. Remove upper control arm ball stud from steering knuckle. Use upper control arm to secure struts.

9) Disconnect electrical connectors to wheel speed sensors at engine frame. Position engine support under engine frame. Remove engine frame and transmission support bolts. Lower engine, transmission and engine frame. Remove transmission. On M/T models, remove clutch housing and clutch. On all models, remove engine mount through-bolts. Remove engine from engine frame.

10) To install, reverse removal procedure. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING. Tighten bolts to specification. See TORQUE SPECIFICATIONS table.

Removal & Installation ("W" Body)

1) Remove hood. Disconnect negative battery cable. Release fuel pressure. See FUEL PRESSURE RELEASE. Remove air cleaner. Disconnect fuel lines from fuel rail. Remove coolant recovery bottle, inner fender electrical cover, and fuel injector cover. Disconnect throttle cables.

2) Remove heat shield from exhaust crossover pipe. Remove throttle cable bracket and vacuum line as an assembly. Remove exhaust crossover pipe. Remove engine torque strut from between engine and top of radiator panel. Drain cooling system. Disconnect oil cooler hoses from radiator.

3) Remove serpentine belt. Remove power steering pump. Where necessary to gain clearance, remove washer reservoir, diagonal braces, cooling fans, generator and generator support bracket with ignition coil pack. Raise and support vehicle. Remove flexplate cover. Mark flexplate in relation to torque converter for reassembly reference. Remove torque converter bolts. Remove A/C compressor (leave hoses attached). Remove starter.

4) Remove bolts securing transaxle mount to engine. Remove nuts securing engine mount to frame. Disconnect oil cooler pipes. Disconnect exhaust pipe from manifold. Lower vehicle. Remove bolts securing transaxle to engine. Separate transaxle from engine. Lift engine out of vehicle.

5) To install, reverse removal procedure. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING. Fill and bleed power steering system. See POWER STEERING BLEEDING. Tighten bolts to specification. See TORQUE SPECIFICATIONS table.

INTAKE MANIFOLD (UPPER)

NOTE: On supercharged engine, supercharger acts as an upper intake manifold. See SUPERCHARGER.

Removal

1) Release fuel pressure. See FUEL PRESSURE RELEASE. Disconnect negative battery cable. Drain cooling system. Remove air intake duct and air cleaner assembly.

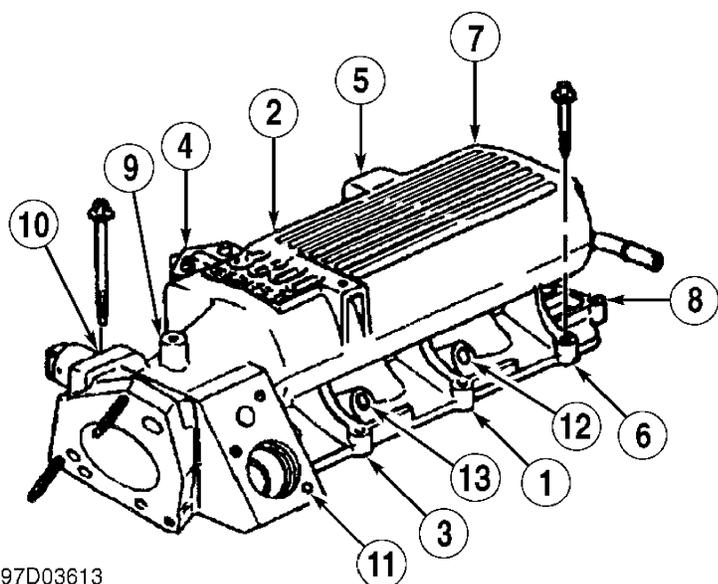
2) Remove spark plug wires and fuel rail. Remove exhaust crossover heat shield and power steering pump bracket. Remove serpentine belt, generator and generator bracket.

3) Remove heater pipes and by-pass hose. Remove throttle cable bracket and if necessary, the throttle body. Remove intake manifold bolts, manifold, gaskets and seals.

Installation

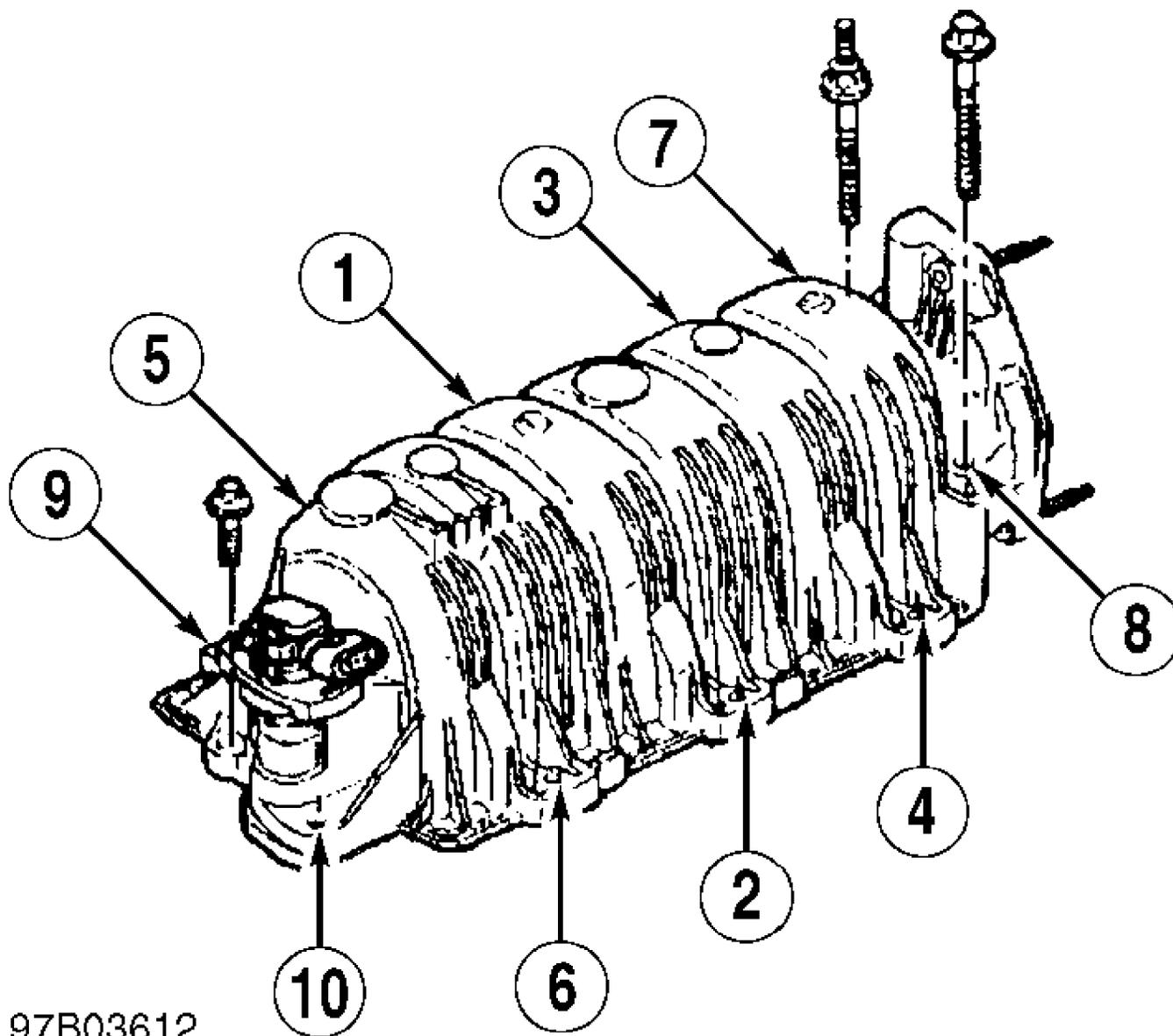
1) Ensure sealing surfaces, bolt threads and bolt holes are clean. Apply GM Sealant (12345336) at end of seals on cylinder block. Install manifold and gaskets.

2) Coat bolt threads with thread locking compound. Tighten intake manifold bolts in sequence to specification. See Figs. 2 and 3. See TORQUE SPECIFICATIONS table. Lubricate fuel rail "O" rings with engine oil. To complete installation, reverse removal procedure. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING.



97D03613

Fig. 2: Upper Intake Manifold Bolt Tightening Sequence ("F" Body)
Courtesy of General Motors Corp.



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Fig. 3: Upper Intake Manifold Bolt Tightening Sequence (Except "F" Body)

Courtesy of General Motors Corp.

INTAKE MANIFOLD (LOWER)

Removal

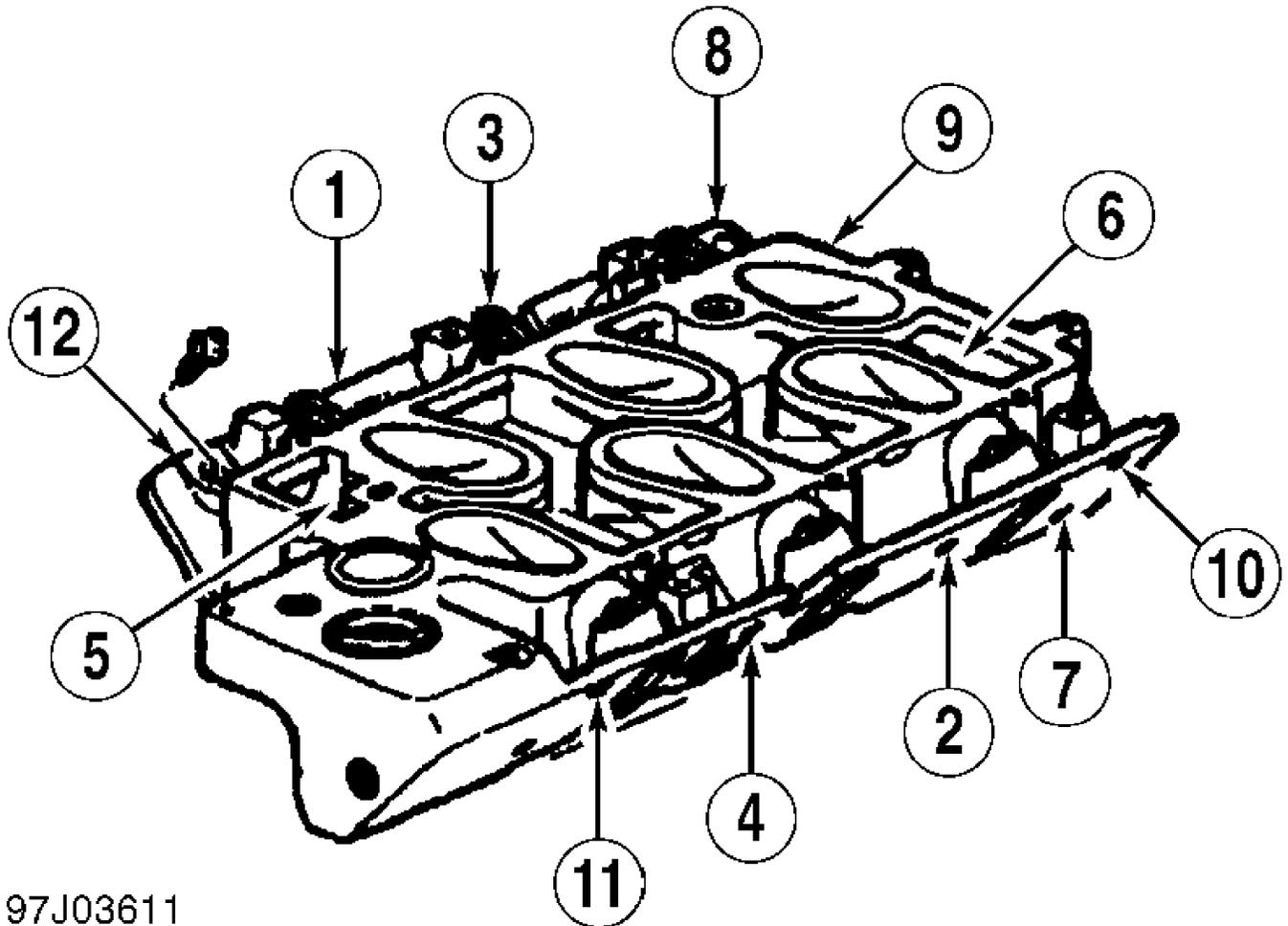
1) Remove upper intake manifold. See INTAKE MANIFOLD (UPPER). Release fuel pressure. See FUEL PRESSURE RELEASE. Disconnect negative battery cable. Drain cooling system. Remove air intake duct and air cleaner assembly.

2) Remove spark plug wires and fuel rail. Remove exhaust crossover heat shield and power steering pump bracket. Remove serpentine belt, generator and generator bracket. Remove cable bracket, heater pipes and by-pass hose. Remove lower intake manifold bolts. On VIN "K", 2 bolts are hidden in right front and left rear corners of lower intake manifold. Remove intake manifold, gaskets and seals.

Installation

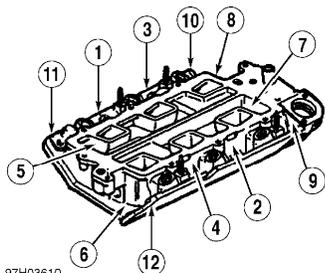
1) Ensure sealing surfaces and bolt threads and holes are clean. Apply GM Sealant (12345336) at end of seals on cylinder block. Install manifold and gaskets. Coat bolt threads with thread locking compound.

2) Tighten the intake manifold bolts in sequence to specification. See Figs. 4 and 5. See TORQUE SPECIFICATIONS table. Lubricate fuel rail "O" rings with engine oil. To complete installation, reverse removal procedure. Fill and bleed engine cooling system. See COOLING SYSTEM BLEEDING.



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Fig. 4: Lower Intake Manifold Bolt Tightening Sequence ("F" Body)
Courtesy of General Motors Corp.



97H03610
Fig. 5: Lower Intake Manifold Bolt Tightening Sequence (Except "F" Body)

Courtesy of General Motors Corp.

EXHAUST MANIFOLD

NOTE: Not all components need to be removed on all models. Remove as necessary for access and clearance.

Removal & Installation (Left)

1) Disconnect negative battery cable. Remove air inlet duct. Disconnect spark plug wires. Remove crossover pipe from manifold. On some models, it may be necessary to remove cooling fan and/or radiator hose for clearance.

2) On all models, remove engine lift hook and manifold heat shield (if equipped). Remove oil dipstick tube and oil dipstick. Remove exhaust manifold bolts, exhaust manifold and gasket. To install, reverse removal procedure using NEW gasket.

NOTE: Whenever right exhaust manifold pipe is removed, inspect EGR outlet pipe for leaks. If any leaks exist, replace EGR adapter.

Removal & Installation (Right)

1) Disconnect negative battery cable. Remove air inlet duct. Remove throttle cable from throttle body. Remove brake booster hose. Remove serpentine belt and power steering pump bracket with hoses attached, and position aside.

2) Drain cooling system. Disconnect spark plug wires and oxygen sensor. Disconnect crossover pipe and exhaust pipe from manifold. Remove transaxle dipstick tube and dipstick.

3) Remove manifold heat shield (if equipped). Remove catalytic converter heat shield and pipe hanger. Remove exhaust pipe-to-manifold nuts. Remove engine lift bracket, exhaust manifold bolts, exhaust manifold and gasket. To install, reverse removal procedure using NEW gasket.

SUPERCHARGER

NOTE: To remove supercharger and lower intake manifold as an assembly, see INTAKE MANIFOLD (LOWER).

Removal

1) Release fuel pressure. See FUEL PRESSURE RELEASE. Disconnect negative battery cable. Partially drain cooling system. Remove accessory drive belt from supercharger pulley. Remove fuel injector shield. Disconnect fuel lines from fuel rail. Disconnect vacuum hoses as necessary.

2) Disconnect electrical connectors from fuel injectors. Remove electrical harness shield. Disconnect electrical harness from front of supercharger. Remove fuel rail and injectors as an assembly. Disconnect electrical connectors as necessary. Remove air intake duct. Disconnect EGR pipe, throttle cable, and cruise control cable from supercharger. Remove boost pressure/vacuum hose block. Remove cable bracket.

3) Remove stud securing tensioner bracket to supercharger (use a stud remover or jam-nut procedure, if necessary). This stud must be removed to allow supercharger to clear lower intake locator pins. Remove throttle body from supercharger. Remove supercharger bolts, supercharger and gasket.

Installation

Install NEW supercharger gasket. DO NOT use sealant on supercharger gasket. Install supercharger. Tighten bolts to specification. See TORQUE SPECIFICATIONS table. To complete

installation, reverse removal procedure.

CYLINDER HEAD

NOTE: Not all components need to be removed on all models. Remove as necessary for access and clearance.

Removal

1) Remove the upper and lower intake manifold. See INTAKE MANIFOLD (UPPER) and INTAKE MANIFOLD (LOWER). Remove exhaust manifold. See EXHAUST MANIFOLD.

2) On front cylinder head applications, disconnect spark plug wires. Remove engine lift bracket and rocker arm cover. Remove exhaust crossover pipe and cooling fan. Remove generator. Remove ignition coil and bracket. Remove A/C compressor bracket bolt.

3) On rear cylinder head, disconnect spark plug wires. Remove exhaust crossover pipe. Remove power steering pump with hoses attached, and position aside. Remove heater pipe from front cover housing. Remove transaxle dipstick tube and dipstick.

4) Remove rocker arms, push rods and guide plates. See ROCKER ARMS & PUSH RODS. Remove cylinder head bolts, and discard. Remove cylinder head and gasket.

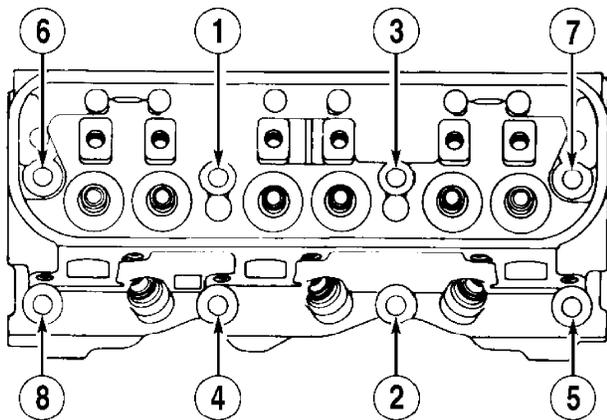
Inspection

Inspect cylinder head for warpage. See CYLINDER HEAD under OVERHAUL.

Installation

1) Ensure cylinder head bolt threads and cylinder block holes are clean. Ensure all gasket holes align with cylinder block and arrow on gasket is pointing to front of engine. Apply GM Sealant (1052080) to cylinder head bolt threads.

2) Install NEW cylinder head gasket. Tighten bolts to specification in sequence. See TORQUE SPECIFICATIONS table. See Fig. 6 . To complete installation, reverse removal procedure.



- Step 1 - Tighten all bolts to 35 ft. lbs. (47 N.m).
- Step 2 - Tighten all bolts an additional 130 degrees.
- Step 3 - Tighten center 4 bolts in sequence an additional 30 degrees.

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Fig. 6: Cylinder Head Bolt Tightening Sequence
Courtesy of General Motors Corp.

FRONT COVER SEAL

Removal

Disconnect negative battery cable. Remove serpentine belt. Raise and support vehicle. Remove right front wheel and inner splash shield. Remove crankshaft pulley/balancer bolt and crankshaft pulley/balancer. Pry seal from front cover and discard seal.

Installation

Coat seal with oil. Using Seal Installer (J 35354) and crankshaft pulley/balancer bolt, install seal. Remove seal installer. Coat sealing surface of crankshaft pulley/balancer with oil. To complete installation, reverse removal procedure.

FRONT COVER

Removal

1) Disconnect negative battery cable. Drain cooling system and crankcase oil. Remove serpentine belt. Remove water pump pulley. Disconnect heater pipes. Disconnect coolant hoses from front cover.

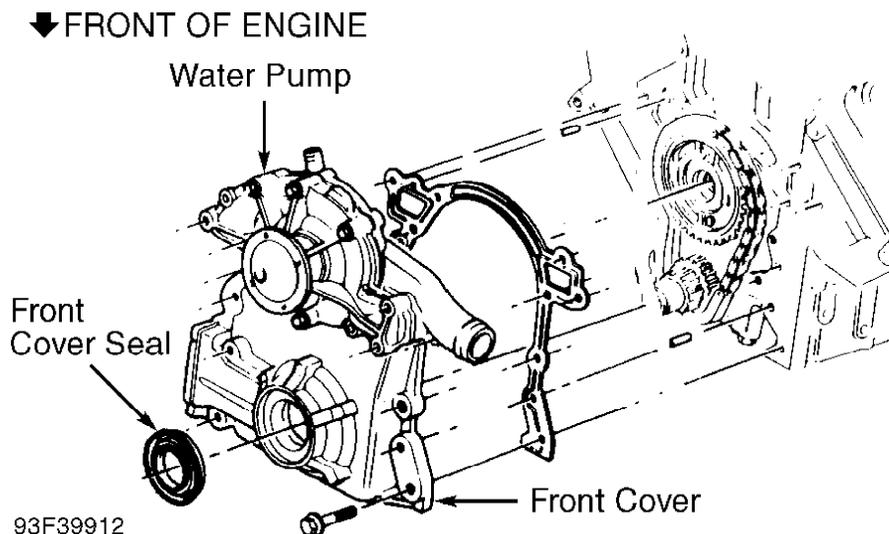
2) Raise and support vehicle. Remove right front wheel and inner splash shield. Remove crankshaft balancer bolt and discard. Remove crankshaft balancer. Disconnect electrical connections at oil pressure sender, camshaft sensor and crankshaft sensor.

3) Remove bolts securing front cover to oil pan. Remove power steering pump (leave hoses attached). Remove remaining bolts, front cover and gasket. See Fig. 7.

Installation

1) Replace timing chain and sprockets if worn. See TIMING CHAIN & SPROCKETS. Install NEW front cover gasket. Coat front cover bolt threads with Sealant (1052080). Install NEW crankshaft balancer bolt. To install, reverse removal procedure. Install crankshaft sensor and shield.

2) Install Crankshaft Sensor Gauge (J 37089) onto rear of crankshaft balancer. See Fig. 8. If gauge contacts balancer at any point, replace crankshaft balancer. To complete installation, reverse removal procedure. Coat sealing surface of crankshaft balancer and seal with oil.



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Fig. 7: Removing Front Cover
Courtesy of General Motors Corp.

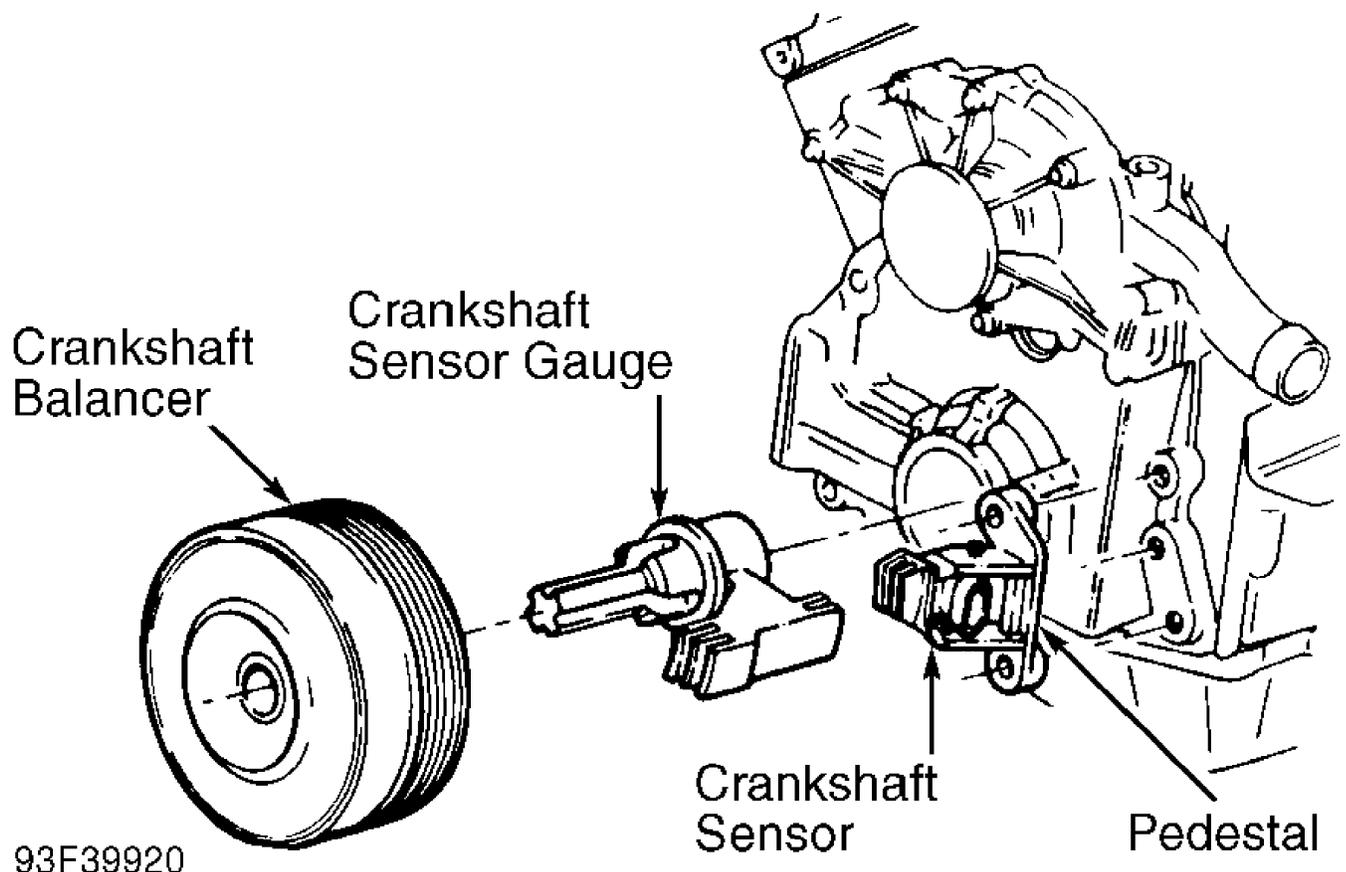


Fig. 8: Checking Crankshaft Balancer Clearance
 Courtesy of General Motors Corp.

TIMING CHAIN & SPROCKETS

Removal

1) Remove front cover. See FRONT COVER. Inspect timing chain and sprockets for wear. Timing chain in-and-out movement should not exceed 1" (25.4 mm). Replace components as necessary.

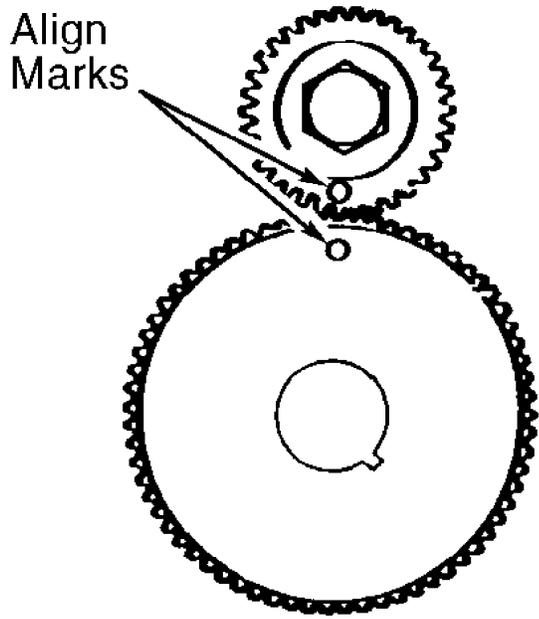
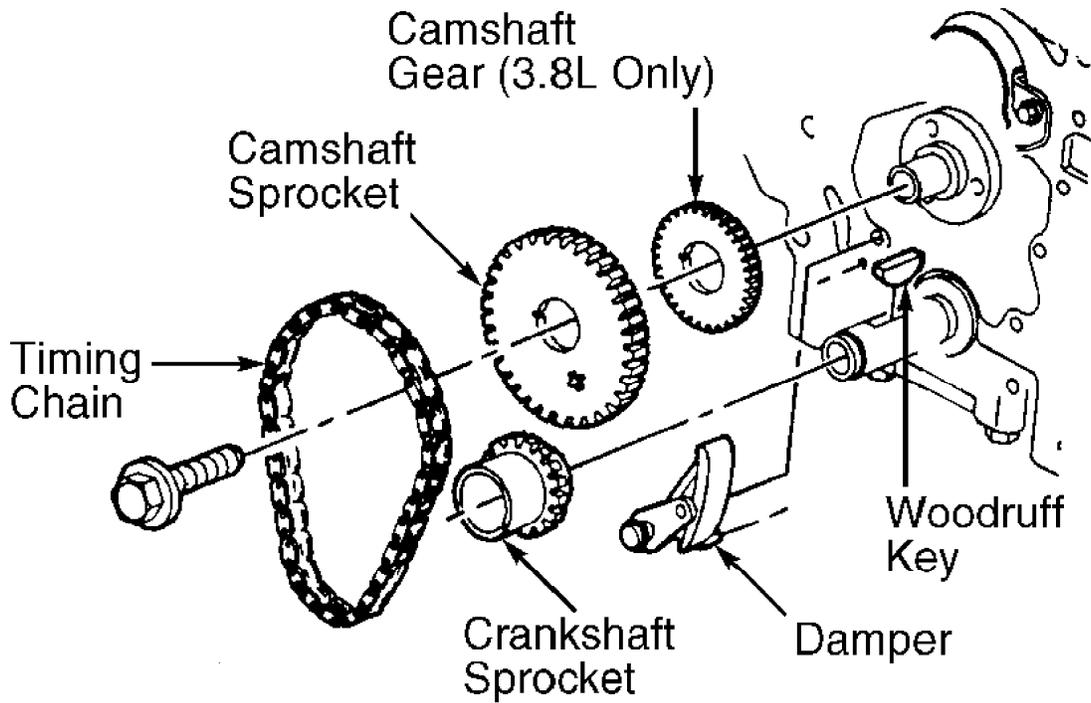
2) Rotate crankshaft to align timing marks on camshaft and crankshaft sprockets. See Fig. 9. Remove timing chain damper assembly. Remove camshaft sprocket bolts, and discard. Remove camshaft sprocket and timing chain. Remove crankshaft sprocket.

NOTE: If balance shaft has been moved, ensure alignment is correct before installing timing chain and sprockets. See BALANCE SHAFT.

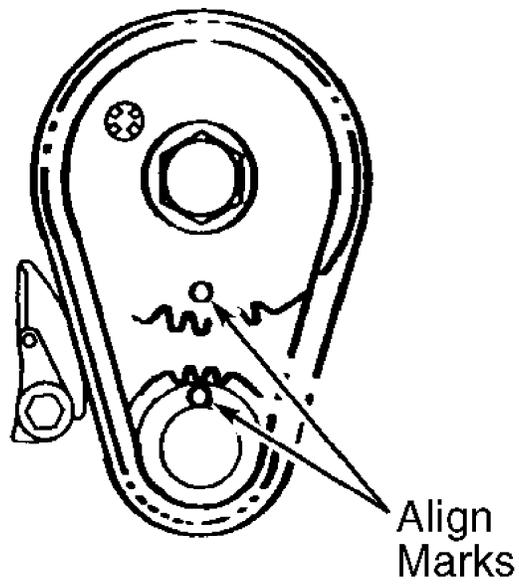
Installation

1) If engine has been rotated, rotate the crankshaft so No. 1 cylinder is at TDC. Temporarily install camshaft sprocket. Rotate camshaft sprocket so timing mark points downward.

2) Install timing chain on camshaft and crankshaft sprockets. Align timing marks. See Fig. 9. Install NEW camshaft sprocket bolts. Install timing chain damper. Rotate engine 2 revolutions. Ensure timing marks are aligned. To complete installation, reverse removal procedure.



BALANCE SHAFT TO CAMSHAFT (3.8L ONLY)



CAMSHAFT TO CRANKSHAFT (ALL MODELS)

93J39932
 Fig. 9: Exploded View Of Timing Chain & Sprockets
 Courtesy of General Motors Corp.

ROCKER ARMS & PUSH RODS

NOTE: Not all components need to be removed on all models. Remove as necessary for access and clearance.

Removal

1) Disconnect negative battery cable. Remove serpentine belt.

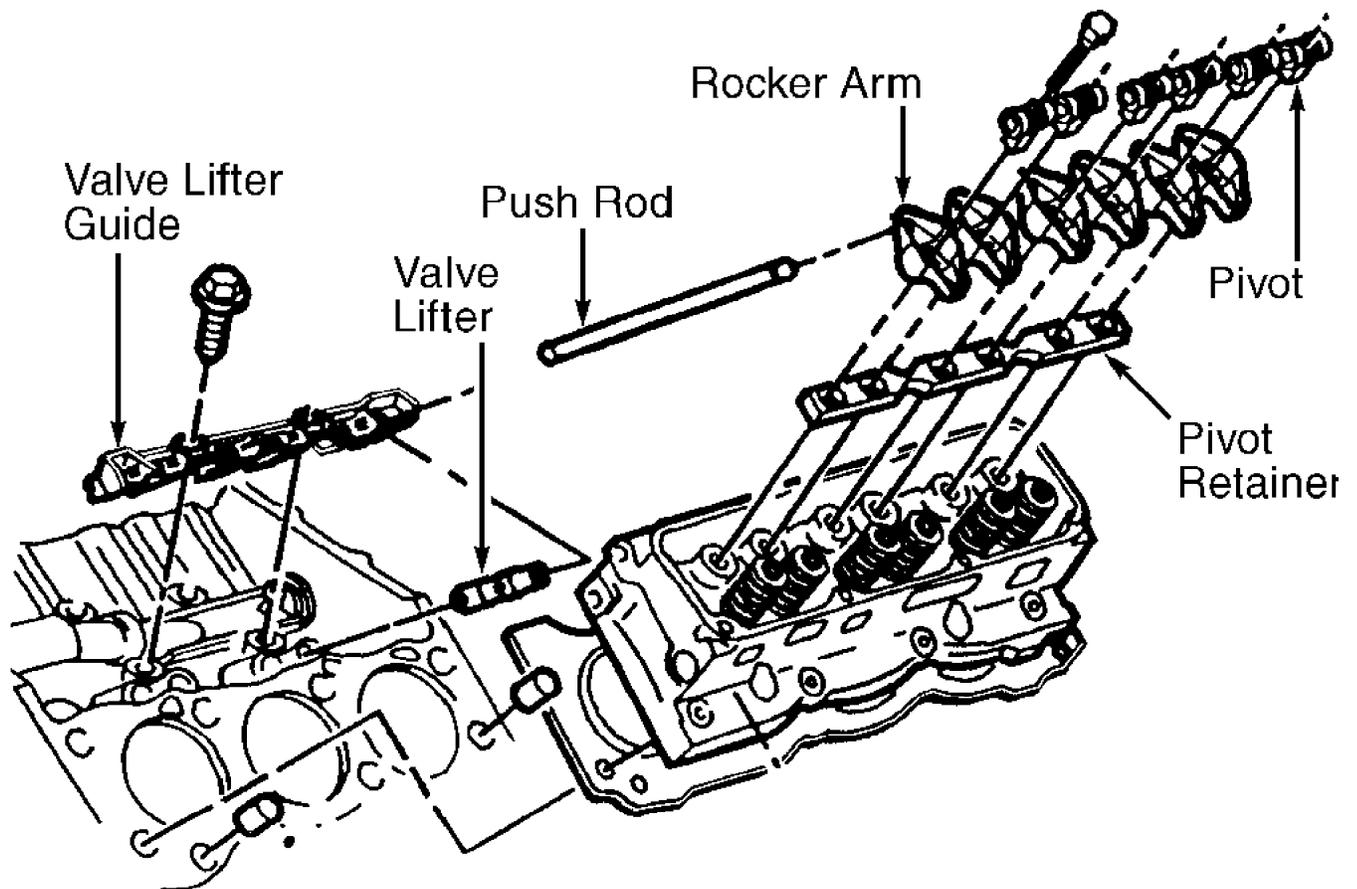
To remove left rocker arm cover, remove generator bracket and spark plug wires. Disconnect torque strut (if equipped) at radiator support. Remove torque strut bracket bolts at manifolds. Remove engine lift bracket.

2) To remove right rocker arm cover, loosen power steering pump bolts, and move pump forward with hoses still attached. Remove power steering pump brackets. Remove spark plug wires.

3) On either side, remove rocker arm cover. Remove and discard rocker arm pivot bolts. Mark rocker arm component locations for reassembly reference. Remove rocker arms and components. See Fig. 10.

Installation

To install, reverse removal procedure. Apply prelube (GM P/N 12345501) or equivalent, to any bearings and friction surfaces. Using NEW bolts, coat rocker arm bolt threads with thread Threadlock (12345493). Apply thread sealant to rocker arm cover bolt threads.



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Fig. 10: Exploded View Of Rocker Arm & Components
Courtesy of General Motors Corp.

VALVE LIFTERS

Removal

Remove upper and lower intake manifold. See INTAKE MANIFOLD (UPPER) and INTAKE MANIFOLD (LOWER). Remove rocker arms and push rods. See ROCKER ARMS & PUSH RODS. Remove valve lifter guide and valve lifters. See Fig. 10. Mark component locations for reassembly reference.

Installation

Coat valve lifters with Engine Oil Supplement (1052365). Install components in original location. To complete installation, reverse removal procedure.

CAMSHAFT

Removal

1) Disconnect negative battery cable. Remove engine. See ENGINE. Remove upper and lower intake manifold. See INTAKE MANIFOLD (UPPER) and INTAKE MANIFOLD (LOWER). Remove rocker arms and push rods. See ROCKER ARMS & PUSH RODS.

2) Remove valve lifters. Remove timing chain and sprockets. See TIMING CHAIN & SPROCKETS. Remove camshaft thrust plate and camshaft. Using Remover/Installer (J-33049), remove camshaft bearings (if necessary).

Inspection

Measure camshaft journal diameter, lobe lift and oil clearance. Replace components if not within specification. See CAMSHAFT table under ENGINE SPECIFICATIONS.

Installation

Install camshaft bearings (if removed). Ensure oil holes are aligned. Coat camshaft journals and lobes with Lubricant (1052365). Install camshaft. Install components in original locations. Apply Sealant (1052914) to camshaft rear plug. To complete installation, reverse removal procedure. Ensure timing marks are aligned.

BALANCE SHAFT

Removal

1) Disconnect negative battery cable. Remove engine. See ENGINE. Remove flexplate/flywheel. Remove upper and lower intake manifolds. See INTAKE MANIFOLD (UPPER) and INTAKE MANIFOLD (LOWER). Remove lifter guide. See Fig. 10.

2) Remove front cover. See FRONT COVER. Remove and discard balance shaft gear bolt. See Fig. 11. Remove camshaft sprocket and timing chain. See TIMING CHAIN & SPROCKETS. Remove balance shaft retainer and gear. See Fig. 11. Using Slide Hammer (J 6125-1B), remove balance shaft from front of engine.

NOTE: Balance shaft and bearings are serviced as a complete assembly only. Use specified installation tools to prevent balance shaft damage.

3) Remove balance shaft plug from rear of cylinder block. Note direction of rear bearing installation. Using Balance Shaft Bearing Remover/Installer (J 36995), remove bearings from block. See Fig. 12.

Inspection

Replace components if damaged or not within specification. See BALANCE SHAFT SPECIFICATIONS table.

Installation

1) Lubricate balance shaft bearings with engine oil. Install NEW front and rear bearings using Balance Shaft Bearing Remover/Installer. On rear bearing, be sure rolled edge faces inward, toward engine, and manufacturer's marking faces flywheel side of engine. See Fig. 12.

2) Using Balance Shaft Installer (J 36996), install balance shaft. Temporarily install balance shaft retainer and bolts. Install balance shaft gear. Apply GM Threadlock (12345493) to NEW gear bolt, and install bolt. Tighten gear bolt to specification. See TORQUE SPECIFICATIONS table.

3) Install balance shaft rear plug. Using dial indicator, measure balance shaft end play and radial clearance at front and rear of balance shaft. See Fig. 13. Replace components if measurements are not within specification. See BALANCE SHAFT SPECIFICATIONS table.

4) Rotate camshaft so timing mark is pointing downward when sprocket is installed. With camshaft sprocket and gear removed, rotate balance shaft so timing mark on gear is pointing downward.

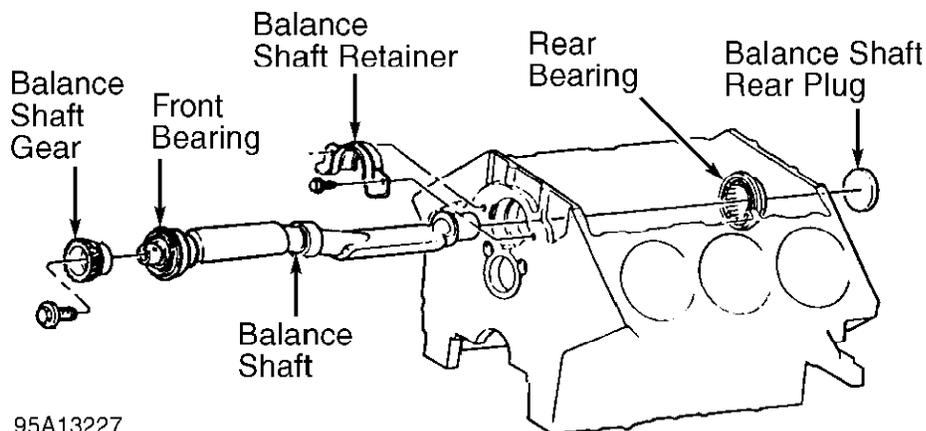
5) Rotate balance shaft to align timing marks on camshaft gear and balance shaft gear, and install camshaft gear. See Fig. 9. Rotate crankshaft so No. 1 piston is at TDC. Install timing chain and sprocket. Ensure timing marks are aligned. See Fig. 9.

6) Using dial indicator, measure gear lash at 4 places, every 1/4 turn. Gear lash should be within specification. See BALANCE SHAFT SPECIFICATIONS table.

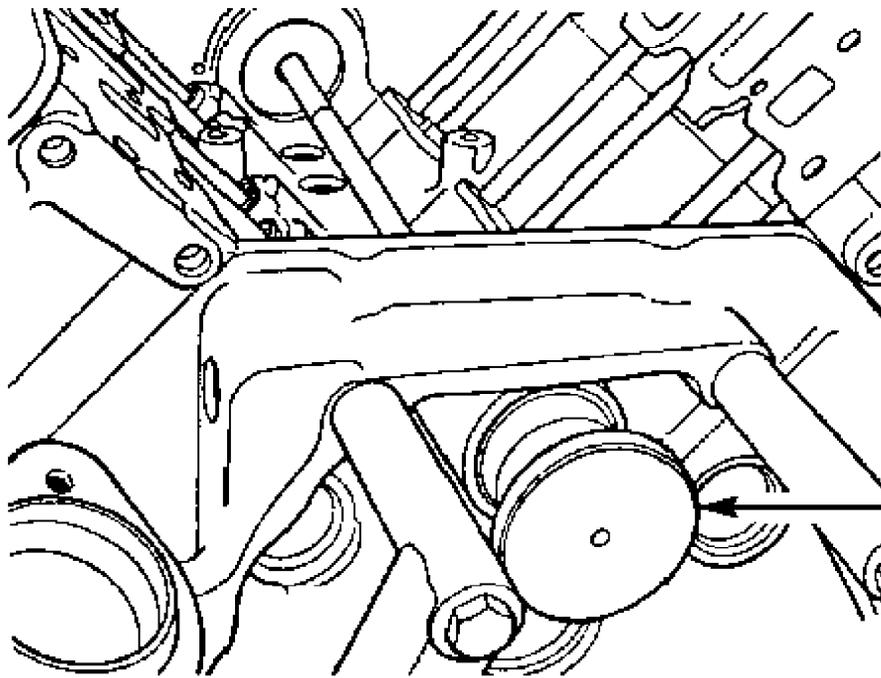
7) If measurements are within specification, tighten balance shaft retainer bolts to specification. See TORQUE SPECIFICATIONS table. To complete installation, reverse removal procedure.

BALANCE SHAFT SPECIFICATIONS

Application	In.	(mm)
Bearing Bore I.D.		
Front	2.0462-2.0472	(51.973-51.999)
Rear	1.8735-1.8745	(47.584-47.612)
End Play	0-.0067	(0-.171)
Gear Lash002-.005	(.05-.13)
Radial Clearance		
Front	0-.0010	(0-.026)
Rear0005-.0043	(.013-.109)

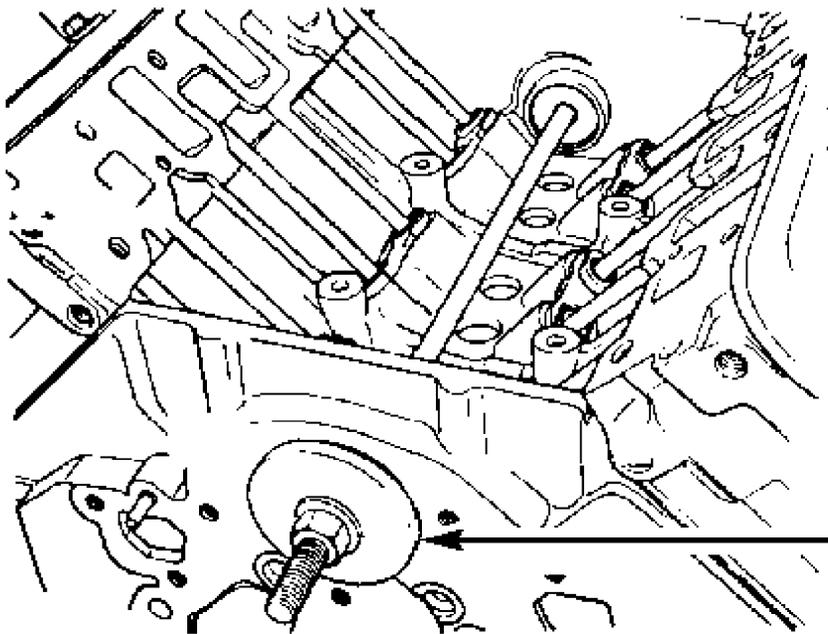


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 Fig. 11: Identifying Balance Shaft & Components
 Courtesy of General Motors Corp.



Rear Bearing
Installer
(J-36995-1)

INSTALLATION

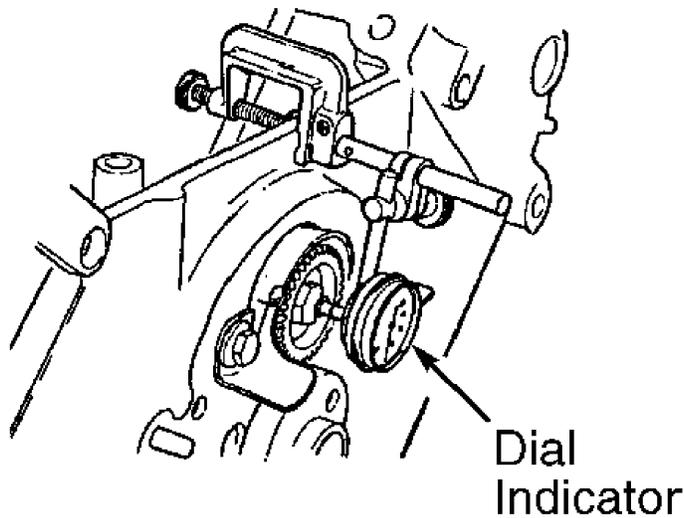


Rear Bearing
Remover
(J-36995-5)

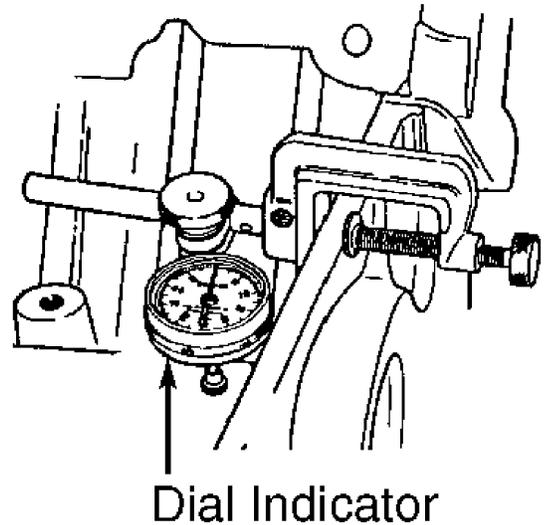
REMOVAL

95C13229

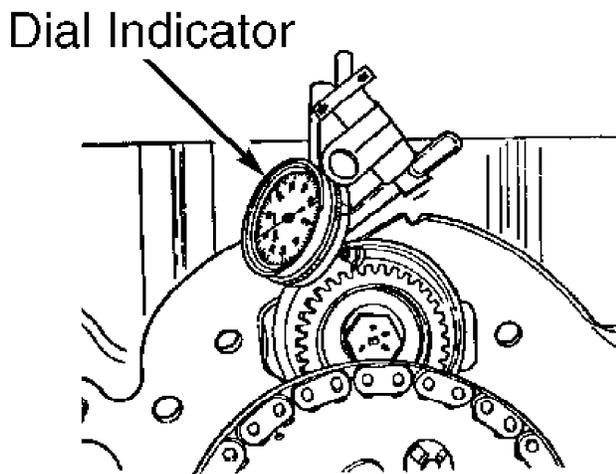
Fig. 12: Replacing Balance Shaft Rear Bearing
Courtesy of General Motors Corp.



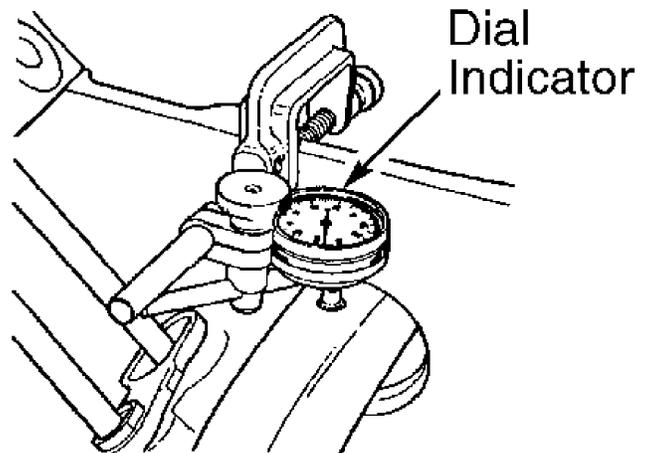
MEASURING END PLAY



MEASURING FRONT RADIAL CLEARANCE



MEASURING GEAR LASH



MEASURING REAR RADIAL CLEARANCE

95G13231

Fig. 13: Measuring Balance Shaft Clearances
 Courtesy of General Motors Corp.

CRANKSHAFT REAR OIL SEAL

NOTE: If rear oil seal housing has been removed, see CRANKSHAFT REAR OIL SEAL HOUSING before installing new seal.

Removal & Installation

Remove transaxle. For A/T, see appropriate TRANSMISSION REMOVAL & INSTALLATION article in TRANSMISSION section. For M/T, see appropriate article in CLUTCHES section. Remove flexplate/flywheel. Pry seal from bore with a screwdriver (DO NOT damage crankshaft or seal bore). To install, apply engine oil to new seal. Press seal into

bore using Seal Installer (J-38196). To complete installation, reverse removal procedure.

CRANKSHAFT REAR OIL SEAL HOUSING

CAUTION: If seal housing bore is not centered in relation to crankshaft flange, seal may leak.

Removal

Remove transaxle. For A/T, see appropriate TRANSMISSION REMOVAL & INSTALLATION article in TRANSMISSION section. For M/T, see appropriate article in CLUTCHES section. Remove flexplate/flywheel. Remove oil pan. See OIL PAN. Loosen seal housing bolts (bolts should stay with housing). Remove seal housing. Remove seal from housing.

Installation

1) DO NOT install seal into housing at this time. Clean gasket surfaces of housing and block. Install NEW gasket onto housing bolts to hold it in place. Install seal housing. Finger-tighten bolts so housing can be aligned (centered). Ensure gasket does not protrude beyond oil pan gasket surface.

2) Apply a thin film of engine oil to inner and outer surfaces of Seal Housing Aligner (J 41349). Install seal housing aligner onto crankshaft, twisting and turning it as necessary to aid installation.

3) Lay a straightedge across cylinder block oil pan flange and seal housing flange. Using a feeler gauge, ensure there is no more than .004" (.10 mm) step (high or low) on either side. Rotate housing if necessary. If specification cannot be met, replace housing.

4) Apply engine oil to NEW seal. Using Seal Installer (J 38196), press seal into bore. To complete installation, reverse removal procedure.

WATER PUMP

NOTE: Not all components need to be removed on all models. Remove as necessary for access and clearance.

Removal & Installation ("F" & "W" Bodies)

1) Disconnect negative battery cable. Drain cooling system. Remove accessory electrical junction block, and position aside. Loosen water pump pulley bolts. Remove drive belt. Remove water pump pulley bolts and pulley.

2) Remove power steering pump mounting bolts, and position aside. Remove water pump bolts, water pump and gasket. To install, reverse removal procedure using NEW gasket. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING.

Removal & Installation (Supercharged "C", "G" & "H" Bodies)

1) Disconnect negative battery cable. Remove A/C compressor splash shield. Loosen water pump pulley bolts. Drain cooling system. Remove drive belts. Remove coil pack. Remove supercharger belt tensioner.

2) Remove engine mount. Remove power steering pump. Remove engine mount bracket. Remove idler pulley. Remove water pump pulley. Remove water pump and gasket. To install, reverse removal procedure using NEW gasket. Fill and bleed the engine cooling system. See COOLING SYSTEM BLEEDING.

Removal & Installation (Non Supercharged "C" & "H" Bodies)

Drain cooling system. Loosen water pump pulley bolts. Remove drive belt. Remove water pump pulley bolts and pulley. Remove water pump and gasket. To install, reverse removal procedure using NEW

gasket. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING.

Removal & Installation (Non Supercharged "G" Body)

1) Drain cooling system. Remove air cleaner assembly. Remove water pump belt cover. Remove water pump drive belt. Remove by-pass hose. Remove lower radiator hose from thermostat housing.

2) Remove bolts from water pump cover. Remove water pump cover. Remove water pump, pump seal, and gasket from housing using Water Pump Remover (J 38816-1A). Turn tool clockwise in order to remove water pump. Remove water pump. To install, reverse removal procedure using NEW gasket. Fill and bleed cooling system. See COOLING SYSTEM BLEEDING.

OIL PAN

NOTE: Not all components need to be removed on all models. Remove as necessary for access and clearance.

Removal & Installation

1) Disconnect negative battery cable. Remove engine torque strut. Raise and support vehicle. Drain crankcase. Disconnect oil level sensor electrical connector. Remove oil level sensor and oil filter. Disconnect front exhaust pipe from manifold. Remove right front wheel and splash shield.

2) Disconnect oil cooler pipes. Disconnect A/C compressor electrical connector. Remove A/C compressor, and position aside. Disconnect engine mounts from frame.

3) Remove flexplate access cover. Use transmission jack at transaxle to raise engine. Remove oil pan bolts and oil pan. To install, reverse removal procedure. Install oil level sensor after oil pan is installed. Tighten retaining bolts to specification. See TORQUE SPECIFICATIONS table.

OVERHAUL

CYLINDER HEAD

Inspection

1) Inspect cylinder head for warpage at deck and manifold surfaces. Resurface cylinder head if warpage exceeds specification. See CYLINDER HEAD table under ENGINE SPECIFICATIONS.

2) After resurfacing, use a depth micrometer to measure distance from deck surface to 3 cast pads. See Fig. 14. Replace cylinder head if dimension is less than .044" (1.12 mm). New cylinder head dimension should be .054-.066" (1.37-1.68 mm).

Valve Seats

No replacement procedure is given by manufacturer.

Valve Guides

If valve stem oil clearance is not within specification, ream valve guides for oversize valve stem. See CYLINDER HEAD table under ENGINE SPECIFICATIONS.

Valve Seat Correction Angles

After grinding, if seat width is too wide, use 20-degree or 70-degree stone to reduce seat width. A 20-degree stone will lower seat. A 70-degree stone will raise seat.

Valve Spring Installed Height

1) Install valve, valve retainer and keepers. Pull upward on valve, and measure height from top of spring seat to spring side of

valve retainer. See Fig. 15.

2) Ensure spring installed height is within specification. See VALVES & VALVE SPRINGS table under ENGINE SPECIFICATIONS. If measurement exceeds specification, add shims under valve spring to obtain correct height.

Valve Stem Height

With valve installed in cylinder head (closed position), use steel ruler to measure distance from spring seat to valve tip. Distance should be 1.935-1.975" (49.15-50.17 mm).

Valve Stem Oil Seals

Oversize valve stem oil seals are used for valves with oversize stems. Intake and exhaust valve stem oil seals are different. Install oil seal according to part number and package instructions.

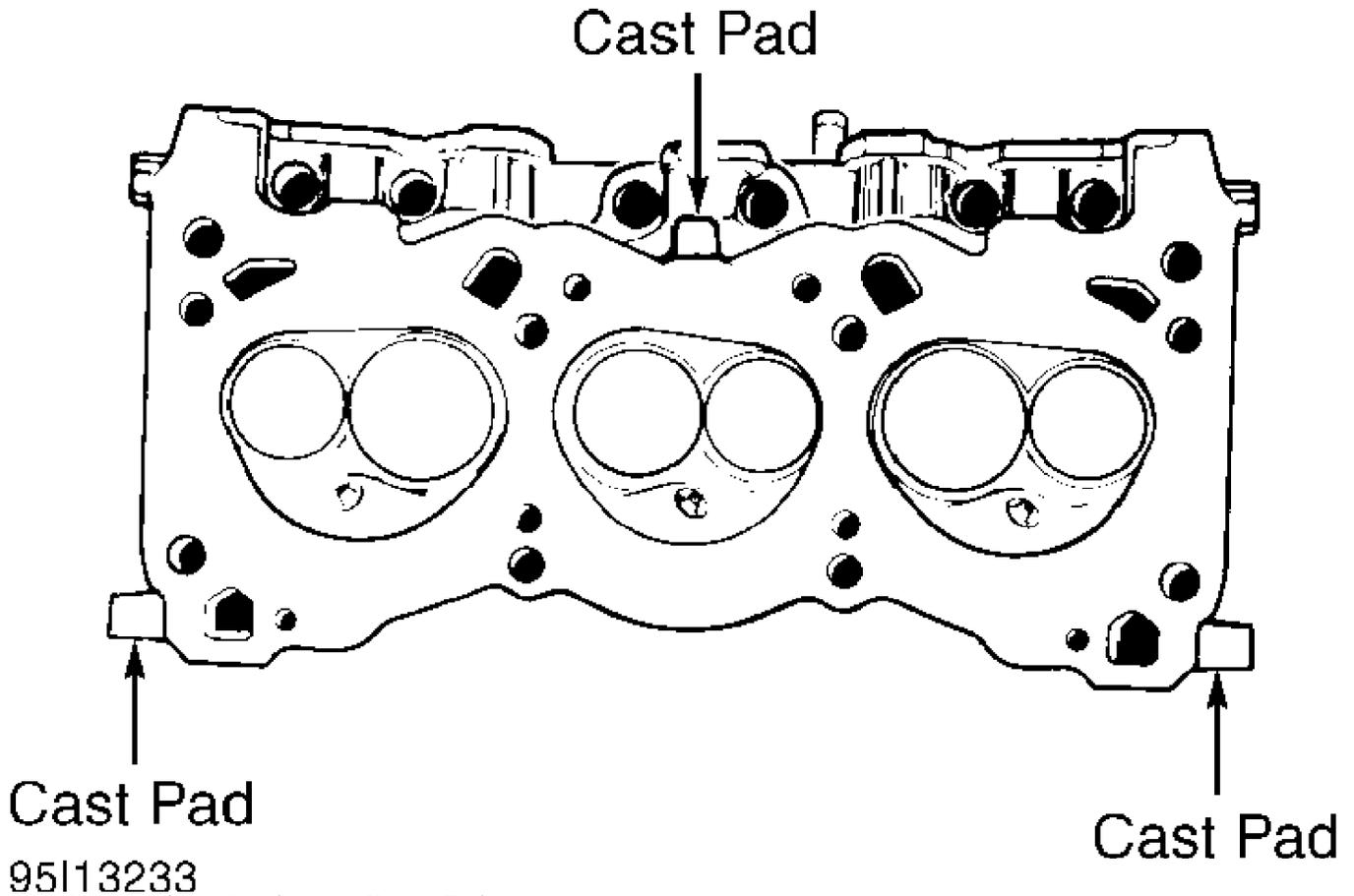
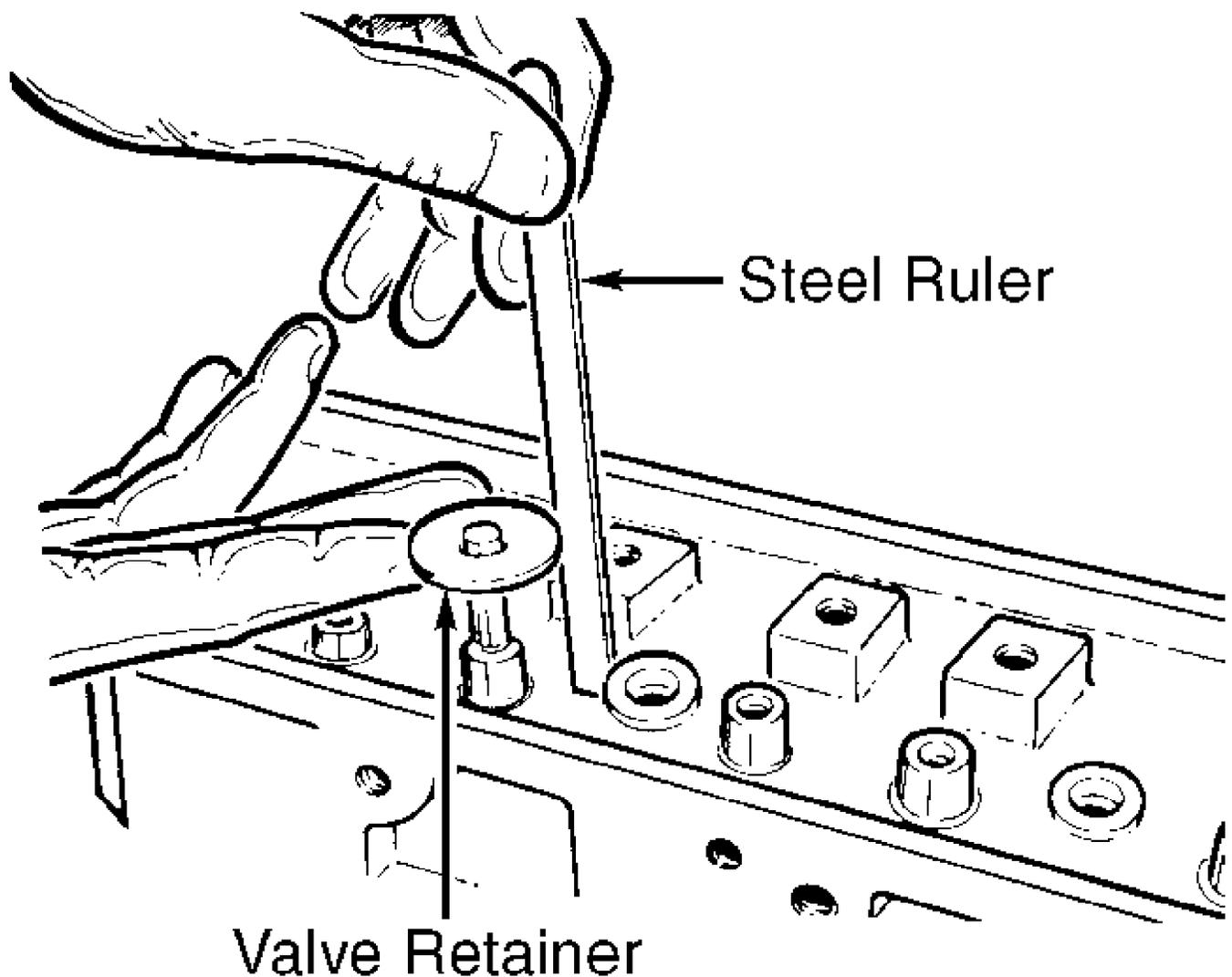


Fig. 14: Measuring Cylinder Head Thickness
Courtesy of General Motors Corp.



95A13235

Fig. 15: Measuring Valve Spring Installed Height
 Courtesy of General Motors Corp.

CYLINDER BLOCK ASSEMBLY

Cylinder Block

Using feeler gauge and straightedge, inspect deck surface for warpage. Replace cylinder block if more than .010" (.25 mm) material is removed from deck surface.

Cylinder Block Flange Runout

1) With engine removed and crankshaft installed, measure cylinder block flange runout. Mount dial indicator gauge plate flat against crankshaft flange. Place dial indicator stem on lower left transmission bolt boss (flat area around bolt hole). Adjust dial indicator to zero.

2) Observe and record readings obtained on all bolt hole bosses. Measurements should not vary more than .010" (.25 mm). If readings exceed specification, check crankshaft flange runout. See CRANKSHAFT FLANGE RUNOUT.

Piston Ring Installation

Install piston rings with identification mark toward top of piston, and ring gaps properly spaced. See Fig. 16.

Piston & Rod Assembly

Piston can be installed on connecting rod in either direction. Install piston and connecting rod onto crankshaft, with arrow on top of piston and/or ridge(s) on bottom of pin boss facing toward front of engine.

NOTE: DO NOT machine oversize pistons, or engine balance will be affected.

Fitting Pistons

Piston diameter should be measured 1.73" (44 mm) from top of piston.

Crankshaft & Main Bearings

1) Main bearing caps are a press fit. All main caps incorporate side bolts except the rear. Remove side bolts. Remove main cap bolts. Using Slide Hammer (J 6125-B) and Main Bearing Cap Puller (J 41348), carefully remove caps for service. Install main bearings and main caps. Tap bearing caps into cylinder block cavity using a brass, lead or leather mallet before installing attaching bolts.

NOTE: Misalignment of No. 4 main bearing cap toward transaxle can cause interference with the flywheel-to-converter bolts.

2) DO NOT use cap bolts to pull crankshaft bearing caps into seats. Tighten NEW main cap bolts evenly. Loosen main cap bolts one turn. Retighten bolts to 26 ft. lbs. (35 N.m). Ensure No. 4 rear main bearing cap is installed flush with rear of block.

NOTE: DO NOT shim, scrape or file bearing inserts. DO NOT touch bearing surface with fingers.

3) Using Torque Angle Meter (J 36660), tighten bolts an additional 50 degrees. Using wooden mallet, carefully tap crankshaft forward and then backward to seat thrust bearing.

Rod Bearings

1) Ensure bearing cap bolt holes and mating surfaces are clean and dry. Use connecting rod stud protector on rod cap bolts. Install bearing inserts in connecting rod and cap. Lubricate bearings and crank pin.

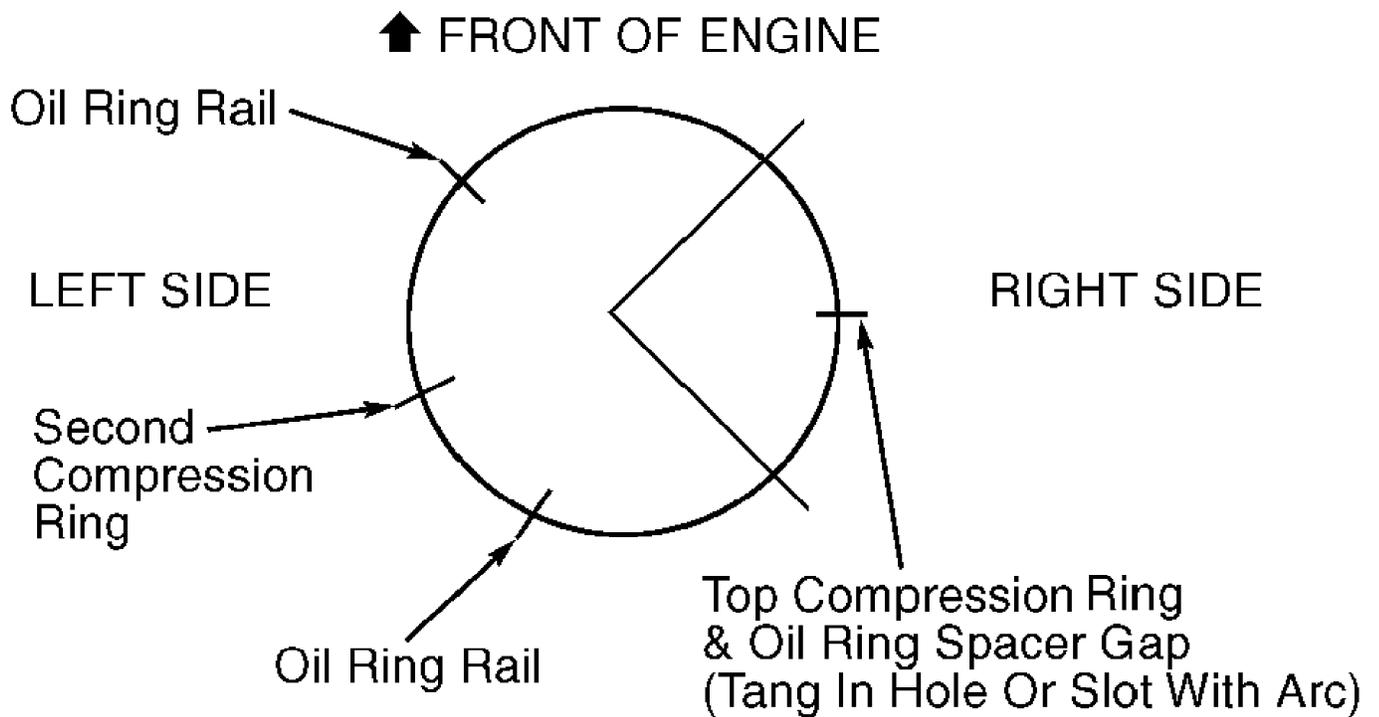
2) Replace both upper and lower bearings as a set. Install bearing cap. Tighten NEW rod bearing cap bolts to 20 ft. lbs. (27 N.m). Tighten bolts an additional 50 degrees using Torque Angle Meter (J 36660).

Crankshaft Flange Runout

1) With engine removed and crankshaft installed, or with crankshaft mounted on "V" blocks, measure crankshaft flange runout. Mount dial indicator and place dial indicator stem on crankshaft flange. Adjust dial indicator to zero.

2) Mark reference point on crankshaft flange. Ensure crankshaft is thrust forward so end float will not affect readings. Turn crankshaft 360 degrees.

3) Observe and record readings. Reading should not vary more than .002" (.05 mm). Replace crankshaft if runout exceeds specification.



95E13221

Fig. 16: Positioning Piston Ring Gaps
 Courtesy of General Motors Corp.

ENGINE OILING

LUBRICATION SYSTEM

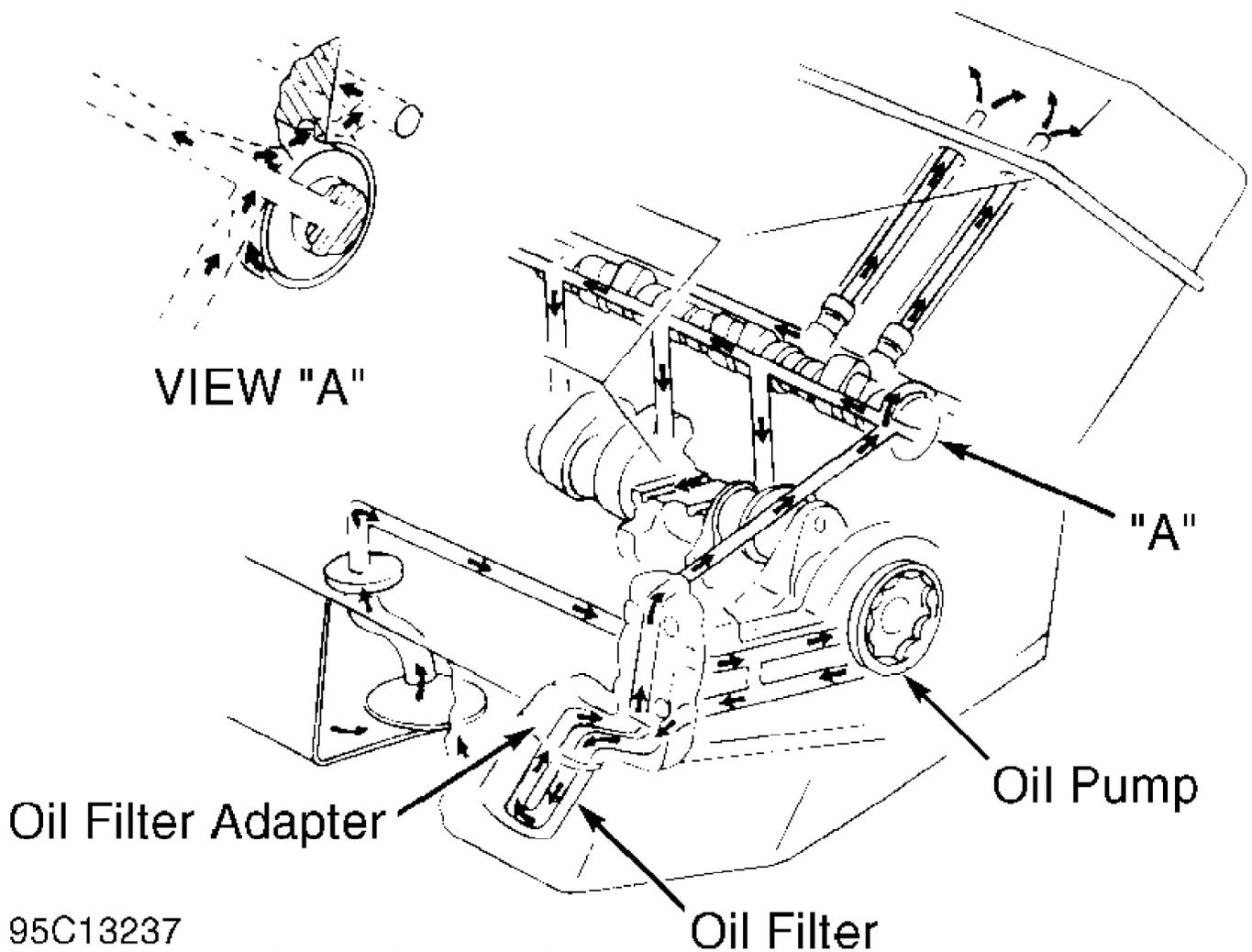
The crankshaft driven, gear-type oil pump provides pressurized lubrication to the main gallery. See Fig. 17. Oil pump and pressure regulator valve are located in front cover.

Crankcase Capacity

Engine oil capacity is approximately 4 qts. (3.7L) without filter change. After changing filter, recheck oil level and add oil as necessary.

Normal Oil Pressure

With engine at normal operating temperature, oil pressure (with 5W-30 or 10W-30 engine oil) should be 60 psi (4.2 kg/cm²) at 1850 RPM.



95C13237
 Fig. 17: Cross-Sectional View Of Engine Oiling System
 Courtesy of General Motors Corp.

OIL PUMP

Removal & Disassembly

Remove front cover. See FRONT COVER under REMOVAL & INSTALLATION. Remove oil filter adapter, gasket, pressure regulator and valve from front cover. Remove pump cover bolts, cover and gears from front cover.

Inspection

1) Inspect components for damage. Measure gear end clearance. Measure housing gear pocket depth and diameter. Measure tip clearance between gears. Measure outer gear-to-housing clearance.

2) Check clearance between pressure regulator valve and bore. Replace components or pump assembly if measurements are not within specification. See OIL PUMP SPECIFICATIONS table.

Reassembly & Installation

To reassemble, reverse disassembly procedure. Lubricate gears, and fill cavities with petroleum jelly. Install pump cover. To install, reverse removal procedure. Tighten bolts to specification. See TORQUE SPECIFICATIONS table.

OIL PUMP SPECIFICATIONS

Application	In. (mm)
Gear End Clearance .....	.0010-.0035 (.025-.089)
Gear Tip Clearance .....	.006 (.15)
Housing Gear Pocket	
Depth .....	.4610-.4625 (11.71-11.75)
Diameter	3.508-3.512 (89.10-89.20)
Outer Gear-To-Housing Clearance .....	.008-.015 (.20-.38)
Pressure Regulator Valve-To-Bore Clearance .....	.0015-.0030 (.038-.076)

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS

Application	Ft. Lbs. (N.m)
Balance Shaft Gear Bolt (1)	
Step 1	16 (22)
Step 2	Additional 70 Degrees
Balance Shaft Retainer Bolt	22 (30)
Camshaft Sprocket Bolt	
Step 1	74 (100)
Step 2	Additional 90 Degrees
Connecting Rod Bolt	
Step 1	20 (27)
Step 2	Additional 50 Degrees
Crankshaft Pulley/Balancer Bolt	
Step 1	110 (150)
Step 2	Additional 76 Degrees
Cylinder Head Bolts (2)	
Step 1	37 (50)
Step 2	Additional 120 Degrees
Step 3 (4 Center Bolts)	Additional 30 Degrees
Drive Bolt Tensioner Bracket Bolt (VIN 1)	37 (50)
EGR Valve Adaptor Nut	37 (50)
Exhaust Manifold Bolt	22 (30)
Flywheel Bolt	
Step 1	11 (15)
Step 2	Additional 50 Degrees
Front Cover Bolt	
Step 1	(3) 15 (20)
Step 2	Additional 40 Degrees
Fuel Feed & Return Line Fitting	22 (30)
Intake Manifold Bolts	
VIN 1	
Lower (4)	11 (15)
Upper (Supercharger)	17 (23)
VIN K	
Lower (4)	11 (15)
Upper	(5)
Main Bearing Cap Bolt	
Step 1	30 (40)
Step 2	Additional 110 Degrees
Oil Cooler Adapter Connector	37 (50)
Oil Filter Adapter-To-Front Cover Bolt	
"H" Body	22 (30)
"W" Body	

Step 1	11 (15)
Step 2	Additional 50 Degrees
Oil Pan Bolt	(1) 10 (14)
Oil Screen-To-Block Bolt	11 (15)
Rocker Arm Bolt (1)	
Step 1	11 (15)
Step 2	Additional 90 Degrees
Side Main Bearing Cap Bolt	
Step 1	11 (15)
Step 2	Additional 45 Degrees
Supercharger-To-Intake Manifold Bolt (VIN 1)	17 (23)
Timing Chain Damper Bolt (Special Bolt)	16 (22)
Valve Lifter Guide Bolt	22 (30)
Water Pump Bolt	
Step 1	11 (15)
Step 2	Additional 80 Degrees

INCH Lbs. (N.m)

Oil Pump Cover Screw	97 (11)
Rocker Arm Cover Bolt	(1) 88 (10)
Throttle Body Nut	89 (10)
Upper Intake Manifold Bolt (Except VIN 1)	88 (10)

- (1) - Apply thread locking compound to bolt(s).
- (2) - Tighten bolts in sequence. See Fig. 8.
- (3) - Apply thread sealant to bolt(s).
- (4) - Tighten bolts in sequence. See Figs. 4 and 5.
- (5) - Tighten in sequence to 89 INCH lbs. (10 N.m). See Figs. 2 and 3.

ENGINE SPECIFICATIONS

GENERAL SPECIFICATIONS

Application	Specification
Displacement	231 Cu. In. (3.8L)
Bore	3.80" (96.5 mm)
Stroke	3.40" (86.4 mm)
Compression Ratio (VIN K)	9.4:1
Compression Ratio (VIN 1)	8.5:1
Fuel System	SFI

CRANKSHAFT, MAIN & CONNECTING ROD BEARINGS

Application	In. (mm)
Crankshaft End Play	.003-.011 (.08-.28)
Main Bearings	
Journal Diameter	2.4988-2.4998 (63.470-63.495)
Journal Out-Of-Round	
1998	.0003 (.008)
1999	.0025 (.0066)
Journal Taper	.0003 (.008)
Oil Clearance (1998)	
Journal No. 1	.0007-.0016 (.0178-.0406)
Journals No. 2 & 3	.0010-.0020 (.0254-.0508)
Journal No. 4	.0009-.0018 (.0229-.0457)
Oil Clearance (1999)	
Journal No. 1	.0007-.0016 (.0178-.0406)

Journals No. 2, 3 & 4	.....	.0009-.0018	(.0229-.0457)
Connecting Rod Bearings			
Journal Diameter	.....	2.2487-2.2499	(57.117-57.147)
Journal Out-Of-Round			
1998	.....	.0003	(.0076)
1999	.....	.0002	(.005)
Journal Taper			
1998	.....	.00030	(.0076)
1999	.....	.00035	(.0089)
Oil Clearance	.....	.0005-.0026	(.0127-.0660)

CONNECTING RODS

Application		In.	(mm)
Maximum Bend	.....	(1)	.005 (.13)
Maximum Twist	.....	(1)	.005 (.13)
Side Play	.....	.0040-.0200	(.102-.508)

(1) - Bend or twist measured over total length.

PISTONS, PINS & RINGS

Application		In.	(mm)
Piston Clearance (1)			
Used Piston (1999)			
VIN 1	.....	.0008-.0039	(.0193-.0997)
All Others	.....	.0020-.0036	(.050-.091)
New Piston			
VIN 1 (1999)	.....	.0008-.0039	(.0193-.0997)
All Others	.....	.0004-.0020	(.010-.051)
Pins			
Diameter			
VIN 1 (1999)	.....	.9053-.9055	(22.995-23.000)
All Others	.....	.8659-.8661	(21.995-22.000)
Piston Fit			
VIN 1 (1999)	.....	.00026-.00061	(.0065-.0155)
All Others	.....	.00008-.00051	(.0020-.0130)
Rod Fit			
VIN 1 (1999)	.....	.00029-.00089	(.0073-.0225)
All Others	.....	.00030-.00090	(.0066-.0217)
Rings			
No. 1			
End Gap	.....	.010-.018	(.25-.46)
Side Clearance	.....	.0013-.0031	(.033-.079)
No. 2			
End Gap	.....	.023-.033	(.58-.84)
Side Clearance	.....	.0013-.0031	(.033-.079)
No. 3 (Oil)			
End Gap	.....	.010-.030	(.25-.76)
Side Clearance	.....	.0009-.0079	(.023-.201)

(1) - Measure 1.5" (39 mm) from top of engine block.

CYLINDER BLOCK

Application		In.	(mm)
Cylinder Bore			

Diameter	3.80 (96.5)
Maximum Taper .....	.001 (.0254)
Maximum Out-Of-Round .....	.001 (.0254)

VALVES & VALVE SPRINGS

Application	Specification
Valves	
Face Angle	45 °
Minimum Margin .....	.025" (.64 mm)
Installed Height	1.935-1.975" (49.15-50.17 mm)
Valve Springs	
Free Length	1.960" (49.78 mm)
Installed Height	1.690-1.720" (42.93-44.45 mm)
	Lbs. @ In. (kg @ mm)
Pressure	
Valve Closed	75 @ 1.72 (34 @ 43.7)
Valve Open	228 @ 1.277 (104 @ 32.4)

CYLINDER HEAD

Application	Specification
Maximum Warpage .....	.010" (.25 mm)
Valve Seats	
Intake Valve	
Seat Angle	45 °
Seat Width .....	.060-.080" (1.52-2.03 mm)
Seat Runout (Maximum) .....	.002" (.05 mm)
Exhaust Valve	
Seat Angle	45 °
Seat Width .....	.090-.110" (2.29-2.79 mm)
Seat Runout (Maximum) .....	.002" (.05 mm)
Valve Guide Oil Clearance .....	.0015-.0035" (.038-.089 mm)

CAMSHAFT

Application	In. (mm)
Journal Diameter	1.8448-1.8762 (46.858-47.655)
Lobe Lift	
Intake .....	.2580 (6.55)
Exhaust .....	.255 (6.48)
Oil Clearance .....	.0016-.0047 (.041-.119)