

1995 Ford Windstar

1995 ENGINES 3.8L V6 - VIN 4

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ENGINE IDENTIFICATION

Engine may be identified by eighth character of Vehicle Identification Number (VIN). VIN is located on top of instrument panel, near lower left corner of windshield.

An emission calibration number is located on driver's door or door-post pillar. This label identifies engine calibration number, engine code and revision label.

Engine code label is located on valve cover. Label contains engine calibration number, engine build date, plant code and engine code. Information from labels are required when ordering replacement parts.

ENGINE IDENTIFICATION CODES

Engine	Code
3.8L MFI	4

ADJUSTMENTS

VALVE CLEARANCE ADJUSTMENT

NOTE: Hydraulic valve lifters are used; no valve adjustment is required. When valve and/or valve seat is machined, valve clearance is reduced and may cause improper valve operation. Different length push rods are available for correcting clearance. Valve lifter must be collapsed to check valve clearance.

1. With valve cover removed, position piston No. 1 at TDC of compression stroke. Completely collapse cylinder No. 1 intake valve lifter and hold valve lifter collapsed. Using feeler gauge, measure clearance between rocker arm and valve stem.
2. Clearance should be within specification. Refer to **COLLAPSED VALVE LIFTER CLEARANCE** table. Replace push rod, if necessary, to obtain correct clearance.
3. Position crankshaft as specified. See, in this article, **VALVE CLEARANCE CHECKING SEQUENCE** table, and check appropriate valves. Replace push rods if clearance is not within specification.
4. If push rod(s) is replaced, ensure corresponding cylinder piston is below TDC. It will be necessary to loosen or remove rocker arm to replace push rod.

CAUTION: DO NOT operate or crank engine after installing push rod until valve lifter has leaked down to normal operating position.

COLLAPSED VALVE LIFTER CLEARANCE

Application	In. (mm)
3.8L	.09-.19 (2.3-4.8)

VALVE CLEARANCE CHECKING SEQUENCE ⁽¹⁾

Crank Position	Check Intake Nos.	Check Exhaust Nos.
Cyl. No. 1 At TDC	No. 1, 3 & 6	No. 1, 2 & 4
Rotate 360°	No. 2, 4 & 5	No. 3, 5 & 6
(1) Begin with cylinder No. 1 at TDC of compression stroke. Check corresponding valves clearance, rotate crankshaft 360 degrees, and recheck clearance of corresponding valves.		

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

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.

TROUBLE SHOOTING

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

REMOVAL & INSTALLATION**FUEL PRESSURE RELEASE & FUEL LINE CONNECTIONS**

WARNING: Fuel system is under pressure. Pressure must be released before servicing fuel system components.

1. Disconnect battery ground cable. Remove fuel cap to release fuel tank pressure. Using EFI Pressure Gauge (T80L-9974-B), release fuel pressure from fuel-pressure relief valve on fuel rail.
2. To disconnect fuel lines, remove retaining clip from outside of fuel line coupling. Use Spring Lock Coupling Remover (D87L-9280-A) for 3/8" line or (D87L-9280-B) for 1/2" line. Install spring lock coupling remover on fuel line coupling so it enters cage opening. See **Fig. 1**.
3. Push spring lock coupling remover into cage opening to release female fitting from garter spring. Pull couplings apart. Remove spring lock coupling remover.
4. When installing fuel lines, install new "O" rings on fuel lines. Use only specified fuel resistant "O" rings (Brown). Before installing, lightly coat "O" rings with clean engine oil. Clean fittings, and replace garter spring (if necessary). Fit female fitting to male fitting and push until garter spring snaps over flared end of female fitting.
5. Ensure lines are locked together and garter spring is over female fitting flared end. Install retaining clip. Ensure horseshoe portion of clip is over coupling. **DO NOT** install retaining clip over rubber fuel line.

NOTE: Install Black retaining clip on fuel supply line and Gray clip on fuel return line.

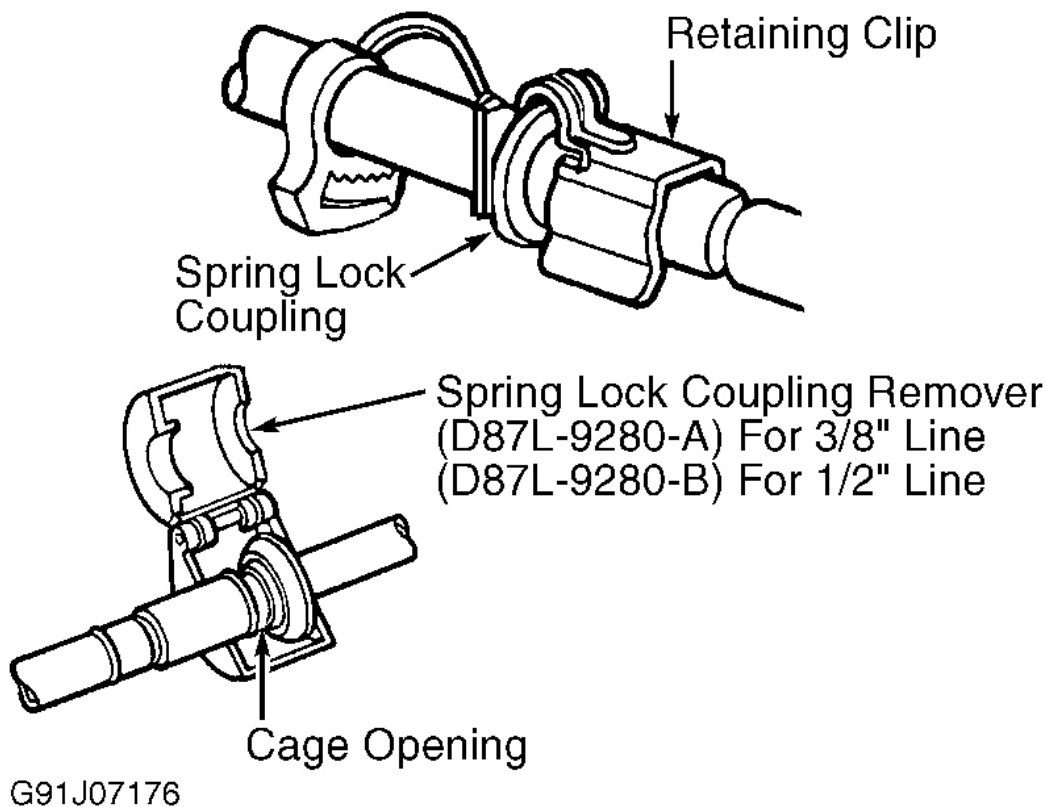


Fig. 1: Disconnecting Fuel Lines
Courtesy of FORD MOTOR CO.

ENGINE

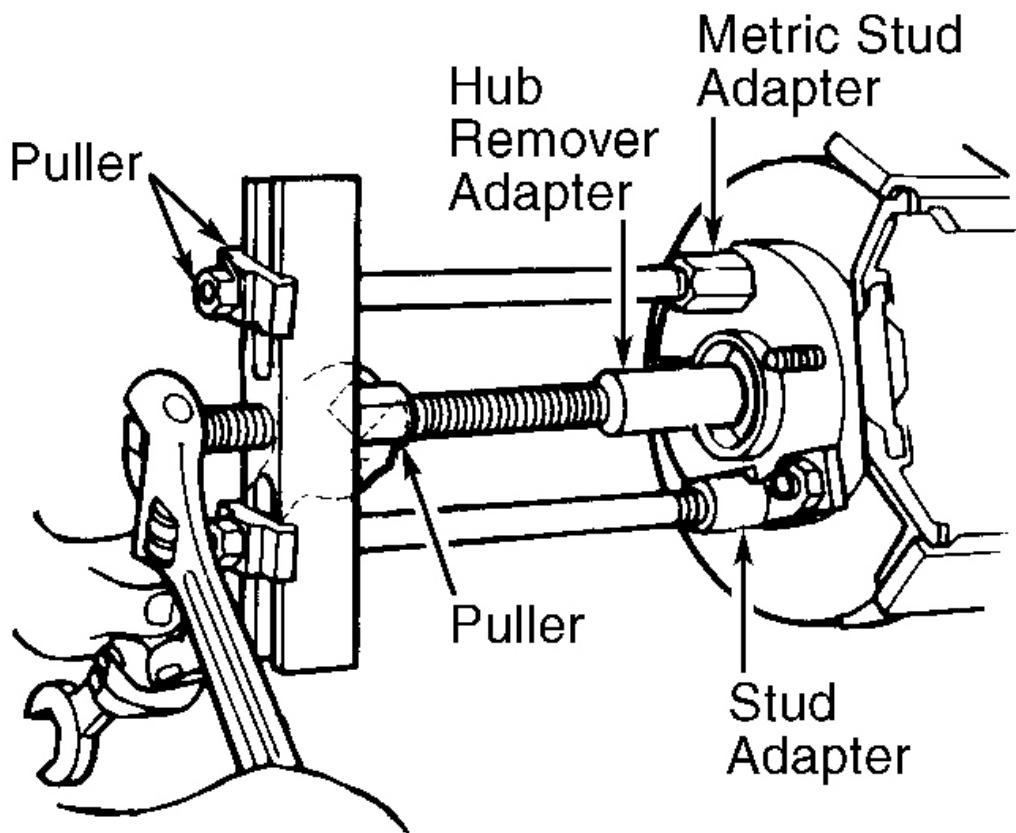
NOTE: Engine is removed from vehicle with transaxle attached, as an assembly.

Removal

1. Disconnect negative battery cable. Disconnect wiring from engine compartment light. Remove hood. Drain cooling system. Remove cowl top vent panel. Disconnect generator and voltage regulator wiring. Remove air cleaner assembly.
2. Remove upper radiator hoses and heater hoses from engine. Remove heater hose bracket. Using Oil Cooler Line Separator (T86P-77265-AH), disconnect oil cooler lines. Discharge A/C system using approved refrigerant recovery/recycling equipment. Disconnect manifold and hose assembly from A/C compressor.
3. Remove accelerator cable bracket. Release fuel pressure, and disconnect fuel lines. Refer to, in the

beginning of this article, **FUEL PRESSURE RELEASE & FUEL LINE CONNECTIONS** . Mark and disconnect wiring harness connectors and vacuum hoses as necessary. Disconnect throttle valve actuating cable. Raise vehicle on hoist.

4. Drain engine oil, and remove oil filter. Remove wheel assemblies. Remove brake calipers, and wire aside. Disconnect ABS sensor electrical connector. Disconnect oxygen sensors. Remove dual converter crossover pipe bolts. Remove dual converter crossover pipe, using Exhaust Connector Holder (T94T-6000-AH).
5. Using Puller (T81P-1104-C), Metric Stud Adapter (T83P-1104-BH), Stud Adapter (T86P-1104-A1), Hub Remover Adapter (T81P-1104-A), separate axle shaft from wheel hub. See **Fig. 2** .



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Fig. 2: Removing Axle Shaft From Hub Assembly
Courtesy of FORD MOTOR CO.

6. Disconnect starter motor wiring. Remove ground strap and positive battery cable bracket. Disconnect oxygen sensor wiring from body. Disconnect power steering fluid cooler lines. Remove lower radiator

hose. Remove steering gear pinch bolt. Separate steering shaft from steering gear, and partially lower vehicle.

7. Remove upper strut assembly retaining nuts. Raise vehicle and position engine table under subframe. Remove 4 subframe bolts and lower engine, transaxle and subframe as an assembly. Install lifting eyes onto engine and lift assembly from table. Remove stabilizer bar links from strut assembly.
8. Use CV Joint Puller (T86P-3514-A1) and slide hammer to disengage axle shafts from transaxle. Remove power steering hoses from steering gear. Remove engine mounting nuts. Remove engine and transaxle assembly from subframe. Remove starter, transaxle inspection cover and torque converter nuts.
9. Disconnect transaxle electrical connectors. Remove right engine mount-to-transmission bolts. Remove engine-to-transaxle bolts. Separate engine from transaxle, and mount engine on engine stand (if necessary).

Installation

1. To install, reverse removal procedure. Tighten bolts and nuts to specification. See **TORQUE SPECIFICATIONS**.
2. When installing fuel lines, install new "O" rings on fuel lines. Use only specified fuel resistant "O" rings (Brown). Lightly coat "O" rings with clean engine oil before installing. Clean fittings, and replace garter spring (if necessary).
3. Adjust control cables and fluid levels. Refill cooling system. Evacuate and recharge A/C system. Check wheel alignment. See SPECIFICATIONS & PROCEDURES article in WHEEL ALIGNMENT.

INTAKE MANIFOLD

Removal

1. Release fuel pressure and disconnect fuel lines. Refer to **FUEL PRESSURE RELEASE & FUEL LINE CONNECTIONS**. Remove cowl top vent panel.
2. Disconnect negative battery cable. Drain cooling system. Remove air cleaner assembly and heat tube. Disconnect control cables and linkage at throttle body. Disconnect accelerator cable bracket and secure it aside.
3. Disconnect necessary linkages at intake manifold. Disconnect wiring harness connectors, vacuum hoses, coolant hoses and PCV hoses as necessary. Remove heater tube with fuel lines attached.
4. Remove A/C compressor support bracket (if equipped). Remove throttle body and EGR valve assembly. Note location of upper intake manifold bolts and studs. Remove upper intake bolts and studs. Remove upper intake manifold. See **Fig. 3**.

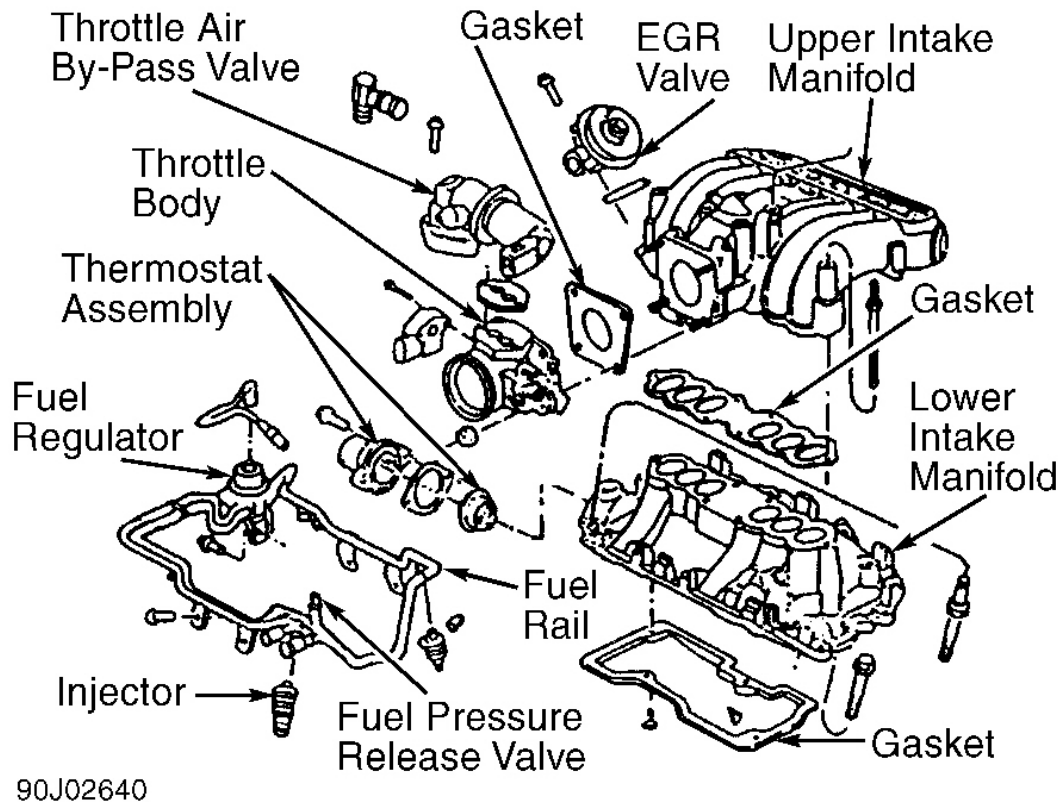


Fig. 3: Exploded View Of Intake Manifold Assembly

Courtesy of FORD MOTOR CO.

5. Remove power steering line bracket from coil bracket. Remove front and rear manifold supports. Remove fuel rail and injectors as an assembly. Note location of lower intake manifold bolts and studs. Remove lower intake manifold bolts and studs.

CAUTION: Note if thread sealant is used on bolts, and note bolt location during removal. Some bolts may require thread sealant during installation.

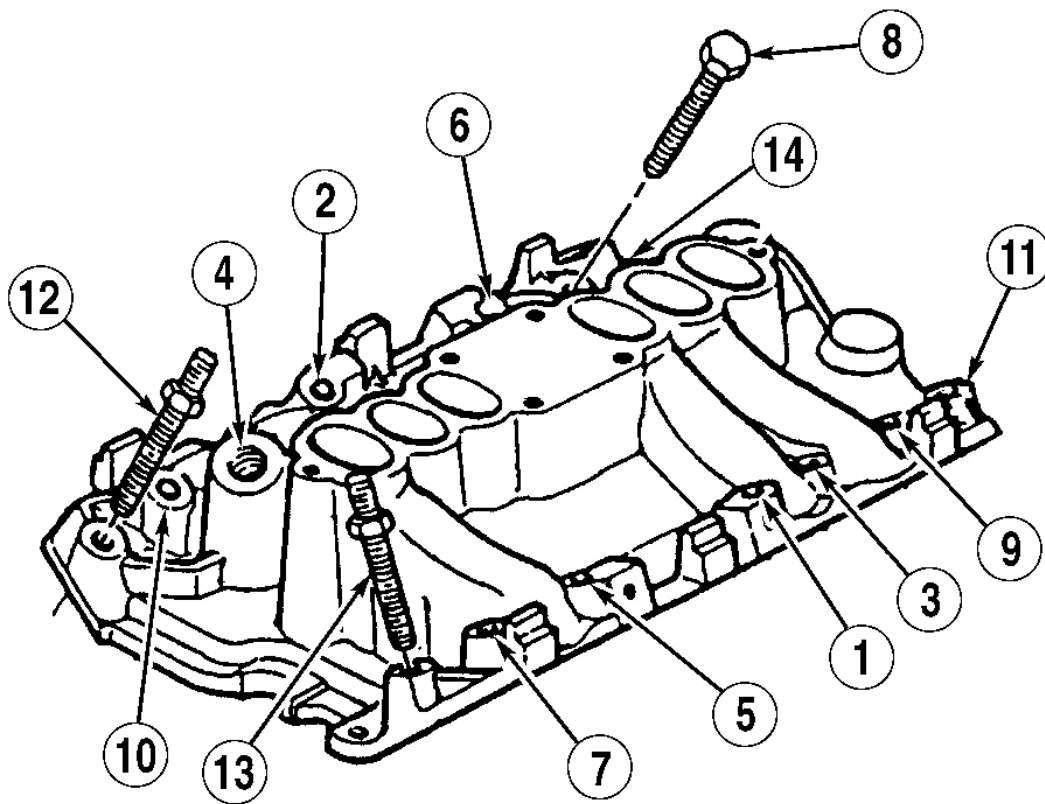
6. Remove lower intake manifold. If necessary, break intake manifold sealing by prying on front of manifold with flat screwdriver. Remove and discard gaskets.

Installation

1. Ensure gasket surfaces are clean. Apply a small amount of Trim Adhesive (D7AZ-19B508-B) to cylinder head surface to hold intake gaskets in place. Install side gaskets.
2. Apply 1/8" bead of Silicone Sealer (D6AZ-19562-BA) at cylinder head-to-cylinder block joining surfaces. Install front and rear intake manifold end seals.

CAUTION: Some bolts may enter coolant passages and require thread sealant. If bolt originally contained thread sealant, clean threads and apply Teflon Sealant (D8AZ-19554-A) before installing.

3. Install lower intake manifold. If thread sealant is not required, lightly oil bolt and stud threads.
4. Install bolts and studs finger tight in original location. Tighten bolts and studs to specification in sequence. See **Fig. 4** . See **TORQUE SPECIFICATIONS** .



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Fig. 4: Lower Intake Manifold Bolt Tightening Sequence
Courtesy of FORD MOTOR CO.

5. Install fuel rail and injectors with new "O" rings. Lubricate "O" rings with engine oil before installing.
6. When installing fuel lines, install new "O" rings on fuel lines. Use only specified fuel resistant "O" rings (Brown). Lightly coat "O" rings with clean engine oil before installing. Clean fittings, and replace garter spring (if necessary).
7. Install upper intake manifold. Tighten bolts to specification starting with 4 center bolts, and proceed to 2 outer bolts. See **TORQUE SPECIFICATIONS** .
8. To install remaining components, reverse removal procedure. Adjust all control cables. Refill cooling

system.

EXHAUST MANIFOLD

Removal (Left Manifold)

Remove oil dipstick tube support bracket. Disconnect spark plug wires from spark plugs. Raise and support vehicle. Separate exhaust pipe from exhaust manifold. Lower vehicle. Remove retaining bolts and exhaust manifold.

Installation

To install, reverse removal procedure. Lightly oil all bolt and stud threads before installing. A slight warpage, causing misalignment, may be corrected by elongating bolt holes as necessary. **DO NOT** elongate lower front bolt hole on cylinder No. 5. Tighten bolts to specification. See **TORQUE SPECIFICATIONS**.

Removal (Right Manifold)

Remove cowl top vent panel. Remove air cleaner assembly and outlet tube. Disconnect spark plug wires from spark plugs. Remove spark plugs. Disconnect EGR valve-to-exhaust manifold tube. Raise and support vehicle. Separate exhaust pipe from exhaust manifold. Lower vehicle. Remove retaining bolts, and remove exhaust manifold.

Installation

To install, reverse removal procedure. Lightly oil all bolt and stud threads before installing. A slight warpage, causing misalignment, may be corrected by elongating bolt holes as necessary. **DO NOT** elongate lower rear bolt hole on cylinder No. 2. Tighten bolts to specification. See **TORQUE SPECIFICATIONS**.

CYLINDER HEAD

Removal

1. Disconnect negative battery cable. Drain cooling system. Remove cowl top vent panel. Remove air cleaner assembly and outlet tube. Rotate drive belt tensioner, and remove drive belt.
2. If removing left cylinder head, remove oil filler cap. Remove power steering pump and bracket with hoses attached, and position aside. Remove generator and generator mounting bracket. If removing right cylinder head, remove drive belt tensioner and PCV valve.
3. Remove upper intake manifold. See **INTAKE MANIFOLD**. Remove fuel injector supply rail. Remove lower intake manifold. Refer to **INTAKE MANIFOLD**. Remove valve covers. Remove exhaust manifold. See **EXHAUST MANIFOLD**.
4. Loosen rocker arm bolts, and pivot rocker arms from push rods. Mark component location for reassembly reference. Remove and discard cylinder head bolts following tightening sequence. See **Fig. 5**. Note location of different size bolts for installation. **DO NOT** reuse bolts. Remove cylinder head and discard gasket.

Inspection

1. Inspect cylinder head for cracks or warpage. Machine cylinder head if warpage exceeds specification. See **CYLINDER HEAD** table under ENGINE SPECIFICATIONS.

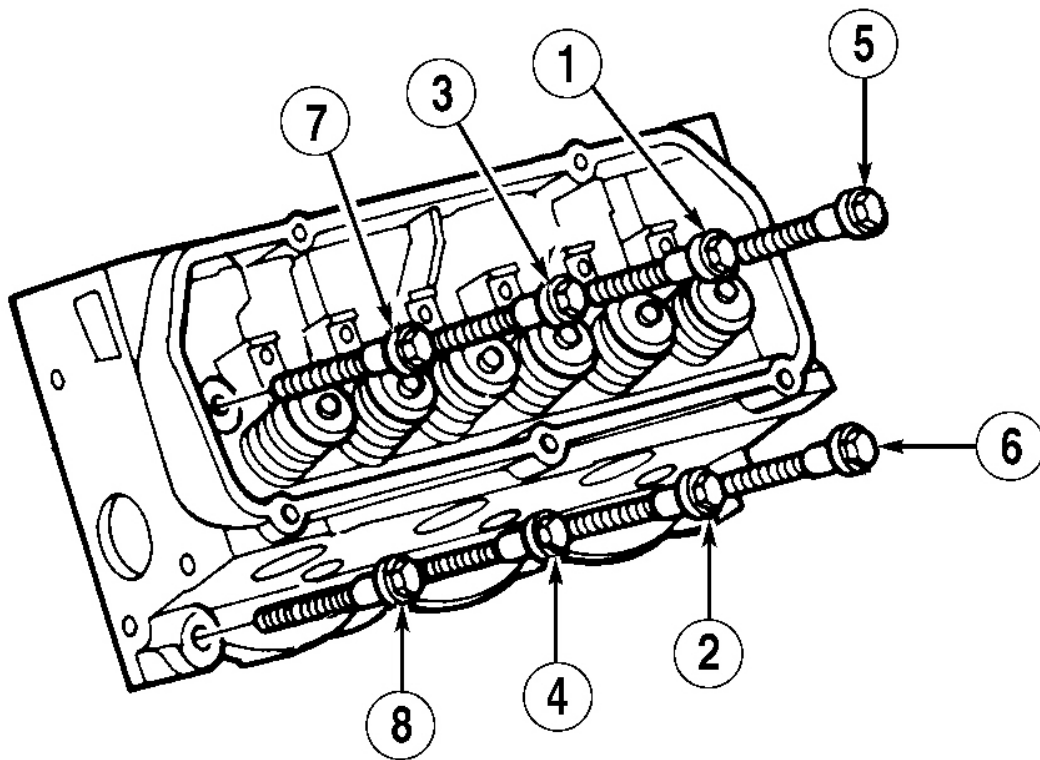
CAUTION: DO NOT machine more than .010" (.25 mm) from original cylinder head thickness or cylinder block surface.

2. Check cylinder block deck surface. Machine cylinder block if warpage exceeds specification. See **CYLINDER BLOCK** table under ENGINE SPECIFICATIONS.

CAUTION: Always use NEW cylinder head bolts. Apply sealant to threads of short cylinder head bolts ONLY. Coat all other cylinder head bolts with engine oil before installing.

Installation

1. Ensure bolt holes in cylinder block are clean. Install gasket and cylinder head. Apply a thin coat of Teflon Pipe Sealant (D8AZ-19554-A) to threads of new short cylinder head bolts (closest to exhaust manifold). Lubricate all other bolts with light coat of engine oil. **DO NOT** apply sealant to long cylinder head bolts.
2. Install cylinder head bolts. Tighten cylinder head bolts to specification in sequence. See **Fig. 5** . See **TORQUE SPECIFICATIONS** .



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Fig. 5: Cylinder Head Bolt Tightening Sequence

Courtesy of FORD MOTOR CO.

3. Coat ends of push rods with Engine Assembly Lubricant (D9AZ-19579-D) and install them in original position. Before installing rocker arm on push rod, rotate crankshaft until push rod is fully downward and valve lifter is on base circle of camshaft. Position rocker arm on push rod, and tighten bolt to 43 INCH lbs. (5 N.m).
4. Repeat procedure for remaining push rods and rocker arms. Tighten rocker arm bolt to final specification. See, in this article, **TORQUE SPECIFICATIONS** . Final tightening of rocker arms may be done with camshaft in any position.

NOTE: If cylinder head or valve train components are serviced, check valve clearance adjustment. See, in this article, **VALVE CLEARANCE ADJUSTMENT** under **ADJUSTMENTS**.

5. To complete installation, reverse removal procedure. Tighten all bolts and nuts to specification. Refill cooling system.

CRANKSHAFT FRONT OIL SEAL

CAUTION: Crankshaft pulley and vibration damper are balanced together and must be installed in original location. If vibration damper is being replaced, note if original vibration damper contains balance pins. If balance pins are used, install new pins in same location on replacement vibration damper.

Removal

1. Rotate drive belt tensioner, and remove drive belt. Raise and support vehicle. Remove wheel assembly. Remove crankshaft pulley from vibration damper. Place reference mark on crankshaft pulley and vibration damper. Remove vibration damper retaining bolt.
2. Using Vibration Damper Remover (T58P-6316-D) and Adapter (T82L-6316-B), remove vibration damper. Using screwdriver, pry seal from front cover.

Installation

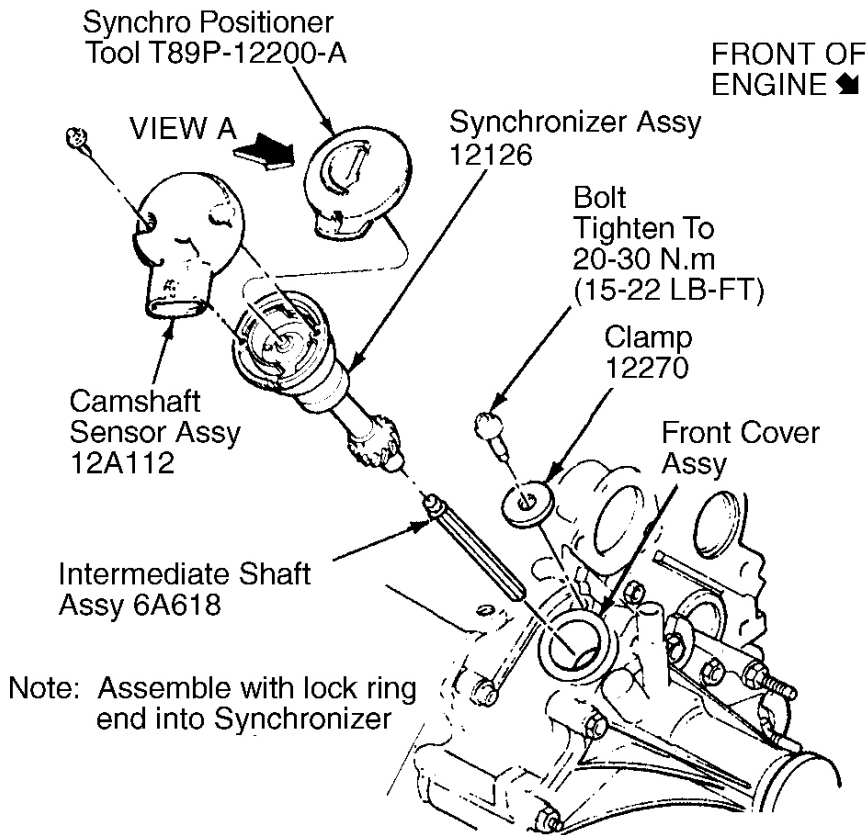
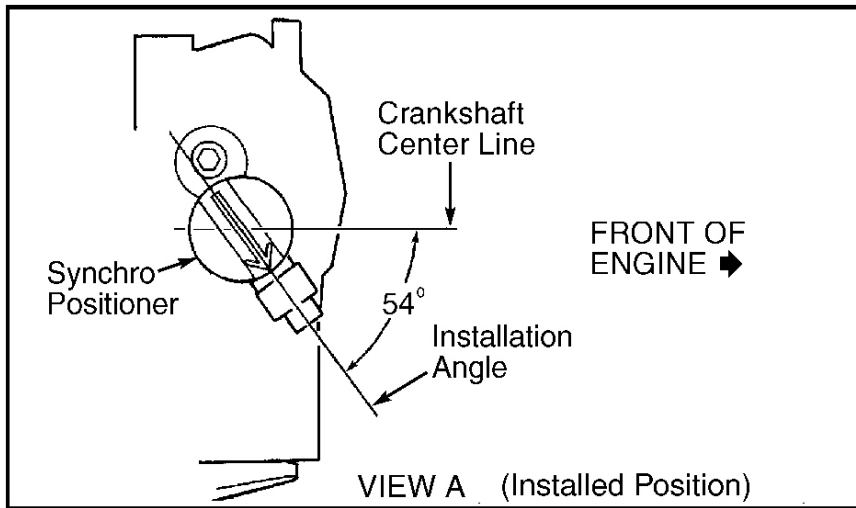
1. Lubricate seal and sealing surfaces with engine oil. Using Seal Installer (T82L-6316-A and T70P-6B070-A), install seal.
2. Coat seal surface of vibration damper with engine oil. Using Vibration Damper Seal Replacer (T82L-6316-A), install vibration damper.
3. To complete installation, reverse removal procedure. Tighten bolts to specification. See **TORQUE SPECIFICATIONS** . Ensure reference marks align on crankshaft pulley and vibration damper.

FRONT COVER

NOTE: Oil pump is attached to front cover and is driven by camshaft position sensor and oil pump intermediate shaft.

Removal

1. Remove engine from vehicle. See **ENGINE** . Loosen drive belt tensioner and remove drive belt. Remove water pump pulley. Disconnect lower radiator and heater hose from water pump. Rotate crankshaft to position piston No. 1 at TDC (compression stroke).
2. Note location of Camshaft Position (CMP) sensor assembly connector for installation reference, and disconnect connector. Remove CMP sensor assembly, and note direction of synchronizer assembly installation. See **Fig. 6** . Remove synchronizer housing retaining bolt. Remove synchronizer housing along with intermediate shaft. Disconnect crankshaft position sensor connector.



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Fig. 6: Exploded View Of CMP/Synchronizer Assembly
Courtesy of FORD MOTOR CO.

CAUTION: Crankshaft pulley and vibration damper are balanced together and

must be installed in original location. If vibration damper is replaced, note if original vibration damper contains balance pins. If balance pins are used, install new pins in same location on replacement vibration.

3. Using Vibration Damper Remover (T58P-6316-D) and Adapter (T82L-6316-B), remove crankshaft pulley and vibration damper. Remove oil pan. See OIL PAN. Remove front cover bolts. Two front cover bolts are behind oil filter mounting flange. See **Fig. 7** . Remove front cover and water pump as an assembly. Remove gasket. Clean gasket surfaces.

CAUTION: Ensure hidden bolts behind oil filter adapter are removed before removing front cover. See **Fig. 7** .

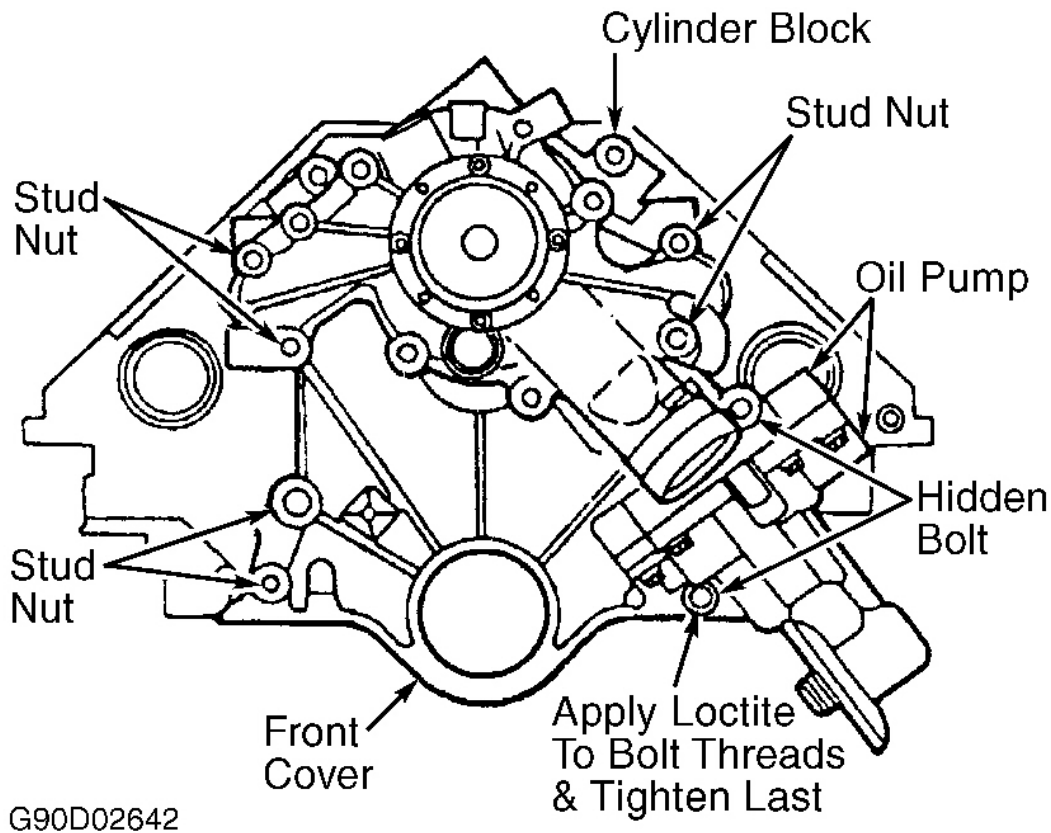


Fig. 7: Identifying Front Cover Mounting Bolts & Studs
Courtesy of FORD MOTOR CO.

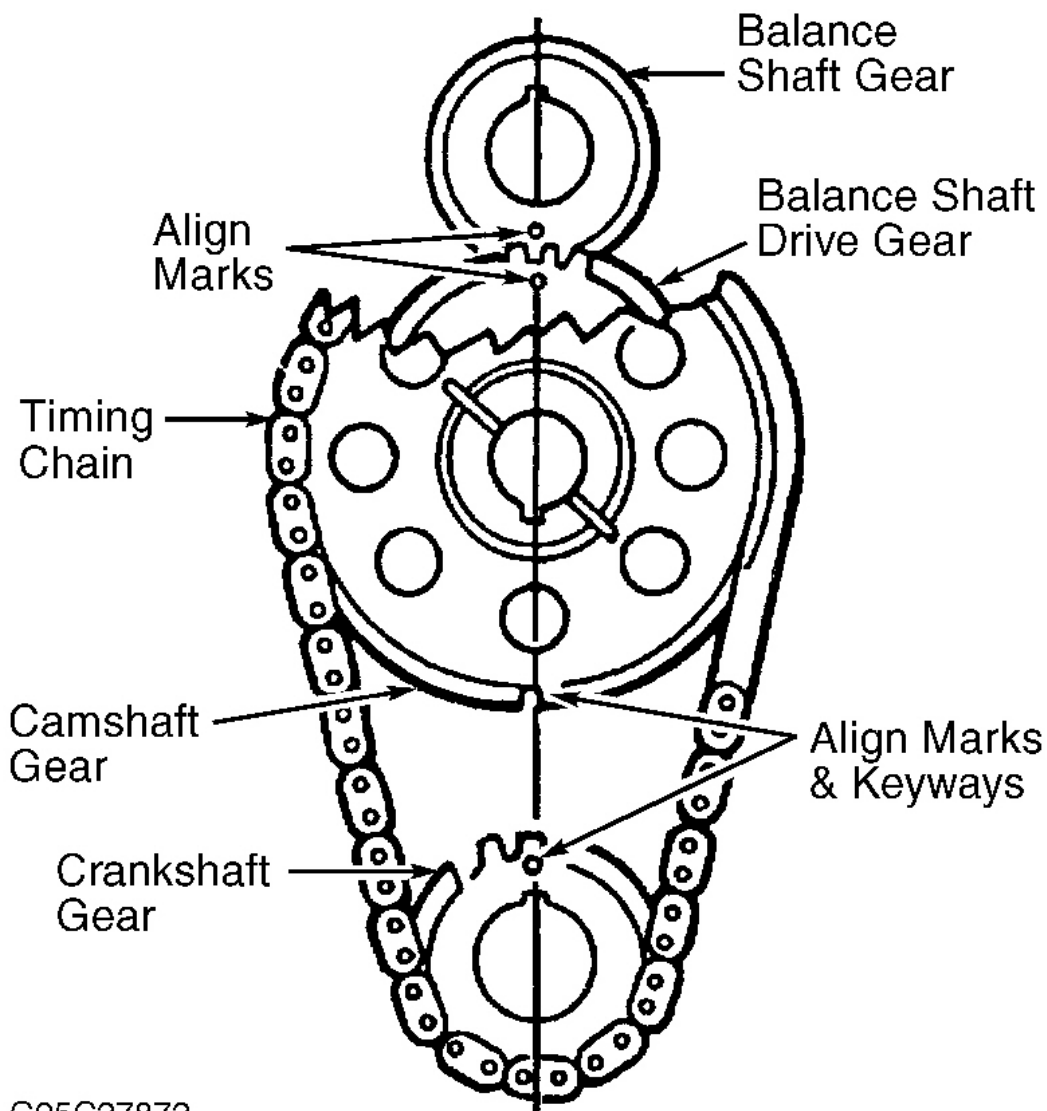
Installation

1. Lightly oil threads of bolt and stud before installing, except those requiring thread sealant. Use Gasket And Trim Adhesive (D7AZ-19B5O8-B) to hold front cover gasket in place on cylinder block.
2. Coat crankshaft front seal lip with engine oil. Install front cover and water pump as an assembly. Install front cover bolts. Apply Loctite to bolt closest to oil filter mounting flange and tighten this bolt last. See **Fig. 7** . Tighten bolts to specification. See **TORQUE SPECIFICATIONS** .
3. Coat seal surface of vibration damper with engine oil. Using Vibration Damper Installer (T82L-6316-A), install vibration damper. Install CMP sensor assembly using Syncro Positioner (T93P-12200-A). See **Fig. 6** . To install remaining components, reverse removal procedure.
4. Ensure reference marks align on crankshaft pulley and vibration damper. Tighten bolts to specification. See, in this article, **TORQUE SPECIFICATIONS** . Refill cooling system.

TIMING CHAIN

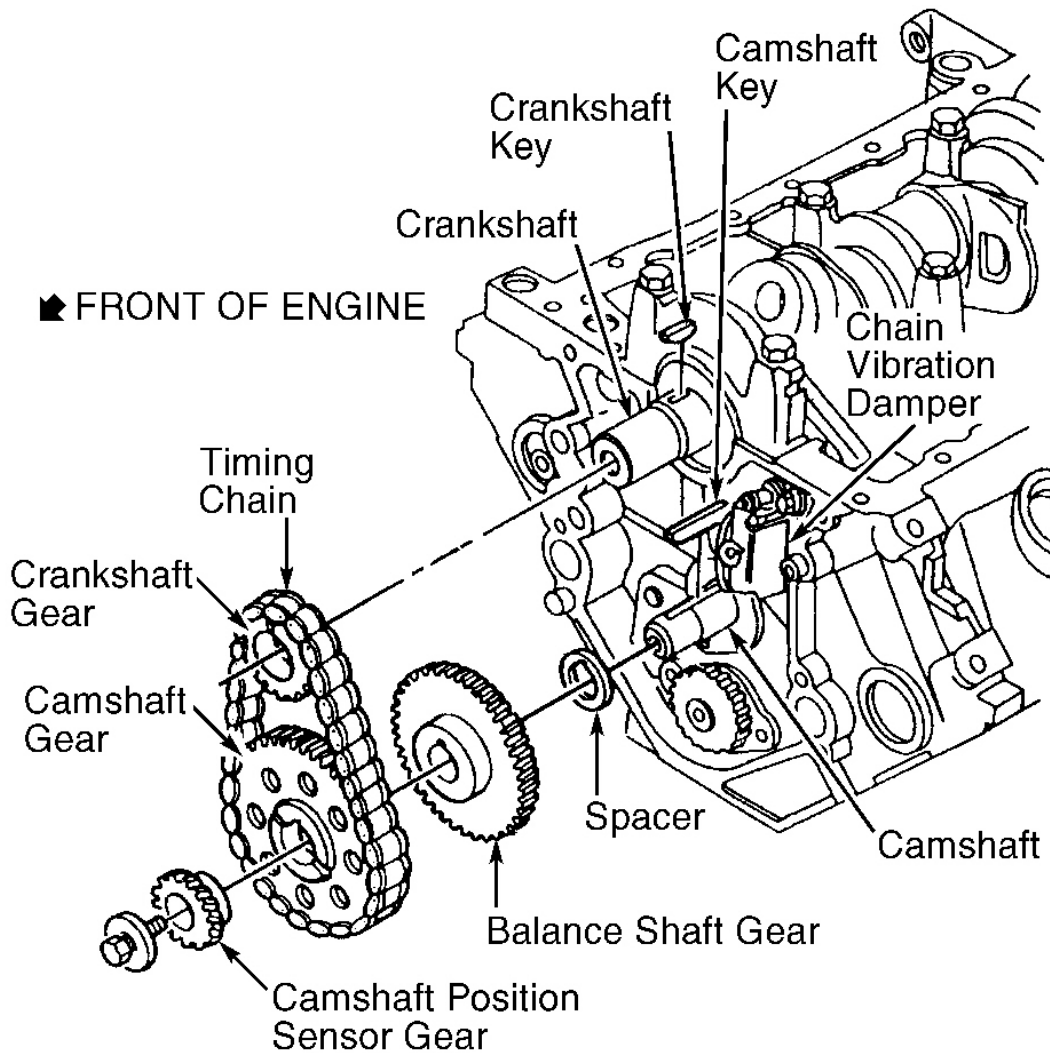
Removal

1. Remove front cover. See **FRONT COVER** . Ensure timing marks on all gears align. See **Fig. 8** . Remove retaining bolt, and remove camshaft position sensor drive gear.
2. Remove camshaft gear, crankshaft gear and timing chain. See **Fig. 9** . If crankshaft gear is difficult to remove, position a pair of screwdrivers evenly on gear and carefully pry it off.
3. Remove tensioner/snubber assembly by pulling back on ratcheting mechanism and installing a pin through hole in bracket. Remove retaining bolts, and remove tensioner/snubber assembly. See **Fig. 9** .



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Fig. 8: Aligning Timing Marks
Courtesy of FORD MOTOR CO.



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Fig. 9: Exploded View Of Timing Chain & Components
 Courtesy of FORD MOTOR CO.

Installation

1. Lightly oil threads of bolts and studs. Ensure crankshaft key is at 12 o'clock position. Install tensioner/snubber assembly with ratcheting mechanism in retracted position and pin in bracket hole facing outward.
2. Install crankshaft gear, camshaft gear and timing chain as an assembly. Ensure timing marks and keyways align. See **Fig. 8** . With all timing marks aligned, remove pin from tensioner/snubber assembly to apply tension to timing chain.
3. Tighten bolts to specification. See **TORQUE SPECIFICATIONS** . To install remaining components,

reverse removal procedure.

VALVE LIFTER

Removal

1. Remove upper and lower intake manifolds. See, in this article, **INTAKE MANIFOLD** . Remove valve covers. Loosen rocker arm bolts, and pivot rocker arms from push rods.
2. Mark push rod location, and remove push rods. Remove guide plate retainers. See **Fig. 10** . Remove guide plate. Mark valve lifter location for reassembly reference. Remove valve lifters.

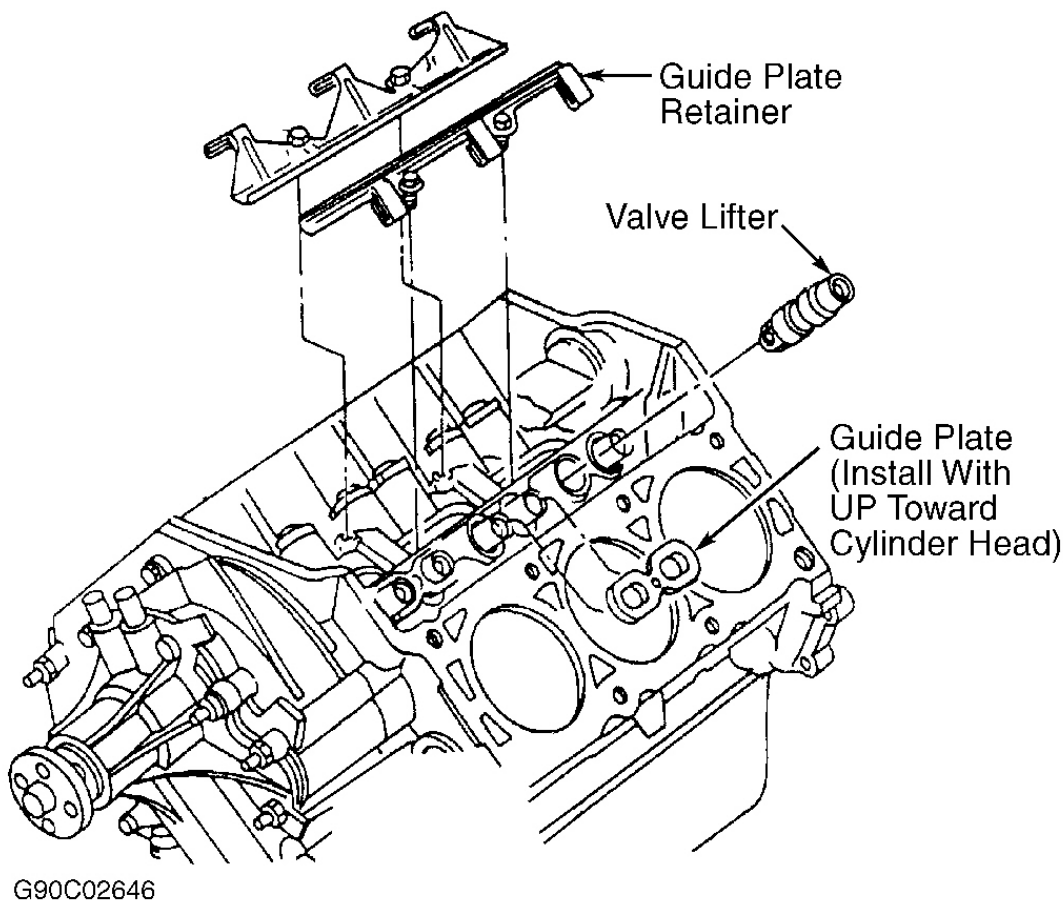


Fig. 10: Exploded View Of Valve Lifter & Components
Courtesy of FORD MOTOR CO.

Inspection

Inspect valve lifter for damage. Ensure roller rotates smoothly and has no flat spots or scoring. Measure valve lifter O.D. and cylinder block lifter bore I.D. If oil clearance is not as specified, replace components. See

VALVE LIFTERS table under ENGINE SPECIFICATIONS.

Installation

1. Lubricate valve lifter and cylinder block bore with Assembly Lubricant (D9AZ-19579-D) or heavy engine oil. Install valve lifter in original location.
2. Align flat sides of valve lifters, and install guide plates with the word UP showing. Install guide plate retainer. Tighten bolts to specification. See **TORQUE SPECIFICATIONS** .
3. Coat push rods with Assembly Lubricant (D9AZ-19579-D) and install them in original position. Before installing rocker arm on push rod, rotate crankshaft until push rod is fully downward and valve lifter is on base circle of camshaft. Position rocker arm on push rod, and tighten bolt to 43 INCH lbs. (5 N.m).
4. Repeat procedure for remaining push rods and rocker arms. Tighten all rocker arms to specification. Final tightening of rocker arms may be done with camshaft in any position. To install remaining components, reverse removal procedure.

CAMSHAFT

NOTE: Engine must be removed from vehicle for camshaft removal. See **ENGINE** under **REMOVAL & INSTALLATION**. Engine must be removed from vehicle when servicing camshaft or balance shaft bearings.

Removal

1. Remove upper and lower intake manifolds. See, in this article, **INTAKE MANIFOLD** . Remove valve lifters and timing chain. Refer to **VALVE LIFTER** under **REMOVAL & INSTALLATION**. Refer to, under **REMOVAL & INSTALLATION** **TIMING CHAIN** . Remove camshaft thrust plate. Remove camshaft through front of engine, while being careful not to damage bearing surfaces.
2. If replacing camshaft bearings, remove flexplate/flywheel. Remove rear camshaft bore plug. Use Camshaft/Balance Shaft Bearing Set (T65L-6250-A) to remove camshaft bearings.

Inspection

Inspect components for damage. Measure camshaft bearing I.D., journal O.D., and lobe lift. Replace components if damaged or not within specification. See **CAMSHAFT** table under ENGINE SPECIFICATIONS.

Installation

1. To install, reverse removal procedure. Ensure oil holes in camshaft bearings and cylinder block align. Apply sealant to rear camshaft bore plug before installing.

NOTE: Oversize rear camshaft bore plug can be identified by oversize stamped on flat area of plug. Ensure proper size plug is installed.

2. Lubricate camshaft lobes and bearing surfaces with Assembly Lubricant (D9AZ-19579-D). Install camshaft. Tighten thrust plate bolts to specification. See **TORQUE SPECIFICATIONS** .

3. Ensure camshaft end play is within specification. See **CAMSHAFT** table under ENGINE SPECIFICATIONS. To complete installation, reverse removal procedure. Refill cooling system.

BALANCE SHAFT

Removal

1. Engine must be removed in order to remove balance shaft. Refer to **ENGINE** . Remove the timing chain and gears. Refer to **TIMING CHAIN** .
2. Remove balance shaft drive gear from camshaft. Remove balance shaft thrust plate bolts. Remove balance shaft. See **Fig. 11** .
3. If replacing balance shaft bearings, remove rear bore plug. Use Camshaft/Balance Shaft Bearing Set (T65L-6250-A) to remove balance shaft bearings.

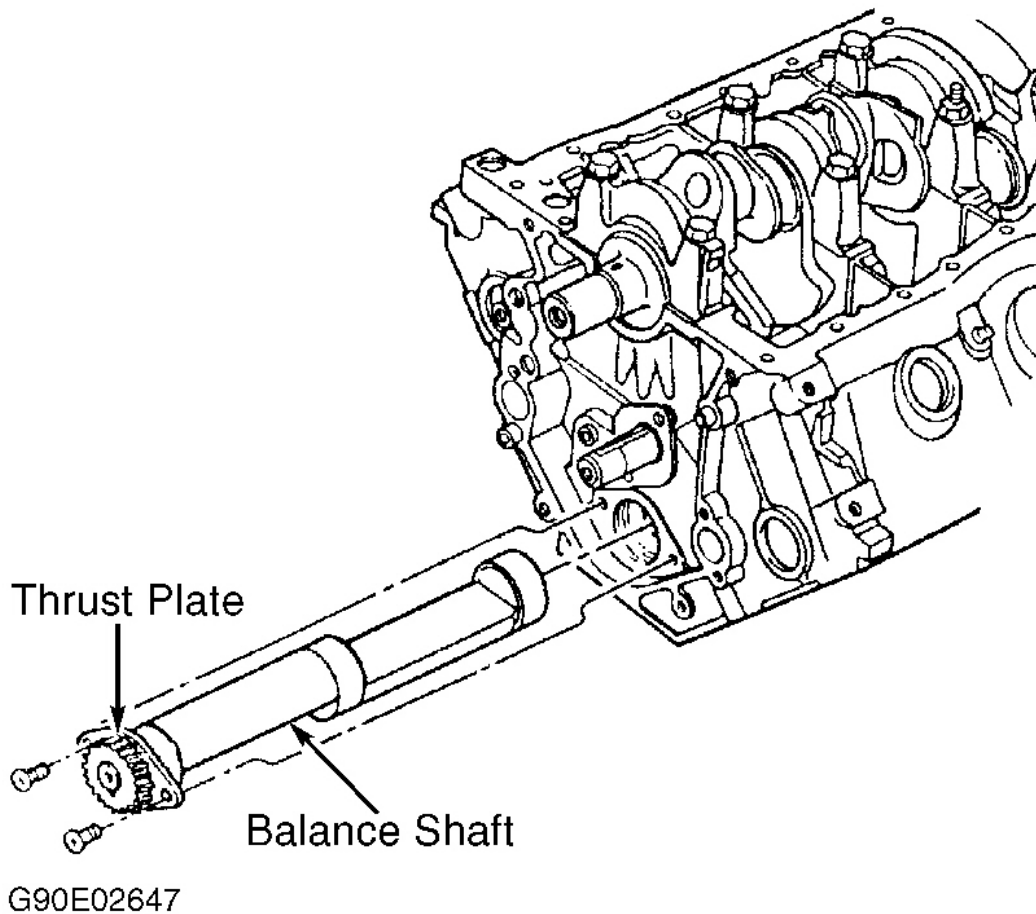


Fig. 11: Locating Balance Shaft & Thrust Plate
Courtesy of FORD MOTOR CO.

Inspection

Inspect components for damage. Measure balance shaft journal O.D. and runout. Replace components if damaged or not within specification. See the **BALANCE SHAFT SPECIFICATIONS** table.

BALANCE SHAFT SPECIFICATIONS

Application	In. (mm)
End Play	.003-.008 (.08-.20)
Journal O.D.	2.0505-2.0515 (52.083-52.108)
Runout	.001 (.03)

Installation

1. To install, reverse removal procedure. Lubricate all components with engine oil before installation. Apply sealant to rear bore plug before installing.

NOTE: **Oversize rear bore plug can be identified by oversize stamped on flat area of plug. Ensure proper size plug is installed.**

2. Ensure all timing marks align. See **Fig. 8** . Check balance shaft end play. Replace thrust plate if end play is not within specification. See the **BALANCE SHAFT SPECIFICATIONS** table.

CRANKSHAFT REAR OIL SEAL**Removal**

Rear main bearing oil seal is a one-piece seal. Remove transmission or transaxle. See TRANSMISSION REMOVAL & INSTALLATION article under TRANSMISSION SERVICING. Remove flexplate/flywheel. Punch hole in metal portion of seal with an awl. Remove seal with a slide hammer.

Installation

1. Lubricate seal and mating surfaces with engine oil. Install seal on crankshaft with spring side toward crankshaft. Using Seal Installer (T82L-6701-A), alternate bolt tightening to install seal properly.
2. To install remaining components, reverse removal procedure. Tighten bolts to specification. See **TORQUE SPECIFICATIONS** .

CAUTION: Apply thread sealant on threads of drive plate or flywheel bolts before installing.

WATER PUMP**Removal**

1. Disconnect negative battery cable. Drain cooling system. Loosen drive belt tensioner, and remove drive belt. Raise and support vehicle. Remove lower radiator hose. Remove lower nut on both front engine

mounts. Lower vehicle. Remove generator. Position drain pan under power steering pump.

2. Using Fuel Line Separator (T90T-9550-S), disconnect power steering pressure line from power steering pump. Remove power steering pump filler cap. Disconnect necessary coolant hoses. Attach lifting eye to front exhaust manifold. Attach engine lift to lifting eye and lift front of engine 2" (51 mm).
3. Remove water pump pulley. Remove drive belt tensioner pulley from power steering pump bracket. Remove power steering pump bracket with power steering pump attached, and position aside. Remove water pump bolts and nuts. Note bolt location. Note if sealant is applied to bolt threads. Remove water pump and gasket.

CAUTION: When bolt is removed, note if sealant is applied to threads. Some bolts are coated with sealant to prevent coolant leakage.

Installation

1. Install gasket using Gasket and Trim Adhesive (D7AZ-19B508-B). To complete installation, reverse removal procedure. Lightly oil threads of bolt and stud not containing thread sealant.
2. If bolts originally contained thread sealant, clean and reapply thread sealant to bolts. Tighten bolts and nuts to specification. See **TORQUE SPECIFICATIONS** . Fill cooling system.

OIL PAN

Removal

1. Disconnect negative battery cable. Raise and support vehicle. Drain engine oil, and remove oil filter.
2. Remove exhaust pipe assembly located below oil pan. Remove starter and torque converter housing cover. Disconnect oil level sensor electrical connector. Remove retaining bolts, oil pan and seals.

Installation

To install, reverse removal procedure. Before installing oil pan, apply Silicone Sealant (F1AZ-19562-A) on oil pan rails of cylinder block, rear main bearing cap and front cover-to-cylinder block areas. Tighten oil pan bolts to specification. See, in this article, **TORQUE SPECIFICATIONS** . Fill oil system.

CAUTION: Ensure silicone sealant fills groove between rear main bearing cap and cylinder block at both edges of main bearing cap.

OVERHAUL

CYLINDER HEAD

NOTE: When valve and/or valve seat are machined, valve clearance is reduced and may cause improper valve operation. Valve lifter must be collapsed and clearance checked. See **VALVE CLEARANCE ADJUSTMENT** under **ADJUSTMENTS** at beginning of article.

Cylinder Head

Check cylinder head warpage. Resurface cylinder head if warpage exceeds specification. See **CYLINDER HEAD** table under ENGINE SPECIFICATIONS.

CAUTION: DO NOT machine more than .010" (.25 mm) from original cylinder head surface.

Valve Springs

1. Inspect pressure of valve spring. Replace valve spring if pressure is not within specification. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS.
2. Check springs for squareness, stand spring on table with closed end of spring downward. Hold square against spring and rotate spring. Measure space between spring and square. See, in this article, **VALVES & VALVE SPRINGS** table.
3. Measure valve spring installed height from cylinder head surface to underside of spring retainer. If installed height is not within specification, install a .03" (.8 mm) shim between cylinder head and valve spring to obtain correct height. See, in this article, **VALVES & VALVE SPRINGS** table.

CAUTION: DO NOT install valve spring shims unless necessary. Using more shims than required can result in spring breakage or worn camshaft lobes.

NOTE: Lubricate all valves, valve stems and valve guides with heavy oil during installation. Use Multi-Purpose Grease (D0AZ-19584-AA) on valve tips.

Valve Stem Oil Seals

Different types of valve stem oil seals are used on intake and exhaust valves. Ensure oil seal bottoms on valve guide. Oversize oil seals should be installed when using oversize valves. Intake valve stem oil seal can be identified by a White stripe.

Valve Guides

1. Valve guides may be reamed for oversize valves if stem-to-guide oil clearance exceeds specification. See **CYLINDER HEAD** table under ENGINE SPECIFICATIONS. Valves are available in .015" (.38 mm) and .030" (.76 mm) oversize.
2. Valve guides may also be bored and replaced with a service guide if oversize valves are not available, or if guide is damaged. Ream valve guides until proper stem-to-guide clearance exists.

CAUTION: DO NOT ream valve guides from standard to maximum oversize in one step. Ream valve guides to oversize in gradual steps so valve guides are reamed in relation to valve seat. Valve seats must be ground when valve guide is reamed or replaced.

Valve Seat

Ensure valve seat angle, seat width and seat runout are within specification. See **CYLINDER HEAD** table under ENGINE SPECIFICATIONS. Valve seats must be ground when valve guide is reamed or replaced. Replacement information is not available from manufacturer.

Valves

Ensure head diameter, valve face runout, stem diameter and valve margin are within specification. See **VALVES & VALVE SPRINGS** table under ENGINE SPECIFICATIONS.

CAUTION: DO NOT remove more than .010" (.25 mm) from end of valve stem when resurfacing tip of valve.

Valve Seat Correction Angles

Use a 30-degree stone to lower seat or a 60-degree stone to raise seat.

CYLINDER BLOCK ASSEMBLY

Piston & Rod Assembly

Install piston on connecting rod, with piston notches on same side as button on connecting rod. See **Fig. 12** . Install piston and connecting rod in engine, with notches on piston's top and button on connecting rod toward front of engine.

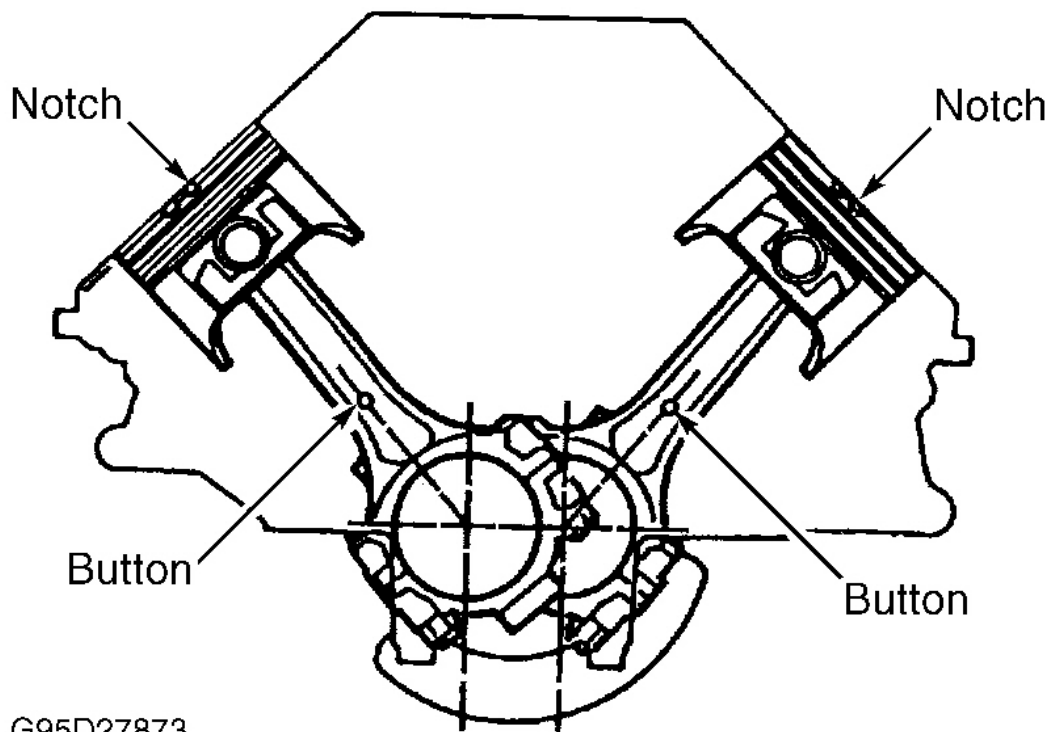


Fig. 12: Positioning Piston & Connecting Rod
 Courtesy of FORD MOTOR CO.

Fitting Pistons

1. Standard selective fit pistons are color-coded Red, Blue and Yellow on piston dome. Measure piston skirt diameter at 90-degree angle to piston pin. Replace piston if not within specification. See **PISTONS PINS & RINGS** table under ENGINE SPECIFICATIONS.
2. Measure cylinder bore 1/2" below top of cylinder bore and 1/2" above bottom of piston travel.
3. Using bore diameter, determine color-coded piston to be used. Ensure piston-to-bore clearance is within specification. See **PISTONS PINS & RINGS** table.

Piston Rings

Ensure ring end gap and side clearance are within specification. See **PISTONS PINS & RINGS** table under ENGINE SPECIFICATIONS. Ensure ring gaps are NOT aligned.

Rod Bearings

1. Coat rod bearings with Engine Assembly Lubricant (D9AZ-19579-D). Coat connecting rod bolts with oil before installing nuts. Ensure piston and connecting rod are installed so notches on piston's top and button

on connecting rod are toward front of engine. Refer to **Fig. 12**.

2. Use plastigage method to check bearing oil clearance. **DO NOT** turn crankshaft while using plastigage. See, in this article, **CRANKSHAFT MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS. See **CONNECTING RODS** table under ENGINE SPECIFICATIONS.
3. If oil clearance exceeds specification, try using a different combination of rod bearings. Refer to, in this article, **SELECTIVE MAIN & ROD BEARINGS** table. Use only bearing combinations listed in table.

CAUTION: DO NOT grind more than .010" (.25 mm) From crankshaft journal surfaces. Further grinding may cause crankshaft failure.

4. If any bearing cannot be adjusted to standard oil clearance specification, grind crankshaft and use undersize bearings. Ensure journal shoulder radius is reproduced when grinding journals. Shoulder radius specification is .002-.003" (.51-.76 mm) X 45 degrees.
5. Upon reassembly, apply Engine Assembly Lubricant (D9AZ-19579-D) to bearing faces, ensure backside of bearing insert is free of grease. Tighten connecting rod bearing cap nuts to specification. See **TORQUE SPECIFICATIONS**.

Crankshaft & Main Bearings

1. Ensure main bearing oil clearance and crankshaft end play is within specification. See **CRANKSHAFT MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS. Replace thrust bearing if end play is not within specification.
2. If oil clearance exceeds specification, try using a different combination of main bearings. See, in this article, **SELECTIVE MAIN & ROD BEARINGS** table. Use only bearing combinations listed in table.

CAUTION: DO NOT grind more than .010" (.25 mm) From crankshaft journal surfaces. Further grinding may cause crankshaft failure.

3. If any bearing cannot be adjusted to standard oil clearance specification, grind crankshaft and use oversize bearings. Oversize main bearings are available in .010" (.25 mm). Tighten main bearing cap bolts to specification.

SELECTIVE MAIN & ROD BEARINGS

Excess Clearance: In. (mm)	Use Upper Bearing: In. (mm)	Use Lower Bearing: In. (mm)
0.0-.0005 (0.0-.013)	.001 (.025)	(1)
0.0005-.0010 (.013-.026)	.001 (.025)	.001 (.025)
0.0010-.0015 (.026-.039)	.002 (.050)	.001 (.025)
0.0015-.0020 (.039-.052)	.002 (.050)	.002 (.050)
(1) Use standard bearing.		

4. Main bearing caps are marked for location, with No. 1 at front and No. 4 at rear of engine. Triangle on main bearing cap must point toward front of engine.

5. Apply a 1/8" bead of silicone sealant to parting line between rear main bearing cap and cylinder block before installing. Install main bearing caps with triangle on cap pointing toward crankshaft pulley end of crankshaft.
6. Tighten bolts finger tight. Pry crankshaft forward, and tighten main bearing cap bolts to specification. See, in this article, **TORQUE SPECIFICATIONS** . Ensure rear main bearing cap is even with rear of cylinder block.

Thrust Bearing

Thrust bearing is located on No. 3 main bearing. Replace bearing if crankshaft end play is not within specification. See **CRANKSHAFT MAIN & CONNECTING ROD BEARINGS** table under ENGINE SPECIFICATIONS.

Cylinder Block

1. Using a straightedge and feeler gauge, check cylinder block head surface warpage. Machine cylinder block if warpage exceeds specification. See **CYLINDER BLOCK** table under ENGINE SPECIFICATIONS.

CAUTION: DO NOT machine more than .010" (.25 mm) of material from original cylinder block deck surface.

2. Check cylinder bore diameter, out-of-round and taper. Cylinder bore is measured 1/2" below top of cylinder block deck and 1/2" above piston when at bottom of cylinder bore. Cylinder block must be bored if measurement is not within specification. See, in this article, **CYLINDER BLOCK** table.

CAUTION: If cylinder block must be bored, ensure main bearing caps are installed and bolts are tightened to specification. This prevents main bearing bores from being distorted when boring cylinder block.

LUBRICATION

ENGINE OILING SYSTEM

Force-feed type system supplies pressurized oil to crankshaft, connecting rods, camshaft and balance shaft bearings, and valve lifters. A controlled volume of oil is supplied to rocker arms and push rods. Oil pump is driven by intermediate shaft connected to camshaft position sensor assembly.

Crankcase Capacity

Crankcase capacity, including filter, is 4.5 qts. (4.3L).

Oil Pressure

Oil pressure is 40-60 psi (2.8-4.2 kg/cm²) at 2500 RPM with engine at normal operating temperature.

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OIL PUMP

Removal & Disassembly

Oil pump is bolted to front cover. Remove oil filter and oil cooler (if equipped). Remove oil pump-to-front cover bolts, and remove oil pump. Disassemble oil pump. Note direction of component installation.

Inspection

1. Place straightedge across mounting surface of oil pump cover. Measure warpage between oil pump cover and straightedge. Replace oil pump or cover if warpage exceeds specification. Refer to the **OIL PUMP SPECIFICATIONS** table.
2. Measure gear thickness and gear pocket depth in pump body. Check gear side clearance by measuring from tip of gear to pump housing. Measure gear diameter and gear pocket diameter in front cover. Replace components if measurements are not within specification. See OIL PUMP SPECIFICATIONS table.
3. Check relief valve tension and relief valve-to-bore clearance. Replace components if measurements are not within specification. See **OIL PUMP SPECIFICATIONS** table.

OIL PUMP SPECIFICATIONS

Application	In. (mm)
Driver Shaft-To-Housing Clearance	.0015-.0030 (.038-.076)
Idler Shaft-To-Gear Clearance	.0005-.0017 (.013-.043)
Oil Pump Cover Warpage	.0016 (.041)
Oil Pump Gear Backlash	.008-.012 (.20-.30)
Oil Pump Gear Height ⁽¹⁾	.0005-.0055 (.013-.140)
Oil Pump Gear Radial Clearance	.002-.005 (.05-.13)
Relief Valve-To-Bore Clearance	.0017-.0029 (.043-.074)
Relief Valve Spring Tension ⁽²⁾	15.2-17.1 @ 1.20 (6.9-7.8 @ 28.2)
(1) Measure amount gear is recessed in housing	
(2) Lbs. @ In. (Kg @ mm).	

Reassembly & Installation

1. To reassemble, reverse disassembly procedure. Ensure components are installed in original location. Lubricate components thoroughly.
2. Tighten oil pump cover bolts to specification. See TORQUE SPECIFICATIONS. To install, reverse removal procedure. Tighten bolts to specification.

TORQUE SPECIFICATIONS

TORQUE SPECIFICATIONS

Application	Ft. Lbs. (N.m)

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Camshaft Sprocket Bolt	30-37 (41-50)
Coil Bracket Nut	15-22 (20-30)
Connecting Rod Nut	
Step 1	31-36 (42-49)
Step 2	Back Off 2-3 Turns
Step 3	31-36 (42-49)
Crankshaft Pulley Bolt	19-28 (26-38)
Cylinder Head Bolt ⁽¹⁾	
Step 1	15 (20)
Step 2	30 (40)
Step 3	37 (50)
Step 4 (Retorque)	
Long Bolt ⁽²⁾	
Step 1	Back Off 2-3 Turns
Step 2	30-37 (40-50)
Step 3	Additional 175-185°
Short Bolt ⁽²⁾	
Step 1	Back Off 2-3 Turns
Step 2	15-22 (20-30)
Step 3	Additional 175-185°
Engine Mount Through Bolt	30-40 (41-54)
Engine-To-Transaxle Bolt	41-50 (56-68)
Exhaust Manifold Bolt/Nut	15-22 (20-30)
Exhaust Manifold-To-Exhaust Pipe Nut	16-24 (22-33)
Flywheel/Drive Plate Bolt ⁽³⁾	54-64 (73-87)
Front Cover Bolt	15-22 (20-30)
Generator Mounting Bolt	30-40 (41-54)
Lower Intake Manifold Bolt ⁽⁴⁾	
Step 1	13 (18)
Step 2	16 (22)
Intake Manifold Support Bolt/Nut	15-22 (20-30)
Main Bearing Cap Bolt/Stud	65-81 (88-110)
Oil Filter Adapter Bolt	18-22 (24-30)
Oil Pick-Up Tube Bolt/Nut	
At Cylinder Block	15-22 (20-30)
At Main Bearing Cap	30-40 (41-54)
Oil Dipstick Tube Retaining Nut	15-22 (20-30)
Oil Pump Cover Bolt	
Large Bolt	17-23 (23-31)
Small Bolt	(5) *

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Power Steering Pump Mounting Bolt	30-45 (41-61)
Rocker Arm Bolt	
Step 1	(6) *
Step 2	19-25 (26-34)
Subframe Mounting Bolt	40-52 (54-70)
Throttle Body Nut	15-22 (20-30)
Timing Chain Vibration Damper Bolt	10 (14)
Torque Converter Nut	20-34 (27-46)
Transaxle-To-Cylinder Block Bolt	40-50 (54-68)
Upper Intake Manifold Bolt	
Step 1	(7) *
Step 2	15 (20)
Step 3	24 (32)
Vibration Damper-To-Crankshaft Bolt	103-132 (140-179)
Water Pump Bolt	15-22 (20-30)
Wheel Lug Nut	85-105 (115-142)
	INCH Lbs. (N.m)
Balance Shaft Thrust Plate Bolt	71-124 (8-14)
Camshaft Thrust Plate Bolt	71-124 (8-14)
Fuel Rail Bolt	71-96 (8-11)
Guide Plate Retaining Bolt	71-124 (8-14)
Lifter Guide Plate Bolt	71-124 (8-14)
Oil Pan Bolt	80-106 (9-12)
Spark Plug	71-124 (8-14)
Timing Chain Tensioner Bolt	71-124 (8-14)
Valve Cover Bolt	80-106 (9-12)

(1) This procedure has been updated per Ford TSB 98-4-9. Dated March 2, 1998. Use NEW cylinder head bolts. Apply sealant to shortest bolts. Tighten bolts in sequence. See **Fig. 5** .

(2) DO NOT loosen all bolts at one time. Work on one bolt at a time in sequence. Sequence for long bolts is 1, 3, 5, 7. Sequence for short bolts is 2, 4, 6, 8.

(3) Apply thread sealant to bolt threads.

(4) Tighten bolts in sequence. See **Fig. 4** .

(5) Tighten bolts to 72-96 INCH lbs. (8-11 N.m).

(6) Tighten bolt to 43 INCH lbs. (5 N.m) with valve lifter on base circle of camshaft. Once all rocker arms are tightened, retighten bolts to 19-25 ft. lbs. (26-34 N.m).

(7) Tighten bolts to 89 INCH lbs. (10 N.m).

ENGINE SPECIFICATIONS**GENERAL SPECIFICATIONS**

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GENERAL SPECIFICATIONS

Application	Specification
Displacement	232 Cu. In. (3.8L)
Bore	3.81" (96.8 mm)
Stroke	3.39" (86.1 mm)
Compression Ratio	9.0:1
Fuel System	MFI
Horsepower @ RPM	160 @ 4400
Torque Ft. Lbs. @ RPM	225 @ 3000

CRANKSHAFT MAIN & CONNECTING ROD BEARINGS SPECIFICATIONS**CRANKSHAFT MAIN & CONNECTING ROD BEARINGS**

Application	In. (mm)
Crankshaft End Play	.004-.008 (.10-.20)
Main Bearings	
Journal Diameter	2.5190-2.5198 (63.983-64.003)
Journal Out-Of-Round	.0003 (.008)
Journal Taper	.0003 Per 1 (.008 Per 25.4)
Oil Clearance	
Standard	.0010-.0014 (.025-.036)
Service Limit	.0023 (.058)
Connecting Rod Bearings	
Journal Diameter	2.3103-2.3111 (58.682-58.702)
Journal Out-Of-Round	.0003 (.008)
Journal Taper	.0003 Per 1 (.008 Per 25.4)
Oil Clearance	
Standard	.0010-.0014 (.025-.036)
Service Limit	.0027 (.069)

CONNECTING RODS SPECIFICATIONS**CONNECTING RODS**

Application	In. (mm)
Bore Diameter	
Pin Bore	.9096-.9112 (23.104-23.145)
Crankpin Bore	2.4266-2.4274 (61.636-61.656)
Center-To-Center Length	5.912-5.915 (150.16-150.24)
Maximum Bend	.0016 Per 1 (.041 Per 25.4)
Maximum Twist	.003 Per 1 (.08 Per 25.4)
Side Play	
Standard	.0047-.0114 (.119-.290)

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Service Limit

.014 (.36)

PISTONS PINS & RINGS SPECIFICATIONS**PISTONS PINS & RINGS**

Application	In. (mm)
Piston	
Piston Clearance	.0014-.0032 (.036-.081)
Diameter ⁽¹⁾	
Red	3.8095-3.8101 (96.761-96.777)
Blue	3.8107-3.8113 (96.792-96.807)
Yellow	3.8119-3.8125 (96.822-96.838)
Pins	
Diameter	.9119-.9124 (23.162-23.175)
Piston Fit	.0002-.0005 (.005-.013)
Rod Fit	(2) *
Rings	
No. 1	
End Gap	.011-.012 (.28-.30)
Side Clearance	.0016-.0034 (.041-.086)
No. 2	
End Gap	.010-.020 (.25-.51)
Side Clearance	.0016-.0034 (.041-.086)
No. 3 (Oil) End Gap	.015-.058 (.38-1.47)
(1) Piston diameter is determined by color code on dome of piston.	
(2) Press fit with load of 1800 lbs. (816 kg).	

CYLINDER BLOCK SPECIFICATIONS**CYLINDER BLOCK**

Application	In. (mm)
Cylinder Bore	
Standard Diameter	3.81 (96.8)
Maximum Taper	.002 (.05)
Maximum Out-Of-Round	.002 (.05)
Maximum Deck Warpage	⁽¹⁾ .003 Per 6 (.08 Per 152)
Balance Shaft Bore I.D.	2.191-2.192 (55.651-55.677)
Camshaft Bearing I.D.	2.0525-2.0535 (52.134-52.159)
Camshaft Bearing Bore I.D.	
No. 1 & 4	2.191-2.192 (55.651-55.671)

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No. 2 & 3	2.176-2.177 (55.270-55.296)
Main Bearing Bore	2.712-2.713 (68.88-68.91)
(1) DO NOT machine more than .010" (.25 mm) from original cylinder block deck surface.	

VALVES & VALVE SPRINGS SPECIFICATIONS**VALVES & VALVE SPRINGS**

Application	In. (mm)
Intake Valves	
Face Angle	45.8°
Head Diameter	1.78 (45.2)
Minimum Margin	.031 (.79)
Stem Diameter	.3415-.3423 (8.674-8.694)
Valve Face Runout	.002 (.05)
Exhaust Valves	
Face Angle	45.8°
Head Diameter	1.46 (37.1)
Minimum Margin	.031 (.79)
Stem Diameter	.3410-.3418 (8.661-8.682)
Valve Face Runout	.002 (.05)
Valve Springs	
Installed Height	1.97 (50.0)
Pressure ⁽¹⁾	
Valve Closed	85 @ 1.65 (38 @ 41.9)
Valve Open	220 @ 1.18 (99 @ 29.9)
(1) Lbs. @ In. (Kg @ mm).	

CYLINDER HEAD SPECIFICATIONS**CYLINDER HEAD**

Application	In. (mm)
Maximum Warpage	⁽¹⁾ .007 (.18)
Valve Seats	
Intake Valve	
Seat Angle	44.5°
Seat Width	.06-.08 (1.5-2.0)
Maximum Seat Runout	.003 (.08)
Exhaust Valve	
Seat Angle	44.5°
Seat Width	.06-.08 (1.5-2.0)

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Maximum Seat Runout	.003 (.08)
Valve Guides	
Valve Guide I.D.	.3433-.3443 (8.720-8.745)
Valve Stem-To-Guide Oil Clearance	
Intake Valve	.0010-.0028 (.025-.071)
Exhaust Valve	.0015-.0033 (.038-.084)
(1) DO NOT machine more than .010" (.25 mm) from original cylinder head surface.	

CAMSHAFT SPECIFICATIONS**CAMSHAFT**

Application	In. (mm)
Camshaft Bearing I.D.	2.0525-2.0535 (52.134-52.159)
Journal Diameter	2.0505-2.0515 (52.083-52.108)
Lobe Lift ⁽¹⁾	
Intake	.245 (6.22)
Exhaust	.259 (6.58)
Oil Clearance	.001-.003 (.02-.08)
(1) Maximum allowable lobe-lift loss is .005" (.13 mm).	

VALVE LIFTERS SPECIFICATIONS**VALVE LIFTERS**

Application	In. (mm)
Lifter Diameter	.8740-.8745 (22.200-22.212)
Oil Clearance	
Standard	.0007-.0027 (.018-.069)
Service Limit	.005 (.13)