TORQUE SPECIFICATIONS

ponents	English Specifications	Metric Specification
shaft. bearing caps		
.3L 4-cylinder engines	14 ft. lbs.	20 Nm
shaft. pulleys		
.3L 4-cylinder engines	37 ft. lbs.	50 Nm
.8L 6-cylinder engine	51-59 ft. lbs.	69-80 Nm
.9L 6-cylinder engine	15 ft. lbs.	20 Nm
.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
shaft. retaining bolt		
.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
kshaft. Damper		
.3L 4-cylinder engines	44 ft. lbs.*	60 Nm*
.8L 6-cylinder engine	177-207 ft. lbs.	240-280 Nm
.9L 6-cylinder engine		
Center nut	221 ft. lbs.	300 Nm
Retaining bolts	26 ft. lbs.	35 Nm
.3L and 2.4L 5-cylinder engines		
Center nut	133 ft. lbs.	180 Nm
Retaining bolts	18 ft. lbs.	25 Nm
nder head bolts		
.3L 4-cylinder engines	①	①
.8L 6-cylinder engine	②	②
.9L 6-cylinder engine	③	③
.3L and 2.4L 5-cylinder engines	④	④
ne mounts	37 ft. lbs.	50 Nm
aust manifold		
.3L 4-cylinder engines	10-20 ft. lbs.	14-27 Nm
.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
.9L 6-cylinder engine	18 ft. lbs.	25 Nm
.3L and 2.4L 5-cylinder engines	18 ft. lbs.	25 Nm
heel/flexplate		
.3L 4-cylinder engines	51 ft. lbs.	70 Nm
.8L 6-cylinder engine	51 ft. lbs.	70 Nm
.9L 6-cylinder engine	55 ft. lbs.	75 Nm
.3L and 2.4L 5-cylinder engines	33 ft. lbs.*	45 Nm*
ke manifold		
.3L 4-cylinder engines	15 ft. lbs.	20 Nm
.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
.9L 6-cylinder engine	15 ft. lbs.	20 Nm
.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
pan		
.3L 4-cylinder engines	8 ft. lbs.	11 Nm
.8L 6-cylinder engine	6-8 ft. lbs.	8-11 Nm
.9L 6-cylinder engine	8 ft. lbs.	11 Nm
.3L and 2.4L 5-cylinder engines	12 ft. lbs.	17 Nm
ump		
230F and B230ft. 4-cylinder engines	8 ft. lbs.	11 Nm
.8L 6-cylinder engine	8 ft. lbs.	11 Nm
.9L 6-cylinder engine	7 ft. lbs.	10 Nm
.3L and 2.4L 5-cylinder engines	7 ft. lbs.	10 Nm
234F 4-cylinder engine	8 ft. lbs.	11 Nm
Drive belt pulley bolt	15 ft. lbs.*	20 Nm*

TORQUE SPECIFICATIONS

nents	English Specifications	Metric Specificat
stat housing		
4-cylinder engines	11-15 ft. lbs.	15-20 Nm
6-cylinder engine	11-15 ft. lbs.	15-20 Nm
6-cylinder engine	7 ft. lbs.	10 Nm
and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
belt tensioner		
4-cylinder engines	37 ft. lbs.	51 Nm
6-cylinder engine	37 ft. lbs.	51 Nm
6-cylinder engine	18 ft. lbs.	25 Nm
and 2.4L 5-cylinder engines	18 ft. lbs.	25 Nm
chain cover		
6-cylinder engine	7-11 ft. lbs.	10-15 Nm
chain tensioner		
6-cylinder engine	5 ft. lbs.	7 Nm
ump		
4-cylinder engines	11-15 ft. lbs.	15-20 Nm
6-cylinder engine	11-15 ft. lbs.	15-20 Nm
6-cylinder engine	15 ft. lbs.	20 Nm
and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
over		
4-cylinder engines	14 ft. lbs.	20 Nm
6-cylinder engine	11 ft. lbs.	15 Nm
6-cylinder engine	13 ft. lbs.	17 Nm
and 2.4L 5-cylinder engines	13 ft. lbs.	17 Nm

n additional 60 degrees

1: Tighten in sequence to 14 ft. lbs. (19 Nm)
1: Tighten in sequence to 43 ft. lbs. (59 Nm)
3: Tighten in sequence an additional 90 degrees

990 asbestos-free gasket
tep 1: Tighten in sequence to 44 ft. lbs. (60 Nm)
tep 2: Loosen bolts, tighten in sequence to 30 ft. lbs. (40 Nm)
tep 3: Tighten in sequence an additional 160-180 degrees
pt 1990 asbestos-free gasket
tep 1: Tighten in sequence to 43 ft. lbs. (59 Nm)
tep 2: Loosen bolt 1, tighten it to 15 ft. lbs. (20 Nm)
tep 3: Tighten bolt 1 an additional 106 degrees
tep 4: Repeat steps 2 and 3 for the remaining head bolts

1: Tighten in sequence to 15 ft. lbs. (20 Nm)
2: Tighten in sequence to 44 ft. lbs. (60 Nm)
3: Tighten in sequence an additional 130 degrees

1: Tighten in sequence to 15 ft. lbs. (20 Nm)
2: Tighten in sequence to 44 ft. lbs. (60 Nm)
3: Tighten in sequence an additional 130 degrees

USING A VACUUM GAUGE

White needle = steady needle ***Dark needle = drifting needle***

acuum gauge is one of the most useful and easy-to-use diagnostic tools. It is inexpensive, easy to hook u
es valuable information about the condition of your engine.

Indication: Normal engine in good condition

reading: Steady, from 17 – 22 in./Hg.

Indication: Late ignition or valve timing, low compression, stuck throttle valve, leaking carburetor or manifold gasket.

reading: Low (15 – 20 in./Hg.) but steady

Indication: Weak valve springs, worn valve stem guides, or leaky cylinder head gasket (vibrating excessively at all speeds).

NOTE: A plugged catalytic converter may also cause this reading.

reading: Needle fluctuates as engine speed increases

Indication: Choked muffler or obstruction in system. Speed up the engine. Choked muffler will exhibit a slow drop of vacuum to zero.

reading: Gradual drop in reading at idle

***Indication: Sticking valve o
tion miss***

Gauge reading: Needle fluctuates from 15 – 20 in./Hg. a

***Indication: Improper carb
adjustment, or minor intak
at carburetor or manifold***

***NOTE: Bad fuel injector
O-rings may also cause
this reading.***

Gauge reading: Drifting needle

***Indication: Burnt valve o
proper valve clearance. Th
dle will drop when the de
valve operates.***

Gauge reading: Steady needle, but drops regularly

Indication: Worn valve guid

*Gauge reading: Needle vibrates excessively at idl
steadies as engine speed increases*

Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
oil leaks	· Cylinder head cover RTV sealant broken or improperly seated	· Replace sealant; inspect cy head cover sealant flang cylinder head sealant su distortion and cracks
	· Oil filler cap leaking or missing	· Replace cap
	· Oil filter gasket broken or improperly seated	· Replace oil filter
	· Oil pan side gasket broken, improperly seated or opening in RTV sealant	· Replace gasket or repair op in sealant; inspect oil pan flange for distortion
	· Oil pan front oil seal broken or improperly seated	· Replace seal; inspect timing cover and oil pan seal fla distortion
	· Oil pan rear oil seal broken or improperly seated	· Replace seal; inspect oil pa oil seal flange; inspect rear bearing cap for cracks, plu return channels, or distortio seal groove
	· Timing case cover oil seal broken or improperly seated	· Replace seal
	· Excess oil pressure because of restricted PCV valve	· Replace PCV valve
	· Oil pan drain plug loose or has stripped threads	· Repair as necessary and ti
	· Rear oil gallery plug loose	· Use appropriate sealant on plug and tighten
	· Rear camshaft plug loose or improperly seated	· Seat camshaft plug or repla seal, as necessary
ve oil consumption	· Oil level too high	· Drain oil to specified level
	· Oil with wrong viscosity being used	· Replace with specified oil
	· PCV valve stuck closed	· Replace PCV valve
	· Valve stem oil deflectors (or seals) are damaged, missing, or incorrect type	· Replace valve stem oil def
	· Valve stems or valve guides worn	· Measure stem-to-guide cle and repair as necessary
	· Poorly fitted or missing valve cover baffles	· Replace valve cover
	· Piston rings broken or missing	· Replace broken or missing
	· Scuffed piston	· Replace piston
	· Incorrect piston ring gap	· Measure ring gap, repair a necessary
	· Piston rings sticking or excessively loose in grooves	· Measure ring side clearan repair as necessary
	· Compression rings installed upside down	· Repair as necessary
	· Cylinder walls worn, scored, or glazed	· Repair as necessary

Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
sive oil consumption)	· Piston ring gaps not properly staggered · Excessive main or connecting rod bearing clearance	· Repair as necessary · Measure bearing clearance, r as necessary
pressure	· Low oil level · Oil pressure gauge, warning lamp or sending unit inaccurate · Oil pump malfunction · Oil pressure relief valve sticking · Oil passages on pressure side of pump obstructed · Oil pickup screen or tube obstructed · Loose oil inlet tube	· Add oil to correct level · Replace oil pressure gauge c warning lamp · Replace oil pump · Remove and inspect oil press relief valve assembly · Inspect oil passages for obstruction · Inspect oil pickup for obstructi · Tighten or seal inlet tube
l pressure	· Low oil level · Inaccurate gauge, warning lamp or sending unit · Oil excessively thin because of dilution, poor quality, or improper grade · Excessive oil temperature · Oil pressure relief spring weak or sticking · Oil inlet tube and screen assembly has restriction or air leak · Excessive oil pump clearance · Excessive main, rod, or camshaft bearing clearance	· Add oil to correct level · Replace oil pressure gauge or warning lamp · Drain and refill crankcase with recommended oil · Correct cause of overheating gine · Remove and inspect oil press relief valve assembly · Remove and inspect oil inlet t and screen assembly. (Fill i tube with lacquer thinner to locate leaks.) · Measure clearances · Measure bearing clearances, repair as necessary
il pressure	· Improper oil viscosity · Oil pressure gauge or sending unit inaccurate · Oil pressure relief valve sticking closed	· Drain and refill crankcase with rect viscosity oil · Replace oil pressure gauge · Remove and inspect oil press relief valve assembly
bearing noise	· Insufficient oil supply · Main bearing clearance excessive · Bearing insert missing · Crankshaft end-play excessive · Improperly tightened main bearing cap bolts · Loose flywheel or drive plate · Loose or damaged vibration damper	· Inspect for low oil level and lo pressure · Measure main bearing cleara repair as necessary · Replace missing insert · Measure end-play, repair as necessary · Tighten bolts with specified to · Tighten flywheel or drive plat attaching bolts · Repair as necessary

Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
g rod bearing noise	• Insufficient oil supply	• Inspect for low oil level a pressure
	• Carbon build-up on piston	• Remove carbon from pis
	• Bearing clearance excessive or bearing missing	• Measure clearance, repa necessary
	• Crankshaft connecting rod journal out-of-round	• Measure journal dimensi repair or replace as ne
	• Misaligned connecting rod or cap	• Repair as necessary
	• Connecting rod bolts tightened improperly	• Tighten bolts with specifi
e	• Piston-to-cylinder wall clearance excessive (scuffed piston)	• Measure clearance and piston
	• Cylinder walls excessively tapered or out-of-round	• Measure cylinder wall di rebore cylinder
	• Piston ring broken	• Replace all rings on pist
	• Loose or seized piston pin	• Measure piston-to-pin cl repair as necessary
	• Connecting rods misaligned	• Measure rod alignment, or replace
	• Piston ring side clearance excessively loose or tight	• Measure ring side cleara repair as necessary
	• Carbon build-up on piston is excessive	• Remove carbon from pis
ating component noise	• Insufficient oil supply	• Check for: (a) Low oil level (b) Low oil pressure (c) Wrong hydraulic tapp (d) Restricted oil gallery (e) Excessive tappet to b ance
	• Rocker arms or pivots worn	• Replace worn rocker arm pivots
	• Foreign objects or chips in hydraulic tappets	• Clean tappets
	• Excessive tappet leak-down	• Replace valve tappet
	• Tappet face worn	• Replace tappet; inspect sponding cam lobe fo
	• Broken or cocked valve springs	• Properly seat cocked sp replace broken spring
	• Stem-to-guide clearance excessive	• Measure stem-to-guide repair as required
	• Valve bent	• Replace valve
	• Loose rocker arms	• Check and repair as nece
	• Valve seat runout excessive	• Regrind valve seat/valve
	• Missing valve lock	• Install valve lock
	• Excessive engine oil	• Correct oil level

Troubleshooting Engine Performance

Problem	Cause	Solution
starting (engine cranks rmally)	• Faulty engine control system component • Faulty fuel pump • Faulty fuel system component • Faulty ignition coil • Improper spark plug gap • Incorrect ignition timing • Incorrect valve timing	• Repair or replace as necessary • Replace fuel pump • Repair or replace as necessary • Test and replace as necessary • Adjust gap • Adjust timing • Check valve timing; repair as necessary
gh idle or stalling	• Incorrect curb or fast idle speed • Incorrect ignition timing • Improper feedback system operation • Faulty EGR valve operation • Faulty PCV valve air flow • Faulty TAC vacuum motor or valve • Air leak into manifold vacuum • Faulty distributor rotor or cap • Improperly seated valves • Incorrect ignition wiring • Faulty ignition coil • Restricted air vent or idle passages • Restricted air cleaner	• Adjust curb or fast idle speed (If possible) • Adjust timing to specification • Refer to Chapter 4 • Test EGR system and replace as necessary • Test PCV valve and replace as necessary • Repair as necessary • Inspect manifold vacuum connec- tions and repair as necessary • Replace rotor or cap (Distributor systems only) • Test cylinder compression, repair as necessary • Inspect wiring and correct as necessary • Test coil and replace as necessar • Clean passages • Clean or replace air cleaner filter element
ty low-speed operation	• Restricted idle air vents and passages • Restricted air cleaner • Faulty spark plugs • Dirty, corroded, or loose ignition secondary circuit wire connections • Improper feedback system operation • Faulty ignition coil high voltage wire • Faulty distributor cap	• Clean air vents and passages • Clean or replace air cleaner filter element • Clean or replace spark plugs • Clean or tighten secondary circuit wire connections • Refer to Chapter 4 • Replace ignition coil high voltage wire (Distributor systems only) • Replace cap (Distributor systems only)
ty acceleration	• Incorrect ignition timing • Faulty fuel system component • Faulty spark plug(s) • Improperly seated valves • Faulty ignition coil	• Adjust timing • Repair or replace as necessary • Clean or replace spark plug(s) • Test cylinder compression, repair as necessary • Test coil and replace as necessar

Troubleshooting Engine Performance

Problem	Cause	Solution
ty acceleration (cont.)	• Improper feedback system operation	• Refer to Chapter 4
ty high speed operation	• Incorrect ignition timing • Faulty advance mechanism • Low fuel pump volume • Wrong spark plug air gap or wrong plug • Partially restricted exhaust manifold, exhaust pipe, catalytic converter, muffler, or tailpipe • Restricted vacuum passages • Restricted air cleaner • Faulty distributor rotor or cap • Faulty ignition coil • Improperly seated valve(s) • Faulty valve spring(s) • Incorrect valve timing • Intake manifold restricted • Worn distributor shaft • Improper feedback system operation	• Adjust timing (if possible) • Check advance mechanism and repair as necessary (Distributor systems only) • Replace fuel pump • Adjust air gap or install correct plu • Eliminate restriction • Clean passages • Cleaner or replace filter element a necessary • Replace rotor or cap (Distributor systems only) • Test coil and replace as necessary • Test cylinder compression, repair as necessary • Inspect and test valve spring tension, replace as necessary • Check valve timing and repair as necessary • Remove restriction or replace manifold • Replace shaft (Distributor systems only) • Refer to Chapter 4
ire at all speeds	• Faulty spark plug(s) • Faulty spark plug wire(s) • Faulty distributor cap or rotor • Faulty ignition coil • Primary ignition circuit shorted or open intermittently • Improperly seated valve(s) • Faulty hydraulic tappet(s) • Improper feedback system operation • Faulty valve spring(s) • Worn camshaft lobes • Air leak into manifold • Fuel pump volume or pressure low • Blown cylinder head gasket • Intake or exhaust manifold passage(s) restricted	• Clean or relace spark plug(s) • Replace as necessary • Replace cap or rotor (Distributor systems only) • Test coil and replace as necessary • Troubleshoot primary circuit and repair as necessary • Test cylinder compression, repair as necessary • Clean or replace tappet(s) • Refer to Chapter 4 • Inspect and test valve spring tension, repair as necessary • Replace camshaft • Check manifold vacuum and repai as necessary • Replace fuel pump • Replace gasket • Pass chain through passage(s) and repair as necessary
er not up to normal	• Incorrect ignition timing • Faulty distributor rotor	• Adjust timing • Replace rotor (Distributor systems only)

Troubleshooting Engine Performance

Problem	Cause	Solution
er not up to normal (cont.)	• Incorrect spark plug gap • Faulty fuel pump • Faulty fuel pump • Incorrect valve timing • Faulty ignition coil • Faulty ignition wires • Improperly seated valves • Blown cylinder head gasket • Leaking piston rings • Improper feedback system operation	• Adjust gap • Replace fuel pump • Replace fuel pump • Check valve timing and repair as necessary • Test coil and replace as necessar • Test wires and replace as necessary • Test cylinder compression and repair as necessary • Replace gasket • Test compression and repair as necessary • Refer to Chapter 4
ke backfire	• Improper ignition timing • Defective EGR component • Defective TAC vacuum motor or valve	• Adjust timing • Repair as necessary • Repair as necessary
aust backfire	• Air leak into manifold vacuum • Faulty air injection diverter valve • Exhaust leak	• Check manifold vacuum and repai as necessary • Test diverter valve and replace as necessary • Locate and eliminate leak
g or spark knock	• Incorrect ignition timing • Distributor advance malfunction • Excessive combustion chamber deposits • Air leak into manifold vacuum • Excessively high compression • Fuel octane rating excessively low • Sharp edges in combustion chamber • EGR valve not functioning properly	• Adjust timing • Inspect advance mechanism and repair as necessary (Distributor systems only) • Remove with combustion chambe cleaner • Check manifold vacuum and repai as necessary • Test compression and repair as necessary • Try alternate fuel source • Grind smooth • Test EGR system and replace as necessary
ging (at cruising to top speeds)	• Low fuel pump pressure or volume • Improper PCV valve air flow • Air leak into manifold vacuum • Incorrect spark advance • Restricted fuel filter • Restricted air cleaner • EGR valve not functioning properly • Improper feedback system operation	• Replace fuel pump • Test PCV valve and replace as necessary • Check manifold vacuum and repai as necessary • Test and replace as necessary • Replace fuel filter • Clean or replace air cleaner filter element • Test EGR system and replace as necessary • Refer to Chapter 4

Troubleshooting the Serpentine Drive Belt

Problem	Cause	Solution
n sheeting fabric failure en fabric on outside circum- ce of belt has cracked or rated from body of belt)	• Grooved or backside idler pulley diameters are less than minimum recommended	• Replace pulley(s) not confor to specification
	• Tension sheeting contacting (rubbing) stationary object	• Correct rubbing condition
	• Excessive heat causing woven fabric to age	• Replace belt
	• Tension sheeting splice has fractured	• Replace belt
objectional squeal, squeak, mble is heard or felt while belt is in operation)	• Belt slippage	• Adjust belt
	• Bearing noise	• Locate and repair
	• Belt misalignment	• Align belt/pulley(s)
	• Belt-to-pulley mismatch	• Install correct belt
	• Driven component inducing vibration	• Locate defective driven com and repair
	• System resonant frequency inducing vibration	• Vary belt tension within spec tions. Replace belt.
unking (one or more ribs has rated from belt body)	• Foreign objects imbedded in pulley grooves	• Remove foreign objects fron ley grooves
	• Installation damage	• Replace belt
	• Drive loads in excess of design specifications	• Adjust belt tension
	• Insufficient internal belt adhesion	• Replace belt
belt wear (belt ribs contact om of pulley grooves)	• Pulley(s) misaligned	• Align pulley(s)
	• Mismatch of belt and pulley groove widths	• Replace belt
	• Abrasive environment	• Replace belt
	• Rusted pulley(s)	• Clean rust from pulley(s)
	• Sharp or jagged pulley groove tips	• Replace pulley
	• Rubber deteriorated	• Replace belt
udinal belt cracking (cracks veen two ribs)	• Belt has mistracked from pulley groove	• Replace belt
	• Pulley groove tip has worn away rubber-to-tensile member	• Replace belt
ps	• Belt slipping because of insufficient tension	• Adjust tension
	• Belt or pulley subjected to substance (belt dressing, oil, ethylene glycol) that has reduced friction	• Replace belt and clean pull
	• Driven component bearing failure	• Replace faulty component b
	• Belt glazed and hardened from heat and excessive slippage	• Replace belt
ve jumping" (belt does not ntain correct position on ey, or turns over and/or runs ulleys)	• Insufficient belt tension	• Adjust belt tension
	• Pulley(s) not within design tolerance	• Replace pulley(s)
	• Foreign object(s) in grooves	• Remove foreign objects fro grooves

Troubleshooting the Serpentine Drive Belt

Problem	Cause	Solution
ping" (belt does not orrect position on urns over and/or runs)	• Excessive belt speed • Pulley misalignment • Belt-to-pulley profile mismatched • Belt cordline is distorted	• Avoid excessive engine tion • Align pulley(s) • Install correct belt • Replace belt
Note: identify and cor- em before replacement alled)	• Excessive tension • Tensile members damaged during belt installation • Belt turnover • Severe pulley misalignment • Bracket, pulley, or bearing failure	• Replace belt and adjus specification • Replace belt • Replace belt • Align pulley(s) • Replace defective com belt
ilure (tensile member edges of belt or om belt body)	• Excessive tension • Drive pulley misalignment • Belt contacting stationary object • Pulley irregularities • Improper pulley construction • Insufficient adhesion between tensile member and rubber matrix	• Adjust belt tension • Align pulley • Correct as necessary • Replace pulley • Replace pulley • Replace belt and adjus specifications
cracking (multiple t ribs at random	• Ribbed pulley(s) diameter less than minimum specification • Backside bend flat pulley(s) diameter less than minimum • Excessive heat condition causing rubber to harden • Excessive belt thickness • Belt overcured • Excessive tension	• Replace pulley(s) • Replace pulley(s) • Correct heat condition sary • Replace belt • Replace belt • Adjust belt tension

Troubleshooting the Cooling System

Problem	Cause	Solution
perature gauge indication— ating	• Coolant level low	• Replenish coolant
	• Improper fan operation	• Repair or replace as nece
	• Radiator hose(s) collapsed	• Replace hose(s)
	• Radiator airflow blocked	• Remove restriction (bug scr fog lamps, etc.)
	• Faulty pressure cap	• Replace pressure cap
	• Ignition timing incorrect	• Adjust ignition timing
	• Air trapped in cooling system	• Purge air
	• Heavy traffic driving	• Operate at fast idle in neutra mittently to cool engine
	• Incorrect cooling system component(s) installed	• Install proper component(s)
	• Faulty thermostat	• Replace thermostat
	• Water pump shaft broken or impeller loose	• Replace water pump
	• Radiator tubes clogged	• Flush radiator
	• Cooling system clogged	• Flush system
	• Casting flash in cooling passages	• Repair or replace as necess Flash may be visible by r ing cooling system comp or removing core plugs.
	• Brakes dragging	• Repair brakes
	• Excessive engine friction	• Repair engine
	• Antifreeze concentration over 68%	• Lower antifreeze concentrat percentage
	• Missing air seals	• Replace air seals
	• Faulty gauge or sending unit	• Repair or replace faulty component
	• Loss of coolant flow caused by leakage or foaming	• Repair or replace leaking co nent, replace coolant
	• Viscous fan drive failed	• Replace unit
perature indication— cooling	• Thermostat stuck open	• Replace thermostat
	• Faulty gauge or sending unit	• Repair or replace faulty component
loss—boilover	• Overfilled cooling system	• Reduce coolant level to pro specification
	• Quick shutdown after hard (hot) run	• Allow engine to run at fast i prior to shutdown
	• Air in system resulting in occasional "burping" of coolant	• Purge system
	• Insufficient antifreeze allowing coolant boiling point to be too low	• Add antifreeze to raise boili point
	• Antifreeze deteriorated because of age or contamination	• Replace coolant
	• Leaks due to loose hose clamps, loose nuts, bolts, drain plugs, faulty hoses, or defective radiator	• Pressure test system to loc source of leak(s) then rep necessary

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Now that you have determined that your engine is worn out, you must make some decisions. The question of whether or not an engine is worth rebuilding is largely a subjective matter and one of personal worth. Is the engine a popular one, or is it an obsolete model? Are parts available? Will it get acceptable gas mileage once it is rebuilt? Is the car its being put into worth keeping? Would it be less expensive to buy a new engine, have your engine rebuilt by a pro, rebuild it yourself or buy a used engine from a salvage yard? Or would it be simpler and less expensive to buy another car? If you have considered all these matters and more, and have still decided to rebuild the engine, then it is time to decide how you will rebuild it.

NOTE: The editors feel that most engine machining should be performed by a professional machine shop. Don't think of it as wasting money, rather, as an assurance that the job has been done right the first time. There are many expensive and specialized tools required to perform such tasks as boring and honing an engine block or having a valve job done on a cylinder head. Even inspecting the parts requires expensive micrometers and gauges to properly measure wear and clearances. Also, a machine shop can deliver to you clean, and ready to assemble parts, saving you time and aggravation. Your maximum savings will come from performing the removal, disassembly, assembly and installation of the engine and purchasing or renting only the tools required to perform the above tasks. Depending on the particular circumstances, you may save 40 to 60 percent of the cost doing these yourself.

A complete rebuild or overhaul of an engine involves replacing all of the moving parts (pistons, rods, crankshaft, camshaft, etc.) with new ones and machining the non-moving wearing surfaces of the block and heads. Unfortunately, this may not be cost effective. For instance, your crankshaft may have been damaged or worn, but it can be machined undersize for a minimal fee.

So, as you can see, you can replace everything inside the engine, but, it is wiser to replace only those parts which are really needed, and, if possible, repair the more expensive ones. Later in this section, we will break the engine down into its two main components: the cylinder head and the engine block. We will discuss each component, and the recommended parts to replace during a rebuild on each.

The first step for any assembly job is to have a clean area in which to work. Next, thoroughly clean all of the parts and components that are to be assembled. Finally, place all of the components onto a suitable work space and, if necessary, arrange the parts to their respective positions.

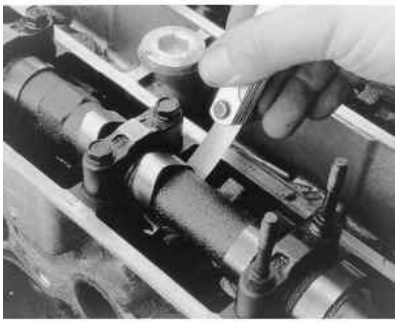
OHC Engines

CUP TYPE CAMSHAFT FOLLOWERS

To install the springs, retainers and valve locks on heads which have these components recessed into the camshaft follower's bore, you will need a small screwdriver-type tool, some clean white grease and a lot of patience. You will also need the C-clamp style spring compressor and the OHC tool used to disassemble the head.

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head. If possible, maintain their original locations.
2. If equipped, install any valve spring shims which were removed.
3. If equipped, install the new valve seals, keeping the following in mind:
    - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
    - If the seal is an O-ring type, it is installed just after compressing the spring but before the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor and the OHC tool, then compress the spring.
6. Using a small screwdriver as a spatula, fill the valve stem side of the lock with white grease. Use the excess grease on the screwdriver to fasten the lock to the driver.
7. Carefully install the valve lock, which is stuck to the end of the screwdriver, to the valve stem then press on it with the screwdriver until the grease squeezes out. The valve lock should now be stuck to the stem.
8. Repeat Steps 6 and 7 for the remaining valve lock.
9. Relieve the spring pressure slowly and insure that neither valve lock becomes dislodged by the retainer.
10. Remove the spring compressor tool.
11. Repeat Steps 2 through 10 until all of the springs have been installed.
12. Install the followers, camshaft(s) and any other components that were removed for disassembly.

Fig. 1: Once assembled, check the valve clearance and correct as needed



ROCKER ARM TYPE CAMSHAFT FOLLOWERS

1. Lightly lubricate the valve stems and insert all of the valves into the cylinder head. If possible, maintain their original locations.
2. If equipped, install any valve spring shims which were removed.
3. If equipped, install the new valve seals, keeping the following in mind:
    - If the valve seal presses over the guide, lightly lubricate the outer guide surfaces.
    - If the seal is an O-ring type, it is installed just after compressing the spring but before the valve locks.
4. Place the valve spring and retainer over the stem.
5. Position the spring compressor tool and compress the spring.
6. Assemble the valve locks to the stem.
7. Relieve the spring pressure slowly and insure that neither valve lock becomes dislodged by the retainer.
8. Remove the spring compressor tool.
9. Repeat Steps 2 through 8 until all of the springs have been installed.
10. Install the camshaft(s), rockers, shafts and any other components that were removed for disassembly.

Whether it is a single or dual overhead camshaft cylinder head, the disassembly procedure is relatively unchanged. One aspect to pay attention to is careful labeling of the parts on the dual camshaft cylinder head. There will be an intake camshaft and followers as well as an exhaust camshaft and followers and they must be labeled as such. In some cases, the components are identical and could easily be installed incorrectly. DO NOT MIX THEM UP! Determining which is which is very simple; the intake camshaft and components are on the same side of the head as was the intake manifold. Conversely, the exhaust camshaft and components are on the same side of the head as was the exhaust manifold.

Fig. 1: Exploded view of a valve, seal, spring, retainer and locks from an OHC cylinder head

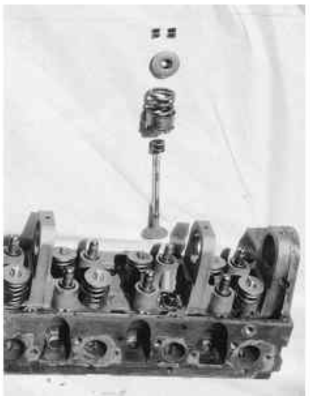


Fig. 2: Example of a multi-valve cylinder head. Note how it has 2 intake and 2 exhaust valve ports

CUP TYPE CAMSHAFT FOLLOWERS

Most cylinder heads with cup type camshaft followers will have the valve spring, retainer and locks recessed within the follower's bore. You will need a C-clamp style valve spring compressor tool, an OHC spring removal tool (or equivalent) and a small magnet to disassemble the head.

Fig. 3: C-clamp type spring compressor and an OHC spring removal tool (center) for cup type followers

1. If not already removed, remove the camshaft(s) and/or followers. Mark their positions for assembly.

Fig. 4: Most cup type follower cylinder heads retain the camshaft using bolt-on bearing caps

2. Position the cylinder head to allow use of a C-clamp style valve spring compressor tool.

   NOTE: It is preferred to position the cylinder head gasket surface facing you with the valve springs facing the opposite direction and the head laying horizontal.

Fig. 5: Position the OHC spring tool in the follower bore, then compress the spring with a C-clamp type tool

3. With the OHC spring removal adapter tool positioned inside of the follower bore, compress the valve spring using the C-clamp style valve spring compressor.
4. Remove the valve locks. A small magnetic tool or screwdriver will aid in removal.
5. Release the compressor tool and remove the spring assembly.
6. Withdraw the valve from the cylinder head.
7. If equipped, remove the valve seal.

   NOTE: Special valve seal removal tools are available. Regular or needlenose type pliers, if used with care, will work just as well. If using ordinary pliers, be sure not to damage the follower bore. The follower and its bore are machined to close tolerances and any damage to the bore will effect this relationship.

8. If equipped, remove the valve spring shim. A small magnetic tool or screwdriver will aid in removal.
9. Repeat Steps 3 through 8 until all of the valves have been removed.

ROCKER ARM TYPE CAMSHAFT FOLLOWERS

Most cylinder heads with rocker arm-type camshaft followers are easily disassembled using a standard valve spring compressor. However, certain models may not have enough open space around the spring for the standard tool and may require you to use a C-clamp style compressor tool instead.

Fig. 6: Example of the shaft mounted rocker arms on some OHC heads

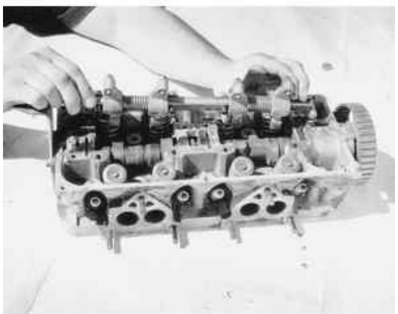
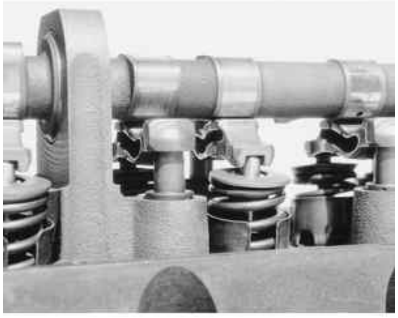


Fig. 7: Another example of the rocker arm type OHC head. This model uses a follower under the camshaft



1. If not already removed, remove the rocker arms and/or shafts and the camshaft. If applicable, also remove the hydraulic lash adjusters. Mark their positions for assembly.

Fig. 8: Before the camshaft can be removed, all of the followers must first be removed . . .

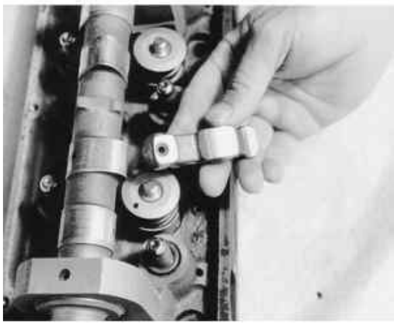
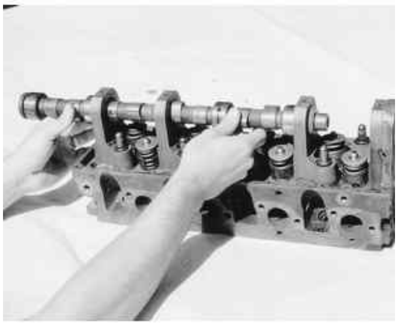
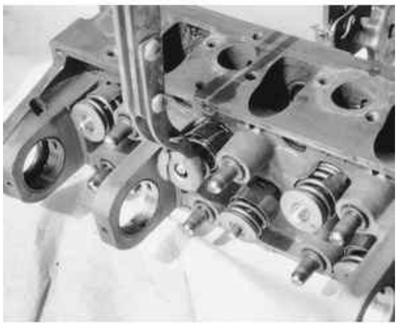


Fig. 9: . . . then the camshaft can be removed by sliding it out (shown), or unbolting a bearing cap (not shown)



2. Position the cylinder head to allow access to the valve spring.
3. Use a valve spring compressor tool to relieve the spring tension from the retainer.

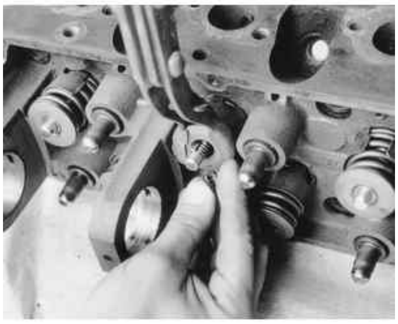
Fig. 10: Compress the valve spring . . .



NOTE: Due to engine varnish, the retainer may stick to the valve locks. A gentle tap with a hammer may help to break it loose.

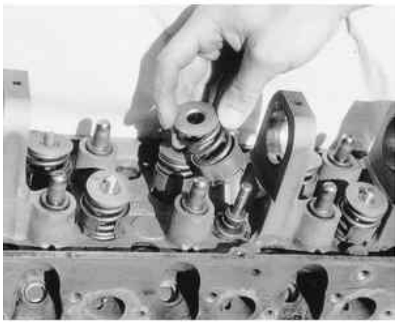
Fig. 11: . . . then remove the valve locks from the valve stem

and spring retainer



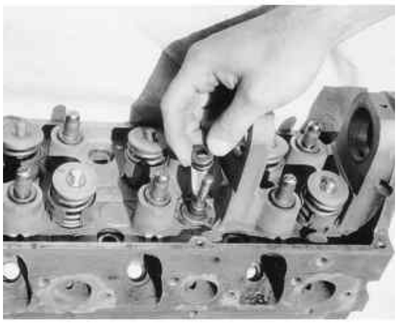
4. Remove the valve locks from the valve tip and/or retainer. A small magnet may help in removing the small locks.
5. Lift the valve spring, tool and all, off of the valve stem.

Fig. 12: Remove the valve spring and retainer from the cylinder head



6. If equipped, remove the valve seal. If the seal is difficult to remove with the valve in place, try removing the valve first, then the seal. Follow the steps below for valve removal.

Fig. 13: Remove the valve seal from the guide. Some gentle prying or pliers may help to remove stubborn ones

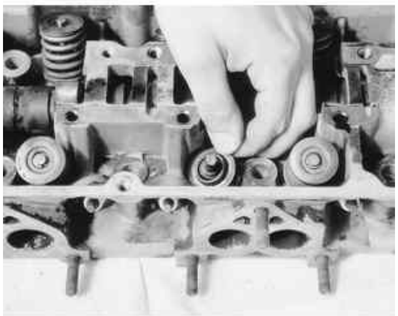


7. Position the head to allow access for withdrawing the valve.

   NOTE: Cylinder heads that have seen a lot of miles and/or abuse may have mushroomed the valve lock grove and/or tip, causing difficulty in removal of the valve. If this has happened, use a metal file to carefully remove the high spots around the lock grooves and/or tip. Only file it enough to allow removal.

8. Remove the valve from the cylinder head.

Fig. 14: All aluminum and some cast iron heads will have these valve spring shims. Remove all of them as well



9. If equipped, remove the valve spring shim. A small magnetic tool or screwdriver will aid in removal.
10. Repeat Steps 3 though 9 until all of the valves have been removed.

Now that all of the cylinder head components are clean, its time to inspect them for wear and/or damage. To accurately inspect them, you will need some specialized tools:

- A 0–1 in. micrometer for the valves
- A dial indicator or inside diameter gauge for the valve guides
- A spring pressure test gauge

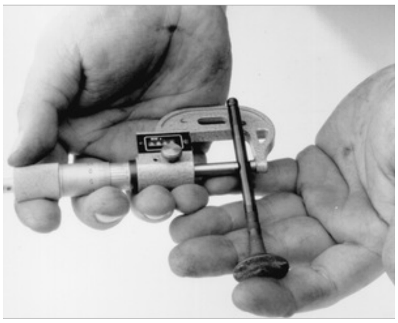
If you do not have access to the proper tools, you may want to bring the components to a shop that does.

Valves

The first thing to inspect are the valve heads. Look closely at the head, margin and face for any cracks, excessive wear or burning. The margin is the best place to look for burning. It should have a squared edge with an even width all around the diameter. When a valve burns, the margin will look melted and the edges rounded. Also inspect the valve head for any signs of tulipping. This will show as a lifting of the edges or dishing in the center of the head and will usually not occur to all of the valves. All of the heads should look the same, any that seem dished more than others are probably bad. Next, inspect the valve lock grooves and valve tips. Check for any burrs around the lock grooves, especially if you had to file them to remove the valve. Valve tips should appear flat, although slight rounding with high mileage engines is normal. Slightly worn valve tips will need to be machined flat. Last, measure the valve stem diameter with the micrometer. Measure the area that rides within the guide, especially towards the tip where most of the wear occurs. Take several measurements along its length and compare them to each other. Wear should be even along the length with little to no taper. If no minimum diameter is given in the specifications, then the stem should not read more than 0.001 in. (0.025mm) below the specification. Any valves that fail these inspections should be replaced.

Fig. 1: Valve stems may be rolled on a flat surface to check for bends

Fig. 2: Use a micrometer to check the valve stem diameter



Springs, Retainers and Valve Locks

The first thing to check is the most obvious, broken springs. Next check the free length and squareness of each spring. If applicable, insure to distinguish between intake and exhaust springs. Use a ruler and/or carpenters square to measure the length. A carpenters square should be used to check the springs for squareness. If a spring pressure test gauge is available, check each springs rating and compare to the specifications chart. Check the readings against the specifications given. Any springs that fail these inspections should be replaced.

The spring retainers rarely need replacing, however they should still be checked as a precaution. Inspect the spring mating surface and the valve lock retention area for any signs of excessive wear. Also check for any signs of cracking. Replace any retainers that are questionable.

Valve locks should be inspected for excessive wear on the outside contact area as well as on the inner notched surface. Any locks which appear worn or broken and its respective valve should be replaced.

Fig. 3: Use a caliper to check the valve spring free-length

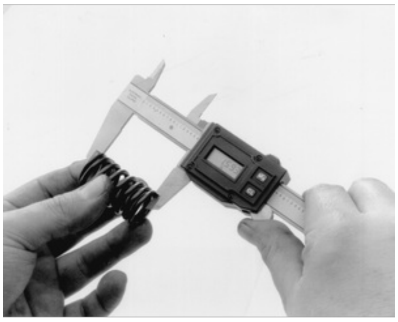


Fig. 4: Check the valve spring for squareness on a flat surface; a carpenter's square can be used

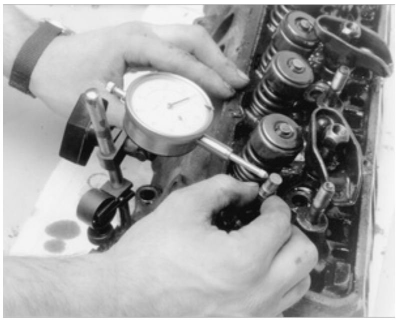
Cylinder Head

There are several things to check on the cylinder head: valve guides, seats, cylinder head surface flatness, cracks and physical damage.

VALVE GUIDES

Now that you know the valves are good, you can use them to check the guides, although a new valve, if available, is preferred. Before you measure anything, look at the guides carefully and inspect them for any cracks, chips or breakage. Also if the guide is a removable style (as in most aluminum heads), check them for any looseness or evidence of movement. All of the guides should appear to be at the same height from the spring seat. If any seem lower (or higher) from another, the guide has moved. Mount a dial indicator onto the spring side of the cylinder head. Lightly oil the valve stem and insert it into the cylinder head. Position the dial indicator against the valve stem near the tip and zero the gauge. Grasp the valve stem and wiggle towards and away from the dial indicator and observe the readings. Mount the dial indicator 90 degrees from the initial point and zero the gauge and again take a reading. Compare the two readings for a out of round condition. Check the readings against the specifications given. An Inside Diameter (I.D.) gauge designed for valve guides will give you an accurate valve guide bore measurement. If the I.D. gauge is used, compare the readings with the specifications given. Any guides that fail these inspections should be replaced or machined.

Fig. 5: A dial gauge may be used to check valve stem-to-guide clearance; read the gauge while moving the valve stem



VALVE SEATS

A visual inspection of the valve seats should show a slightly worn and pitted surface where the valve face contacts the seat. Inspect the seat carefully for severe pitting or cracks. Also, a seat that is badly worn will be recessed into the cylinder head. A severely worn or recessed seat may need to be replaced. All cracked seats must be replaced. A seat concentricity gauge, if available, should be used to check the seat run-out. If run-out exceeds specifications the seat must be machined (if no specification is given use 0.002 in. or 0.051mm).

CYLINDER HEAD SURFACE FLATNESS

After you have cleaned the gasket surface of the cylinder head of any old gasket material, check the head for flatness.

Fig. 6: Check the head for flatness across the center of the head surface using a straightedge and feeler gauge

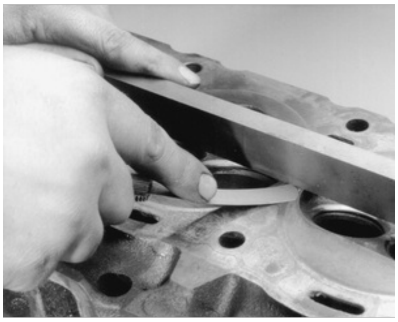
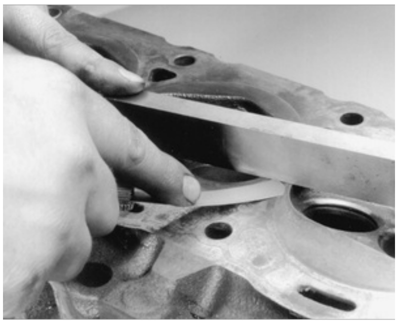


Fig. 7: Checks should also be made along both diagonals of the head surface



Place a straightedge across the gasket surface. Using feeler gauges, determine the clearance at the center of the straightedge and across the cylinder head at several points. Check along the centerline and diagonally on the head surface. If the warpage exceeds 0.003 in. (0.076mm) within a 6.0 in. (15.2cm) span, or 0.006 in. (0.152mm) over the total length of the head, the cylinder head must be resurfaced. After resurfacing the heads of a V-type engine, the intake manifold flange surface should be checked, and if necessary, milled proportionally to allow for the change in its mounting position.

CRACKS AND PHYSICAL DAMAGE

Generally, cracks are limited to the combustion chamber, however, it is not uncommon for the head to crack in a spark plug hole, port, outside of the head or in the valve spring/rocker arm area. The first area to inspect is always the hottest: the exhaust seat/port area.

A visual inspection should be performed, but just because you don't see a crack does not mean it is not there. Some more reliable methods for inspecting for cracks include Magnaflux® , a magnetic process or Zyglo® , a dye penetrant. Magnaflux® is used only on ferrous metal (cast iron) heads. Zyglo® uses a spray on fluorescent mixture along with a black light to reveal the cracks. It is strongly recommended to have your cylinder head checked professionally for cracks, especially if the engine was known to have overheated and/or leaked or consumed coolant. Contact a local shop for availability and pricing of these services.

Physical damage is usually very evident. For example, a broken mounting ear from dropping the head or a bent or broken stud and/or bolt. All of these defects should be fixed or, if unrepairable, the head should be replaced.

Camshaft and Followers

Inspect the camshaft(s) and followers as described earlier in this section.

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Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

Many of the procedures given for refinishing and repairing the cylinder head components must be performed by a machine shop. Certain steps, if the inspected part is not worn, can be performed yourself inexpensively. However, you spent a lot of time and effort so far, why risk trying to save a couple bucks if you might have to do it all over again?

Valves

Any valves that were not replaced should be refaced and the tips ground flat. Unless you have access to a valve grinding machine, this should be done by a machine shop. If the valves are in extremely good condition, as well as the valve seats and guides, they may be lapped in without performing machine work.

It is a recommended practice to lap the valves even after machine work has been performed and/or new valves have been purchased. This insures a positive seal between the valve and seat.

LAPPING THE VALVES

NOTE: Before lapping the valves to the seats, read the rest of the cylinder head section to insure that any related parts are in acceptable enough condition to continue.

NOTE: Before any valve seat machining and/or lapping can be performed, the guides must be within factory recommended specifications.

1. Invert the cylinder head.
2. Lightly lubricate the valve stems and insert them into the cylinder head in their numbered order.
3. Raise the valve from the seat and apply a small amount of fine lapping compound to the seat.
4. Moisten the suction head of a hand-lapping tool and attach it to the head of the valve.
5. Rotate the tool between the palms of both hands, changing the position of the valve on the valve seat and lifting the tool often to prevent grooving.
6. Lap the valve until a smooth, polished circle is evident on the valve and seat.
7. Remove the tool and the valve. Wipe away all traces of the grinding compound and store the valve to maintain its lapped location.

WARNING
Do not get the valves out of order after they have been lapped. They must be put back with the same valve seat with which they were lapped.

Springs, Retainers and Valve Locks

There is no repair or refinishing possible with the springs, retainers and valve locks. If they are found to be worn or defective, they must be replaced with new (or known good) parts.

Cylinder Head

Most refinishing procedures dealing with the cylinder head must be performed by a machine shop. Read the sections below and review your inspection data to determine whether or not machining is necessary.

VALVE GUIDE

NOTE: If any machining or replacements are made to the valve guides, the seats must be machined.

Unless the valve guides need machining or replacing, the only service to perform is to thoroughly clean them of any dirt or oil residue.

There are only two types of valve guides used on automobile engines: the replaceable-type (all aluminum heads) and the cast-in integral-type (most cast iron heads). There are four recommended methods for repairing worn guides.

- Knurling
- Inserts
- Reaming oversize
- Replacing

Knurling is a process in which metal is displaced and raised, thereby reducing clearance, giving a true center, and providing oil control. It is the least expensive way of repairing the valve guides. However, it is not necessarily the best, and in some cases, a knurled valve guide will not stand up for more than a short time. It requires a special knurlizer and precision reaming tools to obtain proper clearances. It would not be cost effective to purchase these tools, unless you plan on rebuilding several of the same cylinder head.

Installing a guide insert involves machining the guide to accept a bronze insert. One style is the coil-type which is installed into a threaded guide. Another is the thin-walled insert where the guide is reamed oversize to accept a split-sleeve insert. After the insert is installed, a special tool is then run through the guide to expand the insert, locking it to the guide. The insert is then reamed to the standard size for proper valve clearance.

Reaming for oversize valves restores normal clearances and provides a true valve seat. Most cast-in type guides can be reamed to accept an valve with an oversize stem. The cost factor for this can become quite high as you will need to purchase the reamer and new, oversize stem valves for all guides which were reamed. Oversizes are generally 0.003 to 0.030 in. (0.076 to 0.762mm), with 0.015 in. (0.381mm) being the most common.

To replace cast-in type valve guides, they must be drilled out, then reamed to accept replacement guides. This must be done on a fixture which will allow centering and leveling off of the original valve seat or guide, otherwise a serious guide-to-seat misalignment may occur making it impossible to properly machine the seat.

Replaceable-type guides are pressed into the cylinder head. A hammer and a stepped drift or punch may be used to install and remove the guides. Before removing the guides, measure the protrusion on the spring side of the head and record it for installation. Use the stepped drift to hammer out the old guide from the combustion chamber side of the head. When installing, determine whether or not the guide also seals a water jacket in the head, and if it does, use the recommended sealing agent. If there is no water jacket, grease the valve guide and its bore. Use the stepped drift, and hammer the new guide into the cylinder head from the spring side of the cylinder head. A stack of washers the same thickness as the measured protrusion may help the installation process.

VALVE SEATS

NOTE: Before any valve seat machining can be performed, the guides must be within factory recommended specifications.

NOTE: If any machining or replacements were made to the valve guides, the seats must be machined.

If the seats are in good condition, the valves can be lapped to the seats, and the cylinder head assembled. See the valves section for instructions on lapping.

If the valve seats are worn, cracked or damaged, they must be serviced by a machine shop. The valve seat must be perfectly centered to the valve guide, which requires very accurate machining.

CYLINDER HEAD SURFACE

If the cylinder head is warped, it must be machined flat. If the warpage is extremely severe, the head may need to be replaced. In some instances, it may be possible to straighten a warped head enough to allow machining. In either case, contact a professional machine shop for service.

NOTE: Any OHC cylinder head that shows excessive warpage should have the camshaft bearing journals align bored after the cylinder head has been resurfaced.

WARNING
Failure to align bore the camshaft bearing journals could result in severe engine damage including but not limited to: valve and piston damage, connecting rod damage, camshaft and/or crankshaft breakage.

CRACKS AND PHYSICAL DAMAGE

Certain cracks can be repaired in both cast iron and aluminum heads. For cast iron, a tapered threaded insert is installed along the length of the crack. Aluminum can also use the tapered inserts, however welding is the preferred method. Some physical damage can be repaired through brazing or welding. Contact a machine shop to get expert advice for your particular dilemma.

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Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

Anything that generates heat and/or friction will eventually burn or wear out (i.e. a light bulb generates heat, therefore its life span is limited). With this in mind, a running engine generates tremendous amounts of both; friction is encountered by the moving and rotating parts inside the engine and heat is created by friction and combustion of the fuel. However, the engine has systems designed to help reduce the effects of heat and friction and provide added longevity. The oiling system reduces the amount of friction encountered by the moving parts inside the engine, while the cooling system reduces heat created by friction and combustion. If either system is not maintained, a break-down will be inevitable. Therefore, you can see how regular maintenance can affect the service life of your vehicle. If you do not drain, flush and refill your cooling system at the proper intervals, deposits will begin to accumulate in the radiator, thereby reducing the amount of heat it can extract from the coolant. The same applies to your oil and filter; if it is not changed often enough it becomes laden with contaminates and is unable to properly lubricate the engine. This increases friction and wear.

There are a number of methods for evaluating the condition of your engine. A compression test can reveal the condition of your pistons, piston rings, cylinder bores, head gasket(s), valves and valve seats. An oil pressure test can warn you of possible engine bearing, or oil pump failures. Excessive oil consumption, evidence of oil in the engine air intake area and/or bluish smoke from the tail pipe may indicate worn piston rings, worn valve guides and/or valve seals. As a general rule, an engine that uses no more than one quart of oil every 1000 miles is in good condition. Engines that use one quart of oil or more in less than 1000 miles should first be checked for oil leaks. If any oil leaks are present, have them fixed before determining how much oil is consumed by the engine, especially if blue smoke is not visible at the tail pipe.

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Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

A noticeable lack of engine power, excessive oil consumption and/or poor fuel mileage measured over an extended period are all indicators of internal engine wear. Worn piston rings, scored or worn cylinder bores, blown head gaskets, sticking or burnt valves, and worn valve seats are all possible culprits. A check of each cylinder's compression will help locate the problem.

NOTE: A screw-in type compression gauge is more accurate than the type you simply hold against the spark plug hole. Although it takes slightly longer to use, its worth the effort to obtain a more accurate reading.

1. Make sure that the proper amount and viscosity of engine oil is in the crankcase, then ensure the battery is fully charged.
2. Warm-up the engine to normal operating temperature, then shut the engine **OFF**.
3. Disable the ignition system.
4. Label and disconnect all of the spark plug wires from the plugs.
5. Thoroughly clean the cylinder head area around the spark plug ports, then remove the spark plugs.
6. Set the throttle plate to the fully open (wide-open throttle) position. You can block the accelerator linkage open for this, or you can have an assistant fully depress the accelerator pedal.

Fig. 1: A screw-in type compression gauge is more accurate and easier to use without an assistant

7. Install a screw-in type compression gauge into the No. 1 spark plug hole until the fitting is snug.

   WARNING
   Be careful not to crossthread the spark plug hole.
8. According to the tool manufacturer's instructions, connect a remote starting switch to the starting circuit.
9. With the ignition switch in the **OFF** position, use the remote starting switch to crank the engine through at least five compression strokes (approximately 5 seconds of cranking) and record the highest reading on the gauge.
10. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes and/or time as the first.
11. Compare the highest readings from each cylinder to that of the others. The indicated compression pressures are considered within specifications if the lowest reading cylinder is within 75 percent of the pressure recorded for the highest reading cylinder. For example, if your highest reading cylinder pressure was 150 psi (1034 kPa), then 75 percent of that would be 113 psi (779 kPa). So the lowest reading cylinder should be no less than 113 psi (779 kPa).
12. If a cylinder exhibits an unusually low compression reading, pour a tablespoon of clean engine oil into the cylinder through the spark plug hole and repeat the compression test. If the compression rises after adding oil, it means that the cylinder's piston rings and/or cylinder bore are damaged or worn. If the pressure remains low, the valves may not be seating properly (a valve job is needed), or the head gasket may be blown near that cylinder. If compression in any two adjacent cylinders is low, and if the addition of oil doesn't help raise compression, there is leakage past the head gasket. Oil and coolant in the combustion chamber, combined with blue or constant white smoke from the tail pipe, are symptoms of this problem. However, don't be alarmed by the normal white smoke emitted from the tail pipe during engine warm-up or from cold weather driving. There may be evidence of water droplets on the engine dipstick and/or oil droplets in the cooling system if a head gasket is blown.

Check for proper oil pressure at the sending unit passage with an externally mounted mechanical oil pressure gauge (as opposed to relying on a factory installed dash-mounted gauge). A tachometer may also be needed, as some specifications may require running the engine at a specific rpm.

1. With the engine cold, locate and remove the oil pressure sending unit.
2. Following the manufacturer's instructions, connect a mechanical oil pressure gauge and, if necessary, a tachometer to the engine.
3. Start the engine and allow it to idle.
4. Check the oil pressure reading when cold and record the number. You may need to run the engine at a specified rpm, so check the specifications chart located earlier in this section.
5. Run the engine until normal operating temperature is reached (upper radiator hose will feel warm).
6. Check the oil pressure reading again with the engine hot and record the number. Turn the engine **OFF**.
7. Compare your hot oil pressure reading to that given in the chart. If the reading is low, check the cold pressure reading against the chart. If the cold pressure is well above the specification, and the hot reading was lower than the specification, you may have the wrong viscosity oil in the engine. Change the oil, making sure to use the proper grade and quantity, then repeat the test.

   Low oil pressure readings could be attributed to internal component wear, pump related problems, a low oil level, or oil viscosity that is too low. High oil pressure readings could be caused by an overfilled crankcase, too high of an oil viscosity or a faulty pressure relief valve.

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Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Before you begin assembling the engine, first give yourself a clean, dirt free work area. Next, clean every engine component again. The key to a good assembly is cleanliness.

Mount the engine block into the engine stand and wash it one last time using water and detergent (dishwashing detergent works well). While washing it, scrub the cylinder bores with a soft bristle brush and thoroughly clean all of the oil passages. Completely dry the engine and spray the entire assembly down with an anti-rust solution such as WD-40® or similar product. Take a clean lint-free rag and wipe up any excess anti-rust solution from the bores, bearing saddles, etc. Repeat the final cleaning process on the crankshaft. Replace any freeze or oil galley plugs which were removed during disassembly.

Crankshaft

1. Remove the main bearing inserts from the block and bearing caps.
2. If the crankshaft main bearing journals have been refinished to a definite undersize, install the correct undersize bearing. Be sure that the bearing inserts and bearing bores are clean. Foreign material under inserts will distort bearing and cause failure.
3. Place the upper main bearing inserts in bores with tang in slot.

   NOTE: The oil holes in the bearing inserts must be aligned with the oil holes in the cylinder block.
4. Install the lower main bearing inserts in bearing caps.
5. Clean the mating surfaces of block and rear main bearing cap.
6. Carefully lower the crankshaft into place. Be careful not to damage bearing surfaces.
7. Check the clearance of each main bearing by using the following procedure:

   A. Place a piece of Plastigage® or its equivalent, on bearing surface across full width of bearing cap and about $1/4$ in. off center.

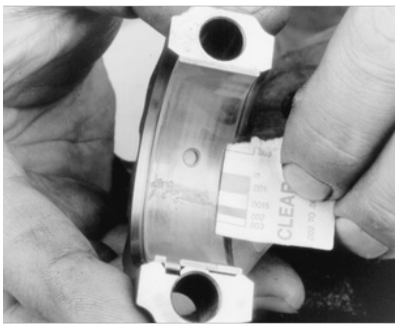
   Fig. 1: Apply a strip of gauging material to the bearing journal, then install and torque the cap

   B. Install cap and tighten bolts to specifications. Do not turn crankshaft while Plastigage® is in place.

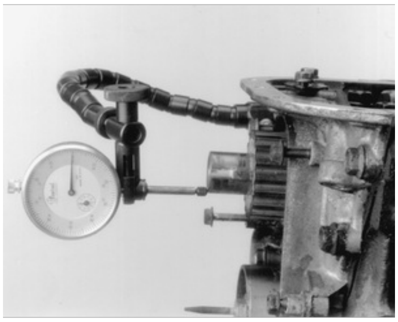
   C. Remove the cap. Using the supplied Plastigage® scale, check width of Plastigage® at widest point to get maximum clearance. Difference between readings is taper of journal.

   Fig. 2: After the cap is removed again, use the scale supplied with the gauging material to check the clearance

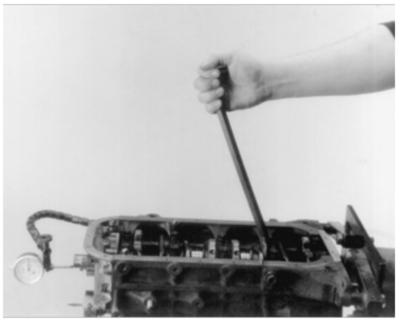
   D. If clearance exceeds specified limits, try a 0.001 in. or 0.002 in. undersize bearing in combination with the standard bearing. Bearing clearance must be within specified limits. If standard and 0.002 in. undersize bearing does not bring clearance within desired limits, refinish crankshaft journal, then install undersize bearings.
8. After the bearings have been fitted, apply a light coat of engine oil to the journals and bearings. Install the rear main bearing cap. Install all bearing caps except the thrust bearing cap. Be sure that main bearing caps are installed in original locations. Tighten the bearing cap bolts to specifications.
9. Install the thrust bearing cap with bolts finger-tight.
10. Pry the crankshaft forward against the thrust surface of upper half of bearing.
11. Hold the crankshaft forward and pry the thrust bearing cap to the rear. This aligns the thrust surfaces of both halves of the bearing.
12. Retain the forward pressure on the crankshaft. Tighten the cap bolts to specifications.
13. Measure the crankshaft end-play as follows:

   Fig. 3: A dial gauge may be used to check crankshaft end-play



A. Mount a dial gauge to the engine block and position the tip of the gauge to read from the crankshaft end.
B. Carefully pry the crankshaft toward the rear of the engine and hold it there while you zero the gauge.

Fig. 4: Carefully pry the crankshaft back and forth while reading the dial gauge for end-play



C. Carefully pry the crankshaft toward the front of the engine and read the gauge.
D. Confirm that the reading is within specifications. If not, install a new thrust bearing and repeat the procedure. If the reading is still out of specifications with a new bearing, have a machine shop inspect the thrust surfaces of the crankshaft, and if possible, repair it.

14. Rotate the crankshaft so as to position the first rod journal to the bottom of its stroke.

Pistons and Connecting Rods

1. Before installing the piston/connecting rod assembly, oil the pistons, piston rings and the cylinder walls with light engine oil. Install connecting rod bolt protectors or rubber hose onto the connecting rod bolts/studs. Also perform the following:

A. Select the proper ring set for the size cylinder bore.
B. Position the ring in the bore in which it is going to be used.
C. Push the ring down into the bore area where normal ring wear is not encountered.
D. Use the head of the piston to position the ring in the bore so that the ring is square with the cylinder wall. Use caution to avoid damage to the ring or cylinder bore.
E. Measure the gap between the ends of the ring with a feeler gauge. Ring gap in a worn cylinder is normally greater than specification. If the ring gap is greater than the specified limits, try an oversize ring set.

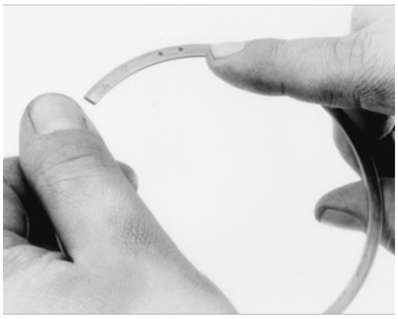
Fig. 5: Checking the piston ring-to-ring groove side clearance using the ring and a feeler gauge

F. Check the ring side clearance of the compression rings with a feeler gauge inserted between the ring and its lower land according to specification. The gauge should slide freely around the entire ring circumference without binding. Any wear that occurs will form a step at the inner portion of the lower land. If the lower lands have high steps, the piston should be replaced.

Fig. 6: The notch on the side of the bearing cap matches the tang on the bearing insert

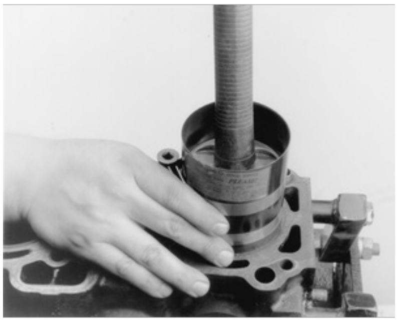
2. Unless new pistons are installed, be sure to install the pistons in the cylinders from which they were removed. The numbers on the connecting rod and bearing cap must be on the same side when installed in the cylinder bore. If a connecting rod is ever transposed from one engine or cylinder to another, new bearings should be fitted and the connecting rod should be numbered to correspond with the new cylinder number. The notch on the piston head goes toward the front of the engine.
3. Install all of the rod bearing inserts into the rods and caps.

Fig. 7: Most rings are marked to show which side of the ring should face up when installed to the piston



4. Install the rings to the pistons. Install the oil control ring first, then the second compression ring and finally the top compression ring. Use a piston ring expander tool to aid in installation and to help reduce the chance of breakage.

Fig. 8: Install the piston and rod assembly into the block using a ring compressor and the handle of a hammer



5. Make sure the ring gaps are properly spaced around the circumference of the piston. Fit a piston ring compressor around the piston and slide the piston and connecting rod assembly down into the cylinder bore, pushing it in with the wooden hammer handle. Push the piston down until it is only slightly below the top of the cylinder bore. Guide the connecting rod onto the crankshaft bearing journal carefully, to avoid damaging the crankshaft.
6. Check the bearing clearance of all the rod bearings, fitting them to the crankshaft bearing journals. Follow the procedure in the crankshaft installation above.
7. After the bearings have been fitted, apply a light coating of assembly oil to the journals and bearings.
8. Turn the crankshaft until the appropriate bearing journal is at the bottom of its stroke, then push the piston assembly all the way down until the connecting rod bearing seats on the crankshaft journal. Be careful not to allow the bearing cap screws to strike the crankshaft bearing journals and damage them.
9. After the piston and connecting rod assemblies have been installed, check the connecting rod side clearance on each crankshaft journal.
10. Prime and install the oil pump and the oil pump intake tube.
11. Install the auxiliary/balance shaft(s)/assembly(ies).

OHC Engines

CYLINDER HEAD(S)

1. Install the cylinder head(s) using new gaskets.
2. Install the timing sprockets/gears and the belt/chain assemblies.

Engine Covers and Components

Install the timing cover(s) and oil pan. Refer to your notes and drawings made prior to disassembly and install all of the components that were removed. Install the engine into the vehicle.

1992 Volvo 940

Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

The engine disassembly instructions following assume that you have the engine mounted on an engine stand. If not, it is easiest to disassemble the engine on a bench or the floor with it resting on the bell housing or transmission mounting surface. You must be able to access the connecting rod fasteners and turn the crankshaft during disassembly. Also, all engine covers (timing, front, side, oil pan, whatever) should have already been removed. Engines which are seized or locked up may not be able to be completely disassembled, and a core (salvage yard) engine should be purchased.

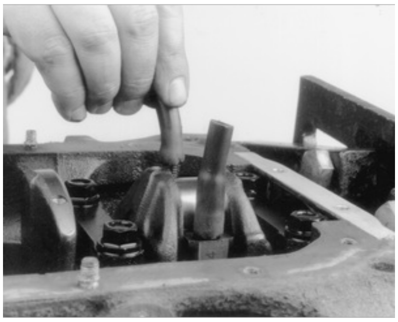
OHC Engines

If not done during the cylinder head removal, remove the timing chain/belt and/or gear/sprocket assembly. Remove the oil pick-up and pump assembly and, if necessary, the pump drive. If equipped, remove any balance or auxiliary shafts. If necessary, remove the cylinder ridge from the top of the bore. See the cylinder ridge removal procedure earlier in this section.

All Engines

Rotate the engine over so that the crankshaft is exposed. Use a number punch or scribe and mark each connecting rod with its respective cylinder number. The cylinder closest to the front of the engine is always No. 1. However, depending on the engine placement, the front of the engine could either be the flywheel or damper/pulley end. Generally the front of the engine faces the front of the vehicle. Use a number punch or scribe and also mark the main bearing caps from front to rear with the frontmost cap being No. 1 (if there are five caps, mark them 1 through 5, front to rear).

Fig. 1: Place rubber hose over the connecting rod studs to protect the crankshaft and cylinder bores from damage



WARNING
Take special care when pushing the connecting rod up from the crankshaft because the sharp threads of the rod bolts/studs will score the crankshaft journal. Insure that special plastic caps are installed over them, or cut two pieces of rubber hose to do the same.

Fig. 2: Carefully tap the piston out of the bore using a wooden dowel

Again, rotate the engine, this time to position the number one cylinder bore (head surface) up. Turn the crankshaft until the number one piston is at the bottom of its travel, this should allow the maximum access to its connecting rod. Remove the number one connecting rods fasteners and cap and place two lengths of rubber hose over the rod bolts/studs to protect the crankshaft from damage. Using a sturdy wooden dowel and a hammer, push the connecting rod up about 1 in. (25mm) from the crankshaft and remove the upper bearing insert. Continue pushing or tapping the connecting rod up until the piston rings are out of the cylinder bore. Remove the piston and rod by hand, put the upper half of the bearing insert back into the rod, install the cap with its bearing insert installed, and hand-tighten the cap fasteners. If the parts are kept in order in this manner, they will not get lost and you will be able to tell which bearings came form what cylinder if any problems are discovered and diagnosis is necessary. Remove all the other piston assemblies in the same manner. On V-style engines, remove all of the pistons from one bank, then reposition the engine with the other cylinder bank head surface up, and remove that banks piston assemblies.

The only remaining component in the engine block should now be the crankshaft. Loosen the main bearing caps evenly until the fasteners can be turned by hand, then remove them and the caps. Remove the crankshaft from the engine block. Thoroughly clean all of the components.

1992 Volvo 940

Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

A thorough overhaul or rebuild of an engine block would include replacing the pistons, rings, bearings, timing belt/chain assembly and oil pump. For OHV engines also include a new camshaft and lifters. The block would then have the cylinders bored and honed oversize (or if using removable cylinder sleeves, new sleeves installed) and the crankshaft would be cut undersize to provide new wearing surfaces and perfect clearances. However, your particular engine may not have everything worn out. What if only the piston rings have worn out and the clearances on everything else are still within factory specifications? Well, you could just replace the rings and put it back together, but this would be a very rare example. Chances are, if one component in your engine is worn, other components are sure to follow, and soon. At the very least, you should always replace the rings, bearings and oil pump. This is what is commonly called a "freshen up".

Cylinder Ridge Removal

Because the top piston ring does not travel to the very top of the cylinder, a ridge is built up between the end of the travel and the top of the cylinder bore.

Pushing the piston and connecting rod assembly past the ridge can be difficult, and damage to the piston ring lands could occur. If the ridge is not removed before installing a new piston or not removed at all, piston ring breakage and piston damage may occur.

NOTE: It is always recommended that you remove any cylinder ridges before removing the piston and connecting rod assemblies. If you know that new pistons are going to be installed and the engine block will be bored oversize, you may be able to forego this step. However, some ridges may actually prevent the assemblies from being removed, necessitating its removal.

There are several different types of ridge reamers on the market, none of which are inexpensive. Unless a great deal of engine rebuilding is anticipated, borrow or rent a reamer.

1. Turn the crankshaft until the piston is at the bottom of its travel.
2. Cover the head of the piston with a rag.
3. Follow the tool manufacturers instructions and cut away the ridge, exercising extreme care to avoid cutting too deeply.
4. Remove the ridge reamer, the rag and as many of the cuttings as possible. Continue until all of the cylinder ridges have been removed.

Now that the engine block and all of its components are clean, its time to inspect them for wear and/or damage. To accurately inspect them, you will need some specialized tools:

- Two or three separate micrometers to measure the pistons and crankshaft journals
- A dial indicator
- Telescoping gauges for the cylinder bores
- A rod alignment fixture to check for bent connecting rods

If you do not have access to the proper tools, you may want to bring the components to a shop that does.

Generally, you shouldn't expect cracks in the engine block or its components unless it was known to leak, consume or mix engine fluids, it was severely overheated, or there was evidence of bad bearings and/or crankshaft damage. A visual inspection should be performed on all of the components, but just because you don't see a crack does not mean it is not there. Some more reliable methods for inspecting for cracks include Magnaflux® , a magnetic process or Zyglo® , a dye penetrant. Magnaflux® is used only on ferrous metal (cast iron). Zyglo® uses a spray on fluorescent mixture along with a black light to reveal the cracks. It is strongly recommended to have your engine block checked professionally for cracks, especially if the engine was known to have overheated and/or leaked or consumed coolant. Contact a local shop for availability and pricing of these services.

Engine Block

ENGINE BLOCK BEARING ALIGNMENT

Remove the main bearing caps and, if still installed, the main bearing inserts. Inspect all of the main bearing saddles and caps for damage, burrs or high spots. If damage is found, and it is caused from a spun main bearing, the block will need to be align-bored or, if severe enough, replacement. Any burrs or high spots should be carefully removed with a metal file.

Place a straightedge on the bearing saddles, in the engine block, along the centerline of the crankshaft. If any clearance exists between the straightedge and the saddles, the block must be align-bored.

Align-boring consists of machining the main bearing saddles and caps by means of a flycutter that runs through the bearing saddles.

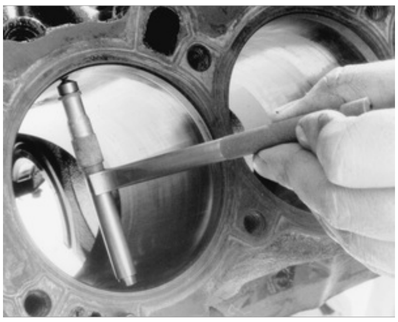
DECK FLATNESS

The top of the engine block where the cylinder head mounts is called the deck. Insure that the deck surface is clean of dirt, carbon deposits and old gasket material. Place a straightedge across the surface of the deck along its centerline and, using feeler gauges, check the clearance along several points. Repeat the checking procedure with the straightedge placed along both diagonals of the deck surface. If the reading exceeds 0.003 in. (0.076mm) within a 6.0 in. (15.2cm) span, or 0.006 in. (0.152mm) over the total length of the deck, it must be machined.

CYLINDER BORES

The cylinder bores house the pistons and are slightly larger than the pistons themselves. A common piston-to-bore clearance is 0.0015–0.0025 in. (0.0381–0.0635mm). Inspect and measure the cylinder bores. The bore should be checked for out-of-roundness, taper and size. The results of this inspection will determine whether the cylinder can be used in its existing size and condition, or a rebore to the next oversize is required (or in the case of removable sleeves, have replacements installed).

Fig. 1: Use a telescoping gauge to measure the cylinder bore diameter — take several readings within the same bore



The amount of cylinder wall wear is always greater at the top of the cylinder than at the bottom. This wear is known as taper. Any cylinder that has a taper of 0.0012 in. (0.305mm) or more, must be rebored. Measurements are taken at a number of positions in each cylinder: at the top, middle and bottom and at two points at each position; that is, at a point 90 degrees from the crankshaft centerline, as well as a point parallel to the crankshaft centerline. The measurements are made with either a special dial indicator or a telescopic gauge and micrometer. If the necessary precision tools to check the bore are not available, take the block to a machine shop and have them mike it. Also if you don't have the tools to check the cylinder bores, chances are you will not have the necessary devices to check the pistons, connecting rods and crankshaft. Take these components with you and save yourself an extra trip.

For our procedures, we will use a telescopic gauge and a micrometer. You will need one of each, with a measuring range which covers your cylinder bore size.

1. Position the telescopic gauge in the cylinder bore, loosen the gauges lock and allow it to expand.

   NOTE: Your first two readings will be at the top of the cylinder bore, then proceed to the middle and finally the bottom, making a total of six measurements.
2. Hold the gauge square in the bore, 90 degrees from the crankshaft centerline, and gently tighten the lock. Tilt the gauge back to remove it from the bore.
3. Measure the gauge with the micrometer and record the reading.
4. Again, hold the gauge square in the bore, this time parallel to the crankshaft centerline, and gently tighten the lock. Again, you will tilt the gauge back to remove it from the bore.
5. Measure the gauge with the micrometer and record this reading. The difference between these two readings is the out-of-round measurement of the cylinder.
6. Repeat Steps 1 through 5, each time going to the next lower position, until you reach the bottom of the cylinder. Then go to the next cylinder, and continue until all of the cylinders have been measured.

   The difference between these measurements will tell you all about the wear in your cylinders. The measurements which were taken 90 degrees from the crankshaft centerline will always reflect the most wear. That is because at this position is where the engine power presses the piston against the cylinder bore the hardest. This is known as thrust wear. Take your top, 90 degree measurement and compare it to your bottom, 90 degree measurement. The difference between them is the taper. When you measure your pistons, you will compare these readings to your piston sizes and determine piston-to-wall clearance.

Crankshaft

Inspect the crankshaft for visible signs of wear or damage. All of the journals should be perfectly round and smooth. Slight scores are normal for a used crankshaft, but you should hardly feel them with your fingernail. When measuring the crankshaft with a micrometer, you will take readings at the front and rear of each journal, then turn the micrometer 90 degrees and take two more readings, front and rear. The difference between the front-to-rear readings is the journal taper and the first-to-90 degree reading is the out-of-round measurement. Generally, there should be no taper or out-of-roundness found, however, up to 0.0005 in. (0.0127mm) for either can be overlooked. Also, the readings should fall within the factory specifications for journal diameters.

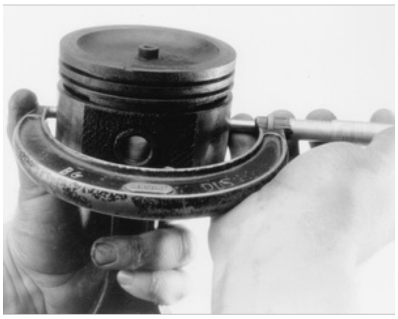
If the crankshaft journals fall within specifications, it is recommended that it be polished before being returned to service. Polishing the crankshaft insures that any minor burrs or high spots are smoothed, thereby reducing the chance of scoring the new bearings.

Pistons and Connecting Rods

PISTONS

The piston should be visually inspected for any signs of cracking or burning (caused by hot spots or detonation), and scuffing or excessive wear on the skirts. The wrist pin attaches the piston to the connecting rod. The piston should move freely on the wrist pin, both sliding and pivoting. Grasp the connecting rod securely, or mount it in a vise, and try to rock the piston back and forth along the centerline of the wrist pin. There should not be any excessive play evident between the piston and the pin. If there are C-clips retaining the pin in the piston then you have wrist pin bushings in the rods. There should not be any excessive play between the wrist pin and the rod bushing. Normal clearance for the wrist pin is approx. 0.001–0.002 in. (0.025–0.051mm).

Fig. 2: Measure the piston's outer diameter, perpendicular to the wrist pin, with a micrometer



Use a micrometer and measure the diameter of the piston, perpendicular to the wrist pin, on the skirt. Compare the reading to its original cylinder measurement obtained earlier. The difference between the two readings is the piston-to-wall clearance. If the clearance is within specifications, the piston may be used as is. If the piston is out of specification, but the bore is not, you will need a new piston. If both are out of specification, you will need the cylinder rebored and oversize pistons installed. Generally if two or more pistons/bores are out of specification, it is best to rebore the entire block and purchase a complete set of oversize pistons.

CONNECTING ROD

You should have the connecting rod checked for straightness at a machine shop. If the connecting rod is bent, it will unevenly wear the bearing and piston, as well as place greater stress on these components. Any bent or twisted connecting rods must be replaced. If the rods are straight and the wrist pin clearance is within specifications, then only the bearing end of the rod need be checked. Place the connecting rod into a vice, with the bearing inserts in place, install the cap to the rod and torque the fasteners to specifications. Use a telescoping gauge and carefully measure the inside diameter of the bearings. Compare this reading to the rods original crankshaft journal diameter measurement. The difference is the oil clearance. If the oil clearance is not within specifications, install new bearings in the rod and take another measurement. If the clearance is still out of specifications, and the crankshaft is not, the rod will need to be reconditioned by a machine shop.

NOTE: You can also use Plastigage® to check the bearing clearances. The assembling section has complete instructions on its use.

Camshaft

Inspect the camshaft and lifters/followers as described earlier in this section.

Bearings

All of the engine bearings should be visually inspected for wear and/or damage. The bearing should look evenly worn all around with no deep scores or pits. If the bearing is severely worn, scored, pitted or heat blued, then the bearing, and the components that use it, should be brought to a machine shop for inspection. Full-circle bearings (used on most camshafts, auxiliary shafts, balance shafts, etc.) require specialized tools for removal and installation, and should be brought to a machine shop for service.

Oil Pump

NOTE: The oil pump is responsible for providing constant lubrication to the whole engine and so it is recommended that a new oil pump be installed when rebuilding the engine.

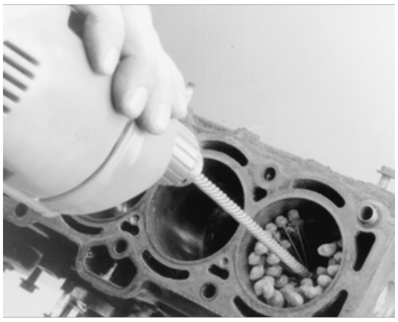
Completely disassemble the oil pump and thoroughly clean all of the components. Inspect the oil pump gears and housing for wear and/or damage. Insure that the pressure relief valve operates properly and there is no binding or sticking due to varnish or debris. If all of the parts are in proper working condition, lubricate the gears and relief valve, and assemble the pump.

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Almost all engine block refinishing must be performed by a machine shop. If the cylinders are not to be rebored, then the cylinder glaze can be removed with a ball hone. When removing cylinder glaze with a ball hone, use a light or penetrating type oil to lubricate the hone. Do not allow the hone to run dry as this may cause excessive scoring of the cylinder bores and wear on the hone. If new pistons are required, they will need to be installed to the connecting rods. This should be performed by a machine shop as the pistons must be installed in the correct relationship to the rod or engine damage can occur.

Fig. 1: Use a ball type cylinder hone to remove any glaze and provide a new surface for seating the piston rings



Pistons and Connecting Rods

Only pistons with the wrist pin retained by C-clips are serviceable by the home-mechanic. Press fit pistons require special presses and/or heaters to remove/install the connecting rod and should only be performed by a machine shop.

All pistons will have a mark indicating the direction to the front of the engine and the must be installed into the engine in that manner. Usually it is a notch or arrow on the top of the piston, or it may be the letter F cast or stamped into the piston.

Fig. 2: Most pistons are marked to indicate positioning in the engine (usually a mark means the side facing the front)

1992 Volvo 940

Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

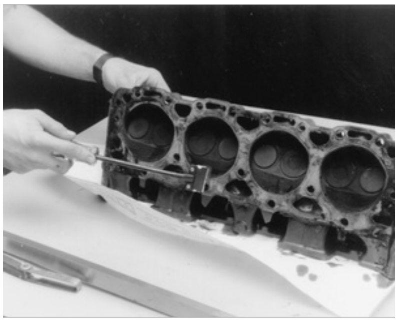
Most engine overhaul procedures are fairly standard. In addition to specific parts replacement procedures and specifications for your individual engine, this section is also a guide to acceptable rebuilding procedures. Examples of standard rebuilding practice are given and should be used along with specific details concerning your particular engine.

Competent and accurate machine shop services will ensure maximum performance, reliability and engine life. In most instances it is more profitable for the do-it-yourself mechanic to remove, clean and inspect the component, buy the necessary parts and deliver these to a shop for actual machine work.

Much of the assembly work (crankshaft, bearings, piston rods, and other components) is well within the scope of the do-it-yourself mechanic's tools and abilities. You will have to decide for yourself the depth of involvement you desire in an engine repair or rebuild.

Before the engine and its components are inspected, they must be thoroughly cleaned. You will need to remove any engine varnish, oil sludge and/or carbon deposits from all of the components to insure an accurate inspection. A crack in the engine block or cylinder head can easily become overlooked if hidden by a layer of sludge or carbon.

Fig. 1: Use a gasket scraper to remove the old gasket material from the mating surfaces

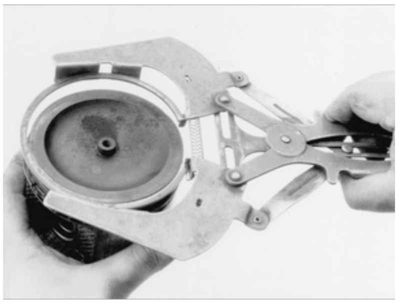


Most of the cleaning process can be carried out with common hand tools and readily available solvents or solutions. Carbon deposits can be chipped away using a hammer and a hard wooden chisel. Old gasket material and varnish or sludge can usually be removed using a scraper and/or cleaning solvent. Extremely stubborn deposits may require the use of a power drill with a wire brush. If using a wire brush, use extreme care around any critical machined surfaces (such as the gasket surfaces, bearing saddles, cylinder bores, etc.). USE OF A WIRE BRUSH IS NOT RECOMMENDED ON ANY ALUMINUM COMPONENTS. Always follow any safety recommendations given by the manufacturer of the tool and/or solvent. You should always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

An alternative to the mess and hassle of cleaning the parts yourself is to drop them off at a local garage or machine shop. They will, more than likely, have the necessary equipment to properly clean all of the parts for a nominal fee.

CAUTION
Always wear eye protection during any cleaning process involving scraping, chipping or spraying of solvents.

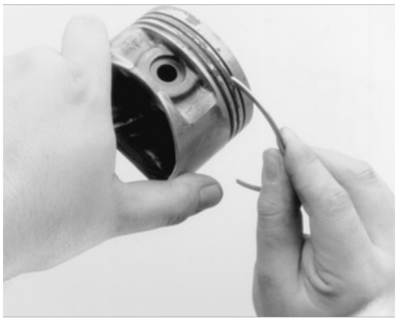
Fig. 2: Use a ring expander tool to remove the piston rings



Remove any oil galley plugs, freeze plugs and/or pressed-in bearings and carefully wash and degrease all of the engine components including the fasteners and bolts. Small parts such as the valves, springs, etc., should be placed in a metal basket and allowed to soak. Use pipe cleaner type brushes, and clean all passageways in the components. Use a ring expander and remove the rings from the pistons. Clean the piston ring grooves with a special tool or a piece of broken ring. Scrape the carbon off of the top of the piston. You should never use a wire brush on the pistons. After preparing all of the piston assemblies in this manner, wash and degrease them again.

Fig. 3: Clean the piston ring grooves using a ring groove cleaner tool, or . . .

Fig. 4: . . . use a piece of an old ring to clean the grooves. Be careful, the ring can be quite sharp



WARNING
Use extreme care when cleaning around the cylinder head valve seats. A mistake or slip may cost you a new seat.

When cleaning the cylinder head, remove carbon from the combustion chamber with the valves installed. This will avoid damaging the valve seats.

1992 Volvo 940

Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

Aluminum has become extremely popular for use in engines, due to its low weight. Observe the following precautions when handling aluminum parts:

- Never hot tank aluminum parts (the caustic hot tank solution will eat the aluminum.
- Remove all aluminum parts (identification tag, etc.) from engine parts prior to the tanking.
- Always coat threads lightly with engine oil or anti-seize compounds before installation, to prevent seizure.
- Never overtighten bolts or spark plugs especially in aluminum threads.

When assembling the engine, any parts that will be exposed to frictional contact must be prelubed to provide lubrication at initial start-up. Any product specifically formulated for this purpose can be used, but engine oil is not recommended as a prelube in most cases.

When semi-permanent (locked, but removable) installation of bolts or nuts is desired, threads should be cleaned and coated with Loctite(r) or another similar, commercial non-hardening sealant.

Fig. 1: Damaged bolt hole threads can be replaced with thread repair inserts

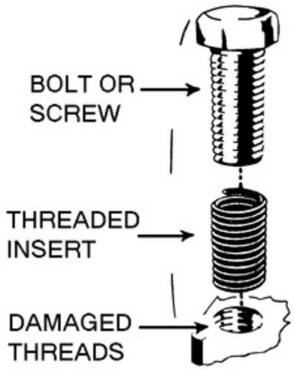


Fig. 2: Standard thread repair insert (left), and spark plug thread insert

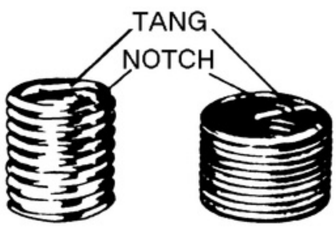


Fig. 3: Drill out the damaged threads with the specified size bit. Be sure to drill completely through the hole or to the bottom of a blind hole

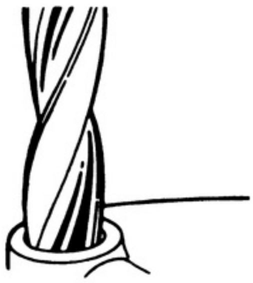


Fig. 4: Using the kit, tap the hole in order to receive the thread insert. Keep the tap well oiled and back it out frequently to avoid clogging the threads

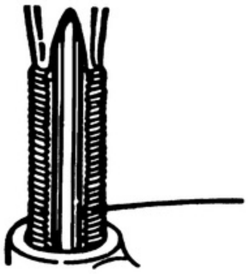
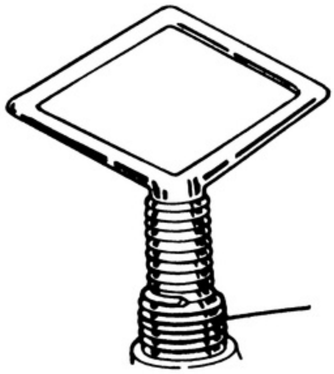


Fig. 5: Screw the insert onto the installer tool until the tang engages the slot. Thread the insert into the hole until it is $^{1}/_{4}$ – $^{1}/_{2}$ turn below the top surface, then remove the tool and break off the tang using a punch



Several methods of repairing damaged threads are available. Heli-Coil(r) (shown here), Keenserts(r) and Microdot(r) are among the most widely used. All involve basically the same principle — drilling out stripped threads, tapping the hole and installing a prewound insert — making welding, plugging and oversize fasteners unnecessary.

Two types of thread repair inserts are usually supplied: a standard type for most inch coarse, inch fine, metric course and metric fine thread sizes and a spark lug type to fit most spark plug port sizes. Consult the individual tool manufacturer's catalog to determine exact applications. Typical thread repair kits will contain a selection of prewound threaded inserts, a tap (corresponding to the outside diameter threads of the insert) and an installation tool. Spark plug inserts usually differ because they require a tap equipped with pilot threads and a combined reamer/tap section. Most manufacturers also supply blister-packed thread repair inserts separately in addition to a master kit containing a variety of taps and inserts plus installation tools.

Before attempting to repair a threaded hole, remove any snapped, broken or damaged bolts or studs. Penetrating oil can be used to free frozen threads. The offending item can usually be removed with locking pliers or using a screw/stud extractor. After the hole is clear, the thread can be repaired, as shown in the series of accompanying illustrations and in the kit manufacturer's instructions.

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

The tools required for an engine overhaul or parts replacement will depend on the depth of your involvement. With a few exceptions, they will be the tools found in a mechanic's tool kit (see Section 1 of this manual). More in-depth work will require some or all of the following:

- A dial indicator (reading in thousandths) mounted on a universal base
- Micrometers and telescope gauges
- Jaw and screw-type pullers
- Scraper
- Valve spring compressor
- Ring groove cleaner
- Piston ring expander and compressor
- Ridge reamer
- Cylinder hone or glaze breaker
- Plastigage®
- Engine stand

The use of most of these tools is illustrated in this section. Many can be rented for a one-time use from a local parts jobber or tool supply house specializing in automotive work.

Occasionally, the use of special tools is called for. See the information on Special Tools and the Safety Notice in the front of this book before substituting another tool.

1992 Volvo 940

Submodel: | Engine Type: L4 | Liters: 2.3
Fuel Delivery: FI | Fuel: GAS

To properly rebuild an engine, you must first remove it from the vehicle, then disassemble and diagnose it. Ideally you should place your engine on an engine stand. This affords you the best access to the engine components. Follow the manufacturer's directions for using the stand with your particular engine. Remove the flywheel or flexplate before installing the engine to the stand.

Now that you have the engine on a stand, and assuming that you have drained the oil and coolant from the engine, its time to strip it of all but the necessary components. Before you start disassembling the engine, you may want to take a moment to draw some pictures, or fabricate some labels or containers to mark the locations of various components and the bolts and/or studs which fasten them. Modern day engines use a lot of little brackets and clips which hold wiring harnesses and such, and these holders are often mounted on studs and/or bolts that can be easily mixed up. The manufacturer spent a lot of time and money designing your vehicle, and they wouldn't have wasted any of it by haphazardly placing brackets, clips or fasteners on the vehicle. If its present when you disassemble it, put it back when you assemble, you will regret not remembering that little bracket which holds a wire harness out of the path of a rotating part.

You should begin by unbolting any accessories still attached to the engine, such as the water pump, power steering pump, alternator, etc. Then, unfasten any manifolds (intake or exhaust) which were not removed during the engine removal procedure. Finally, remove any covers remaining on the engine such as the rocker arm, front or timing cover and oil pan. Some front covers may require the vibration damper and/or crank pulley to be removed beforehand. The idea is to reduce the engine to the bare necessities (cylinder head(s), valve train, engine block, crankshaft, pistons and connecting rods), plus any other 'in block' components such as oil pumps, balance shafts and auxiliary shafts.

Finally, remove the cylinder head(s) from the engine block and carefully place on a bench. Disassembly instructions for each component follow later in this section.

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Make the first miles on the new engine, easy ones. Vary the speed but do not accelerate hard. Most importantly, do not lug the engine, and avoid sustained high speeds until at least 100 miles (161 km). Check the engine oil and coolant levels frequently. Expect the engine to use a little oil until the rings seat. Change the oil and filter at 500 miles (805 km), 1500 miles (2415 km), then every 3000 miles (4830 km) past that.

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Now that you have just gone through all of that hard work, keep yourself from doing it all over again by thoroughly maintaining it. Not that you may not have maintained it before, heck you could have had one to two hundred thousand miles on it before doing this. However, you may have bought the vehicle used, and the previous owner did not keep up on maintenance. Which is why you just went through all of that hard work. See?

TORQUE SPECIFICATIONS

Components	English Specifications	Metric Specifications
Camshaft, bearing caps		
2.3L 4-cylinder engines	14 ft. lbs.	20 Nm
Camshaft, pulleys		
2.3L 4-cylinder engines	37 ft. lbs.	50 Nm
2.8L 6-cylinder engine	51-59 ft. lbs.	69-80 Nm
2.9L 6-cylinder engine	15 ft. lbs.	20 Nm
2.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
Camshaft, retaining bolt		
2.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
Crankshaft, Damper		
2.3L 4-cylinder engines	44 ft. lbs.*	60 Nm*
2.8L 6-cylinder engine	177-207 ft. lbs.	240-280 Nm
2.9L 6-cylinder engine		
Center nut	221 ft. lbs.	300 Nm
Retaining bolts	26 ft. lbs.	35 Nm
2.3L and 2.4L 5-cylinder engines		
Center nut	133 ft. lbs.	180 Nm
Retaining bolts	18 ft. lbs.	25 Nm
Cylinder head bolts		
2.3L 4-cylinder engines	①	①
2.8L 6-cylinder engine	②	②
2.9L 6-cylinder engine	③	③
2.3L and 2.4L 5-cylinder engines	④	④
Engine mounts	37 ft. lbs.	50 Nm
Exhaust manifold		
2.3L 4-cylinder engines	10-20 ft. lbs.	14-27 Nm
2.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
2.9L 6-cylinder engine	18 ft. lbs.	25 Nm
2.3L and 2.4L 5-cylinder engines	18 ft. lbs.	25 Nm
Flywheel/flexplate		
2.3L 4-cylinder engines	51 ft. lbs.	70 Nm
2.8L 6-cylinder engine	51 ft. lbs.	70 Nm
2.9L 6-cylinder engine	55 ft. lbs.	75 Nm
2.3L and 2.4L 5-cylinder engines	33 ft. lbs.*	45 Nm*
Intake manifold		
2.3L 4-cylinder engines	15 ft. lbs.	20 Nm
2.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
2.9L 6-cylinder engine	15 ft. lbs.	20 Nm
2.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
Oil pan		
2.3L 4-cylinder engines	8 ft. lbs.	11 Nm
2.8L 6-cylinder engine	6-8 ft. lbs.	8-11 Nm
2.9L 6-cylinder engine	8 ft. lbs.	11 Nm
2.3L and 2.4L 5-cylinder engines	12 ft. lbs.	17 Nm
Oil pump		
B230F and B230FK 4-cylinder engines	8 ft. lbs.	11 Nm
2.8L 6-cylinder engine	8 ft. lbs.	11 Nm
2.9L 6-cylinder engine	7 ft. lbs.	10 Nm
2.3L and 2.4L 5-cylinder engines	7 ft. lbs.	10 Nm
B234F 4-cylinder engine	8 ft. lbs.	11 Nm
Drive belt pulley bolt	15 ft. lbs.*	20 Nm*

TORQUE SPECIFICATIONS

Components	English Specifications	Metric Specifications
Thermostat housing		
2.3L 4-cylinder engines	11-15 ft. lbs.	15-20 Nm
2.8L 6-cylinder engine	11-15 ft. lbs.	15-20 Nm
2.9L 6-cylinder engine	7 ft. lbs.	10 Nm
2.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
Timing belt tensioner		
2.3L 4-cylinder engines	37 ft. lbs.	51 Nm
2.8L 6-cylinder engine	37 ft. lbs.	51 Nm
2.9L 6-cylinder engine	18 ft. lbs.	25 Nm
2.3L and 2.4L 5-cylinder engines	18 ft. lbs.	25 Nm
Timing chain cover		
2.8L 6-cylinder engine	7-11 ft. lbs.	10-15 Nm
Timing chain tensioner		
2.8L 6-cylinder engine	5 ft. lbs.	7 Nm
Water pump		
2.3L 4-cylinder engines	11-15 ft. lbs.	15-20 Nm
2.8L 6-cylinder engine	11-15 ft. lbs.	15-20 Nm
2.9L 6-cylinder engine	15 ft. lbs.	20 Nm
2.3L and 2.4L 5-cylinder engines	15 ft. lbs.	20 Nm
Valve cover		
2.3L 4-cylinder engines	14 ft. lbs.	20 Nm
2.8L 6-cylinder engine	11 ft. lbs.	15 Nm
2.9L 6-cylinder engine	13 ft. lbs.	17 Nm
2.3L and 2.4L 5-cylinder engines	13 ft. lbs.	17 Nm

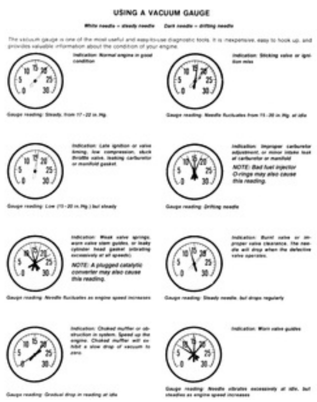
* Plus an additional 60 degrees

① Step 1: Tighten in sequence to 14 ft. lbs. (19 Nm)
Step 1: Tighten in sequence to 43 ft. lbs. (59 Nm)
Step 3: Tighten in sequence an additional 90 degrees

② On 1990 asbestos-free gasket
Step 1: Tighten in sequence to 44 ft. lbs. (60 Nm)
Step 2: Loosen bolts, tighten in sequence to 30 ft. lbs. (40 Nm)
Step 3: Tighten in sequence an additional 160-180 degrees
Except 1990 asbestos-free gasket
Step 1: Tighten in sequence to 43 ft. lbs. (59 Nm)
Step 2: Loosen bolt 1, tighten it to 15 ft. lbs. (20 Nm)
Step 3: Tighten bolt 1 an additional 106 degrees
Step 4: Repeat steps 2 and 3 for the remaining head bolts

③ Step 1: Tighten in sequence to 15 ft. lbs. (20 Nm)
Step 2: Tighten in sequence to 44 ft. lbs. (60 Nm)
Step 3: Tighten in sequence an additional 130 degrees

④ Step 1: Tighten in sequence to 15 ft. lbs. (20 Nm)
Step 2: Tighten in sequence to 44 ft. lbs. (60 Nm)
Step 3: Tighten in sequence an additional 130 degrees



Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
External oil leaks	• Cylinder head cover RTV sealant broken or improperly seated	• Replace sealant; inspect cylinder head cover sealant flange and cylinder head sealant surface for distortion and cracks
	• Oil filler cap leaking or missing	• Replace cap
	• Oil filter gasket broken or improperly seated	• Replace oil filter
	• Oil pan side gasket broken, improperly seated or opening in RTV sealant	• Replace gasket or repair opening in sealant; inspect oil pan gasket flange for distortion
	• Oil pan front oil seal broken or improperly seated	• Replace seal; inspect timing case cover and oil pan seal flange for distortion
	• Oil pan rear oil seal broken or improperly seated	• Replace seal; inspect oil pan rear oil seal flange; inspect rear main bearing cap for cracks, plugged oil return channels, or distortion in seal groove
	• Timing case cover oil seal broken or improperly seated	• Replace seal
	• Excess oil pressure because of restricted PCV valve	• Replace PCV valve
	• Oil pan drain plug loose or has stripped threads	• Repair as necessary and tighten
	• Rear oil gallery plug loose	• Use appropriate sealant on gallery plug and tighten
	• Rear camshaft plug loose or improperly seated	• Seat camshaft plug or replace and seal, as necessary
Excessive oil consumption	• Oil level too high	• Drain oil to specified level
	• Oil with wrong viscosity being used	• Replace with specified oil
	• PCV valve stuck closed	• Replace PCV valve
	• Valve stem oil deflectors (or seals) are damaged, missing, or incorrect type	• Replace valve stem oil deflectors
	• Valve stems or valve guides worn	• Measure stem-to-guide clearance and repair as necessary
	• Poorly fitted or missing valve cover baffles	• Replace valve cover
	• Piston rings broken or missing	• Replace broken or missing rings
	• Scuffed piston	• Replace piston
	• Incorrect piston ring gap	• Measure ring gap, repair as necessary
	• Piston rings sticking or excessively loose in grooves	• Measure ring side clearance, repair as necessary
	• Compression rings installed upside down	• Repair as necessary
	• Cylinder walls worn, scored, or glazed	• Repair as necessary

Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
Excessive oil consumption (cont.)	• Piston ring gaps not properly staggered	• Repair as necessary
	• Excessive main or connecting rod bearing clearance	• Measure bearing clearance, repair as necessary
No oil pressure	• Low oil level	• Add oil to correct level
	• Oil pressure gauge, warning lamp or sending unit inaccurate	• Replace oil pressure gauge or warning lamp
	• Oil pump malfunction	• Replace oil pump
	• Oil pressure relief valve sticking	• Remove and inspect oil pressure relief valve assembly
	• Oil passages on pressure side of pump obstructed	• Inspect oil passages for obstruction
	• Oil pickup screen or tube obstructed	• Inspect oil pickup for obstruction
	• Loose oil inlet tube	• Tighten or seal inlet tube
Low oil pressure	• Low oil level	• Add oil to correct level
	• Inaccurate gauge, warning lamp or sending unit	• Replace oil pressure gauge or warning lamp
	• Oil excessively thin because of dilution, poor quality, or improper grade	• Drain and refill crankcase with recommended oil
	• Excessive oil temperature	• Correct cause of overheating engine
	• Oil pressure relief spring weak or sticking	• Remove and inspect oil pressure relief valve assembly
	• Oil inlet tube and screen assembly has restriction or air leak	• Remove and inspect oil inlet tube and screen assembly. (Fill inlet tube with lacquer thinner to locate leaks.)
	• Excessive oil pump clearance	• Measure clearances
	• Excessive main, rod, or camshaft bearing clearance	• Measure bearing clearances, repair as necessary
High oil pressure	• Improper oil viscosity	• Drain and refill crankcase with correct viscosity oil
	• Oil pressure gauge or sending unit inaccurate	• Replace oil pressure gauge
	• Oil pressure relief valve sticking closed	• Remove and inspect oil pressure relief valve assembly
Main bearing noise	• Insufficient oil supply	• Inspect for low oil level and low oil pressure
	• Main bearing clearance excessive	• Measure main bearing clearance, repair as necessary
	• Bearing insert missing	• Replace missing insert
	• Crankshaft end-play excessive	• Measure end-play, repair as necessary
	• Improperly tightened main bearing cap bolts	• Tighten bolts with specified torque
	• Loose flywheel or drive plate	• Tighten flywheel or drive plate attaching bolts
	• Loose or damaged vibration damper	• Repair as necessary

Troubleshooting Engine Mechanical Problems

Problem	Cause	Solution
Connecting rod bearing noise	• Insufficient oil supply	• Inspect for low oil level and low oil pressure
	• Carbon build-up on piston	• Remove carbon from piston crown
	• Bearing clearance excessive or bearing missing	• Measure clearance, repair as necessary
	• Crankshaft connecting rod journal out-of-round	• Measure journal dimensions, repair or replace as necessary
	• Misaligned connecting rod or cap	• Repair as necessary
	• Connecting rod bolts tightened improperly	• Tighten bolts with specified torque
Piston noise	• Piston-to-cylinder wall clearance excessive (scuffed piston)	• Measure clearance and examine piston
	• Cylinder walls excessively tapered or out-of-round	• Measure cylinder wall dimensions, rebore cylinder
	• Piston ring broken	• Replace all rings on piston
	• Loose or seized piston pin	• Measure piston-to-pin clearance, repair as necessary
	• Connecting rods misaligned	• Measure rod alignment, straighten or replace
	• Piston ring side clearance excessively loose or tight	• Measure ring side clearance, repair as necessary
	• Carbon build-up on piston is excessive	• Remove carbon from piston
Valve actuating component noise	• Insufficient oil supply	• Check for: (a) Low oil level (b) Low oil pressure (c) Wrong hydraulic tappets (d) Restricted oil gallery (e) Excessive tappet to bore clearance
	• Rocker arms or pivots worn	• Replace worn rocker arms or pivots
	• Foreign objects or chips in hydraulic tappets	• Clean tappets
	• Excessive tappet leak-down	• Replace valve tappet
	• Tappet face worn	• Replace tappet; inspect corresponding cam lobe for wear
	• Broken or cocked valve springs	• Properly seat cocked springs; replace broken springs
	• Stem-to-guide clearance excessive	• Measure stem-to-guide clearance, repair as required
	• Valve bent	• Replace valve
	• Loose rocker arms	• Check and repair as necessary
	• Valve seat runout excessive	• Regrind valve seat/valves
	• Missing valve lock	• Install valve lock
	• Excessive engine oil	• Correct oil level

Troubleshooting Engine Performance

Problem	Cause	Solution
Hard starting (engine cranks normally)	• Faulty engine control system component	• Repair or replace as necessary
	• Faulty fuel pump	• Replace fuel pump
	• Faulty fuel system component	• Repair or replace as necessary
	• Faulty ignition coil	• Test and replace as necessary
	• Improper spark plug gap	• Adjust gap
	• Incorrect ignition timing	• Adjust timing
	• Incorrect valve timing	• Check valve timing; repair as necessary
Rough idle or stalling	• Incorrect curb or fast idle speed	• Adjust curb or fast idle speed (If possible)
	• Incorrect ignition timing	• Adjust timing to specification
	• Improper feedback system operation	• Refer to Chapter 4
	• Faulty EGR valve operation	• Test EGR system and replace as necessary
	• Faulty PCV valve air flow	• Test PCV valve and replace as necessary
	• Faulty TAC vacuum motor or valve	• Repair as necessary
	• Air leak into manifold vacuum	• Inspect manifold vacuum connections and repair as necessary
	• Faulty distributor rotor or cap	• Replace rotor or cap (Distributor systems only)
	• Improperly seated valves	• Test cylinder compression, repair as necessary
	• Incorrect ignition wiring	• Inspect wiring and correct as necessary
	• Faulty ignition coil	• Test coil and replace as necessary
	• Restricted air vent or idle passages	• Clean passages
	• Restricted air cleaner	• Clean or replace air cleaner filter element
Faulty low-speed operation	• Restricted idle air vents and passages	• Clean air vents and passages
	• Restricted air cleaner	• Clean or replace air cleaner filter element
	• Faulty spark plugs	• Clean or replace spark plugs
	• Dirty, corroded, or loose ignition secondary circuit wire connections	• Clean or tighten secondary circuit wire connections
	• Improper feedback system operation	• Refer to Chapter 4
	• Faulty ignition coil high voltage wire	• Replace ignition coil high voltage wire (Distributor systems only)
	• Faulty distributor cap	• Replace cap (Distributor systems only)
Faulty acceleration	• Incorrect ignition timing	• Adjust timing
	• Faulty fuel system component	• Repair or replace as necessary
	• Faulty spark plug(s)	• Clean or replace spark plug(s)
	• Improperly seated valves	• Test cylinder compression, repair as necessary
	• Faulty ignition coil	• Test coil and replace as necessary

Troubleshooting Engine Performance

Problem	Cause	Solution
Faulty acceleration (cont.)	• Improper feedback system operation	• Refer to Chapter 4
Faulty high speed operation	• Incorrect ignition timing	• Adjust timing (if possible)
	• Faulty advance mechanism	• Check advance mechanism and repair as necessary (Distributor systems only)
	• Low fuel pump volume	• Replace fuel pump
	• Wrong spark plug air gap or wrong plug	• Adjust air gap or install correct plug
	• Partially restricted exhaust manifold, exhaust pipe, catalytic converter, muffler, or tailpipe	• Eliminate restriction
	• Restricted vacuum passages	• Clean passages
	• Restricted air cleaner	• Cleaner or replace filter element as necessary
	• Faulty distributor rotor or cap	• Replace rotor or cap (Distributor systems only)
	• Faulty ignition coil	• Test coil and replace as necessary
	• Improperly seated valve(s)	• Test cylinder compression, repair as necessary
	• Faulty valve spring(s)	• Inspect and test valve spring tension, replace as necessary
	• Incorrect valve timing	• Check valve timing and repair as necessary
	• Intake manifold restricted	• Remove restriction or replace manifold
	• Worn distributor shaft	• Replace shaft (Distributor systems only)
	• Improper feedback system operation	• Refer to Chapter 4
Misfire at all speeds	• Faulty spark plug(s)	• Clean or relace spark plug(s)
	• Faulty spark plug wire(s)	• Replace as necessary
	• Faulty distributor cap or rotor	• Replace cap or rotor (Distributor systems only)
	• Faulty ignition coil	• Test coil and replace as necessary
	• Primary ignition circuit shorted or open intermittently	• Troubleshoot primary circuit and repair as necessary
	• Improperly seated valve(s)	• Test cylinder compression, repair as necessary
	• Faulty hydraulic tappet(s)	• Clean or replace tappet(s)
	• Improper feedback system operation	• Refer to Chapter 4
	• Faulty valve spring(s)	• Inspect and test valve spring tension, repair as necessary
	• Worn camshaft lobes	• Replace camshaft
	• Air leak into manifold	• Check manifold vacuum and repair as necessary
	• Fuel pump volume or pressure low	• Replace fuel pump
	• Blown cylinder head gasket	• Replace gasket
	• Intake or exhaust manifold passage(s) restricted	• Pass chain through passage(s) and repair as necessary
Power not up to normal	• Incorrect ignition timing	• Adjust timing
	• Faulty distributor rotor	• Replace rotor (Distributor systems only)

Troubleshooting Engine Performance

Problem	Cause	Solution
Power not up to normal (cont.)	• Incorrect spark plug gap	• Adjust gap
	• Faulty fuel pump	• Replace fuel pump
	• Faulty fuel pump	• Replace fuel pump
	• Incorrect valve timing	• Check valve timing and repair as necessary
	• Faulty ignition coil	• Test coil and replace as necessary
	• Faulty ignition wires	• Test wires and replace as necessary
	• Improperly seated valves	• Test cylinder compression and repair as necessary
	• Blown cylinder head gasket	• Replace gasket
	• Leaking piston rings	• Test compression and repair as necessary
	• Improper feedback system operation	• Refer to Chapter 4
Intake backfire	• Improper ignition timing	• Adjust timing
	• Defective EGR component	• Repair as necessary
	• Defective TAC vacuum motor or valve	• Repair as necessary
Exhaust backfire	• Air leak into manifold vacuum	• Check manifold vacuum and repair as necessary
	• Faulty air injection diverter valve	• Test diverter valve and replace as necessary
	• Exhaust leak	• Locate and eliminate leak
Ping or spark knock	• Incorrect ignition timing	• Adjust timing
	• Distributor advance malfunction	• Inspect advance mechanism and repair as necessary (Distributor systems only)
	• Excessive combustion chamber deposits	• Remove with combustion chamber cleaner
	• Air leak into manifold vacuum	• Check manifold vacuum and repair as necessary
	• Excessively high compression	• Test compression and repair as necessary
	• Fuel octane rating excessively low	• Try alternate fuel source
	• Sharp edges in combustion chamber	• Grind smooth
	• EGR valve not functioning properly	• Test EGR system and replace as necessary
Surging (at cruising to top speeds)	• Low fuel pump pressure or volume	• Replace fuel pump
	• Improper PCV valve air flow	• Test PCV valve and replace as necessary
	• Air leak into manifold vacuum	• Check manifold vacuum and repair as necessary
	• Incorrect spark advance	• Test and replace as necessary
	• Restricted fuel filter	• Replace fuel filter
	• Restricted air cleaner	• Clean or replace air cleaner filter element
	• EGR valve not functioning properly	• Test EGR system and replace as necessary
	• Improper feedback system operation	• Refer to Chapter 4

Troubleshooting the Serpentine Drive Belt

Problem	Cause	Solution
Tension sheeting fabric failure (woven fabric on outside circumference of belt has cracked or separated from body of belt)	• Grooved or backside idler pulley diameters are less than minimum recommended	• Replace pulley(s) not conforming to specification
	• Tension sheeting contacting (rubbing) stationary object	• Correct rubbing condition
	• Excessive heat causing woven fabric to age	• Replace belt
	• Tension sheeting splice has fractured	• Replace belt
Noise (objectional squeal, squeak, or rumble is heard or felt while drive belt is in operation)	• Belt slippage	• Adjust belt
	• Bearing noise	• Locate and repair
	• Belt misalignment	• Align belt/pulley(s)
	• Belt-to-pulley mismatch	• Install correct belt
	• Driven component inducing vibration	• Locate defective driven component and repair
	• System resonant frequency inducing vibration	• Vary belt tension within specifications. Replace belt.
Rib chunking (one or more ribs has separated from belt body)	• Foreign objects imbedded in pulley grooves	• Remove foreign objects from pulley grooves
	• Installation damage	• Replace belt
	• Drive loads in excess of design specifications	• Adjust belt tension
	• Insufficient internal belt adhesion	• Replace belt
Rib or belt wear (belt ribs contact bottom of pulley grooves)	• Pulley(s) misaligned	• Align pulley(s)
	• Mismatch of belt and pulley groove widths	• Replace belt
	• Abrasive environment	• Replace belt
	• Rusted pulley(s)	• Clean rust from pulley(s)
	• Sharp or jagged pulley groove tips	• Replace pulley
	• Rubber deteriorated	• Replace belt
Longitudinal belt cracking (cracks between two ribs)	• Belt has mistracked from pulley groove	• Replace belt
	• Pulley groove tip has worn away rubber-to-tensile member	• Replace belt
Belt slips	• Belt slipping because of insufficient tension	• Adjust tension
	• Belt or pulley subjected to substance (belt dressing, oil, ethylene glycol) that has reduced friction	• Replace belt and clean pulleys
	• Driven component bearing failure	• Replace faulty component bearing
	• Belt glazed and hardened from heat and excessive slippage	• Replace belt
"Groove jumping" (belt does not maintain correct position on pulley, or turns over and/or runs off pulleys)	• Insufficient belt tension	• Adjust belt tension
	• Pulley(s) not within design tolerance	• Replace pulley(s)
	• Foreign object(s) in grooves	• Remove foreign objects from grooves

Troubleshooting the Serpentine Drive Belt

Problem	Cause	Solution
"Groove jumping" (belt does not maintain correct position on pulley, or turns over and/or runs off pulleys)	• Excessive belt speed	• Avoid excessive engine acceleration
	• Pulley misalignment	• Align pulley(s)
	• Belt-to-pulley profile mismatched	• Install correct belt
	• Belt cordline is distorted	• Replace belt
Belt broken (Note: identify and correct problem before replacement belt is installed)	• Excessive tension	• Replace belt and adjust tension to specification
	• Tensile members damaged during belt installation	• Replace belt
	• Belt turnover	• Replace belt
	• Severe pulley misalignment	• Align pulley(s)
	• Bracket, pulley, or bearing failure	• Replace defective component and belt
Cord edge failure (tensile member exposed at edges of belt or separated from belt body)	• Excessive tension	• Adjust belt tension
	• Drive pulley misalignment	• Align pulley
	• Belt contacting stationary object	• Correct as necessary
	• Pulley irregularities	• Replace pulley
	• Improper pulley construction	• Replace pulley
	• Insufficient adhesion between tensile member and rubber matrix	• Replace belt and adjust tension to specifications
Sporadic rib cracking (multiple cracks in belt ribs at random intervals)	• Ribbed pulley(s) diameter less than minimum specification	• Replace pulley(s)
	• Backside bend flat pulley(s) diameter less than minimum	• Replace pulley(s)
	• Excessive heat condition causing rubber to harden	• Correct heat condition as necessary
	• Excessive belt thickness	• Replace belt
	• Belt overcured	• Replace belt
	• Excessive tension	• Adjust belt tension

Troubleshooting the Cooling System

Problem	Cause	Solution
High temperature gauge indication—overheating	• Coolant level low	• Replenish coolant
	• Improper fan operation	• Repair or replace as necessary
	• Radiator hose(s) collapsed	• Replace hose(s)
	• Radiator airflow blocked	• Remove restriction (bug screen, fog lamps, etc.)
	• Faulty pressure cap	• Replace pressure cap
	• Ignition timing incorrect	• Adjust ignition timing
	• Air trapped in cooling system	• Purge air
	• Heavy traffic driving	• Operate at fast idle in neutral intermittently to cool engine
	• Incorrect cooling system component(s) installed	• Install proper component(s)
	• Faulty thermostat	• Replace thermostat
	• Water pump shaft broken or impeller loose	• Replace water pump
	• Radiator tubes clogged	• Flush radiator
	• Cooling system clogged	• Flush system
	• Casting flash in cooling passages	• Repair or replace as necessary. Flash may be visible by removing cooling system components or removing core plugs.
	• Brakes dragging	• Repair brakes
	• Excessive engine friction	• Repair engine
	• Antifreeze concentration over 68%	• Lower antifreeze concentration percentage
	• Missing air seals	• Replace air seals
	• Faulty gauge or sending unit	• Repair or replace faulty component
	• Loss of coolant flow caused by leakage or foaming	• Repair or replace leaking component, replace coolant
	• Viscous fan drive failed	• Replace unit
Low temperature indication—undercooling	• Thermostat stuck open	• Replace thermostat
	• Faulty gauge or sending unit	• Repair or replace faulty component
Coolant loss—boilover	• Overfilled cooling system	• Reduce coolant level to proper specification
	• Quick shutdown after hard (hot) run	• Allow engine to run at fast idle prior to shutdown
	• Air in system resulting in occasional "burping" of coolant	• Purge system
	• Insufficient antifreeze allowing coolant boiling point to be too low	• Add antifreeze to raise boiling point
	• Antifreeze deteriorated because of age or contamination	• Replace coolant
	• Leaks due to loose hose clamps, loose nuts, bolts, drain plugs, faulty hoses, or defective radiator	• Pressure test system to locate source of leak(s) then repair as necessary

1992 Volvo 940

Submodel: | **Engine Type:** L4 | **Liters:** 2.3
Fuel Delivery: FI | **Fuel:** GAS

Now that the engine is installed and every wire and hose is properly connected, go back and double check that all coolant and vacuum hoses are connected. Check that you oil drain plug is installed and properly tightened. If not already done, install a new oil filter onto the engine. Fill the crankcase with the proper amount and grade of engine oil. Fill the cooling system with a 50/50 mixture of coolant/water.

1. Connect the vehicle battery.
2. Start the engine. Keep your eye on your oil pressure indicator; if it does not indicate oil pressure within 10 seconds of starting, turn the vehicle off.

   WARNING
   Damage to the engine can result if it is allowed to run with no oil pressure. Check the engine oil level to make sure that it is full. Check for any leaks and if found, repair the leaks before continuing. If there is still no indication of oil pressure, you may need to prime the system.

3. Confirm that there are no fluid leaks (oil or other).
4. Allow the engine to reach normal operating temperature (the upper radiator hose will be hot to the touch).
5. If necessary, set the ignition timing.
6. Install any remaining components such as the air cleaner (if removed for ignition timing) or body panels which were removed.