Automotive Technology
Module 4: Engine Repair
Student Reference

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FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts, and professionalism to develop curriculum for trade, technical, and industrial education programs. The *Introduction to Automotive Technology* module is an outstanding example of what can be accomplished when the right people with the right attitude work together. The curriculum writers and subject matter experts who worked on this guide are to be commended for a job well done.

The module's format has been developed for competency-based teaching and testing. All major components of the module have been keyed to the IML's Automotive Technology Competency Profile.

The format and curriculum management system found in this module may be new to many vocational educators. However, we are confident that, when used as designed, this module will allow for a more productive and rewarding educational experience for both the teacher and the student. Automotive technology, like many technical fields, is undergoing constant and considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

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ACKNOWLEDGMENTS

The 1996 revision of *Introduction to Automotive Technology* is the first of nine modules to make up the Automotive Technology Curriculum Guide. Produced by the Instructional Materials Laboratory (IML), the guide represents IML's commitment to continual improvement of the Missouri Automotive Technology Curriculum. All modules in the guide are based on the Auto Mechanics Technology Competency Profile, which in turn is based on and cross-referenced to the ASE task list. For years ASE has set the professional standards for automotive technicians. Therefore, a strong ASE orientation makes the guide an effective tool for preparing students to enter the technological advanced field of automotive technology.

IML gratefully acknowledges the important contribution of the advisory committee, which, among other tasks, developed the competency profile for the guide. The advisory committee members are listed below:

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HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Cross-Reference Table

The cross-reference table can quickly reveal how competencies relate to instructional objectives, job sheets, and test items.

Objectives

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent.

Information sheets

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. The corresponding student reference page number appears in the upper right hand corner of the Instructor Guide.

Tests

Tests evaluate students knowledge of the material.

Assignment Sheets

Assignment sheets allow students to respond to cognitive questions in writing.

Job Sheets

Job sheets are designed to guide students through various key tasks. Job sheets also provide a means for instructors to evaluate a student's performance of the task.

Suggested Activities

Students should perform the following activities:

1. Read objective sheet.
2. Study information sheets.
3. Take unit test.
4. Do job sheet(s).

CONTENTS OF
MODULE 4: ENGINE REPAIR

MODULE: ENGINE REPAIR

UNIT I: ENGINE DESIGN

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the parts and operation of an internal combustion engine. The student will demonstrate mastery of the material by achieving a score of _____ on the unit test.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with internal combustion engine construction and operation (all competencies in the Engine Repair Module, Unit I Test).

II. Identify the components of a typical internal combustion engine (all competencies in the Engine Repair Module, Unit I Test).

III. Identify the operation of the four-stroke-cycle internal combustion engine (all competencies in the Engine Repair Module, Unit I Test).

IV. Identify basic types of engines (all competencies in the Engine Repair Module, Unit I Test).

MODULE: ENGINE REPAIR

UNIT I: ENGINE DESIGN

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT I: ENGINE DESIGN

LESSON 1: PRINCIPLES OF ENGINE DESIGN

I. Terms and definitions

A. Aluminum alloy—Aluminum that has other metals mixed with it.

B. Bearing—Any device that allows movement between two objects while supporting the position of the objects. For example, bearings are used to hold a shaft in position while allowing the shaft to rotate.

C. Cam—A portion of a shaft that is out-of-round. Because it is out-of-round, the cam can move another part that is resting against it.

D. Cast aluminum—Aluminum that is heated to its molten state and poured into a forming mold.

E. Cast iron—Iron that is heated to its molten state and poured into a forming mold.

F. Cooling system—A system that maintains the correct engine temperature. Cooling systems usually use fluid and/or air.

G. Crank—A shaft that is offset. The portion of the shaft that is offset can be used to gain a mechanical advantage in turning the shaft.

H. Cycle—A term that refers to a repetitive function of a mechanical system. The cycle is a function that is performed repeatedly.

I. Cylinder—The piston chamber within an engine block. The cylinder contains the piston. The piston moves within the cylinder as the engine operates.

J. Diesel engine—A reciprocating piston engine that uses the compression stroke to provide enough heat to initiate ignition. The diesel engine does not use an electrical ignition system; however, the diesel engine can use glow plugs to facilitate starting.

K. Forged steel—Steel that is formed by pressure while still in solid form. Forged steel is heated enough to make it soft. Once soft, the steel is formed and then cooled.

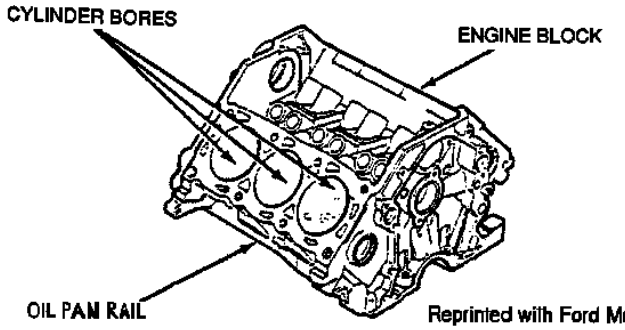
L. Fuel—A chemical that is used to generate the heat required to operate an engine.

M. Gasoline engine—A reciprocating piston engine that relies on an ignition system to ignite the fuel.

II. The components of a typical internal combustion engine

A. Components of the short block include the following: cylinder block, crankshaft, piston and rod assembly, camshaft and timing set.

1. The cylinder block is made from cast iron or cast aluminum. The cylinder block is usually cast in one piece. The block contains the bearings that support the crankshaft and the cylinders within which the pistons move. In liquid-cooled engines, the block contains the water jacket. The block is the foundation for the short block assembly.



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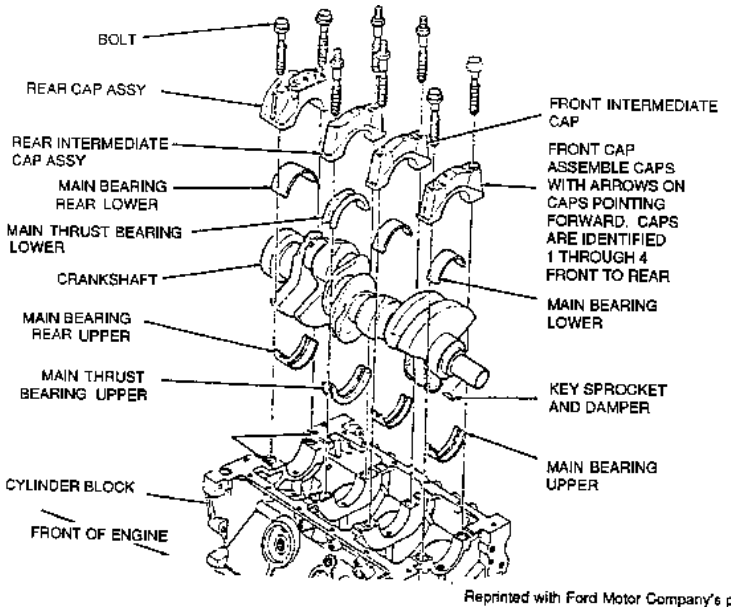
2. The crankshaft converts the reciprocating (up-and-down) motion of the pistons and rods into rotating motion. The crankshaft is located near the center of the short block assembly. Because it is mounted in bearings, the crankshaft can rotate freely within the short block assembly. The crankshaft is also connected to the piston and rod assembly with bearings. The bearings allow each connecting rod to rotate freely on the crankshaft as it turns.



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3. The piston and rod assembly

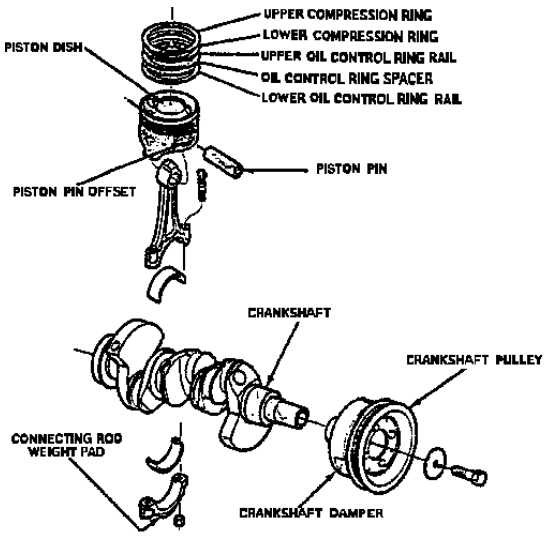
   a. The piston and rod assembly absorbs the power released when the fuel is ignited. The piston is usually made of an aluminum alloy and is usually cam ground so that it fits the cylinder properly when it reaches its operating temperature.

   b. The piston usually contains three piston rings: the bottom ring controls oil flow to the cylinder wall; the other two rings seal the combustion chamber during engine operation. The piston is connected to the other parts of the engine with a piston pin or wrist pin.

   c. The connecting rod assembly (usually made from forged steel) connects the piston to the crankshaft and transmits the energy created by the exploding fuel mixture to the crankshaft.

   d. The “small” end of the connecting rod is connected to the piston by a piston pin.

   e. The lower end (the big end) of the connecting rod contains the rod bearing. The rod bearing allows the rod to be fastened to the crankshaft while still allowing it to rotate.



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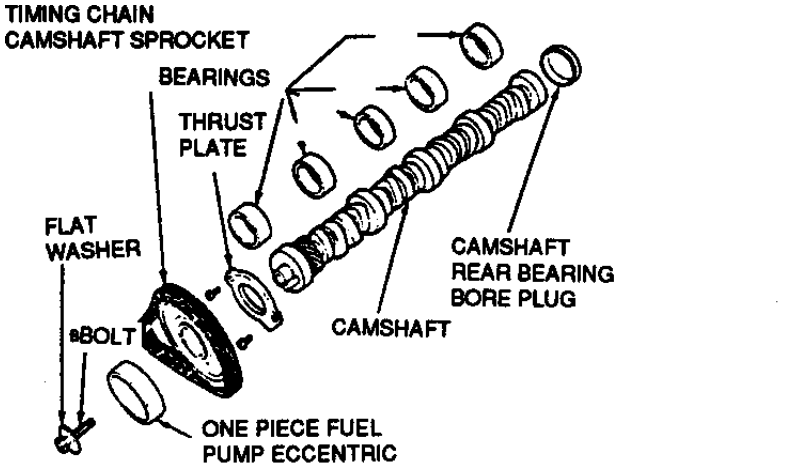
4. Camshaft and timing set

   a. The camshaft operates the engine’s valves. These valves channel the fuel mixture into the cylinders and remove the exhaust products from the cylinders. In some engines, the camshaft is located in units other than the short block; if this is the case, the camshaft will be covered by the unit in which it is located.

b. The camshaft is often responsible for other functions. In diesel engines, the camshaft operates the fuel pump, the oil pump, and the vacuum pump. In gasoline engines, the camshaft may also operate the distributor.

c. Either a chain, a belt, or gears drive the camshaft at one half the speed of the crankshaft. The chain and its sprockets, the gears, or the belt and its sprockets are referred to as the "timing set." Therefore, the timing set includes all components used to drive the camshaft.

d. When located in the block assembly, the camshaft is usually located in the central portion above the crankshaft. If not located in the short block, the camshaft can be found in the cylinder head.



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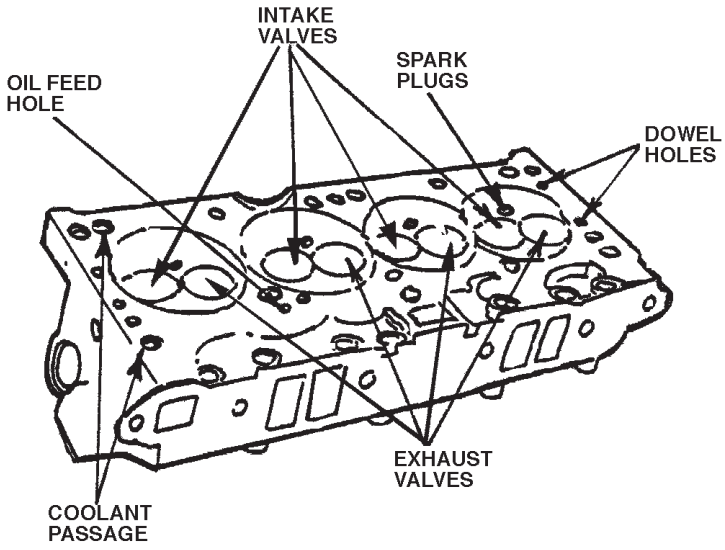
B. Cylinder head assembly

1. Cylinder heads are usually made from cast iron or cast aluminum. In in-line engines, there is only one cylinder head. In vee or opposed engines, there are two cylinder heads.

2. The cylinder heads are located on the top of the cylinders. In gasoline-powered engines, the head (or heads) contains the ignition system parts. In diesel engines, the heads contain the glow plugs.

3. In many engines, a large portion of the valve train will be located in the cylinder head. Many of the cooling system components may also be located in the cylinder head, such as inlet housing, thermostat, and water jacket.



C. Valve train assembly

1. The valve train assembly is responsible for transmitting the valve signals from the camshaft to the engine valves.

2. In some vehicles, the entire valve train is located in the short block assembly. In other vehicles, the entire valve train is located in the cylinder head.

3. Valve train components include, but are not limited to, the following parts:

   a. Valve lifters (tappets)

   b. Push rods

   c. Rocker arms

   d. Rocker shafts or studs

   e. Valves

   f. Valve keepers

   g. Valve springs and other attachment parts

   h. Valve seats

III. Operation of the four-stroke-cycle internal combustion engine

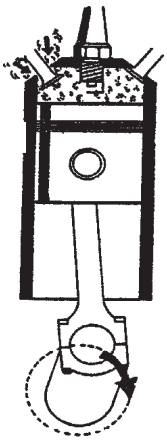
A. Most modern vehicles use four-stroke-cycle internal combustion engines. Over the years, vehicles have used other types of engines, such as rotary piston, turbine, external combustion (steam), and electrical engines. This discussion will focus on the four-stroke-cycle internal combustion engine.

B. The operation of the modern automobile engine can be illustrated by examining a complete cycle of the piston within the cylinder. The four strokes of the cylinder during an engine cycle are: the intake stroke, the compression stroke, the power stroke, and the exhaust stroke. The following description will involve only one of the cylinders. It can be assumed that all of the cylinders in the engine will function in the same manner.

1. The intake stroke

a. The intake stroke is a downward stroke. During the intake stroke, the intake valve is open and the exhaust valve is closed. The downward movement of the piston (which is caused by the rotation of the crankshaft) will draw the air/fuel mixture into the cylinder.

b. The crankshaft must rotate approximately 180 degrees and the camshaft must rotate approximately 90 degrees in order to complete the intake stroke.

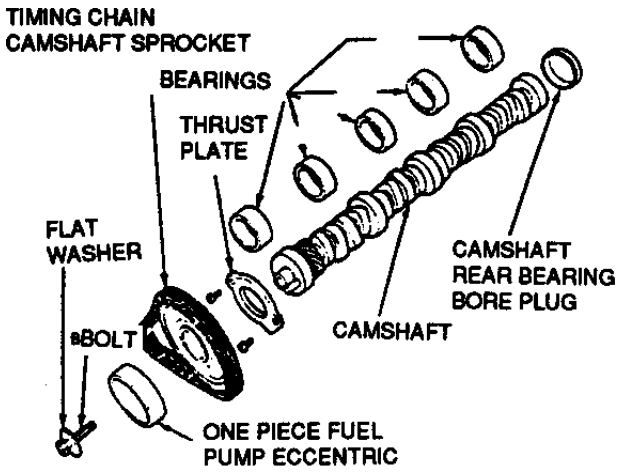


2. The compression stroke

a. The compression stroke is an upward stroke. Both valves will be closed during the compression stroke.

b. During the compression stroke, the upward movement of the piston (also caused by the rotating crankshaft) compresses the air/fuel mixture, which was introduced into the cylinder during the intake stroke.

c. The crankshaft must rotate approximately 180 degrees and the camshaft must rotate approximately 90 degrees in order to complete the compression



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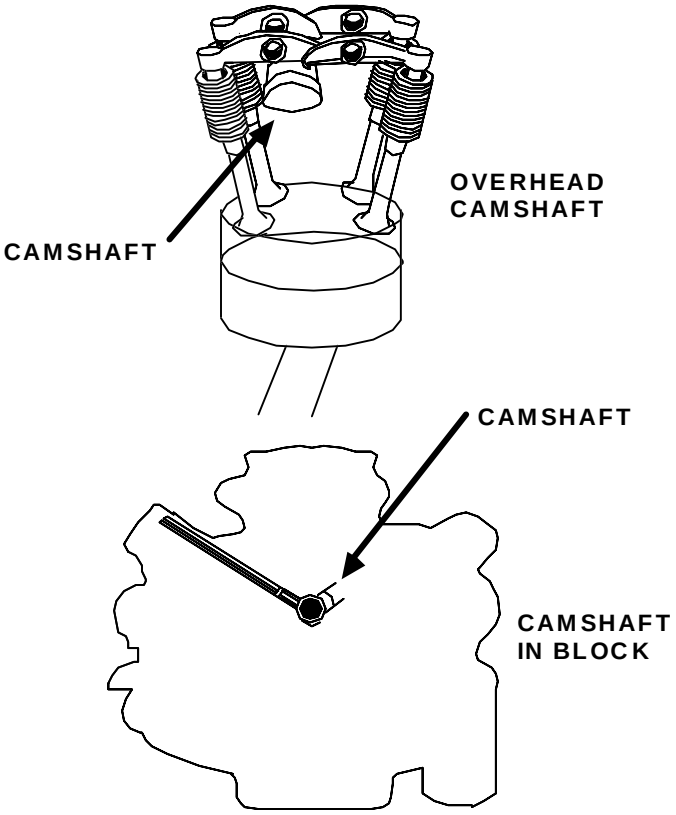

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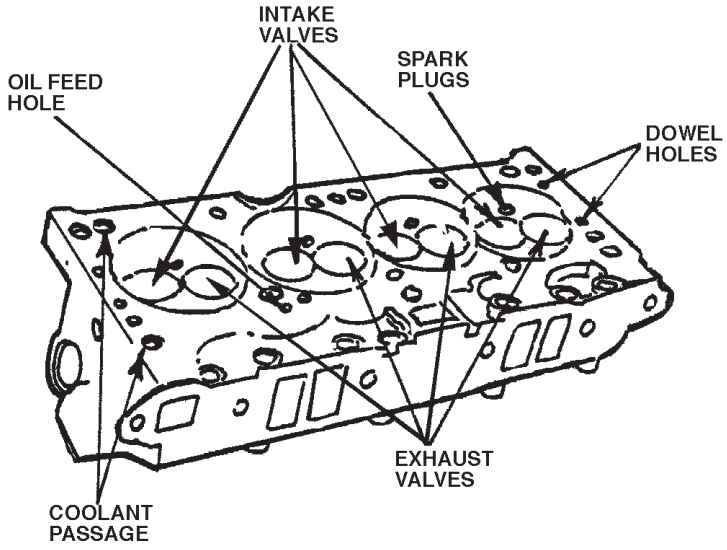

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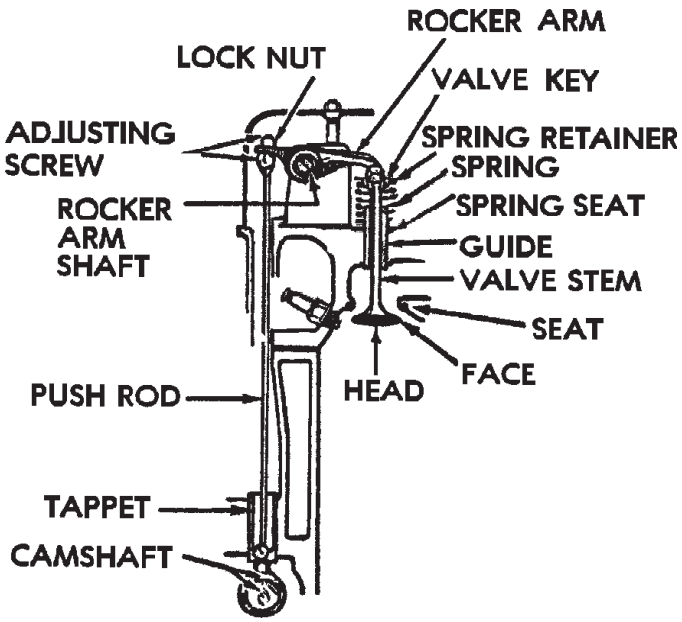

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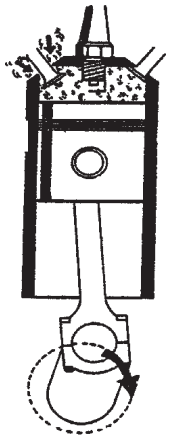

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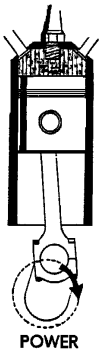
   c. The crankshaft must rotate approximately 180 degrees and the camshaft must rotate approximately 90 degrees in order to complete the compression stroke.

3. The power stroke

   a. The power stroke is a downward stroke. Both the intake and exhaust valves are closed during the power stroke. It is the only stroke in the cycle that produces power. The power stroke supplies the power that moves the piston through all the other strokes in the cycle and ultimately moves the vehicle.

   b. The power stroke begins with the ignition of the air/fuel mixture in the cylinder. Ignition produces a flame in the cylinder.

   c. As the flame travels across the cylinder (the combustion chamber), the pressure within the cylinder rapidly increases, exerting a high pressure on the cylinder's internal surfaces. One of the surfaces on which pressure is exerted is the top of the piston. This pressure drives the piston downward, causing the piston to drive the crankshaft through 180 degrees of rotation.



4. The exhaust stroke

a. The exhaust stroke is an upward stroke. The exhaust valve is open during the exhaust stroke and the intake valve will be closed.

b. The upward movement of the piston during the exhaust stroke (which is caused by the rotating crankshaft) clears the combustion residue from the cylinder and forces it out through the exhaust valve.

c. During the exhaust stroke, the crankshaft rotates the final 180 degrees of the cycle.

(NOTE: Remember that all of the cylinders will be working during each cycle and will deliver their power strokes to the crankshaft. The number of cylinders in the engine will determine the number of power strokes delivered to the crankshaft during the cycle.)

IV. Basic types of engines

(Engines are often classified according to the following characteristics: number of cylinders used; cylinder arrangement; valve arrangement; type of fuel used [i.e., gasoline or diesel]; type of induction system used; and type of cooling system used.)

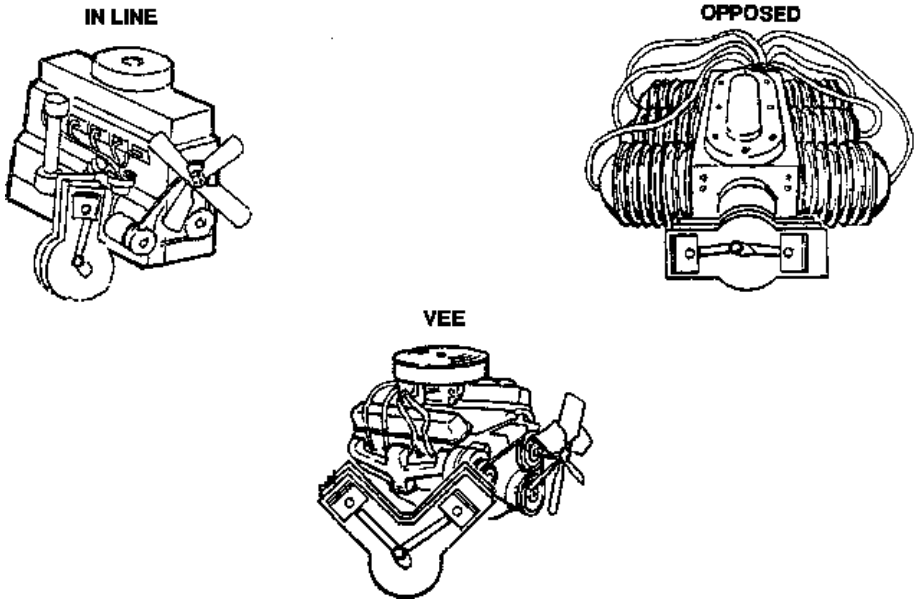
A. Most modern automobile engines have no fewer than four or no more than eight cylinders.

B. The cylinders can be arranged in an in-line, a vee, or an opposed (flat) pattern.

1. In the in-line pattern, one cylinder is placed behind the other in a row.

2. In the vee pattern, the cylinders are placed in two rows. These rows are arranged in either a side-by-side or angled pattern so that all pistons can be connected to the same crankshaft.

3. In the opposed pattern, the cylinders are placed horizontally on either side of the crankshaft. Engines using the opposed pattern are usually air cooled.



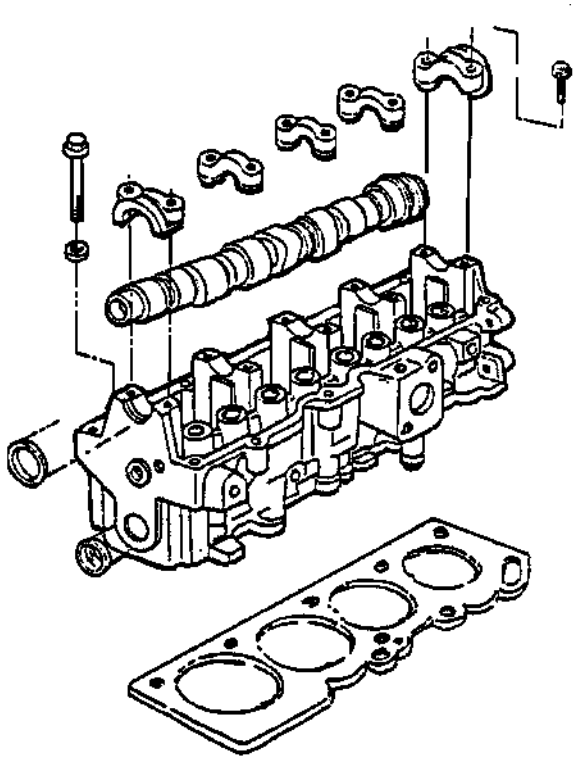
C. Automotive engine valves can be located in the head (I- head design), in the block (L-head design), and can be actuated by a cam in block or single or dual overhead cams.

(NOTE: Some new engines use four or more valves in each cylinder.)

1. If the valves are located in the cylinder head, then thecamshaft can be located in the block.

2. In the L-head design, the entire valve train is located in the block.

3. With an overhead cam, the entire valve train is located in the cylinder head.



4. With dual overhead cams, the entire valve train is located in the cylinder head; however, the intake valves and the exhaust valves are operated by separate cam shafts.

D. Engines can be classified by the fuel they use— usually either gasoline or diesel.

E. Engines can be classified by the induction system they use. Engines may use atmospheric, supercharged, turbo-charged, carbureted, or injected induction systems.

1. Atmospheric induction systems (as their name implies) use only atmospheric pressure for induction.

2. Supercharged induction systems use a belt driven pump to help force air into the system, causing the induction pressure to become greater than atmospheric pressure in certain operating conditions.

3. Turbo-charged induction systems operate much like supercharged systems except that the induction pump is driven by gases from the exhaust system.

4. In carbureted induction systems, fuel is introduced into the engine through a carburetor.

5. In injection induction systems, fuel is introduced by injection; in TBI systems, fuel is introduced at the throttle body; in PFI systems, fuel is introduced at the intake port; in DFI systems, fuel is introduced directly into the cylinder.

F. Engines can be classified according to the type of cooling system they use. Most automotive engines are either air cooled or liquid cooled.

MODULE: ENGINE REPAIR

UNIT II: ENGINE DIAGNOSIS

UNIT OBJECTIVE

After completing this unit, the student should be able to identify and perform various forms of engine diagnosis. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the basic principles of engine diagnosis (Competency M1, Unit II Test).

II. Identify terms and definitions associated with engine performance tests and test results (Competency M1, Unit II Test).

III. Identify normal engine inspection procedures and the order of performing these inspections (Competency M1, Unit II Test).

IV. Identify the procedures for visually inspecting the engine, road testing the vehicle, and listening for engine noises (Competency M1, Unit II Test).

V. Identify the procedures for diagnosing excessive oil consumption, excessive exhaust noise, and inappropriate exhaust color and odor (Competency M1, Unit II Test).

VI. Identify the principles of engine vacuum tests, cylinder power balance tests, cylinder compression tests, and cylinder leakage tests (Competency M1, Unit II Test).

VII. Identify the procedures for diagnosing engine problems revealed by performance tests (Competency M1, Unit II Test).

VIII. Demonstrate the ability to:

a. Perform preliminary engine diagnostic tests (Competency M1, JS1-L1-UII).

b. Perform engine diagnostic tests (Competency M1, JS2-L1-UII).

MODULE: ENGINE REPAIR

UNIT II: ENGINE DIAGNOSIS

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT II: ENGINE DIAGNOSIS

LESSON 1: GENERAL ENGINE DIAGNOSIS

I. Basic principles of engine diagnosis

A. A technician can often improve an engine's performance by making external adjustments. These adjustments can be made on the ignition system, the induction system, and various engine control systems and devices. If the engine has internal defects, however, external adjustments will not improve engine performance. If the engine is worn-out or if some of its internal parts are broken, the engine must be disassembled and measured and the internal parts must be reconditioned or replaced.

B. The technician may perform several tests that can help to identify internal engine problems. Many of these tests are performed after normal tune-up procedures have been completed.

C. Procedures for routine engine tune-up, testing, and adjustment are covered in Module 3, Engine Performance. The technician should perform all routine tests and associated diagnostic procedures before concluding that major engine work is necessary.

II. Terms and definitions associated with engine performance tests and test results

A. Camshaft—A shaft that operates the valves, and can also operate the distributor and the oil pump.

B. Choke—A valve located in the carburetor. The choke restricts airflow into the engine to aid in cold starting.

C. Coking—Solid deposits that form on the valves or in the combustion chamber. These deposits are formed from the residues of oil or fuel.

D. Compression—The process of increasing the pressure upon a gas by reducing the volume of the gas.

E. Connecting rods—In a reciprocating engine, an internal rod that connects the piston to the crankshaft.

F. Coolant—Fluid that carries excessive heat from the engine.

G. Coolant recovery system—A system that removes hot coolant from the cooling system and returns the coolant after the system cools.

H. Cooling system—A system that removes unwanted heat from the engine.

I. Crankcase—A compartment that holds the crankshaft, the oil, the oil pump, etc. The crankcase is located in the lower part of the engine.

J. Crankshaft—A “crank-shaped” shaft that converts the linear motion of the piston into rotating motion.

K. Cylinder—The sleeve in which the piston moves.

L. Cylinder blow-by—Gases that are forced past the piston rings during combustion.

M. Disable—The act of rendering a unit or system inoperative.

N. EGR valve—Exhaust gas recirculating valve. The EGR valve is an emission control device, which controls oxides of nitrogen in the exhaust stream.

O. Emission control system—One of several systems designed to control harmful emissions from the engine.

P. Engine analyzer—An electronic computer that can evaluate the operational characteristics of an engine.

Q. Engine compartment—The area in a vehicle in which the engine is mounted.

R. Engine conditioning—The process of making adjustments on the engine controls in order to improve engine operation. Tune-up is a more common term for engine conditioning.

S. Freeze plugs (core plugs)—Removable plugs located in the engine block and cylinder head.

T. Fuel pump—A pump designed to deliver fuel to the engine.

U. HEI—High Energy Ignition. HEI systems were developed by General Motors.

V. Infrared analyzer—Equipment that uses infrared light to analyze exhaust gases.

W. Intake manifold—Passages that direct the air/fuel mixture from the carburetor to the cylinder head.

X. Oil pan—An engine compartment that contains oil. The oil pan is usually located at the bottom of the engine.

Y. Oil pump—A pump that delivers lubricating oil to the engine.

Z. PCV system—Positive crankcase ventilation system. A system that uses intake manifold vacuum to ventilate the crankcase.

AA. Piston—A moveable engine part that reacts to the combustion of the gases in the engine.

BB. Piston pin (wrist pin)—A pin that connects the piston to the connecting rod.

CC. Primary ignition circuit—A low-tension (12-volt) circuit that the coil uses to create secondary ignition system voltage.

DD. Radiator—A unit that removes heat from the cooling system in liquid-cooled engines.

EE. Relative compression—Cylinder compression that is compared to the highest cylinder compression in the engine.

FF. Rocker arm cover—A metal cover located at the top of the engine.

GG. Rod bearing and journal—The components that connect the connecting rod to the crankshaft.

HH. Secondary ignition circuit—A high-tension circuit that actually fires the spark plug.

II. Sender unit—The component that sends gauge values to the dash instruments.

JJ. Short block assembly—A major portion of the engine. The short block includes the engine block, the crankshaft, the camshaft, the piston and rod assemblies, and all of the core plugs, etc.

KK. Timing chain/belt—The drive line that turns the camshaft.

LL. Translucent—A term used to describe a nontransparent substance through which light can pass.

MM. Vacuum—A pressure that is less than atmospheric pressure.

NN. Vapor—A cloud of liquid droplets.

OO. Water pump—A pump that circulates coolant through the engine. The water pump is usually driven by the engine.

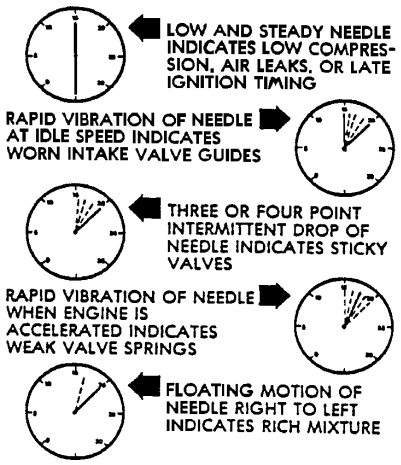
III. Inspecting the engine

A. Before disassembling any part of the engine, visually inspect the engine and prepare a written list of all defects. A visual inspection can be performed with the engine either running or stopped and with the engine either hot or cold.

B. If possible, road test the vehicle before disassembling any part of the engine. Listen for and record any unusual engine noises during the test. The road test should cover all road conditions which may affect the performance of the vehicle.

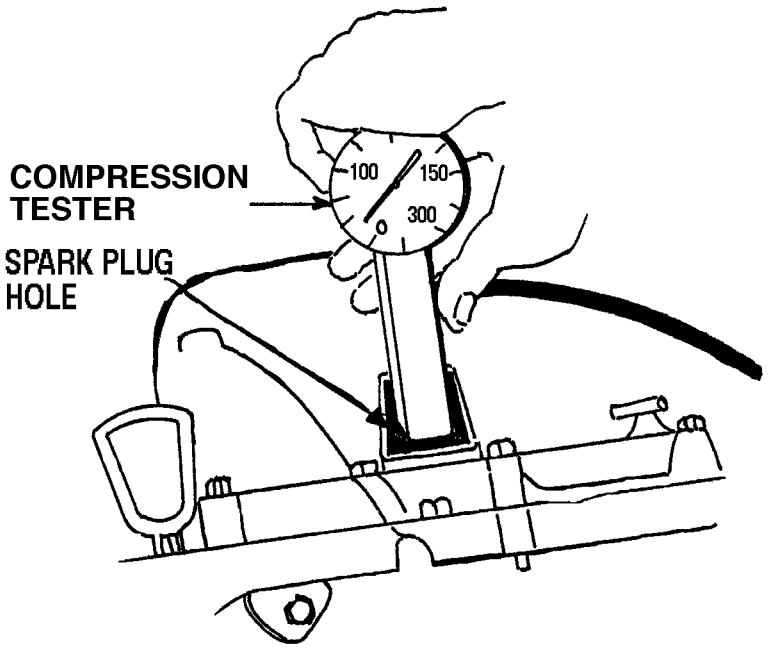
C. Vehicle exhaust can be visually inspected for the following things: the amount and color of smoke and vapor in the exhaust; the sound of the exhaust at various engine speeds; the odor of the gases and vapors in the exhaust. Exhaust gases can also be analyzed with the following electronic equipment: infrared analyzer, two-gas analyzer, or four-gas analyzer. Exhaust gas analysis should be performed during engine tune-up and whenever an internal engine defect is suspected.

D. Vacuum tests are also used to evaluate engine performance. Vacuum is measured at the engine's intake manifold. When determining the internal condition of the engine, the technician should evaluate the vacuum test information carefully.



E. A power balance test is also conducted by the engine analyzer. The power balance test will identify any low-yielding cylinders and provide information concerning the reason for the cylinder problem.

F. Some electronic engine performance analyzers make relative compression tests as part of their general engine analysis. Compression tests are a measurement of the engine's compression taken at each cylinder while the engine is cranking. Compression tests should be taken at each cylinder if internal engine compression leakage is suspected.



G. Cylinder leakage tests will help to determine the exact point of internal leakage. The cylinder leakage test should be performed whenever internal engine leakage is suspected. The leakage test should also be performed prior to engine disassembly.

H. Some tool manufacturers have developed equipment for measuring cylinder blow-by. This equipment is relatively inexpensive and easy to use.

IV. Visually inspecting the engine, road testing the vehicle, and listening for engine noise

A. Procedures for visually inspecting the engine

1. Look for evidence of oil leakage at seals and gaskets.

a. Oil generally flows downward and rearward. If oil is found near the top of the engine compartment, look for leakage above (and possibly in front of) this point.

b. Oil that is covered with dust and dirt is usually old. Such oil may merely be a smear that has built up over time. Fresh oil leakage will be clean and wet.

c. Look for oil blown into the air cleaner by the PCV system. Oil leaking at the front and rear crankshaft seals may be slung by the flywheel, torque converter, or harmonic balancer onto the surfaces adjacent to the seal.

2. Look for evidence of tampering.

a. Look for lines that have been removed or disconnected and plugged. Look for cut belts and disconnected emission control systems.

b. Look very carefully for plugged vacuum lines. In an effort to defeat an EGR valve, some technicians plug the EGR vacuum line with a ball bearing or a piece of lead shot. Plugging lines in such a manner is poor practice. All vacuum lines are essential to the proper operation of the engine.

3. Look for obvious coolant leaks at the water pump, head gaskets, radiator, hoses, and freeze plugs. Look for exceptionally hard or soft hoses. Look for distorted or swollen hoses. Pressurize the cooling system and look again for leakage. Check the system's ability to hold pressure.

4. Look for wiring that is bare, burned, or disconnected.

5. Examine the coolant in the recovery system. The coolant should be clean and translucent. Most brands of coolant are yellowish green in color. If the coolant in the recovery system appears rusty or cloudy, examine the coolant in the radiator. If there is any doubt about the coolant, drain and flush the entire cooling system and replace the coolant with a fresh supply.

6. Examine the oil in the crankcase.

   a. Make sure the oil is at the proper level.

   b. Feel the oil between the fingers. The oil should have body and be clean and slippery.

   c. Smell the oil. If the oil smells like fuel, check for fuel contamination caused either by excessive blow-by or by the fuel pump leaking into the crankcase. Most fuel pumps will leak overboard while they are contaminating the oil. Check for a fuel leak at the bottom of the fuel pump. If the oil is extremely dirty, (black in color) or feels gritty, the oil and the oil filter should be replaced.

7. Start the engine and check for the following:

   a. Check for dynamic leaks in the fuel system at the carburetor, the fuel pump, and the connecting plumbing.

   b. Look for oil leaks at the filter and at the sender unit.

   c. Check for obvious exhaust leaks.

   d. Listen to the engine for knocks, pings, and rattles. Use a mechanic's stethoscope to pinpoint noise locations.

e. If necessary, change the power level at which the engine is operating and listen for noises. The engine can be “loaded” by running it with the transmission in drive and the parking brake applied.

(NOTE: A visual inspection of the engine can be performed without any major disassembly. Visual inspection should be performed as part of a total engine evaluation. The results of the visual inspection can be used to plan for more extensive testing or maintenance procedures.)

B. Procedure for performing a road test

1. The road test should be performed by the technician who will perform the repairs.

2. Ask the vehicle owner to ride along during the road test. The owner can assist in identifying the source of any problems. If the owner cannot come along, then try to get a complete description of the complaint before performing the road test.

3. Drive the vehicle at all speeds and engine power levels that could have a bearing on the owner’s complaint.

(**CAUTION:** Safety should be of prime importance during all road tests. Never drive in an unsafe manner in order to identify a problem.)

C. Evaluating engine noise

1. Locating and evaluating engine noise is a very difficult diagnostic job. A mechanic’s stethoscope can be very helpful in successfully evaluating engine noise. The mechanic’s stethoscope is similar to those used by doctors; the probe of the technician’s stethoscope, however, is a pointed rod instead of a pad. This probe is held against the running engine. The stethoscope can be moved around until the exact location of the noise is determined.

2. Important engine sounds

a. Defective rod bearings will produce a knocking sound. The rod bearing knock will sound loudest at the lower part of the engine. The rod bearing knock will also sound loudest at a particular engine speed. During the road test, the rod bearing knock will be speed sensitive, becoming quieter as speed is increased or decreased. When rod bearing noise becomes more severe, it will tend to lose this “speed sensitivity.”

b. A knock at the piston (wrist) pin will sound somewhat like a rod bearing knock but will be much higher in the engine than the rod knock. In some cases, the location of the knock may be the only way to determine if it is coming from a rod or from a piston pin. In other cases, the rod bearing and piston pin will produce two different types of noises.

(NOTE: Distinguishing between a wrist pin knock and a rod bearing knock is not crucial. To repair either component, the technician will have to disassemble and measure the engine.)

c. A piston slap will sound much like a wrist pin knock. However, unlike a wrist pin knock, a piston slap will quiet down as the engine warms up. Correction of the piston slap will also require engine disassembly and measurement.

d. A main bearing knock will sound more like a dull “thud” than a knock. A main bearing knock will come from lower in the engine. The knock will be loudest when the engine is under a moderate to heavy load.

e. Some engines use timing chains. A twanging sound coming from the front of the engine is usually the result of a noisy timing chain.

f. Valves will sometimes produce a clicking sound that comes from high in the engine. The valve clicking sound will have a higher frequency than a bearing knock.

3. Generally, if internal noises are heard in the lower part of the engine, disassembly of the engine will be required. Noises coming from near the head may be caused by combustion chamber deposits that have come loose and are contacting the tops of the pistons at each stroke. Sometimes when the engine has been rebored, a new head gasket may project into the cylinder enough to contact the tops of the piston. These last two conditions can be corrected without short block disassembly.

V. Diagnosing excessive oil consumption, excessive exhaust noise, and inappropriate exhaust color and odor

A. Diagnosing excessive oil consumption

1. Most vehicle manufacturers consider oil consumption of less than one quart every 1000 miles to be normal. Oil consumption can be reduced below this level but the cost of doing so is very high. The gain in engine performance may not be worth the expense.

2. Oil consumption almost always occurs as a result of oil leaking out of its normal location.

a. Oil may leak out of the engine through a seal or gasket onto the ground. Even a relatively small oil leak can cause the loss of one quart of oil over a thousand miles of vehicle operation. There are approximately 10,000 drops of oil in a quart. If a drop of oil falls to the pavement every 10 feet, the oil consumption rate would be about 1 quart in 200 miles.

b. Oil may be leaking into the combustion chamber or into the induction system where the oil will be burned with the normal air/fuel mixture.

c. Excessive engine blow-by or a fuel leak into the oil pan can dilute the oil.

3. Excessive oil consumption can be stopped by simply locating and eliminating the route by which the oil is leaving the engine. Oil may be leaving the engine by several routes in an older vehicle. For each route that is found and eliminated, oil consumption will be reduced.

4. Usually oil leaks at the engine gaskets are the easiest to find. A visual inspection of the gaskets will usually reveal the problem. Some vehicles require that the engine be removed before the gaskets can be replaced. Check for the proper procedure in the service manual.

5. Procedure for checking for external leaks

   a. Check the rocker cover gaskets first. These gaskets are usually very easy to inspect. It is not uncommon for the engine's only oil leak to be found here.

   b. Check the oil pan gaskets and oil filter. While under the car, look at the areas around the front and rear crankshaft oil seals. In some cases, the engine will have to be removed from the vehicle in order to replace the oil pan gaskets and the crankshaft oil seals.

   c. If the engine is covered with oil, wash it down and then drive the vehicle. Sometimes the crankcase can be pressurized with compressed air by blocking all of the openings with rags and blowing into the crankcase with a blowgun. Oil will leak out with the air.

B. Internal oil leakage

1. Oil can leak into the induction system at many locations in the engine. The technician must be sure to find all leaks and recommend procedures for repairing the leaks. If any leaks are missed, the job will not be completely successful.

2. Oil can enter the intake manifold at any point where oil is close to a leaking intake manifold gasket. Intake manifold vacuum will suck the oil into the manifold and deliver it to the cylinder with the air/fuel mixture.

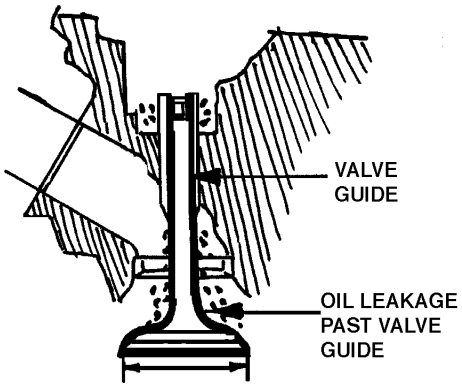
3. Oil can enter the intake runner through defective valve guides.

   a. The intake stroke applies its vacuum directly to the intake valve stem. If the valve stems or valve guides are worn, or if the valve stem seals are defective, oil can be drawn into the intake runner at the cylinder intake port. This oil would then be delivered to the cylinder and burned.

   b. One sign of this condition is a heavy blue smoke coming from the tailpipe immediately after the vehicle is started. The volume of smoke will slowly be reduced as the engine warms.

c. Diagnosis of oil entering the intake runner through defective valve guides can be complicated by a low compression reading on the affected cylinders. The low reading is caused by the oil coking on the backs of the intake valves. A cylinder leakage test will show that compression is at the proper level.

d. The intake valve seals can be replaced without removing the cylinder head. Care should be taken in making this decision because only the seals can be replaced; there may be guide wear present that cannot be repaired without disassembling the cylinder head. The recommended procedure here would be to recondition the cylinder head.



4. Oil can enter the induction system as a result of a vacuum.

   a. At a point between the exhaust stroke and the intake stroke, the exhaust valve will still be open though the piston has reached the top of its stroke. At this point, the weight of the exhaust gases moving out of the engine can pull a vacuum in the combustion chamber. This vacuum is momentary, but can be strong enough to pull oil through the exhaust valve guide. Once pulled through the exhaust valve, the oil will be burned by the hot exhaust gases in the exhaust manifold.

   b. Cylinder head reconditioning can remedy the oil consumption problems created by this vacuum.

5. Oil can enter the combustion chamber through pistons and piston rings.

   a. Worn or broken piston rings can allow oil to be drawn past them into the combustion chamber when it is in a vacuum.

   b. When combustion occurs, gases are blown past the rings into the crankcase, thus pressurizing the crankcase. This pressurization will increase any oil leakage in the engine.

   c. Pistons that are cracked, “holed,” scuffed, or otherwise damaged can result in oil consumption and/or ring damage.

d. Defective pistons or piston rings can cause low compression readings in the affected cylinders. A subsequent cylinder leakage test would also indicate leakage and the air would be heard escaping at the oil fill hole.

e. These problems could be remedied by reconditioning the short block assembly.

C. Diagnosing improper exhaust sound, color, and odor

1. The valve action can often be heard at the tailpipe. If valve leakage is suspected, idle the engine and listen at the tailpipe for a “miss” in the regular pattern of exhaust sound. Listening at the tailpipe should be followed up with other tests to verify suspected problems.

2. Blue smoke coming from the vehicle tailpipe is a sign of oil consumption. However, it should be noted that blue smoke will be visible only when the situation becomes serious.

3. Black smoke is generally caused by rich air/fuel mixtures. This was true of older vehicles. However, the emissions control systems in newer cars can eliminate the black smoke caused by the rich air/fuel problem. If black smoke is seen coming from the tailpipe, a complete test of the exhaust stream should be made using an infrared exhaust analyzer.

4. In vehicles equipped with catalytic converters, a rich air/fuel mixture can sometimes be detected by a “rotten egg” odor at the tailpipe. The presence of this odor does not always indicate a catalytic converter problem. Some high sulphur fuels can produce this odor even when the mixtures are normal.

D. High-mileage engines that consume excessive amounts of oil often have multiple problems. When diagnosing such vehicles, it must be realized that the entire engine assembly will be worn. If any part of the assembly is repaired in order to reduce an oil consumption problem, the repair could cause additional strain to be placed on another part of the engine. High mileage engines are best completely reconditioned the first time; any partial reconditioning may actually increase oil consumption.

VI. The principles of engine vacuum tests, cylinder power balance tests, cylinder compression tests, and cylinder internal leakage tests

(NOTE: Before performing any of the tests described in this section, conduct a thorough visual inspection of the engine. Perform a road test and record all readings.)

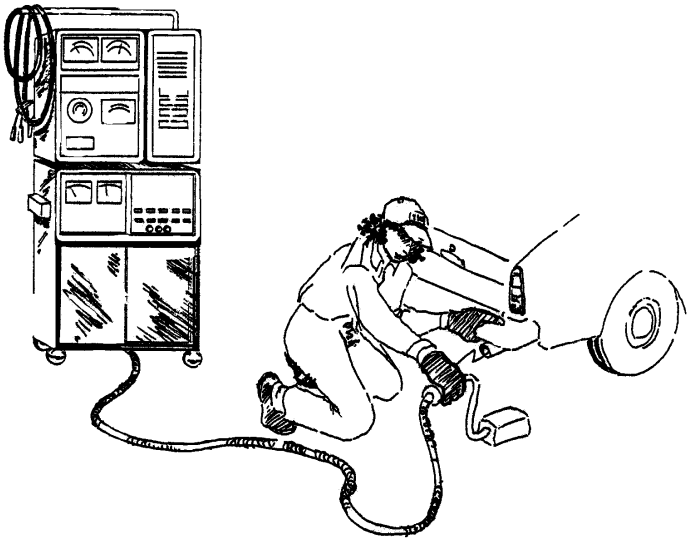
A. Exhaust gas evaluations

1. Because of changes in modern automotive technology, the technician cannot effectively evaluate exhaust gases by merely using sight and smell.

a. In most modern vehicles, air injection systems and catalytic converters alter the gases and vapors found in the exhaust. These gases undergo significant change between the time that they leave the cylinder and the time that they are emitted from the vehicle's tailpipe.

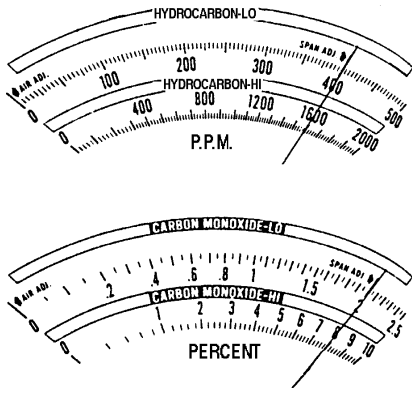
b. Again, a visual analysis of exhaust can be misleading. When the engine is cold, for example, it is not unusual to see large amounts of white vapor in the exhaust. In some cases, an engine with severe internal problems may produce no visible exhaust smoke.

c. Exhaust gas analysis should be performed with an infrared exhaust gas analyzer. The results should be evaluated along with the results of all of the other tests performed.



2. Electronic infrared exhaust gas evaluations are usually a part of the engine tune-up process. Infrared evaluations can be either two-gas or four-gas evaluations.

   a. Two-gas systems evaluate CO (carbon monoxide) and HC (hydrocarbons).



b. Four-gas systems measure the above two gases, plus oxygen, and carbon dioxide.

3. Carbon monoxide forms when fuel burns without sufficient air to support the combustion. High levels of this gas in the exhaust would indicate a rich mixture. A rich mixture would not normally be caused by internal engine problems but rather by a carburetor malfunction.

4. Hydrocarbons are unburned fuel. High levels of hydrocarbons in exhaust gases indicate that the engine is not burning the fuel efficiently. Overly rich air/fuel mixtures, along with several other problems, may cause fuel to burn inefficiently. If hydrocarbon levels are excessively high and carbon monoxide levels remain low, an ignition system problem (possibly a defective spark plug) or an internal engine problem may be causing inefficient combustion. Below is a partial list of these potential internal engine problems.

   (NOTE: High levels of hydrocarbons in exhaust gases can mean internal engine problems other than those listed below. Advance tests may be required before an accurate diagnosis can be made. It is important to diagnose the problem carefully before concluding that major engine service is required.)

   a. Low compression

   b. Excessive oil consumption (which can foul spark plugs)

   c. Cylinder blow-by

   d. Lean mixtures

   e. Late or early ignition or valve timing

   f. Vacuum leaks (which cause lean mixtures)

   g. Leaking valves

5. The amount of oxygen in the exhaust indicates the efficiency of combustion in the cylinders.

    a. Generally speaking, rich mixtures will result in low levels of oxygen in the exhaust because all of the oxygen is consumed during combustion.

    b. In older vehicles, high levels of hydrocarbon and oxygen in the exhaust indicated that the fuel was burning inefficiently within the cylinder. However, most modern vehicles have an air injection system which adds fresh air to the exhaust system. Therefore, the air injection system must be disabled in order to ensure that all of the oxygen being measured in the exhaust actually comes from the cylinders.

    c. Most modern vehicles use catalysts, which cause oxygen and hydrocarbons to react together while in the exhaust system. This reaction alters the levels of oxygen and hydrocarbons in the exhaust. These catalysts also reduce carbon monoxide.

6. Carbon dioxide is a normal product of combustion. Therefore, engine exhaust should contain high levels of carbon dioxide.

7. In general, low levels of carbon monoxide and high levels of hydrocarbons indicate internal engine problems.

8. Exhaust gas analysis can be an important source of information for technicians diagnosing internal engine problems. However, exhaust gas analysis should never be the only source of information. Every diagnosis that is based on exhaust gas analysis should be verified by as many other tests as possible before the engine is disassembled.

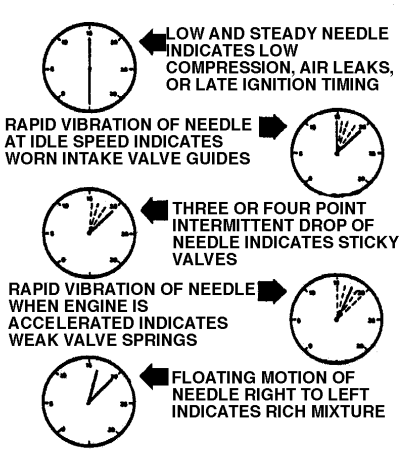
B. Vacuum tests

1. Engine vacuum (manifold vacuum) levels indicate how well an engine is performing.

2. Vacuum measurement is taken at the intake manifold. The vacuum measurements are taken while the engine is running at idle and at off-idle speeds.

3. The vacuum readings should be between 15 and 20 inches of mercury (15" to 20" HG). Vacuum readings should be steady until the throttle is opened abruptly at which time the reading should momentarily decrease and then return to normal.

4. Vacuum readings that are steady but considerably below normal indicate an internal engine problem. Piston ring leakage and late valve and/or ignition timing are likely causes of low vacuum readings. However, these problems have many other potential causes; therefore, these readings should be verified by other tests. Valve leakage will cause fluctuations in the vacuum gauge readings.



C. Power balance tests

1. To perform the power balance test, the technician must disable each of the cylinders one at a time. After disabling a cylinder, the technician must then observe the effect on engine performance. When disabled, weak cylinders will have little or no effect on the engine's performance. (Engine performance is measured by rpm.)

2. The technician can disable the cylinder by shorting the secondary ignition circuit at the spark plug. The technician can then observe the rpm reading on a hand-held tachometer.

   (**CAUTION:** To prevent damage to the catalytic converter, disable the cylinder just long enough to take a tachometer reading. After the reading is taken, allow the engine to run long enough to clean out the catalytic converter before disabling the next cylinder.)

   (**CAUTION:** In a modern automobile, secondary ignition voltage can exceed 100,000 volts. Before attempting to short the secondary ignition circuit, be sure that the shorting wire is grounded before connecting it to the secondary wire.)

   (NOTE: It is usually best to perform the power balance test with an electronic engine analyzer. An electronic engine analyzer uses the primary ignition circuit to disable the cylinders automatically. In most cases, the analyzer records any drop in engine rpm and can display the complete test results when the test is finished.)

D. Compression tests

1. A compression test is performed by screwing a compression gauge into the spark plug hole and cranking the engine with the starter. Though this test has diagnostic value, it also has some limitations that are listed below.

a. All compression test readings will be lower than normal if the throttle and choke valves are not wide open. Throttle and choke valves should, therefore, be blocked or wired wide open prior to beginning the compression test.

b. Restrictions in the intake manifold will result in low compression readings even if the compression in the cylinder is normal. Such restrictions are often caused by coking of fuel or oil residues in the intake manifold passages or on the backs of the intake valves. If such coking has occurred, the problem could be solved by simply reconditioning the cylinder head rather than by rebuilding the entire engine.

c. A worn camshaft could cause low compression readings even though the actual compression in the cylinders is normal.

(NOTE: Engine compression alone should not be used as a basis for disassembling the engine or performing major engine repairs. Engine diagnosis should always be verified by other tests.)

2. Procedure for performing a compression test

(NOTE: Make sure that cranking rpm is maintained throughout the test.)

a. Wire open or block open the throttle and choke valves.

b. Disable the ignition system. Conventional ignition systems can be disabled by removing the coil wire from the distributor cap and connecting it to a good ground.

(NOTE: In HEI systems, the coil wire is not accessible to the technician. When disabling an HEI system, the technician must disconnect the twelve-volt power from the system at the distributor. When disabling other specialized ignition systems such as distributorless ignition systems, follow the manufacturer's instructions.)

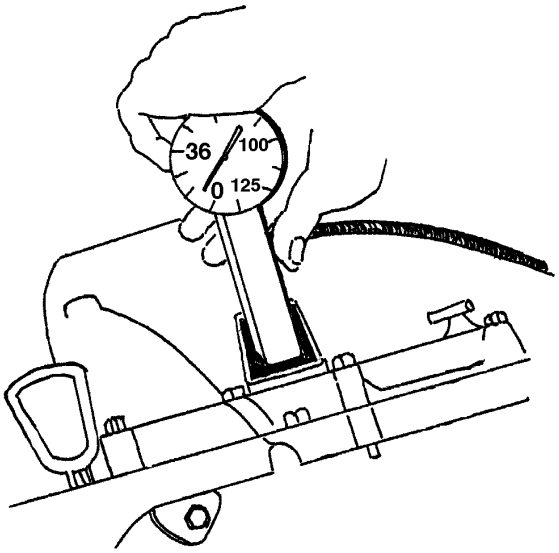
c. Connect a battery charger to the vehicle battery and adjust it to its highest setting.

d. Blow dirt from around the spark plugs.

e. Remove all spark plugs. Keep track of the spark plug locations, and examine the plugs for signs of defects.

(NOTE: Be sure to pull off the secondary wires by the boots rather than by the cable. If there is any doubt about the location of the wires, mark them with masking tape. This may save time later.)

f. Install the compression tester into each spark plug hole in any order and crank the engine through five compressions. Record the highest reading for each cylinder.



g. If any of the cylinders are exceptionally low, perform a “wet” test. The wet test involves squirting about a tablespoon of engine oil into the spark plug hole and measuring the compression as before. If the compression increases when taken wet, it is an indication of leaking piston rings. If there is little or no difference between the two readings, the problem may be leaking valves, a leaking head gasket, etc.

(NOTE: As mentioned before, diagnosis of engine problems should never be based only on one or two tests. Perform as many tests as practically possible when diagnosing an engine.)

E. Cylinder leakage tests

1. Cylinder leakage tests are much more definitive than compression tests. The cylinder leakage tests require more preparation time and are somewhat more difficult to administer. The cylinder leakage tests also require more equipment than the compression and vacuum tests.

2. Procedure for performing cylinder leakage tests

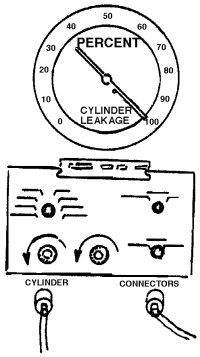
a. Connect a remote starter switch to the engine.

b. Blow dirt from around all spark plugs and remove them. Keep track of the original locations of the plugs. Visually inspect the plugs for signs of oil consumption and oil deposits.

c. Install whistle in spark plug hole and rotate the engine carefully with the starter until the whistle sounds.

d. Rotate the engine by hand to bring the piston in the cylinder (that is to be tested) to its top dead center position. It is very important to position the piston at top dead center; if the top dead center position is missed, the air pressure will kick the engine over and the test will have to be redone. The cylinder can be positioned more easily if either the harmonic balancer or engine flywheel is marked before the test is started.

e. Connect the leakage tester to the cylinder and read the leakage on the gauge provided. There are many types of gauges and a specific procedure for reading each gauge. Generally, if the gauge is calibrated in psi, then the higher the pressure, the lower the leakage. If the gauge is calibrated in percent of leakage, then the lower the reading, the lower the leakage. Study the gauge, and follow the manufacturer's instructions.



f. If the leakage is high, first verify that the engine is still at its top center position and that the gauge is installed in the right cylinder. After making these verifications, listen for escaping air.

g. If air is heard escaping at the carburetor air-horn, the leakage is at the intake valve. If it is heard at the tailpipe, it is an exhaust valve. If it is heard at the oil filler, the rings are leaking. If bubbles are heard at the radiator cap, then the head gasket to the water jacket is blown. If air is heard escaping from an adjacent spark plug hole, then the head gasket is blown between cylinders.

F. Blow-by testing

1. It is now possible to test for the volume of blow-by gases in an engine. New equipment has recently been developed for this purpose.

2. In the blow-by test, the engine crankcase area is closed by blocking the normal PCV passages and other normal openings in the engine. The equipment is then connected to the crankcase. The equipment actually measures the blow-by gases as they are generated by the running engine.

(NOTE: As mentioned before, diagnosis of engine problems should never be based only on one or two tests. Perform as many tests as practically possible when diagnosing an engine.)

VII. Diagnosing engine problems revealed by performance tests

A. Diagnosing an engine that will not start

1. Engine will not crank.

a. Check the starter draw. If the draw is zero, correct the cranking circuit problem.

b. If the starter draw is exceptionally high, check the starter. If the starter is "locked," repair or replace the starter. If the starter is working properly, try turning the engine over by hand. Use a socket on the crankshaft bolt at the front of the engine.

c. If the engine cannot be turned, remove all of the spark plugs and try again. If it still cannot be turned, the engine is locked and will have to be disassembled.

2. Engine cranks but will not start.

a. Check ignition system. If no problems are found in the ignition system, check the fuel system.

b. If the ignition system and fuel system are both without problems, check the timing chain or belt.

c. If the timing chain or belt has no problems, check and, if necessary, correct the engine compression. If engine compression is adequate, check the ignition system, the fuel system, and the timing chain once again. The problem will usually lie in one of these areas; therefore, something may have been missed.

(NOTE: Sometimes a severe flooding condition can foul the spark plugs and give the indications as above. Pull the spark plugs and blow them off with compressed air and try to start the engine again.)

B. Diagnosing an engine that has low power

1. Perform a complete tune-up and correct all problems. If the tune-up shows no specific problems, tune-up the emissions system.

2. If the emission system was tuned-up successfully and no problems with the system were found, examine the timing chain or belt for looseness and check the valve timing and engine compression.

3. If all of the above checks reveal no problems, make sure the exhaust system is not restricted.

a. Remove the exhaust system at the manifold and wire it up.

b. With the exhaust system removed, check the vehicle's power once again. If the vehicle has a normal amount of power after the exhaust is disabled, check the exhaust system for the restriction.

4. If the vehicle's power remains low when the exhaust system is disconnected, check the drive line for binding, the brakes for dragging, etc.

C. Diagnosing an engine that performs poorly (backfires, hesitates, surges, stalls, misfires, produces bad exhaust odor, etc.)

1. Check tune-up.

2. Check electronic engine controls.

3. Check valve timing chain/belt.

D. Diagnosing excessive oil consumption

1. Check oil level.

2. Check PCV system and repair/replace as required.

3. Check for external oil leakage and repair gaskets/seals as required.

4. Check blow-by. Check piston ring leakage. Repair or replace rings as required.

5. Check for loose crankshaft bearings. Replace bearings and/or rework crankshaft as required.

6. Check valve stem seals and valve stem clearances. Rework heads as required.

E. Diagnosing low oil pressure

1. Check oil level and correct as required.

2. Check for faulty oil pressure gauge. Verify pressure using mechanical pressure gauge.

3. Check for diluted oil. Change oil if there is any doubt.

4. Check oil pump, oil pump pick-up screen, and oil pressure relief valve.

5. Check for loose engine crankshaft bearings. If oil pressure is low at idle and becomes normal at cruise rpm, the crankshaft bearings are likely the source of the problem.

F. Diagnosing engine knocks

1. Check and correct oil level. Check for contaminated or diluted oil.

2. Check for and clean out combustion chamber deposits.

3. Check for loose crankshaft bearings.

4. Check piston skirt clearances.

5. Check piston pin clearances.

6. Check and correct valve timing.

7. Check and correct ignition timing.

8. Check and correct valve train looseness. Check and repair/replace valve lifters as required.

G. Diagnosing an engine that overheats

1. Check and correct coolant level. Pressure check system for leaks.

2. Check and clean out foreign material in radiator cooling fins. If vehicle is air conditioned, check for foreign material in condenser fins.

3. Check radiator cap for proper operation.

4. Check and correct engine thermostat.

5. Check all coolant hoses. Check lower hoses for collapsed areas. Replace any hoses that give any indication of defects.

6. Check ignition for late timing.

7. Check for and correct plugged radiator.

JS1-L1-UII

MODULE: ENGINE REPAIR

PERFORMING PRELIMINARY ENGINE DIAGNOSTIC TESTS

Equipment:

Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Assess the driver's complaint. Perform a road test, if necessary. Record observations.

3. Perform a thorough visual inspection of the engine compartment. Give close attention to wiring, coolant hoses, and vacuum hoses. Record observations.

4. Listen to the engine while it is operating both at idle and at various other speeds. Note any unusual noises. Record observations.

5. Observe the color of the exhaust while the engine is idling and, if necessary, while it is running at other speeds. Record observations.

6. Note the odor of the exhaust gases. Record observations.

7. Note engine sounds at the exhaust pipe. Listen for unusual noises. Record observations.

JS2-L1-UII

MODULE: ENGINE REPAIR

PERFORMING ENGINE DIAGNOSTIC TESTS

Equipment:

Common mechanic's hand tools
Vacuum gauge
Engine analyzer with cylinder balance capabilities or a shorting wire
Tachometer
Cylinder leakage tester
Compression tester
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for performing a vacuum test on the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, perform a vacuum test on the vehicle. Record observations.

3. Using a service manual or other information source, locate a procedure for performing a cylinder balance test. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure. Record observations.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, perform a cylinder balance test on the vehicle. Record observations.

4. Using a service manual or other information source, locate a procedure for performing a compression test. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, perform a compression test on the vehicle. Record observations.

5. Using a service manual or other information source, locate a procedure for performing a test for cylinder leakage. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, perform a cylinder leakage test on the vehicle. Record observations.

6. Complete a written evaluation of the condition of the engine based on the above tests. In the evaluation, recommend repairs that would be required to correct any problems revealed by the tests.

MODULE: ENGINE REPAIR

UNIT III: ENGINE REMOVAL

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the procedures and operations needed to remove an engine. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with engine removal (Competency M2, Unit III Test).

II. Identify equipment and safety practices associated with engine removal (Competency M2, Unit III Test).

III. Identify the basic engine removal procedures (Competency M2, Unit III Test).

IV. Identify special removal guidelines for transversely mounted engines in front-wheel-drive vehicles (Competency M2, Unit III Test).

V. Identify general removal guidelines for conventionally mounted engines in rear-wheel-drive vehicles and for transversely mounted engines in front-wheel-drive vehicles (Competency M2, Unit III Test).

VI. Demonstrate the ability to:

   a. Remove a front-wheel-drive engine (Competency M2, JS1-L1-UIII).

   b. Remove a rear-wheel-drive engine (Competency M2, JS2-L1-UIII).

MODULE: ENGINE REPAIR

UNIT III: ENGINE REMOVAL

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT III: ENGINE REMOVAL

LESSON 1: REMOVING ENGINE

I. Terms and definitions associated with engine removal

A. Connector (harness connector)—A disconnecting device with which a number of wires can be connected or disconnected at one time at a central location.

B. Engine assembly—Refers to the engine as it is installed in the vehicle. The engine assembly includes all accessories and fittings associated with it.

C. Engine harness—A bundle of electrical wiring that is usually bound with wrappings or plastic tubing. The harness is usually connected to the vehicle with a harness connector or other type of disconnecting device.

D. Engine mount—A device that serves to fasten the engine assembly to the vehicle.

E. Exhaust manifold—A unit that serves to direct the exhaust gases from the cylinders to the exhaust system.

F. Front-wheel drive—A drive system in which the front wheels provide the force required to move the vehicle.

G. Intake manifold—A unit that serves to direct the induction air or air/fuel mixture to the cylinder head.

H. Rear-wheel drive—A drive system in which the rear wheels of the vehicle provide the force required to move the vehicle.

I. Solid support stands—Supports that have been specially designed to support the vehicle safely for work after it has been lifted by jacking equipment.

J. Transaxle—A unit combining the transmission and final drive. Transaxles have been used in both front wheel drive and rear wheel drive vehicles.

K. Transmission—A unit in the drive line that allows for changing the mechanical advantage of the engine during vehicle operation.

L. Transversely mounted engine—An engine mounted in such a manner that it is facing the side of the vehicle. Transversely mounted engines are often found in front-wheel-drive vehicles.

II. Equipment and safety practices associated with engine removal

A. Equipment needed for major engine removal

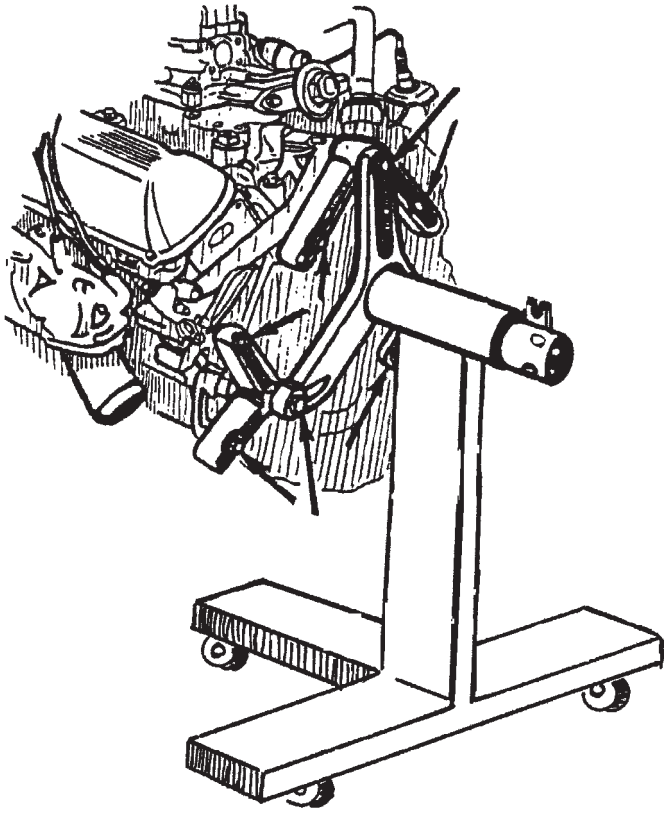
(NOTE: A complete set of common mechanic's hand tools is required for all major engine work. Also required is special equipment for lifting the vehicle, lifting the engine out of the vehicle, and supporting the engine during service.)

1. If a jack is used to lift the vehicle, be sure that solid support stands (safety stands) are placed under the vehicle.

   (**CAUTION:** Never get under a vehicle that has been lifted by a jack unless the vehicle is also supported by safety stands.)

2. The engine assembly could weigh as much as 300 pounds or more. Be sure that the device used to lift the engine is capable of safely supporting the engine assembly. Also be sure that the lifting device (and the cables or chain used to connect the hoist to the engine) can lift the engine assembly high enough to clear the cowl.

3. Many types of engine work stands are available for sale or rent.



B. Follow all the below safety rules when servicing an engine.

1. Wear eye protection at all times.

2. Do not wear loose clothing, jewelry, or other items that may be caught in machinery.

3. Before working underneath the vehicle, make sure that the vehicle is safely supported on a lift or other appropriate equipment. If the vehicle has been lifted with a jack, it should also be supported with safety stands. Never work under a vehicle supported only by a jack.

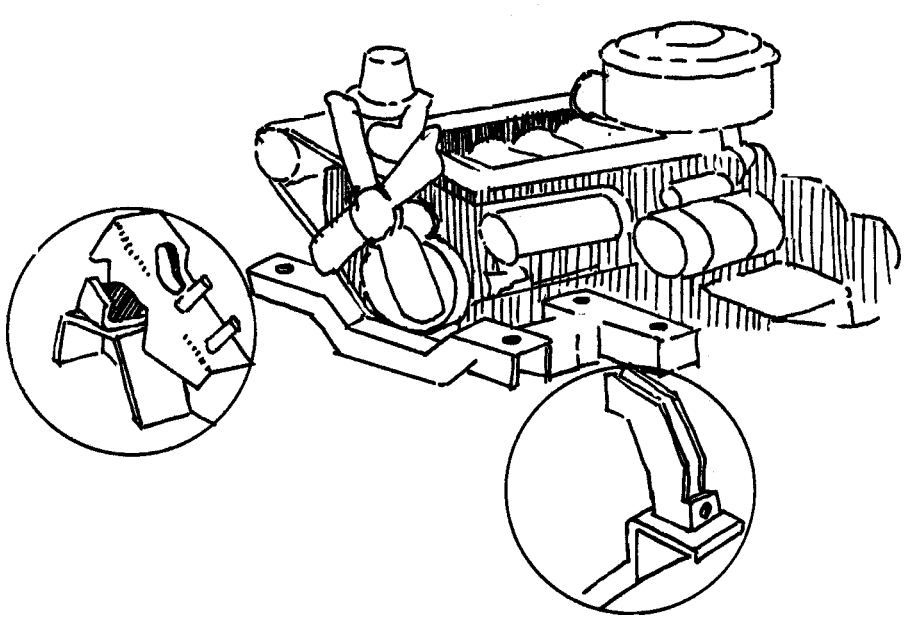
4. Be careful when transporting the engine on the hoist and on the work fixture. An engine is quite heavy and could be uncontrollable if it became unstable.

II. Basic engine removal procedures (both transversely and conventionally mounted engines)

A. Most modern rear-wheel-drive vehicles have three engine mounts—two in the front and one in the rear. The rear engine mount is usually located under the rear of the transmission. The rear mount does not need to be disturbed during engine removal.

1. The two front mounts are located on each side of the engine. The mounts connect the engine to the vehicle frame or body.

2. These mounts are bolted to both the engine and the vehicle frame. Rubber insulates the vibrations of the engine from the frame or body. The mounts are equipped with a device that prevents them from separating should the rubber insulation fail.



B. Before engine removal, the coolant should be drained from the radiator and the engine block. Draining the coolant will prevent the coolant from being spilled during engine removal.

1. Remove block plugs. If block plug removal is difficult, remove the coolant temperature sensor and allow the coolant to drain from the sensor opening. Reinstall the sensor loosely.

2. Examine the condition of the coolant. Note and record its condition.

   (**CAUTION:** Do not pour used coolant down the drain or onto the ground. Coolant is classified as a hazardous chemical and must be disposed of according to law.)

3. Drain oil from the crankcase. Doing so will prevent accidental oil spillage and reduce engine weight during removal.

4. If the power steering pump must be removed, drain the power steering fluid at this time. Usually the pump can be unbolted from the engine and stored out of the way without disconnecting the hoses or draining the fluid.

C. Mark connections.

1. Disconnect only those wires and hoses that connect the engine assembly to the vehicle.

2. All connections that lead to other parts of the engine can be removed with the engine assembly. These connections can be removed and marked as the engine is disassembled for work.

3. Mark all connections. Make sure that the marks are clear and can be used to reassemble the engine properly.

IV. Special removal guidelines for transversely mounted engines in front-wheel-drive vehicles

A. A transversely mounted engine is usually bolted to the transaxle; the whole assembly is mounted to the unibody. In some cases, the engine and transaxle are removed as a unit and then separated. In other cases, the transaxle is supported in the body by special fixtures while the engine is removed.

(NOTE: Engine removal procedures will vary depending on the vehicle model. Be sure to refer to the manufacturer's manual for the correct procedure for engine removal.)

B. In front-wheel-drive vehicles, the engine mounts are located at the front and the rear of the engine.

C. After removal from the vehicle, transversely mounted engines are disassembled and repaired in the same manner as any other type engine.

V. General removal guidelines for conventionally mounted engines in rear-wheel-drive vehicles and for transversely mounted engines in front-wheel-drive vehicles

A. Guidelines for disconnecting the engine

1. Disconnect both battery cables at the battery (always disconnect negative cable first). Remove the battery from the vehicle, charge it, and store it in a safe place.

2. Drain the cooling system as described above.

(**CAUTION:** Do not pour used coolant down the drain or onto the ground. Coolant is classified as a hazardous chemical and must be disposed of according to law.)

3. Permanently mark the locations of the hood hinges with a scribe or some other appropriate tool. Make sure that the markings will not be visible when the hood is closed. The markings will be used to locate the hood when it is reinstalled.

4. Remove the hood at the hinges and store it out of the way in a safe place. In some applications, the hinges must remain with the hood.

5. Remove the carburetor air cleaner. If the vehicle does not have a carburetor, remove the air inlet filter along with any equipment that connects the filter to the intake manifold.

6. Study the engine harnesses and mark all electrical connections that lead away from the engine. It is not necessary to mark connections that will remain on the engine when it is removed.

a. Make sure to identify and mark starter wiring, ignition and alternator wiring, oil pressure and coolant temperature sensor wiring, and carburetor solenoid wiring.

(NOTE: Newer vehicles may have other wires connected to other sensors. Study the harness carefully. If a connection is missed, the wire and/or sensor may be damaged during the engine removal.)

b. Mark both sides of each harness connector. In some applications, some harness connectors may be interchangeable.

c. Mark each harness connector or terminal so that one can determine from which sensor it was removed. If a wire or harness was not marked during engine removal, mark it when disconnecting it. Careful marking of all the wires will make the reinstallation much faster and much easier.

d. Remove the engine to the frame ground strap.

7. Mark and remove all vacuum hoses that lead away from the engine.

8. Remove the radiator shroud, radiator hoses, and the radiator.

(NOTE: Some vehicles require the engine fan to be removed before the shroud is removed. Other vehicles—specifically those using an electrical cooling fan—are designed so that the radiator can be left in place during engine removal. Be sure to refer to the manufacturer's service manual to determine whether or not the radiator should be removed.)

9. If the vehicle is equipped with power steering or air conditioning, remove the compressor and/or pump and tie them out of the way without disconnecting the hoses attached to them.

(NOTE: In some vehicles, the compressor and/or pump may have to be disconnected from the hoses. Check the appropriate service manual for specific procedures.)

(NOTE: If the steering pump or air conditioning compressor needs to be removed, plug all connections and hoses and wrap and store these units in a safe area out of the way. Often these items can be stored in the vehicle's trunk. Be sure that the trunk area is protected from leakage from these units. The refrigerant should be reclaimed using approved equipment before any air conditioning lines are removed.)

10. Disconnect all heater hoses.

11. Disconnect throttle linkage from carburetor.

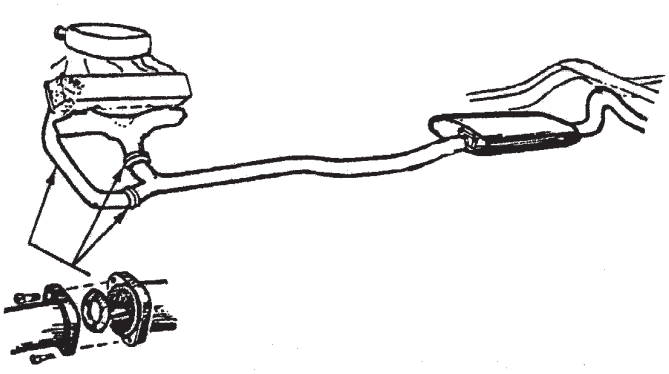
12. Disconnect fuel line (or lines) from fuel pump.

B. Guidelines for engine removal procedures performed under the vehicle

(NOTE: Raise vehicle on a lift before performing the following procedures. Make sure the vehicle is safely supported.)

1. Drain the crankcase. After oil is completely drained, replace the plug loosely.

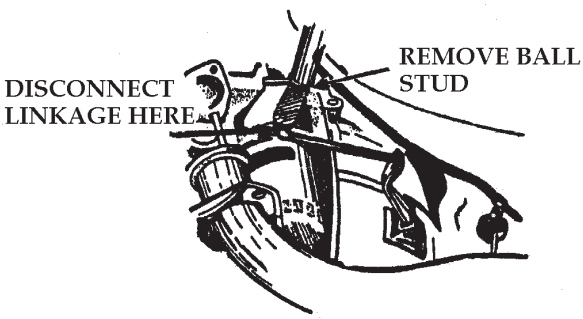
2. Disconnect the exhaust pipe(s) from the exhaust manifold. Tie the exhaust pipe(s) to the frame or body to prevent excessive strain on the hangers.



C. Special removal guidelines for conventionally mounted rear-wheel-drive vehicles

1. If the vehicle is equipped with an automatic transmission, the torque converter must be disconnected from the rear of the engine crankshaft. In most vehicles, the converter is fastened to the engine with three or four bolts or nuts. These fasteners are usually accessed by removing a plate or panel at the lower side of the bell housing. Refer to the manufacturer's service manual. Once the converter is disconnected, slide it toward the transmission.

2. If the vehicle is equipped with a manual transmission, the clutch linkage must be disconnected. Also, the cross-shaft should be disconnected from the side of the engine block.



3. Remove the lower bell housing bolts.

4. If the vehicle has an automatic transmission, remove the transmission filler tube.

5. Disconnect the wiring harness from the starter if this has not already been done.

   a. Disconnect the front engine mount bolts.

   b. Lower the vehicle.

      (**CAUTION:** If a lift is not available, the front of the vehicle may be raised with a jack. If a jack is used, be sure to secure the vehicle with mechanical jack stands before getting under the vehicle. Never work under a vehicle supported only by a jack. Make sure safety stands are also used.)

6. Using a jack and a block of wood, support the transmission by lifting it. The jack may be placed under the transmission pan. This jack is not intended to lift the engine; the jack is merely intended to support the weight of the transmission.

7. Connect a sling to the engine.

   a. Some engines will have lifting eyes fastened to them. If so, the engine can be lifted by a chain hooked to the eyes.

   b. If the engine has no eyes, bolts can be used to fasten the chain or cable to the engine using the holes provided for the intake manifold or cylinder head bolts. Be sure to use bolts that are longer than the bolts that were originally located in these holes. Also be sure that these bolts are turned in at least

      one full turn for each one-sixteenth inch of the bolt's diameter. For example, a three-eighths-inch bolt must be turned at least six turns into the block to provide the strength required to lift the engine safely.

8. Using a suitable lifting device, raise the engine slightly.

   (**CAUTION:** Keep the transmission jack snug under the transmission.)

9. Remove the upper bell housing bolts.

10. Keeping the transmission jack snug against the transmission, lift the engine sufficiently to clear the front engine mounts.

11. Gently slide the engine forward until it is clear of the clutch or torque converter, and lift it clear of the vehicle.

    a. As the engine moves out of its normal position, watch for wiring or hoses that may have not been disconnected. Disconnect and mark these as they are found.

    b. In some applications, the engine may have to be rotated either to the right or to the left in order to clear the fire wall or radiator mounts.

    c. In order to clear obstructions in the engine compartment, the engine may need to be tilted up in the front.

    d. If any problems are encountered, refer to the manufacturer's service manual.

12. Install the engine on a suitable work stand.

JS1-L1-UIII

MODULE: ENGINE REPAIR

REMOVING AN ENGINE FROM A FRONT-WHEEL- DRIVE VEHICLE

Equipment:

Common hand tools
Suitable lifting device for the vehicle
Suitable lifting device for the engine assembly
Suitable work-stand for holding the engine assembly during tear-down
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for preparing the engine for removal. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐ **Instructor Approved**

   Following the procedure, prepare the engine for removal. Record observations.

3. Using a service manual or other information source, locate a procedure for removing the engine from the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, remove the engine from the vehicle. Record observations.

4. Install the engine on the work fixture and prepare it for tear-down.

JS2-L1-UIII

MODULE: ENGINE REPAIR

REMOVING AN ENGINE FROM A REAR-WHEEL-DRIVE VEHICLE

Equipment:

Common hand tools
Suitable lifting device for the vehicle
Suitable lifting device for the engine assembly
Suitable work-stand for holding the engine assembly during tear-down
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for preparing the engine for removal. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, prepare the engine for removal. Record observations.

3. Using a service manual or other informatin source, locate a procedure for removing the engine from the vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐
Instructor Approved

Following the procedure, remove the engine from the vehicle. Record observations.

4. Install the engine on the work fixture and prepare it for tear-down.

MODULE: ENGINE REPAIR

UNIT IV: CYLINDER HEAD AND VALVE TRAIN DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to identify cylinder head and valve train functions, diagnosis, and repair procedures. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify terms and definitions associated with cylinder heads (Competencies N1- N4, Unit IV Test).

II. Identify the construction and functions of the cylinder head and valve train (Competencies N1-N4, Unit IV Test).

Lesson 2.

I. Identify terms and definitions associated with diagnosis and repair of cylinder heads (Competencies N1-N4, Unit IV Test).

II. Identify the procedures for removing and inspecting cylinder heads (Competencies N1-N4, Unit IV Test).

III. Identify the procedures for reconditioning cylinder heads (Competency N3, Part IV of the Unit IV Test).

IV. Identify the procedures for repairing cylinder heads (Competency N3, Part IV of the Unit IV Test).

V. Demonstrate the ability to:

   a. Remove and inspect a cylinder head (Competency N1, JS1-L2-UIV).

   b. Recondition a cylinder head (Competency N3, JS2-L2-UIV).

   c. Install a cylinder head (Competency N2, JS3-L2-UIV).

Lesson 3.

I. Identify terms and definitions associated with the valve train and associated components (Competency N4, Part V of the Unit IV Test).

II. Identify the procedures for inspecting valve train components (Competency N4, Part V of the Unit IV Test).

III. Identify the procedures for checking and setting valve timing (Competency N4, Part V of the Unit IV Test).

IV. Identify the procedures for checking and adjusting valve lash (Competency N4, Part V of the Unit IV Test).

V. Demonstrate the ability to:

a. Inspect valve train components (Competency N4, JS1-L3-UIV).

b. Check and set valve timing in valve-in-head and L-head engines (Competency N4, JS2-L3-UIV).

c. Check and set valve timing in overhead camshaft engines (Competency N4, JS3-L3-UIV).

d. Check and adjust valve lash on mechanical valve lifters (Competency N4, JS4-L3-UIV).

e. Check and adjust valve lash on hydraulic valve lifters (Competency N4, JS5-L3-UIV).

MODULE: ENGINE REPAIR

UNIT IV: CYLINDER HEAD AND VALVE TRAIN DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT IV: CYLINDER HEAD AND VALVE TRAIN DIAGNOSIS AND REPAIR

LESSON 1: CYLINDER HEAD AND VALVE TRAIN FUNCTIONS AND CONSTRUCTION

I. Terms and definitions associated with cylinder heads

A. Air/fuel mixture—A mixture of air and fuel (usually gasoline). The air/fuel mixture is burned within the engine cylinders.

B. Cam bearing—One of several bearings that support the camshaft.

C. Camshaft—A shaft that is driven by the crankshaft at half the crankshaft speed. The camshaft contains the cam lobes, which are responsible for opening the valves. The camshaft may also be used to drive the oil pump, the distributor, and/or the fuel pump.

D. Casting—A method of forming metal. Casting involves heating metal to its melting point and then pouring it into a mold, which gives it a new shape.

E. Exhaust gases—The gases formed by the combustion within the engine.

F. Glow plug—A device that heats the combustion chamber of a diesel engine in order to make starting the engine easier.

G. Push rod—A component in the valve train of an I—head engine. The push rod transmits the movement from the valve lifter to the rocker arm.

H. Rocker arm—A component in the valve train that reverses the direction of the cam lobe. The arm is named for its rocking motion. Some overhead cam engines do not use rocker arms.

I. Rocker arm stud—A stud pressed or turned into the cylinder head upon which the rocker arm is fastened.

J. Rocker shaft—A shaft located on the cylinder head upon which the rocker arm rotates.

K. Spark plug—An electrical plug which is responsible for igniting the air/fuel mixture.

L. Valve—In an internal combustion engine, a device that opens and closes in order to control the passage of gas.

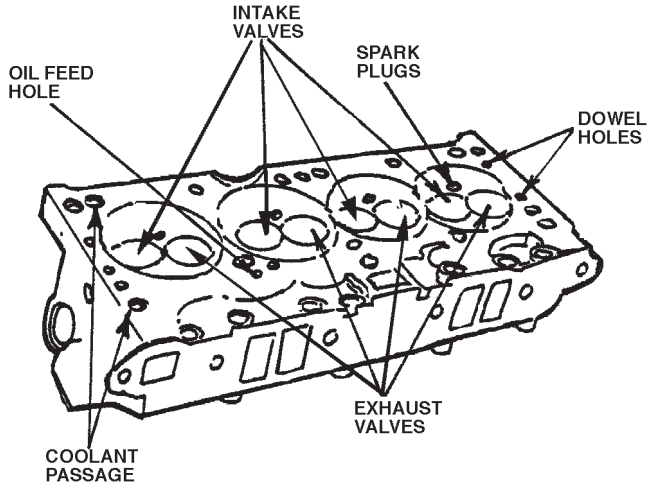
M. Valve guide—A component of the valve train through which the engine valve moves.

N. Valve lifter—A valve train component that rides on the camshaft and causes movement in the valve train.

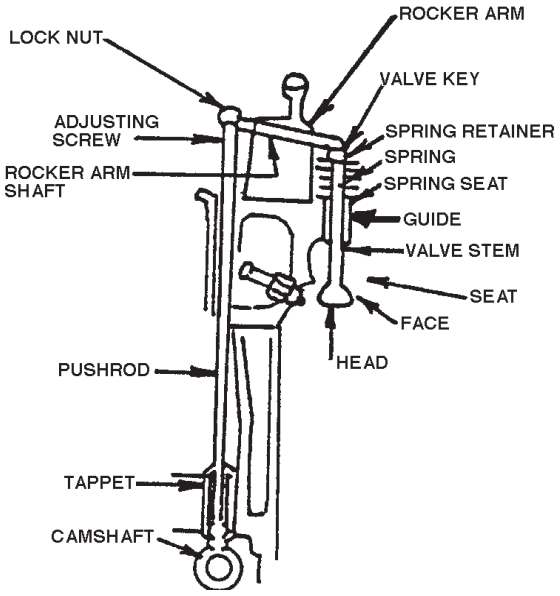
O. Vee engine—An engine design in which the cylinders are arranged in two equal rows and are connected to the same crankshaft. The cylinders appear to form a “vee” when viewed from the end.

II. The construction and functions of the cylinder head and valve train

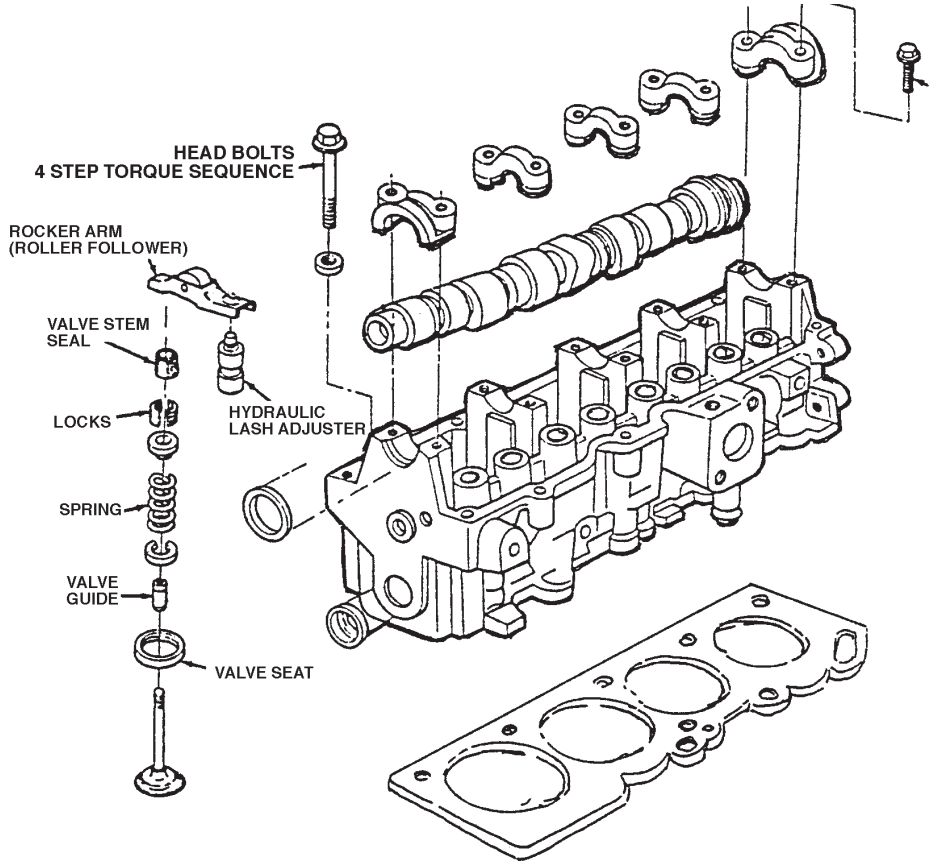
A. The cylinder head is usually constructed of one piece metal casting, which forms the top of the cylinders, including the combustion chamber. The cylinder head also provides a mounting point for the ignition parts such as spark plugs or glow plugs. In many engines, the valves and some valve train mechanisms are mounted in or on the cylinder head. Engines designs that “group” their cylinders (such as vee or flat engine designs) have two cylinder heads.



B. The valve train includes all of the mechanical components that operate the valves. These components include all of the valves, the rocker arms, the push rods, the valve lifters (tappets), and the camshaft. There are many different types of valve trains, some of which may not have all of the components listed above. Some newer engines have as many as four valves in each cylinder.

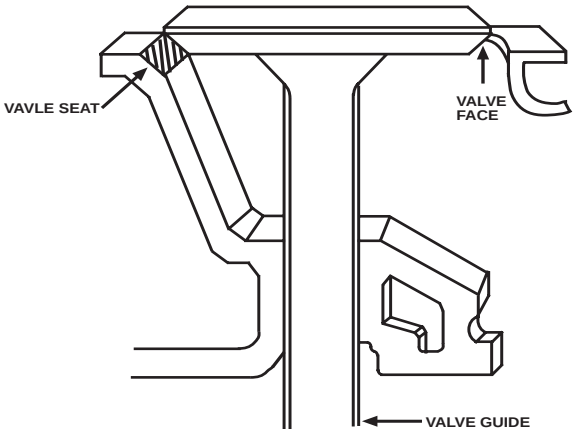


(NOTE: Some older engines may not have any valve parts in the cylinder head; more modern engines may have all of the valve parts in the head. In modern engines, valve trains may include components that disable certain cylinders during engine operation in order to improve fuel economy.)



C. The cylinder head must contain the explosions that occur when the air/fuel mixture ignites in the combustion chamber. Therefore, the cylinder head must be very strong and securely mounted. Some engines have the valves mounted in the head. These engines must include the bearings (the valve guides) upon which the valves move. The cylinder head will include the valve seats—the part upon which the valve "seats" when it closes.

(NOTE: Parts that are used to secure the valve train to the head must also be included in the head. These parts include the cam bearings, rocker shaft bearings, rocker arm studs etc.)



D. The valve train provides the cylinder openings that allow the air/fuel mixture to enter the cylinder and the spent exhaust gases to leave the cylinder. Each valve must open and close at exactly the right time. The valves are operated by the rotation of the crankshaft. The gears or chains that connect the valve train to the crankshaft must be precisely timed in order for the valves to operate at the proper intervals.

MODULE: ENGINE REPAIR

UNIT IV: CYLINDER HEAD AND VALVE TRAIN DIAGNOSIS AND REPAIR

LESSON 2: CYLINDER HEAD DIAGNOSIS AND REPAIR

I. Terms and definitions associated with the diagnosis and repair of cylinder heads

A. Camshaft—A shaft that controls the valves. In some engines, the camshaft also controls the oil pump, the fuel pump, and the ignition distributor.

B. Dial indicator—A tool for measuring the distance that one component moves with respect to another component. The measurement is indicated on a dial.

C. Exhaust manifold—The component that directs the exhaust gases away from the engine.

D. Gasket—A soft material between two components. The gasket prevents leakage and provides a cushion between the two components.

E. Gasket surface—A machined surface on a metal part intended to be sealed or cushioned by a gasket.

F. Intake manifold—The component that directs the air/fuel mixture to the engine.

G. Interference angles—Two angles that “interfere” with or cross each other.

H. Machinist—A technician who specializes in using machine tools to cut and shape metal.

I. Oil gallery—A “cored” passage in the head casting. The oil gallery carries oil.

J. Push rod—A valve train component that transmits movement from the valve lifter to the rocker arm. Push rods are not used in overhead cam engines.

K. Ream—A process in which a hole is enlarged with a machine tool called a reamer. Reamers leave an extremely accurate finish.

L. Reconditioning—A procedure that involves reconditioning, repairing or replacing damaged cylinder head components. A reconditioned cylinder head should function like a new one.

M. Resurfacing—A procedure in which metal is removed from a warped or damaged gasket surface in order to restore its condition.

N. Rocker arm—A valve train component that reverses the direction of the cam lobe. The arm is named for its rocking motion. Some overhead cam engines do not use rocker arms.

O. Rocker arm stud—A threaded stud in the cylinder head. The rocker arm stud is used to hold the rocker arm.

P. Rocker shaft—A shaft located on the cylinder head. The rocker shaft is used to hold the rocker arms in some engines.

Q. Straightedge—A measuring tool with at least one edge that is straight and true. The straightedge can be used to inspect the integrity of a gasket surface.

R. Thermostat housing—A component that contains the cooling system thermostat. The thermostat housing is often bolted to a cylinder head or intake manifold.

S. Torque—A measure of twisting force.

T. Torque sequence chart—A chart that dictates the sequence in which the cylinder head bolts should be torqued.

U. Valve guide—A bearing located in the cylinder head. The valve moves in the valve guide.

V. Valve spring compressor—One of several tools designed to compress the valve springs for cylinder head repairs.

W. Warpage—Distortion of the cylinder head. Warpage interferes with the integrity of the gasket surface.

II. Removing and inspecting cylinder heads

A. Procedure for removing a cylinder head

1. Before removing the cylinder head, perform sufficient tests to ensure that removal is necessary.

2. If the engine is not to be overhauled but the head is to be removed and serviced, perform tests outlined in Unit II of this module in order to determine what service must be performed on which head(s).

3. If the engine is to be reconditioned, then the cylinder head(s) should be reconditioned also.

4. Study the cylinder head to be removed and determine which components can stay on the cylinder head while it is being removed.

(NOTE: In some applications, the manifolds can be removed with the cylinder head. In other applications, the cam or the rocker shaft must be removed in order to gain access to the head bolts. Refer to the proper service manual to determine which components need to be removed.)

5. Remove and mark all components that must be removed prior to removing the head. This will include the push rods on “I” head engines.

6. Drain cooling system.

7. Remove the head bolts.

   (NOTE: When removing head bolts, follow the torque sequence chart in reverse order.)

8. Remove the cylinder head.

   (NOTE: If the cylinder head is difficult to separate, it may be easier to rotate the engine with the starter to allow the engine compression to pop the head loose. If this is done, be sure to leave at least two of the bolts loosely installed in the head to prevent the head from falling if it should suddenly come loose. Overhead camshaft cylinder heads, with cam installed, should not be removed in this manner. Damage to the timing components or valves may result.)

B. Procedure for inspecting the removed cylinder head

1. Remove all parts that are bolted on the cylinder head. Parts that are bolted on the cylinder head should include those listed below.

   a. The thermostat housing

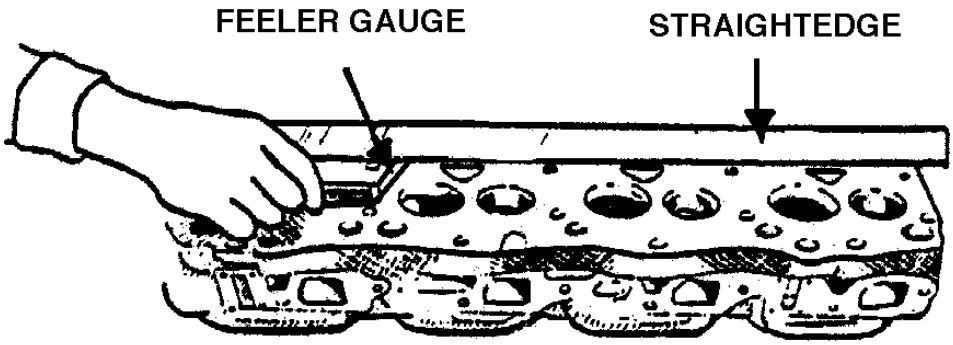
   b. The rocker shaft or camshaft (if not removed prior to cylinder head removal)

   c. Exhaust and intake manifolds

   d. Spark plugs, glow plugs, fuel injectors, etc.

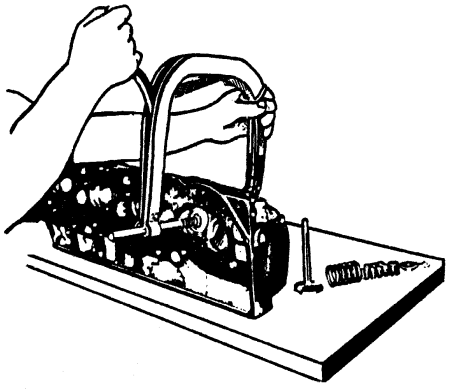
2. Carefully clean all gasket material from the gasket surfaces on the cylinder head. Be sure to clean all gasket surfaces—especially the head gasket surface and the manifold surfaces. Any gasket material left on the head surface will cause a leak when the engine is reassembled.

3. Using a straightedge, check the head gasket surface for warpage. Check the head gasket lengthwise and crosswise in several places. If a .005-inch (0.1 mm) feeler gauge can be inserted anywhere between the straightedge and the head, the head is warped and must be resurfaced. While checking the surface, keep checking for cracks. If the head is found to be cracked during any of these operations, stop all other work until the crack is repaired. If not careful, a technician may spend several hours on a cylinder head only to find that it is unusable.



(NOTE: In some cases, a machinist can repair a cracked cylinder head. If cracks are found, check with a machinist before assuming that the head is unusable.)

4. Using a valve spring compressor, remove the valves from the head. Make sure to mark and record the location of each valve as it is removed.



5. Using a wire brush, carefully clean the carbon from the intake and exhaust ports. Carefully clean the carbon from the valve guides. Special brushes are available for this purpose.

6. Carefully inspect the cylinder head.

   a. Look for cracks at or around the valve seats.

   b. Look around the head bolt holes for cracks and evidence of coolant leaks.

   c. Examine the spark plug hole or the glow plug or injector holes. Look for damaged threads and cracks.

7. Examine the valve seats. If any are damaged, loose, or pitted, they should be replaced or repaired. An automotive machinist can replace valve seats in most modern engines.

8. Examine each of the valves.

   a. Using a micrometer, check the valve stems for taper. Replace all valves that have stems tapered more than the manufacturer allows.

      (NOTE: If the valve stems are tapered and the guides are worn, the new valves can be purchased with oversized stems and the guides reamed to fit the new stems or the guides can be knurled back to size.)

   b. Check the guides for tightness using a serviceable valve and a dial indicator. The valve guides will always “keyhole” in a direction that is crosswise from the head. Set up the dial indicator to contact the edge of the valve when it is in its normal “open” position so that it will indicate crosswise movement. Hold the valve in its normal open position and apply pressure in the cross-wise direction and note any indication on the dial. Rework valve guides that allow the valve to move .005 of an inch or more.

9. Examine all coolant and exhaust passages in the cylinder head and thoroughly clean them using picks and wire brushes. These passages must be clean in order to cool the engine properly.

10. Remove all of the core (freeze) plugs, and clean the water jacket through the holes.

11. Remove oil gallery plugs and thoroughly clean the galleries using a “rifle” cleaning brush.

C. Procedure for installing a cylinder head

1. Make sure that the cylinder head and block gasket surfaces are clean and free of all old gasket materials and sealer. Use a power wire wheel to clean the threads on all of the head bolts.

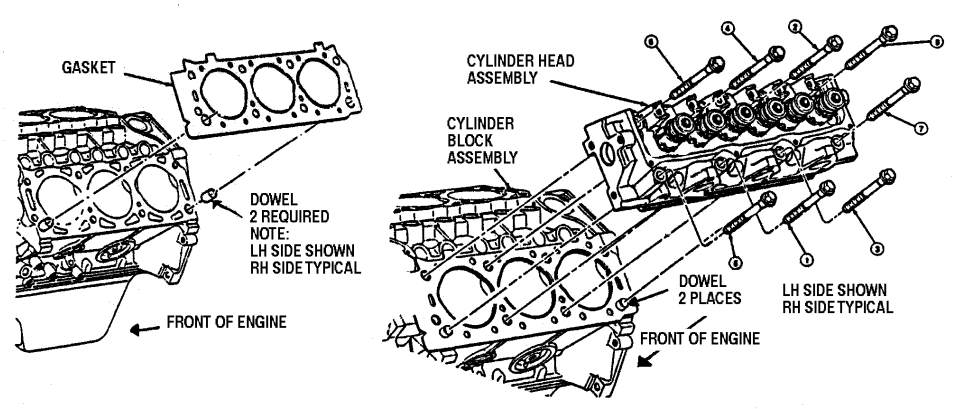
2. Using a tap, clean the threads of all the head bolt holes in the block.

3. Carefully inspect both the head and the block. Make sure that there is no head or block damage that will affect the sealing of the gasket.

4. Examine the locating dowels (if used) and be sure that they are in place and undamaged.

   (NOTE: If locating dowels are not used, it is advisable to use two bolts with their heads cut off as guide pins. Old head bolts are often used for this purpose, but any long bolt with the correct thread size and pitch would be suitable. Because the bolts must be backed out after the head is installed, the bolts must be long enough to reach through the head.)

5. Install the head gasket.



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a. Check the gasket for any directions printed on it or on the packaging in which it came.

b. Look for either the word “front” or an arrow and make sure that this end goes to the front of the engine. Some gaskets can be installed in either direction.

c. Check the gasket or gaskets carefully. In some vee engines, the two gaskets are different; in other vee engines, they are interchangeable.

d. Check and make sure that no coolant or oil passages are left out of the gasket.

e. Most head gaskets are installed “dry;” however, be sure to check the directions which came with the gasket. The gasket may require a sealant.

6. Install the head.

a. Examine the heads on vee engines for differences. In some cases, the fittings on one head may be different than those on the other head. The fittings may therefore be difficult to change over once the head is installed.

b. Place the head on the dowels or the guide pins.

(NOTE: If there is any doubt as to whether the bolt reaches into the water jacket, be sure to coat the threads of the bolt with sealant.)

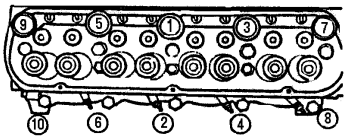
c. Sort the bolts for length. In some cases, all of the bolts are identical. In other cases, there may be as many as four different sizes.

(**CAUTION:** If a long bolt is torqued into a bolt hole meant for a short bolt, the block may be destroyed.)

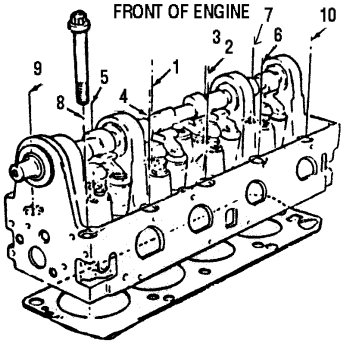
d. Check for special bolts containing studs for mounting accessories. Make sure that these studs are installed in the proper positions. Lubricate the bolts with clean engine oil. Apply sealant to the threads that go into holes that reach through the block into the water jacket.

e. Screw the bolts into the correct holes. One method of head bolt installation is to torque the bolts to the correct torque in three passes. In the first pass, pull the bolts to 1/3 of the published torque; in the second pass, to 2/3 of the published torque; and in the final pass, to the published setting. Be sure to torque the bolts in the correct sequence.

TORQUE CYLINDER HEAD BOLTS, IN SEQUENCE, TO SPECIFICATION



TIGHTEN CYLINDER HEAD BOLTS TO SPECIFICATION IN TWO PROGRESSIVE STEPS IN THE SEQUENCE SHOWN



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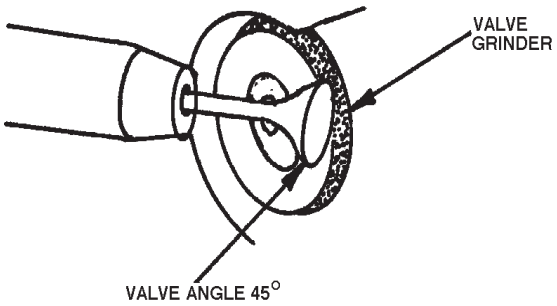
III. Procedures for reconditioning the cylinder head

(NOTE: If the cylinder head needs to be machined, do so before proceeding. In many cases, the technician can do machining jobs, such as grinding valves or valve seats. If machining equipment is not available, have the head reconditioned by the machine shop. If it is decided that the head will be reconditioned by the technician, follow the procedure outlined below.)

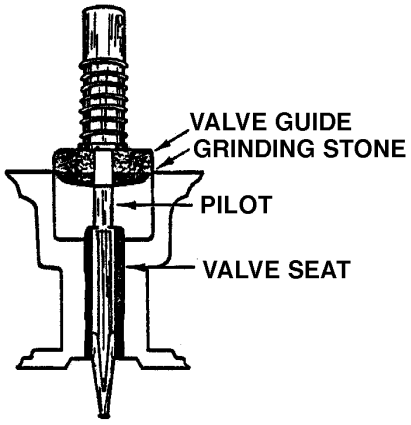
A. After checking for taper and damage, grind the faces of all valves to be re-used. New valves do not need to be ground unless the face angle needs to be changed. Check the manufacturer's service manual for the proper face angle.



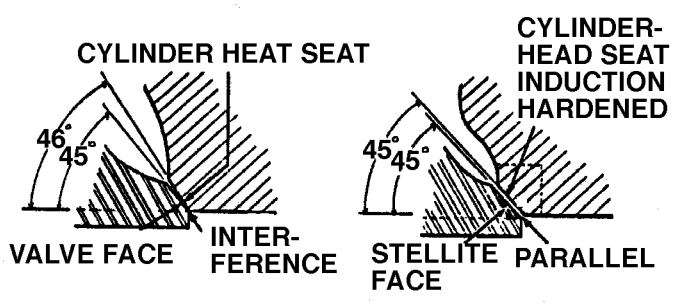
1. After grinding, check the valve margins. Margins that measure less than 1/32 of an inch on intake valves and less than 3/64 of an inch on exhaust valves should be discarded.

2. Grind the tip of the stem to restore its squareness and to reduce its length by the same amount that was removed from the face and the seat together.

B. Using a valve seat grinder, grind the valve seats to the correct angle.



1. In most cases, the angles for both intake and exhaust valves will be 45 degrees. In most modern engines, the valve face and seat will be ground to the same angle. In some older engines, an “interference” of 1 degree is required.



2. Occasionally, a valve angle of 30 degrees is used. Be sure to check the specificaions.

3. The equipment for grinding the valve face is easier to adjust than the seat grinder. Therefore, if an interference is to be ground in the valves, grind it in the valve face rather than the seat.

   a. If the valve seat and face are both ground to the same angle, the valve seat width must be adjusted. Narrow the valve seat by grinding the top down using a 15-degree stone and grinding the bottom up using a 60- degree stone. When this is properly done, the seat should be approximately 1/8 of an inch wide and should contact the valve near the center of its face.

   b. If the valve seat is the interference type, then the valve face will only contact the seat at the point where the two angles intersect. This point should be lowered with a “topping” stone of 15 degrees until it contacts the valve face near its center.

C. Examine each valve guide carefully, using the valve that will run in it. Use a dial indicator. If the guide is worn so that it moves .005 of an inch (0.1 mm) or more, it should be reworked at this time.

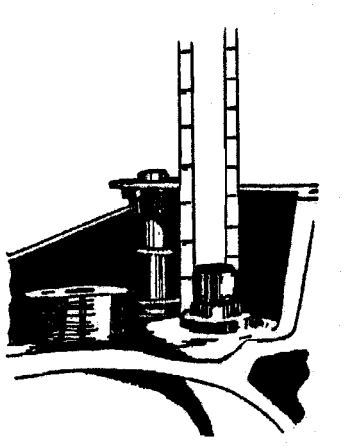
1. If the valves are to be replaced, the guide can be reamed to an oversize and valves with oversized stems can be installed.

2. If the valves are to be re-used, the guides can be knurled, lined, sleeved, or replaced. Check with the machinist who will rework the guides and follow his or her advice.

D. Check the valve springs for length, tension, and squareness.

1. Stand all of the springs on a flat surface next to each other. They should stand the same height, and should stand squarely. If there is any discrepancy in their height or if any one spring does not stand squarely, it is advisable to replace all of the springs.
   (NOTE: It is possible to check each of the springs for tension by using a special gauge.)

2. Using the tools outlined in the appropriate service manual, check the valve spring installation height. Correct the height with shims, if necessary.



3. Check the valve installed stem height and, if necessary, adjust it by removing material from the tip of the valve stem.

E. Replace all core (freeze) plugs with new ones, if required.

F. Replace all oil gallery plugs with new ones, if required.

G. Using a valve spring compressor, replace all of the valves. Be sure to install new valve stem seals if required.

IV. Repairing cylinder heads

(NOTE: Cylinder head repairs are very difficult. If the technician does not have the special equipment, tools, or skills required, he or she should not attempt these repairs.)

A. Repairing cracks in cylinder heads

1. Severe cracks in cylinder heads can seldom be repaired. In some cases, repair may be attempted if the cylinder head is of a rare design and easy to replace. Also, minor cracking is sometimes repaired when the head is reconditioned.

2. If repair of a cylinder head crack is attempted, the first step is to “stop” the crack by drilling a small hole at each end of it. Using special techniques, the technician can then weld or braze over the cracks.

B. Repairing valve seats

1. Occasionally, a valve seat may be damaged or loosened.

2. Valve seats may be replaced in the cylinder head by cutting the head away and pressing a new valve seat into position.
(NOTE: Special equipment and skills are required to press in new valve seats. This procedure should only be attempted by the service technician with the proper skills and equipment.)

C. Repairing valve guides

1. A guide can be knurled and re-reamed to a standard size.

2. A guide can be reamed to an oversize and a valve with an oversized stem can be installed.

3. In some engines, a valve guide can be replaced with a new one.

4. A valve guide can be drilled out and a bronze or iron sleeve pressed in its place.

5. The valve guide can be “threaded” and a special bronze “liner” screwed into it to restore its dimension.

(NOTE: Some of the above procedures can be done by the service technician; however, in most cases a machinist must do these procedures.)

D. Resurfacing heads

1. Cylinder heads that have become warped or damaged at their gasket surfaces can be repaired by removing material from the surface with machine tools.

2. This process is called “planing” or “grinding” and it is common practice at most automotive machine shops.

3. On vee engines, it is advisable to remove material from both heads to “balance” the engine compression and to remove a slight amount of material from the intake manifold surfaces in order to restore the fit of the manifold. This does not have to be done on in-line engines.

JS1-L2-UIV

MODULE: ENGINE REPAIR

REMOVING AND INSPECTING A CYLINDER HEAD

Equipment:

Common hand tools
1/2-inch square drive torque wrench
Valve spring compressor
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Study the cylinder head to be removed and determine which components can stay on the cylinder head while it is being removed. List the components below.

   (NOTE: In some applications, the manifolds can be removed with the cylinder head. In other applications, the cam or the rocker shaft must be removed in order to gain access to the head bolts. Refer to the proper service manual to determine which components need to be removed.)

3. Remove and mark all components that must be removed prior to removing the head. This will include the push rods on "I" head engines. Drain cooling system and remove the head bolts.

   (NOTE: When removing head bolts, follow the torque sequence chart in reverse order.)

4. Remove the cylinder head.

   (NOTE: If the cylinder head is difficult to separate, it may be better to rotate the engine with the starter to allow the engine compression to pop the head loose. If this is done, be sure to leave at least two of the bolts loosely installed in the head to prevent the head from falling if it should suddenly come loose.)

5. Remove all parts that are bolted on the cylinder head. Parts that are bolted on the cylinder head should include those listed below.

a. The thermostat housing

b. The rocker shaft or camshaft (if not removed prior to cylinder head removal)

c. Exhaust and intake manifolds

d. Spark plugs, glow plugs, fuel injectors, etc.

6. Carefully clean all gasket material from the gasket surfaces on the cylinder head. Be sure to clean all gasket surfaces--especially the head gasket surface and the manifold surfaces. Any gasket material left on the head surface will cause a leak when the engine is reassembled.

7. Using a straightedge, check the head gasket surface for warpage. Check the head gasket lengthwise and crosswise in several places. If a .005-inch (0.1 mm) feeler gauge can be inserted anywhere between the straightedge and the head, the head is warped and must be resurfaced.

   (NOTE: While checking the surface, keep checking for cracks. If the head is found to be cracked during any of these operations, stop all other work until the crack is repaired. If not careful, a technician may spend several hours on a cylinder head only to find that it is unusable.)

   (NOTE: In some cases, a machinist can repair a cracked cylinder head. If cracks are found, check with a machinist before assuming that the head is unusable.)

8. Using a valve spring compressor, remove the valves from the head. Make sure to mark and record the location of each valve as it is removed.

9. Using a wire brush, carefully clean the carbon from the intake and exhaust ports. Carefully clean the carbon from the valve guides. Special brushes are available for this purpose.

10. Carefully inspect the cylinder head as outlined below.

    a. Look for cracks at or around the valve seats.

    b. Look around the head bolt holes for cracks and evidence of coolant leaks.

    c. Examine the spark plug hole or the glow plug or injector holes. Look for damaged threads and cracks.

11. Examine the valve seats. If any are damaged, loose, or pitted, they should be replaced or repaired. An automotive machinist can replace valve seats in most modern engines.

12. Examine each of the valves as outlined below.

a. Using a micrometer, check the valve stems for taper. Replace all valves that have tapered stems.

(NOTE: If the valve stems are tapered and the guides are worn, the new valves can be purchased with oversized stems and the guides can be reamed to fit the stems.)

b. Check the guides for tightness using a serviceable valve and a dial indicator. The valve guides will always "keyhole" in a direction that is crosswise from the head. Set up the dial indicator to contact the edge of the valve when it is in its normal "open" position so that it will indicate crosswise movement. Hold the valve in its normal open position and apply pressure in the crosswise direction and note any indication on the dial. Rework valve guides that allow the valve to move .005 of an inch or more.

13. Examine all coolant and exhaust passages in the cylinder head and thoroughly clean them using picks and wire brushes. These passages must be clean in order to cool the engine properly.

14. Remove all of the core (freeze) plugs, and clean the water jacket through the holes. Remove oil gallery plugs and thoroughly clean the galleries using a "rifle" cleaning brush.

JS2-L2-UIV

MODULE: ENGINE REPAIR

RECONDITIONING A CYLINDER HEAD

Equipment:

Common mechanic's hand tools
Valve spring compressor
Valve grinding equipment
Valve seat grinding equipment
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Check valves for taper and damage. Check the manufacturer's service manual for the proper face angle and record the proper angle below. Also record any recommendations for machine shop work to be done on the head.

   (NOTE: New valves do not need to be ground unless the face angle needs to be changed.)

   Face angle specification _____

3. Grind the faces of all valves to be re-used. Follow the procedure outlined below.

   (NOTE: Check with the instructor to make sure the below procedure is appropriate for the vehicle to be serviced.)

   a. After grinding, check the valve margins. Margins that measure less than 1/32 of an inch on intake valves and 3/64 of an inch on exhaust valves should be discarded.

   b. Grind the butt end of the stem to restore its squareness and to reduce its length by the same amount that was removed from the face and the seat together.

4. Using a valve seat grinder, grind the valve seats to the correct angle.

   Follow the procedure outlined below.

   (NOTE: Check with the instructor to make sure the below procedure is appropriate for the vehicle to be serviced.)

a. In most cases, the angles for both intake and exhaust valves will be 45 degrees. In most modern engines the valve face and seat will be ground to the same angle. In some older engines, an "interference" of 1 degree is required.

b. Occasionally, a valve angle of 30 degrees is used. Refer to the proper service manual for the correct specifications and record them below.

exhaust valve angle _____

intake valve angle _____

c. The equipment for grinding the valve face is easier to adjust than the seat grinder. Therefore, if an interference is to be ground in the valves, grind it in the valve face rather than the seat.

d. If the valve seat and face are both ground to the same angle, the valve seat width must be adjusted. Narrow the valve seat by grinding the top down using a 15-degree stone and grinding the bottom up using a 60-degree stone. When this is properly done, the seat should be approximately 1/8 of an inch wide and should contact the valve near the center of its face.

e. If the valve seat is the interference type, then the valve face will only contact the seat at the point where the two angles intersect. This point should be lowered with a "topping" stone of 15 degrees until it contacts the valve face near its center.

5. Examine each valve guide carefully, using the valve that will run in it. Use a dial indicator. If the guide is worn so that it moves .005 of an inch (0.1 mm) or more, it should be reworked at this time. Record in the space below whether the valves are to be replaced or reworked.

a. If the valves are to be replaced, the guide can be reamed to an oversize and valves with oversized stems can be installed.

b. If the valves are to be re-used, the guides can be knurled, lined, sleeved, or replaced. Check with the machinist who will rework the guides and follow his or her advice.

6. Check the valve springs for length, tension, and squareness. Follow the procedure outlined below.

a. Stand all of the springs on a flat surface next to each other. They should stand the same height, and should stand squarely. If there is any discrepancy in their height or if any one spring does not stand squarely, it is advisable to replace all of the springs.

Should the springs be replaced? Yes ____ No ____

(NOTE: It is possible to check each of the springs for tension by using a special gauge. However, because valve springs are inexpensive and labor costs are high, extensive testing of valve springs is not cost effective.)

b. Check the valve spring installation height. Correct the height with shims if necessary.

c. Check the valve stem height and adjust it by removing material from the tip of the valve stem if necessary.

7. Replace all core (freeze) plugs with new ones. Replace all oil gallery plugs with new ones.

8. Using a valve spring compressor, replace all of the valves. Be sure to install new valve stem seals if required.

JS3-L2-UIV

MODULE: ENGINE REPAIR

INSTALLING A CYLINDER HEAD

Equipment:

Common mechanic's hand tools
1/2-inch square drive torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Make sure that the cylinder head and block gasket surfaces are clean and free of all old gasket materials and sealer. Using a tap, clean the threads of all the head bolt holes in the block.

3. Carefully inspect both the head and the block. Record any damage to the head or block that might affect the sealing of the gasket.

4. Examine the locating dowels (if used) and be sure that they are in place and undamaged. Record observations.

   (NOTE: If locating dowels are not used, it is advisable to use two bolts with their heads cut off as guide pins. Old head bolts are often used for this purpose, but any long bolt with the correct thread size and pitch would be suitable. Because the bolts must be backed out after the head is installed, the bolts must be long enough to reach through the head.)

5. Following the procedure outlined below, install the head gasket.

a. Check the gasket for any directions printed on it or on the packaging in which it came.

b. Look for the word "front" and make sure that this end goes to the front of the engine. Some gaskets can be installed in either direction.

c. Check the gasket or gaskets carefully. In some vee engines, the two gaskets are different; in other vee engines, they are interchangeable.

d. Check and make sure that no coolant or oil passages are left out of the gasket.

e. Most head gaskets are installed "dry;" however, be sure to check the directions which came with the gasket. The gasket may require a sealant.

6. Following the procedure outlined below, install the head.

a. Use a power wire wheel to clean the threads on all of the head bolts.

b. Place the head on the dowels or the guide pins.

c. Examine the heads on vee engines for differences. In some cases, the fittings on one head may be different than those on the other head. The fittings may therefore be difficult to change over once the head is installed.

d. Lubricate the bolts with clean engine oil. Apply sealant to the threads that go into holes that reach through the block into the water jacket.

(NOTE: If there is any doubt as to whether the bolt reaches into the water jacket, be sure to coat the threads of the bolt with sealant.)

e. Sort the bolts for length. In some cases, all of the bolts are identical. In other cases, there may be as many as four different sizes.

(CAUTION: If a long bolt is torqued into a bolt hole meant for a short bolt, the block may be destroyed.)

f. Check for special bolts containing studs for mounting accessories. Make sure that these studs are installed in the proper positions.

g. Screw the bolts into the correct holes. Torque the bolts to the manufactures specification. Be sure to torque the bolts in the correct sequence. Record proper torque settings below.

Proper torque specification_____

Proper torque sequence_____

MODULE: ENGINE REPAIR

UNIT IV : CYLINDER HEAD AND VALVE TRAIN DIAGNOSIS AND REPAIR

LESSON 3: INSPECTING, REPAIRING, AND ADJUSTING VALVE TRAIN COMPONENTS

I. Terms and definitions associated with the valve train and associated components

A. Cam bearing—A bearing that supports the camshaft.

B. Cam lobe—A raised part on a cam that acts upon a “follower.” The cam lobe is an eccentric part of the cam.

C. Cam lobe lift—The distance that the cam lobe will lift the follower.

D. Camshaft—A series of cam lobes machined on a shaft.

E. Distributor shaft—The shaft that makes the mechanical input to the ignition system. Some modern engines do not use distributors.

F. Overhead camshaft—Describes an engine in which the camshaft (or camshafts) is located in the cylinder head or heads.

G. Pillow block—A device that allows a bearing to be attached to a machine by way of a threaded fastener.

H. Push rod—A rod used in valve in-head engines. The push rod transfers the movement of the cam followers in the short block to the valve mechanisms located on the cylinder head.

I. Rocker arm—A mechanical link in the valve train. The rocker arm reverses the direction of mechanical movement and/or produces a mechanical advantage. The rocker arm acts in a “rocking” motion and has three points of contact.

J. Short block—The part of an internal combustion engine that contains the crankshaft, pistons, and cylinders.

K. Spherical—Term used to describe objects that take the shape of a sphere.

L. Timing belt—A rubberized cogged belt used to drive the camshaft. In some cases this belt can be used to drive other engine accessories.

M. Timing chain—A steel chain used to drive the camshaft.

N. Timing marks—Marks located on the timing gears or sprockets. Timing marks are used to assist in timing these parts to each other.

O. Valve-in-head—Descriptive of an internal combustion engine in which the valves are located in the cylinder head and the camshaft is located in the short block.

P. Valve lash—The relationship between the valve and the valve train. Valve lash ensures that the valve train will be able to open the valves and that the valve spring will be able to close the valve at the appropriate time.

Q. Valve lifter—A part in the valve train that acts against the cam or head when the valve is opened. Often the valve lash is adjusted at the valve lifter. It is also called a cam follower or tappet.

R. Valve lifter "foot"—The portion of the valve lifter that contacts the cam.

S. Valve train—The mechanical system that operates the valves in an internal combustion engine.

II. Inspecting valve train components

A. Inspecting camshaft

1. Inspecting valve-in-head camshafts

a. These camshafts are located in the short block assembly, supported by a set of cam bearings that are pressed into prepared bores in the block.

b. Oil is directed from the oil pump to each cam bearing through drilled passages in the block and the bearings.

c. Inspection of a valve-in-head camshaft, at this point, is limited to inspecting the "feet" of the valve lifters for abrasion, and measuring the lift of each cam lobe.

d. Cam lobe lift can be determined by measuring the amount of push rod travel as the crankshaft is rotated. The amount of rod travel is then compared with published specifications and the other cam lobes on this shaft. If the lobe lift is less than specified, or if any lobe lift is significantly different than the others, the camshaft should be considered defective.

e. Valve lifter feet are visually inspected for roughness and cupping. The foot should be smooth and shiny and relatively flat.

(NOTE: When inspecting valve lifters, be sure to return each lifter to the bore from which it was removed.)

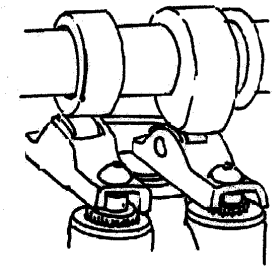
f. If any one lifter is found to be rough or cupped and/or the cam lobe lift is less than specified, then the entire set of lifters and the camshaft should be replaced.

(NOTE: Do not replace the camshaft unless all of the lifters are also replaced. Do not replace any one lifter unless all of the lifters and the camshaft are replaced. An exception to this rule might be the replacement of a relatively new lifter that has become defective.)

2. Inspecting overhead camshafts

   a. Overhead camshafts are located in or on the head and are easily inspected during cylinder head reconditioning.

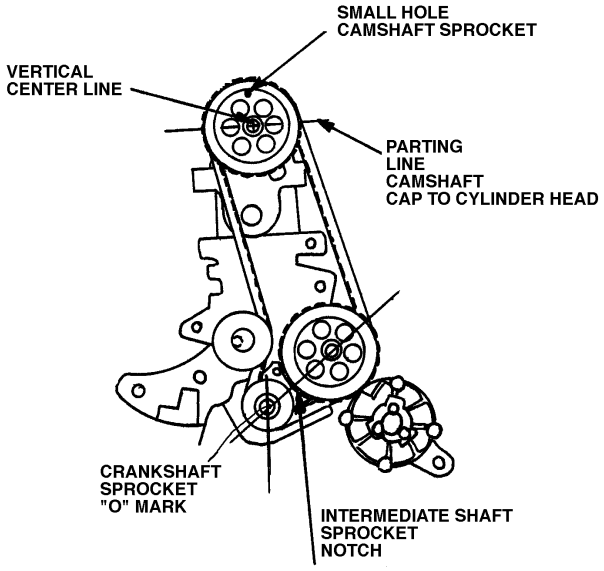
   b. Lifters are not always used in these systems. When lifters are used, they are seldom positioned against the cam lobe, but rather are used to support one end of a rocker arm, which actually opens the valve. This rocker arm is referred to as a cam follower.



   c. When lifters are used in these valve trains, the valve lash is automatically adjusted by the lifters. If lifters are not used, the valve lash must be periodically adjusted by hand.

   d. Camshafts ride on cam bearings that are either pressed into bores in the head or held by pillow blocks that are bolted on. In some applications, the camshaft cannot be removed unless all of the valves are held open using a special tool designed for this purpose. Other applications allow the camshaft to be removed by simply removing the bolted-on pillow blocks that hold the cam bearings.

   e. Overhead camshafts are driven by long timing chains or timing belts, which take their power from the crankshaft. All camshafts must be timed to the crankshaft in order for the valves to open and close at the proper times. These belts or chains must be disconnected from the camshaft for removal and reconnected and timed when the camshaft is reinstalled. Timing marks on the crankshaft and on the camshaft sprockets are provided for the timing process; however, these marks may differ, depending on the manufacturer. Be sure to check the proper manual for valve-timing information. In some applications, the distributor shaft is different from the camshaft but is driven by the same chain or belt. In these applications both the cam and distributor sprockets must be timed when the camshaft is reinstalled.



f. Carefully inspect all contact surfaces. If any abrasion is noted, replace those parts and the parts upon which the abraded part contacts. Measure the height of each cam lobe. If there is any variation between any of the lobe heights, the camshaft and all of the followers should be replaced.

B. Inspecting valve lifters (tappets)

1. If servicing an older vehicle, the technician may have to inspect mechanical lifters. Mechanical lifters are usually used as cam followers and some are used to adjust the valve lash of the system. Mechanical lifters are rarely found in today's modern automobiles. Most modern engines use hydraulically adjusted lifters or no lifters at all.

2. Inspecting hydraulic lifters

a. Hydraulic lifters are operated with engine oil pressure. The lifters adjust the valve lash in the valve train automatically.

b. In valve-in-head engines, the lifters are found in the block assembly and contact the camshaft directly.

c. In overhead cam engines equipped with hydraulic lifters, the lifters will be found on one end of a rocker arm, which contacts the camshaft.

d. In engines using hydraulic valve lifters, the valve train must be adjusted so that the hydraulic lifters have sufficient travel to make the needed adjustments.

e. All valve lifters must be carefully inspected for visible damage. If any damage is found on any lifter that contacts the camshaft, then all of the lifters and the camshaft must be replaced. Lifters that do not directly contact the camshaft can be replaced individually.

f. Lifters can be disassembled for cleaning and also can be tested for "leak-down" by using test equipment intended for this purpose. Internal parts are not available for hydraulic valve lifters; lifters should be replaced individually. If the valve lifters on valve-in-head engines show signs of wear or exhibit signs of excessive "leak-down," it would likely be best to replace the camshaft and all of the lifters on engines that are intended for re-use. Lifters that do not contact the camshaft can be disassembled and cleaned. Be careful not to mix the internal parts from one lifter with another. Any lifter showing internal wear should be replaced.

C. Inspecting push rods

1. Push rods are used only in valve-in-head engines. Push rods transfer the movement of the lifters, located in the block assembly, to the rocker arm, located in the head.

2. Some push rods are hollow and are used to direct oil from the valve lifter to the rocker arm for lubrication. Other push rods do not have an oiling hole and only transmit movement to the rocker. (No push rod is solid; all are tubular.)

3. Carefully inspect the push rods.

a. Roll each push rod on a flat surface such as a table or a workbench. Push rods which are bent do not roll smoothly. Discard all bent push rods.

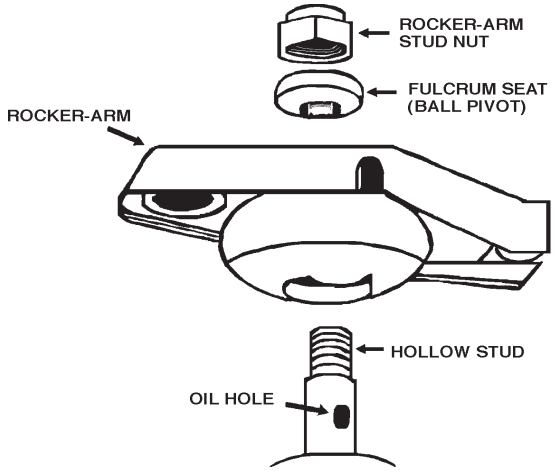
b. Carefully inspect each end of each push rod. Ends should be smooth and spherical. Any roughness of either end, or distortion of the "roundness" of the push rod end, should be reason for rejection.

c. Carefully clean out all hollow push rods using solvent, compressed air, and wires if necessary. It is important that the hollow push rods are internally clean.

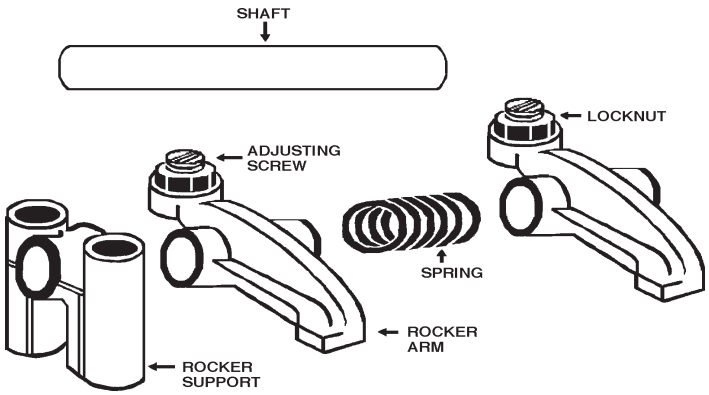
d. Replace all push rods which do not pass inspection. In some applications push rods come in several lengths and valve train adjustments are made by selecting the proper length push rod. If the new push rod does not seem to fit, try a different length push rod, or grind a little more from the valve stem.

D. Inspecting rocker shaft/rocker arm stud

1. Some heads use rocker arm studs to hold individual rocker arms in the head.



2. Other heads use a rocker shaft to hold collectively all of the rocker arms.



3. Inspect rocker studs according to the outline below.

   (NOTE: Some studs are screwed into the head, while others are pressed in.)

   a. Measure all pressed-in studs to be sure that they have not started to “pull out” of the head. If any stud is significantly longer than the others, the head must be repaired by a qualified machinist.

   b. Inspect screwed-in studs to be sure that they are not loose. If in doubt, retorque the studs.

   c. Visually inspect each stud and look for any distortion. Replace any studs that are bent or worn.

   d. Inspect the threads on the end of each stud. The threads should be clean and free from distortion. Do not attempt to rethread a stud using rethreading dies. If the thread is distorted in any way, replace the stud.

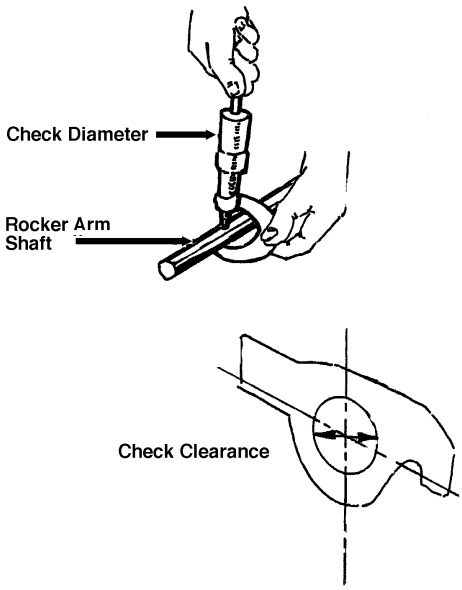
e. Screwed-in studs can be replaced in the service shop. Pressed-in studs are usually replaced in a machine shop. Pressed-in studs can be replaced in the service shop if the proper equipment is available.

(**CAUTION:** Do not attempt to replace pressed-in studs without the proper equipment. The technician should be well-trained in the use of this equipment.)

4. Inspect the rocker shaft according to the outline below.

a. Remove all rocker arms from the shaft.

b. Inspect the shaft for wear at the points where it is contacted by the rocker arms. Replace the shaft if any wear is found.



c. Oil is usually carried inside the rocker shaft to lubricate the rocker arms and the valves. Be sure to clean out the inside of the rocker shaft carefully; also clean out all holes which direct oil to the rocker arms.

d. Find the passage that directs oil to the rocker shaft. Use compressed air to ensure that the passage is open. Often, a restrictor is used to limit the oil flow to the shaft. For this reason, do not use a wire or drill to clean out the passage. In many applications, the oil passage goes through the head gasket. Be sure that the gasket is properly installed so that it does not interfere with the oil passage.

(NOTE: In some vehicles, the oil moves through a drilled passage in the engine block on through a drilled passage in the head and then on to the rocker shaft through one of its mounting caps. In other vehicles, the oil is

directed to one of the bolts that hold down the shaft. In these vehicles, the bolt is machined to allow the oil to pass. In still others, the oil passes through a separate oil line from the oil gallery to the rocker shaft.)

E. Inspecting rocker arms

1. Rocker arms have three contact surfaces: one on each end and one in the center.

2. Some rocker arms are made of stamped steel while others are made of forged steel. Some “high performance” rocker arms are made of forged aluminum or magnesium.

3. The contact at one end may be a push rod (valve-in-head) or a lifter (overhead cam). The contact at the other end is usually the valve. Each end must be carefully inspected for wear and distortion. Replace all worn rocker arms.

4. The center of the rocker arm contacts the rocker arm stud or rocker shaft (valve-in-head) or the camshaft (overhead cam).

5. Carefully examine the center wear point and replace all rocker arms that are worn.

6. In some instances, the bearing that contacts the rocker shaft can be replaced. In other cases, the pad that contacts the valve stem can be replaced.

III. Checking and setting valve timing

A. Procedure for checking valve timing in valve-in-head and L-head engines

1. Valve-in-head and L-head engines have their valve timing mechanisms located in the block assembly.

2. The camshafts are located in the block. The camshaft is driven at one-half crankshaft speed by the crankshaft using timing gears, or a timing chain, and two sprockets.

3. The position of the timing components cannot be directly checked unless the short block assembly is taken apart. The valve timing can be determined by observing the valve rockers or valves while rotating the engine crankshaft in its normal direction of rotation.

4. Disassemble the engine sufficiently to be able to observe the valves in the number one cylinder.

a. In valve-in-head engines, disassembly may require removing the rocker arm cover from the head.

b. In L-head engines disassembly may require removal of either the valve lifter cover (tappet cover), the L-head vee manifold, or the head.

5. Find and clean the timing marks on the harmonic balancer, located at the front of the engine crankshaft.

6. Rotate the engine in its normal direction. Watch the action of the valves in the number one cylinder. Find the “overlap” position of the cylinder by noting when the exhaust valve closes and when the intake valve begins to open.

    a. There is a position where both of the valves are slightly open at the same time, one just coming closed, and the other just coming open. This is the overlap position.

    b. Position the crankshaft so that the valves are in the valve overlap position. At this position the timing marks should be at the “top dead center” position. If it is not, then the engine’s valve timing is off. If this is the case, the engine short block must be partially disassembled and the condition corrected.

7. Check the condition of the timing chain and sprockets using the procedure outlined below.

    a. Remove the distributor cap. Rotate the engine crankshaft while observing the distributor rotor.

    b. As soon as movement is noted at the rotor, stop rotating the crankshaft. Using chalk or other marking device, mark the location of the distributor rotor and the engine crankshaft.

    c. Carefully begin rotating the engine backwards, watching the distributor rotor. As soon as movement of the rotor is detected, stop rotating the crankshaft. Observe the amount of crankshaft rotation that was required in order to start movement of the distributor rotor. This movement is indicative of the amount of looseness of the timing chain. If the movement is more than 3/4 of an inch, replacement of the timing components should be considered.

B. Procedure for checking valve timing in overhead camshaft engines

1. Valve trains in overhead camshaft engines are also driven by the crankshaft at one-half of the crankshaft speed. The camshaft is driven by a long chain or “clogged” belt. In some instances, the chain or belt can be used to drive other accessories such as the water pump, or the distributor. These valve trains are checked by visually inspecting the condition of the chain, belt, and sprockets.

2. The valve timing on these engines is adjusted by positioning the camshaft in relation to the crankshaft. Most of these engines can be adjusted without major disassembly. In some applications, the distributor shaft is driven by the same chain or belt and must be “timed” at the same time as the valve train. Timing chain or belt looseness on these engines is often adjusted automatically by using oil pressure and chain tighteners, or manually adjusted chain or belt tighteners.

3. To set the valve timing, simply align the valve timing marks provided for this purpose, and install the chain or belt. There is no universally “correct” method, so be sure to consult the service manual before attempting this procedure.

IV. Checking and adjusting valve lash

A. Checking and adjusting valve lash in mechanical valve lifters

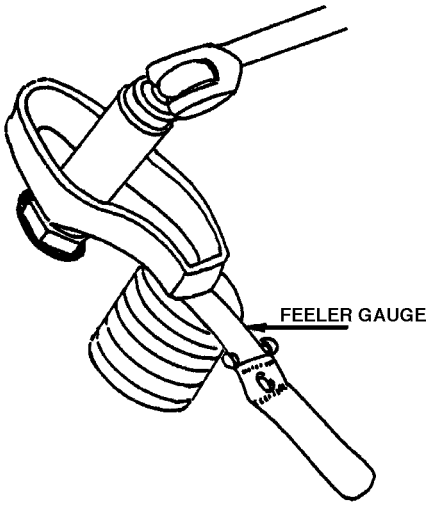
1. Mechanical valve lifters must have clearance (lash) between the cam and the valve while the valve is closed. If there is no clearance, the valve will be held open by the valve train linkage. Methods for adjusting the lash varies, depending on the design of the valve lifter.

a. Some valve trains have adjustable lifters located at the camshaft.

b. Others have adjusters at the rocker arm, composed of a screw and a lock nut.

c. A third type uses valve adjusting shims located at the top of the valve stem.

2. The valve lash (clearance) on mechanical valve trains must be adjusted accurately when the valve train is assembled. The clearance must be maintained byperiodic measurement and adjustment.



3. The clearance is measured by inserting a feeler gauge of the proper thickness between the valve train linkage and the valve stem. In some applications, the clearance is measured with the engine running and at operating temperature. Others require that the engine is cold. Refer to the service manual for the required clearance dimension and the proper adjustment procedure.

B. Checking and adjusting valve lash on hydraulic lifters

1. Hydraulic valve lifters must be adjusted when the valve train is assembled. The clearance will be automatically maintained hydraulically and periodic maintenance is not required.

2. The valve lash in hydraulic valve trains is not measured in the same way as the clearance in mechanical valve trains.

    a. Unlike mechanical valve trains, the lash in hydraulic valve trains is not measured as a clearance. The clearance in hydraulic valve trains is always zero. In hydraulic valve trains, the valve lash is the amount that the lifter piston is deflected into the lifter body when the valve is closed. If there is any measurable clearance, the hydraulic valve train will be noisy. If the piston bottoms in the lifter body, the valve will not close.

    b. If the hydraulic valve train is properly adjusted, the lifter piston will be about one-half of the way down in the lifter body. Consult the proper service manual for more specific directions.

3. In some engines with hydraulic lifters, the lash is adjusted by using a set screw and lock-nut that is located in the rocker assembly.

4. A third method uses selective length push rods; occasionally the valve stems must be ground to the proper length.

JS1-L3-UIV

MODULE: ENGINE REPAIR

INSPECTING VALVE TRAIN COMPONENTS

Equipment:

Common mechanic's hand tools
Micrometer set
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (NOTE: If servicing a vehicle with a valve-in-head camshaft, do procedure 2 below. If servicing a vehicle with an overhead camshaft, do procedure 3 below. Do not do both 2 and 3 unless the instructor requires both.)

2. Following the procedure outlined below, inspect a valve-in-head camshaft.

   a. Using the appropriate service manual, record the specifications for push rod travel.

      Push rod travel specifications _____

   b. Measure the amount of push rod travel as the crankshaft is rotated. Record the mea surement.

      Push rod travel measurement _____

   c. Compare the amount of push rod travel to specifications and the other cam lobes on this shaft. If the lobe lift is less than specified, or if any lobe lift is significantly different than the others, the camshaft should be considered defective.

      Is the camshaft defective? Yes _____ No _____

   d. Visually inspect the valve lifter feet for roughness and cupping. Record observations.

   (NOTE: When inspecting valve lifters, be sure to return each lifter to the bore from which it was removed. Lifters must run on the same cam lobe as they were worn on or their life will be substantially reduced.)

   (NOTE: Do not replace the camshaft unless all of the lifters are also replaced. Do not replace any one lifter unless all of the lifters and the camshaft are replaced. An exception to this rule might be the replacement of a relatively new lifter that has become defective.)

3. Following the procedure outlined below, inspect an overhead camshaft.

   a. Carefully inspect all contact surfaces.

   Is there any abrasion? Yes ____ No ____

   What parts need to be replaced?

   b. Measure the height of each cam lobe.

   Is there any variation between any of the lobe heights?

   Yes ____ No ____

   Should the camshaft and all of the followers be replaced?

   Yes ____ No ____

4. Inspect the hydraulic lifters for damage and record observations below. Indicate if the lifters need to be replaced.

5. Following the procedure outlined below, inspect the push rods.

   a. Roll each push rod on a flat surface such as a table or a work bench. Push rods that are bent do not roll smoothly. Record results and indicate if any push rod should be discarded.

   b. Carefully inspect each end of each push rod. Make sure each end is smooth and spherical. Record results and indicate if any push rod should be discarded.

   c. Carefully clean out all hollow push rods using solvent, compressed air, and wires if necessary.

6. Following the procedure outlined below, inspect rocker studs.

(CAUTION: Do not attempt to replace pressed-in studs without the proper equipment. The technician should be well-trained in the use of this equipment if it is available.)

a. Measure all pressed-in studs to be sure that they have not started to "back out" of the head. If any stud is significantly longer than the others, the head must be repaired by a qualified machinist. Record observations and indicate if repair or replacement is necessary.

b. Make sure screwed-in studs are not loose. If in doubt, retorque the studs.

c. Visually inspect each stud; look for any distortion. Record observations and indicate if repair or replacement is necessary.

d. Inspect the threads on the end of each stud. The threads should be clean and free from distortion. Record observations and indicate if repair or replacement is necessary.

(NOTE: Do not attempt to rethread a stud using rethreading dies. If the thread is distorted in any way, replace the stud.)

7. Following the procedure outlined below, inspect the rocker shaft.

a. Disassemble all rocker arms from the shaft.

b. Inspect the shaft for wear at the points where it is contacted by the rocker arms. Record observations and indicate if repair or replacement is necessary.

c. Clean out the inside of the rocker shaft carefully; also clean out all holes which direct oil to the rocker arms.

d. Find the passage that directs oil to the rocker shaft. Use compressed air to ensure that the passage is open.

(NOTE: Often a restrictor is used to limit the oil flow to the shaft. For this reason, do not use a wire or drill to clean out the passage. In many applications, the oil passage goes through the head gasket. Be sure that the gasket is properly installed so that it does not interfere with the oil passage.)

8. Following the procedure outlined below, inspect the rocker arms.

a. Check each end of rocker arms for wear and distortion. Record observations and indicate if repair or replacement is necessary.

b. Carefully examine the center wear point. Record observations and indicate if repair or replacement is necessary.

JS2-L3-UIV

MODULE: ENGINE REPAIR

CHECKING AND SETTING VALVE TIMING IN VALVE-IN-HEAD AND L-HEAD ENGINES

Equipment:

Common mechanic's hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Disassemble the engine sufficiently to be able to observe the valves in the number one cylinder.

3. Find and clean the timing marks on the harmonic balancer, which is located at the front of the engine crankshaft.

4. Following the procedure outlined below, determine if the engine is out of time.

   a. Rotate the engine in its normal direction. Watch the action of the valves in the number one cylinder. Find the "overlap" position of the cylinder by noting when the exhaust valve closes and when the intake valve begins to open.

   b. There is a position where both of the valves are slightly open at the same time, one just coming closed, and the other just coming open. This is the overlap position.

   c. Position the crankshaft so that each valve is in the same amount of travel. At this position the timing marks should be at the "top dead center" position. If it is not, then the engine is out of time. If this is the case, the engine short block must be partially disassembled and the condition corrected.

      Is the engine out of time? Yes _____ No _____

5. Following the procedure outlined below, check the condition of the timing chain and sprockets.

   a. Remove the distributor cap. Rotate the engine crankshaft while observing the distributor rotor.

b. As soon as movement is noted at the rotor, stop rotating the crankshaft. Using chalk or other marking device, mark the location of the distributor rotor and the engine crank shaft.

c. Carefully begin rotating the engine backwards, watching the distributor rotor. As soon as movement of the rotor is detected, stop rotating the crankshaft. Observe the amount of crankshaft rotation that was required in order to start movement of the distributor rotor. This movement is indicative of the amount of looseness of the timing chain. If the movement is more than 3/4 of an inch, replacement of the timing compo nents should be considered.

Should the timing components be replaced? Yes _____No _____

JS3-L3-UIV

MODULE: ENGINE REPAIR

CHECKING AND SETTING VALVE TIMING IN OVERHEAD CAMSHAFT ENGINES

Equipment:

Common mechanic's hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for checking and setting valve timing in overhead camshaft engine. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, check and set the valve timing in an overhead camshaft engine. Record observations.

JS4-L3-UIV

MODULE: ENGINE REPAIR

CHECKING AND ADJUSTING VALVE LASH ON MECHANICAL VALVE LIFTER ENGINES

Equipment:

Common mechanic's hand tools
Micrometer set
Feeler blade Set
Dial indicator
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for checking and adjusting valve lash on mechanical valve lifter engines. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   ☐
   Instructor Approved

   Following the procedure, check and adjust valve lash on mechanical valve lifter engines. Record observations.

JS5-L3-UIV

MODULE: ENGINE REPAIR

CHECKING AND ADJUSTING VALVE LASH ON HYDRAULIC VALVE LIFTER ENGINES

Equipment:

Common mechanic's hand tools
Feeler blade set
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for checking and adjusting valve lash in hydraulic valve lifters. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor intial the box below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, check and adjust valve lash on hydraulic valve lifter engine. Record observations.

MODULE: ENGINE REPAIR

UNIT V: SHORT BLOCK DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and functions of the short block assembly. The student also should be able to disassemble, measure, and assemble the short block assembly. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify the terms and definitions associated with engine disassembly and inspection (Competencies O1 and O2, Parts I and II of the Unit V Test).

II. Identify the procedures for the short block assembly (Competency O2, Part II of the Unit V Test).

III. Identify the procedures for inspecting short block components (Competencies O3 and O4, Parts III and IV of the Unit V Test).

IV. Identify the methods of and procedures for reconditioning cylinder walls (Competency O3, Part III of the Unit V Test).

V. Demonstrate the ability to:

   a. Disassemble the short block (Competency O2, JS1-L1-UV).

   b. Inspect and replace pans, covers, gaskets, and seals (Competency O1, JS2-L1-UV).

   c. Disassemble, inspect, and clean short block accessory components (Competency O2, JS3-L1-UV).

   d. Check and record short block measurements (Competency O3, JS4-L1-UV).

   e. Check and record short block component measurements (Competency O4, JS5-L1-UV).

   f. Prepare short block components for reassembly (Competency O5, JS6-L1-UV).

Lesson 2.

I. Identify terms and definitions associated with engine assembly (Competency O6, Part VI of the Unit V test).

II. Identify the procedures for reassembling an engine (Competency O6, Part VI of the Unit V Test).

III. Demonstrate the ability to:

a. Assemble the short block (Competency O6, JS1-L2-UV).

MODULE: ENGINE REPAIR

UNIT V: SHORT BLOCK DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT V: SHORT BLOCK DIAGNOSIS AND REPAIR

LESSON 1: SHORT BLOCK DISASSEMBLY AND INSPECTION

I. Terms and definitions associated with engine disassembly and inspection

A. Glaze breaking—The process of using a hone to create a cylinder surface that will allow the new rings to seal.

B. Harmonic balancer puller—A type of puller used to remove the harmonic balancer from the crankshaft.

C. Magnaflux—A process used to find cracks in metal parts.

D. OHC overhead camshaft—Any type of engine in which the camshaft is found in the head rather than in the block.

E. Ridge reamer—A device used to remove a cylinder ridge. A cylinder ridge develops in the cylinders during many years of wear.

II. Procedures for disassembling the short block

A. Following the procedure below, remove the engine accessories.

(NOTE: The engine should be secured on an engine stand and the outside of the engine should be cleaned before this procedure is started.)

(NOTE: While disassembling the engine, the technician should examine each part for excessive wear or defects.)

(NOTE: All brackets, braces and their bolts from the engine should be stored together to facilitate reassembly.)

(NOTE: If possible, the power steering pump should be removed before the engine is removed from the vehicle.)

1. Remove the alternator and attaching hardware. Also remove the starter and attaching hardware.

2. Following the below procedure, remove components of the steering/power train systems.

a. Remove the power steering pump and attaching hardware.

b. Remove the motor mounts from the engine.

c. Remove the flywheel from the crankshaft.

3. Remove components of the fuel, cooling, ignition, exhaust, and emission systems.

a. Remove the fuel pump (if it is the mechanical type).

b. Remove the distributor and related components.

c. Remove the carburetor/fuel injection system and hardware.

d. Remove the water pump and other cooling system accessories.

e. Remove any remaining emission control components.

f. Remove the exhaust manifolds and attaching hardware, if necessary.

(NOTE: As these components are removed, they should be stored in labeled boxes in order to make reassembly easier. Inspection of these various components will be covered later in this unit.)

B. Remove the head (heads) assembly. See Unit IV, Lesson 2 of this module for the proper procedure.

(NOTE: Check the head for obvious damage, such as broken springs, burned valves, etc. Also, be alert to any damage to the block. If found to be cracked, the block will probably have to be discarded.)

(NOTE: If the engine is not OHC, remove the lifters at this point, and keep track of their location for further inspection.)

C. Following the procedure below, remove the front housing (timing chain cover).

1. Remove the pulleys on the harmonic balancer.

2. Remove the harmonic balancer.

(NOTE: A puller is generally needed to remove the balancer.)

3. Remove the front housing (timing chain cover).

(NOTE: It is sometimes necessary to remove the front oil pan bolts in order to remove the front housing.)

(NOTE: On engines that are not OHC, the timing chain and camshaft should now be removed.)

4. If necessary, remove the balancing or counter balancing shaft. These shafts are not found in all engines.

D. Following the procedure below, remove the cylinder ring ridges.

(**CAUTION:** Do not attempt to remove pistons from the cylinder without cutting the ring ridge; doing so will damage the piston ring lands.)

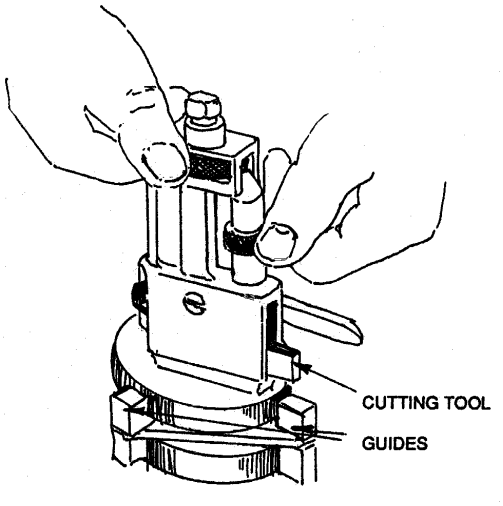
(NOTE: A ridge reamer should be used to remove the ring ridges in each cylinder.)

1. Clean cylinder block gasket surface around cylinders.

2. Adjust the ridge reamer so that it is just a little smaller than the cylinder diameter.

3. Insert ridge reamer in the cylinder.

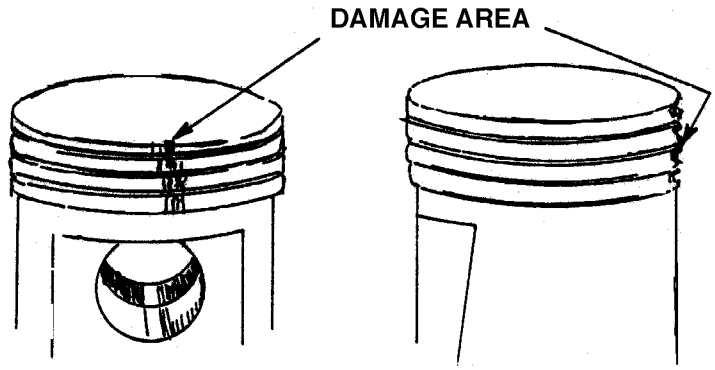
4. Adjust the cutter blade according to tool manufacturer's instructions.



(NOTE: The cutting process should be checked frequently to prevent the cylinder from being damaged at the point where the rings travel.)

5. Cut the ridge out of the top of each cylinder.

(**CAUTION:** Do not attempt to remove pistons from the cylinder without cutting the ring ridge; doing so will damage the piston ring lands.)



E. Turn the engine over on its fixture.

F. Remove the oil pan from the engine.

G. Remove the oil pump if it is not contained within the front housing. If the pump was in the housing, the pickup screen will need to be removed.

(NOTE: Some engines use an oil baffle, which is bolted to the main caps. If this is the case, remove the baffle at this time.)

H. Following the procedures below, remove the piston connecting rod assembly.

(NOTE: The piston should be at bottom dead center [BDC] before removal procedures begin.)

1. If each rod and cap are not already numbered by the manufacturer, mark them so that they can be kept together.

2. Remove the rod cap nuts and separate the rod cap from the connecting rod.

3. Place a piece of rubber hose over each rod bolt to prevent the crankshaft from being scratched.

4. Push the piston connecting rod assembly down through the bore.

   (NOTE: Be careful not to drop the pistons as they come out of the block.)

   (NOTE: If the piston rings hang up on the cylinder ridge, then the ridge will have to be reworked. Never force the piston over the ridge; doing so may damage the piston.)

5. Put the rod cap back on the connecting rod, and keep the bearings with each assembly.

6. Repeat steps 1 through 5 until all pistons are removed.

(NOTE: Store the pistons out of the way of the work.)

I. Following the below procedure, remove the crankshaft.

1. If the main caps are not already numbered by the manufacturer, number them for assembly.

2. Remove all the main bearing cap bolts and keep them in order so that they can be placed in the proper positions during reassembly.

(NOTE: On some engines, main cap bolts are of different lengths; however, the difference in these lengths cannot be seen with the human eye. Nevertheless, if these bolts are placed in the wrong location, the main bearing will fail.)

3. Remove the crankshaft and store it in an out-of-the-way location.

(NOTE: Keep the main bearings in order for later inspection.)

(NOTE: Remove the rear main seal at this time.)

4. Reinstall the main caps.

J. Remove core and galley plugs.

K. Check the block for cracks again.

L. On engines that are not of the OHC design, drive out the camshaft bearings.

M. Place the engine in the hot tank and give it a thorough cleaning.

(NOTE: Be sure to follow all the instructions provided by the hot tank manufacturers.)

(**CAUTION:** Aluminum components cannot be placed in a hot tank that is prepared to clean ferrous metal.)

(NOTE: If the shop does not own equipment for hot tanking and various other block matching processes, then the next step will have to be accomplished before the block is sent to the engine machine shop.)

III. Inspecting short block assembly components

A. Following the procedure below, inspect the accessories for the short block assembly.

1. Clean and inspect the cooling system components, such as the water pump, hoses, belts, thermostat, etc. Also check these components for wear and replace them as necessary.

2. Inspect the fuel system components for leakage and wear. Replace them as necessary.

3. Clean and inspect emission system components.

4. Clean and inspect the power steering pump.

5. Clean and inspect the motor mounts.

6. Clean and inspect any brackets or sub pulleys, lines, or any other assemblies not previously mentioned.

7. Clean and inspect the flywheel/flexplate for cracks or worn starter drive teeth. Make repairs as necessary.

8. Clean and inspect the harmonic balancer.

   (NOTE: In many cases, the harmonic balancer will have a groove worn into it by the front oil seal. This groove is often repaired by a sleeve that is pressed over the end of the balancer.)

B. Following the procedure below, inspect the pans and covers.

1. Inspect the oil pan for cracks or other defects.

2. Inspect the timing chain cover for defects.

3. Clean the gasket area.

4. Check and, if necessary, flatten the area around the mounting holes.

   (NOTE: The area around the mounting holes may have been damaged due to overtightening of the gaskets during previous repairs. Use a ball-peen hammer to repair this damage.)

5. Inspect the cover for obvious holes or cracks.

6. Discard any valve cover that cannot be quickly or easily repaired.

7. If problems were encountered with the drain plug (such as leaking, stripping, etc.), make repairs at this time.

C. Inspect the cylinder head.

D. Following the procedure below, clean and inspect the crankshaft.

1. Wash the crankshaft with a good safety solvent. Using a small rifling brush, clean the oil passages that run through the crankshaft. Blow the crankshaft area dry with compressed air.

2. Inspect the flywheel flange and pilot bushing.

a. Inspect the flywheel flange for signs of cracks or displaced metal that may have been caused by a loose flywheel.

b. If the engine uses a manual transmission, inspect the pilot bushing for wear.

(NOTE: Some technicians will replace the pilot bushing to ensure that it functions properly.)

3. Following the procedure outlined below, inspect the journal.

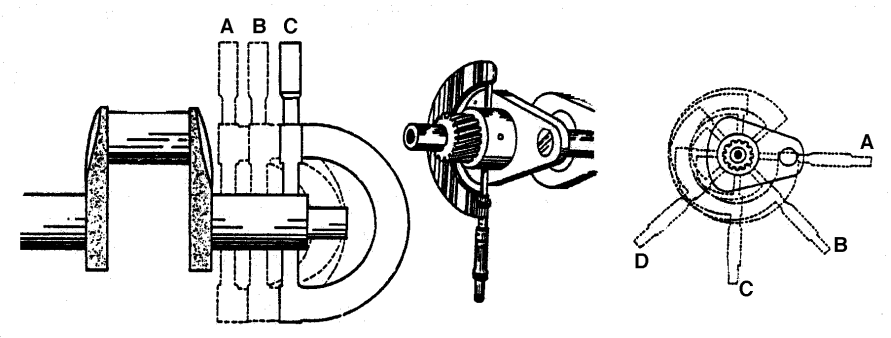
a. The same inspection procedures are used for the main bearing and rod bearing journals.

b. Check the journals for any sign of grooving, scoring, or surface cracks.

(NOTE: If the crankshaft shows any sign of grooving, scoring, or cracking, it will have to be ground to a standard undersize.)

4. Following the procedure outlined below, check the journals for taper.

a. Using a micrometer, measure the size of the journal at points a, b, and c.



b. Compare the three measurements. There should not be more than .001 of an inch difference between the three measurements. If the difference exceeds .001 of an inch, then the crankshaft will need to be ground to the next standard undersize.

(NOTE: Taper problems are usually an indication of a bent connecting rod. Therefore, if taper problems exist, make sure that the connecting rods are adequately straight.)

5. Following the procedure outlined below, check the journals for out-of-round measurement.

a. Using a micrometer, measure the size of the journal at points a, b, c, and d.

b. Compare the four measurements. There should not be more than .001 of an inch difference between the four measurements. If the difference exceeds .001 of an inch, then the crankshaft will need to be ground to the next standard undersize.

E. Following the procedure below, clean and inspect the camshaft.

(NOTE: For camshaft inspection, see Unit IV, Lesson 3 of this unit.)

F. Following the procedure below, inspect and clean the cylinder block.

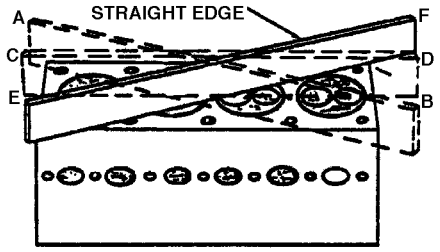
(NOTE: It is assumed that, at this point in the inspection procedure, the block has already been steam cleaned or hot tanked.)

(NOTE: During the inspection, always look for signs of cracks in the block. If a cracked block is found, the technician will have to decide whether the block will be repaired or replaced before continuing with any other procedures.)

1. Clean and check mating surfaces.

a. Using a gasket scraper, remove all remaining gasket material from the head, the timing chain cover, and the oil pan mating surfaces.

b. Using a machined bar and a feeler gauge, check the head mating surface for flatness across points a and b, c and d, and e and f.



c. If a feeler gauge blade larger than .005 of an inch can be slid under the bar at any point, then the mating surfaces will have to be ground flat.

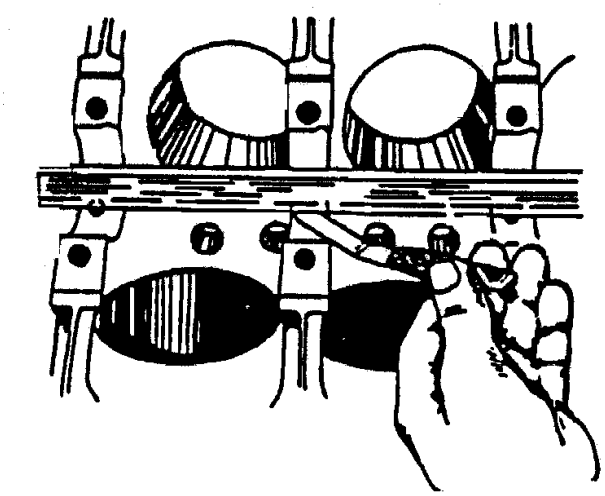
(NOTE: If a vee engine block is planed, the intake manifold will often need to be machined.)

2. Check the crankshaft bore alignment.

a. Remove crankshaft, upper main bearing halves, and rear main bearing seal if they are not already removed.

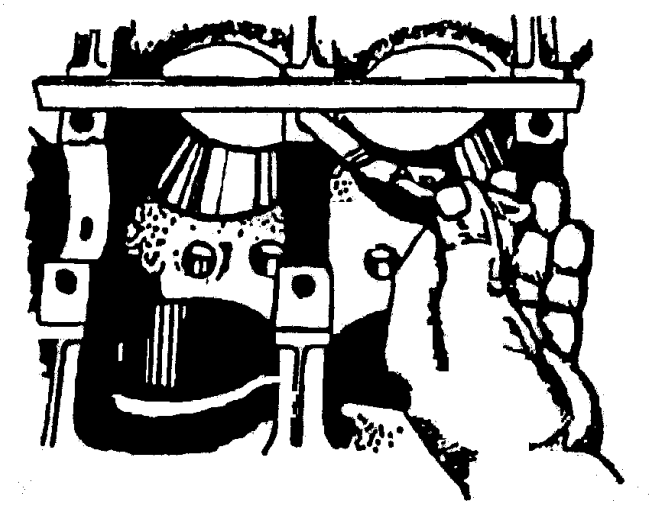
b. Clean the main bearing bore and cap bosses thoroughly and air dry.

c. Place the straightedge at the bottom of the main bearing bore.



d. Check the clearance between each bearing bore surface and straightedge.

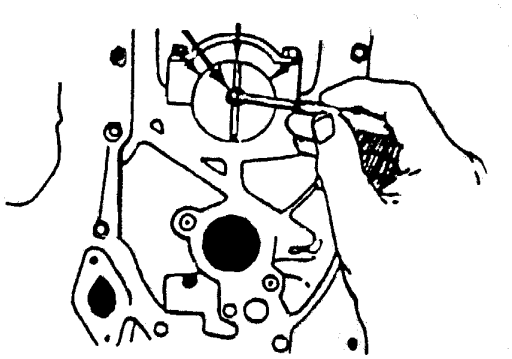
e. Place straightedge on main bearing cap bosses.



f. Check clearance between straightedge and bosses.

(NOTE: Clearance between the surface and straightedge should not exceed one half of the allowable bearing clearance. If the clearance is greater than one-half of the allowable clearance, the block will have to be re-machined or discarded.)

g. Check bearing bore for out-of-round. Install main bearing cup and torque it to specifications. Measure the bearing bore at three locations.



(NOTE: Leave the bearing inserts out when checking bore out-of-round.)

h. Compare the three measurements to obtain bore out-of-round.

(NOTE: Check manufacturer's specifications for allowable bore out-of-round. If out-of-round exceeds allowable limits, the block bore will have to be line bored by a machinist.)

3. Measure the cylinder taper.

(NOTE: Visually inspect the cylinder bores and note any excessive scratches in the cylinder walls.)

(NOTE: There are many methods by which the cylinder taper can be measured. The below procedure involves the use of an inside micrometer and is one of the simplest methods for measuring taper.)

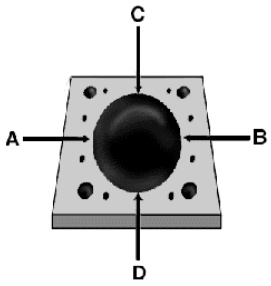
a. Use an inside micrometer or an outside micrometer and a snap gauge to measure the top, middle, and bottom of piston ring travel.

(NOTE: These measurements are made perpendicular to the direction of the crankshaft.)

b. Determine the difference between the top and bottom reading. If this difference is greater than .010 to .012 of an inch, then the block will have to be bored and new pistons will have to be purchased and installed on the rods.

4. Measure cylinder out-of-round.

a. Using an inside micrometer or an outside micrometer and a snap gauge, take cylinder measurements at the top of the cylinder at points a and b and c and d.



b. Determine the difference between measurements of a and b and c and d. If the difference exceeds .003 of an inch, then the block will need to be rebored and the pistons will need to be replaced.

5. Measure cylinder bore size.

(NOTE: After measuring taper and out-of-round, the technician should be able to conclude if bore size is standard or if the bore is already oversized.)

(NOTE: If the cylinder measurements meet specifications and pistons are in satisfactory condition, then the cylinders can be honed and the pistons can be re-used. Honing will be discussed later in this lesson.)

6. Clean and inspect oil passages (galleys).

a. Run rifle brushes through the many oil passages in the block (i.e., oil pump to crankshaft).

(NOTE: Repair manuals usually include diagrams of oil passages. Use these diagrams as a guide in cleaning and checking the oil passages.)

b. If any solid blockage is found in an oil passage, determine the cause of the blockage and correct the problem.

G. Clean and inspect the piston/connecting rod.

1. Wipe the connecting rod bearing. Clean and inspect the bearing.

(NOTE: Abnormal wear patterns on the rod bearing may indicate bent or twisted connecting rods.)

2. Move the piston on the piston pin. Any sign of looseness would warrant the replacement of the piston assembly.

3. Inspect the piston.

a. Visually inspect the piston for cracks, holes, or excessive pitting.

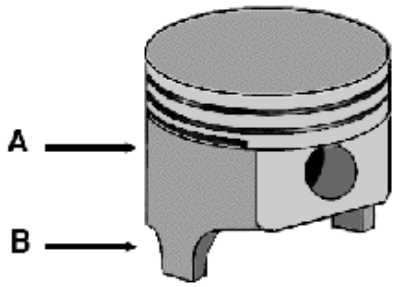
(NOTE: Cracks in the piston will usually be located near the piston pin and/or skirt.)

(NOTE: An unusual wear pattern on the piston skirt usually indicates a problem with a piston or rod assembly.)

b. Inspect the ring land area for signs of stuck rings, broken lands, or broken rings.

c. Using a feeler gauge, measure the clearance between the rings and the ring lands. Clearance should not exceed .006 of an inch.

d. Using a micrometer, measure piston skirt collapse at points a and b. If the size difference between points a and b is less than .015 of an inch, then the skirt can be knurled. If the difference is greater than .015 of an inch, the piston will have to be discarded.



4. If the piston passes all inspections, remove the rings and use a ring groove cleaner to remove the carbon from the piston ring grooves. Also, clean the top of the piston.

(NOTE: Do not use a power brush to clean the top of the piston. Use a carbon scraper. Clean the top of the piston gently; aluminum is soft.)

H. Inspect the oil pump.

(NOTE: If a new pump is purchased along with the engine rebuilding kit, the old pump will not have to be inspected.)

(NOTE: There are significant differences in tolerance specifications between gear and rotor pumps. Therefore, always refer to the manufacturer's procedures for oil pump inspection.)

I. Following the procedure below, inspect and clean threads and bolts.

1. Using various taps, clean the threads of all threaded holes in the block.

2. Clean all the nuts and bolts used to assemble the engine.

3. Inspect the nuts and bolts for signs of stretching, stripping, and for rounded corners on bolts and nuts.

J. Make a list of all components that need to be repaired or replaced.

IV. Reconditioning cylinder walls

A. Boring

(NOTE: Depending upon the condition of the cylinder wall and the size of the piston to be used, the cylinders may or may not have to be bored. All cylinders, however, will have to be honed prior to the installation of the pistons.)

1. The engine cylinders should be bored to correct cylinder taper, out-of-round, or poor cylinder wall surface condition.

2. Boring involves placing a boring machine on the block and enlarging the cylinder's diameter by a set amount—usually .015, .030, or .060 of an inch.

3. Because the old pistons will not work in the enlarged cylinders, bore cylinders require that the old pistons be replaced.

(NOTE: Boring procedures vary significantly depending on the type of equipment used.)

B. Honing (glaze breaking)

1. Honing produces a cylinder wall finish that is conducive to ring sealing.

2. Honing is sometimes done to correct small cylinder wall imperfections or to remove small amounts of metal in order to fit new pistons in bored cylinders.

3. Hones can be either flexible bead or rigid.

a. Flexible hones remove an insignificant amount of metal from the cylinder walls, yet provide a suitable cylinder wall surface for ring sealing.

b. Rigid hones can be used to repair small amounts of cylinder taper or to fit pistons to cylinders after boring. Rigid hones are adjusted by a nut on the honer shaft.

(NOTE: It is easy to remove too much metal from the cylinder walls. Care should be used when working with a rigid hone.)

4. Hone abrasives (stones)

a. Stones are available in a number of grits, ranging from very coarse to very fine.

b. Selection of stone is dependent on the amount of metal to be removed from the cylinder and the nature of the finish needed for the engine piston rings.

5. Procedure for honing a cylinder

   a. Use a slow-speed electric drill to turn the hone. (The slower the speed of the electric drill, the better the results will be.)

   b. Lubricate the stones with light engine oil or honing solvent.

   c. Turn the hone in the bore, slowly moving the hone from the top of the bore to the bottom about eight to ten times. Make sure that the hone covers the entire bore. Continue covering the cylinder with the hone until all of the glaze is removed and the entire bore has a dull finish.

   d. Finally, move the hone rapidly, about five or six times, from top to bottom so that the stone scratches cross each other at 45 to 60 degrees.

   e. Repeat the above steps for all of the cylinders in the engine.

JS1-L1-UV

MODULE: ENGINE REPAIR

DISASSEMBLING THE SHORT BLOCK

Equipment:

Common hand tools
Ring ridge remover
Harmonic balancer puller
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (NOTE: The engine should be secured on an engine stand and cleaned before this procedure is begun.)

   (NOTE: While disassembling the engine, the technician should examine each part for excessive wear or defects.)

2. Remove the alternator and attaching hardware. Also remove the starter and attaching hardware. All brackets and braces from the engine should be stored together to facilitate reassembly.

3. Following the procedure outlined below, remove components of the steering/power train systems.

   a. Remove the power steering pump and attaching hardware.

   b. Remove the motor mounts from the engine.

   c. Remove the flywheel from the crankshaft.

4. Following the procedure outlined below, remove components of the fuel, cooling, ignition, exhaust, and emission systems.

   a. Remove the fuel pump (if it is the mechanical type).

      (NOTE: If possible, the power steering pump should be removed before the engine is removed from the vehicle.)

   b. Remove the distributor and related components.

c. Remove the carburetor/fuel injection system and hardware.

d. Remove the water pump and other cooling system accessories.

e. Remove any remaining emission control components.

f. Remove the exhaust manifolds and attaching hardware, if necessary.

(NOTE: As these components are removed, they should be stored in labeled boxes in order to make reassembly easier. Inspection of these various components will be covered in a later job sheet.)

5. Remove the head (heads) assembly. See Lesson 2 of Unit IV of this module for the proper procedure.

a. Check the head for obvious damage, such as broken springs, burned valves, etc. Also, look for any damage to the block. If found to be cracked, the block will probably have to be discarded. Record findings and indicate if replacement is necessary.

b. If the engine is not OHC, remove the lifters at this point, and keep track of their location for further inspection.

6. Following the procedure outlined below, remove the front housing (timing chain cover).

a. Remove the pulleys on the harmonic balancer.

b. Remove the harmonic balancer.

(NOTE: A puller is generally needed to remove the balancer.)

c. Remove the front housing (timing chain cover).

(NOTE: It is sometimes necessary to remove the front oil pan bolts in order to remove the front housing.)

(NOTE: On engines that are not OHC, the timing chain and camshaft should now be removed.)

d. If necessary, remove the balancing or counter balancing shaft. These shafts are not found in all engines.

7. Following the procedure below, check the cylinder for ring ridges.

(NOTE: A ridge reamer should be used to remove the ring ridges in each cylinder.)

a. Clean cylinder block gasket surface around cylinders.

b. Adjust the ridge reamer so that it is just a little smaller than the cylinder diameter.

c. Insert ridge reamer in the cylinder.

d. Adjust the cutter blade according to tool manufacturer's instructions.

(NOTE: The cutting process should be checked frequently to prevent the cylinder from being damaged at the point where the rings travel.)

e. Cut the ridge out of the top of each cylinder.

(CAUTION: Do not attempt to remove pistons from the cylinder without cutting the ring ridge; doing so will damage the piston ring lands.)

8. Turn the engine over on its fixture.

9. Remove the oil pan from the engine.

10. Remove the oil pump if it is not contained within the front housing. If the pump was in the housing, the pickup screen will need to be removed.

(NOTE: Some engines use an oil baffle, which is bolted to the main caps. If this is the case, remove the baffle at this time.)

11. Following the procedure outlined below, remove the piston connecting rod assembly.

(NOTE: The piston should be at bottom dead center [BDC] before removal procedures are begun.)

a. If each rod and cap are not already numbered by the manufacturer, mark them so that they can be kept together.

b. Remove the rod cap nuts and separate the rod cap from the connecting rod.

c. Place a piece of rubber hose over each rod bolt to prevent the crankshaft from being scratched.

d. Push the piston connecting rod assembly down through the bore.

(NOTE: Be careful not to drop the pistons as they come out of the block.)

(NOTE: If the piston rings hang up on the cylinder ridge, then the ridge will have to be reworked. Never force the piston over the ridge; doing so may damage the piston.)

e. Put the rod cap back on the connecting rod, and keep the bearings with each assembly.

f. Repeat steps "a" through "e" until all pistons are removed.

(NOTE: Store the pistons out of the way of the work.)

12. Following the below procedure, remove the crankshaft.

a. If the main caps are not already numbered by the manufacturer, number them for assembly.

b. Remove all the main bearing cap bolts and keep them in order so that they can be placed in the proper positions during reassembly.

(NOTE: On some engines, main cap bolts are of different lengths; however, the difference in these lengths cannot be seen with the human eye. Nevertheless, if these bolts are placed in the wrong location, the main bearing will fail.)

c. Remove the crankshaft and store it in an out-of-the-way location.

(NOTE: Keep the main bearings in order for later inspection.)

(NOTE: Remove the rear main seal at this time.)

d. Reinstall the main caps.

13. Remove core and galley plugs.

14. Check the block for cracks again.

15. On engines that are not of the OHC design, drive out the camshaft bearings.

16. Place the engine in the hot tank and give it a thorough cleaning.

(CAUTION: Aluminum components cannot be placed in a hot tank prepared for ferrous metal.)

JS2-L1-UV

MODULE: ENGINE REPAIR

INSPECTING AND REPLACING PANS, COVERS, GASKETS, AND SEALS

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure below, inspect the pans and covers.

   a. Inspect the oil pan for damage, cracks, or defects. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   b. Inspect the timing chain cover for defects. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   c. Make certain the gasket area is spotless. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   d. Make certain the area around the mounting holes is flat. Record any signs of wear or defects and indicate if repair or replacement is necessary.

(NOTE: The area around the mounting holes may have been damaged due to overtightening of the gaskets during previous repairs. Use a ball-peen hammer to repair this damage.)

e. Inspect the cover for obvious holes or cracks. Record any signs of wear or defects and indicate if repair or replacement is necessary.

f. Discard any valve cover that cannot be quickly or easily repaired. Record any signs of wear or defects and indicate if repair or replacement is necessary.

g. If problems were encountered with the drain plug (such as leaking, stripping, etc.), record any signs of wear or defects and indicate if repair or replacement is necessary.

JS3-L1-UV

MODULE: ENGINE REPAIR

DISASSEMBLING, INSPECTING, AND CLEANING SHORT BLOCK ACCESSORY COMPONENTS

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure below, inspect the accessories in the short block assembly.

   a. Clean and inspect the cooling system components, such as the water pump, hoses, belts, thermostat, etc. Also check these components for wear. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   b. Inspect the fuel system components for leakage and wear. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   c. Clean and inspect emission system components. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   d. Clean and inspect the power steering pump. Record any signs of wear or defects and indicate if repair or replacement is necessary.

e. Clean and inspect the motor mounts. Record any signs of wear or defects and indicate if repair or replacement is necessary.

f. Clean and inspect any brackets or sub-pulleys, lines, or any other assemblies not previously mentioned. Record any signs of wear or defects and indicate if repair or replacement is necessary.

g. Clean and inspect the flywheel/flexplate for cracks or worn starter drive teeth. Make repairs as necessary. Record any signs of wear or defects and indicate if repair or replacement is necessary.

h. Clean and inspect the harmonic balancer. Record any signs of wear or defects and indicate if repair or replacement is necessary.

(NOTE: In many cases, the harmonic balancer will have a groove worn into it by the front oil seal. This groove is often repaired by a sleeve that is driven over the end of the balancer.)

JS4-L1-UV

MODULE: ENGINE REPAIR

CHECKING AND RECORDING SHORT BLOCK MEASUREMENTS

Equipment:

Common hand tools
Dial indicator
Inside micrometer
Outside micrometer
Dial bore gauge (or other appropriate precision measuring tools)
Snap gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Clean and inspect the camshaft.

   (NOTE: For camshaft inspection, see Unit IV of this module.)

3. Inspect the cylinder head. Record any signs of wear or defects and indicate if repair or replacement is necessary.

4. Following the procedure outlined below, measure the cylinder taper.

   (NOTE: Visually inspect the cylinder bores and note any excessive scratches in the cylinder walls.)

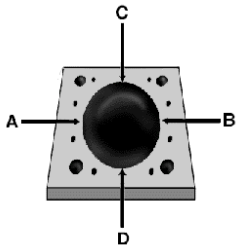
   (NOTE: There are many methods by which the cylinder taper can be measured. The below procedure involves the use of an inside micrometer and is one of the simplest methods for measuring taper.)

   a. Use an inside micrometer or an outside micrometer and a snap gauge to measure the top, middle, and bottom of piston ring travel.

      (NOTE: These measurements are made perpendicular to the direction of the crankshaft.)

5. Following the procedure outlined below, measure cylinder out-of-round.

   a. Using an inside micrometer or an outside micrometer and a snap gauge, take cylinder measurements at the top of the cylinder at points a and b and c and d.



   b. Determine the difference between measurements of a and b and c and d. If the difference exceeds .003 of an inch, then the block will need to be rebored and the pistons will need to be replaced. Record the difference between measurements of a and b and c and d and indicate what boring and replacement procedures are required.

6. Measure cylinder bore size. Record measurements below.

(NOTE: After measuring taper and out-of-round, the technician should be able to conclude if bore size is standard or if the bore is already oversized.)

(NOTE: If the cylinder measurements meet specifications and pistons are in satisfactory condition, then the cylinders can be honed and the pistons can be re-used. Honing will be discussed later in this lesson.)

JS5-L1-UV

MODULE: ENGINE REPAIR

CHECKING AND RECORDING SHORT BLOCK COMPONENT MEASUREMENTS

Equipment:

Common hand tools
Straight edge
Feeler gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure below, clean and inspect the crankshaft.

   a. Wash the crankshaft with a good safety solvent and dry the shaft. Using a small rifling brush, clean the oil passages that run through the crankshaft.

   b. Inspect the flywheel flange and pilot bushing. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   c. Inspect the flywheel flange for signs of cracks or displaced metal that may have been caused by a loose flywheel. Record any signs of wear or defects and indicate if repair or replacement is necessary.

   d. If the engine uses a manual transmission, inspect the pilot bushing for wear. Record any signs of wear or defects and indicate if repair or replacement is necessary.

      (NOTE: Some technicians will replace the pilot bushing to ensure that it functions properly.)

3. Following the procedure outlined below, inspect the journal.

a. The same inspection procedures are used for the main bearing and rod bearing journals.

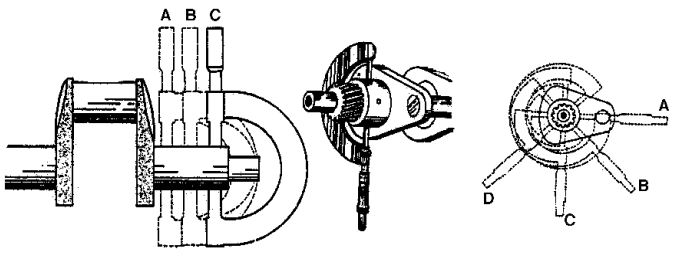
b. Check the journals for any sign of grooving, scoring, or surface cracks. Record any signs of wear or defects and indicate if repair or replacement is necessary.

(NOTE: If the crankshaft shows any sign of grooving, scoring, or cracking, it will have to be ground to a standard undersize.)

4. Following the procedure outlined below, check the journals for taper.

a. Using a micrometer, measure the size of the journal at points a and b and c. Record any signs of wear or defects and indicate if repair or replacement is necessary.

b. Compare the three measurements. There should not be more than .001 of an inch difference between the three measurements. If the difference exceeds .001 of an inch, then the crankshaft will need to be ground to the next standard undersize. Record measurement results and indicate if grinding is necessary.



(NOTE: Taper problems are usually an indication of a bent connecting rod. Therefore, if taper problems exist, make sure that the connecting rods are sufficiently straight.

5. Following the procedure outlined below, check the journals for out-of-round measurement.

a. Using a micrometer, measure the size of the journal at points a and b and c and d.

b. Compare the four measurements. There should not be more than .001 of an inch difference between the four measurements. If the difference exceeds .001 of an inch, then the crankshaft will need to be ground to the next standard undersize. Record measurement results and indicate if grinding is necessary.

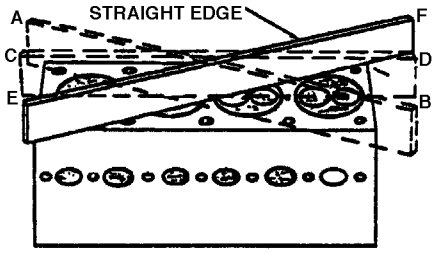
6. Following the procedure below, inspect and clean the cylinder block mating surfaces.

   (NOTE: It is assumed that, at this point in the inspection procedure, the block has already been steam cleaned or hot tanked.)

   (NOTE: During the inspection, always look for signs of cracks in the block. If a cracked block is found, the technician will have to decide whether the block will be repaired or replaced before continuing with any other procedures.)

   a. Using a gasket scraper, remove all remaining gasket material from the head, the timing chain cover, and the oil pan mating surfaces.

   b. Using a straight edge and a feeler gauge, check the head mating surface for flatness across points a and b, c and d, and e and f.



   c. If a feeler gauge blade larger than .005 of an inch can be slid under the bar at any point, then the mating surfaces will have to be ground flat. Record the findings of the inspection and indicate if grinding will be necessary.

   (NOTE: If a vee engine block is planed, the intake manifold will often need to be machined.)

7. Following the procedure outlined below, check the crankshaft bore alignment.

   a. Remove crankshaft, upper main bearing halves, and rear main bearing seal if they are not already removed.

   b. Clean the main bearing bore and cap bosses thoroughly and air dry.

   c. Place the straightedge at the bottom of the main bearing bore.

   d. Check the clearance between each bearing bore surface and straightedge.

   e. Place straightedge on main bearing cap bosses.

f. Check clearance between straightedge and bosses. Clearance between the surface and straightedge should not exceed one half of the allowable bearing clearance. If the clearance is greater than one-half of the allowable clearance, the block will have to be re-machined or discarded. Record clearance measurement and indicate if machining or replacement is necessary.

g. Check bearing bore for out-of-round. Install main bearing cap and torque it to specifications. Measure the bearing bore at three locations. Compare the three measurements to determine bore out-of-round. Record measurements, specifications, and the out-of-round measurement below.

h. Compare bore out-of-round measurements to the manufacturer's specifications. If out-of-round exceeds allowable limits, the block bore will have to be line bored by a machinist. Record recommendations for machining below.

(NOTE: Leave the bearing inserts out when checking bore out-of-round.)

8. Following the procedure outlined below, clean and inspect oil passages (galleys).

a. Run rifle brushes through the many oil passages in the block (i.e., oil pump to crankshaft).

(NOTE: Repair manuals usually include diagrams of oil passages. Use these diagrams as a guide in cleaning and checking the oil passages.)

b. If any solid blockage is found in an oil passage, determine the cause of the blockage and correct the problem.

9. Clean and inspect the piston/connecting rod.

a. Wipe the connecting rod bearing. Clean and inspect the bearing. Record observations.

(NOTE: Abnormal wear patterns on the rod bearing may indicate bent or twisted connecting rods.)

b. Move the piston on the piston pin. Any sign of looseness would warrant the replacement of the piston assembly. Record observations.

JS6-L1-UV

MODULE: ENGINE REPAIR

PREPARING SHORT BLOCK COMPONENTS FOR REASSEMBLY

Equipment:

Common hand tools
Feeler gauge
Ring groove cleaner
Carbon scraper
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, inspect the piston.

   a. Visually inspect the piston for cracks, holes, or excessive pitting. Record observations.

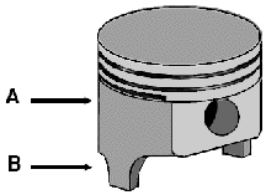
   (NOTE: Cracks in the piston will usually be located near the piston pin and/or skirt.)

   (NOTE: An unusual wear pattern on the piston skirt usually indicates a problem with a piston or rod assembly.)

   b. Inspect the ring land area for signs of stuck rings, broken lands, or broken rings. Record observations.

   c. Using a feeler gauge, measure the clearance between the rings and the ring lands. Clearance should not exceed .006 of an inch. Record observations.

d. Using a micrometer, measure piston skirt collapse at points a and b. If the size difference between points a and b is less than .015 of an inch, then the skirt can be knurled. If the difference is greater than .015 of an inch, the piston will have to be discarded. Record the differences and indicate if knurling or replacement is required.



e. If the piston passes all inspections, remove the rings and use a ring groove cleaner to remove the carbon from the piston ring grooves. Also, clean the top of the piston.

(NOTE: Do not use a power brush to clean the top of the piston. Use a carbon scraper. Clean the top of the piston gently; aluminum is soft.)

3. Using a service manual or other information source, locate a procedure for inspecting the oil pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the box below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, inspect the oil pump. Record observations.

(NOTE: If a new pump is purchased along with the engine rebuilding kit, the old pump will not have to be inspected.)

4. Following the procedure below, inspect and clean threads and bolts.

a. Using various taps, clean the threads of all threaded holes in the block.

b. Clean all the nuts and bolts used to assemble the engine.

c. Inspect the nuts and bolts for signs of stretching and stripping and for rounded corners on bolts and nuts.

MODULE: ENGINE REPAIR

UNIT V: SHORT BLOCK DIAGNOSIS AND REPAIR

LESSON 2: SHORT BLOCK REASSEMBLY

I. Terms and definitions associated with engine assembly

A. Plastigauge—Strips of plastic used to check oil clearances between the crankshaft and its bearings.

B. Progressive torque—Tightening two components together in a progressive sequence—usually 1/3 of the torque the first time, 2/3 the second time, and then full torque.

C. Telescoping (snap) gauge—A tool that is used with an outside micrometer to determine the size between bearing surfaces.

D. Torque sequence—A method of tightening bolts that ensures two surfaces come together evenly.

II. Procedures for reassembling the engine

(NOTE: It is assumed at this point that all engine machining work and cylinder head repairs have been completed.)

A. Following the below procedure, install and measure the cam bearings (non-OHC engines).

(NOTE: Procedures for cam bearing installation vary significantly. Therefore, consult the installation tool manufacturer's instructions as well as the engine repair manual for specific procedures.)

(NOTE: Some engines use cam bearings of different sizes; therefore, be sure to place bearings in the proper location prior to installation.)

1. Measure cam bearings.

a. Insert an inside micrometer or telescoping gauge inside the cam bearing.

b. Record the measurement.

c. Compare the measurement to the manufacturer's recommended specifications.

d. Repeat procedures a, b, and c until all cam bearing measurements are taken.

(NOTE: Bearing surfaces are easily nicked and damaged. Care should be taken when performing this procedure.)

2. Wash the engine with soap and hot water and air dry. Washing removes any metal filings created during the machining process.

   (NOTE: To prevent rust, machined surfaces [i.e. cylinders and head mating surfaces] should be covered with a light coat of oil as soon as the washing and drying is finished.)

3. Install all oil passage plugs and freeze (core) plugs.

   a. Use a high-quality sealer on these components to prevent leaks.

   b. Make sure plugs are tight. Oil or cooling leaks could result in major engine damage.

4. Install the crankshaft main bearings.

   (NOTE: Place the bearing tabs in the recess in the block.)

   a. Locate the thrust bearing and install this bearing first.

      (NOTE: The main bearing often has a hole in one side. The main bearing with the hole should be placed in the block and not in the main cap. Incorrect positioning of the main bearings will cause the engine to wear out prematurely.)

   b. Place the bearings in the block and main caps.

   c. Put assembly lube on the main bearings located in the engine block.

   d. Carefully set the crankshaft in the engine.

   e. Measure the oil clearance between the crankshaft and the main bearings.

      (NOTE: The following procedure is only one of many procedures that can be used to check main bearing clearance.)

   f. For every main bearing, cut a number of pieces of plastigauge to lengths of approximately 1 inch.

   g. Place the pieces of plastigauge on the top of the crankshaft journals.

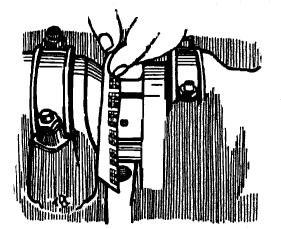
   h. Install the main bearing caps in their correct locations with the bearing locks facing each other. Lightly oil the main bearing cap bolts.

   i. Using a crisscross sequence, progressively torque the main bearing cap bolts until all bolts are at their specified torque.

(NOTE: Do not turn or attempt to turn the crankshaft at this time.)

j. Loosen all the main bearing cap bolts and remove the main bearing caps from the engine block.

k. Using the plastigauge container, measure the flattened plastigauge to determine the oil clearance between the crankshaft and main bearing.



(NOTE: Compare the plastigauge reading to the clearance specifications given in the repair manual. If clearances are too little or too great, a different set of bearings will have to be used in order to correct the clearance problem. The engine will fail almost immediately if oil clearances are incorrect.)

l. Clean the plastigauge material from the bearing and journal surfaces.

m. Remove the crankshaft from the engine.

n. Install the remaining oil seals on the rear main cap and the block.

o. Make certain neoprene lip seals are facing the right direction.

(NOTE: Rope seals should be installed with the aid of a bar seal installer. Rope seals should be trimmed off just above the surface of the block and main cap. On both neoprene and rope seals, add a dab of sealer to the seal connection points to aid in leak prevention.)

p. Set the crankshaft gently back in the engine block.

q. Place assembly lube on all the main bearings in the main bearing caps.

r. Put the main bearing caps on the correct journals.

s. Place the bearings lock to lock.

t. Progressively torque all the main bearing bolts until all main bearing cap bolts are torqued to specification.

u. Attempt to turn the crankshaft in the bearings. Some manufacturers specify the level of torque required to turn the crankshaft at this point in the procedure. Whatever the torque specification, the crankshaft should rotate at this point in the procedure.

v. Check the crankshaft thrust clearance (end play).

w. Attach a magnetic base dial indicator on the block on the flywheel side of the crankshaft. Using some type of pry bar, pry the crankshaft forward in the engine block.

x. At the rear of the crankshaft, set the dial indicator at zero. Using the pry bar, pry the crankshaft rearward in the block.

y. Record the amount of play and compare this reading with the manufacturer's specification.

(NOTE: If end play is insufficient, the thrust bearing can be machined down to increase the end play. If the end play is too great, a thicker thrust bearing or shaft buildup can be employed to bring the end play within specifications.)

B. Install the piston/connecting rod assemblies.

1. Check ring end gap.

(NOTE: On engines that have been bored, ring end gap is checked with the ring approximately 1 inch down the cylinder. On engines that have only been honed, the rings are placed at the bottom of the ring travel during the ring end gap check.)

a. Install a new top compression ring in the cylinder bore.

b. Using a feeler gauge, measure the gap between the two ends of the ring.

c. Compare the gap reading to the manufacturer's specification for ring gap.

(NOTE: If ring gap is excessive, oversized rings may need to be purchased. If the ring end gap is too small, the ends of the ring may need to be filed.)

2. Check piston skirt clearance in the cylinder.

   a. Insert piston and start in the cylinder.

   b. Insert feeler gauge on scale between piston skirt and cylinder wall opposite pin boss.

   c. Lower piston until the bottom of the piston is just below the ring ridge in the top of the cylinder.

   d. Pull the feeler gauge from between the piston and cylinder wall while noting the reading on thespring scale.

      (NOTE: Compare to manufacturer's specifications for piston skirt clearance.)

3. Install the rings on the piston.

   (NOTE: The procedure for piston ring installation varies significantly, depending on the vehicle model; therefore, the below procedure is very general. For specific procedures, consult the appropriate manual.)

   a. Identify each ring as top compression, second compression, and oil scraper.

   b. Identify the top of each ring.

      (NOTE: Some rings have marks to indicate the top of the ring while other rings can be installed either way. Consult the ring manufacturer's manual for proper identification of the top of the ring.)

   c. Install the oil scraper ring first.

   d. Install the expander.

      (NOTE: Butt or overlap the ring ends according to the manufacturer's recommendation.)

   e. Install the bottom ring.

   f. Install the top scraper ring.

      (NOTE: This procedure is used on a three-piece oil scraper ring. For other techniques, consult the ring manufacturer's manual.)

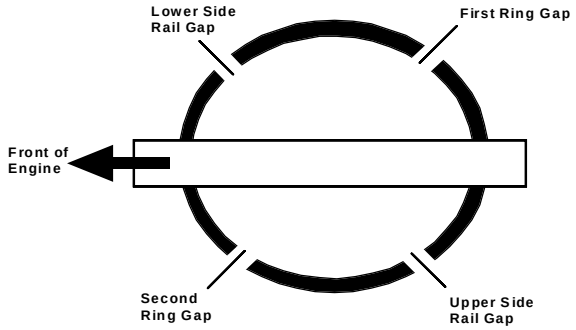
   g. Install the second compression ring. Identify the top of the ring (if necessary). Using a ring expander, expand the ring to slip it over the piston. Install the ring in the second ring groove.

h. Install the top compression ring. Identify the top of the ring (if necessary). Using a ring expander, expand the ring so that it can be slipped over the piston. Install the ring in the top piston groove.

4. Offset the ring gaps.

a. Install rings on piston with end gaps staggered at 180 degree intervals.

b. Ensure ring gap is not in line with thrust face of pin bore.



c. Place the oil scraper rings at right angles to the second compression ring and opposite each other's gaps.

(NOTE: Offsetting of the ring gaps does not have to occur until the piston is about to be installed in the engine; nevertheless, this procedure is very important to the proper sealing of the cylinder.)

5. Install the piston/connecting rod assembly.

a. Install the piston rings and make sure that all the ring gaps are staggered correctly.

b. Thoroughly oil the pistons and rings.

(NOTE: A common way to oil the pistons and rings is to submerge them in clean, straight-weight oil.)

c. Attach the piston ring compressor to the piston and compress the piston rings.

(NOTE: Allow the piston skirt to extend out from the compressor at least an inch to help guide the piston into the cylinder.)

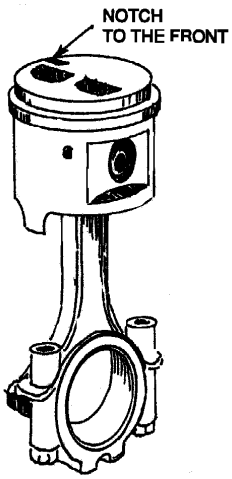
d. Remove the rod cap and install the bearing halves in the rod and cap.

e. Put assembly lube on the bearing located on the connecting rod.

f. Place short pieces of rubber hose (e.g., vacuum, fuel, etc.) on the connecting rod bolts.

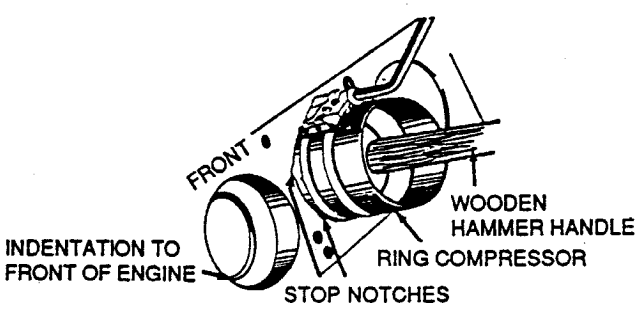
g. Identify the location for the piston/rod assembly. Usually the piston marking points toward the front.

(NOTE: It is important to identify the piston marking that should point to the front of the engine. Installing pistons backwards can severely damage the engine.)



h. Position the crankshaft so that the rod journal is at BDC.

i. Slip the piston into the cylinder until the ring compressor contacts the block mating surface.



j. Using a plastic or rubber mallet, tap on the top of the piston.

(NOTE: If the ring compressor has been used properly, the piston should slide through the compressor and into the cylinder. If the piston gets stuck because the rings are not sufficiently compressed, first try to tighten the compressor and lightly tap the piston again. If this does not work, remove the piston and install the compressor to the piston again.)

(**CAUTION:** Never try to force the piston into the cylinder when the rings are caught. Doing so will probably ruin the rings and/or piston.)

k. Continue to tap on the piston until the piston head is flush with the cylinder and/or the piston compressor is no longer needed.

l. While tapping on the piston, guide the connecting rod down through the cylinder and onto the crankshaft until the connecting rod bearing is seated against the crankshaft. Then remove the pieces of hose from the connecting rod bearings.

m. Place a piece of plastigauge on the crankshaft parallel to the length of the crankshaft.

n. Install the rod cap and tighten the connecting rod nuts to their proper torque.

o. Remove the rod cap nuts and rod cap.

p. Check the plastigauge oil clearance reading against the manufacturer's recommended oil clearance specification. Wipe the plastigauge from the crankshaft and bearing.

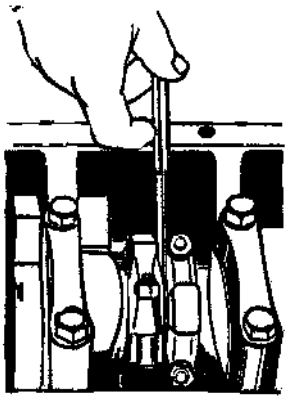
(NOTE: If rod bearing clearance is not correct, this problem must be remedied before further engine assembly can occur. Improper rod bearing oil clearance can result in almost instant engine destruction.)

q. Put assembly lube on the rod cap connecting rod bearings and reinstall and torque the rod cap nuts.

r. Check the connecting rod to the crankshaft journal side clearance.
s. Push the connecting rod to the side of the crankshaft journal.

t. Using a feeler gauge, measure the amount of clearance between the connecting rod and crankshaft journal.

u. Compare the side bearing clearance with the manufacturer's specifications.



On engines in which two connecting rods share the same crankshaft journal - such as vee engines - the distance measured will be between the two connecting rods.

v. Repeat steps a through u for all pistons.

6. Install the camshaft.

(NOTE: If an OHC engine is being serviced, the camshaft should be installed after the head is installed on the cylinder block.)

a. Thread a long bolt (3" to 4") into the bolt hole used to secure the timing gear to the camshaft.

b. Using the long bolt as a handle, liberally spread assembly lube or cam break-in lubricant on all the cam bearings and lube surfaces.

c. Gently slide the camshaft into the camshaft bore. Be careful not to nick the cam bearings as the cam is slid into place.

d. If necessary, bolt the camshaft thrust plate in place so as to hold the camshaft in the block.

7. Install the camshaft/valve timing components.

a. Install the crankshaft gear.

b. Install the woodruff or square key in the crankshaft.

c. Slide the crankshaft timing gear onto the crankshaft with the timing marks facing forward. The notch with the timing gear should allow the gear to pass over the key in the crankshaft.

(NOTE: At this time, do not seat the crank gear against the crankshaft.)

(NOTE: Some crankshaft gears have multiple key ways to allow for advancing or retarding the valve timing. If this is the case, see the repair manual or look on the front of the gear to identify the correct gear notch to place on the crankshaft key.)

d. For installation of the rest of the valve timing components, turn the crankshaft until the crankshaft gear timing mark is in the proper location.

8. Install the valve timing components.

a. Remove the long bolt already in the camshaft.

b. Put the camshaft gear on the camshaft (finger tight) and turn the camshaft gear and camshaft until the timing marks align.

c. Remove the cam gear. Slip the timing chain over the cam gear and crank gear.

d. Reinstall the cam gear on the cam, checking the alignment of the timing marks as the cam gear bolts are torqued.

(NOTE: If the engine uses a mechanical fuel pump, the pump drive is sometimes bolted to the front of the cam gear. Do not forget to install this part.)

(NOTE: As the cam gear is torqued down into place, side strain or cracking can occur on the cam gear if the cam and crank gears are not in vertical alignment. It is a good idea to tap the crank gear up against its stop as the cam gear is being torqued down.)

(NOTE: If the crankshaft uses some sort of oil slinger in front of the crankshaft gear, install it at this time.)

9. Install the oil pump.

(NOTE: Depending on the engine being serviced, the steps of the below procedure may have to be done in a different order. Nevertheless, all of the steps will have to be performed.)

a. Install the pickup screen to the pump.

b. The screen can be bolted into the pump.

c. The screen may be pressed into the pump.

(NOTE: Oil pumps that are located in the timing chain cover will have the pickup screen bolted to the block.)

d. Prime the pump by using one of the two procedures outlined below.

(1ST PROCEDURE: Remove the pump cover and pack the oil pump gears/rotor with petroleum jelly. Reinstall the pump cover.)

(2ND PROCEDURE: Submerge the pump inlet/pickup screen and turn the oil pump drive gear in the proper direction until a steady flow of oil exits the pump.)

e. Attach the pump drive to the pump (if necessary).

f. Install the oil pump in its proper location.

(NOTE: Some oil pumps require that a gasket be placed between the pump and block. Do not forget to install this gasket, if required.)

g. Torque the pump to its location.

10. Install the timing chain/belt.

(NOTE: On OHC engines, the timing chain/belt cover should be installed after the head is installed.)

a. Make sure all gasket surfaces are completely clean and flat.

b. Select the correct cover to block gasket.

c. Correctly install the gasket on the block.

(NOTE: If coolant passes through the cover, it is a good idea to use a sealer in the gasket areas that are nearest the water passages.)

d. Install a new front seal in the cover, if necessary.

e. Bolt the cover to the block using the correct torque and tightening sequence.

11. Install the oil pan.

a. Make sure all gasket surfaces are clean and flat.

b. Select the correct oil pan to block gasket and/or seal.

c. If necessary, install the windage tray/baffle to the engine.

d. Install the oil pan gaskets and/or seals.

e. Place a small dab of gasket sealer where the gaskets and/or seals meet each other.

f. Install all pan bolts finger tight.

(NOTE: Some oil pans use different sizes of pan bolts, so be sure to put the proper bolts into the proper holes.)

(NOTE: Sometimes brackets are bolted on with pan bolts [i.e., ATF line brackets]. Do not forget these brackets or their location.)

g. Tighten the pan bolts to the proper torque using the correct tightening sequence.

12. Install the cylinder head(s).

(NOTE: For a more detailed discussion of head installation, see Unit IV, Lesson 2 of this module.)

a. Make sure the mating surfaces are clean and free from all old gasket material.

b. Set the head gaskets on the block using the dowel pins.

(NOTE: If the head gasket has “top” or “front” on it, be sure to install the gasket accordingly.)

c. Set the head on the block.

(NOTE: Be sure the head is installed on the correct side and with the proper end facing forward.)

d. Screw the head bolts in finger tight.

(NOTE: Head bolts that pass through water jackets should be sealed.)

(NOTE: Head bolts often come in various lengths, so be sure to match the proper bolt with the proper hole.)

e. Torque the head bolts in place.

f. Torque the bolts progressively—first to 1/3 of the torque specification, then to 2/3 of the torque specification, and then to final torque specification.

(NOTE: Torque the bolts according to the manufacturer’s tightening sequence.)

13. Assemble/adjust the valve train on OHC engines.

a. Lubricate and install the lifters and rockers.

b. Lubricate and install the camshaft.

c. Install the camshaft gear.

d. Align all the valve timing marks, crankshaft, camshaft, and distributor, if used.

e. Attach the timing chain/belt.

f. Following the manufacturer’s recommendations, adjust the belt/chain tension device to achieve the required timing chain/belt tension.

g. Following the manufacturer’s recommendations, adjust the valve lash to the desired initial settings.

h. Set the valve covers on the engine.

14. Assemble/adjust the valve train on push rod engines.

a. Lubricate and install the lifters.

(NOTE: Hydraulic lifters need to be filled with oil before installation.)

b. Install the push rods.

c. Install the rockers.

d. Using the manufacturers's procedures, make initial adjustments to the valve lash.

e. Set the valve cover(s) on the engine.

15. Complete the engine assembly.

a. Install the harmonic balancer.

b. Install the intake manifold (if necessary).

c. Make sure all gasket areas are clean.

d. Correctly choose and install the intake manifold gasket on the cylinder head.

(NOTE: Some intake manifold gaskets will have the words "front" or "top" printed on them. Make sure to install these gaskets accordingly.)

(NOTE: In areas where the intake manifold gasket must seal coolant, use a sealer with the gasket to ensure proper sealing.)

e. Carefully set the intake manifold on the engine. Take care not to move the intake manifold gaskets.

f. Using the proper progression and sequence, torque the intake manifold to the cylinder head.

16. Paint the engine.

a. Clean off any oil on the block that has accumulated during the engine assembly.

b. Plug any holes where paint would be undesirable (e.g., spark plugs, exhaust ports).

c. Put a light coat of grease on surfaces where paint would be undesirable (e.g., exhaust manifold surface, etc.).

17. Install engine accessories.

a. Install the motor mounts.

b. Install cooling system components (e.g., water pump thermostat, etc.).

c. Install fuel system components (e.g., carburetor, injector, fuel pump).

d. Install emission system components (smog pump, EGR, etc.).

e. Install air conditioning components (e.g., compressor).

f. Install power train components (e.g., flexplate/flywheel/clutch).

(NOTE: The engine must sometimes be removed from the repair stand before the flywheel clutch can be installed. Nevertheless, always use correct procedures and torque specifications when installing the flexplate/flywheel/clutch.)

g. Install steering components (e.g., power steering pump).

h. Install exhaust components (e.g., exhaust manifolds).

(NOTE: Some accessories cannot be installed until the engine has been installed.

(NOTE: If accessories cannot be cleaned before they are installed on the reconditioned engine, they should at least be blown off with compressed air.)

JS1-L2-UV

MODULE: ENGINE REPAIR

ASSEMBLING THE SHORT BLOCK

Equipment:

Dial indicator
Magnetic base
Cam bearing installation tool
Inside micrometer
Telescoping gauge of outside micrometer
Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (NOTE: It is assumed that all engine machining work and cylinder head repairs will have been completed before the below procedure is begun.)

2. Following the below procedure, measure the cam bearings (non-OHC engines).

   (NOTE: Procedures for cam bearing installation vary significantly. Therefore, consult the installation tool manufacturer's instructions as well as the engine repair manual for specific procedures.)

   (NOTE: Some engines use cam bearings of different sizes; therefore, be sure to place bearings in the proper location prior to installation.)

   a. Insert an inside micrometer or telescoping gauge inside the cam bearing. Repeat this procedure for each bearing.

   b. Compare the measurement of each bearing to the manufacturer's recommended specifications. Record the bearing measurement and the manufacturer's specification below.

   (NOTE: Bearing surfaces are easily nicked and damaged. Care should be taken when performing this procedure.)

3. Wash the engine with soap and hot water and air dry. Washing removes any metal filings created during the machining process.

(NOTE: To prevent rust, machined surfaces [i.e. cylinders and head mating surfaces] should be covered with a light coat of oil as soon as the washing and drying is finished.)

4. Install all oil passage plugs and freeze (core) plugs.

   (NOTE: Use a high-quality sealer on these components to prevent leaks. Make sure plugs are tight. Oil or cooling leaks could result in major engine damage.)

5. Following the procedure outlined below, install the crankshaft main bearings.

   (NOTE: Place the bearing tabs in the recess in the block.)

   a. Locate the thrust bearing and install this bearing first.

      (NOTE: The main bearing often has a hole in one side. The main bearing with the hole should be placed in the block and not in the main cap. Incorrect positioning of the main bearings will cause the engine to wear out prematurely.)

   b. Place the bearings in the block and main caps.

   c. Put assembly lube on the main bearings located in the engine block.

   d. Carefully set the crankshaft in the engine.

   e. Measure the oil clearance between the crankshaft and the main bearings.

      (NOTE: The following procedure is only one of many procedures that can be used to check main bearing clearance.)

   f. For every main bearing, cut a number of pieces of plastigauge to lengths of approximately 1 inch.

   g. Place the pieces of plastigauge on the top of the crankshaft journals.

   h. Install the main bearing caps with the bearing locks facing each other. Lightly oil the main bearing cap bolts.

   i. Using a crisscross sequence, progressively torque the main bearing cap bolts until all bolts are at their specified torque.

      (NOTE: Do not turn or attempt to turn the crankshaft at this time.)

   j. Loosen all the main bearing cap bolts and remove the main bearing caps from the engine block.

k. Using the plastigauge container, measure the flattened plastigauge to determine the oil clearance between the crankshaft and main bearing.

(NOTE: Compare the plastigauge reading to the clearance specifications given in the repair manual. If clearances are too little or too great, changes will have to be made to correct the clearance problem. Nearly instant engine destruction can occur if oil clearances are incorrect.)

l. Clean the plastigauge material from the bearing and journal surfaces.

m. Remove the crankshaft from the engine.

n. Install the remaining oil seals on the rear main cap and the block.

o. Make certain neoprene lip seals are facing the right direction.

(NOTE : Rope seals should be installed with the aid of a bar seal installer. Rope seals should be trimmed off just above the surface of the block and main cap. On both neoprene and rope seals, add a dab of sealer to the seal connection points to aid in leak prevention.)

p. Set the crankshaft gently back in the engine block.

q. Place assembly lube on all the main bearings in the main bearing caps.

r. Put the main bearing caps on the correct journals.

s. Place the bearings lock to lock.

t. Progressively torque all the main bearing bolts until all main bearing cap bolts are torqued to specification.

u. Attempt to turn the crankshaft in the bearings. Some manufacturers specify the level of torque required to turn the crankshaft at this point in the procedure. Whatever the torque specification, the crankshaft should rotate at this point in the procedure.

v. Check the crankshaft thrust clearance (end play).

w. Attach a magnetic base dial indicator on the block on the flywheel side of the crankshaft. Using some type of pry bar, pry the crankshaft forward in the engine block.

x. At the rear of the crankshaft, set the dial indicator at zero. Using the pry bar, pry the crankshaft rearward in the block.

y. Record the amount of play and compare this reading with the manufacturer's specification.

(NOTE: If end play is insufficient, the thrust bearing can be machined down to increase the end play. If the end play is too great, a thicker thrust bearing or shaft buildup can be employed to bring the end play within specifications.)

6. Following the procedure outlined below, install the piston/connecting rod assemblies.

a. Check ring end gap.

(NOTE: On engines that have been bored, ring end gap is checked with the ring approximately 1 inch down the cylinder. On engines that have only been honed, the rings are placed at the bottom of the ring travel during the ring end gap check.)

b. Install a new top compression ring in the cylinder bore.

c. Using a feeler gauge, measure the gap between the two ends of the ring.

d. Compare the gap reading to the manufacturer's specification for ring gap.

(NOTE: If ring gap is excessive, oversized rings may need to be purchased. If the ring end gap is too small, the ends of the ring may need to be filed.)

7. Following the procedure outlined below, check piston skirt clearance in the cylinder.

a. Insert piston and start in the cylinder.

b. Insert feeler gauge on scale between piston skirt and cylinder wall opposite pin boss.

c. Lower piston until the bottom of the piston is just below the ring ridge in the top of the cylinder.

d. Pull the feeler gauge from between the piston and cylinder wall while noting the reading on the spring scale.

(NOTE: Compare to manufacturer's specifications for piston skirt clearance.)

8. Following the procedure outlined below, install the rings on the piston.

(NOTE: The procedure for piston ring installation varies significantly, depending on the vehicle model; therefore, the below procedure is very general. For specific procedures, consult the appropriate manual.)

a. Identify each ring as top compression, second compression, and oil scraper.

b. Identify the top of each ring.

(NOTE: Some rings have marks to indicate the top of the ring while other rings can be installed either way. Consult the ring manufacturer's manual for proper identification of the top of the ring.)

c. Install the oil scraper ring first.

d. Install the expander.

(NOTE: Butt or overlap the ring ends according to the manufacturer's recommendation.)

e. Install the bottom ring.

f. Install the top scraper ring.

(NOTE: This procedure is used on a three-piece oil scraper ring. For other techniques, consult the ring manufacturer's manual.)

g. Install the second compression ring. Identify the top of the ring (if necessary). Using a ring expander, expand the ring to slip it over the piston. Install the ring in the second ring groove.

h. Install the top compression ring. Identify the top of the ring (if necessary). Using a ring expander, expand the ring so that it can be slipped over the piston. Install the ring in the top piston groove.

9. Following the procedure outlined below, offset the ring gaps.

a. Install rings on piston with end gaps staggered at 120 degree intervals.

b. Ensure ring gap is not in line with thrust face of pin bore.

c. Place the oil scraper rings at right angles to the second compression ring and opposite each other's gaps.

(NOTE: Offsetting of the ring gaps does not have to occur until the piston is about to be installed in the engine; nevertheless, this procedure is very important to the proper sealing of the cylinder.)

10. Following the procedure outlined below, install the piston/connecting rod assembly.

a. Install the piston rings and make sure that all the ring gaps are staggered correctly.

b. Thoroughly oil the pistons and rings.

(NOTE: A common way to oil the pistons and rings is to sub-merge them in clean, straight-weight oil.)

c. Attach the piston ring compressor to the piston and compress the piston rings.

(NOTE: Allow the piston skirt to extend out from the compressor at least an inch to help guide the piston into the cylinder.)

d. Remove the rod cap and install the bearing halves in the rod and cap.

e. Put assembly lube on the bearing located on the connecting rod.

f. Place short pieces of rubber hose (e.g., vacuum, fuel, etc.) on the connecting rod bolts.

g. Identify the location for the piston/rod assembly and piston marking for the front.

(NOTE: It is important to identify the piston marking that should point to the front of the engine. Installing pistons backwards can severely damage the engine.)

h. Position the crankshaft so that the rod journal is at bottom dead center.

i. Slip the piston into the cylinder until the ring compressor contacts the block mating surface.

j. Using a plastic or rubber mallet, tap on the top of the piston.

(NOTE: If the ring compressor has been used properly, the piston should slide through the compressor and into the cylinder. If the piston gets stuck because the rings are not sufficiently com-pressed, first try to tighten the compressor and lightly tap the piston again. If this does not work, remove the piston and install the compressor to the piston again.)

(CAUTION: Never try to force the piston into the cylinder when the rings are caught. Doing so will probably ruin the rings and/or piston.)

k. Continue to tap on the piston until the piston head is flush with the cylinder and/or the piston compressor is no longer needed.

l. While tapping on the piston, guide the connecting rod down through the cylinder and onto the crankshaft until the connecting rod bearing is seated against the crankshaft. Then remove the pieces of hose from the connecting rod bearings.

m. Place a piece of plastiguage on the crankshaft parallel to the length of the crankshaft.

n. Install the rod cap and tighten the connecting rod nuts to the proper torque.

o. Remove the rod cap nuts and rod cap.

p. Check the plastigauge oil clearance reading against the manufacturer's recommended oil clearance specification. Record the specification and readings below. Wipe the plastigauge from the crankshaft and bearing.

Clearance specifications _____

Plastigauge oil clearance reading _____

(NOTE: If rod bearing clearance is not correct, this problem must be remedied before further engine assembly can occur. Improper rod bearing oil clearance can result in almost instant engine destruction.)

q. Put assembly lube on the rod cap connecting rod bearings and reinstall and torque the rod cap nuts.

r. Check the connecting rod to crankshaft journal side clearance. Record if clearance is adequate.

s. Push the connecting rod to side of the crankshaft journal.

t. Using a feeler gauge, measure the amount of clearance between the connecting rod and crankshaft journal. Record measurement below.

u. Compare the side bearing clearance with the manufacturer's specifications. Record findings below.

(NOTE: On engines in which two connecting rods share the same crankshaft journal--such as vee engines--the distance measured will be between the two connecting rods.)

v. Repeat steps "a" through "u" for all pistons.

11. Following the procedure outlined below, install the camshaft.

    (NOTE: If an OHC engine is being serviced, the camshaft should be installed after the head is installed on the cylinder block.)

    a. Thread a long bolt (3" to 4") into the bolt hole used to secure the timing gear to the camshaft.

    b. Liberally spread assembly lube or cam break--in lubricant on all the cam bearings and lube surfaces.

    c. Using the long bolt as a handle, gently slide the camshaft into the camshaft bore. Be careful not to nick the cam bearings as the cam is slid in place.

    d. If necessary, bolt the camshaft thrust plate in place so as to hold the camshaft in the block.

    e. Install the camshaft gear.

12. Following the procedure outlined below, install the valve timing components (gear drive).

    a. Install the woodruff or square key in the crankshaft.

    b. Slide the crankshaft timing gear onto the crankshaft with the timing marks facing forward. The notch with the timing gear should allow the gear to pass over the key in the crankshaft.

       (NOTE: At this time, do not seat the crank gear against the crankshaft.)

       (NOTE: Some crankshaft gears have multiple key ways to allow for advancing or retarding the valve timing. If this is the case, see the repair manual or look at the front of the gear to identify the correct gear notch to place on the crankshaft key.)

    c. Turn the crankshaft until the crankshaft gear timing mark is in the proper location for installation of the rest of the valve timing components.

13. Following the procedure outlined below, install the valve timing components (chain drive).

    a. Remove the long bolt already in the camshaft.

    b. Put the camshaft gear on the camshaft (finger tight) and turn the camshaft gear and camshaft until the timing marks align.

    c. Remove the cam gear. Slip the timing chain over the cam gear and crank gear.

d. Reinstall the cam gear on the cam, checking the alignment of the timing marks as the cam gear bolts are torqued.

(NOTE: If the engine uses a mechanical fuel pump, the pump drive is sometimes bolted to the front of the cam gear. Do not forget to install this part.)

(NOTE: As the cam gear is torqued down into place, side strain or cracking can occur on the cam gear if the cam and crank gears are not in vertical alignment. It is a good idea to tap the crank gear up against its stop as the cam gear is being torqued down.)

(NOTE: If the crankshaft uses some sort of oil slinger in front of the crankshaft gear, install it at this time.)

14. Following the procedure outlined below, install the oil pump.

(NOTE: Depending on the engine being serviced, the steps of the below procedure may have to be done in a different order. Nevertheless, all of the steps will have to be performed.)

a. Install the pickup screen to the pump.

b. The screen can be bolted into the pump.

c. The screen may be pressed into the pump.

(NOTE: Oil pumps that are located in the timing chain cover will have the pickup screen bolted to the block.)

d. Prime the pump by using one of the two procedures outlined below.

(1ST PROCEDURE: Remove the pump cover and pack the oil pump gears/rotor with petroleum jelly. Reinstall the pump cover.)

(2ND PROCEDURE: Submerge the pump inlet/pickup screen and turn the oil pump drive gear in the proper direction until a steady flow of oil exits the pump.)

e. Attach the pump drive to the pump (if necessary).

f. Install the oil pump in its proper location.

(NOTE: Some oil pumps require that a gasket be placed between the pump and block. Do not forget to install this gasket, if re-quired.)

g. Torque the pump to its location.

15. Following the procedure outlined below, install the timing chain/belt.

    (NOTE: On OHC engines, the timing chain/belt cover should be installed after the head is installed.)

    a. Make sure all gasket surfaces are completely clean and flat.

    b. Select the correct cover to block gasket.

    c. Correctly install the gasket on the block.

       (NOTE: If coolant passes through the cover, it is a good idea to use a sealer in the gasket areas that are nearest the water passages.)

    d. Install a new front seal in the cover, if necessary.

    e. Bolt the cover up to the block using the correct torque and tightening sequence.

16. Following the procedure outlined below, install the oil pan.

    a. Make sure all gasket surfaces are clean and flat.

    b. Select the correct oil pan to block gasket and/or seal.

    c. If necessary, install the windage tray/baffle to the engine.

    d. Install the oil pan gaskets and/or seals.

    e. Place a small dab of gasket sealer where the gaskets and/or seals meet each other.

    f. Install all pan bolts finger tight.

       (NOTE: Some oil pans use different sizes of pan bolts, so be sure to put the proper bolts into the proper holes.)

       (NOTE: Sometimes brackets are bolted on with pan bolts [i.e., ATF line brackets]. Do not forget these brackets or their location.)

    g. Tighten the pan bolts to the proper torque using the correct tightening sequence.

17. Following the procedure outlined below, install the cylinder head(s).

    (NOTE: For a more detailed discussion of head installation, see Lesson 1 of Unit IV of this module.)

    a. Make sure the mating surfaces are clean and free from all old gasket material.

b. Set the head gaskets on the block using the dowel pins.

(NOTE: If the head gasket has "top" or "front" on it, be sure to install the gasket accordingly.)

c. Set the head on the block.

(NOTE: Be sure the head is installed on the correct side and with the proper end facing forward.)

d. Screw the head bolts in finger tight.

(NOTE: Head bolts that pass through water jackets should be sealed.)

(NOTE: Head bolts often come in various lengths, so be sure to match the proper bolt with the proper hole.)

e. Torque the head bolts in place.

f. Torque the bolts progressively--first to 1/3 of the torque specification, then to 2/3 of the torque specification, and then to final torque specification.

(NOTE: Torque the bolts according to the manufacturer's tightening sequence.)

18. Following the procedure outlined below, adjust the valve train on OHC engines.

a. Lubricate and install the lifters and rockers.

b. Lubricate and install the camshaft.

c. Install camshaft gear.

d. Align all the valve timing marks, crankshaft, camshaft, distributor, if used.

e. Attach timing chain/belt.

f. Following the manufacturer's recommendations, adjust the belt/chain tension device to achieve the required timing chain/belt tension.

g. Following the manufacturer's recommendations, adjust the valve lash to the desired initial settings.

h. Set the valve covers on the engine.

19. Following the procedure outlined below, assemble/adjust the valve train on push rod engines.

a. Lubricate and install the lifters.

(NOTE: Hydraulic lifters need to be filled with oil before installation.)

b. Install the push rods.

c. Install the rockers.

d. Using the manufacturer's procedures, make initial adjustments to the valve lash.

e. Set the valve cover(s) on the engine.

20. Following the procedure outlined below, complete the engine assembly.

a. Install the harmonic balancer.

b. Install the intake manifold (if necessary).

c. Make sure all gasket areas are clean.

d. Correctly choose and install the intake manifold gasket on the cylinder head.

(NOTE: Some intake manifold gaskets will have the word "front" or "top" printed on them. Make sure to install these gaskets accordingly.)

(NOTE: In areas where the intake manifold gasket must seal coolant, use a sealer with the gasket to ensure proper sealing.)

e. Carefully set the intake manifold on the engine. Take care not to move the intake manifold gaskets.

f. Using the proper progression and sequence, torque the intake manifold to the cylinder head.

21. Following the procedure outlined below, paint the engine.

a. Clean off any oil on the block that has accumulated during the engine assembly.

b. Plug any holes where paint would be undesirable (e.g., spark plugs, exhaust ports).

c. Put a light coat of grease on surfaces where paint would be undesirable (e.g., exhaust manifold surface, etc.).

22. Following the procedure outlined below, install engine accessories.

a. Install the motor mounts.

b. Install cooling system components (e.g., water pump thermostat, etc.).

c. Install fuel system components (e.g., carburetor/injectors/fuel pump).

d. Install emission system components (smog pump, EGR, etc.).

e. Install air conditioning components (e.g., compressor).

f. Install power train components (e.g., flexplate/flywheel/clutch).

(NOTE: The engine must sometimes be removed from the repair stand before the flywheel clutch can be installed. Nevertheless, always use correct procedures and torque specifications when installing the flexplate/flywheel/clutch.)

g. Install steering components (e.g., power steering pump).

h. Install exhaust components (e.g., exhaust manifolds).

(NOTE: Some accessories cannot be installed until the engine has been installed.)

(NOTE: If accessories cannot be cleaned before installation on the reconditioned engine, they should at least be blown off with compressed air.)

MODULE: ENGINE REPAIR

UNIT VI: LUBRICATING SYSTEM DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to identify the components and functions of the lubricating system and inspect and repair lubricating systems and components. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the terms and definitions associated with lubricating system construction, inspection, and repair (Competencies Q1 and Q6, Unit VI Test).

II. Identify lubricating system components (Competencies Q1 and Q6, Unit VI Test).

III. Identify the procedures for inspecting and repairing the oil system (Competency Q1, Part I of the Unit VI Test).

IV. Identify the procedures for performing oil and lube service on turbo and nonturbo engines (Competency Q6, Part II of the Unit VI Test).

V. Identify the procedures for diagnosing problems with the lubricating system (Competency Q1, Part I of the Unit VI Test).

VI. Demonstrate the ability to:

a. Diagnose oil system problems (Competency Q1, JS1-L1-UVI).

b. Diagnose and repair the auxiliary oil cooler (Competency Q1, JS2-L1-UVI).

c. Change oil and filter on nonturbo-charged vehicles (Competency Q6, JS3-L1-UVI).

d. Change oil and filter on turbo-charged vehicles (Competency Q6, JS4-L1-UVI).

MODULE: ENGINE REPAIR

UNIT VI: LUBRICATING SYSTEM DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT VI: LUBRICATING SYSTEM DIAGNOSIS AND REPAIR

LESSON 1: DIAGNOSING AND REPAIRING ENGINE OIL SYSTEMS

I. Terms and definitions associated with lubricating system construction, inspection, and repair

A. Auxiliary oil cooler—A device that allows air to cool engine oil. The auxiliary oil cooler functions much like a radiator.

B. Diluted oil—Oil that has lost its ability to lubricate as a result of being mixed with another liquid.

C. Dry lubricant—A lubricant in a metallic or powder form.

D. Grease—A thick gelatinous substance that provides lubrication. Grease is usually a gelled form of oil.

E. Lubricant—A substance that reduces the friction between moving parts by producing a slippery film between the parts.

F. Oil—A liquid form of lubricant.

G. Oil filter bypass valve—A valve usually located in the oil filter mounting base. The oil filter bypass valve will open and bypass the oil filter if the oil filter becomes clogged.

H. Oil pressure relief valve—A valve usually located in or near the oil pump. Oil pressure relief valve will open to limit the maximum oil pressure delivered to the lubricating system.

I. Oil pump—An engine-driven pump that delivers oil to the engine's moving parts.

J. Oil pump drive—The mechanical connection between the engine and the oil pump.

K. PCV valve—A valve that operates the positive crankcase ventilation system.

L. Pickup screen—A metal screen through which the oil pump draws its supply of oil.

M. Turbo-charged engine—An engine that uses exhaust gasses to drive a supercharger as part of its induction system.

N. Viscosity—The ability of a liquid to resist flow. Viscosity is an essential quality of a lubricant.

II. Lubricating system components

A. Lubricants exist in three forms: liquid, grease, and dry metallic particles.

1. Oils are liquids that form a slippery film when they are spread over a surface. Engines are usually lubricated by oil.

a. The federal government classifies oil according to “grades.” These grades are identified by a two-letter code. The first letter will be either a “C” (which indicates that the oil is for commercial use) or an “S” (which indicates that the oil is for use in privately owned vehicles). The second letter indicates the quality of the oil; the closer the second letter is to the end of the alphabet, the higher the quality of the oil. Only oil that is classified as “SF” or better should be used in a vehicle.

b. Oils are also classified by viscosity (the ability to resist flow). The classifications are represented by number. The larger the number, the more viscous the oil; the more viscous the oil, the more slowly it flows (i.e. the more resistance it has to flow). For example, a grade 40 oil will flow more slowly than a grade 10 oil.

c. Normally, oil viscosity is measured at a temperature of 70 degrees Fahrenheit. One classification called “winter” requires the oil to be measured at 0 degrees Fahrenheit. The classification “winter” is suffixed by the letter “W.” For example, a grade 40 oil has been checked at 70 degrees and a grade 10W oil has been checked at 0 degrees. A grade 10W-40 oil has been checked at both temperatures.

(NOTE: The viscosity classification system was developed by the Society of Automotive Engineers [S.A.E.].)

d. Always use the appropriate type and quality of oil for the vehicle to be serviced. When designing a vehicle, engineers identify the best oil for the vehicle. The engineers set the oil clearances in the engine bearings in accordance with the recommended oil. Using oil other than that recommended by the manufacturer will prevent the engine from achieving maximum performance and may even damage the engine.

2. Though more solid than oil, grease lubricates in much the same manner. Most grease will not flow freely. Grease is normally used in gearboxes and on steering and suspension joints.

a. Grease is usually classified as appropriate for either high-temperature or low-temperature application. Grease is also identified according to its intended use: for example, wheel bearing grease, rear axle grease, chassis grease, etc.

b. The vehicle chassis is usually greased at each oil change. The level and condition of the grease in the gearboxes should also be checked at each oil change.

c. In some vehicles, the suspension and steering joints are greased at the manufacturer and do not require periodic lubrication. To determine if lubrication is required, check the appropriate service manual.

d. Some gearboxes, transmissions, and final drive units use oil instead of grease. To determine if grease or oil should be used, check the appropriate service manual.

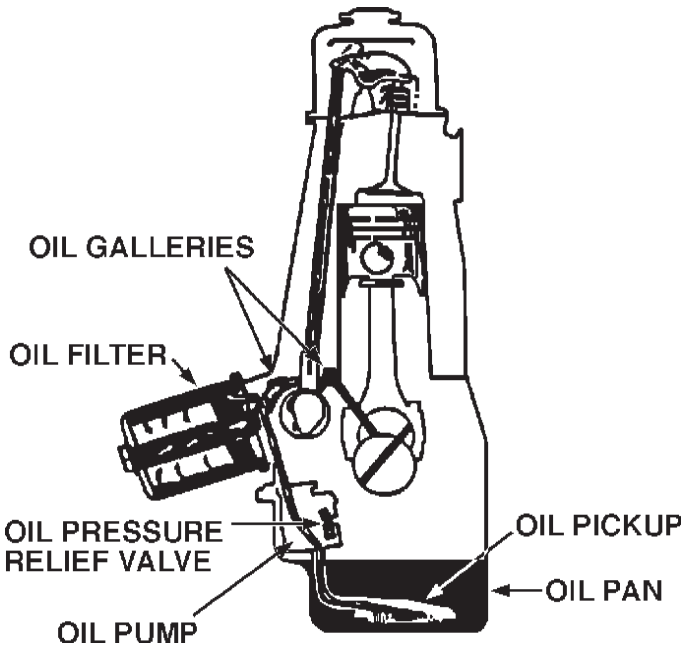
3. Dry, metallic lubricants are composed of rounded particles. Materials used as dry, metallic lubricants include graphite and molybdenum. Dry lubricants are used on devices such as locks and as additives in oil and grease. Dry lubricants may also have other specific applications. Check the appropriate service manual to determine how dry lubricants should be used.

B. Oil pump

1. The oil pump is located in or on the engine itself and is driven by the camshaft or the crankshaft. The oil pump consists of the pump itself, the oil pump drive, the pickup screen and tube, and the oil pressure relief valve.

2. In a modern vehicle, an oil pump failure is extremely rare; however, an oil pickup screen may become plugged, a pump drive may fail, or a pressure relief valve may malfunction.

3. If discovered in time, a defective oil pump, drive, or screen should be replaced. Failure of these components usually results in severe engine damage, requiring extensive engine repair or replacement.



C. Oil galleries

1. Oil galleries are located throughout the engine block and cylinder head castings. The galleries direct the oil from the oil pump to the various components requiring oil.

2. These galleries require little maintenance. However, during engine overhaul, the technician should clean the galleries. The technician should also make sure that all gaskets, seals, and plugs are installed so that they do not plug the galleries at inappropriate times or cause leakage.

D. Oil seals

1. Oil seals are used when a shaft leads from an “oil environment” to a non-oil environment. In some applications, these devices seal oil pressure in the pump, or oil gallery; at other applications, they seal the crankcase area from outside the engine.

2. Most oil seals can be serviced with the engine installed in the vehicle. Most of these leaks are easy to diagnose.

E. Gaskets

1. Gaskets are used to seal and cushion the space between two components. Usually, these components are designed to remain stationary. The gaskets can seal between high- and low-pressure areas or merely form a cushion.

2. Leaking gaskets are usually easy to diagnose and can usually be replaced while the engine is installed in the vehicle. However, if the gasket is leaking oil to the outside of the engine, the result could be disastrous. This kind of leakage can take place at the rubber gasket that is used in the oil filter.

F. Oil filters

1. Modern vehicles are equipped with full-flow oil filters. In a full-flow filter, all of the oil is filtered as it leaves the oil pump.

2. Most manufacturers recommend that the oil filter be replaced at every other oil change. However, considering how little the filters cost and the important function they serve, it is advantageous to replace them at each oil change.

3. A special bypass valve located in the oil filter mounting base will bypass the filter if the filter should become clogged. If the filter is bypassed, the engine will still receive oil but at a lower pressure. However, the oil that is received will not be filtered.

G. Auxiliary oil coolers

1. Auxiliary oil coolers are used on many high-performance engines and on many turbo-charged engines. Engines using auxiliary oil coolers will require more oil than those that do not use auxiliary coolers.

2. Auxiliary oil coolers are subject to oil leakage. This leakage will typically be external and thus can usually be easily detected.

3. Some less easily detected problems typical of auxiliary oil coolers are plugged oil passages within the cooler. Plugged passages may not cause a specific engine problem but will reduce the effectiveness of the cooler. Another problem is plugged cooling fins on the outside of the cooler. Plugged fins may prevent air from properly flowing through the unit.

4. If high oil temperature becomes a problem, thoroughly clean the outside of the auxiliary oil cooler with water and make sure that oil is flowing through the cooler freely.

III. Inspecting and repairing oil systems

A. Procedure for inspecting the condition of engine oil

1. Check oil level using the dipstick provided. The oil level should be between the dipstick marks.

2. Note the color of the oil. The oil should have a light color, much like that of new oil. Generally, the darker the oil, the poorer its condition.

3. Note the odor of the oil. The oil should smell like new oil. A smokey smell about the oil indicates problems. A gasoline odor indicates that the oil is diluted with fuel; if this is the case, the fuel leak should be found and corrected. Oil may also be contaminated with coolant. If the oil is suspected of containing any foreign substances, the oil should be changed immediately.

4. Put a drop of oil on the thumb and rub the oil between the thumb and forefinger. The oil should feel slippery; no grit should be detected.

5. If any of the above checks indicate that the oil is in poor condition, the oil and the filter should be changed at the first opportunity.

B. Checking oil pressure

1. If an oil pressure problem occurs, first check the condition of the oil and the oil level. If the oil level is low, or if the oil condition is poor, perform an oil change service and recheck the oil pressure.

2. The oil pressure should be at a level set by the oil pressure relief valve. Though the specification for oil pressure will vary (depending on the vehicle manufacturer), oil pressure of about 45 psi is usually normal for highway speeds. Lower oil pressure is acceptable at idle speeds; however, pressure should never fall low enough to activate the low-oil-pressure warning system or the “check engine” light.

3. Excessively low oil pressure will trigger one of the warning systems. If the engine is equipped with hydraulic valve lifters, low oil pressure will result in a clattering noise during engine operation.

4. If low oil pressure is expected, verify the problem with a direct-reading oil pressure gauge. Doing so will eliminate the possibility of a warning system malfunction.

5. Low oil pressure can be caused by a malfunctioning pump or relief valve, a plugged pickup screen, diluted or otherwise damaged oil, or either a leak in the oil pickup tube or an oil gallery.

C. Procedure for checking for oil leakage

1. Oil leakage can be classified as either internal or external.

   a. Internal leakage occurs between the oil delivery system (a high-pressure system) and the inside of the engine. Because there is usually no visible evidence of internal leaks, they are difficult to detect.

b. External leakage can occur in either a high- or a low-pressure portion of the system. Because leaking oil can be seen on the engine and on the ground under the vehicle, external leakage is usually easy to detect.

2. Oil usually leaks from a failed gasket or seal; such leaks can be corrected by replacing the failed gasket or seal. In some cases, the PCV system could be allowing the crankcase to become pressurized, thus causing the leaks; another problem may be that the engine is sufficiently worn to allow piston blow-by to pressurize the crankcase, thus causing the leaks. Problems such as these are indicated by oil being blown into the air cleaner housing. These problems can be corrected by cleaning out the PCV system, replacing the PCV valve, or correcting the cylinder blow-by problem.

IV. Performing oil and lube service on turbo and nonturbo engines

(NOTE: Outlined below is a general procedure for changing oil. Though changing oil is a relatively simple task, it is critical that it be done correctly. Be sure to refer to the appropriate manual for specifications and procedures for changing the oil on any particular vehicle. Be especially careful to refer to the manual when changing the oil on turbo-charged vehicles. Vehicles with turbochargers often require special oil; procedures for changing oil on turbo-charged vehicles may also be more complex.)

A. Run the engine until it reaches normal operating temperature. If the vehicle is turbo-charged, allow the engine to idle during the last few minutes of operation.

(NOTE: Even if a turbo-charged vehicle comes into the shop at operating temperature, be sure to start the engine and allow it to idle a few minutes. Even a warm turbo-charged engine must idle in order to scavenge the oil from the turbocharger.)

B. Lift the vehicle in order to get to the underside.

(**CAUTION:** Be sure to follow all safety rules for working under a vehicle. Never work under a vehicle supported by only a jack. A frame lift or jack stand is the only acceptable support for a vehicle. Failure to comply with all safety rules could result in fatal injuries.)

C. Place a drain pan or drain bucket under the crankcase drain plug.

(NOTE: Some engines have two drain plugs.)

D. Remove the oil drain plug or plugs and catch the oil in the drain pan or bucket. Allow the oil to drain for a few minutes. While the oil is draining, check the suspension and steering joints in the vehicle and lubricate these parts if required. The grease in the rear axle (or final drive) and the lubricant in manual transmissions can also be checked at this time.

(NOTE: When checking lubrication points under the vehicle, the technician should check any components or systems that relate to the vehicle's safe operation. These may include suspension components [especially the shock absorber], steering linkages, exhaust systems, fuel tanks and lines, tires, etc. The technician should also check and adjust tire pressure.)

E. Remove the oil filter. Be sure to catch the oil in the drain pan or bucket. Clean the area where the oil filter gasket will seal and make sure that the oil gasket is not still stuck there.

F. Reinstall the drain plug (or plugs) and tighten them securely. Do not over torque or cross thread the plug. Replace worn or damaged gaskets at this time.

G. Install a new oil filter. Lubricate the gasket with clean engine oil. Tighten filter according to manufacturer's directions. Most filters are tightened hand tight. Some have specific torquing techniques. Refer to the appropriate manual for tightening instructions.

H. Recheck all of the work and make sure that the plugs are installed tightly. Also make sure that the oil filter is on tightly.

I. Lower the vehicle to the floor.

J. Open the hood and add the proper amount of new oil to the engine. Perform lubrication service under the hood as required. In some vehicles, the throttle and other control linkages should be lubricated at this time.

(**CAUTION:** Be sure to add the correct amount of oil to the engine. Adding too much or too little oil could result in severe engine damage.)

K. Start the engine and allow it to idle for a few seconds. The oil pressure warning system may actuate for a few seconds but should reset itself within ten seconds.

(NOTE: If the engine does not show signs of developing oil pressure within ten seconds, shut the engine down immediately and locate and correct the problem. The technician should make absolutely sure that he or she remembered to put oil in the engine. Such oversights do occur and can be very costly.)

L. Allow the engine to idle for a few minutes. In turbo-charged vehicles, this is necessary to get the proper amount of oil pressure to the turbocharger before it is actuated. After changing the oil in nonturbo-charged vehicles, idling the engine allows the technician the opportunity to look for leaks. While the engine is idling, lift the vehicle and check the drain plug or plugs and the oil filter for leaks.

M. Lower the vehicle and record on a door tag (or other form) the vehicle's mileage, the date, and precisely what service was performed.

V. Diagnosing problems with the lubricating system

A. Oil leakage can be classified as either external or internal

1. External leakage can be detected visually. Occasionally, the leakage is so slight that the source is not apparent; on the other hand, the leakage may be so massive that the source of the leak is covered with oil. In some cases, the engine must be washed off and run in short cycles to prevent large leaks from flooding the leak area. At other times, the leak area can be washed and coated with a tracing powder to pinpoint an oil seep. An aerosol foot powder is often used for this purpose.

2. Internal leakage is very difficult to detect. In fact, internal leakage will often continue without being detected.

   (NOTE: Usually the technician will detect internal leakage when diagnosing some other problem. For example, when diagnosing an oil consumption problem or a low oil pressure problem, the technician may determine the cause to be an internal oil leak. The leak can be pinpointed by removing the oil pan and pressurizing the lubricating system with the pre-oiler. The leak will become apparent when oil begins to run out of the engine base. In some cases, the engine will need to be disassembled further before the leak can be found.)

B. Oil pressure problems

1. No oil pressure

   a. Much of the time, severe engine damage will result before a complete lack of oil pressure can be detected.

   b. When engine problems such as crankshaft damage are discovered, make sure that the damage was not caused by a defective oil system. If engine components are repaired but the oil system problems go uncorrected, the same damage will likely occur again.

   c. The oil pressure can fall to zero when the oil level in the engine drops below the level of the pickup screen. This drop in the oil level may be the result of an oil leak or simply the failure to change or add oil to the vehicle. Another possible reason for a drop in oil level is oil filter damage caused by a foreign object.

2. Low oil pressure

   a. Low oil pressure is usually caused by one of the following problems: a plugged pickup screen or tube; an internal oil leak in the pickup tube above the oil level in the engine; or a leak in the oil gallery in the block or head. Low oil pressure may also result from oil that has been diluted with fuel.

b. First, check the oil level and the condition of the oil. If oil level is low or if the oil seems very thin or dirty, change the oil and the filter and recheck the oil pressure. If changing the oil corrected the condition, then diluted oil was likely the cause.

(NOTE: Oil will become diluted as a result of a defective fuel pump. A defective fuel pump will often be indicated by fuel leaking from the fuel pump base.)

c. If pressure remains consistently low after the oil change, replace the oil pump and examine the screen. Replace the screen if it is found to be plugged and inspect the condition of the timing chain and sprocket. Very often, excessive wear or defects in the timing chain and sprocket cause fragments of the sprocket to fall into the engine base and clog the screen.

d. If oil pressure is low at idle but normal at highway speeds, the problem may be an internal oil leak or a malfunction in the oil pressure indicating system. Use a direct-reading gauge to measure the pressure. If the direct-reading gauge gives a normal reading, replace the oil pressure sending unit. If replacing the unit does not correct the problem, look for an internal oil leak.

C. Oil consumption

1. If oil leaks into the combustion chamber and is burned at the time of ignition, oil will be consumed by the engine. Oil can also be consumed if it leaks into the exhaust system through an exhaust valve stem seal.

2. Oil may also leak into the induction system through an intake valve stem seal or a defective turbocharger oil seal.

3. A leaking fuel pump can also allow fuel to dilute the oil, thus reducing the oil's viscosity and increasing its tendency to leak.

4. By far, the most common cause of excessive oil consumption is that the oil is leaking past worn piston rings. If the engine has high mileage and a compression or cylinder leakage test indicates leakage past the piston rings, correct this problem before exploring other possible causes. Servicing the rings will probably correct the oil consumption problem.

D. Contaminated oil

1. Oil can become contaminated with fuel or coolant. If the oil has become contaminated, the cause must be found and corrected.

2. As was stated above, oil contaminated with fuel is usually the result of a leaking fuel pump. Oil contaminated by coolant is usually the result of a leaking cylinder head gasket.

JS1-L1-UVI

MODULE: ENGINE REPAIR

DIAGNOSING OIL SYSTEM PROBLEMS

Equipment:

Common hand tools
Oil pressure gauge
Feeler gauge set
Outside micrometer
Telescoping gauge
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Describe below any oil pressure problems the vehicle may have.

3. Using a service manual or other information source, locate a procedure for performing an oil pressure test. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, perform an oil pressure test. Record results.

4. Based on the oil pressure tests and any other symptoms the vehicle may have (such as visible evidence of oil leak, for example), indicate what the problem might be and suggest procedure to correct the problem.

5. Using a service manual or other information source, locate a procedure for inspecting and/or measuring the oil pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐
Instructor Approved

Following the procedure, inspect and/or measure the oil pump. Record inspection results below.

6. Using a service manual or other information source, locate a procedure for repairing or replacing the oil pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐
Instructor Approved

Following the procedure, repair or replace the oil pump. Record observations.

7. Using a service manual or other information source, locate a procedure for testing the oil temperature/pressure switches and sensors. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, test the oil temperature/pressure switches and sensors. Record observations.

8. Using a service manual or other information source, locate a procedure for repairing and replacing the oil temperature/pressure switches and sensors. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, repair and replace the oil temperature/pressure switches and sensors. Record observations.

JS2-L1-UVI

MODULE: ENGINE REPAIR

DIAGNOSING AND REPAIRING THE AUXILIARY OIL COOLER

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Describe below any problems with the auxiliary oil cooler.

3. Using a service manual or other information source, locate a procedure for inspecting the auxiliary oil cooler. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, inspect the auxiliary oil cooler. Record observations.

4. Using a service manual or other information source, locate a procedure for repairing or replacing the auxiliary oil cooler. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, repair or replace the auxiliary oil cooler. Record observations.

JS3-L1-UVI

MODULE: ENGINE REPAIR

CHANGING OIL AND FILTER ON NONTURBO-CHARGED VEHICLES

Equipment:

Common hand tools
Oil filter wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for changing the oil and filter on a nonturbo-charged vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, change the oil and filter on a nonturbo-charged vehicle. Record observations.

JS4-L1-UVI

MODULE: ENGINE REPAIR

CHANGING OIL AND FILTER ON TURBO-CHARGED VEHICLES

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source locate a procedure for changing the oil and filter on a turbo-charged vehicle. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, change the oil and filter on a turbo-charged vehicle. Record observations.

MODULE: ENGINE REPAIR

UNIT VII: REASSEMBLING THE ENGINE

UNIT OBJECTIVE

After completing this unit, the student should be able to assemble the engine and prepare it for installation in the vehicle. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lesson in this unit, the student should be able to:

Lesson 1.

I. Identify the terms and definitions associated with the automobile engine assembly (Competency P1, Part I of the Unit VII Test).

II. Identify the procedures for reassembling the short block assembly (Competency P1, Part I of the Unit VII Test).

III. Identify the procedures for completing the engine assembly (Competency P1, Part I of the Unit VII Test).

IV. Identify the procedures for final engine adjustments and pre-oiling (Competency P1, Part I of the Unit VII Test).

V. Identify the procedures for checking the engine systems before and after starting and running the engine (Competency P2, Part II of the Unit VII Test).

VI. Demonstrate the ability to:

a. Reassemble the short block assembly (Competency P1, JS1-L1-UVII).

b. Complete the short block assembly (Competency P1, JS2-L1-UVII).

c. Install an engine in a front-wheel-drive vehicle (Competency M2, JS3-L1-UVII).

d. Install an engine in a rear-wheel-drive vehicle (Competency M2, JS4-L1-UVII).

e. Check the engine assembly and start the engine (Competency P2, JS5-L1-UVII).

MODULE: ENGINE REPAIR

UNIT VII: REASSEMBLING THE ENGINE

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT VII: REASSEMBLING THE ENGINE

LESSON 1: ENGINE REASSEMBLY

I. Terms and definitions associated with the automobile engine assembly

A. Bearing alignment tabs—Small tabs built into bearing inserts. Bearing alignment tabs prevent bearings from turning in their bores.

B. Bearing oil clearance—Space provided between the engine bearing and its shaft. A film of oil will form in the bearing oil clearance during engine operation.

C. Cam locating device—A device that supports the engine cam and prevents it from moving from end to end in the engine or cylinder head.

D. Core plugs—Metal plugs pressed into the engine block. The core plugs close the core holes and oil galleries.

E. Gasket—A sheet of soft material that is installed between a component and its mounting base. The gasket cushions the components and prevents leakage.

F. Gasket adhesive—A material that holds a gasket in position after the gasket is installed. Gasket adhesive is used to secure cork or rubber gaskets. Usually gasket adhesive is installed on only one side of the gasket, while a gasket sealer is used on the other side. It should be noted that gasket adhesive is different than gasket sealer.

G. Gasket sealer—A material used to assist the sealing properties of a gasket, while still allowing for expansion and contraction of the parts. This material does not harden and will not hold the gasket in position. It should be noted that gasket sealer is not the same substance as gasket adhesive.

H. Head bolt—A special bolt used to hold the cylinder head to the engine block. Head bolts should be replaced only with specially designed bolts.

I. Keying device—A device used to maintain the position of two components. A keying device can be a square key, a woodruff key, or a dowel pin.

J. Oil gallery—A hole bored or cored into the block for the purpose of carrying oil to the moving parts.

K. Pre-oiler—Device that uses an outside pressure source to deliver oil to the engine's lubricating systems. The lubricating system can thus be charged with oil before it is started and the oil pump actuated.

L. Silicon sealant—A material that seals gaps between gasket components. Silicon sealant will cure in place after application and can sometimes be used instead of a gasket.

M. Spit holes (in connecting rods)—A small hole bored through the large end of the connecting rod. The hole will “spit” oil one time during each crank revolution. Some rods do not have spit holes.

N. Thrust main bearing—The main bearing that prevents the crankshaft from moving end to end in the block.

O. Timing indicator—A scale and pointer, usually located at the front of the engine, that indicates the position of the crankshaft. This pointer does not indicate the position of the cam.

P. Valve lash—The relationship between the cam lobe and the valve. Sometimes lash is a positive clearance (space) between the parts; at other times lash is a negative clearance (preload) between the parts. Mechanical lifters will have clearance. Hydraulic lifters will have preload.

Q. Work fixture—A device used to hold the engine block while it is being serviced.

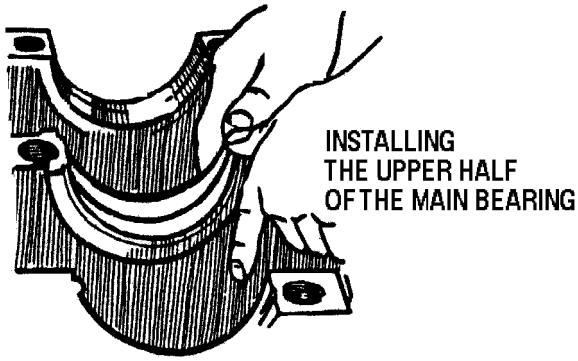
II. Procedures for reassembling the short block assembly

(NOTE: Make sure that the block is clean, that all of the oil passages are clean, and that the new core plugs have been installed in all of the freeze plug locations and in all of the oil gallery locations.)

A. Following the procedure outlined below, install the crankshaft.

1. With the engine block turned with the bottom up on the work fixture, install the upper half of the main bearings.

(NOTE: Use extra care in seating the thrust bearing properly.)



INSTALLING THE UPPER HALF OF THE MAIN BEARING

a. Make sure that the block bearing bores are clean and dry.

b. Make sure that the oil feed holes line up with the oil holes in the block.

c. Make sure that the thrust main is on the right bearing.

d. Make sure that the alignment tabs are fitted into the slots meant for them.

2. Install the crankshaft. Make sure that the crankshaft is clean and dry.

3. Check the main bearing oil clearances. Make sure that the correct caps are used when this measurement is made.

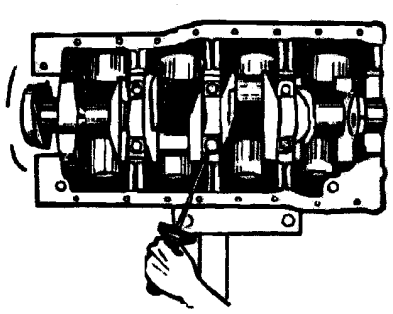
4. Remove the caps and thoroughly prelubricate all of the bearings. Use a special prelubricant or clean engine oil.

   (NOTE: If a two piece rear main seal is used, remove the crankshaft and install the upper seal.)

5. Reinstall the caps and torque them to the prescribed valves.

   a. Install the lower half of the two piece rear main seal.

   b. Torque the caps one at a time, making sure that the shaft is free to turn after each cap is torqued.



   c. If any bearing causes a bind in the free rotation of the shaft, disassemble the bearings, locate the problem and correct it. The shaft may bind slightly when the rear main bearing oil seal is installed. Disassemble the shaft if there is any indication of binding.

B. Following the procedure outlined below, install the camshaft if it is located in the block assembly.

1. Make sure that new cam bearings have been installed and that all oil holes line up.

   a. A bent piece of soft wire can be inserted in the oil holes to ensure that they are lined up with the holes in the block. Solder wire is ideal for this purpose.

b. In many engines, oil holes allow oil to pass between the oil pump and the main bearings or the valve train. Failure to remove blockage in these holes could result in serious damage.

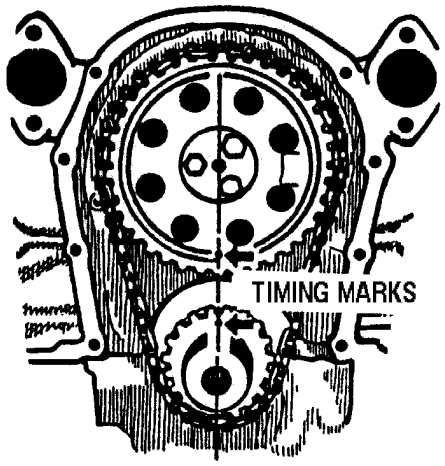
2. Prelubricate the camshaft with a special lubricant made for this purpose. Failure to prelubricate the cam lobes could result in premature lobe or lifter failure.

C. If the cam is located in the block assembly, install the timing gears, the timing chains, and sprockets. Follow the procedure outlined below.

1. Make sure that the keying device is in place and properly indexed to the shaft.

(NOTE: In some applications a square key is used; in other applications, a dowel pin is used. There is always a keying device in both the camshaft and in the crankshaft.)

2. Make sure that the camshaft is timed to the crankshaft. Make sure all accessory parts are installed with the cam gear (for example, a fuel pump cam is included on some models).



D. Following the procedure outlined below, install the piston and rod assemblies.

(NOTE: Ring installation procedures may vary. Refer to the ring manufacturer's instructions or appropriate service manual.

1. Make sure that the pistons are installed in the proper cylinders.

2. Check that the arrow on the piston top faces the front of the engine.

3. Check that the tabs and spit holes on the rods are all facing the same directions on in-line engines or on each bank of a vee engine. On vee type engines, the rods will face in opposite directions from one bank to the other. On all engines, the spit holes should face the camshaft.

4. Turn the rings on the piston so that the compression ring gaps are staggered at 180° intervals. Make sure that the three components of the oil control ring are properly installed.

5. Coat the piston with clean engine oil. Using a ring compressor, compress the rings and tap the piston into its bore using a mallet handle. The piston should tap down rather easily. If it requires more than a few light taps, remove it and check the rings.

   (NOTE: Failure of the piston to tap in easily may be caused by one of several problems: the oil ring may be improperly assembled; one of the compression ring grooves may not have been properly cleaned out; one of the ring gaps may be too tight.)

6. Lubricate each rod bearing and torque the cap to the prescribed specification.

7. Turn the crankshaft after each rod cap is torqued. Increased torque will be required to turn the crankshaft as each rod is torqued; however, the required torque should never be high enough to prevent the engine from being turned with a 24-inch wrench handle. Many overhaul manuals will specify the torque required to turn the engine after overhaul. If the crankshaft cannot be turned, find and correct the problem before continuing with the procedure.

E. Following the procedure outlined below, install the oil pump or the oil pump pick-up tube and screen.

1. In some engines, the oil pump can be found on the front engine housing or some other location outside of the engine block. If this is the case, the pick-up screen and tube are separate and will be installed inside of the engine base.

2. In some engines, the oil pump is located outside of the engine base. If this is the case, another gasket must be used under the pickup tube mounting flange. This gasket is essential because leakage around the pickup tube mounting flange will allow the oil pump to pick up air. Air is much lighter than oil, and, in some cases, the air will fill the system, displacing most of the oil. If the oil is displaced by air, serious engine damage could result.

   (NOTE: No matter where the oil pump is located, a gasket will always be located under a bolt on oil pick-up tube.)

F. Following the procedure outlined below, install the front housing, if one is used.

1. Make sure that the new front seal is installed (if the engine uses one).

2. Once again make sure that the camshaft-locating devices are properly installed.

   a. Some engines use a cam thrust bearing, which is screwed or bolted to the front of the engine block.

b. Other engines use a bearing located in the front housing.

c. Look for the device and make sure that it is properly assembled.

3. If the water pump is part of the front housing, make sure that it is functional. If the water pump is found to be functional, install it, using new gaskets.

G. Install the harmonic balancer and lower crankshaft pulleys if they are used on the engine. Make sure that the keys are installed in the crankshaft groove. Make sure that the #1 cylinder timing indicator scale and pointer are installed. Also make sure that they give proper readings when the #1 cylinder is at the top dead center position.

III. Procedures for completing the engine assembly

A. Turn engine over in the engine fixture. The engine should now be right side up. Install the valve lifters if they are located in the short block.

B. Following the procedure outlined below, install the cylinder head or heads.

1. Install new gaskets. Make sure that they are installed on the proper side.

(NOTE: Always use new gaskets.)

(NOTE: Most gaskets are plainly marked. Most modern gaskets do not require the use of sealers.)

2. Install the heads and start all of the head bolts.

a. All of the head bolts should be clean and lubricated. All of the head bolt holes should be cleaned using a tap. All bolts in holes that go through the block metal into the water jacket should be coated with gasket sealer.
b. Make sure that head bolts of different lengths are put in their proper positions. Start each of the bolts. Turn each bolt one turn into the block. There should be equal distance from the bottom of the bolt head to the surface of the cylinder head. If this distance on any one bolt is more than one inch, make sure that the hole is deep enough to accept it. If there are large variations in the distances, rearrange the bolts from hole to hole until the distances are nearly the same.

3. Using the prescribed torquing sequence, torque the head bolts to the prescribed torque. It is advisable to torque the bolts in three cycles, using progressively higher torque valves until the final torque value is reached.

4. If the engine uses an overhead cam or dual-overhead cam, install the cams and valve train components. On most overhead cams or dual-overhead cams, adjustment is made at assembly.

IV. Procedures for final engine adjustments and pre-oiling

A. Following the procedure outlined below, pre-oil the engine.

(NOTE: The pre-oiling process should be done before the intake manifold or crankcase pan are installed.)

1. Fill the pre-oiler with clean engine oil. Charge the pre-oiler with approximately 45 psi of air pressure.

2. Using the proper adapters, attach the pre-oiler to the engine's oil pressure sender fitting.

3. Open the valve to allow the oil to flow to the engine's oil galleries.

    a. Leave the pressure applied while watching the engine carefully.

    b. Oil will begin to drip slowly from the engine. Look for any excessive oil flow.

    c. If oil is observed "running" from the engine, find the leak and correct it.

    d. Make sure that there is oil flowing from each bearing and from the valve lifters. There should also be some oil dripping from the front of the engine if a timing chain is located there.

    e. As soon as oil has reached all of the engine components, turn the valve on the pre-oiler to the off position and disconnect the equipment.

B. Following the procedure outlined below, continue the assembly process.

1. If a vee engine or other L-head engine is being serviced, install the valve push rods and the rocker arms or rocker shafts.

2. Adjust the valve lash on these engines at this time.

    a. Adjust the valve lash on each cylinder while that cylinder is at top dead center and on its firing stroke.

    b. Some engines have adjusting screws on the rocker arms. Others use selective push rod lengths for adjustment.

3. Install the intake manifold using new gaskets. Torque all intake manifold bolts to the prescribed torque. A good brand of sealant should be used on the intake manifold gasket. Refer to the appropriate service manual for the recommended brand of sealant.

4. Install ignition system parts. Time the system to fire at top dead center on the compression stroke of the #1 cylinder.

    (NOTE: Refer to Module 3: Engine Performance of the Missouri Auto Mechanics Guide for these procedures.)

5. Install the crankcase pan.

a. Make sure that the pickup screen is near the bottom of the pan when the screen is installed.

b. A small piece of putty or similar material may be used to make the measurement. The position can be adjusted by gently bending the oil pickup tube.

c. Make sure the putty is cleaned out after the measurement is taken.

d. Carefully assemble the gaskets. The gaskets can be very vulnerable to leakage. Leakage from the gaskets is difficult to correct after the engine is installed.

(NOTE: Do not use sealant on rubber gaskets that have positioning tabs. Use a good quality silicon sealant on the joints where two gasket components meet.)

e. Lightly torque the pan bolts to prevent them from distorting the pan.

6. Install other pans and covers as required. Make sure that each pan and cover has a new gasket and that proper sealant is used where required.

7. Install the fuel pump and carburetor (if these are used). In some engines where fuel injection is used, there will be no carburetor; nevertheless, fuel system components will need to be installed.

8. Install all engine electrical harnesses and components along with their clamps and plugs. Use the marks and/or pictures that were made during engine disassembly. If the components were not marked during disassembly, use a similar vehicle or a manufacturer's manual for a reassembly guide. Leave the ignition system disconnected at the positive terminal or plug.

9. Install a direct reading oil pressure gauge in the oil pressure sender fitting.

10. Install exhaust manifolds.

C. Following the procedure outlined below, install the engine assembly.

1. Install the engine assembly according to the procedure developed in Unit III of this module.

2. Fill the crankcase with the prescribed amount of engine oil. Make sure that the dipstick indicates that the crankcase is full.

3. Fill the power steering system, the transmission, and the cooling system. Make sure that they are all filled to the proper levels.

V. Procedures for checking the engine systems before and after starting and running the engine

A. Following the procedure outlined below, spin the engine over using the cranking motor and make inspections.

1. Watch for an indication of inadequate pressure on the oil pressure gauge.

2. Make sure that cranking is normal and at the normal speed.

3. Make sure that fuel is being delivered to the engine's fuel system.

4. Stop cranking and carefully check for fuel, oil, or coolant leaks. Look for evidence of leakage on the shop floor and around each fitting.

B. Run the engine and carefully monitor its condition

1. Connect the ignition system, and crank the engine until it starts.

2. Check for oil pressure. If no oil pressure is noted in ten seconds, shut the engine down and correct the problem.

3. Allow the engine to run until the cooling system reaches its normal operating temperature. While the engine is running, keep watching for fuel, oil, or coolant leaks. If any leaks are detected, correct them. Next, restart the engine and make sure that all leaks are corrected and the cooling system has reached its normal operating temperature.

4. Shut the engine down.

5. Check and top off all fluid levels.

6. Connect an electronic engine analyzer to the engine and perform final adjustments to the ignition and fuel systems. Refer to Module 3: Engine Performance of the Missouri Auto Mechanics Guide for these procedures.

JS1-L1-UVII

MODULE: ENGINE REPAIR

REASSEMBLING THE SHORT BLOCK ASSEMBLY

Equipment:

Common hand tools
Harmonic balancer installer
Ring compressor
Torque wrench
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, install the crankshaft.

    a. With the engine block turned with the bottom up on the work fixture, install the upper half of the main bearings.

    b. Make sure that the block bearing bores are clean and dry.

    c. Make sure that the oil feed holes line up with the oil holes in the block.

    d. Make sure that the thrust main is on the right bearing.

    e. Make sure that the alignment tabs are fitted into the slots meant for them.

    f. Install the crankshaft. Make sure that the crankshaft is clean and dry.

    g. Check the main bearing oil clearances. Make sure that the correct caps are used when this measurement is made.

    h. Remove the caps and thoroughly prelubricate all of the bearings. Use a special prelubricant or clean engine oil.

        (NOTE: If a two piece rear main seal is used, remove the crank shaft and install the upper half of the seal.)

i. Reinstall the caps and torque them to the prescribed values. Torque the caps one at a time, making sure that the shaft is free to turn after each cap is torqued.

(NOTE: If a two piece rear main seal is used, install the lower half in the rear main cap.

j. If any bearing causes a bind in the free rotation of the shaft, disassemble the bearings, locate the problem and correct it. The shaft may bind slightly when the rear main bearing oil seal is installed. Disassemble the shaft if there is any indication of binding.

3. Following the procedure outlined below, install the camshaft if it is located in the block assembly.

a. Make sure that new cam bearings have been installed and that all oil holes line up.

(NOTE: A bent piece of soft wire can be inserted in the oil holes to ensure that they are lined up with the holes in the block. Solder wire is ideal for this purpose. In many engines, oil holes allow oil to pass between the oil pump and the main bearings or the valve train. Failure to remove blockage in these holes could result in serious damage.)

b. Prelubricate the camshaft with a special lubricant made for this purpose. Failure to prelubricate the cam lobes could result in premature lobe or lifter failure.

4. If the cam is located in the block assembly, install the timing gears, the timing chains, and sprockets. Follow the procedure outlined below.

a. Make sure that the keying device is in place and properly indexed to the shaft.

(NOTE: In some applications a square key is used; in other applications, a dowel pin is used. There is always a keying device in both the camshaft and in the crankshaft.)

b. Make sure that the camshaft is timed to the crankshaft.

5. Following the procedure outlined below, install the piston and rod assemblies.

a. Make sure that the pistons are installed in the proper cylinders.

b. Check that the arrow on the piston top faces the front of the engine.

c. Check that the tabs and spit holes on the rods are all facing the same directions on in-line engines or on each bank of a vee engine. On vee engines, the rods will face in opposite directions from one bank to the other. On all engines, the spit holes should face the camshaft.

d. Turn the rings on the piston so that the compression ring gaps are staggered at 180^{o} intervals. Make sure that the three components of the oil control ring are properly installed.

e. Soak the piston in clean engine oil. Using a ring compressor, compress the rings and tap the piston into its bore using a mallet handle. The piston should tap down rather easily. If it requires more than a few light taps, remove it and check the rings.

(NOTE: Failure of the piston to tap in easily may be caused by one of several problems: the oil ring may be improperly assembled; one of the compression ring grooves may not have been properly cleaned out; or one of the ring gaps may be too tight.)

f. Lubricate each rod bearing and torque the cap to the prescribed specification.

g. Turn the crankshaft after each rod cap is torqued. Increased torque will be required to turn the crankshaft as each rod is torqued; however, the required torque should never be high enough to prevent the engine from being turned with a 24-inch wrench handle. Many overhaul manuals will specify the torque required to turn the engine after overhaul. If the crankshaft cannot be turned, find and correct the problem before continuing with the procedure.

6. Following the procedure outlined below, install the oil pump or the oil pump pickup tube and screen.

a. In some engines, the oil pump can be found on the front engine housing or some other location outside of the engine block. If this is the case, the pick-up screen and tube are separate and will be installed inside of the engine base.

b. In some engines, the oil pump is located outside of the engine base. If this is the case, another gasket must be used under the pickup tube mounting flange. This gasket is essential because leakage around the pickup tube mounting flange will allow the oil pump to pick up air. Air is much lighter than oil, and, in some cases, the air will fill the system, displacing most of the oil. If the oil is displaced by air, serious engine damage could result.

(NOTE: No matter where the oil pump is located, a gasket will always be located under a bolt on oil pick-up tube.)

7. Following the procedure outlined below, install the front housing, if one is used.

   a. Make sure that the new front seal is installed (if the engine uses one).

   b. Once again make sure that the camshaft-locating devices are properly installed.

      (NOTE: Some engines use a cam thrust bearing, which is screwed or bolted to the front of the engine block. Other engines use a bearing located in the front housing. Look for the device and make sure that it is properly assembled.)

   c. If the water pump is part of the front housing, make sure that it is functional. If the water pump is found to be functional, install it, using new gaskets.

8. Install the harmonic balancer and lower crankshaft pulleys if they are used on the engine. Make sure that the keys are installed in the crankshaft groove. Make sure that the #1 cylinder timing indicator scale and pointer are installed. Also make sure that they give proper readings when the #1 cylinder is at the top dead center position.

9. Turn engine over in the engine fixture. The engine should now be right side up. Install the valve lifters if they are located in the short block.

10. Following the procedure outlined below, install the cylinder head or heads.

    a. Install new gaskets. Make sure that they are installed on the proper side.

       (NOTE: Always use new gaskets.)

       (NOTE: Most gaskets are plainly marked. Most modern gaskets do not require the use of sealers.)

    b. Install the heads and start all of the head bolts.

       (NOTE: All of the head bolts should be clean and lubricated. All of the head bolt holes should be cleaned using a tap. All bolts in holes that go through the block metal into the water jacket should be coated with gasket sealer.)

       (NOTE: Make sure that head bolts of different lengths are put in their proper positions. Start each of the bolts. Turn each bolt one turn into the block. There should be equal distance from the bottom of the bolt head to the surface of the cylinder head. If this distance on any one bolt is more than one inch, make sure that the

hole is deep enough to accept it. If there are large variations in the distances, rearrange the bolts from hole to hole until the distances are nearly the same.)

c. Using the prescribed torquing sequence, torque the head bolts to the prescribed torque. It is advisable to torque the bolts in three cycles, using progressively higher torque values until the final torque value is reached.

11. If the engine uses an overhead cam or dual-overhead cam, install the cams and valve train components. On most overhead cams or dual-overhead cams, adjustment is made at assembly.

JS2-L1-UVII

MODULE: ENGINE REPAIR

COMPLETING THE SHORT BLOCK ASSEMBLY

Equipment:

Common hand tools
Engine pre-oiler
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, pre-oil the engine.

   (NOTE: The pre-oiling process should be done before the intake manifold or crankcase pan are installed.)

   a. Fill the pre-oiler with clean engine oil. Charge the pre-oiler with approximately 45 psi of air pressure.

   b. Using the proper adapters, attach the pre-oiler to the engine's oil pressure sender fitting.

   c. Open the valve to allow the oil to flow to the engine's oil galleries.

   d. Leave the pressure applied while watching the engine carefully.

   e. Oil will begin to drip slowly from the engine. Look for any excessive oil flow.

   f. If oil is observed "running" from the engine, find the leak and correct it.

   g. Make sure that there is oil flowing from each bearing and from the valve lifters. There should also be some oil dripping from the front of the engine if a timing chain is located there.

   h. As soon as oil has reached all of the engine components, turn the valve on the pre-oiler to the off position and disconnect the equipment.

3. Following the procedure outlined below, continue the assembly process.

   a. If a vee engine or other L-head engine is being serviced, install the valve push rods and the rocker arms or rocker shafts.

b. On vee engines, adjust the valve lash at this time.

(NOTE: Adjust the valve lash on each cylinder while that cylinder is at top dead center and on its firing stroke. Some engines have adjusting screws on the rocker arms. Others use selective push rod lengths for adjustment.)

c. Install the intake manifold using new gaskets. Torque all intake manifold bolts to the prescribed torque. A good brand of sealant should be used on the intake manifold gasket. Refer to the appropriate service manual for the recommended brand of sealant.

d. Install ignition system parts. Time the system to fire at top dead center on the compression stroke of the #1 cylinder.

(NOTE: Further information on ignition timing can be found in the engine performance section of this module.)

e. Install the crankcase pan. Make sure that the pickup screen is near the bottom of the pan when the screen is installed.

(NOTE: A small piece of putty or similar material may be used to make the measurement. The position can be adjusted by gently bending the oil pickup tube. Make sure the putty is cleaned out after the measurement is taken.)

f. Carefully assemble the crankcase gaskets. The gaskets can be very vulnerable to leakage. Leakage from the gaskets is difficult to correct after the engine is installed. Lightly torque the pan bolts to prevent them from distorting the pan.

(NOTE: Do not use sealant on rubber gaskets that have positioning tabs. Use a good quality silicon sealant on the joints where two gasket components meet.)

g. Install other pans and covers as required. Make sure that each pan and cover has a new gasket and that proper sealant is used where required.

h. Install the fuel pump and carburetor (if these are used). In some engines where fuel injection is used, there will be no carburetor; nevertheless, fuel system components will need to be installed.

i. Install all engine electrical harnesses and components along with their clamps and plugs. Use the marks and/or pictures that were made during engine disassembly. If the components were not marked during disassembly, use a similar vehicle or a manufacturer's manual for a reassembly guide. Leave the ignition system disconnected at the positive terminal or plug.

j. Install a direct reading oil pressure gauge in the oil pressure sender fitting.

k. Install exhaust manifolds.

JS3-L1-UVII

MODULE: ENGINE REPAIR

INSTALLING AN ENGINE IN A FRONT-WHEEL-DRIVE VEHICLE

Equipment:

Common hand tools
Suitable lifting device for the vehicle
Suitable lifting device for the engine assembly
Suitable work-stand for holding the engine assembly
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for installing the engine assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, install the engine assembly. Record observations.

   (CAUTION: Because engines are very heavy, installing an engine is a very dangerous task. Failure to follow all safety precautions could result in serious injury or death.)

   a. Make sure to fill the crankcase with the prescribed amount of engine oil at the proper point during the installation procedure. Make sure that the dipstick indicates that the crankcase is full.

b. Make sure to fill the power steering system, the transmission, and the cooling system at the proper point during the procedure. Make sure that they are all filled to the proper levels.

JS4-L1-UVII

MODULE: ENGINE REPAIR

INSTALLING AN ENGINE IN A REAR-WHEEL-DRIVE VEHICLE

Equipment:

Common hand tools
Suitable lifting device for the vehicle
Suitable lifting device for the engine assembly
Suitable work-stand for holding the engine assembly
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for installing the engine assembly. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

   Be certain that the instructor approves the procedure and checks this box before continuing.

   Instructor Approved

   Following the procedure, install the engine assembly. Record observations.

   (CAUTION: Because engines are very heavy, installing an engine is a very dangerous task. Failure to follow all safety precautions could result in serious injury or death.)

   a. Make sure to fill the crankcase with the prescribed amount of engine oil at the proper point during the installation procedure. Make sure that the dipstick indicates that the crankcase is full.

   b. Make sure to fill the power steering system, the transmission, and the cooling system at the proper point during the procedure. Make sure that they are all filled to the proper levels.

JS5-L1-UVII

MODULE: ENGINE REPAIR

CHECKING THE ENGINE ASSEMBLY AND STARTING THE ENGINE

Equipment:

EFI pressure gauge
Hand tools
Serviceable vehicle
Special tools as outlined in assignment sheet
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Following the procedure outlined below, spin the engine over using the cranking motor and make inspections.

    a. Watch for an indication of inadequate oil pressure on the oil pressure gauge.

    b. Make sure that cranking is normal and at the normal speed.

    c. Make sure that fuel is being delivered to the engine's fuel system.

    d. Stop cranking and carefully check for fuel, oil, or coolant leaks. Look for evidence of leakage on the shop floor and around each fitting.

3. Run the engine and follow the procedure outlined below.

    a. Connect the ignition system, and crank the engine until it starts.

    b. Check for oil pressure. If no oil pressure is noted in ten seconds, shut the engine down and correct the problem.

    c. Allow the engine to run until the cooling system reaches its normal operating temperature. While the engine is running, keep watching for fuel, oil, or coolant leaks. If any leaks are detected, correct them. Next, restart the engine and make sure that all leaks are corrected and the cooling system has reached its normal operating temperature.

    d. Shut the engine down.

    e. Check and top off all fluid levels.

f. Connect an electronic engine analyzer to the engine and perform final adjustments to the ignition and fuel systems. Refer to Module 3: Engine Performance of the Missouri Auto Mechanics Guide for these procedures.

MODULE: ENGINE REPAIR

UNIT VIII: COOLING SYSTEM DIAGNOSIS AND REPAIR

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose and repair the cooling system. The student will demonstrate mastery of the material by achieving a score of ____ on the unit test and by successfully performing specific tasks.

SPECIFIC OBJECTIVES

After completing the lessons in this unit, the student should be able to:

Lesson 1.

I. Identify cooling system components (Competencies Q2-Q6, Unit VIII Test).

Lesson 2.

I. Identify the procedures for inspecting the coolant and cooling system and making repairs (Competencies Q2 and Q4, Parts I and III of the Unit VIII Test).

II. Identify the procedures for inspecting, replacing, and adjusting drive belts and hoses (Competency Q3, Part II of the Unit VIII Test).

III. Identify the procedures for inspecting coolant and draining, flushing, and refilling the cooling system with recommended coolant (Competency Q5, Part IV of the Unit VIII Test).

IV. Identify the procedures for diagnosing leaks and overheating problems in the cooling system (Competency Q2, Part I of the Unit VIII Test).

V. Demonstrate the ability to:

   a. Test the cooling system and determine needed repairs (Competency Q2, JS1-L2-UVIII).

   b. Repair the cooling system (Competency Q4, JS2-L2-UVIII).

   c. Inspect, adjust, and replace drive belts and hoses (Competency Q3, JS3-L2-UVIII).

   d. Drain, flush, and refill the cooling system (Competency Q5, JS4-L2-UVIII).

MODULE: ENGINE REPAIR

UNIT VIII: COOLING SYSTEM DIAGNOSIS AND REPAIR

CONTENTS OF THIS UNIT

MODULE: ENGINE REPAIR

UNIT VIII: COOLING SYSTEM DIAGNOSIS AND REPAIR

LESSON 1: COOLING SYSTEM CONSTRUCTION

I. Cooling system components

A. The engine coolant absorbs heat while circulating within the engine block and cylinder head. When circulated through the radiator, the coolant releases this heat to the atmosphere.

1. In order for the vehicle to run in a variety of weather conditions, coolant must have a high boiling point and a low freezing point. If the coolant were to boil, it would be unable to absorb heat effectively. If the coolant were to freeze, it would be unable to circulate; the frozen coolant would also expand and destroy portions of the cooling system, heating system, and engine assembly. When mixed with an equal part of clean water, a quality coolant will boil at a temperature above 220 degrees Fahrenheit and freeze at a temperature below -34 degrees Fahrenheit.

2. The coolant must also do the following: resist evaporation; provide lubrication for the water pump and other cooling system components; promote the sealing of leaks in the cooling system; and inhibit the formation of rust and other oxidants in the cooling system.

3. An important cause of cooling system problems is the breakdown of the coolant. As a result of normal use over time, the coolant breaks down and increases its acid content. Eventually the acid content will become high enough to turn the coolant into a viscous “mud,” which can clog the cooling system. The acid will also rust the internal metal components of the cooling system and soften the rubber components.

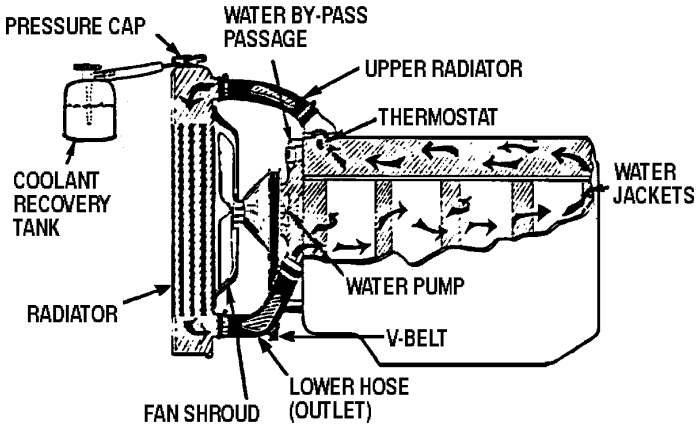
(NOTE: Cooling system overheating often results from depletion of the cooling supply and from the deterioration of the coolant. Overheating can also result from a mass of insects or other debris covering the radiator or air conditioning condenser. Such debris reduces the air flow through the radiator and thus causes overheating. Performing periodic maintenance, washing the insects off the condenser and radiator at least twice a year, and flushing and refilling the system with fresh coolant at least every two years can help prevent overheating indefinitely.)

B. A radiator is a device made of copper or aluminum. The radiator allows air to remove heat from the coolant. As the hot coolant is circulated through the radiator, air moves over the radiator’s thin metal fins, thus lowering the temperature of the coolant.

1. In order to function properly, the radiator must have an unrestricted passage (called the core) to allow the coolant to circulate freely through it. The radiator core can become plugged with scale or other debris The fins can become clogged with insects. Both the inside and the outside of the radiator must be kept clean.

2. The cooling system should be drained, flushed, and refilled with new coolant at least once every two years. In order to ensure proper air flow, keep the radiator and air conditioning condenser free of insects and debris.

C. The cylinder block, along with the cylinder head and head gasket, form the primary collection unit for surplus heat generated within the engine. Passages cast within the block direct coolant around the combustion chambers and to the other parts of the cooling system.



1. The block and/or the cylinder head can become clogged with corrosion and scale, or with mud formed when old coolant breaks down.

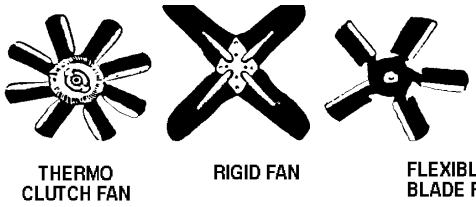
2. Holes in the cylinder head gasket control the circulation of the coolant through the block and head. These holes can corrode open, disrupting the normal pattern of coolant flow and causing “hot spots” to develop in the engine.

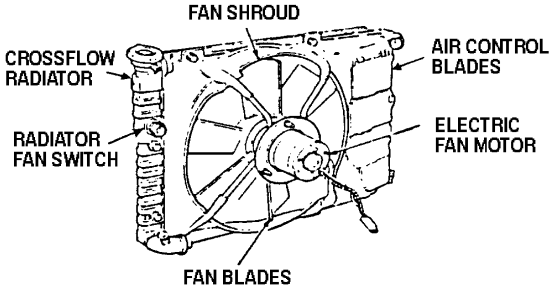
D. The cooling system thermostat is a temperature-operated valve located in the cooling system. The thermostat is used to control the maximum temperature of the coolant by allowing it to circulate through the radiator.

1. The thermostat and its housing are usually located on the front of the engine block near its top.

2. The thermostat controls the temperature of the coolant by controlling the circulation of coolant through the upper radiator hose. The temperature at which this valve opens varies from application to application; often several opening temperatures are available for one application.

3. If the engine overheats for any reason, the temperature-sensing element in the thermostat will likely be destroyed. If overheating occurs, find and correct the cause and replace the thermostat.





(NOTE: Always replace the damaged thermostat with one recommended by the appropriate service manual.)

E. The fan and fan shroud direct air through the radiator at slow vehicle speeds. The fan and shroud help move air over the radiator and air conditioning condenser when the vehicle is stopped or traveling at slow speeds. When the vehicle is moving at highway speeds, sufficient air is moved through the radiator and the fan is not needed. Many vehicles are equipped with either a flex fan, a clutch fan, or an electric fan. These fans run only when necessary and thus save power.

1. Flex fans have blades made of very thin, flexible metal. At low engine speeds, the fan runs normally. At highway engine speeds, the increased air pressure turn the flexible blades, thus reducing the power needed to drive the fan.

2. Clutch fans are connected to their drive pulleys by a fan clutch, which is controlled by a thermostatic spring. The thermostatic spring senses the temperature of the air coming through the radiator. If the air is relatively cool, the clutch disconnects the fan from the pulley. When the air becomes warm, the clutch engages, increasing the air flow through the radiator.

3. Electric fans are driven by a powerful electric motor rather than the engine. These fans are controlled by a thermostatic switch, which is usually located in the lower radiator tank. When the switch senses hot coolant, it actuates the fan motor.

(**CAUTION:** Electric fans are wired “hot” from the electrical system. This means electric fans can come on even when the ignition switch is off. Never work on or near an electric fan unless the battery ground has been disconnected. If the electric fan should come on during a service procedure, the technician could be seriously injured.)

F. The cooling system water pump is a belt-driven device that is responsible for circulating the coolant through the cooling system. The pump is located on the front of the engine and is driven by belts and pulleys.

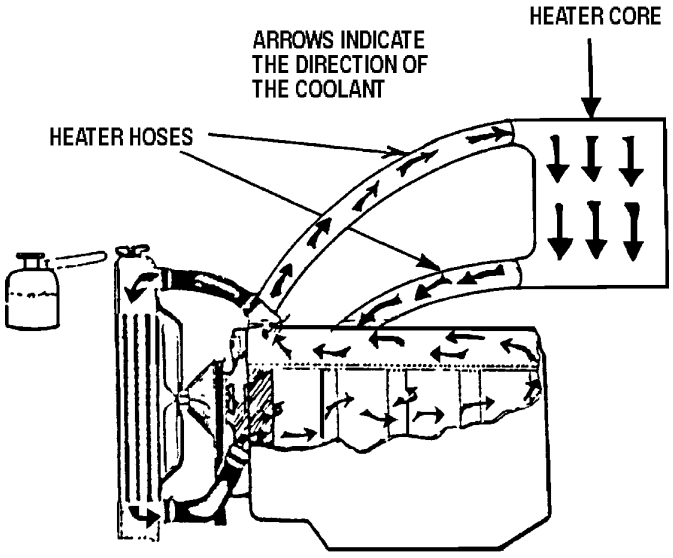
(NOTE: Worn or defective drive belts, poor coolant condition, and leakage at the pump shaft seal are common causes of water pump failure.)

G. The cooling system belts are used to drive the water pump. In many vehicles, the belts drive the fan. Hoses carry the coolant from the water pump to the other parts of the cooling system.

1. Many vehicles use belts to drive accessories such as power steering, air conditioning, and emission control components. In many cases, one belt drives two or more accessories.

(NOTE: The belts require periodic inspection. Inspection is often done when the oil is changed.)

2. At least five rubber hoses are usually required to carry the coolant. One carries coolant from the engine to the radiator (upper hose), another carries coolant from the radiator to the engine (lower hose), two more carry coolant from the cooling system to the heater and back (heater hoses), and another is needed to bypass the thermostat to allow the coolant to actuate its temperature sensor.



(NOTE: For various reasons, some vehicles use more than five hoses.)

(NOTE: All hoses require periodic inspection. This is also commonly done at the oil change interval.)

H. The heater core operates like a small radiator. The heater core allows heat from the coolant to be used to heat the vehicle's passenger compartment. Heater cores require no periodic inspection; however, the core is sensitive to the condition of the coolant and can be plugged or corroded by old coolant. A plugged core will cause the heater to fail. Heater core leaks will appear as wet spots on the right front carpet in the passenger compartment and by excessive fogging of the windshield.

(NOTE: Low coolant level can also cause a heater to perform poorly or fail. In fact, a failed heater is often the first sign of low coolant level.)

MODULE: ENGINE REPAIR

UNIT VIII: COOLING SYSTEM DIAGNOSIS AND REPAIR

LESSON 2: COOLING SYSTEM DIAGNOSIS AND REPAIR

I. Inspecting the coolant and the cooling system

A. Procedure for inspecting the coolant

(**CAUTION:** Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding-hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

(NOTE: The first test in determining the general condition of the cooling system is to inspect the coolant itself.)

1. Check the coolant's condition.

a. The coolant should have a good color and yet be clear (i.e., not clouded by contamination). The coolant should feel slippery.

b. If the coolant looks cloudy, is a dark or rusty color, is foamy, or feels gritty or sticky, it should be replaced immediately.

(NOTE: If the coolant is more than two-years old, replace it no matter what its condition.)

2. Check the coolant's strength.

a. Using a coolant hydrometer, determine the coolant's freezing point. The coolant's freezing point should be about 35 degrees below zero Fahrenheit. A freezing point of 34 degrees below zero is about lowest that can be achieved in most conventional vehicles. Do not add coolant to try to bring the freezing point lower than 34 degrees below zero.

b. Some hydrometers have a built-in acid detector. If the hydrometer being used is equipped with an acid detector, use it to check the coolant's acidity. If the hydrometer has no detector, use litmus paper to check the acidity of the coolant.

B. Procedure for checking the cooling system

1. Following the procedure below, check the cooling system for leaks.

a. Connect a cooling system pressure tester to the radiator filler neck, and pump it up to the release pressure marked on the cap.

(NOTE: The pressure tester can also be used to test the cap.)

b. Leave the tester connected and watch for leaks.

c. Do not forget to check for signs of heater core leaks on the ground or floor under the engine and on the right front carpet in the passenger compartment.

d. Check for leaks at the water pump.

e. Check for leaks at points where hoses connect to metal components.

f. Look for hoses that have expanded in a balloon-like fashion.

2. Following the procedure below, check the circulation within the cooling system.

a. Take off the radiator cap and look down the radiator neck while the engine is running.

(**CAUTION:** Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding-hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

b. As the engine reaches its normal operating temperature, the thermostat will open and coolant can be observed circulating through the tank.

c. If coolant overflows the tank, the radiator core may be plugged.

d. Sometimes the circulation can be felt through the upper hose when the engine is “gunned” while the thermostat is open.

3. Following the procedure outlined below, inspect the water pump

a. Pressure test the cooling system

b. Check for leaks at the pump drive shaft (where the pulley is connected). If any sign of leakage is found, the pump will have to be replaced.

c. Remove drive belt tension from the pump pulley.

d. Test the shaft for play. If play is noted, the pump will have to be replaced.

e. Test the shaft for roughness of rotation. If roughness is noted, the pump will have to be replaced.

4. Following the procedure outlined below, replace the water pump.

(NOTE: Procedures for replacing the water pump vary significantly from vehicle to vehicle. Consult the appropriate repair manual to obtain the correct procedures. Listed below are several tasks that should be performed when replacing any pump.)

a. Before installing the new pump, always compare it with the old pump. (For example, make sure that bolt patterns and drive shaft lengths are the same.)

b. Drain as much coolant as possible before removing the pump.

c. Use gasket sealers to help hold gaskets in place during assembly.

d. After pump installation, pressure test the system to make sure there are no leaks.

5. Following the procedure outline below, inspect the radiator.

a. Pressure test the cooling system and radiator cap and look for signs of leaks at the radiator (e.g., tank or cooling fins and tubes).

b. Look in the radiator tank and inspect the coolant passages. If the passages appear to be restricted, the radiator may need to be removed and taken to a radiator shop to be rodded out.

c. Inspect the condition of the cooling tubes and fins. They should be clear and free of debris so that air can pass through the radiator.

6. Following the procedure outline below, remove and replace the radiator.

(NOTE: Radiator repair is usually considered a specialty. The below procedure deals only with radiator removal and repair.)

a. Release cooling system pressure and drain coolant.

b. On vehicles equipped with automatic transmissions, remove automatic transmission cooler hoses and plug the ends.

c. Remove the shroud.

d. Remove cooling system hoses.

e. Remove mounting brackets.

f. Reverse the procedure for replacement of the radiator.

7. Following the procedure below, check direct-drive fan if the vehicle is so equipped.

(**CAUTION:** Engine fans are very dangerous. Be sure to keep hands away from fan during operation. Disconnect the negative battery cable when inspecting and servicing a direct-drive fan. Of course, the negative battery cable will have to be connected when observing fan operation.)

a. Make sure the fan runs quietly. Fans should make no growling or grinding noises.

b. Make sure the fan spins without noticeable wobble.

c. There should be no more than 3/8 of an inch play in the fan.

d. If any problems are found, consult the appropriate manual for repair procedures.

8. Following the procedure below, check clutch-operated or hydraulically operated fan if the vehicle is so equipped.

(**CAUTION:** Engine fans are very dangerous. Make sure to keep hands away from fan during operation. Disconnect the negative battery cable when inspecting and servicing a fan. Of course, the negative battery cable will have to be connected when observing fan operation.)

a. Make sure the fan runs quietly. Fans should not make growling or grinding noises.

b. The fans should spin without noticeable wobble.

c. There should be no more than 3/8 of an inch play in the fan.

d. Check for signs of oil leaking from the clutch assembly.

e. The technician should be able to spin clutch-operated fans freely when the clutch is cold. It should be harder to turn the fan when the clutch is warm.

f. If any problems are found, consult the appropriate manual for repair procedures.

9. Following the procedure below, check electric radiator fans if the vehicle is so equipped.

(**CAUTION:** Electric radiator fans can come on without warning. Make sure the fan is disconnected and the negative battery cable is disconnected before inspecting, servicing or working close to electric fans. The fan and battery must, of course, be connected when observing the operation of the electric fan.)

a. Make sure the fan runs quietly. Fans should make no growling or grinding noises.

b. Disconnect fan and negative battery cable.

c. Make sure the fan spins without noticeable wobble.

d. There should be no more than 3/8 of an inch play in the fan.

e. Following the procedure outlined in the appropriate repair manual, energize the fan and observe operation of the unit.

f. Following the procedure outlined in the appropriate repair manual, check the sensors and controls that operate the fan.

II. Inspecting, replacing, and adjusting drive belts and hoses

(NOTE: Common hand tools can be used to replace or repair almost all cooling system components. Be sure to replace each component with the proper replacement part. In many cases, parts such as the radiator or heater core can be repaired at a radiator shop and re-used.)

(NOTE: When replacing cooling system components, always refer to the appropriate service manual. Some components may be difficult to access or require special replacement procedures.)

A. Following the procedure below, inspect the belts.

1. Carefully check all the drive belts for excessive wear or fraying, shiny pulley grooves (which indicate slippage), and looseness.

2. Replace all damaged or worn belts. If the condition of a belt is questionable, replace it.

(NOTE: Belts that are used in pairs should be replaced in pairs.)

B. Following the procedure below, inspect the hoses.

1. Check all hoses for the following problems: damage or chaffing; deep cuts at the clamps; excessive softness, hardness, and brittleness; and swollen areas.

2. Check the flexibility of the hoses. Bend each hose sharply; they should not break.

3. Make sure that no hoses have been saturated with engine oil or other fluids.

4. Replace all hoses that show damage or deterioration.

5. Make sure that the lower radiator hose contains a spring. The spring prevents the hose from being sucked shut by the water pump. This spring can sometimes be left out when the hose is replaced.

(NOTE: Some manufacturers recommend that all hoses be replaced periodically. Check the appropriate service manual for the vehicle to be serviced.)

III. Procedures for inspecting coolant and draining, flushing, and refilling the cooling system with recommended coolant

A. Inspect the coolant as directed above.

B. If the cooling system has overheated, replace the thermostat. Determine and correct the cause of the overheating. If there is any doubt about the condition of the radiator and heater core, remove them and have them cleaned.

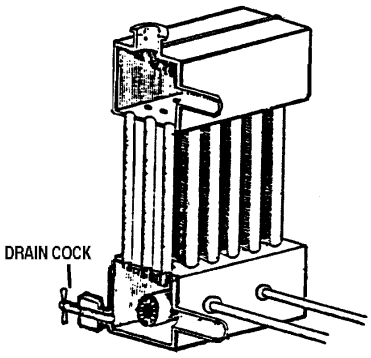
(**CAUTION:** Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding-hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

C. Inspect the system and replace hoses and belts as needed.

D. Following the procedure outlined below, drain, flush, and refill the cooling system.

(**CAUTION:** Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

1. Remove the radiator cap. Make sure the drain cock, located on the bottom radiator tank, can open freely.



(NOTE: Most drain cocks have left-hand threads. These drain cocks screw in rather than out to drain.)

2. Remove the thermostat.

3. Run the engine at idle until the system reaches its normal operating temperature.

4. Shut the engine down and open the drain, allowing the coolant to drain completely from the radiator.

(NOTE: Used coolant is classified as toxic waste and must be disposed of according to law.)

5. Remove one of the heater hoses and connect a supply of fresh water to the hose end that leads into the heater.

6. Allow the system to fill. When the system is full, start the engine and allow it to idle.

7. Adjust the water flow so that the radiator stays full while the drain is running wide open. Keep the engine and the fresh water running until the discharge fluid runs clear.

8. Shut the engine down. Let the drain run until it stops; then close the drain cock. Re-install or replace the thermostat and reconnect the heater hose.

9. Determine the capacity of the cooling system by using a manual or chart.

10. Determine the coolant capacity of the cooling system. Measure out coolant at half this capacity and add this to the radiator. Pour the coolant down the radiator filler neck.

11. Continue to fill the radiator with clean fresh water.

12. When the radiator is full, start the engine and allow it to reach normal operating temperature. The coolant should start to circulate and the upper radiator tank should become warm.

13. If the cooling system appears to be working properly, top off the radiator tank with clean water and replace the cap.

    (NOTE: Chemical cleaners are available to help clean a dirty system. These chemicals circulate through the system and remove dirt and debris. When using these cleaners, follow directions on the package.)

IV. Leaks and overheating in the cooling system

A. Leaks in the cooling system

1. Internal leaks will almost always contaminate the engine oil. If the engine oil is found to be contaminated, the problem is either a leaking head gasket or a cracked cylinder head or engine block. Occasionally, the transmission oil cooler can leak, causing the transmission fluid to be contaminated with coolant and the coolant to be contaminated with transmission fluid.

2. External leaks are relatively easy to detect. When pressure is applied to the system, all leaks should become apparent. Leaks at hoses can usually be stopped by tightening the clamp. When components, such as the water pump, develop leaks, they must usually be replaced. A leaky radiator or heater core can often be repaired by a radiator shop.

B. Diagnosing overheating problems

1. If the engine overheats, the cooling system has, in some way, failed to remove sufficient heat to prevent the coolant from boiling.

   (**CAUTION:** During overheating, temperatures within a cooling system can exceed 400 degrees Fahrenheit and pressures can exceed 25 psi. If the radiator cap is removed when the system is overheating, extremely hot coolant will spew out of the system with considerable force. Do not attempt to remove the cap from a hot cooling system. Wait until the system has cooled. Failure to do this may result in serious injury.)

2. Look for obvious causes of leakage such as disconnected or torn hoses and split radiator tanks. Also look for stains that may indicate leakage.

3. If no leaks can be found, remove the thermostat and check the thermostat housing.

4. Using a cooling system pressure tester, apply pressure to the system.

5. Leave the pressure on the system for at least thirty minutes. Look for visible leaks in the system. Also watch for a decrease in system pressure.

6. If the system loses pressure but no external leak can be found, check for signs of an internal leak. Engine oil contamination is a significant indication of internal coolant system leakage.

7. Correct any external leaks as they are found. Continue to pressure test the system until it holds pressure and all the external leaks are eliminated.

8. Now, with the system full of clean water and the radiator cap off, start the engine and watch for circulation.

9. Keep a close watch on the system as it warms. If coolant overflows through the radiator filler neck or if the engine starts to overheat, shut the engine down, remove the radiator, and send it in for cleaning.

10. If the system seems to circulate normally and keeps a fairly steady temperature, flush the system, install a new thermostat, and fill the system with a fresh coolant mixture.

JS1-L2-UVIII

MODULE: ENGINE REPAIR

TESTING THE COOLING SYSTEM AND DETERMINING NEEDED REPAIRS

Equipment:

Common hand tools
Cooling system pressure tester
Safety glasses

Procedure:

(NOTE: Students will usually have the opportunity to inspect only one type of radiator fan. When making the final evaluation, do not figure job sheet items that involve types of fans which the students will not service.)

1. Wear safety glasses while doing all procedures on this job sheet.

2. Check the coolant's condition. Describe the coolant's color in the space below. Also note whether the coolant feels slippery. Indicate if the coolant needs to be changed.

   (CAUTION: Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

   (NOTE: If the coolant is more than two years old, replace it no matter what its condition.)

3. Using a coolant hydrometer, determine the coolant's freezing point and record the results below.

4. Following the procedure below, check the cooling system for leaks.

   a. Connect a cooling system pressure tester to the radiator filler neck. Pump the pressure tester until the pressure reaches the release pressure marked on the cap.

      (NOTE: The pressure tester can also be used to test the cap.)

   b. Leave the tester connected and watch for leaks. Record observations and suggest repair procedures.

c. Check for signs of heater core leaks on the ground or floor under the engine and on the right front carpet in the passenger compartment. Record observations and suggest repair procedures.

5. Following the procedure below, check the circulation within the system.

a. Take off the radiator cap and look down the radiator neck while the engine is running.

(CAUTION: Never remove a radiator cap unless the engine is sufficiently coo. Removing the radiator cap when the engine is hot can cause scalding hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

b. As the engine reaches its normal operating temperature, the thermostat will open and coolant can be observed circulating through the tank. If coolant overflows the tank, the radiator core may be plugged. Record observations.

c. If circulation is poor, check thermostat. Record observations.

(NOTE: Sometimes the circulation can be felt through the upper hose when the engine is "gunned" while the thermostat is open.)

6. Pressure test the cooling system. While pressure is applied, inspect the cooling system components for leaks. Record observations and suggest repairs.

7. Following the procedure outlined below, inspect the water pump.

a. Pressure test the cooling system. Record observations.

b. Check for leaks at the pump drive shaft (where the pulley is connected). If any sign of leakage is found, the pump will have to be replaced. Record observations.

c. Remove drive belt tension from the pump pulley. Record observations.

d. Test the shaft for play. If play is noted, the pump will have to be replaced. Record observations.

e. Test the shaft for roughness of rotation. If roughness is noted, the pump will have to be replaced. Record observations.

8. Following the procedure outlined below, inspect the radiator.

a. Pressure test the cooling system and radiator cap and look for signs of leaks at the radiator (e.g., tank or cooling fins and tubes). Record observations.

b. Look in the radiator tank and inspect the coolant passages. If the passages appear to be restricted, the radiator may need to be removed and taken to a radiator shop to be rodded out. Record observations. Indicate if the radiator needs to be taken to a radiator repair shop.

c. Inspect the condition of the cooling tubes and fins. They should be clear and free of bugs and debris so that air can pass through the radiator. Record observations.

9. Following the procedure below, check direct-drive fan if the vehicle is so equipped.

   (CAUTION: Radiator fans are very dangerous. Be sure to keep hands away from fan during operation. Disconnect the negative battery cable when inspecting and servicing a direct-drive fan. Of course, the negative battery cable will have to be connected when observing fan operation.)

   a. Make sure the fan runs quietly. Fans should make no growling or grinding noises. Record observations.

   b. Make sure the fan spins without noticeable wobble. Record observations.

   c. Make sure there is no more than 3/8 of an inch of play in the fan. Record observations.

   d. If any problems are found, suggest repairs.

10. Following the procedure below, check clutch-operated or hydraulically operated fan if the vehicle is so equipped.

    (CAUTION: Engine fans are very dangerous. Make sure to keep hands away from fan during operation. Disconnect the negative battery cable when inspecting and servicing a fan. Of course, the negative battery cable will have to be connected when observing fan operation.)

    a. Make sure the fan runs quietly. Fans should make no growling or grinding noises. Record observations.

b. The fans should spin without noticeable wobble. Record observations.

c. Make sure there is no more than 3/8 of an inch of play in the fan. Record observations.

d. Check for signs of oil leaking from the clutch assembly. Record observations.

e. After making sure the negative battery cable is disconnected, attempt to spin the fan. The clutch-operated fan should spin freely when the clutch is cold. It should be harder to turn the fan when the clutch is warm. Record observations.

f. If any problems are found, suggest repairs.

11. Following the procedure below, check electric radiator fan if the vehicle is so equipped.

(CAUTION: Electric radiator fans can come on without warning. Make sure the fan is disconnected and the negative battery cable is disconnected before inspecting, servicing, or working close to an electric fan. The fan and battery must, of course, be connected when observing the operation of the electric fan.)

a. Make sure the fan runs quietly. Fans should make no growling or grinding noises. Record observations.

b. Disconnect fan and negative battery cable.

c. Make sure the fan spins without noticeable wobble. Record observations.

d. There should be no more than 3/8 of an inch of play in the fan. Record observations.

e. Using a service manual or other information source, locate a procedure for energizing the fan. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, energize the fan and observe operation of the unit. Record observations.

f. Using a manual or other information source, locate a procedure for checking the sensors and controls that operate the fan. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Following the procedure, check the sensors and controls that operate the fan. Record observations.

12. Following the procedure outlined below, diagnose overheating problems.

(CAUTION: During overheating, temperatures within a cooling system can exceed 400 degrees Fahrenheit and pressures can exceed 25 psi. If the radiator cap is removed when the system is overheating, extremely hot coolant will spew out of the system with considerable force. Do not attempt to remove the cap from a hot cooling system. Wait until the system has cooled. Failure to do this may result in serious injury.)

a. Look for obvious causes of leakage such as disconnected or torn hoses and split radiator tanks. Also look for stains that may indicate leakage. Record observations.

b. Using a cooling system pressure tester, apply pressure to the system.

c. Leave the pressure on the system for at least thirty minutes. Look for visible leaks in the system. Also watch for a decrease in system pressure. Record observations.

d. If the system loses pressure but no external leak can be found, check for signs of an internal leak. Engine oil contamination is a significant indication of internal coolant system leakage. Record observations and recommend repairs.

e. Correct any external leaks as they are found. Continue to pressure test the system until it holds pressure and all the external leaks are eliminated.

f With the system full of clean water and the radiator cap off, start the engine and watch for circulation. Record observations.

g. Keep a close watch on the system as it warms. If coolant over flows through the radiator filler neck or if the engine starts to overheat, shut the engine down, remove the radiator, and send it in for cleaning. Record observations.

h. If the system seems to circulate normally and keeps a fairly steady temperature, then the thermostat and housing may have to be replaced.

JS2-L2-UVIII

MODULE: ENGINE REPAIR

REPAIRING THE COOLING SYSTEM

Equipment:

Common hand tools
Safety glasses

Procedure:

(NOTE: Students will usually have the opportunity to repair only one type of radiator fan. When making the final evaluation, do not figure job sheet items that involve types of fans which the students will not service.)

1. Wear safety glasses while doing all procedures on this job sheet.

2. Using a service manual or other information source, locate a procedure for replacing the water pump. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ **Instructor Approved**

Following the procedure, replace the water pump. Record observations.

(NOTE: Procedures for replacing the water pump vary significantly from vehicle to vehicle. Consult the appropriate repair manual to obtain the correct procedures. Listed below are several tasks that should be performed when replacing any pump.)

a. Before installing the new pump, always compare it with the old pump. (For example, make sure that bolt patterns and drive shaft lengths are the same.)

b. Drain as much coolant as possible before removing the pump.

c. Use gasket sealers to help hold gaskets in place during assembly.

3. Following the procedure outlined below, remove and replace the radiator.

(NOTE: Radiator repair is usually considered to be a specialty. The below procedure deals only with radiator removal and repair.)

a. Release cooling system pressure and drain coolant.

b. On vehicles equipped with automatic transmissions, remove automatic transmission cooler hoses and plug the ends.

c. Remove the shroud.

d. Remove cooling system hoses.

e. Remove mounting brackets.

f. Reverse the procedure for replacement of the radiator.

4. Using a service manual or other information source, locate a procedure for repairing or replacing a direct drive fan. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the proce dure.

Be certain that the instructor approves the procedure and checks this box before continuing.

Instructor Approved

Follow the procedure and repair or replace the direct drive fan on the vehicle. Record observations.

5. Using a service manual or other information source, locate a procedure for repairing or replacing a clutch operated or hydraulically operated fan. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, repair or replace a clutch operated or hydraulically operated fan. Record observations.

6. Using a service manual or other information source, locate a procedure for replacing the controls and sensors that operate the electric radiator fan. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, replace the controls and sensors that operate the electric radiator fan. Record observations.

7. Using a service manual or other information source, locate a procedure for replacing the thermostat. Make sure the procedure is appropriate for the make and model of the vehicle to be serviced. Submit the procedure to the instructor. Have the instructor initial the space below to indicate his or her approval of the procedure.

Be certain that the instructor approves the procedure and checks this box before continuing.

☐ Instructor Approved

Following the procedure, replace the thermostat.

JS3-L2-UVIII

MODULE: ENGINE REPAIR

INSPECTING, ADJUSTING, AND REPLACING DRIVE BELTS AND HOSES

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

   (NOTE: Common hand tools can be used to replace or repair almost all cooling system components. Be sure to replace each component with the proper replacement part. In many cases parts such as the radiator or heater core can be repaired at a radiator shop and re-used.)

   (NOTE: When replacing cooling system components, always refer to the appropriate service manual. Some components may be difficult to access or require special replacement procedures.)

2. Following the procedure below, inspect the belts.

   a. Carefully check all the drive belts for excessive wear or fraying, shiny pulley grooves (which indicate slippage), and looseness. Be sure to check those not related to the cooling system, such as the alternator belt. Check belts against manufacturer's specifications. Record observations.

   b. Replace all damaged or worn belts (even those not related to the cooling system, such as the alternator belt). If the condition of a belt is questionable, replace it. Record observations.

      (NOTE: Belts that are used in pairs should be replaced in pairs.)

3. Following the procedure below, inspect the hoses.

a. Check all hoses for the following problems: damage or chaffing; deep cuts at the clamps; excessive softness, hardness, and brittleness; and swollen areas. Record observations.

b. Check the flexibility of the hoses. Bend each hose sharply; they should not break. Record observations.

c. Make sure that the hoses have not been saturated with engine oil or other fluids.

d. Replace all hoses that show damage or deterioration.

e. Make sure that the lower radiator hose contains a spring. The spring prevents the hose from being sucked shut by the water pump. This spring can sometimes be left out when the hose is replaced.

(NOTE: Some manufacturers recommend that all hoses be replaced periodically. Check the appropriate service manual for the vehicle to be serviced.)

JS4-L2-UVIII

MODULE: ENGINE REPAIR

DRAINING, FLUSHING, AND REFILLING THE COOLING SYSTEM

Equipment:

Common hand tools
Safety glasses

Procedure:

1. Wear safety glasses while doing all procedures on this job sheet.

2. Check the coolant's condition. Describe the coolant's color in the space below. Also note whether the coolant feels slippery. Indicate if the coolant needs to be changed.

   (CAUTION: Never remove a radiator cap unless the engine is sufficiently cool. Removing the radiator cap when the engine is hot can cause scalding hot coolant to be sprayed over a wide area, resulting in serious injury to the technician.)

   (NOTE: If the coolant is more than two years old, replace it no matter what its condition.)

3. Following the procedure outlined below, drain, flush, and refill the cooling system.

   a. Remove the radiator cap. Make sure the drain cock, located on the bottom radiator tank, can open freely.

   b. Remove the thermostat.

   c. Run the engine at idle until the system reaches its normal operating temperature.

   d. Shut the engine down and open the drain, allowing the coolant to drain completely from the radiator.

      (NOTE: Used coolant is classified as toxic waste and must be disposed of according to the law.)

4. Following the procedure outlined below, flush and refill the cooling system.

   (NOTE: Chemical cleaners are available to help clean out dirty systems by circulating through the systems. When using these cleaners, follow directions on the package.)

a. Remove one of the heater hoses and connect a supply of fresh water to the hose end that leads into the heater.

b. Allow the system to fill. When the system is full, start the engine and allow it to idle.

c. Adjust the water flow so that the radiator stays full while the drain is running wide open. Keep the engine and the fresh water running until the drain runs clear.

d. Shut the engine down. Let the drain run until it stops; then close the drain. Re-install or replace the thermostat and reconnect the heater hose.

e. Determine the capacity of the cooling system by using a manual or chart.

f. Determine the coolant capacity of the cooling system. Measure out coolant at half this capacity and add this to the radiator. Pour the coolant down the radiator filler neck.

g. Continue to fill the radiator with clean fresh water.

h. When the radiator is full, start the engine and allow it to reach normal operating temperature. The coolant should start to circulate and the upper radiator tank should become warm.

i. If the cooling system appears to be working properly, top off the radiator tank with clean water and replace the cap.