Automotive Mechanics

Level-III

Based on October 2023, Curriculum Version II

Module Title: Engine Tune up

Module Code: EIS AUM3 M02 1023

Nominal Duration: 80 Hours

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Table of Contents

Acronyms

BTDC	Before Top Dead Center
CO	Carbon monoxide
DTC	Diagnostic Trouble Codes
ECM	Electronic control Module
EEC	Engine Control System
EGR	Exhaust Gas Recirculation
HC	Hydro Carbon
Hg	Helium
Kpa.	Kilo Pascal
OEM	Original Equipment Module
OHC	Overhead-Camshaft
OHV	Over Head Valve
PCV	Positive Crankcase Ventilation
PSI	Per square inch
RPM	Revolution per minute
SOHC	Single Overhead Camshaft
TDC	Top Dead Center
TDC	Top Dead Center
VIN	Vehicle Identification Number

Acknowledgment

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Introduction to Module

In Automotive industry *Engine Tune-up* is one of imperative chore the mechanic undertaking during servicing. This module contain to performing tune up in diesel and gasoline engine.

This module is designed to meet the industry requirement under the Automotive Mechanics level III occupational standard, particularly for the unit of competency: Engine Tune-up

This module covers the units:

- Introduction to Engine Tune-up
- Diagnosing Engine Faults
- Rectifying Engine Faults

Learning Objective of the Module

- Introduction to Engine Tune-up
- Diagnose Engine Faults
- Rectify Engine Faults

Module Instruction

For effective use these modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit.
2. Accomplish the Self-checks at the end of each unit.
3. Perform Operation Sheets which were provided at the end of units.
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise.

Unit one: Introduction to Engine Tune-up

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Purpose of Engine Tune-up
- Troubleshooting Principles
- Engine Tune-up Tools and Equipment
- Engine Pre-tuning Requirements
- Typical Tune-up Procedure

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Understand Purpose of Engine Tune-up
- Familiar with Troubleshooting Principles
- Identify Engine Tune-up Tools and Equipment
- Identify Engine Pre-tuning Requirements
- Follow Typical Tune-up Procedure

1.1 Purpose of Engine Tune-up

"Tune-up" means checking all phases of engine operation and making any adjustments, repairs and replacements required for the engine auxiliaries and accessories to conform to the car manufacturers' specifications.

Tuning an engine does not mean rebuilding or performing repair operations on the engine itself even though these may be required. However checkup operations which are a part of every tune-up job may reveal serious engine defects which require corrective measures. It is as essential to check engine operation after adjustments are made as it is to test before doing corrective work.

The only assurance of a corrective adjustment is a double check after work has been completed. Trying to tune on engine that has poor bearings, rings, pistons or valves is difficult if not impossible. Tune-up as it will be used here means re-establishing original factory specifications as nearly as possible. An automotive tune-up is an orderly process of inspection, diagnosis, testing, and adjustment that is periodically necessary to maintain peak engine performance or restore the engine to original operating efficiency.

The three fundamental divisions of tune-up procedure can also be considered as:

1. The engine
2. Electrical system
3. The fuel system

These three designations cover the same items as the terms compression, ignition and carburetion. The tune-up man must first detect the faulty parts and units whose deterioration is affecting the proper functioning of the engine. He must then report engine faults and correct defects of auxiliary units by adjustment, repair, or replacement, restoring the units as near to their original condition as possible.

Diagnosis of the engine and its auxiliary systems is an important element of tune-up, since without knowing what is needed; it is difficult to know what should be done.

A good tune-up job, therefore, consists of two parts.

1. Diagnosis, analysis or troubleshooting
2. Correction, which may be adjustment, replacement or repair

1.2 Troubleshooting Principles

The following sections are a method, or checklist, to help you troubleshoot engine performance problems.

1. Ask the Driver

Even if an owner brings you a car for routine maintenance (change oil, filters, spark plugs, and so on), he or she may have a general complaint about performance or a vague idea that, "It's not running the way it should."

- Ask the driver about specific problems.
- Also ask about overall performance. Even a general answer such as,
- "Well, sometimes it's hard to start," or
- "Mileage isn't too good," can be a helpful clue for your testing.

If the car has a specific problem, it's helpful to talk to the person who was driving when it occurred. Ask questions such as:

- Does the problem occur at specific times or temperatures – idle, cruising, acceleration, at night with heavy electrical loads, cold starting, hot starting, or any combination?
- Does the problem occur regularly or at random?
- What are all the symptoms – noises, smells, vibrations, or combination of signs?
- Has the problem occurred before and what was done to fix it?
- When was the car last serviced, and what was done then?

Many large shops have service writers who prepare work orders and get information from customers. If you can't talk to the owner directly, read the work order carefully and ask the service writer for details.

2. Ask the Car

Equally important, drive the car and check performance for yourself. The owner may complain about a rough idle and never notice the mushy automatic transmission shifting and slight high – speed surge caused by the same vacuum leak. Combined clues that lead to a single cause can save you time. Also, by driving the car to analyze the owner's comments, you will get an idea of what the owner expects in the way of drivability. A "hard – starting" problem may occur because the driver does not follow specific starting instructions for the vehicle.

You may operate the car immediately or later during your testing. You may have to let it cool down to check a cold – engine problem. When you do drive it, observe the symptom carefully to be sure when it does occur and when it doesn't.

If the problem is a "rough idle," does it happen with the engine hot or cold, or both?

Does it happen with the air conditioner on or off, or both?

Does the car overheat?

Does it smoke?

Are there other related symptoms?

3. Know the Car, Know the Specifications

Before you start troubleshooting, be sure you know what you are working on. That sounds simple, but the same type of vehicle can have different engines. It can have different transmissions. It may or may not have air conditioning. It may be designed for different countries with specific differences.

Start to identify the car by checking the vehicle identification number on the VIN plate. Then check the engine "emission control" decal for basic specifications, such as timing, idle speed, and spark plug gap. The engine decal also has summary instructions for idle and timing adjustments and, along with other calibration labels, will identify a car with running changes made during the model year.

The VIN and engine decals will lead you to detailed specifications and procedures in reference manuals. You also may need electrical and vacuum diagrams. Look them up, using the VIN and engine decal numbers. Most cars have a decal under the hood that shows engine vacuum hose connections.

4. Identify the Possible Causes and Cures

You actually start this step when you learn the owner's complaint, and you continue identifying and eliminating causes until you finish the job. Make a list, in your head or on paper, of the symptoms and possible causes. Then check the possibilities one at a time. Begin with the simplest. Don't condemn an alternator for a low – voltage problem without checking for a loose drive belt first.

5. Test from the General to the Specific

Testing is a process of elimination. If you immediately look for the cause of a rough idle in the ignition system, you eliminate other possible causes in the fuel and emission systems without checking them. To isolate a problem accurately, you must begin by checking general engine condition and performance. Then, test each system – fuel, electrical, emission – for overall operation. Finally, check individual components.

Start by general tests of overall system operation which are also called area tests. These tests allow you to narrow down the cause of a problem. Detailed, or pinpoint tests, then allow you to isolate a bad component. Carmakers follow the same principle with their test procedures.

6. Know the System, Isolate the Problem

Suppose the driver's complaint is a rough acceleration when cold, and you're testing shows that the exhaust gas recirculation (EGR) valve is opening when it should not. You then must ask yourself, "Why?" Is vacuum to the valve controlled by a coolant temperature vacuum valve or by a solenoid? If a solenoid is used, how is it switched, by a coolant switch or an engine computer? Is the EGR valve broken and stuck open? To isolate the problem, you must know what parts are in the system and how they work. This is another way to identify possible causes. The EGR valve may open at the wrong time because of:

- A mechanical problem – broken valve
- A wrong electric signal to a solenoid
- A broken coolant temperature sensor
- A cooling system problem – over – heating
- Incorrect vacuum hose connections

7. Test Logically and Systematically

Now that you have isolated the problem to one system, you can use vacuum diagrams to determine hose connections and vacuum sources. Use electrical diagrams to determine the power source, the ground connection, and how a solenoid is energized. You can determine when vacuum should and should not be present at the valve and when a solenoid should be energized and de-energized. If engine roughness occurs only on cold acceleration, the problem probably is not a bad EGR valve.

If the valve were stuck open, performance also would suffer at hot and cold idle and at full throttle. If you find vacuum at the valve as you accelerate a cold engine, you must check the vacuum control devices. If a solenoid is energized to open a vacuum valve, check for voltage at the solenoid. If voltage is not present, but the solenoid valve is open, you probably have a bad solenoid. If voltage is present when it should not be, you must check the electrical circuit. Check the electrical diagram and manufacturer's test procedures to trace voltage to the source.

8. Double-check Your Test Results

Suppose your tests in step 7 seem to show that a vacuum solenoid is permanently grounded and energized. The specific cause could be:

- A ground inside the solenoid
- A grounded wire between the switch and the solenoid
- A defective switch
- An overheating engine that closes the switch too soon

Disconnect the switch wire, first at the solenoid and then at the switch, to see if the solenoid stays energized. Check for voltage and short circuits to ground at the solenoid, in the wire, and at the switch. Check the switch itself to see if it is closing when it should not.

The important principle, whether you are testing electrical, vacuum, hydraulic, or mechanical systems, is to test systematically from one point to another and double-check your results before making repairs. You often work with several systems – vacuum and electrical, for example – to isolate a problem. The symptom may come from a vacuum component, but the final cause may be an electrical fault.

9. Repair and Retest

Suppose your results in steps 7 and 8 show that the coolant switch is bad. Replace the switch and reconnect and check all vacuum and electrical connections in the system. Then, retest the complete system. Be sure the EGR valve opens only when it should and that the switch and solenoid work properly.

Most importantly, be sure you have cured the original "roughness on cold acceleration" problem. You may have replaced one bad part and eliminated a problem in one system. But if you haven't corrected the owner's original complaint, you haven't finished the job. If the roughness still exists, there is another problem, or problems, in another system that you must find and fix, using these same steps.

1.2.1 Gasoline Engine Trouble Diagnosis Chart

Table1: 1 Gasoline Trouble diagnosis Chart

Complaint	Possible Cause	Check or Correction
Engine will not crank	▪ Run-down battery ▪ Starting circuit open ▪ Starting-motor drive jammed ▪ Starting motor jammed ▪ Engine jammed ▪ Transmission not in neutral or neutral switch out of adjustment. ▪ Seat belt not fastened or interlock faulty ▪ See also causes listed under item 3; driver may have run battery down trying to start.	▪ Recharge or replace battery; start engine with jumper battery and cables. ▪ Find and eliminate the open; check for dirty or loose cables. ▪ Remove starting motor and free drive ▪ Remove starting motor for disassembly and repair. ▪ Check engine to find trouble. ▪ Check and adjust neutral switch if necessary ▪ Check interlock.
Engine cranks slowly but will not start	▪ Partly discharged battery ▪ Defective starting motor ▪ Bad connections in starting circuit	▪ Recharge or replace battery; start engine with jumper battery and cables. ▪ Repair or replace ▪ Check for undersize, loose, or dirty cables; replace or clean and tighten.
Engine cranks at normal speed but will not start	▪ Defective ignition system ▪ Defective fuel pump or over-choking ▪ Air leaks in intake manifold or carburetor ▪ Defect in engine ▪ Ignition coil or resistor burned out ▪ Plugged fuel filter	▪ Try spark test; check timing, ignition system ▪ Prime engine, check accelerator pump discharge, fuel line, choke, carburetor ▪ Tighten mounting; replace gaskets as needed

Complaint	Possible Cause	Check or Correction
	▪ Plugged or collapsed exhaust system	▪ Check compression or leakage, valve action, timing ▪ Replace ▪ Clean or replace ▪ Replace collapsed parts
Engine runs but misses: one cylinder	▪ Defective spark plug ▪ Defective distributor cap or spark plug cable ▪ Valve stuck open ▪ Broken valve spring ▪ Burned valve ▪ Bent pushrod ▪ Flat cam lobe ▪ Defective piston or rings ▪ Defective head gasket ▪ Intake – manifold leak	▪ Clean or replace ▪ Replace ▪ Free valve; service valve guide ▪ Replace ▪ Replace ▪ Replace ▪ Replace camshaft ▪ Replace; service cylinder wall as necessary ▪ Replace ▪ Replace gasket; tighten manifold bolts
Engine runs but misses: different cylinders.	▪ Defective distributor advance, coil, condenser ▪ Defective fuel system ▪ Cross-firing plug wires ▪ Loss of compression ▪ Defective valve action ▪ Worn pistons and rings ▪ Overheated engine ▪ Manifold heat-control valve stuck ▪ Restricted exhaust	▪ Check distributor, coil, condenser ▪ Check fuel pump, flex line, carburetor ▪ Replace or relocate ▪ Check compression or leakage ▪ Check compression, leakage, vacuum ▪ Check compression, leakage, vacuum ▪ Check cooling system ▪ Free valve

Complaint	Possible Cause	Check or Correction
		▪ Check exhaust, tail pipe and muffler, eliminate restriction.
Engine lacks power, acceleration, or high speed performance: hot or cold	▪ Defective ignition ▪ Defective fuel system ▪ Secondary throttle valve not opening fully ▪ Restricted exhaust ▪ Loss of compression ▪ Excessive carbon in engine ▪ Defective valve action ▪ Excessive rolling resistance from low tires, dragging brakes, wheel misalignment, etc. ▪ Heavy oil ▪ Wrong or bad fuel ▪ Transmission not downshifting, or defective torque converter ▪ See also item 6 in Diesel Fuel-Injection-system Trouble-Diagnosis	▪ Check timing, distributor, wiring, condenser, coil, and plugs ▪ Check carburetor, choke, filter, air cleaner, and fuel pump. ▪ Adjust linkage ▪ Check tail pipe and muffler; eliminate restriction ▪ Check compression leakage ▪ Service engine ▪ Check with compression, leakage, vacuum testers ▪ Correct the defect causing rolling resistance ▪ Use correct oil ▪ Use correct octane fuel ▪ Check transmission
Engine lacks power, acceleration, or high speed performance: hot only	▪ Engine overheads ▪ Choke stuck partly open ▪ Sticking manifold heat-control valve ▪ Vapor lock	▪ Check cooling system ▪ Repair or replace ▪ Free valve ▪ Use different fuel or shield fuel line
Engine lacks power, acceleration, or high	▪ Automatic choke stuck open ▪ Manifold heat-control valve stuck open	▪ Repair or replace ▪ Free valve ▪ Repair or replace

Complaint	Possible Cause	Check or Correction
speed performance: cold only	▪ Cooling-system thermostat stuck open ▪ Engine valves stuck open	▪ Free valves; service valve stems and guide as needed
Engine overheats	▪ Lack of coolant ▪ Ignition timing late ▪ Loose or broken fan belt ▪ Thermostat stuck closed ▪ Clogged water jackets or radiator core ▪ Defective radiator hose ▪ Defective water pump ▪ Insufficient oil ▪ High-altitude, hot-climate operation ▪ Defective clutch ▪ Valve timing late; slack timing chain has allowed chain to jump a tooth ▪ No vacuum advance in any gear	▪ Add coolant; check for leak ▪ Adjust timing ▪ Tighten or replace ▪ Replace ▪ Flush and clear ▪ Replace ▪ Repair or replace ▪ Add oil ▪ Drive more slowly; keep radiator filled ▪ Replace ▪ Retime, adjust or replace ▪ TCS system or distributor defective
Engine idles roughly	▪ Incorrect idle adjustment ▪ PCV or EGR vale stuck open ▪ See also other causes listed under items 6 to 8	▪ Readjust idle mixture and speed ▪ Replace
Engine stalls cold or as it warms up	▪ Choke valve stuck closed or will not close ▪ Fuel not getting to or through carburetor ▪ Manifold heat-control valve stuck ▪ Throttle solenoid improperly set ▪ Idling speed set too low ▪ PCV or EGR valve stuck open	▪ Open choke valve; free or repair automatic choke ▪ Check fuel pump, lines, filter, float and the systems ▪ Free valve ▪ Adjust ▪ Increase idling speed to specified rpm

Complaint	Possible Cause	Check or Correction
	▪ Damper in thermostatic air cleaner in cold-air mode stuck closed.	▪ Replace ▪ Free; repair or replace control motor
Engine stalls after idling or slow-speed driving	▪ Defective fuel pump ▪ Overheating ▪ High carburetor float level ▪ Incorrect idling adjustment ▪ Malfunctioning PCV or EGR valve ▪ Throttle solenoid improperly set	▪ Repair or replace fuel pump ▪ See item 9 ▪ Adjust ▪ Adjust ▪ Replace ▪ Adjust
Engine stalls after high speed driving	▪ Vapor lock ▪ Carburetor venting or idle compensator valve defective ▪ Engine overheats ▪ PCV or EGR valve stuck open ▪ Improperly set idle solenoid	▪ Use different fuel or shield fuel line ▪ Check and repair ▪ See item 9 ▪ Replace ▪ Adjust
Engine backfires	▪ Ignition timing off ▪ Spark plugs of wrong heat range ▪ Excessively rich or lean mixture ▪ Engine overheats ▪ Carbon in engine ▪ Valves hot or stuck ▪ Cracked distributor cap ▪ Inoperative anti-backfire valve ▪ Cross-firing plug wires	▪ Adjust timing ▪ Install correct plugs ▪ Repair or readjust fuel pump or carburetor ▪ See item 9 ▪ Clean ▪ Adjust, free, clean; replace if bad ▪ Replace ▪ Replace ▪ Replace
Engine run-on, or dieseling	▪ Incorrect idle-solenoid adjustment ▪ Engine overheats ▪ Hot spots in cylinders ▪ Timing advanced	▪ Adjust; fix solenoid ▪ See item 9 ▪ Check plugs, pistons, cylinders for carbon; check

Complaint	Possible Cause	Check or Correction
	▪ In diesel engine, could be due to injection-pump solenoid not turning off fuel valve	valves for defects and faulty seating ▪ Adjust
Too much HC and CO in exhaust gas	▪ Ignition miss ▪ Incorrect ignition timing ▪ Carburetor troubles ▪ Faulty air injection ▪ Defective TCS system ▪ Defective catalytic converters	▪ Check plugs, wiring, cap, coil, etc ▪ Time ignition ▪ Check choke, float level, idle mixture screw, etc, as listen in item 20 ▪ Check pump, hoses, manifold ▪ Check system ▪ Replace converters or catalyst
Smoky exhaust ✓ Blue smoke ✓ Black smoke ✓ White smoke ✓ See also item 8 in Diesel Fuel Injection system Trouble Diagnosis	▪ Excessive oil consumption ▪ Excessively rich mixture ▪ Steam in exhaust	▪ See item 18 ▪ See item 20 ▪ Replace gasket; tighten cylinder-head bolts to eliminate coolant leakage into combustion chambers.
Excessive oil consumption	▪ External leaks ▪ Burning oil in combustion chamber ▪ High-speed driving	▪ Correct seals; replace gaskets ▪ Check valve-stem clearance, piston rings, cylinder walls, rod bearings ▪ Drive more slowly

Complaint	Possible Cause	Check or Correction
Low oil pressure	▪ Worn engine bearings ▪ Engine overheating ▪ Oil dilution or foaming ▪ Lubricating-system defects	▪ Replace ▪ See item 9 ▪ Replace oil ▪ Check oil lines, oil pump, relief valve
Excessive fuel consumption	▪ Jackrabbit starts ▪ High-speed driving ▪ Short-run operation ▪ Excessive fuel-pump pressure or pump leakage ▪ Choke partly closed after warm-up ▪ Clogged air cleaner ▪ High carburetor float level ▪ Stuck metering rod or power piston ▪ Worn carburetor jets ▪ Stuck metering rod or power piston ▪ Idle too rich or too fast ▪ Stuck accelerator-pump check valve ▪ Carburetor leaks ▪ Cylinder not firing ▪ Automatic transmission slipping or not up shifting ▪ Loss of engine compression (worn engine) ▪ Defective valve action (worn camshaft, belt or chain slack, or jumped tooth)	▪ Drive more reasonably ▪ Drive more slowly ▪ Drive longer distances ▪ Reduce pressure; repair pump ▪ Open; repair automatic choke ▪ Clean ▪ Adjust ▪ Free and clean ▪ Replace ▪ Free ▪ Adjust ▪ Free ▪ Replace gaskets; tighten screws; etc ▪ Check coil, condenser, timing, plugs, contact points, wiring ▪ Check transmission ▪ Check compression or leakage ▪ Check with compression, leakage, or vacuum tester

Complaint	Possible Cause	Check or Correction
	▪ Excessive rolling resistance from low tires, dragging brakes, wheel misalignment, etc. ▪ Clutch slippage	▪ Correct the defects causing the rolling resistance ▪ Adjust or repair
Engine noises 1. Regular clicking 2. Ping load on acceleration 3. Light knock or pound with engine floating 4. Light, metallic double knock usually most audible during idle 5. Chattering or rattling during acceleration 6. Hollow, muffled bell-like sound (engine cold) 7. Dull, heavy, metallic knock under load or acceleration, especially when cold. 8. Miscellaneous noises (rattles, etc) 9. See also items 4,7 &8 in diesel Fuel-Injection-System Trouble Diagnosis	▪ Valve and lifter ▪ Detonation due to low-octane fuel, carbon, advanced ignition timing, or causes listed under item 14 ▪ Worn connection-rod bearings or crankpin; misaligned rod; lack of oil ▪ Worn or loose pin or lack of oil ▪ Worn rings, cylinder walls, low ring tension, or broken rings ▪ Piston slap due to worn pistons or walls, collapsed piston skirts, excessive clearance, misaligned connecting rods, or lack of oil ▪ Regular noise; worn main bearings; irregular noise: worn thrust bearing knock on clutch engagement or on hard acceleration. ▪ Loosely mounted accessories: alternator, horn, oil pan, front bumper, water pump	▪ Readjust valve clearance or replace noisy hydraulic lifters ▪ Use higher-octane fuel; remove carbon; adjust ignition timing ▪ Replace bearings; service crankpins; replace rod; add oil ▪ Service pin and bushing; add oil ▪ Service walls; replace rings ▪ Replace or resize pistons; service walls; replace rods; add oil ▪ Replace or service bearings and crankshaft ▪ Tighten mounting

1.3.1 Diesel Fuel-Injection System Trouble-Diagnosis Chart

Table1: 2 Diesel Fuel-Injection System Trouble-Diagnosis Chart

Complaint	Possible Cause	Check or Correction
Engine cranks normally but will not start	▪ Incorrect or dirty fuel ▪ No fuel to nozzle or injection pump ▪ Plugged fuel return ▪ Pump timing off ▪ Inoperative glow plugs, incorrect starting procedure, or internal engine problems	▪ Flush system-use correct fuel ▪ Check for fuel to nozzle ▪ Check return, clean ▪ Retime
Engine starts but stalls on idle	▪ Fuel low in tank ▪ Incorrect or dirty fuel ▪ Limited fuel to nozzles or injection pump ▪ Restricted fuel return ▪ Idle incorrectly set ▪ Pump timing off ▪ Injection-pump trouble ▪ Internal engine problems	▪ Fill tank ▪ Flush system-use correct fuel ▪ Check for fuel to nozzles and to pump ▪ Check return, clean ▪ Reset idle ▪ Retime ▪ Install new pump
Rough idle, no abnormal noise or smoke	▪ Low idle incorrect ▪ Injection line leaks ▪ Restricted fuel return ▪ Nozzle trouble ▪ Fuel-supply pump problem ▪ Uneven fuel distribution to nozzles	▪ Adjust ▪ Fix leaks ▪ Clear ▪ Check, repair or replace ▪ Check, replace if necessary ▪ Selectively replace nozzles until condition clears up

Complaint	Possible Cause	Check or Correction
	▪ Incorrect or dirty fuel	▪ Flush system-use correct fuel
Rough idle with abnormal noise and smoke	▪ Injection-pump timing off ▪ Nozzle trouble	▪ Retime ▪ Check in sequence to find defective nozzle
Idle okay but misfires as throttle opens	▪ Plugged fuel filter ▪ Injection-pump timing off ▪ Incorrect or dirty fuel	▪ Replace filter ▪ Retime ▪ Flush system-use correct fuel
Loss of power	▪ Incorrect or dirty fuel ▪ Restricted fuel return ▪ Plugged fuel-tank vent ▪ Restricted fuel supply ▪ Plugged fuel filter ▪ Plugged nozzles	▪ Flush system-use correct fuel ▪ Clear ▪ Clean ▪ Check fuel lines, fuel-supply pump, injection pump ▪ Replace filter
Noise – "rap" from one or more cylinders.	▪ Air in fuel system ▪ Gasoline in fuel system ▪ Air in high-pressure line ▪ Nozzle sticking open ▪ Engine problems	▪ Check for cause and correct ▪ Replace fuel ▪ Bleed system ▪ Replace defective nozzle
Combustion noise with excessive black smoke	▪ Timing off ▪ Injection-pump trouble ▪ Nozzle sticking open ▪ Internal engine problems	▪ Reset ▪ Replace pump ▪ Clean or replace

1.3 Engine Tune-up Tools and Equipment

Quick and accurate diagnosis and service of the engine require the use of various test instruments and gauges. These will show if the battery, starting, charging, fuel ignition and emissions systems are operating properly. They would also indicate the mechanical condition of the engine.

1.3.2 Compression Tester

The cylinder compression tester measures the ability of the cylinders to hold compression while the starting motor cranks the engine. The compression tester is a pressure gauge that measures the amount of pressure or compression, built-up in the cylinder during the compression stroke.

How well a cylinder holds compression is an indication of the condition of the piston, piston rings, cylinder wall, valves and head gasket. The dial face on the typical compression gauge indicates pressure in both pounds per square inch (PSI) and metric kilopascals (kPa.). Most compression gauges have a vent valve that holds the highest pressure reading on its meter.

Figure 1:1 Compression Tester

1.3.3 Cylinder Leakage Tester

The cylinder leakage tester checks compression but in a different way. It applies air pressure to the cylinder with the piston at TDC on the compression stroke.

In this position, the engine valves are closed. Very little air should escape from the cylinder if the engine is in good condition.

Figure 1:2 Cylinder Leakage Tester

1.3.4 Tachometer

The tach counts how many times per second a mark on the pulley passes by. The magnetic tachometer is usually combined with the magnetic timing tester. It uses a probe inserted in the engine probe hole. The probe reacts to a mark on the crankshaft pulley or to a pulse ring or location indicator on the crankshaft. On an engine with electronic engine control system (EEC), engine-speed data is available through the diagnostic connector. A scan tool or a computerized engine analyzer can display the rpm.

Figure 1:3 Tachometer

1.3.5 Dwell Meter

The dwell meter electrically measures how long the contact points remain closed during each ignition cycle of a contact-point ignition system. The average for all cylinders is then displayed in degrees of distributor-cam rotation.

The technician can also use the dwell meter to set contact-point gap and to check for unwanted dwell variation as engine speed increases. Excessive variation indicates mechanical trouble in the distributor. In electronic ignition systems, the ECM controls dwell. It is not adjustable.

Figure 1: 4 Portable Tachometer

The dwell meter is used to check the duty cycle of the mixture-control solenoid in a feedback carburetor. A dwell-tach meter is a single meter that serves as both a dwell meter and a tachometer. This is possible because both meters have two leads and require the same connections. Pushing a button or turning a knob on the meter switches the reading from rpm to dwell.

Figure 1: 5 Dwell Meter

1.3.6 Engine Vacuum Gauge

The engine vacuum gauge measures intake-manifold vacuum um. The intake-manifold vacuum changes with the load on engine defects. The way the vacuum varies from normal indicates what could be wrong inside the engine. Before making the test, check that all vacuum hoses are properly connected and not leaking. Make a backpressure test if a restricted exhaust system is indicated.

Figure 1: 6 Engine Vacuum Gauge

1.3.7 Exhaust Gas Analyzer

The exhaust gas analyzer measures the amount of various gases in the exhaust. The purpose of making these measurements is to help determine the condition of the engine, ignition system, fuel system and emission controls. On a car with a catalytic converter, tail pipe readings made with a two-gas analyzer are often of little value.

Figure 1:7 Exhaust Gas Analyzer

1.3.8 Engine Analyzer

An engine analyzer combines several testers, meters and gauges into a single piece of portable shop equipment. When connected to the vehicle, the analyzer provides quick and accurate testing and diagnosis of various engine and vehicle systems. Most shop engine analyzers include an oscilloscope. It displays voltage patterns of the ignition system and electronic fuel injectors. Some computerized analyzers include a second screen.

Figure 1:8 Engine Analyzer

1.3.9 Dynamometer

The chassis dynamometer measures engine power and vehicle speed under various operating conditions. The vehicle is driven onto two rollers so the drive wheels can spin the rollers. The rollers drive a power absorber which is usually under the floor. The vehicle remains stationary, but the engine and other components operate the same as on a road test. Meters on a console report wheel speed and torque or power. The power absorber may be a heavy metal flywheel with an inertia weight, the same as the weight of the vehicle. Or the power absorber may be a brake that places a variable load on the rollers. The technician can connect an oscilloscope and a variety of other testers to check the engine under operating conditions.

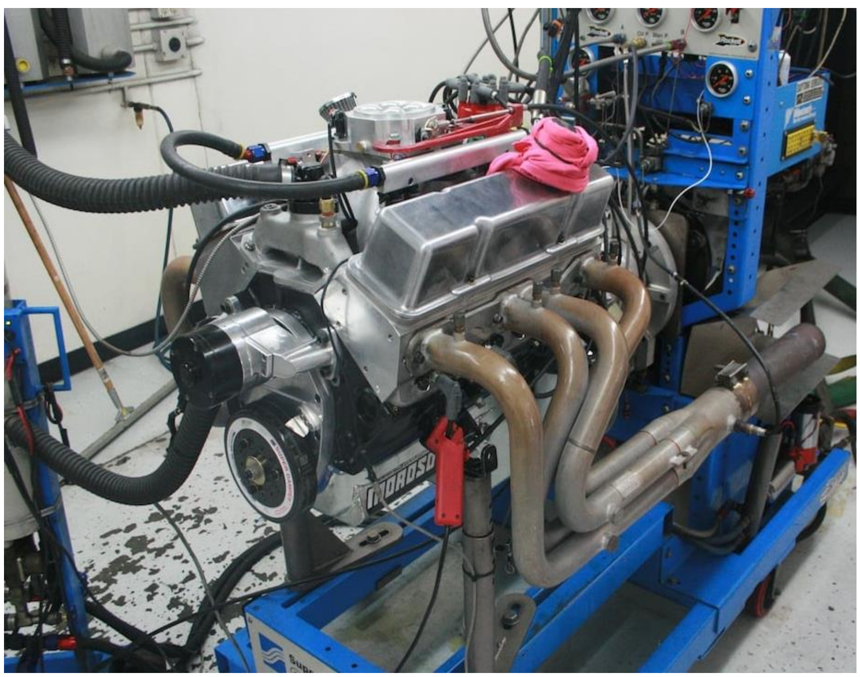


Figure 1: 9 Engine Dynamometer

1.3.10 Stroboscope Timing Light

A timing light is a stroboscope used to dynamically set the ignition timing of an Otto cycle or similar internal combustion engine equipped with a distributor. Modern electronically controlled passenger vehicle engines require use of a scan tool to display ignition timing. The timing light is connected to the ignition circuit and used to illuminate the timing marks on the engine's crankshaft pulley or flywheel, with the engine running. The apparent position of the marks, frozen by the stroboscopic effect, indicates the current timing of the spark in relation to piston position.

A reference pointer is attached to the flywheel housing or other fixed point, and an engraved scale gives the offset between the spark time and the top dead center position of the piston in the cylinder. The distributor can be rotated slightly until the reference pointer aligns with the specified point on the timing scale.

Figure 1:10 Stroboscope Timing Light

1.3.11 Oil Pressure Gauge

Checking the engine’s oil pressure gives information about the condition of the oil pump, the pressure regulator, and the entir e lubrication system. Lower-than-normal oil pressures can be caused by excessive engine bearing clearances.

Oil pressure is checked at the sending unit passage with an externally mounted mechanical oil pressure gauge. Various fittings are usually supplied with the oil pressure gauge to fit different openings in the lubrication system.

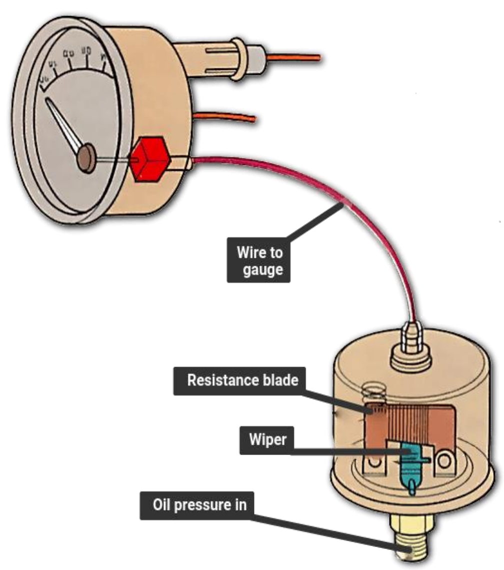


Figure 1:11 Oil Pressure Gauge

1.3.12 Injector Nozzle Tester

This practical tool helps test diesel injectors for leakage, spray patterns, opening pressure, and leakage between injector needle and injector body. Suitable for pressure-activated injectors.

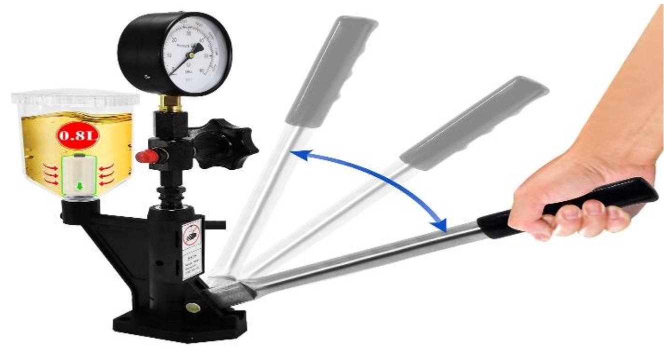


Figure 1: 12 Injector Nozzle Tester

1.3.1 Stethoscope

A stethoscope is used to locate the source of engine and other noises. The stethoscope pickup is placed on the suspected component, and the stethoscope recep tacles are placed in the technician’s ears . Some sounds can be heard easily without using a lis-tening device, but others are impossible to hear unless amplified, which is what a stethoscope does. It can also help you distinguish between normal and abnormal noise.

Figure 1: 13 a Mechanic Check Engine Noises

1.3.2 Oscilloscope

An oscilloscope or lab scope is a visual voltmeter. A lab scope converts electrical signals to a visual image representing voltage changes over a period of time. This information is displayed in the form of a continuous voltage line called a waveform or trace. A scope displays any change in voltage as it occurs. An upward movement of the trace on an oscillo-scope indicates an increase in voltage, and a downward movement represents a decrease in voltage.

Figure 1: 14 PC-Based Lab Scopes

1.3.3 Scan Tool

A scan tool is a computer designed to communicate with the vehicle's computers. Connected to the electronic control system through diagnostic connectors, a scan tool can access diagnostic trouble codes (DTCs), run tests to check system operations, and monitor the activity of the system. Trouble codes and test results are dis-played on a screen or printed out on the scan tool's printer.

Figure 1: 15 Scan Tool

1.4 Engine Pre-tuning Requirements

There are a general pre-tuning requirements before checking engine tune-up. These are

1.4.1 Electrical Issues

Electrical issues can be a complete nightmare, and more so while trying to dyno tune your race car. Some of the more common issues that you should be aware of while completing your race project.

A. Wiring and Connectors

- No exposed wires on engine harness. This can lead to a short to ground and cause melted wires or fire
- Solder or crimp all connections. Never twist wires together the connection can and will fail, especially while tuning!
- Chassis grounds should be bare metal and cleaned. Poor ground will cause major electrical problems.
- Have the battery ground cable the same gage or larger than power cable. Often times we see a smaller gage battery ground cable cause voltage or charging problems when tuning.

- Make sure battery voltage is 13~14 volts when engine is running. We see alternator charging issues often on race vehicles as a result of poor grounding or bad alternator. The battery voltage MUST be between 13.5~14v when engine is running.

B. Ignition Issues

- Make sure you are using at least one step colder spark plug in your performance race application. Stock heat range spark plugs can lead to pre ignition can cause engine damage very quickly.
- If running colder spark plugs, don't start and stop your engine when cold. The spark plug takes longer for self-cleaning to occur. If you don't bring the engine up to operating temperature be prepared to change spark plugs more frequently.
- Spark plug gap often times needs to be reduced in a forced induction application over the preset plug gap. Generally in a forced induction application 0.025~0.030" plug gap works very well.

1.4.2 Fuel Issues

In a performance race application fuel system delivery and operation is paramount for fueling super high power levels. One small issue in the system can cut you short of your desired horsepower level. Check out the list below to make sure you are ready!

A. Fuel Pumps

- Do not install an in tank style fuel pump with dirt, rust or debris inside of the gas tank. You will be sure to either ruin the pump or clog the pre filter and have fuel pressure starvation while tuning.
- When adding a fuel sump tray to your OEM fuel tank make sure you clean out any metal chips, weld slag or debris after you are done.
- When you are running an external fuel pump, you will need to run a pre and post fuel filter. The pre and post filters should be stainless material so you can service and clean them over time. Pre-filter fuel filters should be 40-75 micron rating, post-filter fuel filters should be 100+ micron rating.

B. Fuel Pressure

- Base fuel pressure should be between 40-50 PSI for most any application.

- When possible we recommend using a fuel pressure sensor wired into the engine management system you are using. Some systems do not support this. Many systems offer fail safe protection based on fuel pressure. Having a fuel pressure reading while tuning is invaluable information that can allow us to troubleshoot a fueling problem instantly.
- When installing any super high flowing fuel pumps you need to upgrade the OEM fuel pressure regulator. The stock regulators in most cases cannot bypass enough fuel, and the base fuel pressure becomes way too high.
- Many newer OEM fuel systems are a return less style system, and lack an external fuel pressure regulator. Because the fuel pressure does not increase at a 1:1 rate under boost, the fuel delivery under boost can be substantially decreased. You may need to upgrade to a return style fuel system in order to achieve much higher power levels.
- Make sure the vacuum line going from the intake manifold to the external fuel pressure regulator is secured with zip ties or similar, and is free of cracks or tears.
- Make sure you have a 1/2 tank of fuel for the tuning session. If you run low on fuel, fuel pressure will drop which could damage the engine while doing high rpm pulls.

1.4.3 Mechanical Issues

A. Engine

- All cylinders should have good compression. A general rule of thumb is not having more than 20 PSI of compression variance between cylinders.
- If engine compression is 20 PSI or lower in a cylinder (s), pour a small amount of oil into the cylinder. Redo the compression test "wet" and see if the compression increases. If the compression increases you have a piston ring sealing problem or damage. If it does not, your compression issue is related to the valves.
- Make sure your engine oil is full, and bring extra oil with you at the time of the tuning appointment. We have limited oil in stock at the shop.
- Make sure the coolant level is full in the engine/coolant system. The cooling system MUST be bleed before the tuning appointment. This can take 1-2 hours to bleed in some cases, which will be billed to you at our shop labor rate of 150.00/hr to resolve before tuning can resume.

- Check valve lash before tuning. Too tight of valve lash will lose compression, and reduce power. Too loose will make noise. If using aftermarket cams make sure your valve lash is set to the manufacturers suggested specs. Many engines do not have adjustable lash, ignore this step.
- Timing chain or timing belt need to be installed correctly, or engine will be out of "time". In these cases we cannot tune the car for you until the problem is resolved.

B. Clutch

- Make sure your clutch is rated for the torque capacity of the power you plan to make.
- Stock clutches on many higher power applications will not "hold" the torque the engine is producing. Please be aware that if the clutch slips during the tuning session you will be charged for the tune, and will need to return at a later date at a retune rate. This has happened numerous times over the years, so please do yourself a favor and ours and upgrade the clutch if you think there may be an issue!

1.5 Typical Tune-up Procedure

The steps in a typical tune-up procedure are given below

NOTE: All steps do not apply to all vehicles or to all engines.

1. Test and service the battery and starting motor.
2. Inspect the drive belts.
3. If the engine is cold, operate it for at least 20 minutes at 1500 rpm or until the engine reaches normal operating temperature. Note any problems during warm-up.
4. Connect the engine analyzer or oscilloscope and perform an electrical diagnosis.
5. Perform a comparison test.
6. Remove the spark plugs and inspect the firing ends.
7. Inspect the ignition system.
8. Recheck the ignition system with the oscilloscope.
9. Check the manifold heat-control valve
10. Test the fuel pump with a fuel-pump tester.
11. Clean or replace the air-cleaner filter.
12. Check the action of the throttle valves.
13. Inspect all engine vacuum fittings, hoses and connections.

14. Clean the engine oil-filler cap; inspect the conditions of its gasket or seal.
15. Check the cooling system
16. Inspect the PCV system.
17. If the engine has an air-injection pump, replace the pump inlet-air filter, if used. Inspect the system hoses and connections.
18. If the evaporative-control system uses an air filter in the charcoal canister, replace the filter.
19. Inspect the EGR valve.
20. Adjust the engine valves, if necessary.
21. Adjust the engine idle speed.
22. If the engine has a turbocharger, check the waste gate operation.
23. Tighten the intake and exhaust-manifold bolts to the specified torque.
24. Check the maintenance sticker or the lubrication schedule to see if an oil and oil- filter change is due.
25. While the car is on the lift, check the exhaust system for leaks.
26. Road-test the car on the road. Check for drive ability, power and idling.

Self-check 1.1

Directions: Answer all the questions listed below.

Part I: Say True or False

1. A compression gauge will show the amount of air leaking through a cylinder.
2. A lab scope is a visual voltmeter that shows voltage over a period of time
3. A dwell-tach meter is a single meter that serves as both a dwell meter and a tachometer
4. The way the vacuum varies from normal indicates what could be wrong in engine.

Part-II: Choose the appropriate answer from the given alternatives

1. Which of the following conditions can be revealed by fuel pressure readings?
   a. Faulty fuel pump
   b. Faulty fuel pressure regulator
   c. Restricted fuel delivery system
   d. All of the above
2. The tests conducted by a scan tool can also be done by some ___.
   a. fuel injector pulse testers
   b. exhaust analyzers
   c. engine analyzers
   d. digital volt/ohmmeters
3. When conducting an oil pressure test: Technician A says that lower than normal pressure can be caused by faulty piston oil rings. Technician B says that lower than normal oil pressure can be caused by excessive engine bearing clearances. Who is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
4. While diagnosing the cause for blue smoke from the tailpipe of a gasoline engine: Technician A says that a faulty fuel injection system is a likely cause. Technician B says that it is most likely caused by coolant leaking into the combustion chamber. Who is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
5. While diagnosing the cause for an engine having good results from a compression test and cylinder leakage test but poor results from a cylinder power balance test: Technician A says that incorrect valve timing is the most likely cause. Technician B says that a severely worn cam lobe is a likely cause. Who is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

6. While looking at the results of an oil pressure test: Technician A says that higher than normal readings can be caused by using an incorrect viscosity oil. Technician B says that higher than normal readings can be expected on a cold engine. Who is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

7. While determining the most likely problem of an engine with poor compression test results but acceptable cylinder leakage readings: Technician A says that the problem may be incorrect valve timing. Technician B says that the problem is worn valve seats. Who is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

8. When a customer states that black exhaust smoke is coming from the exhaust: Technician A says faulty oil rings may be the cause. Technician B says a faulty head gasket may be the cause. Who is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

9. While conducting an engine vacuum test: Technician A says that a steady low vacuum reading can be caused by a burned intake valve. Technician B says that an overall low vacuum reading is caused by something that affects all of the engine's cylinders. Who is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

Part-III: Answer the following questions accordingly.

A good tune-up job, therefore, consists of two parts.

1.______________________________2.________________________________

The three fundamental divisions of tune-up procedure can also be considered as:

1.______________________________

2.______________________________ 3.______________________________

Unit Two: Diagnosing Engine Faults

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Engine-Related Complaints
- Visual Checks
- Exhaust Smoke Diagnosis
- Engine Noise Diagnosis
- Engine Performance Test
- Exhaust Gas Analysis

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Figure out Engine-Related Complaints
- Observe Visual Checks
- Diagnose Exhaust Smoke
- Diagnosis Engine Noise
- Perform Engine Performance Test
- Perform Exhaust Gas Analysis

2.1 Engine-Related Complaints

Many drivability problems are not caused by engine mechanical problems. A thorough inspection and testing of the ignition and fuel systems should be performed before testing for mechanical engine problems. Typical engine mechanical-related complaints include the following:

- Loss of power
- Engine misfiring
- Engine noise
- Excessive oil consumption
- Smoke from the engine or exhaust
- Failed Emission Test

The driver of the vehicle knows a lot about the vehicle and how it is driven. Before diagnosis is started, always ask the following questions.

- When did the problem first occur?
- Under what conditions does it occur?
  - ✓ Cold or hot?
  - ✓ Acceleration, cruise, or deceleration?
  - ✓ How far was it driven?
  - ✓ What recent repairs have been performed?

After the nature and scope of the problem are determined, the complaint should be verified before further diagnostic tests are performed.

2.2 Visual Checks

The first and most important "test" that can be performed is a careful visual inspection.

2.1.1 Oil Level and Condition

The first area for visual inspection is oil level and condition.

1. Oil level—oil should be to the proper level
2. Oil condition
   - ✓ Using a match or lighter, try to light the oil on the dipstick; if the oil flames up, gasoline is present in the engine oil.
   - ✓ Drip some of the engine oil from the dipstick onto the hot exhaust manifold. If the oil bubbles or boils, there is coolant (water) in the oil.

- ✓ Check for grittiness by rubbing the oil between your fingers.

2.1.2 Coolant Level and Condition

Most mechanical engine problems are caused by overheating. The proper operation of the cooling system is critical to the life of any engine. Check the coolant level in the radiator only if the radiator is cool. If the radiator is hot and the radiator cap is removed, the drop in pressure above the coolant will cause the coolant to boil immediately and can cause severe burns when the coolant explosively expands upward and outward from the radiator opening.

2.1.3 Fluid Leaks

When inspecting the engine, check it for leaks. There are many different fluids under the hood of an automobile so care must be taken to identify the type of fluid that is leaking. Carefully look at the top and sides of the engine, and note any wet residue that may be present. Sometimes road dirt will mix with the leaking fluid and create a heavy coating. Also look under the vehicle for signs of leaks or drips; make sure you have good lighting. Note the areas around the leaks and identify the possible causes. All leaks should be corrected because they can result in more serious problems. Sometimes smell will identify the fluid. Gasoline evaporates when it leaks out and may not leave any residue, but it is easy to identify by its smell.

Description	Probable Source
Honey or dark greasy fluid	Engine oil
Honey or dark thick fluid with a chestnut smell	Gear oil
Green, sticky fluid	Engine coolant
Slippery clear or yellowish fluid	Brake fluid
Slippery red fluid	Transmission or power-steering fluid
Bluish watery fluid	Washer fluid

Figure 2:1 Types of Fluid Leaks

2.3 Exhaust Smoke Diagnosis

Examining and interpreting the vehicle's exhaust can give clues of potential engine problems. Basically there should be no visible smoke coming out of the tailpipe. There is an exception to this rule, however, on a cold day after the vehicle has been idling for a while, it is normal for white smoke to come out of the tailpipe. This is nothing else but the water that has condensed in the exhaust system becoming steam. However, the steam should stop once the engine reaches normal operating temperature. If it does not, a problem is indicated. The color of the exhaust is used to diagnose engine concerns.

Engine Type	Visible Sign	Diagnosis	Probable Causes
Gasoline	Gray or black smoke	Incomplete combustion or excessively rich A/F mixture	■ Clogged air filter ■ Faulty fuel injection system ■ Faulty emission control system ■ Ignition problem ■ Restricted intake manifold
Diesel	Gray or black smoke	Incomplete combustion	■ Clogged air filter ■ Faulty fuel injection system ■ Faulty emission control system ■ Wrong grade of fuel ■ Engine overheating
Gasoline and Diesel	Blue smoke	Burning engine oil	■ Oil leaking into combustion chamber ■ Worn piston rings, cylinder walls, valve guides, or valve stem seals ■ Oil level too high
Gasoline	White smoke	Coolant/water is burning in the combustion chamber	■ Leaking head gasket ■ Cracked cylinder head or block
Diesel	White smoke	Fuel is not burning	■ Faulty injection system ■ Engine overheating

Figure2:2 Exhaust Smoke Diagnosis

2.4 Engine Noise Diagnosis

More often than not, malfunction in the engine will reveal itself first as an unusual noise. This can happen before the problem affects the drivability of the vehicle. Problems such as loose pistons, badly worn rings or ring lands, loose piston pins, worn main bearings and connecting rod bearings, loose vibration damper or flywheel, and worn or loose valve train components all produce telltale sounds. Unless the technician has experience in listening to and interpreting engine noises, it can be very hard to distinguish one from the other.

When correctly interpreted, engine noise can be a very valuable diagnostic aid. For one thing, a costly and time-consuming engine teardown might be avoided. Always make a noise analysis before doing any repair work. This way, there is a much greater likelihood that only the necessary repair procedures will be done.

Some engine sounds can be easily heard without using a listening device, but others are impossible to hear unless amplified. A stethoscope is very helpful in locating engine noise by amplifying the sound waves. It can also distinguish between normal and abnormal noise. The procedure for using a stethoscope is simple. Use the metal prod to trace the sound until it reaches its maximum intensity. Once the precise location has been discovered, the sound can be better evaluated. A sounding stick, which is nothing more than a long, hollow tube, works on the same principle, though a stethoscope gives much clearer results.

The best results, however, are obtained with an electronic listening device. With this tool you can tune into the noise. Doing this allows you to eliminate all other noises that might distract or mislead you. An engine knocking noise is often difficult to diagnose. Several items that can cause a deep engine knock include:

Figure2:3 Technician Uses Mechanical Statoscope

- **Valves clicking**. This can happen because of lack of oil to the lifters. This noise is most noticeable at idle when the oil pressure is the lowest.
- **Torque converter.** The attaching bolts or nuts may be loose on the flex plate. This noise is most noticeable at idle or when there is no load on the engine.
- **Cracked flex plate.** The noise of a cracked flex plate is often mistaken for a rod- or main-bearing noise.
- **Loose or defective drive belts or tensioners.** If an accessory drive belt is loose or defective, the flopping noise often sounds similar to a bearing knock.
- **Piston pin knock.** This knocking noise is usually not affected by load on the cylinder. If the clearance is too great, a double knock noise is heard when the engine idles. If all cylinders are grounded out one at a time and the noise does not change, a defective piston pin could be the cause.
- **Piston slap.** A piston slap is usually caused by an undersized or improperly shaped piston or oversized cylinder bore. A piston slap is most noticeable when the engine is cold and tends to decrease or stop making noise as the piston expands during engine operation.

- **Timing chain noise**. An excessively loose timing chain can cause a severe knocking noise when the chain hits the timing chain cover. This noise can often sound like a rod-bearing knock.
- **Rod-bearing noise**. The noise from a defective rod bearing is usually load sensitive and changes in intensity as the load on the engine increases and decreases. A rod-bearing failure can often be detected by grounding out the spark plugs one cylinder at a time. If the knocking noise decreases or is eliminated when a particular cylinder is grounded (disabled), then the grounded cylinder is the one from which the noise is originating.
- **Main-bearing knock**. A main-bearing knock often cannot be isolated to a particular cylinder. The sound can vary in intensity and may disappear at times depending on engine load.

2.5 Engine Performance Test

As the trend toward the integration of ignition, fuel, and emission systems progresses, diagnostic test equipment must also keep up with these changes. New tools and techniques are constantly being developed to diagnose electronic engine control systems. However, not all engine performance problems are related to electronic control systems; therefore, technicians still need to understand basic engine tests. These tests are an important part of modern engine diagnosis.

2.5.1 Cylinder Power Balance Test

The cylinder power balance test is used to check if all of the engine’s cylinders are producing the same amount of power. Ideally, all cylinders will produce the same amount. To check an engine’s power balance, each cylinder is disabled, one at a time, and the change in engine speed is recorded. If all of the cylinders are producing the same amount of power, engine speed will drop the same amount as each cylinder is disabled.

Unequal cylinder power balance can be caused by the following problems:

- Defective ignition coil
- Defective spark plug wire
- Defective or worn spark plug
- Damaged head gasket
- Worn piston rings
- Damaged piston
- Damaged or burned valves
- Broken valve spring
- Worn camshaft
- Defective lifters, pushrods, and
- Leaking intake manifold
- Faulty fuel injector

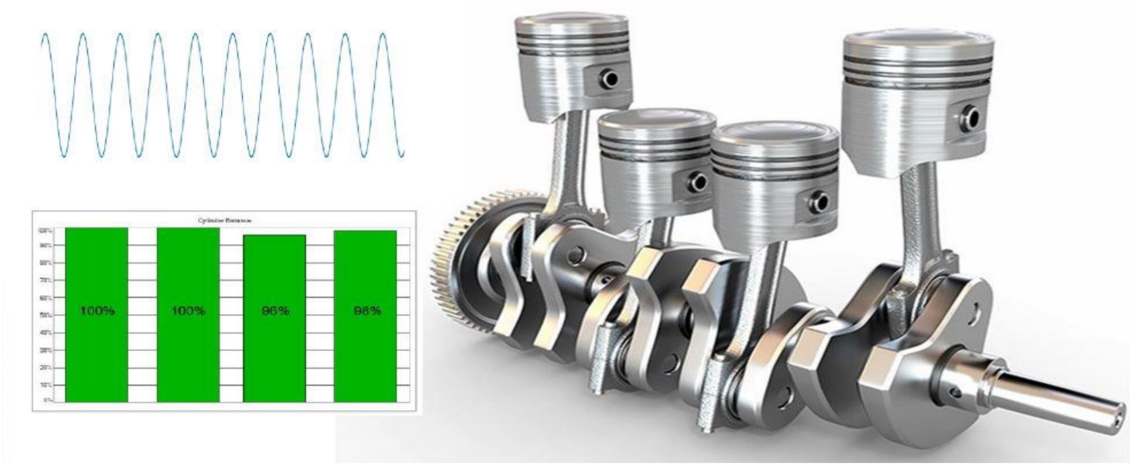


Figure2: 4 Power Balance Test

A power balance test is performed quickly and easily using an engine analyzer, because the firing of the spark plugs can be automatically controlled or manually controlled by pushing a button. Some vehicles have a power balance test built into the engine control computer. This test is either part of a routine self-diagnostic mode or must be activated by the technician.

Connect the engine analyzer's leads according to the manufacturer's instructions. Turn the engine on and allow it to reach normal operating temperature. Set the engine speed at 1,000 rpm and connect a vacuum gauge to the intake manifold. As each cylinder is shorted, note and record the rpm drop and the change in vacuum.

As each cylinder is shorted, a noticeable drop in engine speed should be noted. Little or no decrease in speed indicates a weak cylinder. If all of the readings are fairly close to each other, the engine is in good condition. If the readings from one or more cylinders differ from the rest, there is a problem. Further testing may be required to identify the exact cause of the problem.

2.5.2 Cranking Vacuum and Speed Tests

Cranking vacuum and speed tests are basic mechanical tests of gasoline engine condition. If the engine is in good shape, all air entering the engine is drawn through the carburetor or injection system, past the valves, and compressed in the cylinders. If the engine is worn, air can leak into the cylinders past valve guides, piston rings, valve seats, or bad gasket, figure 8.3. By checking cranking vacuum, you can tell if all cylinders are drawing air through the induction system. If they are not, air leaks will cause a low or uneven vacuum reading and keep you from tuning the engine for best performance.

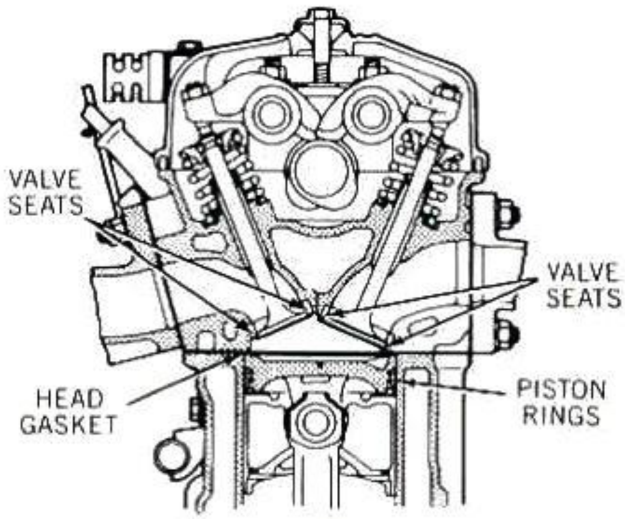


Figure2: 5 Leakage past the Valves, Rings, and Other Points

Different engines produce cranking vacuum readings from 3 to 15 inches of mercury. Some carmakers publish cranking vacuum specifications; others do not. The important things to look for are a steady vacuum and cranking speed. If the battery and starting system are in good condition, do the test as follows:

1. Warm the engine to normal temperature.
2. Connect a vacuum gauge to a manifold vacuum source. Do not connect the gauge to ported vacuum. Check a vacuum diagram to ensure correct connection.
3. Connect a tachometer.
4. Close the throttle and disable the ignition.
5. Crank the engine for 10 to 15 seconds and note the vacuum gauge and tachometer readings.
6. Vacuum and cranking speed (approximately 200 RPM) are steady. The engine probably is mechanically sound.
7. Vacuum and cranking speed are uneven. The engine probably has leakage past valves, rings, or the head gasket.
8. Speed is uneven, but vacuum is steady – You may have a bad starter or worn flywheel ring gear.
9. Cranking speed is normal or high and vacuum is low and slightly uneven – The engine probably has low compression or retarded valve timing.

Further testing will pinpoint possible problems indicated by this cranking test. You can do a quick check of the PCV system while cranking the engine. Test cranking vacuum as explained above.

Then pinch the PCV hose to the manifold closed with a pair of pliers and repeat the test. Vacuum with the PCV hose closed should be higher than with it open. If there is no change in vacuum, test the PCV system for blockage.

Caution: Do not crank a converter-equipped car for more than 15 seconds to avoid drawing fuel into the catalyst.

2.5.3 Manifold Vacuum Tests

Measuring intake manifold vacuum is another way to diagnose the condition of an engine. Vacuum is formed by the downward movement of the pistons during their intake stroke. If the cylinder is sealed, a maximum amount will be formed. Manifold Figure2:6 Manifold Vacuum Tester vacuum is tested with a vacuum gauge. The gauge's hose is connected to a vacuum fitting on the intake manifold. Normally a "tee" fitting and short piece of vacuum hose are used to connect the gauge.

Vacuum gauge readings can be interpreted to identify many engine conditions, including the ability of the cylinder to seal, the timing of the opening and closing of the engine's valves, and ignition timing.

Ideally each cylinder of an engine will produce the same amount of vacuum; therefore, the vacuum gauge reading should be steady and give a reading of at least17 inches of mercury (in. Hg).

Figure 1: 16 Vacuum Gauge

If one or more cylinders produce more or less vacuum than the others, the needle of the gauge will fluctuate. The intensity of the fluctuation indicates the severity of the problem. For example, if the reading on the vacuum gauge fluctuates between 10 and 17 in. Hg we should look at the rhythm of the needle. If the needle seems to stay at 17 most of the time but drops to 10 and quickly rises, we know that the reading is probably caused by a problem in one cylinder. Fluctuating or low readings can indicate many different problems.

For example, a low, steady reading might be caused by retarded ignition timing or incorrect valve timing. A sharp vacuum drop at regular intervals might be caused by a burned intake valve.

Other conditions that can be revealed by vacuum readings follow:

- Stuck or burned valves
- Improper valve or ignition timing
- Weak valve springs
- Faulty PCV, EGR, or other emission-related system
- Uneven compression
- Worn rings or cylinder walls
- Leaking head gaskets
- Vacuum leaks
- Restricted exhaust system
- Ignition defects

2.5.4 Oil Pressure Testing

An oil pressure test is used to determine the wear of an engine's parts. The oil pressure test is performed with an oil pressure gauge, which measures the pressure of the oil as it circulates through the engine. Basically, the pressure of the oil depends on the efficiency of the oil pump and the clearances through which the oil flows.

Excessive clearances, most often caused by wear between a shaft and its bearings, will cause a decrease in oil pressure. Loss of performance, excessive engine noise, and poor starting can be caused by abnormal oil pressure. When the engine's oil pressure is too low, premature wear of its parts will result.

Excessive bearing clearances are not the only possible causes for **low oil pressure readings**; others are:

- Oil pump-related problems,
- Plugged oil pickup screen,
- Weak or broken oil pressure relief valve,
- Low oil level,
- Contaminated oil, or low oil viscosity.

Higher than normal readings can be caused by:

- Too much oil,
- Cold oil,
- High oil viscosity,
- Restricted oil passages, and a faulty pressure regulator

2.5.5 Compression Test

Internal combustion engines depend on compression of the air-fuel mixture to maximize the power produced by the engine. The upward movement of the piston on the compression stroke compresses the air-fuel mixture within the combustion chamber. The air-fuel mixture gets hotter as it is compressed. The hot mixture is easier to ignite, and when ignited it generates much more power than the same mixture at a lower temperature.

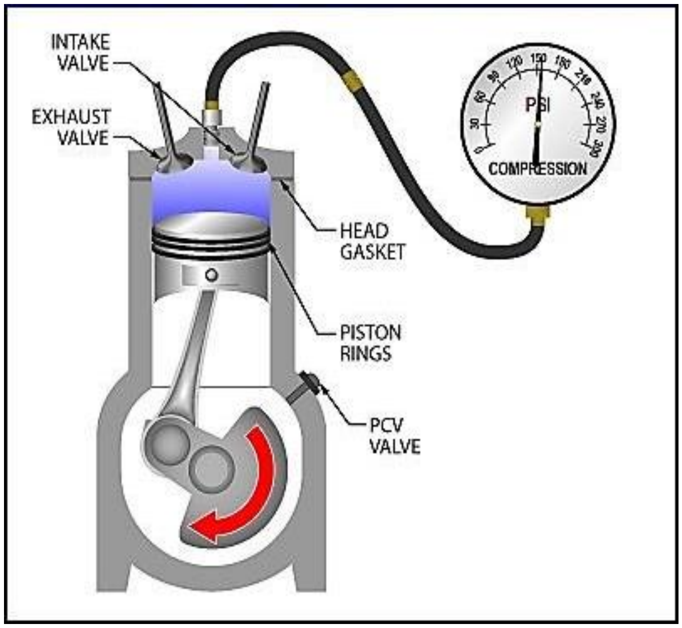


Figure2: 7 Compression Test

If the combustion chamber leaks, some of the air-fuel mixture will escape when it is compressed, resulting in a loss of power and a waste of fuel. The leaks can be caused by burned valves, a blown head gasket, worn rings, slipped timing belt or chain, worn valve seats, a cracked head, and more. An engine with poor compression (lower compression pressure due to leaks in the cylinder) will not run correctly. If a symptom suggests that the cause of a problem may be poor compression, a compression test is performed.

Carmakers publish compression specifications in one of two ways:

- Specifications may list a minimum pressure and an allowable variation between cylinders. For example, minimum compression may be 120PSI with a 20-PSI difference between cylinders. Compression, then, would be okay if each cylinder is at least 120 to 140 PSI.
- Specifications may say that the lowest cylinder must be within 75 percent of the highest cylinder. If the highest cylinder is 140PSI, the lowest should be 105PSI (75 percent of 140) or higher.

In either case, less compression variation among cylinders indicates an engine in better condition. Even if a carmaker does not list a minimum compression, you can suspect a worn engine if compression is below 85 to 100 PSI.

A. Wet Compression Test

If the compression test reading indicates low compression on one or more cylinders, add three squirts of oil to the cylinder and retest. This is called a wet compression test, when oil is used to help seal around the piston rings.

Caution: Do not use more oil than three squirts from a hand-operated oil squirt can. Too much oil can cause a hydrostatic lock, which can damage or break pistons or connecting rods or even crack a cylinder head.

Perform the compression test again and observe the results. If the first-puff readings greatly improve and the readings are much higher than without the oil, the cause of the low compression is worn or defective piston rings. If the compression readings increase only slightly (or not at all), then the cause of the low compression is usually defective valves.

NOTE: During both the dry and wet compression tests, be sure that the battery and starting system are capable of cranking the engine at normal cranking speed.

B. Running (Dynamic) Compression Test

A compression test is commonly used to help determine engine condition and is usually performed with the engine cranking. What is the RPM of a cranking engine? An engine idles at about 600 to 900 RPM, and the starter motor obviously cannot crank the engine as fast as the engine idles. Most manufacturers' specifications require the engine to crank at 80 to 250 cranking RPM.

Therefore, a check of the engine's compression at cranking speed determines the condition of an engine that does not run at such low speeds. But what should be the compression of a running engine? Some would think that the compression would be substantially higher, because the valve overlap of the cam is more effective at higher engine speeds, which would tend to increase the compression.

A running compression test, also called a dynamic compression test, is done with the engine running rather than during engine cranking as is done in a regular compression test. Actually, the compression pressure of a running engine is much lower than cranking compression pressure. This results from the volumetric efficiency.

The engine is revolving faster, and therefore, there is less time for air to enter the combustion chamber. With less air to compress, the compression pressure is lower. Typically, the higher the engine RPM, the lower the running compression. For most engines, the value ranges are as follows:

- Compression during cranking: 125 to 160 PSI
- Compression at idle: 60 to 90 PSI
- Compression at 2,000 RPM: 30 to 60 PSI

As with cranking compression, the running compression of all cylinders should be equal. Therefore, a problem is not likely to be detected by single compression values, but by variations in running compression values among the cylinders.

Broken valve springs, worn valve guides, bent pushrods, and worn cam lobes are some items that would be indicated by a low running compression test reading on one or more cylinders.

C. Performing A Running Compression Test

To perform a running compression test,

- Remove just one spark plug at a time.
- With one spark plug removed from the engine, use a jumper wire to ground the spark plug wire to a good engine ground. This prevents possible ignition coil damage.
- Start the engine, push the pressure release on the gauge, and read the compression.
- Increase the engine speed to about 2,000 RPM and push the pressure release on the gauge again.
- Read the gauge.
- Stop the engine, reinstall the spark plug, reattach the spark plug wire, and repeat the test for each of the remaining cylinders.
- Just like the cranking compression test, the running compression test can inform a technician of the relative compression of all the cylinders.

2.5.6 Cylinder Leakage Test

If a compression test shows that any of the cylinders are leaking, a cylinder leakage test can be performed to measure the percentage of compression lost and to help locate the source of leakage.

A cylinder leakage tester applies compressed air to a cylinder through the spark plug hole. The source of the compressed air is normally the shop's compressed air system. The tester's pressure regulator controls the pressure applied to the cylinder.

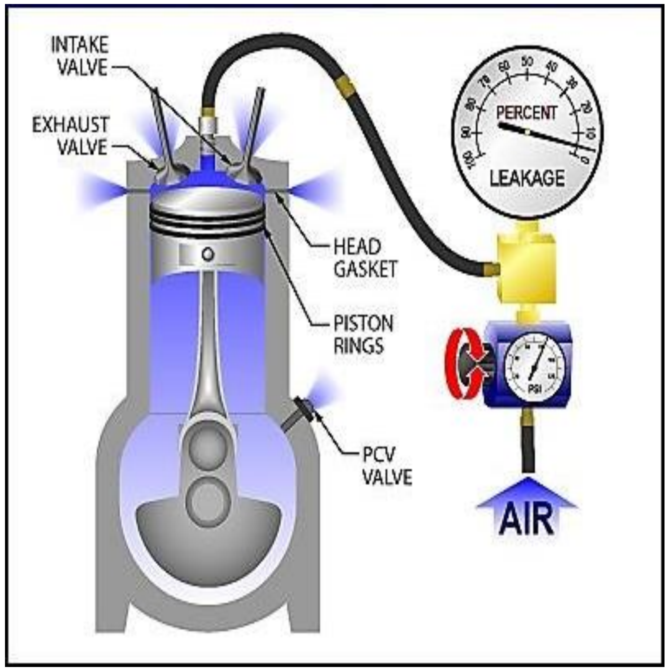


Figure2:8 Leakage Test Process

A gauge registers the percentage of air pressure lost when the compressed air is applied to the cylinder. The scale on the gauge typically reads 0% to 100%. The amount and location of the air that escapes give a good idea of the engine's condition and can pinpoint where compression is lost.

A zero reading means there is no leakage in the cylinder. Readings of 100% indicate that the cylinder will not hold any pressure. Any reading that is more than 0% indicates there is some leakage. Most engines, even new ones, experience some leakage around the rings. Up to 20% is considered acceptable.

Measured Leakage	Conclusion
Less than 10%	Good
Between 10 and 20%	Acceptable
Between 20 and 30%	**Worn engine**
Above 30%	Definite problem
100%	Serious problem

Figure 2:9 Typical Standard of Leakage

When the engine is running, the rings will seal much better and the actual leakage will be lower. The location of the compression leak can be found by listening and feeling around various parts of the engine.

Source of Leakage	Probable Cause
Radiator	Faulty head gasket Cracked cylinder head Cracked engine block
Throttle body	Damaged intake valve
Tailpipe	Damaged exhaust valve
Oil filler or dipstick tube	Worn piston rings
Adjacent spark plug hole	Faulty head gasket Cracked cylinder head

Figure 2: 10 Source of Leakage and Probable Cause

2.6 Exhaust Gas Analysis

The final step in general engine testing is exhaust analysis. For thorough testing, check the exhaust at idle and at 2,500 rpm with the engine warmed to normal operating temperature. Checking the exhaust at idle and at cruising – speed rpm allows you to test the idle and main-metering fuel circuits and emissions at basic and advanced timing.

2.6.1 Exhaust Gases

A popular method of engine gas analysis, involves the use of five-gas exhaust analysis equipment. The five gases analyzed and their significance include:

A. Hydrocarbons

Hydrocarbons (HC) are unburned gasoline and are measured in parts per million (ppm). A correctly operating engine should burn (oxidize) almost all the gasoline; therefore, very little unburned gasoline should be present in the exhaust. Acceptable levels of HC are 50 PPM or less for vehicles with catalytic converter. High levels of HC could be due to excessive oil consumption caused by weak piston rings or worn valve guides. The most common cause of excessive HC emissions is a fault in the ignition system. Items that should be checked include:

- Spark plugs
- Spark plug wires
- Distributor cap and rotor (if the vehicle is so equipped)
- Ignition timing (if possible)
- Ignition coil

B. Carbon Monoxide

Carbon Monoxide (CO) is unstable and will easily combine with any oxygen to form stable carbon dioxide (CO_2). The fact that CO combines with oxygen is the reason that CO is a poisonous gas (in the lungs, it combines with oxygen to form CO_2 and deprives the brain of oxygen). CO levels of a properly operating engine with catalytic converter should be less than 0.5%. High levels of CO can be caused by clogged or restricted crankcase ventilation devices such as the PCV valve, hose(s), and tubes. Other items that might cause excessive CO include:

- Clogged air filter
- Incorrect idle speed
- Too-high fuel-pump pressure
- Any other items that can cause a rich condition

C. Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is the result of oxygen in the engine combining with the carbon of the gasoline. An acceptable level of CO_2 is between 12% and 15%. A high reading indicates an efficiently operating engine. If the CO_2 level is low, the mixture may be either too rich or too lean.

D. Oxygen (O_2)

The next gas is oxygen (O_2). There is about 21% oxygen in the atmosphere, and most of this oxygen should be "used up" during the combustion process to oxidize all the hydrogen and carbon (hydrocarbons) in the gasoline. Levels of O_2 should be very low (about 0.5%). High levels of O_2, especially at idle, could be due to an exhaust system leak.

E. Oxides of Nitrogen (NOx)

An oxide of nitrogen (NO) is a colorless, tasteless, and odorless gas when it leaves the engine, but as soon as it reaches the atmosphere and mixes with more oxygen, nitrogen oxides (NO2) are formed. NO2 is reddish-brown and has an acid and pungent smell. NO and NO2 are grouped together and referred to as NOx, where X represents any number of oxygen atoms. NOx, the symbol used to represent all oxides of nitrogen, is the fifth gas commonly tested using a five-gas analyzer. The exhaust gas recirculation (EGR) system is the major controlling device limiting the formation of NOx.

	Without Catalytic Converter	With Catalytic Converter
HC	300 PPM or less	30 to 50 PPM or less
CO	3% or less	0.3% to 0.5% or less
O_2	0% to 2%	0% to 2%
CO_2	12% to 15% or higher	12% to 15% or higher
NO_x	Less than 100 PPM at idle and less than 1,000 PPM at WOT	Less than 100 PPM at idle and less than 1,000 PPM at WOT

Figure 0-1 Acceptable Exhaust Emissions include

2.6.2 Exhaust Gas Test Procedure

Sample the exhaust at idle and at 2,500 rpm as follows:

1. Using the engine inspection procedure from the beginning of this chapter, be sure that:
   a. The air filter is installed properly and not clogged
   b. The choke is fully open and is not stuck
   c. All vacuum line connections are secure and not leaking

d. The exhaust system is not leaking and the manifold heat control valve will open correctly

2. Be sure the engine is at normal operating temperature and the analyzer probe is installed properly in the tail pipe.
3. Disconnect the outlet line from the air injection pump or pulse air valve.
4. Check and adjust the ZERO and SPAN setting on the analyzer, if required.
5. Run the engine at normal slow idle and note the HC and CO readings (also CO_2 and O_2 if using a 4 – gas analyzer).
6. Increase engine to a steady 2,500 rpm and again note all meter readings. Return the engine to idle and note any change in meter readings as the engine decelerates. Note the meter readings again as the engine runs at steadily idle speed.

   HC and CO emissions should be within legal limits or within the guidelines. Emissions will increase during closed – throttle deceleration, but the readings in step 7 should be as low as, or lower than, the readings in step 5.

2.6.3 O_2 and CO_2 Analysis

CO emissions are directly related to air-fuel mixture. High CO results from a rich mixture, too much gasoline, or not enough air.

A. Common Causes of High CO Emissions

1. A restricted air filter
2. Restricted air passages in the carburetor or injection system.
3. A rich carburetor or injection fuel adjustment.
4. High float level in the carburetor
5. A stuck or improperly adjusted choke
6. Leaking power valve or accelerator pump in the carburetor.
7. Wrong idle speed
8. Engine oil contaminated by fuel due to excessive blow by or a leaking fuel pump. You can isolate this problem by disconnecting the PCV valve from the crankcase and letting it draw fresh air while monitoring exhaust CO. If CO drops by 0.5 percent or more, the oil is probably contaminated with fuel.

High HC emissions indicate unburned fuel in the exhaust. Incomplete combustion due to a lack of ignition (misfire) or a lean mixture will cause high HC. Although ignition problems often cause high HC, engine mechanical problems and vacuum leaks can also increase HC emissions.

B. Common Causes of High HC Emissions

1. Wrong ignition timing
2. Fouled or worn spark plugs, defective secondary cables, worn breaker points, and other ignition problems that cause a misfire.
3. An overly rich or lean air-fuel ratio.
4. Low compression (incomplete combustion)
5. Vacuum leaks at the carburetor, the manifold, the injection system,
6. Worn valve train parts.
7. Worn cylinders and piston rings

C. Combined High Readings For HC And CO

1. Defective catalytic converter or PCV system.
2. A defective thermostatic air cleaner or restricted air filter.
3. A defective manifold heat control valve

D. Rules of thumb for basic HC and CO testing

- High HC emissions indicate a lean mixture or misfire – unburned fuel
- High CO emissions indicate a rich mixture

E. O2 And CO2 Gas Analysis

Late – model cars with catalytic converters can reduce HC and CO at the tailpipe to levels where they are almost no measurable. CO_2 and O_2 , however, can be measured. On a non-catalyst car, high HC indicates unburned gasoline in the exhaust. This is usually due to a lean misfire. On a converter – equipped car, O_2 indicates a lean condition. If O_2 is above 2.0 percent, the air-fuel mixture is probably lean. If O2 is above 4 percent, the mixture is definitely too lean.

At the stoichiometric 14.7:1 air-fuel ratio, HC and CO emissions should be low. Similarly, O_2 should be low, but CO_2 should be high. At lean air fuel ratios, O_2 increases and CO_2 decreases. Also at a 14.7:1 air-fuel ratio, the total percentage of CO and CO2 is about 14.7

percent. Acceptable combustion in a converter – equipped car will produce the following 4 – gas analyzer readings.

- HC and CO – within specifications
- O_2 – 1.0 to 2.0 percent
- CO2 – above 10 percent (ideally 13 to 15 percent)

Self-check 2.1

Directions: Answer all the questions listed below.

Part I: Say True or False

1. Most mechanical engine problems are caused by overheating.
2. A dwell meter is very helpful in locating engine noise by amplifying the sound waves.
3. High CO results from a rich mixture, too much gasoline, or not enough air.
4. If CO drops by 0.5 percent or more, the oil is probably contaminated with fuel.
5. Always make a noise analysis before doing any repair work

Part-II: Choose the appropriate answer from the given alternatives

1. If O_2 exceeds CO and CO is above 0.5 percent, the catalytic converter may be defective. If CO is above 0.5 percent and also higher than O_2, the converter probably is okay, but the air fuel mixture is rich.
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
2. Technician A says that black exhaust smoke is an indication of a too-rich air-fuel mixture. Technician B says that white smoke (steam) is an indication of coolant being burned in the engine. Which technician is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
3. Technician A says that cranking vacuum should be the same as idle vacuum. Technician B says that a sticking valve is indicated by a floating valve gauge needle reading. Which technician is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
4. Two technicians are discussing a cylinder power balance test. Technician A says the more the engine RPM drops, the weaker the cylinder. Technician B says that all cylinder RPM drops should be within 50 RPM of each other. Which technician is correct?
   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
5. A cylinder leakage (leak-down) test indicates 30% leakage, and air is heard coming out of the air inlet. Technician A says that this is a normal reading for a slightly worn engine. Technician B says that one or more intake valves are defective. Which technician is correct?

a. Technician A b. Technician B c. Both A and B d. Neither A nor B

6. The low oil pressure warning light usually comes on _______________.
   a) Whenever an oil change is required
   b) Whenever oil pressure drops dangerously low (3 to 7 psi)
   c) Whenever the oil filter bypass valve opens
   d) Whenever the oil filter anti-drain-back valve opens
7. A compression test gave the following results: cylinder #1 = 155, cylinder #2 = 140, cylinder #3 = 110, and cylinder #4 = 105. Technician A says that a defective (burned) valve is the most likely cause. Technician B says that a leaking head gasket could be the cause. Which technician is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B
8. An engine noise is being diagnosed. Technician A says that a double knock is likely to be due to a worn rod bearing. Technician B says that a knock only when the engine is cold is usually due to a worn piston pin. Which technician is correct?

   a. Technician A b. Technician B c. Both A and B d. Neither A nor B

Part-III: Give a short answer for the following table

No	Description	Probable Source
1.	Honey or Dark Grease	
2.	Green Sticky Fluid	
3.	Slippery Clear or yellowish	
4.	Slippery Red Fluid	
5.	Bluish Watery Fluid	

Operation Sheet 2.1

Operation Title: Power Balance Test

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To check an engine performance

Required Tools and Equipment: Engine Test Light and electrical plier

Precautions: Before making a test make sure engine safe conditions

Quality Criteria: - Check properly the engine performance

Procedures:

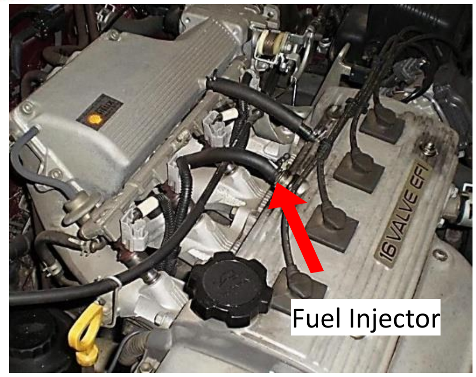
Testing Power Balance of Gasoline Engine steps in the process are noted below.

Step 1: Visually inspect the engine to determine the best method to disable the cylinders. If this involves connecting a scan tool, installing vacuum lines on each coil, or removing spark plug wires, prepare the engine accordingly. If necessary, disable the idle control system.

Step 2: Engine Warm-up. Start the engine and allow it to idle. Record the idle rpm.

Step 3: Using the method chosen to disable cylinders, disable the first cylinder and record the rpm. (Do not leave the cylinder disabled for more than a few seconds).

Note: For Ignition System – Distributor Type: If the vehicle is equipped with distributor, disconnect one spark plug at a time from the distributor cap (itis good to use a test lead to ground the spark at the distributor cap terminal to prevent the spark from damaging the ignition module in the distributor), which shuts down the spark for the cylinder being tester.



Note: For Fuel System – EFI: To disable the fuel injectors that are accessible, disconnecting the electrical connector from each injectors one at a time will shut off the fuel to the cylinder.

Step 4: Reactivate the cylinder and allow the engine to run for approximately 10 seconds to stabilize. Then leave the engine to idle for another 10 seconds before proceeding to the next cylinder.

Step 5: Repeat the steps on each of the cylinders and record your readings. Determine any necessary action.

Testing Power Balance of Gasoline Engine steps in the process are noted below.

The two possible ways are:-

A. Idle speed-drop test

1.5.1.1 Connect a diesel tachometer to the engine according to the equipment maker's direction.

1.5.1.2 Run the engine to normal operating temperature.

1.5.1.3 Loosen a fitting at an injection nozzle or pump outlet line to relief pressure with the engine running at idle.

a. If the cylinder is delivering its share then the engine rpm will drop.
b. If there is no change or less change in engine rpm or engine sound, it means that cylinder does not produce or produces less power.

Note

The problem may be:-

a. Low compression
b. Incorrect valve adjustment or timing
c. An injector that is leaking, sticking, or otherwise malfunctioning.

B. Glow plug resistance test

On some engines, an idle speed drop test will not work because the pump has a pressure relief rotor. When you reduce pressure to one cylinder (loosening the injector fitting), all pump pressure will drop, and the engine will stop.

1. Run the engine to normal operating temperature, then shut if off.
2. Disconnect the alternator so the ohmmeter will not be damaged by voltage through the engine ground of the electrical systems.
3. Disconnect the electrical leads to all glow plugs.
4. Start and run the engine at idle.
5. Set the ohmmeter on its lowest range and connect one lead to a good ground.
6. Touch the other ohmmeter lead to the terminal of each glow plug and not the meter reading.

Note

Check the specification (eg. 1.8 to 3.4 ohm). High resistance within the range shows high temperature in a cylinder. Low resistance within the range shows low cylinder temperature. Glow plug resistance, cylinder temperature, and injector opening pressure are directly related. If one injector opens at slightly lower pressure, it admits more fuel and causes higher temperature and resistance.

Example

Each 0.1ohm resistance difference between cylinders indicates about 30PSI (206.7 kPa) differences in injector pressure opening.

Low resistance and low temperatures can indicate insufficient injection.

Result

Engine Power-balance Test						
Cylinder	1	2	3	4	5	6
Idling rpm						
Test rpm						
Diff/rpm						
Remark						
Note: For the remark, write **G** (Good) if the cylinder is contributing power and write **F** (Failed) if the cylinder does NOT contribute power.						

Observation: ____

Operation Sheet 2.2

Operation Title: Compression Test

Instruction:

- Always wear safety eye protection.
- Put transmission in “park” (for automatic) or “neutral” (for manual). Set parking brake and block drive wheels.
- Make sure the fuel system is disable to prevent the car from accidental starting.

Purpose: To check an engine performance

Required Tools and Equipment: Compression gauge kit, spark plug socket, basic hand tools, vehicle service manual and a notepad to record results.

Precautions: Before making a test make sure engine safe conditions

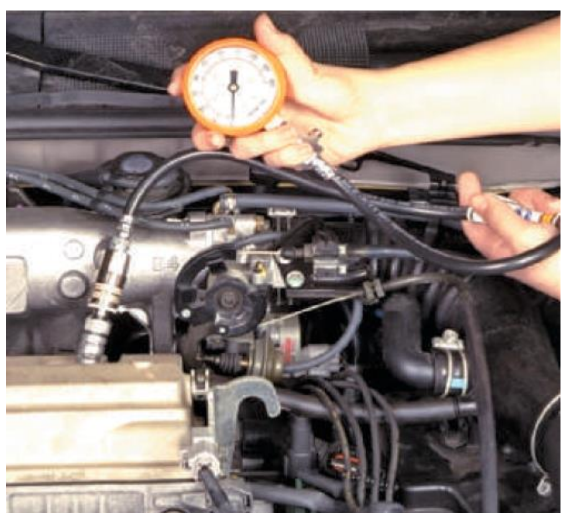
Quality Criteria: - Properly check the Compression test

Before Testing

- To ensure that compression readings are accurate, perform the following pre-test procedures.
- Make sure the vehicle battery is fully charged, and the starter system is in good condition.
- Warm up the engine until normal operating temperature is reached.
- Make sure to remove all glow plugs before performing the compression test, or for non-glow plug diesel engine remove all the fuel injectors.

Procedures:

1. Run the engine to normal operating temperature; then stop the engine.
2. Use compressed air to blow dirt away from the spark plugs or glow plugs.
3. Remove all spark plugs (gaskets and plug tubes, if installed) or glow plugs and keep them in cylinder number order for reinstallation.
4. Disable the ignition or diesel injection system.



5. On a gasoline engine, block the throttle and choke linkage fully open to allow air to enter the engine. This also keeps fuel from being drawn through the idle and low-speed circuits of the carburetor, which could flood the engine and reduce cylinder lubrication.
6. Connect a remote starter switch to the engine, if desired.
7. Connect the gauge in to the plug opening of cylinder number 1 by:
   a. Screwing a gauge adapter into the threaded opening or
   b. Inserting a tapered rubber gauge adapter into the plug opening and holding it firmly during testing,

Using the ignition switch or a remote starter switch, crank the engine for four complete compression strokes on that cylinder. Note the gauge reading on the first and fourth strokes.

Disconnect the gauge from the first cylinder and repeat step 7 and 8 on all other cylinders. Compare the gauge readings to the carmaker's specifications and the following test guidelines.

a) Compression increases steadily on all four strokes and is within specifications – the cylinder compression is okay.
b) Compression is low on the first stroke and increases on following strokes but does not reach specifications – the piston rings or cylinder is probably worn.
c) Compression is low on the first stroke and increases only slightly on following strokes – the valves may be sticking or burned, or rings may be broken.
d) Compression in two side – by – side cylinders is low – the head gasket probably is leaking between the cylinders.
e) The gauge reading is higher than normal – that cylinder may have excessive carbon deposits in the combustion chamber.

If compression is low in any cylinder, you can continue with a wet compression test as follows:-

Caution

Do not perform a wet compression test on a diesel engine. Oil in the cylinders may cause premature ignition and engine damage.

Wet compression testing is not valid on a horizontal engine because oil will not flow evenly around a horizontal piston.

1. Pour a small amount of oil (about 1 tablespoon or 8 squirts from an oil can) into the cylinder through the spark plug opening.
2. Allow about 30 seconds for the oil to flow around the top of the piston.
3. Repeat step 7 and 8 of the basic compression test.
4. Compare the wet test results to the basic test results for that cylinder.

If compression increases by 5 percent or 12 to 14PSI, or more, that cylinder probably has worn rings or cylinder walls. If compression does not increase, that cylinder probably has leakage past the valves or head gasket.

Operation Sheet 2.3

Operation Title: Cylinder Leakage Test

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To check an engine performance

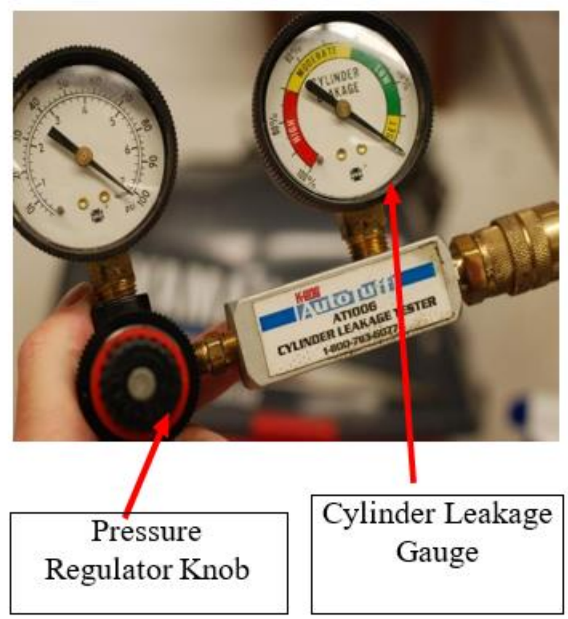
Required Tools and Equipment: Air source, a leak-down gauge kit, spark plug socket, basic hand tools, vehicle service manual and a notepad to record results.

Precautions: Before making a test make sure engine safe conditions

Quality Criteria: - Properly check the cylinder leakage

Procedures:

To perform the cylinder leakage test, take the following steps:



Step 1: For best results, the engine should be at normal operating temperature (upper radiator hose hot and pressurized).

Step 2: Remove the radiator cap, oil filler cap, dipstick tube, air filter cover, and all spark plugs or glow plugs.

NOTE: Take precaution when removing the radiator cup, because the engine is warm – pressure has been develop in the cooling system. Refer to service manual on how to release radiator pressure.

Step 3: Connect the tester input port to the air compressor and calibrate the cylinder leakage unit as per manufacturer's instructions.

NOTE: Set the leakage gauge to zero by turning the pressure regulator knob.

Step 4: Connect the leakage tester with the appropriate adaptor into the spark plug or glow plug hole. Make sure the cylinder being tested must be at top dead center (TDC) of the compression stroke.

NOTE: The greatest amount of wear occurs at the top of the cylinder because of the heat generated near the top of the cylinders. The piston ring flex also adds to the wear at the top of the cylinder.

Step 5: Inject air into the cylinders one at a time, and take note of the result (Job Sheet 3).

Evaluate the results:

- Less than 10% leakage: good
- Lessthan20%leakage: acceptable
- Less than 30% leakage: poor
- Morethan30%leakage: definite problem

NOTE: If leakage seems unacceptably high, repeat the test, being certain that it is being performed correctly and that the cylinder being tested is at TDC on the compression stroke.

STEP 6: Check the source of air leakage.

- If air is heard escaping from the oil filler cap, the piston rings are worn or broken.
- If air is observed bubbling out of the radiator, there is a possible blown head gasket or cracked cylinder head.
- If air is heard coming from the throttle body or air inlet on fuel-injection- equipped engines, there is a defective intake valve(s).
- If air is heard coming from the tailpipe, there is a defective exhaust valve(s).

Step 7: Repeat process to all cylinders by following the firing order.

- For four cylinder turn the crankshaft 180 degrees for the next piston to TDC compression.
- For six cylinder turn the crankshaft 120 degrees for the next piston to TDC compression.
- For 8 cylinder turn the crankshaft 90 degrees for the next piston to TDC compression

SHOP TALK

Some leakage testers read in the opposite way; a reading of 100% may indicate a totally sealed cylinder, whereas 0% indicates a very serious leak. Always refer to the manufacturer's literature before using test equipment.

Operation Sheet 2.4

Operation Title: Checking Engine Vacuum

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications for vacuum (Most engine specification for idle vacuum is 17 – 21 in. Hg.)

Purpose: To check the engine vacuum

Required Tools and Equipment: Engine Vacuum Tester

Precautions: Before testing make sure the vacuum tester plug tighten properly

Quality Criteria: - Check properly the vacuum with the standard

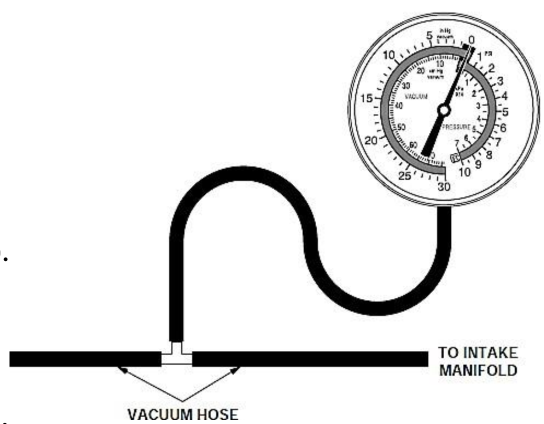
Procedures:

The steps in the process are noted below.

Checking Vacuum at Engine Idle

NOTE: Refer to your vehicle's service manual to obtain the manufacturer's specifications for vacuum (Most engine specification for idle vacuum is 17 – 21 in. Hg.)

1. Make Sure the ignition is off.
2. Locate a vacuum hose which is connected directly to the intake manifold. Disconnect the vacuum hose and connect the gauge in its place.
3. Start engine and idle (Be sure engine is warm-up).
4. Note the value of vacuum and compare this value to the manufacturer's specifications.
5. If vacuum indication is LOWER than specified, check for the following:
6. Incorrect ignition timing
7. Incorrect valve timing or adjustment
8. Incorrect idle mixture screw adjustment
   - ✓ Worn piston rings (cylinder compression)
   - ✓ Intake manifold vacuum leaks



- If vacuum indication OSCILLATES SLOWLY, check for incorrect idle mixture screw adjustment.
- If vacuum indication OSCILLATES RAPIDLY, check for the following:
  - ✓ Sticky valve guides
  - ✓ Burned valve seats
  - ✓ Leak(s) in the head gasket

Checking Vacuum at High Speed

1. With gauge connected and engine idling as described above, increase engine speed to approximately 2000 RPM.
2. Note the new vacuum value.

- If vacuum value at high speed is LOWER than value at idle, check for restriction(s) in the exhaust system.
- If vacuum indication OSCILLATES, check for weak valve springs.

Observation:

3. Start the engine and run it at idling speed. Observe the vacuum gauge based on the vacuum test guide. What is the condition?

____

____

4. Accelerate the engine rpm to 2,000 rpm and maintain it for a few seconds. Observe the vacuum gauge based on the vacuum test guide. What is the condition?

____

____

5. Adjust the ignition timing to advance and retard. At idling speed observe the vacuum gauge based on the vacuum test guide. What is the condition?

____

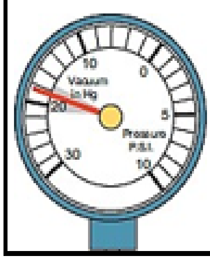
____

6. Cover the exhaust pipe to create a restriction. Accelerate the engine rpm to 2,000 rpm and maintain it for a few seconds. Observe the vacuum gauge based on the vacuum test guide. What is the condition?

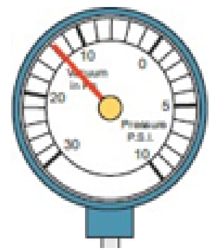
____

____

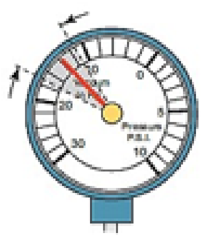
Vacuum Test Guide



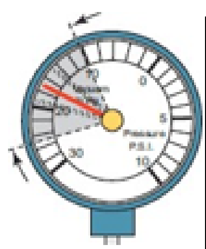
An engine in good mechanical condition should produce 17 to 21 in. Hg of vacuum at idle at sea level.



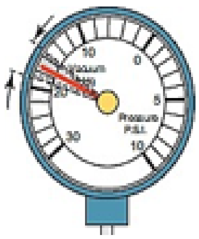
A Steady but low reading could indicate retarded valve or ignition timing.



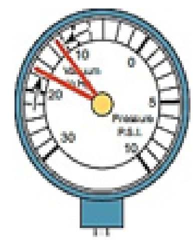
A gauge reading with the needle fluctuating 3 to 9 in.Hg below normal often indicates a vacuum leak in the intake system



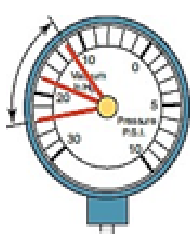
A Leaking head gasket can cause the needle to vibrate as it moves through a range from below to above normal.



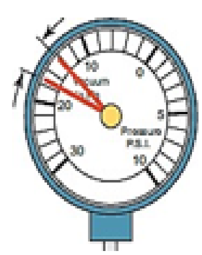
A rapid vibrating needle at idle that becomes steady as engine speed is increased indicates worn valve guide



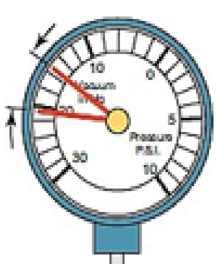
If the needle drops 1 or 2 in.Hg from the normal reading, one of the engine valves is burned or not seating properly



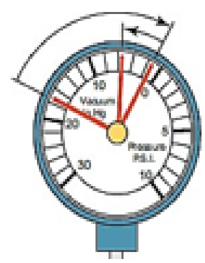
Weak valve springs will produce a normal reading at idle, but as engine speed increases, the needle will fluctuate rapidly between 12 and 24 in.Hg.



A steady needle reading that drops 2 or 3 in.Hg when the engine speed is increased slightly above idle indicates that the ignition timing is retarded



A steady needle reading that rises 2 or 3 in.Hg when the engine speed is increased slightly above idle indicates that the ignition timing is advanced



A needle that drops to near zero when the engine is accelerated rapidly and then rises slightly to a reading below normal indicatesan external

Operation Sheet 2.5

Operation Title: Oil Pressure Testing

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To check an engine performance

Required Tools and Equipment: Engine Test Light and electrical plier

Precautions: Before making a test make sure engine safe conditions

Quality Criteria: - Check properly the oil pressure in engine

Procedures:

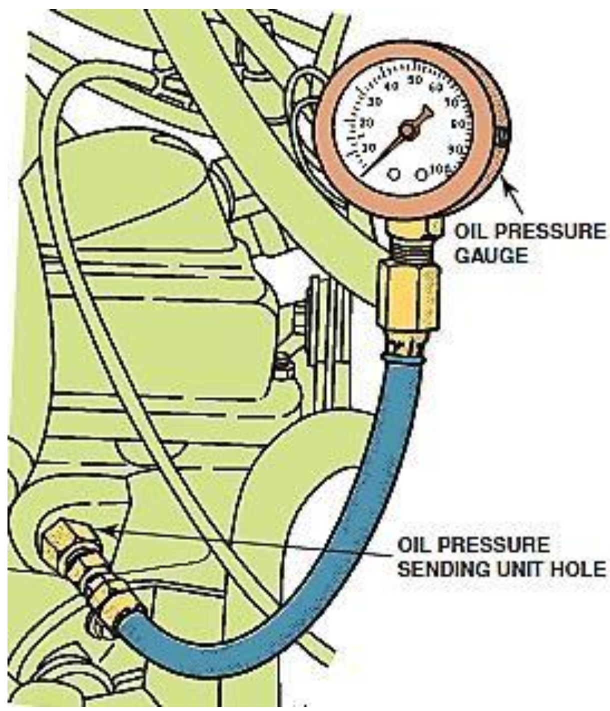
Oil pressure testing is usually performed with the following steps.

Step 1: Operate the engine until normal operating temperature is achieved.

Step 2: With the engine off, remove the oil pressure sending unit or sender, usually located near the oil filter. Thread an oil pressure gauge into the threaded hole

Note: An oil pressure gauge can be made from another gauge, such as an old air-conditioning gauge and a flexible brake hose. The threads are often the same as those used for the oil pressure sending unit.

Step 3: Start the engine and observe the gauge. Record the oil pressure at idle and at 2500 RPM. Most vehicle manufacturers recommend a minimum oil pressure of 10 PSI per 1000 RPM. Therefore, at 2500 RPM, the oil pressure should be at least 25 PSI.



To measure engine oil pressure, remove the oil pressure sending (sender) unit usually located near the oil filter. Screw the pressure gauge into the oil pressure sending unit hole.

Step 4: Always compare your test results with the manufacturer's recommended oil pressure. Besides engine bearing wear, other possible causes for low oil pressure include:

- Low oil level
- Diluted oil
- Stuck oil pressure relief valve

Step 5: The red oil pressure warning lamp in the dash usually lights when the oil pressure is less than 4 to 7 PSI, depending on vehicle and engine. The oil light should not be on during driving. If the oil warning lamp is on, stop the engine immediately. Always confirm oil pressure with a reliable mechanical gauge before performing engine repairs. The sending unit or circuit may be defective.

Operation Sheet 2.6

Operation Title: Petrol Engine Exhaust Gas Analysis

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To measure the concentration of different exhaust gas

Required Tools and Equipment: Exhaust Gas Analyzer

Precautions: Before making a test make sure engine safe conditions

Quality Criteria: - Measure properly the gases in exhaust gas

Procedures:

1. Compare the gas reading on different rpm with normal engine condition and with fault (Disable the ignition of one cylinder by using test lamp to by-pass the current or adjust the spark plug gap to widen or closed).
2. While performing exhaust gas analysis, monitor the oxygen sensor signal with the use of oscilloscope. Draw the signal of the oxygen sensor on the graph below.

Petrol Emission Test: Gas Reading				
Gas	**Reference**	**Actual**		**Remark (Passed/Failed)**
		Low Speed (Idling Speed)	**High Speed (2,500rpm)**	
CO	0 - 3%			
CO2	12 – 15% or higher			
HC	0 - 300 ppm			
NO	0 – 800 ppm			
O2	0 – 2%			
Lambda (λ) - 1	450 mv (14.7:1 A/F)			

Note: For lambda place if the air-fuel mixture is normal, lead or rich mixture.

Diagnostic Results:

Carbon MoNOxide____

Carbon Dioxide____

Hydrocarbon____

Oxygen____

Unit Three: Rectifying Engine Faults

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Engine Mechanical Tune-Up
- Fuel System Tune-Up
- Engine Electrical Systems Tune-Up

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Perform Engine Mechanical Tune-Up
- Carry out Fuel System Tune-Up
- Perform Engine Electrical Tune-Up

3.1 Engine Mechanical Tune-Up

3.1.1 Valve Adjustment

Mechanical valve lifter adjustment is an engine service rather than a test. However, incorrect valve clearance (valve lash) can cause combustion problems that you will detect during engine testing. Accurate engine tuning is impossible if valve clearances are too tight or too loose. Hydraulic valve lifters, which require no periodic adjustment, have been used on many passenger car engines for decades. Many other engines, however, have mechanical lifters, or cam followers, that do require adjustment. You will find adjustable lifters, or followers, on several high – performance engines.

A. Valve Clearance Specifications

Valve clearance, or valve lash, is the gap between the rocker arm or the cam follower and the tip of the valve stem when the valve is closed. Clearance specifications are measured when the heel or base of the cam lobe is against the tappet or follower and the gap is at its maximum.

Valve clearance specifications are given either as hot or cold measurements. Cold clearances usually are greater than hot clearances for the same engine. This allows for metal expansion in a hot engine. If you adjust the valves with the engine cold, coolant temperature should be close to ambient air temperature.

If you adjust the valves hot, the engine must be fully warmed to its normal operating temperature. You can adjust the valves with the engine running or with it off, as explained below. If you adjust the valves with the engine off and adjustment takes more than 5 to 10 minutes, reinstall the valve covers and run the engine to keep it hot.

Intake valve clearances range from 0.004 to 0.025 inch (0.10 to 0.64mm). Exhaust valve clearances range from 0.004 to 0.030 inch (0.10 to 0.76mm). Exhaust valve clearances usually are greater than intake valve clearances because exhaust valves run hotter and expand more.

We have discussed how you discover waste and what to do to remove it; but it doesn’t end there. Unfortunately, problems always crop up, and we prevent them from becoming sources of waste we will be right back where we started in no time at all. That is one reason why one of the very first things mentioned about discovering waste adopting the right attitude. If everyone is paying attention to keeping waste from taking hold, then you have a good chance of sustaining production flow. There are four important methods you can use for maintaining a waste-free production environment.

B. Checking Valve Clearance

To check the clearance of any valve accurately, hot or cold, you must rotate the engine so that the valve is fully closed and the heel, or base circle, of the cam lobe is on the tappet. This provides maximum clearance.

Insert a flat feeler gauge of the specified thickness between the valve stem and the rocker arm or cam follower. Special feeler gauges for valve adjustment may be bent for easier adjustment of valves near manifolds or at the rear of an engine.

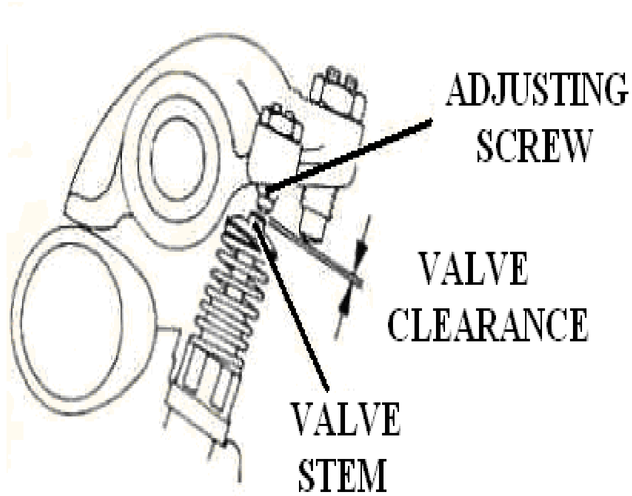


Figure 3: 1 Checking Valve Clearance

Some gauges are the go/no-go type. These have two thicknesses on one blade. The outer, thinner, part of the gauge will fit into the gap when clearance is correct. The inner, thicker, part will not.

On a high-mileage engine, or one that has run for a long time within correctly adjusted valves, the rocker arms or followers may be worn.

In this case, a feeler gauge may give an inaccurate measurement, and clearance will be too large. The best solution to this problem is to reface the rockers or followers to remove the wear. However, you may be able to adjust such worn valve train parts by using a narrow feeler gauge that fits into the wear area.

C. Valve Adjustment Methods

The valve-train clearance on engines with solid or mechanical valve lifters (tappets) must be adjusted after any cylinder-head or valve service. The vehicle maintenance schedule may also require a valve adjustment periodically. This is the same as adjusting valve clearance or making a tappet or lash adjustment. "Lash" means free play or clearance.

Engines with hydraulic valve lifters and lash adjusters normally require no adjustment of valve-train clearance. The clearance is taken up hydraulically. The hydraulic lifter or lash adjuster also takes care of any small changes in the valve-train length.

In any valve train, refinishing the valves and seats reduces valve-train clearance. Too much clearance results from worn valve-train parts. Because exhaust valves run hotter and expand more, exhaust-valve clearance usually is greater than intake-valve clearance. Too much valve clearance causes noise and poor engine performance. Too little valve clearance causes valve and seat burning.

a) Overhead Valve Clearance Adjusting

I. Adjusting Valve Clearance in Solid-Lifter OHV

1. The engine should be off and at normal operating temperature.
2. Disable the ignition and remove the valve cover.
3. Bump the crankshaft with the starting motor until the heel or base circle of the cam is under the valve lifter.
4. Measure the clearance between the valve stem and rocker arm with a thickness gauge (feeler gauge).
5. Turn the adjusting screw until the clearance is within the manufacturer's specifications.
6. Tighten the locknut and recheck the clearance.

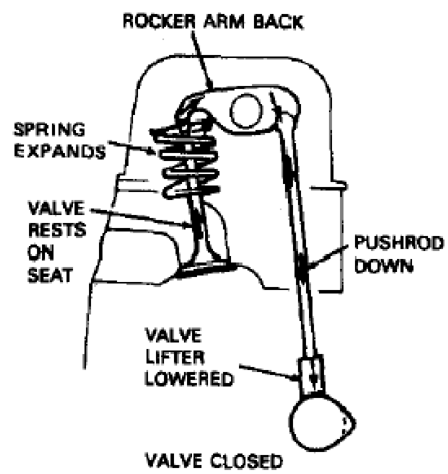


Figure 3: 2 Adjusting valve clearance on an OHV engine that has solid lifters and shaft-mounted rocker arm

II. Adjusting Hydraulic Valve Lifters on OHV Engines

Adjustment of the hydraulic-lifter initial setting may be needed after resurfacing the cylinder head or refinishing the valves and seats. This adjustment should properly position the lifter plunger in the center of its travel. Sometimes additional clearance is needed and no adjustment method is provided by the engine manufacturer. Then up to 0.020 inch (0.5 mm) may be ground off of the tip end of the valve stem. An excessively high valve stem will bottom the plunger in the lifter.

Figure 3: 3 OHC Valve train with bucket tappets showing location of adjusting shims inside the bucket tappets.

A. Turn the crankshaft until the lifter is on the base circle of the cam.
B. Use a tappet collapse to force the oil out of the lifter.
C. This bottoms the plunger in the lifter.
D. Check valve clearance with a thickness gauge.
E. Install a longer pushrod is the clearance is excessive. Pushrods are available in various lengths.
F. If the clearance is too small, use a shorter pushrod.

III. Adjusting Valves on OHC Engines

Overhead-camshaft (OHC) engine use a variety of valve trains to operate the valves. OHC engines with hydraulic tappets or lash adjusters normally do not require valve adjustments. Various adjusting methods are used with mechanical tappets. On an OHC engine, always check valve-train clearance every time the cylinder head is resurfaced. Cylinder-head resurfacing changes the center-to-center distance between the crankshaft and the camshaft. This then affects valve timing.

1) Solid Bucket Tappets

A. Rotate the crankshaft until the tappet is loose.
B. Measure the clearance between the adjusting shim and the base circle of the cam with a thickness gauge.
C. Change the thickness of the shim to adjust the clearance.
D. To remove the shim, a special spring depressor may be needed to slightly compress the spring.
E. Then remove the shim with special pliers.

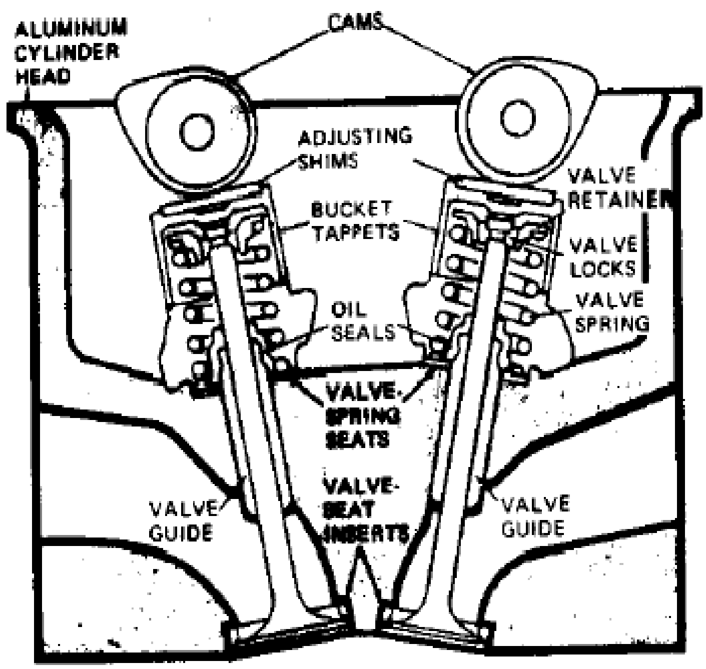


Figure 3: 4 Adjusting Hydraulic Valve Lifters on OHV Engines

2) Adjustable Shaft-Mounted Rocker Arms

A single overhead camshaft (SOHC) uses adjustable rocker arms mounted on shafts to operate the valves.

A. Rotate the crankshaft until the rocker arm is on the base circle of the cam.
B. Measure the clearance between the rocker-arm adjusting screw and the valve stem.
C. If adjustment is necessary, hold the adjusting screw with a screwdriver.
D. Loosen the locknut and turn the adjusting screw to get the specified clearance.
E. Then tighten the locknut and recheck the clearance.

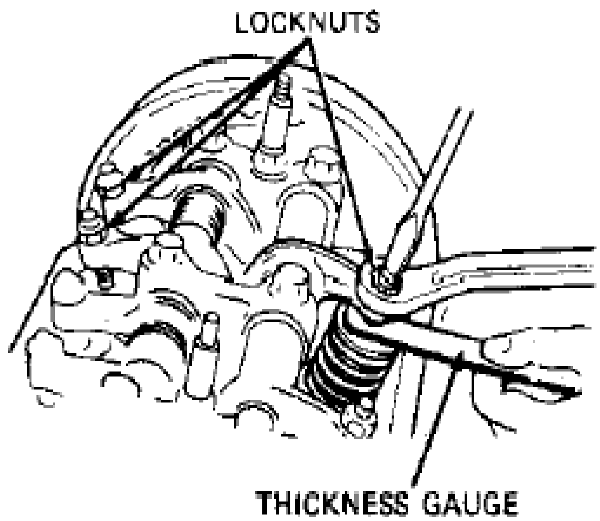


Figure 3: 5 Adjustable Shaft-Mounted Rocker Arms

3) Adjustable Stud-Mounted Rocker Arms

A. Turn the crankshaft until the lifter is on the base circle of the cam.
B. Measure the clearance between the rocker-arm and the valve stem
C. Adjust the clearance by turning the stud nut.

Valve train for an OHC engine using a rocker arm. The valve-train clearance is adjustable by turning the nut on the rocker-arm stud.

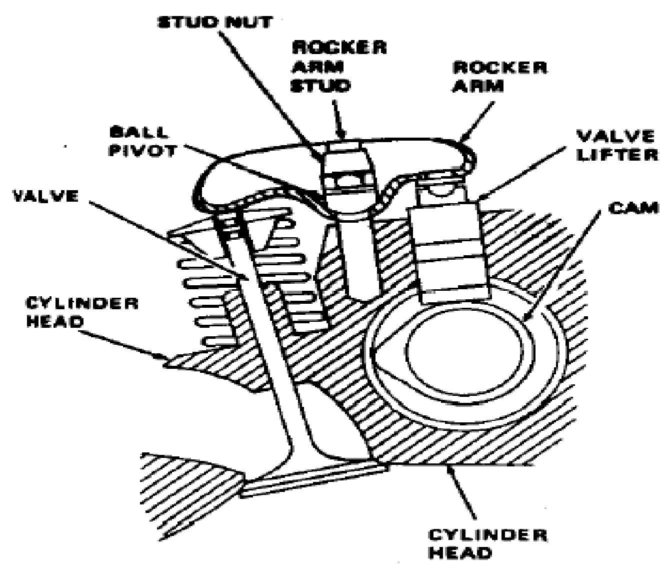


Figure 3:6 Valve train for an OHC engine using a rocker arm. The valve-train clearance is adjustable by turning the nut on the rocker-arm stud.

4) Adjustable Stud and Floating Rocker Arms

A. Rotate the crankshaft until the base circle of the cam is over the center of the rocker arm.
B. Measure the clearance between the two with a thickness gauge
C. Adjust the clearance by loosening the locknut and turning the adjusting screw.
D. Turning the screw increases clearance.
E. After making the adjustments, tighten the locknut.
F. Then recheck the clearance.

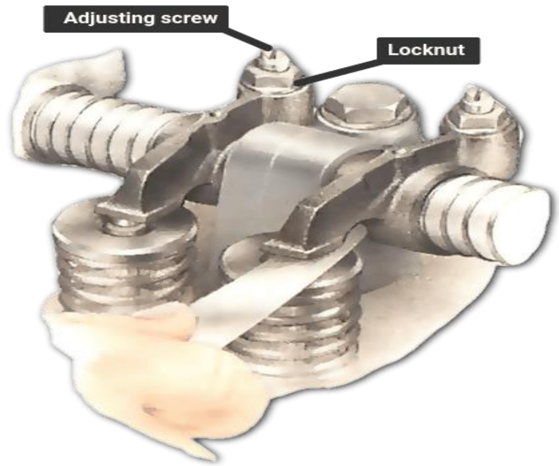


Figure 3:7 OHC Valve Train With Bucket Tappets Showing Location Of Adjusting Shims Inside The Bucket Tappets.

D. Adjusting Valves with the Engine Running and Off

a) Adjusting Valves with the Engine Off

You can adjust the valves of any engine with the engine off. Overhead – cam engines with removable cam follower discs or tapered adjusting screws must be adjusted with the engine off.

To adjust valves with the engine off, either hot or cold, you must rotate the engine so that the valves for a particular cylinder are fully closed. You can do this accurately and quickly by using the cylinder running mate principle:

1. Write down the engine firing order. A typical 4 – cylinder engine firing order is 1-3-4-2
2. Write the first half of the firing order above the second half:

   1 – 3

   4 – 2

   The cylinders written above and below each other are running mates. When one cylinder is at TDC on the exhaust stroke, the other is at TDC on the compression stroke with both valves closed.
3. With the valve cover removed, rotate the engine until the exhaust valve of number 4 cylinder just closes.

4. Adjust the intake and exhaust valves of number 1 cylinder. Both valves are fully closed because the piston is at TDC on the compression stroke.
5. Rotate the engine until the exhaust valve of number 2 cylinder just closes and adjust the valves for number 3 cylinder.
6. Continue to rotate the engine and adjust the valves for cylinders 4 and 3 in the same way.

Carmakers often provide instructions that are a variation on this method, but you can use the above procedure on any engine.

b) Adjusting Valves with the Engine Running

If an engine has adjustment screws in the rocker arms (either in the ends or in the center pivot), you usually can adjust the valves with the engine running. Be sure the engine is completely warmed up and use hot valve clearance specifications. Follow the carmaker's procedures and these guidelines for easy and accurate adjustment.

- Work in a logical pattern from one end of the engine to the other
- Run the engine at its slowest idle speed.
- Adjust all intake or all exhaust valves first.
- Adjust auxiliary intake valves before adjusting the main intake valves.
- Insert the specified feeler gauge between the rocker arm and the valve stem.
  - ✓ If the gauge slides freely with a slow, steady drag and engine speed does not change, clearance is correct.
  - ✓ If you have to force the gauge and the engine misfires or stubbles, clearance is too tight.
  - ✓ If the gauge slides easily with a jerky feel, clearance is too loose.
- Turn the adjusting screw as needed to change the clearance.

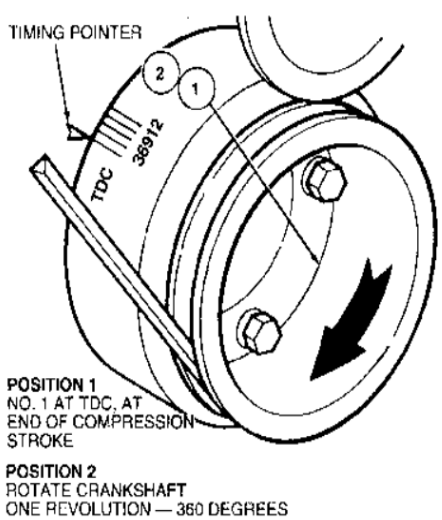
3.1.2 Valve Timing

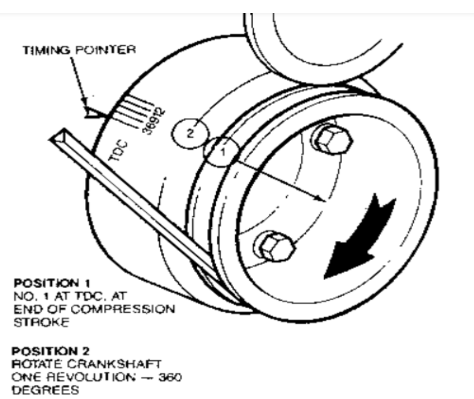
Valve Timing adjustment determines how far the valves enter the cylinder and how long they stay open and/or closed. While all valve adjustments must be made as accurately as possible, it is better to have the valve adjustment slightly loose than slightly tight, as a burned valve may result from overly tight adjustments.

The valve stem-to-rocker arm clearance for all engines should be within specification with the valve lifter completely collapsed. To determine the rocker arm-to-valve lifter clearance, make the following checks:

1. Set the No. 1 piston on TDC of the compression stroke. The timing marks on the camshaft and crankshaft gears will be together. Check the clearance in the No. 1 intake, No. 1 exhaust, No. 2 intake and No. 3 exhaust valves.
2. Rotate the crankshaft 1 complete turn (360°), or 180° for the camshaft gear. Check the clearance on the No. 2 exhaust, No. 3 intake, No. 4 intake and No. 4 exhaust valves.
3. The clearance between the rocker arm and the valve stem tip should be 0.071- 0.170 in. (1.80-4.34mm) with the lifter on the base circle of the cam.
4. Rotate the engine until the No. 1 cylinder is at TDC of its compression stroke and check the clearance between the following valves:
    - No. 1 intake and No. 1 exhaust valves
    - No. 3 intake and No. 2 exhaust valves
    - No. 6 intake and No. 4 exhaust valves
5. Rotate the crankshaft 360° and check the clearance between the rocker arm and the following valves:
    - No. 2 intake and No. 3 exhaust valves
    - No. 4 intake and No. 5 exhaust valves
    - No. 5 intake and No. 6 exhaust valves

6. The clearance should be 0.085-0.185 in. (2.15-4.69mm) for the 3.0L engine and 0.089-0.189 in. (2.25-4.79mm) for the 3.8L engine.





CYL. NO.	CRANKSHAFT POSITION 1	2
	SET GAP OF VALVES NOTED	
1	INT — EXH	NONE
2	EXH	INT
3	INT	EXH
4	EXH	INT
5	NONE	INT — EXH
6	INT	EXH

Figure 3:8 Valve Timing Adjustment

For doing Valve timing referring Timing Cycle

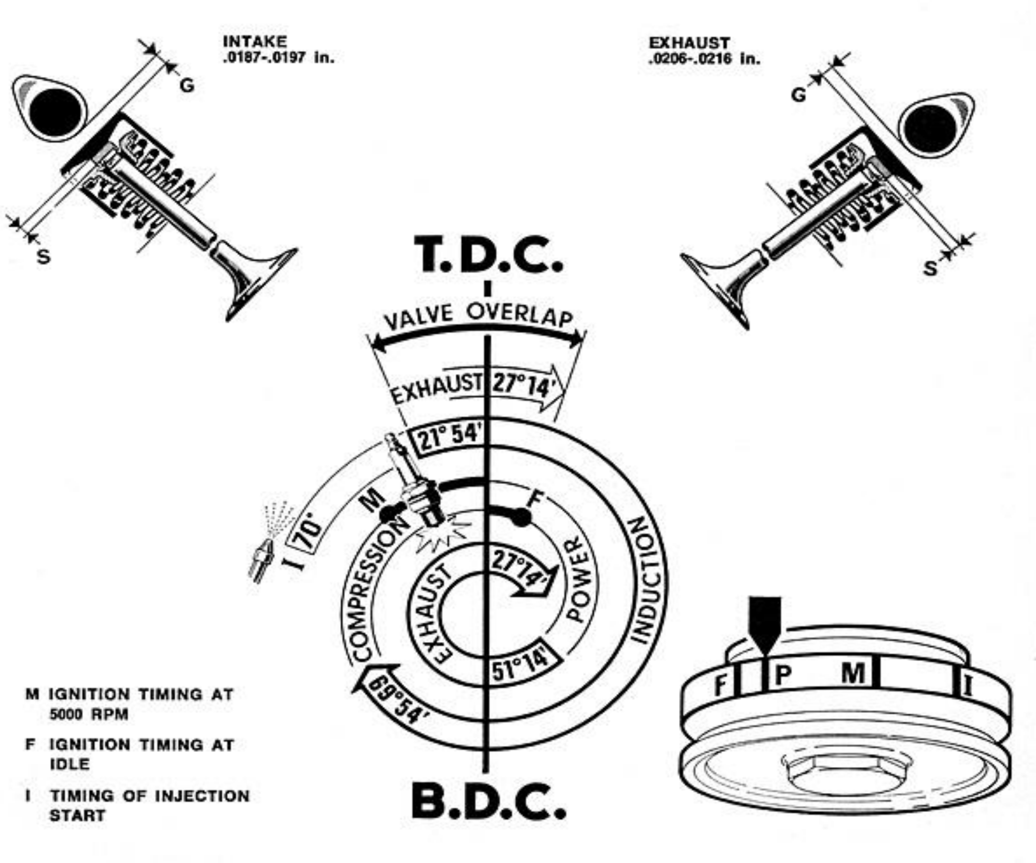


Figure 3: 9 Timing Cycle Chart

3.2 Fuel System Tune-Up

3.2.1 Tuning Up Gasoline Fuel System

A. Carburetor

I. Carburetor Troubles

Engine troubles can come from many other causes besides problems in the fuel system and carburetor. Troubles caused by conditions inside the carburetor itself are listed and described below.

- **Excessive fuel consumption can result from:**
  1. A high float or dirty float needle valve
  2. A sticking or dirty float needle valve
  3. Worn jets or nozzles
  4. A stuck metering rod or power piston
  5. Idle too rich or too fast

6. A stuck accelerator pump check valve
7. A leaky carburetor
8. A dirty air cleaner

- **Lack of engine power, acceleration, or high-speed performance can result from**
    1. The power step-up on the metering rod not clearing the jet
    2. Dirt or gum clogging the fuel nozzle or jets
    3. A stuck power piston or valve
    4. A low float level
    5. A dirty air cleaner
    6. The choke stuck or not operating
    7. Air leaks into the manifold
    8. The throttle valve not fully opening
    9. A rich mixture, due to causes listed under item 1, above
- **Poor idle**
    1. A leaky vacuum hose
    2. A stuck PCV valve
    3. Retarded timing
    4. An incorrectly adjusted idle mixture or speed
    5. Clogged idle system
    6. Causes listed under item 2
- **Failure of the engine to start unless primed**
    1. No gasoline in the fuel tank or carburetor
    2. Wrong tank cap, or a plugged tank or cap vent, which cause a vacuum to develop in the tank, which prevents delivery of fuel to the carburetor.
    3. Holes in the fuel- pump flex line, which allow air leakage and prevent fuel delivery
    4. Carburetor jets or lines clogged
    5. Defective choke
    6. Clogged fuel filter
    7. Air leaks into the manifold
    8. Hard starting with the engine warm could be due to an inoperative choke
    9. Slow engine warm-up could be due to a defective choke or manifold heat-control valve.

10. A smoky, black exhaust is due to an over-rich mixture. Carburetor conditions that could cause this are listed in item 1 above.
11. If the engine stalls as it warms-up, this could be due to a defective choke
12. If the engine stalls after a period of high speed driving, this could be due to malfunctioning anti percolator.
13. If the engine back fires, this could be due to an excessively rich or lean mixture. If the noise is in the exhaust system, it is usually caused by an excessively rich mixture in the exhaust gas. This results from a defective air-injection-system anti -back fire valve. Lean mixture usually caused a pop back though the intake manifold to the carburetor.
14. If the engine runs but misses, the most likely cause is a vacuum leak. It may be caused by a vacuum hose or intake manifold leak.
15. Some of the above conditions can be corrected by external adjustments, others require removal of the carburetor from the engine so that it can be disassembled, repaired, and reassembled.

II. Carburetor Quick Checks

a) Float Level

With the engine idling, observe the high-speed discharge jet. If the tip of this jet is wet and fuel is dripping from the jet, then the float level is probably too high or the fuel pump pressure too great.

b) Idle and Low Speed Circuits

A rough or uneven idling condition that cannot be corrected by minor adjustment of the mixture or speed screws indicates problems in the idle or low speed circuits. Rough operation at the off idle speeds indicates problems in the low speed circuit.

c) High Speed Circuits

With the engine running at medium speed, slowly cover part of the air horn with a piece of stiff cardboard. If the engine increases its speed slightly, then the system is working properly. If the speed remains the same or slows down, then the system requires service.

d) Accelerator Circuit

A small amount of fuel should spray from the accelerator discharge jet each time the throttle valve is opened. The discharge should continue for a few seconds after the movement of the throttle has been stopped. Failure of either condition indicates repairs are required.

III. Carburetor Adjustments

At one time, there were several adjustments that could be made on carburetors. Now the requirements of the clean Air Act regarding automotive emissions have eliminated most adjustments. Today, the only carburetor adjustment for most cars is to adjust the idle speed. The idle mixture is preset at the factory, and limiter caps, dowels, or plugs are installed to prevent tampering. The adjustment procedure is shown in a tune up decal in the engine compartment. The decal procedure must be followed.

a) Idle Speed and Mixture Adjustment

Idle speed and mixture adjustments vary considerably for different cars of different years. The principles explained below will help use the manufacturer's procedure more easily. Remember that on many late model engines, the mixture screws are sealed. Also, some carburetors have electronic idle speed control, and traditional speed adjustment is not possible. Generally, you will adjust idle speed first, then the mixture. After adjusting the mixture, check and readjust the speed. Then recheck the mixture adjustment. Before any adjustment, do the following:

There are several kinds of throttle solenoids, each with different adjustment procedures, but we can group them into five basic types:

a) Solenoid adjusted by turning the plunger in or out.
b) Throttle linkage with an idle speed screw that is turned in or out to contact the solenoid plunger.
c) Solenoids on movable brackets with bracket adjustment screws.
d) Solenoids with an adjusting screw or nut at the rear of the solenoid
e) Solenoids that are rotated in a bracket after loosening a locknut.

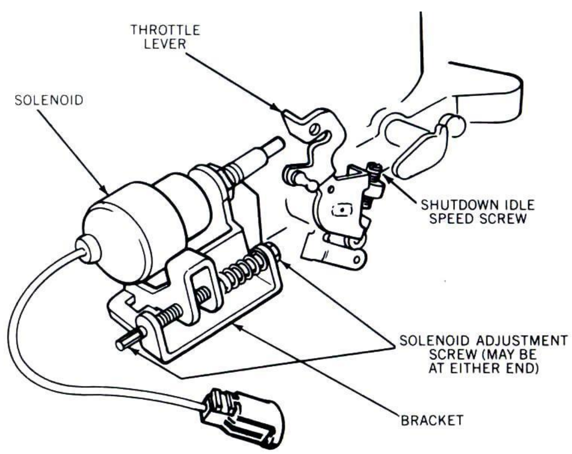


Figure 3: 11 Solenoids on Movable Brackets

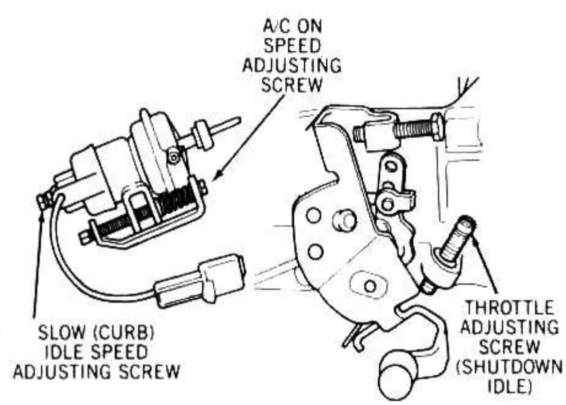


Figure 3: 10 Adjusting Screw at the Rear of the Solenoid

Before adjusting idle speed with a solenoid, you may have to check the solenoid operation. Do this by disconnecting the solenoid lead and holding or blocking the throttle party open with the engine off. Apply battery voltage to the solenoid lead with a jumper wire and verify that the solenoid extends. Remove voltage and verify that the solenoid retracts. If the solenoid does not work right, replace it.

When you adjust idle speed with a solenoid, you will follow the carmaker’s procedures and these principles:

With the engine running at idle, be sure the solenoid is energized with its plunger extended.

Adjust the solenoid plunger, the idle speed screw, the solenoid body, or the bracket screw, as described above, to get the specified slow-idle speed.

b) Basic Idle Speed Adjustment

You will still find some engines on which you set the idle speed simply by turning an idle speed screw on the throttle linkage. Turn the screw clockwise to increase speed, counter clockwise to decrease speed.

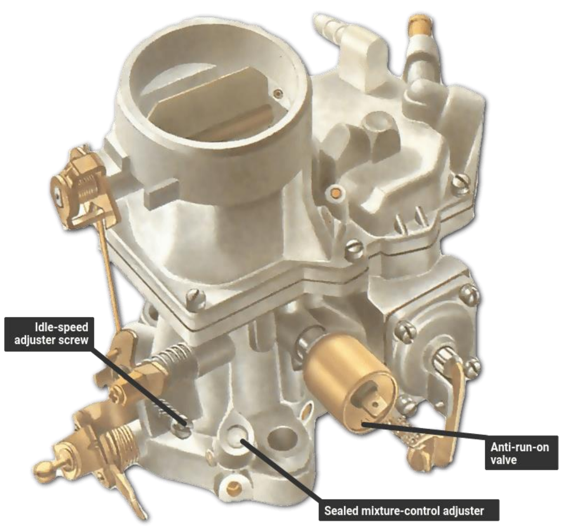


Figure 3: 13 Idle Speed Adjusting Screws

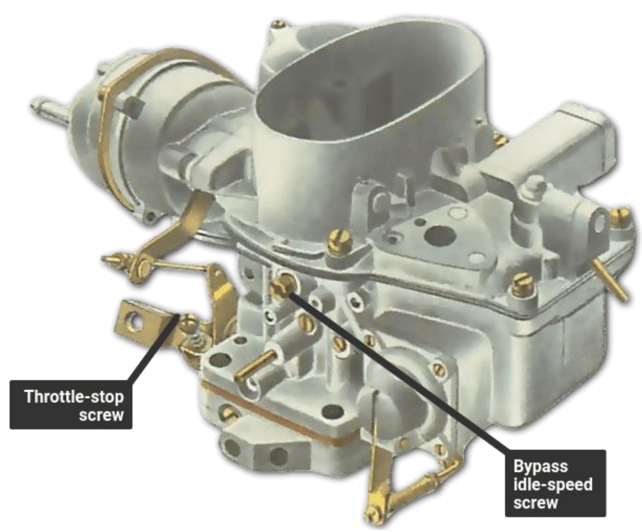


Figure 3:12 Idle Air Bypass Adjustment

Adjust the idle speed on a carburetor with an idle air bypass adjustment by turning the large adjusting screw. This screw opens and closes the bypass passage to regulate idle airflow. Turn it clockwise to decrease speed, counterclockwise to increase speed.

- Turning the screw clockwise closes the idle passage and creates a lean mixture.
- Turning it counterclockwise opens the passage and creates a reach mixture.

If you have to remove a cap or plug from a sealed mixture screw for a major adjustment, you will still follow these principles:

- When you seat a mixture screw, do it carefully so that the tapered end just touches the seat. Over tightening will groove the needle and damage the seat.
- Adjust dual mixture needles of 2 and 4 barrel carburetors equally and alternately in small increments to balance the idle mixture.

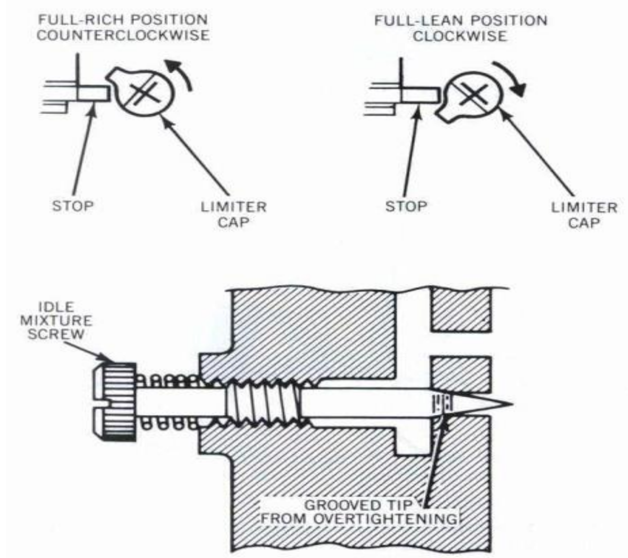


Figure 3:14 Idle Mixture Adjustment

Limiter caps restrict adjustments to one turn or less. If you can't adjust the mixture with the caps in place, the carburetor may need an overhaul, or other engine problems may exist. If specified by the carmaker you may remove limiter caps for adjustment when using an infrared analyzer.

Idle mixture instructions on an engine decal or in a reference manual usually call for one of the three basic adjustment methods below. The lean best idle and one-quarter turn rich methods are most often used on older engines. Adjust idle speed to the correct rpm setting and then proceed as follows:

i. Lean Drop Method

Adjust the mixture screws equally to get the highest speed and smoothest idle. Readjust the idle speed to specifications. Then continue turning the mixture screws clockwise (leaner) until speed decrease by a specified amount.

ii. Lean Best Idle Method

Adjust the mixture screws equally to get the smoothest idle. Then turn the screws clockwise (leaner) until idle speed decreases. Finally, turn the screws counterclockwise (richer) equally just enough to regain the lost speed.

iii. One- Quarter- Turn – Rich Method

Adjust the screws clockwise (leaner) past the smoothest idle until idle speed decreases slightly. Then turn the screws counterclockwise (richer) one-quarter turn.

B. Fuel Pump

If the owner has complained of poor high speed performance, the fuel pump may be at fault. Too low a pump pressure or volume will cause a high speed miss because of lack of fuel delivered to the carburetors, while too high a pressure will cause carburetor flooding.

a) Pump Volume Test

1. Disconnect both fuel lines at carburetors, plug one line and direct opposite line into a container, preferable one indicating the pint level.
2. Start engine and run at idle using fuel in carburetor bowl.
3. Measure the time required to deliver one pint of fuel, then shut off engine. At idle the pump should deliver one pint of fuel in 45 seconds or less.

- If no gasoline or only a small amount flows from open end of pipe, then the fuel line is clogged or the pump is inoperative. Before removing pump, remove gas cap, disconnect both inlet and outlet pipes and blow through them with an air hose to make sure they are clear. This will eliminate the possibility of a clogged gas strainer in the fuel tank. Reconnect pipes to pump and retest flow.
- If capacity is within limits, proceed with Pump

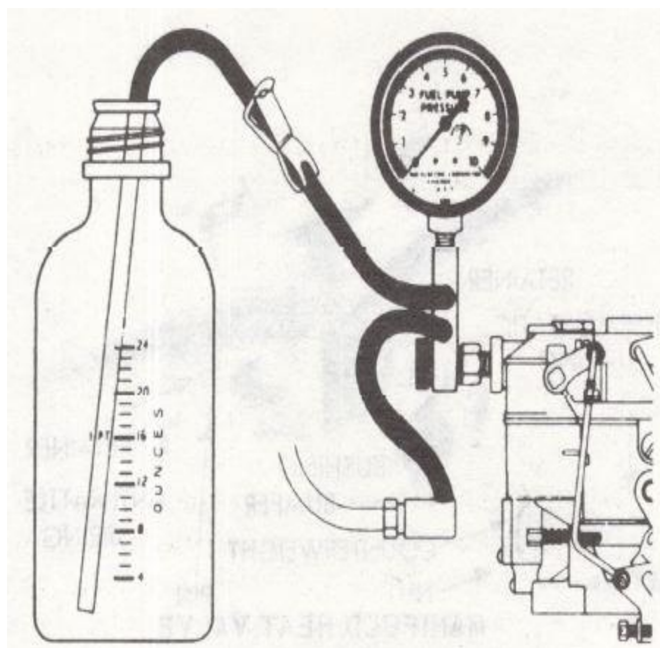


Figure 3: 15 Fuel Pump Volume Test

b) Pump Pressure Test

1. Attach vacuum-pressure gauge hose to fuel line while opposite line remains plugged from above test.
2. Operate engine at idle and observe reading on gauge. Pressure should be 4 to 5 lbs. and should remain constant at all speeds between idle and 1000 rpm.

- If pressure is too low or too high or varies materially at different speeds, the pump should be removed for repairs or replacement.
- If the fuel pump checks out correctly on a high speed complaint, overhaul the carburetor.

3. Remove gauge and plug and reconnect fuel lines to carburetors. Inspect fuel lines for kinks and bends, and check all connections for leaks.

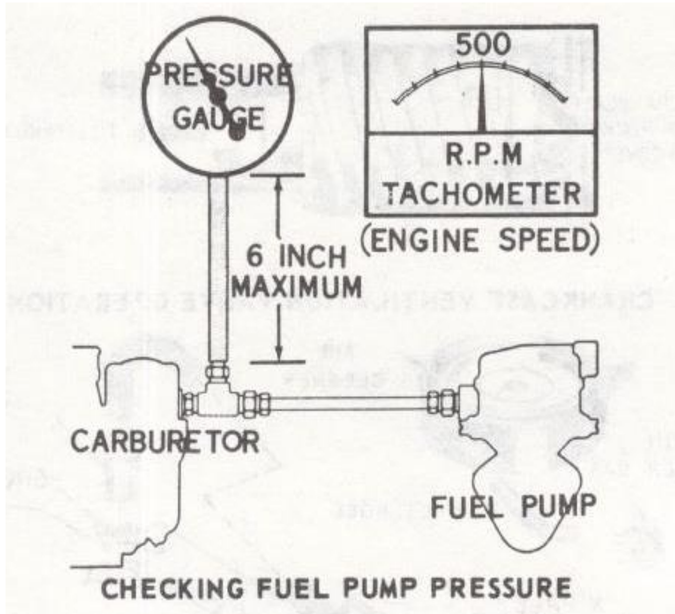


Figure 3: 16 Check Fuel Pump Pressure

3.2.2 Tuning Up Diesel Fuel System

A. Bleeding Diesel Fuel System

The diesel fuel system should be bleed whenever components had been removed, repaired or replaced in order to avoid malfunction. Air also enters the system when the vehicle runs out of fuel, and the tank becomes completely empty. Various manufactures describe different procedures for venting the fuel system. The following steps describe a general procedure.

Note

Manufactures specification and recommendations should always be taken into consideration when executing any kind of work on diesel equipment!

I. System with In-Line pumps

In general, bleeding is executed with the help of a priming pump, and follows certain steps of procedure.

a) Loosen the priming pumps by turning it counterclockwise.
b) Loosen the air vent screw positioned nearest to the priming pumps in the system (usually found on the fuel filter unit)
c) Operate the priming pumps by hand until pure diesel fuel, free from air bubbles, comes out of the air vent screw.

d) Tighten the air vent screw-

e) Now, open the air vent plug on the fuel injection pump.

f) Close the air vent screw when air bubbles disappear from fuel coming out of the plug

g) Tighten the priming pump by pushing it down wards and turning it clockwise at the same time.

With fuel systems provided with suction-side scavenging of the injection pump, the fuel manifold can be bled without opening the air vent plug on the injunction pump, by cranking the engine at starter motor speed .The air escapes via the check valve and the fuel tank. Pull the stop lever back completely to ensure that the engine will not run.

II. System with Distributor (VE) Pump

- Usually, the bleeding procedure is the same as mentioned above
- The priming pump is usually positioned on the filter unit or fit to a pre-delivery pump which is placed between filter unit and tank-
- Often the distributor pump does not require venting. In this case no priming pump and pre-delivers feed pump is found in these fuel systems. The injection pump is "self-venting" when the engine operates.

If high pressure injection lines where loosened or dismounted, execute the following procedure

- Loosen injection lines at nozzle side and crank engine with pressed down accelerator pedal
- Crank engine until fuel escapes from the loosen pressure pipes
- After this, tighten injection pipe flare nuts and run the engine

B. Adjusting Injection Timing of diesel Engines

I. Checking And Adjusting Fuel Injection Timing

a) Remove injunction pipe, delivery valve, spring and stopper from No.1 pumping element of the injection pump and reinstall delivery valve holder again.

Note: Put the valve holder components in clean diesel fuel in order to keep them clean and out of dust!

b) Fit an inspection pipe to no.1 pumping element delivery valve holder so that out coming fuel is clearly observed.

c) Rotate the crankshaft in normal direction of engine rotation until No. 1 cylinder is close to 300 BTDC.

d) While operating the priming pump (fuel will run out from the inspection pipe) slowly rotate the crankshaft in its direction of normal rotation.

e) Make sure that the stop lever, positioned on top of the governor, is not in its "stop" position!

f) Use a container to collect the fuel coming out from the inspection pipe.

g) Rotate the engine until fuel has almost stopped from running out of the inspection pipe.

h) After the fuel has completely stopped from running out, stop rotating the engine.

Now check

- If injection timing marks placed on crankshaft pulley and engine casting are in alignment example (18^0 BTDC)
- If this is not the case, the injection timing has to be corrected (adjusted)

II. Injection Timing Adjustment Procedure

- Loosen the injection pump fastening nuts slightly-
- Adjust injection timing according to manufacturer's specification
- If injection timing is retarded
- Slowly move pump towards the crankcase
- If injection timing is advanced
- Slowly move pumps away from the crankcase

Note:

By moving the pump one division of the adjusting amount mark, this will advance or retard the injection timing for 60 of crankshaft rotation

- Tighten the injection pump and recheck the injection timing adjustment-
- If the injection timing adjustment is correct, install the delivery valve components and tighten the delivery valve holder to the specified torque-
- Fit the injection pipe to the delivery valve holder and test run the engine

3.3 Engine Electrical Tune-Up

3.3.1 Tuning Up Ignition System

A. Factors Affecting Ignition Timing

Various factors affecting ignition timing are:-

a. **Engine Load: -** For less load, engine combustion is slower and hence requires more ignition advance. But with more load on the engine, faster combustion and hence lesser advance is required.

b. **Engine Speed: -** For high speed, engine needs more time for complete combustion and hence requires more ignition advance. For low speed, engine needs less time for complete combustion and hence requires lesser ignition advance.

c. **Engine Temperature: -** Combustion is slower and requires more ignition advance when the engine is cold. But combustion will be faster requiring lesser ignition advance if the engine is hot.

d. **Cylinder Bore: -** Faster is the combustion and lesser the ignition advance required for smaller bore. But the combustion is slow requiring more ignition advance for larger bore.

e. **Compression Pressure: -** combustion will be slower and ignition advance is required for low compression pressure whereas, for high compression pressure the combustion is faster with lesser ignition advance required.

B. Adjusting Contact Point (Air) Gap on vehicle

1. Remove the distributor cap and rotor.
2. Rotate the engine with the starter or by turning the belt until the points are fully open.
3. Measure the gap with feeler gauge
4. Loosen the point hold – down screw and move the points if adjustment is necessary.
5. Tighten the screw and check the gap
6. Apply cam grease on the distributor cam.

C. Checking Condition Of Condenser On Vehicle

Methods of checking condition of condenser are:

I.By Observing Spark Length

1. First, check the length of the existing spark. Operate the points manually. Use a screwdriver.

2. With the other hand, hold the high-tension cable about 10mm away from a metallic part of the engine.
2. If you find that there is a good spark, increase the distance until the spark begins to miss. As soon as this happens, estimate the distance and record it.
3. If no spark appears at a distance of 10mm, then reduce the distance until you get a proper spark. Again, estimate and record it.
4. Switch off the ignition, then disconnect and remove the condenser. Replace it by a new one, or one which still appears to be serviceable and connect it between the distributor low-tension terminal and earth.
5. Now switch on the ignition again and repeat the operation described in step 1, 2 and 3.
6. If you receive a better result with a longer and more powerful spark, then the condenser was faulty.
7. If you cannot see any change and the length of the spark is still less than 10mm, then it shows that the condenser is in good condition.

II.By Using Ohmmeter

Another possible way of checking the condenser is to use an ohmmeter. The ohmmeter must have a measurement range of up to 400 kΩ = 400000 (ohm).

1. Disconnect the condenser from the cable.
2. Open the contact breaker points. The best thing to do is to put a strip of cardboard about 1mm thick between both points, to ensure that no contact can be made.
3. Now carefully read the instructions on how to operate the ohmmeter and set it at zero.
4. With one tip of the ohmmeter touch the housing (ground). With the other tip, touch the cable of the condenser.
5. Now check the reading of the ohmmeter and record it.
6. The reading, which means the resistance of the insulation, should not be less than 200 kΩ (200000 ohms).
7. A condenser with less than 200 kΩ resistance must be replaced

III.By Using Capacity Tester

Read carefully the manual of the tester before trying to use it.

1. Keep the selector of the tester to capacity test position.

2. Connect one terminal of the tester to the body of the condenser.
3. Connect the other terminal to pig tail (insulated terminal) of the condenser.
4. Take the reading from the meter and compare it with the specification.

D. Setting Dwell Angle on Vehicle

Measuring and adjusting the dwell angle on a breaker – point ignition is an important and basic service because it affects coil saturation and secondary voltage, as well as ignition timing.

You must always adjust breaker – point dwell before setting the timing. A tach-dwell meter measures rpm as well as dwell angle. Most tach-dwell meter show an average dwell reading for all cylinders (they do not show individual cylinder dwell angles). An oscilloscope or a distributor tester shows individual cylinder dwell.

A tack-dwell meter has negative and positive leads, as a voltmeter does.

- Connect the negative lead to an engine ground.
- Connect the positive lead to the coil + or – terminal depending on the instruction of the meter.
- Set the cylinder selector knob on the meter for the number of cylinders in the engine you are testing usually 4, 6 or 8.
- Set the function selector knob for tachometer or dwell measurement.
- For a basic dwell measurement, start and idle the engine and read both rpm and dwell measurements.
- Always check the manufacturer's specifications for dwell angle and allowable variation.

Example

- Dwell angle 570^{0} (4 cylinder)
- Dwell angle $620^{0} \pm 3^{0}$ (4 cylinder)
- Dwell angle $440^{0} \rightarrow 50^{0}$ (4 cylinder)
- Dwell angle $380^{0} \rightarrow 40^{0}$ (6 cylinder)

The dwell will be given for a specified rpm usually as idle (the speed may be given in engine rpm or distributor rpm). Set the dwell for a new set of points to the lower end of the specified range. The higher dwell range is given for rubbing block wear, which will increase the dwell angle during several thousand miles of operation.

Measure the dwell angle at the specified RPM by the carmaker. Normally, you will adjust the dwell at cranking or idle speed. Delco v-6 and v-8 breaker – point distributors have windows in the cap that let you adjust dwell with the engine running at the specified idle speed.

You can measure dwell on other distributors with the engine running, but you must remove the cap to adjust it. A good – tach dwell meter will give an accurate dwell measurement at engine cranking speed. Crank the engine with the ignition switch or a remote starter switch and read the meter. Adjust the point assembly until dwell is within specifications and tighten the lock screw. Then reinstall the distributor cap and check the dwell adjustment with the engine running at the specified speed.

E. Testing Spark Advance

You can test the spark advance mechanisms with the distributor in the engine, but it is difficult (often impossible) to adjust them accurately. A distributor tester allows you to test and adjust centrifugal and vacuum advance with precision. A distributor tester is a useful instrument to check any distributor for:

- Shaft and bushing wear, and cam wear on a breaker-point distributor
- Centrifugal operation at all points on an advance curve
- Vacuum advance operation at various vacuum levels and speeds
- Dwell angle and dwell variation on a breaker-point distributor
- Breaker-point alignment, bounce, and spring tension

Spark advance specifications, or curves, can be given in engine speed and degrees or in distributor speed and degrees. You will need specifications in distributor speed and degrees for use with a tester. If you have them in engine speed and degrees, divide them in half. Vacuum specifications in inches of mercury are the same for use in a tester or on the engine.

F. Ignition Timing

a) Setting Initial Ignition Timing Statically

Open the bonnet and locate the timing mark, which is usually on the crankshaft pulley, but is sometimes on the flywheel.

Various timing marks with and without graded scale. However, before you begin to time the engine, check the Workshop Manual to find out where the timing marks are placed and the number of degrees between each notch, point, etc.

i. You may have to turn the engine slightly until the timing mark appears and this can be done by one of the following methods:
   - ✓ Jerking the starter a little;
   - ✓ Putting the vehicle into fourth gear and rocking it;
   - ✓ Using a wrench or crank handle;
   - ✓ Turning the dynamo pulley by hand.

   Note: Never try to turn the engine by turning the fan.

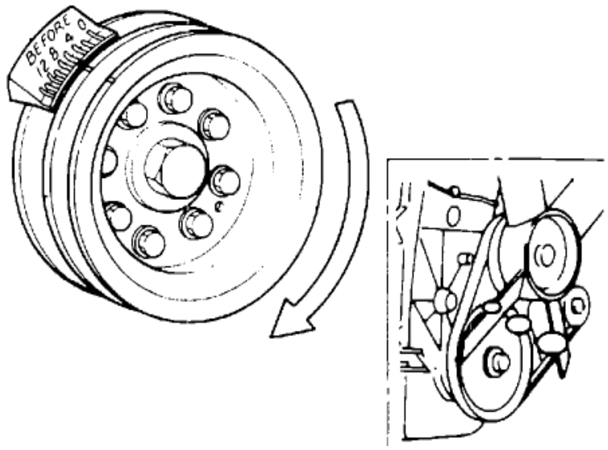


Figure 3: 17 Engine Timing Mark

ii. It is a good idea to clean and mark the pointer with white chalk to make it more visible.
iii. When you have made sure that the rotor is in the correct position, put back the distributor cap and remove the high-tension central lead from the coil or distributor cap.
iv. Take a control lamp. If you haven't one, then make it.
v. Now, connect your control lamp to coil terminal no. 1. (CB). (–)
vi. Connect the other terminal on the lamp to the engine or a chassis part, to earth it.
vii. Switch on the ignition. Do not crank the engine.
viii. Now you are ready to begin checking the present position of the ignition. Turn the crankshaft very slowly by hand in the same direction as the engine runs.
ix. The moment a light appears on the control lamp the contact points begin to open, precisely at the same moment as the spark plug of cylinder no. 1 fires.

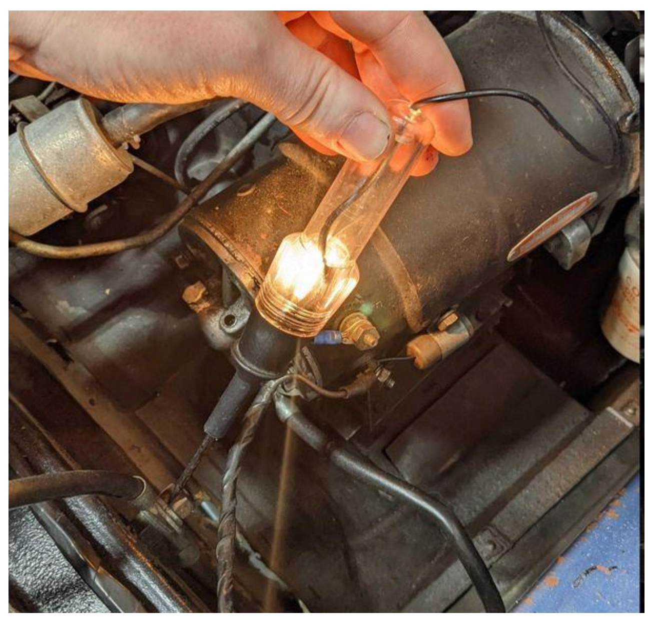


Figure 3:18 Checking Initial Timing by Test Light

x. When the light appears, stop immediately and compare the position of the timing mark with the position of the pointer. Record and compare them with the manufacturer's data.

xi. If you discover that the timing is incorrect, which means that the light comes on before or after the mark, you must make the necessary correction.

xii. Turn the engine until the marks meet at the recommended degree. To eliminate any play on the distributor drive, advance at least 15^0 beyond this point, and then slowly turn back to the correct position. Only by using this method you can be sure that the setting is exact.

xiii. Loosen the distributor clamp screw.

xiv. Slowly turn the distributor housing in the opposite direction to the rotation of the rotor, until the light on the control lamp appears.

xv. You may have to repeat the process several times before you find the correct position, because you may just miss the exact point where the light appears, which is identical with the firing point of the spark plug on cylinder no. 1.

xvi. When this happens, turn the distributor back and start again. Lightly tapping the distributor with the handle of a screwdriver may be sufficient to move it slightly and help you to find the position.

Note: When timing the ignition, the distributor must always be turned in the opposite direction to the rotation of the rotor. This will avoid any clearance from the rotor advance mechanism which causes misalignment.

xvii. Now, carefully tighten the clamp screw so that you will not change the position of the distributor. After tightening, re-check the ignition timing.

xviii. If the ignition point is still incorrect, you must repeat the whole operation until the timing is correct. This means that the light on the test lamp must appear at the exact moment when the mark is in alignment with the recommended degree or, as on some types of engine, when the recommended degree is in alignment with the pointer.

xix. When the timing is correct, remove the control lamp and re-fit the central high-tension lead.

xx. You can then start the engine.

b) Setting Initial Ignition Timing Dynamically

i. It may be necessary to turn the engine until the timing marks appear.

ii. If the marks are not clearly visible, coat the timing mark and the pointer with white chalk.

iii. Start the engine and warm it up until it runs smoothly without assistance from the choke. Never pollute the atmosphere of the workshop. Extend the exhaust pipe with a flexible tube to transfer the exhaust gas outside.
iv. Stop the engine.
v. Connect the rpm tester (tachometer) to the engine. Read the manufacturer's operation description for the correct connection.
vi. The tachometer is, in most cases, connected to the coil connection no. 15 (plus or SW). The other lead should be connected to the terminal marked no. 1 (minus or CB).
vii. Disconnect the distributor vacuum hose from the carburetor and tape the manifold opening. This is necessary to avoid obtaining a wrong result from the vacuum advance mechanism. If the distributor is equipped with two vacuum hoses, disconnect and take both away. Then close the openings with tape.
viii. Now connect the wire marked HT (it is usually the thick wire on the Stroboscope Lamp) to the spark plug of no. 1 cylinder distributor cap tower. This usually requires an extension which will be supplied with the Stroboscope Lamp.
ix. Connect the other two wires. Connect the one marked + (15 or SW) to the battery + terminal, or to the ignition coil connection no. 15 (SW) and the other one, marked with the ground symbol, to earth.
x. Note: Before connecting the Stroboscope Lamp, ensure that the described recommendation is identical with the manufacturer's instructions.
xi. Start the engine. Set it at idle speed, mostly at about 750 engine revolutions. Engines with automatic transmission often require a higher speed but some engines should be timed at a lower speed.
xii. Now, push the button of the timing light which will flash when cylinder no. 1 fires. Hold the flashlight beam as close as possible to the pointer.

Warning: The Stroboscope Lamp, and your hand, will be close to the rotating and driving belt during the test. Be careful!!!

xiii. The flashlight makes the mark visible to you and gives you more, or less, the impression that it is standing still.

xiv. If the timing is correct then the pointer will be in alignment with the recommended number of degrees at idle speed or at the recommended test speed.

xv. Should the timing be incorrect, then loosen the distributor clamp screw at the base of the housing.

xvi. Slowly turn the distributor housing in the opposite direction to the rotation of the rotor. You will find that this advances the timing.

xvii. To retard the timing, turn the distributor slowly in the rotating direction of the rotor.

xviii. When the recommended degree is in alignment with the pointer, stop turning the distributor housing, then tighten the clamp carefully.

xix. Re-check after you have tightened the clamp to make sure that the alignment is still correct. If not, you must repeat the operation until you get it right.

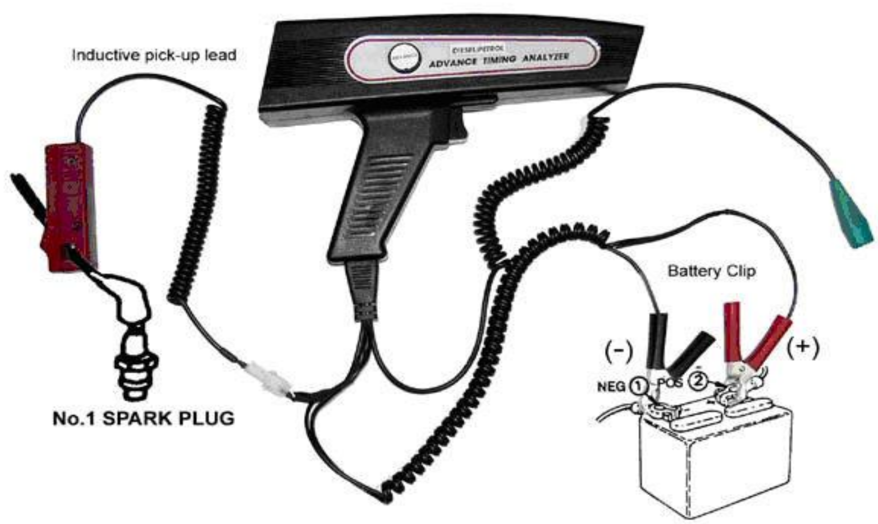


Figure 3: 19 Stroboscopic Timing Gun Installation

xx. Coming now to the second stage of the check, increase the engine speed to 2,000 rpm. **Note:** In each car repair manual you will find information about specific engine speed and corresponding ignition advance.

xxi. Now check the existing advance of the ignition timing.

xxii. Again, increase the engine speed to 4,000 rpm and the timing advance should now be 27^0

xxiii. At 4,500 engine revolutions, the advance should be 31^0.

xxiv. If you discover that there is any difference from the manufacturer's specification it means that the timing is only correct at low speeds. As the engine speed is increased, the timing becomes incorrect. It may be too advanced or too much in retard. This shows that the flyweight is not operating correctly and must be checked, or replaced.

xxv. The maximum advance at high engine speed should never be more than the manufacturer's given data or 'pinking' will occur and ruin the engine components. When the repair of the mechanical advance mechanism cannot be carried out immediately then retard the timing so that the maximum advance at high speed is exactly the same as the manufacturer's recommendation.

xxvi. If the result is to your satisfaction, stop the engine and remove the lead connection of your stroboscope lamp. Re-set the engine idle speed to the manufacturer's value, when necessary. Also remove the rpm tester. Make sure that the high-tension cables are again correctly fitted. Do not forget to fit back the vacuum line to the vacuum control unit. Take a glance once more to see that everything is correct and then close the bonnet.

G. Spark Plug inspection and Testing

I. External Influences on a Spark Plug's

- **Air/Fuel Mixtures seriously affect engine performance and spark plug operating temperatures.**
  - ✓ Rich air/fuel mixtures cause tip temperature to drop, causing fouling and poor drivability
  - ✓ Lean air/fuel mixtures cause plug tip and cylinder temperature to increase, resulting in pre-ignition, detonation, and possibly serious spark plug and engine damage
  - ✓ It is important to read spark plugs many times during the tuning process to achieve the optimum air/ fuel mixture
- **Higher Compression Ratios/Forced Induction will elevate spark plug tip and in-cylinder temperatures**
  - ✓ Compression can be increased by performing any one of the following modifications:
    - a) Reducing combustion chamber volume (i.e.: domed pistons, smaller chamber heads, milling heads, etc.)
    - b) Adding forced induction (Nitrous, Turbocharging or Supercharging)

c) Camshaft change

- ✓ As compression increases, a colder heat range plug, higher fuel octane, and careful attention to ignition timing and air/fuel ratios are necessary. Failure to select a colder spark plug can lead to spark plug/engine damage

- **Advancing Ignition Timing**
  - ✓ Advancing ignition timing by 10° causes tip temperature to increase by approx. 70°-100° C
- **Engine Speed and Load**
  - ✓ Increases in firing-end temperature are proportional to engine speed and load. When traveling at a consistent high rate of speed, or carrying/pushing very heavy loads, a colder heat range spark plug should be installed
- **Ambient Air Temperature**
  - ✓ As air temperature falls, air density/air volume becomes greater, resulting in leaner air/fuel mixtures.
  - ✓ This creates higher cylinder pressures/temperatures and causes an increase in the spark plug's tip temperature. So, fuel delivery should be increased.
  - ✓ As temperature increases, air density decreases, as does intake volume, and fuel delivery should be decreased
- **Humidity**
  - ✓ As humidity increases, air intake volume decreases
  - ✓ Result is lower combustion pressures and temperatures, causing a decrease in the spark plug's temperature and a reduction in available power.
  - ✓ Air/fuel mixture should be leaner, depending upon ambient temperature.
- **Barometric Pressure/Altitude**
  - ✓ Also affects the spark plug's tip temperature
  - ✓ The higher the altitude, the lower cylinder pressure becomes. As the cylinder temperature decreases, so does the plug tip temperature
  - ✓ Many mechanics attempt to "chase" tuning by changing spark plug heat ranges
  - ✓ The real answer is to adjust jetting or air/fuel mixtures in an effort to put more air back into the engine

- **Abnormal Combustion**
  - ✓ **Pre-ignition**
    - ➢ Defined as: ignition of the air/fuel mixture before the pre-set ignition timing mark
    - ➢ Caused by hot spots in the combustion chamber...can be caused
    - ➢ (or amplified) by over advanced timing, too hot a spark plug, low octane fuel, lean air/fuel mixture, too high compression, or insufficient engine cooling
    - ➢ A change to a higher octane fuel, a colder plug, richer fuel mixture,
    - ➢ or lower compression may be in order
    - ➢ You may also need to retard ignition timing, and check vehicle's cooling system
    - ➢ Pre-ignition usually leads to detonation; pre-ignition an detonation are two separate events
  - ✓ **Detonation**
    - ➢ The spark plug's worst enemy! (Besides fouling)
  - ➢ Can break insulators or break off ground electrodes
  - ➢ Pre-ignition most often leads to detonation
  - ➢ Plug tip temperatures can spike to over 3000°F during the combustion process
  - ➢ Most frequently caused by hot spots in the combustion chamber.
  - ➢ Hot spots will allow the air/fuel mixture to pre-ignite. As the piston is being forced upward by mechanical action of the connecting rod, the pre-ignited explosion will try to force the piston downward. If the piston can't go up (because of the force of the premature explosion) and it can't go down (because of the upward motion of the connecting rod), the piston will rattle from side to side. The resulting shock wave causes an audible pinging sound. This is detonation.
  - ➢ Most of the damage than an engine sustains when "detonating" is from excessive heat
  - ➢ The spark plug is damaged by both the elevated temperatures and the accompanying shock wave, or concussion
- **Misfires**
  - ➢ A spark plug is said to have misfired when enough voltage has not been delivered to light off all fuel present in the combustion chamber at the proper moment of the power stroke (a few degrees before top dead center)

- A spark plug can deliver a weak spark (or no spark at all) for a variety of reasons...defective coil, too much compression with incorrect plug gap, dry fouled or wet fouled spark plugs, insufficient ignition timing, etc.
- Slight misfires can cause a loss of performance for obvious reasons (if fuel is not lit, no energy is being created)
- Severe misfires will cause poor fuel economy, poor drivability, and can lead to engine damage

- **Fouling**
  - Will occur when spark plug tip temperature is insufficient to burn off carbon, fuel, oil or other deposits
  - Will cause spark to leach to metal shell...no spark across plug gap will cause a misfire
  - Wet-fouled spark plugs must be changed...spark plugs will not fire
  - Dry-fouled spark plugs can sometimes be cleaned by bringing engine up to operating temperature
  - Before changing fouled spark plugs, be sure to eliminate root cause of fouling

II. Reading and Understanding Spark Plugs

A lot can be learned about your engine condition and what it sees by properly reading and "understanding" your spark plugs. This following sections will show you pictures as well as explanations on causes and effects of what you see when viewing you spark plugs.

- **Normal Spark Plug**

Grayish-tan to white in color indicates the plug is operating at the proper heat range as well as correct jetting and the cylinder is running healthy. That vertical color band on the ceramic shows you where the plug is indexed. Meaning that band is aimed slightly at the exhaust valve. If the band is anywhere but here, it means that the plug is not at its optimum location.

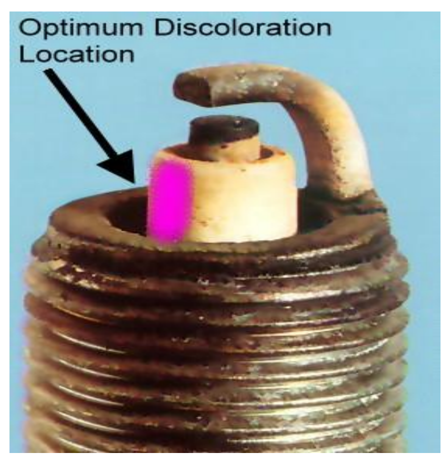


Figure 3: 20 Normal Condition of Spark Plug

- **Severe Detonation**

Detonation is somehow difficult make sure that you are using the correct octane fuel first and then verify correct ignition timing. Next check for an inoperative EGR system (if equipped) as well as proper function of the Knock Sensor (if equipped). Also, you will want to make sure you are using the correct heat range plug.

Figure 3: 21 Severe Detonation of Sparkplug

- **Overheated**

On this symptom you will notice a chalky appearance, white insulator, rapid electrode wear as well as an absence of deposits.

The actual shell may also be discolored. To cure this you must first verify that the plug is the correct heat range, the ignition timing settings are correct, the air/fuel mixture is not too lean, there are no vacuum leaks and that the EGR valve (if equipped) is functioning properly.

Figure 3: 22 Overheated Sparkplug

- **Ash Deposits**

These are light-brownish deposits that are encrusted to the ground and/or center electrode(s). This situation is caused by oil and/or fuel additives. This condition can cause misfires.

The cure for this is to verify worn valve guides or valve seals, not using fuel additives, or you might even try changing fuel brands. By the way, a hotter plug is what most people try to fix this problem. You need to first understand that the plug is NOT typically the problem.

Figure 3: 23 Ash Deposits in the Spark Plug

- **Oil Fouled**

Oily coating caused by poor oil control. Oil is leaking past worn valve guides, piston rings, or on some race engines a possible intake gasket leak and then entering the combustion chamber.

Check for worn valve guides (NEVER knurl valve guides), intake gasket sealing alignment, as well as worn cylinder walls and piston rings. A leak down test is a good place to start for what is causing this.


Figure 3: 24 Oil Fouled Sparkplug

- **Initial Pre-ignition**

This will usually look as a melted center electrode and/or ground electrode. Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber.

If the engine builder took the time, all areas of combustion chamber should have been de-burred to eliminate this problem.


Figure 3: 25 Initial Pre-ignition in Sparkplug

- **Sustained Pre-ignition**

Check for incorrect heat range plug, over-advanced timing, lean fuel mixtures, inoperative EGR valve or Knock Sensor (if equipped) and also look for hot spots or deposit accumulation inside the combustion chamber.

If the engine builder took the time, all areas of combustion chamber should have been de-burred to eliminate this problem. This includes the sharp edges on the chamber, piston top, and cylinder wall valve reliefs (if applicable).


Figure 3: 26 Sustained Pre-ignition in sparkplug

- **Splashed Deposits**

These look as if they are small islands of contaminants on the insulator. This is usually a dirty carburetor bores or air intake as well as the possibility of a dirty or faulty injector.

You must use aggressive carburetor and choke cleaner or other solvent cleaner before installing new spark plugs.


Figure 3: 27 Splashed Deposits

- **Carbon Fouled**

This is very common visual condition on our race engines. Soft, black, sooty, dry-looking carbon. This indicates a rich mixture, weak ignition or wrong heat range plug (too cold). You will first need to verify plug heat range. On carbureted engines, check choke as well as choke pull-off (if equipped) for proper function and adjustment.


Figure 3: 28 Splashed Deposits

As a general rule on all computer-controlled engines, you need to also make sure that all input signals to the computer are working and accurate. This includes, but is not limited to, all temperature and pressure sensors as well as the EFI system components.

Lastly on all engines, check for vacuum leaks and weak spark or low voltage output. (Good reason for a better coil and aftermarket ignition unit "amplifier").

3.3.2 Tuning Up Charging System

A. On – Vehicle Inspection

Check the following system components:

- Drive belt tension:
- Fuses
- Installed condition of the wiring for alternator and regulator.
- Battery terminal and fusible link
    - ✓ Loss
    - ✓ Corroded

- ✓ Burnt
- Specific gravity:
- Alternator on –vehicle condition
- Abnormal noise from the alternator when the engine is running.

B. Performance Test Using Voltmeter And Ammeter

Connect the voltmeter and ammeter as shown in the following figure

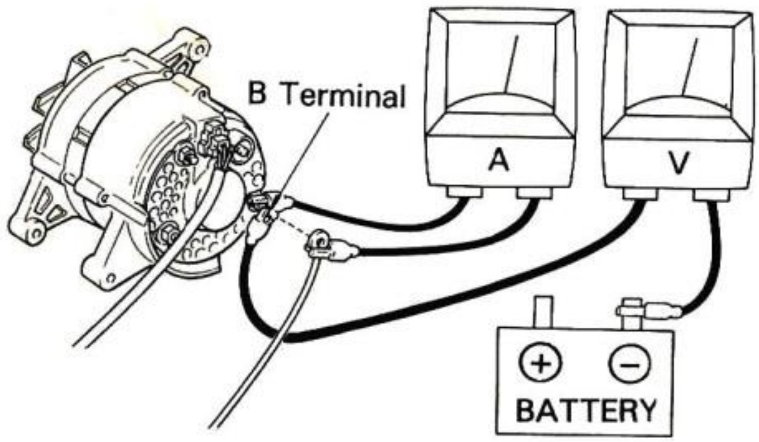


Figure 3:29 Performance Test Using Voltmeter and Ammeter

I. No - load Performance Test

1. Start the engine.
2. Slowly increase the engine speed from idle to the recommended RPM.
2. The voltmeter reading should increase as the engine speed increases until the voltage regulator starts operating. After which the voltage should remain constant and within specification.
3. Momentarily increase the engine speed. The voltage reading should remain constant and the ammeter should read less than the specified limit. (Example less than 10A).
4. If the voltage reading is not within the specified limits or does not remain constant the regulator needs adjustment or replacement.

II. Load Performance Test

1. Connect the voltmeter and ammeter as in the above diagram and start the engine
2. Run it at the specified speed.
3. Turn on the headlights and other accessories.
4. The ammeter reading should be more than the specified limit. (Example 20 A)

3.3.3 Tuning Up Starting System

A. Testing the Starting Motor

Starting motor test can be performed when it is on the vehicle, or after dismantled from the car. There are two basic starting system troubles that lead the starter to be tested.

These Are:-

a. The starting motor does not crank the engine
b. The starting motor cranks the engine slowly, and the engine does not start

The causes of these problems are usually traceable to the starting system. A discharged battery should be replaced after testing its condition. A problem in the starting motor can be checked using a jumper wire and a fully charged battery.

Procedures

a. Connect one end of the jumper wire to the battery positive terminal and the other end to the ignition switch terminal of the starter. This is to check if the solenoid meshes the pinion with the ring gear.
b. Connect a heavy gauge wire between battery positive and starter motor terminal of the solenoid to check if the armature rotates.
c. If at least one of them fails to operate, the starter motor should be dismantled from the vehicle for further test.

B. No – Load Test

The no – load test is the basic check for the starting motor's internal condition.

Procedure:

a. Insert an ammeter capable of measuring several hundred amperes between the battery and the starter.
b. Connect the voltmeter to the starting motor terminal and frame.
c. Connect a carbon pile resistor across the battery as shown. The variable resistor is used to obtain the specified operating voltage of the starter.
d. Place a jumper lead between the battery terminal and the switch terminal on the solenoid to complete the test circuit.
e. Place a tachometer on the end of the armature to measure the armature speed.

f. When the specified voltage is attained, read the ammeter for the current drawn, and the tachometer for the armature speed.
g. Compare these readings with the manual specifications for the starter being tested.

C. Interpreting the No – Load Test Result

Note: Open – circuited field coils will not be detected with this test on starters with series field coils which are connected in parallel.

1. Rated current draw and no – load speed indicates a normal starting motor condition.
2. Low free speed and high current draw indicates too much friction, shorted armature and grounded armature or field.
3. Failure to operate with high current draw indicates direct ground in the terminal or fields.
4. Failure to operate with no current draw indicates open field circuit, open armature coil, broken brush springs, worn brushes, high insulation between the commutator bars or between the brush and commutator.
5. Low speed and low current draw indicates high internal resistance due to poor connection, defective leads, dirty commutator, or open field circuit.
6. High free speed and high current draw indicates shorted field.
7. Eg. 2.0KW type less than 120A at 11.5 volt.
8. If the no – load tests show that the starting motor does not perform per specifications, this requires disassembly of the starter for further test.

Operation Sheet 3.1

Operation Title: Contact Breaker Setting- Gap Adjustment

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

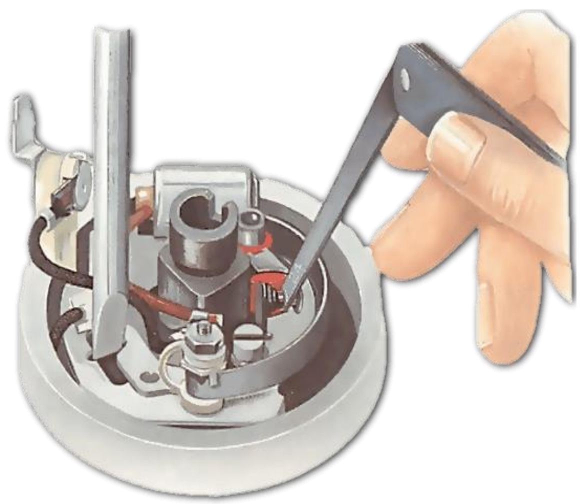
Purpose: To tune an engine ignition system

Required Tools and Equipment: Ignition distributor of multi-cylinder engines, Thickness or feeler gauge and appropriate hand tools

Precautions: Before installing make sure an engine in safe conditions

Quality Criteria: - Remove properly the spark plug from engine

Procedure:



1. Remove the distributor cap and rotor
2. Disassemble the contact-breaker set-
3. But parts in a dry and clean place
4. Clean contact-breaker base-plate with clean piece of cotton
5. Inspect contact points if excessively burned
6. Fit contact-breaker in to the distributor and only slightly pre-tighten the securing screw at this stage
7. Rotate the engine until the cam opens the points fully (full life position of the cam)
8. Measure the gap between the points with a feeler gauge and adjust or correct gap if necessary-Check vehicle manufacturer specification correct contact breaker setting:

   Standard Contact- point gap = ………mm

   Often, manufacturer recommend to measure the gap between rubbing block and cam shaft when the points are fully in rubbing block and cam shaft when the points are fully in contact (fully closed position!) in order to avoid oily or dirty contact point surface and hence a reduced service life of the breaker points.

   Standard gap, rubbing block-cam shaft = …………mm

9. Tighten security screw-
10. Rotate engine or distributor drive a few times and recheck gap adjustment
11. Repeat steps from g) to J) if gap adjustment found incorrect-
12. Clean contact point surface
13. Assemble distributor cap and rotor

Operation Sheet 3.2

Operation Title: Dwell Angle Test and Adjustment

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

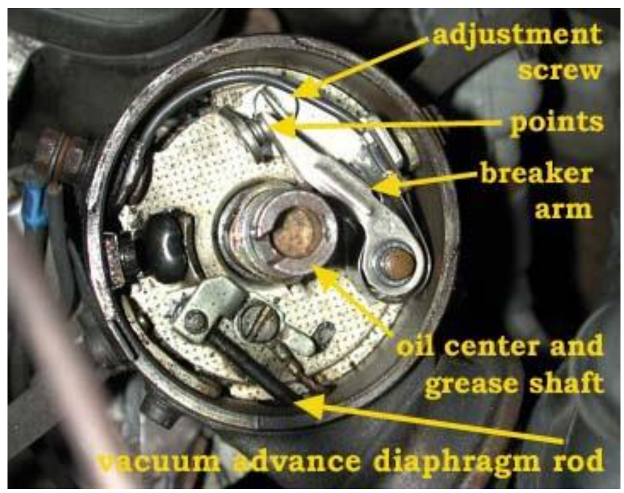
Purpose: To tune an engine ignition system

Required Tools and Equipment: Dwell angle tester, four cylinder Toyota engine Repair manual and appropriate hand tools

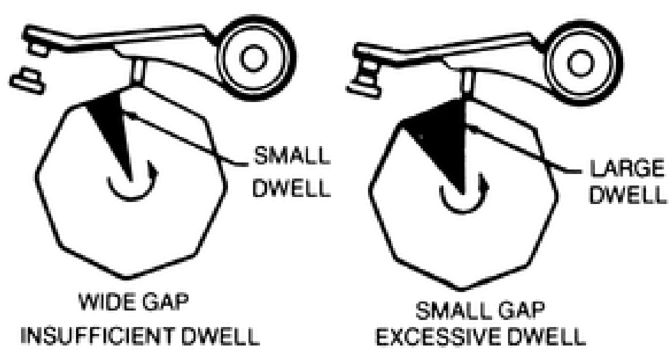
Precautions: Before installing make sure an engine in safe conditions

Quality Criteria: - Properly adjust dwell angle

Procedure:



a) Connect the dwell angle tester according to the recommendations of vehicle or test equipment manufacturer
b) Calibrate testing instrument according to manufacturer's recommendations
c) Remove distributor cap and rotor
d) Crank engine with starter motor speed and write down dwell angle readings
e) Compare the actual dwell angle reading with manufacturers specification as written in the workshop manual and correct dwell if necessary slightly untighten the security screw of the of the contact breaker-



f) Set contact point gap and carefully tighten the security screw
g) Crank engine and check reading
h) Repeat steps starting from d) to h) until the reading shown the lower tolerance limit of the given value (specification)
i) Assemble the distributor

j) Run engine, accelerate if for a few times and check if dwell angle changes or drops below its lower tolerance limit if required repeat adjustment procedure

k) Disconnect testing instrument

Standard dwell angle in [o] or [%]	**Actual dwell angle in [o] or [%]**	**Correction of dwell: Yes/No**

Notice:

- As bigger the connect point gap -- > as smaller the dwell angle
- As smaller the contact point gap → as larger the dwell angle
- The swell angle normally increase during its break- in period and according to wear
- Change of dwell angle results in a change of the ignition timing
- Tester cables should not get in to contact with hot engine parts

Operation Sheet 3.3

Operation Title: Removing the Old Spark Plugs

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To tune an engine ignition system

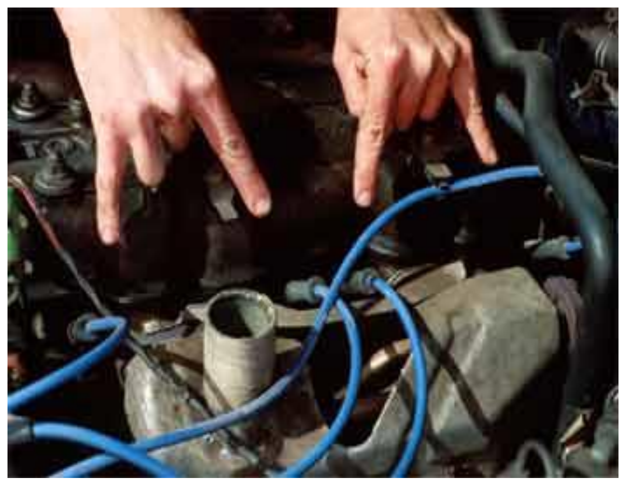
Required Tools and Equipment: Spark plug socket wrench, T and long extension and flat screw driver

Precautions: Before installing make sure an engine in safe conditions

Quality Criteria: - Remove properly the spark plug from engine

Steps:

1. Pull the hood release lever located under the dashboard.
2. Walk around to the front of the car, reach under the hood, find the latch and squeeze it. Open the hood.
3. Find the spark plugs, located in a row along one side of the engine (on an in-line four-cylinder engine) and attached to thick wires, called spark plug wires. Cars with V-shaped engines (which can have four, six or eight cylinders) will have spark plugs and spark plug wires on both sides of the engine.



4. Change one spark plug at a time, always putting the plug wire back on before changing the next spark plug.

Warning:

5. Change one spark plug at a time, putting the wire back on after you're done. If you pull all the wires off at once, you may put them back on the wrong spark plugs; this

changes the firing order, and your car will run badly or not at all. If you must take all the wires off at once, label them with white correction fluid or with masking tape and a marker.

6. Pull off one spark plug wire where it attaches to the plug. There is a little rubber boot at the plug end of the wire; pull on this part. Pulling higher up on the wire can damage the spark plug wire and cause it to separate.

7. Blow or wipe away any dirt or debris around the spark plug. You do not want anything to fall into the cylinder while the spark plug is out.
8. With the spark plug socket and a ratchet, remove the spark plug by turning it in a counterclockwise direction. You may need an extension for your ratchet if the spark plugs are deep-set or not directly accessible. Ratchets with flexible heads are especially helpful for hard-to-reach spark plugs.
9. Check the spark plug to make sure it needs replacing. A good spark plug should be lightly coated with grayish brown deposits. If heavy deposits are present, if the spark plug is black or if the electrode or core nose is damaged, the plug needs to be replaced.

Operation Sheet 3.4

Operation Title: Gapping the Spark Plug

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To tune an engine ignition system

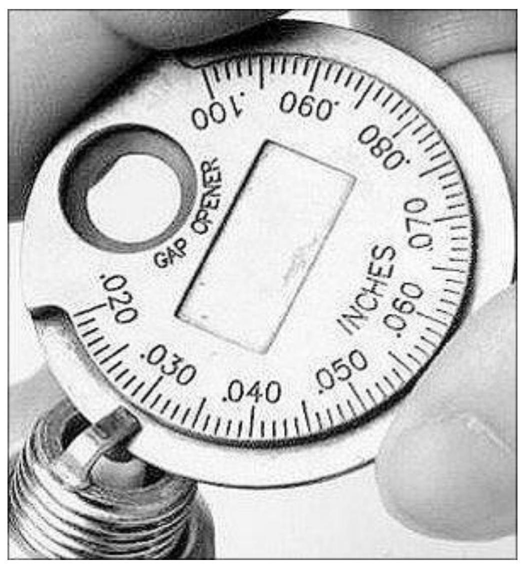
Required Tools and Equipment: Feller gauge and flat screw driver

Precautions: Before installing make sure an engine in safe conditions

Quality Criteria: - Properly measure spark plug with in the standard

Steps:

1. Find the chart listing the proper "gap" for your plugs in your car's repair manual. The spark plug gap may also be on the sticker on the inside of the car's hood. The parts store can provide you with this specification as well or read the basics below.
2. Insert the spark plug gapping tool in the gap between the metal center electrode and the metal side electrode of the plug's tip.
3. 3Look at the tools ruled edge and find the gap's measurement. If it is too big, bend the spark plug's end with the tool to widen the gap. To make the gap smaller, push the side electrode (the metal part at the very top) against a hard surface.
4. After adjusting, measure again. Repeat this procedure until the gap matches the specification listed in your car's manual.
5. Repeat with each plug.



Note: Spark plug gap specifications are listed in inches and/or millimeters. The gaper will have inches on one side and millimeters on the other.

Operation Sheet 3.5

Operation Title: Installing Spark Plugs

Instruction:

- Keep safe your working area
- Refer to your vehicle's service manual to obtain the manufacturer's specifications

Purpose: To tune an engine ignition system

Required Tools and Equipment: Spark plug socket wrench, extensions and flat screw driver

Precautions: Before installing make sure an engine in safe conditions

Quality Criteria: - Properly measure spark plug with in the standard

Procedures:

Steps:

1. Hand-tighten each spark plug in place. If you feel any resistance, stop and start over to prevent cross-threading.
2. Tighten the plugs with a socket wrench until snug. Do not overtighten.
3. Replace the spark plug wires. Usually, you will hear a soft pop when the plug wire snaps onto the plug.
4. Start the engine. Listen. If the engine runs roughly or doesn't start, make sure the wires are pushed all the way onto the new plugs.

Note: Improperly gapped plugs will make your car run roughly, start poorly and have bad gas mileage. Always clean the threads before installing.

Torque Reference for Installing for Installing Spark Plugs

Spark plug type	**Thread Diameter**	**Cast Iron Cylinder Head (lb-ft.)**	**Aluminum Cylinder Head (lb-ft.)**
Flat seat type (with gasket)	18 ø mm	25.3~32.5	25.3~32.5
"	14 ø mm	18.0~25.3	18.0~21.6
"	12 ø mm	10.8~18.0	10.8~14.5
"	10 ø mm	7.2~10.8	7.2~8.7
Conical seat type (without gasket)	18 ø mm	14.5~21.6	14.5~21.6
Conical seat type (without gasket)	14 ø mm	10.8~18.0	7.2~14.5

LAP-Test

Practical Demonstration

Name: ___________________________ **Date: _____________**

Time started: ____________________ **Time finished: _______________**

Instruction I: Perform the following tasks

Task 1: Inspect visual check, smoke diagnosis and noise diagnosis

Task 2: Perform Engine Performance Test

- Power Balance Test
- Vacuum And Speed Test
- Manifold Vacuum Test
- Oil Pressure Test
- Compression Test
- Cylinder Leakage Test

Task 3: Adjust Valve Clearance and Timing

Task 4: Tuning Up Gasoline Fuel System

Task 5: Tuning Up Diesel Fuel System

Task 6: Tuning Up Engine Electrical Systems

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