INTRODUCTION

The diagnostic process is a strategy that eliminates known good components or systems in order to find the root cause of automotive engine performance problems. All vehicle manufacturers recommend a step-by-step diagnostic procedure.

Many different things can cause an engine performance problem or concern. The service technician must narrow the possibilities to find the cause of the problem and correct it. All problem diagnosis deals with symptoms that could be the result of many different causes. The wide range of possible solutions must be narrowed to the most likely and these must eventually be further narrowed to the actual cause.

Many manufacturers recommend eight steps that the service technician can take to narrow the possibilities to one cause. Figure 1.

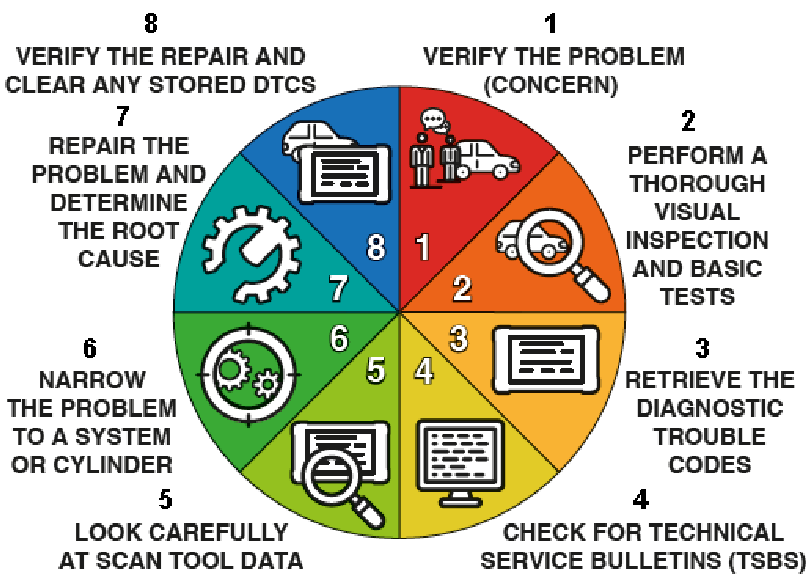

Figure 1. Eight step diagnostic process.

<u>Step 1</u>—Verify the problem (Concern).

Before a minute is spent on diagnosis , be certain that a problem exists. If the problem cannot be verified, it cannot be solved or tested to verify that the repair was complete.

<u>Step 2</u>—Perform a thorough visual inspection and basic tests.

Check for obvious problems

- Fuel leaks
- Vacuum hoses that are disconnected or split
- Corroded connectors
- Unusual noises, smoke, or smell

Step 3—Retrieve the diagnostic trouble codes (DTCs).

If a diagnostic trouble code (DTC) is present in the computer memory, it may be signaled by illuminating a malfunction indicator lamp (MIL), commonly labeled "check engine" or "service engine soon."

Step 4—Check for technical service bulletins (TSBs).

Check for corrections in technical service bulletins (TSBs) that match the symptoms. DTCs must be known before searching for service bulletins, because bulletins often include information on solving problems that involve a stored diagnostic trouble code.

Step 5—Look carefully at scan tool data.

Data on a scan tool connected to the data link connector (DLC) can help indicate some areas check. The best way to look at scan data is in a definite sequence and with specific, selected bits of data that can tell the most about the operation of the engine, such as the following:

- Engine coolant temperature (ECT) is the same as intake air temperature (IAT) after the vehicle sits for several hours.
- Electronic throttle actual percentage matches commanded percentage.

Step 6—Narrow the problem to a system or cylinder.

Narrowing the focus to a system or individual cylinder is the hardest part of the entire diagnostic process.

- Perform a cylinder power balance test.
- If a weak cylinder is detected, perform a compression test and a cylinder leakage test to determine the probable cause.

Step 7—Determine the root cause and repair the problem.

The repair or part replacement must be performed following vehicle manufacturer's recommendations and be certain that the root cause of the problem has been found.

Step 8—Verify the repair and clear any stored DTCs.

- Test-drive to verify that the original problem (concern) is fixed.
- Verify that no additional problems have occurred during the repair process.
- Check for and then clear all diagnostic trouble codes. If the vehicle is going to be tested for emissions, drive the vehicle until all of the monitors run and pass.

ASE TEST TOPICS

1. Verify driver's complaint, perform visual inspection, and/or road test vehicle.

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

- Is the malfunction indicator light (MIL) or check engine light on?

- What was the temperature outside?
- Was the engine warm or cold?
- Was the problem during starting, acceleration, cruise, or some other condition?
- How far had the vehicle been driven?
- Were any dash warning lights on? If so, which one(s)?
- Has there been any service or repair work performed on the vehicle lately?

After the nature and scope of the problem are determined, the complaint should be verified before further diagnostic tests are performed. If possible a test drive of the vehicle should be performed. Because drivers differ, it is sometimes the best policy to take the customer on the test-drive to verify the concern.

2. Research applicable vehicle and service information, such as: engine management system operation, vehicle service history, service precautions, technical service bulletins, and service campaigns/recalls.

Service information is needed to correctly service or repair vehicles because it contains all of the specifications, engine management system operation, and specified procedures to follow when servicing or repairing a vehicle. The most comprehensive and accurate service information is the service information from the vehicle manufacturer.

A technical service bulletin (TSB) is issued by the vehicle manufacturer to notify service technicians of a potential problem or other critical information. The TSB may include diagnostic procedures and the necessary corrective action.

A campaign is typically issued when a manufacturer wants to improve a product's performance or increase the customer's satisfaction. If the campaign involves a safety or emissions concern, it is considered a recall. A recall can occur when either the manufacturer or the National Highway Traffic Safety Administration (NHTSA) determines there is a concern.

Whenever service work is performed, a record of what was done is usually kept on file or stored electronically on a network or online server for a number of years. Often, a previous repair may indicate the reason for the current problem, or it could be related to the same circuit or components.

3. Diagnose base engine mechanical problems; determine needed action.

Base engine mechanical diagnosis is covered in ASE Area 8, Tasks 4 through 9, below.

4. Diagnose noise and/or vibration problems; determine needed action.

Several items that can cause an engine noise include the following:

- Valves clicking. 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.

5. Diagnose the cause of unusual exhaust color, odor, and sound; determine needed action.

The color of engine exhaust smoke can indicate what engine problem might exist.

- Blue exhaust indicates that the engine is burning oil. Oil is getting into the combustion chamber either past the piston rings or past the valve stem seals. Blue smoke only after start-up is usually due to defective valve stem seals.
- Black exhaust smoke is due to excessive fuel being burned in the combustion chamber. Typical causes include a leaking fuel injector or excessive fuel-pump pressure.
- White smoke or steam from the exhaust is normal during cold weather and represents condensed steam. If the steam from the exhaust is excessive, then water (coolant) is getting into the combustion chamber. Typical causes include a defective cylinder head gasket, a cracked cylinder head, or in severe cases a cracked block. Figure 2.

Figure 2. Excessive white exhaust indicates water or coolant in the combustion chamber.

6. Perform engine manifold vacuum or pressure tests; determine needed action.

For a cranking vacuum test, crank the engine while observing the vacuum gauge. Cranking vacuum should be higher than 2.5 inch Hg. (Normal cranking vacuum is 3 to 6 inch Hg.) If it is lower than 2.5 inch Hg, the following could be the cause:

- Too slow a cranking speed
- Worn piston rings
- Leaking valves
- Excessive amounts of air bypassing the throttle plate

An engine in proper condition should idle with a steady vacuum between 17 and 21 inch Hg. Figure 3.

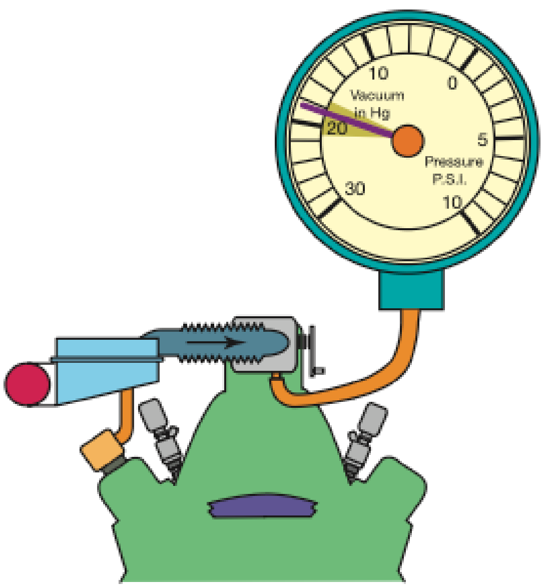

Figure 3. Normal vacuum at idle.

7. Perform cylinder power balance test; determine needed action.

The purpose of a cylinder power balance test is to determine if all cylinders are contributing power equally. It determines this by shorting out one cylinder at a time. If the engine speed (RPM) does not drop as much for one cylinder as for other cylinders of the same engine, the shorted cylinder must be weaker than the other cylinders.

One way to check to see if all cylinders are mechanically able to contribute to the operation of the engine is to perform a cylinder contribution test using a scan tool. A cylinder contribution test, also called a power balance test, is an automated test that a scan tool performs by turning a fuel injector off to one cylinder at the time and monitoring the drop, or increase in engine speed. This change in engine speed should be the same for all cylinders if all cylinders are working correctly.

8. Perform cylinder cranking, relative, and running compression tests; interpret test results; determine needed action.

An engine compression test is one of the fundamental engine diagnostic tests that can be performed. For smooth engine operation, all cylinders must have equal compression. An engine can lose compression by leakage of air through one or more of only three routes:

- Intake or exhaust valve
- Piston rings (or piston, if there is a hole)
- Cylinder head gasket

For a cranking compression test, thread a compression gauge into one spark plug hole at a time and crank the engine. Continue cranking the engine through four compression strokes. Record the highest readings and compare the results. Most manufacturers specify a maximum difference of 20% between the highest reading and the lowest reading.

A relative compression test uses a digital storage oscilloscope (DSO) and a current clamp is to measure the change in current that occurs when an engine is cranking to determine the relative compression. This relative compression test uses the starter motor current to determine the compression values of all cylinders.

A relative compression test uses an amp clamp around the starter motor power cable and a Pico scope. The result is a waveform that displays the current needed for each cylinder under compression. This test indicates all cylinders are requiring the same current to rotate the starter motor which indicates that all cylinders have the same relative compression. Figure 4.

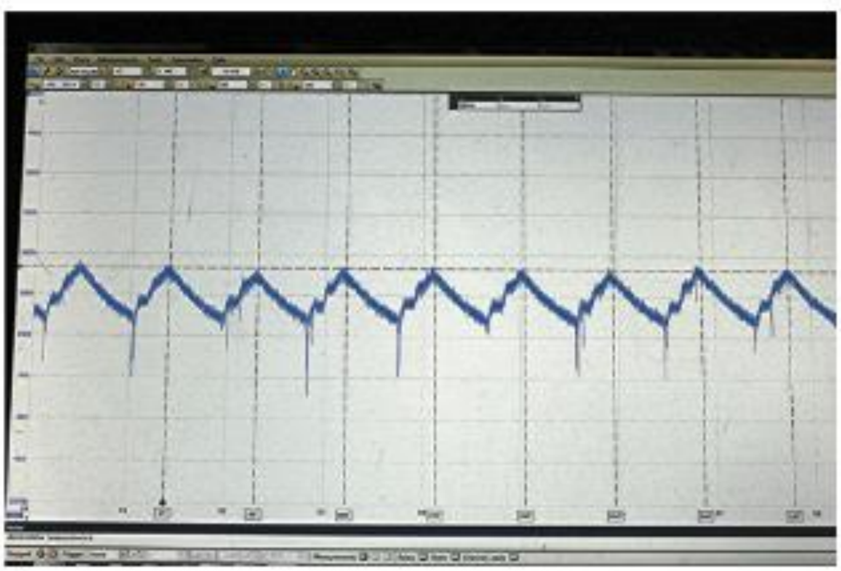

Figure 4. Relative compression test using a DSO.

9. Perform cylinder leakage/leak-down test; determine needed action.

The cylinder leakage test involves injecting air under pressure into the cylinders one at a time. The amount and location of any escaping air helps the technician determine the condition of the engine. The air is injected into the cylinder through a cylinder leakage gauge into the spark plug hole.

Air is injected into the cylinders one at a time, rotating the engine as necessitated by firing order to test each cylinder at TDC on the compression stroke.

Less than 10% leakage: good

Less than 20% leakage: acceptable

Less than 30% leakage: poor

More than 30% leakage: definite problem

10. Diagnose engine mechanical, electrical, electronic, fuel, and ignition problems with an oscilloscope, engine analyzer, and/or scan tool; determine needed action.

An oscilloscope (usually called a scope) is a visual voltmeter with a timer that shows when a voltage changes. A digital scope takes samples of the signals that can be stopped or stored and is therefore called a digital storage oscilloscope (DSO).

A DSO can be connected to a sensor output signal wire and can record the voltage signals over a long period of time. It can be replayed, and a technician can see if any faults were detected. This feature makes a DSO the perfect tool to help diagnose intermittent problems.

A two-channel scope can display the waveform from two separate sensors or components at the same time. This feature is very helpful when testing the accelerator position sensor or brake switch inputs to ensure they change at the appropriate voltage levels. Figure 5.

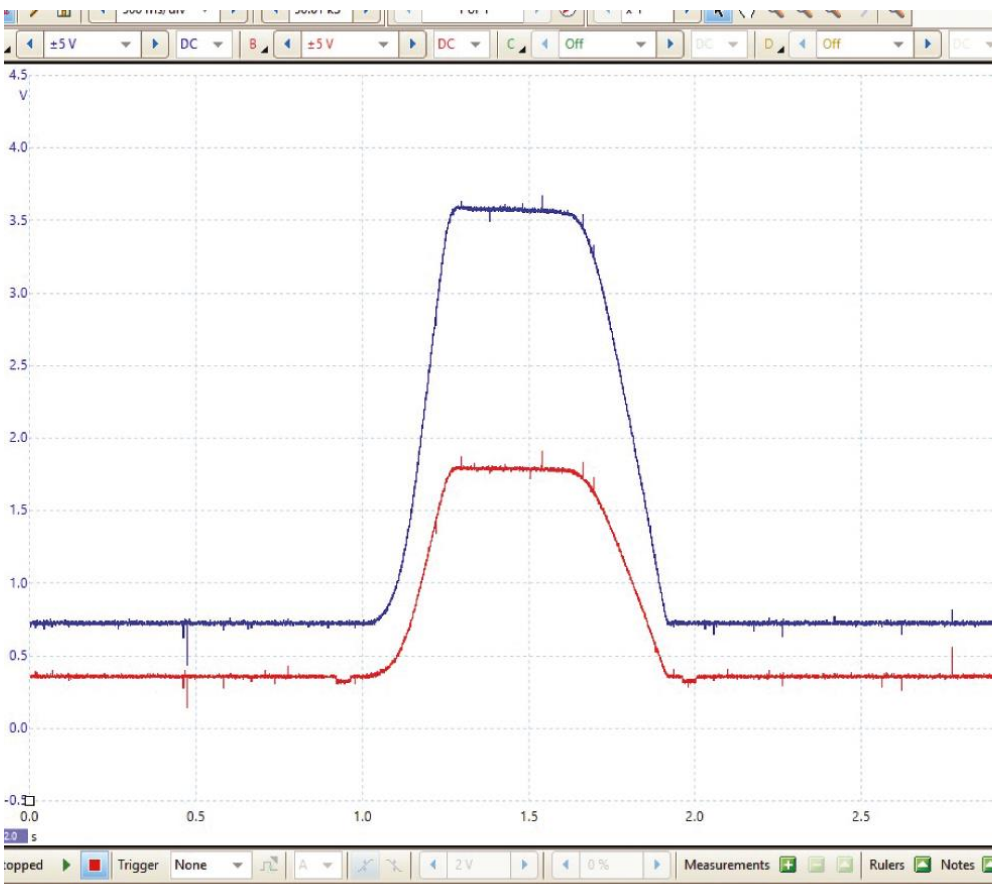

Figure 5. Accelerator position sensor DSO trace.

Factory scan tools are the scan tools required by all dealers that sell and service the brand of vehicle. Aftermarket diagnostic scan tools are manufactured by many manufacturers and use the data licensed from each original equipment manufacturer (OEM).

The best way to look at scan data is in a definite sequence and with specific, selected bits of data that can tell the most about the operation of the engine. Some examples are:

- With the key on, engine off (KOEO):
  - Engine coolant temperature (ECT) is the same as intake air temperature (IAT) after the vehicle sits for several hours.
  - MAP should equal BARO.
- With the key on, engine running (KOER), the upstream conventional zirconia oxygen sensor should switch rapidly within 200 mV and 800 mV. Figure 6.

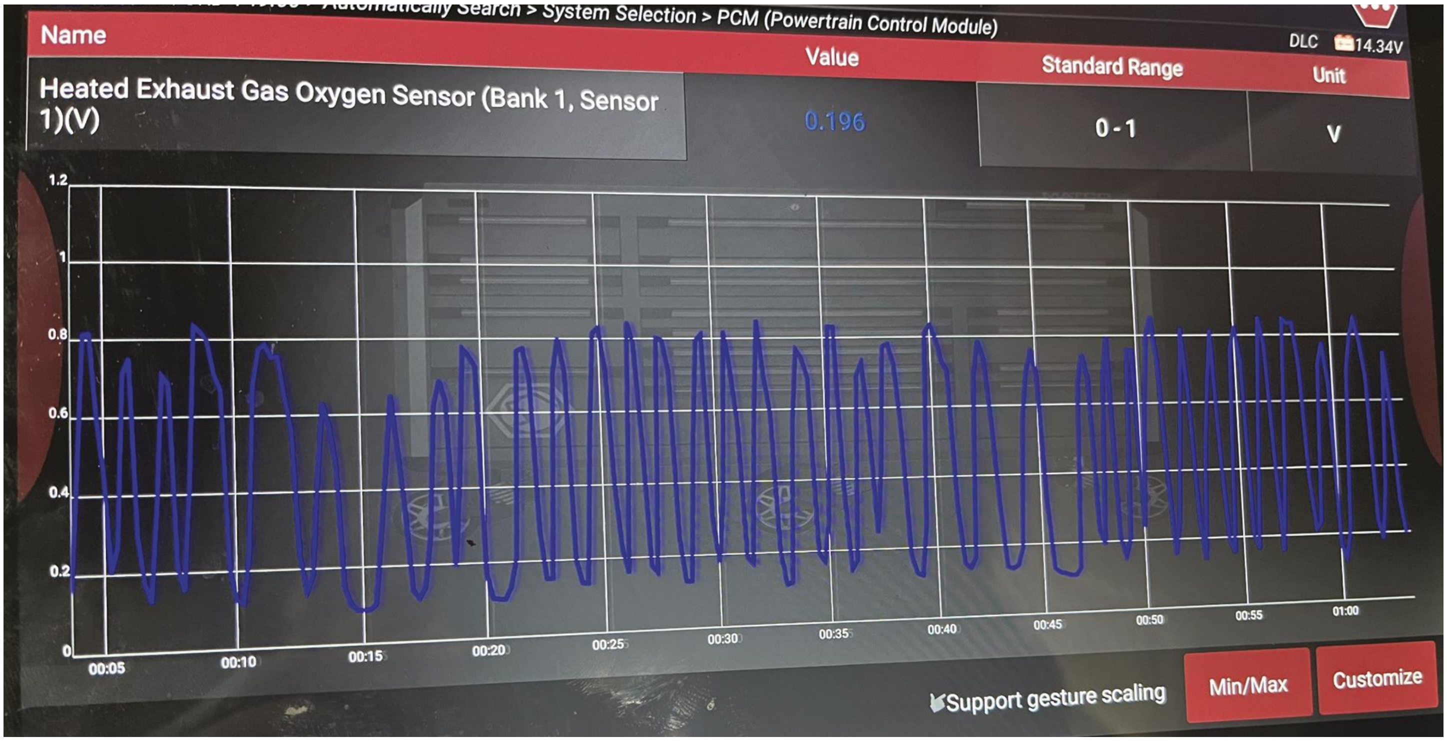

Figure 6. A scan tool graph showing oxygen sensor activity.

11. Verify valve adjustment on engines with mechanical or hydraulic lifters.

On solid lifters, the valve clearance or lash is checked with the overhead camshaft in place. Some engines use shims under a follower disk. On these engine types, the camshaft is turned so that the follower is on the base circle of the cam. The clearance of each bucket follower can be checked with a feeler gauge. The amount of clearance is recorded and compared with the specified clearance, and then a shim of the required thickness is put in the top of the bucket followers. Figure 7.

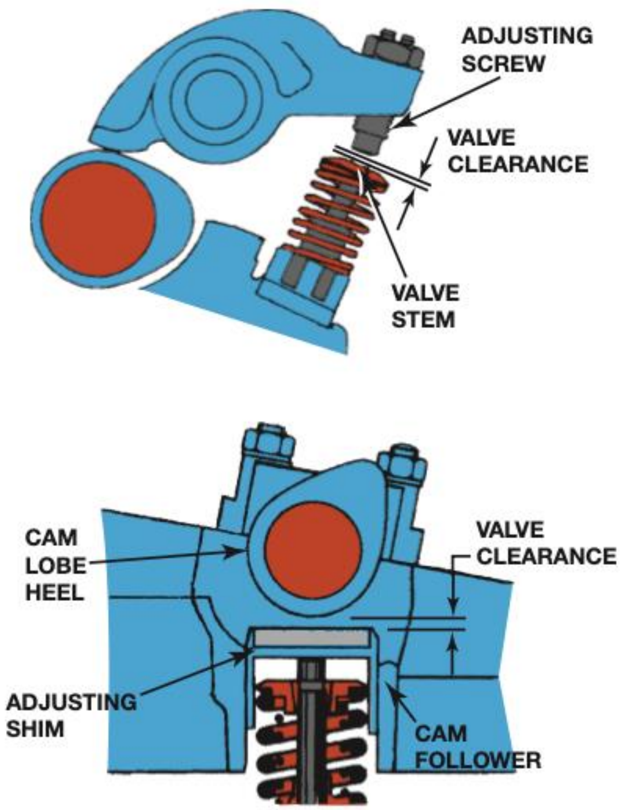

Figure 7. Mechanical or solid lifters adjust with an adjusting screw or shim.

For engines with hydraulic lifters, rocker arms are tightened to a position that will center the hydraulic lifter. The general steps are:

- Rotate the engine until cylinder 1 is at TDC on the compression stroke to be assured that both the intake and exhaust valves are on the base circle of the cam lobes.
- Tighten the retaining nut to the point that all free lash is gone and the pushrod cannot be easily rotated. Figure 8.
- From this point, the retaining nut is tightened by a specified amount, such as three-fourths of a turn or one and one-half turns.
- Rotate the engine until the next cylinder in the firing order is at top dead center on the compression stroke. The valves on this next cylinder are adjusted in the same manner as those on cylinder 1. This procedure is repeated on each cylinder following the engine firing order until all the valves have been adjusted.

Figure 8. Adjusting to zero lash.

12. Verify camshaft timing; verify operation of camshaft timing components, including engines equipped with variable valve timing (VVT) and variable valve lift (VVL); determine needed action.

Checking the cam-to-crank timing is done by aligning the timing marks of the crankshaft and camshaft drive sprockets with their respective timing marks. The location of these marks differs between engines, but the marks can be identified by looking carefully at the sprockets. Figure 9.

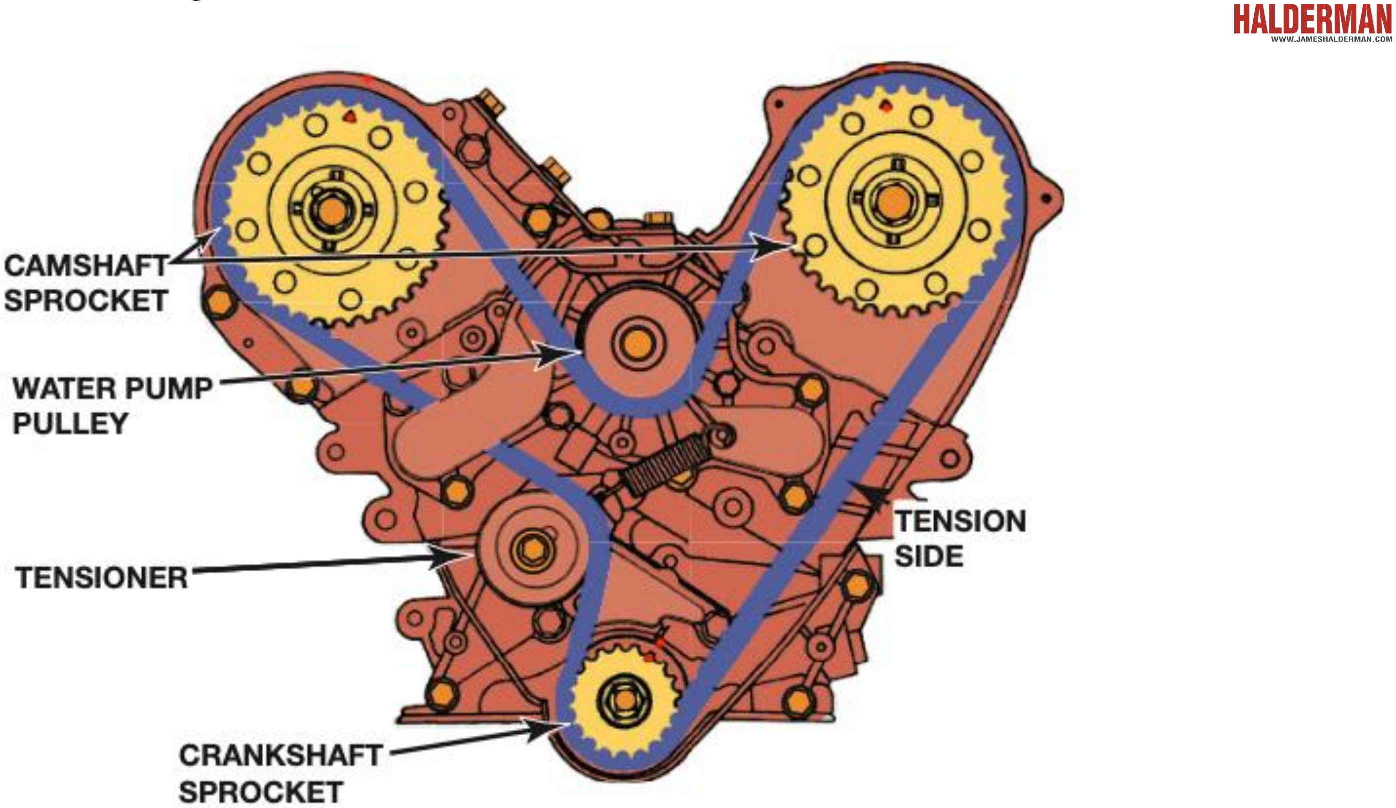

Figure 9. Cam drive timing marks on the sprockets and front engine cover (red marks). Normal rotation for this engine is clockwise.

To double check the cam timing, rotate the crankshaft through two full revolutions in the normal direction. On the first full revolution, the exhaust valve will be almost closed, and the intake valve will just be starting to open when the crankshaft timing mark aligns. At the end of the second revolution, both valves should be closed, and all the timing marks should align. This is the position the crankshaft should have when cylinder 1 is ready to be fired.

Variable valve timing (VVT) involves the use of electric and hydraulic actuators that are used to change the timing of the camshaft(s) in relation to the crankshaft.

The vane phaser system used on OHC engines uses a camshaft position (CMP) sensor on each camshaft. Each camshaft has its own actuator and its own oil control valve (OCV). The vane phaser uses a rotor with four vanes, which is connected to the end of the camshaft. Oil pressure is controlled on both sides of the vanes of the rotor. The OCV varies the balance of pressure on either side of the vanes and thereby controls the position of the camshaft. A return spring is used under the reluctor of the phaser to help return it to the home position. Figure 10.

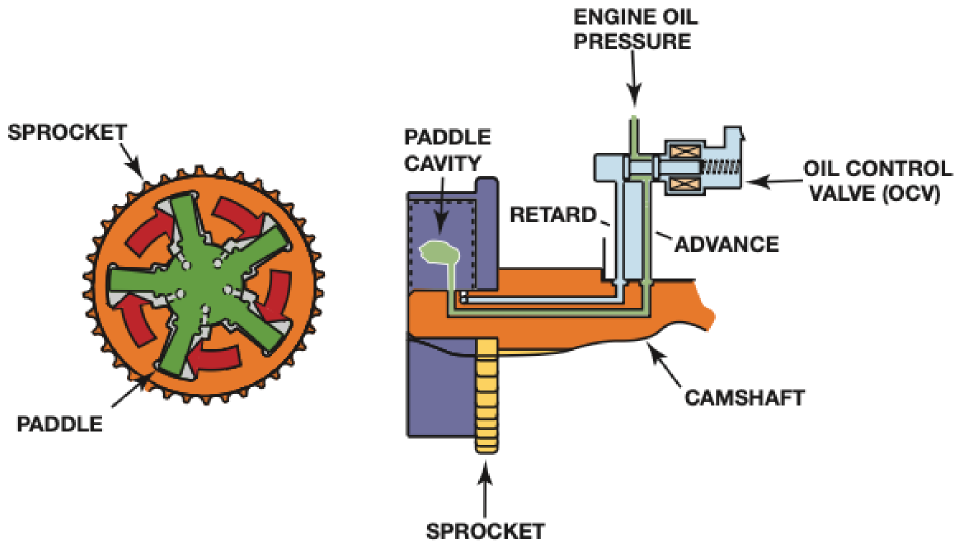

Figure 10. Variable valve timing vane-type phaser.

Variable camshafts such as the system used by Honda/Acura are called variable valve timing and lift electronic control (VTEC). This system uses two different camshafts profiles for low and high RPM. If the system is malfunctioning a diagnostic trouble code (DTC) will be set.

13. Diagnose emissions or driveability problems caused by oil-related issues such as: incorrect pressure, poor quality, incorrect level, or incorrect type used for the application.

An SAE 5W-30 multigrade oil meets the SAE 5W viscosity specification when cooled to 0°F (−18°C) and meets the SAE 30 viscosity specification when tested at 212°F (100°C). Most vehicle manufacturers recommend the following multiviscosity engine oils.

- SAE 0W-16
- SAE 0W-20
- SAE 5W-20
- SAE 5W-30

Engine oil checks include:

- Oil level—oil should be to the proper level
- Oil condition
    - If the oil is very thin or has a gas smell, gasoline is present in the engine oil.
    - If the oil is cloudy or milky, there is coolant (water) in the oil.
    - Check for grittiness by rubbing the oil between your fingers.

Proper oil pressure is very important for the operation of any engine. Low oil pressure can cause engine wear, and engine wear can cause low oil pressure. If main thrust or rod bearings are worn, oil pressure is reduced because of leakage of the oil around the bearings. To check oil pressure:

- 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. Figure 11.
- 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.

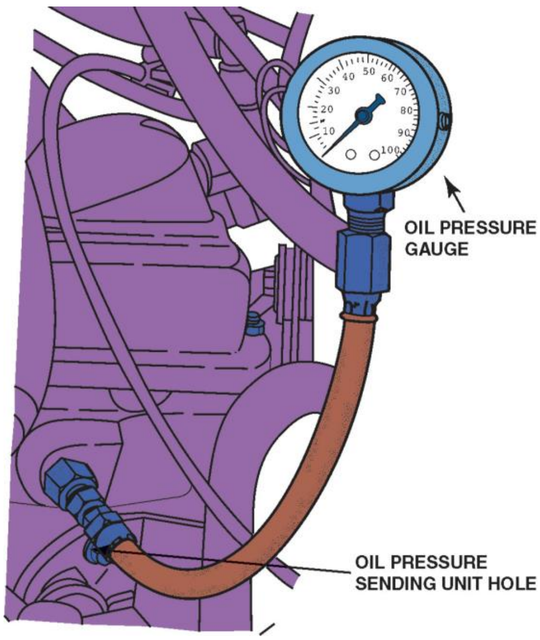

Figure 11. Checking oil pressure.

14. Verify engine operating temperature; check coolant level and condition; perform cooling system pressure test; determine needed action.

An infrared thermometer (also called a pyrometer) can be used to measure the temperature of the coolant near the thermostat. Then a scan tool is used to read the temperature of the coolant as detected by the engine coolant temperature (ECT) sensor. Compare the two readings. Figure 12.

Engine Data		
Engine Speed	603	RPM
Desired Idle Speed	600	RPM
ECT Sensor	194	°F
IAT Sensor 1	143	°F
IAT Sensor 2	158	°F
Ambient Air Temperature	-36	°F
Cold Start-Up	No	
MAF Sensor	0.01	lb/s
Engine Load	14.5	%
Accelerator Pedal Position	0	%
Throttle Position	4	%

Esc | Decrease | Increase | Pg Up | Pg Dn

Figure 12. Scan tool data showing engine coolant temperature (ECT).

The coolant level in the coolant recovery container should be within the limits indicated on the overflow bottle. If this level is too low or the coolant recovery container is empty, check the level of coolant in the radiator (only when cool) and also check the operation of the pressure cap.

Pressure test the cooling system and look for leakage. Coolant leakage can often be seen around hoses or cooling system components because it will often cause:

a. A grayish-white stain

b. A rust-colored stain

c. Dye stains from antifreeze (greenish or yellowish depending on the type of coolant)

A typical hand-operated pressure tester applies pressure equal to the radiator cap pressure. The pressure should hold; if it drops, this indicates a leak somewhere in the cooling system. Figure 13.

Figure 13. Pressure testing.

15. Inspect and test mechanically/hydraulically/electronically operated fans, fan clutch, fan shroud/ducting, active grille air flow control systems, and fan control devices; determine needed action.

Many rear-wheel-drive vehicles and all transverse engines drive the fan with an electric motor. Most electric cooling fans are computer controlled. To save energy, most cooling fans are turned off whenever the vehicle is traveling faster than 35 mph (55 km/h). Two types of electric cooling fans used, a one two-speed cooling fan, or two cooling fans (one for normal cooling and one for high heat conditions)

On some rear-wheel-drive vehicles, a thermostatic cooling fan is driven by a belt from the crankshaft. The thermostatic fan is designed so that it uses little power at high engine speeds and minimizes noise. Figure 14.

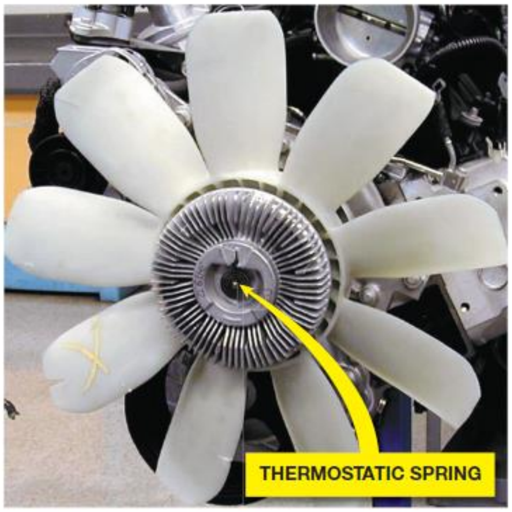

Figure 14. The thermostatic system engages the fan as engine temperatures increase.

Active Grille Shutters (AGS), also called a Radiator Shutter Assembly, are located between the front grille and the condenser. The plastic shutters open or close to control the airflow going under the hood. The primary function of the active grille shutters is to reduce the aerodynamic drag of the vehicle when closed. Unnecessary air entering the engine bay can create aerodynamic drag, decreasing fuel economy. Figure 15.

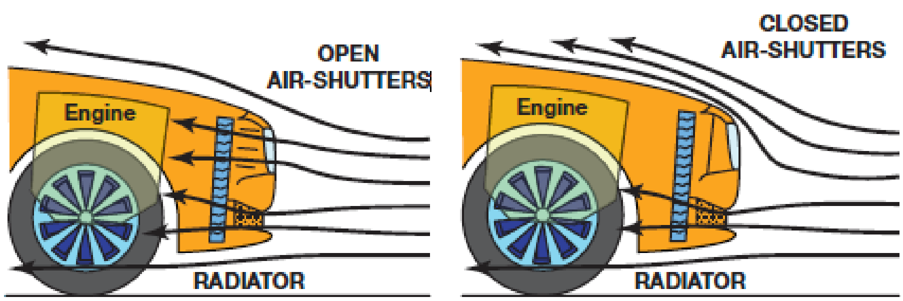

Figure 15. Active grill shutters.

16. Read and interpret electrical schematic diagrams and symbols.

In a schematic drawing, photos or line drawings of actual components are replaced with a symbol that represents the actual component. A typical section of a wiring diagram is shown in figure 16. Notice that the wire color changes at connection C210. The “0.8” represents the metric wire size in square millimeters.

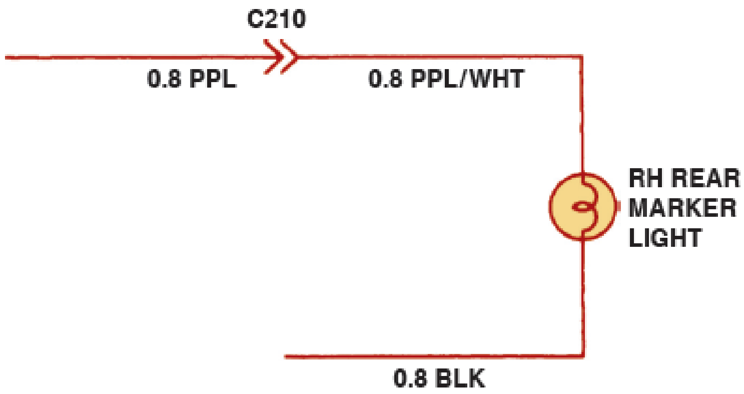

Figure 16. Schematic symbols and notations.

The following page shows typical electrical and electronic symbols used in automotive wiring and circuit diagrams. Both the conventional and the global symbols are shown side by side to make reading schematics easier. The global symbols are used by many vehicle manufacturers. Figure 17.

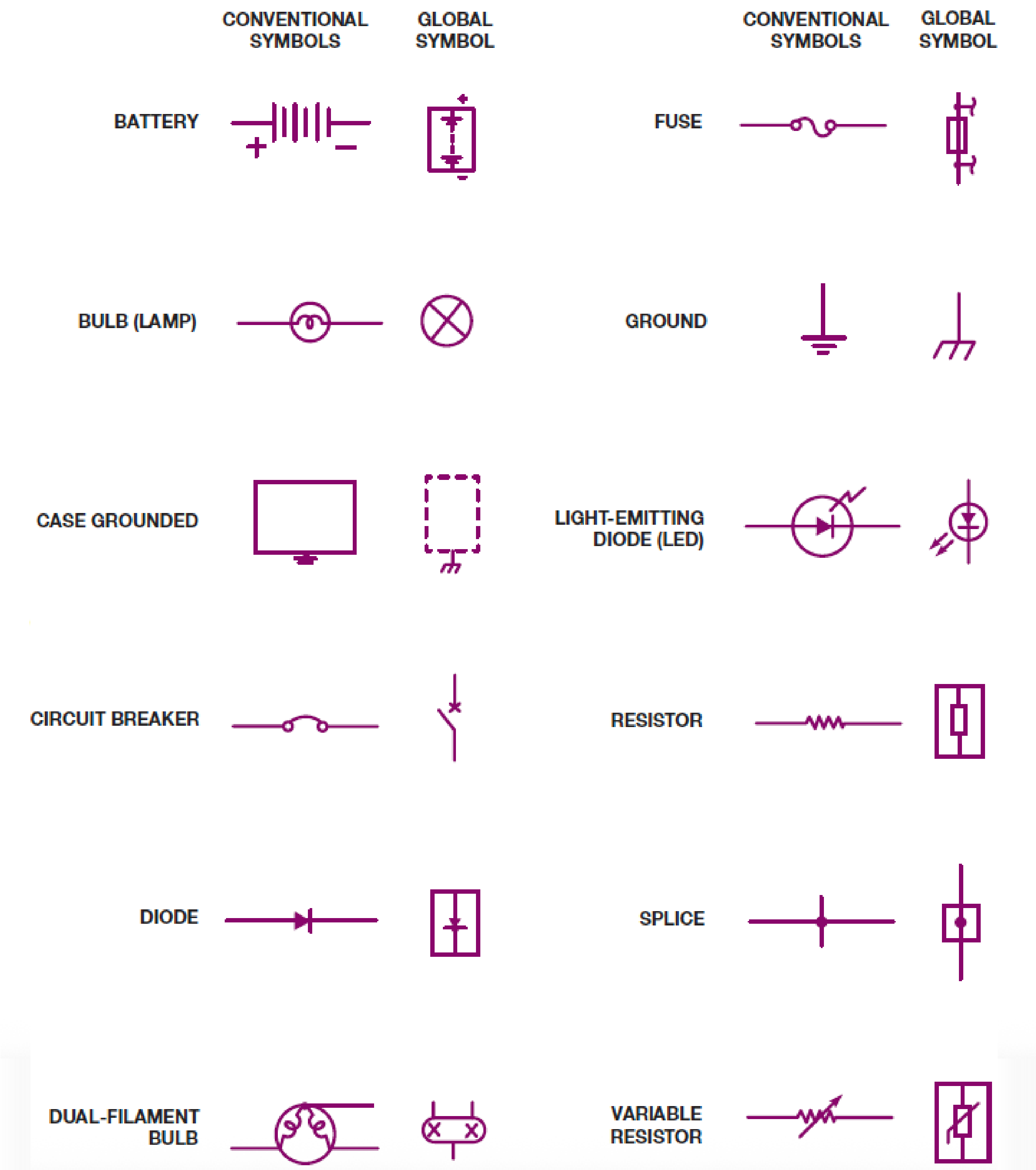

Figure 17. Schematic symbols.

17. Test and diagnose emissions or driveability problems caused by battery condition, connections, or excessive key-off battery drain; determine needed action.

Testing the battery voltage with a voltmeter is a simple method for determining the state of charge of any battery.

BATTERY VOLTAGE (V)	STATE OF CHARGE
12.6 or higher	100% charged
12.4	75% charged
12.2	50% charged
12.0	25% charged
11.9 or lower	Discharged

Battery maintenance includes making certain that the battery case is clean and checking that the battery cables and hold-down fasteners are clean and tight. The following warning signs indicate that a battery is near the end of its useful life.

- Excessive corrosion on battery cables or connections. Figure 18.
- Slower than normal engine cranking, especially during cold weather.

Figure 18. Corroded cable connections can cause slow cranking.

The battery electrical drain test determines if any component or circuit in a vehicle is causing a drain on the battery when everything is off. This test is also called the ignition off draw (IOD) or parasitic load test.

The fastest and easiest method to measure battery electrical drain is to connect an inductive DC ammeter that is capable of measuring low current (10 milliamperes). Figure 19.

- Normal = 20 to 30 milliamperes (0.02 to 0.03 ampere)
- Maximum allowable = 50 milliamperes (0.05 ampere)

Figure 19. An inductive clamp-on meter can measure parasitic drain.

18. Test and diagnose engine performance problems resulting from starting system failures; determine needed action.

The engine is cranked by an electric motor that is controlled by a key operated ignition switch or the PCM on vehicles equipped with electronic starting. Fig 20.

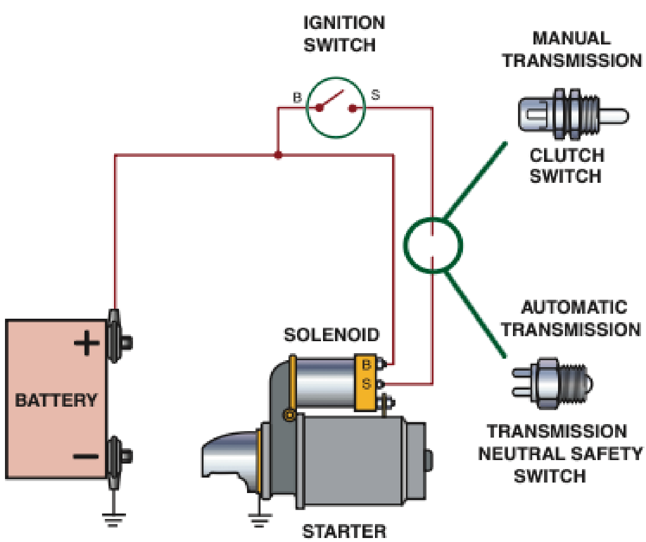

Figure 20. System and safety switches.

The proper operation of the starting system depends on a good battery, good cables and connections, and a good starter motor . Because a starting problem can be caused by a defective component anywhere in the starting circuit , it is important to check for the proper operation of each part of the circuit to diagnose and repair the problem quickly.

- Visually inspect the battery and battery connections. The starter is the highest amperage draw device used in a vehicle and any faults , such as corrosion on battery terminals, can cause cranking system problems.

- Test battery condition. Perform a battery load or conductance test on the battery to be sure that the battery is capable of supplying the necessary current for the starter.
- Check the control circuit . An open or high resistance anywhere in the control circuit can cause the starter motor to not engage. Items to check include:
  - "S" terminal of the starter solenoid
  - Neutral safety or clutch switch
  - Starter enable relay (if equipped)
  - Antitheft system fault (If the engine does not crank or start and the theft indicator light is on or flashing, there is likely a fault in the theft deterrent system.

19. Perform starter current draw test; determine needed action.

A starter should be tested to see if the reason for slow or no cranking is due to a fault with the starter motor or another problem. A starter amperage draw test determines if the starter motor is the cause of a no or slow cranking concern. Figure 21.

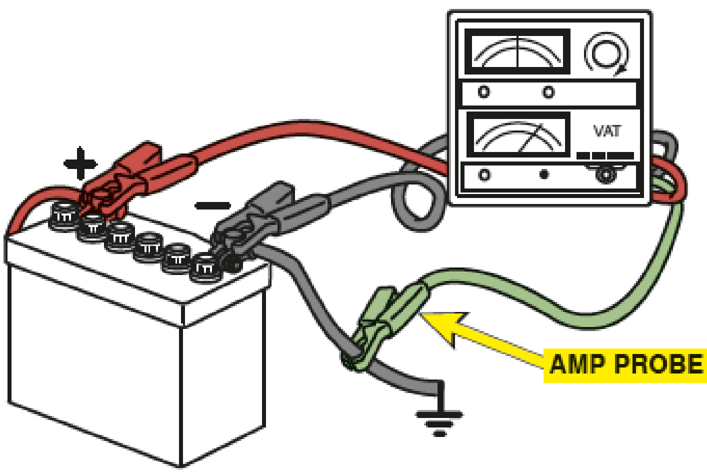

Figure 21. Connections for a starter current draw test.

Normal amperage draw:

- 4 cylinder engines 150 to 185 amperes (normally less than 100 amperes) at room temperature
- 6 cylinder engines 160 to 200 amperes (normally less than 100 amperes) at room temperature
- 8 cylinder engines 185 to 250 to amperes (normally less than 125 amperes) at room temperature

Excessive current draw may indicate one or more of the following:

- Binding of starter armature as a result of worn bushings
- Oil too thick (viscosity too high) for weather conditions
- Shorted or grounded starter windings or cables
- Tight or seized engine
- Shorted starter motor (usually caused by fault with the field coils or armature)

Lower amperage draw and slow or no cranking may indicate one or more of the following:

- Dirty or corroded battery connections
- High internal resistance in the battery cable(s)
- High internal starter motor resistance
- Poor ground connection between the starter motor and the engine block

20. Perform starter and charging circuit voltage drop tests; determine needed action.

- Check voltage drop of the starter circuit . Any high resistance in either the power side or ground side of the starter circuit causes the starter to rotate slowly or not at all. Fig 22.

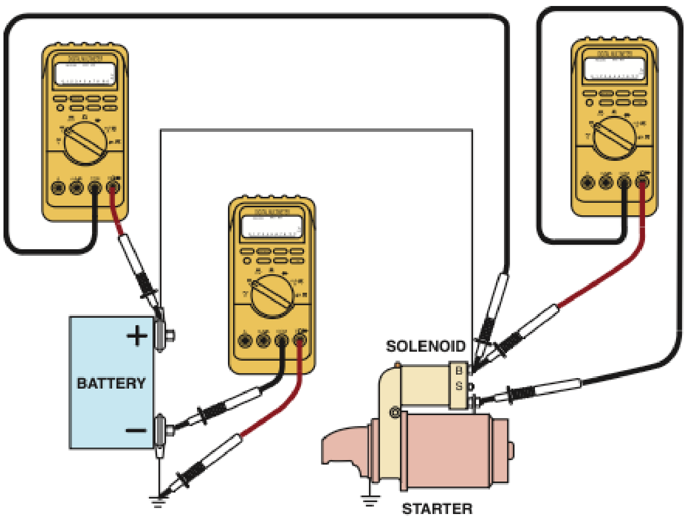

Figure 22. Voltmeter connections for starter voltage drop tests.

When there is a suspected charging system problem (with or without a charge indicator light on), follow these steps to measure the voltage drop of the insulated (power-side) charging circuit. Figure 23.

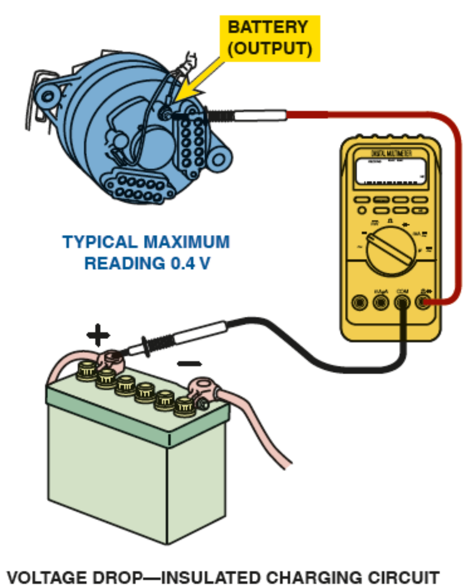

Figure 23. Charging system voltage drop test.

STEP 1 Start the engine and run it at a fast idle (about 2,000 engine RPM).

STEP 2 Turn on the headlights to ensure an electrical load on the charging system.

STEP 3 Using any voltmeter set to read DC volts, connect the positive test lead (red) to the output terminal of the alternator. Attach the negative test lead (black) to the positive post of the battery. There should be less than a 0.4 volt (400 millivolts) reading.

21. Test and diagnose engine performance problems resulting from charging system failures; determine needed action.

The charging voltage test is the easiest way to check the charging system voltage at the battery. Use a digital multimeter to check the voltage, as follows:

STEP 1 Select DC volts.

STEP 2 Connect the red meter lead to the positive (+) terminal of the battery and the black meter lead to the negative (−) terminal of the battery.

STEP 3 Start the engine and increase the engine speed to about 2,000 RPM (fast idle) and record the charging voltage. Specifications for charging voltage = 13.5to15 volts

22. Inspect, adjust, and replace alternator (generator) drive belts, pulleys, clutches, tensioners, and/or fans.

It is generally recommended that all belts be inspected regularly and replaced as needed. Replace any serpentine belt that has more than three cracks in any one rib that appears in a 3 inch span. Fig. 24.

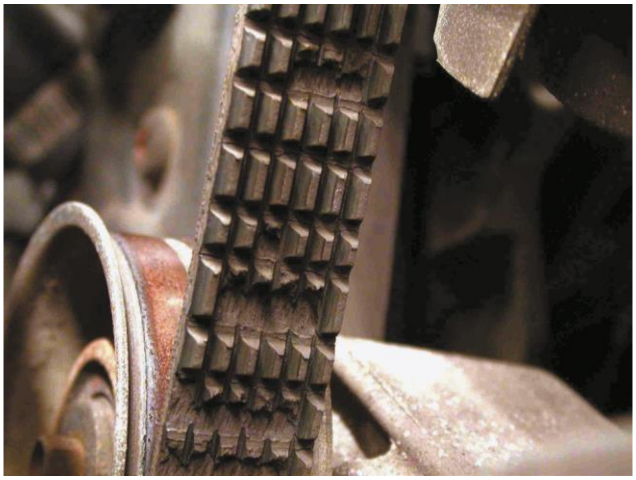

Figure 24. A defective belt.

If the belt needs replacement, first make note of the belt routing. There may be a diagram under the hood. Use a tool to release the tensioner and then remove the belt. Install the new belt and check it for the proper tension. Using a new tensioner is recommended. Fig. 25.

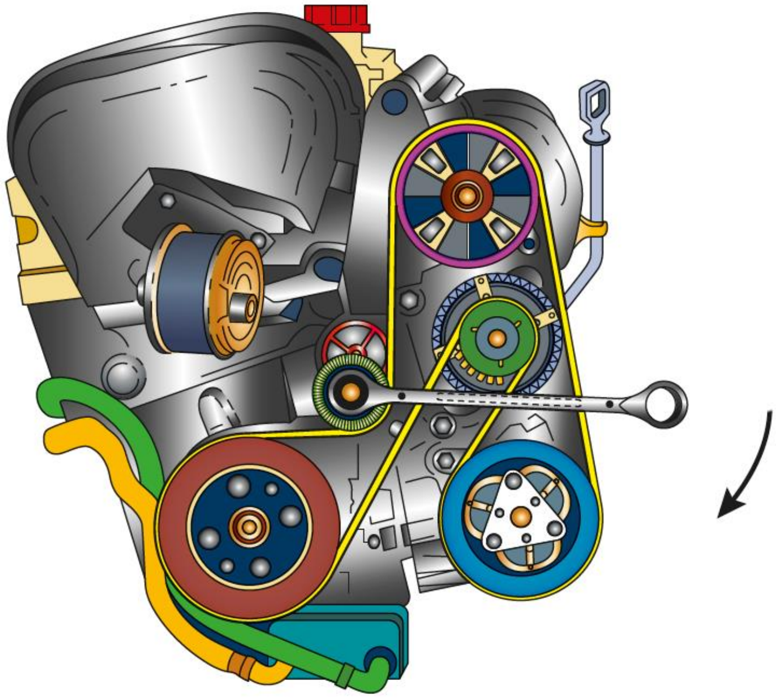

Figure 25. To release the tensioner, push the wrench in the direction shown.

23. Inspect, test, and repair or replace components, connectors, and wires in the starter and charging control circuits.

Components of the starter and charging control circuits are usually connected using harness connectors and metal wire terminals. A terminal is a metal fastener attached to the end of a wire, which makes the electrical connection. The term connector usually refers to the plastic portion that snaps or connects together, making the mechanical connection. Wire terminal ends usually snap into, and are held by, a connector. Figure 26.

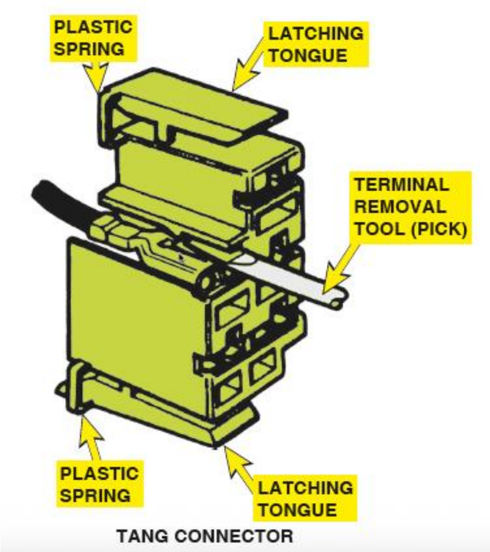

Figure 26. A small removal tool, sometimes called a pick, is used to release terminals from the connector.

If corroded connectors are noticed, the terminal should be cleaned and the condition of the electrical connection to the wire terminal end(s) confirmed. Many vehicle manufacturers recommend using dielectric silicone or lithium-based grease inside connectors to prevent moisture from getting into and attacking the connector.