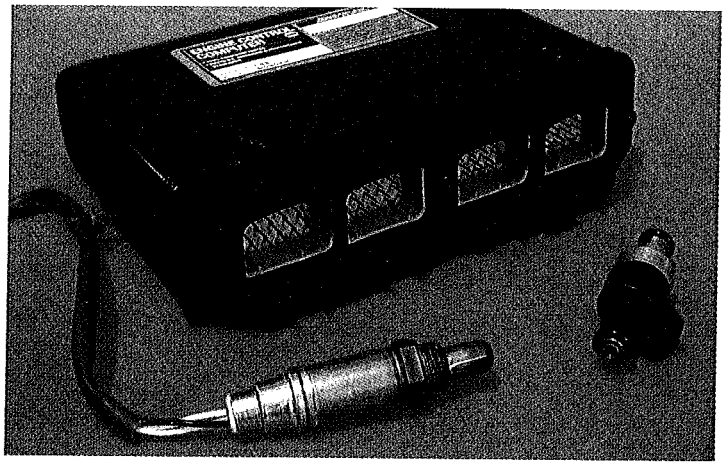
13. Technician A says on certain OBD I vehicles, you can activate the computer's self-diagnostics by pushing two dash climate control buttons at the same time. Technician B says on certain OBD I vehicles, you can activate the computer's self-diagnostics by turning the ignition key on and off within a few seconds. Who is right?
    (A) A only.
    (B) B only.
    (C) Both A and B.
    (D) Neither A nor B.
14. Which of the following test instruments can be used to read OBD I trouble codes?
    (A) Test light.
    (B) Voltmeter.
    (C) Scan tool.
    (D) All of the above.
15. Trouble codes need to be erased from an OBD II computer system. Technician A wants to accomplish this by unplugging the ECM fuse. Technician B wants to accomplish this by using the shop's scan tool. Who is right?
    (A) A only.
    (B) B only.
    (C) Both A and B.
    (D) Neither A nor B.

Activities—Chapter 18

1. Demonstrate, on at least one vehicle, the proper method for using a scan tool.
2. Videotape a service technician using a scan tool to "check out" an engine. Ask the technician to explain each step as he or she performs the work. Show the completed tape to the class.



19 Computer System Service

After studying this chapter, you will be able to:

- Perform a visual inspection of the engine, its sensors, actuators, and the systems they monitor and control.
- Test sensors and their circuits.
- Remove and replace sensors.
- Test and replace actuators.
- Remove and replace a computer.
- Remove and replace a computer PROM.
- Program an EEPROM.
- Demonstrate safe working practices when servicing automotive computers.
- Correctly answer ASE certification test questions on servicing computer system components.

Since almost all vehicle systems now use computer components, you must have a basic knowledge of computer service before studying the remaining chapters in this text. Otherwise, you will not fully understand the chapters on fuel injection, ignition, and emissions systems.

This chapter will briefly summarize how to test computer components and circuits and help you develop the skills needed to verify *where problems are.*

After you have checked the computer for trouble codes, you can find the exact source of the problem by doing pinpoint tests. ***Pinpoint tests*** are more specific tests of individual components. The service manual will normally have charts that explain how to do each pinpoint test. It will show specific tests, as well as provide component electrical values and other critical information.

Remember that trouble codes only indicate the area of trouble and sometimes the type of problem, *not* what part or circuit is at fault. It is therefore imperative that you know how to do basic electrical tests on individual components.

Preliminary Visual Inspection

A ***preliminary visual inspection*** involves looking for signs of obvious trouble: loose wires, leaking vacuum hoses, part damage, etc. For example, if the trouble code says there is something wrong in the coolant temperature sensor circuit, you should check the sensor resistance and the wiring going to the sensor. You should also check the coolant level and the thermostat. A low coolant level or engine overheating could also set this code.

When there is a malfunction in a system, always remember that the cause is often something simple. It is easy for the untrained person to instantly think "computer problem" when an engine runs rough, fails to start properly, or exhibits some other performance problem.

For example, *contaminated engine oil* can trigger a computer trouble code, **Figure 19-1.** Fumes from the contaminated oil can be drawn into the engine's intake manifold from the crankcase. If these fumes are excessively strong, the oxygen sensor could be tricked into signaling a rich air-fuel mixture. The computer would then lean the mixture to compensate for the crankcase fumes. An oxygen sensor trouble code may be produced and, in some cases, an engine performance problem could result.

As this points out, it is critical that you check for conventional or simple problems *first.* Start checking for computer problems only after all the conventional causes have been eliminated.

KISS Principle

KISS is an acronym that could help you find the source of performance problems on a computer-controlled vehicle. ***KISS*** stands for *keep it simple, stupid.* This means you should start your troubleshooting with the simple checks and tests. Then, as the common causes are eliminated as the source of the problem, you will move to more complex tests.

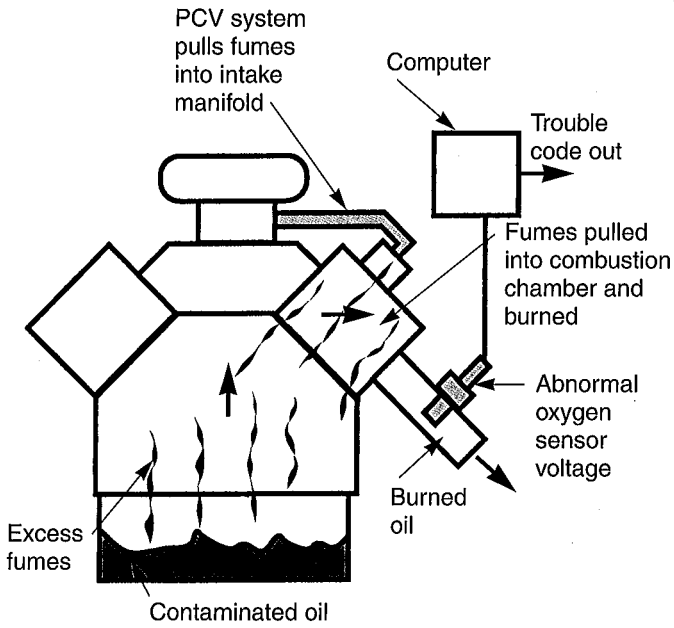


Figure 19-1. This example shows that a trouble code can be tripped by factors other than a computer system problem. Contaminated engine oil can cause excess fumes to be pulled into the PCV system. When burned in the combustion chambers, the fumes could trick the computer into sensing that something is wrong with the oxygen sensor circuit.

Electrical Component Damage

Semiconductor devices, such as transistors and integrated circuits, are very easy to damage. They can be damaged by static electricity, voltage spikes, heat, and impact shocks. Here are some things to remember when working with semiconductor devices and their wiring:

- Arc welding can damage the on-board computers. If welding on the vehicle is necessary, remove all of the on-board computers. If this is not possible or too time-consuming, unplug their connectors and make sure the welder's lead is securely grounded.
- Never disconnect the battery cables while the engine is running. In the past, some technicians would do this to see if the alternator was working. This can destroy or weaken electronic circuits, causing failure in a short period of time.
- Do not disconnect or connect wiring, especially the computer wiring, with the ignition key on. This can cause a current surge that can damage the computer.
- Make sure you do not reverse the battery cable connections. This can destroy electronic components.
- Wear an anti-static wrist strap whenever you handle static-sensitive components (removable PROM chips, for example) to protect them from damage.
- Use only high-impedance test lights and meters when checking electronic circuits or their wiring. A conventional test light or meter will draw too much current and destroy electrical components.
- Do not disconnect a scan tool from the data link connector while the ignition key is on. This could create a voltage spike that can damage the computer.

Computer System Circuit Problems

Almost all electrical-electronic problems are actually basic circuit problems. A ***basic circuit problem*** is caused by a problem in a circuit that increases or decreases current, resistance, or voltage. For example, a broken wire could stop current flow or a charging system problem could decrease output voltage and current flow.

Unfortunately, when a minor problem occurs in a complex circuit like a computer control system, it may *not* seem like a minor problem. For example, a poor electrical connection in a feed wire to a body ground may cause the computer system or one of the systems it controls to lose power. This can result in a shutdown of the fuel injection system, the emissions control system, the ignition system, or the entire vehicle.

You might think that any of these systems or the computer itself is at fault. Several systems could appear to have a problem. In reality, it is simply a poor electrical connection in one wire that is causing all the problems. It is important for an automotive technician to remain calm when diagnosing electrical problems. If analyzed properly, problems can usually be found and corrected easily.

Locating Computer Problems

The most difficult aspect of making computer system repairs is finding the source of the problem. To find the source of computer problems, you must ask yourself the following types of questions:

- What could be causing the specific symptoms? Mentally picture the parts in the circuit and how they function. Trace through the circuit while referencing a wiring diagram to find out which wires, connections, and components are in the circuit leading to potential trouble source.

- How many components are affected? If several components are *not* working, something close to a common power source or ground point is at fault. If only one or two sections of the circuit are faulty, begin your tests at those sections of the circuit.
- Is the problem always present or is it ***intermittent*** (only occurs under some conditions)? If the problem is intermittent, the conditions causing the problem will have to be simulated. For example, a loose electrical connection could open and close with vibration or movement. You might simulate driving conditions by wiggling wires and connectors in the circuit to make the problem occur.
- Is the problem's occurrence related to heat or cold? If it occurs only on a hot day or when the engine is warmed to full operating temperature, heat is related to the problem's occurrence. Electronic circuits (transistors in particular) are greatly affected by heat. In fact, too much heat can ruin an electronic component. You can use a heat gun to simulate the heat in an engine compartment.
- Is the problem's occurrence affected by moisture? If the trouble occurs only on wet or humid days, you have information to use when analyzing the source of a problem. In most cases, moisture cannot enter a sealed electronic component, but it may enter and affect the wire connections and any components exposed to the environment.

Stress testing refers to the use of heat, cold, or moisture to simulate extreme operating conditions of components, like spark plug wires, explained in a later chapter under spark plug wire leakage.

Sensor and Actuator Problems

As with other electrical and electronic components, sensors, actuators, and their circuits can develop opens, shorts, or abnormal resistance or voltage values. When your pinpoint tests find a problem, the sensor or actuator should be replaced or the circuit repaired.

In most cases, a scan tool is used to find the problem circuit and a digital multimeter is used to measure the resistance in the circuit and the actual sensor output or actuator input. Then, this value (voltage, resistance, current, or action) is compared to factory specifications. If the test value is too high or too low, you would know that the sensor or actuator is faulty and must be replaced.

The shop manual will also have a wiring diagram, or ***schematic,*** for the computer system. The diagram will show the color codes of the wires and the number of connectors that are used to feed signals from the sensors to the computer and from the computer to the actuators. This can be very helpful when servicing any computer system. The following paragraphs discuss the most frequent circuit problems.

Poor Electrical Connections

Poor electrical connections are the most common cause of electrical-related problems in a computer system. Discussed in Chapter 18, a wiggle test will help find poor connections and intermittent problems. Always check electrical connections when diagnosing sensors and other electronic components. **Figure 19-2** shows how to test a wiring harness for opens or poor connections.

Poor electrical connections can be due to corroded terminals, loose terminal ends, burned terminals, chafed wires, and other problems. Dirt and moisture can get into connectors, causing high resistance. Any of these conditions can prevent a normal sensor signal from returning to the computer. They can also prevent the control current from reaching an actuator.

Vacuum Leaks

Vacuum leaks are frequently caused by deteriorated, broken, or loose vacuum hoses. Vacuum leaks often make a *hissing sound.* Some vacuum leaks can upset the operation of a computer system and cause a wide range of

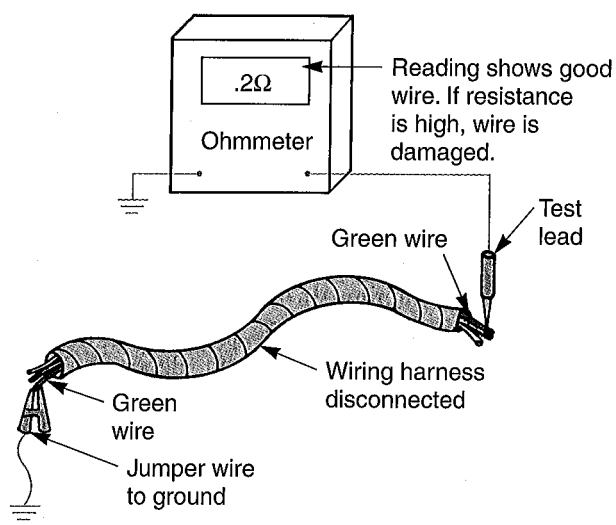


Figure 19-2. If you suspect a wire is broken inside the harness, this is an easy way to test the wire. Disconnect the wiring harness at both ends, and ground the suspect wire on one end. Then use an ohmmeter to check the wire's resistance. If the wire's resistance is high, the wire must be repaired, bypassed, or replaced.

symptoms. Also, some engine sensors and actuators rely on engine vacuum for operation.

Always check for vacuum leaks when they could be causing a performance problem, **Figure 19-3.** For example, if the trouble code indicates a problem with the MAP (manifold absolute pressure) sensor, check the vacuum lines leading to the sensor. If there is a vacuum leak, the sensor cannot function normally. Also check the intake manifold gasket area, as this is a common location for vacuum leaks.

Air leaks after a mass airflow sensor can also cause problems. The sensor cannot measure the actual amount of air being drawn into the engine, and an incorrect air-fuel mixture will result.

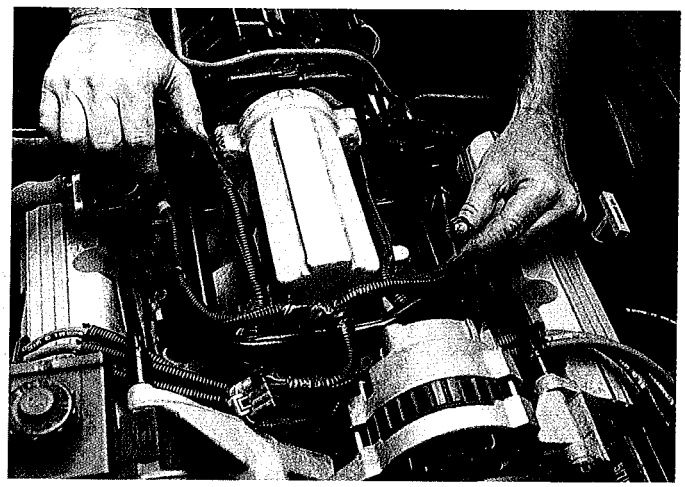


Figure 19-3. Always inspect the engine compartment for signs of trouble. A loose or corroded connection or a vacuum leak may be setting trouble codes or tricking the computer system.

Sensor Service

Sensor service involves testing and, if needed, replacing computer system sensors. Since sensor designs vary and some can be damaged by incorrect testing methods, it is important for you to know the most common ways of checking sensor values.

For testing purposes, you can classify sensors into one of two categories: passive sensors or active sensors. This will help you select a testing method.

As detailed in Chapter 17, a passive sensor varies its internal resistance as an operating condition changes. There are two common types of passive sensors: variable resistance sensors and switching sensors. The variable resistance sensor modifies a reference voltage that is sent from the computer. A switching sensor acts as either a conductor or an insulator, switching on and off with condition changes. Common passive sensors include the following:

- Intake air temperature sensors.
- Coolant temperature sensors.
- Throttle position sensors.
- Transmission linkage position sensors.
- EGR pintle position sensors.
- Manifold absolute pressure sensors.
- Fuel tank pressure sensors.
- Mass airflow sensors.
- Oil level sensors.
- Brake fluid level sensors.
- Suspension height sensors.

Active sensors, or voltage-generating sensors, produce a very weak internal voltage, which is sent to the computer for analysis. Typical active sensors include:

- Oxygen sensors.
- Engine speed sensors.
- Camshaft sensors.
- Crankshaft sensors.
- Vehicle speed sensors.
- Knock sensors.
- Solar sensors.

Each type of sensor needs a slightly different testing method. Refer to the service manual for exact sensor types and locations.

Testing Passive Sensors

Since passive sensors do *not* generate their own voltage, the computer must feed them a reference voltage. A passive sensor can change its internal resistance with a change in system or vehicle condition or operation. This resistance change modifies the reference voltage, which is interpreted and used by the computer to control the engine's various systems.

To test a passive sensor, either measure its internal resistance with an ohmmeter or measure the voltage drop across the sensor with its reference voltage applied. Depending on the sensor or manufacturer, both tests may be performed. You can also read computer data stream values with your scan tool. However, the scan tool cannot isolate the sensor, wiring, or computer for individual tests. Any unusual sensor readings by a scan tool should be verified using a multimeter.

Testing Variable Resistance Sensors

To test a variable resistance sensor with an ohmmeter:

1. Disconnect the sensor wires.
2. Connect the ohmmeter's test leads to the sensor terminals, **Figure 19-4A.**
3. Compare the ohmmeter reading to the manufacturer's specifications.

The sensor's resistance must be within factory specifications. For example, if you are testing a temperature sensor, connect an ohmmeter to the sensor terminals and then measure coolant temperature with a digital thermometer. Note the resistance readings at various coolant temperatures and compare these readings to service manual specifications.

If the sensor's resistance is within specifications, check for opens or shorts in the wires going to the sensor. If the wires are good, suspect the ECM. The service manual will give detailed instructions for testing the control module.

To check a variable resistance sensor with a voltmeter:

1. Connect the voltmeter in parallel with the sensor. Be sure to leave the computer wires connected to the sensor, **Figure 19-4B.**
2. Measure the voltage drop across the sensor with the computer reference voltage applied.
3. Compare your measurements to specifications.

Testing Switching Sensors

With a switching sensor, such as a power steering pressure switch, you can use an ohmmeter to check that the switch is opening and closing. As in **Figure 19-4C,** connect your ohmmeter and move the switch opened and closed. Your meter should register infinite ohms and then zero ohms. Replace the sensor if it is defective. You could also use a high impedance test light to quickly check the operation of a switching sensor.

Note that some auto manufacturers do not give resistance specifications for passive sensors, they only give voltage drops. You may have to use a test harness to connect the meter in parallel with the sensor. You can make or purchase this type of test harness.

Testing Reference Voltage

A reference voltage (typically *5 volts*) is fed to passive sensors. Then, when conditions and sensor resistance change, the amount of voltage flowing back to the computer also changes. The reference voltage is needed so that a signal returns to the computer.

To measure reference voltage to a passive sensor:

1. Disconnect the wires leading to the sensor.
2. Connect a digital voltmeter to the wires.
3. Turn the ignition key on and note your readings.
4. Compare your voltage readings to specifications.

Typically, the open circuit voltage should be about 5 volts. Refer to **Figure 19-5.**

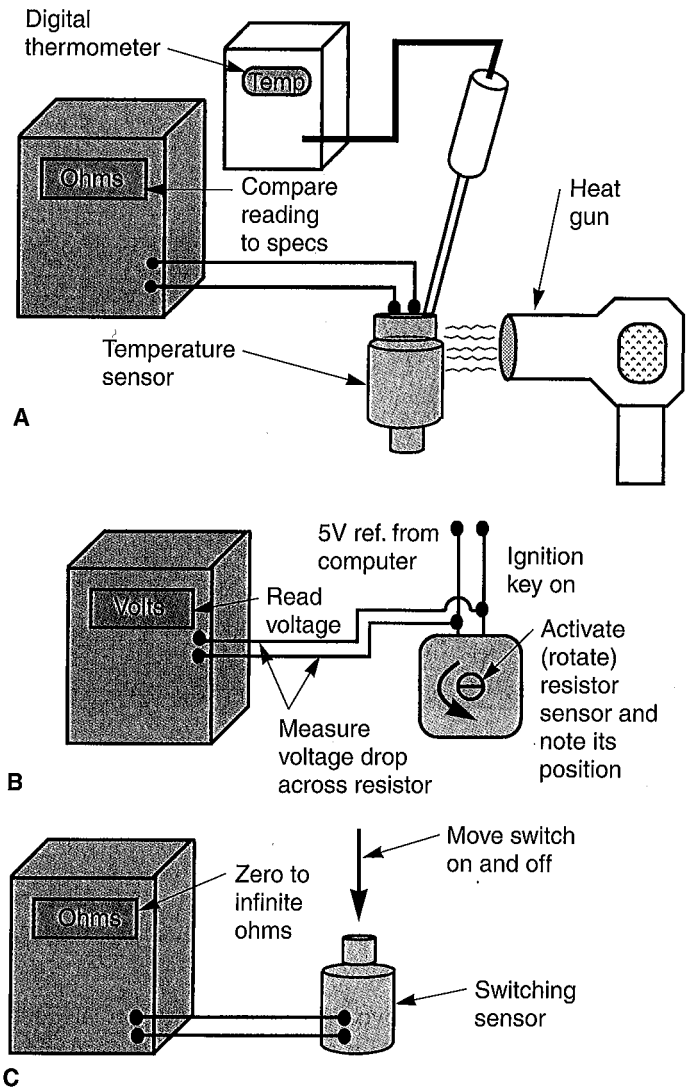


Figure 19-4. There are many ways to test passive sensors. A—An ohmmeter can be used to measure internal resistance. Some sensors can be heated with a heat gun while measuring resistance. A digital thermometer may also be used to compare actual temperature with sensor resistance. B—A voltmeter can be used if sensor specifications are only given as a voltage drop. The sensor must have reference voltage while testing occurs. C—Switching sensors may be tested with an ohmmeter or a high-impedance test light. The meter or light should show a change in condition when the switch is turned on and off.

If the reference voltage to the sensor is low, check the wiring harness for high resistance, as something is preventing the full reference voltage from reaching the sensor. Low reference voltage would cause a sensor to produce erroneous readings. It is possible for the reference voltage to be too high if a current-carrying wire is shorted into the circuit. High voltage may also be caused by a computer malfunction, but this is rare.

Testing Active Sensors

As mentioned, an active sensor produces its own voltage and sends it back to the computer. The voltage produced by an active sensor is very low, often under 1 volt. This makes sensor wiring harness continuity very critical. One poor electrical connection can keep the low voltage from returning to the computer.

Figure 19-6 shows several ways to test an active sensor. In **Figure 19-6A,** an ohmmeter is connected to a

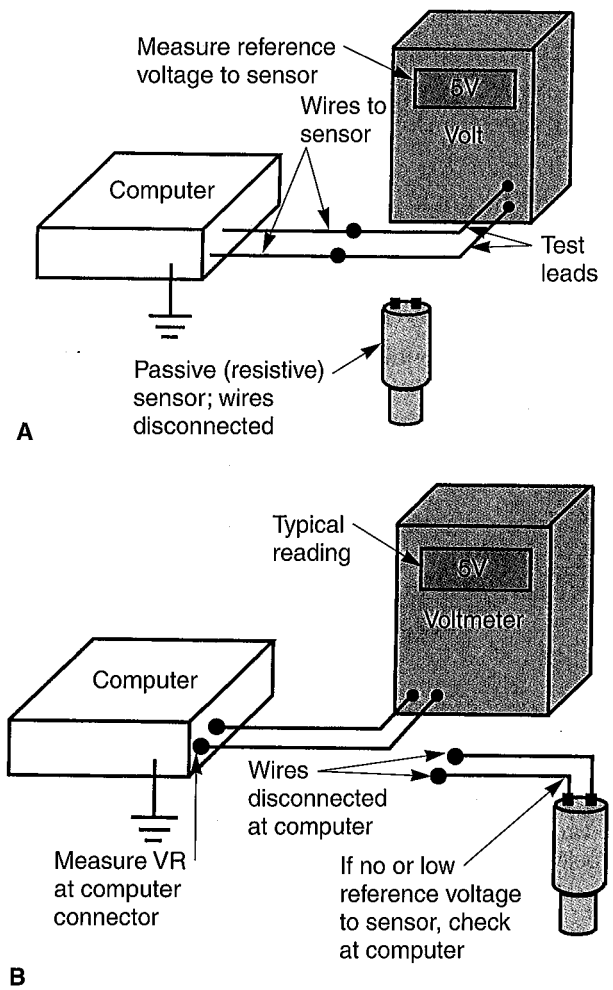


Figure 19-5. Passive sensors rely on a computer reference voltage for proper operation. A—Use a digital voltmeter to measure the amount of voltage supplied to the sensor. Typical reference voltage might be 5 volts, but refer to the service manual specifications. B—If the reference voltage is not correct, test for voltage at the computer. If the reference voltage at the computer is correct, a problem with the wiring harness is indicated.

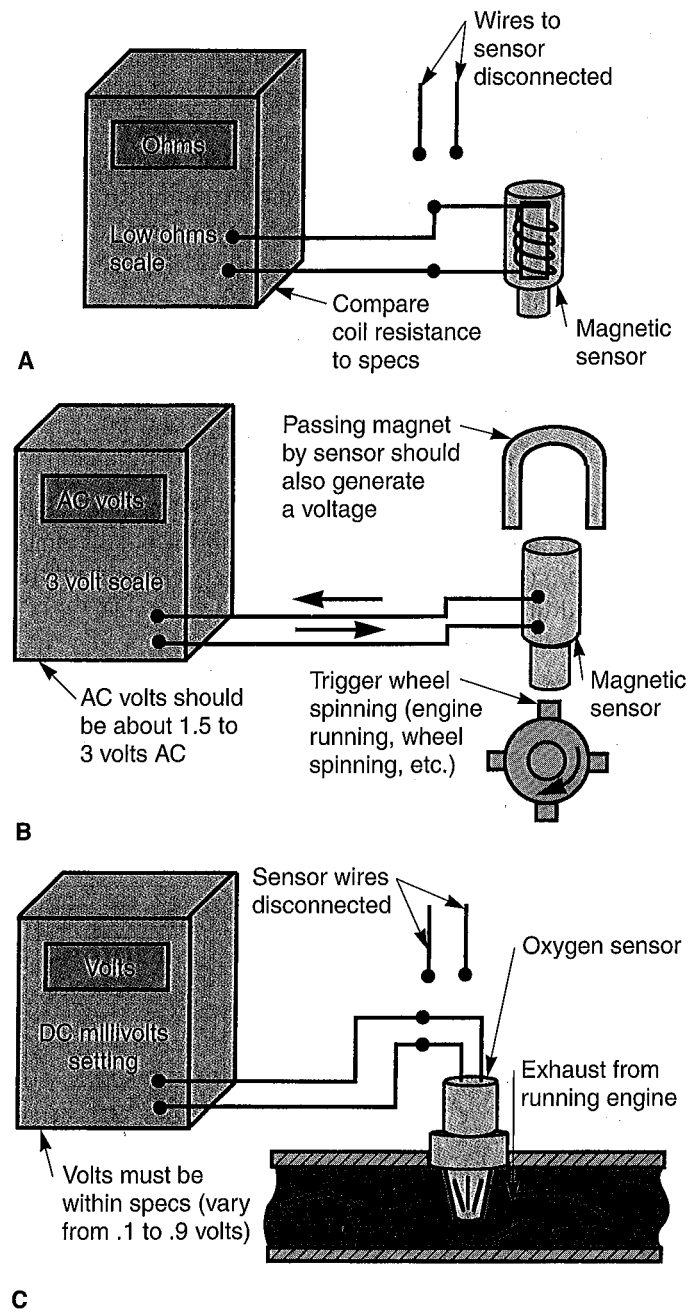


Figure 19-6. Since an active sensor generates its own output signal, testing methods for active sensors are slightly different than those for passive sensors. A—Magnetic sensor internal coil resistance can be measured with an ohmmeter. B—An ac voltmeter can be used to check a magnetic sensor while it is operating. With the triggering device moving, an ac voltage signal should be generated. C—Sometimes it is recommended to connect a meter directly to the sensor. You can compare the operating sensor's output to specifications. Be sure to test the harness leading to the sensor.

common magnetic sensor. The ohmmeter will measure the resistance of the coil winding. Replace the sensor if the resistance is high or low.

In **Figure 19-6B,** an ac voltmeter is connected to a magnetic sensor. The trigger wheel must be rotated (engine cranked over, wheel or hub in an ABS system turned, etc.) to make the sensor generate voltage. A magnetic sensor should typically produce about 1.5-3 volts ac. A magnet can also be passed by a coil to make it produce a voltage.

In **Figure 19-6C,** a digital voltmeter is connected to an oxygen sensor. With the engine running in closed loop, the voltmeter should show the sensor's output voltage. If the output voltage from the sensor is low or high, the sensor may require replacement.

Tech Tip!
Whenever a sensor tests good, check the wiring leading to the sensor. Bad wiring may be blocking current flow back to the computer.

Figure 19-7 shows how to use small jumper wires to connect a meter to check a sensor while it is still functioning in the circuit. More advanced testing will be explained in later chapters.

Replacing Sensors

When replacing a sensor, there are several general rules you should remember:

- Always purchase an exact sensor replacement. Even though two sensors may look identical, their internal resistance or circuitry may be different. See **Figure 19-8.**
- Release the sensor connector properly. Most connectors have positive locks that must be released. If you damage the connector, intermittent problems may result from a loose connection.
- Use special tools as needed. Some sensors, such as oxygen sensors, require the use of a ***sensor socket.*** This socket has a deep pocket and a cutout that will fit over the sensor and any wires. Conventional deep sockets may not fit over the wiring or the sensor head.
- Use thread sealant sparingly. If the sensor seals a coolant, oil, or vacuum passage, do not use too much sealant.
- Use thread and engine sealants that are safe for oxygen sensors. Some sealants can poison the oxygen sensors.
- Tighten the sensor properly. Overtightening a sensor could damage it. Undertightening could cause leaks.
- Adjust the sensor, if needed. Some throttle position sensors require adjustment after installation.
- Scan for trouble codes after sensor replacement.

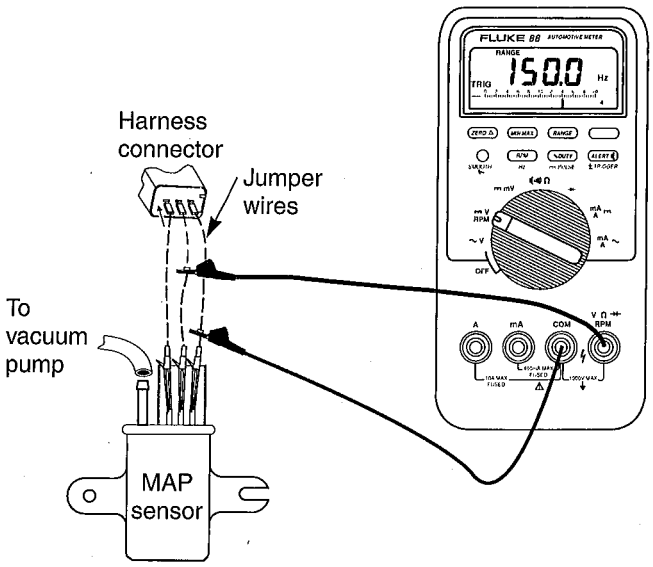


Figure 19-7. Small jumper wires are often used when measuring sensor circuit values. Make sure you do not short the jumper wires together or to ground. This test is used to measure the frequency signal in hertz from a manifold absolute pressure sensor. (Fluke)

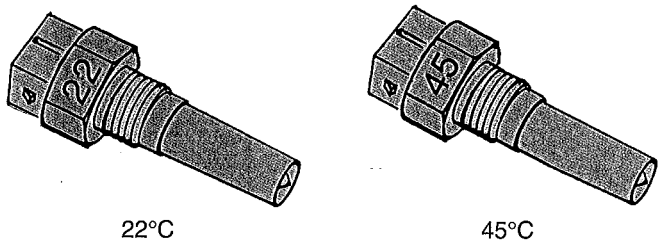


Figure 19-8. Always make sure the replacement sensor is same as the old one. These two temperature sensors look the same but have different temperature and resistance values. If the wrong one is installed, the vehicle may not function correctly. (Snap-on Tools)

Actuator Service

Actuator service involves testing the actuators for possible electrical or mechanical problems and replacing them, if necessary. If an actuator fails, the computer cannot control the engine and vehicle systems properly.

Testing Actuators

Since actuators are simply relays, solenoids, and motors, they are fairly easy to test. **Figure 19-9** shows several ways to test actuators.

Testing Servo Motors

In **Figure 19-9A**, a voltage source has been connected to a servo motor. The wiring harness to the motor has been disconnected. Jumper wires feed current directly to the motor. This is a simple way to check the operation of an electric or servo motor. If the motor begins to function with an external voltage source, you should test the wire harness leading to the motor.

Testing Solenoids

In **Figure 19-9B,** a voltage source is being used to check a solenoid. When jumper wires are connected to the vehicle's battery and the solenoid, the solenoid should operate. If the solenoid tests good, you should check the voltage coming to the solenoid through its harness.

An ohmmeter can also be used to test an actuator. You can use the meter to measure the internal resistance of the unit. By comparing resistance readings to specifications in the service manual, you can find out if the actuator must be replaced.

Testing Relays

Figure 19-9C shows how to test a relay. Check the voltage entering the relay and the voltage leaving the relay. It is possible that voltage is applied to the relay but the relay points are not sending voltage out to the controlled device.

Since relays contain movable contact points, they are a common source of computer system problems. The scan tool may indicate a problem with the circuit containing the relay. However, you must test the relay to pinpoint the problem source.

Relays can be located almost anywhere on a vehicle: in the engine compartment, under the dash, under the seat, or in the trunk. The service manual will give exact locations. See **Figure 19-10.**

An integrated ***junction block*** encloses most or all of the vehicle's mechanical relays in a single housing. Some of the relays found in this block are the fuel pump relay, cooling fan relay, wide open throttle relay, air conditioning relay, and a host of others. The junction block is usually mounted in the engine compartment.

When testing a relay, refer to the service manual wiring diagrams for pin numbers and wire color codes. Special ***relay testers*** can be used to quickly test relay operation. They plug into the relay and test the unit automatically.

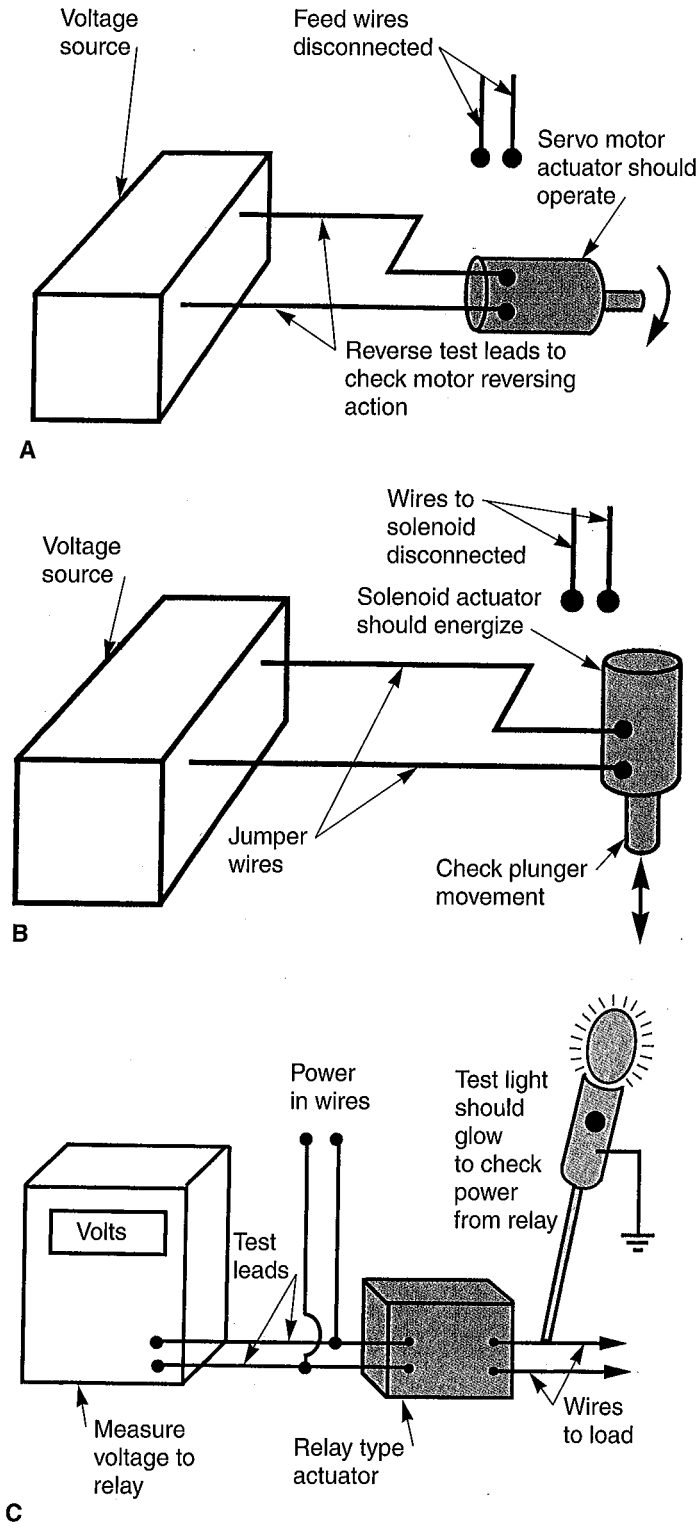


Figure 19-9. Actuator testing is straightforward. It is similar to testing a conventional motor, relay, or solenoid. A—Voltage can be jumped to a servo motor. The motor should function when energized by the power source. B—A solenoid can also be tested in the same manner as a servo motor. C—A relay is slightly more complex to test. You must make sure there is an output when voltage is supplied to its input terminals. This can be done using a voltmeter or a high-impedance test light.

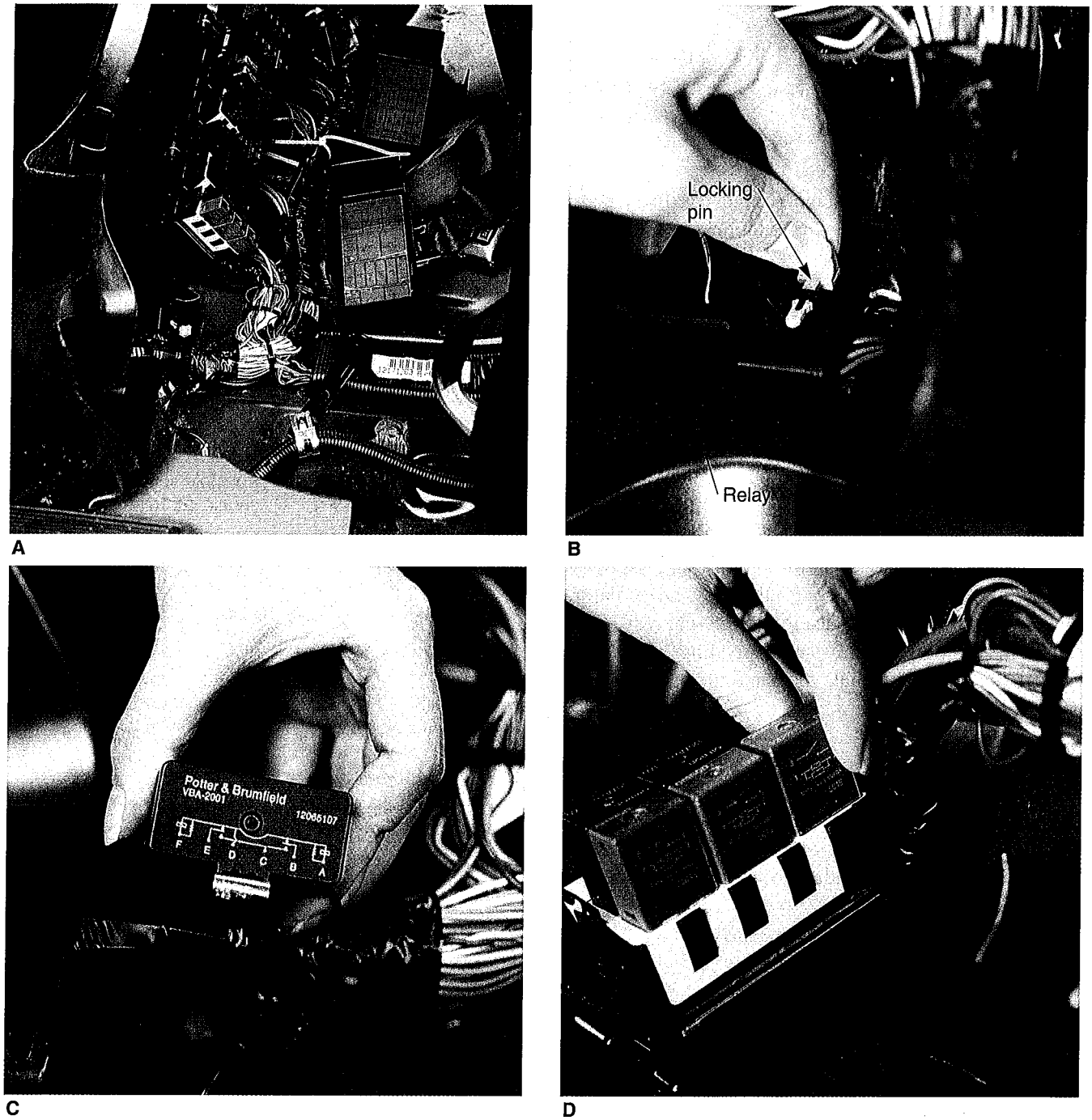


Figure 19-10. Relays have moving parts that can fail in service. Relays can be located almost anywhere on the vehicle. A—Technician has removed the rear seat cushion to gain access to the fuses and relays. B—This relay has a locking pin that must be removed before disconnecting the harness. C—Relays can have different internal construction. Make sure the replacement unit is identical to the original. D—The service manual will give relay locations for pinpoint testing and replacement.

For information on actuator service, refer to the index in this textbook. You can find instructions on testing fuel injectors, glow plugs, and more specialized actuators.

Replacing Actuators

Actuator replacement will vary with the type and location of the unit. Here are a few rules to follow when replacing an actuator.

- Do not damage the wire connectors when releasing them. They are made of plastic and will break if forced open improperly.
- Do not drop the actuator mounting screws during removal or installation. If a screws falls into an engine, major problems can occur.
- Make sure you have the correct replacement actuator before attempting installation.
- Check that the actuator is fully seated before tightening the mounting screws.
- Double check actuator operation after replacement.

Tech Tip!
Make sure you obtain the correct replacement relay. Two relays may look the same, but relays often have different internal construction.

Computer Service

Computer service involves replacing the computer. The computer is the last component to be suspected of being the problem source, only after all other potential sources of trouble have been eliminated. It is sometimes possible for an integrated circuit, transistor, or other electronic part in the computer to fail and upset system operation.

The diagnostic trouble code will tell you which computer or electronic control unit is having a problem. This information can help you find when the computer circuitry is at fault.

Measuring Computer Output

If the computer is not tested, in most cases, a defective computer is found through the process of eliminating the sensors, actuators, and related wiring as the cause of the problem. In the process of sensor and actuator testing, it was necessary for you to measure the computer's output. A ***computer output*** can be a reference voltage to a sensor or a supply voltage to an actuator.

Use a voltmeter to make sure the correct reference voltage is being sent to a sensor. Most computers produce a reference voltage of about 5 volts. If the reference voltage is not correct, check the wiring before condemning the computer. You can also measure voltage to make sure the correct voltage output is being fed to the actuators.

Each computer input and output passes through an individual metal terminal, or pin, which plugs into the vehicle wiring harness. ***Pin numbers*** identify the location and purpose (electrical value and internal connection) of each terminal in a computer wiring harness connector. You may have to probe computer terminal pins to find the source of complex problems. This will be discussed in Chapter 46.

Again, always refer to the service manual for exact procedures when testing a computer system. One wrong electrical connection can destroy the computer.

Caution!
Never use an ohmmeter to check a computer, as it will damage the computer's internal circuitry. If it is necessary to use an ohmmeter to check the continuity of a wire or circuit in the computer harness, disconnect all wiring harnesses from the computer before testing.

Saving Memory

Saving memory can be done by connecting a small battery (such as a 9-volt battery) across the two battery cables *before* the vehicle's battery is disconnected. This will provide enough power to keep the clock, stereo, and computer from losing the information stored in their memories. When using a memory saver, turn off all accessories (radio, blower, etc.). The current drain from these devices, combined with even the smallest voltage drop, could cause electronic devices (computer, clock, radio, etc.) to lose their preprogrammed data. You are still disconnecting the vehicle battery for safety. The smaller battery cannot produce enough current to cause an electrical fire or operate the starting system.

Computer Replacement

Before disconnecting the battery and removing the computer from the vehicle, you should scan the computer and obtain the PROM identification number or the EEPROM calibration number. This information is needed to check for updated PROMs that should be installed and calibration programs that should be downloaded to the new computer. External identification numbers are not always placed on the PROM.

When removing a computer, the ignition key should be off and the vehicle's negative battery cable disconnected. This will prevent voltage spikes from damaging the computer when the harness connectors are removed. Remove any shields or components necessary to access the computer. Unbolt the brackets holding the computer in place and unplug the computer connectors.

Identification information is usually stamped or printed on the computer. Use this data and the year, make, and model of vehicle to order the correct replacement computer. The VIN (vehicle identification number) may be helpful, as well.

Caution!
When handling computers, keep one hand on chassis ground and use the other to remove the component. This will prevent a static electrical charge from entering and damaging the electronic circuitry. If available, wear an anti-static wrist strap when working on computer circuits. Static electricity may not instantly ruin an electronic part, but it can reduce the part's useful service life from years to days.

PROM Service

Many computers use a PROM to store data for the specific make and model vehicle. In most cases, you must remove the PROM from the old computer and install it in the new computer.

Remove the cover over the PROM. Then, use a PROM tool to grasp and pull the PROM out of its socket. Most PROMs use a ***carrier***, which is a plastic housing that surrounds the outside of the integrated circuit chip. Avoid touching the PROM terminals with your fingers because the body oils on your hand could adversely affect the PROM's operation.

Before installing the PROM in the new computer, check that the pins (terminals) are straight. Check for the presence of ***reference marks*** (indentations or other markings to show how to reinstall the unit) on the PROM or the carrier. If you install a PROM backwards, it will usually require replacement because of physical damage.

To install the PROM, install the carrier and PROM in the computer with the reference mark correctly positioned. First press down on the carrier only. Then, carefully press the PROM down into the computer. Press on each corner until the PROM is fully seated in its socket. If the PROM socket has locking tabs, make sure they are connected to the carrier housing, **Figure 19-11.**

After installing the PROM, install the access cover, connect the wiring harness to the computer, and install the computer into its mounts. Reconnect the battery, turn on the ignition, and activate self-diagnostics. As a final check of the computer and PROM, make sure no trouble codes are set. A code might be set if the PROM is not fully seated or a pin is bent over.

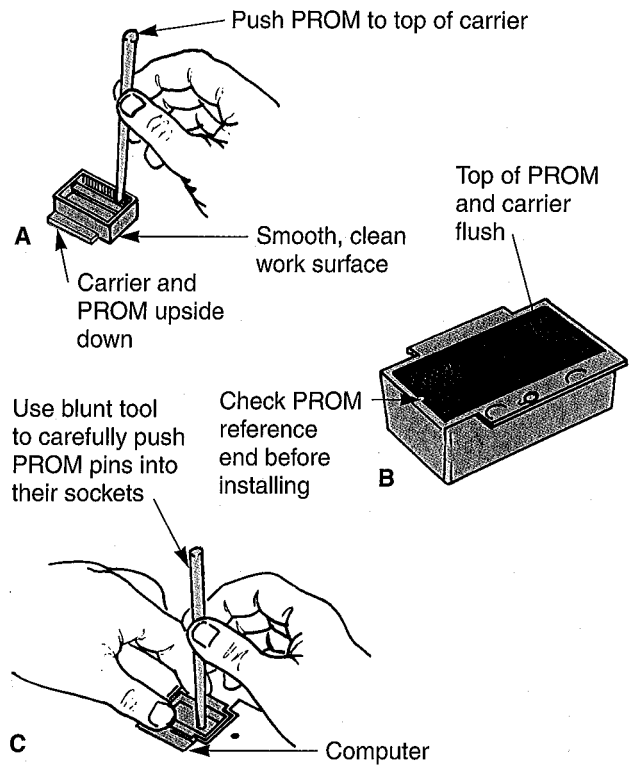


Figure 19-11. Most PROMs use a carrier, which is a plastic case around the IC chip. The PROM from the old computer may have to be installed in the new computer. A—Before installing the PROM in the new computer, use a blunt tool to push the top of the chip flush with the top of the carrier. The IC pins should be sticking up and straight. B—Make sure reference marks are positioned correctly before installation. If you install the PROM backwards, it will be ruined. C—Touching only the carrier, position the PROM pins into the socket in the computer. Use a blunt tool or a small wooden dowel to carefully push the PROM into its socket. Push lightly on all corners until the PROM is fully seated. Do not press too hard. (General Motors)

Updated PROMS

An ***updated PROM*** is a modified integrated circuit produced by the auto manufacturers to correct a driveability problem or improve a vehicle's performance. The old PROM is simply removed from the computer and replaced with the updated PROM.

Updated PROMs are produced to correct problems like surging, extended cranking periods, excessive emissions, cold and hot start problem, and unusual driveability problems that cannot be isolated to one system. If you are faced with a problem and cannot find the cause, check with the local dealership to find out if there are any updated PROMs for the vehicle that address the problem.

Caution!
Installing a performance chip (aftermarket PROM chip that enhances engine performance) or a nonstock ECU will void the vehicle's warranty and may be a violation of federal law. Before installing any nonstock performance part, make sure the product is emissions legal or emissions certified for street use. All street-legal nonstock performance parts will be assigned an EO (executive order) exemption number by CARB (the California Air Resources Board). Products without this exemption number are not street legal.

EEPROM Programming Using Computerized Equipment

Most newer computers use Electrically Erasable Programmable Read Only Memory (EEPROM) or Flash Erasable Programmable Read Only Memory (FEPROM) chips that are permanently soldered to the circuit board. These chips must be programmed using electronic equipment. They are often reprogrammed to correct driveability and performance problems.

EEPROMs are programmed using a method referred to as flash programming. ***Flash programming*** may be performed by downloading the vehicle's information through a computer, a computerized diagnostic analyzer, or a scan tool. Actual programming details vary between manufacturers, but the basic procedure begins by placing the computer in the programming mode. One of three methods is used to program the computer:

- Direct programming using a service computer or a laptop computer, **Figure 19-12.**
- Indirect programming using a scan tool and a computer or computerized analyzer.
- Remote programming with the computer off the vehicle.

Direct Programming

Direct programming is the fastest and simplest method. The new information is downloaded by attaching a shop recalibration device (usually a laptop computer directly to the data link connector. The erasure and programming is done by accessing the programming menu and following the instructions as prompted by the computer. Then, the vehicle's operating information and parameters are entered into the vehicle's computer through the connector.

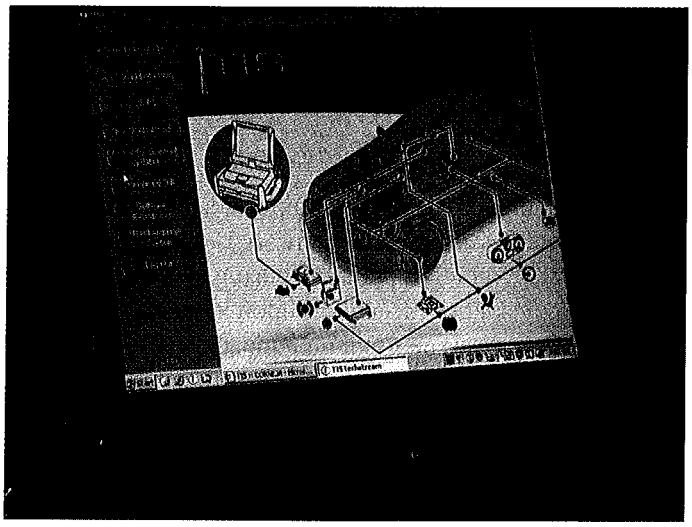
Indirect Programming

To perform ***indirect programming,*** an advanced scan tool must be available to connect to the programming computer and to the vehicle, as well as to reset some computer-controlled vehicle systems after programming. The programming computer may resemble the personal computer (PC) used in the home, or it may be a computerized analyzer like the one used for direct programming.

In this type of programming, the vehicle information is downloaded from the programming computer into the scan tool. The information is then downloaded from the scan tool into the vehicle's computer. The scan tool menu is accessed using the keypad. Most scan tools will use a high-capacity generic program cartridge to store the information. Some newer scan tools have enough fixed memory to hold the information and, therefore, do not use a separate program cartridge. In either case, follow the manufacturer's procedure as prompted.

Remote Programming

Remote programming is done with the vehicle's computer removed from the vehicle. This procedure is used when changes need to be made through a direct modem connection to a manufacturer's database computer. It can also be done in cases where direct or indirect programming



A

B

Figure 19-12. Most dealerships now have a dedicated laptop computer for EEPROM reprogramming. A—The laptop is plugged into the diagnostic link so it can download new information into the vehicle's computer. B—Icons buttons on the laptop screen allow the technician to select the correct software for downloading.

is not practical or possible. Since special connectors and tools are required for this type of programming, this procedure is done only at new vehicle dealerships.

EEPROM Programming Procedure

To begin programming the EEPROM-equipped computer, make sure that the vehicle's battery is fully charged. Recharge the battery if necessary. Do not charge the battery during the programming procedure, as damage to the computer will result. Connect the programming computer or scan tool to the data link connector. Make any other vehicle connections as needed before proceeding with the programming sequence.

Caution!
Do not disconnect the scan tool or programming computer from the data link connector during the programming sequence. Doing so will damage the vehicle's computer.

To start the programming sequence, the programming computer or scan tool prompt may ask you to enter the engine type, vehicle type, and vehicle identification number (VIN) in a specific sequence. Once the vehicle information is entered, go to the programming software and follow the directions as prompted.

Depending on the manufacturer, it may be necessary to turn the ignition switch on or off during the connection and programming procedure. Double-check any instructions on ignition switch position before making any connections or beginning the programming procedure. The next step is to determine the type of programming that is needed.

Programming a New Computer

If a new computer is being installed, program only that computer. In many cases, other on-board computers can be accessed and programmed using the data link connector. While most computers have internal circuitry that protects them from accidental programming, be careful not to program the wrong computer. Do not attempt to program a new computer with information from the old computer or a computer from another vehicle. Any attempt to do this will set a failed programming sequence code in the new computer's memory.

Tech Tip!
In some cases, an erasure may need to be performed on a new computer before initial programming can take place.

Reprogramming Computers

Before reprogramming a vehicle's computer, determine the date that the current programming was downloaded or check the program's calibration number. If the current program is the latest version, no further actions are required. If the latest program has not been downloaded, proceed with the reprogramming sequence.

Before reprogramming most computers, you must first erase the existing information. After this step is complete, select the updated calibration information from the programming computer or scan tool menu. Then download the new information into the computer. On some systems, the erasure step is not necessary since the programming computer or scan tool will erase or overwrite the old information as it loads the new program into the computer.

Tech Tip!
If the computer does not accept the new program or cannot be programmed, check all connections first. Ensure that the correct computer is being reprogrammed with the proper information and that all procedures are being followed. If the computer still cannot be programmed, it may need to be replaced.

Allow sufficient time for the programming to take place. Monitor the computer or scan tool to determine when the programming sequence is complete. Do not touch any connections until you are sure the programming sequence is complete. After programming is completed, turn the ignition switch to the position called for and disconnect the computer or scan tool. Then, use a scan tool to check the computer and control system operation. While doing this, make sure you have installed the proper program into the computer by checking the program calibration number.

Computer Relearn Procedures

After being serviced, the computer system may have to go through a relearn procedure. A ***relearn procedure*** is a period of vehicle operation during which the computer system adapts to new components and programming information. The computer must receive inputs to formulate adaptive strategy to set some of its output parameters. The relearn procedure can often be done by simply driving the vehicle for several minutes. Some vehicles require a specific relearn procedure. Always check the manufacturer's service literature for exact relearn methods. In a few cases, sensors or actuators may have to be manually adjusted using a scan tool.

Duff's Garage

Problem: Mr. Hayes brought his 1993 Firebird into the shop, complaining of a hesitation, or stumble, when he accelerates the vehicle from a standing start.

Diagnosis: Duff test drives the vehicle to double-check the symptoms and to observe engine performance. He immediately notices a hesitation during acceleration. The vehicle seems to operate normally at cruising speed.

Once back at the shop, Duff opens the hood and inspects the engine compartment for obvious problems, such as loose connections, split vacuum hoses, etc. Although he does not notice any obvious problems, he does hear a slight hissing sound that seems to be coming from somewhere near the top of the engine. He turns the job over to one of his technicians, who checks the vehicle for trouble codes but finds none.

Based on Duff's initial inspection, the technician uses a piece of vacuum hose to help locate the source of the hissing sound. He holds one end of the hose to his ear while moving the other end around the engine compartment in an attempt to pinpoint the hissing sound. The sound seems to be loudest near the engine's MAP sensor.

Upon further inspection, the technician finds a hairline crack in the end of the vacuum hose going to the sensor. The crack opens up as the engine vibrates during acceleration. This causes a vacuum leak during acceleration. The crack closes up once the vehicle reaches cruising speed, sealing the leak. Even during acceleration, the vacuum leak is too small to set a trouble code.

Repair: The technician replaces the vacuum hose leading to the MAP sensor. He then inspects the other hoses for cracks and hardened ends. In all, he replaces three vacuum hoses. He then test drives the vehicle to make sure the repair fixed the problem before releasing the vehicle to the customer.

Summary

- Pinpoint tests are specific tests of individual components. They are completed after scanning for trouble codes.
- A preliminary inspection involves looking for signs of obvious trouble: loose wires, leaking vacuum hoses, part damage, etc.
- Semiconductors are very easy to damage. They can be damaged by static electricity, voltage spikes, heat, and impact shocks.
- Stress testing refers to the use of heat, cold, or moisture to simulate extreme operating conditions of components, like an electronic control unit.
- Poor electrical connections are the most common cause of electrical-related problems in a computer system.
- Vacuum leaks are frequently caused by deteriorated, broken, or loose vacuum hoses. Vacuum leaks often make a *hissing sound.*
- A reference voltage (typically *5 volts*) is fed to switching and variable resistance type sensors.
- Sensor sockets have a deep pocket and cutout from any sensor pigtail (wires).
- Since they contain movable contact points, relays are a common source of computer system problems.
- Computer service usually involves a few tests and computer replacement if needed.
- Some computers use the old PROM (memory chip) during computer replacement, since it stores data for the specific make and model vehicle.

Important Terms

Pinpoint tests	Sensor socket
Preliminary visual inspection	Actuator service
Basic circuit problem	Junction block
Intermittent	Relay testers
Stress testing	Computer service
Schematic	Computer output
Poor electrical connections	Pin numbers
Vacuum leaks	Saving memory
Sensor service	Carrier
	Reference marks
	Relearn procedure

Review Questions—Chapter 19

Please do not write in this text. Place your answers on a separate sheet of paper.

1. What should you look for during a preliminary inspection of a computer system?
2. Explain five questions you should ask yourself when analyzing computer system problems.
3. How can a vacuum leak upset the operation of a computer system?
4. An engine runs poorly only when cold. Symptoms and a trouble code indicates a problem

with the engine coolant temperature sensor. Technician A says to measure the engine coolant temperature sensor's resistance with a digital ohmmeter while measuring coolant temperature with a digital thermometer. Technician B says to measure the sensor's ac voltage output while measuring its temperature with a digital thermometer. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

5. How do you check sensor reference voltage?
6. Explain three ways to test an active sensor.
7. Describe three ways to test an actuator.
8. Relays are a common source of problems in a modern computer system. True or false?
9. How do you save computer memory?
10. The computer must be removed from a late-model vehicle. Technician A says to keep one hand on chassis ground when handling the computer. Technician B says to wear an anti-static wrist strap when handling the computer. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

ASE-Type Questions

1. Technician A says automotive computer system trouble codes are used to detect faulty components in the system. Technician B says automotive computer system trouble codes are used to indicate the general area of trouble in a computer system. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

2. A trouble code is triggered in an automotive computer system. Technician A says fuel-contaminated engine oil could possibly trigger this trouble code. Technician B says fuel-contaminated engine oil has no effect on computer system operation. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

3. Technician A says a basic circuit problem is caused by something in the circuit that increases or decreases current. Technician B says a basic circuit problem is caused by something in the circuit that increases or decreases resistance. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

4. A scan tool indicates a problem with the MAP sensor. Technician A says you should check the operating condition of the MAP sensor. Technician B says you should check for poor electrical connections in the system. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

5. Technician A says a passive automotive sensor is capable of generating its own voltage. Technician B says a passive automotive sensor is not capable of generating its own voltage. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

6. Which of the following is not considered a passive automotive computer sensor?
(A) Intake air temperature sensor.
(B) EGR sensor.
(C) Oxygen sensor.
(D) Mass airflow sensor.

7. Technician A says a reference voltage of about 12 volts is normally required for an automotive variable resistance type sensor to operate properly. Technician B says a reference voltage of about 5 volts is normally required for an automotive variable resistance type sensor to operate properly. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

8. A trouble code shows a problem with an active sensor. Technician A says the voltage produced by an active sensor is very low, often under 1 volt. This makes sensor output and wiring harness continuity very critical. Technician B

says that active sensor signals are just as strong as passive sensor signals. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

9. An automobile's oxygen sensor output needs to be checked. Technician A uses a digital voltmeter to check this sensor's output. Technician B uses an analog ohmmeter to check this sensor's output. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

10. An oxygen sensor tested faulty and must be replaced. Technician A says to avoid using sealer because it can contaminate the new sensor. Technician B says to use a sensor socket to prevent sensor damage. Who is right?
(A) A only.
(B) B only.
(C) Both A and B.
(D) Neither A nor B.

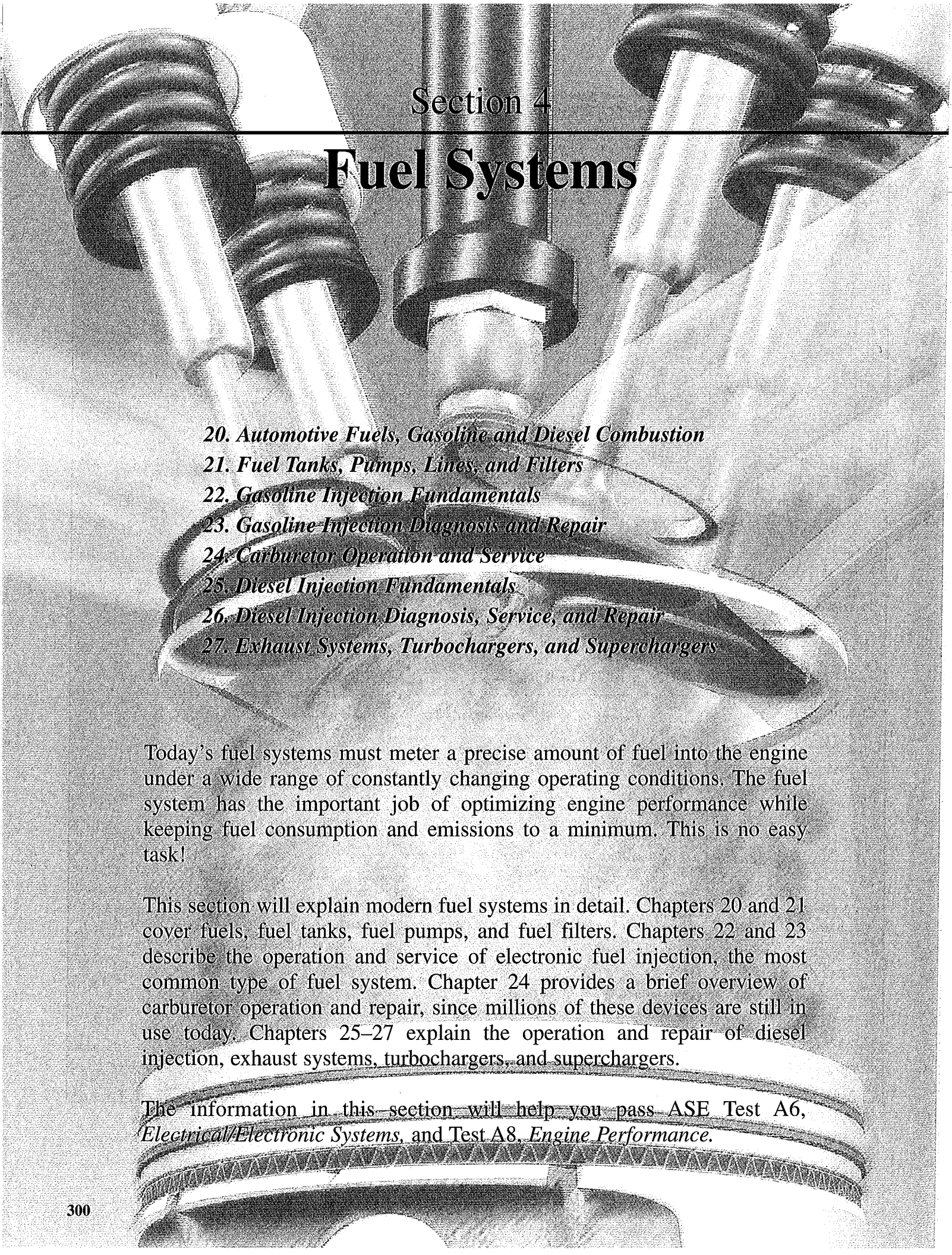
Activities—Chapter 19

1. Describe and sketch the procedure you would use to test a temperature sensor for proper operation.
2. Demonstrate two methods of checking a knock sensor—with a multimeter and by manual tapping.
3. Obtain an unserviceable vehicle computer with a removable PROM from a junkyard or other source and use it to practice removing and replacing the PROM.

Computer System Sensor and Actuator Diagnosis		
Condition	**Possible Causes**	**Correction**
Hard starting.	1. Faulty coolant temperature sensor. 2. Defective intake air temperature sensor. 3. Maladjusted or defective throttle position sensor. 4. Faulty crankshaft position sensor. 5. Faulty manifold absolute pressure sensor. 6. Bad mass airflow sensor. 7. Faulty idle speed motor. 8. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.
Engine stalling.	1. Faulty coolant temperature sensor. 2. Defective intake air temperature sensor. 3. Maladjusted or defective throttle position sensor. 4. Faulty crankshaft position sensor. 5. Faulty manifold absolute pressure sensor. 6. Bad mass airflow sensor. 7. Faulty idle speed motor. 8. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.
Rough idle or surging.	1. Faulty coolant temperature sensor. 2. Defective intake air temperature sensor. 3. Maladjusted or defective throttle position sensor. 4. Faulty crankshaft position sensor. 5. Faulty manifold absolute pressure sensor. 6. Bad mass airflow sensor. 7. Faulty idle speed motor. 8. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.
Erratic idle speeds.	1. Maladjusted or defective throttle position sensor. 2. Faulty crankshaft position sensor. 3. Bad idle speed motor.	Test components and related circuitry. Service or replace as necessary.
Cold engine warm-up problems.	1. Faulty coolant temperature sensor. 2. Faulty intake air temperature sensor. 3. Faulty manifold absolute pressure sensor. 4. Bad mass airflow sensor. 5. Bad idle speed motor.	Test components and related circuitry. Service or replace as necessary.
Engine hesitation.	1. Faulty coolant temperature sensor. 2. Faulty air temperature sensor. 3. Maladjusted or defective throttle position sensor. 4. Faulty EGR position sensor. 5. Defective or contaminated oxygen sensor. 6. Maladjusted or faulty crankshaft position sensor. 7. Faulty manifold absolute pressure sensor. 8. Bad mass airflow sensor. 9. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.

(Continued)

Computer System Sensor and Actuator Diagnosis		
Condition	**Possible Causes**	**Correction**
Poor performance and gas mileage.	1. Faulty coolant temperature sensor. 2. Faulty air temperature sensor. 3. Maladjusted or defective throttle position sensor. 4. Faulty EGR position sensor. 5. Defective or contaminated oxygen sensor. 6. Maladjusted or faulty crankshaft position sensor. 7. Faulty manifold absolute pressure sensor. 8. Bad mass airflow sensor. 9. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.
Erratic acceleration.	Faulty EGR position sensor.	Test sensor and related circuitry. Service as necessary.
Pinging.	1. Bad coolant temperature sensor. 2. Maladjusted or defective throttle position sensor. 3. Defective EGR position sensor. 4. Faulty manifold absolute pressure sensor. 5. Bad mass airflow sensor. 6. Faulty knock sensor.	Test sensors and related circuitry. Service or replace as necessary.
Surging at highway speeds.	1. Bad coolant temperature sensor. 2. Maladjusted or defective throttle position sensor. 3. Defective EGR position sensor. 4. Faulty manifold absolute pressure sensor. 5. Bad mass airflow sensor.	Test sensors and related circuitry. Service or replace as necessary.
Backfiring.	1. Maladjusted or defective throttle position sensor. 2. Faulty manifold absolute pressure sensor. 3. Bad mass airflow sensor.	Test sensors and related circuitry. Service or replace as necessary.
Black exhaust smoke.	1. Bad coolant temperature sensor. 2. Faulty intake air temperature sensor. 3. Faulty oxygen sensor. 4. Faulty manifold absolute pressure sensor. 5. Bad mass airflow sensor. 6. Bad fuel injectors.	Test components and related circuitry. Service or replace as necessary.
No torque converter lockup.	1. Maladjusted or defective throttle position sensor. 2. Faulty EGR position sensor. 3. Faulty manifold absolute pressure sensor. 4. Bad mass airflow sensor. 5. Faulty torque converter lockup solenoid. 6. Faulty or maladjusted brake light switch.	Test components and related circuitry. Service or replace as necessary.
Run on.	Defective idle speed motor.	Test motor and related circuitry. Service or replace as necessary.



Section 4

Fuel Systems

Today's fuel systems must meter a precise amount of fuel into the engine under a wide range of constantly changing operating conditions. The fuel system has the important job of optimizing engine performance while keeping fuel consumption and emissions to a minimum. This is no easy task!

This section will explain modern fuel systems in detail. Chapters 20 and 21 cover fuels, fuel tanks, fuel pumps, and fuel filters. Chapters 22 and 23 describe the operation and service of electronic fuel injection, the most common type of fuel system. Chapter 24 provides a brief overview of carburetor operation and repair, since millions of these devices are still in use today. Chapters 25–27 explain the operation and repair of diesel injection, exhaust systems, turbochargers, and superchargers.

The information in this section will help you pass ASE Test A6, *Electrical/Electronic Systems,* and Test A8, *Engine Performance.*