

## chapter 1

# THE DIAGNOSTIC PROCESS

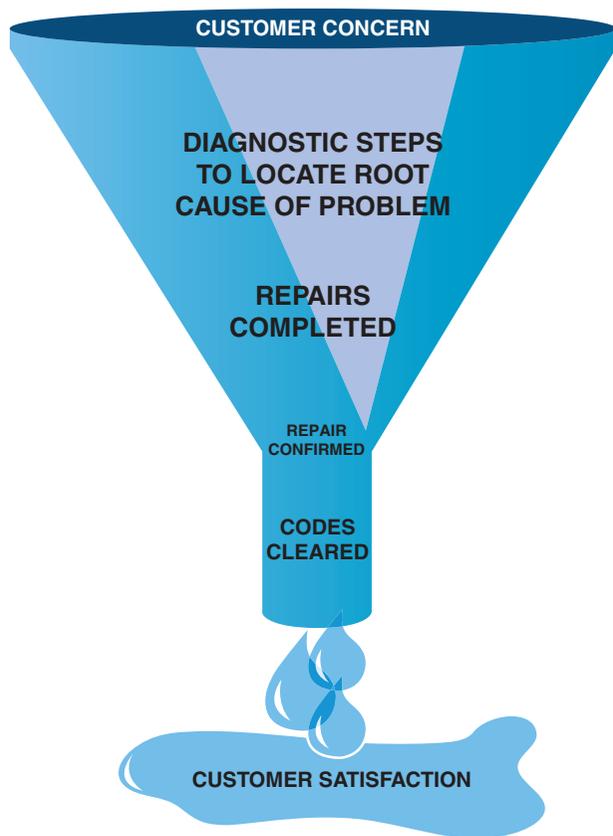
### LEARNING OBJECTIVES

**After studying this chapter, the reader should be able to:**

1. List the steps of the diagnostic process.
2. Discuss the type of scan tools that are used to assess vehicle components.
3. Describe how to retrieve diagnostic information from a vehicle.
4. Explain the troubleshooting procedures to follow if a diagnostic trouble code has been set.
5. Describe diagnostic trouble code retrieval, diagnosis, and testing for OBD-II vehicles.
6. Explain the troubleshooting procedures to follow if no diagnostic trouble code has been set.
7. List the steps in most manufacturers' diagnostic routines.
8. Describe how to verify the repair and conduct a universal drive cycle.
9. Describe how to run OBD-II monitors on a light duty diesel vehicle.

### KEY TERMS

Data link connector (DLC) 7	Smoke machine 5
Drive cycle 20	Strategy-based diagnosis 2
Flash code retrieval 11	Technical service bulletin (TSB) 7
No-code diagnosis 17	Trip 16
Paper test 5	
Pending code 6	



**FIGURE 1-1** A funnel is one way to visualize the diagnostic process. The purpose is to narrow the possible causes of a concern until the root cause is determined and corrected.

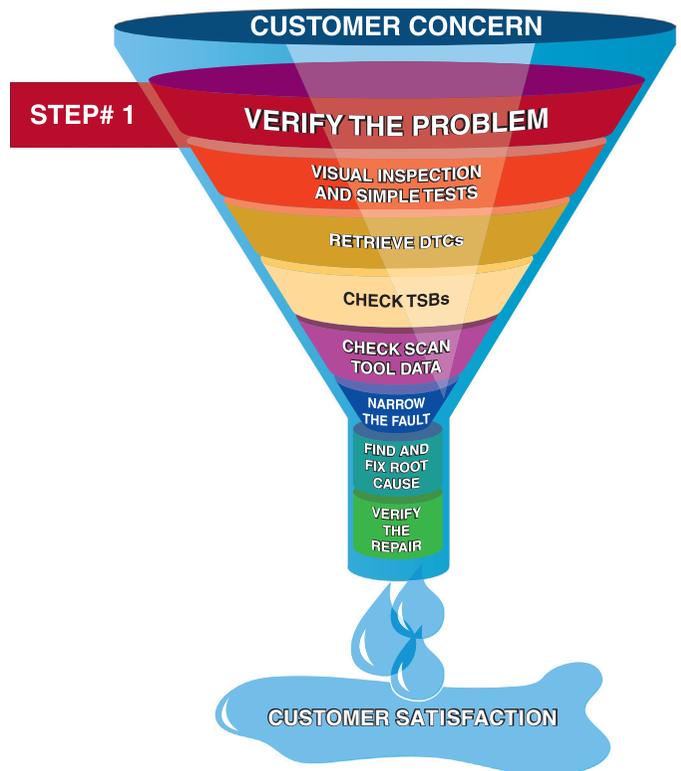
## THE EIGHT-STEP DIAGNOSTIC PROCEDURE

**STRATEGY-BASED DIAGNOSIS** Successful diagnose depends on using the same process for all problems and customer concerns to arrive at the root cause of the problem. The process is called **strategy-based diagnosis**.

Many different things can cause an engine performance problem or concern. The service technician has to narrow the possibilities to find the cause of the problem and correct it. A funnel is a way of visualizing a diagnostic procedure. ● **SEE FIGURE 1-1**. At the wide top are the symptoms of the problem; the funnel narrows as possible causes are eliminated until the root cause is found and corrected at the bottom of the funnel.

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. The following section describes eight steps the service technician can take to narrow the possibilities to one cause.

**STEP 1 VERIFY THE PROBLEM (CONCERN)** Before a minute is spent on diagnosis, be certain that a problem exists.



**FIGURE 1-2** Step #1 is to verify the customer concern or problem. If the problem cannot be verified, then the repair cannot be verified.

If the problem cannot be verified, it cannot be solved or tested to verify that the repair was complete. ● **SEE FIGURE 1-2**.

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

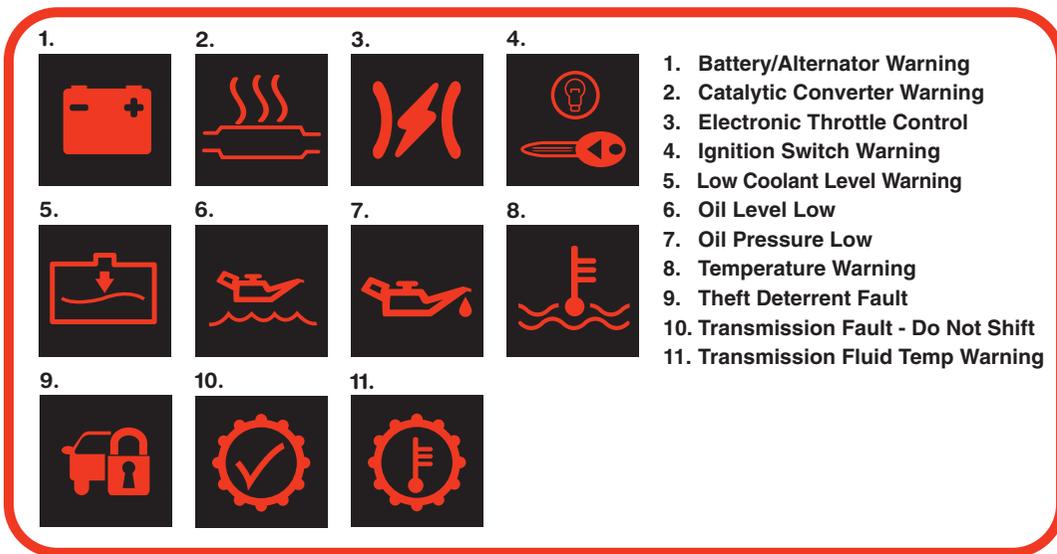
- Is the malfunction indicator light (check engine) on?
- What was the temperature outside?
- Was the engine warm or cold?
- Was the problem during starting, acceleration, cruise, or some other condition?
- How far had the vehicle been driven?
- Were any dash warning lights on? If so, which one(s)? ● **SEE FIGURE 1-3**.
- Has there been any service or repair work performed on the vehicle lately?

**NOTE:** This last question is very important. Many engine performance faults are often the result of something being knocked loose or a hose falling off during repair work. Knowing that the vehicle was just serviced before the problem began may be an indicator as to where to look for the solution to a problem.

After the nature and scope of the problem are determined, the complaint should be verified before further diagnostic tests are performed. A sample form that customers could fill out with details of the problem is shown in ● **FIGURE 1-4**.



1. Anit-Lock Brake System Warning
2. Gas Cap Loose
3. Low Coolant Level Detected
4. Low Fuel
5. Malfunction Indicator Lamp (MIL)
6. Reduced Power
7. Service Required
8. Theft Deterrent
9. Time for Maintenance Indicator
10. Transmission Warning



1. Battery/Alternator Warning
2. Catalytic Converter Warning
3. Electronic Throttle Control
4. Ignition Switch Warning
5. Low Coolant Level Warning
6. Oil Level Low
7. Oil Pressure Low
8. Temperature Warning
9. Theft Deterrent Fault
10. Transmission Fault - Do Not Shift
11. Transmission Fluid Temp Warning

**FIGURE 1-3** The amber dash warning symbols indicate that a fault has been detected. A red dash warning light indicates that a major fault has been detected requiring action by the driver as soon as possible.

**NOTE:** Because drivers differ, it is sometimes the best policy to take the customer on the test-drive to verify the concern.

**STEP 2 PERFORM A THOROUGH VISUAL INSPECTION AND BASIC TESTS**

The visual inspection is the most important aspect of diagnosis! Most experts agree that between 10% and 30% of all engine performance problems can be found simply by performing a *thorough* visual inspection. The inspection should include the following:

■ **Check for obvious problems (basics, basics, basics).**

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

Check the air cleaner and air duct (squirrels and other small animals can build nests or store dog food in them). ● **SEE FIGURE 1-5.**

- **Check everything that does and does not work.** This step involves turning things on and observing that everything is working properly.
- **Look for evidence of previous repairs.** Any time work is performed on a vehicle, there is always a risk that something will be disturbed, knocked off, or left disconnected.
- **Check oil level and condition.** Another area for visual inspection is oil level and condition.
  - Oil level.** Oil should be to the proper level.
  - Oil condition.** Using a match or lighter, try to light the oil on the dipstick; if the oil flames up, gasoline is present

# ENGINE PERFORMANCE DIAGNOSIS WORKSHEET

(To Be Filled Out By the Vehicle Owner)

Name: \_\_\_\_\_ Mileage: \_\_\_\_\_ Date: \_\_\_\_\_

Make: \_\_\_\_\_ Model: \_\_\_\_\_ Year: \_\_\_\_\_ Engine: \_\_\_\_\_

(Please Circle All That Apply in All Categories)	
<b>Describe Problem:</b>	
<b>When Did the Problem First Occur?</b>	<ul style="list-style-type: none"> <li>• Just Started    • Last Week    • Last Month</li> <li>• Other _____</li> </ul>
<b>List Previous Repairs in the Last 6 Months:</b>	
<b>Starting Problems</b>	<ul style="list-style-type: none"> <li>• Will Not Crank    • Cranks, but Will Not Start    • Starts, but Takes a Long Time</li> </ul>
<b>Engine Quits or Stalls</b>	<ul style="list-style-type: none"> <li>• Right after Starting    • When Put into Gear    • During Steady Speed Driving</li> <li>• Right after Vehicle Comes to a Stop    • While Idling    • During Acceleration</li> <li>• When Parking</li> </ul>
<b>Poor Idling Conditions</b>	<ul style="list-style-type: none"> <li>• Is Too Slow at All Times    • Is Too Fast    • Intermittently Too Fast or Too Slow</li> <li>• Is Rough or Uneven    • Fluctuates Up and Down</li> </ul>
<b>Poor Running Conditions</b>	<ul style="list-style-type: none"> <li>• Runs Rough    • Lacks Power    • Bucks and Jerks    • Poor Fuel Economy</li> <li>• Hesitates or Stumbles on Acceleration    • Backfires    • Misfires or Cuts Out</li> <li>• Engine Knocks, Pings, Rattles    • Surges    • Dieseling or Run-On</li> </ul>
<b>Automatic Transmission Problems</b>	<ul style="list-style-type: none"> <li>• Improper Shifting (Early/Late)    • Changes Gear Incorrectly</li> <li>• Vehicle Does Not Move when in Gear    • Jerks or Bucks</li> </ul>
<b>Usually Occurs</b>	<ul style="list-style-type: none"> <li>• Morning    • Afternoon    • Anytime</li> </ul>
<b>Engine Temperature</b>	<ul style="list-style-type: none"> <li>• Cold    • Warm    • Hot</li> </ul>
<b>Driving Conditions During Occurrence</b>	<ul style="list-style-type: none"> <li>• Short—Less Than 2 Miles    • 2–10 Miles    • Long—More Than 10 Miles</li> <li>• Stop and Go    • While Turning    • While Braking    • At Gear Engagement</li> <li>• With A/C Operating    • With Headlights On    • During Acceleration</li> <li>• During Deceleration    • Mostly Downhill    • Mostly Uphill    • Mostly Level</li> <li>• Mostly Curvy    • Rough Road</li> </ul>
<b>Driving Habits</b>	<ul style="list-style-type: none"> <li>• Mostly City Driving    • Highway    • Park Vehicle Inside    • Park Vehicle Outside</li> <li><b>Drive Per Day:</b> • Less Than 10 Miles    • 10–50    • More Than 50</li> </ul>
<b>Gasoline Used</b>	<b>Fuel Octane:</b> • 87    • 89    • 91    • More Than 91 <b>Brand:</b> _____
<b>Temperature when Problem Occurs</b>	<ul style="list-style-type: none"> <li>• 32–55° F    • Below Freezing (32° F)    • Above 55° F</li> </ul>
<b>Check Engine Light/Dash Warning Light</b>	<ul style="list-style-type: none"> <li>• Light on Sometimes    • Light on Always    • Light Never On</li> </ul>
<b>Smells</b>	<ul style="list-style-type: none"> <li>• “Hot”    • Gasoline    • Oil Burning    • Electrical</li> </ul>
<b>Noises</b>	<ul style="list-style-type: none"> <li>• Rattle    • Knock    • Squeak    • Other</li> </ul>

**FIGURE 1–4** A form that the customer should fill out if there is a driveability concern to help the service technician more quickly find the root cause.



**FIGURE 1-5** This is what was found when removing an air filter from a vehicle that had a lack-of-power concern. Obviously the nuts were deposited by squirrels or some other animal, blocking a lot of the airflow into the engine.



#### TECH TIP

##### “Original Equipment” Is Not a Four-Letter Word

To many service technicians, an original equipment (OE) part is considered to be only marginal and to get the really “good stuff” an aftermarket (renewal market) part has to be purchased. However, many problems can be traced to the use of an aftermarket part that has failed early in its service life. Technicians who work at dealerships usually begin their diagnosis with an aftermarket part identified during a visual inspection. It has been their experience that simply replacing the aftermarket part with the factory OE part often solves the problem.

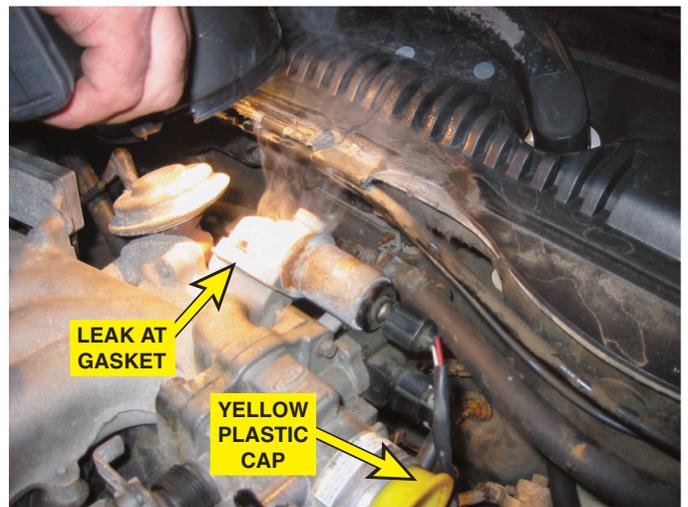
OE parts are *required* to pass quality and durability standards and tests at a level not required of aftermarket parts. The technician should be aware that the presence of a new part does not necessarily mean that the part is good.



#### TECH TIP

##### Smoke Machine Testing

Vacuum (air) leaks can cause a variety of driveability problems and are often difficult to locate. One good method is to use a machine that generates a stream of smoke. Connecting the outlet of the **smoke machine** to the hose that was removed from the vacuum brake booster allows smoke to enter the intake manifold. Any vacuum leaks will be spotted by observing smoke coming out of the leak. ● **SEE FIGURE 1-6.**



**FIGURE 1-6** Using a bright light makes seeing where the smoke is coming from easier. In this case, smoke was added to the intake manifold with the inlet blocked with a yellow plastic cap and smoke was seen escaping past a gasket at the idle air control.

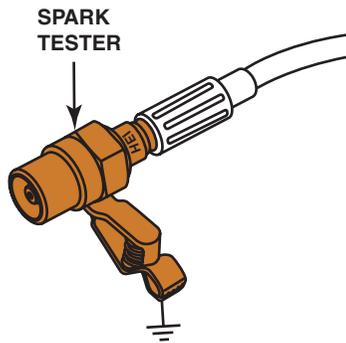
in the engine oil. Drip some engine oil from the dipstick onto the hot exhaust manifold. If the oil bubbles or boils, coolant (water) is present in the oil. Check for grittiness by rubbing the oil between your fingers.

**NOTE: Gasoline in the oil will cause the engine to run rich by drawing fuel through the positive crankcase ventilation (PCV) system.**

- **Check coolant level and condition.** Many mechanical engine problems are caused by overheating. The proper operation of the cooling system is critical to the life of any engine.

**NOTE: Check the coolant level in the radiator only if the radiator is cool. If the radiator is hot and the radiator cap is removed, the drop in pressure above the coolant will cause the coolant to boil immediately, which can cause severe burns because the coolant expands explosively upward and outward from the radiator opening.**

- **Use the paper test.** even and steady exhaust flow at the tailpipe when running. For the **paper test**, hold a piece of paper (even a dollar bill works) or a 3-by-5-inch card within 1 inch (2.5 m) of the tailpipe with the engine running at idle. The paper should blow evenly away from the end of the tailpipe without “puffing” or being drawn inward toward the end of the tailpipe. If the paper is at times drawn *toward* the tailpipe, the valves in one or more cylinders could be burned. Other reasons why the paper might be drawn toward the tailpipe include the following:

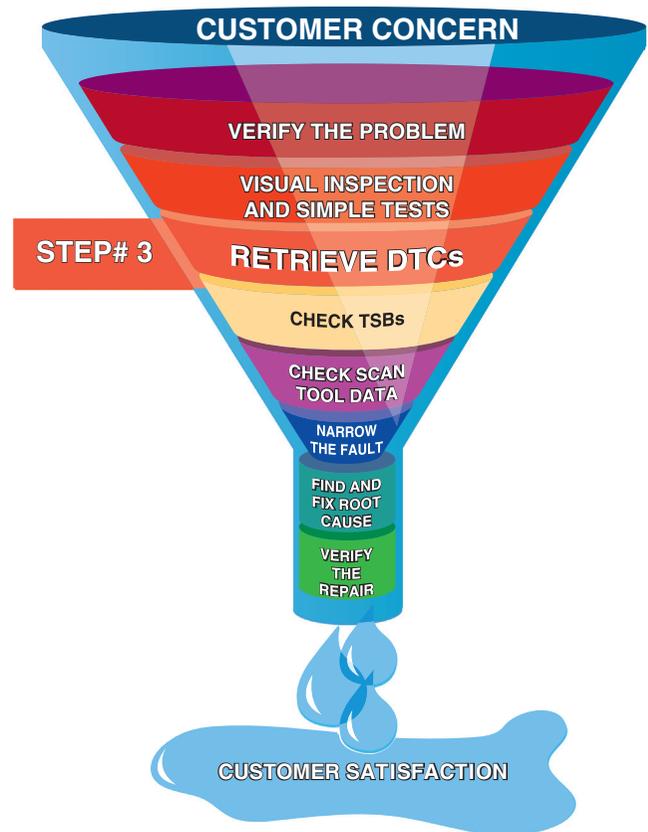


**FIGURE 1-7** A spark tester connected to a spark plug wire or coil output. A typical spark tester will only fire if at least 25,000 volts are available from the coil, making a spark tester a very useful tool. Do not use one that just lights when a spark is present, because they do not require more than about 2,000 volts to light.

1. The engine could be misfiring because of a lean condition that could occur normally when the engine is cold.
2. Pulsing of the paper toward the tailpipe could also be caused by a hole in the exhaust system. If exhaust escapes through a hole in the exhaust system, air could be drawn—in the intervals between the exhaust puffs—from the tailpipe to the hole in the exhaust, causing the paper to be drawn toward the tailpipe.

- **Ensure adequate fuel level.** Make certain that the fuel tank is at least one-fourth to one-half full; if the fuel level is low, it is possible that any water or alcohol at the bottom of the fuel tank is more concentrated and can be drawn into the fuel system.
- **Check the battery voltage.** The voltage of the battery should be at least 12.4 volts and the charging voltage (engine running) should be 13.5 to 15.0 volts at 2000 RPM. Low battery voltage can cause a variety of problems, including reduced fuel economy and incorrect (usually too high) idle speed. Higher-than-normal battery voltage can also cause powertrain control module (PCM) problems and could cause damage to electronic modules.
- **Check the spark using a spark tester.** Remove one spark plug wire and attach the removed plug wire to the spark tester. Attach the grounding clip of the spark tester to a good clean engine ground, start or crank the engine, and observe the spark tester. ● **SEE FIGURE 1-7.** The spark at the spark tester should be steady and consistent. If an intermittent spark occurs, then this condition should be treated as a no-spark condition. If this test does not show satisfactory spark, carefully inspect and test all components of the primary and secondary ignition systems.

**NOTE:** Do not use a standard spark plug to check for proper ignition system voltage. An electronic ignition spark tester is designed to force the spark to jump about 0.75 inch (19 mm). This amount of gap requires between 25,000 and 30,000 volts (25 and



**FIGURE 1-8** Step 3 in the diagnostic process is to retrieve any stored diagnostic trouble codes.

**30 kV) at atmospheric pressure, which is enough voltage to ensure that a spark can occur under compression inside an engine.**

- **Check the fuel-pump pressure.** Checking the fuel-pump pressure is relatively easy on many port-fuel-injected engines. Often the cause of intermittent engine performance is due to a weak electric fuel pump or clogged fuel filter. Checking fuel-pump pressure early in the diagnostic process eliminates low fuel pressure as a possibility.

**STEP 3 RETRIEVE THE DIAGNOSTIC TROUBLE CODES (DTCs)** If a 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.” ● **SEE FIGURE 1-8.** Any code(s) that is displayed on a scan tool when the MIL is *not* on is called a **pending code**. Because the MIL is not on, this indicates that the fault has not repeated to cause the PCM to turn on the MIL. Although this pending code is helpful to the technician to know that a fault has, in the past, been detected, further testing will be needed to find the root cause of the problem. Check and record the freeze-frame information. This indicates when the DTC was set, and this not only will help the technician determine what may have caused the code to set but also helps to verify the repair by operating the vehicle under the same or similar conditions.



## TECH TIP

### Perform Both a Pre-Scan and a Post-Scan

Many experts advise shops to make a pre-scan of all the vehicle's computer modules as well as a scan after the vehicle has been repaired to be a part of their standard operation procedure (SOP). Not only is this good business practice, but it really helps communications with the customer about possible faults with the vehicle that may not be part of the original customer concern.

- **Pre-scan:** This involves accessing all of the modules in the vehicle and retrieving any or all of the stored diagnostic trouble codes (DTCs), including pending codes. Any stored DTCs are recorded on the work order, and if related to the customer concern, the customer may need to be notified to get their approval before proceeding with the repairs.
- **Post-scan:** After the vehicle has been repaired and before it is released to the customer, a total module scan is performed again to not only verify the repair but also to ensure that another DTC was not set during the repair process. The results of this post-scan should also be documented on the repair order so it becomes a part of the documentation for the vehicle history.

### STEP 4 CHECK FOR TECHNICAL SERVICE BULLETINS (TSBS)

Check for corrections or repair procedures in **technical service bulletins (TSBs)** that match the symptoms. ● **SEE FIGURE 1-9.** According to studies performed by automobile manufacturers, as many as 30% of vehicles can be repaired following the information, suggestions, or replacement parts found in a service bulletin. DTCs must be known before searching for service bulletins, because bulletins often include information on solving problems that involve a stored diagnostic trouble code.

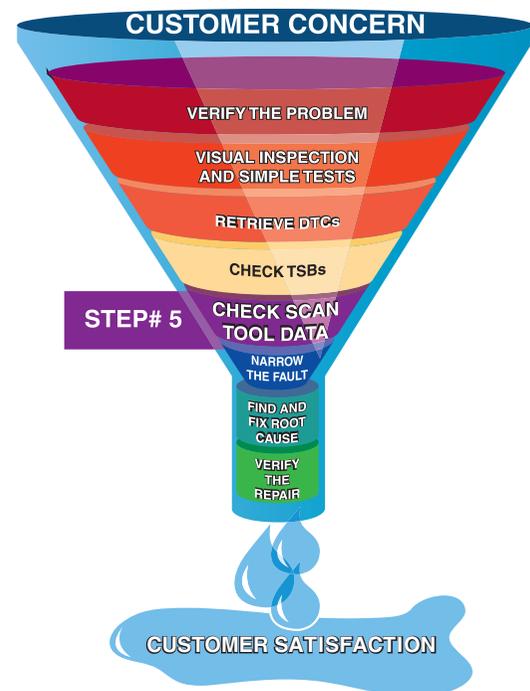
### STEP 5 LOOK CAREFULLY AT SCAN TOOL DATA

Vehicle manufacturers have been giving the technician more and more data on a scan tool connected to the **data link connector (DLC)**. ● **SEE FIGURE 1-10.** Beginning technicians are often observed scrolling through scan data without a real clue about what they are looking for. When asked, they usually reply that they are looking for something unusual, as if the screen will flash a big message "LOOK HERE—THIS IS NOT CORRECT." That statement does not appear on scan tool displays. 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.
- Idle air control (IAC) valve is being commanded to an acceptable range.
- Oxygen sensor (O2S) is operating properly:



**FIGURE 1-9** After checking for stored diagnostic trouble codes (DTCs), the wise technician checks service information for any technical service bulletins that may relate to the vehicle being serviced.



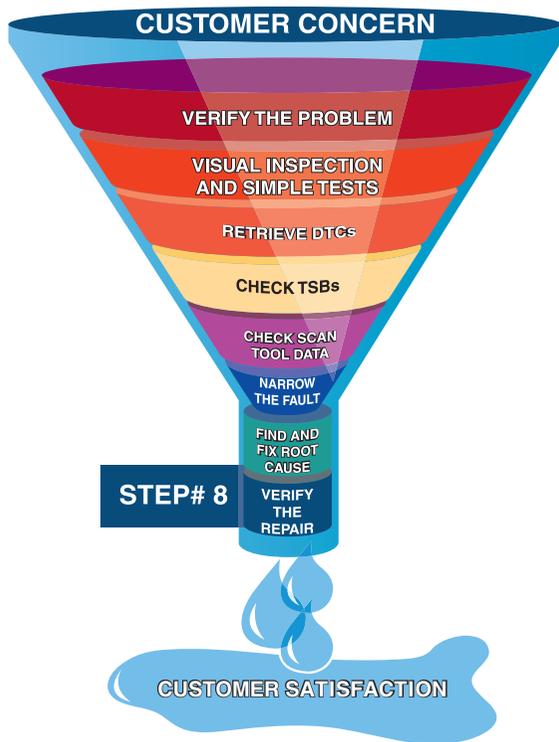
**FIGURE 1-10** Looking carefully at the scan tool data is very helpful in locating the source of a problem.

1. Readings below 200 mV at times
2. Readings above 800 mV at times
3. Rapid transitions between rich and lean

### 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. For example:

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



**FIGURE 1-11** Step 8 is very important. Be sure that the customer’s concern has been corrected.

**STEP 7 REPAIR THE PROBLEM AND DETERMINE THE ROOT CAUSE** 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. Also follow the manufacturer’s recommended repair procedures and methods.

**STEP 8 VERIFY THE REPAIR AND CLEAR ANY STORED DTCs** ● SEE FIGURE 1-11.

- 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. (This step ensures that the computer will not make any changes based on a stored DTC, but should not be performed if the vehicle is going to be tested for emissions because all of the monitors will need to be run and pass.)
- Return the vehicle to the customer and double check the following:
  1. The vehicle is clean.
  2. The radio is turned off.
  3. The clock is set to the right time and the radio stations have been restored if the battery was disconnected during the repair procedure.



**CASE STUDY**

**The Case of the No-Start Lexus**

The owner of a Lexus IS250 had the car towed to a shop as a no-start. The technician discovered that the “check engine” light would not come on even with key on, engine off (KOEO). A scan tool would not communicate either. Checking the resources on www.iatn.net, the technician read of a similar case where the fuel pressure sensor was shorted, which disabled all serial data communications. The technician disconnected the fuel pressure sensor located on the backside of the engine and the communications were restored and the engine started. The fuel pressure sensor was replaced and the vehicle returned to the happy owner.

**Summary:**

- **Complaint**—The vehicle owner stated that the engine would not start.
- **Cause**—A shorted fuel pressure sensor was found as per a previous similar case.
- **Correction**—The fuel pressure sensor was replaced and this corrected the serial data fault that caused the no-start condition.

**SCAN TOOLS**

Scan tools are the workhorse for any diagnostic work on all vehicles. Scan tools can be divided into two basic groups:

1. **Factory scan tools.** These are the scan tools required by all dealers that sell and service the brand of vehicle. Examples of factory scan tools include:
  - **General Motors**—Tech 2 or GM MDI ● SEE FIGURE 1-12.
  - **Ford**—New Generation Star (NGS) and IDS (Integrated Diagnostic Software).

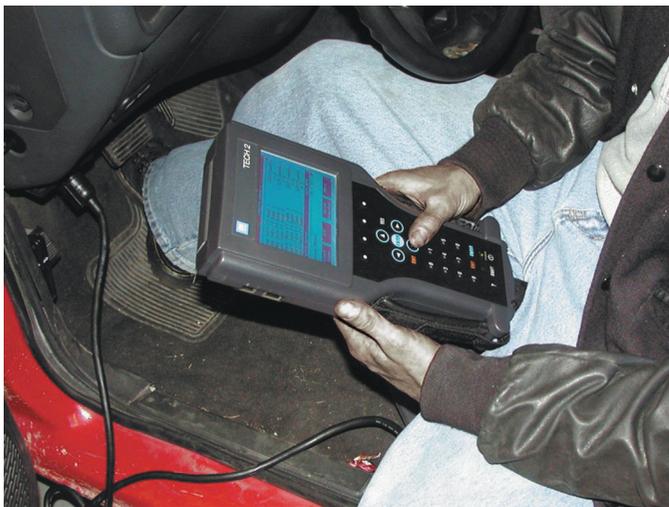


**TECH TIP**

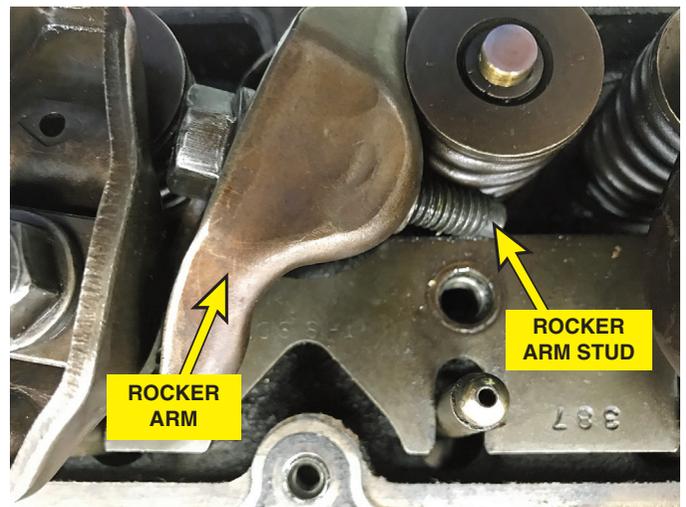
**One Test Is Worth 1,000 “Expert” Opinions**

Whenever any vehicle has an engine performance or driveability concern, certain people always say:  
 “Sounds like it’s a bad injector.”  
 “I’ll bet you it’s a bad computer.”  
 “I had a problem just like yours yesterday and it was a bad EGR valve.”

Regardless of the skills and talents of those people, it is still more accurate to perform tests on the vehicle than to rely on feelings or opinions of others who have not even seen the vehicle. Even your own opinion should not sway your thinking. Follow a plan, perform tests, and the test results will lead to the root cause.



**FIGURE 1-12** A TECH 2 scan tool is the factory scan tool used on General Motors vehicles.



**FIGURE 1-13** What the technician discovered after removing the valve cover was the root cause of the misfire.



### The Case of the Rough-Running Impala

A customer with a Chevrolet Impala equipped with a 3.4 liter engine is complaining of a running-rough condition and the MIL is illuminated. The customer commented the condition first occurred after a hard acceleration.

The technician was able to verify the customer concern.

The technician retrieved the codes from the engine control module and found a P0306 and a P0300 to be present.

Using the graphic misfire counter on the scan tool, the technician was able to confirm that cylinder #6 was consistently misfiring.

The technician was able to confirm that both the injector and the ignition coil were operating normally.

A compression test of the cylinder #6 revealed compression readings below specifications. A cylinder leakage test of cylinder #six showed leakage percentage to be at an acceptable level.

The technician removed the valve cover to discover the bolt that held the #6 intake valve rocker arm had pulled out of the cylinder head. ● **SEE FIGURE 1-13.**

The technician was able to repair the bolt hole in the cylinder head with a thread repair kit and reinstall the rocker arm. The technician completed a drive cycle and confirmed the misfire condition was repaired.

#### Summary:

- **Complaint**—The owner complained of a running-rough condition and an illuminated MIL.
- **Cause**—Following the correct diagnostic procedure it was determined that the rocker arm bolt had pulled out of the cylinder head.
- **Correction**—The cylinder head was repaired and the rocker arm was reinstalled, which corrected the rough-running concern and turned off the MIL.

- **Chrysler**—DRB-III or Star Scan, wiTECH
- **Honda**—HDS or Master Tech
- **Toyota**—Master Tech or Tech Stream

All factory scan tools are designed to provide bidirectional capability, which allows the service technician the opportunity to operate components using the scan tool, thereby confirming that the component is able to work when commanded. Also, all factory scan tools are capable of displaying all factory parameters.

2. **Aftermarket scan tools.** These scan tools are designed to function on more than one brand of vehicle while many aftermarket scan tools can display most, if not all, of the parameters of the factory scan tool, there can be a difference when trying to troubleshoot some faults. Examples of aftermarket scan tools include:

- **Snap-on** (various models including the MT2500 and Modis)
- **OTC** (various models including Pegasus, Genisys, and Task Master)
- **AutoEnginuity** and other programs that use a laptop or handheld computer for the display

3. **Global (generic) scan tools.** Scan tools that read and display just global data are capable of only displaying emission-related information. While global only data is helpful at times, generic scan tools are not usually considered to be suitable for use by professional service technicians. ● **SEE FIGURE 1-14.**

## RETRIEVAL OF DIAGNOSTIC INFORMATION

To retrieve diagnostic information from the PCM, a scan tool is needed. If a factory or factory-level scan tool is used, then all of the data can be retrieved. If a global (generic)-only-type scan tool is used, only the emissions-related data can be retrieved. To retrieve diagnostic information from the PCM, use the following steps:



**FIGURE 1-14** A Bluetooth adapter that plugs into the DLC and transmits global OBD II information to a smart phone that has a scan tool app installed.

**STEP 1** Locate and gain access to the data link connector (DLC).

**STEP 2** Connect the scan tool to the DLC and establish communication.

**NOTE:** If no communication is established, follow the vehicle manufacturer's specified instructions.

**STEP 3** Follow the on-screen instructions of the scan tool to correctly identify the vehicle.

**STEP 4** Observe the scan data, as well as any diagnostic trouble codes.

**STEP 5** Follow vehicle manufacturer's instructions if any DTCs are stored. If no DTCs are stored, compare all sensor values with a factory-acceptable range chart to see if any sensor values are out of range.

Parameter Identification (PID)		
Scan Tool Parameter	Units Displayed	Typical Data Value
Cycles of Misfire Data	Counts	0-99
Desired EGR Position	Percent	0
ECT	°C/°F	Varies
EGR Duty Cycle	Percent	0
Engine Run Time	Hr: Min: Sec	Varies
EVAP Canister Purge	Percent	Low and Varying
EVAP Fault History	No Fault/Excess Vacuum/Purge Valve Leak/Small Leak/Weak Vacuum	No Fault
Fuel Tank Pressure	Inches of H <sub>2</sub> O/ Volts	Varies
HO2S Sensor 1	Ready/Not Ready	Ready
HO2S Sensor 1	Millivolts	0-1,000 and Varying
HO2S Sensor 2	Millivolts	0-1,000 and Varying
HO2S X Counts	Counts	Varies
IAC Position	Counts	15-25 preferred
IAT	°C/°F	Varies
Knock Retard	Degrees	0
Long-term FT	Percent	0-10
MAF	Grams per second	3-7
MAF Frequency	Hz	1,200-3,000 (depends on altitude and engine load)
MAP	kPa/Volts	20-48 kPa/0.75-2 Volts (depends on altitude)
Misfire Current Cyl. 1-10	Counts	0
Misfire History Cyl. 1-10	Counts	0
Short-term FT	Percent	0-10
Start Up ECT	°C/°F	Varies
Start Up IAT	°C/°F	Varies
Total Misfire Current Count	Counts	0
Total Misfire Failures	Counts	0

Parameter Identification (PID)		
Scan Tool Parameter	Units Displayed	Typical Data Value
<b>Engine Idling/Radiator Hose Hot/Closed Throttle/ Park or Neutral/Closed Loop/Accessories Off/ Brake Pedal Released</b>		
3X Crank Sensor	RPM	Varies
24X Crank Sensor	RPM	Varies
Actual EGR Position	Percent	0
BARO	kPa/Volts	65-110 kPa/ 3.5-4.5 Volts
CMP Sensor Signal Present	Yes/No	Yes
Commanded Fuel Pump	On/Off	On

Parameter Identification (PID)		
Scan Tool Parameter	Units Displayed	Typical Data Value
Total Misfire Passes	Counts	0
TP Angle	Percent	0
TP Sensor	Volts	0.20–0.74
Vehicle Speed	MPH/Km/h	0

**Note:** Viewing the PID screen on the scanner is useful in determining if a problem is occurring at the present time

## TROUBLESHOOTING USING DIAGNOSTIC TROUBLE CODES

Pinning down causes of the actual problem can be accomplished by trying to set the opposite code. For example, if a code indicates an open throttle position (TP) sensor (high resistance), clear the code and create a shorted (low-resistance) condition. This can be accomplished by using a jumper wire and connecting the signal terminal to the 5-volt reference terminal. This should set a diagnostic trouble code.

- **If the opposite code sets**, this indicates that the wiring and connector for the sensor is okay and the sensor itself is defective (open).
- **If the same code sets**, this indicates that the wiring or electrical connection is open (has high resistance) and is the cause of the setting of the DTC.

**METHODS FOR CLEARING DIAGNOSTIC TROUBLE CODES** Clearing diagnostic trouble codes from a vehicle computer sometimes needs to be performed. There are three methods that can be used to clear stored diagnostic trouble codes.

**CAUTION: Clearing diagnostic trouble codes (DTCs) also will clear all of the noncontinuous monitors.**

- **Clearing codes—Method 1.** The preferred method of clearing codes is by using a scan tool. This is the method recommended by most vehicle manufacturers if the procedure can be performed on the vehicle. The computer of some vehicles cannot be cleared with a scan tool.
- **Clearing codes—Method 2.** If a scan tool is not available or a scan tool cannot be used on the vehicle being serviced, the power to the computer can be disconnected.
  1. Disconnect the fusible link (if so equipped) that feeds the computer.
  2. Disconnect the fuse or fuses that feed the computer.

**NOTE: The fuse may not be labeled as a computer fuse. For example, many Toyotas can be cleared**



**FIGURE 1-15** Diagnostic trouble codes (DTCs) from Chrysler and Dodge vehicles can be retrieved by turning the ignition switch to on and then off three times.

**by disconnecting the fuel-injection fuse. Some vehicles require that two fuses be disconnected to clear any stored codes.**

- **Clearing codes—Method 3.** If the other two methods cannot be used, the negative battery cable can be disconnected to clear stored diagnostic trouble codes.

**NOTE: Because of the adaptive learning capacity of the computer, a vehicle may fail an exhaust emissions test**



### TECH TIP

#### Do Not Lie to a Scan Tool!

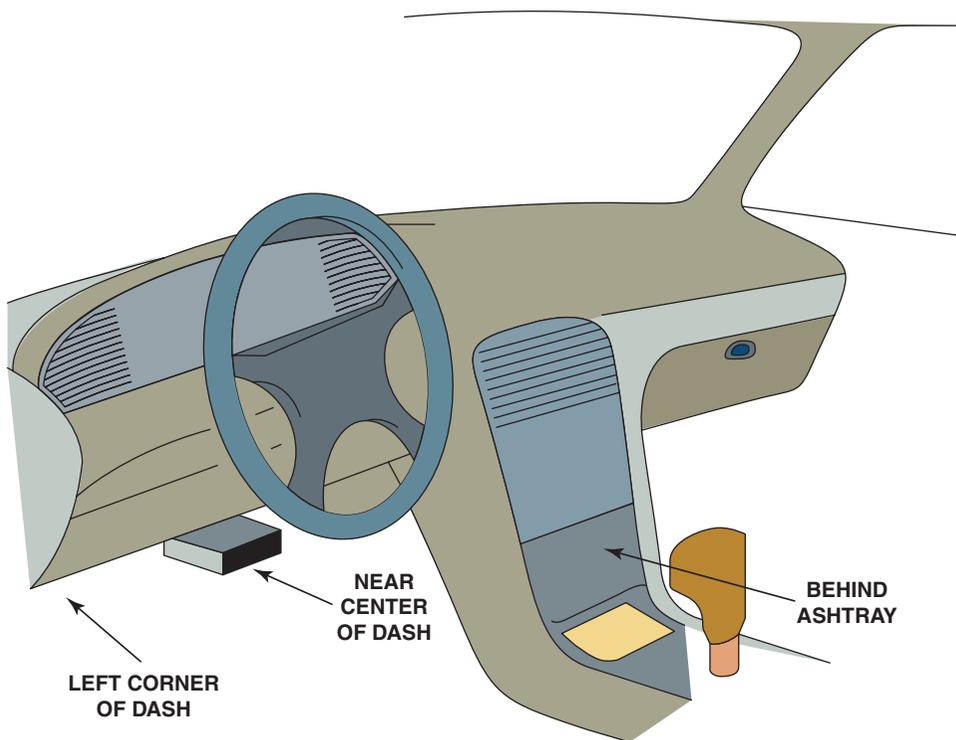
Because computer calibration may vary from year to year, using the incorrect year for the vehicle while using a scan tool can cause the data retrieved to be incorrect or inaccurate.



### TECH TIP

#### Quick and Easy Chrysler Code Retrieval

Most Chrysler-made vehicles (Dodge, Ram, and Chrysler) can display the diagnostic trouble code on the dash by turning the ignition switch on and then off and then on three times with the last time being on. This makes it easy for anyone to see if there are any stored trouble codes without having to use a scan tool. ● **SEE FIGURE 1-15.**



**FIGURE 1-16** The data link connector (DLC) can be located in various locations.

if the vehicle is not driven enough to allow the computer to run all of the monitors.

**CAUTION:** By disconnecting the battery, the radio presets will be lost. They should be reset before returning the vehicle to the customer. If the radio has a security code, the code must be entered before the radio will function. Before disconnecting the battery, always check with the vehicle owner to be sure that the code is available.



**FIGURE 1-17** A typical OBD-II data link connector (DLC). The location varies with make and model and may even be covered, but a tool is not needed to gain access. Check service information for the exact location if needed.

## DLC LOCATIONS

The data link connector (DLC) is a standardized 16-cavity connector where a scan tool can be connected to retrieve diagnostic information from the vehicle's computers.

The normal location is under the dash on the driver's side but it can be located within 12 inches (30 cm) of the center of the vehicle. It can be covered, but if it is, then the cover has to be able to be removed without the use of a tool, such as when it is located underneath the ash tray. ● **SEE FIGURE 1-16.**

## OBD-II DIAGNOSIS

Starting with the 1996 model year, all vehicles sold in the United States must use the same type of 16-pin data link connector (DLC) and must monitor emission-related components.

● **SEE FIGURE 1-17.**

**RETRIEVING OBD-II CODES** A scan tool is required to retrieve diagnostic trouble codes from most OBD-II vehicles. Every OBD-II scan tool will be able to read all generic Society of Automotive Engineers (SAE) DTCs from any vehicle.

### Fuel and Air Metering System

- P0100 Mass or Volume Airflow Circuit Problem
- P0101 Mass or Volume Airflow Circuit Range or Performance Problem
- P0102 Mass or Volume Airflow Circuit Low Input
- P0103 Mass or Volume Airflow Circuit High Input
- P0105 Manifold Absolute Pressure or Barometric Pressure Circuit Problem

P0106	Manifold Absolute Pressure or Barometric Pressure Circuit Range or Performance Problem	P0142	O2 Sensor Circuit Problem (Bank 1* Sensor 3)
P0107	Manifold Absolute Pressure or Barometric Pressure Circuit Low Input	P0143	O2 Sensor Circuit Low Voltage (Bank 1* Sensor 3)
P0108	Manifold Absolute Pressure or Barometric Pressure Circuit High Input	P0144	O2 Sensor Circuit High Voltage (Bank 1* Sensor 3)
P0110	Intake Air Temperature Circuit Problem	P0145	O2 Sensor Circuit Slow Response (Bank 1* Sensor 3)
P0111	Intake Air Temperature Circuit Range or Performance Problem	P0146	O2 Sensor Circuit No Activity Detected (Bank 1* Sensor 3)
P0112	Intake Air Temperature Circuit Low Input	P0147	O2 Sensor Heater Circuit Problem (Bank 1* Sensor 3)
P0113	Intake Air Temperature Circuit High Input	P0150	O2 Sensor Circuit Problem (Bank 2 Sensor 1)
P0115	Engine Coolant Temperature Circuit Problem	P0151	O2 Sensor Circuit Low Voltage (Bank 2 Sensor 1)
P0116	Engine Coolant Temperature Circuit Range or Performance Problem	P0152	O2 Sensor Circuit High Voltage (Bank 2 Sensor 1)
P0117	Engine Coolant Temperature Circuit Low Input	P0153	O2 Sensor Circuit Slow Response (Bank 2 Sensor 1)
P0118	Engine Coolant Temperature Circuit High Input	P0154	O2 Sensor Circuit No Activity Detected (Bank 2 Sensor 1)
P0120	Throttle Position Circuit Problem	P0155	O2 Sensor Heater Circuit Problem (Bank 2 Sensor 1)
P0121	Throttle Position Circuit Range or Performance Problem	P0156	O2 Sensor Circuit Problem (Bank 2 Sensor 2)
P0122	Throttle Position Circuit Low Input	P0157	O2 Sensor Circuit Low Voltage (Bank 2 Sensor 2)
P0123	Throttle Position Circuit High Input	P0158	O2 Sensor Circuit High Voltage (Bank 2 Sensor 2)
P0125	Excessive Time to Enter Closed-Loop Fuel Control	P0159	O2 Sensor Circuit Slow Response (Bank 2 Sensor 2)
P0128	Coolant Temperature Below Thermostat Regulating Temperature	P0160	O2 Sensor Circuit No Activity Detected (Bank 2 Sensor 2)
P0130	O2 Sensor Circuit Problem (Bank 1* Sensor 1)	P0161	O2 Sensor Heater Circuit Problem (Bank 2 Sensor 2)
P0131	O2 Sensor Circuit Low Voltage (Bank 1* Sensor 1)	P0162	O2 Sensor Circuit Problem (Bank 2 Sensor 3)
P0132	O2 Sensor Circuit High Voltage (Bank 1* Sensor 1)	P0163	O2 Sensor Circuit Low Voltage (Bank 2 Sensor 3)
P0133	O2 Sensor Circuit Slow Response (Bank 1* Sensor 1)	P0164	O2 Sensor Circuit High Voltage (Bank 2 Sensor 3)
P0134	O2 Sensor Circuit No Activity Detected (Bank 1* Sensor 1)	P0165	O2 Sensor Circuit Slow Response (Bank 2 Sensor 3)
P0135	O2 Sensor Heater Circuit Problem (Bank 1* Sensor 1)	P0166	O2 Sensor Circuit No Activity Detected (Bank 2 Sensor 3)
P0136	O2 Sensor Circuit Problem (Bank 1* Sensor 2)	P0167	O2 Sensor Heater Circuit Problem (Bank 2 Sensor 3)
P0137	O2 Sensor Circuit Low Voltage (Bank 1* Sensor 2)	P0170	Fuel Trim Problem (Bank 1*)
P0138	O2 Sensor Circuit High Voltage (Bank 1* Sensor 2)	P0171	System Too Lean (Bank 1*)
P0139	O2 Sensor Circuit Slow Response (Bank 1* Sensor 2)	P0172	System Too Rich (Bank 1*)
P0140	O2 Sensor Circuit No Activity Detected (Bank 1* Sensor 2)		
P0141	O2 Sensor Heater Circuit Problem (Bank 1* Sensor 2)		

(continued)

P0173 Fuel Trim Problem (Bank 2)  
 P0174 System Too Lean (Bank 2)  
 P0175 System Too Rich (Bank 2)  
 P0176 Fuel Composition Sensor Circuit Problem  
 P0177 Fuel Composition Sensor Circuit Range or Performance  
 P0178 Fuel Composition Sensor Circuit Low Input  
 P0179 Fuel Composition Sensor Circuit High Input  
 P0180 Fuel Temperature Sensor Problem  
 P0181 Fuel Temperature Sensor Circuit Range or Performance  
 P0182 Fuel Temperature Sensor Circuit Low Input  
 P0183 Fuel Temperature Sensor Circuit High Input

**Fuel and Air Metering (Injector Circuit)**

P0201 Injector Circuit Problem—Cylinder 1  
 P0202 Injector Circuit Problem—Cylinder 2  
 P0203 Injector Circuit Problem—Cylinder 3  
 P0204 Injector Circuit Problem—Cylinder 4  
 P0205 Injector Circuit Problem—Cylinder 5  
 P0206 Injector Circuit Problem—Cylinder 6  
 P0207 Injector Circuit Problem—Cylinder 7  
 P0208 Injector Circuit Problem—Cylinder 8  
 P0209 Injector Circuit Problem—Cylinder 9  
 P0210 Injector Circuit Problem—Cylinder 10  
 P0211 Injector Circuit Problem—Cylinder 11  
 P0212 Injector Circuit Problem—Cylinder 12  
 P0213 Cold Start Injector 1 Problem  
 P0214 Cold Start Injector 2 Problem

**Ignition System or Misfire**

P0300 Random Misfire Detected  
 P0301 Cylinder 1 Misfire Detected  
 P0302 Cylinder 2 Misfire Detected  
 P0303 Cylinder 3 Misfire Detected  
 P0304 Cylinder 4 Misfire Detected  
 P0305 Cylinder 5 Misfire Detected  
 P0306 Cylinder 6 Misfire Detected  
 P0307 Cylinder 7 Misfire Detected  
 P0308 Cylinder 8 Misfire Detected  
 P0309 Cylinder 9 Misfire Detected  
 P0310 Cylinder 10 Misfire Detected  
 P0311 Cylinder 11 Misfire Detected  
 P0312 Cylinder 12 Misfire Detected  
 P0320 Ignition or Distributor Engine Speed Input Circuit Problem

P0321 Ignition or Distributor Engine Speed Input Circuit Range or Performance  
 P0322 Ignition or Distributor Engine Speed Input Circuit No Signal  
 P0325 Knock Sensor 1 Circuit Problem  
 P0326 Knock Sensor 1 Circuit Range or Performance  
 P0327 Knock Sensor 1 Circuit Low Input  
 P0328 Knock Sensor 1 Circuit High Input  
 P0330 Knock Sensor 2 Circuit Problem  
 P0331 Knock Sensor 2 Circuit Range or Performance  
 P0332 Knock Sensor 2 Circuit Low Input  
 P0333 Knock Sensor 2 Circuit High Input  
 P0335 Crankshaft Position Sensor Circuit Problem  
 P0336 Crankshaft Position Sensor Circuit Range or Performance  
 P0337 Crankshaft Position Sensor Circuit Low Input  
 P0338 Crankshaft Position Sensor Circuit High Input

**Auxiliary Emission Controls**

P0400 Exhaust Gas Recirculation Flow Problem  
 P0401 Exhaust Gas Recirculation Flow Insufficient Detected  
 P0402 Exhaust Gas Recirculation Flow Excessive Detected  
 P0405 Air Conditioner Refrigerant Charge Loss  
 P0410 Secondary Air Injection System Problem  
 P0411 Secondary Air Injection System Insufficient Flow Detected  
 P0412 Secondary Air Injection System Switching Valve or Circuit Problem  
 P0413 Secondary Air Injection System Switching Valve or Circuit Open  
 P0414 Secondary Air Injection System Switching Valve or Circuit Shorted  
 P0420 Catalyst System Efficiency below Threshold (Bank 1\*)  
 P0421 Warm Up Catalyst Efficiency below Threshold (Bank 1\*)  
 P0422 Main Catalyst Efficiency below Threshold (Bank 1\*)  
 P0423 Heated Catalyst Efficiency below Threshold (Bank 1\*)  
 P0424 Heated Catalyst Temperature below Threshold (Bank 1\*)  
 P0430 Catalyst System Efficiency below Threshold (Bank 2)  
 P0431 Warm Up Catalyst Efficiency below Threshold (Bank 2)

P0432	Main Catalyst Efficiency below Threshold (Bank 2)	P0706	Transmission Range Sensor Circuit Range or Performance
P0433	Heated Catalyst Efficiency below Threshold (Bank 2)	P0707	Transmission Range Sensor Circuit Low Input
P0434	Heated Catalyst Temperature below Threshold (Bank 2)	P0708	Transmission Range Sensor Circuit High Input
P0440	Evaporative Emission Control System Problem	P0710	Transmission Fluid Temperature Sensor Problem
P0441	Evaporative Emission Control System Insufficient Purge Flow	P0711	Transmission Fluid Temperature Sensor Range or Performance
P0442	Evaporative Emission Control System Leak Detected	P0712	Transmission Fluid Temperature Sensor Low Input
P0443	Evaporative Emission Control System Purge Control Valve Circuit Problem	P0713	Transmission Fluid Temperature Sensor High Input
P0444	Evaporative Emission Control System Purge Control Valve Circuit Open	P0715	Input or Turbine Speed Sensor Circuit Problem
P0445	Evaporative Emission Control System Purge Control Valve Circuit Shorted	P0716	Input or Turbine Speed Sensor Circuit Range or Performance
P0446	Evaporative Emission Control System Vent Control Problem	P0717	Input or Turbine Speed Sensor Circuit No Signal
P0447	Evaporative Emission Control System Vent Control Open	P0720	Output Speed Sensor Circuit Problem
P0448	Evaporative Emission Control System Vent Control Shorted	P0721	Output Speed Sensor Circuit Range or Performance
P0450	Evaporative Emission Control System Pressure Sensor Problem	P0722	Output Speed Sensor Circuit No Signal
P0451	Evaporative Emission Control System Pressure Sensor Range or Performance	P0725	Engine Speed Input Circuit Problem
P0452	Evaporative Emission Control System Pressure Sensor Low Input	P0726	Engine Speed Input Circuit Range or Performance
P0453	Evaporative Emission Control System Pressure Sensor High Input	P0727	Engine Speed Input Circuit No Signal
<b>Vehicle Speed Control and Idle Control</b>			
P0500	Vehicle Speed Sensor Problem	P0730	Incorrect Gear Ratio
P0501	Vehicle Speed Sensor Range or Performance	P0731	Gear 1 Incorrect Ratio
P0502	Vehicle Speed Sensor Low Input	P0732	Gear 2 Incorrect Ratio
P0505	Idle Control System Problem	P0733	Gear 3 Incorrect Ratio
P0506	Idle Control System RPM Lower Than Expected	P0734	Gear 4 Incorrect Ratio
P0507	Idle Control System RPM Higher Than Expected	P0735	Gear 5 Incorrect Ratio
P0510	Closed Throttle Position Switch Problem	P0736	Reverse Incorrect Ratio
<b>Computer Output Circuit</b>			
P0600	Serial Communication Link Problem	P0740	Torque Converter Clutch System Problem
P0605	Internal Control Module (Module Identification Defined by J1979)	P0741	Torque Converter Clutch System Performance or Stuck Off
<b>Transmission</b>			
P0703	Brake Switch Input Problem	P0742	Torque Converter Clutch System Stuck On
P0705	Transmission Range Sensor Circuit Problem (PRNDL Input)	P0743	Torque Converter Clutch System Electrical
		P0745	Pressure Control Solenoid Problem
		P0746	Pressure Control Solenoid Performance or Stuck Off
		P0747	Pressure Control Solenoid Stuck On
		P0748	Pressure Control Solenoid Electrical
		P0750	Shift Solenoid A Problem
		P0751	Shift Solenoid A Performance or Stuck Off
		P0752	Shift Solenoid A Stuck On
		P0753	Shift Solenoid A Electrical

(continued)

P0755	Shift Solenoid B Problem
P0756	Shift Solenoid B Performance or Stuck Off
P0757	Shift Solenoid B Stuck On
P0758	Shift Solenoid B Electrical
P0760	Shift Solenoid C Problem
P0761	Shift Solenoid C Performance or Stuck Off
P0762	Shift Solenoid C Stuck On
P0763	Shift Solenoid C Electrical
P0765	Shift Solenoid D Problem
P0766	Shift Solenoid D Performance or Stuck Off
P0767	Shift Solenoid D Stuck On
P0768	Shift Solenoid D Electrical
P0770	Shift Solenoid E Problem
P0771	Shift Solenoid E Performance or Stuck Off
P0772	Shift Solenoid E Stuck On
P0773	Shift Solenoid E Electrical

\* The side of the engine where number one cylinder is located.

## OBD-II ACTIVE TESTS

The vehicle computer must run tests on the various emission-related components and turn on the malfunction indicator lamp (MIL) if faults are detected. OBD II is an *active* computer analysis system because it actually tests the operation of the oxygen sensors, exhaust gas recirculation system, and so forth whenever conditions permit. It is the purpose and function of the powertrain control module (PCM) to monitor these components and perform these active tests.

For example, the PCM may open the EGR valve momentarily to check its operation while the vehicle is decelerating. A change in the manifold absolute pressure (MAP) sensor signal will indicate to the computer that the exhaust gas is, in fact, being introduced into the engine. Because these tests are active and certain conditions must be present before these tests can be run, the computer uses its internal diagnostic program to keep track of all the various conditions and to schedule active tests so that they will not interfere with each other.

**OBD-II DRIVE CYCLE** The vehicle must be driven under a variety of operating conditions for all active tests to be performed. A **trip** is defined as an engine-operating drive cycle that contains the necessary conditions for a particular test to be performed. For example, for the EGR test to be performed, the engine has to be at normal operating temperature and decelerating for a minimum amount of time. Some tests are performed when the engine is cold, whereas others require that the vehicle be cruising at a steady highway speed.

**TYPES OF OBD-II CODES** Not all OBD-II diagnostic trouble codes are of the same importance for exhaust emissions.

Each type of DTC has different requirements for it to set, and the computer will only turn on the MIL for emissions-related DTCs.

**TYPE A CODES.** A type A diagnostic trouble code is emission related and will cause the MIL to be turned on at the *first trip* if the computer has detected a problem. Engine misfire or a very rich or lean air-fuel ratio, for example, would cause a type A diagnostic trouble code. These codes alert the driver to an emissions problem that may cause damage to the catalytic converter.

**TYPE B CODES.** A type B code will be stored as a pending code in the PCM and the MIL will be turned on only after the second consecutive trip, alerting the driver to the fact that a diagnostic test was performed and failed.

**NOTE: Type A and Type B codes are emission related and will cause the lighting of the malfunction indicator lamp, usually labeled “check engine” or “service engine soon.”**

**TYPE C AND D CODES.** Type C and type D codes are for use with non-emission-related diagnostic tests. They will cause the lighting of a “service” lamp (if the vehicle is so equipped).

**OBD-II FREEZE-FRAME** To assist the service technician, OBD II requires the computer to take a “snapshot” or freeze-frame of all data at the instant an emission-related DTC is set. A scan tool is required to retrieve this data. CARB and EPA regulations require that the controller store specific freeze-frame (engine-related) data when the first emission-related fault is detected. The data stored in freeze-frame can only be replaced by data from a trouble code with a higher priority such as a problem related to a fuel system or misfire monitor fault.

**NOTE: Although OBD II requires that just one freeze-frame of data be stored, the instant an emission-related DTC is set, vehicle manufacturers usually provide expanded data about the DTC beyond that required. However, retrieving enhanced data usually requires the use of an enhanced or factory-level scan tool.**

The freeze-frame has to contain data values that occurred at the time the code was set (these values are provided in standard units of measurement). Freeze-frame data are recorded during the first trip on a two-trip fault. As a result, OBD-II systems record the data present at the time an emission-related code is recorded and the MIL activated. These data can be accessed and displayed on a scan tool. Freeze-frame data are one frame or one instant in time. They are not updated (refreshed) if the same monitor test fails a second time.

### REQUIRED FREEZE-FRAME DATA ITEMS.

- Code that triggered the freeze-frame
- A/F ratio, airflow rate, and calculated engine load
- Base fuel injector pulse width
- ECT, IAT, MAF, MAP, TP, and VS sensor data
- Engine speed and amount of ignition spark advance
- Open- or closed-loop status

- Short-term and long-term fuel trim values
- For misfire codes—identify the cylinder that misfired

**NOTE:** All freeze-frame data will be lost if the battery is disconnected, power to the PCM is removed, or the scan tool is used to erase or clear trouble codes.

**DIAGNOSING INTERMITTENT MALFUNCTIONS** Of all the different types of conditions that you will see, the hardest to accurately diagnose and repair are intermittent malfunctions. These conditions may be temperature related (only occur when the vehicle is hot or cold), or humidity related (only occur when it is raining). Regardless of the conditions that will cause the malfunction to occur, you must diagnose and correct the condition.

When dealing with an intermittent concern, you should determine the conditions when the malfunction occurs, and then try to duplicate those conditions. If a cause is not readily apparent to you, ask the customer when the symptom occurs. Ask if there are any conditions that seem to be related to, or cause the concern.

Another consideration when working on an OBD-II-equipped vehicle is whether a concern is intermittent, or if it only occurs when a specific diagnostic test is performed by the PCM. Since OBD-II systems conduct diagnostic tests only under very precise conditions, some tests may be run only once during an ignition cycle. Additionally, if the requirements needed to perform the test are not met, the test will not run during an ignition cycle. This type of onboard diagnostics could be mistaken as “intermittent” when, in fact, the tests are only infrequent (depending on how the vehicle is driven). Examples of this type of diagnostic test are HO<sub>2</sub>S heaters, evaporative canister purge, catalyst efficiency, and EGR flow. When diagnosing intermittent concerns on an OBD-II-equipped vehicle, a logical diagnostic strategy is essential. The use of stored freeze-frame information can also be very useful when diagnosing an intermittent malfunction if a code has been stored.

## NO-CODE DIAGNOSIS

**POSSIBLE CAUSES** No-code diagnosis is what the service technician needs to perform when there is a customer concern but there are no stored diagnostic trouble codes (DTCs). This type of customer complaint often results in a potential long process to locate the root cause. There are many possible causes of a problem such as a hesitation, stalling or poor performance that will not cause a DTC to set. Some of the possible causes include:

- Alcohol (ethanol) in high concentrations in the fuel
- Contaminated fuel that has water or diesel fuel mixed with the fuel
- Clogged air intake systems due to an animal nest or road debris caught in the air intake system
- Partially clogged or restricted exhaust system
- Engine mechanical fault such as recessed valves into the cylinder head resulting in reduced valve lift, thereby reducing engine power.

- Incorrect oil level or viscosity
- Incorrectly timed timing belt or chain causing valve timing to off but not enough to cause a crank/cam correlation DTC to be set.

**NO-CODE DIAGNOSTIC STRATEGY** If there are no stored DTCs, diagnostic strategy the wise service technician follows includes the following steps:

**STEP #1:** After verifying the customer concern, check vehicle service history and perform a thorough visual inspection checking for the following:

- Evidence of a previous repair or recent body work that may be an indication of an accident (collision).
- Check the fuel for contamination or excessive alcohol content
- Check that all of the tire sizes are the same, because if they are not, this can cause a vibration that is often confused as being a misfire, especially in four-wheel-drive and all-wheel-drive vehicles.
- Check for evidence of previous service work if the vehicle history is not available that may include engine work such as a timing belt or water pump replacement.
- Check for technical service bulletins (TSBs) that relate to the customer’s concern.

**STEP #2:** Check scan tool data and look at fuel trim numbers. A preferred fuel trim is less than 5% whereas anything less than 10% is considered to be acceptable. A diagnostic trouble code for a rich or lean air–fuel ratio is usually set when the fuel number exceeds 25%. Sometimes driveability issues can be experienced by the driver when the exhaust is lean but not lean enough to set a DTC.

**STEP #3:** Perform a test drive using a scan tool set to record the major high-authority sensors in movie mode. The high-authority sensors that should be selected include:

- MAP/MAF
- ECT/IAT
- TP sensor
- O<sub>2</sub> sensors

The TP and MAF sensor should track each other, and when shown using the graphing capability on the scan tool, they show a direct relationship to each other as the vehicle is accelerated. Any sensor that shows to be not responding during engine load test needs to be checked more thoroughly.

**STEP #4:** If the root cause has not been located, perform a five-gas analysis of the exhaust gases. See Chapter 26 for details regarding what the results may indicate.

**STEP #5:** Using all available resources, including vehicle manufacturer’s recommended testing procedures, determine the root cause of the problem. After making the repair,



## CASE STUDY

### The Case of the No-Power Kia

A customer had a Kia Sorento towed to a shop because it would not accelerate and the engine would not increase in speed higher than 1000 RPM. No diagnostic trouble codes were found and no technical service bulletins were found that pertained to this condition either. The data display on the scan tool did not show anything out of range and a through visual inspection found that the engine appeared to well maintain without any obvious or visible faults. Then another technician in the shop told the technician working on the vehicle that the brake lights were on whenever the engine was running even though no one was in the vehicle. This led to a closer examination of the brake switch, and when it was moved the engine was then able to be accelerated normally. A replacement brake switch was installed and the problem of a lack of acceleration was solved, and after replacement, the vehicle performed normally. The customer was pleased that a simple and low-cost solution was found.

#### Summary:

- **Complaint**—The vehicle owner complained that the engine would not accelerate and the engine speed would not increase higher than 1000 RPM.
- **Cause**—A defective brake switch caused the PCM to sense that the brake was applied and limited engine speed.
- **Correction**—A replacement brake switch fixed the problem and allowed the vehicle to accelerate normally.

verify the repair by performing a test-drive under similar conditions that caused the customer concern to make sure that the cause has been successfully repaired.

## DETERMINING ROOT CAUSE OF REPEATED COMPONENT FAILURES

**THE FIVE WHYS** Typically when a component or system fails multiple times, the root cause of the failure was not corrected. When diagnosing the root cause of repeated component or system failure, the wise technician asks why five times. For example, for a case where the PCM set repeated P0017 (CKP/CMP correlation) DTCs, the oil control valve was replaced and the DTC cleared. According to the repair forums, this was a common repair for this condition. The engine

appeared to be operating correctly; however, the check engine light with the same code occurred again after a week? Why?

**Why #1:** The technician did not complete a thorough diagnosis, instead relying on a silver bullet in a repair forum. On the second attempt to repair the vehicle the technician followed the diagnostic procedure for the code. The resistance of the new oil control valve was found to be within specifications. The camshaft position (CMP) sensor was tested based on the advice from another technician. The sensor passed all the diagnostic tests and appeared to be generating a normal signal.

**Why #2:** If the oil control valve and the sensor are both good, why did the code reset? The technician checked all of the wiring and the electrical connectors and found them to be okay. Why was the problem still occurring?

**Why #3:** During a subsequent test drive, the code set again. This time the technician tested the crankshaft sensor and verified the condition of the timing belt. Each of the components tested normally.

**Why #4:** The technician thought that the recurring problem was related to the OCV because when these were replaced, it fixed the vehicle for some time. The technician then noticed the engine oil was low and very dirty. Why was this important?

**Why #5:** Understanding that clean oil was needed for the system to operate properly, the engine oil and filter were replaced making sure to use the oil recommended by the manufacturer and an oil filter that met original equipment specifications. The code was cleared and on subsequent test drives the failure did not reoccur.

On the second repair attempt the technician followed the diagnostic process to a logical end. No assumptions were made, but instead decisions were made based on the test results. In the end, the root cause of the problem was actually very simple and the repair was relatively inexpensive.

**MULTIPLE COMPONENT FAILURE DIAGNOSIS** If more than one component is found to be defective, the root cause has to be found. If the components are electrical, use a wiring diagram and check for the following:

- Do the components share a common ground connection? If so, this could be the most likely cause and the first place to check.



### TECH TIP

#### The Brake Pedal Trick

If the vehicle manufacturer recommends that battery power be disconnected, first disconnect the negative battery cable and then depress the brake pedal. Because the brake lights are connected to battery power, depressing the brake pedal causes all of the capacitors in the electrical system and computer(s) to discharge through the brake lights.

- Do the components share the same power? If so, then this could be the source of common component failure.
- Are the components or wiring near a heat source such as the exhaust system or EGR system components? Heat can cause electrical issues and often cause issues with more than one component.
- Are the components or wiring near something that is moved such as a door, hood, or trunk (tailgate) opening? The movement can cause electrical issues and often cause issues with more than one component.
- Follow the diagnostic strategy to find and correct the root cause, then verify the repair has solved the customer concern before returning the vehicle.

## MANUFACTURER'S DIAGNOSTIC ROUTINES

Each vehicle manufacturer has established their own diagnostic routines and they should be followed. Most include the following steps:

- STEP 1** Retrieve diagnostic trouble codes.
- STEP 2** Check for all technical service bulletins that could be related to the stored DTC.
- STEP 3** If there are multiple DTCs, the diagnostic routine may include checking different components or systems instead of when only one DTC was stored.
- STEP 4** Perform system checks.
- STEP 5** Perform the necessary service or repair
- STEP 6** Perform a road test matching the parameters recorded in the freeze-frame to check that the repair has corrected the malfunction.
- STEP 7** Repeat the road test to cause the MIL to be extinguished.

**NOTE: Do not clear codes (DTCs) unless instructed by the service information.**

Following the vehicle manufacturer's specific diagnostic routines will ensure that the root cause is found and the repair verified. This is important for customer satisfaction.

## VERIFYING THE REPAIR

**PROCEDURE** After the repair has been successfully completed, the vehicle should be driven under similar conditions that caused the original concern in order to verify that the problem has been corrected. To perform this test drive, it is helpful to have a copy of the freeze-frame parameters that



### TECH TIP

#### Drive the Light Out

If working on a vehicle that is subject to state emission testing, it is best to not clear codes. When diagnostic trouble codes are cleared, all of the monitors have to be rerun and this can be a time-consuming job. Instead of clearing the code, simply drive the vehicle until the PCM clears the code. This will likely take less time compared to trying to drive the vehicle under varying conditions to run all of the monitors.

were present when the DTC was set. By driving under similar conditions, the PCM may perform a test of the system and automatically extinguish the malfunction indicator light (MIL). This is the method preferred by many vehicle manufacturers.

**OBD MONITORS FOR REPAIR VERIFICATION** All 1996 and newer vehicles perform enhanced diagnostic checks of specific emission control components such as engine, transmission, fuel systems, and other emissions controls. Each diagnostic check communicates with the powertrain control module's (PCM) diagnostic executive to record the data in the *readiness monitor*. These diagnostic checks are generally performed while the vehicle is driven in a specific manner and are a great way to prove the repair was successful. If the diagnostic checks have been performed and passed, the PCM marks them as "ready." Technicians in a non-emissions test area are able to use the data to ensure the vehicle is repaired and that no other codes are set prior to returning the vehicle to the customer.

For technicians who work on vehicles in an emission test area this is an important step in the repair process. If diagnostic data has been erased during vehicle repairs or through battery disconnection, the PCM will flag the monitors as "incomplete" or "not ready." Vehicles are rejected from emission testing when these diagnostic checks are not completed. The number of monitors allowed to be not complete depends on the year of the vehicle and the emission testing area requirements.

The vehicle performs the self-diagnostic tests when the vehicle is driven, referred to as a "drive cycle." Therefore, after the repair is complete the vehicle will need to be driven through a drive cycle. If the check engine light does not turn off, then additional repair(s) may be required. If the repairs require the DTCs to be cleared or a battery disconnect (which also clears DTCs), then the vehicle needs to be driven to get the monitors to run and pass.

## ROAD TEST (DRIVE CYCLE)

Use the freeze-frame data and test-drive the vehicle so that the vehicle is driven to match the conditions displayed on the freeze-frame. If the battery has been disconnected, then the vehicle may have to be driven under conditions that allow the PCM to

conduct monitor tests. This drive pattern is called a **drive cycle**. The drive cycle is different for each vehicle manufacturer but a universal drive cycle may work in many cases. In many cases performing a universal drive cycle will reset most monitors in most vehicles.

## UNIVERSAL DRIVE CYCLE

### PRECONDITIONING: Phase I.

MIL must be off.

No DTCs present.

Fuel fill between 15% and 85%.

Cold start – Preferred = 8 – hour soak at 68°F to 86°F.

Alternative: ECT = IAT.

1. With the ignition off, connect scan tool.
2. Start engine and drive between 20 and 30 mph for 22 minutes, allowing speed to vary.
3. Stop and idle for 40 seconds, gradually accelerate to 55 mph.
4. Maintain 55 mph for 4 minutes using a steady throttle input.
5. Stop and idle for 30 seconds, then accelerate to 30 mph.
6. Maintain 30 mph for 12 minutes.
7. Repeat steps 4 and 5 four times.

Using scan tool, check readiness. If insufficient readiness set, continue to universal drive trace phase II.

**Important: (Do not shut off engine between phases).**

### Phase II:

1. Vehicle at a stop and idle for 45 seconds, then accelerate to 30 mph.
2. Maintain 30 mph for 22 minutes.
3. Repeat steps 1 and 2 three times.
4. Bring vehicle to a stop and idle for 45 seconds, then accelerate to 35 mph.
5. Maintain speed between 30 and 35 mph for 4 minutes.
6. Bring vehicle to a stop and idle for 45 seconds, then accelerate to 30 mph.
7. Maintain 30 mph for 22 minutes.

8. Repeat steps 6 and 7 five times.
9. Using scan tool, check readiness.

## DIESEL OBDII MONITOR READINESS

### PRIOR TO START

- Fuel level greater than 25%.
- Coolant temperature below 140°F (60°C)
- Battery voltage must be between 11 and 16 volts. PTO is not engaged

### TO RUN THE MONITORS

1. Allow the engine to idle for a minimum of two minutes and warm the engine to greater than 140 degrees. (Vehicle must be stationary and the accelerator must not be depressed during this time.)
2. Drive for 5 minutes at speeds above 25 mph and less than 45 mph (in-town driving).
3. Drive the vehicle at highway speeds and perform 10–15 zero fueling events (decelerate for 10 seconds with foot off of accelerator).
4. Drive the vehicle at highway speeds and perform 15–20 boost events (sudden depression of the accelerator pedal to provide turbocharger boost to the system).
5. Drive the vehicle at highway speeds in a steady state for 12–15 minutes.
6. Return to the shop and let vehicle idle for 30 seconds.
7. With the vehicle in park increase the engine speed to 1200–1300 RPM for 2–3 minutes (repeat 3–4 times).
8. Let idle for 30 seconds.
9. Shut off vehicle.
10. Cycle key back on and check readiness status.

## SUMMARY

1. Funnel diagnostics—Visual approach to a diagnostic procedure:

**Step 1** Verify the problem (concern)

**Step 2** Perform a thorough visual inspection and basic tests

**Step 3** Retrieve the diagnostic trouble codes (DTCs)

**Step 4** Check for technical service bulletins (TSBs)

**Step 5** Look carefully at scan tool data

**Step 6** Narrow the problem to a system or cylinder

**Step 7** Repair the problem and determine the root cause

**Step 8** Verify the repair and check for any stored DTCs

2. A thorough visual inspection is important during the diagnosis and troubleshooting of any engine performance problem or electrical malfunction.
3. If the MIL is on, retrieve the DTC and follow the manufacturer's recommended procedure to find the root cause of the problem.
4. OBD-II vehicles use a 16-pin DLC and common DTCs.

## REVIEW QUESTIONS

1. Why should TSBs be checked after retrieving diagnostic trouble codes?
2. Why does the customer concern need to be verified?
3. What is the difference between an aftermarket scan tool and a factory-level scan tool?
4. What is the preferred method to use to clear DTCs?
5. What is the definition of a trip?

## CHAPTER QUIZ

1. Technician A says that the first step in the diagnostic process is to verify the problem (concern). Technician B says the second step is to perform a thorough visual inspection. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
2. Which item is *not* important to know before starting the diagnosis of an engine performance problem?
  - a. List of previous repairs
  - b. The brand of engine oil used
  - c. The type of gasoline used
  - d. The temperature of the engine when the problem occurs
3. A generic (global)-type scan tool can retrieve \_\_\_\_\_ data.
  - a. emissions-related
  - b. HVAC
  - c. ABS brake system
  - d. All of the above
4. The steps in a manufacturer-specific diagnostic routine are being discussed. Technician A says that after recording any DTCs, the codes should be erased. Technician B says to road test the vehicle twice to turn off the MIL. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both technicians are correct
  - d. Neither technician is correct
5. Technician A says that if the opposite DTC can be set, the problem is the component itself. Technician B says if the opposite DTC cannot be set, the problem is with the wiring or grounds. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
6. The preferred method to clear diagnostic trouble codes (DTCs) is to \_\_\_\_\_.
  - a. disconnect the negative battery cable for 10 seconds
  - b. use a scan tool
  - c. remove the computer (PCM) power feed fuse
  - d. cycle the ignition key on and off 40 times
7. Which is the factory scan tool for Chrysler brand vehicles equipped with CAN?
  - a. wiTECH
  - b. Tech 2
  - c. NGS
  - d. Master Tech
8. What fault could occur that can cause a driveability issue and not set a diagnostic trouble code (DTC)?
  - a. Alcohol (ethanol) in high concentrations in the fuel
  - b. Contaminated fuel that has water or diesel fuel mixed with the fuel.
  - c. Clogged air intake systems due to an animal nest of road debris caught in the air intake system
  - d. Any of the above
9. Technician A says that knowing if there are any stored diagnostic trouble codes may be helpful when checking for related technical service bulletins. Technician B says that only a factory scan tool should be used to retrieve DTCs. Which technician is correct?
  - a. Technician A only
  - b. Technician B only
  - c. Both Technicians A and B
  - d. Neither Technician A nor B
10. A drive cycle is designed to reset all the OBD-II monitors. Before starting the drive cycle the engine should be \_\_\_\_\_.
  - a. fully warmed up (cooling fans cycled on and off two times)
  - b. have a full tank of fuel
  - c. cold (ECT = IAT)
  - d. operated at idle for two minutes