

Computers and On-Board Diagnostics

OBJECTIVES: After studying Chapter 26, you should be able to:

1. Prepare for the interprovincial Red Seal certification examination in Appendix VIII (Engine Performance) on the topics covered in this chapter.
2. Explain the purpose, function and operation of "flash" codes.
3. Describe the diagnostic procedures and routines relating to a trouble code.
4. Explain the purpose and operation of a scan tool.
5. Describe the differences between OBD I and OBD II.
6. Describe how the powertrain control module performs active and passive tests of the computerized engine control system.
7. Describe the standardized OBD II DTCs and terminology.
8. Explain the purpose behind one- and two-trip logic.

■ ON-BOARD DIAGNOSTICS

During the 1980s, many manufacturers began equipping their vehicles with full-function control systems capable of alerting the driver of a malfunction and of allowing the technician to retrieve codes that identify circuit faults. These early diagnostic systems were meant to reduce emissions and assist the technician. The automotive industry calls these systems on-board diagnostics (OBD).

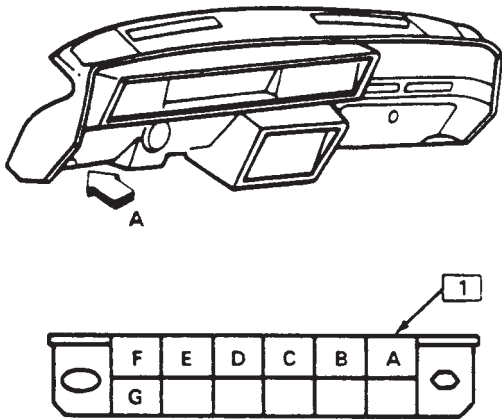


Figure 26–1 A typical malfunction indicator lamp (MIL), often labelled “Check Engine” or “Service Engine Soon.”

On-Board Diagnostics: Early Systems

The powertrain control module (PCM) has a built-in self-diagnosis program that detects failures or major faults in the engine management system and alerts the driver by illuminating a Malfunction Indicator Lamp (MIL). The MIL informs the driver to “Check Engine,” “Service Engine Soon,” or “Power Loss.” See Figure 26–1.

The lamp will stay on if the problem is present (hard fault) and will go out if the problem no longer exists (soft fault). A *fault code* will set and remain in computer memory for approximately 25 to 30 engine starts (most vehicles). This is an aid to the technician when diagnosing the system.



VIEW A

- | | |
|---------------------------------|--------------------------------------|
| 1 ALCL CONNECTOR | D C.E. LAMP |
| A GROUND | E SERIAL DATA
(SEE SPECIAL TOOLS) |
| B DIAGNOSTIC
"TEST TERMINAL" | F T.C.C. |
| C A.I.R. | G FUEL PUMP |

Figure 26-2 The data link connector (DLC) is located under the dash on this General Motors vehicle. It is known as the assembly-line communications link (ALCL) on early GM vehicles because it allowed the assembly plant to test engine operations before the vehicle left the factory. It is used by service technicians in the field to access trouble codes and read live data stream. (Courtesy General Motors of Canada Ltd.)

Fault codes (diagnostic trouble codes—DTCs) are accessed through a diagnostic (data link connector—DLC) found in many different locations, e.g., under the hood, under the dash, in the console or the glove box. Often, the shop manual must be consulted for the exact location. See Figure 26-2. The DLC also varies in appearance among makes.

Flash Codes

The procedures for retrieving DTCs differs among makes. Many on-board computer diagnostics are entered by connecting two or more terminals in the DLC with a jumper (GM and many imports); see Figure 26-3. Chrysler cycles the ignition key a given number of times within 5 seconds. This will activate the MIL, which begins to flash; count the number of flashes.

Voltmeters are used with some Ford and Mitsubishi vehicles to identify trouble codes. Connecting a voltmeter into the system, as shown in Figure 26-4, will cause the meter needle to rise and fall; counting the number of needle sweeps will identify the DTC. Ford vehicles also go through a self-test, which checks the sensors and actuators before giving out trouble codes.

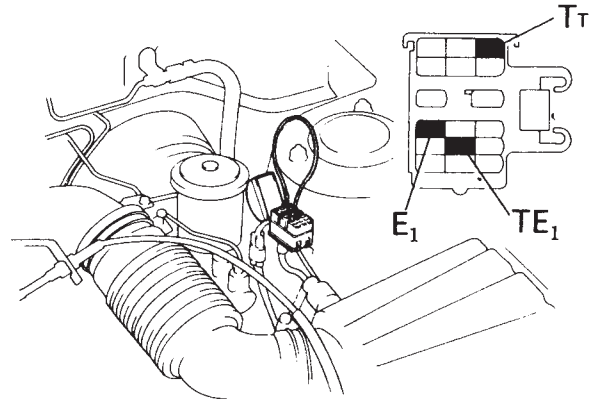


Figure 26-3 The data link connector on many Asian and domestic vehicles (non-OB2 II) will cause the malfunction indicator lamp to flash trouble codes when the designated terminals are connected with a jumper wire. (Courtesy Toyota Canada Inc.)

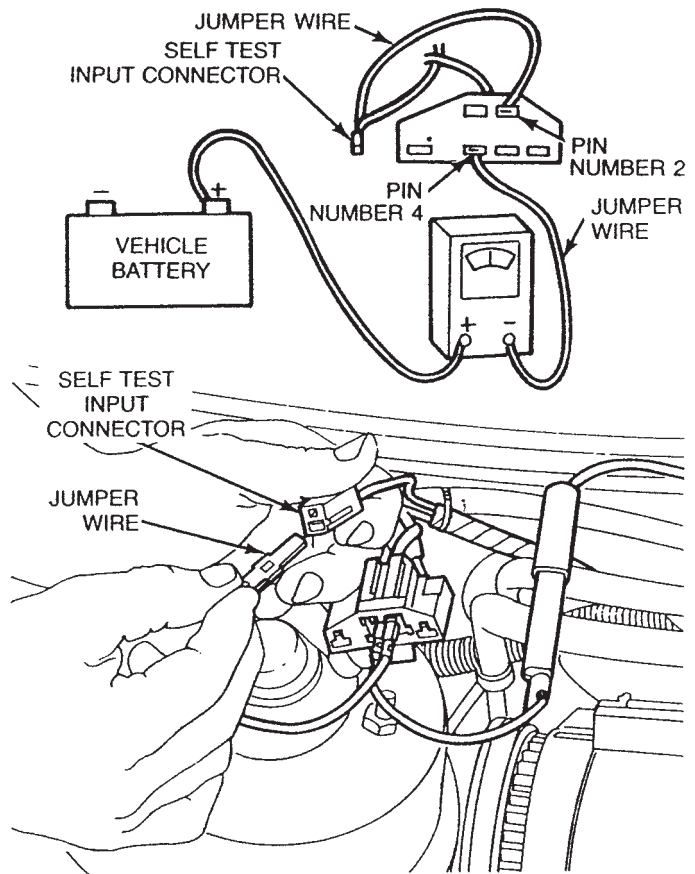


Figure 26-4 Analog voltmeters are used by Ford and some import vehicles to read diagnostic trouble codes. Counting the number of needle sweeps (pulses) will determine the code. (Courtesy Ford Motor Co. of Canada Ltd.)

PCM DIAGNOSTIC CODES

CODE	DESCRIPTION	ILLUMINATE SES
13	Oxygen Sensor - open circuit	YES
14	Coolant Temperature Sensor - high temp. indicated	YES
15	Coolant Temperature Sensor - low temp. indicated	YES
16	System Voltage high or low	YES
17	Spark Reference Circuit Problem	NO
21	Throttle Position Sensor voltage high	YES
22	Throttle Position Sensor voltage low	YES
23	Intake Air Temperature Sensor - low temp. indicated	NO
24	Vehicle Speed Sensor Circuit Problem	YES
25	Intake Air Temperature Sensor - high temp. indicated	NO
26	QDM Failure	YES
31	PRNDL Switch Circuit Problem	NO
34	MAF Sensor - low gm/sec indicated	YES
36	Trans Shift Circuit	NO
38	Brake Input Circuit Problem	NO
41	Cam Sensor Circuit Problem	YES
42	Electronic Spark Timing (EST) Circuit Problem	YES
43	Electronic Spark Control (ESC) Circuit Problem	YES
44	Oxygen Sensor - lean exhaust indicated	YES
45	Oxygen Sensor - rich exhaust indicated	YES
51	MEM-CAL Error	YES
58	PASS Key (VATS) Fuel Enable Circuit	NO
61	Cruise Vent Solenoid Circuit	NO
62	Cruise Vac Solenoid Circuit	NO
65	Cruise Servo Position Circuit	NO
66	Excessive A/C Cycling (low refrigerant charge)	NO
67	Cruise Switches Circuit	NO
68	Cruise System Problem	NO
69	A/C Head Pressure Switch Circuit Problem	NO

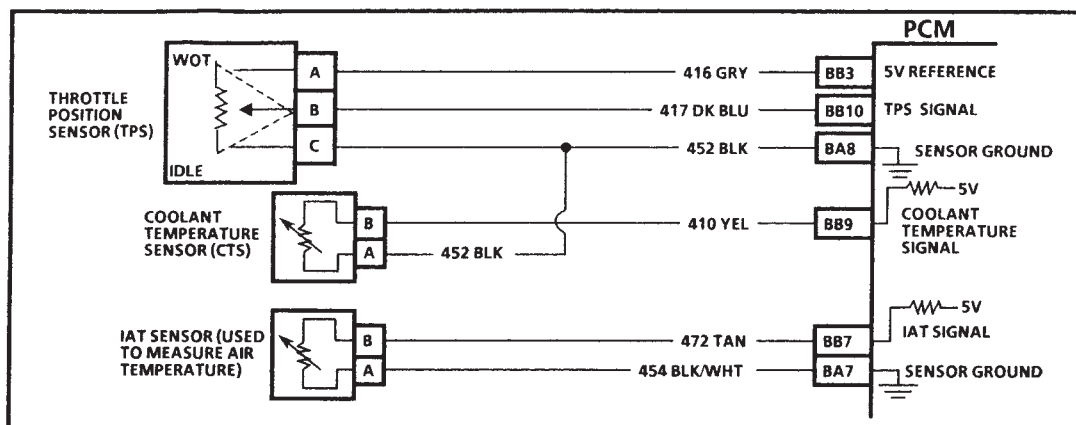
Figure 26–5 Typical list of early 1990s diagnostic trouble codes (DTC). It is important to use the shop manual (or data bank) when checking codes as they are different between car makers. On-board diagnostics, generation II (OBD II) standardized most trouble code numbers and terminology. (Courtesy General Motors of Canada Ltd.)

Diagnostic Trouble Codes

Trouble codes, known previously as fault codes, are usually listed in numerical order to identify the circuit. See Figure 26–5. The technician is then instructed to follow a set of diagnostic routines related to the trouble code. See Figures 26–6 and 26–7.

Clearing Trouble Codes

Trouble codes are cleared from computer memory by disconnecting a jumper wire, removing a fuse, or through the use of a scan tool. Refer to the shop manual since procedures differ. Disconnecting the vehicle battery to clear codes is not recommended, as this will also erase any adaptive strategy program changes



CODE 15

COOLANT TEMPERATURE SENSOR (CTS) CIRCUIT (LOW TEMPERATURE INDICATED) 3800 (VIN L) (TPI)

Circuit Description:

The Coolant Temperature Sensor (CTS) uses a thermistor to control the signal voltage to the PCM. The PCM applies a voltage on CKT 410 to the sensor. When the engine is cold the sensor (thermistor) resistance is high, therefore, the PCM will see high signal voltage.

As the engine warms, the sensor resistance becomes less, and the voltage drops. At normal engine operating temperature 85°C to 95°C (185°F to 203°F), the voltage will measure about 1.5 to 2.0 volts.

Code 15 will set if:

- Engine is running over 2 seconds.
- Signal voltage indicates a coolant temperature less than -39°C (-36°F) for at least 4 seconds.

Test Description: Number(s) below refer to circled number(s) on the diagnostic chart.

1. Determines if conditions necessary to set Code 15 exist.
2. This test simulates a Code 14. If the PCM recognizes the low signal voltage, (high temperature) and the "Scan" reads 130°C (266°F) or more, the PCM and wiring are OK.
3. This test will determine if CKT 410 is open. There should be 5 volts present at sensor connector if measured with a DVM.

Diagnostic Aids:

A Tech 1 displays engine temperature in degrees. After engine is started the temperature should rise steadily to about 90°C (194°F) then stabilize when thermostat opens.

An intermittent may be caused by a poor connection, rubbed through wire insulation or a wire broken inside the insulation.

Check For:

- **Poor Connection or Damaged Harness** - Inspect PCM harness connectors for backed out terminal "BB9", improper mating, broken locks, improperly formed or damaged terminals, poor terminal to wire connection and damaged harness.
- **Intermittent Test** - With Tech 1, monitor coolant temperature while moving related connectors and wiring harness. If the failure is induced, the display will change. This may help to isolate the location of the malfunction.
- **Shifted Sensor** - The "Temperature To Resistance Value" scale may be used to test the coolant sensor at various temperature levels to evaluate the possibility of a "shifted" (mis-scaled) sensor which may result in driveability complaints.

A faulty connection, or an open in CKTs 410 or 452 will result in a Code 15.

Figure 26-6 Typical diagnostic early 1990s flow chart for a DTC. This section of the chart gives the circuit description, wiring schematic, and diagnostic aids. (Courtesy General Motors of Canada Ltd.)

stored in the computer. Other components such as the radio, which uses battery power to retain memory, will also lose their settings.

Scan Tools

Scanners are small hand-held computers that provide a major improvement over flash-code diagnostics. They typically plug into the data link connector

and interface with the on-board computer. Power to operate the scanner is supplied through the lighter socket or a battery adaptor; late-model OBD II scanners receive power at the DLC. See Figure 26-8.

Scanners have the ability to read directly from live data stream; information from the input sensors and output actuators may be monitored during a road test. Many scan tools have a snap-shot mode, which allows the technician to freeze certain data at the point the

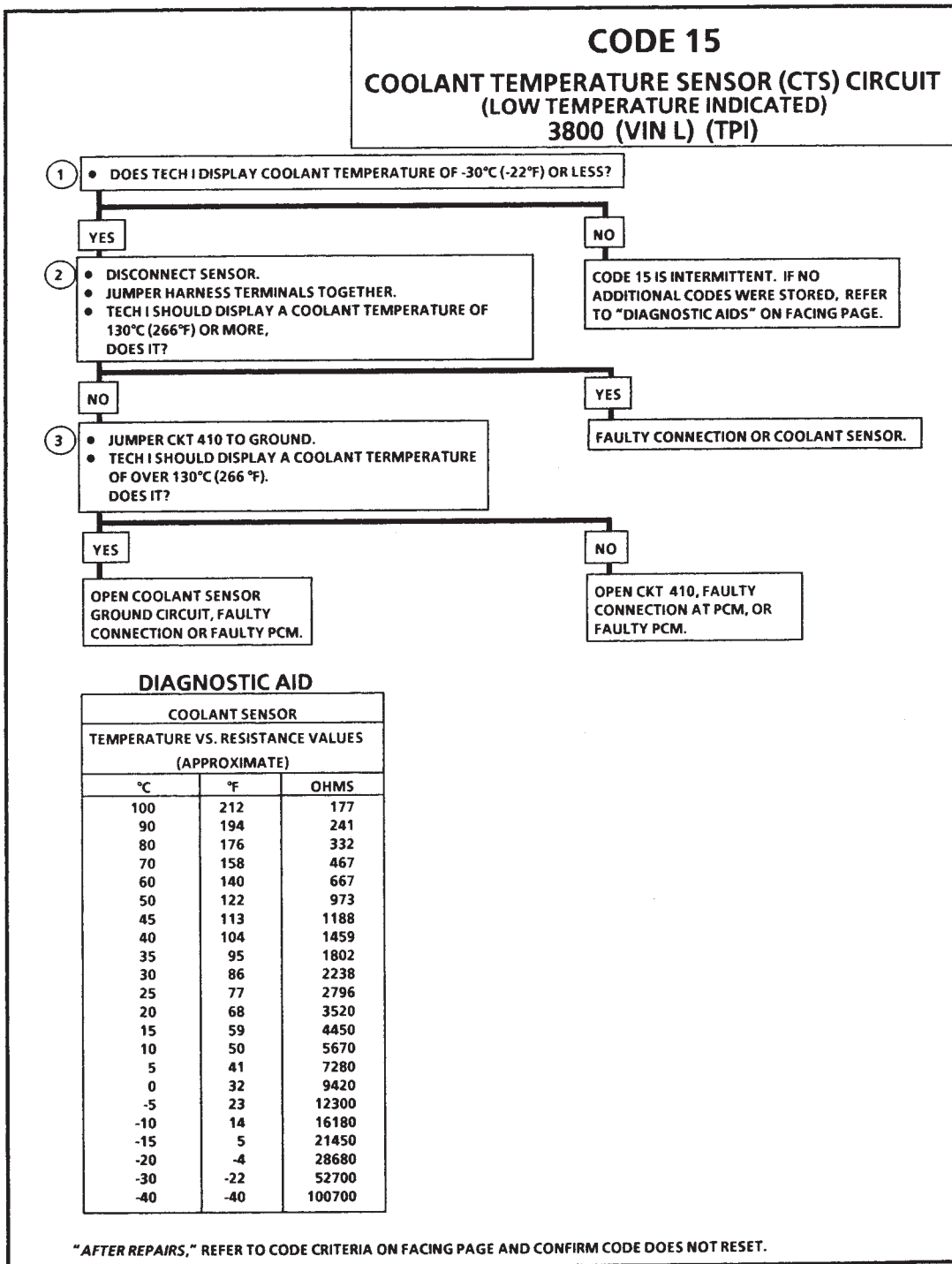


Figure 26-7 Typical diagnostic flow chart. This section takes the technician, step by step, through the diagnostic routines. (Courtesy General Motors of Canada Ltd.)

driveability concern arrives. This information can then be reviewed and interpreted back in the service bay. The majority of Asian and European vehicles have no provisions for live data stream readouts with early on-board diagnostics. Today, virtually every automobile sold in Canada and the U.S. is equipped to provide running data.

Scanners also supply trouble code information in numerical form; there are no light flashes or needle sweeps to count.

Some scanners have the ability to control the output actuators and solenoids for test purposes. Performing a cylinder-balance test by interrupting the ignition spark is a common diagnostic routine used with

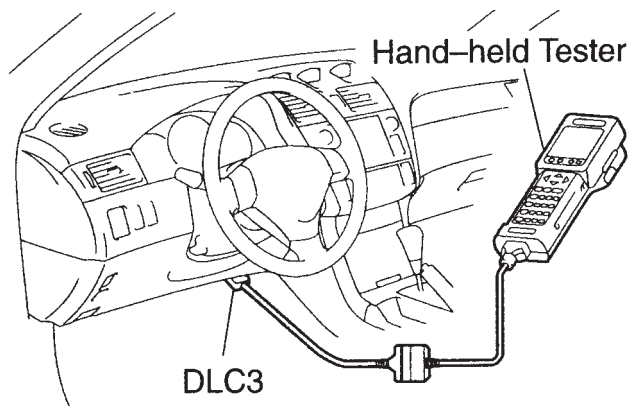


Figure 26–8 Hand-held scan tools interface with the on-board computer. They not only extract fault codes (DTC), they read live data from the sensors and actuators. Prior to OBD II, the scan tool required a different DLC adaptor and program cartridge when switching between makes. (Courtesy Toyota Canada Inc.)

many large oscilloscopes. This must be done very carefully, as the fuel and air from the dead cylinder will flow into the catalytic converter, causing it to overheat. Feeding the converter raw fuel and oxygen causes internal catalyst temperatures to rise quickly and the converter will begin to melt if the cylinder is "killed" for long. Vehicles with sequential (individual injector control) fuel injection often use scanners to cancel each fuel injector, instead of ignition, for cylinder balance testing. This protects the converter and eliminates any chance of a backfire in the exhaust pipes.

Many late vehicles have no provision for flash-code retrieval and a scanner must be used to extract trouble codes.

On-Board Diagnostics: Generation I (OBD I)

The California Air Resources Board (CARB) developed the first regulation requiring manufacturers selling vehicles in that state to install OBD. Called OBD Generation I (OBD I), OBD I applies to all vehicles sold in California beginning with the 1988 model year. It carries the following requirements:

1. An instrument panel warning lamp able to alert the driver of certain control system failures, now called a **malfunction indicator lamp (MIL)**.
2. The system's ability to record and transmit **diagnostic trouble codes (DTCs)** for emission-related failures.
3. Electronic system monitoring of the HO₂S, EGR valve, and evaporative purge solenoid. Although not EPA-required during this time, most manufacturers also equipped vehicles sold outside of California with OBD I.

These initial regulations failed to meet many expectations. By failing to monitor the catalytic converter, the evaporative system for leaks, and the presence of engine misfire, OBD I did not do enough to lower automotive emissions. In addition, the OBD I monitoring circuits that were installed lacked sufficient sensitivity.

Aside from OBD I's lack of emission-reduction effectiveness, another problem existed. Auto manufacturers implemented OBD I rules as they saw fit, resulting in a vast array of servicing tools and systems. Rather than simplifying the job of locating and repairing a failure, the aftermarket technician faced a tangled network of procedures often requiring the use of expensive special test equipment and dealer-proprietary information.

Soon it became apparent that more stringent measures were needed if the ultimate goal, reduced automotive emission levels, was to be achieved. This led to the development of OBD Generation II (OBD II).

OBD II Objectives

Generally an OBD II vehicle is defined by its ability to:

1. Detect component degradation or a faulty emission-related system that prevents compliance with federal emission standards.
2. Alert the driver of needed emission-related repair or maintenance.
3. Use standardized DTCs and accept a generic scan tool.

OBD II was first introduced on some 1994 vehicles; by 1998, all light-duty vehicles sold in Canada (U.S. 1996) were required to be OBD II compliant. The primary purpose of OBD II is emission-related, whereas the primary purpose of OBD I (1988) was to detect faults in sensors or sensor circuits. OBD II regulations require that not only must the sensors be tested but that all exhaust control devices be tested and verified for proper operation.

All new vehicles must pass the **Federal Test Procedure (FTP)** for exhaust emissions while being tested for 505 seconds on rollers that simulate the urban drive cycle around downtown Los Angeles, California.

NOTE: IM 240 is simply a shorter version of the 505-second-long federal test procedure.

The regulations for OBD II vehicles state that the vehicle computer must be capable of testing for exhaust emissions, and determining whether or not they are within 1 1/2 times the allowable standard for a new vehicle based on the FTP limits. In order to achieve this goal, the computer has to do all of the following:

1. Test all exhaust emission system components for correct operation.
2. Actively operate the system and measure the results.
3. Continuously monitor all aspects of the engine operation to be certain that the exhaust emissions do not exceed 1 1/2 times the FTP.
4. Check engine operation for misfire.
5. Turn on the malfunction indicator lamp (MIL) (check engine) if the computer senses a fault in a circuit or system.
6. Flash the MIL if an engine misfire occurs that could damage the catalytic converter.

Comprehensive Component Monitor

The **comprehensive component monitor (CCM)** is an internal program in the PCM designed to monitor a failure in any electronic component or circuit (including emission-related and non-emission-related circuits) that provide input or output signals to the PCM. The PCM considers that an input or output signal is inoperative when a failure exists due to an open circuit, out-of-range value or if an on-board rationality check fails. If an emission-related fault is detected, the PCM will set a code and activate the MIL (requires two consecutive trips). Some exceptions are (a) serious engine misfire that could damage the catalytic converter—this requires one trip only; (b) catalyst monitoring which requires three trips.

Many PCM sensors and output devices are tested at key on or immediately after engine startup. However, some devices, such as the idle air control (IAC), are only tested by the CCM after the engine meets certain engine conditions. The number of times the CCM must detect a fault before it will activate the MIL depends upon the manufacturer, but most require two consecutive trips to activate the MIL. The components tested by the CCM include:

- 4-wheel-drive low switch
- Brake switch
- Camshaft (CMP) and crankshaft (CKP) sensors
- Clutch switch (manual transmissions/transaxles only)
- Cruise servo switch
- Engine coolant temperature (ECT) sensor
- EVAP purge sensor or switch
- Fuel composition sensor
- Intake air temperature (IAT) sensor
- Knock sensor (KS)
- Manifold absolute pressure (MAP) sensor
- Mass airflow (MAF) sensor
- Transmission fluid temperature (TFT) sensor
- Transmission turbine speed sensor
- Vacuum sensor
- Vehicle speed (VS) sensor

- EVAP canister purge and EVAP purge vent solenoid
- Idle air control solenoid
- Ignition control system
- Transmission torque converter clutch solenoid
- Transmission shift solenoids

Main Monitors

On OBD II systems, the PCM incorporates a special segment of software. This software program is designed to manage the operation of all OBD II monitors by controlling the sequence of steps necessary to execute the diagnostic tests and monitors:

- Comprehensive component monitor
- Catalyst monitor
- EGR and EVAP system monitors
- Fuel system monitor
- Misfire monitor
- Oxygen sensor monitor
- Oxygen sensor heater monitor
- Secondary AIR system monitor

A list of devices or systems tested by OBD II comprehensive component monitor (CCM) and main monitors includes the devices in the following table.

Comprehensive Component Monitor	Main Monitors
BARO, ECT, and IAT sensor	Fuel control system (fuel trim)
MAF, MAP, or MDP sensors	Misfire detection
Oxygen sensor—voltage level, activity	Catalyst efficiency
CMP, CKP, and TP sensors	EGR system
EGR, EVAP solenoids	EVAP system
Idle speed control motor	Oxygen sensor—response time
Fuel injectors	Oxygen sensor heater
Some PCM switches	Secondary AIR system

NOTE: The number of trips required by the CCM and main monitors before a code is set and the MIL is activated varies among vehicle manufacturers.

See Figures 26-9 to 26-11.

OBD II Drive Cycle

The vehicle must be driven under a variety of operating conditions for all active tests to be performed. OBD II regulations also established a vehicle “drive cycle” pattern that would allow the CCM and main monitors to run and complete their individual diagnostic tests.

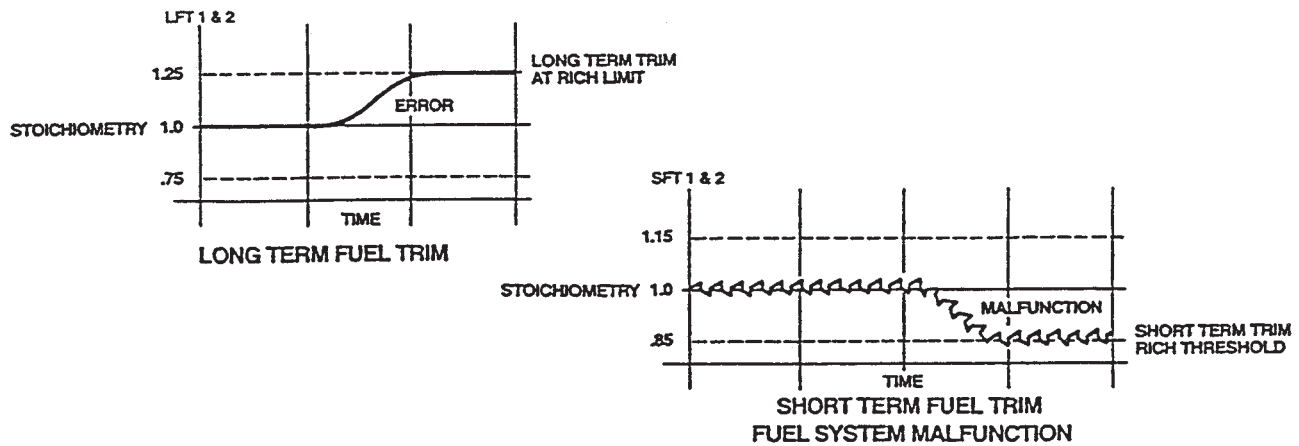


Figure 26-9 Fuel system monitor. The exhaust-gas oxygen sensor monitors the air-fuel ratio (in closed loop) and signals the on-board computer. If the mixture is incorrect, the computer adds or subtracts fuel to bring the mixture into range. This happens constantly and is known as short-term fuel trim. When short-term fuel trim is always rich (or lean), long-term fuel trim shifts from its original program and adjusts fuel delivery to bring the air-fuel mixture again back into range. If the correction needed reaches a pre-set limit, the MIL will illuminate. (Courtesy Ford Motor Co.)

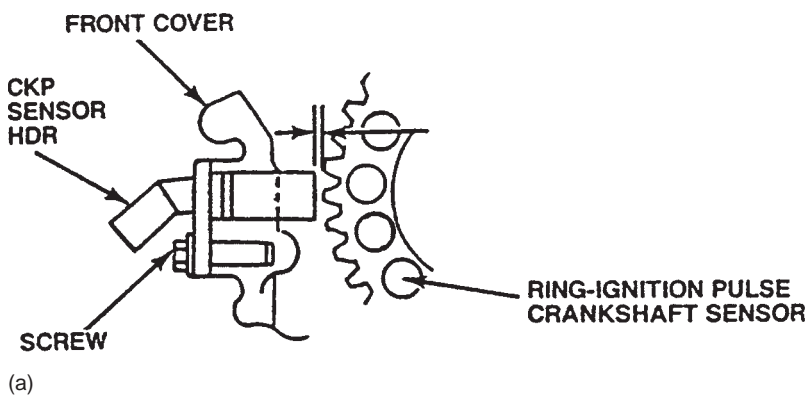
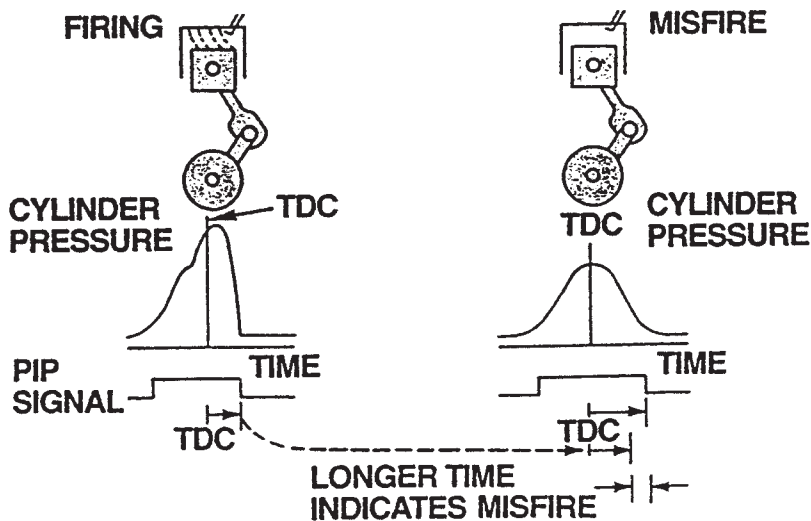


Figure 26-10 The misfire monitor reduces emissions and protects the catalytic converter. When a misfire occurs, raw hydrocarbons and unburned oxygen are pumped into the converter, raising internal temperatures. (a) The crankshaft position sensor (CKP), also used for ignition, sends a signal to the PCM for each pulse ring tooth. (b) A misfire will cause the crankshaft to slow. The increased time between pulses indicates a misfire. The fuel injector for the offending cylinder may be shut off by the PCM. (Courtesy Ford Motor Co.)



(b)

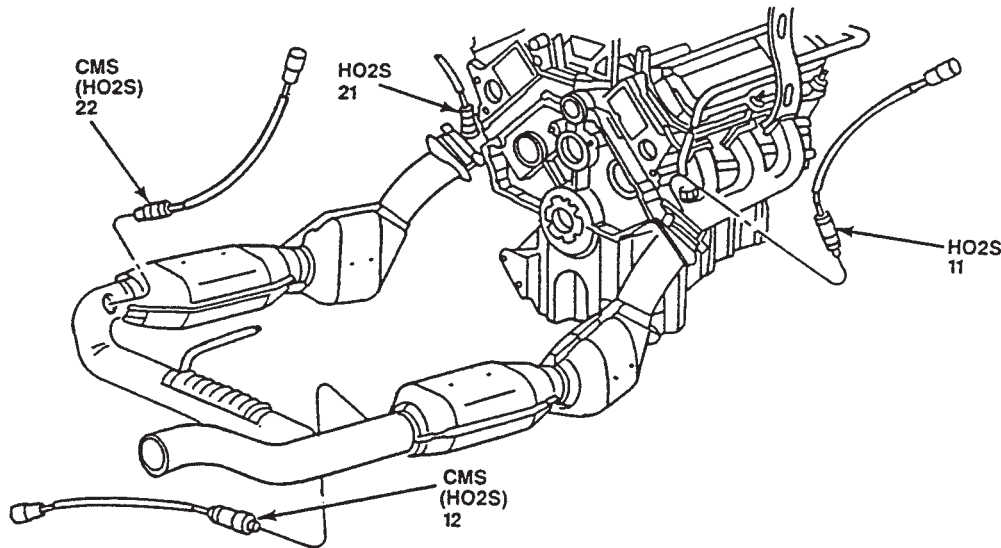
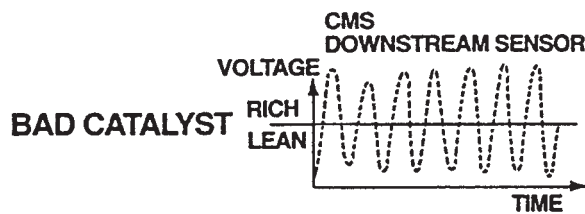
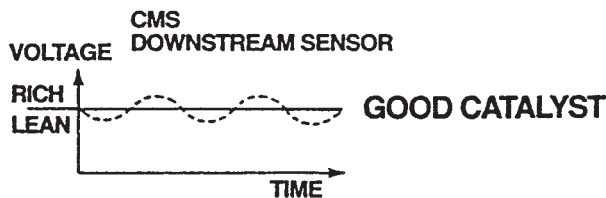


Figure 26-11 Catalyst efficiency. The efficiency of the catalytic converter(s) is determined by: (a) placing oxygen sensors before and after the converter; (b) comparing the downstream sensor reading with the upstream signal. If a malfunction is detected on three drive cycles, the MIL is illuminated. (Courtesy Ford Motor Co.)

(a) 3.8L MUSTANG



(b)

The OBD II monitors that should run during the drive cycle include the CCM, EGR, EVAP, Fuel System, Misfire, Oxygen Sensor, and Secondary AIR System. One

manufacturer has a special code (Ford—DTC P1000) that sets if all the main monitors have not been run to completion.

A trip is defined as an engine-operating drive cycle that contains the necessary conditions for a particular test to be performed. These conditions are called the enable criteria. 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.

Frequently Asked Question ????

What Does “Rationality Check” Mean?

The power train control module (PCM) is programmed to detect faults that do not seem rational. For example, if the engine has been operating for 20 minutes and suddenly the engine coolant temperature changes from 90°C (195°F) to -40°C (-40°F), then the rationality test part of the computer program (CCM) determines that this is not possible (rational) and then defaults to a fail-safe operating temperature based largely on the intake air temperature (IAT) sensor. Before OBD II regulations, if the engine coolant temperature sensor became unplugged, the computer would increase the amount of fuel delivered to the engine because it assumed that the engine was in fact very cold. With rationality, the OBD II computer can reason that there must be a fault and continue to deliver fuel for proper operation and not too much, which could affect the exhaust emissions.

Warm-Up Cycle

The MIL will deactivate (turn off) if the PCM no longer detects a fault during three consecutive trips (warm-up cycles). Once a MIL is deactivated, the original code will remain in memory until 40 warm-up cycles are completed without the fault reappearing. A warm-up cycle is defined as a trip with an engine temperature increase of at least 22°C (40°F) and where engine temperature reaches at least 70°C (160°F).

MIL Condition: Off

This condition indicates that the PCM has not detected any faults in an emissions-related component or system, or that the MIL circuit is not working.

MIL Condition: On Steady

This condition indicates a fault in an emissions-related component or system that could affect the vehicle emission levels.

MIL Condition: Flashing

This condition indicates a misfire or fuel control system fault that could damage the catalytic converter.

NOTE: In a misfire condition with the MIL on steady, if the driver reaches a vehicle speed and load condition with the engine misfiring at a level that could cause catalyst damage, the MIL would start flashing. It would continue to flash until engine speed and load conditions caused the level of misfire to subside. Then the MIL would go back to the on steady condition. This situation might result in a customer complaint of a MIL with an intermittent flashing condition.

MIL: Off

The PCM will turn off the MIL if any of these actions or conditions occur:

- The codes are cleared with a scan tool.
- Power to the PCM is removed at the battery or with the PCM power fuse for an extended period of time (may be up to several hours or longer).

- A vehicle is driven on three consecutive trips with a warm-up cycle and meets all code set conditions without the PCM detecting any faults.

The PCM will set a code if a fault is detected that could cause tailpipe emissions to exceed 1 1/2 times the FTP standard. However, the PCM will not deactivate the MIL until the vehicle has been driven on three consecutive trips with vehicle conditions similar to actual conditions present when the fault was detected. This is not merely three vehicle start-ups and trips. It means three trips where certain engine operating conditions are met so that the OBD II monitor that found the fault can run again and pass the diagnostic test.

Fuel Trim and Misfire Codes

If a fuel control system (fuel trim) or misfire-related code sets, then the vehicle must be driven under conditions similar to when the fault was detected before the PCM will deactivate the MIL. Similar conditions are:

- The vehicle must be driven with engine speed within 375 rpm of the engine speed stored in the freeze-frame data when the code set.
- The vehicle must be driven within engine load $\pm 10\%$ of the engine load value stored in the freeze-frame data when the code set.
- The vehicle must be driven with engine temperature conditions similar to the temperature value stored in freeze-frame data when the code set.

See Figure 26–12.

Frequently Asked Question



How Can All the Readiness Tests Be Set?

Readiness tests (sometimes called **flags**) are tests performed on all of the monitored systems as displayed on a scan tool. To run all tests, the engine coolant temperature should be less than 50°C (122°F) with the IAT within 6°C (11°F) of the ECT temperature and the fuel tank filled from 15% to 85% of capacity before starting the test. Proceed as follows:

1. *Start the engine and allow it to idle for 2 1/2 minutes.* This step tests the oxygen sensor heater, canister purge system, misfire, fuel trim, and time to closed loop operation.
2. *Accelerate at half throttle to 90 km/h (55 mph).* This step tests for misfire, fuel trim diagnostics, and canister purge.
3. *Hold the speed steady for 3 minutes.* This step tests the oxygen sensor, EGR system, canister purge, misfire, and fuel trim diagnostics.
4. *Decelerate without using the brake or clutch (if equipped).* This step tests the EGR system, canister purge, and fuel trim diagnostics.
5. *Accelerate at three-fourths throttle to 90 to 100 km/h (55 to 60 mph).* This step tests for misfire, fuel trim diagnostics, and canister purge.
6. *Hold steady speed for 5 minutes.* This step tests the catalytic converter.
7. *Decelerate without using the brake or clutch, if equipped.* This step tests the EGR system, canister purge, and fuel trim diagnostics.

TRIP (Run Monitors)

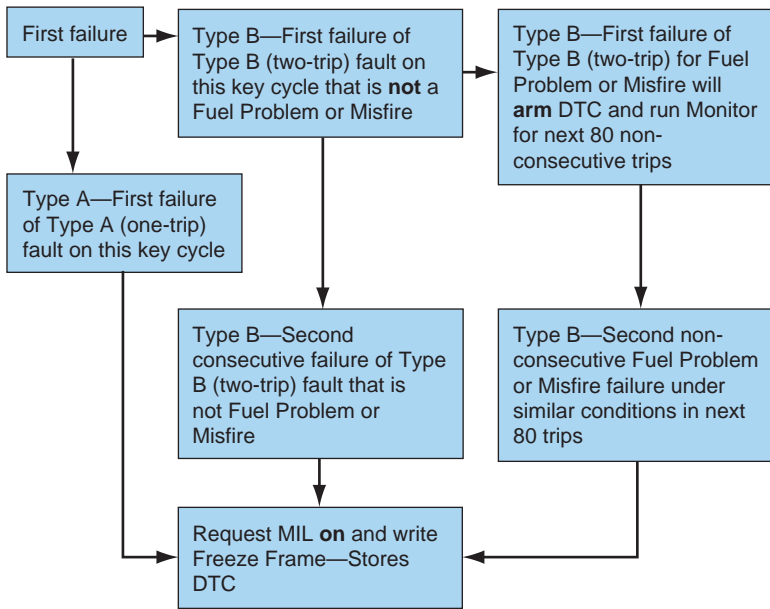
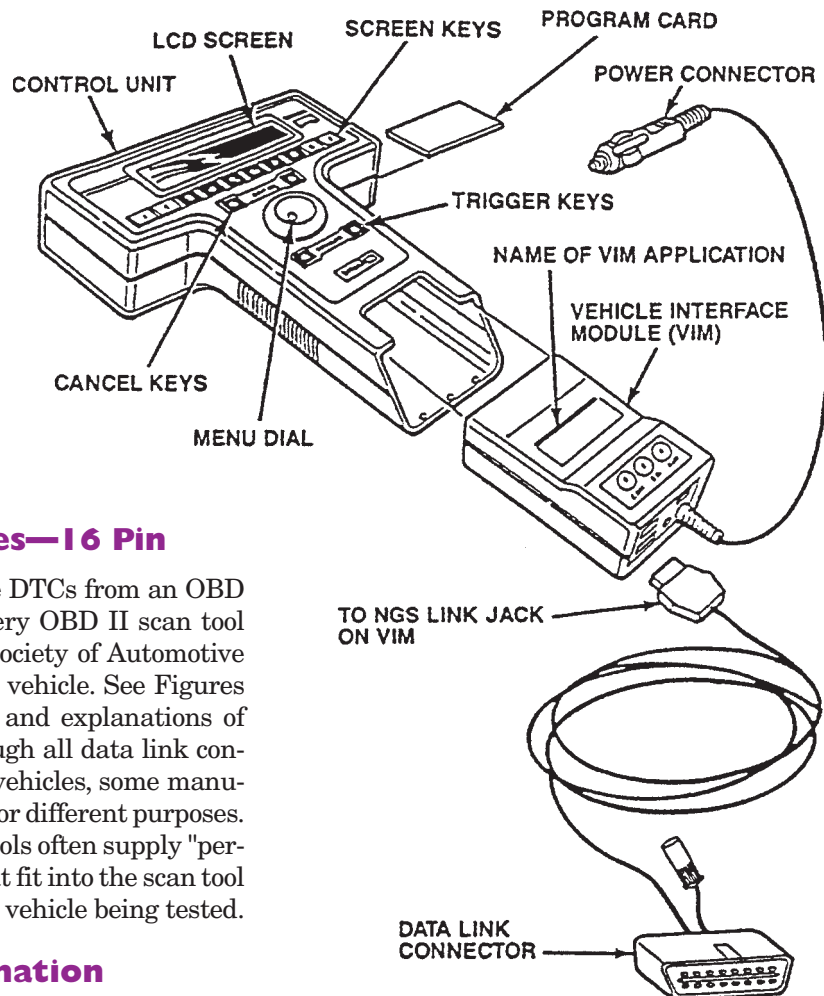


Figure 26–12 How a PCM turns on the MIL.

Figure 26–13 A typical scan tool set up for OBD II diagnostics. Ford calls this a New Generation Self-Test Automatic Readout tester (NG STAR or NGS). Most OBD II scan tools receive power through the DLC and do not require a separate power connector. (Courtesy Ford Motor Co.)



Retrieving OBD II Codes—16 Pin

A scan tool is required to retrieve DTCs from an OBD II vehicle. See Figure 26–13. Every OBD II scan tool will be able to read all generic Society of Automotive Engineers (SAE) DTCs from any vehicle. See Figures 26–14 and 26–15 for definitions and explanations of OBD alphanumeric DTCs. Although all data link connectors are the same on OBD II vehicles, some manufacturer-discretion pins are used for different purposes. See Figure 26–16. Generic scan tools often supply "personality keys" (small adaptors that fit into the scan tool plug) to match the pin use for the vehicle being tested.

DTC Numbering Explanation

The number in the hundredth position indicates the specific vehicle system or subgroup that failed. This position should be consistent for P0xxx and P1xxx

DTC FORMAT

Diagnostic Trouble Codes for EEC-V are formatted according to SAE J2012. SAE J2012 dictates a five-digit alphanumeric DTC with each digit defined as follows:

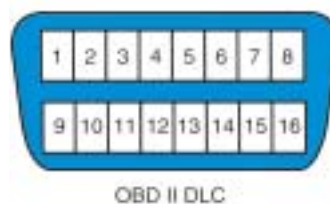
- Prefix letter of DTC indicates DTC function:
 - P — Powertrain
 - B — Body
 - C — Chassis
- First number indicates who was responsible for DTC definition:
 - 0 — SAE
 - 1 — Manufacturer
- Third digit of powertrain DTC indicates subgroup:
 - 0 — Total System
 - 1 — Fuel/Air Control
 - 2 — Fuel/Air Control
 - 3 — Ignition System/Misfire
 - 4 — Auxiliary Emission Controls
 - 5 — Idle/Speed Control
 - 6 — PCM and I/O
 - 7 — Transmission
 - 8 — Non-EEC Powertrain
- The fourth and fifth digit specify the area involved.

Let's take a possible DTC and break it into defined segments.

For Example: P1711

- P — First digit letter indicates a Powertrain DTC.
- 1 — Second digit indicates a manufacturer defined DTC.
- 7 — Third digit indicates a transmission sub-group concern.
- 11 — Fourth and fifth digits indicate a TOT Circuit out of range.

Figure 26-15 Sixteen-pin OBD II DLC with terminals identified. Scan tools use the power (#16) pin and ground (#4) pin so that a separate cigarette lighter plug is not necessary on OBD II vehicles.



type codes. The following numbers and systems were established by SAE:

- P0100—air metering and fuel system fault
- P0200—fuel system (fuel injector only) fault
- P0300—ignition system or misfire fault
- P0400—emission control system fault
- P0500—idle speed control, vehicle speed sensor fault

Figure 26-14 An alphanumeric DTC chart for OBD II. SAE (generic) codes are standardized for all vehicles. The example P1711 indicates a transmission oil temperature circuit out of range. (Courtesy Ford Motor Co.)

PIN NO.	ASSIGNMENTS
1.	MANUFACTURER'S DISCRETION
2.	BUS + LINE, SAE J1850
3.	MANUFACTURER'S DISCRETION
4.	CHASSIS GROUND
5.	SIGNAL GROUND
6.	MANUFACTURER'S DISCRETION
7.	K LINE, ISO 9141
8.	MANUFACTURER'S DISCRETION
9.	MANUFACTURER'S DISCRETION
10.	BUS-LINE, SAE J1850
11.	MANUFACTURER'S DISCRETION
12.	MANUFACTURER'S DISCRETION
13.	MANUFACTURER'S DISCRETION
14.	MANUFACTURER'S DISCRETION

- P0600—computer output circuit (relay, solenoid, etc.) fault
- P0700—transaxle, transmission faults

NOTE: The tens and ones numbers indicate the part of the system at fault.

OBD II Active Tests

The vehicle computer must run tests on the various emission-related components and turn on the malfunction indicator lamp (MIL). OBD II is an *active* computer analysis system because it actually tests the operation of the oxygen sensors, exhaust gas recirculation system, and other systems 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.

Types of DTCs

Not all OBD II DTCs 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 DTC is emission-related and will cause the MIL to be turned on on 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 DTC. These codes alert the driver to an emission problem that may cause damage to the catalytic converter.

Type B Codes A type B code will be stored and the MIL will be turned on during the *second consecutive trip*, alerting the driver to the fact that a diagnostic test was performed and failed.

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

Type C and D Codes Type C and 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). Type C codes are also called type C1 codes, and D codes are also called type C0 codes.

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.

What Are Each of the Pins for in the OBD II 16-Pin Data Link Connector (DLC)?

All OBD II vehicles use a 16-in connector that includes:

- Pin 4 = chassis ground
- Pin 5 = signal ground
- Pin 16 = battery power (4A max)

Vehicles may use one of two major standards including:

- **ISO 9141-2 Standard** (ISO = International Standards Organization)
Pins 7 and 15 (or wire at pin 7 and no pin at 2 or a wire at 7 and at 2 and/or 10)
- **SAE J-1850 Standard** (SAE = Society of Automotive Engineers)
Two types: **VPW** (variable pulse width) or **PWM** (pulse width modulated)
Pins 2 and 10 (no wire at pin 7)

DaimlerChrysler, European, and Asian vehicles use:

- ISO 9141-2 standard, which uses pins 4, 5, 7, 15, and 16
- **DaimlerChrysler Domestic OBD II**
Pins 2 and 10—CCM
Pins 3 and 14—OEM Enhanced—60 500 baud rate
Pins 7 and 15—Generic OBD II—ISO 9141—10 400 baud rate

Ford vehicles use:

- SAE J-1850(PWM) (PWM - 41.6 kB) standard, which uses pins 2, 4, 5, 10, and 16
- **Ford Domestic OBD II**
Pins 2 and 10—CCM
Pins 6 and 14—OEM Enhanced—Class C—40 500 baud rate
Pins 7 and 15—Generic OBD II—ISO 9141—10 400 baud rate

General Motors vehicles use:

- SAE J-1850 (VPW - Class 2 - 10.4 kB) standard, which uses pins 2, 4, 5, and 16 and not 10
- **GM Domestic OBD II**
Pins 1 and 9—CCM (Comprehensive Component Monitor) slow baud rate—8192 UART
Pins 2 and 10—OEM Enhanced—Fast Rate—40 500 baud rate
Pins 7 and 15—Generic OBD II—ISO 9141—10 400 baud rate

Figure 26–16 OBD II DLC pin use.

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, to retrieve this enhanced data usually requires the use of the vehicle-specific scan tool.

Freeze-frame items include:

- Calculated load value
- Engine speed (RPM)
- Short-term and long-term fuel trim percent
- Fuel system pressure (on some vehicles)
- Vehicle speed (km/h or mph)
- Engine coolant temperature (ECT)
- Intake manifold pressure
- Closed/open loop status
- Fault code that triggered the freeze-frame
- If a misfire code is set, identify which cylinder is misfiring

Clearing OBD II DTCs

A DTC should not be cleared from the vehicle computer memory unless the fault has been corrected and the technician is so directed by the diagnostic procedure. If the problem that caused the DTC to be set has been corrected, the computer will automatically clear the DTC after 40 consecutive warm-up cycles with no further faults detected (misfire and excessively rich or lean condition codes require 80 warm-up cycles). The codes can also be erased by using a scan tool.

NOTE: Disconnecting the battery may not erase OBD II DTCs or freeze-frame data. Most vehicle manufacturers recommend using a scan tool to erase DTCs rather than disconnecting the battery because the memory for the radio, seats, and learned engine operating parameters are lost if the battery is disconnected.

Diagnostic Procedures

Diagnostic procedures for OBD I and OBD II vehicles are covered in Chapter 31, “Engine Performance Diagnosis and Testing.”

■ DIAGNOSING COMPUTER PROBLEMS

If a computer fails, it is often difficult to determine if the computer itself is at fault or if there is a problem with some other system in the vehicle. For example, if the engine stalls, it could be the result of a fault in the ignition system, fuel system, or a failed sensor such as a crankshaft position sensor (CKP).

As part of the diagnostic process, check the computer grounds as shown in Figure 26–17. Also gently

TECH TIP



Don't Forget—Three Clicks

OBD II requires that the fuel system integrity be checked for possible leakage. If the fuel (gas) cap is not securely tightened, then a DTC such as P0442 may be set. To help prevent such false codes and to ensure that the gas cap is properly tightened, General Motors Corporation has printed on the cap itself a note that the cap should be tightened until three clicks are heard. This also applies to other screw-thread-type gas caps of all years and makes to be assured that the cap is tight. Some vehicles are equipped with an amber “Check Gas Cap” lamp that will light if a system leak is detected.

NOTE: Gas caps are frequently tested as part of an exhaust emission test. Ask the person performing the test on your gas cap to tighten the cap three clicks to ensure proper tightness. This will help prevent false defective test results.

Frequently Asked Question



What Are Pending Codes?

Pending codes are set when operating conditions are met and the component or circuit is not within the normal range, yet the conditions have not yet been met to set a DTC. For example, a sensor may require two consecutive faults before a DTC is set. If a scan tool displays a pending code or a failure, a driveability concern could also be present. The pending code can help the technician try to determine the root cause before the customer complains of a check engine light indication.



Figure 26–17 Always check that the computer grounds are clean and tight.



Figure 26–18 Tap testing a vehicle computer. General Motors recommends that only the four fingers of an open hand be used to tap test any component to avoid causing damage.

tap on the computer with the engine running. If the engine stalls or changes the way it is operating, check the wiring connector. If the wiring is OK, replace the computer. See Figure 26–18.

SUMMARY

1. Malfunction indicator lamp (MIL) is the name given to the amber check engine or “service engine soon” light.
2. On-board diagnostics second generation, called OBD II, is used on all vehicles sold in Canada since 1998.
3. OBD II requires that all emission-related components be checked and tested.
4. The vehicle must be driven with approximately the same speed, load, and temperature (similar conditions) before the PCM will deactivate the MIL for fuel trim and misfire codes.
5. The data link connector (DLC) and generic diagnostic trouble codes (DTC) are the same for all OBD II vehicles.

REVIEW QUESTIONS

1. List four components that are tested by the comprehensive component monitor (CCM).
2. What is the difference between a warm-up cycle and a trip?
3. What is a pending code?
4. What are “flash” codes?
5. How are codes cleared from PCM memory?

RED SEAL CERTIFICATION-TYPE QUESTIONS

1. All vehicles sold in Canada since ____ must be equipped with OBD II.
 - a. 1996
 - b. 1998
 - c. 2000
 - d. 2002
2. The primary purpose of OBD I is _____.
 - a. Emission related
 - b. Fuel injection control
 - c. To detect faults in sensors or circuits
 - d. Improving fuel economy
3. A loose gas cap can set a diagnostic trouble code (DTC).
 - a. True
 - b. False
4. OBD II DTC P0172 (System Too Rich) will automatically clear from memory after ____ warm-up cycles when the problem is corrected.
 - a. 2
 - b. 3
 - c. 40
 - d. 80
5. A warm-up cycle has to achieve at least how many degrees of engine coolant temperature?
 - a. 15°C (60°F)
 - b. 50°C (122°F)
 - c. 70°C (160°F)
 - d. 80°C (177°F)
6. Which DTC represents an ignition or misfire fault?
 - a. P0100
 - b. P0200
 - c. P0300
 - d. P0400
7. An ignition misfire or fuel mix problem is an example of what type of DTC?
 - a. A
 - b. B
 - c. C
 - d. D
8. A type B DTC requires how many faults to turn on the MIL?
 - a. One
 - b. Two
 - c. Three
 - d. Four
9. A freeze-frame is generated on an OBD II vehicle _____.
 - a. Whenever a type C or D diagnostic trouble code is set
 - b. Whenever a type A or B diagnostic trouble code is set
 - c. Every other trip
 - d. Whenever the PCM detects a problem with the O2S
10. Terminal 16 of the OBD II DLC supplies volts to a scan tool, and terminal ____ supplies the signal ground.
 - a. 2
 - b. 5
 - c. 4
 - d. 1