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Introduction

NATEF Task VIII. Engine Performance

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4. Diagnose emissions or driveability concerns resulting from malfunctions in the computerized engine control system with no stored diagnostic trouble codes; determine necessary action. P-1

5. Check for module communication errors using a scan tool. P-2

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STC Standards

A-8 Competencies for OBD II 16040.02W

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2. Describe the OBD II requirements as mandated by Federal law for gas engines

3. Describe the OBD II requirements as mandated by Federal law for diesel engines

4. Identify the control modules GM uses for powertrain management and on-board diagnostics

5. Explain the use of the Data Link Connector (DLC) and identify its location
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5. Describe how to perform diagnostic procedures
6. Describe how to diagnose intermittent malfunctions
7. Describe how to navigate service publications
8. Identify possible causes of faulty DTCs
Objectives

Upon successful completion of engine performance module 14, the ASEP student will be able to:

• Diagnose engine control system faults with a focus on:
  – Sensor deterioration
  – Oxygen sensor deterioration and catalytic converter efficiency
  – Misfire detection
  – Exhaust Gas Recirculation (EGR) system performance
  – Evaporative (EVAP) emissions control system performance

• Demonstrate specific diagnostic skills:
  – Follow service information procedures
  – View DTC information and data with Techline scan tool (TECH 2)
  – Capture and save DTC data with Techline scan tool (TECH 2)
  – Use Techline equipment for control module reprogramming
  – Use the EVAP system diagnostic kit
1. System Overview

Overview
In the early 1980's, General Motors pioneered the use of On-Board Diagnostics (OBD) to help technicians diagnose and repair computer controlled automotive systems. In 1988, California required that all automotive manufacturers provide a system which could identify faults in a vehicle's computer control system. This system was called On-Board Diagnostics Generation One (OBD I).

Also in 1988, requirements were set for the second generation of on-board diagnostics, designated OBD II. Federal law now requires that all automotive manufacturers meet OBD II standards, which went into effect in 1996. For that reason, we have seen name changes of components, a new Diagnostic Trouble Code (DTC) numbering system and additional DTC's.

OBD II requires that the on-board computer monitors and actively performs diagnostic tests on vehicle emission systems. The Federal Test Procedure (FTP) sets maximum allowable emissions levels. The FTP is an emissions testing program required of vehicle manufacturers by the government to become certified for sale in the United States. A Malfunction Indicator Lamp (MIL) must illuminate if a system or component either fails or deteriorates to the point where the vehicle emissions could rise above 1-1/2 times the FTP standards.

Control Modules
GM currently uses four different system control modules for powertrain management and on-board diagnostics:

- Engine Control Module (ECM)
- Powertrain Control Module (PCM)
- Vehicle Control Module (VCM)
- Transmission Control Module (TCM)

The control module used is dependent on the application. The Engine Control Module (ECM) controls only engine functions. The Powertrain Control Module (PCM) controls both the engine functions and the transmission functions. The Vehicle Control Module (VCM) incorporates the transmission and engine control functions of the PCM with the control of the Anti-lock Brake System (ABS) system. Some vehicles use a TCM in addition to the ECM to control transmission functions.

For simplicity, this book will refer to the vehicle's control module as the PCM since it is the most commonly used control module. Throughout this book, it should be assumed that statements about the PCM will apply to the other control modules, unless the text states otherwise.
Serial Communications

The various system control modules of the vehicle communicate with each other as well as with the off-board diagnostic equipment. The communication between control modules and communication with the off-board diagnostic equipment is achieved on the serial communication lines using serial data. Serial Data transfers information in a linear fashion over a single line, one bit at a time. The serial data line is referred to as the Data Bus.

Data Link Connector

The Data Link Connector (DLC) is used for communication with the off-board diagnostic equipment. OBD II standardizes Data Link Connector (DLC) configurations. The DLC, formerly referred to as the ALDL, is a 16-cavity connector found on the lower left side of the driver's side instrument panel. All manufacturers must comply with this standard. Although this style connector was used on some 1994 and 1995 GM vehicles, the connector does not necessarily indicate that the vehicle is OBD II compliant.

Figure 14-1, Data Link Connector
Serial Data Circuits

The PCM can use two types of serial communication:

- UART (Universal Asynchronous Receive and Transmit)
- Class 2

UART communication was used prior to OBD II for communication between the PCM, off-board diagnostic equipment and other control modules. UART is a 5-volt data line that toggles the voltage to ground at a fixed bit pulse width during communication (refer to figure 1-2). UART transmits data at the rate of 8.2 kilobits per second (8192 bits/sec.). Some OBD II compliant vehicles still use UART; but for GM vehicles, communication with the off-board diagnostic equipment is handled on the Class 2 data line.

OBD II requires more sophisticated communications between the PCM, other control modules and the scan tool. Class 2 serial data was designed to meet this need. The Class 2 data line transfers information by toggling the line from zero volts to 7 volts. The data line at rest is zero volts. The information can be transferred in short or long pulse widths (refer to figure 1-2). The two pulse widths and a higher transfer rate (10.4 kilobits per second average) allow the Class 2 data to better utilize the data line.

![Serial Data Wave Forms](figure-14-2.png)
**System Hardware**

Due to the standards of OBD II, many engines require additional hardware to monitor system operation and vehicle emissions. The following list highlights some general changes:

- More vehicles will have both a MAP sensor and a MAF sensor.
- Most vehicles will use only Heated Oxygen Sensors (HO2S), decreasing the time to activity.
- More "V" engines will have multiple pre-converter Heated Oxygen Sensors (HO2S).
- All vehicles will have a heated post-converter HO2S.
- More EGR systems will use a linear EGR valve that is electronically operated and has a pintle position sensor.
- Most engines will have sequential fuel injection.
- EVAP systems have been modified to be OBD II compliant. These systems use the following additional components:
  - The Non-Enhanced EVAP systems use a diagnostic switch for purge monitoring.
  - The Enhanced EVAP system will have a vent solenoid, fuel tank pressure sensor and a diagnostic test fitting.

*Figure 14-3, System Hardware*
System Diagnostics Overview

The PCM has two functions to perform. The PCM must control vehicle systems using sensor input and internal software. The PCM must also perform system diagnostics (refer to figure 14-4). Both management systems have the ability to share information and communicate.

The PCM diagnostics are controlled by the Diagnostic Management System and:

- Perform diagnostic testing
- Record the results of diagnostic testing
- Request TEST FAIL actions

---

**Figure 14-4, PCM Management Systems**
Diagnostic Testing

One of the primary functions of the Diagnostic Management System is to perform diagnostic testing of engine management and emissions systems. The Diagnostic is the test or tests run on a system or component to determine if it is operating according to specifications. The different types of diagnostic tests include (refer to figure 14-6):

- Passive
- Active
- Intrusive

Passive testing simply monitors the system or components during operation. During Active testing, the PCM controls the system or component in a specific action while monitoring takes place. The PCM may perform active tests as the result of failed passive tests. The Intrusive test is a special type of active test that involves an action by the PCM that may affect vehicle performance or emissions.

The Enable Criteria are the exact conditions required for a diagnostic test to run. The enable criteria for any DTC are listed under "Conditions to Set" (or "Conditions to Run" on Cadillac) as part of diagnostic information in the service manual.

Diagnostic testing occurs during a trip. A Trip is a key-on cycle in which all the enable criteria for a given diagnostic test are met, followed by a key-off/power-down (refer to figure 14-5). Since the enable criteria for each DTC is different, a trip for each DTC is different.

The PCM counts warm-up cycles instead of key cycles to clear DTCs. A Warm-Up Cycle is achieved when the engine coolant temperature rises at least 22°C (40°F) from start-up and achieves a minimum temperature of 71°C (160°F).

The PCM also has the ability to "learn" from the results of its diagnostic testing. The PCM internally charts the results of diagnostic testing over a period of time and creates a baseline the "normal" results of the test. This is called Statistical Filtering. By using this learning capability, the PCM is able to filter out information that could cause a false DTC to set.

Important:

The loss of battery power to the PCM will result in the loss of “learned” information. The PCM will perform an aggressive testing schedule to re-learn information. This mode of testing is called Quick Learn and is not noticeable in most cases.
Figure 14-5, A Trip

Figure 14-6, Diagnostic Management Testing
Diagnostic Test Results (Diagnostic Executive)

The results of diagnostic testing are stored by Diagnostic Management software called the Diagnostic Executive. The Diagnostic Executive stores the following information (refer to figure 14-7):

- DTC Information
- Freeze Frame
- Fail Records
- System Status (I/M Ready)
- Warm-Up Cycles

DTC Information indicates the status of the Diagnostic testing for the specified DTC. It contains information on pass/fail status of the test, when the diagnostic test failed and if the DTC is requesting the illumination of any lamp. Freeze Frame stores information about operating conditions at the moment an emission-related history DTC is stored and the MIL is commanded ON. Fail Records contain a GM enhancement of the OBD II Freeze Frame. Fail Records are stored for any DTC. Unlike Freeze Frame, the PCM has the ability to store Fail Records for more than one DTC. The System Status (I/M Flag) stores information on which Diagnostics have run. If a system Diagnostic has run, the system status flag (yes/no) will set.

**Figure 14-7, Diagnostic Executive**
TEST FAIL Actions

When a test fails and a DTC is set, the Diagnostic Management System performs TEST FAIL actions. The TEST FAIL actions are dependent on the DTC. The Diagnostic Management System may perform the following if a DTC is set (refer to figure 14-8):

- Illuminate the MIL (controlled by the Diagnostic Executive)
- Illuminate the Service Lamp (controlled by the Diagnostic Executive)
- Send a message to the Driver Information Center (DIC)
- Substitute default values
- Request PCM default operations
- Store a Freeze Frame (if empty)
- Store or update a Fail Record

Figure 14-8, TEST Fail Actions
Driver Alert

Malfunction Indicator Lamp (MIL)

The Malfunction Indicator Lamp (MIL) operates differently on OBD II compliant vehicles. OBD II guidelines require that the MIL (CHECK ENGINE or SERVICE ENGINE SOON) illuminate only for DTCs that impact vehicle emissions (type A and B). The Diagnostic Executive turns on the MIL if the test fails or the emissions exceed the FTP by 1-1/2 times.

If the vehicle is experiencing a misfire that may cause damage to the Three-Way Catalytic Converter (TWC), the MIL flashes once per second. Flashing of the MIL continues until the vehicle is out of engine speed and load conditions that could cause possible catalyst damage. The MIL remains illuminated after flashing stops.

The Diagnostic Executive turns off the MIL after three consecutive trips in which a "test passed" has been reported for the diagnostic test that originally caused the MIL to illuminate. For fuel trim or misfire DTCs, the tests must also pass the same operating conditions under which the DTC was set (within 375 RPM, within 20% of the engine load and similar engine temperature when the DTC is set).

Notice:

With the implementation of misfire relief, the MIL goes out when the misfire is no longer present. See Chapter 5 for more information on misfire relief.

Service Lamp

The service lamp is only available on certain vehicles. The service lamp is used to alert the driver to a non-emissions malfunction in systems like cruise control and air conditioning. The service lamp illuminates only for non-emission Diagnostic Trouble Codes (type C).

Driver Information Center (DIC)

The Driver Information Center displays messages to alert the driver of malfunctions, warnings and instructions. The DIC may display alerts related to diagnostic trouble codes (type C).
2. Diagnostic Trouble Codes (DTC)

DTC Identification

OBD II requires that the automotive industry use a standardized Diagnostic Trouble Code (DTC) structure. This code structure is very different from OBD I DTC structure (refer to figure 1-9). The OBD II DTCs contain a letter and a four-digit number. The letter identifies the function of the device that has the fault:

- B = Body
- C = Chassis
- P = Powertrain
- U = Network or data link code

The first digit of the number indicates if the DTC is generic or manufacturer-specific (0 = generic, 1 = specific). The second number indicates the specific vehicle system that has the fault. Below are the powertrain system identifiers:

- 1 = Fuel and Air Metering
- 2 = Fuel and Air Metering (injector circuit malfunctions only)
- 3 = Ignition System or Misfire
- 4 = Auxiliary Emission Controls
- 5 = Vehicle Speed Control and Idle Control System
- 6 = Computer Output Circuit
- 7 = Transmission
- 8 = Transmission

The last two digits indicate the component or section of the system that has the fault.

**EXAMPLE: P0137 LOW VOLTAGE BANK-1 SENSOR-1**

- **B - BODY**
- **C - CHASSIS**
- **P - POWERTRAIN**
- **U - NETWORK**

**SPECIFIC FAULT DESIGNATION**

**SPECIFIC VEHICLE SYSTEM**

Figure 14-9, DTC Structure
DTC Types
Each DTC is directly related to a diagnostic test. The Diagnostic Management System sets DTCs based on the failure of the tests during a trip or trips. Certain tests must fail two consecutive trips before the DTC is set.

The following are the five types of DTCs and the characteristics of those codes:

**Type A**
- Emissions related.
- Requests illumination of the MIL on the first trip with a fail.
- Stores a HISTORY DTC on the first trip with a fail.
- Stores a Freeze Frame on the first trip with a fail (if empty).
- Stores a Fail Record.
- Updates the Fail Record the first time the test fails each ignition cycle.

**Type B**
- Emissions related.
- "Armed" after one trip with a fail.
- "Disarmed" after one trip with a pass.
- Requests illumination of the MIL on the second consecutive trip with a fail.
- Stores a HISTORY DTC on the second consecutive trip with a fail (the DTC is armed after the first fail).
- Stores a Freeze Frame on the second consecutive trip with a fail (if empty).
- Stores a Fail Record when the first test fails (not dependent on consecutive trip fails).
- Updates the Fail Record the first time the test fails each ignition cycle.
**Type C (or C1)**
Non-emissions related.*
Requests illumination of the Service Lamp (not the MIL) or the service message on the DIC on the **first** trip with a fail.
Stores a HISTORY DTC on the **first** trip with a fail.
Does **NOT** store a Freeze Frame.
Stores Fail Record when test fails.
Updates the Fail Record the first time the test fails each ignition cycle.

**Type D (or C0)**
Non-emissions related.*
Does **NOT** request illumination of any lamps.
Stores a HISTORY DTC on the **first** trip with a fail.
Does **NOT** store a Freeze Frame.
Stores a Fail Record when test fails.
Updates the Fail Record the first time the test fails each ignition cycle.

**Type X**
Diagnostics that are coded into the software, but are disabled and will not run. This is mostly for export vehicles that do not require MIL illumination or DTC storing.
Some domestic vehicles use X DTCs.
Even though the codes are not stored, the DTC chart can still be used as a resource when diagnosing problems with systems that are associated with the Type X DTCs.

**Important:**
The Diagnostic Executive stores a limited number of Fail Records, usually five or less. Each Fail Record is for a different DTC. Fail Records for every DTC may not occur if multiple DTCs are set.
Notice:

The C0 and C1 designations may or may not show up in the service manual but are used here to differentiate the recent changes to type C and D diagnostics. In the middle of 1997, Type C and Type D codes were changed to the following:

Type C = Type C1
Type D = Type C0

*Failure condition does not cause emissions greater than 1-1/2 times FTP standards.
DTC Information

The status of the test and the related DTC messages can be viewed by using the Tech 2. The combination of messages is dependent on the status of the test. The following is a list of DTC Information messages (some applications do not display all messages listed below):

- **LAST TEST FAILED**: This message indicates that the last diagnostic test failed. If the DTC is a type A or B, this test could have occurred in a previous ignition cycle. This message remains until the test passes or the DTCs are cleared. If the DTC is a type C or D, this message clears when the ignition is turned off.

- **TEST FAILED SINCE CODE CLEARED**: This message indicates that the test has failed at least once since the DTCs were cleared.

- **FAILED THIS IGNITION**: This message indicates that the diagnostic test related to the DTC has failed this ignition cycle.

- **HISTORY**: This message indicates that the DTC has been stored to memory as a valid fault. Type B DTCs are not stored as history DTCs until the test has failed two consecutive trips.

- **MIL SVS OR MESSAGE REQUESTED**: This message indicates that the DTC has requested illumination of the MIL. Only type A and B DTCs can request illumination of the MIL. The MIL SVS or MESSAGE REQUESTED message is cleared after three consecutive trips without a fault or if DTCs are cleared using the scan tool.

- **NOT RAN SINCE CODE CLEARED**: This message indicates that the test related to this DTC has not been run since the codes have been cleared. The status of the system cannot be determined since a trip for the DTC test has not occurred.

- **NOT RUN THIS IGNITION**: This message indicates that the test has not run this ignition and the PCM is uncertain of the status of the system this ignition cycle. A trip must be completed for the PCM to run the test and know the status of the system.

- **LAST TEST PASSED**: This message indicates that a diagnostic test that failed previously has passed the latest diagnostic test. This does not indicate that the fault is gone. It only indicates that the fault was not present during the latest test.

- **TEST RAN AND PASSED**: This message indicates that the latest test passed. The test ran and passed this ignition cycle, and ran and passed since DTCs were cleared. The test has not failed since the DTCs were cleared.

*These messages may not appear on the scan tool display.*
Important:

It is very important when assessing the status of tests and DTCs that the assessment is based only on the DTC information listed since some DTCs will not be available on all applications.

Figure 14-10, Diagnostic Flow
DTC Freeze Frame

The Diagnostic Executive in the PCM records certain vehicle operating conditions when a type A or B (emission related) DTC is stored as a history Diagnostic Trouble Code. The PCM only stores one Freeze Frame record. Freeze Frame data is stored for the first failed test that sets the DTC and illuminates the MIL.

Freeze Frame is not updated (refreshed) if the test fails a second time. However, fuel trim and misfire DTCs take priority over all other DTCs. Fuel trim and misfire DTCs always overwrite the Freeze Frame record unless a fuel trim or misfire DTC is already stored. Any previous information related to DTCs stored in the Freeze Frame that are overwritten due to a priority DTC setting is lost.

DTC Fail Records

Due to the limitations of the Freeze Frame, GM has created Fail Records. Fail Records assist the technicians when multiple DTCs have been set or when the DTC is non-emission related. Fail Records have similar data parameters to those that are stored in the Freeze Frame. However, the PCM has the ability to store multiple Fail Records.

Fail Records are stored any time a diagnostic test fails. Fail records are only updated (refreshed) the first time the test fails during each ignition cycle. This includes B type DTCs that fail only one trip. Unlike Freeze Frame, Fail Records are not limited to emission DTCs. Type C and D Diagnostic Trouble Codes store Fail Records.

Some PCMs can store up to five individual DTC Fail Records. When a diagnostic tests fails, Fail Records are stored in the PCM memory and assigned to the first Fail Record position. If a different diagnostic test fails, a second Fail Record related to that DTC is stored in memory. Additional failed diagnostic tests for different DTCs also store Fail Records until Fail Record memory is full. If more than the maximum number of DTCs are stored, the fail records are replaced on a "first-in, first-out" basis.

Important:

Freeze Frame and Fail Records are very valuable diagnostic tools for the technician. They can be used to determine the operating conditions that were present when a failure occurred.
Conditions to Set DTCs
A DTC sets when the enable criteria are met, the diagnostic test is run and the results of the test are outside of the PCM parameters. Type B DTCs require two consecutive trips with a fault to set as a history DTC and turn on the MIL. Some DTCs, typically type B, have certain conditions in which they are stored in history and illuminate the MIL without two consecutive trips with a test fail.

Conditions to Clear DTCs
There are three methods for clearing DTCs from the PCM memory on OBD II equipped vehicles.

Important:
Always use CAPTURE INFO to save FREEZE FRAME, FAIL RECORDS and DTC INFO in the Tech 2 before using the CLEAR INFO command to clear the DTCs.

Important:
On many GM OBD II systems, the PCM retains memory for an extended period of time with the battery disconnected. Memory may be retained for several days.

Method 1
Tech 2 can be used to clear the DTC information. This also clears all Freeze Frame, Fail Record data, and statistical PCM filters. 1995 and 1996 system status flags (I/M ready) are cleared for only those systems which had a DTC stored. On 1997 and later vehicles, all system status flags are cleared with the Tech 2 CLEAR INFO command. When code clearing is required, Method 1 is the preferred procedure.

Important:
Always use CAPTURE INFO to save FREEZE FRAME, FAIL RECORDS and DTC INFO in the Tech 2 before using the CLEAR INFO command to clear the DTCs.

Important:
On many GM OBD II systems, the PCM retains memory for an extended period of time with the battery disconnected. Memory may be retained for several days.
Method 2
If battery positive or ground to the PCM is interrupted, all current information concerning the DTC, including Freeze Frame, Fail Records, Statistical Filters and System Status (I/M ready) information may be lost. Battery disconnect is not the preferred method for clearing DTCs.

Important:
Always use CAPTURE INFO to save FREEZE FRAME, FAIL RECORDS and DTC INFO in the Tech 2 before using the CLEAR INFO command to clear the DTCs.

Important:
On many GM OBD II systems, the PCM retains memory for an extended period of time with the battery disconnected. Memory may be retained for several days.

Method 3
If the fault that caused the DTC to be stored into memory has been corrected, the Diagnostic Executive begins to count the warm-up cycles. Once it has counted forty consecutive warm-up cycles with no further faults detected, the DTC is automatically cleared from the PCM memory.

Important:
Always use CAPTURE INFO to save FREEZE FRAME, FAIL RECORDS and DTC INFO in the Tech 2 before using the CLEAR INFO command to clear the DTCs.

Important:
On many GM OBD II systems, the PCM retains memory for an extended period of time with the battery disconnected. Memory may be retained for several days.
Diagnostic Trouble Codes Summary

OBD II has many different ways to set and clear DTCs and the MIL. Here are some numbers that may help you remember what you've learned:

1

- One failed test always writes or updates a Failure Record.
- One failed test requests the MIL for a type A diagnostic.
- The first type A emissions-related failure writes a Freeze Frame.
- One failed test arms a type B diagnostic.
- One passed trip disarms a type B diagnostic.
- One failure of a type C or D diagnostic stores a history DTC.
- One failure of any DTC writes or updates the DTC INFO messages.

2

- Two consecutive failures for any type B diagnostic requests the MIL.
- Two consecutive failures for any type B diagnostic writes a Freeze Frame (if empty).
- Two non-consecutive failures for fuel trim or misfire DTCs requests the MIL and attempts to write a Freeze Frame if the second fault is within ± 375 RPM, ± 20% load and the same warm-up condition as the first failure.

3

- Three consecutive passing trips for a diagnostic requesting the MIL disables the MIL request on the next ignition cycle. This occurs as long as there have been no additional failures reported to the Diagnostic Executive.

40

- Forty warm-up cycles with no faults reported to the Diagnostic Executive clears a previously stored DTC, its Freeze Frame and Failure Record. However, special conditions apply to misfire and fuel trim diagnostics (see number 80).
Fuel trim and non-catalyst damaging misfire are type B DTCs. After the first failure, these diagnostics remain armed for up to 80 trips. If a second failure occurs during similar engine speed, load and temperature conditions, the DTC stores as history, the MIL is requested, and data is written to the Freeze Frame and updates the Fail Record. This occurs even if it is not a consecutive trip. If a second failure does not occur and conditions similar to the original failure are not encountered, the diagnostic is disarmed after 80 trips. The diagnostic can also be disarmed if similar conditions are encountered and a second failure does not occur.
Emission Control Systems Monitored

The OBD II system must monitor all emission control systems that are onboard. Not all vehicles have a full complement of emission control systems. For example, a vehicle may not be equipped with AIR, so naturally no AIR Readiness/Function Code would be present. OBD II requires monitoring of the following:

• Air Conditioning System (if the Vehicle uses R12).
• Catalytic Converter Efficiency.
• Comprehensive Component Monitoring (emissions related inputs and outputs).
• Evaporative Emissions Control System (EECS).
• Exhaust Gas Recirculation System (EGR).
• Fuel Delivery System.
• Heated Catalyst Monitoring.
• Misfire.
• Oxygen Sensor System (HO2S).
• Oxygen Sensor Heater System (HO2S Heater).
• Secondary Air Injection (AIR)
OBD II Drive Cycle

The purpose of the OBD II Drive Cycle is to run all of the emission-related on-board diagnostics. When all diagnostics have been run, the System Status (Inspection/Maintenance ready) "flags" are set to "Yes."

System Status flags must be set to "No" in the following cases:

- The battery or PCM is disconnected from the wiring harness (all flags must be set to "No").
- The vehicle is new from the factory and has not been through an OBD II Drive Cycle (possibly all flags must be set to "No").
- The PCM's DTC's have been erased after completion of repairs.

You can use a scan tool to determine if on-board diagnosis is complete. To do this, go to SYSTEM INFORMATION on the main scan tool menu. Choose SYSTEM STATUS and the scan tool will display a diagnostic list to indicate the status of the diagnostic tests. In this way, you can determine the status of the I/M flags. Remember I/M Status only reports on whether or not a diagnostic has been run not what the test's outcome was. In addition, for multiple sensor diagnostics, such as oxygen sensors, tests must be completed for all sensors before the I/M flag will set.

The following is a list of the tests that are performed during the drive cycle and the requirements that must be met for the I/M ready flags to be set (refer to figure 14-19).

Cold Start

A cold start is determined by measuring Engine Coolant Temperature and comparing it to the ambient air temperature during start up. The PCM considers the engine to be cold if the following conditions are met:

- ECT less than 50°C (122°F)
- ECT and IAT are within 6°C (11°F) of each other at start up

Important:

DO NOT leave key ON prior to cold start or H02S heater diagnostic may not run.

Idle (2 min., 30 sec.)

During this period, the O2 heater, "Passive" AIR, Purge "NO Flow," Misfire, and possibly Fuel Trim (if closed loop is achieved) diagnostics will run. The A/C and electrical loads will help the Misfire diagnostic by stabilizing normal combustion variation.
Accelerate
Prior to accelerating, turn off the A/C. Then apply half throttle until 55 mph is achieved. During acceleration, the Misfire, Fuel Trim, and Purge Flow diagnostics will run.

Steady State Cruise
During this portion of the cycle, the O2 "Response," AIR "Intrusive," EGR, Purge, Misfire and Fuel Trim diagnostics will run.

Declerate
During the deceleration portion of the Drive Cycle, the EGR, Purge, and Fuel Trim diagnostics will run. It is important to have a gradual coast down with NO brake application. If the vehicle is equipped with a manual transmission, DO NOT depress the clutch, and remain in high gear.

Accelerate
Apply 3/4 throttle until 55-60 mph is reached. The same diagnostics will run as during the last acceleration portion of the Drive Cycle.

Steady State Cruise
During this portion of the Drive Cycle, the Catalyst Monitor diagnostic will run. Note that if the catalyst is marginal and if a battery disconnect has occurred prior to the Drive Cycle, it may take six separate Drive Cycles to determine the state of the catalyst. The same diagnostics that were performed during the last steady state cruise are repeated during this portion of the Drive Cycle.

Declerate
The same diagnostics that were performed during the last deceleration portion of the Drive Cycle are repeated again. Remember, NO clutch, NO brake, NO manual downshift.
Figure 14-19, OBD II Drive Cycle, Pre-1998
Diagnostic Test Status

DTC status is listed in figure 14-20. DTCs that have not been tested will be listed as a "NO" under the "RAN" heading and "- - -" under the "FAIL" heading. DTCs that have run and passed will not be listed under DTC status. Tests that have run and failed will have YES under the "RAN" heading and YES under the "FAIL" heading. If the latest test passed but it failed previously, the status will display "INT" for a possible intermittent condition.

Figure 14-20, Diagnostic Test Status
3. Sensor Diagnostics

Comprehensive Input Monitoring

Input components are monitored for a minimum of circuit continuity and out of range values. This includes rationality checking. Rationality checking refers to detecting a fault when the signal from the sensor does not match the PCM's expected value (e.g., Throttle Position (TP) sensor indicating an open throttle when other inputs are indicating an "at idle" condition).

Engine Coolant Temperature (ECT) Sensor Diagnostics

Sensor Operation

The PCM provides a 5 volt signal to the temperature sensor. When the sensor is cold, it provides a high resistance. The PCM measures this as a high voltage drop across the sensor. As the sensor warms, the resistance decreases and the PCM measures a lower voltage drop across the sensor. During warm-up (at approximately 50° C) the PCM decreases its internal resistance in the circuit to achieve greater resolution. At this point the signal voltage increases although the sensor resistance continues to decrease (refer to figure 14-21).

![Figure 14-21, Temperature Sensor Voltage](image_url)
ECT Monitoring Diagnostic Operation

OBD II requires that the ECT sensor is monitored for performance deterioration. The engine coolant sensor diagnostic includes several tests. These tests include:

- ECT voltage out of range.
- ECT input failed to enable closed loop.

This Diagnostic also tests for intermittent circuit operation.

The ECT out of range test monitors the temperature readings from the ECT sensor at approximately 100 millisecond intervals. For a fixed interval of time, the diagnostic counts the number of ECT readings outside of the sensor's expected range. If the number of ECT readings in the high or low ranges exceeds a calibrated threshold, the sensor shows a high or low failure.

If a relatively small number of samples fall in either the high or low ranges, the sensor is diagnosed as intermittently out of range high or low. The intermittent diagnostic is not required by OBD II legislation, so no DTC is set in Freeze Frame.

The diagnostic for closed loop enable monitors the engine run time required for the ECT to reach the closed loop enable threshold. This diagnostic is intended to identify an ECT sensor reading that is delaying or preventing closed loop, yet has not failed out of range.

**Important:**

Low coolant level may prevent the ECT sensor from achieving a temperature adequate for closed loop. If a closed loop ECT fault is observed, it is important to verify proper coolant level prior to servicing the ECT sensor.

In late model GM vehicles, the PCM enriches the air/fuel mixture when high Engine Coolant Temperature (ECT) is detected. This procedure Hot Coolant Enrichment (HCE) can cause exhaust emissions to exceed federal standards. HCE is initiated when the high temperature indicator lamp illuminates. DTC P1483 is an HCE-related code that monitors cooling system performance and sets when the actual ECT exceeds calculated HCE value. When this DTC sets, HCE is disabled until the hot lamp comes on. HCE is enabled again after the hot lamp comes on. This code has been implemented on all 4.0 and 4.6L cars (excluding Seville), 3.4L U-vans and 3100 W-cars since these vehicles enable HCE prior to the hot lamp coming on.
Manifold Absolute Pressure (MAP) Diagnostics

Sensor Operation
The MAP sensor measures changes in intake manifold pressure. MAP sensor readings are displayed in both kilopascals (kPa) and voltage (refer to figure 14-22). Kilopascals are a measurement of pressure.

Intake manifold pressure changes are the result of engine load and speed changes. To measure these changes the MAP sensor varies resistance. The MAP sensor receives a 5 volt signal from the PCM and drops the voltage according to the pressure in the intake manifold. A high voltage signal indicates high pressure (kPa). High kPa indicates the engine is under a heavy load. Low kPa indicates the engine is under a light load.

The MAP sensor input is used to determine barometric pressure, changes in linear EGR flow and changes in manifold pressure during certain diagnostic testing.

![Figure 14-22, Map Sensor kPa Compared to Volts](image)

MAP Monitoring Diagnostic Operation
The MAP Monitoring Diagnostic tests for voltages outside of the normal range. The PCM also compares actual MAP output to calculated values to determine sensor performance deterioration. The calculated values are based on TP and various engine load factors.
**Throttle Position (TP) Sensor Diagnostics**

**Sensor Operation**

The PCM provides a 5 volt reference signal to the Throttle Position (TP) sensor. The position of the throttle plate determines the resistance of the TP sensor and the voltage signal (refer to figure 14-23). The TP sensor signal is used to determine idle, Wide Open Throttle (WOT), deceleration enleanment and acceleration enrichment.

![Throttle Position Sensor Circuit](image)

*Figure 14-23, Throttle Position Sensor Circuit*

**TP Monitoring Diagnostic Operation**

The TP Monitoring Diagnostic tests for voltages outside of the normal range. The PCM also compares actual TP output to calculated values to determine sensor performance deterioration. The calculated values are based on MAP and engine speed.
Mass Air Flow (MAF) Sensor Diagnostics

Sensor Operation

The Mass Air Flow (MAF) sensor is a device that measures the rate of airflow through the throttle body. The MAF sensor outputs a signal that varies with airflow (refer to figure 14-24). This signal is used by the PCM primarily for fuel control. MAF readings during acceleration are much higher than those during deceleration or idle.

![Figure 14-24, Mass Air Flow Sensor Circuit](image)

MAF Monitoring Diagnostic Operation

The MAF Monitoring Diagnostic tests for signals outside of the normal range. The PCM also compares actual MAF output to calculated values to determine sensor performance deterioration. The calculated values are based on MAP, RPM, TP and IAT.
4. HO2S and Catalyst Diagnostics

Heated Oxygen Sensors (HO2S)

Overview

Traditionally, Oxygen (O2) sensor input has been used to calculate fuel trim when the vehicle is in closed loop. Oxygen sensors still perform this function. However, to meet emission regulations, GM also uses oxygen sensors to monitor the catalyst.

The emission regulations require that the vehicle enter closed loop sooner. This is because a vehicle that operates in closed loop produces less emissions than if it is operating in open loop. Unheated Oxygen (O2) sensors may take longer to become activated. Therefore, they are slower to go into closed loop. Heated Oxygen Sensors (HO2S) are being used more frequently. The heater warms the sensor to help achieve activation temperature sooner allowing the system to enter and maintain closed

Figure 14-25, Four Cylinder Oxygen Sensor Designations
(1996 through 1998 vehicles)
Oxygen Sensor Designations

To determine which sensor reading is being displayed on the Data List of the Tech 2, the oxygen sensors are given number designations based on their placement in the exhaust system. First, any oxygen sensor that detects exhaust on the cylinder number 1 side is identified as BANK 1 HO2S. If the engine is a V6 or V8, it is possible to have an oxygen sensor for both banks. The sensor reading exhaust for cylinder number 2 is identified as BANK 2 HO2S. Each oxygen sensor is also given a number. Sensors are numbered consecutively HO2S 1, HO2S 2 and HO2S 3 the further down in the exhaust stream they are.

Figure 14-26, Six Cylinder Oxygen Sensor Designations (1996 through 1998 Vehicles)
OBD II Requirements

OBD II requires Heated Oxygen Sensor (HO2S) monitoring for deterioration. The HO2S Monitoring Diagnostic has been designed to meet the following requirements:

• Monitor voltage and response rate of the pre-catalyst sensors.
• Monitor output voltage or insufficient activity of any post-catalytic sensors.
• Monitor the heating system for appropriate performance.

HO2S Monitoring Diagnostic Operation

To achieve the requirements of the HO2S Monitoring Diagnostic, diagnostic tests have been designed to monitor the following:

• Time To Activity.
• Response Time.
• Sensor Voltage.

Time to Activity Test

The Time To Activity test monitors the heater system by measuring the time the sensor requires to become active and compares this result to calibrated fail parameters in the PCM. If the heater circuit is failing, the time to activity will increase and the test will fail. The Time To Activity test can only be run following a "cold start."
Response Time Test

Response Time test monitors the lean-to-rich and the rich-to-lean transition times of the pre-catalyst Heated Oxygen Sensors. If the time between rich-to-lean transitions is too great, the test will fail. Figure 14-28 illustrates lean-to rich and rich-to-lean transitions. Both charts A and C illustrate correct transitions and charts B and D illustrate transitions that could cause the test to fail. Transition times are compared to calibrated fail parameters in the PCM to determine pass or fail of the test.

![Figure 14-28, Response Time Diagnostic Test](image)
Sensor Voltage Test

The Sensor Voltage tests monitor both pre- and post-catalyst HO2S for voltage ranges outside of the calibrated parameters. This test looks for the following:

- Inactive sensor.
- Shorted to voltage.
- Shorted to ground conditions.
- Rich and lean shifts of the fuel control system.

The HO2S voltage test also samples sensor voltage over a period of time and detects a fault if the voltage is beyond the thresholds calibrated in the PCM for a specified time period (refer to figure 14-29).

The operation of the oxygen sensor can be affected by the vehicle operating conditions, quality of the fuel used and the condition of the catalytic converter. Check for possible conditions, such as an exhaust leak, before servicing the oxygen sensor.

![Sensor Voltage Test Diagram](image)

*Figure 14-29, HO2S Voltage Test*
Interface and Diagnostics

The Heated Oxygen Sensors (HO2S) used on OBD II equipped vehicles are connected to the PCM differently than those that were used with OBD I (refer to figure 14-30). An OBD II HO2S has a high signal wire and a low signal wire that connect to a comparator in the PCM.

The HO2S low signal wire runs to the oxygen sensor to provide the comparator with reference low. On most OBD I vehicles, the return low circuit goes directly to a ground on the engine.

Important:

During testing, if the HO2S connector is opened for diagnosis, the low signal wire must be jumpered to ground to check the high signal wire reference voltage. This is necessary because the low signal wire must be at ground potential for the comparator to work properly.

Important:

Do not replace an oxygen sensor just because an oxygen sensor-related DTC is set. Follow service manual diagnostics to ensure that the entire system (wiring, PCM, sensor) has been tested before replacing an oxygen sensor.

Figure 14-30, Heated Oxygen Sensor
Catalyst Diagnostics

Overview

The Three-Way Catalytic Converter (TWC) contains one or more precious metals (palladium, platinum and rhodium) to convert hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NOx) into less harmful gasses. When the catalyst is working properly, the unburned hydrocarbon and carbon monoxide are oxidized by combining with oxygen. This oxidation forms water vapor (H2O) and carbon dioxide (CO2). The oxides of nitrogen are reduced to nitrogen and oxygen.

To help aid in these processes, most modern TWCs also contain a base metal known as cerium. Cerium has the ability to attract and release oxygen in the exhaust stream. This stabilizes the operation of the catalyst and enhances the effectiveness of the precious metals in converting undesirable by-products of combustion into harmless gases. As a catalyst becomes less effective in promoting chemical reactions, its capacity to store and release oxygen also generally degrades.

A good catalyst (e.g., 95% hydrocarbon conversion efficiency) will show a relatively flat output voltage on the post-catalyst HO2S. A bad catalyst will show peaks and valleys in output voltage. This indicates that the catalyst has lost some of its ability to process the exhaust gases properly. A catalyst that indicates a reduced efficiency based on the post HO2S is likely to be inefficient at converting not only HC, but CO and NOx as well. The post-catalyst HO2S is used to measure the oxygen storage/release capacity of the catalyst. From this we can infer the oxygen storage capacity of the catalyst. A high oxygen storage capacity indicates a good catalyst. A low oxygen storage capacity indicates a catalyst that is failing. The TWC and oxygen sensors must be at operating temperature to achieve accurate oxygen sensor voltages like those shown in figure 14-31.

![Figure 14-31, HO2S Outputs](image)
OBD II Requirements

According to OBD II regulations, the on-board diagnostic system must monitor the catalyst once per trip. The catalyst is considered malfunctioning when hydrocarbon (HC) tailpipe emissions exceed the EPA standard.

Catalyst Monitoring Diagnostic Operation

The Catalyst Monitoring Diagnostic measures oxygen storage capacity. The diagnostic is based on an observed correlation between catalyst conversion efficiency and oxygen storage capacity. To do this, oxygen sensors are installed before and after the Three Way Catalytic Converter (TWC). Voltage variations between the sensors allow the PCM to measure the catalyst performance.

When the TWC is operating properly, the post-catalyst oxygen sensor is significantly less active than the pre-catalyst oxygen sensor. This is because the TWC stores and releases oxygen as needed during its normal reduction and oxidation processes. This exposes the post-catalyst oxygen sensor to exhaust gases with very little variation in oxygen levels.

Steady State Cruise Catalyst Monitoring (Most Pre-1998 Vehicles)

To calculate the storage capacity of the TWC, the engine and catalyst must reach operating temperature and the vehicle must remain at a steady cruising speed long enough for multiple oxygen samples to be recorded. In pre-1998 vehicles, to test the oxygen storage capacity of the TWC, the PCM runs a two stage Diagnostic test. In Stage 1, the PCM calculates the oxygen storage capacity of the TWC and compares it to a calibrated value. If the activity of the post-catalyst oxygen sensor approaches the activity of the pre-catalyst sensor, the oxygen storage capacity has decreased. If calculated oxygen storage capacity reaches the calibrated fail value, the catalyst monitoring fails Stage 1. Failing Stage 1 of the test does not necessarily indicate a failed catalyst. The catalyst may be marginal or the sulfur content of the fuel being burned could be very high.

If Stage 1 fails, the diagnostic test enters Stage 2. Further monitoring of the storage capacity of the TWC occurs to increase the accuracy of the test. If Stage 2 of the test fails, the diagnostic is reported as failed and a DTC is set.
In pre-1998 vehicles, the TWC Monitor Test Counter displayed on the scan tool may be used to monitor the progress of the Catalyst Monitoring Diagnostic (refer to figure 14-32). In 1998 and later vehicles, the idle catalyst monitor may be used for this purpose. To complete the Catalyst Monitoring Diagnostic with a good catalyst, the TWC Monitor Test Counter must be allowed to increment to 49 samples and roll over to 0 at least twice. A failed catalyst requires three or more 50 sample tests to report a fail.

The staged testing levels allow the PCM to statistically filter the test information so as to not falsely pass or fail the catalyst monitoring test, and yet quickly pass or fail a marginal or aged TWC. It is not always possible to judge the operation of the TWC by simply comparing oxygen sensor activity on the scan tool. The calculations performed by the on-board diagnostic system are based on internal statistical filters.

Figure 14-32, TWC Monitor Test Counter Data (Pre-1998 Vehicles)
Idle Catalyst Monitoring

Idle Catalyst Monitoring (or ICM) is another method of testing the catalytic converter’s efficiency (or Oxygen Storage Capacity, sometimes called OSC). The Idle Catalyst Monitoring Test is performed at idle instead of at highway speeds as in the past. For the PCM to run this test, all relevant enable criteria must be satisfied. The PCM will then drive the fuel mixture from lean to rich (or rich to lean) while monitoring the pre- and post-catalyst HO2S. High catalytic converter efficiency is recognized when the post converter HO2S signal does not closely follow the voltage toggle of the pre-catalyst HO2S. If both HO2S’s react quickly to the PCM’s change in fuel mixture, the PCM concludes that the catalytic converter's efficiency is low (has low OSC). (Refer to figures 14-33 and 14-34.)

OBD systems that use the Idle Catalyst Monitor have the capability of running the diagnostic while the vehicle is being serviced. The purpose of this technician-directed test is to (1) determine the catalyst performance following a catalyst-damaging event, or (2) exercise the diagnostic until the catalyst diagnostic’s I/M flag is set for vehicles that have not set this flag.
Catalyst Degradation and Failure

When a catalyst monitoring DTC sets, it is important to determine the cause of the failure. TWCs do not generally wear-out. Catalyst damage can be caused by poor engine performance, excessive fuel and oil consumption. The Catalyst Monitoring DTC may also be associated with aftermarket parts, exhaust system damage or leaks.

Exhaust leaks can also adversely affect the catalyst monitor diagnostic. Relatively small exhaust leaks allow ambient oxygen into the exhaust stream. Depending on their size and location, exhaust leaks may do the following:

- Prevent a degraded catalyst from failing the diagnostic.
- Cause a false failure for a normally functioning catalyst.
- Prevent the diagnostic from running.

Contamination of the catalyst can also be a problem. Some of the poisons that may be encountered are phosphorus, lead, silica and sulfur. Poisons may reach the catalyst from fuels, engine oil or engine coolant. These prevent the converter from functioning properly and can affect the relationship between the catalyst's oxygen storage capacity and emission performance.

Aftermarket HO2S characteristics may be different from the original equipment manufacturer sensor. This may lead to either a false pass or a false fail of the catalyst monitor diagnostic. Similarly, if an aftermarket catalyst does not contain the same amount of cerium as the original part, the correlation between oxygen storage and conversion efficiency may be altered sufficiently to set a false DTC.
5. Misfire Detection Diagnostics

Misfire Monitoring

Monitoring misfire is based on the principle that crankshaft rotational velocity fluctuates as each cylinder contributes a power input. When the engine misfires, the crankshaft slows down momentarily (refer to figure 14-35). The PCM monitors crankshaft rotational velocity using the crankshaft sensor. The camshaft position sensor is for cylinder identification.

Figure 14-35, Misfire Monitoring (8 cyl)
OBDII Requirements
OBD II requires misfire detection under the following criteria:

Catalyst-Damaging
- A level of misfire sufficient to result in catalyst damage at the current operation conditions.
Dectects misfire within 200-1000 crankshaft revolutions.
Upon detection, sets a DTC and flashes the MIL (type A DTC, or type B with misfire relief).*
When catalyst damaging misfire is no longer present, the MIL will stay on steady.*

Emission-Threatening
- A level of misfire sufficient to result in emissions levels exceeding 1-1/2 times the FTP standard.
Dectects misfire within 1000-4000 crankshaft revolutions.
First trip arms the DTC (type B DTC).
Second consecutive trip failed, sets DTC in history and MIL will illuminate.

This DTC can set and the MIL will illuminate on a non-consecutive trip if the misfire occurs under the same operating conditions (within 375 RPM of engine speed and 20% of engine load and similar coolant temperature) within 80 trips.
Remember, a misfire DTC will overwrite the Freeze Frame data if a lower priority DTC is already stored in the Freeze Frame.

*See page 14-38 for details of misfire relief
Catalyst Damaging Misfire -- Pre-Misfire Relief

When specific enabling criteria are met, the PCM monitors the engine for misfires. If a misfire occurs which could cause damage to the TWC, the diagnostic must flash the MIL within 200 engine revolutions of the misfire. This type of misfire causes a DTC to set within 200-1000 crankshaft revolutions. The MIL will flash when the misfire is present and will stay "ON" steady after misfire stops.

To effectively detect misfire, the PCM maintains a record of the previous 3200 crankshaft revolutions. These 3200 revolutions are divided into sixteen 200 revolution counters/samples. If a misfire occurs during any given 200-1000 revolution sample* that could damage the TWC, the Diagnostic Executive will flash the MIL and set a misfire DTC (refer to figure 14-36).

*Misfire detection laws are scheduled to change to loosen this requirement, allowing more revolutions with misfire before the MIL illuminates.
**Emission-Threatening Misfire -- Pre-Misfire Relief**

Emissions-threatening misfire is also monitored in sets of 200 crankshaft revolutions. As shown in figure 14-37, if the misfire is not constant, the amount of time to set a DTC might be much longer than the catalyst-damaging misfire diagnostic. This is because the misfire must fail five (1000 crankshaft revolutions [5x200]) of the test samples. The diagnostic will constantly monitor all sixteen test samples for any five that may have failed, indicating a misfire and arming the DTC. In a second trip with a failed emissions-threatening misfire, diagnostic tests will set a history DTC and illuminate the MIL. At this time, the Freeze Frame and Fail Record will be recorded.

The DTC will set and the MIL will illuminate only under the following conditions:

- A second consecutive trip contains an emissions-threatening misfire.
- A second non-consecutive trip contains an emissions-threatening misfire that occurred under the same operating conditions as the first test (within 375 RPM of the engine speed, and 20% of the engine load and similar coolant temperature). This non-consecutive test must occur within 80 trips of the first similar fail.

*Figure 14-37, Detection of an Emissions-Threatening Misfire*
Catalyst Damaging and Emission-Threatening Misfire with Misfire Relief

In 1996, the federal government relaxed the laws concerning misfire detection. This change is sometimes called "misfire relief." With misfire relief, the PCM still monitors cylinder misfire in 3200 crankshaft revolution blocks, but allows more 200 crankshaft revolution blocks with misfires within each 3200 revolution block before turning on the MIL (refer to figure 14-38). Misfire relief is being rolled out gradually via software programmed into the PCM of new vehicles, or via flash calibration for certain current model vehicles. Figure 14-38 is an example of how many engine revolutions with a catalyst-damaging misfire are allowed on a typical engine under misfire relief.

![Engine Revolutions Required to Fail Misfire Diagnostic (Misfire Relief)](image)

*Figure 14-38, Engine Revolutions Required to Fail Misfire Diagnostic (Misfire Relief)*
Full Range Misfire Detection

GM is rolling out full range misfire detection beginning in 1997. Full range misfire detection senses misfire under all positive speed and load conditions up to redline. Misfire is not monitored under negative speed/load conditions (deceleration).

Prior to full range misfire detection, misfire was only monitored during the speed and load conditions that were required by the Federal Test Procedure (FTP).

Figure 14-39, Misfire Detection Ranges
Rough Roads and Misfire Monitoring

Rough roads can cause false misfire detections. A rough road will cause torque to be applied to the drive wheels and drivetrain. This torque can temporarily and intermittently decrease the engine speed and may be falsely interpreted as a misfire. The solution to rough road misfire detection problems is to disable the diagnostic when rough roads are present.

Two methods exist for rough road detection. The first method involves a software approach, and will detect most, but not all, rough roads. The software-only rough road detector processes the same crankshaft sensor signal used by the diagnostic and detects patterns characteristic of rough roads (refer to figure 14-40). This method will be used on all vehicles.

The second method involves the use of the Anti-lock Brake System (ABS) to detect rough roads. The high-resolution wheel speed sensors of the ABS are capable of sensing rapid variation of wheel speed due to a rough road in the same way as the crankshaft sensor can be used to detect misfire. When the ABS senses the rough road, a signal will be sent to the PCM. The ABS rough road detection technique will be employed as an enhancement to the software detection method on a wide range of vehicles that use ABS as standard equipment.

For vehicles with automatic transmissions there is another diagnostic feature. On these vehicles, the Torque Converter Clutch (TCC) will be disabled when misfire is suspected. Disabling the TCC isolates the engine from the rest of the driveline and virtually eliminates the effect of drive wheel inputs on crankshaft rotation.

Whenever TCC has been disabled, it will be re-enabled after 3200 engine revolutions if no misfire activity is detected. The TCC will remain disabled as long as some misfire activity is detected to allow the misfire diagnostic to continue to evaluate the system. However, during a transmission over-temperature condition, the misfire diagnostic will be disabled and TCC will operate normally to avoid further increasing the temperature of the transmission.

Figure 14-40, Impact of Rough Road on Misfire Monitoring
Misfire Counters

A feature that General Motors has incorporated into the Misfire Detection Diagnostic as an aid for technicians in diagnosing misfire problems is the misfire counters. These counters are basically a record on each engine cylinder. There are History Misfire and Current Misfire counters for each cylinder. Any time a cylinder misfires, the Misfire Detection Diagnostic counts the misfire. The scan tool will display a misfire counter for each cylinder.

When misfire is detected, the acceleration and deceleration of the crankshaft becomes very erratic. The data that is collected by the diagnostic sometimes identifies misfiring in all cylinders. As you can see from figure 14-41, there are misfires counted in almost all the cylinders, but the History Misfire Counters for cylinder #1 have the greatest number. This indicates that cylinder #1 has the majority of the misfires. A very low number of counts may occasionally be stored in the other counters due to normal combustion variation. If the number of counted misfires between two cylinders was too close together for the diagnostic to identify beyond any doubt which specific cylinder is misfiring, the Diagnostic Executive may set a RANDOM MISFIRE DTC (DTC P0300).

History Misfire counters store total misfires for the cylinder after the DTC has been armed. The Current Misfire counters only contain the misfires from the current 200 sample. After 200 crankshaft revolutions and the DTC is armed, the misfires in the Current Misfire counter are added to the History Misfire counter.

Figure 14-41, Misfire Counters
Misfire Display

On many vehicles, the Tech 2 Misfire Graphic allows you to view the current misfire counters in a bar graph (refer to figure 14-42). This is in addition to the data list misfire counters.

Figure 14-42, Tech 2 Misfire Graphic
6. Control System Diagnostics

Comprehensive Output Monitoring

Output components are to be monitored for proper response to PCM commands. Components for which functional monitoring is not feasible are monitored for circuit continuity and out-of-range values if applicable.

Idle Control Diagnostics

Overview

Idle control is achieved by using the Idle Air Control valve (IAC) for coarse adjustment and spark timing for fine adjustment of the idle speed.

Idle Control Monitoring Diagnostic Operation

The Idle Control Monitoring Diagnostic begins by comparing the desired engine idle speed to the actual engine idle speed. When desired and actual engine speeds differ by a calibrated fail value, the Diagnostic runs a follow-up test.* The follow-up test may be calibrated to operate either as a passive test or as an intrusive test. The passive test monitors the measured intake airflow to determine whether the idle control system is delivering a reasonable amount of bypass air. The passive test is performed at idle with the IAC valve operating normally. If the intrusive mode is enabled by calibration, this check is made by moving the IAC valve during off-idle operation and observing the change in intake air rate or the MAP sensor signal voltage.

Important

The primary concern associated with this Diagnostic is the potential impact of active actuation of the IAC valve on driveability and emissions. At this time, these concerns are managed by careful calibration of the IAC system diagnostic.

*Follow-up testing is being phased out in the 1998 model year.
Fuel Trim Diagnostics

Overview
Fuel delivery can be controlled by either open loop or closed loop. Open loop is when the PCM determines fuel delivery based on sensor inputs (except oxygen sensor) and programming inside the PCM. Closed loop fuel delivery is based on the input of many sensors, including the oxygen sensors, and programming within the PCM. During closed loop, the input from the oxygen sensors is used by the PCM to calculate long-term and short-term fuel trims (or fuel delivery adjustments). If the oxygen sensors indicate a lean condition, fuel trim values will be above 0%. If the oxygen sensors indicate a rich condition, fuel trim values will be below 0%. Fuel trim values that are between +10% and -10% are an indication that the PCM is maintaining proper fuel control.

OBD II Requirements
The OBD II requirements for fuel system monitoring state that the fuel delivery system must be continuously monitored for the ability to provide compliance with emission standards. The fuel trim monitoring system is considered malfunctioning when it causes the emission levels to exceed 1.5 times the FTP standards. The regulations specifically require a monitor of the long-term fuel trim authority limits. Finally, the operating conditions at the instant of fault detection must be stored in Freeze Frame data for the service technician.

To meet OBD II requirements, fuel trim information in the Data List is displayed using percentages. This differs from the way fuel trim has been traditionally displayed on the scan tool. Refer to figure 14-43 for a cross-reference of fuel trim numbers and percentages. Short-term and long-term fuel trim function the same as in the past. Only their measurement units differ.

Figure 14-43, Fuel Trim Conversion
Fuel Trim Diagnostic Operation

To meet OBD II requirements, the PCM uses fuel trim cells to determine the need to set a fuel trim DTC. The cells represent various operating conditions. Some of the cells are weighted. Only failed tests in the weighted cells can cause a fuel trim DTC to be set. The greater the weight of the cell, the greater the chance of a DTC setting if fuel trim counts exceed specifications. The cells used for diagnostics and the weight of the cells are based on FTP testing and OBD II requirements.

The fuel trim Diagnostic monitors the averages of long-term and short-term fuel trim. If these fuel trim values reach and stay at their maximum limits for a period of time, a malfunction is indicated. The fuel trim Diagnostic compares an average of long-term trim values and short-term trim values to rich and lean limits which are the calibrated fail thresholds for the test. If either value is within the fail thresholds, a pass is recorded. The closed loop system still has control authority. If both values are outside the fail thresholds, then a failure condition exists. This will cause a DTC to be stored and the rich or lean condition to be recorded. The fuel trim diagnostic also conducts an intrusive test to determine if a rich condition is being caused by excessive vapor from the EVAP canister.

In figure 14-44, fuel trim cells 4, 5 and 9 are the weighted cells. No fuel trim DTC will set regardless of the fuel trim count unless that fuel trim count is located in one of the weighted cells. This means that the vehicle could have a fuel trim problem that is causing a concern under certain conditions located in the unweighted cells but will not set a DTC.

![Figure 14-44, Typical Fuel Trim Cells (Other Vehicles Are Similar)](image-url)
Exhaust Gas Recirculation Diagnostics

Overview
The Exhaust Gas Recirculation (EGR) system allows exhaust gases to enter the cylinders. The introduction of exhaust gases into the cylinders reduces the temperature of combustion. This reduction in combustion temperature reduces the production of oxides of nitrogen (NOx).

The position of the EGR valve affects the manifold pressure (refer to figure 14-45). Opening the valve increases manifold pressure. Closing the valve decreases manifold pressure. In both cases, the amount of MAP change can be correlated to the amount of EGR flow through the valve.

![Figure 14-45, Changes in MAP as EGR Operates](image)

OBD II Requirements
OBD II requires that the Exhaust Gas Recirculation (EGR) system be monitored for abnormally low and high flow rate malfunctions.

The EGR system is considered malfunctioning when an EGR system component fails, or a change in the EGR flow rate results in the vehicle exceeding 1-1/2 times the FTP emission standard. The linear EGR Pintle Diagnostics detects the component "hard" failures (opens, shorts, stuck valves), and the linear EGR Flow Rate Diagnostic detects a reduction in EGR flow.
EGR Flow Rate Diagnostic Operation

The EGR Flow Rate Diagnostic uses changes in the Manifold Absolute Pressure (MAP) during actuation of the EGR valve to determine how effectively the EGR system is operating. The EGR Flow Rate Diagnostic forces the EGR valve open during a closed throttle deceleration or forces the EGR valve closed during a steady state cruise. Selection of the cruise test or the deceleration test is determined by the Diagnostic calibration.

A complete test of EGR valve flow rate is the average of MAP changes over several valve actuations. The results of each single test are averaged to minimize variation and avoid misdiagnosis. Failure of the EGR valve is indicated when this averaged value exceeds a calibrated fail value.

Usually only one test is run per ignition cycle. The following are two occasions where multiple tests are run during a given ignition cycle:

- The Fast Initial Response (FIR) feature is enabled after a code clear or battery disconnect.
- The Rapid Step Response (RSR) feature is enabled due to an abrupt change in the measured flow rate.

This diagnostic is intrusive in that it opens the EGR valve when it is normally closed, or vice versa. This may result in a perceptible change in engine speed on automatic transmission equipped vehicles during the deceleration test. Operation of the vehicle should not be affected, but customers may notice the engine speed fluctuation on vehicles equipped with tachometers.
Secondary Air Injection (AIR) System Diagnostics

Overview
The secondary Air Injection (AIR) system uses a pump to create air flow into the exhaust stream. The secondary AIR pump is turned on to promote oxidation of HC and CO by adding oxygen to the exhaust until the vehicle goes into closed loop (stoichiometric) control. When the HO2S becomes active, it will read a low voltage (approximately 0-200mV) if the secondary AIR pump is delivering air to the exhaust.

OBD II Requirements
On engines that are equipped with secondary Air Injection (AIR) pumps, OBD II requires monitoring for the presence of airflow in the exhaust stream. OBD II also requires either functional monitoring of the secondary AIR pump or switching valves.

If the airflow distribution system is considered durable or leak proof for the life of the vehicle or the emissions impact of a total secondary AIR system failure is less than 1-1/2 times the FTP standards, the PCM does not have to measure the amount of air flow, rather, just the presence of air flow.

AIR System Diagnostic Operation
The Secondary AIR Monitoring Diagnostic uses both a passive and an active test to evaluate the secondary AIR system. The passive test monitors the voltage of the pre-catalyst HO2S after start-up and prior to closed loop control.

The secondary AIR diagnostic will indicate a pass if the passive portion of the secondary AIR diagnostic observes the proper lean reading of the pre-catalyst HO2S prior to closed loop. The passive test also looks for O2S to toggle when the secondary AIR pump is turned off.

If the passive test indicates a pass, no further action is taken. If the passive test fails or is inconclusive (lean HO2S 1 readings not observed or unclear), the diagnostic will proceed to the active test. The active test will activate the secondary AIR pump during closed loop operation under normal operating conditions. The active test will indicate pass or fail based on the observed response of the pre-catalyst oxygen sensor (HO2S 1) and/or the short-term fuel trim value in response to activation of the secondary AIR pump. As with the passive test, a lean HO2S 1 reading indicates that the secondary AIR system is functioning. An increasing short-term fuel trim value also indicates secondary AIR system function.
The secondary AIR test requires failure of the active test on two consecutive trips to illuminate the MIL and store a DTC in the PCM's memory.

A concern with the secondary AIR diagnostic is the potential impact of the active test on vehicle idle quality and emissions. Activating the secondary AIR pump during normal operation will disable closed loop control. This may result in a minor impact to vehicle emissions. The active test should not be perceptible to the driver. Note that the active test will only be run in cases where the passive test has failed or was inconclusive.
7. EVAP System Diagnostics

Evaporative Emissions System Overview

The EVAP system is used to collect fuel vapor from the fuel tank. These vapors are stored in a canister filled with activated carbon. The EVAP system allows the vapors to be drawn from the canister and routed to the intake manifold or throttle body during certain operating conditions. This is called canister purging since the vapors are purged from the canister. OBD II requires PCM monitoring for proper operation of the EVAP system and for possible leaks to the atmosphere.

Non-Enhanced EVAP System

Overview

The typical non-enhanced EVAP system contains the following components (refer to figure 14-46):

- EVAP emission pressure control valve.
- Vented canister.
- Diagnostic switch
- EVAP purge solenoid.

The EVAP purge solenoid is pulse-width modulated and allows evaporative emissions from the canister to enter the intake manifold when the solenoid is on. The low pressure inside the manifold and the higher atmospheric pressure in the canister create the flow of air and fuel vapors.

Figure 14-46, Non-Enhanced EVAP System
**EVAP Canister Purge Solenoid Diagnostic Operation**

The EVAP canister purge solenoid Diagnostic uses the EVAP diagnostic switch in the hose between the EVAP canister and purge solenoid to determine correct function of the EVAP purge solenoid. The EVAP diagnostic switch is normally closed. When the EVAP purge solenoid is open (purge on) and enough vacuum is present in the manifold, the switch should open, indicating a vacuum. An EVAP purge solenoid that is stuck in the open position will result in the switch consistently indicating the presence of vacuum at the switch. An EVAP purge solenoid stuck closed will result in the switch constantly indicating atmospheric pressure.

A concern pertains to the canister fresh air vent. Clogging of the vent could allow the purge hose between the switch and canister to trap vacuum with the purge solenoid closed. This would result in a diagnostic indication of a purge solenoid stuck open or power-up vacuum switch failure. Similarly, tears or blockages in the purge hoses may result in misdiagnosis of the purge solenoid.

Operating conditions that cause very high vapor pressure (high RVP fuel) may fool the diagnostic. This may decrease the level of vacuum measured by the switch with purge on, and could potentially cause the purge diagnostic to indicate a false failure. This concern can only be addressed at this time through careful calibration of the EVAP purge solenoid diagnostic to minimize sensitivity to high vapor generation conditions.

**Notice:**

When servicing a purge solenoid DTC, it is important to check the canister fresh air vent, vacuum switch and integrity of all purge hoses prior to servicing the solenoid.
Enhanced EVAP System

Overview

The Enhanced EVAP System uses the following components (refer to figure 14-47):

- Evaporative system canister.
- Fuel tank pressure sensor.
- Canister purge solenoid.
- Canister vent solenoid.
- Service port.
- Fuel cap.
- Fuel level sensor.

Figure 14-47, Enhanced EVAP System
Enhanced EVAP System Components

Canister
The evaporative system canister is filled with activated carbon that stores fuel vapors from the fuel tank. Controlled engine vacuum purges fuel vapor and air from the canister during certain driving conditions.

Purge Solenoid
The normally closed solenoid is pulse-width modulated by the PCM to precisely control the vapor flow. When energized, the evaporative canister purge solenoid allows fuel vapor and air to flow from the canister to the engine.

Vent Solenoid
The evaporative canister vent solenoid replaces the fresh air vent used on past canisters. The normally open vent solenoid not only allows fresh outside air to the canister during purge modes, but also can be commanded closed to allow the diagnostic to draw a vacuum in the fuel tank.

Fuel Tank Pressure Sensor
The fuel tank pressure sensor mounts at the top of the fuel sending unit or the top of the fuel tank. The sensor is a three wire strain gauge sensor much like the common MAP sensor. However, this sensor measures the difference between the air pressure (or vacuum) in the fuel tank and the outside air pressure (refer to figure 14-48).

![Figure 14-48, Pressure Verses Voltage](image-url)
Service Port

The system service port has a green cap and is located in the hose between the purge solenoid and canister (refer to figure 14-49). The port contains a schrader valve and fittings to allow connection of the service tool kit J41413.

Fuel Cap

The fuel cap is an important part of the Enhanced EVAP system. In addition to its normal duties of fuel system containment, the cap must maintain a leak-free seal on the fuel fill neck. Improper or inadequate sealing may cause the PCM's on-board EVAP diagnostic to "fail" the EVAP system and turn on the MIL.

Various fuel cap designs have been used over the years. Many late model GM cars use a "threaded" cap design that requires a minimum of 3 clicks to be heard from the ratcheting mechanism to ensure a proper seal (refer to figure 14-50).

In the near future, GM will convert most fuel caps to an "easy on" design. The "easy on" fuel cap provides a better seal with less effort from the owner.
Fuel Level Sensor

Starting in 1997, some Enhanced EVAP models switched from a wire-wound 0-90 potentiometer to a ceramic card resistor 40-250 potentiometer. (The 0-90 sender is still used with some systems.) The new 40-250 card has better resolution and better accuracy, which is needed when the PCM performs on-board Enhanced EVAP diagnostic tests since most PCM's run Enhanced EVAP diagnostics when fuel level is between 15 and 85 percent (refer to figure 14-51). The new sensors indicate a full tank with a 250 reading, just as the wire-wound 0-90 sensors indicate a full tank with a 90 reading.

Notice:

It is important to determine which sensor is being used on a particular vehicle, since use of the 90 Ohm fuel gage tester on the new sensor will not be accurate and can result in misdiagnosis. The new fuel level circuit uses a 5-volt reference to replace the conventional 12-volt reference circuit.
Enhanced EVAP Diagnostic Operation

The Enhanced EVAP Diagnostic is required to detect EVAP system leaks as small as 0.040 inch in diameter. On fuel tanks that are 25 gallons or larger, .040" - .080" holes must be detected.* The enable criteria for these larger tanks is different than that of vehicles with smaller fuel tanks.

The Diagnostic uses several different tests to evaluate the status of the EVAP system:

- Power-Up Vacuum Test.
- Excess Vacuum Test.
- Loaded Canister Test.
- Weak Vacuum Test.
- Small Leak Test.
- Purge Solenoid Leak Test.

Power-up Vacuum Test

The Power-up Vacuum test is a passive test designed to detect restrictions or blockages in the vent path. The test runs when the vent solenoid is open, the purge solenoid is closed, the engine is cold and the key is in the run position with the engine off. The fuel tank pressure sensor should not indicate pressure or vacuum with the vent solenoid open. This test will only run when the fuel level is between 15% and 85%.

Excess Vacuum Test

The Excess Vacuum test is a passive test designed to detect vent path restrictions. The test runs during normal canister purging with the vent solenoid open. The fuel tank pressure sensor should not indicate excessive vacuum during this test. This test does not run continuously, only when the enable criteria are met. This test will only run when the fuel level is between 15% and 85%.

Loaded Canister Test (NON-ORVR SYSTEMS)

The Loaded Canister test is a passive test designed to determine if the canister is sufficiently loaded. On most vehicles, the diagnostic monitors the PCM's purge duty cycle "ramp-in" rate to determine if the canister is sufficiently loaded. A low "ramp-in" rate (due to a relatively large amount of vapor stored in the canister) is an indication that the canister is sufficiently loaded. A high "ramp-in" rate indicates insufficient canister loading.
Weak Vacuum Test
The Weak Vacuum test is an active test designed to detect gross leaks. The test commands the vent solenoid closed during normal canister purging. The fuel tank pressure sensor should indicate a vacuum during this test. This test occurs only during normal canister purging after the Loaded Canister test has run and determined that the canister is not sufficiently loaded. This test will only run when the fuel level is between 15% and 85%.

Small Leak Test
The Small Leak test is an active test designed to detect minor leaks. This test runs immediately following a passing Weak Vacuum test. While a vacuum is still present in the fuel tank, the vent and purge solenoids are commanded closed to seal the system. The test monitors the fuel tank pressure sensor for a vacuum decay rate that is too fast. This test will only run when the fuel level is between 15% and 85%.

Purge solenoid leak test
The Purge Solenoid Leak test is an active test designed to detect a manifold vacuum leak through the purge solenoid. The test commands the vent solenoid and purge solenoid closed. If the fuel tank pressure sensor indicates vacuum, the purge solenoid is leaking. This test will only run when the fuel level is between 15% and 85%.

* Leak size detection for tanks greater than 25 gallons depends on the tank size and tank design.

* Power-up Vacuum test was discontinued in 1997
**EVAP Cart**

The EVAP cart pressure test can be used to diagnose fuel tank and EVAP system leaks (refer to figure 14-52). The fuel tank and EVAP vapor line are pressurized with dry nitrogen and an ultrasonic leak detector is used to locate the pressure leak.

**Caution:**

To reduce the risk of fire and personal injury, do not leave the EVAP pressure purge diagnostic station (J 41413) unattended during operation.

**Important:**

Before performing any EVAP testing or repair using the EVAP Pressure/Purge Diagnostic Station (J 41413), follow the self-test procedure provided with the station.

**Notice:**

Fuel level has a strong influence on this test, especially fuel tanks larger than 25 gallons. As fuel level decreases, the air space within the tank increases. The larger the air space, the greater the volume of nitrogen that must escape before pressure drops below the specified minimum value. When testing an EVAP system with a leak, the greater the air space, the longer it will take for the pressure to drop.

![Figure 14-52, EVAP Pressure/Purge Diagnostic Station](image-url)
EVAP Service Bay Test

A new Tech 2 Special Functions feature called the "EVAP Service Bay Test" (refer to figure 14-53) is now available on certain models such as:

- 1997 S/T truck with 4.3L.
- 1997 H car with 3800 (VIN K).
- 1997 W car with 3800 and 3100.
- 1997 N car with 3100.

This list will grow as the EVAP Service Bay Test becomes available in more models in 1998. The EVAP Service Bay test was developed anticipating that some state I/M programs might include looking at the I/M flags as part of their inspections. In the event that a customer had a car at the dealership for service that required a code clear (a battery disconnect or Tech 2 DTC clear), all I/M flags would reset to NO (test not run). A short drive from the dealership to the I/M test site would not be adequate for the EVAP diagnostic to run, and therefore, an owner might have trouble passing the I/M test.

To help alleviate this situation, the Tech 2 EVAP Service Bay test sends a Class II message to the PCM commanding it to relax certain enable criteria for the EVAP diagnostic. The idea is to allow the EVAP I/M flag to set quicker than it would normally (switch to YES, indicating that the diagnostic has run).

The EVAP Service Bay Test does not command the Purge and Vent valves on and off like the current Seal System, and System Performance test in Special Functions. Rather, it lets the on-board diagnostic control the purge and vent valves.

The EVAP Service Bay Test does NOT replace any Service manual diagnostics. The EVAP test cart and related service manual diagnostics are still the recommended for EVAP service.

Keep in mind that there are limits to when the EVAP Service Bay Test is allowed to run. For example, if ECT is too warm when the test is attempted, the test will abort.
Figure 14-53, Typical Sequence for EVAP Service Bay Test
On-Board Refueling Vapor Recovery (ORVR)

On-Board Refueling Vapor Recovery (ORVR) is a government mandated emission control system designed to prevent HC vapor from escaping to the atmosphere while refueling a vehicle. The flow of liquid fuel down the fill pipe provides a "liquid seal" which prevents HC vapor from exiting the fill pipe opening. The refueling vapor that was traditionally lost to the atmosphere is now routed to the Evaporative Emission Canister, located near the fuel tank, and temporarily stored until purged by the Powertrain Control System (refer to figure 14-54).

Normal Operating Characteristics of ORVR

The objective of ORVR is to avoid releasing vapors into the atmosphere. The customer should not see or smell fuel vapors during fueling. During fueling, the nozzle should be inserted into the tank easily. Cars equipped with ORVR may be difficult to fill when some Stage II vapor recovery nozzles are inserted too far into the tank.

ORVR Components

The ORVR system shares many of the components used in the Enhanced EVAP system. The system architectures vary by platform, and some of the items listed below are optional, depending on the application. The following list describes ORVR components and their operation:

- **Fill Pipe** - A pipe or tube that carries dispensed fuel from the fuel nozzle to the fuel tank. ORVR uses a 1-inch diameter fill pipe. The small pipe diameter allows a "liquid seal" to be created while fueling. This prevents refueling vapors from escaping out of the fill pipe. Some applications use a coaxial fill pipe. The inner tube of the coaxial fill pipe is the 1-inch diameter of the pipe. The outer pipe is used for vapor recirculation.

- **Check Valve** - Limits fuel "spitback" from the fuel tank during refueling by allowing fuel flow only into the tank. The check valve is located at the bottom of the fill pipe. Two check valve designs are in use: a spring loaded valve and a flapper valve.

- **Vapor Recirculation Line** (optional) - Used to transport vapor from the fuel tank to the top of the fill pipe (in the liquid seal area) during refueling to reduce vapor loading of the canister. This line can be located inside or outside of the fill pipe.
• **Shutoff Valve Assembly** - Located in the tank, the shutoff valve has the following functions and features:
  – Controls the fuel tank fill level by closing the primary vent from the tank.
  – Prevents liquid fuel from exiting the tank via the vapor line to the canister.
  – Provides fuel spillage protection in the unlikely event of vehicle rollover by closing the vapor path from the tank to the canister.

• **Evaporative Emissions Canister** - Routing refueling vapors to the canister adds additional demands to the job the canister already performs. Therefore, a larger canister is required with ORVR. ORVR canisters will range in size from 1.5 to 2.1 liters depending on the application. When refueling an ORVR equipped vehicle, the canister can temporarily get hot (up to 50° C above ambient temperature). This increase is due to HC bonding with the carbon in the canister (called exothermic adsorption).

• **Pressure/Vacuum Relief Valve** (optional) - Provides venting of excessive fuel tank pressure and vacuum to atmosphere. On vehicles equipped with plastic fuel tanks, the gas cap performs pressure/vacuum relief, while on vehicles equipped with steel fuel tanks, the pressure/relief valve is integral to the shutoff valve assembly.

**Note:** All cars with ORVR are scheduled to be equipped with "easy on" gas caps.
• **Vapor Lines** - Transport fuel vapor between various fuel system components. ORVR uses a 1/2 inch line between the tank and canister to accommodate the additional demands of refueling vapor on the system.

**Important:**

Do not refuel the vehicle while the engine is running. If the engine is running and the on-board EVAP diagnostic is running while attempting to refuel, you may set a DTC, turn on the MIL, or encounter a “difficult to fill” condition.

*Figure 14-54, Conventional and ORVR-Equipped Fuel Systems*
<table>
<thead>
<tr>
<th>Component</th>
<th>Difficult to Fill</th>
<th>Over Fill</th>
<th>Premature Shut-Off</th>
<th>Wellback/Spitback</th>
<th>Liquid to Cannister</th>
<th>Liquid Leak to Ground</th>
<th>Fuel Odor</th>
<th>EVAP/OBD Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press. Relief Valve in Fuel Cap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O, C or L</td>
</tr>
<tr>
<td>Press. Relief Valve in Shutoff Valve</td>
<td></td>
<td>O, L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O, C or L</td>
</tr>
<tr>
<td>Check Valve</td>
<td>C</td>
<td>O, C, L</td>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td>O, L</td>
</tr>
<tr>
<td>Vapor Recirculation Line</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>R</td>
<td></td>
<td>L</td>
</tr>
<tr>
<td>Shutoff Valve</td>
<td>C</td>
<td>O, L</td>
<td>C</td>
<td>O, L</td>
<td>O</td>
<td>O</td>
<td>O, L, C</td>
<td></td>
</tr>
<tr>
<td>Carbon Cannister</td>
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<td>R</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EVAP Vent Solenoid</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td></td>
<td></td>
<td>O, C, L</td>
<td></td>
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</tr>
<tr>
<td>High RVP/High Temperature Fuel</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>EVAP Vent Solenoid, Fill Pipe</td>
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<td></td>
</tr>
<tr>
<td>Vapor Lines</td>
<td>R</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td>L, C, R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refueling with engine running while the on-board diagnostic is running (EVAP vent solenoid closed)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

C=Closed  R=Restricted  O=Open  L=Leak  X=Possible Cause

*Figure 14-55, ORVR Diagnostic Chart*
8. Diagnosis and Service

Strategy Based Diagnosis

Figure 14-56, Strategy Based Diagnosis
Verifying The Customer Concern

The first step that you should always take when dealing with a customer concern is to verify it. Sometimes a customer can mistake normal vehicle operation for a problem. An example of this is the customer whose vehicle has an Anti-Lock Brake System (ABS), and is concerned because of a pulsating brake pedal during hard braking on ice or snow. Since many people are unaware of normal ABS operating characteristics during hard braking, this customer has mistaken normal ABS operation for a malfunction.

If you start diagnosing this vehicle for a problem when the vehicle is operating normally, you're in for a long frustrating day.

Another important aspect of verifying the customer concern is understanding the issue. The average customer may not be very technically oriented. Customers may describe concerns in their own terms. An engine miss is often described as "jerking" or "chugging". Some customers get detailed when describing a malfunction. They will throw in body gestures and even make faces and try to imitate vehicle noises. While sometimes this can be humorous to watch, what these people are trying to do is make sure you understand the vehicle symptoms.

Always try to observe vehicle symptoms under the conditions the customer says they occur, such as vehicle temperature, loading, speed, etc.

If you cannot verify the customer concern, consider taking the customer on a road test with you. This ensures that the malfunction you are going to diagnose is the one with which the customer is concerned, is a true malfunction, and not just a lack of understanding of normal vehicle operation.

Few things are more frustrating for you and the customer than repairing a suspension noise in the front of the car when it was an engine noise the customer wanted fixed.
Visual Inspection

Your visual inspection should initially focus on the system that you suspect is the cause. An engine miss under load is not likely to be caused by a defective Idle Air Control (IAC) valve. Similarly, a hard starting engine is not likely the result of a failed Vehicle Speed Sensor (VSS). A logical diagnostic strategy includes first looking at the systems that are most likely to cause the customer concern.

The visual inspection actually begins with the initial road test and continues through the entire service procedure. During the initial road test, look for add-on electrical accessories such as car phones, alarms, radios, etc. Incorrect wiring of these accessories by unqualified personnel often causes vehicle malfunctions. Another important inspection point, especially on ODB II equipped vehicles, is the use of non-General Motors parts. Aftermarket catalytic converters and oxygen sensors often have different operating characteristics than genuine GM parts. This may cause the PCM to set a DTC because they don't work within the parameters of the PCM's programming. This is not a quality issue, but a compatibility issue.

Important:

Continue your visual inspection throughout the diagnosis and repair procedure. Keep alert to indications of damaged components. Attention to detail when diagnosing and servicing vehicles is one of the best traits you can develop.

Checking Service Bulletins and Vehicle Service Records

The use of service bulletins and vehicle service records should not be underestimated. Sometimes a specific condition is common to a certain vehicle. If this is the case, there is likely to be a service bulletin issued about the condition. The bulletin will also contain proven repair procedures that will save you time when servicing the vehicle.

Checking the vehicle records is also important. The vehicle records will tell you if a customer's vehicle has previously been repaired for the same concern. This could indicate that the last repair cured only the symptom of the condition instead of the cause. Or, it may indicate that the customer is operating or maintaining the vehicle in some way that causes the condition to reoccur. Always ask the customer about any service that has been performed on the vehicle.
Performing Diagnostic Procedures

Using the "right tool for the job" is important to automotive technicians. That's why most technicians invest thousands of dollars for the tools and equipment needed to service vehicles. Using the right diagnostic tools is equally important. You can't replace a damaged or failed part unless you know which one it is.

When working with OBD II equipped vehicles, one of the most valuable diagnostic tools you have is the Tech 2. The tests it allows you to perform provide you with the information you need to take a wide range of symptoms and narrow them down to the specific area that is causing them.

The data provided by Freeze Frame or Failure Records can be useful when trying to determine the cause of a Diagnostic Trouble Code (DTC). These records indicate what was occurring when the DTC was entered into the PCM's memory.

For example, a vehicle comes in with engine miss. You can retrieve the Freeze Frame data to determine if the fuel trim was rich or lean, or what load the engine was under when the miss first occurred. This same type of information is available on Failure Records, even for non-emission-related DTCs. This information will help you learn the conditions which were present when the fault occurred, such as idle, low speed, high speed, high engine temperature, etc., to allow you to efficiently diagnose the system.

If more than one DTC is present, always correct the cause of a component DTC before diagnosing any system DTCs. This is because a component fault, such as a failed sensor, may cause a system diagnostic to fail. Once the failed component is replaced, the cause of the system DTC may be corrected, eliminating the need for further diagnosis.

Also, when diagnosing an OBD II equipped vehicle, remember that a DTC could be caused by the failure of a conventional component. For example, a gradual failure of a fuel pump may cause a drop in fuel pressure which is large enough to set a fuel trim DTC. Don't forget the basics because a vehicle is OBD II equipped.
Diagnosing Intermittent Malfunctions

Of all the different types of conditions that you will see, the hardest to accurately diagnose and repair are random and 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 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 random, intermittent, or occurs only 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 only be run 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 on-board 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 HO2S Heaters, Evaporative Canister Purge, Catalyst Efficiency, and EGR Flow.

Important:

When diagnosing intermittent concerns on an OBD II equipped vehicle, a logical diagnostic strategy is essential.
Navigating Service Publications

Earlier in this section we discussed the need for a logical diagnostic strategy. Driveability complaints, which can be among the most difficult to diagnose, make a logical diagnostic strategy even more important. General Motors Service Manuals support Strategy Based Diagnostics by providing you with logical strategies to help you diagnose customer concerns.

If a customer comes to you with a vehicle concern, but no DTC is in the PCM's memory, the first place to look for information on the symptom is in the Driveability and Emissions section of the Service Manual.

If a DTC is present in the PCM's memory, first move to the section which contains DTC diagnosis. The contents page has a list of the possible DTCs that may be stored in the PCM's memory. Turn to the pages that describe the specific diagnostic tests for the DTC you found.

OBD II provides the technician with more DTCs to help repair the vehicle. The DTC information has been reorganized in the service manual. It is important (as it always has been) to be familiar with the DTC information and to use the added information to help during diagnostics. The DTC information is organized as follows:

**Circuit Description** - This contains information about the normal operation and operating parameters of the system or components.

**Conditions for Setting the DTC (Conditions to Run for Cadillacs)** - This lists the specific enable criteria as well as the exact conditions that caused the DTC to set.

**Action Taken When the DTC Sets** - This lists a description of what the PCM will do when the diagnostic test fails and the DTC is set.

**Conditions for Clearing the MIL/DTC** - This lists the requirements to clear a DTC and what is required to turn off the MIL.

**Diagnostic Aids** - Additional information that should be checked if the condition is not resolved by following the diagnostic table.

**Diagnostic Table** - This table tells you which diagnostic tests to perform and the correct order in which to perform them. This diagnostic table has been redesigned into five columns.
The order in which DTCs are diagnosed has changed. The On-Board System check will often help you determine which DTC to repair first. If the OBD system check does not direct you to the first DTC to diagnose, the DTCs in the following order:

- PCM memory DTCs.
- System voltage and Ignition voltage DTCs.
- Component/circuit DTCs (sensors, etc.).
- System DTCs (misfire, fuel trim, etc.).

If more than one DTC is set in any group, diagnose DTCs from the lowest number to the highest.

Service

Non-OBD II Related Causes Which May Set DTCs or Cause Emission Malfunctions

Some vehicle malfunctions may be created by non-OBD II related causes. These causes could make a system or component malfunction or set DTCs. Items that can cause this to occur include:

- Engine mechanical conditions.
- Vacuum leaks.
- Exhaust leaks.
- Failure to replace a fuel cap.
- Contaminated fuel.
- Driving a vehicle with a very low fuel level (sloshing could allow air to enter the system, causing a misfire condition).

Because OBD II checks for degraded emissions systems as well as component malfunctions, OBD II equipped vehicles are more likely to set DTCs than OBD I equipped vehicles. This is because OBD II vehicles monitor more vehicle systems, and they may also run active diagnostic tests. Whenever a vehicle has a DTC, always check for basic mechanical or electrical causes that could affect the systems or set DTCs.
Cam Retard Offset (V8)

V8 crossfire adjustment is necessary due to differing tolerances between secondary terminals, and the increased number of secondary terminals (refer to figures 14-57 and 14-58). This adjustment applies to crossfire limits only, not timing. The following procedure should be used for 1996 and later L30, L31 and L29 engines:

1. With the ignition "OFF," install the Scan Tool to the vehicle DLC.
2. Start the engine and bring it to operating temperature.
3. Monitor CAM RETARD OFFSET on the scan tool.
4. If CAM RETARD OFFSET indicates a value of $0^\circ \pm 2^\circ$, the distributor is properly adjusted.
5. If CAM RETARD OFFSET does not indicate $0^\circ \pm 2^\circ$, the distributor must be adjusted.

If the distributor needs adjustment:
1. With the engine "OFF," slightly loosen the distributor retaining screw.
2. Start the engine and again monitor the CAM RETARD OFFSET located in the ENGINE 2 data list.
3. Rotate the distributor as follows:
   - To compensate for a negative reading, rotate the distributor counterclockwise
   - To compensate for a positive reading, rotate the distributor clockwise
4. Momentarily "crack" the throttle to raise engine speed above 1,000 RPM. (This will update the CAM RETARD OFFSET value.)
5. Repeat Steps 3 and 4 until the correct value is obtained.
6. Tighten the distributor screw to specifications.

Figure 14-57, Strategy Based Diagnosis

Figure 14-58, X-Ray View of Distributor (from top)
9. Appendix

Scan Tool Usage

Tech 1 Hardware

In order to access the data of OBD II compliant PCMs with the Tech 1 scan tool, special equipment is required. For the Tech 1 to interpret the Class 2 Data Bus used by OBD II, it is necessary to use the Tech 1 application kit part number 7000041 (refer to figure 14-59).

GM has developed a new scan tool called the Tech 2. This tool will connect directly to the DLC and will not require this application kit.

![Tech 1 OBD II Application Kit Configuration](image1)

![Tech 1 Series A OBD II Application Kit Configuration](image2)

Figure 14-59, Tech 1 OBD II Application Kit

Note: The Tech 1 Series A is powered through the DLC, and does not need to be plugged into the cigar lighter. The Series A also must not be used with the 14/21 VIM adapter #3000086. Also, when using the Tech 1 Series A, remove the 12/14 PIN adapter (P/N TA01140) from the Series A data connector cable.
EEPROM Reprogramming

Techline equipment is able to reprogram the Electronically Erasable Programmable Read Only Memory (EEPROM) in the PCM of many vehicles (refer to figure 14-60). EEPROM is not specifically an OBD II feature. Some non-OBD II compliant PCMs have EEPROM.

The Service Programming System (SPS) is the method used to reprogram the EEPROM. There are three methods:

- Direct Programming.
- Remote Programming.
- Off-Board Programming.

It is important that the equipment used in programming communicates only with the PCM that will be reprogrammed. PCMs have internal security that will not allow them to be programmed with another PCM's information. If replacing a PCM, only communicate with the new PCM. The vehicle information will need to be input through the Techline equipment. Uploading information from the old PCM will result in a reprogramming failure when the new PCM is being reprogrammed (refer to the Service Manual for additional information on replacing a PCM).

Important:

Before programming, the battery must be between 12 and 14 volts. If the battery requires charging, it must be completed before programming. Do not attempt to program while charging the battery.

Direct Programming

To direct program the PCM, connect the Techline terminal to the vehicle DLC, then follow the directions on the diagnostic menu as they appear on the terminal's screen.
Remote Programming

Remote programming uses the Tech 1 to transfer data from the Techline terminal to the PCM. This is accomplished by performing the following steps:

1. Connect the Tech 1 to the vehicle's DLC.
2. Enter the vehicle information into the Tech 1 from the Programming application.
3. Gather VIN and current calibration using Tech 1. Press EXIT.
4. Disconnect the Tech 1 from the DLC and connect it to the Techline terminal.
5. If the PCM to be programmed was not previously programmed, or if the VIN recorded from the PCM did not match the vehicle, enter the vehicle information into the Techline terminal.
6. Download the new data from the Techline terminal to the Tech 1.
7. Reconnect the Tech 1 to the vehicle’s DLC. Download the data from the Tech 1 into the PCM.

All supported Techline terminals can be used for remote programming when the Tech 1 is used as an intermediary. However, the Tech 1 must be equipped with a Mass Storage Cartridge (MSC) and the reprogramming software.

Always be certain the VIN is correctly entered into the Tech 1 or other Techline terminals.
Off-Board Programming

Off-board programming is used if the PCM must be programmed away from the vehicle. This is performed using the Off-Board Programming Adapter (OBPA) Kit, part number J 41207-B. The OBPA can be connected to either the Techline terminal for direct programming of the PCM or to the Tech 1 for remote programming of the PCM.

Figure 14-60, PCM Programming
Hot Keys

When using the Tech 1 with an OBD II equipped vehicle, you will find that there are "Hot" keys which allow you to take shortcuts to retrieve information. By pressing the "Hot" key, you will immediately gain access to another function of the Tech 1.

F2

From the Data List, press the F2 key. This will display any DTCs that are stored in memory. Holding the F2 key when a DTC is displayed will bring up a brief description of the DTC. When the F2 key is released, the screen will return to the previous display.

From the engine Data List, pressing the F2 key will display only the DTCs related to engine management. From the transmission data list, pressing F2 will display DTCs related to transmission operation.

F6

F6 is for passenger cars only. From Data List, press the F6 key. This will show DTC status for the current ignition cycle. The Tech 1 can determine if a diagnostic has run this ignition cycle and if it has passed or failed. If a diagnostic has both passed and failed this ignition cycle, it will display Int for intermittent.

F7

While in any of the selected Data Lists, a different Data List can be viewed by pressing the F7 key. This will switch the Tech 1 screen to the next data list selection without having to exit. For example, while in the ENGINE 1 data list, pressing the F7 key will switch the display to the ENGINE 2 data list.

The F7 key will also work while viewing DTC information. Pressing F7 will switch the Tech 1 from one DTC screen to the next screen without having to press exit.
DTC Information

The Tech 1 will display DTC information stored in the Diagnostic Executive. This information will be available by request through the DTC INFO menu.

The following is a list of the DTC messages displayed under DTC Info on the Tech 1:

• **HISTORY**: This lists DTCs that are stored in the control module history memory. It will not display type B DTCs until they have failed two consecutive trips.

• **MIL REQUEST**: This lists DTCs that are requesting the illumination of the MIL. Type C and D DTCs will not be listed in this category.

• **LAST TEST FAIL**: This lists DTCs that have failed the last test that was run. The last test run could have occurred during an earlier trip for type A and B DTCs. For type C and D DTCs, this message means that the last test failed during the current ignition cycle.

• **TEST FAIL SCC** (Test Fail Since Codes Clear): This lists DTCs that have reported a test failed since the last time the DTCs were cleared.

• **NOT RUN SCC** (Not Run Since Codes Clear): This lists DTCs that have not run since the DTCs were cleared. Any DTCs that are displayed here have not run the diagnostic test and the status of the particular system is unknown.

• **FAIL THIS IGN**: This lists DTCs that have failed the current ignition cycle.

• **DTC STATUS**: This lists DTC status (refer to figure 9-3). DTCs that have not been tested will be listed as a NO under the "RAN" heading and "- - -" under the "FAIL" heading. DTCs that have run and passed will not be listed under DTC status. Tests that have run and failed will have YES under the "RAN" heading and YES under the "FAIL" heading. If the latest test passed but it failed previously, the status will display "INT" for a possible intermittent condition. The current status is based on the latest test that ran.

![DTC Status Screen on Tech 1](image-url)
Capture Information (CAPTURE INFO)

CAPTURE INFO is a feature that allows the Tech 1 to store Diagnostic Trouble Codes, Freeze Frame and Fail Records data held in the PCM memory. This allows the DTCs, Freeze Frame and Fail Records data to be cleared from the PCM memory and the information to still be available for display in the Tech 1.

When CAPTURE INFO is selected, the scan tool displays a menu selection that allows you to store, in the scan tool memory, data from the PCM memory (RETRIEVE INFO), or replace the data stored in the scan tool with new data from the PCM memory (REFRESH INFO).

The CAPTURE INFO data saved in the scan tool memory is not cleared by the Clear Info command. The saved Capture Info data will be cleared when updating (refreshing) the Capture Info data with the most current data stored in the PCM.

CAPTURE INFO is a different function than SNAPSHOT. CAPTURE INFO retrieves Freeze Frame and Fail Records data which are in the PCM memory. The Tech 1 is capable of downloading the captured information from the PCM memory into the Tech 1. SNAPSHOT is a Tech 1 function. SNAPSHOT records live data list information into Tech 1 memory.
System Information (SYS. INFO)

System Status

System Status information is a display of the Inspection Maintenance (I/M) Flags. The System Status (I/M) Flags are an indication that all the diagnostics of certain critical emissions-related systems have run. This information may be required in some states for I/M test programs, such as the I/M 240. The EPA may refer to the System Status (I/M) Flags when auditing vehicles as part of the FTP (Federal Test Procedure). This information may also be useful for technicians to determine if diagnostics have run when verifying repairs.

The SYS INFO on the Tech 1 displays a list of emission system or component diagnostics under the heading TEST (refer to figure 9-4). Each diagnostic requires at least one, and sometimes several, diagnostic tests to be completed. Once all tests are completed, the N (for No) under the COMPLETE column will change to a Y (for Yes). This indicates the diagnostics have been completed. This does not mean that diagnostics have passed, only that they have run. If a diagnostic test failed, a DTC will be stored.

The System Status (I/M) Flags will be cleared if any of the following occurs:

- The PCM power or ground has been disconnected.
- The battery has been disconnected or discharged below operating voltage.
- The DTCs have been erased after completion of repairs (only the flags that pertain to the DTCs that were stored will be cleared).
- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to set the flags.

It is not necessary to set all the System Status (I/M) Flags unless it is a requirement for emissions testing in your area. It is, however, useful for verifying the integrity of the emissions systems on a vehicle and a valuable tool for repair verification. To set all the flags, it is necessary to drive the vehicle under specific conditions. Most flags will set during normal driving conditions, but it may take numerous trips by the customer. In order to set all the flags, it is necessary to perform a Drive Cycle.

<table>
<thead>
<tr>
<th>SYSTEM STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST</td>
</tr>
<tr>
<td>Catalyst</td>
</tr>
<tr>
<td>Catalyst heater</td>
</tr>
<tr>
<td>HO2S</td>
</tr>
<tr>
<td>HO2S heater</td>
</tr>
<tr>
<td>EGR system</td>
</tr>
<tr>
<td>Evap</td>
</tr>
<tr>
<td>Misfire</td>
</tr>
<tr>
<td>Comp Mon</td>
</tr>
<tr>
<td>Fuel sys</td>
</tr>
<tr>
<td>Air</td>
</tr>
</tbody>
</table>

Figure 14-62, System Status
10. Reference

Glossary

Acronym
A word formed from the initial letter or letters of each successive part or major parts of a compound term. Example: CARB (California Air Resources Board).

Active Testing
Diagnostic testing in which the PCM controls the system or component in a specific action while monitoring takes place.

AIR
An abbreviation for Secondary Air Injection. An emissions system found primarily on large-engine vehicles that pumps fresh air into the exhaust stream to reduce HC and CO emissions.

Baud Rate
The speed at which bits of computer information are transmitted on a serial data stream. Measured in bits per second (bps).

Bit
The individual voltage signal of a serial data stream; also, the smallest unit of measurement recognized by a computer. Refers to a digital data transfer rate. Class 2 data has a 10.4 kilobits per second transfer rate.

Class 2
The type of digital data stream utilized in most GM OBD II diagnostic systems. Faster than UART, the data stream used on non-OBD II diagnostic systems. Class 2 uses two-bit pulse widths and toggles between 0 (passive) and 7 volts (active).

CO
An acronym for Carbon Monoxide, a colorless, odorless and highly poisonous gas. It is formed by incomplete combustion of gasoline.
Diagnostic
Any number of on-board tests run by the Diagnostic Management System which checks for malfunctions, errors or breakdowns in vehicle systems or components.

Diagnostic Executive
The Diagnostic Management System software that stores testing results and controls the illumination of the lamps.

Diagnostic Management System
The PCM system responsible for performing testing of powertrain components and systems, recording testing results and performing TEST FAIL actions.

DIC
An acronym for Driver Information Center. It displays messages to alert the driver of malfunctions, warnings and instructions. The DIC may display alerts related to type C diagnostic trouble codes.

DLC
An acronym for Data Link Connector. Formerly referred to as the ALDL, this is the connector to which diagnostic scan tools are connected. Under OBD II, the DLC is a standardized 16-cavity connector and has a standardized location under the driver-side instrument panel.

DTC
An acronym for Diagnostic Trouble Code. It is also referred to as a fault code or code. Any code stored in the PCM memory.

ECM
An acronym for Engine Control Module, the on-board computer that controls fuel and emissions, as well as diagnostics, for the vehicle’s engine management system.

ECT
An acronym for Engine Coolant Temperature sensor.
**EGR**

An acronym for Exhaust Gas Recirculation. An emissions system which recirculates some of the exhaust gas back into the intake manifold to reduce NOx (oxides of nitrogen) emissions. Under full OBD II implementation, the PCM will monitor the EGR system for effectiveness.

**Emissions**

Gases and particles left over after the combustion event of an engine, or from a fuel system. The primary emissions of concern are hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx).

**Enable Criteria**

These are the exact conditions required for a diagnostic test to run.

**EPA**

An acronym for the Environmental Protection Agency, the federal government agency that establishes regulations and oversees the enforcement of laws related to the environment. Included in these laws are regulations on the amount and content of automotive emissions.

**EVAP**

An abbreviation for Evaporative Emission System. This system is used to collect fuel vapor from the fuel tank. The fuel vapors are drawn into the intake manifold and combusted during certain engine operating conditions.

**Fail Record**

These records store information about operating conditions when a DTC is stored. The PCM has the ability to store multiple Fail Records, and it also has the ability to update Fail Records.

**Freeze Frame**

Operating conditions which are stored in the memory of the PCM at the instant a DTC is stored and the MIL is illuminated. A Freeze Frame is stored for only one DTC and can only be overwritten under certain conditions.
FTP
An acronym for Federal Test Procedure. A stringent series of automotive tests which the EPA uses to measure and certify the emissions output of all fleets of new cars and light-duty trucks sold in the United States.

Fuel Trim
An ECM function that adjusts fuel delivery during closed-loop operation to bring the air/fuel mix to as close to the optimum ratio (14.7:1) as possible.

HC
An acronym for Hydrocarbons. Any number of compounds of carbon and hydrogen used as fuel, such as gasoline. High levels of hydrocarbons in tailpipe emissions are a result of unburned gasoline.

HO2S
An abbreviation for Heated Oxygen Sensor.

IAC
An acronym for Idle Air Control valve.

IAT
An acronym for Intake Air Temperature sensor.

I/M
An abbreviation for Inspection and Maintenance, usually referring to state emissions inspection and testing programs.

Intrusive Diagnostic Test
Any on-board test run by the PCM which could have an effect on vehicle performance or emissions.

ISO 9141
International Standards Organization recommended data communication network interface.
**MAF**
An acronym for Mass Air Flow sensor.

**MAP**
An acronym for Manifold Absolute Pressure.

**MIL**
An acronym for Malfunction Indicator Lamp. The MIL was formerly called the "service engine soon" or "check engine" lamp.

**Misfire**
When incomplete or no combustion occurs in one or more cylinders due to improper fuel, ignition, cylinder compression, or air.

**NOx**
An acronym for Oxides of Nitrogen, a primary emission produced in the combustion chamber under high temperatures when nitrogen combines with oxygen. Oxides of nitrogen contribute to the formation of smog (O3).

**OBD I**
An acronym for On-Board Diagnostics Generation One. An on-board automotive diagnostic system required by the California Air Resources Board since 1988, which uses a microprocessor and sensors to monitor and control various engine driveability functions.

**OBD II**
An acronym for On-Board Diagnostics Generation Two. OBD II expands upon OBD I to include emissions system and sensor deterioration monitoring.

**Passive Testing**
During this type of testing, the PCM monitors the component or system during normal operation.

**PCM**
An acronym for Powertrain Control Module, the on-board control module that monitors both engine and transmission/transaxle functions.
SAE
An acronym for the Society of Automotive Engineers, a professional organization made up of automotive engineers and designers that establishes standards and conducts testing for many automotive-related functions.

Statistical Filtering
The PCM internally charts the results of diagnostic testing over a period of time and creates a baseline for testing. By doing this, the PCM is able to filter out information that could cause a false DTC to set.

System Status (I/M Ready)
A signal for emission testing which states that all the vehicle’s on-board emissions diagnostics have been run. System status (I/M ready) is not concerned whether the emission system passed or failed the test, only that it was run.

TCC
An acronym for Torque Converter Clutch. A clutch device found in automatic transaxles or transmissions which creates a fluid coupling between the engine and the final drive output.

TP
An acronym for Throttle Position sensor.

TRIP
A key cycle (key ON, run, key OFF/power-down) where the enable criteria for a particular diagnostic are met and the diagnostic test runs.

TWC
An acronym for Three-Way Converter.

UART
Universal Asynchronous Receive and Transmit. The type of data stream used on non-OBD II diagnostic systems. UART toggles between 5 volts (passive) and 0 volts (active).
VCM
An acronym for Vehicle Control Module, the on-board computer that controls the engine management, transmission, and other systems such as anti-lock brakes.

Warm-Up Cycle
The PCM uses warm-up cycles instead of key cycles to clear DTCs. A Warm-Up Cycle is achieved when the engine coolant temperature rises at least 22°C (40° F) from start-up and achieves a minimum temperature of 71°C (160° F).