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Introduction

NATEF Tasks

Engine Performance

For every task in Engine Performance the following safety requirement must be strictly enforced:

Comply with personal and environmental safety practices associated with clothing; eye protection; hand tools; power equipment; proper ventilation; and the handling, storage, and disposal of chemicals/materials in accordance with local, state, and federal safety and environmental regulations.

A. General Engine Diagnosis

1. Identify and interpret engine performance concern; determine necessary action. P-1

2. Research applicable vehicle and service information, such as engine management system operation, vehicle service history, service precautions, and technical service bulletins. P-1

11. Diagnose engine mechanical, electrical, electronic, fuel, and ignition concerns with an oscilloscope and/or engine diagnostic equipment; determine necessary action. P-1

B. Computerized Engine Controls Diagnosis and Repair

3. Diagnose the causes of emissions or driveability concerns resulting from malfunctions in the computerized engine control system with stored diagnostic trouble codes. P-1

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

9. Diagnose driveability and emissions problems resulting from malfunctions of interrelated systems (cruise control, security alarms, suspension controls, traction controls, A/C, automatic transmissions, non-OEM-installed accessories, or similar systems); determine necessary action. P-3

C. Ignition System Diagnosis and Repair

1. Diagnose ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns on vehicles with electronic ignition (distributorless) systems; determine necessary action. P-1

2. Diagnose ignition system related problems such as no-starting, hard starting, engine misfire, poor driveability, spark knock, power loss, poor mileage, and emissions concerns on vehicles with distributor ignition (DI) systems; determine necessary action. P-1
D. Fuel, Air Induction, and Exhaust Systems Diagnosis and Repair

1. Diagnose hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems on vehicles with carburetor-type fuel systems; determine necessary action. P-3

2. Diagnose hot or cold no-starting, hard starting, poor driveability, incorrect idle speed, poor idle, flooding, hesitation, surging, engine misfire, power loss, stalling, poor mileage, dieseling, and emissions problems on vehicles with injection-type fuel systems; determine necessary action. P-1

E. Emissions Control Systems Diagnosis and Repair

1. Positive Crankcase Ventilation
   Diagnose oil leaks, emissions, and driveability problems resulting from malfunctions in the positive crankcase ventilation (PCV) system; determine necessary action. P-2

2. Exhaust Gas Recirculation
   Diagnose emissions and driveability problems caused by malfunctions in the exhaust gas recirculation (EGR) system; determine necessary action. P-1
   Inspect, test, service and replace components of the EGR system, including EGR tubing, exhaust passages, vacuum/pressure controls, filters and hoses; perform necessary action. P-2

3. Exhaust Gas Treatment
   Diagnose emissions and driveability problems resulting from malfunctions in the secondary air injection and catalytic converter systems; determine necessary action. P-2

4. Intake Air Temperature Controls
   Diagnose emissions and driveability problems resulting from malfunctions in the intake air temperature control system; determine necessary action. P-3

5. Early Fuel Evaporation (Intake Manifold Temperature) Controls
   Diagnose emissions and driveability problems resulting from malfunctions in the early fuel evaporation control system; determine necessary action. P-3

6. Evaporative Emissions Controls
   Diagnose emissions and driveability problems resulting from malfunctions in the evaporative emissions control system; determine necessary action. P-1
STC Competencies

H. Strategy Based Diagnostics (SBD)

1. Describe how to apply Strategy Based Diagnostics
2. Describe how to verify the customer concern
3. Describe how to conduct a visual inspection
4. Explain how to research a vehicle using Service Bulletins and Vehicle Service Records
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 13 Diagnosis, the ASEP student will be able to:

• Apply Strategy Based Diagnostics
• Describe Preliminary Checks
• Describe Published Diagnostic System Checks
• Explain bulletin search procedures
• Explain Stored DTC diagnostic procedures
• Explain Symptom No DTC diagnostic procedures
• Explain No Published Diagnostic procedures
• Describe Intermittent diagnostic procedures
• Navigate Service Information (eSI)
Overview

Although the diagnostic path will be determined by the fault, there are some engine performance checks that can be performed. These are all fully supported in the service information and are generally part of a diagnostic procedure. The purpose of exploring these outside of the service procedures is to provide an understanding of what they are and the information they will provide.

This module does not contain all the possible tests that are used to diagnose engines and the sections on fuel and ignition do not apply to diesel engines. Diesel engines operate very differently from gas engines and modules are available that provide diagnostic approaches for diesel engines.

Air Intake

The air intake system is essential for airflow into the engine. It has a system of ductwork with an air filter to prevent debris from entering the engine. Most new vehicles will also have a mass air flow sensor located in the ductwork after the air filter. If the air intake is damaged or restricted, it can prevent sufficient airflow to the engine, reduce power and potentially cause a misfire.

The following are the air intake system checks (figure 13-1): Air inlet for obstructions

- Air filter for clogging
- MAF sensor for debris
- Air leaks after the MAF sensor
- Damaged or restricted air ducts
- Damaged or leaking air intake manifold
- Missing, damaged or disconnected vacuum hoses

Many of the newer air intake systems have a restriction gauge, also known as a change filter gauge. This can be used to initially check the system for possible restrictions. However, make certain that the gauge is reset before testing since the environment that it works in can result in contamination.

Reset the gauge and then restart the engine. Open the throttle several times to place a vacuum on the system and then check the gauge. If the gauge indicates a restriction, check the filter. If the filter is good, then check the rest of the system for restrictions.

Figure 13-1, Air Intake System (Typical)
Fuel System

The fuel system is responsible for providing fuel to the engine (figure 13-2). The system uses a pump to provide fuel to a fuel rail, where it is stored until utilized by the fuel injectors. Fuel systems vary by the vehicle application and many times the special tools are unique to the engine.

The fuel system, like other engine control systems, has several DTCs related to its components and operation. If a DTC is stored, diagnose it first. DTCs like PO300 will require a complete diagnosis of the fuel system to determine if it is operating correctly.

If a DTC is not stored but incorrect engine operation is suspected, the fuel system should be checked to determine if it is operating correctly.

Figure 13-2, Fuel System (Typical)
Injector Test Light

When checking the fuel system start with the easiest thing first. Use an injector test light (noid light) to see if the injectors are firing. This tool is specific to the engine and vehicle, and it is commonly referred to as a noid light (figure 13-3). The tool contains an LED that will flash as the PCM provides pulsed power on the injector circuit. The rate of flashing will increase as the engine speed increases.

If there is a fault, the light will either flash erratically or not flash. This is generally an indication of either a control circuit fault or PCM driver fault. Also remember, the PCM cannot control the fuel injection system correctly if the inputs are providing incorrect information. The primary inputs for fuel injection are:

- Manifold Absolute Pressure (MAP) sensor
- Mass Air Flow (MAF) sensor
- Throttle Position (TP) sensor
- Accelerator Pedal Position (APP) sensor (if so equipped)
- Crankshaft Position (CKP) sensor. Camshaft Position (CMP) sensor
- Intake Air Temperature (IAT) sensor. Engine Coolant Temperature (ECT) sensor
- Oxygen (O2) sensor (used during closed loop)

There are additional inputs used for fuel control, but they are generally used to fine-tune the basic control.
Fuel Pressure Testing

Next, check the fuel pressure. This test will help identify any leaks that could be resulting in fuel starvation. It will also indicate high pressure, which can result in excess fuel delivery and misfire. If excessive or insufficient fuel delivery is identified, there are special tools available that can help isolate the source (figures 13-4 and 13-5).

Fuel pressure can be checked at the fuel rail tap, using a fuel pressure gauge and the appropriate adapter if necessary. The service information will contain specifications for the correct fuel pressure. The diagnostics will generally check pressure build-up and pressure bleed down with the fuel pump off. The system fuel pump should be able to rapidly pressurize the fuel rail to the specified range and then able to maintain the correct pressure when the pump is turned off.

If initial checks indicate a malfunction, the fuel system shut-off tools must be used to isolate the source (figure 13-5). When the checks indicate a rail-mounted regulator malfunction, take the time to check the vacuum hose connected to the pressure regulator. It uses manifold vacuum to control the pressure of the fuel in the rail. Its hose must be connected and undamaged. Also check it for restrictions. It is also generally connected with a series of other hoses. If these hoses are damaged or disconnected, the pressure regulator may not operate correctly. These checks do not apply to a "returnless" system, where the regulator is in the tank.

Figure 13-5, Fuel System Schematic with Tools Installed
Fuel Trim and Oxygen Sensor Readings

Fuel trim numbers and oxygen sensor readings can also be very useful for an experienced driveability technician, but they can be easily misinterpreted if not commonly used for diagnosis. In general, trim numbers (either negative or positive) indicate that the PCM is trying to compensate for the operating conditions. If the numbers are above +10% or below -10%, this can indicate a concern, but testing will be required to isolate the root cause.

There are two types of fuel trim numbers: short term and long term (figure 13-8). These were once known as integrator and block learn, respectively. The short term fuel trim numbers control the fine-tuning of the fuel system, and it is normal for these numbers to fluctuate. If the short-term fuel trim adjustment cannot compensate for the engine operating conditions, the PCM will adjust the long-term fuel trim. Short-term fuel trim only has a limited amount of adjustment.

Long-term fuel trim contains the learned information that the PCM uses to perform larger, more permanent, adjustments to fuel control (figure 13-9). These larger changes do not frequently fluctuate like short term.

![Figure 13-8, Scan Tool Fuel Trim Numbers](image)

![Figure 13-9, Fuel Trim Percentages](image)
If the long-term fuel adjustment becomes too large, the PCM will store a DTC since the system is operating outside of the normal parameters for fuel control. This generally indicates either a concern in the fuel system or with the inputs used to control fuel. However, malfunctions that result in incorrect combustion will also have a large effect on the fuel trim numbers since the PCM will try to compensate. Anything that causes the oxygen sensors to either indicate an excessively lean or rich condition (even if it is false), will affect the fuel trim numbers. This can include:

- **Engine mechanical concerns**
  - Low compression
  - Damaged spark plugs
  - Carbon deposits
- **Exhaust concerns**
  - Leaks
  - Incorrect air injection operation
  - Damaged 02 sensors

Oxygen (02) sensors are a major input for fuel control during closed loop (figure 13-10). Also with the introduction of OBD II, oxygen sensors are used to monitor the efficiency of the catalytic converter. Oxygen sensors monitor the amount of free oxygen in the exhaust stream. They do not measure richness or leanness. However, the PCM uses this input to make an "educated guess" at what this input indicates about the conditions in the combustion chamber.

As long as everything is operating correctly, this "educated guess" is very close. However, if a malfunction (such as a cracked exhaust manifold) occurs, the oxygen sensor can provide "false" information. It provides what it actually sees, but due to the malfunction, it is not an indication of what occurred during combustion. This can result in incorrect control during closed loop operation.

*Figure 13-10, Oxygen Sensor Designation (V-8 Example)*
On OBD II-complaint vehicles, the pre-catalyst sensors can range between 100 and 900 millivolts. However, the voltage fluctuations generally range from approximately 300 to 600 millivolts in closed loop with the engine operating at a near ideal fuel ratio (stoichiometric). The post-catalyst sensors will be much flatter.

An extended low voltage indicates a high amount of oxygen in the exhaust system, which is interpreted as a lean condition. An extended high voltage indicates a low amount of oxygen in the exhaust system, which is interpreted as a rich condition (figure 13-11).

Figure 13-11, Oxygen (02) Sensor Voltages
Ignition System

The ignition system is responsible for providing a spark for ignition. There are many different systems; however, most current ignition systems are distributorless and have multiple ignition coils (figure 13-12).

![Figure 13-12, Coil Near Plug Ignition System (GEN III)](image)

The first basic test for the ignition system is the spark test. It uses the spark tester, which is a special tool (J 26792) and commonly called the ST-125 (figure13-13). It connects to the spark plug wire and will provide a bright blue spark when the coil provides sufficient voltage. Some systems will require additional steps to use this tool since they do not use spark plug wires.

If the tester does not provide a bright blue spark, the plug will not fire, and there will be a misfire in that cylinder. Check the resistance of the plug wires and then follow the service procedures to further diagnose the system.

![Figure 13-13, Spark Tester (J 26792)](image)
Insufficient spark or no spark can be the result of the following (figure 13-14):

- **Coil malfunction**
  - Open, short (to ground or across the coil) or high resistance in either the secondary or primary

- **Coil circuit**
  - Carbon tracking on the coil or plug wire (providing a short to ground)

- **Ignition Control Module (ICM) malfunction**
  - Damaged internal circuits
  - Damaged circuits (wiring, connectors) between the ICM and PCM

- **PCM malfunction**
  - Internal malfunction
  - Incorrect inputs
  - Damaged control circuits (including terminals, connectors and wires) - Calibration

- **Triggering circuit malfunctions**
  - CKP or circuit damage
  - CMP or circuit damage

If there is a good spark, the plug still needs to be checked since it may be damaged (cracks, carbon tracking, etc.). Swapping plugs can be a useful method to determine if the spark plug is damaged and inoperative. If a plug is damaged, it will generally create a misfire. When the spark plugs are swapped, the misfire should move with the plug. Also consider incorrect spark plugs if the concern occurs in multiple cylinders or is related to engine temperature. This is because engines are designed to operate with spark plugs that meet a specific heat range, have a specific gap and position the spark plug tip at the correct depth in the cylinder head.
Also remember, a good spark doesn't indicate that the plug is being fired at the correct time. Make sure plug wires are not crossed and that the engine is being fired in the correct order.

Figure 13-14, Ignition System Circuit
Next Steps

If the previous diagnostics do not isolate a fault, it's time to consider a mechanical or emission system fault. There is also the possibility there is a sensor fault that did not set a DTC. Sensor faults that cause engine concerns but do not set DTCs should only be diagnosed by a driveability technician. Without proper training, these can be very difficult to isolate.

Sensors

The following are the primary sensors for engine control:

- Mass Air Flow (MAF) sensor
- Heated Oxygen Sensor (HO2S)
- Throttle Position (TP) and/or Accelerator Pedal Position (APP) sensor
- Engine Coolant Temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Manifold Absolute Pressure (MAP) sensor
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Knock sensor

These sensors provide signals to the PCM that help determine the engine operating conditions and the control necessary for these conditions. All of these sensors have DTCs related to them, and on OBD II compliant vehicles, the PCM will often compare their input to other sensor values to determine if they are providing accurate information.

However, some sensor faults may not produce a DTC. If this occurs, the PCM will not be aware that the sensor information is incorrect and engine performance can be affected. The data list on the scan tool can be used to monitor sensor input to the PCM and may indicate when a sensor is providing incorrect information. Be cautious when using this information. The data list can be too slow to catch very transient (rapidly fluctuating) faults, and sometimes the data list displays a substitute value when the PCM detects a fault. Also, you can use a known good vehicle to compare data values with the suspect vehicle.
MAF Sensor

The MAF sensor measures the amount of airflow into the engine. The measurement is provided in grams per second (figure 13-15). The amount of airflow considered normal will be based on the engine, but airflow should be low at idle and increase as the throttle plate is opened and the engine speed increases.

Figure 13-15, MAF Sensor

Oxygen Sensor

The oxygen sensor provides information on the amount of oxygen in the exhaust system. Heated oxygen sensors have been used for several years to achieve reliable voltage output quicker. The oxygen sensors are used during closed loop operation, and their feedback is provided in millivolts. The pre-catalyst sensors should provide a voltage that fluctuates from approximately 300 and 600 millivolts. Extended low voltage indicates a lean/high oxygen condition, and high voltage indicates a rich/low oxygen condition (figure 13-16). The post-catalyst sensor should provide a similar voltage range but will fluctuate much less.

Figure 13-16, Oxygen Sensors
TP and APP Sensors

The TP and APP sensors provide throttle plate angle and accelerator pedal position. Both provide an input that is measured in voltage and will vary from 0.25-5 volts (figure 13-17). The PCM can also provide data on the calculated percentage (0-100%) of angle. The APP and the "drive-by-wire" TP sensors use multiple potentiometers and will provide multiple inputs. The inputs will follow different voltage ranges for the various positions of the throttle or accelerator pedal.

![Figure 13-17, TP and APP Circuit Schematic](image-url)
ECT and IAT Sensors

The ECT/IAT are both thermistors that change resistance based on temperature (figure 13-18). The resistance determines the voltage provided to the PCM. The PCM uses the voltage to calculate the temperature. The PCM will display the calculated temperature on the data list. If the engine is at ambient temperature, the ECT and IAT inputs should both indicate a temperature near ambient.

![ECT and IAT Sensor Circuit Schematic](image)

**Figure 13-18, ECT and IAT Sensor Circuit Schematic**

MAP Sensor

The MAP sensor measures the negative pressure (vacuum) in the intake manifold and provides a voltage signal to the PCM (figure 13-19). The PCM uses this signal to calculate the pressure. The PCM can display the information from the MAP as either voltage or kilopascal (kPa). Kilopascals are a metric measurement of pressure. Generally, it will vary from 20 to 48 kPa (1.0-2.0V). At idle, the MAP reading should be low and increase as the throttle angle increases.

![MAP Sensor Circuit Schematic](image)

**Figure 13-19, MAP Sensor Circuit Schematic**
CKP and CMP Sensors

The Camshaft (CMP) and Crankshaft Position (CKP) sensors are used to determine engine speed and the location of the pistons in the four-stroke cycle (figure 13-20). This is important information for sequential fuel control and for systems that use coil-on-plug spark control. The data for these sensors will vary based on the type of sensor and the system. Refer to the service information for the specific vehicle. It will provide the data available and the normal range of operation. Some systems also have additional information related to fuel and spark control resulting for the engine inputs.

Knock Sensor

The knock sensor produces a voltage signal when an engine knock (detonation) is detected (figure 13-20). This signal is used to control spark timing. If the PCM is detecting knock, it will adjust the spark timing, and this will be displayed as the knock retard. It can vary from 0-16 degrees. Some systems will also display the knock sensor input on the data list.

Figure 13-20, CKP, CMP and Knock Sensor Circuit Schematic
Engine Mechanical Testing

If a mechanical fault is suspected, there are several tests that can be used to isolate it:

- Manifold vacuum test
- Compression test
- Cylinder leakage test
- Restricted exhaust test

Manifold Vacuum Test

The manifold vacuum test uses a vacuum gauge to measure vacuum in the intake manifold (figure 13-21). This test can be used to determine the basic condition of the engine when compared to vacuum charts (figure 13-22). This test is only a preliminary check for engine mechanical concerns since testing results can be inconclusive due to intake manifold design, engine operation and location of vacuum tap.

*Figure 13-21, Manifold Gauge Check*
### Manifold Vacuum Gauge Testing Results

<table>
<thead>
<tr>
<th>Readings</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Average, steady readings between 15–22 inches Hg (normal readings</td>
<td>1. Normal</td>
</tr>
<tr>
<td>2. Low but steady, between 12 and 15 inches Hg</td>
<td>2. Leakage around piston rings, late ignition timing, or late valve timing</td>
</tr>
<tr>
<td>3. Needle fluctuates or drops between 1 and 2 inches Hg at idle</td>
<td>3. Burned or leaking valve or spark plug in one of the cylinders is not firing</td>
</tr>
<tr>
<td>4. Irregular needle drop between 1 and 2 inches Hg</td>
<td>4. Sticking valve, intermittent spark plug misfire, or rich or lean air/fuel mixture</td>
</tr>
<tr>
<td>5. Normal at idle speed, but excessive vibrations at higher rpm</td>
<td>5. Weak valve springs; valves sticking in guides</td>
</tr>
<tr>
<td>6. Excessive vibrations at idle speed, but steadies at higher rpm</td>
<td>6. Worn valve guides</td>
</tr>
<tr>
<td>7. Excessive vibration at all rpm</td>
<td>7. Leaky head gasket</td>
</tr>
<tr>
<td>8. Needle oscillates slowly, or drifts, between 3 and 9 inches Hg lower</td>
<td>8. Intake system leak</td>
</tr>
<tr>
<td>9. Normal at idle speed, but after “snapping” throttle, vacuum drops</td>
<td>9. Restriction in exhaust system</td>
</tr>
<tr>
<td>to near zero and rises to lower than normal</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 13-22, Manifold Vacuum Gauge Testing Results*
Compression Test

The static compression test is one of the best tests for engine mechanical concerns (figure 13-23). It tests the ability of the engine to draw-in air and compress it. The test uses a compression gauge and requires the engine to be cycled through four compression strokes (puffs) with all spark plugs removed. The readings from all cylinders are compared against each other and the minimum specification for the engine. Weak cylinders show-up as below the minimum specification or outside the range of the other cylinders.

A second version of the compression test is the running compression test. It checks the dynamic operation of the cylinder. This test is generally only necessary to identify cylinders with intermittent compression concerns (sticky valves, bad valve guide, etc.).

Cylinder Leakage Test

The cylinder leakage test is used to isolate the source of a leak when a cylinder has failed the compression test (figure 13-24). The tool for this test connects to the spark plug hole and applies pressurized air to the cylinder when positioned at the compression stroke. With air applied, the leak can be isolated by checking for air at the tail pipe, oil fill tube, intake manifold and bubbles in the radiator.
Restricted Exhaust Test

The last engine mechanical test is restricted exhaust (figure 13-25). A restricted exhaust system can prevent the cylinder from completely expelling all the exhaust. This displaces the air/fuel mixture and can cause reduced power, possible misfire or partial misfire. The restricted exhaust test uses a pressure gauge to measure the amount of pressure in the exhaust system during both idle and at an elevated rpm (generally 2000 rpm). The pressure should be at or below 2 psi. If it is above this, the exhaust system must be inspected for restrictions. It is possible on dual exhaust systems for only one side to be restricted and only one bank of cylinders to be operating abnormally.

Figure 13-25, Restricted Exhaust Test
Emission Systems

The operation of the emission systems can have a large effect on the operation of the engine when they are not operating correctly. The following are the primary emission systems:

- EGR
- EVAP
- Secondary Air Injection System
- PCV

Exhaust Gas Recirculation

The EGR system is used to reduce emissions by allowing exhaust gases into the combustion chambers (figures 13-26 and 13-27). Generally, the PCM compensates for the operation of the EGR; however if it is malfunctioning, it can produce a chuggle. A common concern with EGR valve is carbon deposits on the pintle valve, which allows exhaust gases into the intake. Since the valve is held open when the PCM is not commanding the EGR operation, the PCM does not compensate for the mixture change and engine performance is affected.

Figure 13-26, Linear EGR
Evaporative Emissions System

The EVAP system is used to direct evaporative emissions from the fuel tank (stored in the canister) into the intake for consumption by the engine (figure 13-28). If this system allows evaporated fuel into the intake when the PCM is not commanding it, the fuel ratio will be too rich. Check to make sure the purge solenoid is closed until purge is commanded.
Secondary Air Injection

The secondary air injection system uses an air pump to deliver fresh air into the exhaust system (figure 13-29). This will increase the efficiency of the catalytic converter. If this system operates when commanded off, the oxygen sensors can detect a false lean condition and enrich the fuel. This can result in a misfire due to excessive fuel. Check to see if the pump is running when commanded off by the PCM.

![Secondary Air Injection System](image)

Positive Crankcase Ventilation

The PCV is used to direct crankcase gases into the intake manifold (figure 13-30). If this valve malfunctions, excessive crankcase gases and oil can be directed into the intake manifold. This can result in oil fouling, carbon deposits and misfires.

![PCV System](image)
Strategy Based Diagnosis

Accurate diagnosis of any system fault requires an organized systematic approach to your work. GM Strategy Based Diagnostics (SBD) provides the guidance to create such an approach for any diagnostic situation. The SBD process consists of three parts; the diagnostic thought process and problem solving, the vehicle specific diagnostic flow chart which provides the application specific details, and the knowledge and experience of the technician.

Refer to eSI Document ID# 6856

The goal of Strategy Based Diagnostics is to provide guidance when you create a plan of action for each specific diagnostic situation. Following a similar plan for each diagnostic situation, you will achieve maximum efficiency when you diagnose and repair vehicles. Although each of the Strategy Based Diagnostics boxes is numbered, you are not required to complete every box in order to successfully diagnose a customer concern. The first step of your diagnostic process should always be, verify the Customer Concern box. The final step of your diagnostic process should be Repair and verify the Fix box 7. Refer to the following chart for the correct Strategy Based Diagnostics.

(1) Verify the Customer Concern: The first part of this step is to obtain as much information as possible from the customer. Are there aftermarket accessories on the vehicle? When does the condition occur? Where does the condition occur? How long does the condition last? How often does the condition occur? In order to verify the concern, the technician should be familiar with the normal operation of the system and refer to the owner or service manual for any information needed.

(2) Preliminary Checks: Conduct a thorough visual inspection. Review the service history. Detect unusual sounds or odors. Gather diagnostic trouble code (DTC) information in order to achieve an effective repair.

(3) Perform Published Diagnostic System Checks: One or more DTCs may not support a system. System checks verify the proper operation of the system. This will lead the technician in an organized approach to diagnostics.

(4) Check Bulletins and Other Service Information: Use videos, newsletters, and the Pulsat programs.

(5.1) Stored DTCs: Follow the designated DTC table exactly in order to make an effective repair.

(5.2) Symptom No DTC: Select the symptom from the symptom tables. Follow the diagnostic steps or suggestions in order to complete the repair, or refer to the applicable component/system check.
(5.3) No Published Diagnostics: Analyze the Concern. Develop a plan for the diagnostics. The service manual schematics will help you to see system power, ground, and input and output circuits. You can also identify splices and other areas where multiple circuits are tied together. Look at component locations to see if components, connectors or harnesses may be exposed to extreme temperature, moisture, road salt or other corrosives battery acid, oil or other fluids. Utilize the wiring diagrams, system description and operation, and system circuit description.

(5.4) Intermittent: An intermittent condition is one that does not occur continuously and will occur when certain conditions are met. Generally, intermittents are caused by faulty electrical connections and wiring, malfunctioning components, electromagnetic/radio frequency interference, and aftermarket equipment. Combine technician knowledge with efficient use of the available service information. Evaluate the symptoms and conditions described by the customer. Use a check sheet or other method in order to identify the component. Follow the suggestions for intermittent diagnosis found in the service manual. The Tech 1 and Tech 2 scan tools, and the J 39200 (Fluke 87) have data capturing capabilities that can assist in detection of intermittents.

(5.5) Vehicle Operates as Designed: This condition exists when the vehicle is found to operate normally. The condition described by the customer may be normal. Verify against another like vehicle that is operating normally under the same conditions described by the customer. Explain your findings and the operation of that system to the customer.

(6) Re-examine the Concern: If a technician cannot successfully find or isolate the concern, a re-evaluation is necessary. Re-verify the concern. The concern could be an intermittent or normal.

(7) Repair and Verify Fix: After isolating the cause, make the repairs and validate for proper operation. Verify that the symptom has been corrected, which may involve road testing the vehicle.

Application of SBD to Engine Performance

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 Information (eSI) 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 Engine Controls section of the Service Information.

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 information. 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 Cadillac)** - 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, 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.
Diagnostic Approach

Starting Point
Reference eSI Document ID# 661938

Diagnostic Starting Point - Engine Controls

Begin the system diagnosis with Diagnostic System Check - Engine Controls. The Diagnostic System Check-Engine Controls will provide the following information:

- The identification of the control modules which command the system
- The ability of the control modules to communicate through the serial data circuit
- The identification of any stored diagnostic trouble codes (DTCs) and the codes' statuses

The use of the Diagnostic System Check-Engine Controls will identify the correct procedure for diagnosing the system and where the procedure is located.

Diagnostic System Check

Reference eSI Document ID# 839781

Description

The Diagnostic System Check-Engine Controls is an organized approach to identifying a condition that is created by a malfunction in the powertrain control system. The Diagnostic System Check must be the starting point for any driveability concern. The Diagnostic System Check directs the service technician to the next logical step in order to diagnose the concern. Understanding and correctly using the diagnostic table reduces diagnostic time, and prevents the replacement of good parts.
Diagnostic Information and Procedures

In each of the diagnostic information and procedures menus the information is listed in the same sequence. This sequence is displayed in groups.

The groups are the following:

• Support Information
• DTCs
• Symptoms
• Systems

These groups allow the technician to quickly navigate through the content.

Support Information

The first portion of the diagnostic information is not directed diagnostics but rather support material. In other words, the technician was not directed to this document by another procedure. This information is used to help define and/or assist with other procedures. The list below can be considered support information.

• Scan Tool Data List
• Scan Tool Data Definitions
• Scan Tool Output Controls - Engine Controls
• Export Application Components Table
• Diagnostic Trouble Code (DTC) List

DTC Diagnosis

With each new model year, the DTC list becomes longer and longer. Currently DTCs go far beyond the simple diagnosis of electrically controlled component and circuit faults. PCMs are capable of providing diagnosis of components and systems that are not directly controlled by the PCM. Misfire Detection is only one of many examples of this type of diagnosis.

Symptoms Diagnosis

There are driveability concerns that the PCM is not capable of diagnosing. When this occurs, the technician will need to have a clearly defined symptom or symptoms and employ symptom diagnosis. Symptom diagnosis provides suggested components and systems that are related to the concern and possible root causes of the fault.

Systems Diagnosis

Occasionally diagnosis may isolate a concern to a system without the root cause being found. Or, the diagnostics directs the technician to a system diagnostic procedure. Under these conditions, the technician will employ system diagnosis. The approach of system diagnostics is that all of the system’s functions, components and associated circuits are check for proper operation with the goal of isolating the root cause.