ASE 8 - Engine Performance

Module 3

Emission Control Systems
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Introduction

This course is designed to give the learner an understanding of the 7 main emission control systems used on today’s vehicles. Hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (Nox) are the main emissions that these 7 systems deal with.

Objectives

Upon completion of this module, the successful learner will be able to:

• Identify the 7 main emission systems
• List the main components of each system
• Describe the operation of these systems
• Perform the necessary diagnostics of these systems

NATEF Task List

E. Emissions Control Systems Diagnosis and Repair

A. Positive Crankcase Ventilation

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

2. Inspect, test and service positive crankcase ventilation (PCV) filter/breather cap, valve, tubes, orifices, and hoses; perform necessary action. P-2

B. Exhaust Gas Recirculation

1. Diagnose emissions and driveability problems caused by malfunctions in the exhaust gas recirculation (EGR) system; determine necessary action. P-1

2. 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. Inspect and test electrical/electronic sensors, controls, and wiring of exhaust gas recirculation (EGR) systems; perform necessary action. P-2
C. Exhaust Gas Treatment
   1. Diagnose emissions and driveability problems resulting from malfunctions in the secondary air injection & catalytic converter systems; determine necessary action. P-2
   2. Inspect and test mechanical components of secondary air injection systems; perform necessary action. P-3
   3. Inspect and test electrical/electronically-operated components and circuits of air injection systems; perform necessary action. P-3
   4. Inspect and test catalytic converter performance. P-1

D. Evaporative Emissions Controls
   1. Diagnose emissions and driveability problems resulting from malfunctions in the evaporative emissions control system; determine necessary action. P-1
   2. Inspect and test components and hoses of evaporative emissions control system; perform necessary action. P-2
   3. Interpret evaporative emission related diagnostic trouble codes (DTCs); determine necessary action. P-1

STC Tasks:

A-8 Competencies for GM Powertrain Performance 16044.10 W/D/H

A. Emission Control System
   1. Identify the components of the ORVR System
   2. Explain the operation of the ORVR System
   3. Identify the components of the Enhanced EVAP System
   4. Explain the operation of the Enhanced EVAP System
   5. Identify the components of the Non-Enhanced EVAP System
   6. Explain the operation of the Non-Enhanced EVAP System
   7. Identify the components of the Linear EGR System
   8. Explain the operation of the Linear EGR System
   9. Identify the components of the Vacuum EGR System
  10. Explain the operation of the Linear EGR System
  11. Identify the components of the Three Orifice EGR System
  12. Explain the operation of the Three Orifice EGR System
  13. Identify the components of the PCV System
  14. Explain the operation of the PCV System
  15. Describe the function of the Secondary Air System
D. HO2S and Catalyst Diagnostics
   7. Explain the operation of the Catalytic Converter
   12. Explain the causes of Catalytic Converter failure

G. Evaporative Emissions System Diagnostics
   1. Describe the evaporative emissions systems diagnostics
   2. Describe the components of an Enhanced EVAP system
   3. Describe Enhanced EVAP Diagnostic operation
   4. Describe the Enhanced EVAP Diagnostic operation Power-up Vacuum Test
   5. Describe the Enhanced EVAP Diagnostic operation Excess Vacuum Test
   6. Describe the Enhanced EVAP Diagnostic operation Loaded Canister Test
   7. Describe the Enhanced EVAP Diagnostic operation Large Leak Test
   8. Describe the Enhanced EVAP Diagnostic operation Small Leak Test
   9. Describe the Enhanced EVAP Diagnostic operation Purge Solenoid Leak Test
  10. Describe the use of the EVAP cart pressure test
  11. Describe the procedure for conducting an EVAP service bay test using the Tech 2
  12. Describe on-board refueling vapor recovery (ORVR)
Lesson 1. Positive Crankcase Ventilation (PCV)

Objective
At the end of this lesson, the learner will be able to:

• List the main components of the PCV system
• Describe the operation of the PCV system
• Test PCV system operation

The positive crankcase ventilation, or PCV, system (Figure 3-1) consumes crankcase vapors during the combustion process instead of venting them to the atmosphere.

During engine operation, blow-by gases accumulate in the crankcase. If not vented, moisture, sludge and acids, as well as unwanted crankcase pressures, will build up.

Figure 3-1, Typical PCV System
The P C V system is used to remove these gases from the crankcase and route them back into the combustion chamber.

The tension of the P C V valve's spring is designed specifically for each engine.

The spring tension controls the flow rate (Figure 3-2) of crankcase vapors into the engine.

This prevents pressure buildup in the crankcase and excessive oil consumption.

Fresh air from the air cleaner is supplied to the crankcase. There it is mixed with the blow-by gases from the combustion process.

The mixture of fresh air and blow-by gases passes through the P C V valve into the intake system. From there, it travels through the engine and is burned in the combustion process.

![PCV CROSS-SECTION](image)

*Figure 3-2, PVC Valve Flow*

Failure of the P C V valve or an incorrect application may cause sludge build-up, incorrect crankcase pressures, and engine performance concerns. A plugged P C V valve or hose may result in oil leaks from engine seals.
Lesson 2. Catalytic Converter (CAT)

Objective
At the end of this lesson, the learner will be able to:
• List the main components of the CAT system
• Describe the operation of the CAT system
• Test CAT system operation

The catalytic converter in general use is known as a three-way converter (Figure 3-3).

This means that it contains catalysts, which act upon the three main exhaust emissions, Hydrocarbons (HC), Carbon Monoxide (CO) and Oxides of Nitrogen (Nox). The catalysts used are rhodium, palladium and platinum. Small amounts of these materials are used as catalysts to convert the HC, CO and Nox into the harmless emissions of water (H2O), carbon dioxide (CO2) and nitrogen (N).

Cerium is added for oxygen storage and release during lean and rich exhaust pulses.

This improves conversion efficiency.

Nickel is sometimes added to help reduce sulfur odor.

Figure 3-3, Exhaust Emission Conversion
Catalytic converters are part of the exhaust system and are located between the exhaust manifold and the muffler (Figure 3-4). Some vehicles use multiple converters.

In a search to control pollutants and reduce exhaust emissions, engineers have discovered that they can be reduced effectively if a gasoline engine operates at an air/fuel ratio of 14.7:1. The technical term for this ideal air/fuel ratio is Stoichiometric. An air/fuel ratio of 14.7:1 provides the best control of the three main pollutants in the exhaust under almost all conditions. This air/fuel ratio also increases the efficiency of the catalytic converter (Figure 3-4).
Lesson 3. Exhaust Gas Recirculation (EGR)

Objective
At the end of this lesson, the learner will be able to:
• List the main components of the EGR system
• Describe the operation of the EGR system
• Test EGR system operation

The exhaust gas recirculation, or EGR, system is used to lower oxides of nitrogen emission levels caused by high combustion temperatures. A small amount of exhaust gas is fed back into the combustion chamber (Figure 3-5). With the fuel air mixture diluted by the exhaust gases, combustion temperatures are reduced, thus reducing oxides of nitrogen. Too much EGR flow can be the cause of a drivability concern, while too little or no EGR can cause spark knock, overheating, or emission test failure.

Figure 3-6, EGR Flow to Combustion Chamber
Vacuum Controlled EGR Valves

Vacuum controlled EGR valves are single diaphragm, positive back pressure types or negative back pressure types (Figure 3-6). Back pressure EGR valves depend on engine vacuum, as well as exhaust system back pressure, to control EGR flow. Changes in back pressure caused by engine load will vary the diaphragm control vacuum. By venting the control vacuum, the EGR flow is limited.

Both positive and negative back pressure EGR valves require correct exhaust system back pressure to operate properly.

Vacuum Solenoid Controlled EGR Valve

The PCM controls a pulse-width modulated EGR valve through the EGR vacuum solenoid (Figure 3-7). There are two systems for controlling the EGR valve through the PCM. In one system, the PCM regulates the time the EGR valve is open by regulating the time the solenoid is grounded (energized). Energizing the solenoid allows more EGR; de-energizing the solenoid allows less EGR. The percentage of time the solenoid is energized represents the duty cycle: 0% equals no EGR; 100% equals maximum EGR. By varying the solenoid "ON" time, the PCM regulates EGR flow. Some applications operate in exactly the opposite fashion.
Integrated Electronic EGR Valve

The integrated electronic EGR valve combines vacuum and electronic operation (Figure 3-8). The PCM uses PWM signals to operate the regulator solenoid and control the amount of vacuum. Ported vacuum is supplied to the EGR valve assembly. An EGR pintle sensor provides feedback to the PCM to indicate that the desired action has occurred.

Figure 3-7, Vacuum Solenoid Controlled EGR Valve Circuit

Figure 3-9, Integrated Electronic EGR Valve Circuit
Digital EGR Valve Circuit

The control of the digital EGR valve is entirely electronic; there is no vacuum involved (Figure 3-9). Depending on engine application, two or three PCM controlled solenoids operate separate valves to close and open EGR ports. The electric solenoids share a common power supply, while each one has a separate ground at the PCM driver.

![Digital EGR Valve Circuit Diagram](image)

Figure 3-10, Digital EGR Valve Circuit

The EGR ports are of different diameters for different exhaust gas flow. Each valve is either entirely open or entirely closed. The valves are operated either together or separately, in order to provide various gas flow combinations.

Linear EGR Valve

The EGR valve is controlled by a high side driver. This means that the PCM controls the 12-volt supply to the EGR valve instead of controlling the ground side.

The PCM uses a "closed loop" strategy for controlling the EGR valve, similar to the closed loop fuel control strategy.

The PCM calculates the desired amount of exhaust gas recirculation and commands the pintle valve to move by sending a pulse width modulated voltage signal to the valve.

The PCM monitors the EGR pintle position sensor's feedback voltage to determine if the actual pintle position matches the desired pintle position.

If the desired pintle position does not match the actual pintle position, the PCM will adjust the duty cycle of the pulse width modulated command to make corrections.
This continual feedback and correction technique is what makes the EGR system "closed loop" style.

![EGR System Operation](image)

*Figure 3-11, Linear EGR System Operation*

To aid in diagnostics, the Tech 2 can be used to command the EGR valve to different positions.

The Tech 2 will show the actual position of the pintle. Desired positions can be selected to determine if the PCM is able to control the position of the valve.

When a desired position is commanded, the actual position may fluctuate at first. Therefore, it may be necessary to wait a second or two for the data parameter to stabilize before taking a reading.

The Tech 2 will display data related to the EGR system.

EGR duty cycle displays a range from zero to one hundred percent, indicating the EGR valve driver pulse width modulation signal from the PCM. Zero percent indicates no EGR flow; one hundred percent indicates maximum flow.

Desired EGR position will display a range from zero to one hundred percent, indicating the pintle position that is commanded by the PCM.

Actual EGR position will display a range from zero to one hundred percent, indicating the actual position of the pintle.

This value should be close to the desired position.

EGR Feedback will display a value from 0 to 5 volts. 0 volts indicates a fully closed valve; 5 volts indicates a fully open valve.
EGR Position Error will display the difference between the desired and actual positions currently being monitored by the PCM. The scan tool range is negative one hundred percent to positive one hundred percent.

EGR Closed Pintle Position will display a value between 0 and 255 counts.

EGR Closed Valve Pintle Position will display a voltage between 0 and 5 volts. This voltage is used by the PCM to determine if the EGR valve is fully closed.

If the desired position is 0%, and a difference of more than point 4 volts between the EGR feedback and EGR closed valve pintle position is detected, DTCP-1406 will be set.

EGR Flow Test Count will display a value between 0 and 255 counts. This indicates the number of flow test samples collected.

GM is transitioning its linear EGR valves to "High Side" PCM drivers for the following reasons:

- The "High Side" driver has more current carrying capacity than the low side drivers do.
- The "High Side" driver contains built-in diagnostic features that allow it to signal the microprocessor when a fault is detected.

Prior to this feature, diagnostics were done using a software approach. DTCP-0403 indicates that this new fault detection circuit is being used.

The "High Side" driver also contains a recirculation diode to prevent EGR valve oscillations.

Note that some linear EGR's are lowside controlled. Refer to Service Information for your particular application.
Lesson 4. Evaporative System (EVAP)

Objective
At the end of this lesson, the learner will be able to:

- List the main components of the EVAP and Enhanced EVAP systems
- Describe the operation of the EVAP and Enhanced EVAP systems
- Test and diagnose EVAP and Enhanced EVAP system concerns

The Evaporative Emission Control System, or EVAP, is designed to collect hydrocarbons that are released from fuel in the form of a vapor. These vapors are stored in a canister filled with activated carbon.

The EVAP system allows the vapors to be drawn from the canister, into the engine and burned during certain operating conditions. This is called canister purging, because the vapors are purged from the canister.

The temperature of the fuel, the type of fuel used, and the integrity of the EVAP system components affect evaporative emission levels of a vehicle.

OBD-2 requires PCM monitoring for proper operation of the EVAP system and to detect possible leaks to the atmosphere.

The typical non-enhanced EVAP system contains the following components: an EVAP emission pressure control valve, a vented canister, a diagnostic switch, and an 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.

The Enhanced EVAP system was developed to meet stricter evaporative emission standards and emission component monitoring requirements.

In 1996, cars and light trucks were required to illuminate the mill when the onboard diagnostic system detects an evaporative emission system leak equivalent to an orifice of forty thousandths of an inch in diameter or greater. On fuel tanks that are twenty-five gallons or larger, forty to eighty thousands of an inch holes must be detected.
In model year 2000, G M introduced software on some vehicles that will illuminate the mill if the OBD-2 system detects an EVAP system leak of twenty thousands of an inch in diameter or greater.

The Enhanced EVAP System includes the addition of a vent solenoid and fuel tank pressure sensor. A service port has been added and is located in the purge hose between the purge solenoid and canister. The canister is filled with activated carbon.

**Figure 3-13, Enhanced Evaporative System**

**Enhanced EVAP Components**

A. Purge Solenoid  
B. Service Port  
C. Carbon Canister  
D. Vent Solenoid  

E. FT Pressure Sensor  
F. Fuel Cap  
G. Fuel Level Sensor

The fuel tank pressure sensor (Figure 3-14) measures the difference between the air pressure or vacuum in the fuel tank and the outside air pressure. The vent solenoid replaces the fresh air vent used on past canisters. The normally open vent solenoid allows fresh outside air to the canister. The vent solenoid is closed during system diagnostics, allowing a vacuum to be created in the fuel tank.
**Figure 3-14, Fuel Tank Pressure Sensor**

**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.

**Figure 3-15, Vent Solenoid**

**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.
On the Pontiac Vibe and Chevrolet Prisms, the enhanced E Vap system includes an EVAP pressure switching solenoid (Figure 3-20), which opens the evaporative line between the fuel tank and the EVAP canister. When the EVAP pressure switching solenoid is closed, or off, air is blocked from entering the fuel tank side of the system.

The pressure switching solenoid is off, or closed, during engine warm-up. With the pressure switching solenoid closed, vacuum pressure is blocked from entering the fuel tank and pressure in the fuel tank will rise. The FTP sensor will see a significant decrease in pressure in the tank only when the pressure switching solenoid is on, or open, during a purge event. If the pressure switching solenoid malfunctions during this portion of the EVAP system operation, a DTCP-0440 and P-0441 can set.

During the DTCP-0446 portion of the EVAP system diagnostic, the pressure switching solenoid is on. This enables the FTP sensor to see a rapid decrease in vacuum, with the air from the EVAP vent solenoid entering the tank. When the PCM commands the pressure switching solenoid off, the FTP sensor should see the tank pressure stabilize. If the FTP sensor still sees a significant decrease in vacuum, the PCM concludes the solenoid did not close and sets a DTCP-0446.

The Tech 2 Special Functions feature called the "E Vap Service Bay Test" is available on many vehicles.
The EVAP Service Bay test was developed with the idea that some state inspection maintenance programs will include looking at the IM 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, all Inspection and Maintenance flags would reset to NO, test not run.
A short drive from the dealership to the Inspection and Maintenance site might not be adequate for the EVAP diagnostic to run, meaning that the vehicle might have a problem passing the Inspection and Maintenance test.

To prevent this, the Tech 2 EVAP Service Bay test sends a Class Two message to the PCM commanding it to relax certain enable criteria for the EVAP diagnostic, allowing the EVAP inspection and maintenance flag to set more quickly.

This Tech 2 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 diagnostics control the purge and vent valves.

The EVAP service bay test does NOT replace any service information diagnostics. The EVAP test cart and related service information diagnostics are still required for EVAP service.

The Evaporative Emission System Tester, or EEST, tool number J-41413 dash 200, updates the Evaporative Pressure Purge Diagnostic Station.

Some 1996 to 1998, and all 1999 and newer G M cars and light trucks, are required to illuminate the mill when the OBD-2 system detects an EVAP system leak equivalent to an orifice of 1 millimeter in diameter or greater. In model year 2000, GM introduced software on some vehicles, which illuminates the mill when the OBD-2 system detects an EVAP system leak equivalent to an orifice of point five millimeters in diameter or greater.

GM cars and light duty trucks that meet this new standard cannot be diagnosed using the existing ultrasonic leak detection equipment. The new J-41413 dash 200 EEST (Figure 3-17) can be used to identify leaks and to verify repairs.
The J-41413-200 EEST introduces chemically inert smoke into the sealed EVAP system under low pressure. System leaks are located by using the J-41413-SPT high intensity white light to inspect for traces of smoke escaping from the sealed EVAP system.
Lesson 5. Air Injection Reaction System (AIR)

Objective
At the end of this lesson, the learner will be able to:
• List the main components of AIR systems
• Describe the operation of AIR systems
• Test and diagnose AIR system concerns

On vehicles equipped with a secondary air injection system, the AIR system is used to reduce exhaust emissions. The system forces fresh filtered air into the exhaust stream in order to accelerate catalyst operation.

The PCM turns on the AIR system during start up, when engine coolant and intake air temperatures are between forty-one and one hundred nine degrees Fahrenheit.

The AIR pump will run for approximately one minute. The air pump supplies filtered air through the secondary air injection system into the exhaust stream. The control module provides ground to the pump relay, and battery voltage is supplied to the pump when the relay is energized. When the PCM turns the AIR pump off, it also de-energizes the AIR solenoid valve.

The AIR vacuum control solenoid controls the AIR shutoff valves. When the secondary air injection system is enabled, the control module provides a ground to the solenoid. Enabling the solenoid allows engine vacuum to be applied to the AIR shutoff valves.

To ensure there is vacuum to the AIR solenoid when it's needed, a one-way check valve is installed in the line between the vacuum source and the AIR solenoid. When the secondary air injection system is enabled, vacuum is applied to the valves. The vacuum opens the valves and allows air from the air pump to flow through the check valve and into the exhaust system.

The check valve prevents backflow of exhaust gases into the secondary air injection system. An air pump that has become inoperative or has shown indications of having exhaust gases in the outlet port would indicate a check valve failure.

The plumbing carries the air from the pump to the exhaust stream. The plumbing can be tested for leaks using a soapy water solution. If the solution bubbles, a leak exists.
The Tech 2 may be used to evaluate the AIR system. The vehicle needs to be at operating temperature and at idle in neutral.

Select Special Functions on the Tech 2, then Engine Controls. Select Air System to turn on the AIR Pump.

Monitor HO2S Sensor 1 on the Tech 2. The HO2S voltage should remain under 350 millivolts because air is being added to the exhaust. Also, the PCM may turn on the AIR pump at idle to perform diagnostics.

Do not command the AIR system on using the Tech 2 Special Functions Test with the engine not running.

Because engine vacuum is not available with engine off, the AIR control valve will be closed. The AIR pump can be damaged if the pump is running and air cannot pass the AIR control valve.
Lesson 6. On-Board Refueling Vapor Recovery System (ORVR)

Objective
At the end of this lesson, the learner will be able to:

• List the main components of the ORVR system
• Describe the operation of the ORVR system
• Test and diagnose ORVR system concerns

On-Board Refueling Vapor Recovery, or ORVR, is a government mandated emission control system designed to prevent hydrocarbon vapor from escaping to the atmosphere while refueling a vehicle.

On an ORVR equipped vehicle, the fuel fill pipe is a smaller diameter than on non-ORVR vehicles. The flow of liquid fuel down the smaller diameter fill pipe provides a "liquid seal" that prevents hydrocarbon vapor from exiting the fill pipe opening.

As the tank becomes nearly full, the fill limit valve floats up to close off the vapor line. As the fuel level continues to rise, the remaining vapor space is compressed and tank pressures start to increase. The increase in pressure causes liquid fuel to back up in the fill pipe, covering the aspirator on the nozzle, which activates the shutoff mechanism.

The refueling vapor that was traditionally lost to the atmosphere is now routed to the evaporative emissions canister, located near the fuel tank, and temporarily stored until purged by the powertrain control system.

The objective of the ORVR system is to avoid releasing vapors into the atmosphere.

The customer should not see or smell fuel vapors during fueling.

The ORVR system shares many of the components used in the enhanced EVAP system. The system architecture varies by platform and some items are optional, depending on the application.
If both the engine and the on-board EVAP diagnostic are running while attempting to refuel, you may set a DTC, turn on the mill, or encounter a difficult to fill condition.

The ORVR diagnostic chart provides possible solutions to commonly found concerns.
Lesson 7. Engine-Off Natural Vacuum Diagnostic (EONV)

Objective

At the end of this lesson, the learner will be able to:

• List the main components of the EONV system
• Describe the operation of EONV system
• Test and diagnose EONV system concerns

The new Engine Off Natural Vacuum Diagnostic, or EONV, is the new small-leak detection diagnostic for the E-Vap system. The EONV system is shown in (Figure 3-21). EONV utilizes the dynamic temperature changes in the fuel tank immediately following a drive cycle to generate natural vacuum, or pressure, in the fuel tank. When the vehicle is driven, temperature increases in the tank. After the vehicle is parked, temperature in the tank continues to build for finite amount of time, and then will start to drop. The EONV diagnostic relies on corresponding pressure change to make a determination as to whether the system is leaking.

![Figure 3-18, EONV System](image-url)
The diagnostic can determine if a small leak is present based on vacuum or pressure readings in the EVAP system. The EONV diagnostic is designed to detect leaks as small as twenty-thousandths of an inch. When the system is sealed, a finite amount of pressure or vacuum will be seen. With a twenty-thousandths leak present, often little or no pressure or vacuum is observed.

The EONV diagnostic replaces the previous small-leak detection method. All of the other comprehensive component tests are still used during engine operation. EONV will run as long as the other comprehensive component tests do not fail.

The EONV system will be introduced on 2003 model year trucks meeting federal emission standards, having a GVW of eighty six hundred pounds or less. California vehicles having a GVW of fourteen-thousand pounds or less will also have the new EONV system.

While previous leak detection methods were performed with the engine running, the new OBD- 2 EONV system monitors EVAP system pressure or vacuum with the key off. Because this system performs diagnostic testing after the key has been turned off, it may be normal to wait up to 40 minutes for the PCM to power down. This is an important point to remember when performing a parasitic draw test on vehicles equipped with EONV.

The system differences between the previous diagnostic and those equipped with EONV are PCM software modifications and wiring the canister vent solenoid to battery voltage instead of Ignition One.

The EONV diagnostic looks at several parameters before enabling. Ambient temperature must be between forty and ninety-six degrees Fahrenheit; fuel level between fifteen and eighty-five percent full, and the engine run time, distance traveled, and engine coolant temperatures must indicate that the system is adequately warmed up. Finally, the PCM enables the diagnostic only enables after a cold start to make sure the fuel tank pressure sensor is properly initialized.

Since EONV runs when the charging system is not running, the diagnostic will limit the number of complete and non-complete tests run over a specific period of time to prolong battery life. When an EONV test passes, the calibrated time between tests is lengthened.

The EONV diagnostic is very sensitive to large amounts of fuel vaporization due to high volatility fuel and has a simple test to make sure the vaporization rates will not negatively impact the results of the test. The EONV volatility test runs immediately after key down if all the enable criteria have been met. The PCM monitors pressure for a calibrated amount of time with the canister vent open and uses preprogrammed values to predict fuel volatility. The fundamental idea behind this test is that if pressure builds in the system with the canister vent open, it will certainly be able to mask a twenty-thousandths leak with the vent closed.
For example, if the volatility of the fuel were high, the PCM would abort the diagnostic. If the fuel was moderately volatile, the PCM would perform the diagnostic and would correct the pressure result to compensate for volatility. For low fuel volatility, the PCM would perform the diagnostic, but would not apply corrections.

There are a number of DTC’s that will prohibit EONV from running. Refer to service information for specifics.

Note that OBD-2 standards will be driving powertrain DTC numbering changes, beginning in model year 2003. These numbering changes will be phased in. The chart below (Figure 3-19) shows how EVAP DTCs will change in model year 2003 on certain engines.

![Figure 3-19, EVAP Diagnostics DTCs](image)

Now let’s take a look at the operation of the EONV diagnostic from beginning to end.

There are three tests that make up the EONV diagnostic. The three tests are volatility, pressure, and vacuum.

The PCM begins the EONV diagnostic by conducting a fuel volatility test with the vent solenoid open. If the fuel volatility is determined to be high, then the PCM will abort the diagnostic test. If the fuel volatility is moderate, the PCM will make minor corrections to the results, close the canister vent solenoid, and continue into the vacuum portion of the testing.
The pressure test begins by closing the canister vent solenoid and observing the pressure increase inside the fuel tank. If the pressure increase results in obtaining the calibrated pressure threshold, the diagnostic passes, and the test is over. The pressure threshold is a function of predicted ambient temperature and fuel level. If a vacuum occurs, then the diagnostic switches directly to vacuum testing without bleed-down.

If the pressure threshold is not reached, the PCM will record the peak pressure, and adjust the vacuum threshold for the vacuum test. The pressure must decay a calibrated amount from the peak pressure for the PCM to consider it a peak, and switch to the vacuum test. The adjusted vacuum threshold equals the difference between the pressure peak and the pressure threshold. When the pressure threshold is not reached, the PCM then monitors for peak pressure. Once peak pressure is obtained, the PCM opens the canister vent valve and waits for system pressure to bleed down.

During vacuum testing, the PCM closes the canister vent valve and monitors the tank vacuum to determine if the vacuum threshold is reached. If the vacuum threshold is reached, the diagnostic passes, and the test is complete.

The PCM quantifies the diagnostic result using the shown equation, which incorporates the results of the pressure and vacuum tests. A zero will equal a perfectly passing system, while a 1 equals a perfectly failing system. A normalized result will most likely fall between zero and one. The Exponentially Weighted Moving Average, or you-ma filter, within the PCM filters the current normalized result with the previous stored normalized results to calculate a filtered value. If the filtered value moves above the fail threshold, then the mill is turned on and DTC Pzero442 is set. The fail threshold is a set value within the PCM that, if reached, indicates an evaporative emissions system leak greater than or equal to twenty-thousands of an inch.

The EONV system must perform a number of sub-functions to run the EONV diagnostic:

The EONV must estimate ambient temperature.
Because EONV occurs at the end of the drive cycle, measuring intake air temperature at start-up will not suffice. The PCM:

- Uses vehicle speed and airflow to calculate an offset value, which is subtracted from the intake air temperature to predict ambient temperature.
- Equates the estimated ambient temperature to intake air temperature for a calibrated amount of time after a cold start.

The PCM looks for a net increase in fuel level over the course of a test. The PCM also looks for an abrupt change in vacuum over a calibrated amount of time, as well as changes in fuel level or system pressure that exceed a calibrated value that indicate a refueling event. The PCM only detects refueling events when the vent is closed.

If a refueling event is detected, the PCM aborts the diagnostic and opens the canister vent. The canister vent must be opened quickly to prevent the canister vent from corking closed. Corking is a condition when the canister vent solenoid is not opened quick enough, causing pressure in the EVAP system to hold the canister vent solenoid closed.

The PCM performs a “rationality test.” The rationality test determines if the refueling detection was caused by an intermittent signal or by the refueling of the vehicle. During the test, the PCM checks to see if the current fuel level is greater than the initial fuel level for a calibrated amount of time. If the calibrated amount of time passes and the PCM is not able to determine whether the fuel level is greater, the refueling event is declared irrational and DTC is set for the sensor that falsely detected the refueling event.
Exercise 3–1

Objective: At the completion of this worksheet, you will be able to:
- Describe PCV System Operation
- Identify results PCV System failure

1. What is the purpose of the PCV System?

_________________________________________________________________________________  
_________________________________________________________________________________

2. Why should the crankcase be vented?

_________________________________________________________________________________  
_________________________________________________________________________________

3. Technician A says all PCV valve internal springs are the same. Technician B says that PCV valves use spring tension specifically designed for an engine application. Who is right?
   a. Technician A
   b. Technician B
   c. Both A and B
   d. Neither A nor B

4. Is fresh air mixed with the blow-by gasses in the crankcase?
   ___Yes   ___No

5. List five results that could occur in the case of a faulty PCV valve, an incorrect PCV valve application or a plugged PCV valve hose.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
   d. __________________________________________
Exercise 3-2

Objective: At the completion of this worksheet, you will be able to:
• Perform a PCV system test

Vehicle Yr. _____ Make ________ Model ______ Engine _____

To check for correct volume of airflow through the PCV system, remove the oil dipstick and attach a water manometer to the dipstick tube using a tapered fitting and hose. Start the engine and monitor the readings.

1. What does the manometer reading at idle?
   ______________________________________________________
   (Reading should be between zero and 1 ½ inches of water.)

2. List three causes for readings that would indicate pressure in the crankcase.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________

3. Block the drive wheels, apply the parking brake, place the gear selector in drive and open the throttle to about ¼ throttle. What is the manometer reading?
   ______________________________________________________
   (Reading should be less than 6 inches of water.)

4. Release throttle, place the selector in park and turn the engine off. Remove the manometer and install the dipstick.

5. List two conditions that could cause the readings to be above 6 inches of water (too much vacuum)?
   a. __________________________________________
   b. __________________________________________

6. What is the condition of the PCV system?
   _____Pass   _____No Pass
Exercise 3-3

Objective: At the completion of this worksheet, you will be able to:
- Describe Catalytic Converter Operation
- List Catalytic Converter failure results

1. What is the purpose of a catalytic converter?
   __________________________________________________________
   __________________________________________________________

2. Identify the following emissions.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________

3. List the main three catalysts used in catalytic converters.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________

4. Which three harmless emissions are HC, CO and NOx converted into?
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________

5. Why is Cerium added to a converter?
   __________________________________________________________

6. What is the purpose of adding Nickel to a converter?
   __________________________________________________________

7. The ideal air/fuel ratio for optimum converter operation is
   __________________________________________________________

8. What is the technical term for this air/fuel ratio?
   __________________________________________________________
9. What can cause a converter to become plugged?

10. What is the customer's concern for a restricted converter?
Exercise 3-4

Objective: At the completion of this worksheet, you will be able to:

• Describe EGR System Operation
• List EGR System failure results

1. What is the purpose of an EGR system?
   ___________________________________________________________

2. What exhaust pollutant does the EGR system help to reduce?
   ___________________________________________________________

3. How can too much EGR flow cause a drivability concern?
   ___________________________________________________________
   ___________________________________________________________

4. List three things that can be caused by too little or no EGR flow.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________

5. List five types of EGR system design.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
   d. __________________________________________
   e. __________________________________________

6. How is a linear EGR valve controlled?
   ___________________________________________________________

7. In order to move the EGR valve pintle, what type of voltage signal does the PCM send to the valve?
   ___________________________________________________________
8. Can the Tech 2 be used to command the EGR valve to different positions?
   ____Yes  ____No

9. What is the EGR duty cycle range displayed on a Tech 2?
   __________________________________________________________

10. How much EGR flow would occur with a zero percent duty cycle signal?
    _________________________________________________________
Exercise 3-5

Objective: At the completion of this worksheet, you will be able to:
• Utilize the Tech 2 to operate and monitor the Linear EGR Valve.

Vehicle Yr. 2003 Make Chevrolet Model Malibu Engine 3.1L

1. Go to the classroom vehicle and disconnect the EGR valve connector. Attach the connector to the EGR valve provided by the instructor and place the valve where you can view the pintle.

2. Connect a Tech 2 to the vehicle, turn the key on and clear the DTCs by selecting FO: Diagnostic Trouble Codes (DTC), F2: Clear DTC Information, and then press the YES key to complete the clear.

3. Press exit and then select F2: Special Functions.

4. Select FO: Engine Output Controls.

5. Select F4: EGR Solenoid.

6. Complete the following chart by commanding the EGR valve on and recording the readings.

7. Note: As you command the EGR valve open, observe the pintle movement.
Readings may vary slightly.

<table>
<thead>
<tr>
<th>Commanded State</th>
<th>Actual EGR %</th>
<th>Desired EGR %</th>
<th>EGR Feedback Volts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>.59</td>
</tr>
<tr>
<td>10%</td>
<td>9-10</td>
<td>10</td>
<td>1.00</td>
</tr>
<tr>
<td>20%</td>
<td>19-20</td>
<td>20</td>
<td>1.24</td>
</tr>
<tr>
<td>30%</td>
<td>29-30</td>
<td>30</td>
<td>1.51</td>
</tr>
<tr>
<td>40%</td>
<td>38-40</td>
<td>40</td>
<td>1.76</td>
</tr>
<tr>
<td>50%</td>
<td>49-50</td>
<td>50</td>
<td>2.04</td>
</tr>
<tr>
<td>60%</td>
<td>58-60</td>
<td>60</td>
<td>2.49</td>
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<tr>
<td>70%</td>
<td>68-70</td>
<td>70</td>
<td>2.67</td>
</tr>
<tr>
<td>80%</td>
<td>78-80</td>
<td>80</td>
<td>3.12</td>
</tr>
<tr>
<td>90%</td>
<td>88-90</td>
<td>90</td>
<td>3.35</td>
</tr>
<tr>
<td>100%</td>
<td>99-100</td>
<td>100</td>
<td>3.87</td>
</tr>
</tbody>
</table>

8. Did the pintle move as you commanded it open?  ___YES    ___NO

9. Return the pintle to a commanded state of 0%

10. Disconnect the connector from the EGR valve provided and reconnect the connector to the vehicle EGR valve

11. Start the vehicle and allow it to idle.

12. Command the pintle open to 10%.

13. What happens to engine idle?

14. Exactly why does this happen?

15. What does this tell us about EGR operation at idle?
16. If the idle was not affected, what could be wrong?

____________________________________________________________________________

____________________________________________________________________________

17. Return the pintle to a commanded state of 0%.

18. Clear DTCs from the PCM.

19. Turn the engine off, power down and disconnect the Tech 2.
Exercise 3-6

Objective: At the completion of this worksheet, you will be able to:

- Describe EVAP System Operation
- List EVAP System failure results

1. What is the purpose of an EVAP system?

2. What major emission does the EVAP system help to reduce?

3. How is a typical EVAP purge solenoid controlled?

4. Why was the Enhanced EVAP System developed?

5. In 1996, the MIL would illuminate if a leak of _____ were detected.
   a. .010"
   b. .020"
   c. .030"
   d. .040"

6. If a fuel tank is 25 gallons or more, what size leaks should be detected?

7. What is the job of the fuel tank pressure sensor?

8. What is the normal state of operation of the vent solenoid?

9. What is the vent solenoid state of operation during diagnostics?

10. How does a technician accurately locate an EVAP system leak?