# *Next Generation Engine Management Part 3, Advanced OBD II Diagnosis*

## *Course Code 0841916*

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## INTRODUCTION

OBD II regulations require that more vehicle systems be monitored for more types of failures than were done in the past. OBD II has increased vehicle complexity, but it has also simplified diagnosis by standardizing systems, function and terminology.

This course will describe the new StarSCAN scan tool, Diagnostic Trouble Codes (DTCs) and Monitors. The content of this course is based on vehicles with the Speed Density fuel system, which is used on most Chrysler Group gasoline-powered vehicles.

## STUDENT LEARNING OBJECTIVES

Upon completion of this course, you should be able to:

- Describe the new StarSCAN scan tool.
- Identify and interpret the different types of DTC information.
- Identify the different types and status of the Monitors.
- Run the $O_2$ Monitor and interpret the results.
- Run the $O_2$ Heater Monitor and interpret the results.
- Run the Catalyst Monitor and interpret the results.
- Run the Rich/Lean Fuel Trim Monitor and interpret the results.
- Run the Downstream Fuel Trim Monitor and interpret the results.
- Run the Misfire Monitor and interpret the results.
- Run the EGR Monitor and interpret the results.
- Run the EVAP Purge and Leak Monitors and interpret the results.

## ACRONYMS

The acronyms listed here are used throughout this course:

- AIR Air Injection Reaction System
- BARO Barometric Pressure Sensor
- BCM Body Control Module
- CARB California Air Resources Board
- CKP Crankshaft Position Sensor
- CMP Camshaft Position Sensor
- DLC Data Link Connector
- DRBIII® Diagnostic Readout Box – 3rd Generation
- DTC Diagnostic Trouble Code
- ECT Engine Coolant Temperature Sensor
- EELD Evaporative Emissions Leak Detection
- EGR Exhaust Gas Recirculation
- EPA Environmental Protection Agency
- EWMA Exponentially Weighted Moving Average
- ETC Electronic Throttle Control
- EVAP Evaporative Emissions System
- FTP Federal Test Procedure
- IAC Idle Air Control
- IAT Intake Air Temperature Sensor
- I/M Inspection and Maintenance Program
- JTEC Jeep/Truck Engine Controller
- KOEO Key On Engine Off
- KOER Key On Engine Running
- LDP Leak Detection Pump

- LTFT Long Term Fuel Trim
- MAF Mass Air Flow Sensor
- MAP Manifold Absolute Pressure Sensor
- MDS2® Mopar Diagnostic System – 2nd Generation
- MIL Malfunction Indicator Lamp
- NGC Next Generation Controller
- NTC Negative Temperature Coefficient
- NVLD Natural Vacuum Leak Detection
- OBD II On-Board Diagnostics – 2nd Generation
- ORVR On-Board Refueling Vapor Recovery
- O2 Oxygen
- PCM Powertrain Control Module
- PCV Positive Crankcase Ventilation Valve
- PTC Positive Temperature Coefficient
- PWM Pulse Width Modulated
- PZEV Partial Zero Emissions Vehicle
- RPM Revolutions Per Minute
- SAE Society of Automotive Engineers
- SBEC Single Board Engine Controller
- SRI Service Required Interval
- STFT Short Term Fuel Trim
- TCM Transmission Control Module
- T-MAP Throttle MAP (calculated MAP value)
- TPS Throttle Position Sensor
- VSS Vehicle Speed Signal
- WOT Wide Open Throttle

# MODULE 1  NEW STARSCAN SCAN TOOL

## STARSCAN SCAN TOOL

The new StarSCAN Scan Tool uses a keypad and a touch-screen interface. The StarSCAN must be used on vehicles with Can-Bus communications to the DLC. This begins with 2004 HB and LX models. The StarSCAN is a standalone device and does not need to communicate with the MDS2. Flash files and updates can be downloaded directly over the internet. The tool is battery-powered and has a plug-in charger.

For the latest information, refer to this internet site: www.dcctools.com.


Figure 1  StarSCAN Scan Tool

Notes:

## MODULE 2 DIAGNOSTIC TROUBLE CODES (DTCS)

Diagnostic Trouble Codes (DTCs) are stored in PCM memory when a Monitor recognizes an abnormal condition within a system being checked. SAE standard J2012 and the EPA define OBD II standards for the five-digit alphanumeric DTC codes.

DTCs can help speed diagnosis by telling the technician which systems are affected by the fault. The MIL will illuminate when a DTC is set, based on Monitor failure criteria.

SAE J2012 requires a uniform DTC format. This format assigns alphanumeric codes to malfunctions and suggests standard definitions for all generic (SAE universal) DTCs. Manufacturers can also assign their own unique DTCs. The second digit indicates whether the DTC is generic or manufacturer-specific.

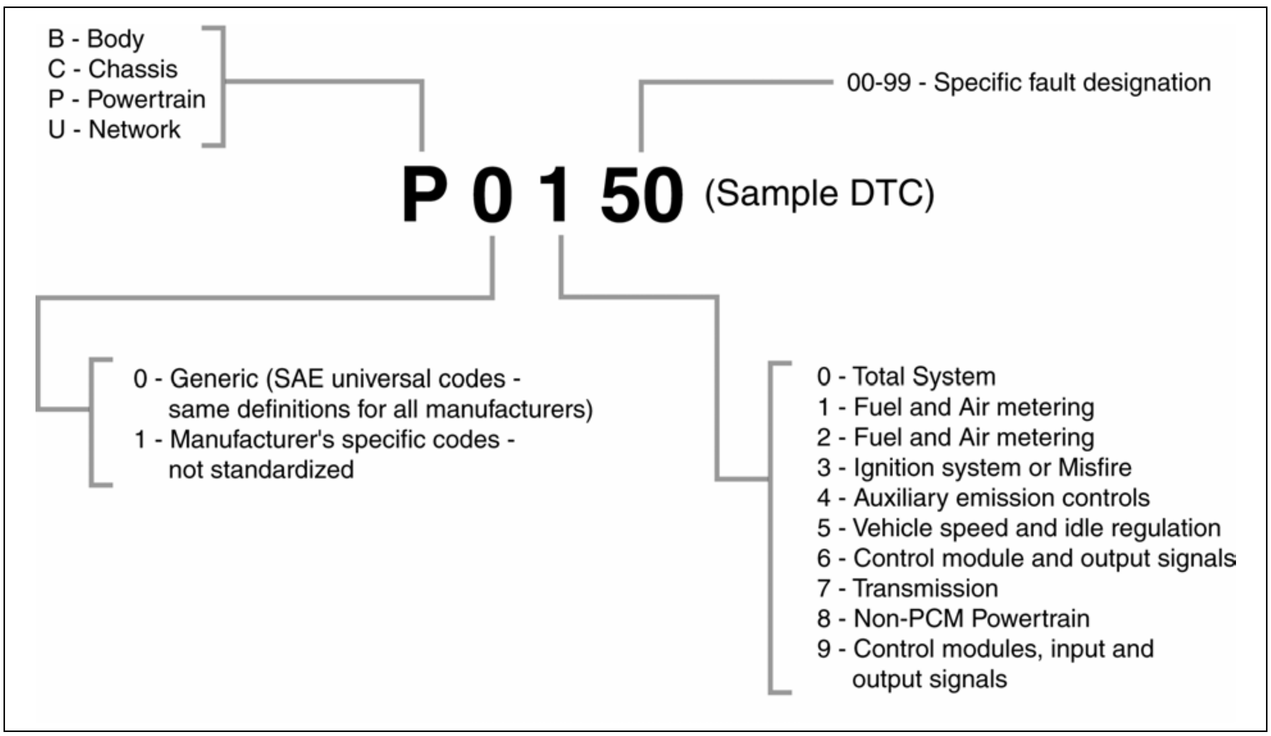


Figure 2 Diagnostic Trouble Code Format

### HEX ID CODE

Prior to P-code implementation, the PCM used a Hex ID code identifier system. The Hex ID Code is a two-digit hexadecimal code read by the DRB III and MDS. A “$” appears before the two digits and identifies the code as a Hex code. The DRB III deciphers this code and displays the DTC text. The Hex code appears on the “On-Board Diagnostics Monitor” DRB III screen, and on the MDS when monitoring the Data Recorder and in the Service and Powertrain Diagnostics Procedures Manuals.

**DTC TEXT**

Diagnostic Trouble Code text appears on DRB III and MDS screens when reading DTCs. The text description will define the fault detected.

**TYPES OF FAULTS**

**Circuit Continuity**

Circuits for power train comprehensive components are tested for:

- Open Circuits
- Shorts to Ground
- Shorts to Positive (power)

Any circuit abnormality detected will cause a DTC to be set. Example: P0107 MAP SENSOR LOW can be caused by an open in the 5V supply or the supply circuit or signal circuit shorted to ground.

**Rationality**

In addition to continuity checks, OBD II systems also check power train component inputs for rationality. This means that the input signal is compared against other inputs and stored information to see if it makes sense under the current conditions.

Sensor inputs that are checked for rationality include:

- Manifold Absolute Pressure (MAP) Sensor
- Crankshaft Position (CKP) Sensor
- Camshaft Position (CMP) Sensor
- Vehicle Speed (VSS) Sensor
- Engine Coolant Temperature (ECT) Sensor
- Intake Air Temperature (IAT) Sensor
- Throttle Position (TPS) Sensor
- Ambient/Battery Temperature (BTS) Sensor
- Oxygen Sensor
- Oxygen Sensor Heater
- Power Steering Switch
- Brake Switch
- Leak Detection Pump/NVLD Switch

- Park/Neutral Switch
- Transmission Controls
- CNG Fuel Temperature Sensor
- PCM

**Functionality**

OBD II systems test PCM outputs for functionality as well as circuit continuity. When the PCM supplies a voltage to an output component, it can verify that the command was carried out by monitoring specific input signals for expected changes. For example, when the PCM commands the Idle Air Control (IAC) Motor to change position under certain operating conditions, it expects to see a specific target idle speed. If it does not, a DTC is stored.

Outputs that are checked for functionality include:

- Fuel Injectors
- Ignition Coils
- Idle Air Control (IAC) Motor
- Torque Converter Clutch (TCC) Solenoid
- Purge Solenoid
- EGR Solenoid
- Electric Air Pump
- Leak Detection Pump Solenoid
- Radiator Fan Control
- Transmission Controls

**DTC AND MIL STRATEGIES**

**Self-Clearing DTCs**

If the PCM detects an emissions-related component fault or system fault, it will illuminate the MIL and set a DTC.

Most emissions-related faults must fail the diagnostic Monitor test on two consecutive trips for the MIL to illuminate. These tests are “Two-Trip Monitors”.

When the first test fails, the Task Manager stores a pending DTC. If the component fails for a second time on the next trip, the DTC “matures” and the MIL is illuminated.

Most emissions-related components and non-emissions related Monitor tests illuminate the MIL after a single failure. These tests are known as "One-Trip Monitors". A DTC is set and the MIL illuminated after one failure.

If the component or system failure does not reoccur after three consecutive Good Trips, the MIL is turned OFF, but the stored DTC will remain in memory. If the failure does not repeat after 40 Warm-Up Cycles, the DTC will be erased from memory.

**Distance Since MIL Set**

This was phased in on some NGC vehicles in the 2000 model year to satisfy EURO requirements. The counter updates every 0.6 mi. (1.0 km). It stops counting when three consecutive Good Trips occur. The data remains in memory until 40 warmup cycles are completed. If another DTC is set, the counter starts again at zero.

**DTCs and the DRB III**

DTCs can be erased at any time with the DRB III. Erasing the DTC will also erase all stored OBD II Monitor information. This includes all counter information for warm-up cycles, start cycles, trips, Freeze Frame Data, and monitor completion data.

**DTC PRIORITIES**

CARB has mandated that DTCs are entered and ranked according to priority. In earlier vehicles with limited memory storage, DTCs with higher priority overwrite lower priority DTCs. Later vehicles can store as many as eight DTCs before overwriting.

Non-emission related failures have the lowest priority. One trip failures of two trip faults have the next level of priority, followed by matured two trip failures. One trip and two trip failures of fuel system and misfire monitors have higher priority over non-fuel system and non-misfire faults.

- Priority 0: Non-emission related DTC
- Priority 1: One trip failure of a two trip fault, not for fuel system or misfire
- Priority 2: JTEC/SBEC: One trip failure of a two trip fault for fuel system and misfire
- Priority 3: Two trip failure or matured fault, not for fuel system or misfire
- Priority 4: JTEC/SBEC: Two trip failure or matured fault for fuel system and misfire.

- Priority 4: NGC: One trip failure of a two trip fault for fuel system and misfire
- Priority 5: (currently not used)
- Priority 6: NGC: Two trip failure or matured fault for fuel system and misfire

**FREEZE FRAMES**

When a fault is detected, the input data from various inputs and outputs is stored in the PCM's Freeze Frame memory.

Data stored in Freeze Frame is usually recorded at the first occurrence. If the fault is a Two Trip Fault, the MIL will not illuminate until after the second occurrence, but Freeze Frame Data is stored after the first occurrence. CARB Freeze Frame data will only be overwritten by a different fault with a higher priority.

Freeze Frame data may include:

- Open/Closed Loop
- Calculated Load
- Engine Coolant Temperature
- Short Term Adaptive
- Long Term Adaptive
- Manifold Absolute Pressure
- RPM
- Vehicle Speed
- DTC (Hex)
- Freeze Frame Priority

**WARNING: ERASING DTCS WITH A SCAN TOOL OR BY DISCONNECTING THE BATTERY WILL ALSO ERASE FREEZE FRAME DATA.**

During model year 2000, Freeze Frame 1 and Freeze Frame 2 appeared. Freeze Frame 1 is the CARB-mandated Freeze Frame, and the previous rules for priority apply. When a failure occurs, the data first tries to occupy Freeze Frame 1. If Freeze Frame 1 is occupied with data of equal or greater priority, the data will occupy Freeze Frame 2. Data transfer between locations is not possible.

NGC PCMs have five Freeze Frame locations. The first is still the CARB-mandated Freeze Frame, but this has been expanded to include more data, such as IAC steps, P/N status, etc. Freeze Frame number 1 is the first failure regardless of priority. Freeze Frame 2 is the second failure, Freeze Frame 3 is the third failure, and the most recent failure is the last Freeze Frame. An intermittent or chronic condition could fill all five freeze frames with the same DTC, but snapshot conditions and priority could vary. Current rules state that for a two trip fault in the CARB-mandated Freeze Frame, only the priority is updated, not the data. EPA/CARB rules may change, so consult the Service Information for the latest information.

Service Required Interval (SRI) mileage is entered in a Freeze Frame. This is a PCM mileage counter that updates every 8.1 miles of continuous driving.

| CARB Freeze Frame | Freeze Frame 1 | Freeze Frame 2 | Freeze Frame 3 | Most Recent Freeze Frame |
|---|---|---|---|---|
| Order of Occurrence Does Not Matter | First Failure | Second Failure | Third Failure | Last Failure |
| Priority Does Matter | Priority Does Not Matter | Priority Does Not Matter | Priority Does Not Matter | Priority Does Not Matter |
| Could Be Trip Failure or DTC | Could Be Trip Failure or DTC | Could Be Trip Failure or DTC | Could Be Trip Failure or DTC | Could Be Trip Failure or DTC |
| Highest Priority Failure | | | | |

Figure 3 NGC Freeze Frame Rules

## ACTIVITY 1: FREEZE FRAME, MIL RULES AND GOOD TRIPS

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# MODULE 3 SPEED DENSITY FUEL CONTROL REVIEW

## SPEED DENSITY EQUATION

Most Chrysler Group vehicle use Speed Density fuel control systems. This system changes fuel injection quantity largely based on changes in engine speed and load. Other parameters modify the basic fuel calculation. The Speed Density Equations below are a representation of how NGC, JTEC and SBEC controllers calculate fuel injector pulse width in order to maintain a stoichiometric (14.7:1) air/fuel ratio.

This shows a representation of the Speed Density Equation used by SBEC and JTEC controllers to modify fuel injection quantity:

| Load | Base PW Calculation | O2 | Adaptive | P.W. |
|---|---|---|---|---|
| $\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$ | (X) TPS (X) ECT (X) IAT (X) Sensed B+ (X) LT | (X) Up02 | (X) STFT (X) LTFT | = Pulse Width |

Figure 4 JTEC/SBEC Speed Density Equation

NGC controllers utilize a new updated representation of the Speed Density Equation to modify fuel injection quantity. Because of the increased capabilities of NGC, the equation is a little different. EGR flow and extra fuel from EVAP purge are also part of the equation now. This is a representation of the NGC Speed Density Equation:

| Air Flow | Fuel Modifiers | Feedback Input | Adaptives | P.W. |
|---|---|---|---|---|
| $\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$ (X) EGR Flow* | (X) TPS (X) ECT (X) IAT (X) Sensed B+ | (X) Up O2 | (X) ST (X) LT (X) Purge Vapor Ratio* | = Pulse Width |

*Where Equipped

Figure 5 NGC Speed Density Equation

The following explains how the PCM derives each multiplier in the NGC Speed Density Equation:

### Air Flow

The PCM calculates engine rpm from the Crankshaft Position (CKP) Sensor signal. The Camshaft Position (CMP) Sensor determines which of the two companion cylinders should receive fuel and spark. Basic airflow requirements are determined by dividing the current engine rpm value by the theoretical maximum (rated) rpm. The Speed Density Equation allows the PCM to determine the percentage of the maximum possible airflow currently entering the engine.

The Manifold Absolute Pressure (MAP) Sensor measures the level of pressure (vacuum) in the intake manifold to determine the level of engine load. This measurement is compared with atmospheric (barometric) pressure. The Speed Density Equation divides MAP by BARO to determine the level of engine load.

There is always a slight lag in response from the MAP sensor itself. Therefore, NGC vehicles calculate the expected MAP value based on inputs for throttle position, barometric pressure and IAC position. This is part of the "Model-Based Fuel Strategy" and this calculated value is called "T-MAP". MAP sensor input validates this calculated value. Whenever a MAP DTC is set or a MAP problem occurs, the PCM will use the T-MAP value. T-MAP values will appear on the DRB III as "real" MAP values.

Exhaust Gas Recirculation (EGR) is used for control of NOx emissions and to improve fuel economy. Exhaust gases are metered through a valve into the intake manifold. Exhaust is mostly inert carbon dioxide and in the engine cylinder, it displaces a percentage of the incoming air. Because EGR gases effectively reduce the size of the combustion chamber, there is less room for air/fuel mixture. Less air is drawn in and less fuel is needed. The PCM compensates by reducing fuel quantity.

**Fuel Modifiers**

Throttle Position Sensor (TPS) input informs the PCM of operating conditions such as idle (Min TPS), wide open throttle (WOT), decel and the rate of throttle opening. These conditions can affect engine fuel requirements and the fuel injection pulse width calculation: acceleration enrichment, decel fuel shutoff, WOT indicating open loop while running or fuel injector shutoff (clear-flood) while cranking.

The Engine Coolant Temperature (ECT) Sensor is monitored to determine initial cranking injector pulse width and also temperature compensation while the engine is running.

Air density changes as a factor of air temperature and altitude. Denser air requires more fuel to maintain a stoichiometric air/fuel ratio. The Intake Air Temperature (IAT) Sensor allows the PCM to calculate the density of the incoming air and modify the Speed Density calculation accordingly.

The voltage applied to the fuel injectors affects how rapidly and how far the injector pintle opens. The quantity of fuel injected in a given amount of time changes with variations in voltage. Sensed B+ or sensed system voltage is monitored and used by the PCM to correct injector pulse width.

**Feedback Input**

The oxygen sensor provides the PCM with a feedback signal for oxygen levels in the exhaust. The PCM infers air/fuel ratio from this signal to see how well the Speed Density calculation has predicted fuel requirements for current engine speed, load and other conditions.

### Open Loop Operation

The PCM is in Open Loop mode during a cold start when the oxygen sensors are below 660°F (349°C), and also when the engine is operated at wide open throttle (WOT). In Open Loop, the PCM ignores the oxygen sensors and performs air/fuel ratio adjustments based on pre-programmed values and inputs from other sensors.

### Closed Loop Operation

In Closed Loop operation, the PCM monitors oxygen levels in the exhaust and makes air/fuel ratio adjustments based on oxygen sensor feedback. The upstream oxygen sensor voltage signal verifies that the fuel system is operating at the 14.7:1 stoichiometric ratio. All tailpipe emissions, HC, CO and NOx are at their lowest points simultaneously when this fuel ratio is maintained.

There are two types of Closed Loop operation:

Short-Term: Immediate corrections are made to the pulse-width in response to the oxygen sensor, but these values are not stored in memory. The parameters are:

- Engine temperature exceeds 30 - 35°F (-1 - 2°C)
- Oxygen sensor is switching
- All timers have timed out following the START to RUN transfer (the timer lengths vary, based upon engine temperature at key-on)

Long-Term: Values are stored in non-volatile memory based on short-term corrective values. The parameters are:

- Full operating temperature (typically 158°F)
- All timers have expired

**Note: Times and temperatures may vary for each engine package**

**Short Term Adaptive**

Short Term Adaptive or Short Term Fuel Trim (STFT), is an immediate correction to fuel injector pulse width. It is an immediate response to an $O_2$ sensor signal that is not switching or is consistently high or low. Short Term Adaptive begins functioning shortly after the vehicle has started, as soon as the oxygen sensor is heated to operating temperature.

Short Term Adaptive values change very quickly and are not stored when the ignition is OFF. The maximum range of authority for Short Term Adaptive is ±33% for NGC and JTEC, and ±25% for SBEC.

**Long Term Adaptive**

After the vehicle has reached full operating temperature, the correction factors generated by Short Term Adaptive will be stored in Long Term Adaptive or Long Term Fuel Trim (LTFT) memory cells. These long term values allow the Short Term Adaptive value to be brought back close to zero. Once this correction factor is stored in memory, it will be used by the PCM under all operating conditions, open loop and closed-loop.

Long Term and Short Term Adaptive can each change the pulse width by as much as ±33% (NGC and JTEC) or ±25% (SBEC) for a maximum total correction of ±66% (NGC and JTEC) or ±50% (SBEC) from the base pulse width calculation.

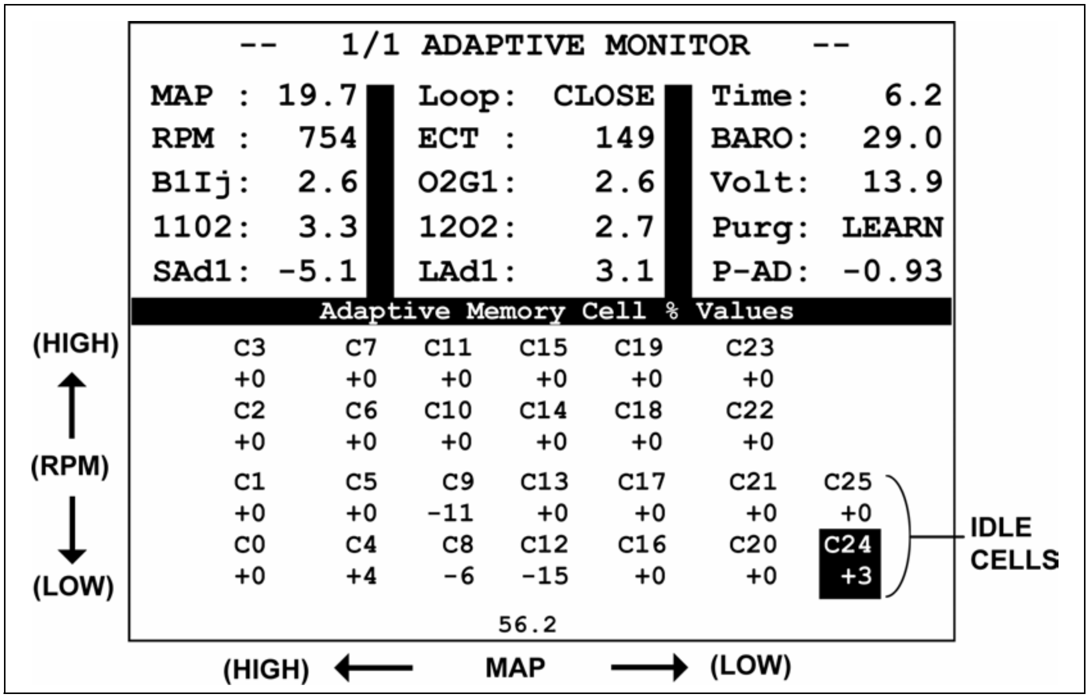



Figure 6 NGC Adaptive Fuel Monitor Screen

**Purge Vapor Ratio**

Purge Vapor Ratio is the proportion or concentration of fuel (Hydrocarbon) vapors in the EVAP system purge flow. If purge flow contains a high ratio of HC vapors, less fuel from the injectors is required.

**ACTIVITY 2: FUEL ADAPTIVES**

Notes:

## MODULE 4 MONITORS

### OBD II MONITORS

OBD II Powertrain Control Modules (PCMs) use software called Monitors to check and verify the performance of emissions-related systems and components. Some Monitors operate at all times while the engine is running. Other Monitors make their checks only once per trip (when enabling conditions permit).

The following Monitors are Continuous Monitors, and are actively checking whenever the engine is running:

- Comprehensive Components
- Fuel Control System (Fuel Trim)
- Misfire

The following Monitors are Once-Per-Trip Monitors. These Monitors do not run continuously, but run one time per trip after the necessary Enabling Conditions are met:

- Catalyst
- Oxygen Sensors
- Oxygen Sensor Heaters
- Evaporative (EVAP) System
  - Small Leak/Medium Leak/Large (Gross) Leak
  - NVLD Switch
  - LDP Switch
  - Purge
- EGR System (if equipped)
- Secondary Air (if equipped)

### ONE-TRIP VS. TWO-TRIP MONITORS

Some emissions system tests will set a DTC and illuminate the MIL the first time a failure is detected. These tests are known as “One-Trip Monitors”. Other diagnostic tests must fail more than one time before the PCM sets a DTC and illuminates the MIL. These tests are “Two-Trip Monitors”.

## FEDERAL TEST PROCEDURE

The Federal Test Procedure (FTP) is a specific Drive Cycle used by the EPA to test vehicle emissions. A test vehicle is driven in a specific way to allow most monitors to run and perform their tests. Drive Cycles can specify calibrated values for engine temperature increase, vehicle speed, time, and other parameters. Drive Cycles are calibrated for different models and engines, and the requirements vary widely. This is a typical Federal Test Procedure Drive Cycle:

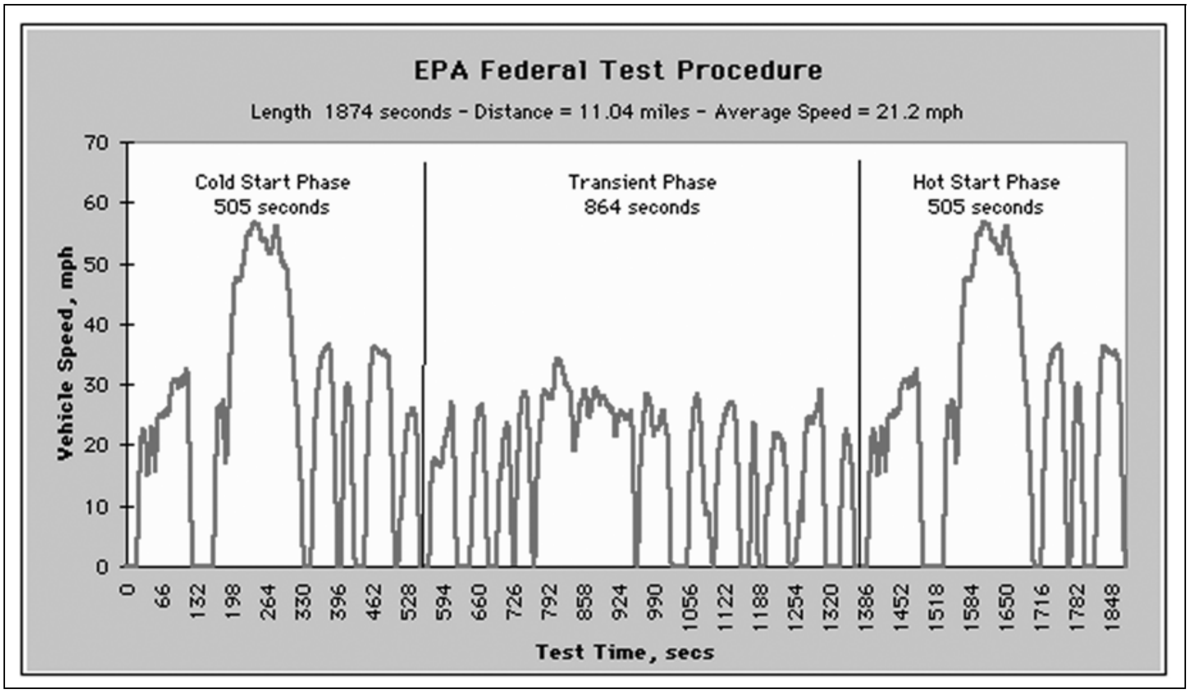



Figure 7 EPA Federal Test Procedure Drive Cycle

**MONITOR STATUS**

Monitor Status Conditions are a list of operating parameters or conditions that must be met for the monitor to run. The list of conditions that may permit a monitor to run or prevent or suspend monitor operation is calibrated and varies for each package.

The status of all monitors is displayed on the DRB III Monitor Status Screen. This screen shows only whether a monitor can be allowed to run or is running. This screen will not show the results.

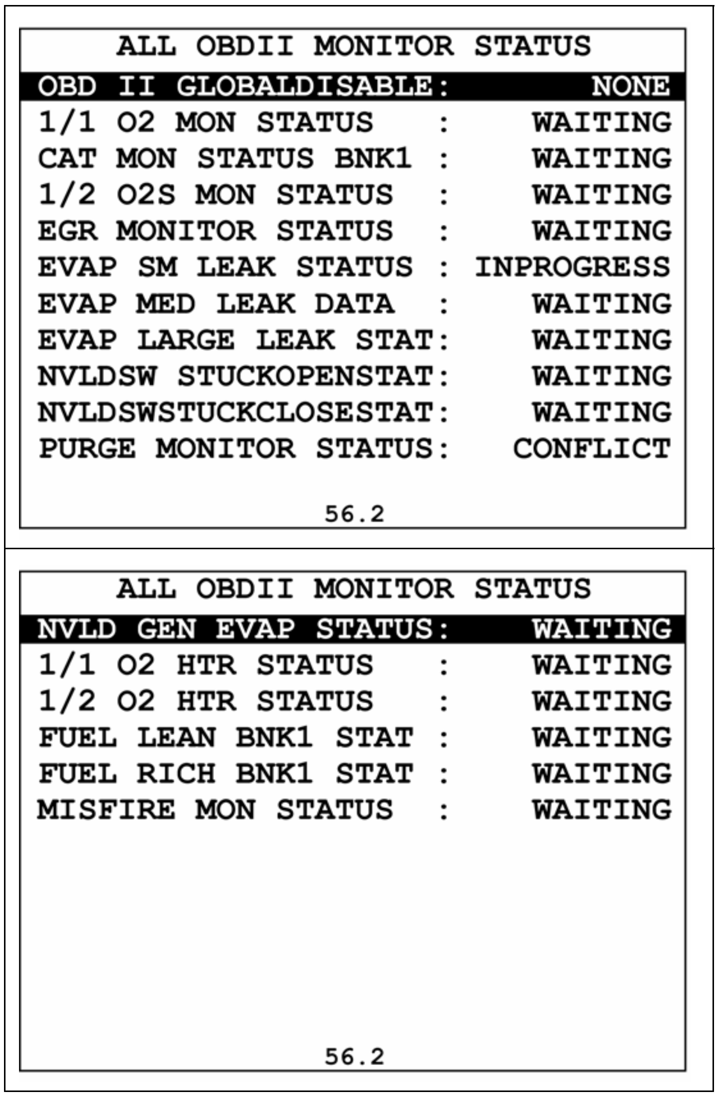



Figure 8 OBD II Monitor Status Screens

**Global Disable (NGC)**

On NGC vehicles, monitors can be Globally Disabled if certain conditions occur. If there is more than one condition, the DRB III will display only one. The conditions are ranked by the DRB III in this order:

- New Cat Bnk2
- New Cat Bnk1
- Very Lo Batt
- Hi Ethanol
- PTO Engage
- Low Fuel
- High Fuel
- Hi Altitud
- Low Batt V
- Hi Batt V
- Lo Amb Temp
- Very Lo Amb

Not every condition affects every monitor. For example, Global Disable can display "High Fuel" and the monitor status can indicate "Waiting". In this example, the Global Disable condition is not calibrated to prevent that monitor from running, so the monitor can run and complete its test.

**1/1 O2S Mon Status**

This line displays the current status of the monitor. The monitor state is ranked by the DRB III and displayed in the following order:

- **Pass Test** – Displayed when the once-per-trip monitors (or non-continuous monitors) have completed and passed. Continuous monitors, once enabled are always In Progress and will never say Pass Test unless they have failed on a previous trip. When the failed continuous monitor (Fuel or Misfire), re-runs and passes on a following trip, Pass Test will be displayed when the monitor has completed enough time in the passing region. If the Fuel System Monitor fails, Pass Test will set when the calibrated amounted of time below the fail threshold is reached (approximately 30 seconds for the Fuel System Monitor). This is enough time to pass but not enough time to increment a Good Trip. Continue to run the engine for two minutes while still under the Fuel System Rich threshold, and then shut the Engine OFF. Upon restarting, the Good Trip counter will increment by one. All Good Trip counters for all NGC vehicles are processed on powerdown, but you will need to re-start the Engine to see the Good Trip counter increment).

– If Pass Test is displayed for a non-continuous monitor, the monitor will not run again. Therefore the monitor cannot fail after this point until the key is cycled and the enabling conditions are again met.

- **Fail Test** – This text is displayed when the monitor has run and failed. At this point no other monitor 'knows' or can 'see' that this monitor has failed. This is the first of two possible failures which can be set.

- **FailThsTrp** – This text is displayed when the Task Manager processes the "Fail Test" bit above. The Task Manager then checks to see if the monitor has been Suspended or not.

  – If the monitor has not been Suspended, the Task Manager will clear "Fail Test" and set "FailThsTrp" to inform other monitors that this monitor has failed. A one-trip failure or DTC will be recorded at this point.

  – If the monitor has been Suspended, the Task Manager will not set "FailThsTrp" and will not record a one-trip failure or DTC.

- **GloblDisab** – This text is displayed when this specific monitor has a global disable. This means that the monitor is disabled and will not run this trip. Look at "OBDII GlobalDisable" to identify the specific reason why the monitor is disabled.

- **Stopped** - This text is displayed when the monitor has been stopped for one of the following reasons:

  1. If the monitor is running "In Progress", the Task Manager 'suggests' to the monitor that it should stop, but the Task Manager does not stop the monitor. The monitor must stop itself in order to have an orderly exit of an intrusive test.
  2. When the monitor has completed (failing or passing).
  3. If the monitor is not running (not intrusive or not in progress), the Task Manager stops the monitor from starting due to another Fault. For

example, a MAP Sensor Shorted High DTC will prevent the Oxygen Sensor and Catalyst Monitors from running.

- **InProgress** – This text is displayed when the monitor is in progress and/or intrusive (running now).

- **Conflict** – This text is displayed when another monitor is running, or other enable conditions have not yet been met to allow this monitor to run (example: Closed Loop). This text is dynamic and can change from being displayed to not being displayed, as the monitor is 'conflicted' or not 'conflicted'. When this text is displayed, the monitor CANNOT run, but may run at some later point in the same trip. When the Conflict text is displayed, you may want to go to the "All OBDII Monitor Status" screen to see what other monitors may be running.

- **Suspended** – This text is displayed when a monitor has been Suspended from running during this trip due to another one-trip failure. For example, a misfire one-trip failure suspends the Catalyst Monitor. The Catalyst Monitor depends on the $O_2$ sensor and the $O_2$ sensor is adversely affected by the misfire.

- **Waiting** – This text is displayed when the enable conditions for this specific monitor have not yet been met, and it still can run this Trip.

  – If Waiting is displayed and the OBDII Global Disable displays anything other than "None" (e.g., Low Fuel Level), then the Global Disable displayed does not apply for this monitor.

**Pending - SBEC/JTEC**

On JTEC and SBEC vehicles, the Task Manager may not run a monitor if the MIL is illuminated and a fault is stored. If this occurs, the Task Manager postpones the monitor pending resolution of the fault. The Task Manager does not run the test until the problem is remedied. For example, when the MIL is illuminated for an $O_2$ sensor fault, the Task Manager does not run the Catalyst Monitor until the $O_2$ sensor fault is remedied. Running the test might produce inaccurate results since the Catalyst Monitor relies on a good $O_2$ sensor signal.

**CARB READINESS**

The DRB III CARB Readiness Status screen indicates whether or not the once per trip monitors have run. These monitors include EVAP, Catalyst, $O_2$ Response, $O_2$ Heater and EGR. Downstream $O_2$ is also a once per trip Monitor, but its listing is not required here.

Note: The CARB Readiness Status screen shows whether the monitors have run. The screen does not indicate whether the test passed or failed. A monitor can fail and the display will still indicate "YES".

There is one listing on screen for each component type, even if the vehicle has more than one of the component. Example: multiple catalysts.

This screen shows that the PCM diagnostics have checked the appropriate systems. In some states, this information is used as part of an emissions or inspection test. This readiness information is kept in PCM memory until DTCs are erased.

The MIL can now indicate whether the monitors have run. With Key-ON-engine-not-running for at least twelve seconds, a flashing MIL indicates that the monitors have not run and are not ready. This capability is on all NGC, SBEC from 2001 and JTEC from 2002.

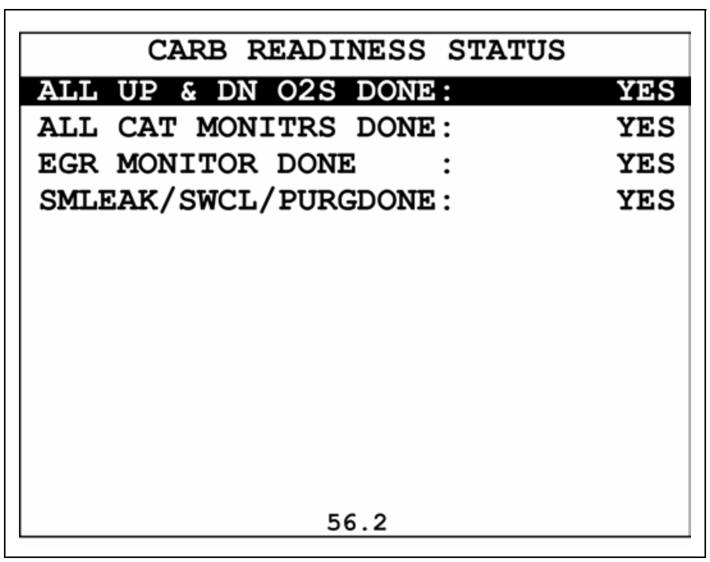



Figure 9 CARB Readiness Screen

## ACTIVITY 3: SCAN TOOL ACTIVITY ON NGC EQUIPPED VEHICLE

Notes:

## MODULE 5 OXYGEN SENSOR RESPONSE MONITOR

### BACKGROUND

The Oxygen Sensor Response Monitor tests upstream $O_2$ sensor operation and its ability to respond. This Monitor is a two-trip-fault Monitor that is tested once per trip. On NGC vehicles, the Monitor runs when the vehicle is under light load at approximately 25-50 mph. On JTEC and SBEC vehicles, the Monitor typically runs at idle, in gear. A/C-ON does not inhibit running the Monitor.

### OXYGEN SENSOR OPERATION

Oxygen Sensors provide a feedback signal that allows the PCM to maintain the desired stoichiometric air/fuel ratio of 14.7:1.

When hot, the $O_2$ sensor becomes a galvanic battery that typically generates a voltage signal between 0.0 - 1.0V. On NGC vehicles, a bias voltage in the PCM shifts the signal voltage to fluctuate between 2.5 - 3.5V.

The voltage generated by the Oxygen Sensor is consistently high when air/fuel ratios are richer than ideal, and the voltage generated is consistently low when air/fuel ratios are leaner than ideal. The sensor signal voltage switches dramatically at stoichiometry and is relatively unchanging at all other air/fuel ratios.

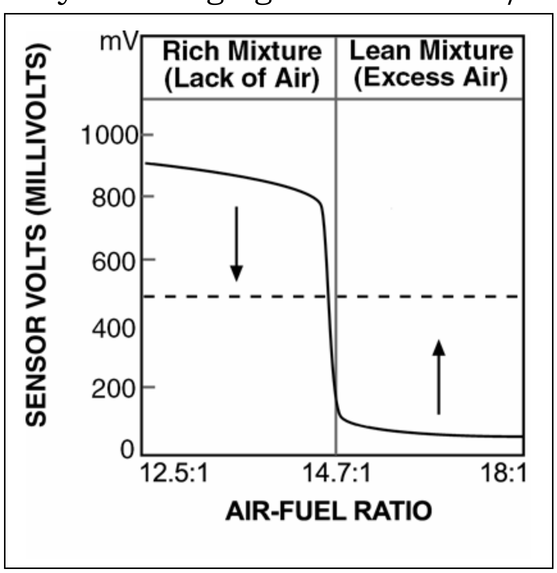



Figure 10 $O_2$ Sensor Signal

In closed-loop operation, the PCM attempts to keep the air/fuel ratio at stoichiometry by continuously increasing and decreasing fuel injector pulse width in response to changes in the Oxygen Sensor signal voltage.

By varying the amount of fuel injected, the PCM alternately increases and decreases the amount of oxygen in the exhaust. This drives the upstream Oxygen Sensor voltage higher and lower. This variation in air/fuel ratio and exhaust oxygen content causes the Oxygen Sensor to output a signal voltage that continuously hunts back and forth from high to low. When there is a large amount of oxygen in the exhaust caused by a lean mixture, the Oxygen Sensor produces a low voltage. When the oxygen content is lower caused by a rich mixture, the Oxygen Sensor produces a higher voltage. This produces the familiar oxygen sensor sine waveform. The waveform from a good Oxygen Sensor will swing above and below Rich and Lean Switch Points.

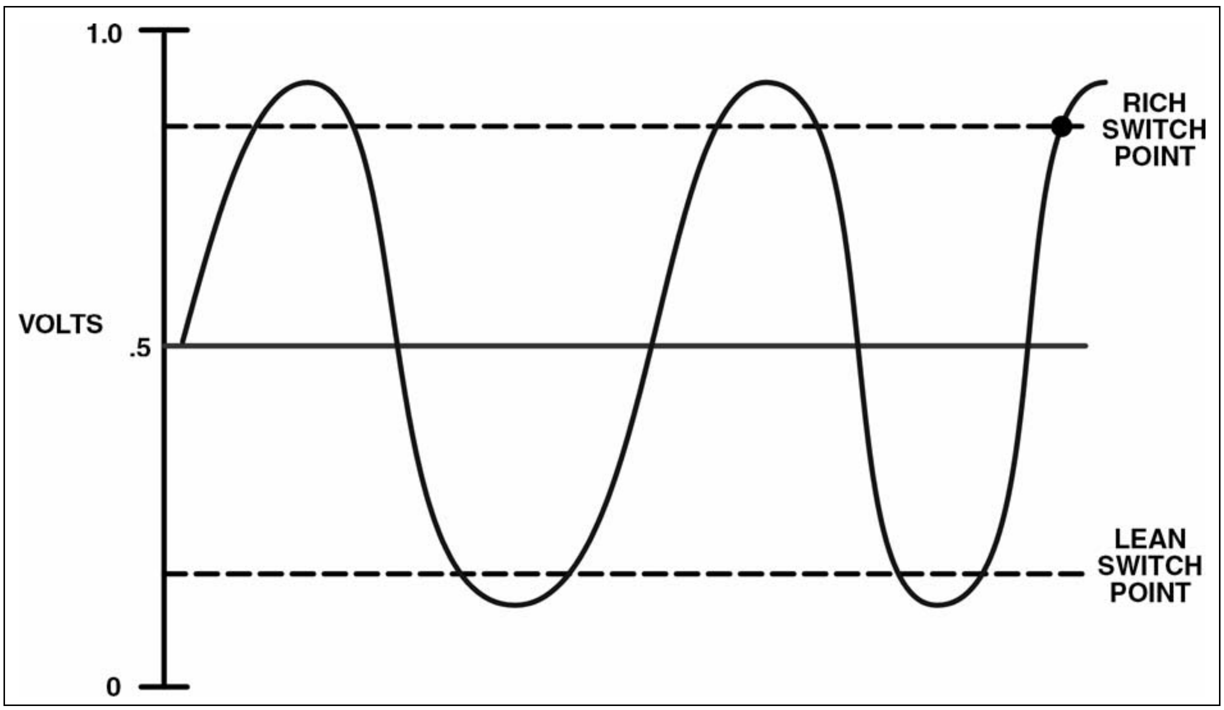



Figure 11 Oxygen Sensor Waveform and Switch Points

The sensor must detect changes in oxygen levels and output a signal voltage that reacts quickly. The Oxygen Sensor Response Monitor determines whether the sensor responds rapidly or has become lazy.

## OXYGEN SENSOR MONITOR

The Oxygen Sensor Response Monitor is a two-trip fault and a once-per-trip monitor. Oxygen sensor signal voltage range for NGC vehicles is 2.5 – 3.5 V. This is higher than SBEC and JTEC vehicles.

The monitor on NGC vehicles runs when the vehicle is under light load, at approximately 20 – 50 mph. With SBEC and JTEC, the monitor runs at idle, in gear. A/C ON does not inhibit the monitor from running. The monitor takes 20 seconds to run, and there is a "fast pass mode" if the specification is met within 10 seconds. Two consecutive failures result in a DTC for OXYGEN SENSOR SLOW RESPONSE.

### JTEC/SBEC Big Slope and Half Cycle Counters

On JTEC and SBEC vehicles, the Oxygen Sensor Response Monitor checks two oxygen sensor performance parameters. These parameters are called Big Slope and Half Cycles.

Big Slope refers to how rapidly the sensor signal voltage changes or swings. In other words, how steep the curves of the waveform are. This is the response rate of the sensor. A sensor that has aged will not respond as quickly as a good sensor.

Big Slope is determined by this formula:

$$\textbf{SLOPE=} \; \frac{\Delta \text{ VOLTAGE}}{\Delta \text{ TIME}} \text{ OR } \frac{\text{CHANGE IN VOLTAGE}}{\text{CHANGE IN TIME}}$$

The PCM checks $O_2$ Sensor voltage every few milliseconds. The waveform is a plot of these voltage values. The Monitor checks the slope of the curve by calculating the change in voltage divided by the change in time. If the slope value is not sufficient, the Monitor judges the sensor failed and sets a one-trip failure.

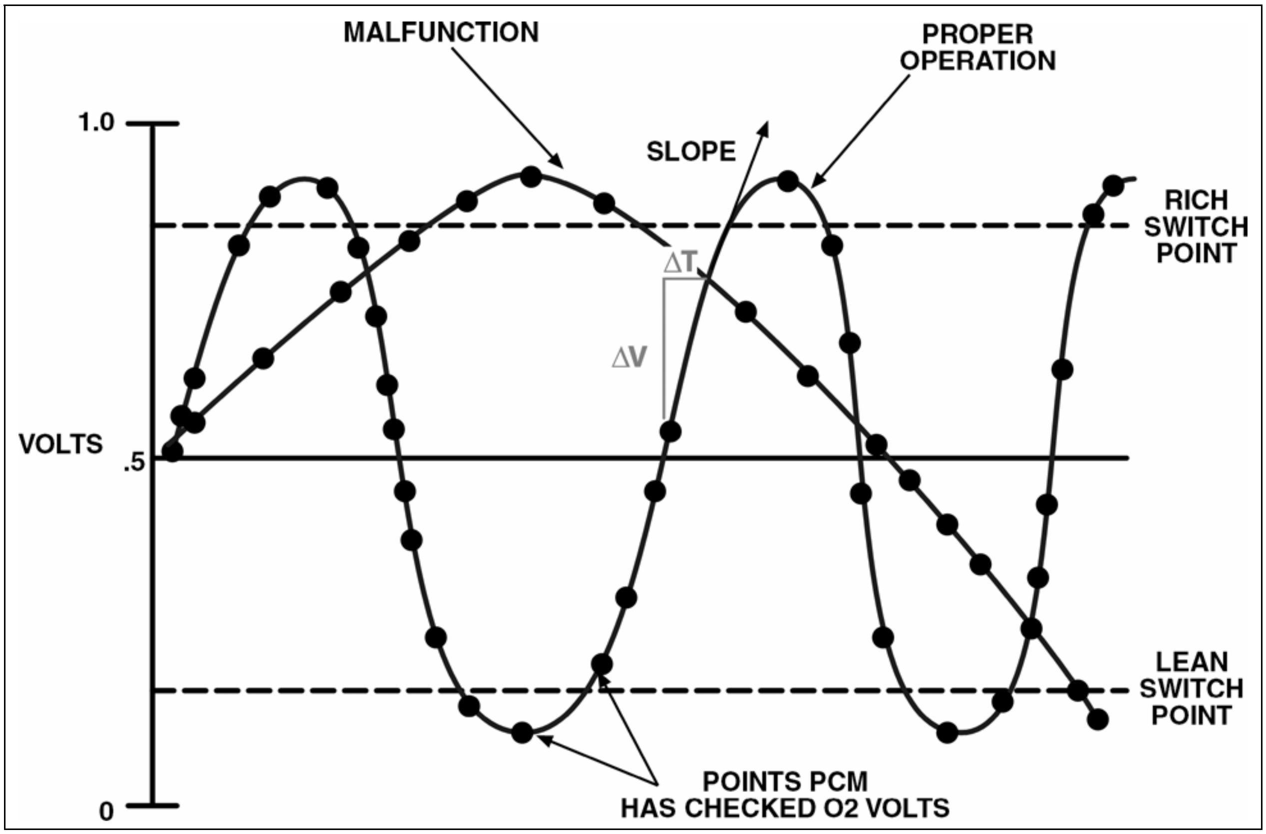



Figure 12 JTEC/SBEC Oxygen Sensor Big Slope

Half Cycles refers to the number of times that the sensor signal voltage swings exceed the upper and lower Switch Point or Threshold voltages set by the PCM. Each time the signal voltage surpasses a Switch Point, a threshold a counter increments by one. The Switch Points are calibrated voltages, typically around 0.2V and 0.8V.

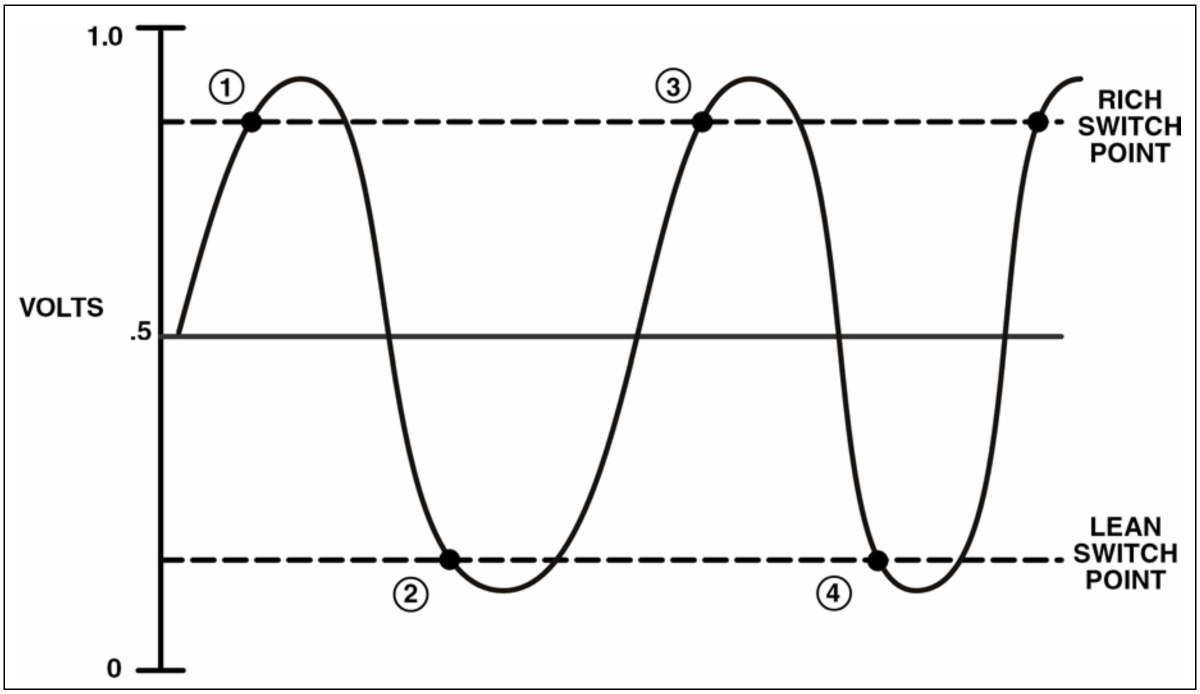



Figure 13 JTEC/SBEC Oxygen Sensor Half Cycles

Only one of the parameters (Big Slope or Half Cycles) needs to pass for the $O_2$ Sensor Monitor to register a pass.

**NGC Switch Counter**

The NGC Oxygen Sensor Switch Counter Monitor counts the number of times the sensor signal crosses calibrated high and low thresholds (Switch Points) in a calibrated time period. Each time the voltage signal goes beyond both thresholds, a counter increments by one. If the sensor is lazy and the waveform does not switch rapidly enough, or if the amplitude of the voltage swings is insufficient to cross the Switch Points, the count will be low. The counter increments only when the waveform crosses the Switch Points.

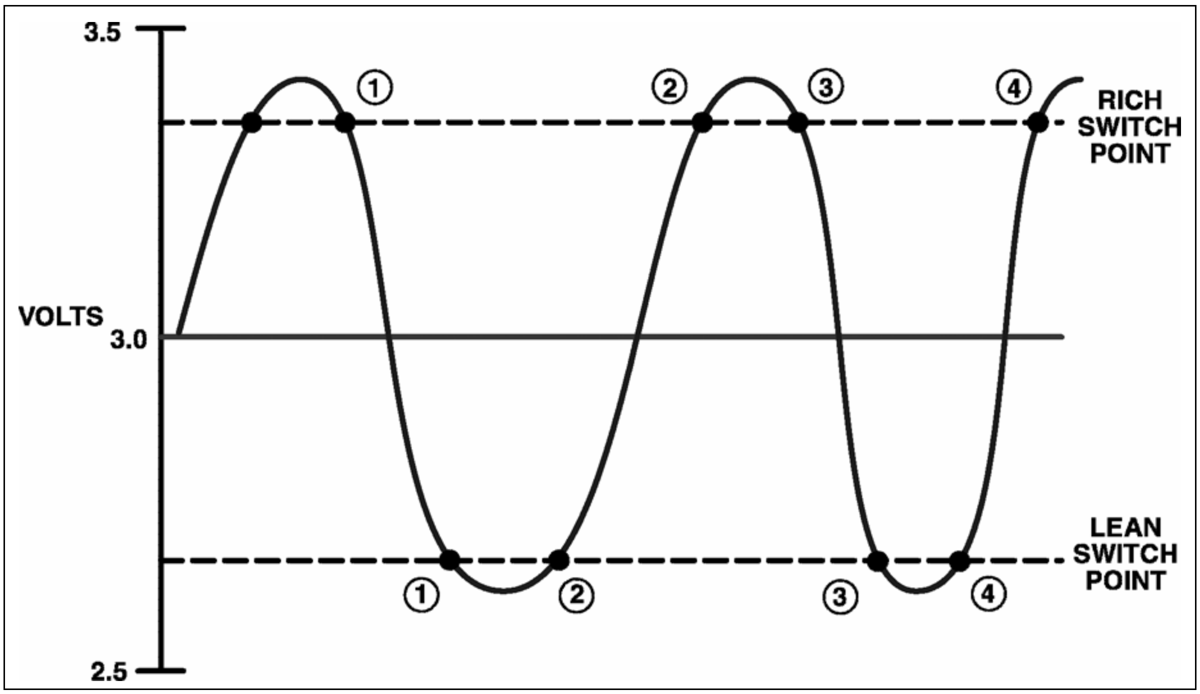



Figure 14 NGC Oxygen Sensor Switch Counts

The Oxygen Sensor Switch Counter Monitor takes 20 seconds to run. The Monitor will register a PASS if the counter reaches a calibrated value within the time period. There is a Fast Pass Mode if the calibrated count is reached within 10 seconds. The Monitor is a two trip monitor that is tested once per trip. The Monitor must fail on two consecutive trips to set DTC "P0133 - UPSTREAM HO2S RESPONSE" and to illuminate the MIL.

The MIL is extinguished when the Monitor passes on three consecutive Good Trips. The DTC is erased from memory after 40 consecutive warm-up cycles without a failure.

**SCAN TOOL PRETEST SCREEN – NGC SWITCH COUNTER MONITOR**

This screen allows the user to determine when the conditions have been met to run the Oxygen Sensor Switch Counter Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

```
      -- Upstream O2s Pre-Test --
ECT Range   :  158►[  120]    260
Min Run Time:  1.9►[  0.0]   13.9
Cat Tmp Rang:  932►[  -83]   1650
--- ENABLING CONDITIONS ---
VSS Range   : 20.0►[  0.0]   50.0
RPM Range   : 1312►[    0]   2016
RpmVSS Ratio:    0 [  255]◄    80
TestBlockTim:    0 [    0]◄   819
MaxTest Time:  0.0 [  0.0]   25.0



                56.2
```

Figure 15 NGC III Oxygen Sensor Switch Counter Monitor Pretest Screen

The main objective of this and other pre-test screens is to “make the arrows go away”. When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**ECT Range:** Engine coolant temperature value must be within the indicated range; minimum value on the left, actual value in the middle, and maximum value to the right.

**Min Run Time:** Minimum amount of engine run time since start, displayed in minutes. The number right of the decimal are tenths of a minute (e.g., 1.5 is equal to 1 minute and 30 seconds)

**Cat Temp Range:** Catalyst temperature is a calculated value based on load, road speed, ambient temperature, short-term and long-term fuel correction, spark advance, run time, coolant temp, etc.

**VSS Range:** Vehicle speed must fall within this range, with minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM Range:** Engine speed must fall within this range, with minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM VSS Ratio:** This is a calculation of RPM divided by vehicle speed (N/V ratio). It is used to verify selected transmission gear (usually used to prevent monitor from running in 1st or 2nd gear). The ranges are displayed as a percent or ratio.

**Test Block Time:** Minimum amount of time in seconds where the O2 switch counts can be summed to the total counter.

This does not require a consecutive 10 second block for a fast pass; it can be over a period of time. Requires 20 seconds for a normal pass. It is possible for the minimum value to be calibrated to zero (0) (e.g., 2003 5.7L Truck). The maximum value of 819 seconds is a hard coded value, which is not possible to reach (but needed to display the range).

**Max Test Time:** This is the maximum time allowed during the monitor

**SCAN TOOL MONITOR DATA SCREEN – NGC SWITCH COUNTER MONITOR**

This screen indicates the status of the Oxygen Sensor Switch Counter Monitor.

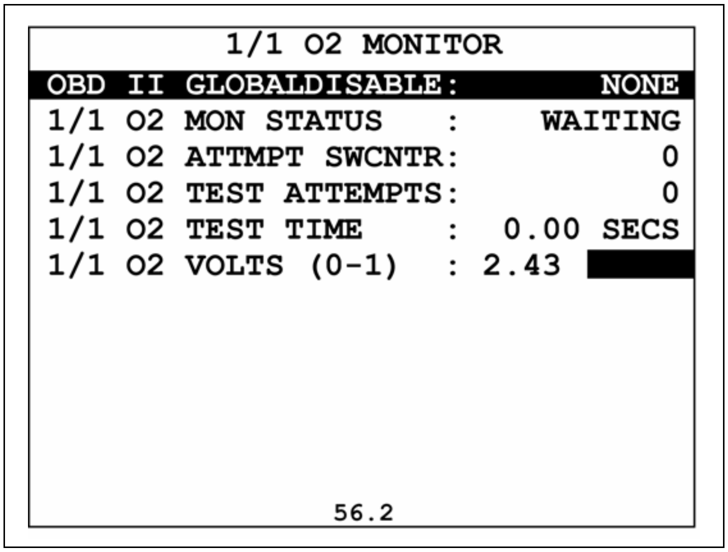



Figure 16  NGC Oxygen Sensor Switch Counter Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**1/1 O2 Mon Status:** Displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in the Module 4 Monitors.

**1/1 O2 Attmpt Swcntr:** Total number of O2 Sensor switch counts within the maximum test time period.

**1/1 O2 Test Attempts:** Number of tests attempted for that key cycle. Can be as many attempts as shown on Last Result screen.

**1/1 O2 Test Time:** Amount of time in seconds that monitor has been in progress. This number may stop and start as enable conditions are entered and exited. This timer will max out when the monitor is completed – stop at the value from the monitor pre-test screen (i.e. “MaxTest Time” 20 seconds)

**1/1 O2 Volts (0-1):** This is actual $O_2$ sensor voltage.

## SCAN TOOL LAST RESULT SCREEN – NGC SWITCH COUNTER MONITOR

This screen can be used to track previous Oxygen Sensor Switch Counter Monitor results.

1/1 O2 MON LAST RESULT

| | | |
|---|---|---|
| 1/1 O2 CNTR RESULTS | : | VALID |
| 1/1 O2SW CNTR RESULT | : | 11 |
| 1/1 O2 SW CNTR SPEC | : | 10 |
| 1/1 O2 FASTPASS SPEC | : | 6 |
| 1/1 O2 TEST ATTEMPTS | : | 0 |
| 1/1 O2 TEST ATMPSPEC | : | 3 |
| 1/1 O2 THRESH TYPE | : | MINIMUM |
| 1/1O2TESTFAILTHISTRP | : | NO |
| 1/1O2TESTFAILLASTTRP | : | NO |
| 1/1 O2LAST TEST TYPE | : | FASTPASS |

56.2

Figure 17 NGC Oxygen Sensor Switch Counter Monitor Last Result Screen

**1/1 O2 Cntr Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from the last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**1/1 O2SW Cntr Result:** Total amount of O2 switch counts within the last completed O2 Monitor test time period. Same as the "1/1 O2 Attmpt SwCntr" for the same key cycle in which the monitor has run and completed.

**1/1 O2 Sw Cntr Spec:** Minimum passing specification for the total amount of O2 switch counts required for the normal test period (e.g., 20 seconds)

**1/1 O2 Fastpass Spec:** Minimum specification which allows the monitor to pass prior to the full test period (e.g., 10 seconds rather than 20 seconds). This was done to reduce the tailpipe emissions during the O2 Monitor. Due to the shorter test time period of the Fast Pass test, the Fast Pass Spec. is less than the Normal Switch Counter Spec. A value of 255 indicates that this test is not enabled (calibrated) for this package. A fast pass will only be indicated if both O2 monitor and Catalyst monitor meet the "fast pass" criteria.

**1/1 O2 Test Attempts:** Number of fail attempts accumulated trying to reach a pass by exceeding the O2 Sw Cntr Spec. Not associated with the FastPass – FastPass can only be used to pass and not fail. O2 Test Attempts only increments when the monitor is incrementing toward a failure (e.g., to fail O2 monitor, it must run three (3) 20 second test attempts in the same key cycle to set a 1-trip failure).

**1/1 O2 Test Atmpspec:** Specification for the maximum number of soft fail attempts before setting a 1-trip failure.

**1/1 O2 Thresh Type:** Displayed as “minimum”. Indicates that the result must exceed the specification for the switch counter to pass

**1/1 O2 Test Fail This Trip:** Indicates if the monitor has ran and failed during this trip. Results in a “Yes” or “No”.

**1/1 O2 Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a “Yes” or “No”.

**1/1 O2 Last Test Type:** Indicates which threshold was compared against “1/1 O2Sw Cntr Results” to determine the Pass or Fail. Displayed as “Normal” or “FastPass”.

## ACTIVITY 4: OXYGEN SENSOR SWITCH COUNTER MONITOR

Notes:

**NGC State of Change**

Beginning in 2004, 2.0L, 2.4L, and 5.7L engines with NGC III controllers use a new Oxygen Sensor Response Monitor strategy. This new method is called State of Change.

During testing, $O_2$ sensor signal voltage readings are taken every 10 ms.

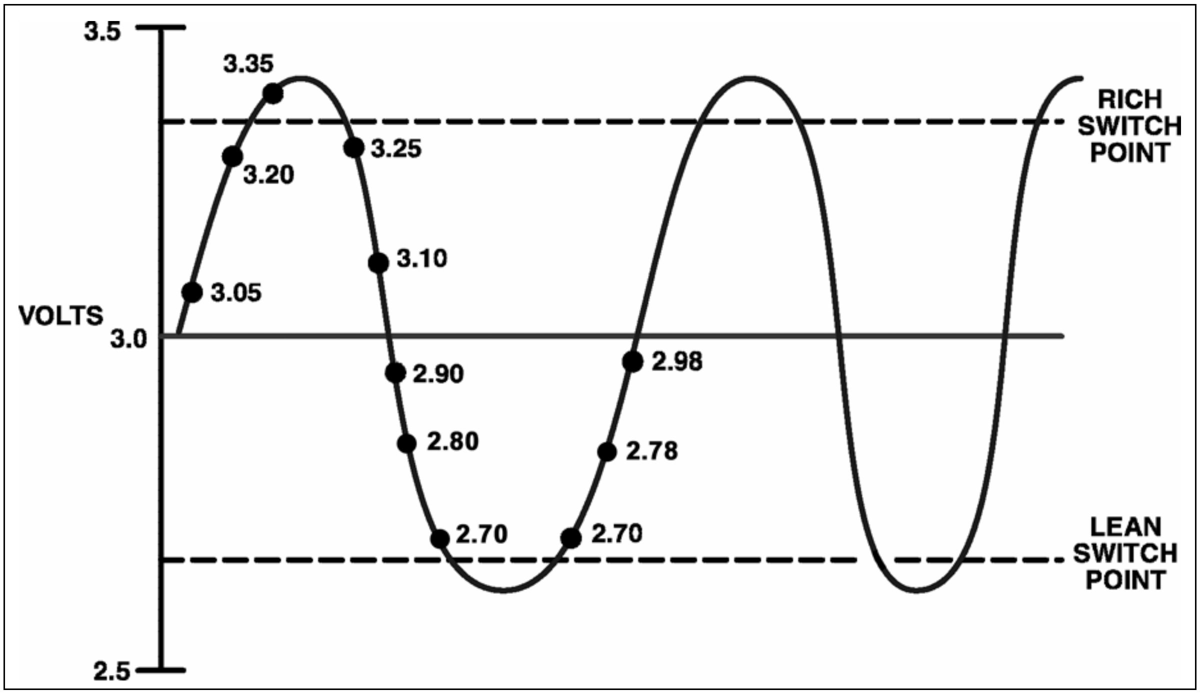



Figure 18 NGC State of Change

Each value representing the difference between consecutive 10 ms voltage readings (in other words, the change in voltage) is placed in a set of five bins. Each bin is based on a MAP and RPM matrix, similar to Long Term Adaptive memory cells.

| Bin 1 | Bin 2 | Bin 3 | Bin 4 | Bin 5 |
|---|---|---|---|---|
| .15<br>.10 | .20 | | .28 | |

Figure 19 NGC State of Change Bins

When the total test time is completed, the bin values are added to calculate the bin total values.

| Bin 1 | Bin 2 | Bin 3 | Bin 4 | Bin 5 |
|---|---|---|---|---|
| .15<br>.10 | .20 | | .28 | |

**Sum of Bin Values at End of Test Time**

| | | | | |
|---|---|---|---|---|
| .25 | .20 | | .28 | |

Figure 20  Sum of NGC State of Change Bin Values

Each sum for each bin is multiplied by a weighted factor. The five weighted bin values are then added together and divided by the total test time. The result is an Average Voltage Change value. If this value exceeds a calibrated value, the monitor passes.

Sum of Bin 1 X Weighted Factor=B1Voltage

You do the same for each Bin

$$\frac{\text{B1V + B2V + B3V + B4V + B5V}}{\text{Total Test Time}} = \text{O2 Average Voltage Change}$$

Figure 21  NGC State of Change Calculation

## SCAN TOOL PRETEST SCREEN – NGC STATE OF CHANGE MONITOR

This screen allows the user to determine when the conditions have been met to run the Oxygen Sensor State of Change Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

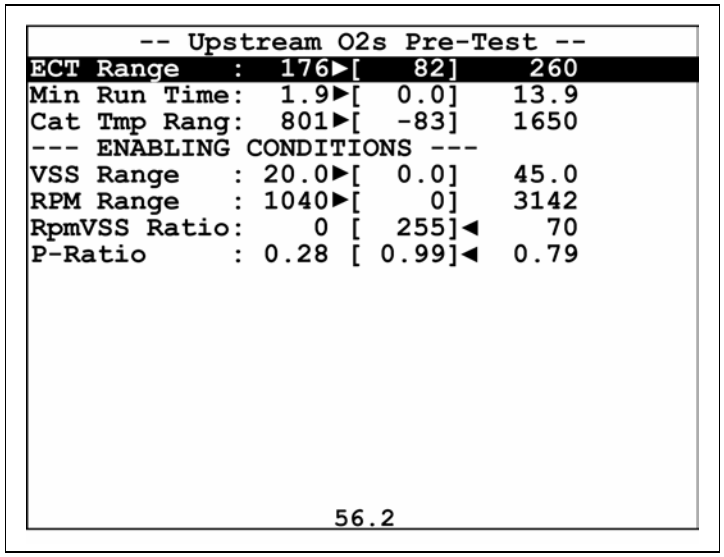



Figure 22 NGC SOC Oxygen Sensor Monitor Pretest Screen

**ECT Range:** Engine coolant temperature value must be within the indicated range, with minimum value on the left, actual value in the middle, and maximum value to the right.

**Min Run Time:** Minimum amount of engine run time since start, displayed in minutes. The number right of the decimal are tenths of a minute (e.g., 1.5 is equal to 1 minute and 30 seconds)

**Cat Temp Range:** Catalyst temperature is a calculated value based on load, road speed, ambient temperature, short-term and long-term fuel correction, spark advance, run time, coolant temp, etc.

**VSS Range:** Vehicle speed must fall within this range; minimum value on left, actual value in the middle, and maximum value to the right.

**RPM Range:** Engine speed must fall within this range, minimum value on left, actual value in the middle, and maximum value to the right.

**RPM VSS Ratio:** This is a calculation of RPM divided by vehicle speed (N/V ratio). It is used to verify selected transmission gear (usually used to prevent monitor from running in 1st or 2nd gear). The ranges are displayed as a percent or ratio.

**P Ratio:** This is a calculation of absolute MAP divided by barometric pressure. A sample reading is; 0.99 volts = wide open throttle (Map equal to Baro).

## SCAN TOOL MONITOR DATA SCREEN – NGC STATE OF CHANGE MONITOR

This screen indicates the status of the Oxygen Sensor State of Change Monitor.

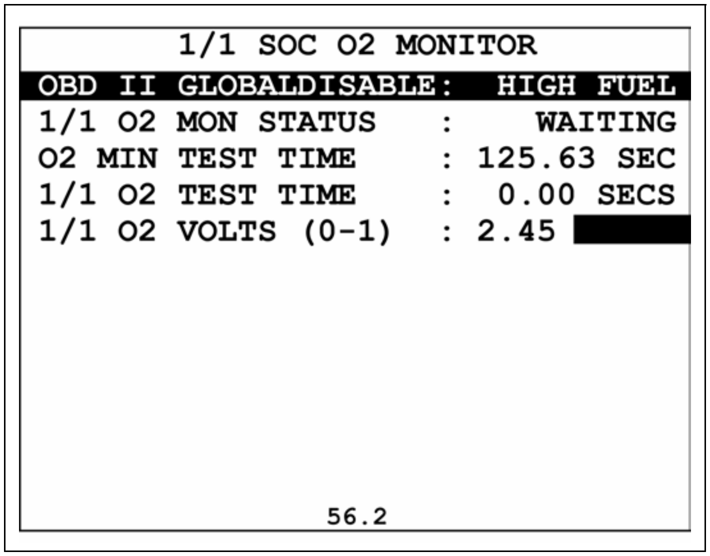



Figure 23 NGC SOC Oxygen Sensor Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**1/1 O2 Mon Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**O2 Min Test Time:** The amount of time necessary to complete the State of Change Monitor.

**1/1 O2 Test Time:** This is the live reading of the time that the vehicle has been driven within the 5 MAP/RPM bins. This timer will start and stop as the vehicle is driven in and out of the MAP/RPM based bins. The total time must equal the O2 Min Test Time before the monitor will complete.

**1/1 O2 Volts (0-1):** This is the live reading of the 1/1 O2 sensor. This reading is displayed in the 0v to 1v range.

## SCAN TOOL LAST RESULT SCREEN – NGC STATE OF CHANGE MONITOR

This screen can be used to track previous Oxygen Sensor State of Change Monitor results.

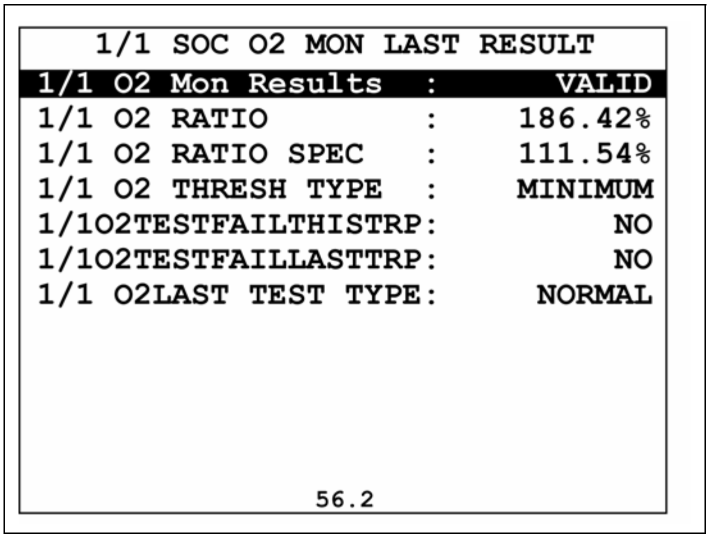



Figure 24 NGC SOC Oxygen Sensor Monitor Last Result Screen

**1/1 O2 Mon Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**1/1 O2 Ratio:** The O2 sensor voltage is read every 10ms. The difference between each reading provides a delta voltage. The sum of the accumulated O2 delta voltage readings which are gathered during the O2 Test Time is then divided by the Total Test Time. The total will be expressed as a ratio. The accumulated voltage is typically higher than the accumulated time, which results in the ratio being greater than 100%. Example: a lazy O2 sensor will generate less voltage change over time, resulting in a ratio below 100%.

**1/1 O2 Ratio Spec:** The percentage of accumulated volts divided by test time. Below this percentage, the monitor will fail.

**1/1 O2 Thresh Type:** Displayed as "minimum". Indicates that the result must exceed the specification for the switch counter to pass

**1/1 O2 Test Fail This Trip:** Indicates if the monitor has run and failed during this trip. Results in a "Yes" or "No".

**1/1 O2 Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a "Yes" or "No".

**1/1 O2 Last Test Type:** For the State of Change Monitor this will display "Normal" all the time. "Fast Pass" is currently not necessary on the SOC Monitor.

## ACTIVITY 5: OXYGEN SENSOR STATE OF CHANGE MONITOR

Notes:

## SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

| Upstream O2S Pre-Test | | | | |
|---|---|---|---|---|
| ECT Range | : | 120 | [95] | 260 |
| Min Run Time | : | 1.0 | [3.0] | 13.9 |
| VSS MPH Range | : | 14.0 | [0] | 100 |
| Open Thr Time | : | 1.0 | [0.0] | 13.9 |
| Cat Tmp Range | : | 0.0 | [145] | 2500 |
| ENABLING CONDITIONS | | | | |
| VSS Range | : | 0.0 | [0.0] | 1 |
| Target RPM | : | -192 | [-816] | 320 |
| Exhst Time | : | 1.1 | [0.0] | 13.9 |
| Cat Tmp Range | : | 0 | [145] | 2500 |

**JTEC**

| Upstream O2S Pre-Test | | | | |
|---|---|---|---|---|
| ECT Range | : | 147 | [68] | 260 |
| Bat Tmp Range | : | 21 | [66] | 130 |
| VSS MPH Range | : | 10 | [0] | 100 |
| Open Thr Time | : | 1.9 | [0.0] | 13.9 |
| ENABLING CONDITIONS | | | | |
| VSS Range | : | 0.0 | [0.0] | 5.0 |
| RPM Range | : | 448 | [0] | 992 |
| Exhst Time | : | 1.9 | [0.0] | 13.9 |
| MaxTestTime | : | 0.0 | [0.0] | 1.6 |
| Adap Cell ID | : | 0.0 | [21.0] | 20.0 |

Figure 25 JTEC/SBEC Oxygen Sensor Response Monitor Pretest Screen

**Adap Cell ID:** The vehicle must be in the indicated adaptive cell before the monitor runs.

## SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

| 1/1 O2S MONITOR | | |
|---|---|---|
| 1/1 O2S MON DATA | : | 80 |
| 1/1 O2S MON IN PROGRESS | : | NO |
| 1/1 O2S MON DONE THIS TRP | : | NO |
| 1/1 O2S MON FAIL 1 TRIP | : | NO |
| 1/1 O2S MON FAIL DTC SET | : | NO |
| 1/1 O2S MON STOP TESTING | : | NO |
| 1/1 O2S MON TEST TIME | : | 0.00 SECS |
| 1/1 O2S HALF CYCLE CNTR | : | 0 |
| 1/1 O2S BIG SLOPE CNTR | : | 0 |
| 1/1 O2S VOLTS | : | 0.47 VOLTS |

**JTEC**

| 1/1 O2S MONITOR | | |
|---|---|---|
| 1/1 O2S MON DATA | : | 00 |
| 1/1 O2S MON IN PROGRESS | : | NO |
| 1/1 O2S MON DONE THIS TRP | : | NO |
| 1/1 O2S MON FAIL THIS TRIP | : | NO |
| 1/1 O2S MON STOP TESTING | : | NO |
| 1/1 O2S MON TEST TIME | : | 0.00 SECS |
| 1/1 O2S HALF CYCLE CNTR | : | 0 |
| 1/1 O2S BIG SLOPE CNTR | : | 0 |
| 1/1 O2S VOLTS | : | 5.00 VOLTS |

Figure 26 JTEC/SBEC Oxygen Sensor Response Monitor Data Screen

**1/1 O2 Half-Cycle Counter:** The counter records the activity of the O2 sensor during the monitor by counting the number of times the O2 voltage exceeds the upper switch point (0.80 volts) and falls below the lower switch point (0.20 volts).

**1/1 O2 Big Slope Counter:** This is an indicator of O2 sensor response time. The counter increments every time the O2 sensor responds quickly. Big slope is defined as a change in voltage over a change in time.

**SCAN TOOL LAST RESULT SCREEN – JTEC/SBEC**

**SBEC**

```
      1/1 O2S MON LAST RESULT
1/1 O2 HALF CYCLE STATUS : C0
1/1 HALF CY LAST RESULT  : MIN
1/1 HALF CY FAIL THIS TST: NO
1/1 HALF CY FAIL PREV TST: NO
LAST 1/1 O2 HALF CY CNTR : 255
1/1 O2 HALF CY CNTR SPEC : 18
1/1 O2 BIG SLOPE STATUS  : C0
1/1 BIG SLOPE LAST RESULT: MIN
1/1 BIG SLP FAIL THIS TST: NO
1/1 BIG SLP FAIL PREV TST: NO
LAST 1/1 O2 BIG SLP CNTR : 53
1/1 O2 BIG SLP CNTR SPEC : 20
```

**JTEC**

```
      1/1 O2S MON LAST RESULT
LAST 1/1 O2 HALF CY CNTR: 0
1/1 O2 HALF CY CNTR SPEC: 56
LAST 1/1 O2 BIG SLP CNTR: 0
1/1 O2 BIG SLP CNTR SPEC: 10
```

Figure 27 JTEC/SBEC Oxygen Sensor Response Monitor Last Result Screen

**1/1 O2 Half-Cycle Status:** The value represented on this line is a data byte.

**1/1 Half-Cycle Last Result:** The term “min”, when seen on the DRBIII®, indicates the PCM is looking for a minimum value to be exceeded during the monitor. The term “max” indicates the PCM is looking for a maximum value not to be exceeded during the monitor. In this example, the PCM was looking for a minimum value to be exceeded during the monitor.

**1/1 Half-Cycle Failed Prev Test:** The monitor result from the trip previous to the last trip is recorded on this line.

**1/1 Half-Cycle Failed This Test:** The monitor result from the previous trip is recorded on this line.

**Last 1/1 O2 Half-Cycle Counter:** The number of half-cycles that occurred during the previous trip is recorded on this line.

**1/1 O2 Half-Cycle Counter Spec:** The number of half-cycle counts that needed to be exceeded to pass the monitor is specified here.

**1/1 O2 Big Slope Status:** The value represented on this line is a data byte.

**1/1 Big Slope Last Result:** The term “min”, when seen on an OBD DRBIII®, indicates the PCM is looking for a minimum value to be exceeded. The term “max” indicates the PCM is looking for a maximum value not to be exceeded. In this example, the PCM was looking for a minimum value to be exceeded during the trip.

**1/1 Big Slope Failed This Test:** The monitor result from the previous trip is recorded on this line.

**1/1 Big Slope Failed Previous Test:** The monitor result from the trip previous to this trip is recorded on this line.

**Last 1/1 O2 Big Slope Counter:** The number of big slopes during the previous test is recorded on this line.

**1/1 O2 Big Slope Counter Spec:** The number of big slope counts that needed to be exceeded to pass the monitor is specified here.

**Note: The monitor pass is based on which counter first satisfies the requirements, the half-cycle counter or the big slope counter.**

Notes:

# MODULE 6 CATALYST MONITOR

## BACKGROUND

Three-way catalytic converters use two reactions to change three harmful exhaust gases into harmless gases. In the first part of the catalytic converter, Oxides of Nitrogen (NOx) are reduced to Nitrogen ($N_2$) and Oxygen ($O_2$). In the second part of the catalytic converter, Hydrocarbons (HC) and Carbon Monoxide (CO) emissions are oxidized into water (H2O) and Carbon Dioxide ($CO_2$). The three-way catalytic converter is most efficient at the stoichiometric air/fuel ratio for gasoline (14.7:1).

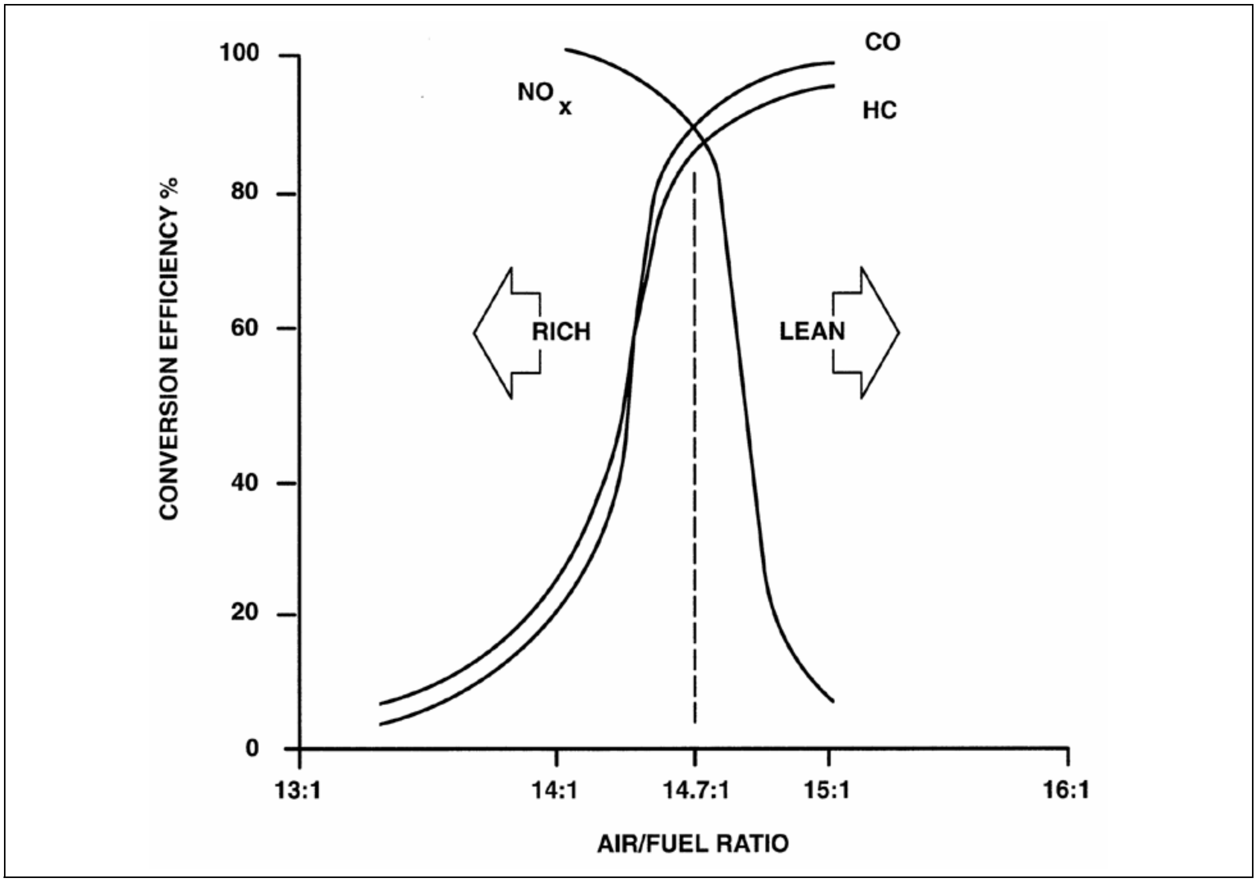



Figure 28 Three-Way Catalyst Conversion Efficiency

## CATALYST MONITOR

OBD II regulations require monitoring catalyst functionality and efficiency. The MIL must illuminate when the amount of catalyst deterioration might cause emissions to exceed 1.75 times the FTP standard.

There are two types of Catalyst Monitors: the Exponentially Weighted Moving Average (EWMA) Monitor and the Non-Exponentially Weighted Moving Average Monitor. Both monitors compare upstream $O_2$ sensor switching to downstream $O_2$ sensor switching and then evaluate a ratio of the two sensors.

For both monitors, the PCM expands the rich and lean switch points of the upstream $O_2$ sensor. This drives the air/fuel ratio swings richer and leaner and overburdens the catalytic converter. When the oxygen sensor signal crosses and goes above the rich threshold or below the lean threshold, a counter increments. The number of downstream $O_2$ sensor switches is divided by the number of upstream $O_2$ sensor switches to determine the Switching Ratio (also called the Instantaneous Switching Frequency).

$$\text{Switching Ratio \%} = \frac{\text{Number of Downstream O2 Sensor Switches}}{\text{Number of Upstream O2 Sensor Switches}}$$

Figure 29 Catalyst Monitor Switching Ratio

The higher the Switching Ratio percentage, the more efficient the catalyst. The example in the figure below shows a Switching ratio of 0.1 or 10%. The downstream $O_2$ sensor switches one time for every ten switches of the upstream $O_2$ sensor. This indicates that the catalyst can store most of the oxygen that it receives.

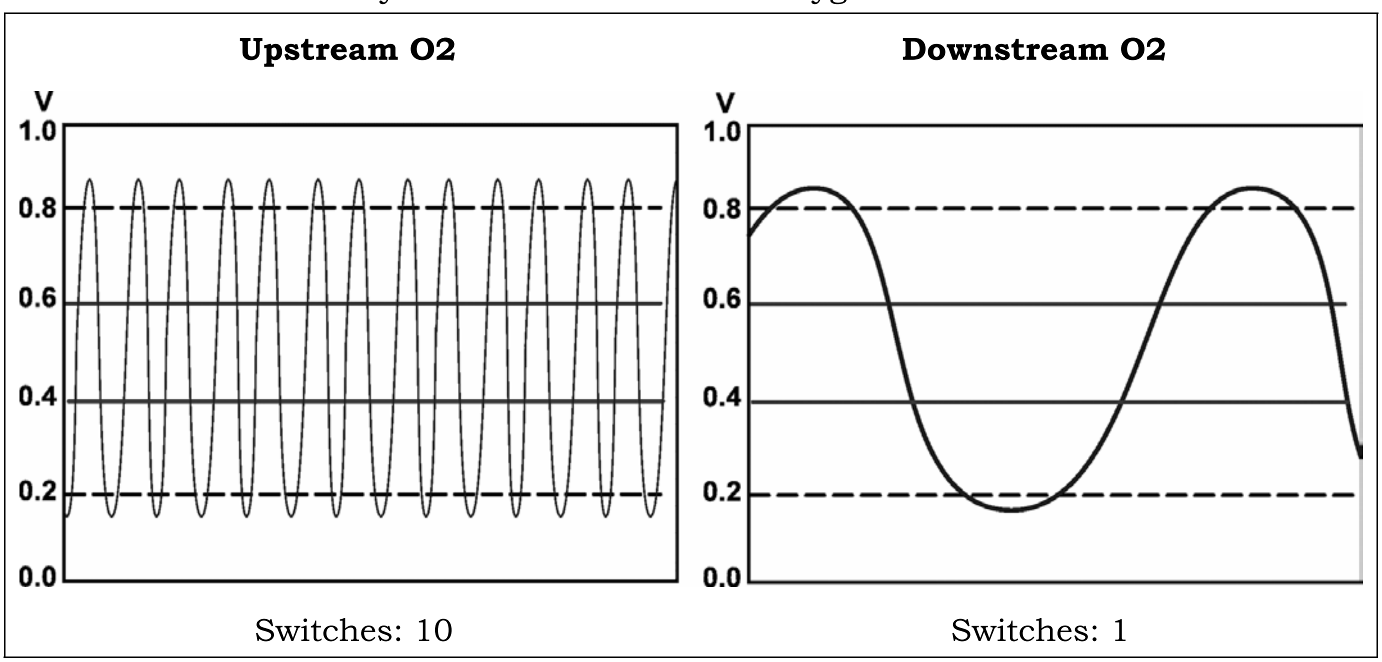



Figure 30 10% Switching Ratio = Good Catalyst

In this example, a Switching Ratio of 0.8 or 80% indicates a deteriorated catalyst. The downstream $O_2$ sensor switches almost as often as the upstream sensor. For every ten switches of the upstream $O_2$ sensor, the downstream $O_2$ sensor switches eight times. The catalyst cannot store oxygen properly, so the composition of the gases leaving the catalyst fluctuates almost as much as the gases entering it.

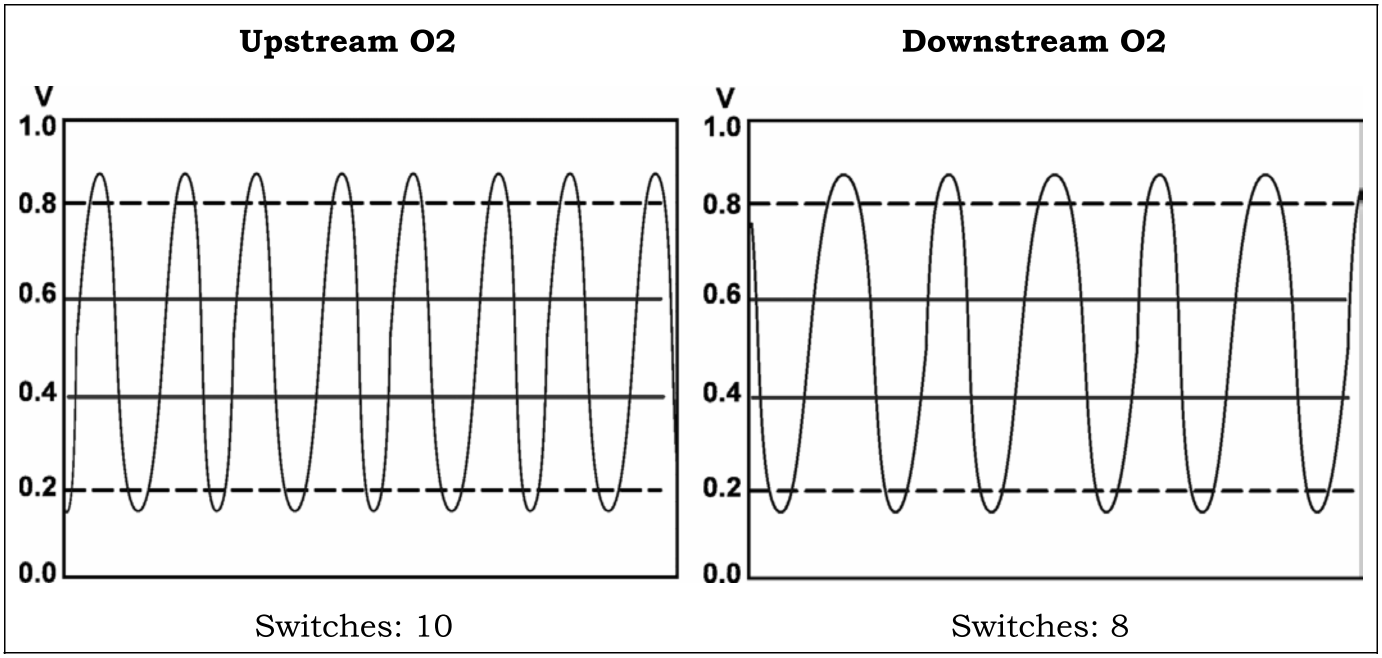



Figure 31 80% Switching Ratio = Failed Catalyst

**NGC Exponentially Weighted Moving Average Catalyst Monitor (EWMA)**

The Exponentially Weighted Moving Average (EWMA) Catalyst Monitor compares the Switching Ratio of the upstream $O_2$ sensor vs the downstream $O_2$ sensor, and also looks at past catalyst performance. To do this, the PCM compares the current upstream and downstream $O_2$ sensor switching frequency with stored data from past trips.

The DRB III will display SLOW MOVING AVG and FAST MOVING AVG. These are known as Exponentially Weighted Moving Averages and are indicators of past catalyst performance. They are periodically recalculated by the PCM.

The Slow Moving Average is used to detect aging catalysts. When calculating a new Slow Moving Average, the PCM weights the Old Slow Moving Average 90%, and the current Switching Ratio 10%.

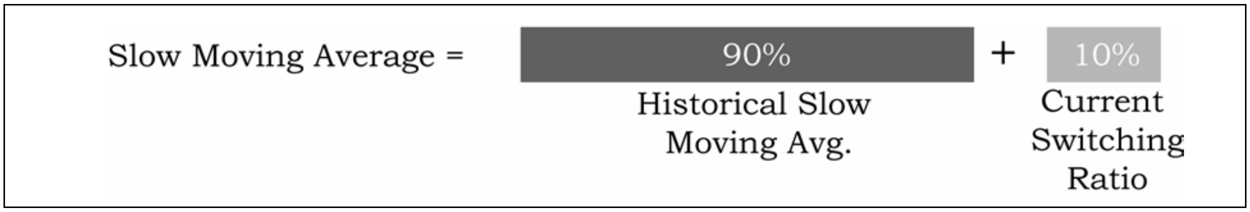



Figure 32 EWMA Slow Moving Average

The Fast Moving Average is used to detect catastrophic, rapid catalyst failure. When calculating a new Fast Moving Average, the PCM weights the old Fast Moving Average 75% and the current Switching Ratio 25%.

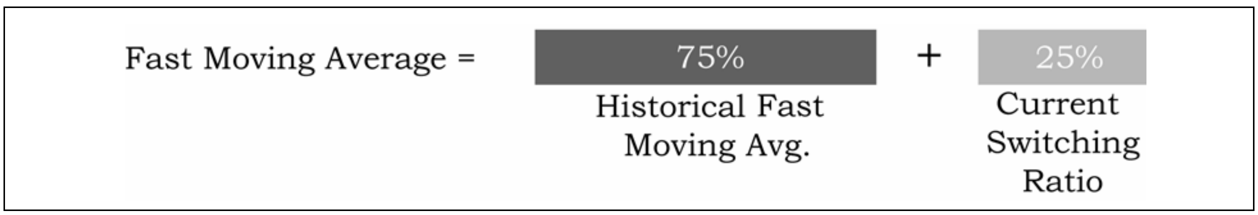



Figure 33 EWMA Fast Moving Average

The EWMA Catalyst Monitor requires six separate test sequences to run and fail before a failure is recorded. This allows the PCM to determine whether the catalyst is aging normally or failing catastrophically. Each time the PCM sees that the Switching Ratio has exceeded the historical data by 20%, it increments a Suspicious Counter. When six suspicious counts have accumulated, a fault is recorded.

The NGC EWMA Catalyst Monitor is a once-per-trip monitor with a one-trip fault. All six suspicious counts can accumulate during one trip. There is a Fast Pass option. If the data clearly indicates fully functioning components, the NGC controller will stop the test early. A DTC will set when all three parameters, Slow Moving Average, Fast Moving Average, and Suspicious Counter, exceed their thresholds.

The NGC EWMA Catalyst Monitor can run one of three ways:

- Hot, partial load, moderate speed (conventional)
- The Unified Cycle (higher vehicle speed, usually 55+mph, even if the DRB III arrows do not indicate)
- Idle Method (warm idle, but load and speed windows must be satisfied first)

The MIL is extinguished after three consecutive Good Trips.

**NGC Non-Exponentially Weighted Moving Average Catalyst Monitor**

Older vehicles use the Non-Exponentially Weighted Moving Average Monitor. This method compares upstream $O_2$ sensor switching to downstream $O_2$ sensor switching and then evaluates a ratio of the two sensors, similar to the Exponentially Weighted Moving Average Monitor. Historical data is not used in the calculation, however. Only the current Switching Ratio is evaluated by the PCM.

$$\text{Switching Ratio \%} = \frac{\text{Number of Downstream O2 Sensor Switches}}{\text{Number of Upstream O2 Sensor Switches}}$$

Figure 34 Catalyst Monitor Switching Ratio

The monitor runs once per trip. The test runs for 20 seconds. If at any point, the Switching Ratio reaches a calibrated threshold value, a counter increments by one and the monitor is enabled to run another test during that trip. When the test fails three times, the counter increments to three, a maturing code is set and Freeze Frame Data is stored. On the next trip, when the test fails three more times, the code is matured and the MIL is illuminated. If the test passes the first time, no further testing takes place during that trip.

The MIL is extinguished after three consecutive Good Trips. The Good Trip criteria is more stringent than the failure criteria. In order to pass the test and increment one Good Trip, the switching rate for the downstream sensor must be less than 80% of the upstream rate (60% for manual transmissions). The failure percentages are 90% and 70% respectively.

Table 1 Pass/Fail Switching Ratio

| TRANSMISSION TYPE | FAIL RATE (SWITCH RATE OF UPSTREAM SENSOR) | PASS RATE (SWITCH RATE OF UPSTREAM SENSOR) |
|---|---|---|
| Automatic | 90% | 80% |
| Manual | 70% | 60% |

**SCAN TOOL PRETEST SCREEN - NGC**

This screen allows the user to determine when the conditions have been met to run the Catalyst Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

```
        -- Catalyst Pre-Test --
ECT Range    :  126►[   82]    260
Min Run Time:  1.9►[  0.0]   13.9
Cat Tmp Rang:  801►[  -83]   1650
--- ENABLING CONDITIONS ---
VSS Range    : 20.0►[  0.0]   45.0
RPM Range    : 1040►[    0]   3142
RpmVSS Ratio:     0 [  255]◄    70
P-Ratio      : 0.28 [ 0.99]◄  0.79

                  56.2
```

Figure 35  NGC Catalyst Monitor Pretest Screen

The main objective of this and other pre-test screens is to "make the arrows go away". When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**ECT Range:** Engine coolant temperature value must be within the indicated range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**Min Run Time:** Minimum amount of engine run time since start, displayed in minutes. The number right of the decimal are tenths of a minute (e.g., 1.5 is equal to 1 minute and 30 seconds).

**Cat Temp Range:** Catalyst temperature is a calculated value based on load, road speed, ambient temperature, short-term and long-term fuel correction, spark advance, run time, coolant temp, etc.

**VSS Range:** Vehicle speed must fall within this range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM Range:** Engine speed must fall within this range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM VSS Ratio:** This is a calculation of RPM divided by vehicle speed (N/V ratio). It is used to verify selected transmission gear (usually used to prevent monitor from running in 1st or 2nd gear). The ranges are displayed as a percent or ratio.

**P-Ratio:** This is a calculation of absolute MAP divided by barometric pressure. A sample reading is; 0.99 volts = wide open throttle (Map equal to Baro).

**SCAN TOOL MONITOR DATA SCREEN - NGC**

This screen indicates the status of the Catalyst Monitor.

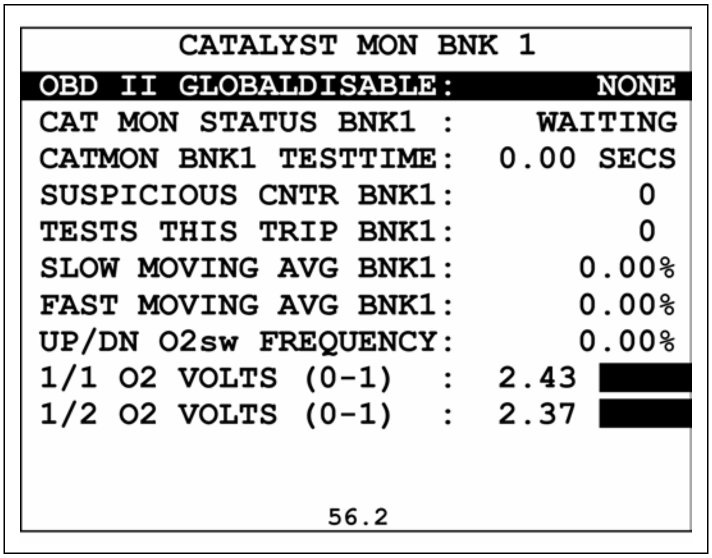



Figure 36  NGC Catalyst Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**Cat Mon Status Bnk1:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Catmon Bnk1 Test Time:** Amount of time in seconds that monitor has been in progress. This number may stop and start as enable conditions are entered and exited. This timer will max out when the monitor is completed – stop at the value from the monitor pre-test screen (i.e., “MaxTest Time” 20 seconds).

**Suspicious Cntr Bnk1:** When the Catalyst Monitor is in progress, this indicates the number of soft failures of the EWMA type of monitor. If this counter is counting up from zero (0) or is a non-zero value, this means that the Catalyst Monitor is tending toward a failure, but has not yet failed. For example, this counter may count only once per trip which would mean than FWD would take 6 trips to fail and RWD would take 8 Trips to fail (in the worst case or slowest case). This value is non-volatile (remains) between key cycles. If the previous test was counting Suspicious Counts, this number will be remembered until the next time the Catalyst Monitor runs and either passes or fails (increments or decrements the Suspicious Counts number).

FWD packages may run up to 6 tests or Suspicious Counts in a row (this is the ARL number or Average Run Length of the EWMA) within the same trip (key cycle), which results in the Catalyst Monitor failing, a DTC setting and the MIL On.

RWD Truck packages may run up to 4 tests and then stop for that trip (key cycle) without setting a 1 Trip Failure. The key must be then cycled off and then the Engine re-started and the Monitor re-run to get another 4 Suspicious counts and then the Catalyst Monitor will fail and a DTC will set and the MIL will be On.

**Tests This Trip Bnk1:** This parameter is similar to the Suspicious Counter, but only for this trip, where the Suspicious Counter is a total of all of the soft fails of the Catalyst Monitor, the Tests This Trip value gets resets to zero (0) every key cycle.

FWD Packages, if this counter is counting up from zero (0), it will mirror the Suspicious Counter (up to 6).

RWD Truck packages, this will mirror the Suspicious Counter for the first trip only (zero through 4). On the second trip (key cycle), this counter gets zeroed while the Suspicious Counter will remain at its last known value.

**Slow Moving Avg Bnk1:** Current calculated slow moving average, including the last time the monitor ran.

**Fast Moving Avg Bnk1:** Current calculated fast moving average, including the last time the monitor ran.

**Up/Dn O2sw Frequency:** Actual calculated switch frequency comparing the upstream O2 sensor to the downstream O2 sensor.

**1/1 O2 Volts (0-1):** Live reading of the upstream O2 sensor.

**1/2 O2 Volts (0-1):** Live reading of the downstream O2 sensor.

**SCAN TOOL LAST RESULT SCREEN - NGC**

This screen can be used to track previous Catalyst Monitor results.

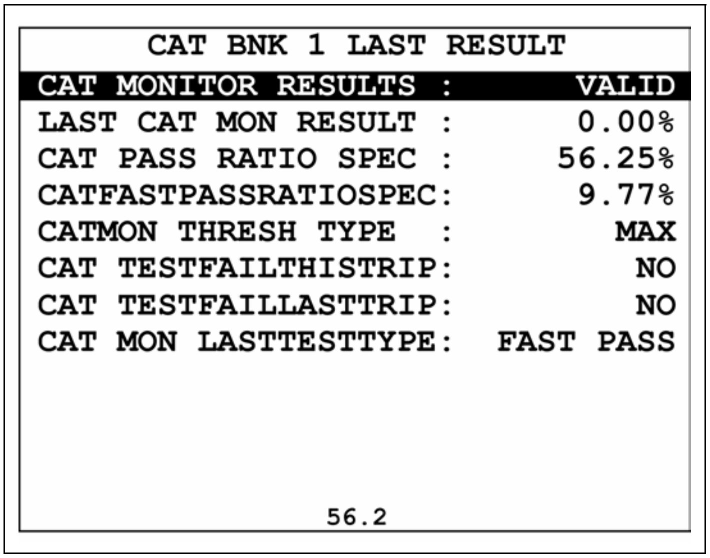



Figure 37 NGC Catalyst Monitor Last Result Screen

**Cat Monitor Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last Cat Mon Result:** Percent (or ratio) of the Upstream O2 Switch Counts divided by the Downstream Switch Counts, during the Catalyst Monitor test period of the last completed monitor (pass or fail).

**Cat Pass Ratio Spec:** Maximum passing specification for the percent (%) or ratio of the Upstream O2 divided by the Downstream O2 Switch Counts for the Catalyst Monitor.

**Cat Fast Pass Ratio Spec:** Maximum passing Spec. which allows the monitor to pass prior to the full test period (e.g., 10 seconds rather than 20 seconds). This was done to reduce the tailpipe emissions during the Catalyst Monitor. Due to the shorter test time period of the Fast Pass test, the Fast Pass Spec. is less than the Normal Cat Pass Ratio Spec. A Fast Pass Ratio Spec of 99.60 % indicates that this test is not enabled (calibrated) for this package. A fast pass will only be indicated if both O2 monitor and Catalyst monitor meet the "fast pass" criteria.

**Cat Mon Thresh Type:** Displayed as “Max”. Indicates that the result must be below the specification for the Catalyst Monitor to pass.

**Cat Test Fail This Trip:** Indicates if the monitor has run and failed during this trip. Results in a “Yes” or “No”.

**Cat Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a “Yes” or “No”.

**Cat Mon Last Test Type:** Indicates which threshold was compared against “Last Cat Mon Result” to determine the Pass or Fail. “Normal” or “FastPass”.

## ACTIVITY 6: EWMA CATALYST MONITOR SCREENS

Notes:

**NGC State of Change**

Beginning in 2004, 2.0L, 2.4L and 5.7L engines with NGC III controllers use a new Catalyst Monitor strategy. This new method is the State of Change Catalyst Monitor, and it is similar to the State of Change Oxygen Sensor Monitor.

During testing, $O_2$ sensor signal voltage readings are taken for both upstream and downstream $O_2$ sensors every 10 ms.

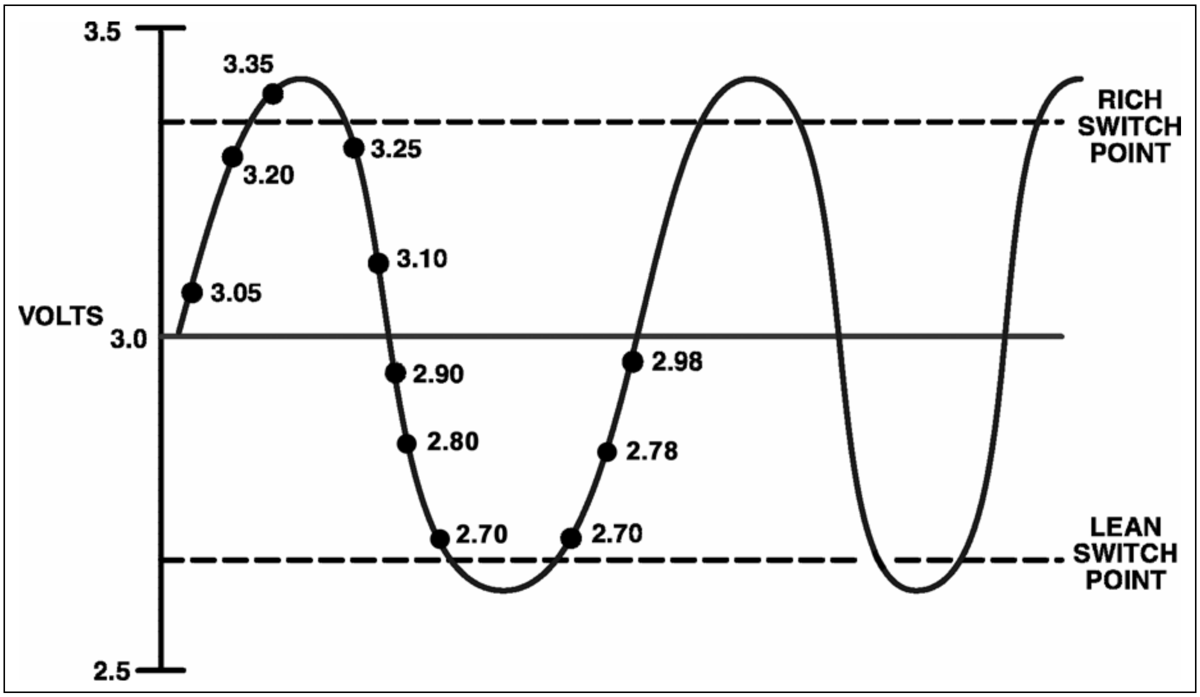



Figure 38 NGC State of Change

Each value representing the difference between consecutive 10 ms voltage readings (in other words, the change in voltage) is placed in one of five bins. Each bin is based on a MAP and RPM matrix, similar to Long Term Adaptive memory cells. There is a set of bins for the upstream $O_2$ sensor and a separate set of bins for the downstream $O_2$ sensor.

**Upstream O2 Sensor Readings**

| Bin 1 | Bin 2 | Bin 3 | Bin 4 | Bin 5 |
|---|---|---|---|---|
| .15 | .20 | | .28 | |
| .10 | | | | |

**Downstream O2 Sensor Readings**

| Bin 1 | Bin 2 | Bin 3 | Bin 4 | Bin 5 |
|---|---|---|---|---|
| .02 | .03 | | .07 | |
| .01 | | | | |

Figure 39  NGC State of Change Bins

When the total test time is completed, the bin values are added to calculate the total value for each bin. Each sum for each bin is then multiplied by a weighted factor and the five weighted bin values are added together. The sum of the upstream $O_2$ sensor weighted values is then divided by the sum of the downstream $O_2$ sensor weighted values. The result is a ratio comparing the response of the upstream and downstream $O_2$ sensors. If this value exceeds a calibrated value, the monitor passes.

**Sum of Upstream O2 Sensor Bin 1X weighted Factor = UB1Voltage**
**Sum of Downstream O2 Sensor Bin 1X weighted Factor = DB1Voltage**

**You do the same for each Bin for both the Upstream and Downstream O2 Sesnors**

$$\frac{UB1V + UB2V + UB3V + UB4V + UB5V}{DB1V + DB2V + DB3V + DB4V + DB5V} = \text{Catalyst Efficiency}$$

Figure 40  NGC State of Change Calculation

**SCAN TOOL PRETEST SCREEN – NGC STATE OF CHANGE**

This screen allows the user to determine when the conditions have been met to run the State of Change Catalyst Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

```
        -- Catalyst Pre-Test --
ECT Range    :  126►[   82]    260
Min Run Time:  1.9►[  0.0]   13.9
Cat Tmp Rang:  801►[  -83]   1650
--- ENABLING CONDITIONS ---
VSS Range   : 20.0►[  0.0]   45.0
RPM Range   : 1040►[    0]   3142
RpmVSS Ratio:     0 [  255]◄    70
P-Ratio     : 0.28 [ 0.99]◄  0.79




               56.2
```

Figure 41 NGC SOC Catalyst Monitor Pretest Screen

The main objective of this and other pre-test screens is to "make the arrows go away". When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**ECT Range:** Engine coolant temperature value must be within the indicated range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**Min Run Time:** Minimum amount of engine run time since start, displayed in minutes. The number right of the decimal are tenths of a minute (e.g., 1.5 is equal to 1 minute and 30 seconds).

**Cat Temp Range:** Catalyst temperature is a calculated value based on load, road speed, ambient temperature, short-term and long-term fuel correction, spark advance, run time, coolant temp, etc.

**VSS Range:** Vehicle speed must fall within this range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM Range:** Engine speed must fall within this range, with the minimum value on the left, actual value in the middle, and maximum value to the right.

**RPM VSS Ratio:** This is a calculation of RPM divided by vehicle speed (N/V ratio). It is used to verify selected transmission gear (usually used to prevent monitor from running in 1$^{st}$ or 2$^{nd}$ gear). The ranges are displayed as a percent or ratio.

**P-Ratio:** This is a calculation of absolute MAP divided by barometric pressure. A sample reading is; 0.99 volts = wide open throttle (Map equal to Baro).

**SCAN TOOL MONITOR DATA SCREEN – NGC STATE OF CHANGE**

This screen indicates the status of the State Of Change Catalyst Monitor.

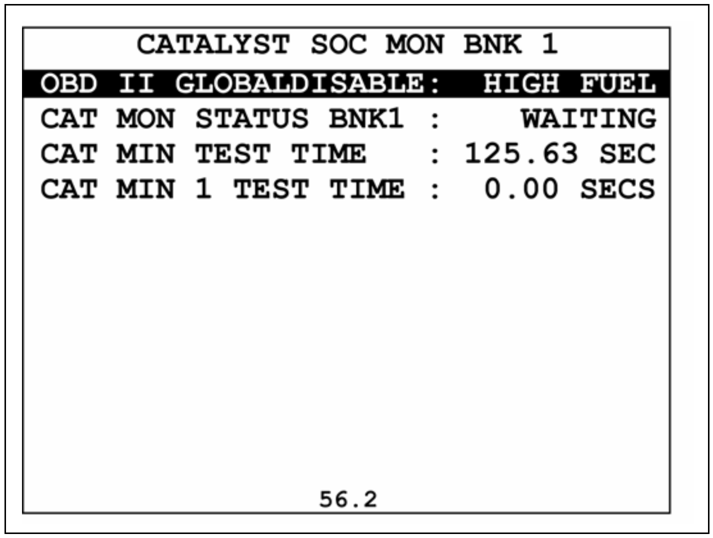



Figure 42 NGC SOC Catalyst Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**Cat Mon Status Bnk1:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Cat Min Test Time:** Amount of time in seconds that monitor will be required to run before it can be completed.

**Cat Min 1 Test Time:** Amount of time in seconds that monitor has been in progress. This number may stop and start as enable conditions are entered and exited. This timer will max out when the monitor is completed – stop at the value equal to the Cat Min Test Time.

**SCAN TOOL LAST RESULT SCREEN – NGC STATE OF CHANGE**

This screen can be used to track previous State Of Change Catalyst Monitor results.

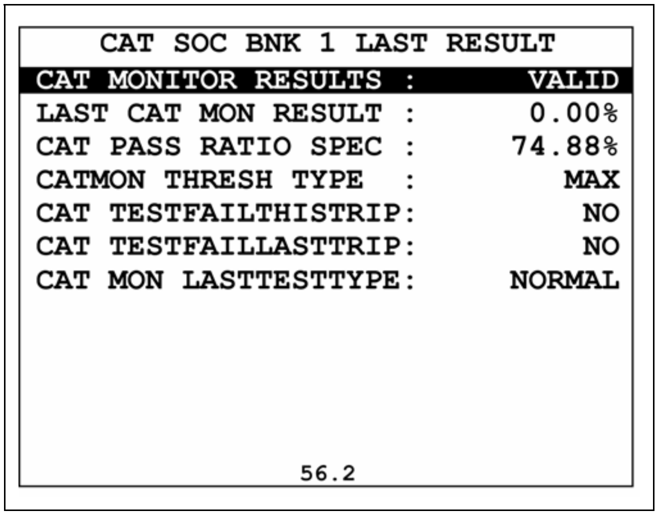



Figure 43 NGC SOC Catalyst Monitor Last Result Screen

**Cat Monitor Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last Cat Mon Result:** Percent (or ratio) of the Calculated Upstream O2 Switch Volts divided by the Calculated Downstream Switch Volts, during the Catalyst Monitor test period of the last completed monitor (pass or fail).

**Cat Pass Ratio Spec:** Maximum passing specification for the percent (%) or ratio of the Upstream O2 divided by the Downstream O2 Switch voltages for the Catalyst Monitor.

**Cat Mon Thresh Type:** Displayed as "Max". Indicates that the result must be below the specification for the Catalyst Monitor to pass.

**Cat Test Fail This Trip:** Indicates if the monitor has run and failed during this trip. Results in a "Yes" or "No".

**Cat Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a "Yes" or "No".

**Cat Mon Last Test Type:** Indicates which threshold was compared against "Last Cat Mon Result" to determine the Pass or Fail. "Normal" will be displayed, "Fast Pass" is not an option when the vehicle uses the SOC monitor.

## ACTIVITY 7: SOC CATALYST MONITOR SCREENS

Notes:

## JTEC/SBEC EXPONENTIALLY WEIGHTED MOVING AVERAGE CATALYST MONITOR

On JTEC vehicles, the six tests are run on two consecutive trips. Three tests are run on the first trip and three tests on the second trip.

On SBEC vehicles, the EWMA Catalyst Monitor can run up to six tests in one trip. The Catalyst Monitor may pass or fail in one trip.

## SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

| Catalyst Pre-Test | | | |
|---|---|---|---|
| ECT Range | : 131 | [95] | 260 |
| VSS MPH Range | : 35 | [0] | 100 |
| RPM Range | : 1440 | [0] | 2016 |
| RPM/SpdRatio | : 25 | [255] | 255 |
| MAP Range | : 12.9 | [0.0] | 17.6 |
| Open Thr Time | : 1.5 | [0.0] | 13.9 |
| Cat Tmp Range | : 0 | [145] | 2500 |
| ENABLING CONDITIONS | | | |
| MAP Range | : 11.7 | [0.0] | 17.6 |
| RPM Range | : 1440 | [0] | 2016 |
| Exhst Time | : 1.5 | [0.0] | 13.9 |
| Cat Tmp Range | : 0 | [145] | 2500 |

**JTEC**

| Catalyst Pre-Test | | | |
|---|---|---|---|
| ECT Range | : 147 | [68] | 260 |
| Bat Tmp Range | : 21 | [66] | 130 |
| VSS MPH Range | : 45 | [0] | 100 |
| Open Thr Time | : 3.0 | [0.0] | 13.9 |
| Cat Tmp Range | : 0 | [336] | 2040 |
| VSS MPH TIME | : 1 | [0] | 100 |
| ENABLING CONDITIONS | | | |
| VSS Range | : 50.0 | [0.0] | 65.0 |
| MAP Range | : 12.0 | [0.0] | 30.0 |
| RPM Range | : 1344 | [0] | 2048 |
| Exhst Time | : 3.0 | [0.0] | 13.9 |
| Cat Tmp Range | : 0 | [336] | 2040 |
| MinTestTime | : 0.3 | [0.0] | 13.9 |

Figure 44 JTEC/SBEC Catalyst Monitor Pretest Screen

**RPM/SpdRatio:** The PCM determines gear selection by comparing the RPM to the VSS ratio. The vehicle must be driven in a high enough gear to ensure sufficient load is placed on the vehicle to heat the exhaust for accurate testing.

**VSS MPH Range:** A specific vehicle speed for specific length of time must be maintained.

**Exhst Time:** This is a calculated value. After the PCM has inferred that the exhaust components have reached a specific temperature, a timer begins.

**SBEC:** If it is difficult to maintain the vehicle in the proper MAP/RPM range to meet monitor requirements, turn on electrical accessories to load the engine. The increased load typically satisfies the parameters and enables the monitor to run.

**JTEC:** Some vehicles do not run the monitor unless the vehicle speed exceeds 50 mph. Some vehicles may require the catalyst monitor to run on a specific emissions certification drive cycle (i.e. FTP cycle, unified cycle, or idle). See the appendix for drive cycle specific information.

## SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
        EWMA CATALYST MON BNK1
CAT EFFICIENCY DATA BNK1 : 80
CAT MON 1 IN PROGRESS    : NO
CAT MON 1 DONE THIS TRIP : NO
CAT MON 1 FAIL DTC SET   : NO
CAT MON 1 STOP TESTING   : NO
SLOW MOVING AVG BNK1     : 0.00
FAST MOVING AVG BNK1     : 0.00
CAT MON 1 SUSPICIOUS CNTR: 0
UP/DN O2 SWITCH FREQ BNK1: 0.00
1/1 O2S VOLTS            : 0.47 VOLTS
1/2 O2S VOLTS            : 0.49 VOLTS
```

**JTEC**

```
        EWMA CATALYST MON BNK1
CAT EFFICIENCY DATA BNK1 : 00
CAT MON 1 IN PROGRESS    : NO
CAT MON 1 DONE THIS TRIP : NO
CAT MON 1 FAIL THIS TRIP : NO
CAT MON 1 FAIL DTC SET   : NO
CAT MON 1 STOP TESTING   : NO
CAT MON 1 TEST TIME      : 0.0
SLOW MOVING AVG BNK1     : 0.00
FAST MOVING AVG BNK1     : 0.00
CAT MON 1 SUSPICIOUS CNTR: 0
1/1 1/2 O2 SW FREQ       : 0 %
1/1 O2S VOLTS            : 5.00 VOLTS
1/2 O2S VOLTS            : 4.88 VOLTS
```

Figure 45 JTEC/SBEC EWMA Catalyst Monitor Data Screen

**Slow Moving Avg Bnk1:** This is used to detect a naturally aging high mileage catalyst. The slow moving average is determined by adding 90% of the "old" slow moving average and 10% of the "new" instantaneous switching frequency.

**Fast Moving Avg Bnk1:** This is used to detect a major catalyst failure, such as a severe misfire that has melted the catalyst substrate. The fast moving average is determined by adding 75% of the "old" fast moving average and 25% of the "new" instantaneous switching frequency.

**Cat Mon 1 Suspicious Counter:** A suspicious counter is incremented when the slow moving average is 20% or more different than the instantaneous switching frequency. On SBEC vehicles, if the suspicious counter increments six times, and the slow or fast moving average is above a calibratable frequency, a DTC sets and the MIL illuminates. On JTEC vehicles, the third suspicious count sets a 1-trip failure. Counting resumes on the next trip. After three more suspicious counts, a DTC is declared and the MIL is illuminated.

**Up O2/Dn O2 (or 1/1, 1/2) Switch Freq Bnk1 (Instantaneous Switching Frequency):** This is the rate at which both the upstream and downstream O2 sensors cross the rich to lean switching points. The number of downstream O2 switches is divided by the number of upstream O2 switches to determine the switching frequency ratio.

**Note:** **Oxygen sensor response is re-tested during the catalyst monitor to verify that a lazy oxygen sensor is not corrupting the results of the catalyst monitor.**

## SCAN TOOL LAST RESULT SCREEN – JTEC/SBEC

**SBEC**

```
        CAT MON BNK1 LAST RESULT
LAST CAT MON 1 STATUS      : 80
CAT MON 1 LAST RESULT      : MAX
CAT MON 1 FAIL THIS TEST   : NO
CAT MON 1 FAIL PREV TEST   : NO
LAST CAT MON 1 FREQ RATIO  : 0
LAST CAT MON 1 FREQ SPEC   : 62
LAST CAT SLOW O2S 1 STATUS: 00
CAT SLOW O2S 1 LAST RESULT: MAX
CAT SLOW O2S 1 FL THIS TST: NO
CAT SLOW O2S 1 FL PREV TST: NO
LAST CAT SLOW O2 1 HALF CY: No R
CAT SLOW O2 1 HALF CY SPEC: No R
```

**JTEC**

```
        CAT MON BNK1 LAST RESULT
LAST CAT MON 1 FREQ RATIO : 0
LAST CAT MON 1 FREQ SPEC  : 75
LAST CAT SLOW O2 1 HALF CY: 0
CAT SLOW O2 1 HALF CY SPEC: 2
1/1 O2S SWITCH COUNT      : 0
```

Figure 46  JTEC/SBEC Catalyst Monitor Last Result Screen

**Last Cat Monitor 1 Frequency Ratio:** This data represents the stored switching frequency from the last trip.

**Last Cat Monitor 1 Frequency Spec:** This is the maximum switching frequency allowed for this calibration.

Notes:

Notes:

# MODULE 7 DOWNSTREAM OXYGEN SENSOR MONITOR

## BACKGROUND

The Downstream Oxygen Sensor Monitor was first implemented on 2000 model year Chrysler Group vehicles. Previously, the downstream $O_2$ sensor was monitored only for continuity. The Downstream Oxygen Sensor Monitor may run as a passive or an intrusive test. The passive test simply watches $O_2$ sensor response. If the sensor voltage signal drifts above and below the calibrated upper and lower thresholds, the monitor passes. The monitor can even pass at idle. If the PCM does not see the expected voltage change, an intrusive test is done.

Typically this monitor is disabled until the vehicle accumulates a predetermined amount of mileage. New or "green" catalysts are very efficient and the downstream $O_2$ sensor voltage may not fluctuate enough to pass the monitor.

**Note: On some models, when a catalyst is replaced, the downstream $O_2$ sensor monitor must be reset to prevent false failures. Reset the mileage counter on the DRB III MISC screen.**

## DOWNSTREAM OXYGEN SENSOR OPERATION

Downstream sensors were first used in 1996 and have two functions.

The first function is to measure catalyst efficiency to meet OBD II requirements. If the catalytic converter is working properly, the oxygen content of the exhaust gases at the converter outlet fluctuates significantly less than at the converter inlet. The PCM compares the switching rates of both downstream and upstream $O_2$ sensors under specific operating conditions to determine if the catalyst is functioning properly. Any time the upstream to downstream switching ratio exceeds a calibrated value, a catalyst efficiency fault will be stored.

The second function is downstream fuel control and is active only during downstream closed loop operation. This function trims the Upstream $O_2$ Goal Voltage within the range of operation of the upstream $O_2$ sensor. The upstream Goal Voltage is modified to ensure long catalytic converter life by allowing the PCM to control the amount of oxygen that is supplied to the catalytic converter. A good catalytic converter can store and hold oxygen until it is used in a reaction, so the gases leaving the catalytic converter has significantly less oxygen fluctuation than the gases entering the catalytic converter. The downstream $O_2$ sensor is a good indicator for how much oxygen remains after all of the reactions take place in the converter.

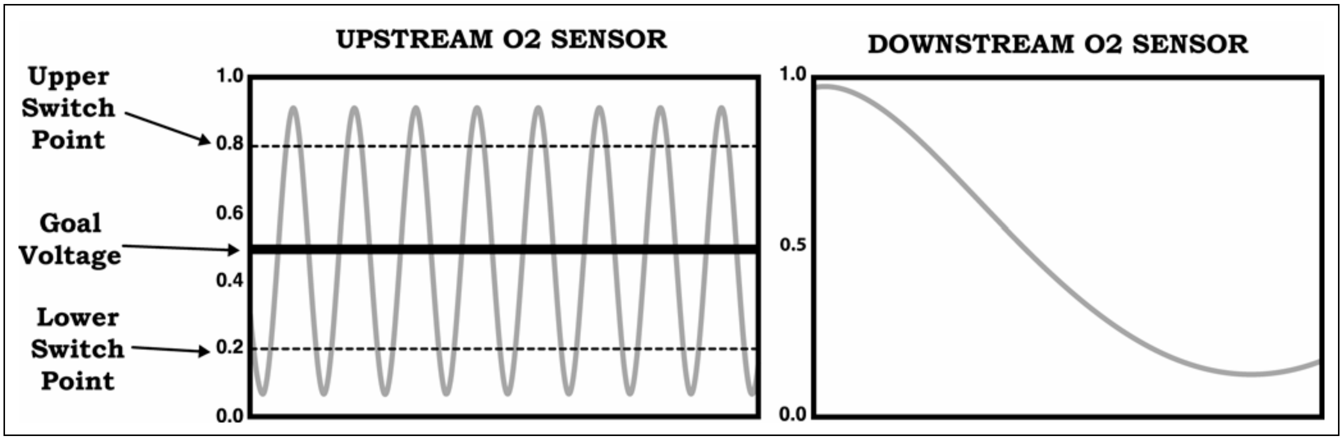



Figure 47  Upstream vs Downstream Oxygen Sensor Waveforms

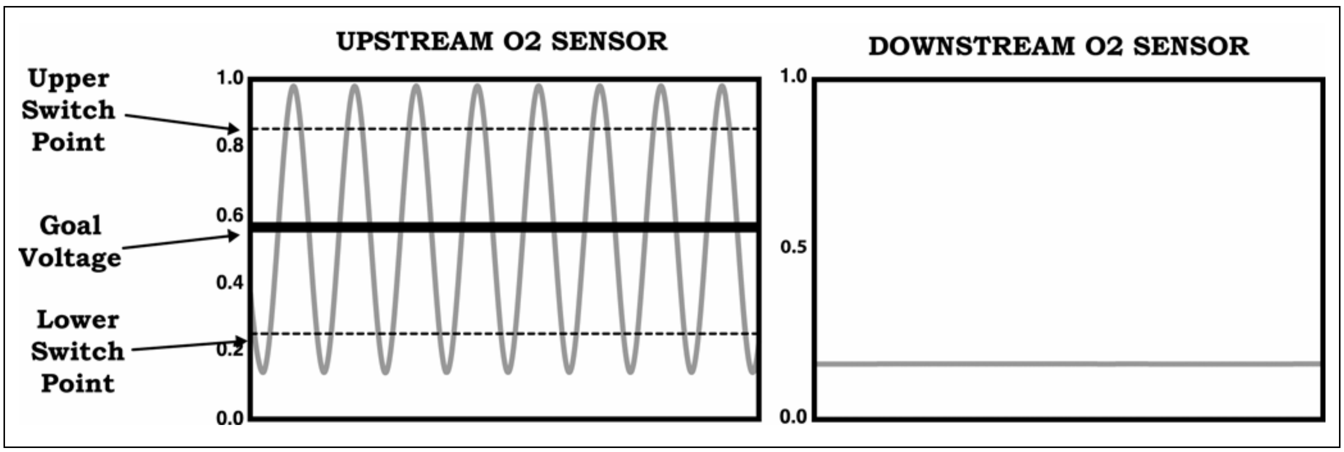



Figure 48  Goal Voltage and Switch Points Shift to Reduce High $O_2$ Content

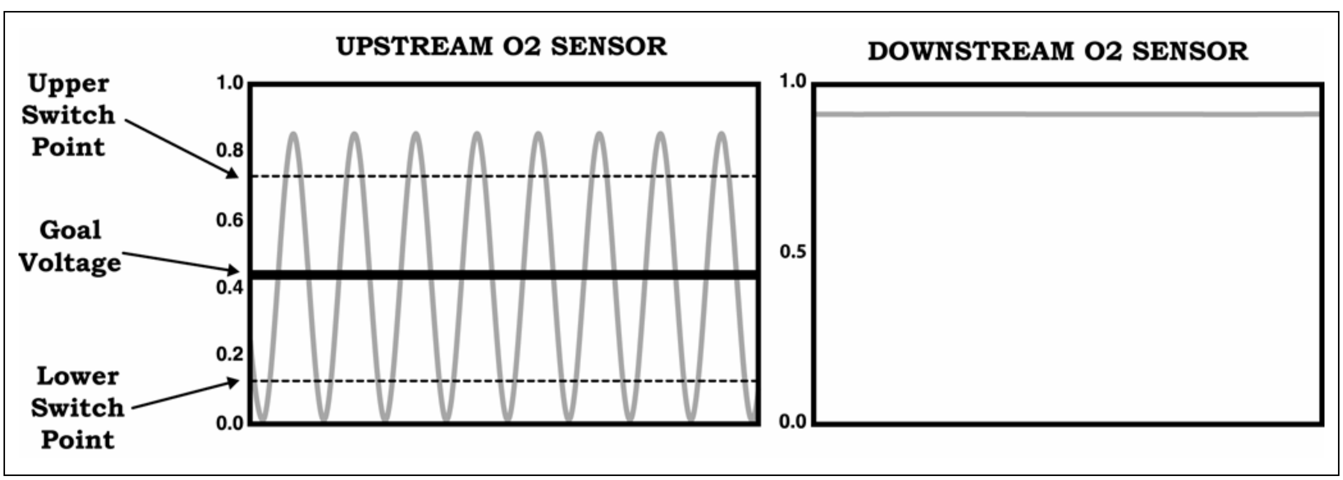



Figure 49  Goal Voltage and Switch Points Shift to Increase Low $O_2$ Content

## NGC DOWNSTREAM OXYGEN SENSOR MONITOR

Like the Upstream Oxygen Sensor Response Monitor, the Downstream Oxygen Sensor Monitor is a two-trip fault and a once-per-trip monitor. Oxygen sensor signal voltage range for NGC vehicles is biased to 2.5 – 3.5 V, which is higher than the 0 – 1.0V range seen on SBEC and JTEC vehicles.

### Non-Intrusive (Passive) Downstream Oxygen Sensor Monitor

The monitor on NGC vehicles runs when the vehicle is under light load, at approximately 20 – 50 mph. The Non-Intrusive (Passive) Downstream Oxygen Sensor Monitor test simply watches $O_2$ sensor response. If the sensor signal voltage drifts above and below the calibrated upper and lower thresholds, the monitor passes. If the PCM does not see the expected change in voltage, an intrusive test is done.

### Intrusive Downstream Oxygen Sensor Monitor

In the Intrusive Downstream Oxygen Sensor Monitor test, the PCM can determine if the lack of voltage fluctuation is due to a faulty downstream $O_2$ sensor. The PCM changes the fuel injector pulse width in an attempt to drive the mixture leaner and richer than normal. When more oxygen than normal enters the catalytic converter, the catalyst cannot store all of it and the quantity of oxygen exiting the catalyst increases. The opposite occurs when less oxygen than normal enters the catalytic converter. Little oxygen is stored and very little is left over to exit the converter. These lean and rich swings cause the downstream $O_2$ sensor signal voltage to swing higher and lower. If the sensor voltage signal swings above and below the calibrated upper and lower thresholds, the monitor passes.

### 1/2, 2/2 SCAN TOOL PRETEST SCREEN - NGC

This screen allows the user to determine when the conditions have been met to run the Downstream Oxygen Sensor Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

The Downstream Oxygen Sensor Pretest screen is only valid during the intrusive test. If the downstream $O_2$ sensor passes the passive test, disregard the values on this screen.

```
      -- Downstream O2s Pre-Test --
Min Cat Mile:    98►[    57]  999999
1/2PasViaCat:-0.50 [ 0.00]    0.50
1/2 CLoopMet: 0.50►[ 0.00]    1.50
1/2NonInttmr:  375►[     0]    819
1/2IntrusTmr:  187►[     0]    819
--- ENABLING CONDITIONS ---
VSS Range   : 20.0►[  0.0]   50.0
RPM Range   : 1184►[     0]   2336
P-Ratio     : 0.27 [ 0.99]◄  0.74





                  56.2
```

Figure 50 NGC Downstream Oxygen Sensor Monitor Pretest Screen

The main objective of this and other pre-test screens is to “make the arrows go away”. When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**Min Cat Mile:** The minimum mileage (Catalyst mileage) which has to be accumulated before enabling the Downstream O2 Monitor. This is calibrateable but usually is lower than 4,000 miles. This is allowed by CARB and used by the Chrysler Group due to the fact that a new (green) Catalyst is so efficient that the Downstream

O2 may barely 'move' and therefore may false fail the monitor. Aging the Catalyst (via accumulated mileage) makes sure that the monitor results are accurate.

**1/2 Pas Via Cat:** A bit which indicates whether or not the Downstream O2 Sensor switched (at least once) during the last Catalyst Monitor. If the value "1/2PasViaCat" is set to "1.00" (one), this means that the Downstream O2 Sensor 'moved' during the last Catalyst Monitor and therefore is 'active' and is declared to be passed for the Downstream O2 Monitor. The Downstream O2 Monitor in this example will NOT run this trip because of the Pass Via Cat Mon being set to "1" (already passed by another method).

If the "1/2PasViaCat" is set to "0.00" (zero), this means that Downstream O2 Monitor may run this trip (if the enable conditions are met) due to the fact that the Downstream O2 Sensor did not switch ('move') during the last Catalyst Monitor and therefore may be inactive and needs to be tested.

**1/2 C Loop Met:** A bit, which indicates whether or not, the Fuel System is in Downstream Closed Loop. If the value "1/2 CloopMet" is set to "1.00" (one), this means that the Fuel System is in Downstream Closed Loop and is ready to begin the non-intrusive portion of the monitor. The non-intrusive portion of the monitor just 'watches' to see if the Downstream O2 Sensor will go high enough and low enough on its own to pass the monitor (without changing the fueling to force it Rich and Lean). This non-intrusive way of passing the monitor helps tail pipe emissions.

**1/2 Non Int Tmr:** This is the minimum amount of time that the non-intrusive portion of the Downstream O2 Monitor test must run (e.g. 350 seconds) before the intrusive portion can begin.

**1/2 Intrus Tmr:** This is the minimum amount of time that the intrusive portion of the Downstream O2 Monitor test must run (e.g. 210 seconds) before the monitor will fail a 1-Trip.

The "1/2IntrusTmr" only increments if the non-intrusive timer is maxed-out (e.g., 350 secs.) and the enable conditions below are all met (Vehicle Speed, MAP and RPM).

**VSS Range:** Range that vehicle speed must be within for the intrusive Downstream O2 Monitor to run.

**RPM Range:** Range that MAP must be within for the intrusive Downstream O2 Monitor to run.

**P-Ratio:** This is a calculation of absolute MAP divided by barometric pressure. A sample reading is; 0.99 volts = wide open throttle (Map equal to Baro).

### 1/2, 2/2 SCAN TOOL MONITOR DATA SCREEN - NGC

This screen indicates the status of the Downstream Oxygen Sensor Monitor.

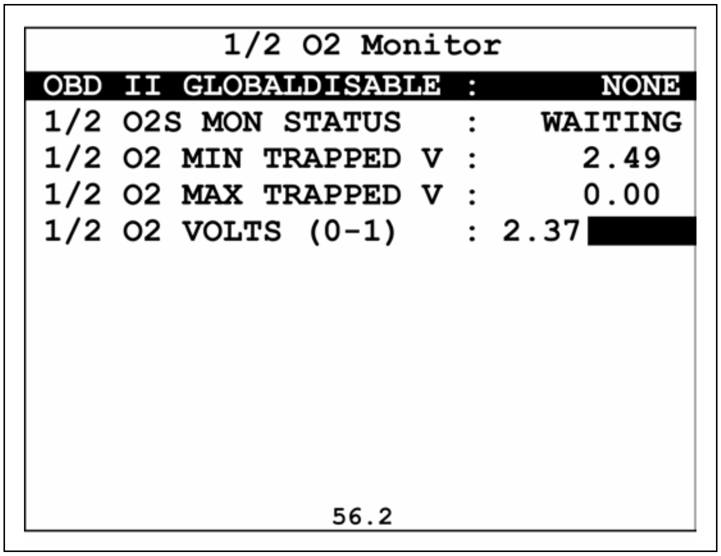



Figure 51 NGC Downstream Oxygen Sensor Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**1/2 O2S Mon Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**1/2 O2 Min Trapped V:** The lowest Downstream O2 Sensor volts stored (trapped) during either the non-intrusive or intrusive portion of the monitor.

**1/2 O2 Max Trapped V:** The highest Downstream O2 Sensor volts stored (trapped) during either the non-intrusive or intrusive portion of the monitor.

**1/2 O2 Volts (0-1):** This is live downstream $O_2$ sensor voltage.

**1/2, 2/2 SCAN TOOL MIN LAST RESULT SCREEN - NGC**

This screen can be used to track previous Downstream Oxygen Sensor Monitor results.

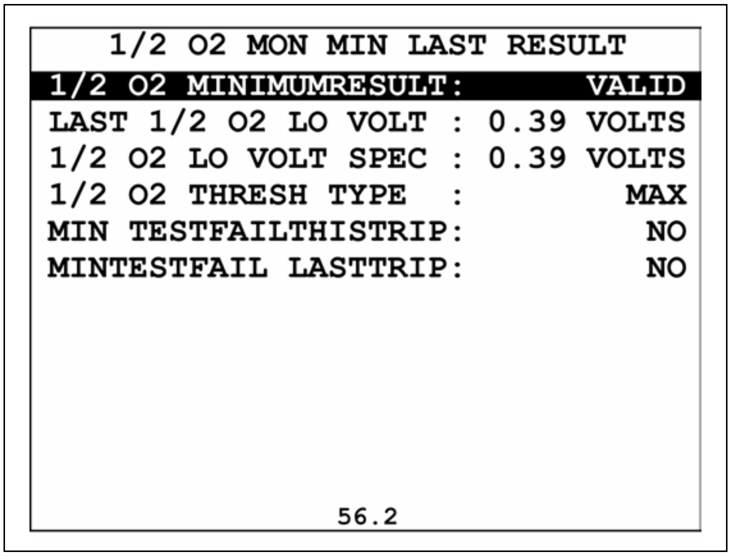



Figure 52 NGC Downstream Oxygen Sensor Monitor Min Last Result Screen

**1/2 O2 Minimum Result:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last 1/2 O2 Lo Volt:** This is typically the lowest Downstream O2 Sensor voltage that is reported (via Mode 6 Last Result) during either the non-intrusive or intrusive portion of the monitor. This will be the same voltage as the "1/2 O2 Lo Volt Spec" value because once the monitor goes below that spec., it 'passes' that portion of the monitor even though the actual Min Trapped voltage may be lower (for the Lo test). This happens because the "1/2 O2 Min Trapped V" is the lowest voltage seen during the monitor, while the "Last 1/2 O2 Lo Volt" is stored after the threshold is met.

**1/2 O2 Lo Volt Spec:** The "1/2 O2 Lo Volt Spec" is a Maximum specification for the "1/2 O2 Mon Min Last Result" screen. It is a maximum spec. because it is the highest voltage allowed for the lower threshold. If the result was above the max spec. (i.e., 0.43 volts) it would fail the monitor (see above).

**1/2 O2 Thresh Type:** Indicates that the result must be equal (or below) the specification for the Downstream 1/2 O2 Monitor to pass.

**Min Test Fail This Trip:** Indicates if the monitor has ran and failed during this trip. Results in a “Yes” or “No”.

**Min Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a “Yes” or “No”.

**1/2, 2/2 SCAN TOOL MAX LAST RESULT SCREEN – NGC**

This screen can be used to track previous Downstream Oxygen Sensor Monitor results.

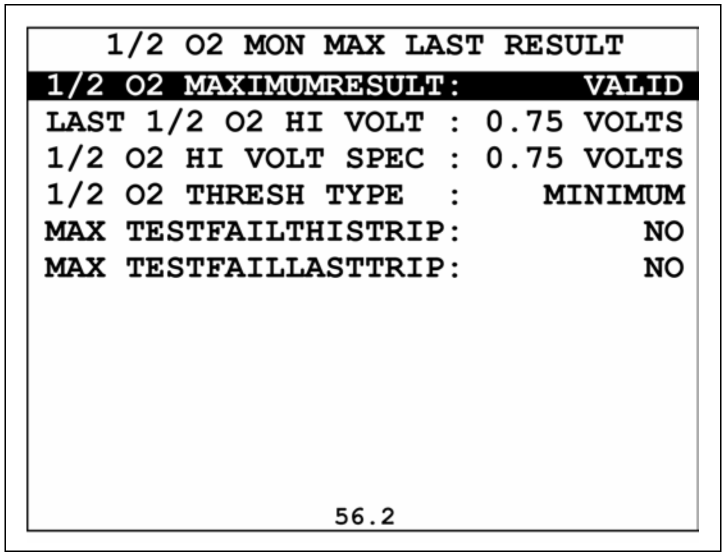



Figure 53 NGC Downstream Oxygen Sensor Monitor Max Last Result Screen

**1/2 O2 Maximum Result:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last 1/2 O2 Hi Volt:** This is typically the highest Downstream O2 Sensor voltage, which is reported (via Mode 6 Last Result) during either the non-intrusive or intrusive portion of the monitor. This will be the same voltage as the "1/2 O2 Hi Volt Spec" value because once the monitor goes above that spec., it 'passes' that portion of the monitor even though the actual Max Trapped voltage may be higher (for the Hi test). This happens because the "1/2 O2 Max Trapped V" is the highest voltage seen during the monitor, while the "Last 1/2 O2 Hi Volt" is stored after the threshold is met.

**1/2 O2 Hi Volt Spec:** The "1/2 O2 Hi Volt Spec" is a Minimum specification for the "1/2 O2 Mon Max Last Result" screen. It is a minimum spec. because it is the highest voltage allowed for the upper threshold. If the result was below the max spec. (i.e., 0.62 volts) it would fail the monitor (see above).

**Max Test Fail This Trip:** Indicates if the monitor has ran and failed during this trip. Results in a "Yes" or "No".

**Max Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a "Yes" or "No".

## ACTIVITY 8: DOWNSTREAM O2 SENSOR MONITOR SCREENS

Notes:

## JTEC/SBEC DOWNSTREAM OXYGEN SENSOR MONITOR

With SBEC and JTEC, the monitor runs at idle, in gear. A/C ON does not inhibit the monitor from running. The monitor takes 20 seconds to run, and there is a “fast pass mode” if the specification is met within 10 seconds. Two consecutive failures result in a DTC for OXYGEN SENSOR SLOW RESPONSE.

### 1/2, 2/2 SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

```
      Downstream O2S Pre-Test
Min Run Time: 6.6    [4.8]    13.9
         ENABLING CONDITIONS
VSS Range    : 19.0   [0.0]    46.0
MAP Range    : 9.9    [0.0]    18.9
RPM Range    : 1216   [0]      1984
```

**JTEC**

```
      Downstream O2S Pre-Test
Max Dly Time: 0.0     [13.6]   5.8
         ENABLING CONDITIONS
VSS Range    : 50.0    [0.0]    65.0
MAP Range    : 11.8    [0.0]    30.0
RPM Range    : 1344    [0]      2400
```

Figure 54 JTEC/SBEC Downstream Oxygen Sensor Monitor Pretest Screen

### 1/2, 2/2 SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
         1/2 O2S MONITOR
1/2 O2S MON DATA           : 80
1/2 O2S MON IN PROGRESS    : NO
1/2 O2S MON DONE THIS TRP: NO
1/2 O2S MON FAIL 1 TRIP    : NO
1/2 O2S MON FAIL DTC SET : NO
1/2 O2S MON STOP TESTING : NO
CAT MON 1/2 O2S SWITCHED : NO
1/2 O2S MIN TEST VOLTS     : 0.00 VOL
1/2 O2S MAX TEST VOLTS     : 0.00 VOL
1/2 O2S VOLTS              : 0.49 VOLTS
```

**JTEC**

```
         1/2 O2S MONITOR
1/2 O2S MON DATA            : 00
1/2 O2S MON IN PROGRESS     : NO
1/2 O2S MON DONE THIS TRP   : NO
1/2 O2S MON FAIL THIS TRIP: NO
1/2 O2S MON STOP TESTING    : NO
1/2 O2S MON TEST TIME       : 0.00 SECS
1/2 O2S VOLTS               : 4.84 VOLTS
```

Figure 55 JTEC/SBEC Downstream Oxygen Sensor Monitor Data Screen

**CAT Mon 1/2 (or 2/2) O2 Switched:** The PCM looks for the O2 sensor voltage to drift above and below the predetermined switch points.

**1/2 (or 2/2) O2 Min Test Volts:** This is the lowest O2 voltage value the PCM recorded while running the monitor.

**1/2 (or 2/2) Max Test Volts:** This is the maximum O2 voltage value the PCM recorded while running the monitor.

## 1/2, 2/2 SCAN TOOL LAST RESULT SCREEN – JTEC/SBEC

**SBEC**

```
      1/2 O2S MON LAST RESULT
1/2 O2 LOW VOLT STATUS    : C0
1/2 LOW VOLT LAST RESULT  : MIN
1/2 LOW VOLT FAIL THIS TST: NO
1/2 LOW VOLT FAIL PREV TST: NO
LAST 1/2 O2 LOW VOLT      : 0.97
1/2 O2 LOW VOLT SPEC      : 0.68
1/2 O2 HI VOLT STATUS     : 80
1/2 HI VOLT LAST RESULT   : MAX
1/2 HI VOLT FAIL THIS TST : NO
1/2 HI VOLT FAIL PREV TST : NO
LAST 1/2 O2 HI VOLT       : 0.37
1/2 O2 HI VOLT SPEC       : 0.37
```

**JTEC**

```
      1/2 O2S MON LAST RESULT
LAST 1/2 O2 LOW VOLT: 0.44
1/2 O2 LOW VOLT SPEC: 0.44
LAST 1/2 O2 HI VOLT : 0.66
1/2 O2 HI VOLT SPEC : 0.66
```

Figure 56 JTEC/SBEC Downstream Oxygen Sensor Monitor Last Result Screen

**1/2 Low Volt Last Result:** The PCM is looking for O2 sensor voltage to fall below a minimum value.

**Last 1/2 O2 Low Volt:** This is the result of the last low voltage reading.

**1/2 O2 Low Volt Spec:** This is the specification.

**1/2 Hi Volt Last Result:** The PCM is looking for O2 sensor voltage to exceed a maximum value.

**Last 1/2 O2 Hi Volt:** This is the result of the last high voltage reading.

**1/2 O2 Hi Volt Spec:** This is the specification.

## 1/2, 2/2 O2 SENSOR MONITOR SPECIFICS – SBEC

**SBEC Only**

```
        1/2 O2S MON SPECIFICS
1/2 O2S MON PASS DATA    : 00
1/2 O2 PASS HI VOLT LIMIT: NO
1/2 O2 PASS LO VOLT LIMIT: NO
1/2 O2S MIN TEST VOLTS   : 0.00 VOL
1/2 O2S MAX TEST VOLTS   : 0.00 VOL
1/2 O2S VOLTS            : 0.49 VOLTS
```

Figure 57  SBEC Downstream Oxygen Sensor Monitor Specifics Screen

**1/2 O2 Pass Hi Volt Limit:** This line indicates whether the test result exceeded the high voltage threshold.

**1/2 O2 Pass Lo Volt Limit:** This line indicates whether the test result fell below the low voltage threshold.

**1/2 O2 Min Test Volts:** This is the minimum O2 sensor voltage during monitor.

**1/2 O2 Max Test Volts:** This is the maximum O2 sensor voltage during monitor.

Notes: ____________________

# MODULE 8 OXYGEN SENSOR HEATER MONITOR

## BACKGROUND

Oxygen sensors use Positive Temperature Coefficient (PTC) heater elements. $O_2$ sensor heaters get the sensors up to operating temperature quickly after startup. The heaters also help keep the sensor above operating temperature of 660°F (349°C). The heater uses two of the four sensor wires.

## NGC OXYGEN SENSOR HEATER OPERATION

The oxygen sensor heaters on NGC vehicles are controlled using a pulse width modulated (PWM) 12V high-side driver. The resistance of NGC sensor heaters is constantly monitored by the PCM.

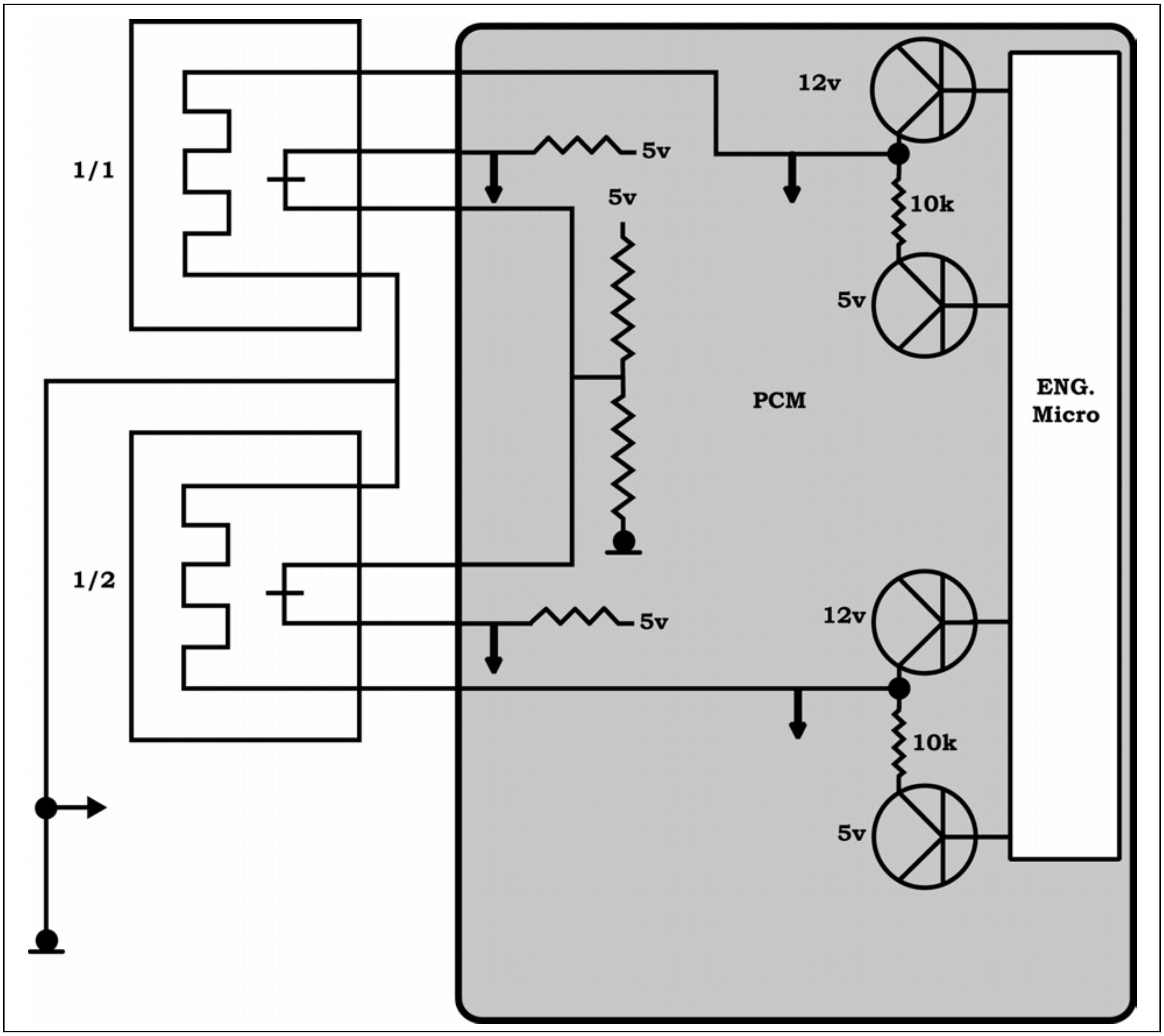



Figure 58  NGC Oxygen Sensor Heater Circuit

## NGC OXYGEN SENSOR HEATER MONITOR

The NGC controller has the ability to maintain desired $O_2$ heater temperature under most operating conditions.  Remember that the heater circuit can increase the temperature of the $O_2$ sensor, but it cannot decrease the temperature of an overheated sensor.

To determine the operating temperature of the heater circuit, the PCM performs a voltage drop test with a 5V pull-up across a 10K-ohm resistor and the $O_2$ heater. This information is used to verify proper operation of the heater circuit, and to indirectly determine the temperature of the $O_2$ sensor.  The PCM then adjusts the pulse width modulated heater current to maintain proper temperature.  The NGC controller also uses the 5V pull-up to perform open circuit, short to ground and short to power diagnostics, when the 12V high-side heater driver is in the OFF state.

On NGC vehicles, although the PCM is constantly maintaining the desired $O_2$ heater temperature, the Oxygen Sensor Heater Monitor is considered a once-per-trip monitor which may run after startup.  Pass information is processed when the vehicle is turned OFF.  The monitor may fail at any time during the drive cycle.

The oxygen sensor heater can fail in two ways.  The first way is an electrical circuit failure.  This results in a DTC for heater circuit fault.  This is a one-trip fault.

The second fault is a monitor failure.  This results in a DTC for performance failure. This is a two-trip fault.  The Oxygen Sensor Heater Monitor is a once-per-trip monitor.

**SCAN TOOL PRETEST SCREEN - NGC**

This screen allows the user to determine when the conditions have been met to run the Oxygen Sensor Heater Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

**Note: The Pretest Screen applies to all $O_2$ sensors on the vehicle.**

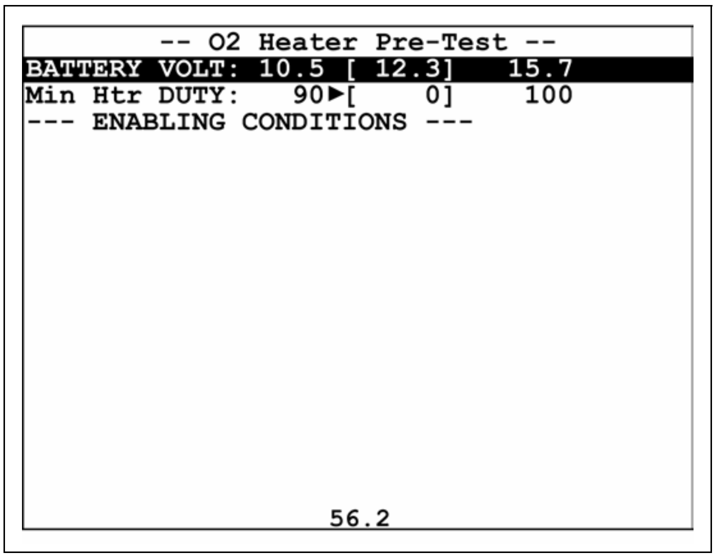



Figure 59 NGC Oxygen Sensor Heater Monitor Pretest Screen

The main objective of this and other pre-test screens is to "make the arrows go away". When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**Battery Volt:** The minimum and maximum voltages which will allow the O2 Heater monitor to run.

**Min Htr Duty:** The minimum O2 Heater Duty cycle that must be requested by the PCM. The high duty cycle makes the assumption that the O2 sensor is cold and ready to be tested.

**SCAN TOOL MONITOR DATA SCREEN - NGC**

This screen indicates the status of the Oxygen Sensor Heater Monitor.

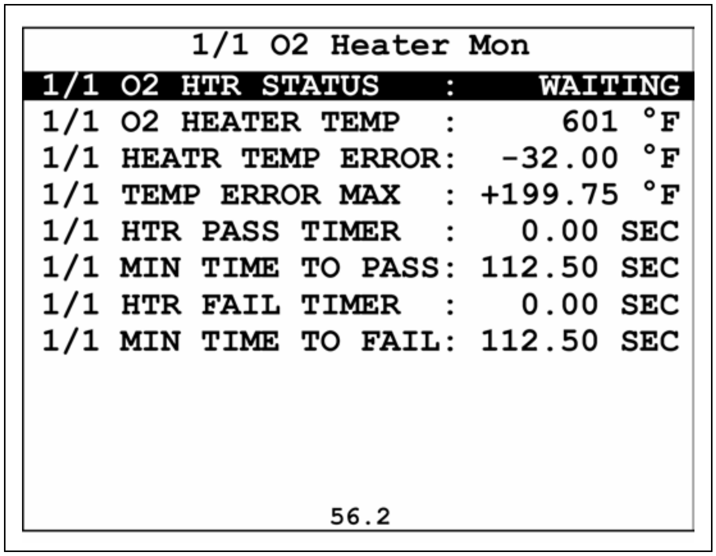



Figure 60 NGC Oxygen Sensor Heater Monitor Data Screen

**1/1 O2 Htr Status:** This line item is covered in Module 4 Monitors.

**1/1 O2 Heater Temp:** This is the actual measured temperature of the O2 Heater.

**1/1 Heatr Temp Error:** This is the temperature away from specification of the O2 heater while the engine is running. If it exceeds Error Max specification, the fail timer starts counting.

**1/1 Temp Error Max:** The amount the O2 Heater is allowed to be away from the specified temperature (not shown). The + sign needs to be ignored; this value applies above and below the specification.

**1/1 Htr Pass Timer:** This is the amount of time the PCM is controlling the O2 heater and is within the Temp Error Max. It is possible for this counter to "peg"; it will continue to count up from 0 as long as the PCM is in control of the O2 heater.

**1/1 Min Time To Pass:** Number of seconds required by the monitor to "pass". This is a continuous monitor. Even after this specification is attained, the PCM will continue to monitor the O2 Heater functionality.

**1/1 Htr Fail Timer:** This is the amount of time the PCM is controlling the O2 heater and is outside of the Temp Error Max. If the timer reaches the 1/1 Min Time To Fail specification the PCM will consider this a failure and set a 1-Trip failure.

**1/1 Min Time To Fail:** Number of seconds required by the monitor to "Fail".

**JTEC/SBEC OXYGEN SENSOR HEATER OPERATION**

The heaters on SBEC and JTEC vehicles are either low side controlled by the PCM, or are ASD controlled. There are three methods of heating oxygen sensors.

The first method utilizes a Positive Temperature Coefficient (PTC) heater element. This heater element receives power from the ASD relay and has a constant ground.

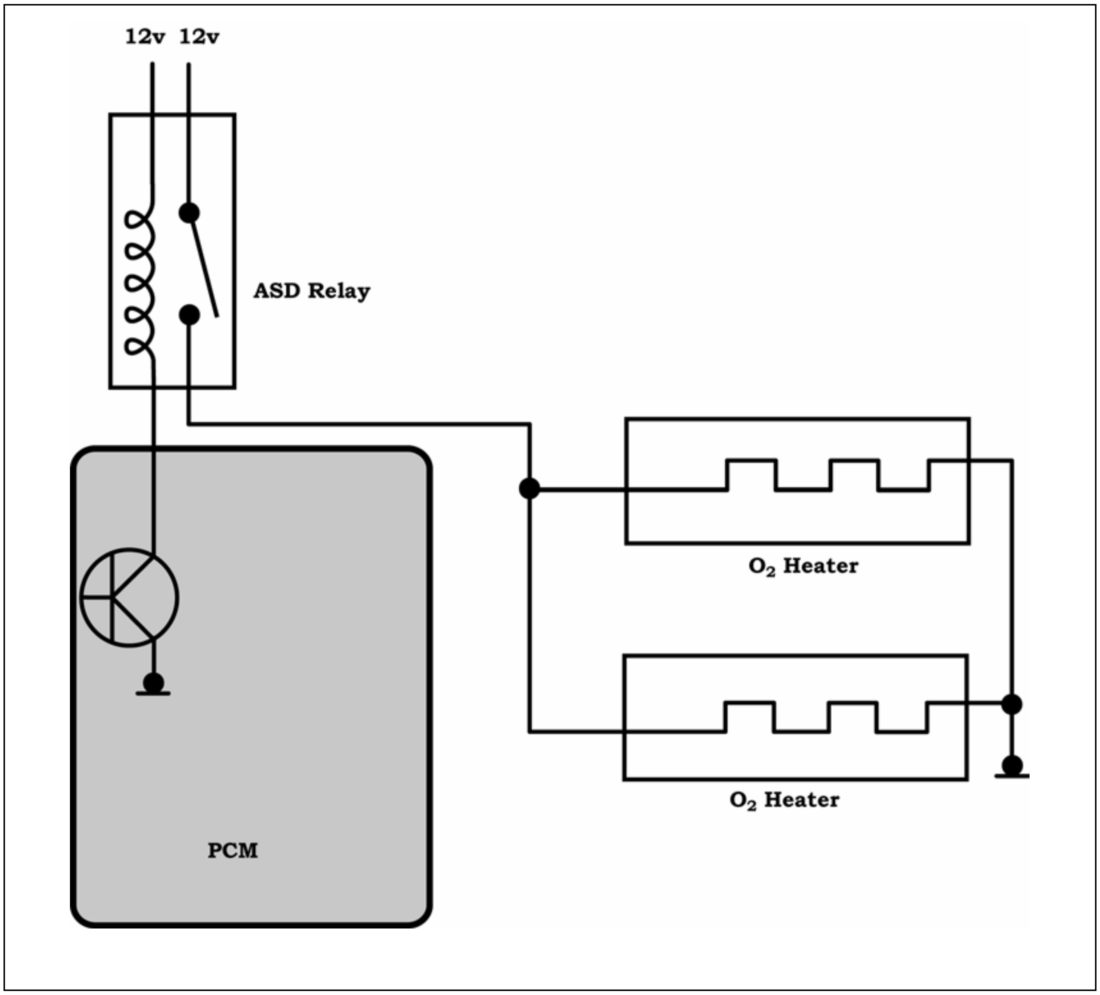



Figure 61 Oxygen Sensor Heater Element – ASD Power/Constant Ground

The second method is a Pulse-Width Modulated (PWM) heater circuit. The heater element receives power from the ASD relay and the ground is pulse-width modulated by the PCM. Current is varied on a duty-cycle of 0 - 100%.

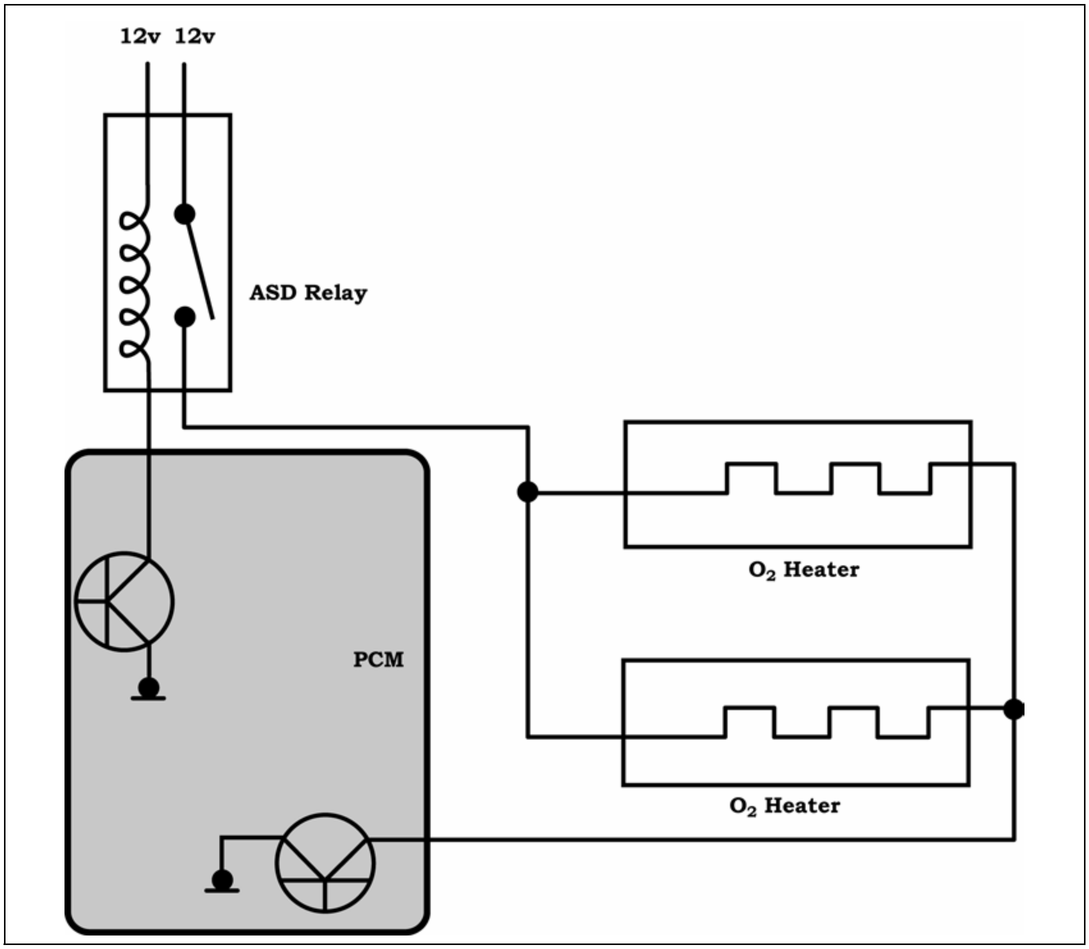



Figure 62 Oxygen Sensor Heater Element – ASD Power/PWM Ground

The third method includes an $O_2$ heater relay. On these vehicles, power is provided to the $O_2$ heater element by the $O_2$ heater relay and its ground is fixed. The $O_2$ heater relay receives power from the ASD relay and the PCM controls the $O_2$ heater relay ground.

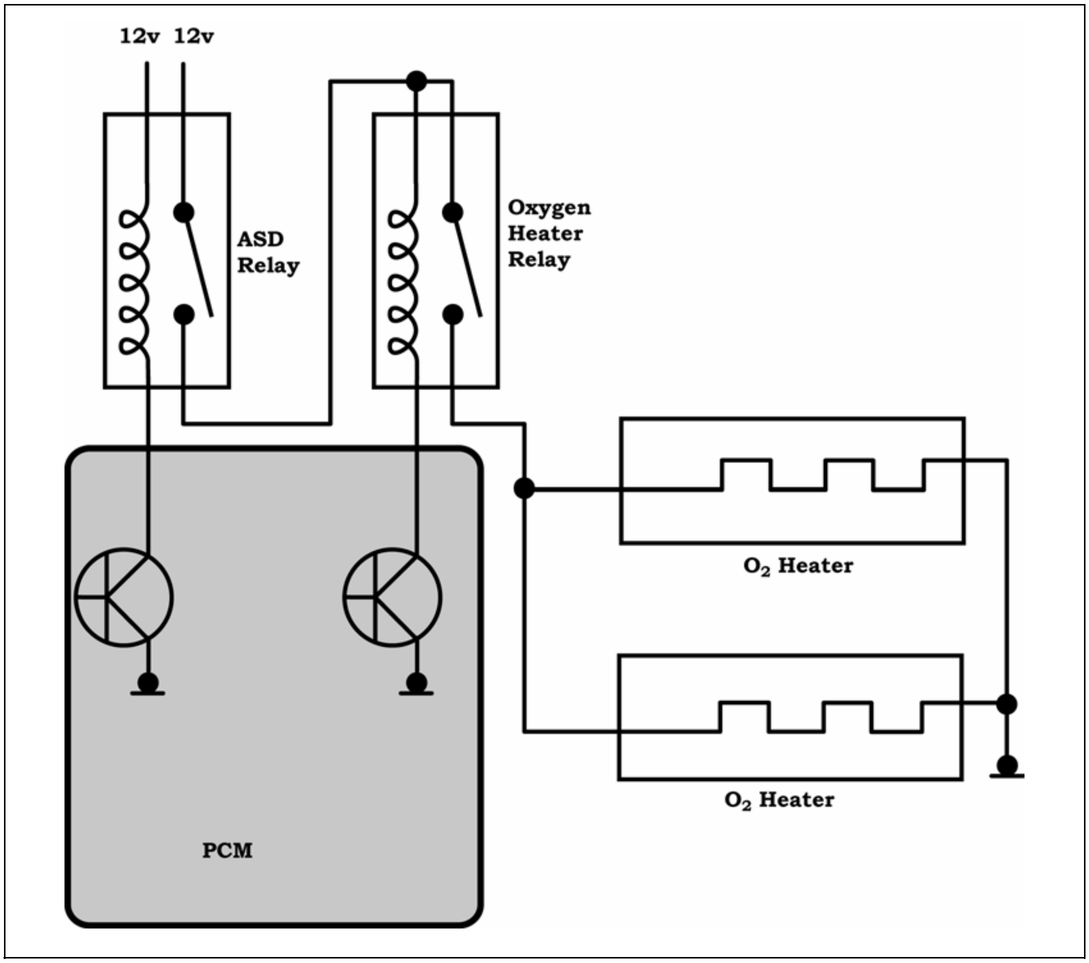



Figure 63 Oxygen Sensor Heater Element – Relay Power/Constant Ground

## ACTIVITY 9: O2 SENSOR HEATER MONITOR SCREENS

Notes:

### JTEC/SBEC OXYGEN SENSOR HEATER MONITOR

SBEC vehicles run the Oxygen Sensor Heater Monitor after a drive cycle when the vehicle is turned OFF hot.

JTEC vehicles run the Oxygen Sensor Heater Monitor after a cold start.

### SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

```
        O2 HEATER Pre-Test
Min Run Time : 3.7    [11.3]   13.9
Cat Tmp Range: 0      [145]    2500
       ENABLING CONDITIONS
Exhst Time   : 2.1    [0.0]    13.9
Cat Tmp Range: 0      [145]    2500
```

**JTEC**

```
          O2 HEATER Pre-Test
ECT Range     :  -50    [68]     104
ECT/Bat Rang:  0.0    [1.8]    14.4
1/2 O2S VOLT:  4.0    [5.0]    5.0
2/2 O2S VOLT:  4.0    [4.8]    5.0
         ENABLING CONDITIONS
Volts Range : 10.5    [12.2]   15.0
```

Figure 64  JTEC/SBEC Oxygen Sensor Heater Monitor Pretest Screen

**Min Run Time:** This is the minimum amount of time the engine needs to run in order to satisfy the monitor requirement.

**Exhaust Time:** The timer counts up with open throttle, and counts back down with closed throttle. Too much closed throttle time allows the oxygen sensors to cool down.

**Volts Range:** This is the battery voltage range required to satisfy the heater monitor.

**Cat Tmp Range:** This is a calculated value. Satisfying this requirement ensures the exhaust system has reached full load temperature.

**ECT Bat Range:** ECT and battery temperature must to be within a specific percentage of one another.

**Note:** **SBEC vehicles run the O2 sensor heater monitor after a drive cycle when the vehicle is shut off. JTEC vehicles run the O2 sensor heater monitor during a cold start.**

## SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
        1/1 O2S HEATER MON
1/1 O2 HEATER MON DATA    : 80
1/1 O2 HTR IN PROGRESS    : NO
1/1 O2 HTR DONE THIS TRIP: NO
1/1 O2 HTR FAIL THIS TRIP: NO
1/1 O2 HTR FAIL 1 TRIP    : NO
1/1 O2 HTR FAIL DTC SET   : NO
1/1 O2 HTR STOP TESTING   : NO
1/1 O2S VOLTS             : 0.47 VOLTS
```

**JTEC**

```
        1/1 O2S HEATER MON
1/1 O2 HEATER MON DATA    : 00
1/1 O2 HTR IN PROGRESS    : NO
1/1 O2 HTR DONE THIS TRIP: NO
1/1 O2 HTR FAIL THIS TRIP: NO
1/1 O2 HTR STOP TESTING   : NO
1/1 O2S VOLTS             : 5.00 VOLTS
```

Figure 65 JTEC/SBEC Oxygen Sensor Heater Monitor Data Screen

## SCAN TOOL LAST RESULT SCREEN – JTEC/SBEC

**SBEC**

```
      1/1 O2S HTR LAST RESULT
1/1 HTR TREND STATUS      : C0
1/1 HTR TREND LAST RESULT : MIN
1/1 HTR TREND FAIL THS TST: NO
1/1 HTR TREND FAIL PRV TST: NO
LAST 1/1 HTR TREND        : 255
1/1 HTR TREND SPEC        : 6
1/1 HTR DELTA VOLT STATUS : C0
1/1 HTR DELTA LAST RESULT : MIN
1/1 HTR DELTA FAIL THS TST: NO
1/1 HTR DELTA FAIL PRV TST: NO
LAST 1/1 HTR DELTA VOLT   : 10
1/1 HTR DELTA VOLT SPEC   : 9
```

**JTEC**

```
      1/1 O2S HTR LAST RESULT
LAST TIME TO REACH 1/1 VOLT: 27
TIME TO REACH 1/1 VOLTS SPE: 63
```

Figure 66 JTEC/SBEC Oxygen Sensor Heater Monitor Last Result Screen

**SBEC**

**1/1 Htr Trend Last Result:** This line indicates whether the O2 sensor voltage fell below a predetermined minimum value during the monitor.

**1/1 Htr Delta Last Result:** This line indicates whether a predetermined amount of voltage change occurred during the monitor.

**JTEC**

**Last Time To Reach 1/1 Volt:** This line indicates the length of time, in seconds, it took for the O2 sensor voltage to drop below a specific value.

**Time To Reach 1/1 Volts Spe:** This value is the amount of time, in seconds, which must not be exceeded.

Notes:

# MODULE 9 EVAP LEAK MONITOR

## BACKGROUND

Current engine management technology does an excellent job of maintaining low tailpipe emissions. However, a large percentage of hydrocarbon (HC) emissions results from evaporating fuel, not from tailpipe emissions.

The current California Air resources Board (CARB) regulations require detection of leaks equivalent to a hole 0.020 in. (0.5 mm) diameter. Testing has shown that a leak of this size can cause HC emissions of around 1.35 grams HC per mile. This is more than 30 times the allowable standard. This is why EVAP systems must be monitored.

OBD II regulations require that the diagnostic system:

- Verify Airflow
- Monitor For HC Loss

NGC vehicles use a new evaporative emissions leak detection system that can dependably detect 0.020 in. (0.5 mm) leaks. The new system is called Natural Vacuum Leak Detection (NVLD), and it replaces the leak detection pump system previously used on SBEC and JTEC vehicles.

NGC vehicles can perform two types of EVAP system leak tests. The first type of test is a passive test, called Natural Vacuum Leak Detection. This is a small leak (0.020 in. (0.5 mm)) test, and is run after enabling conditions are met and the vehicle is turned OFF. The second type of test is an intrusive test and checks the EVAP system for medium or large leaks (0.040 – 0.090 in. (1.02 – 2.29 mm)) during a cold start. This second test is only conducted if the small leak test results are "inconclusive." If the small leak test passes, obviously there is no medium or large leak.

## NVLD PRINCIPLES

The NVLD system relies on the "Gas Law" principle, which states that "the pressure of a gas in a sealed vessel will change with changes in the temperature of the gas." This principle applies only if the vessel is sealed. Any leak, even a small leak in the system will allow the pressure to equalize with ambient atmospheric pressure.

A vent valve seals the charcoal canister vent during engine-OFF conditions. If the EVAP system does not have a leak larger than the failure threshold, the system pressure will drop when ambient temperatures drop at night. When vacuum in the system exceeds approximately 1 in. $H_2O$ (0.25 kPa), a vacuum switch closes. When the PCM detects that this switch has closed, the Small Leak Monitor Test will record a "pass" on the next start. If the switch state does not change, either the system has a leak, or the required temperature change did not occur. In either case, the test results at this point are inconclusive.

See example below of the Natural Vacuum principle at work. This tanker had been steam cleaned and the tank vents were not open while it cooled.

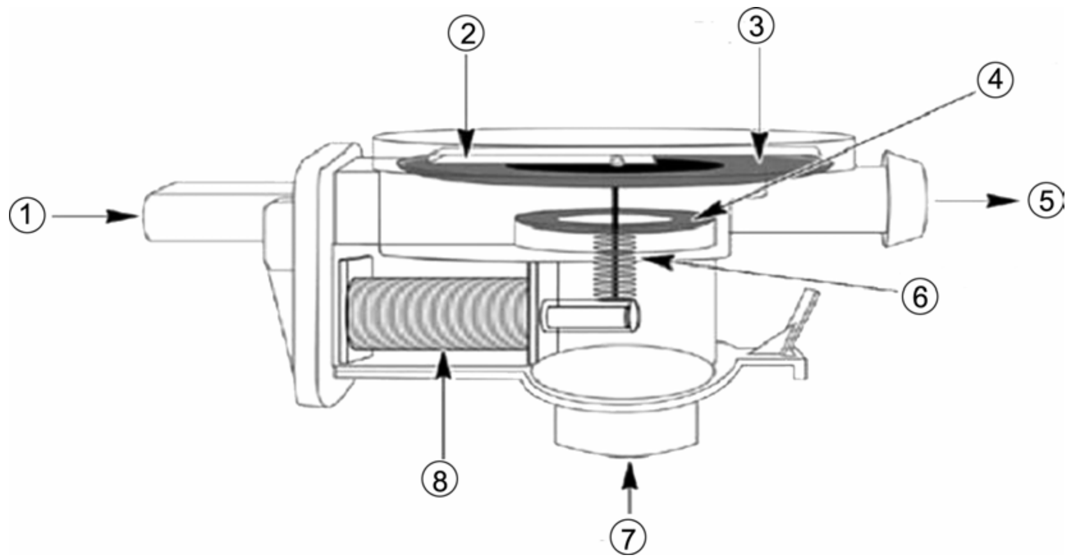
Figure 67 Natural Vacuum Principle Demonstrated

**NGC NVLD OPERATION**

The NVLD assembly is located on the atmospheric vent side of the charcoal canister. The NVLD assembly is designed with a normally open vacuum switch, a normally closed (de-energized) solenoid, and a pressure/vacuum relief valve, which is actuated by both the solenoid and a diaphragm. The normally open vacuum switch will close when about 1 in. H2O (0.25 kPa) vacuum lifts the diaphragm. The normally closed pressure/vacuum relief valve in the NVLD is intended to maintain the seal on the evaporative system during engine off conditions.

If vacuum in the evaporative system exceeds 3 – 6 in. $H_2O$ (0.75 – 1.5 kPa), the valve will be pulled off the seat, opening the seal. This protects the system from excessive vacuum and allows sufficient purge flow if the solenoid is inoperative. A noise may be heard if this happens.

The solenoid actuates the valve to unseal the canister vent while the engine is running. The solenoid is de-energized to close the vent during the medium and large leak tests and during the purge flow check. Pressure in the EVAP system exceeding 0.5 in. $H_2O$ (0.12 kPa) will open the seal. This will vent pressure from the evaporative system to permit the venting of vapors, via the canister, during refueling. This also allows the tank to "breathe" during increasing temperatures, thus limiting the pressure in the tank to a low level. Limiting pressure build-up allows vacuum to be achieved sooner than if the tank had to decay this pressure with declining temperatures after shutdown.




| | | | |
|---|---|---|---|
| 1 | Electrical Connector | 5 | To Remote Filter |
| 2 | Vacuum Switch | 6 | Spring and Plunger |
| 3 | Diaphragm | 7 | To Canister |
| 4 | Pressure/Vacuum Relief Valve | 8 | Solenoid |

Figure 68 NVLD Assembly

**NGC NVLD Small Leak Monitor**

The NVLD Small Leak Monitor used on all NGC vehicles is a non-intrusive switch test. A special circuit in the NGC PCM stays alive after the vehicle is turned OFF to monitor for NVLD switch closure for up to 1050 minutes (17.5 hours) after key-OFF. This circuit consumes very little power.

The NGC controller uses key-ON (engine at stable idle, no min run time) followed by key-OFF, to complete a small leak test. Results depend on what the switch does and when the vehicle is restarted. A temperature drop of 3°F (1.7°C) reduces pressure enough to cause switch closure.

Specific milestones must be met for switch closure to be a "SMALL LEAK PASS" or for no switch closure to accumulate time toward a failure. Here are the milestones:

Table 2 Small Leak Test Time Thresholds

| | |
|---|---|
| 0 to 1050 minutes | This is the total available test time allowed during KEY OFF |
| 0 to 10 minutes | This is the time that the NGC will IGNORE anything the NVLD switch does |
| 10 to 1050 minutes | During this time, if the NVLD switch closes, the Small Leak test will "PASS" |
| 0 to 60 minutes | If the switch does not close during this time, the PCM will NOT accumulate this time towards a failure |
| 60 to 1050 minutes | This is the time that will be stored towards a failure if the NGC does not see switch closure before the vehicle is restarted |
| 4200 minutes TOTAL | TO RECORD A FAILURE, this is the total number of minutes of vehicle OFF time to be accumulated without seeing switch closure. |
| 1050 minutes | This is the maximum number of minutes that can be accumulated without switch closure in one "Key OFF" period toward the total of 4200 min. |
| 100 minutes TOTAL | TO RECORD A FAILURE, this is the total number of minutes to be accumulated in the "Key ON, Engine Running" state, in between the 4200 minutes of accumulated "OFF" time. |
| 25 minutes | This is the maximum number of minutes that can be accumulated per drive cycle (key on engine running) towards the total of 100 minutes. |

The timer starts counting as soon as the key is turned OFF, but the PCM IGNORES ANYTHING that the NVLD switch does for the first 10 minutes.

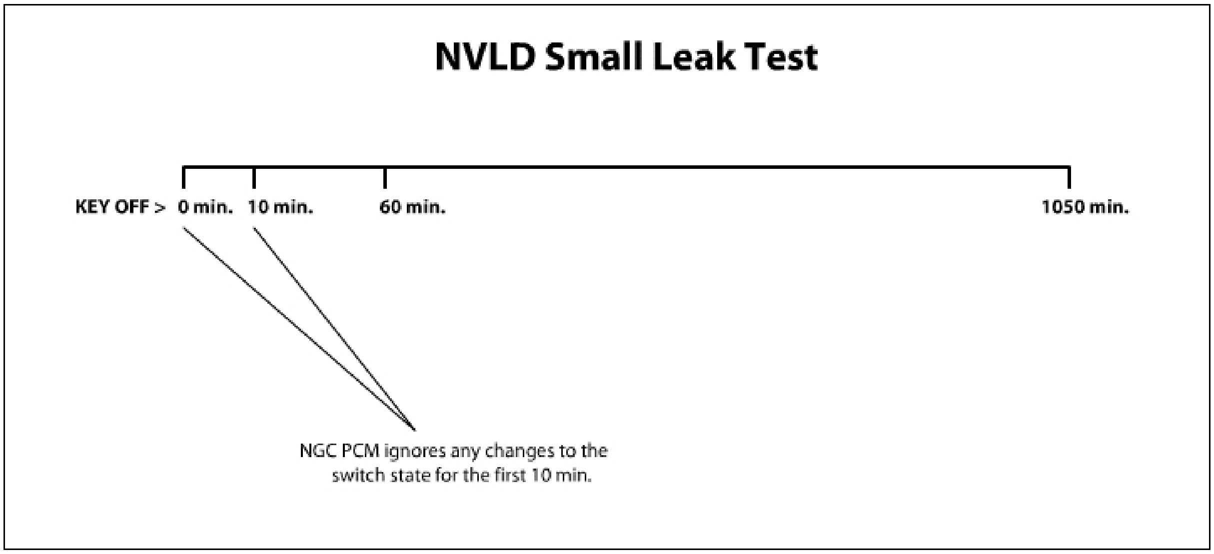



Figure 69  Small Leak Test Main Time Thresholds

The PCM will record a SMALL LEAK PASS if the NVLD switch contacts CLOSE any time between 10 - 1050 minutes after the vehicle is turned OFF.  The switch contacts may have been open or closed during the first 10 minutes, but the PCM ignores the switch state until after the first 10 minutes.  AS LONG AS the NVLD switch closes sometime between 10 - 1050 minutes, the system registers a SMALL LEAK PASS.

If the NVLD switch contacts DO NOT CLOSE within the first 60 minutes after key OFF, the PCM ignores the switch state until after 60 minutes.

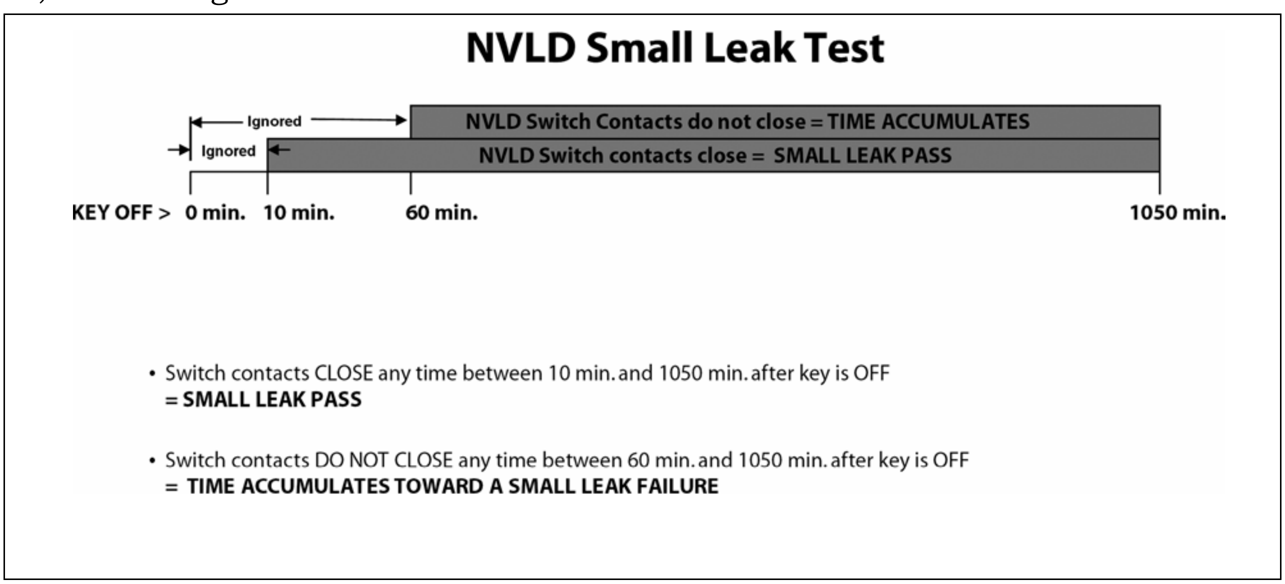



Figure 70  Small Leak Pass or Fail

If the NVLD switch contacts DO NOT CLOSE any time between 60 - 1050 minutes after the vehicle is turned OFF, the time is recorded for a possible SMALL LEAK FAIL. A failure is not immediately recorded. Several time thresholds must be met.

If the vehicle is restarted before 60 minutes without switch closure, this is considered a NO-TEST. If the vehicle is restarted between 60 – 1050 minutes without switch closure, this test is INCONCLUSIVE.

4200 minutes KEY OFF time + 100 minutes KEY ON ENGINE RUNNING time are required without switch contact closure to record a SMALL LEAK FAILURE.

1050 minutes is the maximum KEY OFF time that can be stored in any one KEY OFF period toward the 4200 minute total.

25 minutes is the maximum time that can be stored in any drive cycle toward the 100 minute total.

Whenever Small Leak Test results are inconclusive, the PCM will attempt to run the MEDIUM/LARGE LEAK AND PURGE MONITOR to determine whether the reason for no switch closure is a larger leak.

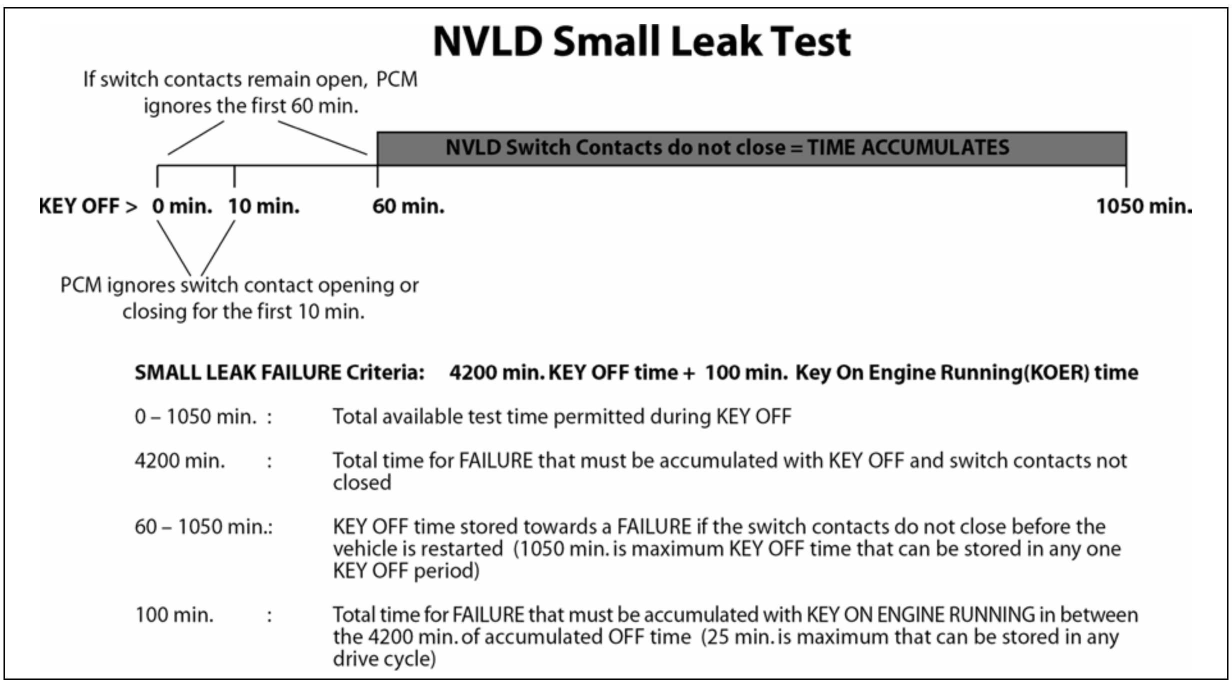



Figure 71 Small Leak Failure Time Thresholds

This diagnostic test can take a week or longer to mature a leak fault. This time period has been chosen to allow the vehicle to be exposed to the largest possible number of drive scenarios before a leak decision is made. This also satisfies CARB's stated goal of getting three MIL illuminations within a month for 0.020 in. (0.5 mm) leak detection. The diagnostics will log engine OFF and RUN time to determine when a week has elapsed. There is a limit on the total amount of run time that is applied to the one-week timer. There is also a limit on the total soak time that will be allowed to be applied to the one-week timer and a limit on the amount of accrued run time during one specific drive that can be applied to the one-week timer.

**NVLD SWITCH AND SOLENOID RATIONALITY TESTS**

- At key-ON, the NVLD solenoid will be energized to vent any vacuum that may be trapped in the evaporative system from the previous soak. This should result in an open switch condition. If the switch state does not indicate an open condition, the DTC "NVLD Pressure Switch Stuck Closed" will be set.
- The solenoid will be de-energized (to seal the system) and purge will be ramped-on. The system/NVLD component rationality passes for that drive cycle if the switch closes after purge begins.
- The solenoid is then re-energized for the remainder of the drive cycle. If the switch events are not seen within two trips, the rationality test will fail.
- This rationality check is considered sufficient to confirm proper purge solenoid operation.

**NGC MEDIUM AND LARGE LEAK TEST**

This intrusive test will only be run if the Small Leak test is inconclusive (the switch does not close). The intrusive Medium and Large leak are conducted as follows:

- The NVLD solenoid is de-energized to seal the canister vent.
- Purge is activated shortly after closed loop. A vacuum builds in the EVAP system that is greater than the NVLD vacuum switch point value of 1 in. $H_2O$ (0.25 kPa), for a specified time.
- Purge is then turned off and a determination is made on how long it takes for the tank vacuum to decay and the switch to reopen. This is also known as the “vacuum decay” method.

Leak size is determined by the time it takes for the switch to reopen. Medium or Large leak DTCs will be set if the switch closes, and then re-opens before the calibrated time. If the switch does not close, a more aggressive purge flow will be applied to determine whether a very large leak is present, a missing fuel cap, a problem with the NVLD assembly, a purge flow problem, etc. If the switch never closes, a "General EVAP System Failure" DTC will be set.

**ACTIVITY 10: NVLD**

Notes:

## ACTIVITY 11: NVLD FORCED MONITOR TEST

Notes:

**NGC PURGE FLOW MONITOR**

On NGC vehicles with NVLD, if the vehicle passes the small leak test, the PCM will run a two-stage Purge Flow Monitor while watching Short Term Adaptive.

During Stage One, the NGC PCM monitors purge vapor ratio. If the ratio is above the calibrated specification, the monitor passes. Stage One is passive and non-intrusive.

If the purge vapor ratio is not above the specification, Stage Two runs. During this test, the PCM commands the purge solenoid to flow at a specified rate to force the purge vapor ratio to update. The vapor ratio is compared to the calibrated specification and if it is below, a one-trip failure is recorded. Stage Two is an active intrusive test.

## ACTIVITY 12: PURGE FLOW ACTIVITY

Notes:

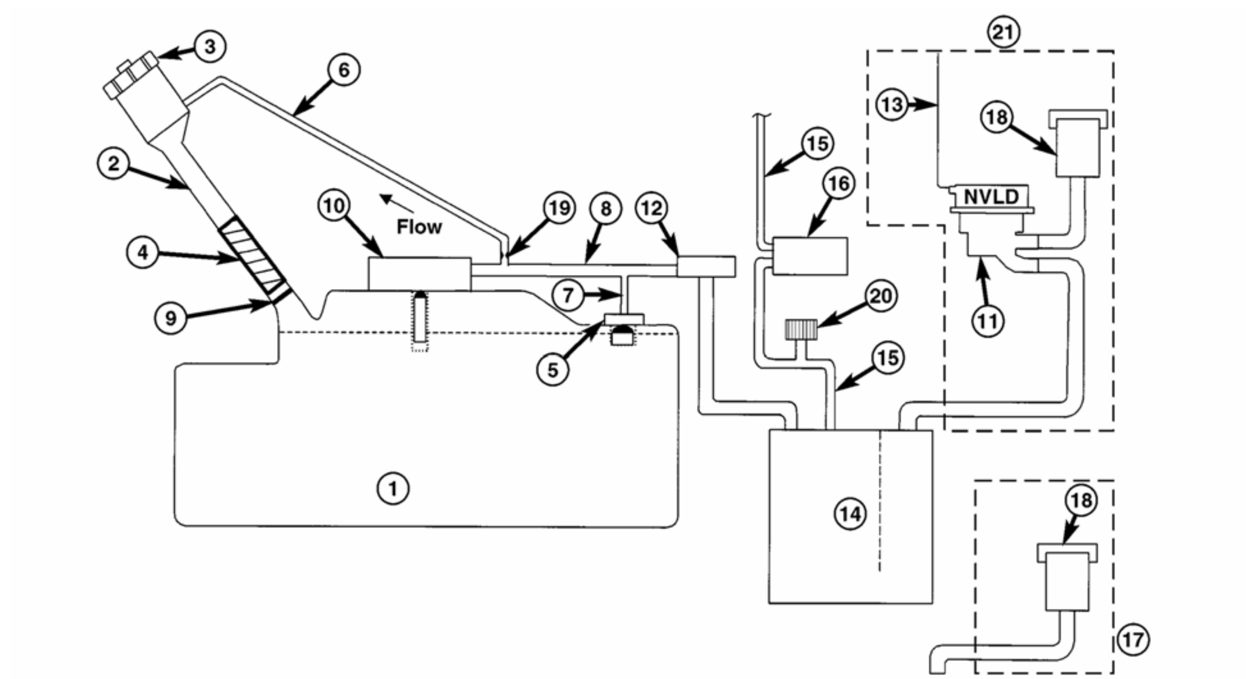
**ONBOARD REFUELING VAPOR RECOVERY**

The Onboard Refueling Vapor Recovery (ORVR) system was first introduced on some 1998 passenger vehicles. Previous EVAP systems vented fuel vapor (HC) emissions during refueling. ORVR greatly reduces these HC emissions.

Fuel flowing into the tank filler tube (approx. 1 in. I.D.) creates an aspiration effect which draws air into the fill tube. During refueling, the fuel tank is vented to the charcoal canister to capture HC vapors. With air flowing into the filler tube, no fuel vapors escape to the atmosphere.

As fuel starts to flow through the fill tube, it opens a normally closed check valve and enters the fuel tank. Vapor and air is expelled from the tank through the control valve to the vapor canister. Vapor is absorbed by the charcoal in the canister until vapor flow in the lines stops, either following shut-off or by having the fuel level in the tank rise high enough to close the control valve. The control valve contains a float that rises to seal the large diameter vent path to the canister. At this point in the fueling of the vehicle, the tank pressure increase, the check valve closes (preventing tank fuel from spiting back at the operator), and fuel then rises up the filler tube to shut-off the dispensing nozzle.

Once the HC vapors from refueling are captured by the canister, the vehicle’s computer controlled purge system draws the HC out of the canister for the engine to burn. The vapor flow is metered by the purge solenoid so that there is minimal impact on driveability or on tailpipe emissions.




| | | | |
|---|---|---|---|
| 1 | Fuel Tank (Plastic) | 12 | Liquid Separator (If Equipped) |
| 2 | Fuel Filler Tube | 13 | Engine Wiring Harness to NVLD |
| 3 | Fuel Cap (Pressure/Relief) | 14 | Vapor Canister |
| 4 | Fill Tube to Fuel Tank Connector (Elastomeric) | 15 | Purge Line |
| 5 | Tank Vent/Rollover Valve(s) | 16 | Purge Device |
| 6 | Vapor Recirculation Line | 17 | Without NVLD |
| 7 | Tank Vapor Line | 18 | Breather Element |
| 8 | Vapor Line to Canister | 19 | Flow Control Orifice |
| 9 | Check Valve (N/C) | 20 | Service Port |
| 10 | Control Valve | 21 | With NVLD |
| 11 | Natural Vacuum Leak Detection (NVLD) | | |

Figure 72  ORVR System Schematic

**SCAN TOOL SMALL LEAK PRETEST SCREEN - NGC**

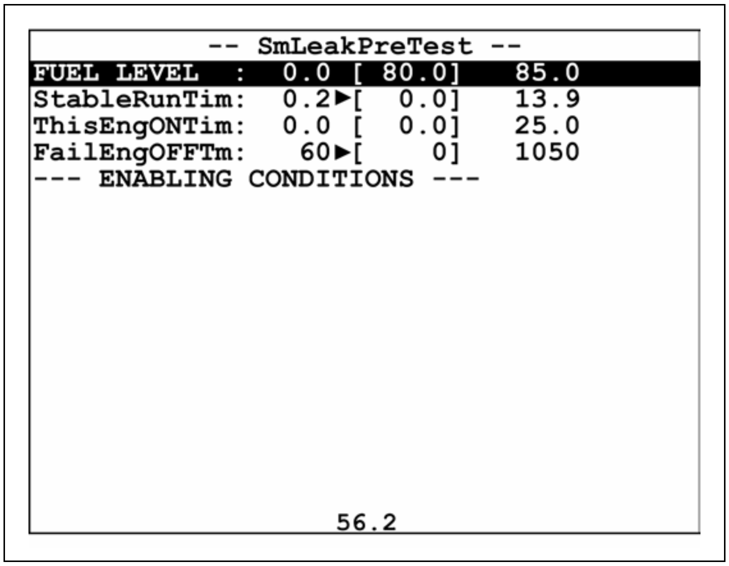



Figure 73  NGC Small Leak Monitor Pretest Screen

**Fuel Level:** Fuel level in the tank is displayed in percentage (100% = full tank; 0% = empty). Upper limit exists (e.g., 85%) for Small Leak Monitor to ensure a large enough vapor dome in the fuel tank in which a vacuum can be created to close the NVLD Switch during the Engine OFF test.

**Stable Run Tim:** Used by NGC before processing any of the Small Leak values. This ensures that the engine has started, is running and has not stalled (the NVLD Small Leak timers will not be updated with data from previous shutdown until this 10 second threshold is met).

**This Eng ON Tim:** This is live data indicating the length of engine run time for the current trip in minutes (e.g. 1.5 is equal to 1 minute and 30 seconds)

**Fail Eng OFF Tm:** This Fail Engine OFF Time is the stored amount of Engine OFF time without an NVLD Switch closure during the last Engine OFF cycle (tending toward a failure; but not yet failed). The “FailEngOFFTm” data will only update if at the last Engine off event, there was no NVLD Switch closure (for at least 61 minutes of Engine Off time and for a maximum of 1051 minutes per Engine Off event); and at the next Engine start-up, the minimum “StableRunTim” of 10 seconds has been met or exceeded.

**SCAN TOOL SMALL LEAK MONITOR DATA SCREEN - NGC**

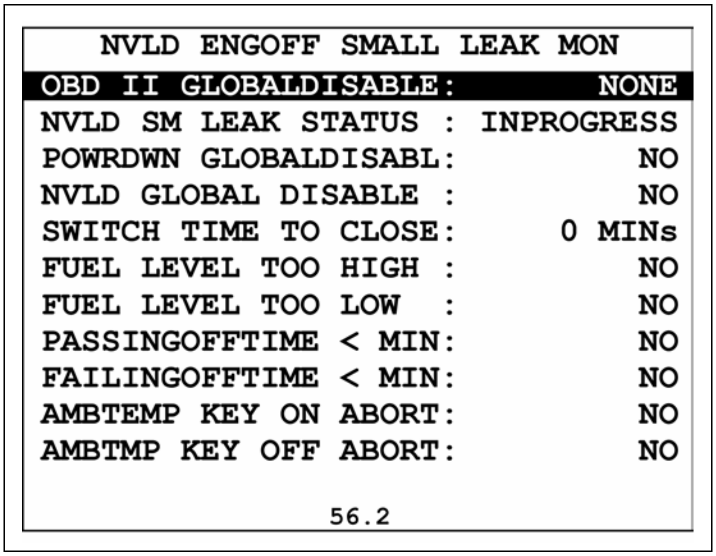



Figure 74 NGC Small Leak Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**NVLD Sm Leak Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Powrdwn Global Disabl:** Powerdown Global Disable will display a "Yes" if any of the bits (indicators) of the TM_GLOBAL_DIS_REG (see below) are set at powerdown. If this were the case, then the NVLD Small Leak Monitor would not have run the last Engine OFF cycle.

| |
|---|
| Flag to indicate the status of disable green catalyst2 (PCM Miles below the minimum calibration) |
| Flag to indicate the status of disable green catalyst1 (PCM Miles below the minimum calibration) |
| Flag to indicate the status of disable very low battery voltage |
| Flag to indicate the status of disable high Flex Fuel Level |
| Flag to indicate the status of disable power takeoff |
| Flag to indicate the status of disable low fuel level |
| Flag to indicate the status of disable high fuel level |

| |
|---|
| Flag to indicate the status of disable high altitude |
| Flag to indicate the status of disable low battery voltage |
| Flag to indicate the status of disable high battery voltage |
| Flag to indicate the status of disable low ambient temperature |
| Flag to indicate the status of disable very low ambient temperature |

**NVLD Global Disable:** NVLD Global Disable will display a “Yes” if any of the bits (indicators) of the TM_GLOBAL_DIS_REG (see above) are set at while the Engine is running. If this is the case, the NVLD Small Leak Monitor will not run the next Engine OFF cycle.

**Switch Time To Close:** The Switch Time to Close is the time in minutes that the NVLD Switch took to close the last Engine OFF cycle. 10 minutes is the minimum time that will be displayed, regardless of when the NVLD Switch really closed (e.g., 2 minutes to close NVLD Switch will not be displayed, only 10 minutes will be displayed if the Key was left OFF for 10 minutes or longer). This is the time that the NGC will ignore the NVLD Switch (which is called the “PassingOFFTime < Min” which is calibrated to 10 minutes). The maximum per Engine OFF time this display can read is 1051 minutes; thereby making sure that at least 4 tests are need to fail the Engine OFF Small Leak Monitor (4200 accumulated Minutes Max OFF Time to fail).

**Fuel Level Too High:** This display will go to “Yes” if the fuel level in the Fuel Tank goes above the maximum calibration (e.g., 85%). If this display shows “Yes”, then the NVLD Small Leak Monitor will not run the next Engine OFF cycle.

**Fuel Level Too Low:** This display will go to “Yes” if the fuel level in the Fuel Tank goes below the minimum calibration. Currently, all NVLD Small Leak Monitor calibrations are set to 0% as the minimum disable point, which means that this monitor will never be disabled by this calibration; however, we have to protect for the calibrators setting this to some value above 0 (zero), hence the reason for leaving it on the DRB 3 screen. If this display shows “Yes”, then the NVLD Small Leak Monitor will not run the next Engine OFF cycle. If this was calibrated on for this monitor, you will need to go above the calibration (e.g., 15%) and then accumulate 16.384 miles to clear the Fuel Level Too Low indicator.

**Passing OFF Time < Min:** The “Passing Off Time less than the Minimum” display (NVLD_ENG_OFFTIME_LESSTHAN_IGNORE), will be set to “Yes” if the Engine was shut down for less than 10 minutes and restarted. The 10 minute time is required by engineering to make sure that the fuel has stopped sloshing in the tank and that everything else associated with NVLD Small Leak has been stabilized before they ‘believe’ the state of the NVLD Switch. No decision will be made before this 10 minute Engine Off period has elapsed (passing or failing). The NGC will always wait the 10 minutes before making any decision.

**Failing OFF Time < Min:** The "Failing Off Time less than the Minimum" display (NVLD_ENG_OFF_TIME_LESS_THAN_MIN), will be set to "Yes" if the Engine was shut down for less than 60 minutes without an NVLD Switch closure and the Engine was restarted. The 60 minute time is required by engineering to make sure that enough time has elapsed to potentially create a vacuum and close the NVLD Switch:

– Either allowing the fuel to cool over time (creating a vacuum),
– Or for a weather front (Baro change) to lower the pressure that the Fuel Tank 'sees' thus allowing the Fuel Tank to expand and creating a vacuum, etc.

After 60 minutes without an NVLD Switch closure, this time is valid to be counted "towards a failure" (has not yet failed); because either fuel cooling or the Baro change should have created enough vacuum to cause the NVLD Switch to close.

**Amb Temp Key On Abort:** The Ambient Temperature Key ON Abort display will be set to "Yes" if the Key ON ambient temperature is outside the calibration (e.g., 39.2° F – 109.4° F). If this is the case, the NGC will NOT be counting the last Engine OFF time without an NVLD Switch closure because you're out of the enable conditions.

**Amb Temp Key Off Abort:** The Ambient Temperature Key OFF Abort display will be set to "Yes" if the Key OFF ambient temperature is outside the calibration (e.g., 39.2° F – 109.4° F) thus disabling the Engine Off NVLD Small Leak Monitor for that Engine OFF period.

**SMALL LEAK LAST RESULT MONITOR DATA SCREEN - NGC**

```
-NVLD Eng OFF Switch Time Last Results-
 LstOffTm: xxxx M     LastOnTm: xxxx M
 SWCITime: xxxx M     ThisOnTm: xxxx M
  LAST OFF TIME         LAST  ON TIME
 LAST OFF:   10 M     LAST  ON:    3 M
 2ND  OFF:  135 M     LAST  ON:   25 M
 3RD  OFF: FAIL M     LAST  ON: FAIL M
 4TH  OFF:   14 M     LAST  ON:   26 M
 5TH  OFF:   10 M     LAST  ON:   10 M
 6TH  OFF:   35 M     LAST  ON:    7 M
 7TH  OFF:   10 M     LAST  ON:   17 M
 8TH  OFF:   15 M     LAST  ON:   24 M
 9TH  OFF:   43 M     LAST  ON:   26 M
 10TH OFF:   31 M     LAST  ON:   25 M

-NVLD EngOFF SwOpenFailTimes LastResult-
AccumOFF:      0 M    Accum ON:    0 M
LastFail:  4365 M    LastFail:  127 M
                    56.2
```

Figure 75  NGC Small Leak Last Result Monitor Data Screen

**LstOffTm:** This is the amount of time the key was turned off during the last small leak test attempt. This value will be the actual time. If the vehicle was only shutdown for 58 minutes with no switch closure, it will display 58 minutes, even though the monitor was aborted. If the test is a true pass or fail, this time will be stored in the Last OFF Time section or the SwOpenFailTimes section after the next key ON with 10 seconds of engine run time.

**LastOnTm:** This is the amount of time the Engine was running before the last small leak test attempt. This value will stop at 25 minutes. If the test is a true pass or fail, this time will be stored in the Last ON Time section or the SwOpenFailTimes section after the next key ON with 10 seconds of engine run time.

**ThisOnTm:** This is a live data read of the current engine run time.

**Last OFF Time:** This is a listing of the last 10 small leak monitors. The times listed represent the number of minutes required to see a switch closure. This time will never be less than 10 minutes. If a MIL is set this will register as a Fail. The Fail will stay listed for 10 passing tests.

**Last ON Time:** The length of time the vehicle was running before the monitor was attempted and passed.

**Accum Off:** the number of key off minutes accrued without seeing a switch closure. This number will go to 0 once a failure occurs, or the small leak monitor passes.

**Accum On:** Number of Key On minutes between key off tests without seeing a switch closure. This number will go to 0 once a failure occurs, or the small leak monitor passes.

**Last Fail:** (under OFF) This is the number of key off minutes which were accumulated for that vehicle to set a failure.

**Last Fail:** (under ON) This is the number of Key on minutes accumulated when the monitor failed.

**Max OFF:** This is the specification for the total number of Key OFF minutes required to set a DTC.

**Max ON:** This is the specification for the total number of Key ON minutes required to set a DTC.

**SCAN TOOL EVAP SWITCH MONITOR LAST RESULT DATA SCREEN - NGC**

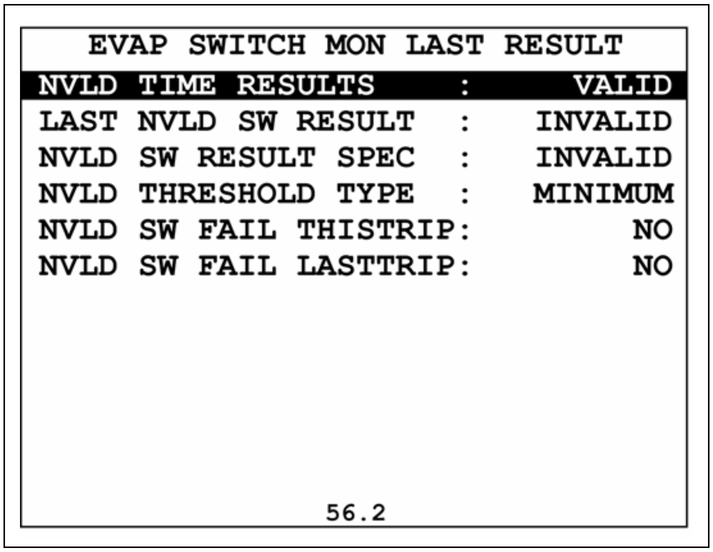



Figure 76 NGC EVAP Switch Monitor Last Result Screen

**NVLD Time Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e., not Ready).

**Last NVLD Sw Result:** This will indicate the state of the switch the last time the NVLD Switch was tested. 0= open, 255=closed. This test may run with the Medium/Large Leak test or if the switch is stuck closed (solenoid turned on at start up and switch does not change state to open).

**NVLD Sw Result Spec:** The specification for this monitor is 128, which is the half way point between 0 and 255. This represents the switch point that the NVLD Switch must cross.

**NVLD Threshold Type:** This specification is set to Min. This is because all the PCM needs to see is the NVLD Switch change from open (0) to closed (255).

**NVLD Sw Fail This Trip:** Indicates if the monitor has ran and failed during this trip. Results in a "Yes" or "No"

**NVLD Sw Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a "Yes" or "No".

**SCAN TOOL MED/LARGE LEAK PRETEST SCREEN - NGC**

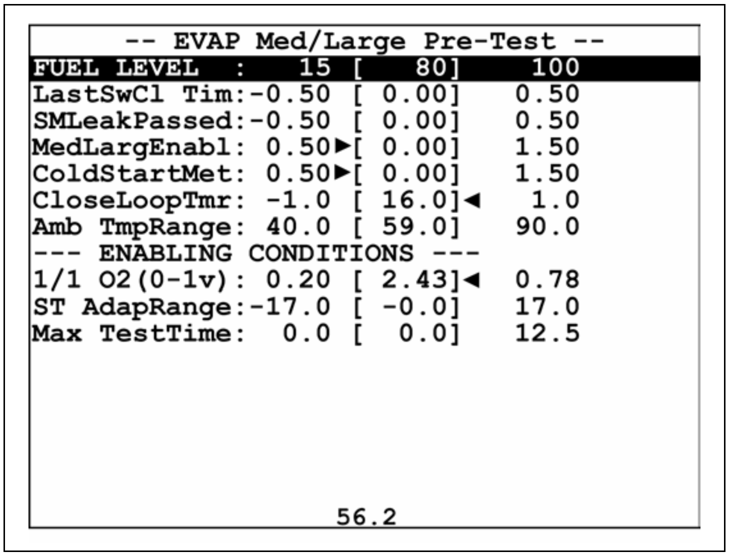



Figure 77 NGC Med/Large Leak Monitor Pretest Screen

**Fuel LEVEL:** Fuel level in the tank is displayed in percentage (100% = full tank; 0% = empty).

**Last Sw Cl Tim: to be removed, redundant of sm leak passed**

**Sm Leak Passed:** This Small Leak Passed indicator (bit) is displayed so that you will know that the Medium/Large Leak Monitors will not run because Small Leak passed the previous Key OFF (if Small Leak passed, you cannot have a Medium or Large Leak and therefore do not run the test). "1.00" (one) in the center column means Yes, the Small Leak Monitor passed the last Key OFF (and therefore Medium/Large are "declared" to be passed, even though they never ran this Key ON). "0.00" (zero) in the center column means No, the Small Leak Monitor has not passed the last Key OFF, and therefore run the Medium/Large Leak Monitor (if the enable conditions are met).

**Med Large Enabl:** This Medium/Large Leak Monitors enable indicator (bit) will display "1.00" (one) in the center column which means Yes, the monitors are enabled to run this trip.

**Cold Start Met:** This ColdStartMet indicator (bit) will display "1.00" (one) in the center column which means Yes, the cold start conditions have been met for the Medium/Large Leak Monitors.

**Close Loop Tmr:** The PCM need to ensure the engine is in Closed Loop. When Purge comes on for the monitor the PCM needs to make sure the it will not overcome the engine with purge vapors. Any non-zero value (e.g., 4.00) indicates that the fuel system is in open loop now (there is time left on the closed loop delay timer).

**Amb Tmp Range:** Range which is allowable for the monitor to run.

**1/1 O2 (0-1V):** Live O2 sensor reading

**ST Adap Range:** Live Short term adaptive range.

**Max Test Time:** This is the maximum allowable test time after a cold start.

## SCAN TOOL MED/LARGE LEAK MONITOR DATA SCREEN - NGC

```
        EVAP ENG RUN MED/LARGE MON
OBD II GLOBALDISABLE:          NONE
MED/LARG ABORTSTATUS:          NONE
MED/LARG SUSPEND 1  :          NONE
MED/LARG SUSPEND 2  :          NONE
MEDIUM STATUS       :       WAITING
LARGE STATUS        :       WAITING
PURGE AIRFLOW       : 0.000 gm/s
EVAP ACCUM PURG FLOW:         0.0 g
NVLD SWITCH         :          OPEN
NVLD TEST TIMER     :  0.00 SECS
LAST MEDSW TIMRESULT: 819.19 SEC

                 56.2
```

Figure 78  NGC Med/Large Leak Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**1/2 O2S Mon Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in the Module 4 Monitors.

**Med/Large Abort Status:** The monitor can be aborted based upon a list of calibratable information. This is similar to the Global Disable status line, except these items are specific to the Medium/Large Leak Monitor.

**Med/Large Suspend 1:** The monitor can be suspended based upon a list of calibratable information. This is similar to the Global Disable status line, except these items are specific to the Medium/Large Leak Monitor.

**Med/Large Suspend 2:** This is a continuation of the Suspend 1 list.

**Medium Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Large Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in the Module 4 Monitors.

**Purge Airflow:** Calculated amount of purge airflow. Measured in Grams per Second.

**EVAP Accum Purg Flow:** This represents the amount of accumulated purge vapor that has flowed into the engine during the monitor. This value is only valid during the monitor.

**NVLD Switch:** Actual NVLD Switch state.

**NVLD Test Timer:** Current length of time the Med leak monitor has been testing.

**Last Med Sw Tim Result:** Length of time before the Switch reopened the last time the monitor was able to complete.

**SCAN TOOL MED/LARGE LEAK LAST RESULT DATA SCREEN - NGC**

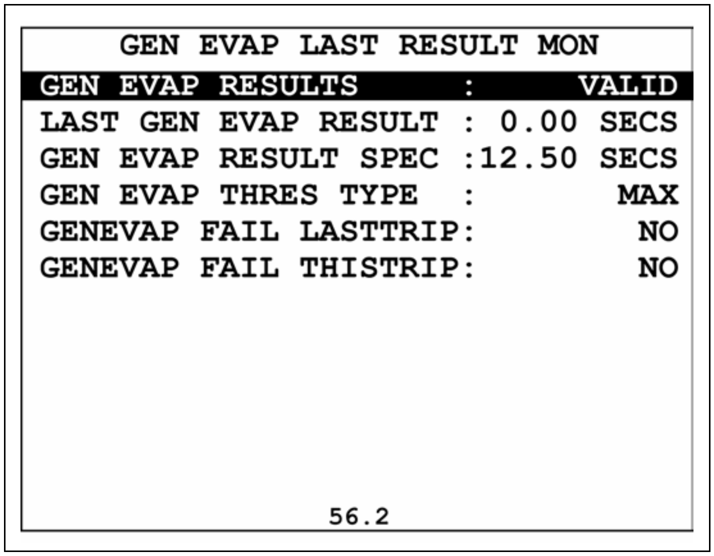



Figure 79 NGC General EVAP Monitor Last Result Screen

**Gen EVAP Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last Gen EVAP Result:** The amount of time required to make the NVLD switch close. If the switch closes this value is substituted with a dummy value of 0.

**Gen EVAP Result Spec:** This is the maximum amount of time allowable for the purge vacuum to make the NVLD switch close. This purge vacuum is created during the Med/Large leak monitor "draw down" time.

**Gen EVAP Thres Type:** This is normally set to "MAX" due to the nature of the monitor. The length of time to cause a switch change must not exceed the specification.

**Gen EVAP Fail Last Trip:** Indicates if the monitor has ran and failed during this trip. Results in a "Yes" or "No".

**Gen EVAP Fail This Trip:** Indicates if the monitor failed during the previous trip. Results in a "Yes" or "No".

## JTEC/SBEC LEAK DETECTION PUMP (LDP)

On JTEC and SBEC vehicles, the Leak Detection Pump pressurizes the EVAP system to detect leaks. It was first used in 1996 on vehicles with California emissions, and on all Federal packages starting in the 2001 model year.

### Enabling Conditions Required to Run LDP Monitor

The following conditions must be met for the EVAP System LDP Leak Monitor to run:

- Fuel Level 15 - 85%
- ECT and IAT within 10°F (5.56°C)
- Ambient temperature 40 - 90°F (4 - 32°C)

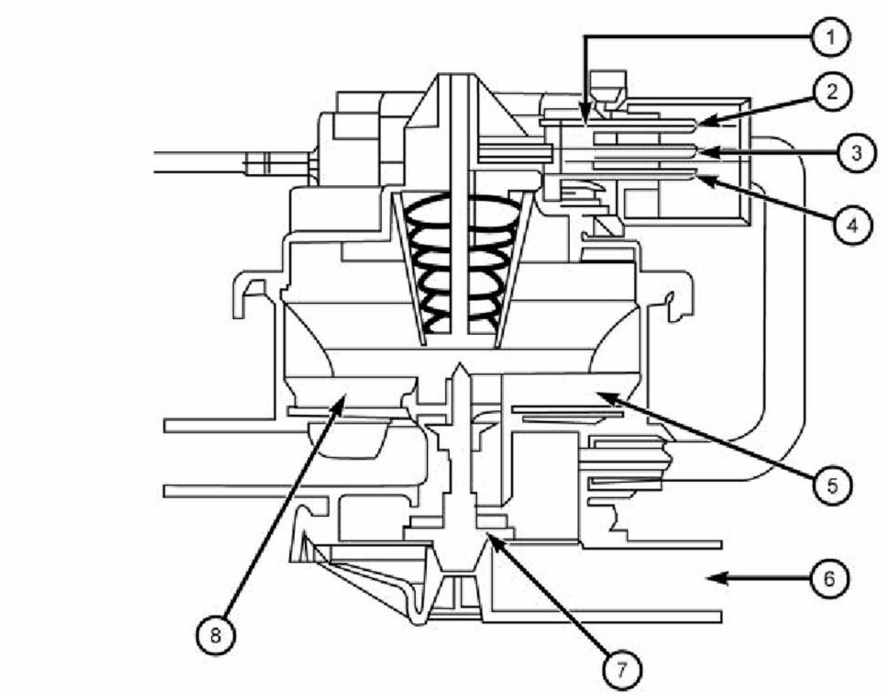
### Leak Detection Pump Operation

The Leak Detection Pump contains a solenoid, a diaphragm, an atmospheric vent valve, two check valves, and a reed switch. The solenoid is cycled ON and OFF during EVAP system leak testing. This allows engine vacuum to be applied to the Leak Detection Pump diaphragm to pressurize the EVAP system. The reed switch state is used to monitor the position of the diaphragm.

When enabling conditions are met, the Leak Detection Pump Monitor runs immediately after a cold start. The LDP Solenoid is briefly energized, allowing engine vacuum to lift the diaphragm. When the diaphragm is up, the atmospheric vent is closed and the normally-closed reed switch contacts are open. This initializes the LDP.

After initialization, the PCM cycles the solenoid. The diaphragm is pulled up, drawing outside air into the pump body through the inlet check valve. When the solenoid is de-energized, the spring, which is rated at 7.5 in. $H_2O$, pushes the diaphragm down, closing the inlet check valve and opening the outlet check valve. This pumps air into the EVAP system and increases EVAP system pressure.

The pump continues to cycle. The increasing EVAP system pressure exerts a force on the bottom of the diaphragm and opposes spring tension on the top of the diaphragm. This slows down the pump. The PCM measures how long it takes for the diaphragm to drop down far enough for the reed switch to change state from open to closed. If the switch state changes too quickly, a leak is assumed. If the system pressurizes too quickly and the switch state changes too slowly, there may be a restriction.




| | | | |
|---|---|---|---|
| 1 | Normally Closed Reed Switch | 5 | Inlet Check Valve |
| 2 | PCM Sense Circuit | 6 | To Inlet Air Filter Fuel Tank Vent: Pres and Vacuum |
| 3 | Solenoid Control from PCM | 7 | Atmospheric Vent Valve |
| 4 | 12-volt Supply (SBEC-Ignition / JTEC-ASD via the PCM) | 8 | Outlet Check Valve |

Figure 80 Leak Detection Pump

**JTEC/SBEC PURGE FLOW MONITOR**

The Purge Flow Monitor on SBEC and JTEC vehicles with LDP is a two-stage monitor. During Stage One, the PCM looks for a difference between purge and purge-free adaptive values. Stage One is passive and non-intrusive.

If the difference between purge and purge-free adaptive values in Stage One are not great enough, Stage Two runs. During this test, the PCM ramps open the purge solenoid and looks for Short Term Adaptive shift. If Short Term Adaptive shifts downward, the PCM determines that HC from the canister is purging. If Short Term Adaptive shifts upward, the PCM determines that the solenoid is allowing purge flow and there is no HC in the canister. In either case, the system passes. Stage Two is an active intrusive test.

## SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

```
           LDP Pre-Test
Bat Tmp Range: 39.2    [69.8]    89.6
ECT/Bat Range: 0.0     [25.2]    19.8
       ENABLING CONDITIONS
Volts Range  : 9.0     [12.1]    15.8
Vacuum Range : 3.9     [0.0]     31.0
```

**JTEC**

```
           LDP Pre-Test
Amb Tmp Range: 39.2    [68.0]    89.6
Bat Tmp Range: 21      [66]      130
Baro Range   : 22.1    [29.5]    31.0
ECT/Bat Range: 0.0     [1.8]     18.0
FUEL LEVEL   : 2.6     [1.1]     5.0
       ENABLING CONDITIONS
VSS Range    : 0.0     [0.0]     10.0
Volts Range  : 10.5    [12.2]    15.2
Vacuum Range : 4.9     [29.5]    31.0
```

Figure 81 JTEC/SBEC LDP Monitor Pretest Screen

## SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
     EVAP LEAK DETECT MONITOR
LDP SWITCH STATUS     : 80
LDP SWITCH TEST       : Test Pend
PINCHED LINE STATUS   : 80
PINCHED LINE TEST     : Test Pend
GROSS LEAK STATUS     : 80
GROSS LEAK TEST       : Test Pend
.040 LEAK STATUS      : 80
.040 LEAK TEST        : Test Pend
.020 LEAK STATUS      : 00
020 LEAK TEST         : Comp/Stop
LDP ABORT STATUS      : NONE
LDP MON STATE         : 0-Test Ini
LDP MON AVG PUMP TIME: 25.60 SEC
LEAK DETECT PUMP SW   : CLOSED(DN
DES LDP SOLENOID      : BLOCK
PURGE SOLENOID FLOW   : 0 %
```

**JTEC**

```
     EVAP LEAK DETECT MONITOR
LDP MONITOR DATA           : 00
LDP MON IN PROGRESS        : NO
LDP MON DONE THIS TRIP     : NO
LDP MON FAIL THIS TRIP     : NO
LDP MON DONE/STOP TESTING: NO
LDP ABORT STATUS           : Pending
LDP MON STATE              : 9-Comp/Sto
LDP MON AVG PUMP TIME      : 0.00 SEC
LEAK DETECT PUMP SW        : OPEN (UP)
DES LDP SOLENOID           : VACBLOCKED
PURGE DUTY CYCLE           : 0 %
```

Figure 82 JTEC/SBEC LDP Monitor Data Screen

## SCAN TOOL MONITOR LAST RESULT SCREEN – JTEC/SBEC

**SBEC**

```
          LDP MON LAST RESULT
LAST LDP MON STATUS       : CO
LDP MON LAST RESULT       : MIN
LDP MON FAIL THIS TEST    : NO
LDP MON FAIL PREV TEST    : NO
LDP MON AVG PUMP TIME     : 25.60 SEC
LDP MON AVGPUMP TIME SPEC: 1.91
LDP MON PUMP TIME RESULT : VALID
LDP MON FAILURE           : None
```

**JTEC**

```
          LDP MON LAST RESULT
LDP MON AVG PUMP TIME       : 0.00 SEC
LDP MON AVGPUMP TIME SPEC  : 1.58
LDP AVG PUMP TIME           : VALID
LDP .020 AVG PUMP TIME      : 0.00 SEC
LDP .020 AVG PUMP TIME SPEC: 1.8
LDP AVG PUMP TIME           : VALID
```

Figure 83 JTEC/SBEC LDP Monitor Last Result Screen

Notes:

## MODULE 10 RICH/LEAN FUEL TRIM MONITOR

### BACKGROUND

The primary function of the fuel control system is to optimize the engine air/fuel ratio. The PCM calculates the fuel injection pulse width required for the current operating conditions. The goal is to maintain the stoichiometric air/fuel ratio of 14.7:1. At this ratio, all harmful tailpipe emissions are as low as possible and the catalytic converter is also getting the feed gases it needs to be efficient. When the air/fuel ratio is rich (lower than 14.7:1, low oxygen content), HC and CO emissions increase. When the air/fuel ratio is lean (higher than 14.7:1, high oxygen content), NOx emissions increase.

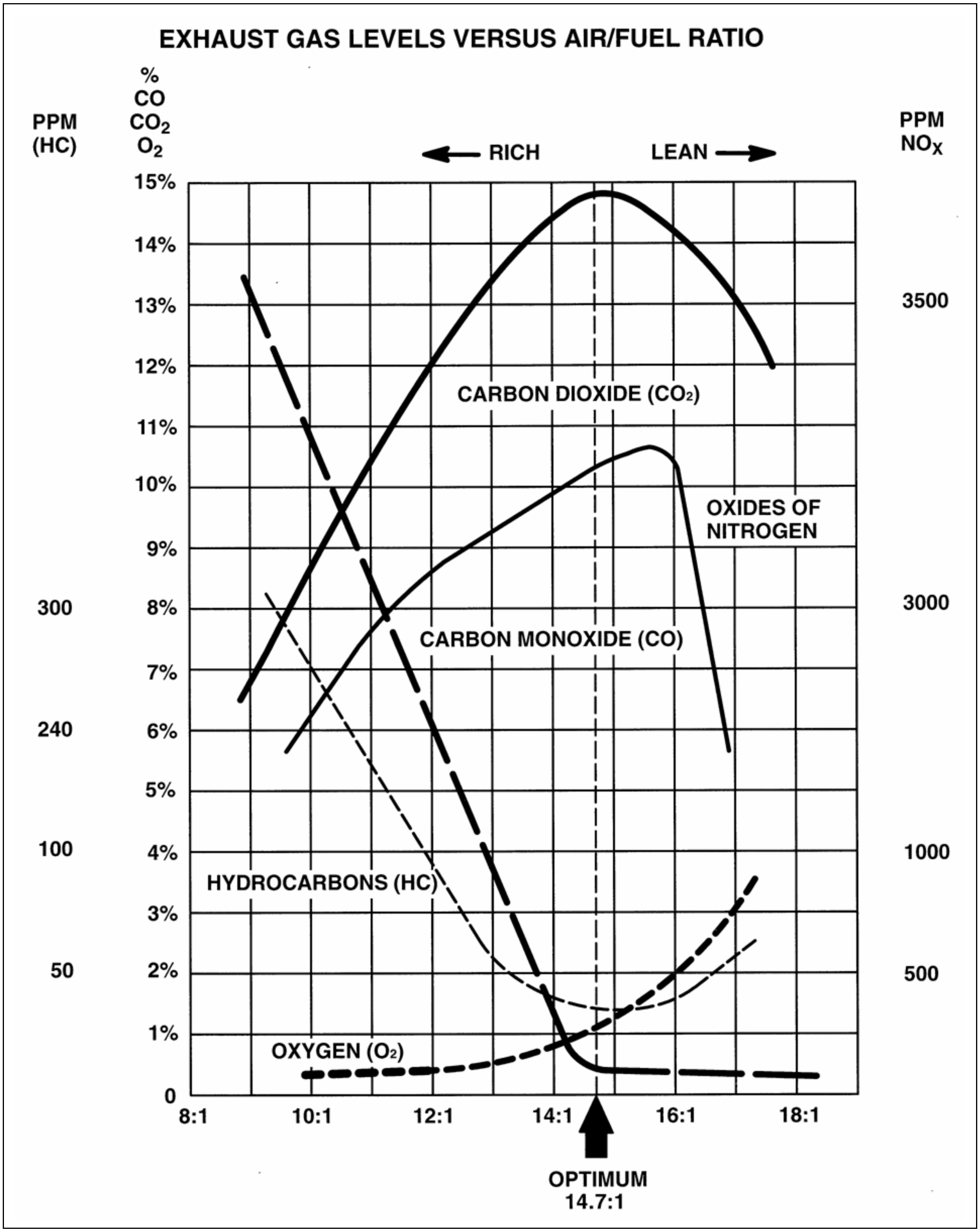



Figure 84 Exhaust Emissions vs. Air/Fuel Ratio

## FUEL TRIM OPERATION

Most Chrysler Group vehicles use Speed Density engine management systems. This system changes fuel injection quantity largely based on changes in engine speed and load. Other parameters modify the basic fuel calculation.

The following formulas represent how inputs to NGC, JTEC and SBEC PCMs are used to modify fuel injector pulse width in order to maintain the stoichiometric air/fuel ratio of 14.7:1.

| Load | Base PW Calculation | O2 | Adaptive | P.W. |
|---|---|---|---|---|
| $\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$ | (X) TPS (X) ECT (X) IAT (X) Sensed B+ (X) LT | (X) Up02 | (X) STFT (X) LTFT | = Pulse Width |

Figure 85 JTEC/SBEC Speed Density Equation

| Air Flow | Fuel Modifiers | Feedback Input | Adaptives | P.W. |
|---|---|---|---|---|
| $\frac{\text{RPM}}{\text{Max RPM}}$ (X) $\frac{\text{MAP}}{\text{Baro}}$ (X) EGR Flow* | (X) TPS (X) ECT (X) IAT (X) Sensed B+ | (X) Up O2 | (X) ST (X) LT (X) Purge Vapor Ratio* | = Pulse Width |

*Where Equipped

Figure 86 NGC Speed Density Equation

### Short Term Adaptive

Short Term Adaptive or Short Term Fuel Trim (STFT) is an immediate correction to fuel injector pulse width. During Closed Loop operation, Short Term Adaptive makes immediate adjustments to fuel delivery in direct response to the signal from the upstream $O_2$ sensor. The PCM infers air/fuel ratio by monitoring oxygen content measured by the upstream $O_2$ sensor.

This is an immediate response to an $O_2$ sensor signal that is not switching or is consistently high or low. If the upstream oxygen sensor voltage is not consistently switching between 2.5 -3.5V (NGC) or 0 – 1.0V (JTEC and SBEC), the PCM knows that the base pulse width calculation needs to be modified by adjusting the injector pulse width until a switching $O_2$ sensor voltage is achieved. This immediate correction is known as Short Term Adaptive, or Short Term Fuel Trim (STFT), and begins functioning shortly after the vehicle has started and the oxygen sensor is heated to operating temperature.

The need to adjust the injector pulse width may be a result of vehicle operating conditions, vehicle wear, fuel quality, etc. The maximum range of authority for Short Term Adaptive is ±33% for NGC and JTEC, and ±25% for SBEC. Short Term Adaptive values are not stored when ignition is OFF.

During Open Loop operation, the value for Short Term Adaptive Memory is 1 (no change).

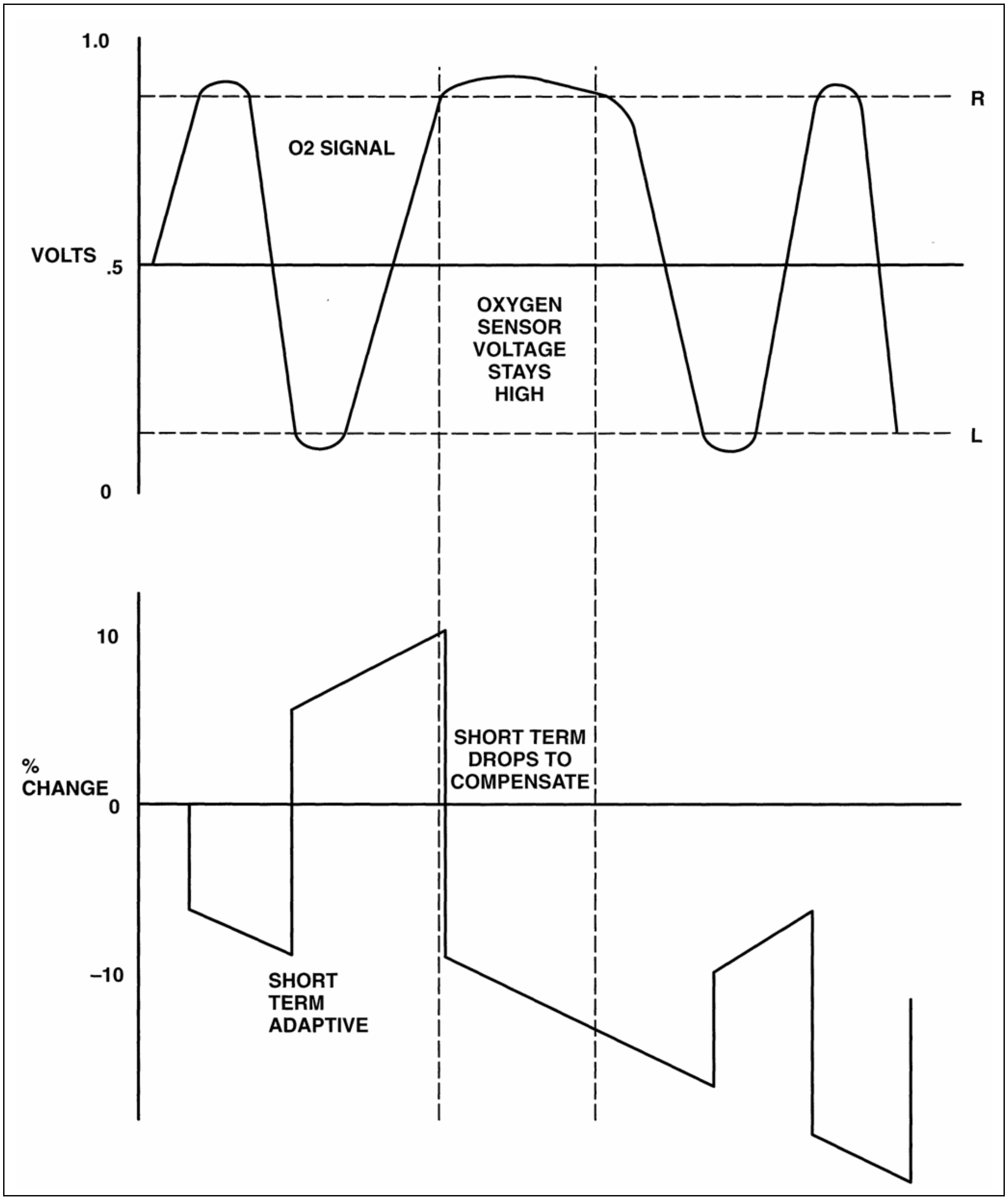



Figure 87 Short Term Adaptive vs. $O_2$ Sensor Voltage

**Long Term Adaptive**

The main function of Long Term Adaptive is to make fuel corrections that permit Short Term Adaptive to hover around zero. In order to maintain correct emissions throughout all operating ranges of the engine, a cell structure based on engine rpm and load (MAP) is used.

There are 26 cells on NGC vehicles, up to 22 cells on JTEC-equipped vehicles and up to 16 cells on SBEC-equipped vehicles. Two of the cells are used only during idle, as determined by TPS and Park/Neutral switch inputs. The other cells each represent a given off-idle manifold pressure and rpm range.

After the vehicle has reached full operating temperature, short term correction factors will update Long Term Adaptive Memory cells based on vehicle load (RPM/MAP) to allow the Short Term Adaptive value to be brought back to near zero. Once this correction factor is updated in memory, it will be used by the PCM under all operating conditions, open loop and closed-loop. However, the values stored in Long-term are updated only after the vehicle has entered long-term closed loop at full operating temperature. This is done to prevent any transition temperature or start–up compensation from corrupting long term fuel correction.

Long Term and Short Term Adaptive can each change the pulse width by as much as ±33% (NGC and JTEC) or ±25% (SBEC) for a maximum total correction of ±66% (NGC and JTEC) or ±50% (SBEC) from the base pulse width calculation. Long Term Adaptive values are used during both Open Loop and Closed Loop operation.

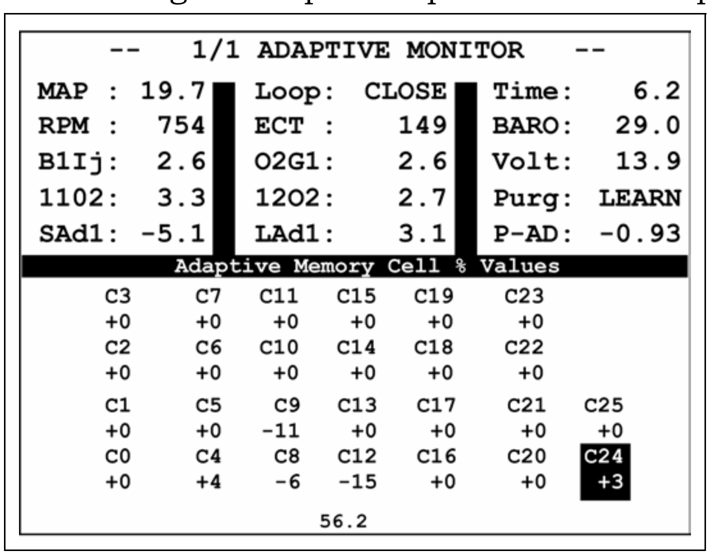



Figure 88 NGC Adaptive Fuel Monitor Screen

## NGC RICH/LEAN FUEL TRIM MONITOR

The Fuel Trim Monitor is a continuous monitor that runs when the fuel system is in Closed Loop. Continuous monitors never actually pass during a trip since the PCM is never "Done/Stop Testing", unless the monitor failed on the previous trip. When the vehicle is turned OFF, a pass is recorded if no malfunction occurred on that trip. The monitor passes or fails based on a combination of Short Term Adaptive and Long Term Adaptive memory values. This combined effect is called Adaptive Memory Factor (this is not currently displayed on the DRB III).

### NGC Monitor Operation

The PCM continuously monitors Short Term and Long Term Adaptive Memory. At any time during engine operation, if total fuel addition exceeds a calibrated threshold for an extended period, the PCM sets a FUEL SYSTEM LEAN fault for that trip and stores Freeze Frame data. If total fuel subtraction exceeds a calibrated threshold for an extended period, the PCM sets a FUEL SYSTEM RICH fault for that trip and stores Freeze Frame data.

NGC controllers do not have to update Purge Free Cells during a rich failure because with NGC, all cells are Purge Free Cells. Also, a loaded EVAP system will not cause a rich fault. The NGC controller will update the Purge Vapor Ratio Adaptive in the Speed Density Equation, instead of changing short term and long term fuel trim adaptives.

The Fuel Trim Monitor is a two-trip monitor. After the first fault, or maturing code, the PCM records Freeze Frame data. After the second fault during the second consecutive trip, the code is matured and the MIL illuminated. The Freeze Frame Data remains stored from the first fault.

As with all DTCs, three good trips are required to extinguish the MIL, and 40 warm-up cycles are required to erase the DTC. If the engine does not run in a Similar Conditions Window, the Task Manager extinguishes the MIL after 80 good trips.

**SCAN TOOL PRETEST SCREEN - NGC**

This screen allows the user to determine when the conditions have been met to run the Fuel Trim Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

```
      -- Fuel Sys 1/1 Pre-Test --
ECT Range    :   126 [  115]    260
LT CLoop Met: 0.50▶[ 0.00]   1.50
--- ENABLING CONDITIONS ---
LeanFailTimr:  0.0 [  0.0]   37.6
LeanLimitTmr:  0.0 [  0.0]   25.2
RichFailTimr:  0.0 [  0.0]   37.6
RichLimitTmr:  0.0 [  0.0]   25.2

                   56.2
```

Figure 89 NGC Fuel Trim Monitor Pretest Screen

The main objective of this and other pre-test screens is to “make the arrows go away”. When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**ECT Range:** Engine coolant temperature value must be within the indicated range, minimum value on left, actual in middle, and max to right.

**LT CLoop Met:** This indicates if the vehicle has reached the window for Long Term Adaptives to take effect. A “1” means the monitor is ready.

**Lean Fail Timr:** This is the amount of time the Adaptive Memory Factor is exceeding the calibrated threshold for the vehicle.

**Lean Limit Tmr:** This is the amount of time the Adaptive Memory Factor is pegged against the maximum threshold for the vehicle (e.g., +33%).

**Rich Fail Timr:** This is the amount of time the Adaptive Memory Factor is exceeding the calibrated threshold for the vehicle.

**Rich Limit Tmr:** This is the amount of time the Adaptive Memory Factor is pegged against the maximum threshold for the vehicle (e.g., -33%).

**SCAN TOOL MONITOR DATA SCREEN - NGC**

This screen indicates the status of the Fuel Trim Lean Monitor.

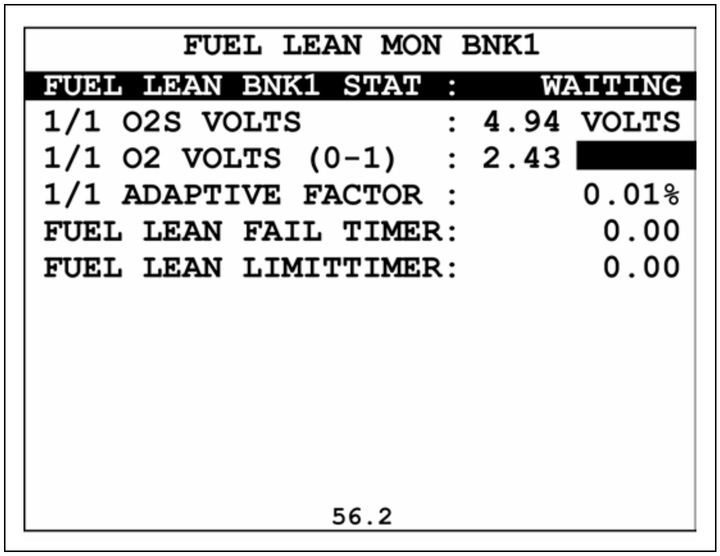



Figure 90  NGC Fuel Trim Lean Monitor Data Screen

**Fuel Lean Bnk1 Stat:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**1/1 O2S Volts:** Actual O2 sensor voltage displayed in 2.5 -3.5 volt scale.

**1/1 O2 Volts (0-1):** Actual O2 sensor voltage displayed in 0-1 volt scale.

**1/1 Adaptive Factor:** Total amount of fuel correction being used. This is the addition of the Long Term and Short Term adaptives.

**Fuel Lean Fail Timr:** This is the amount of time the Adaptive Memory Factor is exceeding the calibrated threshold for the vehicle.

**Fuel Lean Limit Tmr:** This is the amount of time the Adaptive Memory Factor is pegged against the maximum threshold for the vehicle (e.g., +33%).

This screen indicates the status of the Fuel Trim Rich Monitor.

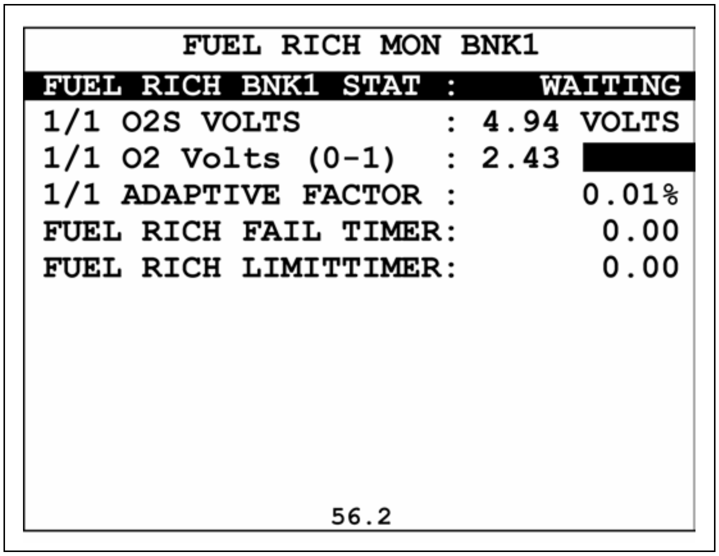



Figure 91 NGC Fuel Trim Rich Monitor Data Screen

**Fuel Rich Bnk1 Stat:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**1/1 O2S Volts:** Actual O2 sensor voltage displayed in 2.5 -3.5 volt scale.

**1/1 O2 Volts (0-1):** Actual O2 sensor voltage displayed in 0-1 volt scale.

**1/1 Adaptive Factor:** Total amount of fuel correction being used. This is the addition of the Long Term and Short Term adaptives.

**Fuel Rich Fail Timr:** This is the amount of time the Adaptive Memory Factor is exceeding the calibrated threshold for the vehicle.

**Fuel Rich Limit Tmr:** This is the amount of time the Adaptive Memory Factor is pegged against the maximum threshold for the vehicle (e.g., -33%).

## SCAN TOOL SIMILAR CONDITIONS WINDOW SCREEN - NGC

The Fuel Trim Monitor is a continuous monitor and must pass in a Similar Conditions Window in order for the PCM to extinguish the MIL. The Similar Conditions Window allows the user to operate the vehicle in the same load and temperature state as it was when the monitor failed. The Similar Conditions Window occurs when engine rpm and MAP vacuum are within a calibrated range of engine rpm and MAP vacuum when the fault occurred. The vehicle must also be in the same warm-up state, with engine temperature above or below a threshold value, as it was when the fault occurred.

As with all DTCs, three good trips are required to extinguish the MIL, and 40 warm up cycles are required to erase the DTC. If the engine does not run in a Similar Conditions Window, the Task Manager extinguishes the MIL after 80 good trips.

With this screen, the user can compare present operating conditions with the operating conditions that occurred at the time of the failure. To re-test the monitor, drive the vehicle until the Similar Conditions Window value changes from “no” to “yes”. Once in the window, maintain a steady load until the PCM reports that it is “done this trip”.

**Note: Certain failures create a Similar Conditions Window that cannot be duplicated after the vehicle is repaired. For example, a lean condition may decrease vacuum to a level that cannot be duplicated after repairs. If this occurs, verify the repair by clearing Long Term Adaptive cells, road test the vehicle under all load conditions, then check Long Term Adaptive cells for excessive fuel correction.**

```
         FUEL LEAN SCW BNK1
FUEL LEAN BNK1 STAT :     WAITING
1/1 ADAPTIVE FACTOR :       0.01%
HIT WINDOW THIS TRIP:          NO
2 MINS FOR GOOD TRIP:  0.00 MINS
LIVE ENGINE RPM     :       0 RPM
SCW ENGINE RPM      :       0 RPM
LIVE ABSOLUTE MAP   :  28.8 inHg
SCW ABSOLUTE MAP    :   0.0 inHg
PASSING TIMER       :   0.00 SEC
GOOD TRIP COUNTER   :           0


               56.2
```

Figure 92  NGC Fuel Trim Lean SCW Screen

**Fuel Lean Bnk1 Stat:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**1/1 Adaptive Factor:** Total amount of fuel correction being used. This is the addition of the Long Term and Short Term adaptives.

**Hit Window This Trip:** Indicates if the vehicle has been driven in the SCW during this key cycle.

**2 Mins For Good Trip:** On NGC vehicles it is necessary to run for 2 minutes without a failure reoccurring.

**Live Engine RPM:** Live reading of actual engine RPM.

**SCW Engine RPM:** Engine RPM at the time of failure.

**Live Absolute MAP:** Live reading of actual engine MAP.

**SCW Absolute MAP:** Engine MAP at the time of failure.

**Passing Timer:** The length of time that the vehicle is running in the SCW.

**Good Trip Counter:** Number of good trips completed to clear this failure.

```
          FUEL RICH SCW BNK1
FUEL RICH BNK1 STAT :      WAITING
1/1 ADAPTIVE FACTOR :        0.01%
HIT WINDOW THIS TRIP:           NO
2 MINS FOR GOOD TRIP:    0.00 MINS
LIVE ENGINE RPM     :        0 RPM
SCW ENGINE RPM      :        0 RPM
LIVE ABSOLUTE MAP   :   28.8 inHg
SCW ABSOLUTE MAP    :    0.0 inHg
PASSING TIMER       :    0.00 SEC
GOOD TRIP COUNTER   :            0


                56.2
```

Figure 93  NGC Fuel Trim Rich SCW Screen

**Fuel Rich Bnk1 Stat:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**1/1 Adaptive Factor:** Total amount of fuel correction being used. This is the addition of the Long Term and Short Term adaptives.

**Hit Window This Trip:** Indicates if the vehicle has been driven in the SCW during this key cycle.

**2 Mins For Good Trip:** On NGC vehicles it is necessary to run for 2 minutes without a failure reoccurring.

**Live Engine RPM:** Live reading of actual engine RPM.

**SCW Engine RPM:** Engine RPM at the time of failure.

**Live Absolute MAP:** Live reading of actual engine MAP.

**SCW Absolute MAP:** Engine MAP at the time of failure.

**Passing Timer:** The length of time that the vehicle is running in the SCW.

**Good Trip Counter:** Number of good trips completed to clear this failure.

## ACTIVITY 13: RICH/LEAN FUEL TRIM MONITOR

Notes: ____________________

### JTEC/SBEC RICH/LEAN FUEL TRIM MONITOR

If total fuel subtraction exceeds a calibrated threshold for an extended period, the PCM recognizes a rich condition. First the PCM updates Purge Free cells, which allows the PCM to see if the rich condition is caused by a saturated charcoal canister. If there is a significant difference between normal Long Term Adaptive cells and Purge Free cells, then canister purge is NOT the cause of the rich condition. If Purge Free cells and normal Long Term Adaptive cells have approximately the same value, then the PCM knows that the problem exists both with and without purge flow. A one-trip failure and Freeze Frame data are generated.

### SCAN TOOL FUEL ADAPTIVE MONITOR SCREEN – JTEC/SBEC

**SBEC**

```
          1/1 ADAPTIVE MONITOR
MAP : 0.00   Loop: OPEN   Time: 13.9
RPM : 0.00   ECT : 95.0   Baro: 29.3
b1Ij: 7.0    O2Gl: 0.00   PF 4: 3.5
11O2: 0.47   12O2: 0.49   PF13: -3.9
SAd1: 0.00   LAd1: 0.00   Purg: 0.00

Adaptive Memory Cell % Values
C1  C3  C5  C7  C9  C11 C13 C15
+4  +5  +4  +4  +4  +4  -4  -4
C0  C2  C4  C6  C8  C10 C12 C14
+9  +4  +4  +4  +4  +4  -4  +0
```

**JTEC**

```
          1/1 ADAPTIVE MONITOR
MAP : 0.00   Loop: OPEN   PF 7: 0.00
RPM : 0.00   ECT : 68.0   PF 4: 0.00
b1Ij: 0.00   O2Gl: 0.33   PF 3: 0.00
11O2: 5.0    12O2: 4.8    PF20: +0.0
SAd1: 0.00   LAd1: 0.00   Purg: 0.00

Adaptive Memory Cell % Values
C2  C5  C8  C11  C14  C17
+0  +0  +0  +0   +0   +1
C1  C4  C7  C10  C13  C16  C19  C21
+0  +0  +0  +0   +0   +0   +0   +0
C0  C3  C6  C9   C12  C15  C18  C20
+0  +1  +1  +0   +0   +1   +1   +0

            Fuel Sys Pre-Test
Bat Tmp Rang: 21 [66] 130

ENABLING CONDITIONS
MAP Range: 7.1 [0.0] 30.0
```

Figure 94 JTEC/SBEC Fuel Adaptive Monitor Screen

**1/1 (2/1) Adaptives:** 1/1 and 2/1 refer to left and right banks, if applicable.

**Note: Some JTEC vehicles have a pre-test screen similar to the pre-test screen of other monitors; however this is only a partial list of enablers.**

## SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
        FUEL SYS LEAN MON BNK1
FUEL SYS LEAN BNK1 DATA    : 80
FUEL LEAN 1 IN PROGRESS    : NO
FUEL LEAN 1 DONE THIS TRIP: NO
FUEL LEAN 1 FAIL THIS TRIP: NO
FUEL LEAN 1 FAIL 1 TRIP    : NO
FUEL LEAN 1 FAIL DTC SET   : NO
FUEL LEAN 1 STOP TESTING   : NO
1/1 O2S GOAL VOLTS         : 0.00 VOLTS
1/1 O2S VOLTS              : 0.47 VOLTS
1/2 O2S VOLTS              : 0.49 VOLTS
1/1 ADAP MEM FACTOR        : 0.0 %
```

**JTEC**

```
          FUEL SYS MON BNK1
FUEL SYSTEM BNK1 DATA        : 00
FUEL SYS BNK1 IN PROGRESS    : NO
FUEL SYS BNK1 DONE THIS TRI: NO
FUEL SYS BNK1 FAIL THIS TRI: NO
FUEL SYS BNK1 STOP TESTING : NO
1/1 O2S VOLTS                : 5.00 VOLT
1/1 SHORT TERM ADAP          : 0.0 %
1/1 LONG TERM ADAP           : 0.0 %
1/1 ADAP MEM FACTOR          : 0.0 %
FUEL SYS STATUS BK1          : OPEN LOOP
CURRENT ADAP CELL ID         : 21
```

Figure 95 JTEC/SBEC Fuel Trim Lean Monitor Data Screen

**Fuel System Lean Monitor:** The PCM is constantly monitoring the total fuel correction being made to the pulse-width. Any time the adaptive memory factor exceeds the programmed value, the PCM declares a 1-trip failure on the first occurrence and sets a DTC on the next consecutive trip if the fault is still evident.

**Fuel System Rich Monitor:** The fuel system rich monitor is conducted the same way as the lean monitor, except purge-free cells must be updated before the PCM can conclude that the fuel system correction is excessive. The PCM updates the purge-free cells in order to eliminate a saturated canister as the cause of a rich failure. To update the purge-free cells, the vehicle must be operated in each purge-free cell.

## SCAN TOOL SCW SCREEN – JTEC/SBEC

**SBEC**

```
        FUEL SYS LEAN SCW BNK1
FUEL LEAN 1 SAME WARMUP    : NO
FUEL LEAN 1 SIM WINDOW     : NO
FUEL LEAN 1 ABSOLUTE MAP   : 0.0 in
ABSOLUTE MAP               : 29.3 in Hg
FUEL LEAN 1 ENGINE RPM:    : 0 RPM
ENGINE RPM                 : 0 RPM
1/1 O2S VOLTS              : 0.47 VOLTS
1/1 ADAP MEM FACTOR        : 0.0 %
FUEL LEAN 1 GOOD TRIP CNTR: 0
FUEL SYS LEAN BNK1 DATA    : 80
FUEL LEAN 1 DONE THIS TRIP: NO
FUEL LEAN 1 FAIL 1 TRIP    : NO
```

**JTEC**

```
           FUEL SYS SCW BNK1
FUEL SYS 1 SIM WINDOW      : NO
FUEL ABSO MAP WHEN FAIL    : 0.0 in Hg
ABSOLUTE MAP               : 29.5 in Hg
FUEL SYS RPM WHEN FAIL     : 0 RPM
ENGINE RPM                 : 0 RPM
1/1 O2S VOLTS              : 5.00 VOLTS
1/1 ADAP MEM FACTOR        : 0.0 %
FUEL SYS 1 GOOD TRIP CNTR: 0
FUEL SYS DATA BNK1         : 00
```

Figure 96 JTEC/SBEC Fuel Trim Monitor SCW Screen

**Fuel Lean 1 Same Warm-up:** There are two warm-up states: above 160°F or below 160°F. The vehicle must be tested in the same warm-up state in which it failed.

**Fuel Lean 1 Good Trip Counter:** If the monitor passes it increments the good trip counter. Three good trips self-extinguish the MIL. Forty warm-up cycles self-erase the DTC and Freeze Frame. If there is a 1-trip failure, and the vehicle cannot be operated in the similar conditions window, 80 warm-up cycles are required to erase the failure and Freeze Frame.

**Note:** **All screens and procedures are the same for fuel system rich as for fuel system lean.**

Notes: ______________________________________________

# MODULE 11 DOWNSTREAM FUEL TRIM MONITOR

## BACKGROUND

A Downstream Fuel Trim Monitor has been added to NGC III controllers. Downstream Fuel Trim is used to shift the upstream $O_2$ sensor Goal Voltage in order to fine tune the air/fuel ratio and the amount of oxygen in the exhaust.

The ideal proportions of gases, especially oxygen, for a new catalyst are different than the ideal proportions for an older catalyst. Downstream Fuel Trim modifies the upstream $O_2$ sensor Goal Voltage to reduce emissions over the life of the catalyst.

## DOWNSTREAM FUEL TRIM

When fuel trim is correct and the catalyst is receiving the correct amount of oxygen for its age and condition, the waveforms for both upstream and downstream $O_2$ sensors are symmetrical. The upper part of the waveform is about the same shape and size as the lower part.

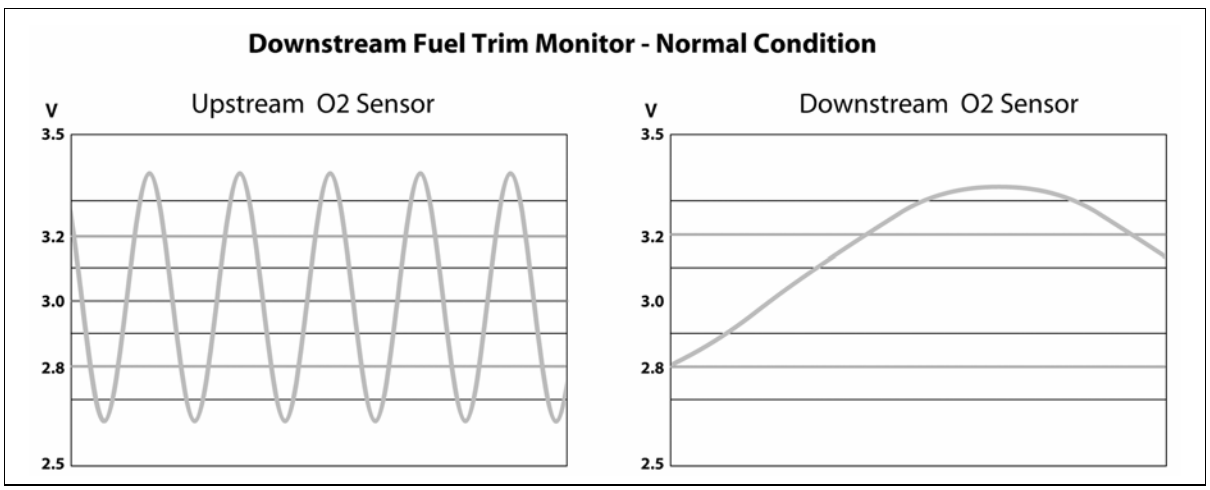



Figure 97 Upstream and Downstream $O_2$ Sensors Switching Normally

When exhaust gases consistently have too little oxygen, the downstream $O_2$ sensor voltage remains high. To compensate, the PCM shifts the upstream $O_2$ sensor goal voltage downward. This reduces injector pulse width and increases the amount of oxygen in the exhaust.

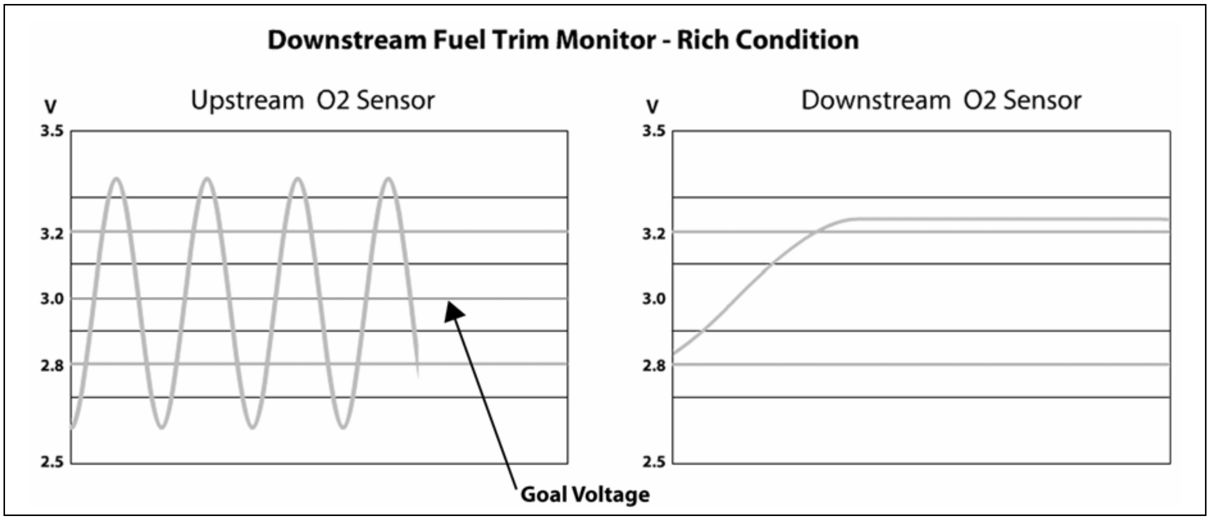



Figure 98 Upstream and Downstream $O_2$ Sensors – Rich Condition (lack of oxygen)

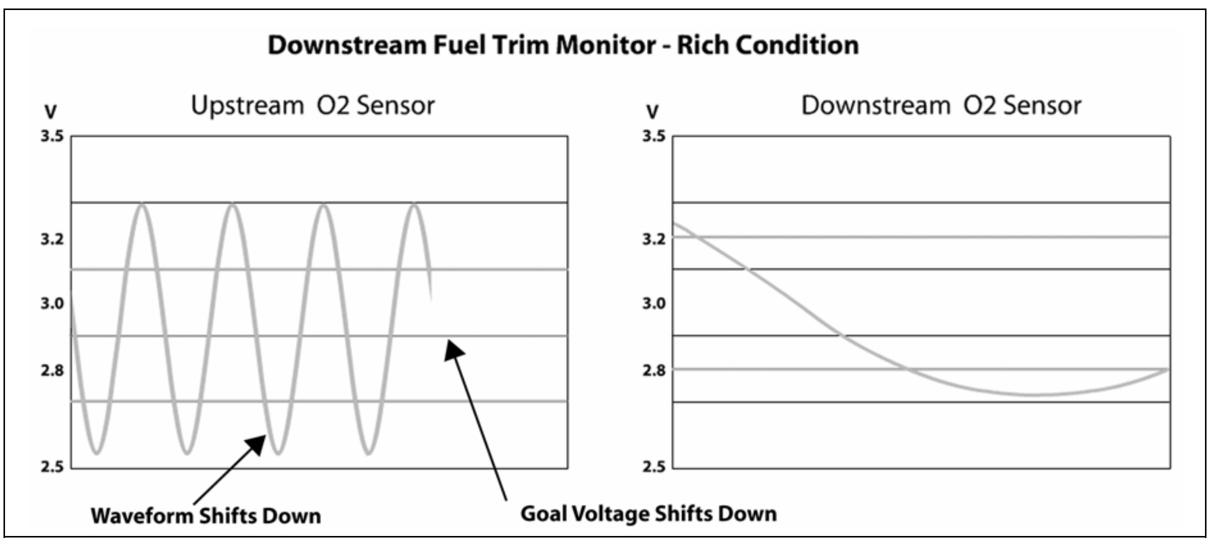



Figure 99 Upstream Goal Voltage Shifts Downward to Increase Oxygen

The opposite is true when exhaust gases consistently have too much oxygen. The downstream $O_2$ sensor voltage remains low. To compensate, the PCM shifts the upstream $O_2$ sensor goal voltage upward. This increases injector pulse width and decreases the amount of oxygen in the exhaust.

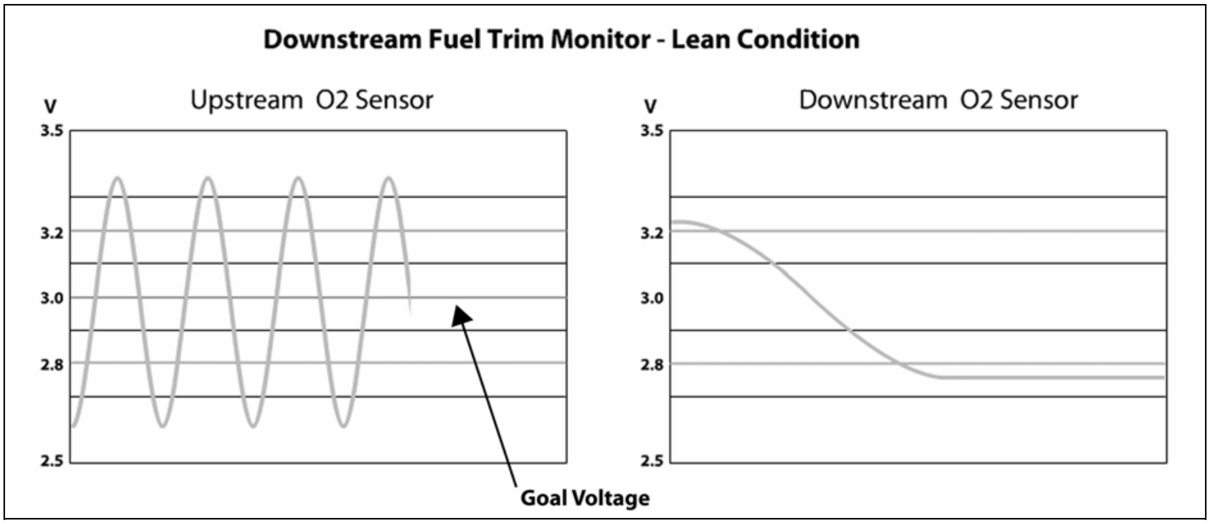



Figure 100 Upstream and Downstream $O_2$ Sensors – Lean Condition (excess oxygen)

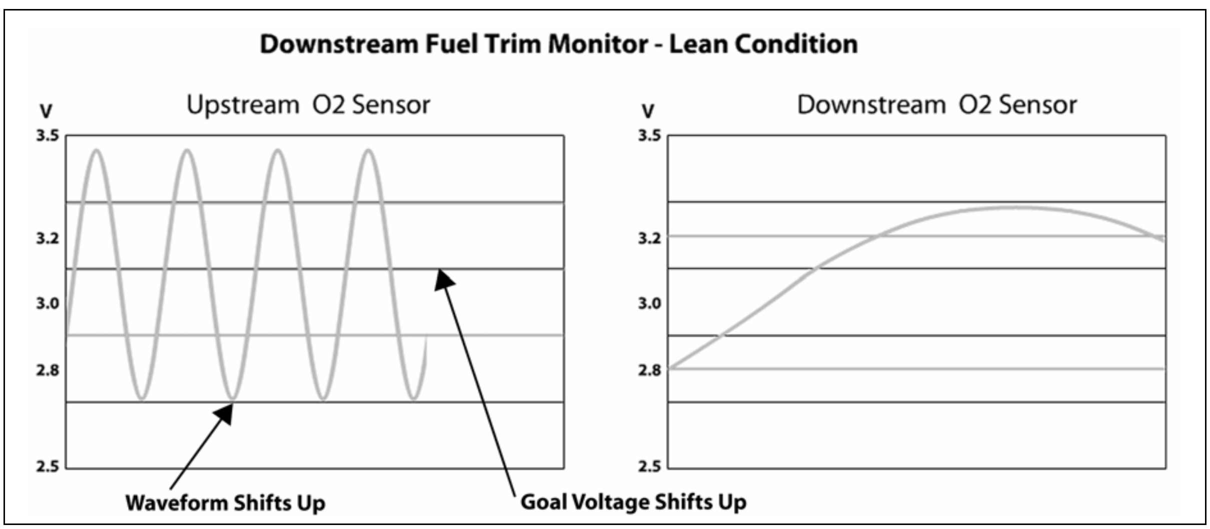



Figure 101 Upstream Goal Voltage Shifts Upward to Decrease Oxygen

**DOWNSTREAM FUEL TRIM MONITOR**

A failed downstream $O_2$ sensor or a condition such as an exhaust leak can drive the upstream $O_2$ sensor goal voltage to an extreme value but not cause a fault to be set. This can increase emissions without any indication to the driver. The Downstream Fuel Trim Monitor was added because it is possible for emissions to fail while all upstream $O_2$ parameters are within an acceptable range. The monitor is intended to identify failures in the downstream $O_2$ sensor that may cause emissions to exceed 1.5 times the FTP standards.

To ensure that the Upstream $O_2$ Sensor Goal Voltage remains within a calibrated range, the downstream $O_2$ sensor signal is monitored. The Downstream Fuel Trim Monitor is enabled in downstream closed loop operation. The Downstream Fuel Trim Monitor is a Continuous Monitor and has two non-intrusive (passive) tests.

During the first test, the PCM watches only the downstream $O_2$ sensor voltage. If the downstream $O_2$ sensor voltage exceeds a threshold, or is at its limit for more than a calibrated time, a failure is set.

During the second test, the PCM watches both the downstream $O_2$ sensor voltage and an adaptive fuel trim value. If the trim value exceeds its limit for more than a calibrated time, a failure is set.

When this material was written, support for DRB III Scan Tool information was not available.

Notes:

Notes:

# MODULE 12 MISFIRE MONITOR

## BACKGROUND

Misfire is the lack of combustion in a cylinder during a power stroke. When misfire occurs, raw, unburned fuel and excess oxygen enter the exhaust stream. Two things happen that adversely affect emissions. First, the unburned fuel (hydrocarbons) in the exhaust continues to burn in the catalytic converter. This elevates catalytic converter temperatures and increases tailpipe HC emissions. Second, the oxygen sensors detect increased oxygen levels and the PCM incorrectly assumes that this is due to a lean mixture condition. The PCM increases fuel injector pulse width and more raw fuel enters the exhaust. Prolonged misfire may overheat the catalytic converter and cause permanent damage.

OBD II rules require that the vehicle diagnostic system monitors engine misfire and identifies specific cylinders with misfire. A separate DTC must be stored if multiple cylinders misfire. When multiple cylinders misfire, identifying specific misfiring cylinders is optional.

## CKP SENSOR

Misfire is not directly sensed in the engine, but is indirectly detected by monitoring crankshaft acceleration. Each power stroke causes the crankshaft to accelerate. In an eight-cylinder engine, a power stroke occurs and the crankshaft receives a kick every 90° of rotation. Between power strokes, the crankshaft coasts and slows down. When a cylinder misfires, the crankshaft slows down more than normal. The Crankshaft Position Sensor (CKP) signal is monitored to detect this deviation.

## ADAPTIVE NUMERATOR

To accurately detect misfire, the Misfire Monitor needs to take into account variations due to component wear, machining tolerances and sensor fatigue. The PCM compares the CKP signal for the crankshaft in the vehicle with ideal data and determines a variance value, or "Adaptive Numerator". The Adaptive Numerator is also called the Target Linear Compensation or Target Learning Coefficient.

The Adaptive Numerator is learned during fuel-cutoff deceleration, when there are no power strokes to affect crankshaft speed of rotation. To calculate the variance, the PCM uses the first group of crank signal slots as a reference. The PCM then compares the position of the second group of slots against the stored ideal data and calculates the difference or variance. This value is the Adaptive Numerator.

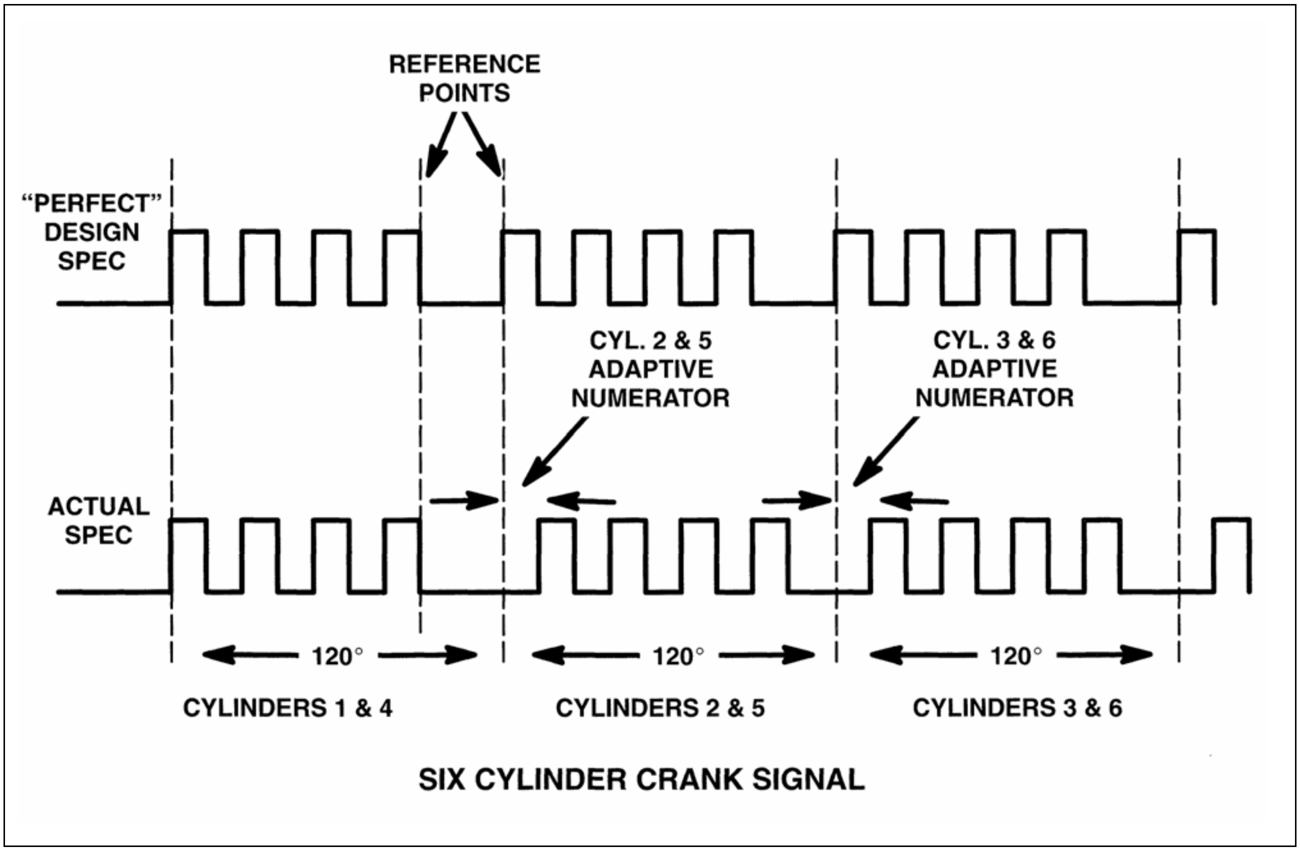



Figure 102 Adaptive Numerator

The PCM updates the Adaptive Numerator at every key-ON, and is relearned after battery disconnect. The Misfire Monitor will not run until the Adaptive Numerator has updated since the last battery disconnect. If the Adaptive Numerator is equal to the default value then the PCM knows that the Adaptive Numerator has not been learned and does not permit the Misfire Monitor to run. On NGC, if the Adaptive Numerator exceeds a calibrated percentage, the PCM sets a DTC for CKP NOT LEARNED and illuminates the MIL. Previously, this DTC was MISFIRE ADAPTIVE NUMERATOR AT LIMIT failure.

**Note: Normal engine operation is necessary for proper PCM update. If misfire is present when a PCM is replaced or when battery power is reconnected, the PCM will consider the misfire normal.**

The PCM also checks the machining tolerances for the CKP sensor slots. The PCM calculates engine rpm by monitoring crankshaft speed from the first slot to the last slot in a group. Variance between groups of slots is called RPM Error. RPM Error must be less than approximately 5% for the Misfire Monitor to run.

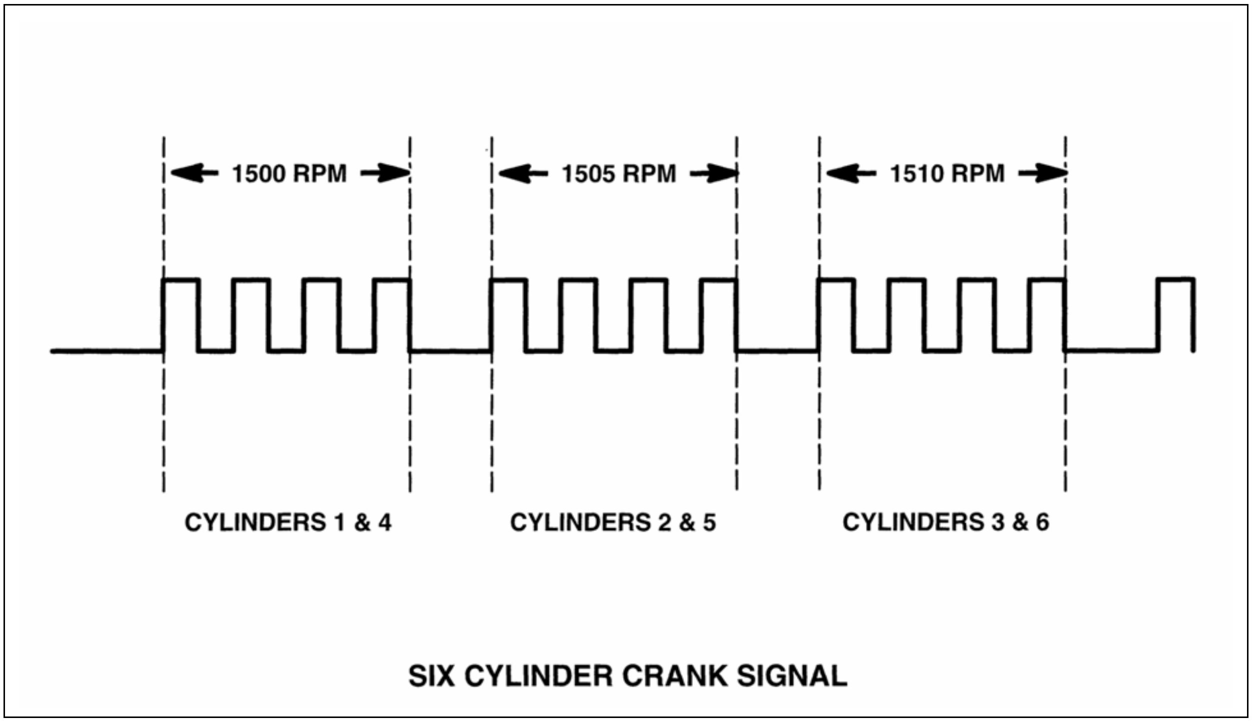



Figure 103 RPM Error

**NGC MISFIRE MONITOR**

The NGC Misfire Monitor is a continuous two-trip monitor. The monitor uses two different tests/counters:

- 200 Revolution Counter - Looks for misfire that can cause immediate catalyst damage.
- 1000 Revolution Counter - Looks for misfire that can cause emissions to increase 1.5 times the Federal Test Procedure (FTP) standards. This test must also identify misfire percentages that might cause a "durability demonstration vehicle" to fail an Inspection and Maintenance Program tailpipe emissions test.

**Note: The percentage of misfire for failure in each test is calibrated by the manufacturer. The percentage of misfire for failure varies with engine speed and load. As engine speed increases or load decreases, the effects of misfire decrease due to crankshaft momentum.**

**200 Rev Counter - NGC**

Once the enabling conditions are met, the Misfire Monitor is enabled and the PCM counts the number of misfires during every 200 revolutions of the crankshaft. If during five 200 rev counters, the misfire percentage exceeds a calibrated value, a Maturing Code is set and a Freeze Frame is entered. Freeze Frame Data is recorded during the last 200 revolutions of the 1000 rev period. A failure on the second consecutive trip matures the code and a DTC is set.

The percentage of misfire to set a fault varies with rpm and load. As engine speed increases and load decreases, crankshaft inertia reduces the effects of misfire. The values also vary with different engine packages.

If misfire continues during the initial trip, the MIL is not illuminated. However, when the percentage of misfire exceeds the malfunction percentage in any 200 revolution period that would cause permanent catalyst damage, the MIL will flash, a DTC and Freeze Frame Data are stored. The engine defaults to open loop operation to prevent increased fuel flow to the cylinders. If misfire drops below the calibrated percentage, the MIL stops flashing but remains illuminated.

If the engine is under 3000 rpm, failure in a group of three 200 revolution blocks is required to set a one-trip failure. If the engine is over 3000 rpm, one failure in one 200 revolution block will set a one-trip failure. A second consecutive trip with misfire is required to set a DTC. When the DTC will set depends on rpm, so it is possible to have a flashing MIL without a DTC set.

**1000 Rev Counter - NGC**

The 1000 revolution counter for FTP failure is a two-trip monitor. Freeze Frame Data is stored after the first occurrence of the fault. Every 1000 revolution counter contains five 200 revolution counters. The PCM counts misfires for each 200 revolution counter and carries the value over to the 1000 revolution counter. The 1000 revolution counter increments a count of one for each 200 revolution period where the misfire percentage exceeds the threshold for a FTP or I/M failure. Beginning with all 2004 NGC III controllers, the 200 rev counter does not count up, it counts down to zero.

A misfire that is present upon start-up will set a one-trip failure after one set of 1000 revolutions. A misfire that occurs after the engine has run at least 1000 revolutions without misfire requires four blocks of 1000 revolutions to set a one-trip failure. The DTC will set after misfire is detected during two-consecutive trips. On the second trip it will only take one block of 1000 revolutions to set a misfire DTC, whether the misfire was present on start-up or not.

Number of Misfire Events

| 200 REVS | 400 REVS | 600 REVS | 800 REVS | 1000 REVS | |
|---|---|---|---|---|---|
| 5 | 0 | 10 | 10 | 5 | 200 REV COUNTERS |
| 5 | 5 | 15 | 25 | 30 | 1000 REV COUNTERS |

Figure 104  Misfire Events and Counters

**600 and 4000 Rev Counters**

Starting with 1999 models, if catalyst-damaging misfire does not occur in the first 200 revolutions, but does occur after the first 200 revolutions, then the 600 revolution counter detects the misfire.  This new counter counts from 0 to 3 (3 x 200) to equal 600 revolutions.

**DIAGNOSTICS**

When misfire occurs, these DTCs may be stored:  P0300  MULTIPLE CYLINDER MISFIRE, or P030#  CYLINDER # MISFIRE.

Misfire may occur and may not be caused by component failure.  Be sure to eliminate these possible causes:

- Moisture on ignition system components
- Insufficient fuel
- Low quality fuel
- Manual transmission bog
- Towing overload

**SCAN TOOL PRETEST SCREEN - NGC**

This screen allows the user to determine when the conditions have been met to run the Misfire Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

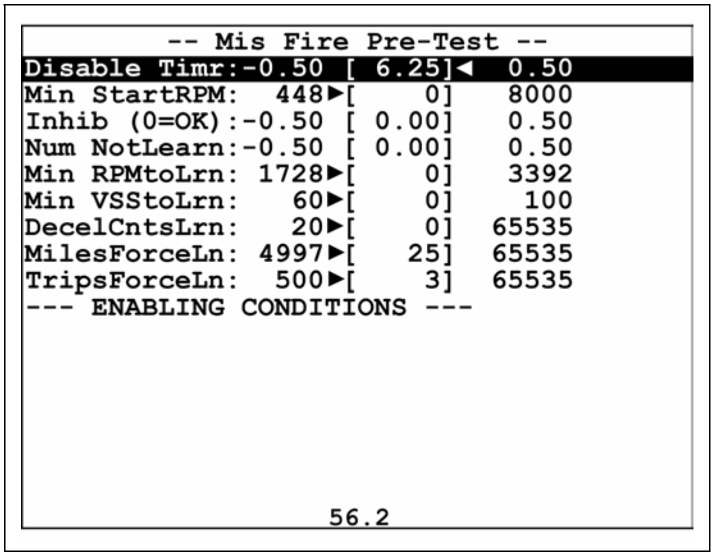



Figure 105 NGC Misfire Monitor Pretest Screen

The main objective of this and other pre-test screens is to “make the arrows go away”. When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**Disable Time:** This represents the amount of time, in seconds, that the Misfire Monitor will be disabled after a start up.

**Min Start RPM:** The minimum amount of engine RPM required before the PCM will begin to monitor for misfires.

**Inhib (0=OK):** If the Misfire Monitor is disabled for any reason, this bit will be equal to something other than 0.

**Num Not Learn:** This 0 or 1 value represents the state of the Adaptive Numerator learned bit. A 0 in this case represents the Numerator being learned.

**Min RPM To Lrn:** The required Engine RPM for the PCM to go into the necessary Full Fuel Shut Off Decel to learn the Adaptive Numerator.

**Min VSS To Lrn:** The required VSS for the PCM to go into the necessary Full Fuel Shut Off Decel to learn the Adaptive Numerator.

**Decel Cnts Lrn:** Number of Full Fuel Shutoff decal counts required before the PCM will begin to count misfires.

**Miles Force Lrn:** If the vehicle has traveled more than the specified mileage, the PCM will attempt to relearn the Adaptive Numerator. The PCM will widen the specified ranges normally necessary to learn the Adaptive Numerator. This method insures the PCM will go no more than the specified mileage without updating the Adaptive Numerator.

**Trips Force Lrn:** If the vehicle has had the minimum number of starts (stable run time), the PCM will attempt to relearn the Adaptive Numerator. The PCM will widen the specified ranges normally necessary to learn the Adaptive Numerator. This method insures the PCM will go no more than the specified number of trips without updating the Adaptive Numerator.

## SCAN TOOL MONITOR DATA SCREEN - NGC

To confirm that the Adaptive Numerator is learned, view the 200/1000 rev screen. This screen indicates the status of the Misfire Monitor.

```
       MIS FIRE MON 200/1000
MISFIRE MON STATUS   :    WAITING
MISFIRE DISABLED     :       NONE
ADAP NUMERATOR       :    LEARNED
200 REV COUNTER      :          2
1000 REV COUNTER     :          0
MIS-FIRE 200 REV CTR:           0
MIS-FIRE 1000REV CTR:           0
MIS-FIRE 600 REV CTR:           0
MIS-FIRE 4000REV CTR:           0



              56.2
```

Figure 106 NGC Misfire Monitor Data Screen

**Misfire Mon Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Misfire Disabled:** The data displayed here tells what may be preventing the Misfire Monitor from running. Examples are Adap Num, Torque.

**Adap Numerator:** Tells the state of the Adaptive Numerator, learned or not learned

**200 Rev Counter:** Once the Adaptive Numerator is learned, this counter will begin counting the number of crankshaft revolutions. It will reset to 0 every 200 revs.

**1000 Rev Counter:** This counter represents the number of 200 Rev counters that have gone by. This counter will display 0-3 for the number of 1000 rev counters completed

**Mis-Fire 200 Rev Counter:** Number of misfires being counted in 200 revolutions.

**Mis-Fire 1000 Rev Counter:** Number of misfires being counted in 1000 revolutions.

**Mis-Fire 600 Rev Counter:** Number of misfires being counted in 600 revolutions.

**Mis-Fire 4000 Rev Counter:** Number of misfires being counted in 4000 revolutions.

**SCAN TOOL SIMILAR CONDITIONS WINDOW SCREEN - NGC**

The Misfire Monitor is a continuous monitor and must pass in a Similar Conditions Window in order for the PCM to extinguish the MIL. The Similar Conditions Window allows the user to operate the vehicle in the same load and temperature state as it was when the monitor failed. The Similar Conditions Window occurs when engine rpm and MAP vacuum are within a calibrated range of engine rpm and MAP vacuum when the fault occurred. The vehicle must also be in the same warm-up state, with engine temperature above or below a threshold value, as it was when the fault occurred.

As with all DTCs, three good trips are required to extinguish the MIL, and 40 warm up cycles are required to erase the DTC. If the engine does not run in a Similar Conditions Window, the Task Manager extinguishes the MIL after 80 good trips.

With this screen, the user can compare present operating conditions with the operating conditions that occurred at the time of the failure. To re-test the monitor, drive the vehicle until the Similar Conditions Window value changes from “no” to “yes”. Once in the window, maintain a steady load until the PCM reports that it is “done this trip” or increments a Good Trip.

**Note: Some failures create a Similar Conditions Window that cannot be duplicated after the vehicle is repaired. For example, a misfire condition may drop manifold vacuum to a value that cannot be achieved once the vehicle is repaired. When this occurs, use the live “Which Cylinder is Misfiring” screen while operating the vehicle under all load conditions.**

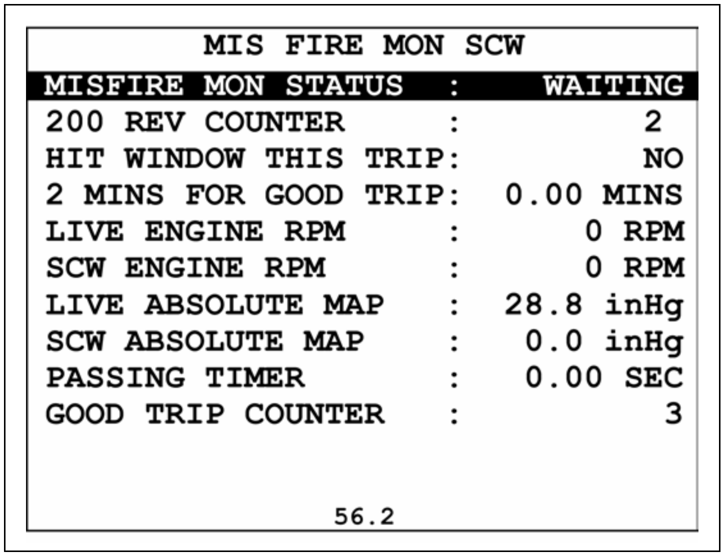



Figure 107 NGC Misfire SCW Screen

**Misfire Mon Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**200 Rev Counter:** Once the Adaptive Numerator is learned, this counter will begin counting the number of crankshaft revolutions. It will reset to 0 every 200 revs.

**Hit Window This Trip:** Indicates if the vehicle has been driven in the SCW during this key cycle.

**2 Mins For Good Trip:** On NGC vehicles it is necessary to run for 2 minutes with out a failure reoccurring.

**Live Engine RPM:** Live reading of actual engine RPM

**SCW Engine RPM:** Engine RPM at the time of failure

**Live Absolute MAP:** Live reading of actual engine MAP

**SCW Absolute MAP:** Engine MAP at the time of failure

**Passing Timer:** The length of time that the vehicle is running in the SCW.

**Good Trip Counter:** Number of good trips completed to clear this failure.

## ACTIVITY 14: MISFIRE MONITOR

Notes:

### 200 Rev Counter – JTEC/SBEC

On 1999 and earlier SBEC and JTEC vehicles, misfire is a one-trip monitor. The first occurrence of the fault based on a 200 revolution counter will set a MIL-illuminating DTC.

In later vehicles, misfire is a two-trip monitor. Two consecutive occurrences of a failure based on a 600 revolution counter are required to set a MIL-illuminating DTC. The 600 revolution counter records three cycles of the 200 revolution counter.

### 1000 Rev Counter – JTEC/SBEC

FTP misfire detection on SBEC and JTEC vehicles may be based on the 1000 revolution counter or the 4000 revolution counter. The 1000 revolution test requires information from five cycles of the 200 revolution counter. On vehicles using the 4000 revolution counter, this counter is supplied four cycles of the 1000 revolution counter.

### SCAN TOOL PRETEST SCREEN – JTEC/SBEC

**SBEC**

```
       MIS-FIRE MON PRE-TEST
MIS-FIRE EPP DISABLED 0=OK: 0
MIS-FIRE DISABLED     0=OK: 0
ADAP NUMERATOR LEARNED    : YES
MIS-FIRE DETECTION ENABLED: YES
200  REV CNTR(Counting=OK): 0
ADAP NUM CYL 2&5 (2625)   : 2624
ADAP NUM CYL 2&5 (A000)   : 0703
AVG RPM ERROR CYL 2&5     : -0.01
ADAP NUM CYL 3&6 (2625)   : 261A
ADAP NUM CYL 3&6 (A000)   : 4177
AVG RPM ERROR CYL 3&6     : -0.01
```

**JTEC**

```
       MIS-FIRE MON PRE-TEST
MIS-FIRE DISABLED 0=OK     : 0
ADAP NUMERATOR LEARNED     : NO
REVS TO LEARN ADAPNUMERATR: 32
AVERAGE RPM ERROR TOO LARG: Y
200  REV CNTR(Counting=OK): 0
LO ADP NUM. CYL 2&3(1C9C) : 1C9C
LO ADP NUM. CYL 2&3(3800) : 3800
HI ADP NUM. CYL 2&3(3938) : 3938
HI ADP NUM. CYL 2&3(7000) : 7000
AVERAGE RPM ERROR CYL 2&3 : +0.00
LO ADP NUM. CYL 4&7(1C9C) : 1C9C
LO ADP NUM. CYL 4&7(3800) : 3800
HI ADP NUM. CYL 4&7(3938) : 3938
HI ADP NUM. CYL 4&7(7000) : 7000
LO ADP NUM. CYL 5&8(1C9C) : 1C9C
LO ADP NUM. CYL 5&8(3800) : 3800
HI ADP NUM. CYL 5&8(3938) : 3938
HI ADP NUM. CYL 5&8(7000) : 7000
AVERAGE RPM ERROR CYL 5&8 : +0.00
AVERAGE RPM ERROR CYL 4&7 : +0.00
```

Figure 108 JTEC/SBEC Misfire Monitor Pretest Screen

- **Misfire EPP Disabled:** The PCM counts down from a predetermined number of engine position pulses on start up, to allow the engine to stabilize prior to performing misfire detection.
- **Misfire Disabled:** Any number other than zero indicates something is disabling misfire detection.

**200 Rev Counter:** The 200 rev counter begins incrementing when the PCM is performing misfire detection.

### SCAN TOOL MONITOR DATA SCREEN – JTEC/SBEC

**SBEC**

```
         MIS-FIRE MON 200/1000
MIS-FIRE EPP DISABLED 0=OK: 0
MIS-FIRE DISABLED     0=OK: 0
200  REV CNTR(Counting=OK): 0
1000 REV CNTR(Counting=OK): 0
MIS-FIRE CNTR CAT  200 REV: 0
MIS-FIRE CNTR CAT  600 REV: 0
MIS-FIRE CNTR FTP 1000 REV: 0
MIS-FIRE CNTR FTP 4000 REV: 0
ENGINE RPM                : 0 RPM
MIS-FIRE MON DATA         : 80
MIS-FIRE MON FAIL 1 TRIP  : NO
MIS-FIRE MON FAIL DTC SET : NO
```

**JTEC**

```
         MIS-FIRE MON 200/1000
MIS-FIRE DISABLED 0=OK      : 0
AVERAGE RPM ERROR TOO LARG : Y
200  REV CNTR(Counting=OK)  : 0 1000
REV CNTR(Counting=OK)       : 0
MIS-FIRE CNTR CAT  200 REV : 0
MIS-FIRE CNTR CAT  600 REV : 0
MIS-FIRE CNTR FTP 1000 REV : 0
MIS-FIRE CNTR FTP 4000 REV : 0
ENGINE RPM                  : 0 RPM
MIS-FIRE MON DATA           : 00
MIS-FIRE MON FAIL THIS TRIP: NO
```

Figure 109  JTEC/SBEC Misfire Monitor Data Screen

- **Catalyst Damaging Misfire:** This value is based on the percentage of misfire within three 200 revolution counts. When a misfire percentage exceeds a predetermined value, a 1-trip failure is declared, unless the percentage of misfire is above a predetermined threshold within the first 200 revolutions. The MIL flashes while the misfire is severe enough to cause imminent catalyst damage.
- **FTP or I/M Misfire:** This value is based on the percentage of misfire within four counts of 1000 revolutions. When the percentage of misfire exceeds a predetermined value and causes an emissions increase, based on either FTP or I/M (smog test no longer used), the PCM increments a 1-trip failure.
- **Misfire Counter Cat 200 Rev:** This line indicates the PCM is counting misfires within a 200 rpm block.
- **Misfire Counter Cat 600 Rev (Cat Damage):** Misfires are counted in 200 rpm blocks. The 600 revolution counter increments a count of one for each 200 revolution period where misfire percentage exceeds the threshold for a catalyst damaging misfire.
- **Misfire Counter FTP 1000 Rev (FTP Emissions):** Misfires are counted in 200 rpm blocks. The 1000 revolution counter increments a count of one for each 200 revolution period where misfire percentage exceeds the threshold for a FTP or I/M failure.
- **Misfire Counter FTP 4000 Rev (FTP Emissions):** Due to a change in the EPA standards, all '98 and newer vehicles count FTP misfires based on a percentage of misfire within 4000 revolutions. Each time the percentage of misfire based on 1000 revolutions exceeds the threshold, the 1000 revolution counter increments a count of one. When it counts to four, a 1-trip failure is recorded.

**Average RPM Error Too Large:** This is determined by comparing the high adaptive numerator specification to the low adaptive numerator specification.

## SCAN TOOL SIMILAR CONDITIONS WINDOW SCREEN – JTEC/SBEC

**SBEC**

```
          MIS-FIRE MON SCW
MIS-FIRE SAME WARMUP STATE: NO
MIS-FIRE IN SIM WINDOW    : NO
MIS-FIRE ABSOLUTE MAP     : 7.9 in Hg
ABSOLUTE MAP              : 29.3 in Hg
MIS-FIRE ENGINE RPM       : 1440 RPM
ENGINE RPM                : 0 RPM
200  REV CNTR(Counting=OK): 0
SCW CAT  200 REV CNTR     : 0
MIS-FIRE GOOD TRIP CNTR   : 0
MIS-FIRE MON DATA         : 80
```

**JTEC**

```
          MIS-FIRE MON SCW
MIS-FIRE IN SIM WINDOW     : NO
MIS-FIRE ABSOLUTE MAP      : 0.0 in Hg
ABSOLUTE MAP               : 29.5 in Hg
MIS-FIRE ENGINE RPM        : 0 RPM
ENGINE RPM                 : 0 RPM
200  REV CNTR(Counting=OK) : 0
SCW FTP 1000 REV COUNTER   : 0
MIS-FIRE GOOD TRIP CNTR    : 0
MIS-FIRE MON DATA          : 00
```

Figure 110  JTEC/SBEC Misfire SCW Screen

**Misfire Same Warm-up State:** There are two warm-up states, above 160°F or below 160°F. You must be in the same warm-up state as the failed trip to enter the similar conditions window.

**200 Rev Counter:** The counter increments if the PCM is performing misfire detection.

**SCW Cat 200 Rev Counter:** The counter increments if the PCM is detecting catalyst damaging misfire while in the similar conditions window.

**SCW FTP 1000 Rev Counter:** The counter increments if the PCM is detecting an emissions (FTP) misfire while in the similar conditions window.

**Misfire Good Trip Counter:** If the monitor passes, it increments the good trip counter. Three good trips extinguish the MIL, and 40 warm-up cycles erase the DTC and Freeze Frame.

## SCAN TOOL WHICH CYLINDER IS MISFIRING SCREEN – JTEC/SBEC

**SBEC**

```
      WHICH CYL IS MIS-FIRING
CYL 1 MIS-FIRE 200 REVS: 0
CYL 2 MIS-FIRE 200 REVS: 0
CYL 3 MIS-FIRE 200 REVS: 0
CYL 4 MIS-FIRE 200 REVS: 0
CYL 5 MIS-FIRE 200 REVS: 0
CYL 6 MIS-FIRE 200 REVS: 0
```

**JTEC**

```
     WHICH CYL IS MIS-FIRING-8 CYL
CYL 1 MIS-FIRE COUNTER: 0
CYL 8 MIS FIRE COUNTER: 0
CYL 4 MIS FIRE COUNTER: 0
CYL 3 MIS FIRE COUNTER: 0
CYL 6 MIS FIRE COUNTER: 0
CYL 5 MIS FIRE COUNTER: 0
CYL 7 MIS FIRE COUNTER: 0
CYL 2 MIS-FIRE COUNTER: 0
```

Figure 111  JTEC/SBEC Which Cylinder is Misfiring Screen

## SCAN TOOL LAST RESULT SCREEN – JTEC/SBEC

**SBEC**

```
        MIS-FIRE MON LAST RESULT
RUNTIME AT MIS-FIRE         : 0.00 MINs
RATE WHICH CAUSED MIS-FIRE: 0
MIS-FIRE ABSOLUTE MAP       : 7.9 in Hg
MIS-FIRE ENGINE RPM         : 1440 RPM
DTC TYPE - CAT MIS-FIRE     : NO
DTC TYPE - FTP MIS-FIRE     : NO
DTC TYPE - I/M MIS-FIRE     : NO
FAULT TYPE - 1 TRIP CAT MF: NO
FAULT TYPE - 1 TRIP FTP MF: NO
FAULT TYPE - 1 TRIP I/M MF: NO
```

**JTEC**

```
        MIS FIRE MON LAST RESULT
DTC TYPE - CAT DAMAGE MF   : NO
DTC TYPE - FTP MIS-FIRE    : NO
DTC TYPE - I/M MIS-FIRE    : NO
FAULT TYPE - 1 TRIP CAT MF: NO
FAULT TYPE - 1 TRIP FTP MF: NO
FAULT TYPE - 1 TRIP I/M MF: NO
```

Figure 112  JTEC/SBEC Last Result Screen

Notes:

# MODULE 13 EGR MONITOR

## BACKGROUND

The Exhaust Gas Recirculation (EGR) system controls the amount of exhaust gases that are fed back into the engine cylinders during the intake stroke.

When combustion temperatures in the cylinder exceed approx. 2500°F (1371°C), large quantities of Oxides of Nitrogen (NOx) are formed. Recycling some inert exhaust gases back into the intake air/fuel mixture can lower combustion temperatures and reduce the quantity of NOx formed. The EGR system does this by diluting the incoming mixture and displacing a portion of burnable mixture with inert gas. EGR also improves fuel economy, since less air and fuel enter the cylinders on each stroke, and it reduces engine knocking.

OBD II regulations require vehicles with EGR to monitor the EGR system for flow rate. A malfunction must be indicated when:

- Any component in the system fails to perform within specifications
- EGR flow rate is above or below the manufacturer's high and low limits that might cause emissions to increase more than 1.5 times the FTP standard.

An EGR valve stuck closed prevents the flow of exhaust gases. This can increase NOx emissions, engine knocking, and fuel consumption. An EGR valve stuck open can increase HC emissions and fuel consumption, and can cause rough engine operation.

Diagnostics must illuminate the MIL after two failures are detected on two consecutive trips.

**Linear EGR Systems**

NGC vehicles with EGR use Linear EGR Valves. In Linear EGR systems, EGR valve opening is controlled by a pulse-width-modulated solenoid built into the EGR Valve. The EGR Valve opens when the PCM energizes this solenoid.

A position sensor potentiometer is built into the EGR Valve. This sensor sends a signal to the PCM for EGR Valve opening. Since the amount of exhaust gases in the intake affect the quantity of fuel that the engine requires, the EGR Position Sensor signal is used by the PCM to adjust fuel injection quantity in the Speed Density Equation.

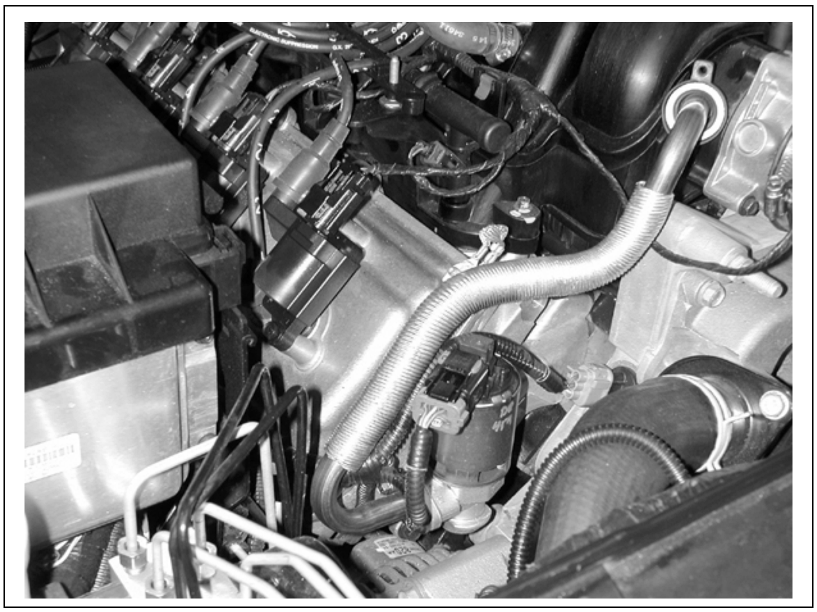
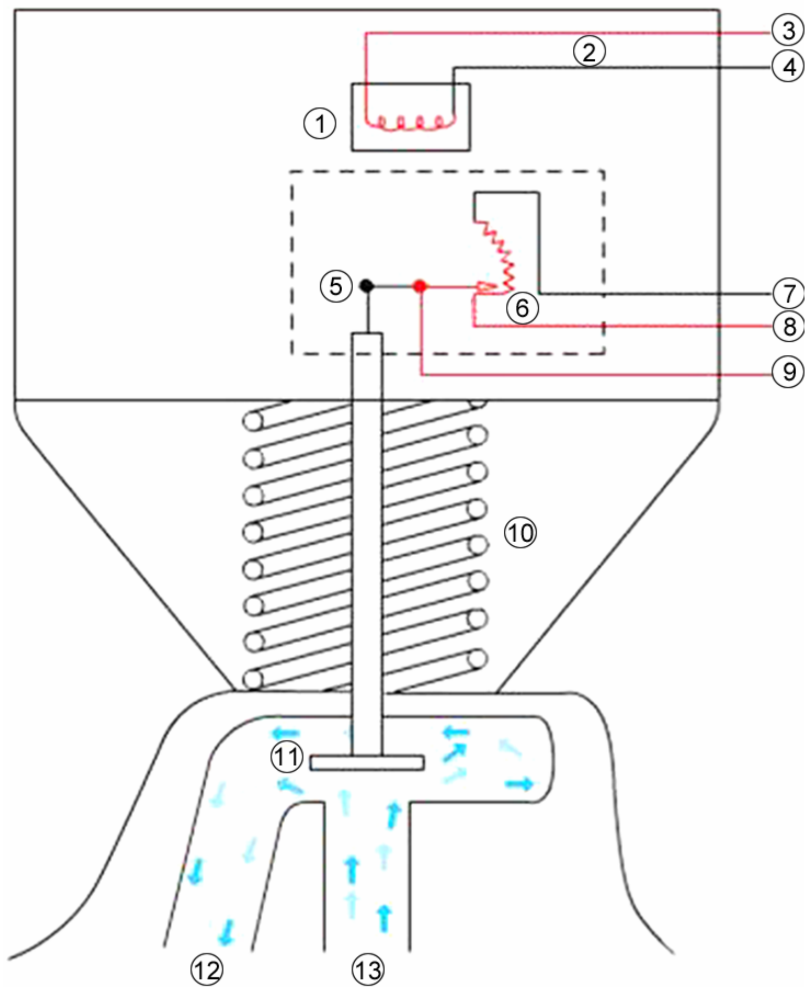


Figure 113 Typical Linear EGR Valve




| | | | |
|---|---|---|---|
| 1 | Solenoid | 8 | 5 Volt Power |
| 2 | Solenoid Circuit | 9 | Sense Circuit |
| 3 | PCM Control Power | 10 | Spring |
| 4 | PCM Control Ground | 11 | Valve |
| 5 | Pintle | 12 | To Intake Manifold |
| 6 | Potentiometer Circuit | 13 | From Exhaust Manifold |
| 7 | Ground | | |

Figure 114 Linear EGR Valve Components

**Back Pressure EGR Systems**

JTEC vehicles with EGR may use Linear EGR or Back Pressure EGR systems. Unlike Linear EGR, flow rate is not PCM controlled in Back Pressure EGR systems.

Figure 115 Typical Back Pressure Transducer EGR Valve

Back Pressure EGR systems have a vacuum transducer that modifies the vacuum signal to the EGR valve to control how much the valve opens.

The vacuum transducer responds to changes in exhaust back pressure. When the engine is under load and exhaust back pressure is high, exhaust pressure pushes the transducer diaphragm upwards, closing a vacuum bleed. This allows full engine vacuum to the EGR valve and the valve opens fully.

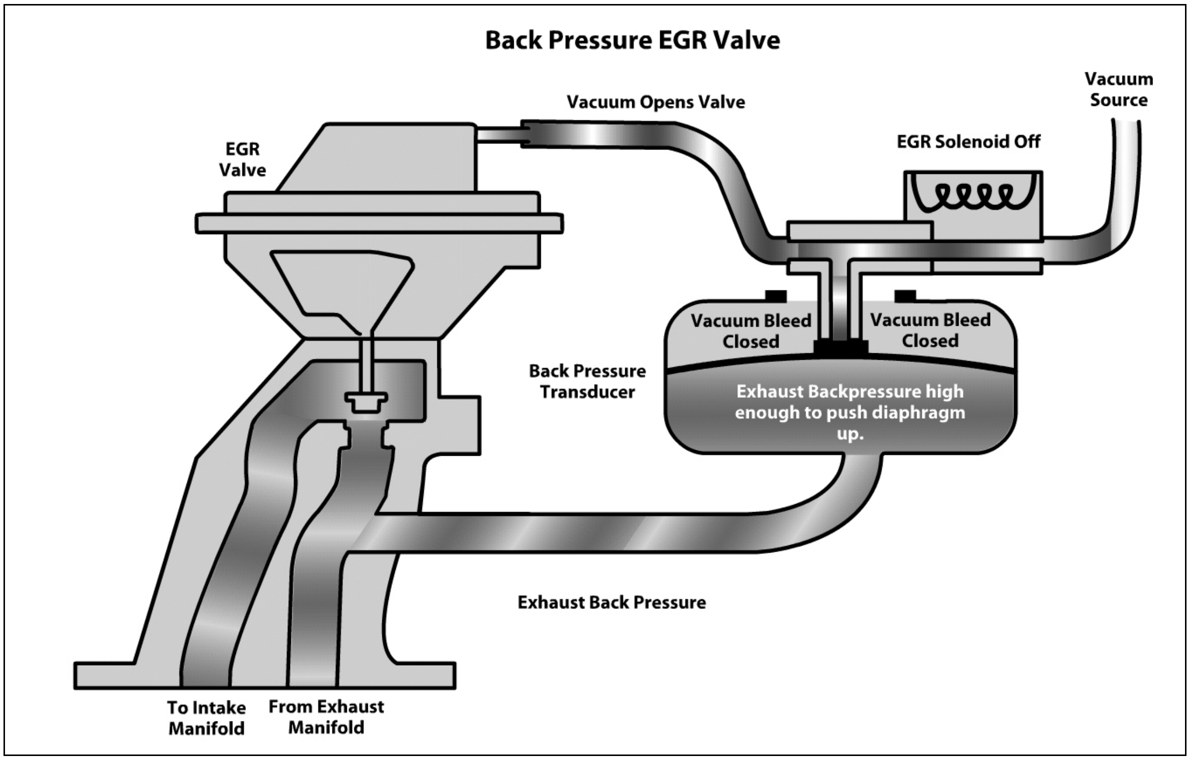



Figure 116 Back Pressure EGR Valve – High Back Pressure

Reduced exhaust back pressure does not push the diaphragm up as far, and some vacuum bleeds. This reduces vacuum to the EGR valve and reduces EGR valve opening.

Very low exhaust back pressure allows the diaphragm to drop and bleeds all vacuum from the line. The EGR valve then does not open.

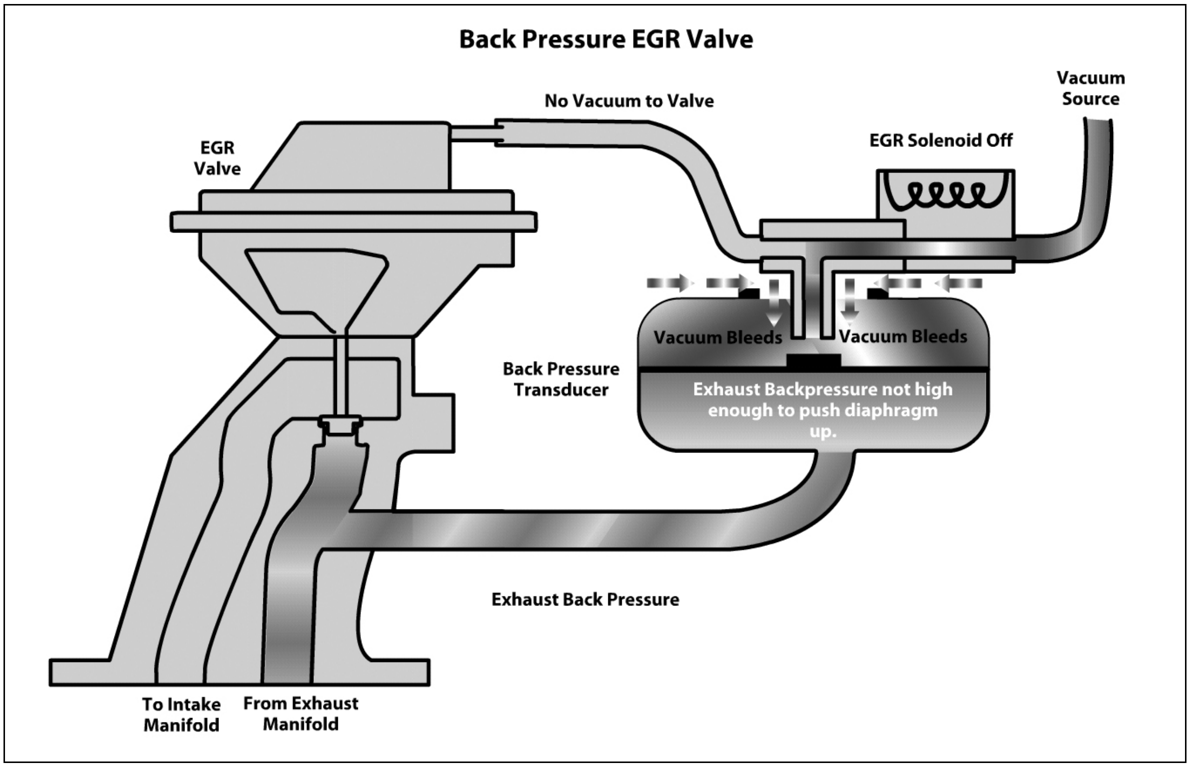
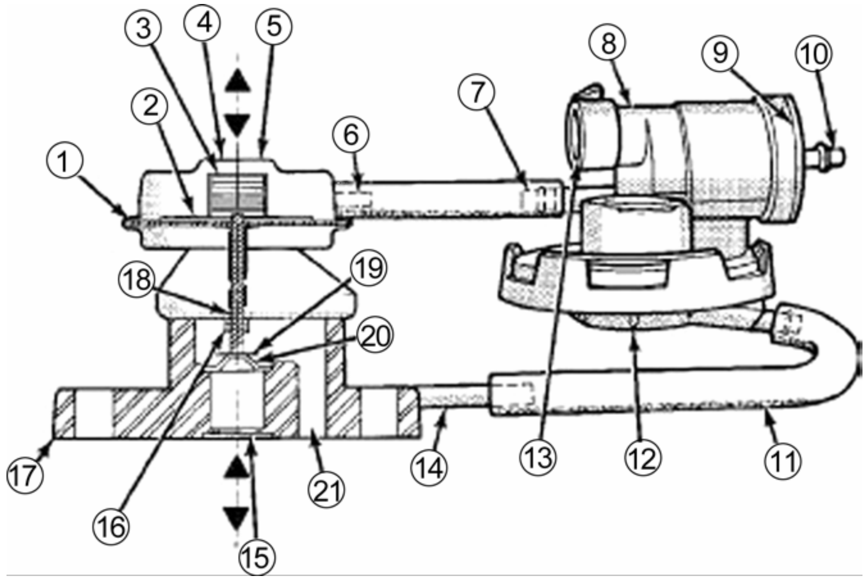



Figure 117 Back Pressure EGR Valve – Low Back Pressure




| | | | |
|---|---|---|---|
| 1 | Diaphragm | 12 | Transducer Portion of Valve Control |
| 2 | Piston | 13 | Electrical Connection Point |
| 3 | Spring | 14 | EGR Valve Back-Pressure Fitting |
| 4 | EGR Valve Assembly | 15 | Exhaust Gas Inlet |
| 5 | Vacuum Motor | 16 | Stem Protector and Bushing |
| 6 | Vacuum Motor Fitting | 17 | Base |
| 7 | Vacuum Outlet Fitting to EGR Valve | 18 | Movement Indicator |
| 8 | EGR Valve Control Assembly | 19 | Poppet Valve |
| 9 | Elevtric Solenoid Portion of Valve Control | 20 | Seat |
| 10 | Vacuum Inlet Fitting from Engine | 21 | Exhaust Gas Outlet |
| 11 | Back Pressure Hose | | |

Figure 118  Back Pressure Transducer EGR Valve Components

**EGR MONITOR OPERATION**

To run the EGR Monitor, the PCM closes the EGR valve to stop the flow of exhaust gases to the intake manifold and then monitors Short Term Adaptive values. On Linear EGR systems, the PCM turns the EGR solenoid OFF to stop EGR flow. On Back Pressure EGR systems, the PCM turns the EGR solenoid ON to stop EGR flow.

When the EGR system is functioning normally, blocking EGR flow increases the amount of oxygen in the cylinders, shifting the air/fuel ratio lean. The oxygen sensor signal voltage indicates increased oxygen in the exhaust and Short Term Adaptive increases injector pulse width to add fuel. By monitoring this shift in Short Term Adaptive values, the PCM can indirectly infer EGR system performance.

If the PCM does not detect a change in Adaptive Memory Factor within the calibrated range for four consecutive tests during a single trip, the monitor fails and a maturing code and Freeze Frame are set. When the monitor fails on the second consecutive trip, the MIL is illuminated and DTC P0401 EGR SYSTEM FAILURE and Freeze Frame are set.

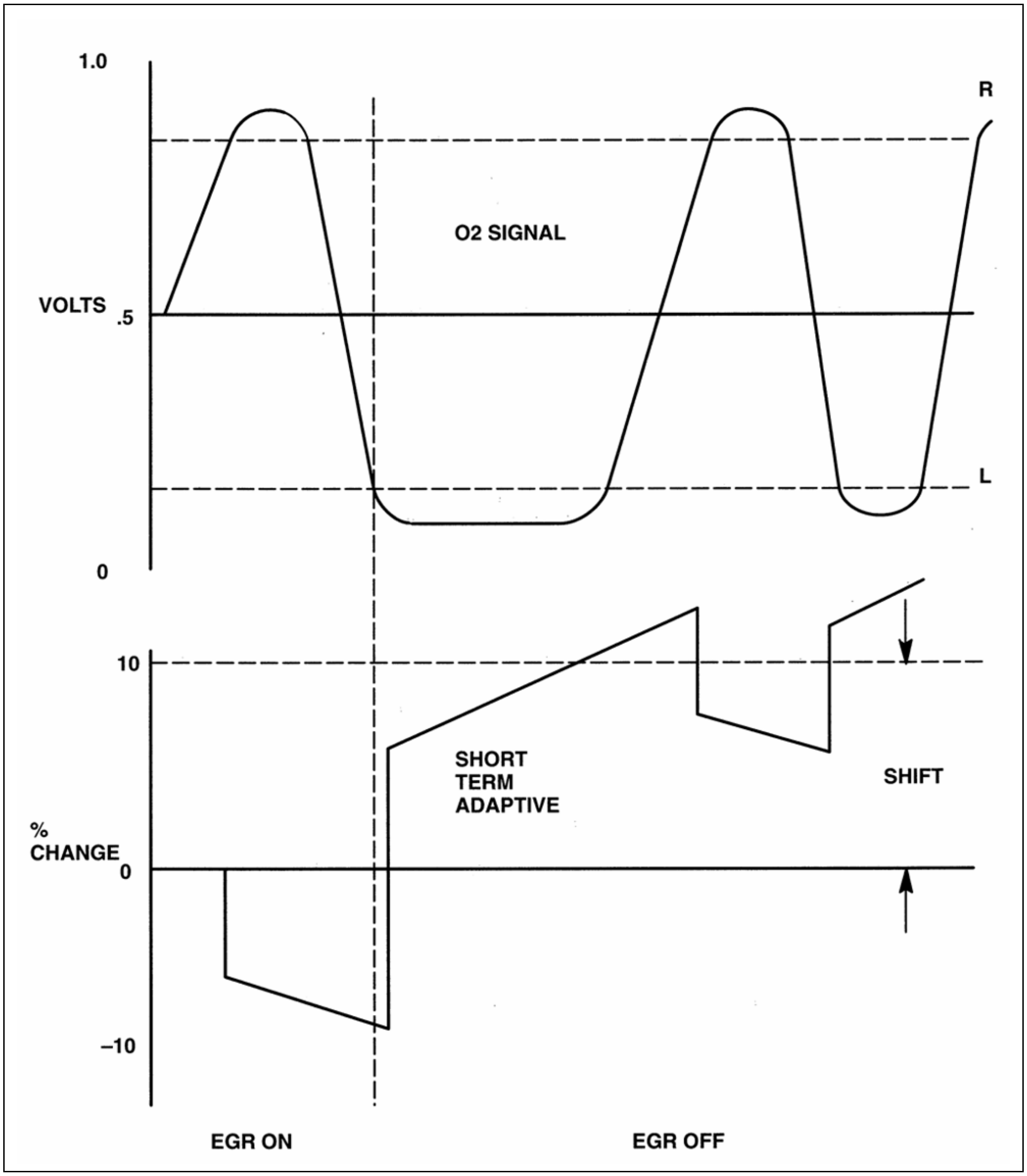



Figure 119 Fuel System Adaptive Shift

**SCAN TOOL PRETEST SCREEN - NGC**

This screen allows the user to determine when the conditions have been met to run the EGR Monitor. This is a split screen. Pre-test enabling conditions are located on the top half of the screen and the conditions required to actually run the monitor are located on the bottom half of the screen.

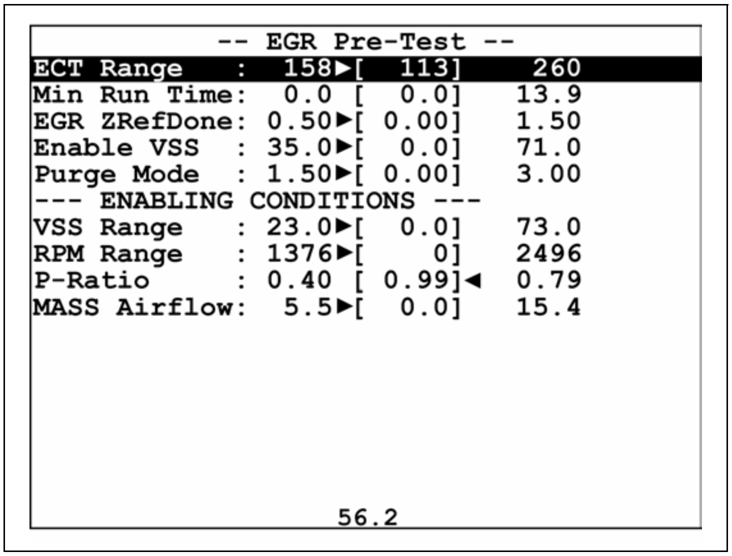



Figure 120 NGC EGR Monitor Pretest Screen

The main objective of this and other pre-test screens is to “make the arrows go away”. When the arrows disappear, the conditions required to run the monitor have been satisfied and the monitor should run.

The vehicle can be driven, either on the road or on a lift, to satisfy the conditions of a pre-test. The parameters of this pre-test include several timers. The expiration of the timers indicates the vehicle, including the exhaust components, is hot enough to ensure accurate test results. To meet these enabling conditions, drive the vehicle until the arrows on the screen disappear. You can now ignore the arrows on the top half of the screen and begin satisfying the conditions on the bottom half of the screen.

**Note: Refer to the enabling conditions list for other possible requirements.**

**ECT Range:** Engine coolant temperature value must be within the indicated range, with minimum value on the left, actual value in the middle, and maximum to the right.

**Min Run Time:** Minimum amount of engine run time since start, displayed in minutes. The number right of the decimal are tenths of a minute (e.g., 1.5 is equal to 1 minute and 30 seconds).

**EGR ZRef Done:** A bit that indicates the Linear EGR Valve Position Sensor is in a range that would indicate the EGR Valve is closed. For example, the EGR Valve Position Sensor may indicate 4.1 volts when the valve is closed and the ZREF (zero reference) voltage range has an allowable Low Threshold of 3.4 volts and High Threshold of 4.7 volts. In addition to the shorted to voltage and shorted to ground checks, the NGC also checks to see the EGR Sensor (and therefore the EGR Valve) is in the proper closed position BEFORE beginning the actual EGR Monitor Test. The NGC needs this Pre-Test value to go to a "1" for the Monitor to be enabled.

**Enable VSS:** Vehicle speed must fall within this range, with minimum value on the left, actual value in the middle, and maximum to the right. This range needs to be met before the monitor will attempt to run.

**Purge Mode:** Indicates which Mode the Purge Solenoid is in:

- 0=Off
- 1=Learn Mode
- 2=Norm Flow
- 3=Testing

The NGC needs this Pre-Test value be a "2" (Normal Purge flow) for the EGR Monitor to be enabled.

**VSS Range:** Vehicle speed must fall within this range, with minimum value on the left, actual value in the middle, and maximum to the right.

**RPM Range:** Engine speed must fall within this range, with minimum value on the left, actual value in the middle, and maximum to the right.

**P-Ratio:** This is a calculation of absolute MAP divided by barometric pressure. A sample reading is; 0.99 volts = wide open throttle (Map equal to Baro).

**Mass Airflow :** Displayed in grams per second. A Mass Air Flow calculation (derived from the MAP Sensor and other inputs) of the Intake Manifold inflow of Mass Air which must be in a certain range to enable the EGR Monitor (Engine running above idle and not at wide open throttle – similar to a part throttle cruise).

**SCAN TOOL MONITOR DATA SCREEN - NGC**

This screen indicates the status of the EGR Monitor.

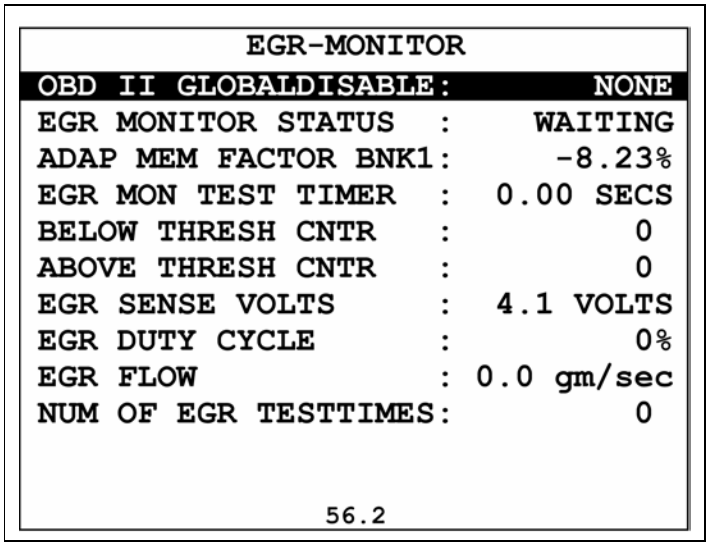



Figure 121 NGC EGR Monitor Data Screen

**OBD II Global Disable:** This line item is covered in Module 4 Monitors.

**EGR Monitor Status:** The monitor status displays the current status of the monitor. There are multiple states of a monitor and they will be ranked by the DRB 3. This is covered in Module 4 Monitors.

**Adap Mem Factor Bnk1:** This is the Long Term Fuel Adaptive Memory for Bank 1 for the Cell you are in at that time. It is displayed in percent as a signed value (-33% to +33%).

**Adap Factor w/o EGR:** (This item will appear in future software releases). This is the trapped value of the Fuel Adaptive Memory when the EGR is not flowing, which is stored only during the EGR Monitor. It is compared to the Adapt Mem Factor BNK1 (Line 3), which is the same Adaptive Memory item only with EGR flowing. The difference between the two must be within a band (above a Lower Threshold and below an Upper Threshold) in order to pass.

This is how the 2004 NGC EGR Monitor works (software year and not early VINed 2004 vehicles which were 2003 NGC software year). The 2002+2003 NGC EGR Monitor was a roughness type of monitor. The 2004 NGC EGR Monitor is a Fuel Shift type of monitor similar to what SBEC did.

The EGR Monitor, once the enable conditions are met, shuts off the EGR Valve and then after a delay period, traps and stores the Adaptive Memory Fuel Factor. The EGR Valve is then opened and then the Adaptive Memory Fuel Factor is compared to the trapped value. If the EGR gasses are flowing properly there will be a difference seen in the Adaptive Fuel Factor between the EGR off (trapped value) and the EGR on values.

This happens because when EGR gasses are flowing, it makes the combustion chamber smaller by introducing inert gasses which cannot aid in combustion. Once the EGR is shut off, 'extra' oxygen in the air is allowed to enter the combustion chamber. The O2 Sensor sees this extra oxygen and then the NGC will add the extra fuel to keep the Air/Fuel Ratio at stoichiometric (14.7:1). This additional fuel is seen in the Adaptive Memory Factor shift (Short and Long Term correction). The NGC expects to see this change in Fuel from EGR off to EGR on. If not, a problem is assumed.

If it is either too high or too low (EGR stuck closed or EGR stuck open) a failure counter will begin counting (BELOW THRESH CNTR or ABOVE THRESH CNTR). If the failure counter reaches its threshold (e.g., 20), the "Num of EGR TESTTIMES" counter will increment. Once the "Num of EGR TESTTIMES" reaches its threshold (e.g., 4), an EGR Monitor 1 Trip Failure will be logged.

Shown in percent as a signed value (-33% to +33%).

**EGR Mon Test Timer:** The amount of time in seconds that the EGR Monitor Test will run (e.g., 2 seconds per test attempt, 4 failed tests, max = 1 Trip Failure)

**Below Thresh Cntr:** This counter will count when a possible failure exists if expected Fuel Shift (the difference between Adap Mem Factor BNK1 and Adap Factor w/o EGR) is below the "Lo EGR FailCNTR Spec" (EGR stuck closed).

**Above Thresh Cntr:** This counter will count when a possible failure exists if expected Fuel Shift (the difference between Adap Mem Factor BNK1 and Adap Factor w/o EGR) is above the "Hi EGR FailCNTR Spec".

**EGR Sense Volts:** Live reading of the EGR position sense voltage.

**EGR Duty Cycle:** Live reading of the requested EGR duty cycle (EGR flow rate).

**EGR Flow:** Amount of EGR flow, calculated by the PCM and displayed in grams per second.

**Num Of EGR Test Times:** Number of times the EGR Monitor attempted to run during this key cycle. Only one passing test is required to pass the monitor. Four failed attempts during one key cycle will result in a One-Trip Failure.

## SCAN TOOL LAST RESULT SCREEN - NGC

This screen can be used to track previous EGR Monitor results.

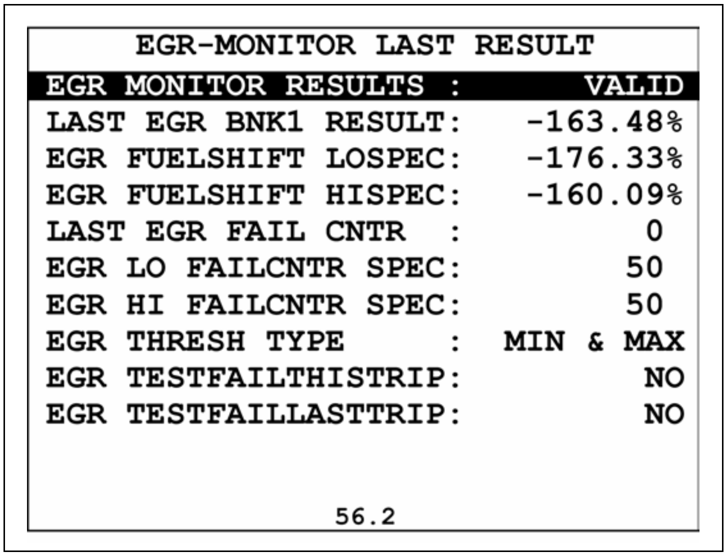



Figure 122 NGC EGR Monitor Last Result Screen

**EGR Monitor Results:** This tells the status of the monitor's results. "Valid" indicates monitor has completed and has passed or failed. This data is from the last time the monitor completed and does not necessarily mean that the data came from last drive cycle. "Invalid" indicates monitor has not run since battery disconnect or clear DTCs (i.e. not Ready).

**Last EGR Bnk1 Result:** This is the actual amount of fuel shift seen during the monitor the last time the monitor completed. This is not necessarily the last key cycle, but the last time the monitor was able to run and complete.

**EGR Fuel Shift Lo Spec:** The most fuel correction allowed to be removed from the pulsewidth equation.

**EGR Fuel Shift Hi Spec:** The most fuel correction allowed to be added to the pulsewidth equation.

**Last EGR Fail Cntr:** The number of counts that the Fuel Adaptive percentage is outside the allowable range. This counter can start and stop during the monitor.

**EGR Lo Fail Cntr Spec:** The total number of fail counts allowed if the Fuel Adaptive range is exceeding the Lo Spec during the monitor.

**EGR Ho Fail Cntr Spec:** The total number of fail counts allowed if the Fuel Adaptive range is exceeding the Hi Spec during the monitor.

**EGR Thresh Type:** This threshold will be MIN and MAX because the EGR monitor is trying to identify if, during the EGR Monitor, the Fuel Shift is too great. The fuel shift is based on a positive amount of fuel added or negative amount of fuel removed from the pulsewidth.

**EGR Test Fail This Trip:** Indicates if the monitor has ran and failed during this trip. Results in a “Yes” or “No”.

**EGR Test Fail Last Trip:** Indicates if the monitor failed during the previous trip. Results in a “Yes” or “No”.

## ACTIVITY 15: EGR MONITOR

Notes:

**SCAN TOOL PRETEST SCREEN – SBEC**

**SBEC Only**

```
               EGR Pre-Test
ECT Range      : 64     [95]     260
Bat Tmp Range  : 19     [70]     130
Min Run Time   : 6.0    [7.4]    13.9
VSS MPH Range  : 25     [0]      100
TPS Range     : 2.0    [0.0]    5.1
RPM Range      : 1408   [0]      2112
MAP Range      : 12.7   [0.0]    18.9
           ENABLING CONDITIONS
TPS  Range     : 2.0    [0.0]    5.1
RS/T Adp Range: -11.9   [0.0]    11.9
LS/T Adp Range: -11.9   [0.0]    11.9
Vacuum Range   : 3.9    [0.0]    31.0
MAP Range      : 10.6   [0.0]    18.9
RPM Range      : 1408   [0]      2112
```

Figure 123  SBEC EGR Monitor Pretest Screen

**SCAN TOOL MONITOR DATA SCREEN – SBEC**

**SBEC Only**

```
              EGR MONITOR
EGR MONITOR DATA       : 80
EGR MON IN PROGRESS    : NO
EGR MON DONE THIS TRIP: NO
EGR MON FAIL THIS TRIP: NO
EGR MON FAIL 1 TRIP    : NO
EGR MON FAIL DTC SET   : NO
EGR MON STOP TESTING   : NO
EGR SENSE VOLTS        : 3.8 VOLTS
EGR DUTY CYCLE         : 0 %
1/1 SHORT TERM ADAP    : 0.0 %
```

Figure 124  SBEC EGR Monitor Data Screen

**1/1 Short-Term Adap:** This line indicates the adaptive shift while the EGR is disabled. If the EGR system is functional, the adaptive percentage should increase enough to indicate there was the correct amount of EGR flow. Reduced exhaust gas in the combustion chamber increases the amount of oxygen in the chamber. The O2 sensor(s) records the increased oxygen content and pulse-width is also increased.

## SCAN TOOL LAST RESULT SCREEN – SBEC

**SBEC Only**

```
        EGR MONITOR LAST RESULT
LAST EGR MON STATUS    : 00
EGR MON LAST RESULT    : MAX
EGR MON FAIL THIS TEST: NO
EGR MON FAIL PREV TEST: NO
EGR S T ADAP SHIFT     : 3.01 %
EGR S T ADAP LO SPEC   : 0.00 %
EGR S T ADAP HI SPEC   : 0.00 %
```

Figure 125  SBEC EGR Monitor Pretest Screen

Notes:

Notes:

# MODULE 14 SECONDARY AIR MONITOR

## BACKGROUND

Secondary air systems with electric pumps are installed on the 2004 JR vehicle with the 2.4L engine and Partial Zero Emissions Vehicle (PZEV) emissions classification. PZEV vehicles must meet a "zero EVAP emissions" standard.

These vehicles have a number of changes to the engine management, fuel and EVAP systems to further reduce emissions. These changes include a Secondary Air System.

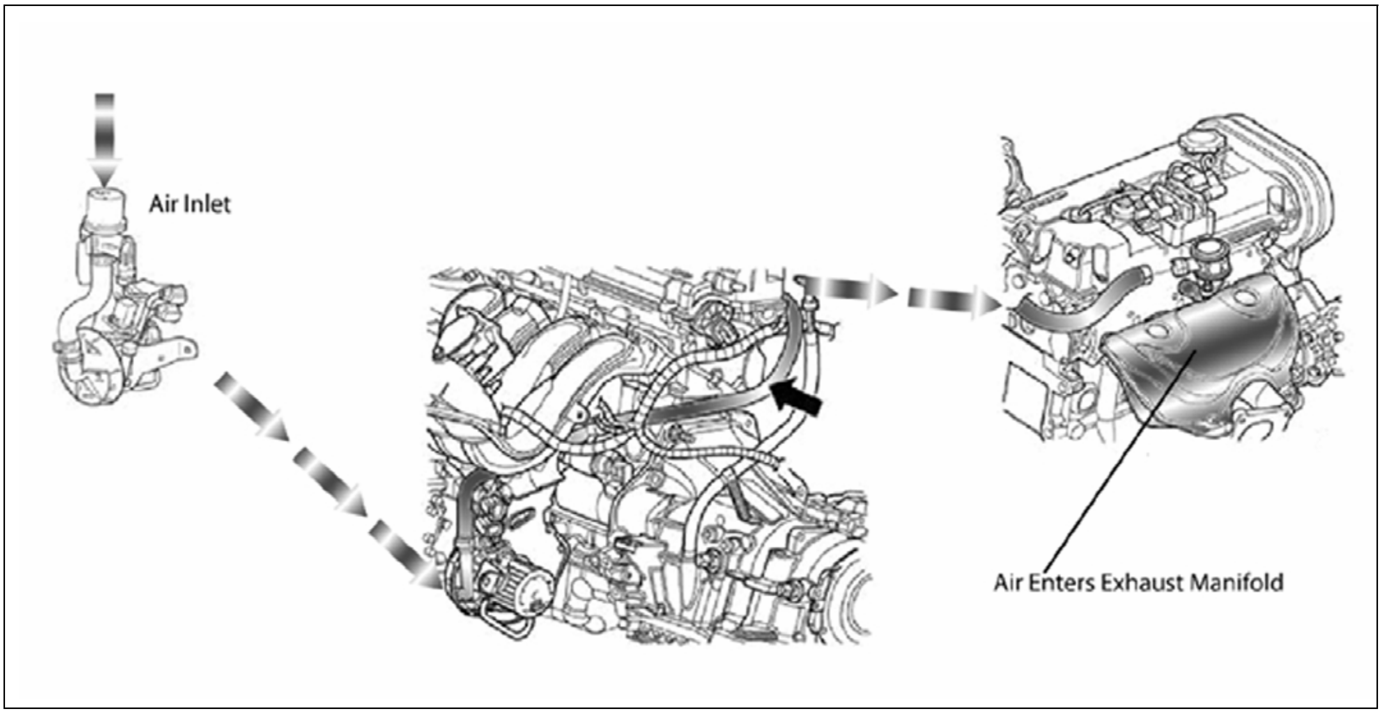



Figure 126 Secondary Air System

## SECONDARY AIR SYSTEM OPERATION

The Secondary Air System injects air into the engine exhaust ports near the exhaust valves. This extra air helps to oxidize unburned HC and CO in the exhaust stream. This oxidation creates more heat in the exhaust gases. This extra heat helps the catalytic converter to heat up and begin to function faster.

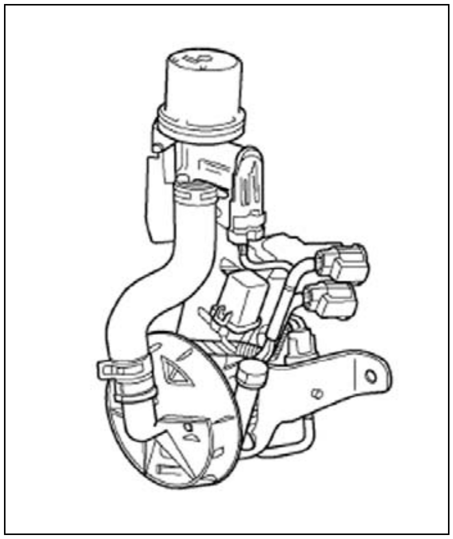
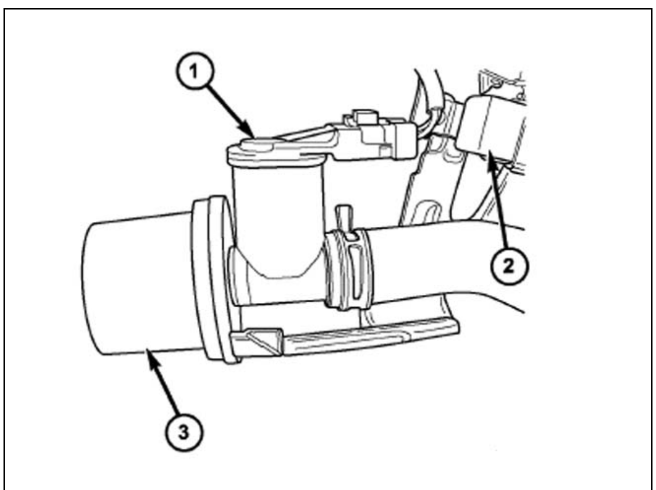


Figure 127  Secondary Air Pump

The electric air pump is on only during a cold start when coolant temperature is between 46-117°F (7.8-47.2°C).  The pump runs for a maximum of 18 seconds.  The run time is based on the amount of air injected.  A mass airflow (MAF) sensor in the pump inlet measures the volume of air injected.




| | |
|---|---|
| 1 | Mass Airflow (MAF) Sensor |
| 2 | Relay |
| 3 | Inlet Filter |

Figure 128  Secondary Air MAF Sensor

As this is written, the Secondary Air Monitor is not displayed on the DRB III.

## GLOSSARY

**Adaptive Memory Factor** — Short Term Fuel Trim value and Long Term Fuel Trim values combined. This provides a maximum total correction of ±66% (NGC and JTEC) or ±50% (SBEC) from the base fuel injector pulse width calculation.

**Adaptive Numerator** — Learned variance in ideal and actual CKP signal. Also called the Target Linear Compensation or Target Learning Coefficient. Takes into account variations in machining of the trigger wheel and CKP sensor response.

**Air Injection Reaction System** — AIR systems reduce hydrocarbon and carbon monoxide emissions by injecting air directly into the exhaust and/or the catalytic converter.

**Alternate Good Trip** — Used in place of Global Good Trips for Comprehensive Components and Major Monitors. If a Global Good Trip cannot be run, the Task Manager will count an Alternate Good Trip after two minutes of engine run time where no other faults occur. The Task Manager counts an Alternate Good Trip for a specific Major Monitor when the monitor runs and passes.

**CARB Readiness Status** — A scan tool screen indicating whether or not CARB mandated once-per-trip monitors have run.

**Catalyst** — A substance that enhances a chemical reaction while not being changed or used up in that reaction.

**Catalytic Converter** — Used in exhaust systems to convert pollutants into harmless substances such as water and $CO_2$. The three-way Catalytic Converter oxidizes HC and CO, and reduces oxides of nitrogen (NOx).

**Closed Loop** — When the PCM uses input from the $O_2$ sensors to make feedback corrections to the speed density equation. Also see Open Loop.

**Comprehensive Components** — All input and output components that can affect emissions. These components are monitored for electrical faults such as opens and shorts, and may also monitored for rationality and functionality.

**Conflict** — A condition where a monitor may not be run because it would interfere with or be affected by another currently running monitor. The Task Manager will prevent the second monitor from running until the first monitor has finished.

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| **Drive Cycle** | A Federal emissions procedure to drive a vehicle and allow most monitors to run and perform their tests. Drive Cycles can specify calibrated values for engine temperature increase, vehicle speed, time, and other parameters. |
| **Enabling Conditions** | Operating parameters or conditions that must be met for a monitor to run. The list of conditions that may permit a monitor to run or prevent or suspend monitor operation is calibrated and varies for each package. |
| **Evaporative Emissions System** | Fuel vapors from evaporating fuel in the tank and from refueling is absorbed and stored in the EVAP charcoal canister. Engine vacuum causes air flow through the canister during engine operation. This flow purges HC and meters it into the intake manifold. |
| **Exhaust Gas Recirculation** | EGR systems dilute the air/fuel mixture with inert exhaust gases. Recycling some inert exhaust gases back into the intake mixture can lower combustion temperatures and reduce the quantity of Oxides of Nitrogen (NOx) formed. EGR also improves fuel economy, since less air and fuel enter the cylinders, and it reduces engine knocking. |
| **Freeze Frame** | Data stored from various sensors describing the engine operating conditions at the time a fault is detected. |
| **Fuel System Good Trip** | Counted when engine is in closed loop, operating in similar conditions window, and total Adaptive Memory Factor (Short Term Adaptive value and Long Term Adaptive value combined) does not exceed the threshold for a calibrated time. If these conditions are met, the PCM will count a Good Trip toward erasing a fuel system monitor (rich/lean) DTC. |
| **Functionality** | OBD II systems test PCM outputs for functionality as well as circuit continuity. When the PCM supplies a voltage to an output component, it can verify that the command was carried out by monitoring specific input signals for expected changes. |
| **Global Disable** | On NGC vehicles, Monitors can be Globally Disabled if certain conditions occur. If there is more than one condition, the DRB III will display only the highest-ranked one. Not every condition affects every monitor. For example, Global Disable can display "High Fuel" and the monitor status can indicate "Waiting". The "High Fuel" condition is not calibrated to prevent that monitor from running, so the monitor can run and complete its test. |

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| **Global Good Trip** | When all Monitors that run once-per-trip have run and have passed. The definition varies by vehicle and model year. Typically, the Oxygen Sensor and Catalyst Efficiency Monitors must run in order to increment a Global Good Trip. |
| **Good Trip** | An indication that the vehicle was operated under a specific set of operating conditions and no fault was detected. There are different types of Good Trips depending upon what the PCM is trying to verify. |
| **Intrusive** | An active Monitor test that actively changes operating conditions to run its test. Also see Non-Intrusive. |
| **Leak Detection Pump** | A Leak Detection Pump pressurizes the EVAP system to detect leaks. Used on JTEC and SBEC vehicles. |
| **Long Term Adaptive** | See Long Term Fuel Trim |
| **Long Term Fuel Trim** | After the vehicle has reached full operating temperature, the fuel injector pulse width correction factors generated by Short Term Adaptive will be stored in Long Term Adaptive or Long Term Fuel Trim memory cells. Once stored, it will be used under all operating conditions. Also see Short Term Fuel Trim. |
| **Misfire** | Lack of combustion in a cylinder during the power stroke. |
| **Misfire Good Trip** | Counted when operating in Similar Conditions Window (SBEC/JTEC only) and 1000 engine revolutions occur with no misfire. |
| **Monitor** | Software in the PCM that checks and verifies the performance of various emission-related systems and components. |
| **Natural Vacuum Leak Detection** | NGC vehicles use the Natural Vacuum Leak Detection (NVLD) method to dependably detect 0.020 in. (0.5 mm) leaks in the EVAP system. NVLD replaces the leak detection pump previously used on SBEC and JTEC vehicles. NVLD seals the EVAP system and monitors for a slight pressure drop as the system cools. |
| **Non-Intrusive** | A passive Monitor test that does not actively change any operating condition to run its test. Also see Intrusive. |
| **Onboard Refueling Vapor Recovery** | ORVR systems greatly reduce HC emissions during refueling by capturing vapors in the EVAP canister. Previous EVAP systems vented fuel vapor (HC) emissions during refueling. |

**One-Trip Monitor** An emissions system test that will set a DTC and illuminate the MIL the first time a failure is detected. Also see Two-Trip Monitor.

**Oxygen Sensor** Oxygen Sensors provide a signal to the PCM for oxygen content in the exhaust and make the closed-loop feedback engine management system possible. The PCM infers air/fuel ratio from the sensor signal for oxygen content and adjusts the quantity of fuel injected to keep the air/fuel ratio at stoichiometry (14.7:1).

**Open Loop** When the PCM ignores $O_2$ sensor feedback and only uses pre-programmed values to perform air/fuel ratio adjustments. Also see Closed Loop.

**Pending** A Monitor may not be run if the MIL is illuminated and a fault is stored. The Monitor will not be run until the problem is no longer present.

**Priority** CARB mandated DTCs are entered and ranked according to priority. In earlier vehicles with limited memory storage, DTCs with higher priority overwrite lower priority DTCs. Later vehicles can store as many as eight DTCs before overwriting.

**Purge** The process of taking stored hydrocarbon vapors from the charcoal canister and adding them to the intake mixture.

**Purge Vapor Ratio** The proportion or concentration of fuel (Hydrocarbon) vapors in the EVAP system purge flow. If purge flow contains a high ratio of HC vapors, less fuel from the injectors is required.

**Rationality** OBD II systems compare input signals against other inputs and stored information to see they make sense under the current conditions.

**Short Term Adaptive** See Short Term Fuel Trim.

**Short Term Fuel Trim** An immediate correction to fuel injector pulse width. An immediate response to an $O_2$ sensor signal that is not switching or is consistently high or low. Short Term Fuel Trim (also called Short Term Adaptive) begins functioning shortly after the vehicle has started, as soon as the oxygen sensor is heated to operating temperature. Short Term Adaptive values change very quickly and are not stored when the ignition is OFF. Also see Long Term Fuel Trim.

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| **Similar Conditions Window** | Displayed on the scan tool, allows the user to operate the vehicle under operating conditions similar to when the fault occurred. |
| **Speed Density Fuel Control** | A fuel control systems that changes fuel injection quantity largely based on changes in engine speed and load. Most Chrysler Group vehicle use the Speed Density system. |
| **Stoichiometry** | The ideal air/fuel ratio. For gasoline, it is 14.7 parts air to 1 part fuel. Other fuels have different ratios. |
| **StarSCAN** | Can-bus compatible scan tool replacing the DRB III. |
| **Suspend** | The Task Manager may not allow a two-trip fault to mature if conditions might lead to erroneous results. This reduces the chances of the MIL illuminating for the wrong fault. |
| **Task Manager** | Software in the PCM that determines whether enabling conditions have been met to run appropriate tests, monitors parameters during tests, and records test results. |
| **Trip Counter** | Criteria used by the PCM to turn OFF the MIL. A trip is defined as “starting the vehicle and operating it to meet the criteria necessary to run a given diagnostic test”. CARB requires three good trips to extinguish the MIL. |
| **Two-Trip Monitor** | Some diagnostic tests must fail more than one time before the PCM sets a DTC and illuminates the MIL. These tests are “Two-Trip Monitors”. Also see One-Trip Monitor. |
| **Warm-Up Cycle** | A Warm-Up Cycle occurs when engine coolant temperature starts below and rises above 160°F (71°C), and increases at least 40°F (22.2°C), while no other faults occur. Counted by the PCM and used to erase DTCs and Freeze Frames. |

## TOOL APPENDIX


StarSCAN Scan Tool