DRIVEABILITY—HO2S (HEATED OXYGEN SENSOR), CATALYST, AND FUEL SYSTEM MONITORS—SERVICE TIPS—OBD II VEHICLES ONLY

Article No. 01-9-7

FORD: 1994-1997 THUNDERBIRD
1994-2001 MUSTANG
1995-2001 CROWN VICTORIA
1996-1997 PROBE
1996-2000 CONTOUR
1996-2001 ESCORT, TAURUS
2000-2001 FOCUS
1994-1997 F SUPER DUTY, F-250 HD, F-350
1995-2001 ECONOLINE, RANGER, WINDSTAR
1996 BRONCO
1996-1997 AEROSTAR
1996-2001 EXPLORER
1997-2001 EXPEDITION, F-150, F-250 LD
1999-2001 SUPER DUTY F SERIES
2000-2001 EXCURSION
2001 ESCAPE

LINCOLN: 1995-2001 CONTINENTAL, TOWN CAR
1996-1998 MARK VIII
2000-2001 LS
1998-2001 NAVIGATOR

MERCURY: 1994-1997 COUGAR
1995-2001 GRAND MARQUIS
1996-1999 TRACER
1996-2000 MYSTIQUE
1996-2001 SABLE
1999-2001 COUGAR
1997-2001 MOUNTAINEER

ISSUE

This article is intended to be an aide in diagnosing conditions related to Heated Oxygen Sensor (HO2S), Catalyst, and Fuel System Monitor related Diagnostic Trouble Codes (DTCs). Additional information is included to assist in diagnosing certain vehicle symptoms. This article is NOT intended to be a shortcut to the Powertrain Control/Emissions Diagnosis (PC/ED) Workshop Manual pinpoint tests. The pinpoint tests in the PC/ED Manual should ALWAYS be followed when diagnosing vehicle conditions.

ACTION

Use the following information and Service Tips to assist in the diagnosis of HO2S, Catalyst, and Fuel System Monitor related DTCs.

INDEX

A.) Description of Terms and Acronyms

- **CHT** - Cylinder Head Temperature Sensor or PID
- **CKP** - Crankshaft Position Sensor or PID
- **DTC** - Diagnostic Trouble Code
- **ECT** - Engine Coolant Temperature Sensor or PID
- **EGR** - Exhaust Gas Recirculation
- **EEC** - Electronic Engine Control
- **EVR** - EGR Vacuum Regulator
- **FMEM** - Failure Mode Effects Management
- **GND** - Ground
- **HC** - Hydrocarbons
- **HO2S** - Heated Oxygen Sensor or PID
- **IAT** - Inlet Air Temperature Sensor or PID
- **KAM** - Keep Alive Memory
- **KOEO** - Key On Engine Off
- **KOER** - Key On Engine Running
- **LONGFT** - Long Term Fuel Trim
- **MAF** - Mass Air Flow Sensor or PID
- **MIL** - Malfunction Indicator Lamp ("Check Engine")
- **NGS** - New Generation Star Tester (Scan Tool)
- **OBD II** - On-Board Diagnostics II
- **OSM** - Output State Monitor
- **PC/ED** - Powertrain Control/Emissions Diagnosis
- **PCM** - Powertrain Control Module
- **PCV** - Positive Crankcase Ventilation
- **PID** - Parameter Identification Display
- **RAM** - Random Access Memory
- **RPM** - Revolutions Per Minute
- **SHRTFT** - Short Term Fuel Trim
- **Stoichiometric** - 14.7:1 Air/Fuel Ratio (Gasoline Engines)
- **TP** - Throttle Position Sensor or PID
- **VMV** - Vapor Management Valve
- **VPWR** - Vehicle Power (Battery Voltage)
- **VREF** - Vehicle Reference Voltage (5 volts)

B.) HO2S Location Diagrams

Refer to Figure 1 to better understand the HO2S sensor names and locations. Regardless of how the engine is mounted in the vehicle, conventional or transverse, the HO2S naming convention stays the same in relationship to engine banks 1 and 2. Bank 1 will always be the bank containing the #1 cylinder.

C.) HEATED OXYGEN SENSOR (HO2S) MONITOR

C1.) Heated Oxygen Sensor (HO2S) Monitor - Information

The HO2S Monitor is an on-board strategy designed to monitor the HO2S sensors for a malfunction or deterioration that can affect emissions. Under specific conditions, the fuel control or upstream HO2S sensors (Figures 1 and 3) are checked for proper output voltage and response rate (the time it takes to switch from lean to rich or rich to lean). Downstream HO2S sensors (Figures 1 and 3) used for Catalyst Monitor are also monitored for proper output voltage. Input is required from the ECT or CHT, IAT, MAF, TP and CKP sensors to activate the HO2S Monitor. The Fuel System Monitor and Misfire Detection Monitor must also have completed successfully before the HO2S Monitor is enabled.

- The HO2S sensor senses the oxygen content in the exhaust flow and outputs a voltage between zero and 1.0 volt. Lean of stoichiometric (air/fuel ratio of approximately 14.7:1 for gasoline engines), the HO2S will generate a voltage between zero and 0.45 volt. Rich of stoichiometric, the HO2S will generate a voltage between 0.45 and 1.0 volt.
- The HO2S Monitor evaluates both the upstream (Fuel Control) and downstream (Catalyst Monitor) HO2S for proper function.
- Once the HO2S Monitor is enabled, the upstream HO2S signal voltage amplitude and response frequency are checked. Excessive voltage is determined by comparing the HO2S signal voltage to a maximum calibratable threshold voltage.
- A fixed frequency closed loop fuel control routine is executed and the upstream HO2S voltage amplitude and output response frequency are observed. A sample of the upstream HO2S signal is evaluated to determine if the sensor is capable of switching or has a slow response rate.
- An HO2S heater circuit fault is determined by turning the heater on and off and looking for a corresponding change in the OSM and by measuring the current going through the heater circuit.
- The MIL is activated after a fault is detected on two consecutive OBD II drive cycles.

The HO2S Monitor DTCs can be categorized as follows:

- HO2S signal circuit malfunction - P0131, P0136, P0151, P0156
- HO2S slow response rate - P0133, P0153
- HO2S heater circuit malfunction - P0135, P0141, P0155, P0161
- Downstream HO2S not running in on-demand self test - P1127
- Swapped HO2S connectors - P1128 and P1129
- HO2S lack of switching - P1130, P1131, P1132, P1150, P1151, P1152
- HO2S lack of switching (sensor indicates lean) - P1137
- HO2S lack of switching (sensor indicates rich) - P1138

C2.) Heated Oxygen Sensor (HO2S) Monitor - Diagnostic Trouble Codes

HEATED OXYGEN SENSOR (HO2S) MONITOR - HO2S LACK OF SWITCHING		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P1130 - Lack of HO2S-11 Switch, Fuel Trim at Limit	The HEGO Sensor is monitored for switching. The code will set when the HO2S fails to switch due to circuit or fuel at or exceeding a calibrated limit.	**Electrical:** •Short to VPWR or VREF in harness or HO2S •HO2S circuit shorted to Ground •Water in harness connector •Open circuit •Corrosion or poor mating terminals and wiring •Damaged HO2S •Damaged PCM (other DTCs should be present) **Fuel System:** •Excessive fuel pressure (stuck fuel pressure regulator, restricted fuel return lines, etc.) •Leaking/contaminated fuel injectors or fuel pressure regulator •Low fuel pressure or running out of fuel (fuel pump concern, fuel supply line restrictions, low fuel level, etc.) •Vapor recovery system (stuck VMV, etc.) **Induction System:** •MAF contamination •Air leaks between MAF and throttle plate •PCV system / Other vacuum leaks •Improperly seated engine oil dipstick **EGR System:** •Leaking gasket •Stuck EGR valve / Leaking diaphragm or EVR **Base Engine:** •Oil overfill •Incorrect cylinder compression •Exhaust leaks before or near the HO2S •Secondary air stuck on

HEATED OXYGEN SENSOR (HO2S) MONITOR - HO2S LACK OF SWITCHING		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P1131 - Lack of HO2S-11 Switch, Indicates Lean	When an HO2S sensor indicates lean at the end of a test, the system is trying to correct for an over-lean condition. The code is set when the fuel control system no longer detects switching for a calibrated amount of time.	See Possible Causes for DTC P1130
P1132 - Lack of HO2S-11 Switch, Indicates Rich	When an HO2S sensor indicates rich at the end of a test, the system is trying to correct for an over-rich condition. The code is set when the fuel control system no longer detects switching for a calibrated amount of time.	See Possible Causes for DTC P1130
P1137 - Lack of HO2S-12 Switch, Sensor Indicates Lean	The downstream HO2S sensors are forced rich and lean and monitored by the PCM. The code is set if the PCM does not detect the output of the HO2S in a calibrated amount of time.	•Pinched, shorted or corroded wiring and pins •Crossed sensor wires •Exhaust leaks •Contaminated or damaged sensor
P1138 - Lack of HO2S-12 Switch, Sensor Indicates Rich	Same as DTC P1137, but indicating rich.	See Possible Causes for DTC P1137
P1150 - Lack of HO2S-21 Switch, Fuel Trim at Limit	Same as DTC P1130, but opposite bank.	See Possible Causes for DTC P1130
P1151 - Lack of HO2S-21 Switch, Indicates Lean	Same as DTC P1131, but opposite bank.	See Possible Causes for DTC P1130
P1152 - Lack of HO2S-21 Switch, Indicates Rich	Same as DTC P1132, but opposite bank.	See Possible Causes for DTC P1130

HEATED OXYGEN SENSOR (HO2S) MONITOR - HO2S SLOW RESPONSE RATE		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0133 - HO2S Sensor Circuit Slow Response (HO2S-11)	The HO2S monitor checks the HO2S sensor frequency and amplitude. If during testing, the frequency and amplitude were to fall below a calibrated limit, the code will set.	**Electrical:** •Shorted/open wiring •PCM **Induction System:** •MAF sensor (On 4-cylinder engines, if P0133 is present, this could be caused by a MAF issue - on 6- and 8-cylinder engines, this could only be a MAF issue if P0133 and P0153 are both present) •Inlet air leaks (unmetered air) **Fuel Concerns:** •Poor fuel quality **Base Engine:** •Exhaust leaks (upstream or near HO2S) **HO2S Concerns:** •Contaminated HO2S sensor (contamination from the use of silicone-based cleaners and sealants, leaded fuel, excessive oil consumption, etc.) •Deteriorating HO2S sensor
P0153 - HO2S Sensor Circuit Slow Response (HO2S-21)	Same as DTC P0133, but Bank 2.	See Possible Causes for DTC P0133

HEATED OXYGEN SENSOR (HO2S) MONITOR - HO2S SIGNAL CIRCUIT MALFUNCTION		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0131 - HO2S Sensor Circuit Out of Range Low Voltage (HO2S-11)	The HO2S sensor is monitored for a negative voltage known as Characteristic Shift Downward (CSD). If the sensor is switching from 0 volts to -1 volts during testing and DTC P0131 is present, the PCM will be in FMEM.	**Electrical:** •Contaminated HO2S sensor or connector (coolant, water, silicone, fuel, oil, etc.) •Chafed/damaged wiring •Crossed HO2S signal/signal return wiring •PCM
P0136 - HO2S Sensor Circuit Malfunction (HO2S-12)	The downstream HO2S sensor(s) are continuously checked for maximum and minimum voltages. The code will set when the voltages fail to meet the calibrated limits.	•Disconnected sensor •Pinched, shorted, corroded wiring or pins •Crossed sensor wires •Exhaust leaks •Contaminated or damaged sensor •Chafed/damaged wiring
P0151 - HO2S Sensor Circuit Out of Range Low Voltage (HO2S-21)	Same as DTC P0131, but Bank 2.	See Possible Causes for DTC P0131
P0156 - HO2S Sensor Circuit Malfunction (HO2S-22)	Same as DTC P0136, but Bank 2.	See Possible Causes for DTC P0136

HEATED OXYGEN SENSOR (HO2S) MONITOR - HO2S SIGNAL CIRCUIT MALFUNCTION		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0135 - HO2S Sensor Heater Circuit Malfunction (HO2S-11)	During testing, the HO2S heaters are checked for opens/shorts and excessive current draw. The code will set when current draw exceeds a maximum calibrated limit or falls below a minimum calibrated limit and/or an open or short is detected.	•Blown fuse •Short to VPWR in harness or HO2S •Water in harness connector •Open VPWR or GND circuit •Low battery voltage •Poor electrical connections from PCM to HO2S sensor •HO2S heater •PCM
P0141 - HO2S Sensor Heater Circuit Malfunction (HO2S-12)	Same as DTC P0135, but downstream Bank 1.	See Possible Causes for DTC P0135
P0155 - HO2S Sensor Heater Circuit Malfunction (HO2S-21)	Same as DTC P0135, but Bank 2.	See Possible Causes for DTC P0135
P0161 - HO2S Sensor Heater Circuit Malfunction (HO2S-22)	Same as DTC P0141, but downstream Bank 2.	See Possible Causes for DTC P0135

HEATED OXYGEN SENSOR (HO2S) MONITOR - EXHAUST TEMPERATURE OUT OF RANGE, O2 SENSOR TEST NOT COMPLETED		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P1127 - Exhaust Not Warm Enough, Downstream Sensor Not Tested	The HEGO monitor uses an exhaust temperature model to determine when the HO2S heaters can safely be turned on. The code is set when the inferred exhaust temperature is below a minimum calibrated value.	•Engine not operating long enough prior to performing KOER self-test •Exhaust temperature not warm enough •Pre-existing P0135, P0141, P0155, P0161

HEATED OXYGEN SENSOR (HO2S) MONITOR - SWAPPED HO2S CONNECTOR		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P1128 - Upstream Oxygen Sensors Swapped from Bank 1 (HO2S-11) to Bank 2 (HO2S-21)	The HEGO monitor checks and determines if the HO2S signal response for a KOER fuel shift corresponds to the correct engine bank. The code is set when the expected HO2S response is seen on the opposite bank.	•Crossed HO2S harness connectors - Bank to Bank (upstream) •Crossed HO2S wiring at 104-pin PCM connector or at the HO2S connectors
P1129 - Downstream Oxygen Sensors Swapped from Bank 1 (HO2S-12) to Bank 2 (HO2S-22)	Same as DTC P1128, but downstream.	See Possible Causes for DTC P1128

D.) CATALYST EFFICIENCY MONITOR

D1.) Catalyst Efficiency Monitor - Information

The Federal Test Procedure Catalyst Monitor monitors for deterioration in the catalyst system and illuminates the MIL when tailpipe emissions exceed the appropriate HC emission thresholds. The Catalyst Monitor is enabled after the upstream and downstream HO2S sensors have been tested and verified to be functional. This monitor relies on the front and rear heated oxygen sensors (HO2S) to infer catalyst efficiency based upon oxygen storage capacity. Under normal closed loop fuel conditions, high efficiency catalysts have oxygen storage which makes the switching frequency of the rear HO2S quite slow compared with the frequency of the front HO2S. As catalyst efficiency deteriorates, its ability to store oxygen declines, and the rear HO2S begins to switch more rapidly, approaching the frequency of the front sensor. In general, as catalyst efficiency decreases, the switch ratio increases from a switch ratio of 0 for a low mileage catalyst to a switch ratio of 0.8 or 0.9 for a low efficiency catalyst.

Some vehicles will monitor substantially less than the entire catalyst volume in order to meet the stringent catalyst monitoring malfunction thresholds. In many cases, only the front, light-off catalyst is monitored.

- Front and rear HO2S switches are counted under specified closed loop fuel conditions. After the required number of front switches are obtained, a rear-to-front HO2S switch ratio is calculated. The switch ratio is compared against a threshold value. If the switch ratio is greater than the calibrated maximum limit, the catalyst has failed. The test entry conditions for the Catalyst Efficiency Monitor are as follows: ECT or CHT (warmed engine), IAT (not at extreme ambient temperatures), MAF (greater than minimum engine load), VSS (within vehicle speed window) and TP (at part throttle) are required.
- Because an exponentially weighted moving average is used for malfunction determination, up to six OBD II drive cycles may be required to illuminate the MIL.

NOTE

THE CATALYST MONITOR ON SOME EARLY OBD II VEHICLES (SOME 1994-1996 VEHICLES) WAS REFERRED TO AS THE "STEADY-STATE CATALYST MONITOR" AS OPPOSED TO THE "FTP CATALYST MONITOR" (DESCRIBED ABOVE) THAT IS MOST COMMON FOR VEHICLES BUILT AFTER 1996. BELOW IS A BRIEF DESCRIPTION OF THE STEADY-STATE CATALYST MONITOR:

The Steady-State Catalyst Monitor performs a 20 second test during steady state rpm and load conditions. The Monitor transfers closed loop fuel control from the front to the rear O2 sensors. The Monitor then observes the switching frequency and compares it to a threshold frequency stored in an rpm/load table. A frequency higher than the maximum calibrated threshold indicates a malfunction.

The Catalyst Monitor DTCs can be categorized as follows:

- Catalyst system efficiency below threshold (Bank 1) - P0420
- Catalyst system efficiency below threshold (Bank 2) - P0430

D2.) Catalyst Efficiency Monitor - Diagnostic Trouble Codes

CATALYST EFFICIENCY MONITOR		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0420 - Catalyst System Efficiency Below Threshold (Bank 1)	Indicates Bank 1 catalyst system efficiency is below the acceptable threshold.	•Malfunctioning ECT/CHT •High fuel pressure •Damaged exhaust manifold •Cylinder misfiring •HO2S wiring concerns (shorted or chafed, bent pins, etc.) •Damaged exhaust system pipe •Damaged muffler/tailpipe assembly •Retarded spark timing **Damaged Catalytic Converter:** •Use of leaded fuel •Oil contamination/consumption •Silicone contamination (sealants/cleaners)
P0430 - Catalyst System Efficiency Below Threshold (Bank 2)	Same as DTC P0420, but opposite bank.	See Possible Causes for DTC P0420

E.) FUEL SYSTEM MONITOR

E1.) Fuel System Monitor - Information

The Fuel System Monitor is an on-board strategy designed to monitor the fuel trim system. The fuel control system uses fuel trim tables stored in the PCM's KAM to compensate for variability in fuel system components due to normal wear and aging. Fuel trim tables are based on vehicle speed and engine load. During closed loop vehicle operation, the fuel trim strategy learns the corrections needed to correct a "biased" rich or lean fuel system. The correction is stored in the fuel trim tables. The fuel trim has two means of adapting; a LONGFT and a SHRTFT. LONGFT relies on the fuel trim tables and SHRTFT refers to the desired air/fuel ratio parameter "LAMBSE". LAMBSE is calculated by the PCM from HO2S inputs and helps maintain a 14.7:1 air/fuel ratio during closed loop operation. SHRTFT and LONGFT work together. If the HO2S indicates the engine is running rich, the PCM will correct the rich condition by moving SHRTFT in the negative range (less fuel to correct for a rich combustion). If after a certain amount of time SHRTFT is still compensating for a rich condition, the PCM "learns" this and moves LONGFT into the negative range to compensate and allows SHRTFT to return to a value near 0%. Input from the ECT or CHT, IAT, and MAF sensors is required to activate the fuel trim system, which in turn activates the Fuel System Monitor. Once activated, the Fuel System Monitor looks for the fuel trim tables to reach the adaptive clip (adaptive limit) and LAMBSE to exceed a calibrated limit. The Fuel System Monitor will store the appropriate DTC when a fault is detected as described below.

- The HO2S detects the presence of oxygen in the exhaust and provides the PCM with feedback indicating a rich or lean condition.
- A correction factor is added to the fuel injector pulsewidth calculation according to the Long and Short Term Fuel Trims as needed to compensate for variations in the fuel system.
- When deviation in the parameter LAMBSE increases, air/fuel control suffers and emissions increase. When LAMBSE exceeds a calibrated limit and the fuel trim table has clipped (reached adaptive limit), the Fuel System Monitor sets a DTC.
- The MIL is activated after a fault is detected on two consecutive OBD II drive cycles.

The Fuel System Monitor DTCs can be categorized as follows:

- Fuel Delivery Error - P0148
- Lean shift in fuel system operation - P0171 (Bank 1) and P0174 (Bank 2)
- Rich shift in fuel system operation - P0172 (Bank 1) and P0175 (Bank 2)

E2.) Fuel System Monitor - Diagnostic Trouble Codes

FUEL SYSTEM MONITOR		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0148 - Fuel Delivery Error	At least one bank lean at wide open throttle.	**Fuel System:** •Severely restricted fuel filter •Severely restricted fuel supply line
P0171 - System Too Lean (Bank 1)	The Adaptive Fuel Strategy continuously monitors fuel delivery hardware. The code is set when the adaptive fuel tables reach a rich calibrated limit.	**Fuel System:** •Contaminated fuel injectors •Low fuel pressure or running out of fuel (fuel pump, filter, fuel supply line restrictions) •Vapor recovery system (VMV) **Induction System:** •MAF contamination •Air leaks between the MAF and throttle body •Vacuum leaks •PCV system concern •Improperly seated engine oil dipstick **EGR System:** •Leaking gasket •Stuck EGR valve •Leaking diaphragm or EVR **Base Engine:** •Exhaust leaks before or near the HO2S •Secondary air concern **Powertrain Control System:** •PCM concern
P0174 - System Too Lean (Bank 2)	Same as DTC P0171, but Bank 2.	See Possible Causes for DTC P0171

FUEL SYSTEM MONITOR		
Diagnostic Trouble Code	**Description**	**Possible Causes**
P0172 - System Too Rich (Bank 1)	The Adaptive Fuel Strategy continuously monitors fuel delivery hardware. The code sets when the adaptive fuel tables reach a lean calibrated limit.	**Fuel System:** •Excessive fuel pressure •Leaking/contaminated fuel injectors •Vapor recovery system concern **Base Engine:** •Oil overfill •Cam timing concern •Low cylinder compression •Excessive engine wear **Powertrain Control System:** •PCM concern **Induction System:** •MAF contamination
P0175 - System Too Rich (Bank 2)	Same as DTC P0172, but Bank 2.	See Possible Causes for DTC P0172

F.) DIAGNOSTIC SERVICE TIPS

F1.) Diagnostic Service Tips - General

1. **Always reset KAM after performing a repair:** After performing a repair on a vehicle with the MIL on, and/or DTCs present, always clear KAM. When a malfunction is present, the PCM adapts (attempts to correct) for this condition. Once the vehicle has been repaired, if the KAM is not reset, the PCM will once again have to adapt back to the normal operating conditions. Clearing the KAM will erase what the PCM has learned, so the PCM will be able to start with "base tables".

2. **Always view and record Freeze Frame Data:** Freeze Frame Data can be a valuable asset in duplicating and diagnosing concerns. This data (a snapshot of certain PID values, recorded at the time the MIL was activated) indicates the manner in which the vehicle was being driven at the time the fault occurred. This can be especially useful on intermittent concerns. Freeze Frame Data, in some cases, can also help to isolate possible areas of concern, as well as ruling out others. Always record (write down) the Freeze Frame Data.

3. **Multiple DTCs (with the same meaning):** When multiple (paired) DTCs with the same meaning are set for multiple sensors, it is unlikely that replacing both HO2S sensors will resolve the concern. In most cases, there will be another issue that is causing the codes. Examples of multiple (paired) DTCs: (P0135/P0155), (P0141/P0161), (P1131/P1151), (P1132/P1152).

To further clarify this, see the more detailed scenario as follows:

A vehicle comes in with a MIL On concern. KOEO self test reveals DTCs P0135 and P0155 (HTR-11 and HTR-21 circuit malfunction), with no other DTCs present. The most likely cause of these DTCs would be something in the heater power circuit that both of these HO2S sensors have in common (Example: open or shorted heater circuit wiring or splice). It is highly unlikely that multiple sensors would fail at the same time. When multiple DTCs of this nature are encountered, reviewing the appropriate wiring diagram(s) can help to isolate possible areas of concern. When reviewing the wiring diagram, look for things that the affected sensors have in common.

In this example, the most likely cause of DTCs P0135 and P0155 (with no other DTCs present) would be a concern with Splice "B" (refer to Figure 2).

NOTE

THIS ILLUSTRATION IS ONLY AN EXAMPLE. SPLICE NAMES "A", "B", AND "C" ARE USED IN THIS EXAMPLE FOR CONVENIENCE ONLY. ON AN ACTUAL VEHICLE, SPLICE NAMES WILL DEPEND ON THE CIRCUIT NUMBER FOR THE VEHICLE UNDER REPAIR. NOTE ALSO THAT THIS FIGURE IS NOT INTENDED TO SHOW ALL SPLICES/CONNECTIONS ON ALL VEHICLES. OTHER EEC CIRCUITS, NOT SHOWN, MAY ALSO BE SPLICED IN WITH THE CIRCUITS SHOWN.

4. **View HO2S PID data carefully:** NGS PIDs for HO2S sensors that do not exist (with certain exhaust configurations) will show a value of "0" volts (refer to Figures 3 and 4).

In this example, the vehicle (equipped with a 4-cylinder engine) has one upstream and one downstream HO2S. Notice that the NGS (scan tool) display shows two upstream and two downstream HO2S PIDs, and that the "unused" HO2S sensor PIDs display "0" volts.

5. **HO2S sensors measure oxygen in the exhaust, not fuel:** The exhaust gas condition reported by the HO2S sensor is based on the presence of oxygen in the exhaust, not the presence of unburned fuel.

Example: In the event of an ignition-related misfire, you might expect a rich HO2S reading, due to the amount of unburned fuel in the exhaust system. However, there is also a large amount of unburned oxygen, since no combustion took place in the misfiring cylinder. Since the HO2S senses oxygen only, it would report a lean condition in this particular situation.

F2.) Tips Related to Heated Oxygen Sensor (HO2S) Monitor

1. **OBD II Response Rate Monitor:** The OBD II Response Rate Monitor (P0133/P0153) is only run at vehicle speeds between approximately 50-95 km/h (30-60 mph), during steady-state conditions. The test lasts approximately 6 seconds. Therefore, P0133/P0153 cannot be diagnosed at idle in the repair bay.

2. **Do not compare HO2S switch rate - Bank-to-Bank or vehicle-to-vehicle:** Different HO2S switch rates, from Bank-to-Bank, are considered normal. The HO2S switch rate, from one Bank to the other, should not be compared as a gauge of the HO2S's ability to switch/react. The PCM is continuously adjusting spark and fuel in reaction to engine operating conditions (rpm, load, air flow, throttle angle, etc.). The PCM is also continuously adapting to certain conditions (customer driving habits, engine and component wear, etc.).

F3.) Tips Related to Catalyst Efficiency Monitor

1. **Determining catalyst efficiency/switch ratio:** The upstream HO2S sensors will have a high switch frequency, due to normal closed loop fuel control. With an efficient catalyst, the downstream HO2S will have a low switch frequency. The switch ratio is determined by dividing the number of downstream switches by the number of upstream switches over a given period of time. As the catalyst ages (or if the catalyst is damaged or contaminated), the downstream switches will increase. When the downstream switch rate crosses a threshold value (approximately 0.75 switch ratio), a code is stored (P0420 and/or P0430) and the MIL illuminates (refer to Figures 5 and 6).

NOTE

IF A CATALYST IS DETERMINED TO HAVE LOW EFFICIENCY AND REQUIRES REPLACEMENT, REPLACEMENT OF THE DOWNSTREAM HO2S SENSORS WILL NOT BE NECESSARY.

2. **Use care in handling HO2S sensors:** In the event of catalyst replacement, use care in the handling of HO2S sensors to prevent damage or contamination. Do not use power tools in the removal or installation of sensors. Use a 22mm wrench or crow foot to remove and install HO2S sensors; do not use slotted sockets, as these sockets may damage wires. HO2S sensors should be torqued to 41 ±5 N•m (30 ±4 lb-ft).

3. **Do not replace downstream HO2S sensors (HO2S12/HO2S22) for DTCs P0420 and/or P0430:** When diagnosing a vehicle with a customer concern of MIL On and DTCs P0420/P0430 in continuous memory, do not replace the downstream HO2S sensors (HO2S12/HO2S22). Damaged or malfunctioning downstream HO2S sensors will not cause these DTCs to be set. Always verify the vehicle concern, then perform the pinpoint diagnostics in the appropriate PC/ED Service Manual.

F4.) Tips Related to the Fuel System Monitor

1. **HO2S sensors are not likely to be the cause of adaptive DTCs P0171, P0172, P0174, P0175:** Most warranty-returned HO2S sensors (replaced for these DTCs) are found to function normally. Additional related DTCs will normally be present if there is a concern with the HO2S sensors. Do not replace an HO2S sensor unless verified through pinpoint diagnostic tests found in the PC/ED Service Manual.

2. **DTCs P0171, P0172, P0174, and P0175 are not related to downstream HO2S sensors:** When diagnosing a vehicle with a MIL On and DTC(s) P0171, P0172, P0174, and/or P0175 in continuous memory, do not replace the downstream HO2S sensors. These DTCs have no connection to the downstream HO2S sensor function nor its diagnosis for faults. Always verify the vehicle concern, then perform the pinpoint diagnostics from the appropriate PC/ED Service Manual.

3. **Diagnosing lean conditions and lean DTCs P0171, P0174:** Freeze Frame Data can often help to identify the type of lean condition, even if the fault is intermittent, by indicating how the vehicle was being driven when the fault occurred. Diagnosis of lean conditions and lean adaptive DTCs can be difficult, especially if the concern is intermittent. Verifying the concern is extremely important. There are different types of lean conditions. The ability to identify the type of lean condition causing the concern can be crucial to a correct diagnosis. When DTCs P0171 and P0174 are both present, there is a strong likelihood of another concern being present:

   a. **Vacuum leaks/unmetered air:** In this type of condition, the engine may actually run lean of stoichiometry (14.7:1 air/fuel ratio) if the PCM is not able to compensate enough to correct for the condition. This condition is typically caused by air entering the engine through an abnormal source (opening), or due to a MAF malfunction. In this situation, the volume of air entering the engine is actually greater than what the MAF is indicating to the PCM. Vacuum leaks will normally be most apparent when high manifold vacuum is present, during idle or light throttle. If Freeze Frame Data indicates that the fault occurred at idle, a check for vacuum leaks/unmetered air when the engine is cold might be the best starting point.

Examples: Loose, leaking or disconnected vacuum lines, intake manifold gaskets or O-rings, throttle body gaskets, brake booster, air inlet tube, stuck/frozen/aftermarket PCV valve, unseated engine oil dipstick, MAF reading lower than normal, etc.

   b. **Insufficient fueling:** In this type of condition, the engine may actually run lean of stoichiometry (14.7:1 air/fuel ratio) if the PCM is not able to compensate enough to correct for the condition. This condition is typically caused by a fuel delivery system concern that restricts or limits the amount of fuel being delivered to the engine. This condition will normally be most apparent when the engine is under a heavy load, when a higher volume of fuel is required. If Freeze Frame Data indicates that the fault occurred under a heavy load, a check of the fuel delivery system (checking fuel pressure with engine under a load) might be the best starting point.

Examples: Low fuel pressure (fuel pump, fuel filter, fuel leaks, restricted fuel supply lines), fuel injector concerns, etc.

c. **Exhaust system leaks:** In this type of condition, the engine may actually be running near stoichiometry (14.7:1 air/fuel ratio), but the exhaust gas mixture will be lean. This condition is caused by oxygen-rich air entering the exhaust system through an external source. This condition will cause the exhaust gas mixture to be lean, even though the actual combustion in the engine may not be.

Examples: Exhaust system leaks upstream or near HO2S, malfunctioning Secondary Air Injection system.

d. **MAF concerns:** If a MAF concern is suspected, see TSB 98-23-10.

4. **Checking fuel pressure:** Check fuel pressure with engine under a load when diagnosing a lean concern. A partially plugged fuel filter can be difficult to detect and can be easily overlooked if fuel pressure is only checked at idle. The same is true for other types of fuel supply concerns (e.g., bent or kinked lines, degraded fuel pump).

At idle, an engine requires only a small volume of fuel. Due to the fact that there is a small volume of fuel needed at idle, a restriction in the fuel supply line in many cases will not cause the fuel pressure to be low. When the vehicle is under a load, the engine requires much more fuel than at idle. Under a load, a restriction in the fuel supply line will prevent the high rate of fuel flow that is needed to maintain the correct fuel pressure.

OTHER APPLICABLE ARTICLES: 98-23-10
WARRANTY STATUS: INFORMATION ONLY
OASIS CODES: 623000, 690000, 698298

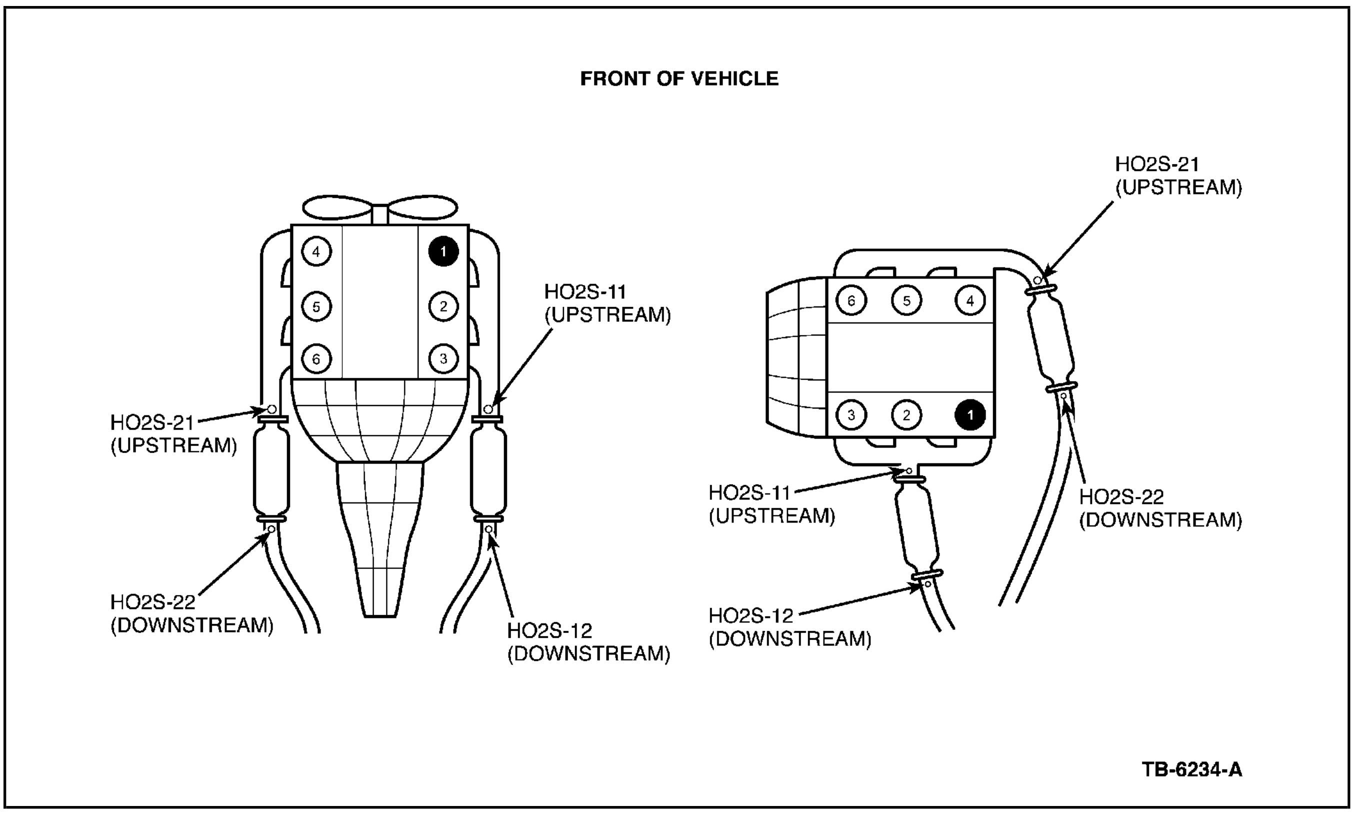

Figure 1 - Article 01-9-7

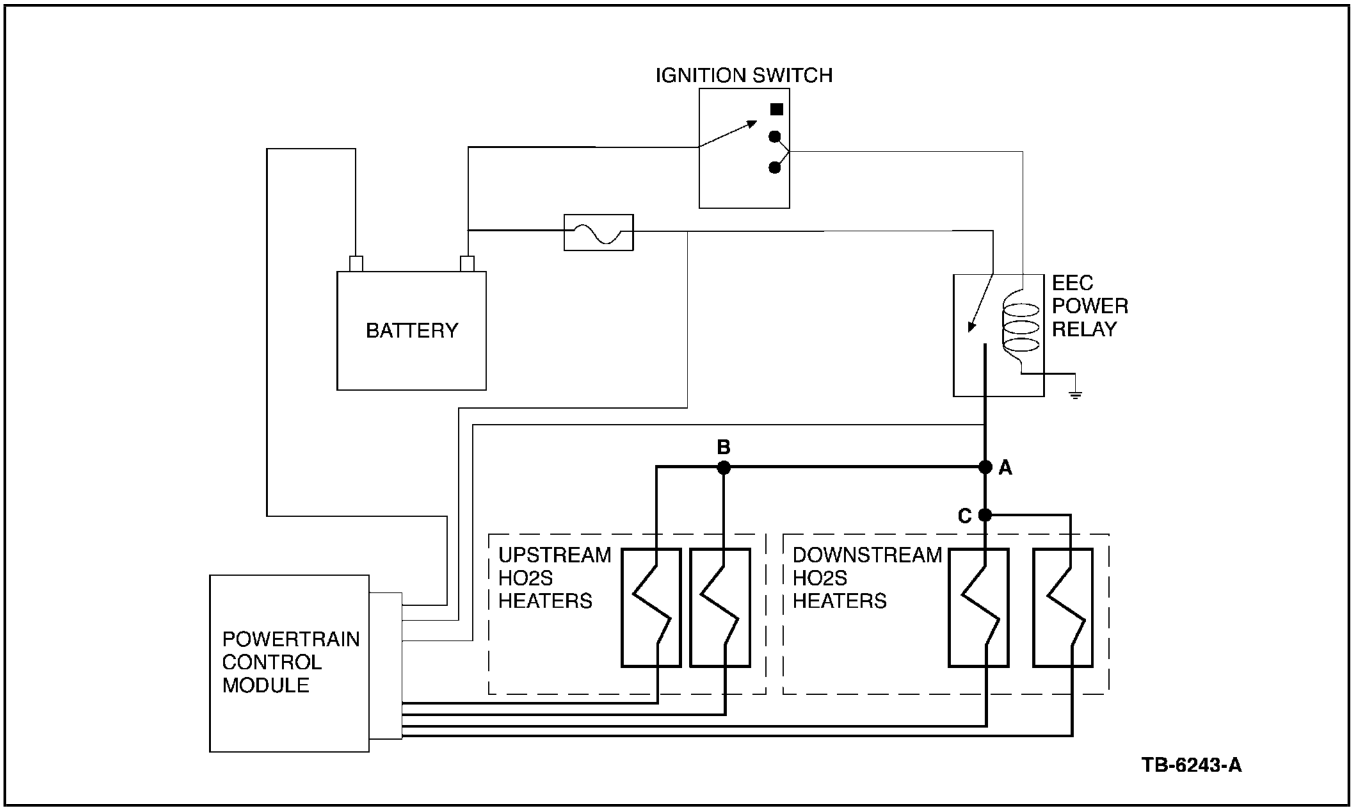

Figure 2 - Article 01-9-7

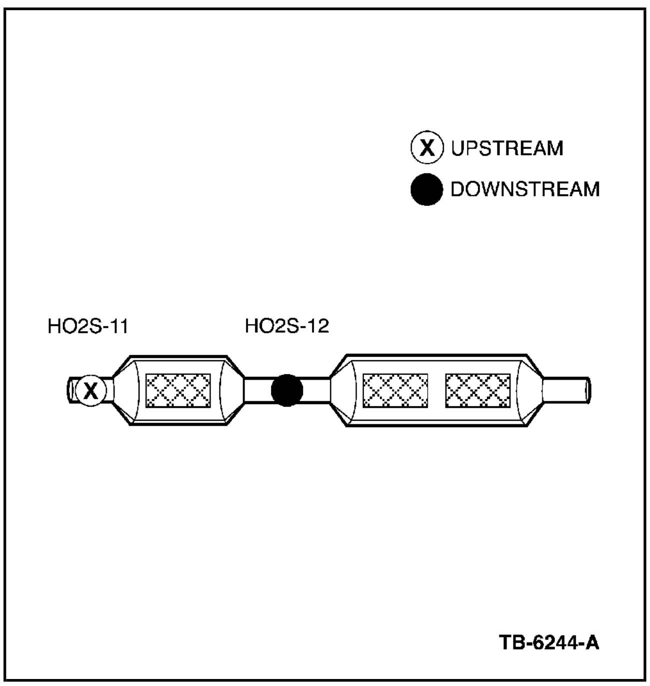

Figure 3 - Article 01-9-7

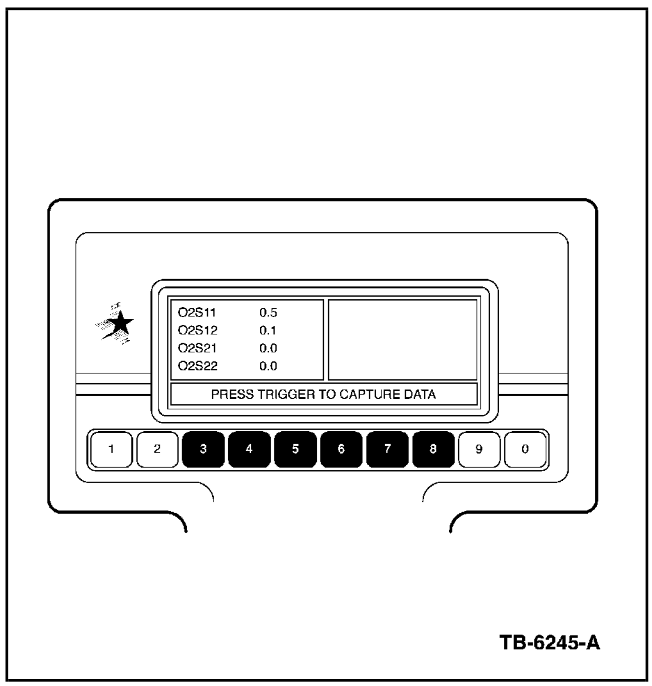

Figure 4 - Article 01-9-7

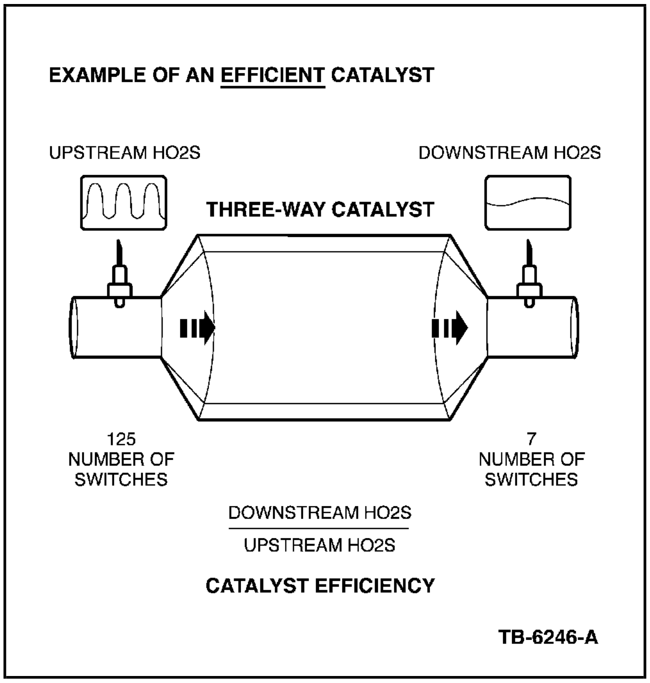

Figure 5 - Article 01-9-7

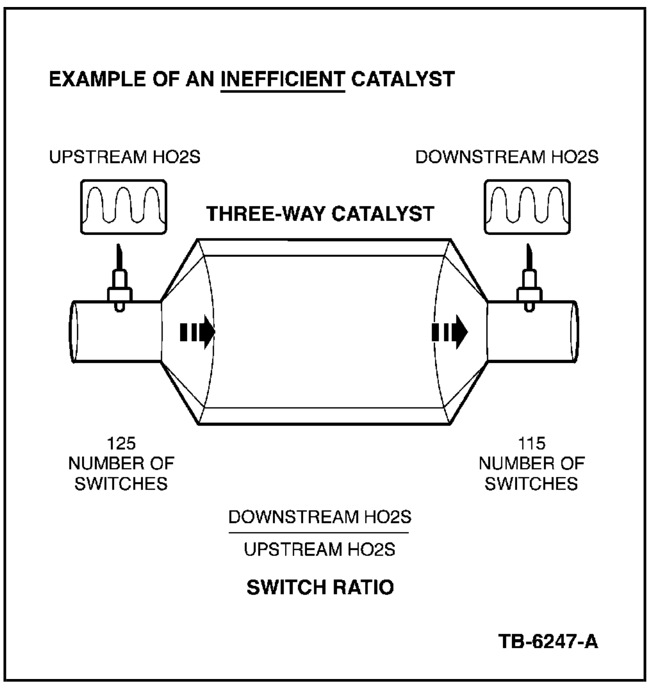

Figure 6 - Article 01-9-7