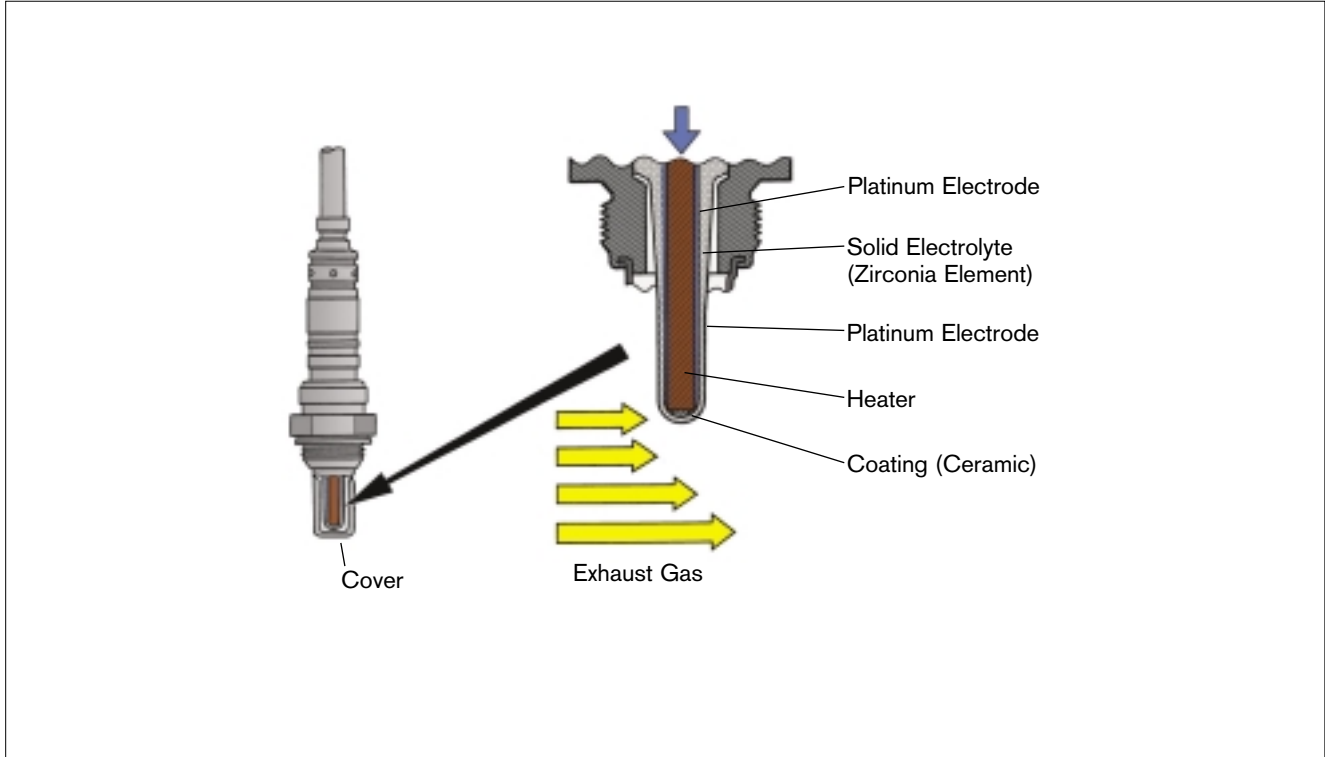


## O<sub>2</sub> and A/F Sensor Diagnosis

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### Learning Objectives:

1. Determine the condition of an O<sub>2</sub> sensor, A/F sensor and heater based on data and engine symptoms and determine appropriate repair.
2. Use Modes 5, 6, and 7 to determine monitored O<sub>2</sub> sensor results.
3. Accurately measure and interpret oxygen content of the exhaust gases based on sensor signal data.
4. Describe the primary difference between the O<sub>2</sub> sensor and the A/F sensor.
5. Use Modes 6 and 7 to determine monitored A/F sensor results.

# O2 & A/F Sensor Diagnosis

## O2 Sensor Locations

*S1 designates the oxygen sensor is before the catalytic converter, S2 after the catalytic converter. B1 indicates the sensor is on the bank with cylinder No. 1.*

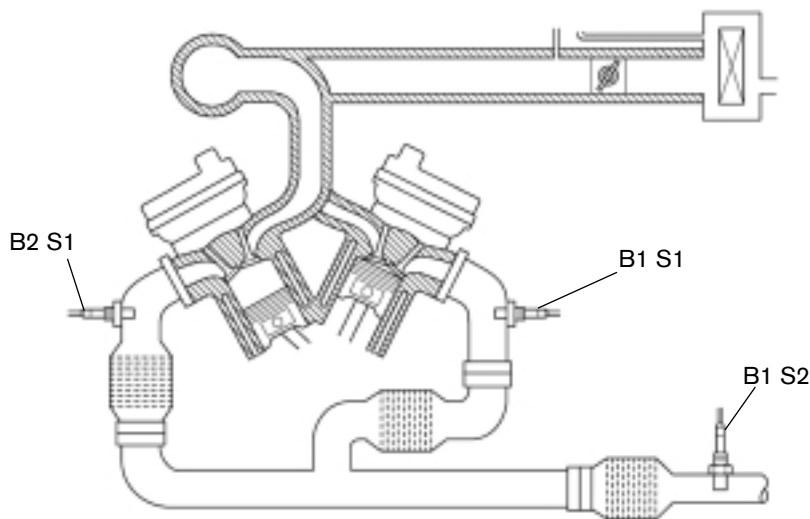


Fig. 7-1

TL874f701

**Overview** The ECM uses an O2 sensor to ensure the A/F Ratio is correct for the catalytic converter. Based on the oxygen sensor signal, the ECM's fuel control program adjusts the amount of fuel injected into the cylinder. This program varies based on the type of O2 sensor.

There are different types of O2 sensors, but two of the more common types are the:

- narrow range O2 sensor, the oldest style, simply called the O2 sensor.
- wide range O2 sensor, the newest style, called the A/F sensor.

OBD II vehicles require two O2 sensors: one before and one after the catalytic converter. The O2 sensor, or A/F sensor before the catalytic converter is used by the ECM to adjust the A/F Ratio. The O2 sensor after the catalytic converter is primarily used for catalytic converter efficiency control and monitoring. (See Section 8 Overview)

## O2 Sensor Monitor

The O2 sensor monitor checks for sensor circuit malfunctions, slow response rate, and for a malfunction of the sensor's heater circuit. There is a DTC for each condition for each sensor. The sub-sensor(S2) is not monitored for response rate. O2 sensors are required to be monitored once per trip, however, the ECM continuously monitors O2 sensor operation.

When the ECM sees the right conditions, the ECM will test the O2 sensors for performance by measuring the signal response as the fuel injected into the cylinder is varied. The faster the O2 sensor responds, the better the sensor. Mode 5 will report the results of this monitor test.

The repair confirmation drive pattern in the Repair Manual provides the driving conditions for the ECM to operate the O2 sensor monitor.

## P0125 for O2 Sensor

DTC P0125 is stored when there is little or no signal response from the O2 sensor. Although the description in the Repair Manual states "insufficient coolant temp for closed loop fuel control" for this code, this can be one cause for no signal output from the O2 sensor. The sensor is monitored for a rise in voltage to (0.45V) when:

- Engine speed is 1,500 rpm or more
- Vehicle speed is 25 – 62 mph (40 – 100 km/hr)
- TPS does not register idle
- The condition continues for at least 90 sec.
- 140 seconds or more must have passed since the engine was started

This DTC is a one trip code, and will also set as a result of a problem due to any of the following items:

- Air induction system
- EGR system
- Fuel pressure
- Fuel injection
- Gas leakage on exhaust system
- Other related parts failure

**NOTE** This DTC will set when a sensor output has very little or no activity.

**HINT** A lean condition or an inoperative sensor will have very little activity.

If the vehicle runs out of fuel, the A/F Ratio is lean and DTC P0125 may be recorded. This DTC will also set if no signal is received by the ECM; for example, an open circuit (broken wire).

**P0130, P0150:** This portion of the monitor is concerned with sensor voltage output.

**O2 Sensor Output Voltage** These DTC(s) set if the output voltage stays high or low during the test period.

### ***O2 Sensor Monitor P0130, P0150 (Output Voltage)***

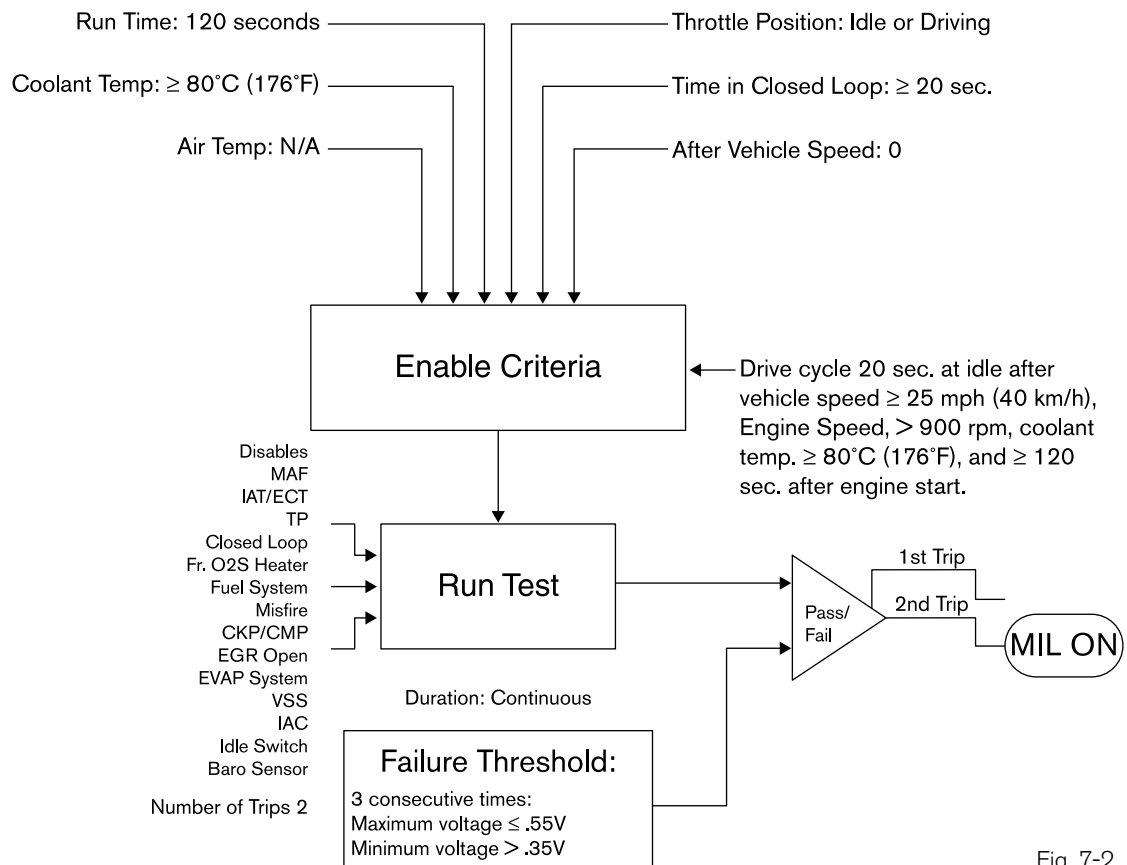


Fig. 7-2

TL8747702

P0133, P0153: The ECM monitors the response of the O2 sensor.

### O2 Sensor

**Response Rate** This part of the monitor is concerned with the time the O2 sensor takes to switch from .35V and .55V.

#### NOTE

The failure threshold for switching can be as much as 1.1 seconds (max).

### ***O2 Sensor Monitor P0133, P0153 (Response Rate)***

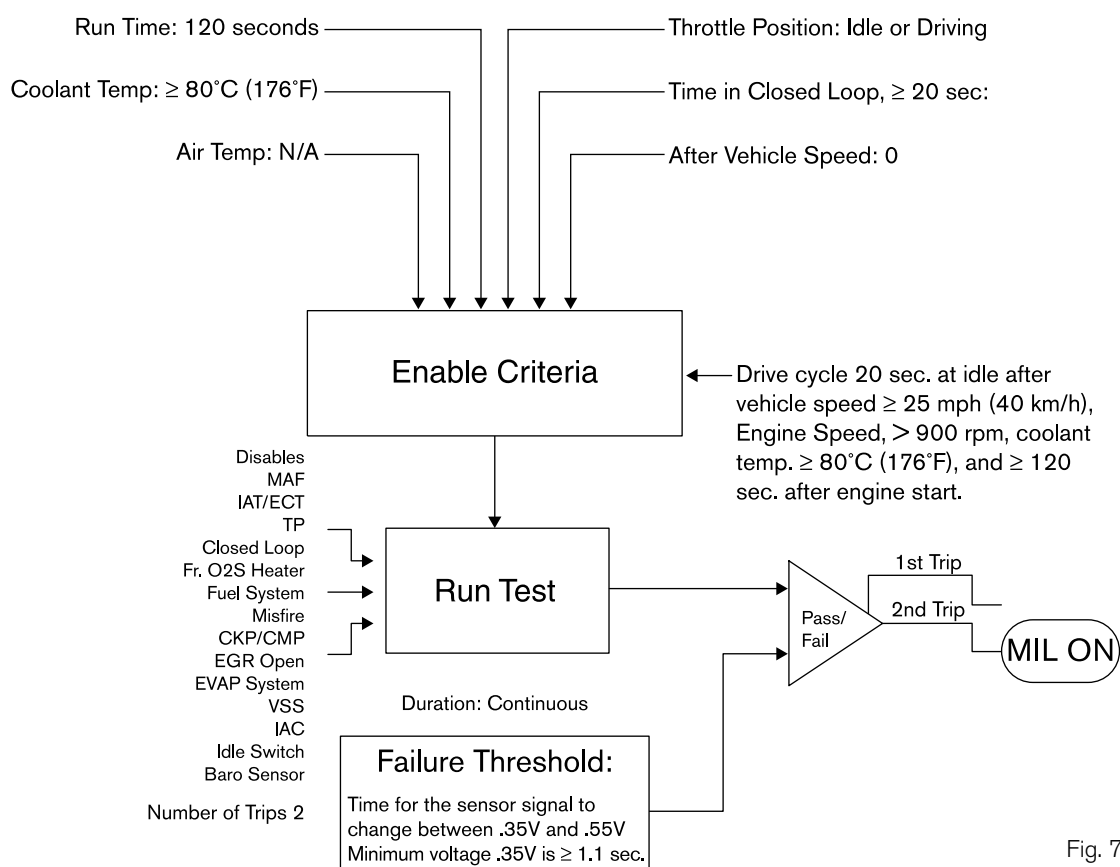


Fig. 7-3

TL874f703

### O2 Sensor Detection Driving Pattern

The detection driving pattern shown will provide the conditions necessary for the O2 Sensor to show a response. If the sensor output remains within the failure threshold a DTC will set when all test parameters are met.

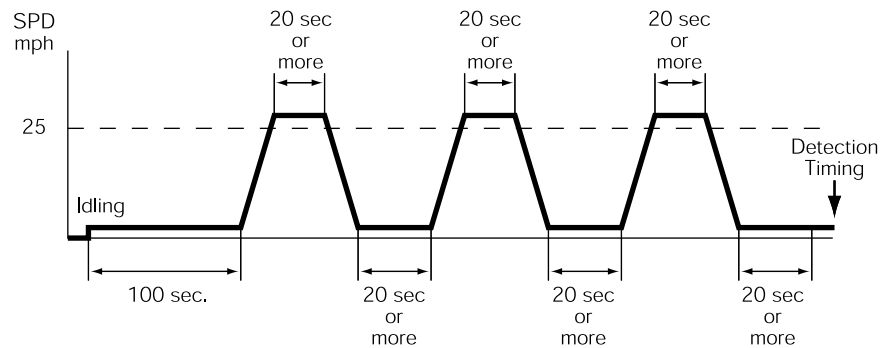


Fig. 7-4

TL874f704

### Mode 5 O2 Sensor Monitoring Test Results

This mode displays the test results of the O2 sensor test monitor. These values are stored values, not current values that are found in Mode 1 (DATA LIST). Not all test values are applicable to all manufacturers. The A/F sensor test values are not applicable and are not displayed in Mode 5. Some vehicles use Non-Continuous Test Results mode to report results.

The following is a definition for the displayed terms under Mode 5, O2S Test Results:

- **R>>L O2S V** Rich to lean threshold voltage – voltage used by the ECM to determine the boundary line when going from rich to lean  
**L>>R O2S V** Lean to rich threshold voltage – voltage used by the ECM to determine the boundary line when going from lean to rich
- **LOW SW V** Low sensor voltage point for switch time calculation – value used by the ECM for switch time calculation  
**HIGH SW V** High sensor voltage point for switch time calculation – value used by the ECM for switch time calculation
- **R>>L SW TIM** Rich to lean switch time – time in seconds it takes to switch from Rich to Lean based on high to low switch voltages  
**L>>R SW TIM** Lean to rich switch time – time in seconds it takes to switch from Rich to Lean based on low to high switch voltages
- **MIN O2S V** Minimum sensor voltage during the test cycle  
**MAX O2S V** Maximum sensor voltage during the test cycle
- **O2S TRANS T** Time between sensor transitions – time between the rich to lean and lean to rich threshold voltages

- **TID \$30** – The amount of time, used as a reference for the number (counts) each time the O2 sensor signal crosses the low and high sensor voltage points

**TID \$70** – The number of counts, determined by the number of times the signal crossed the low and high sensor voltage points

This screens data can be used as a report on the condition of the O2 sensor. A malfunctioning sensor will switch slowly or not at all. Please keep in mind that other factors can affect O2 sensor performance.

### **O2 Sensor Monitoring Screens - Mode 5**

*These screens are found under the  
CARB section, O2S Test results.*

#### O2 SENSOR TEST (B1 - S1)

LOW SW V..... 0.350V  
HIGH SW V..... 0.550V  
MIN O2S V..... 0.025V  
MAX O2S V..... 0.790V  
Time \$31..... 0.04s  
Time \$32..... 0.04s

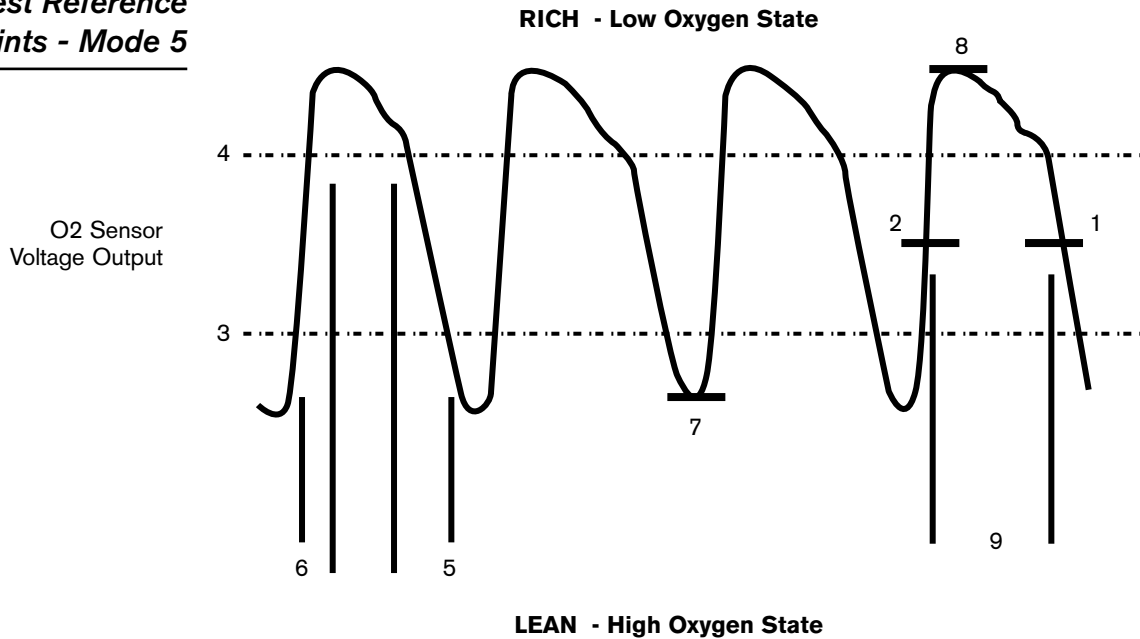
#### O2 SENSOR TEST (B2 - S2)

MIN O2S V..... 0.085V  
MAX O2S V..... 0.785V

Fig. 7-5

TL874f705

**O2 Sensor  
Test Reference  
Points - Mode 5**



- 1) R>>L O2S V Rich to lean threshold voltage
- 2) L>>R O2S V Lean to rich threshold voltage
- 3) LOW SW V Low sensor voltage for switch time calculation
- 4) HIGH SW V High sensor voltage for switch time calculation
- 5) R>>L SW TIM Rich to lean switch time
- 6) L>>R SW TIM Lean to rich switch time
- 7) MIN O2S V Minimum sensor voltage during the test cycle
- 8) MAX O2S V Maximum sensor voltage during the test cycle
- 9) O2S TRANS T Time between sensor transitions

Fig. 7-6

TL874f706



### **O2 Sensor Counts**

*The ECM provides the number of counts in a given time period. A count is when the voltage signal first crosses the high or low sensor voltage point.*

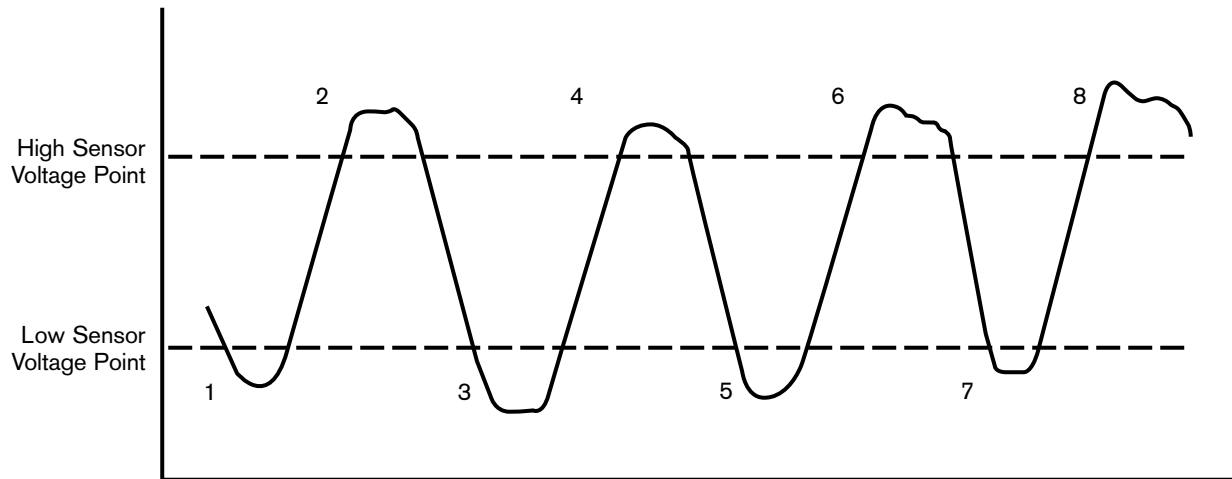


Fig. 7-7  
TL874707

### **Poor O2 Sensor Response**

*Poor O2 Sensor  
response as seen  
on an oscilloscope.*

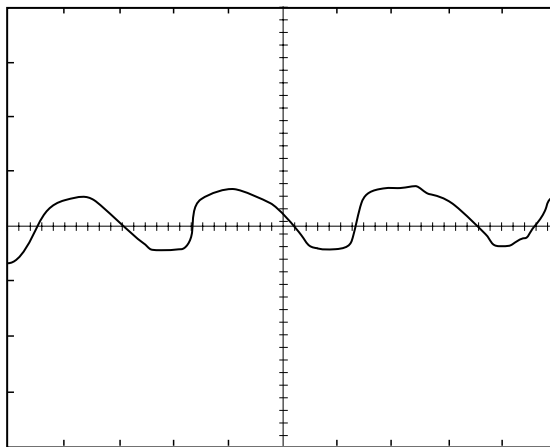


Fig. 7-8  
TL874708

P0136, P0156: The ECM monitors the output voltage of the O2 sensor. A DTC will set if Sub O2 Sensor output voltage remains high or low during the test period. See Mode 5, Output Voltage O2S Test Results.

### Sub O2 Sensor Test Results

O2 SENSOR TEST (B2 - S2)

MIN O2S V..... 0.085V

MAX O2S V..... 0.785V

Fig. 7-9

TL874709

### Sub O2 Sensor Monitor P0136, P0156

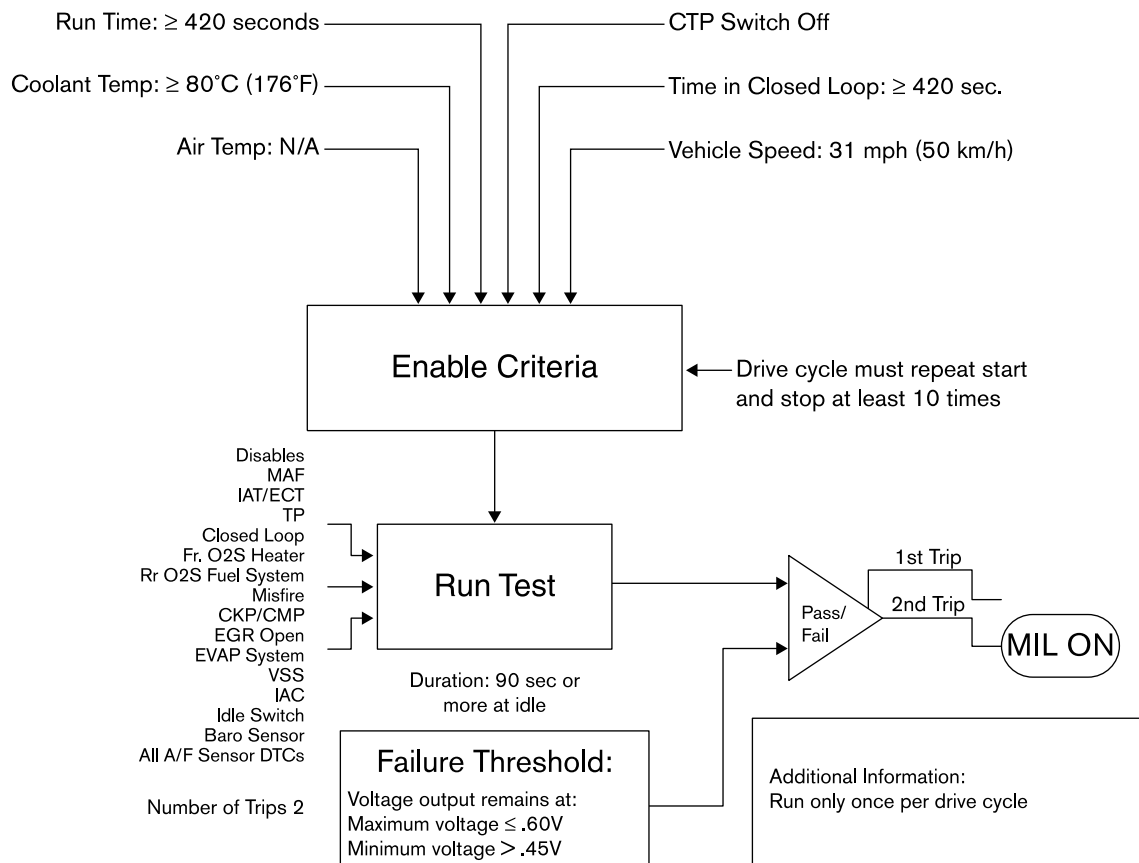


Fig. 7-10

TL874403710

**Sub O2****Sensor Detection  
Driving Pattern**

The detection driving pattern shown will provide the conditions necessary for the Sub or rear O2 Sensor to show a response. If the sensor output remains within the failure threshold a DTC will set when all test parameters are met.

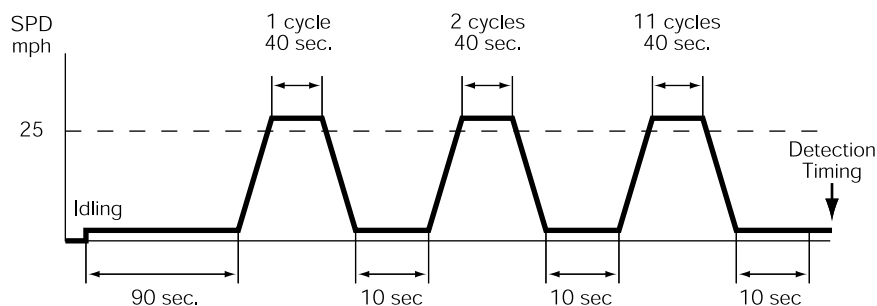


Fig. 7-11

TL874F711

**P0135, P0141, P0155, P0161:** All heated O2 sensors are monitored for abnormal heater condition. The ECM checks the amount of current required for the sensor heater. If the current is too high or too low a DTC will be set.

**O2 Sensor Heater Monitor**

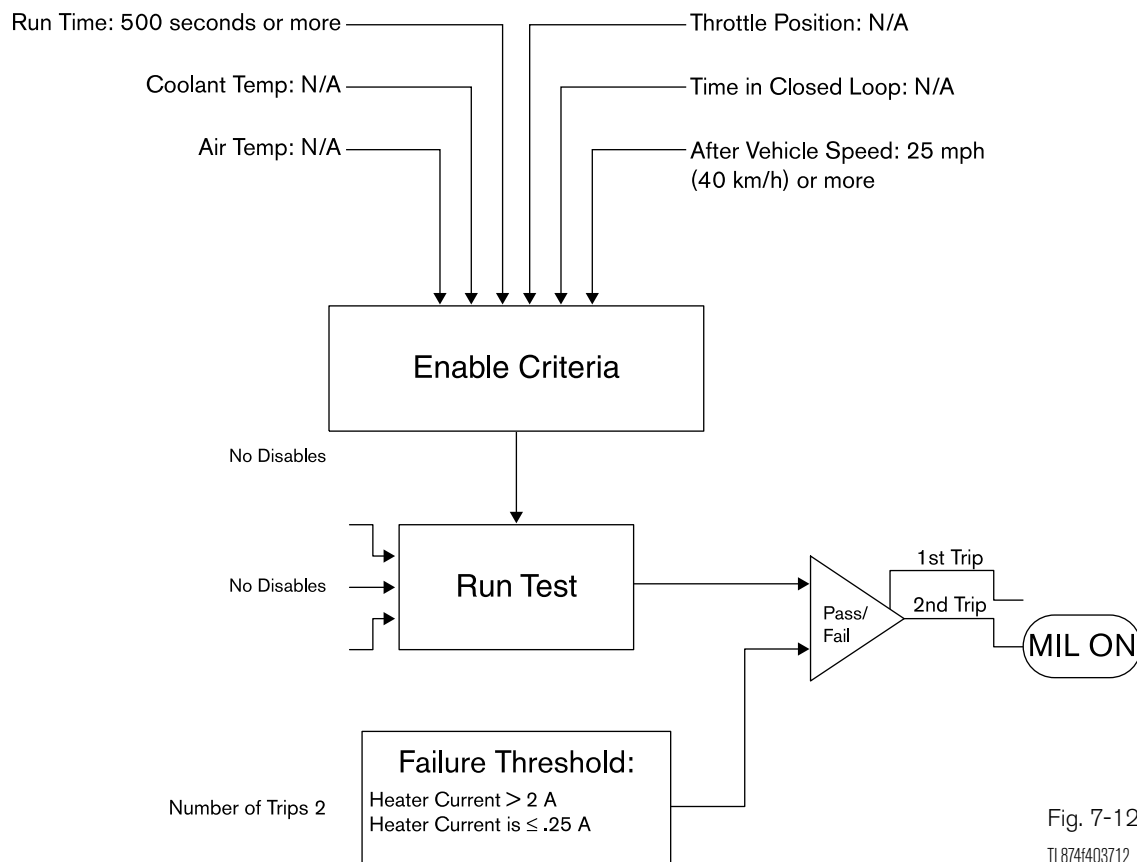
**O2 Sensor Heater Monitor**  
**P0135, P0141, P0155**  
**(Circuit Current)**


Fig. 7-12

TL874F403712

## O2 Sensor DTC(s)

**P0125:** After the engine is warmed up, heated O2 sensor output does not indicate RICH even when conditions (a), (b), (c) and (d) continue for at least 1.5 min.:

**Coolant Temperature Insufficient for Closed Loop Operation (Bank 1 or 2 Sensor 1)**

- a. Engine speed: 1,500 rpm or more
- b. Vehicle speed: 25 - 62 mph (40 - 100 km/h)
- c. Throttle valve does not fully close
- d. 140 sec. or more after starting engine

This DTC can be set due to other related parts failure.

**P0130:** Voltage output of heated O2 sensor remains at 0.40V or more, or 0.55V or less, during idling after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.

**Heated O2 Sensor Circuit Malfunction (Bank 1 Sensor 1)** (two trip detection logic)

This DTC can be set due to other related parts failure.

**P0133:** Response time for the heated O2 sensor's voltage output to change from rich to lean, or from lean to rich, is 1.1 sec. or more during idling after the engine is warmed up.

**Heated O2 Sensor Circuit Slow Response (Bank 1 Sensor 1)** (two trip detection logic)

This DTC can be set due to other related parts failure.

**P0135:** Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.

**O2 Sensor Heater Circuit Malfunction (Bank 1 Sensor 1)** (two trip detection logic)

This DTC can be set due to other related parts failure.

**P0136:** Voltage output of the heated O2 sensor (bank 1 sensor 2, bank 2 sensor 2) remains at 0.4V or more or 0.5V or less when the vehicle is driven at 19 mph (30 km/h) or more after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.  
**Heated O2 Sensor Circuit Malfunction**  
(Bank 1 Sensor 2)

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P0141:** Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.  
**Heated O2 Sensor Heater Circuit Malfunction**  
(Bank 1 Sensor 2)

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P0150:** Voltage output of heated O2 sensor remains at 0.40V or more, or 0.55V or less, during idling after the engine is warmed up. Please confirm voltage specification in vehicle Repair Manual.  
**Heated O2 Sensor Circuit Malfunction**  
(Bank 2 Sensor 1)

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P0153:** Response time for the heated O2 sensor's voltage output to change from rich to lean, or from lean to rich, is 1.1 sec. or more during idling after the engine is warmed up.  
**Heated O2 Sensor Circuit Slow Response**  
(Bank 2 Sensor 1)

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P0155:** Heater current exceeds 2A or heater current of 0.2A or less when the heater operates. Please confirm heater resistance specification in vehicle Repair Manual.  
**Heated O2 Sensor Heater Circuit Malfunction**  
(Bank 2 Sensor 1)

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P0156:** Voltage output of the heated O2 sensor (bank 1 sensor 2, bank 2 sensor 2) remains at 0.4V or more or 0.5V or less when the vehicle is driven at 19 mph (30 km/h) or more after the engine is warmed up.  
**Heated O2 Sensor Circuit Malfunction**  
**(Bank 2 Sensor 2)** (two trip detection logic)

This DTC can be set due to other related parts failure.

**P0141:** Heater current exceeds 2A or heater current of 0.2A or less when the heater operates.  
**Heated O2 Sensor Heater Circuit Malfunction**  
**(Bank 2 Sensor 2)** (two trip detection logic)  
This DTC can be set due to other related parts failure.

**O2 Sensor Monitor Diagnosis** When an O2 sensor DTC is found, it is important to look at each DTC description carefully before proceeding with diagnosis. In addition to P0125, each main O2 sensor has three DTC(s), one for a sensor circuit malfunction, one for slow response, and one for the sensor's heater circuit malfunction.

The sub O2 sensors have two DTC(s), one for a sensor circuit malfunction and one for the sub-sensor's heater circuit malfunction. The sub-sensor does not have a DTC for slow response because a sub-sensor shows very little activity during normal operation. Each DTC requires a different approach to diagnosis. Refer to the Repair Manual for the proper diagnostic procedure to follow for each DTC.

The CARB section of the diagnostic tester and the Readiness Test Confirmation procedure can be very useful for O2 sensor diagnosis, particularly Modes 5, 6, and 7. The following screen flows are guides. Varying conditions will have an effect on the outcome.

### O2 Sensor Case

The screens shown here demonstrate the importance of checking the CARB screens.

#### NON-CONTINUOUS TESTS

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#04 CID#01..... Fail
Time#04 CID#02..... Pass
```

Driving the vehicle after the DTCs were cleared, TIME\$04 showed FAIL, O2 Sensor Heater.



#### CONTINUOUS TESTS

ECU: \$10 (Engine)  
Number of Tests: 1

```
P0135
O2 Sensor Heater Circuit
Malfunction (Bank 1,
Sensor 1)
```

Pending Codes or Mode 7 reported DTC P0135.



```
ECU: $10 (Engine)
Number of DTCs: 1
MIL ON
```

```
P0125
Insufficient Coolant
Temperature for Closed
Loop Fuel Control
```

Further driving on the same trip produced DTC P0125, and the MIL turned on.



# CHECK



#### FREEZE FRAME 0

```
TROUBLE CODE..... P0125
ENGINE SPD..... 2415RPM
COOLANT TEMP..... 185°F
VEHICLE SPD..... 55MPH
CALC LOAD..... 40.3%
FUEL SYS #1..... OL
FUEL SYS #2..... UNUSED
SHORT FT #1..... 0.0%
LONG FT #1..... 2.3%
```

The Freeze Frame recorded P0125.

Mode 6 and 7 displayed the reason for P0125, an O2 Sensor Heater not functioning.

Fig. 7-13

TL074713

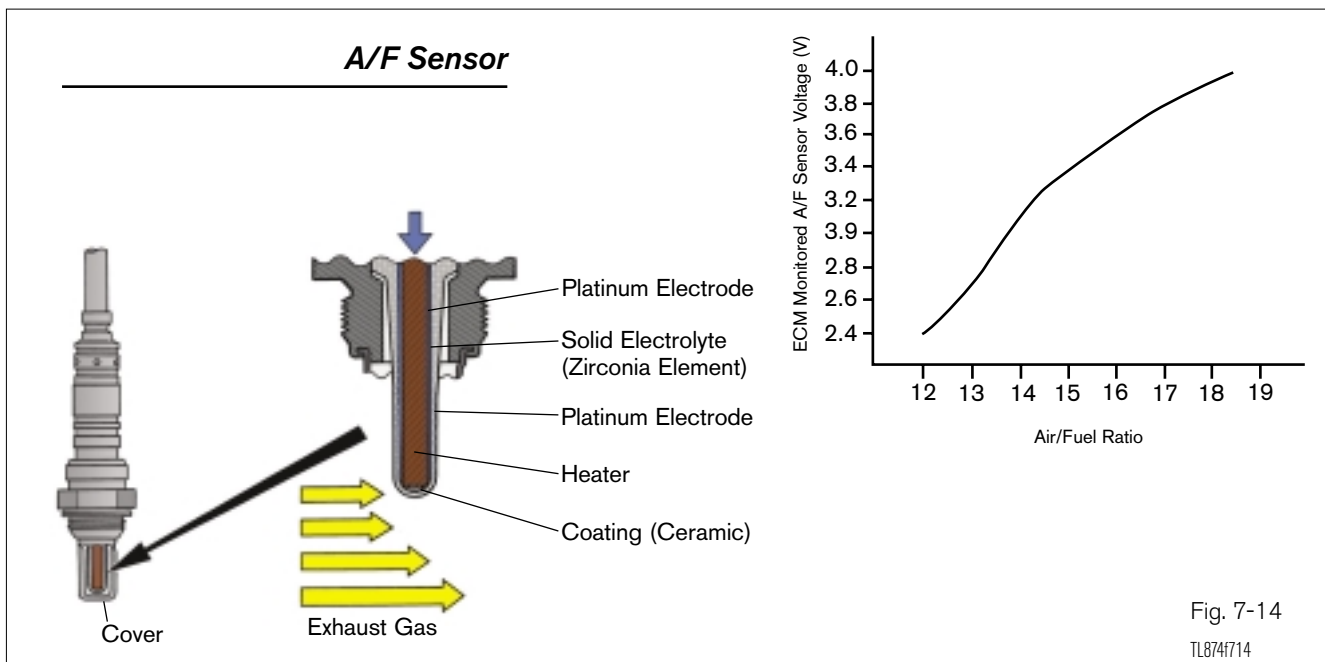
## A/F Sensor Monitor

The A/F sensor monitor is similar to the O2 sensor monitor; however, the A/F sensor has different characteristics. Therefore, the operating parameters of the monitor also differ.

The A/F sensor monitor checks for sensor circuit malfunction, slow response rate, and for a malfunction of the sensor's heater circuit. There is a DTC for each condition for each sensor. A/F sensors are required to be monitored once per trip; however, the ECM does continuously monitor A/F sensor operation.

When the ECM sees the right conditions, the ECM will test the A/F sensors for performance by measuring the signal response as the fuel injected into the cylinder is varied. The faster the A/F sensor responds, the better the sensor. The results of this monitor test are NOT reported in Mode 5. Mode 6, Non-Continuous Test Results is used to determine if the A/F sensor passed or failed.

The repair confirmation drive pattern in the Repair Manual provides the driving conditions for the ECM to operate the A/F sensor monitor.





**A/F Sensor** The A/F sensor is similar to the O<sub>2</sub> sensor. It appears similar to the O<sub>2</sub> sensor, but it is constructed differently and has different operating characteristics.

The A/F sensor is also referred to as a wide range or wide ratio sensor because of its ability to detect A/F Ratios over a wide range.

The advantage of using the A/F sensor is that the ECM can more accurately meter the fuel reducing emissions.

To accomplish this, the A/F sensor:

- operates at approximately 650°C (1200°F), much hotter than the O<sub>2</sub> sensors which operate at 400°C (750°F)
- changes its current (amperage) output in relation to the amount of oxygen in the exhaust stream

### ***A/F Sensor Detecting Circuit***

*The detection circuit, located inside the ECM, is needed for the A/F Sensor to operate. The A/F Sensor output cannot be detected externally. A Diagnostic Tester is needed to read A/F Sensor signal output.*

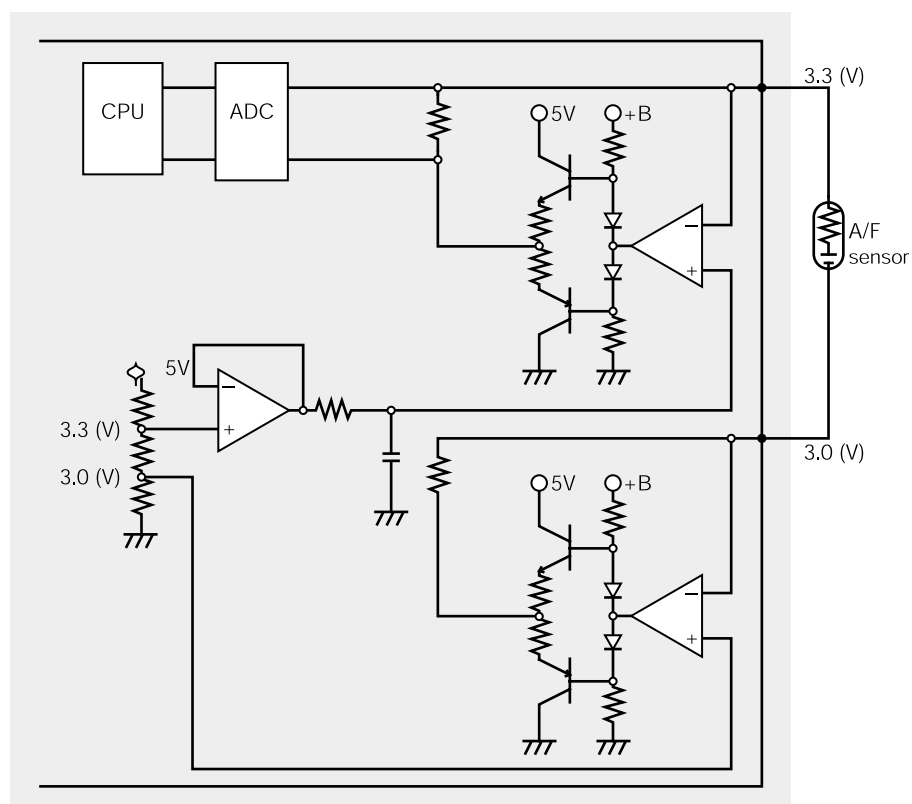


Fig. 7-15

TL874715

**Operation** A detection circuit in the ECM detects the change and strength of current flow and puts out a voltage signal relatively proportional to exhaust oxygen content.

**NOTE** This voltage signal can only be measured by using the Diagnostic Tester or OBD II compatible scan tool. The A/F sensor current output cannot be accurately measured directly. If a Diagnostic Tester or OBD II compatible scan tool is used refer to the Repair Manual for conversion, for the output signal is different.

The A/F sensor is designed so that at stoichiometry, there is no current flow and the voltage put out by the detection circuit is 3.3 volts. A rich mixture, which leaves very little oxygen in the exhaust stream, produces a negative current flow. The detection circuit will produce a voltage below 3.3 volts. A lean mixture, which has more oxygen in the exhaust stream, produces a positive current flow. The detection circuit will now produce a voltage signal above 3.3 volts.

Exhaust Oxygen Content		Current Flow		Voltage Signal		Air/Fuel Mixture Judged to be:
Low oxygen content	⇒	- direction	⇒	Below 3.3 volts	⇒	Rich
Stoichiometry	⇒	0	⇒	3.3 volts	⇒	14.7:1
High oxygen content	⇒	+ direction	⇒	Above 3.3 volts	⇒	Lean

**NOTE** The A/F sensor voltage output is the opposite of what happens in the narrow range O2 sensor. Voltage output through the detection circuit increases as the mixture gets leaner.

### ***A/F Sensor Signal Pattern***

*The A/F sensor responds to changes in exhaust oxygen. Note that the signal changes with engine RPM and does not move in cycles like the O<sub>2</sub> sensor.*

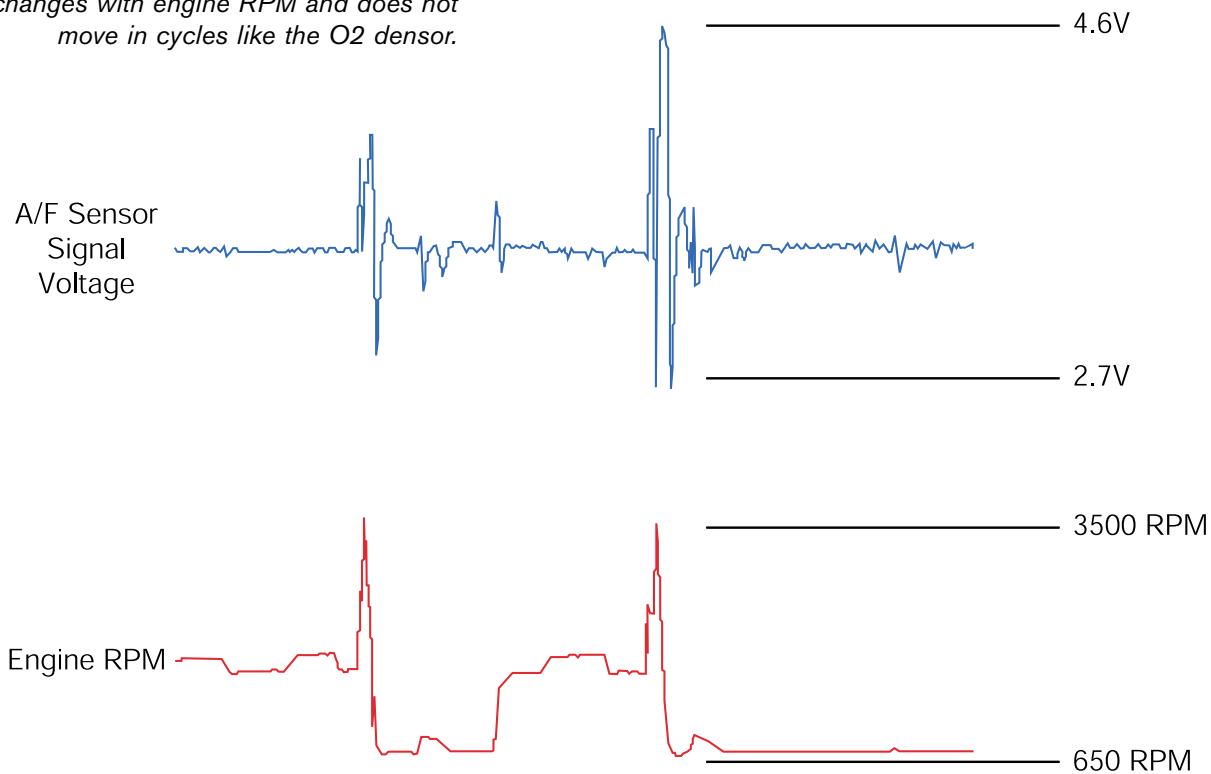


Fig. 7-16

TL874716

The A/F sensor voltage signal is proportional to the change in the air/fuel mixture. This allows the ECM to more accurately judge the exact A/F Ratio under a wide variety of conditions and quickly adjust the amount of fuel to the stoichiometric point. This type of rapid correction is not possible with the narrow range O<sub>2</sub> sensor. With an A/F sensor, the ECM does not follow a rich lean cycle.

**P0125 for A/F Sensor** DTC P0125 is related to voltage output, although the description states insufficient coolant temp for closed loop fuel control. The A/F sensor is monitored for activity (voltage change) when:

- Engine speed is 1,500 rpm or more
- Vehicle speed is 25 – 62 mph (40 – 100 kph)
- TPS does not register idle
- The condition continues for at least 90 seconds.
- 140 seconds or more must have passed since the engine was started

This DTC will set when a sensor output has very little or no activity.

**HINT**

A lean condition or an inoperative sensor will have very little activity.

This DTC is a one trip code, and will also set as a result of a problem due to any of the following items:

- Air induction system
- EGR system
- Fuel pressure
- Fuel injection
- Gas leakage on exhaust system
- Other related parts failure

**P1130, P1150:** This monitor is concerned with A/F sensor voltage output. These DTC(s) are found if the output voltage remains fixed for a predetermined period.

**A/F Sensor Output Voltage**

**NOTE**

Voltage output changes take place inside the ECM. The Diagnostic Tester must be used for diagnosis.

***A/F Sensor Monitor  
P1130, P1150 (Output Voltage)***

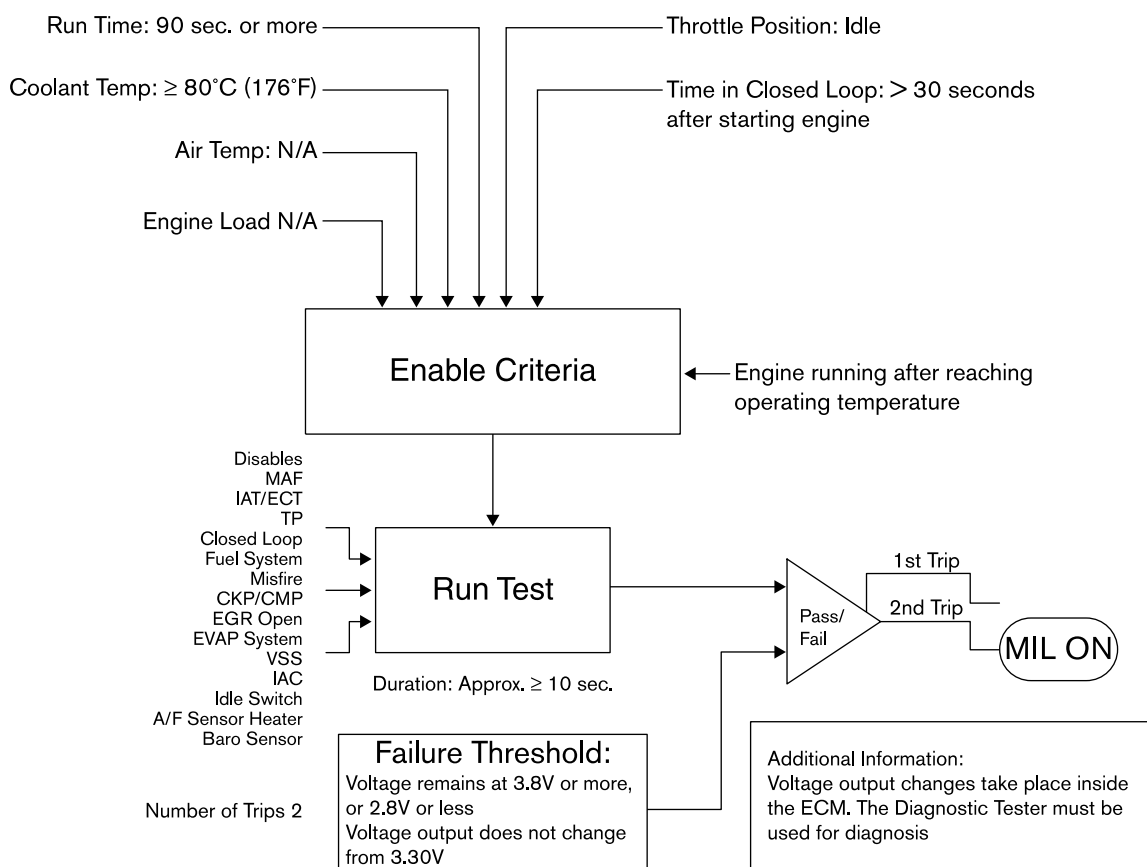


Fig. 7-17

TL874f717

**HINT**

If output voltage of A/F sensor remains at  $3.30\text{V}$ , the sensor circuit may be open. If output voltage of the A/F sensor remains  $3.8\text{V}$  or more or  $2.8\text{V}$  or less, the sensor circuit may be shorted.

**P1133, P1153:** The ECM monitors the A/F sensors response characteristics. If the sensor response rate deteriorates, a fault will be recorded. The response rate cannot be confirmed by tests performed at the sensor. The response rate calculation is a function of the ECM only. The ECM compares the A/F sensor's response to the specifications stored in the ECM's programming.

**HINT**

In addition to Repair Manual procedures, the sensor's operation can be verified using the injector volume active test. This test is done while monitoring the A/F sensors output with the Diagnostic Tester.

### ***A/F Sensor Monitor P1133, P1153 (Output Voltage)***

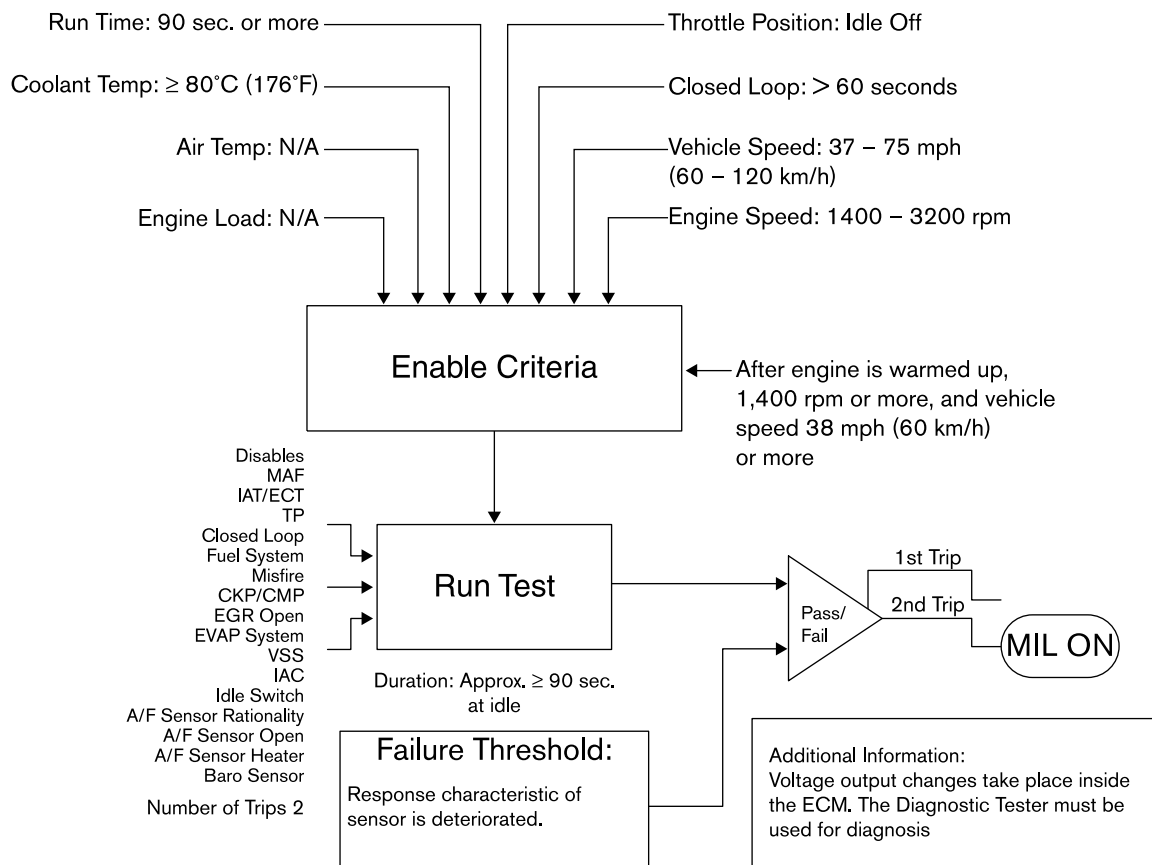


Fig. 7-18

TL874718

### **A/F Sensor Detection Driving Pattern**

*The detection driving pattern shown will provide the conditions necessary for the A/F Sensor to show a response (voltage change). If the sensor output remains within the failure threshold, a DTC will set when all test parameters are met.*

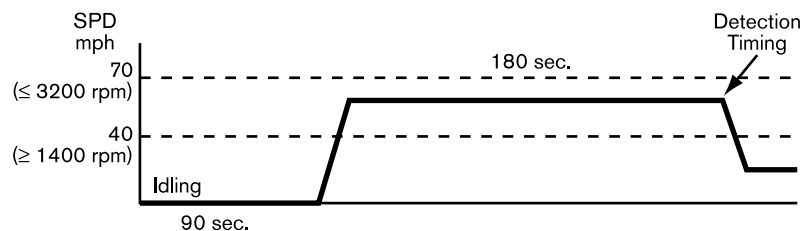


Fig. 7-19

TL874f719

**P1135, P1155: A/F Sensor Heater Monitor** All A/F sensors are monitored for abnormal heater condition. The ECM checks the amount of current required for the sensor heater. If the current is too high or too low, a DTC will be set. If the current level detected is too high, the ECM will shut off the heater. When this happens, a P0125 can set.

The ECM provides a pulse width modulated control circuit to adjust current through the heater. On engines with two A/F sensors, the A/F sensor Heater circuit uses a relay on the B+ side of the circuit. In early models, heater DTCs are two trip detection. Beginning with 2001 models, a phased change to one trip DTC detection began.

**A/F Sensor  
Heater Monitoring  
P1135, P1155 (Circuit Current)**

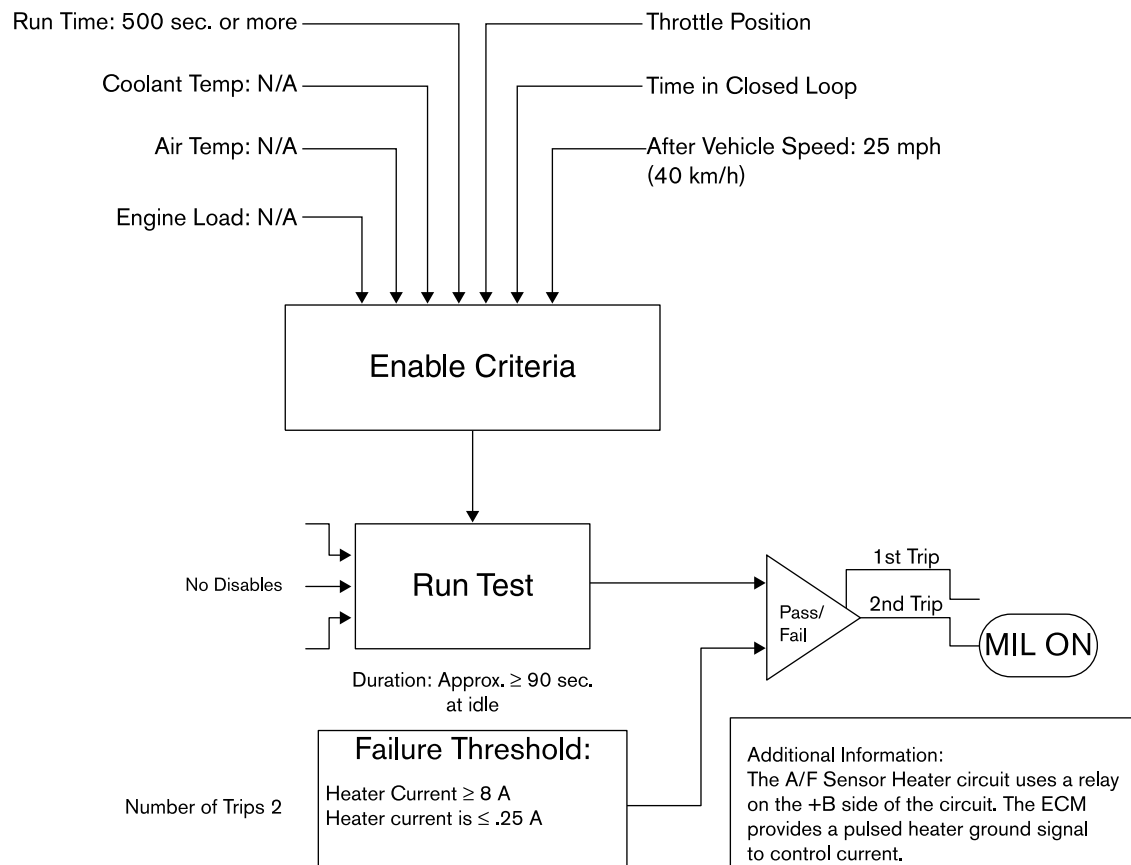


Fig. 7-20

TL874720



## A/F Sensor DTC(s)

**P0125:** After the engine is warmed up, A/F sensor Output\* does not change when conditions (a), (b), (c), and (d) continue for at least 1.5 min.:  
**Coolant Temperature Insufficient for Closed Loop Operation (Bank 1 or 2 Sensor 1)**

- a. Engine speed: 1,500 rpm or more
- b. Vehicle speed: 25 – 62 mph (40 –100 km/h)
- c. Throttle valve is not fully closed
- d. 140 seconds or more after starting engine

This DTC can be set due to other related parts failure.

**P1130:** DTC P1130 will set from one of the following conditions:  
**Circuit Range/Performance Malfunction (Bank 1 Sensor 1)**

- Voltage output of A/F sensor remains at 3.8V or more, or 2.8V or less, with engine running after the engine is warmed up
- Voltage output of A/F sensor does not change from 3.30V, with engine running after the engine is warmed up
- Open or short in A/F sensor circuit

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P1133:** After the engine reaches operating temperature, engine speed is 1,400 rpm or more, vehicle speed 38 mph (60 km/h) or more, and if the A/F sensor signal response is weaker than normal, DTC P1133 sets.  
**Circuit Response Malfunction (Bank 1 Sensor 1)**

(two trip detection logic)

This DTC can be set due to other related parts failure.

**P1135:** When the heater operates, heater current exceeds 8A or heater current is 0.25A or less. Please confirm heater resistance specification in the vehicle Repair Manual.  
**Heater Circuit Malfunction (Bank 1 Sensor 1)**

(two trip detection logic, early models; phased change to one trip detection beginning 2001 model.)

This DTC can be set due to other related parts failure.

- P1150:** DTC P1150 will set from one of the following conditions:
- Circuit Range/  
Performance  
Malfunction  
(Bank 2 Sensor 1)**
- Voltage output of A/F sensor remains at 3.8V or more, or 2.8V or less, during engine running after the engine is warmed up
  - Voltage output of A/F sensor does not change from 3.30V, during engine running after the engine is warmed up
  - Open or short in A/F sensor circuit

(two trip detection logic)

This DTC can be set due to other related parts failure.

- P1153:** After the engine reaches operating temperature, engine speed is 1,400 rpm or more, vehicle speed 38 mph (60 km/h) or more, and if the A/F sensor signal response is weaker than normal, DTC P1153 sets.
- Circuit Response  
Malfunction  
(Bank 2 Sensor 1)**

(two trip detection logic)

This DTC can be set due to other related parts failure.

- P1155:** When the heater operates, heater current exceeds 8A or heater current is 0.25A or less. Please confirm heater resistance specification in vehicle Repair Manual.
- Heater Circuit  
Malfunction  
(Bank 2 Sensor 1)**

(two trip detection logic, early models; phased change to one trip detection beginning 2001 model.)

This DTC can be set due to other related parts failure.

#### **NOTE**

When an A/F sensor DTC is found, it is important to look at each DTC description carefully before proceeding with diagnosis. In addition to P0125, the A/F sensors each have three DTC(s), one for a sensor range/performance malfunction, one for response malfunction, and one for the sensor's heater circuit malfunction. Each DTC requires a different approach to diagnosis. Refer to the Repair Manual for the proper diagnostic procedure to follow for each DTC.

### Planar A/F Sensor

*The newer planar A/F sensor can be identified by its shorter body.*

*The planar has the heater integrated into the sensing element. This sensor has the same detecting range as the previous, cup type A/F sensor.*

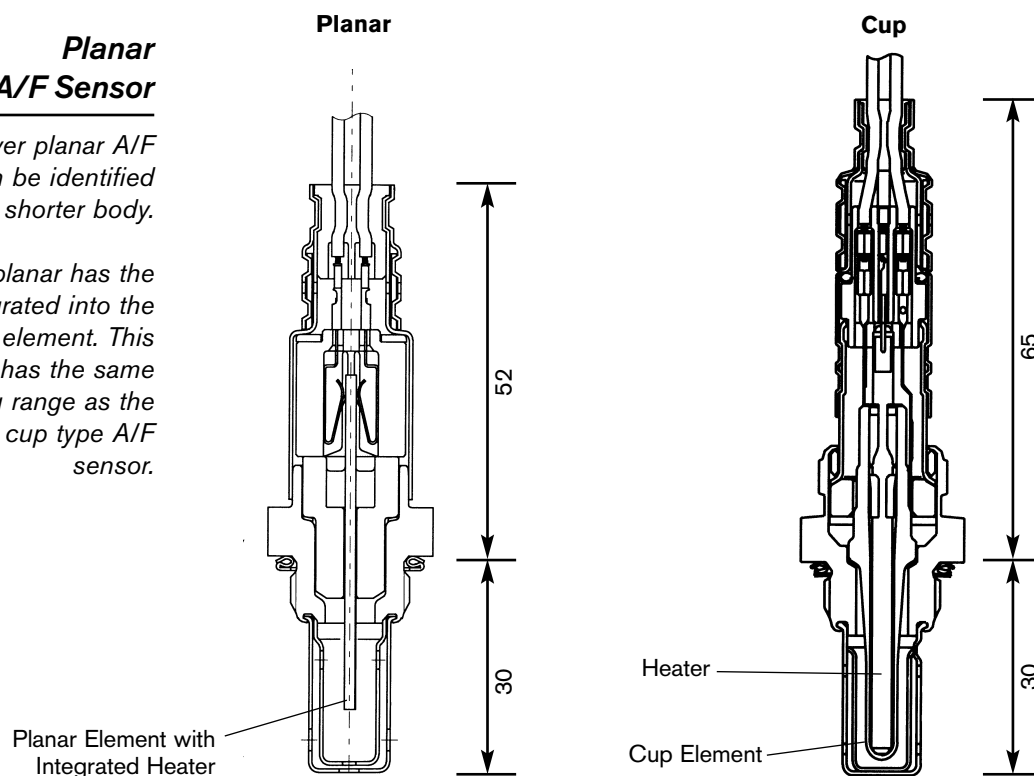


Fig. 7-21

TL874f721

### Planar A/F Sensor Operation

A second generation A/F sensor (referred to here as the planar A/F sensor) was developed to meet more stringent emission regulations. This A/F sensor reaches operating temperature faster than the previous (referred to here as the cup element) A/F sensor. This allows the ECM to go into closed loop fuel control faster when the engine is cold reducing cold start emissions.

The planar A/F sensor has the same detecting range and signal characteristics as the previous cup element A/F sensor. The major differences are:

- goes into closed loop fuel control faster.
- heater element has a higher resistance.
- heater DTCs set in one trip.

#### NOTE

This A/F sensor is not interchangeable with the older, cup element A/F sensor.

### ***Planar Element***

*Like previous O<sub>2</sub> and A/F sensors, the planar A/F sensor has ambient air on one side of the ZrO<sub>2</sub> and exhaust gases on the other side.*

*The aluminum oxide layer conducts heat directly to the ZrO<sub>2</sub> element providing a rapid warm up.*

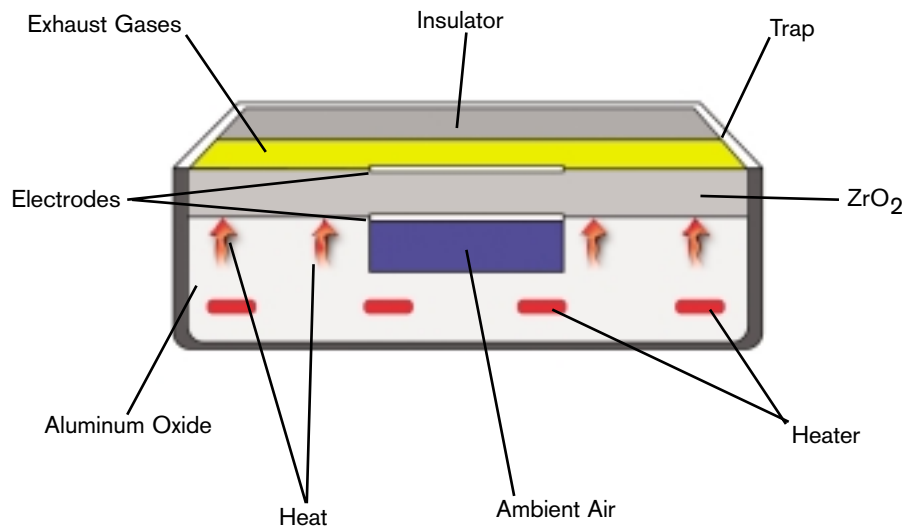


Fig. 7-22

TL874f722

The heater is imbedded into the aluminum oxide. When the heater is on, the aluminum oxide conducts heat directly to the zirconium dioxide layer bring the A/F sensor to operating temperature quickly.

Aluminum oxide is also an excellent electrical insulator. This prevents any voltage from the heater affecting signal output. Cracks or element contamination can alter signal output.

### Signal Characteristics

The generated voltage output signal is identical to the previous A/F sensor. A high exhaust gas oxygen content (lean) produces a higher voltage signal. Stoichiometry is at 3.30 volts.

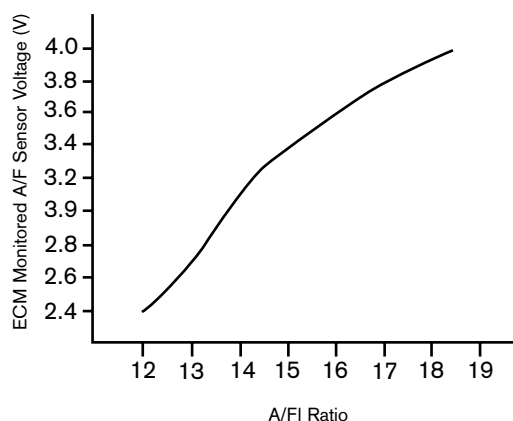


Fig. 7-23

TL874723

### Planar A/F Sensor Signal Detection DTCs

The detection logic for the planar A/F sensor is the same as the cup element A/F sensor EXCEPT for heater related DTCs. Please see the information on A/F sensor signal output DTCs P0125, P1130, P1133, P1150, and P1153 in this section.

### Planar A/F Sensor Heater Detection DTCs

The heater circuit and operation is similar to the cup element, though amperage specifications are different. The heater monitor continuously detects over current or under current conditions and will set DTC in one trip. Therefore, heater related DTCs (such as P1135, P1155) will be set on the first trip when a malfunction is detected.

The heater resistance for the planar AF sensor is slightly higher than the cup element A/F sensor. Heater resistance is checked with a DVOM.

HEATER TEMPERATURE	PLANAR A/F SENSOR	CUP ELEMENT A/F SENSOR	O2 SENSOR
20°C (68°F)	1.8 - 3.4Ω	0.8 - 1.4Ω	11 - 16Ω

A characteristic of this AF sensor is that when it fails it can drive the A/F signal output high or low causing a rich or lean condition.

### A/F Sensor Diagnosis Case Using CARB

#### NON-CONTINUOUS TESTS

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#02..... Pass
Time#05 CID#01..... Pass
Time#05 CID#02..... Pass
Time#06 CID#01..... Pass
Time#06 CID#10..... Pass
Time#07 CID#01..... Pass
Time#07 CID#10..... Fail
```

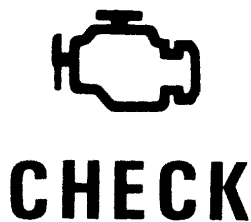
Driving the vehicle after the DTCs were cleared, TIME\$07 showed FAIL, A/F Sensor Heater.

#### CONTINUOUS TESTS

ECU: #10 (Engine)  
Number of Tests: 1

P1150  
Manufacturer Controlled  
Fuel and Air Metering

Pending codes or Mode 7 reported  
DTC P1150



ECU: #10 (Engine)  
Number of DTCs: 1  
MIL ON

P0125  
Insufficient Coolant  
Temperature for Closed  
Loop Fuel Control

Further driving on the same trip  
produced DTC P0125, and the MIL  
turned on.

#### FREEZE FRAME 0

```
TROUBLE CODE..... P0125
ENGINE SPD..... 1833RPM
COOLANT TEMP..... 187°F
VEHICLE SPD..... 37MPH
CALC LOAD..... 49.8%
FUEL SYS #1..... OLDRIVE
FUEL SYS #2..... OLDRIVE
SHORT FT #1..... 0.0%
LONG FT #1..... -1.5%
SHORT FT #2..... -0.0%
LONG FT #2..... 3.9%
```

The Freeze Frame recorded P0125.

Conclusion: Mode 6 and 7 displayed the reason for P0125, an A/F Sensor Heater not functioning.

Fig. 7-24

TL874724



**Notes**



## **WORKSHEET 7-1** **A/F Sensor Tests**

Vehicle	Year/Prod. Date	Engine	Transmission

### **Worksheet Objectives**

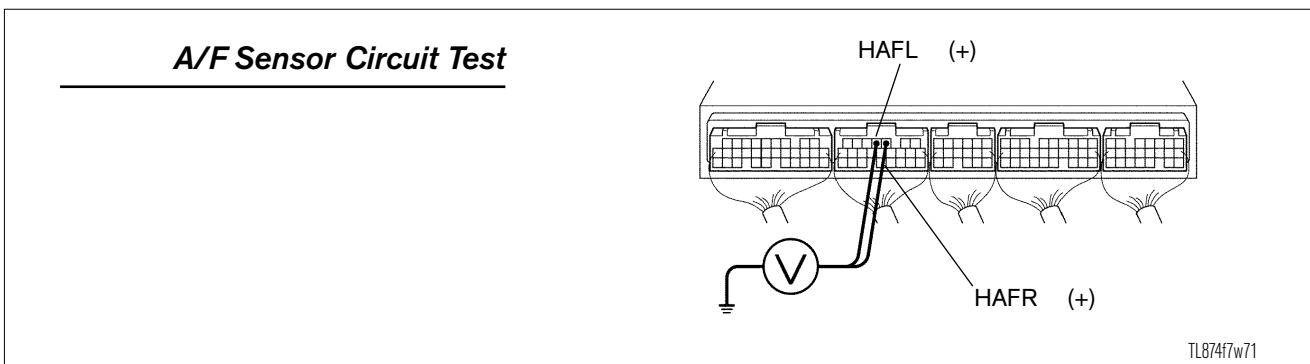
In this worksheet, you will use the Diagnostic Tester to test A/F sensor performance and compare to specifications to determine condition.

### **Tools and Equipment**

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

### **Section 1: A/F Sensor**

1. With the key on and engine off, measure voltage between ECM terminals HAFL and HAFL and body ground.



2. Use the EWD to trace the A/F Sensor Heater circuit.

This test confirms the operation of which components and continuity of which circuits?

---



---

3. Using the repair manual(s), compare the resistance of an O2 sensor heater to the A/F sensor heater.
4. What is the major difference between the two sensors?

---



## Section 2: A/F Sensor Response

Connect the Diagnostic Tester. With the engine at operating temperature, go to DATA LIST, USER DATA and select one of the A/F sensors, SHORT TERM FUEL TRIM, and select ENTER. Select F4. With a set of jumper leads, connect a Fluke 87 (or comparable) DVOM in series with the A/F signal wire. Make sure, the + lead is in the milliamp socket.

1. Record A/F sensor engine idling. Briefly, snap the throttle wide open and release. What happened?

---

2. Disconnect a vacuum hose. Was there a change to A/F voltage signal and Short Term Fuel Trim?

---

3. Reconnect vacuum hose.

4. **Predict** what **will** happen to A/F signal voltage and amperage if more fuel is added?

---

5. Go to INJECTOR VOLUME ACTIVE TEST. Increase injector duration. What happened to A/F sensor voltage and amperage signal?

---

6. Decrease injector duration. What happened to A/F sensor signal voltage amperage?

---

### Test or confirm repair method using CARB OBD II Readiness Tests.

1. Access READINESS TEST Mode under CARB OBD II. What does it report?

---

**Case 1**

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. Answer the following questions using the listed screen prints.

**READINESS TEST**

```
MISFIRE MON..... AVAIL
FUEL SYS MON..... AVAIL
COMP MON..... AVAIL
CAT EVAL..... COMPL
HTD CAT EVAL..... N/A
EVAP EVAL..... INCMPL
2nd AIR EVAL..... N/A
A/C EVAL..... N/A
O2S EVAL..... INCMPL
O2S HTR EVAL..... INCMPL
EGR EVAL..... COMPL
```

**NON-CONTINUOUS TESTS**

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#02..... Pass
Time#05 CID#01..... Pass
Time#05 CID#02..... Pass
Time#06 CID#01..... Pass
Time#06 CID#10..... Pass
Time#07 CID#01..... Pass
Time#07 CID#10..... Pass
```

TL874f7w71

2. Do the screens indicate a problem with the vehicle?

---

3. What area(s) is affected?

---

4. Will there be DTC(s) and Freeze Frame?

---

**Case 2**

An A/F sensor equipped vehicle was driven after DTCs were cleared. Answer the questions from the following screens.

**READINESS TEST**

```
MISFIRE MON..... AVAIL
FUEL SYS MON..... AVAIL
COMP MON..... AVAIL
CAT EVAL..... INCMPL
HTD CAT EVAL..... N/A
EVAP EVAL..... INCMPL
2nd AIR EVAL..... N/A
A/C EVAL..... N/A
O2S EVAL..... INCMPL
O2S HTR EVAL..... INCMPL
EGR EVAL..... INCMPL
```

**NON-CONTINUOUS TESTS**

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#02..... Pass
Time#05 CID#01..... Pass
Time#05 CID#02..... Pass
Time#06 CID#01..... Pass
Time#06 CID#10..... Pass
Time#07 CID#01..... Pass
Time#07 CID#10..... Fail
```

TL8747w71

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

**Case 3**

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. Answer the following questions using the listed screen prints.

**READINESS TEST**

```
MISFIRE MON..... AVAIL
FUEL SYS MON..... AVAIL
COMP MON..... AVAIL
CAT EVAL..... COMPL
HTD CAT EVAL..... N/A
EVAP EVAL..... COMPL
2nd AIR EVAL..... N/A
A/C EVAL..... N/A
O2S EVAL..... INCMPL
O2S HTR EVAL..... COMPL
EGR EVAL..... N/A
```

**NON-CONTINUOUS TESTS**

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#02..... Pass
Time#06 CID#01..... Fail
Time#06 CID#10..... Pass
Time#07 CID#01..... Pass
Time#07 CID#10..... Pass
Time#08 CID#01..... Pass
```

TL8747w71

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

**Case 4**

After DTCs were cleared, an A/F sensor equipped vehicle was driven one trip according to the drive pattern. The MIL illuminated. Answer the following questions using the listed screen prints.

**FREEZE FRAME 0**

```
TRouble CODE..... P0125
ENGINE SPD..... 1833RPM
COOLANT TEMP..... 187°F
VEHICLE SPD..... 37MPH
CALC LOAD..... 49.8%
FUEL SYS #1..... OLDRIVE
FUEL SYS #2..... OLDRIVE
SHORT FT #1..... 0.0%
LONG FT #1..... -1.5%
SHORT FT #2..... 0.0%
LONG FT #2..... 3.9%
```

**NON-CONTINUOUS TESTS**

```
Time#01 CID#01..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#02..... Pass
Time#05 CID#01..... Pass
Time#05 CID#02..... Pass
Time#06 CID#01..... Pass
Time#06 CID#10..... Pass
Time#07 CID#01..... Pass
Time#07 CID#10..... Fail
```

TL874f7w71

1. Do the screens indicate a problem with the vehicle?

---

2. What area(s) is affected?

---

3. Will there be more DTC(s) on the second trip if driven according to the drive pattern?

---

# A/F Sensor Tests

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

*I have questions*

*I know I can*

**Topic**

**Comment**

Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Check condition of heater circuit with DVOM			
Accurately measure & interpret; oxygen content of the exhaust gases based on sensor signal data			
Describe the primary difference between the O2 sensor and the A/F sensor			
Use Modes 6 and 7 to determine monitored A/F sensor results			
Measure A/F sensor signal with DVOM and determine engine operating conditions			



**Notes**



## WORKSHEET 7-2 O2 Sensor Test

Vehicle	Year/Prod. Date	Engine	Transmission

### Worksheet Objectives

In this worksheet, you will use the Diagnostic Tester and to check and test O2 sensor monitor performance and determine needed action.

### Tools and Equipment

- Vehicle Repair Manual
- Vehicle EWD
- Diagnostic Tester
- Hand Tool Set

### Case 1

Answer the following from the screen shots. The O2 sensor equipped vehicle was driven after clearing DTCs.

READINESS TEST

```

MISFIRE MON..... AVAIL
FUEL SYS MON..... AVAIL
COMP MON..... AVAIL
CAT EVAL..... INCMPL
HTD CAT EVAL..... N/A
EVAP EVAL..... INCMPL
2nd AIR EVAL..... N/A
A/C EVAL..... N/A
O2S EVAL..... INCMPL
O2S HTR EVAL..... INCMPL
EGR EVAL..... N/A
        
```

NON-CONTINUOUS TESTS

```

Time#01 CID#01..... Pass
Time#01 CID#02..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#01..... Pass
Time#04 CID#02..... Pass
Time#04 CID#10..... Pass
Time#04 CID#20..... Pass
        
```

TL8747w72

1. What is the status of the O2S monitor and O2S HTR heater monitor?

---

2. What does the Readiness Test indicate?

---



**Case 2**

Answer the following questions from the screen shot.

```
O2 SENSOR TEST (B1 - S1)

LOW SW V..... 0.350V
HIGH SW V..... 0.550V
MIN O2S V..... 0.025V
MAX O2S V..... 0.790V
Time $31..... 0.04s
Time $32..... 0.04s
```

TL874f7w72

<b>Low SW V</b>	
<b>High SW V</b>	
<b>Min O2S V</b>	
<b>Max O2S V</b>	
<b>Time \$31</b>	
<b>Time \$32</b>	

1. What information is given in this mode?

\_\_\_\_\_

2. What does Low/High SW mean and how is this information useful?

\_\_\_\_\_

3. What does Min/Max O2S mean and how is this information useful?

\_\_\_\_\_

4. What does Time \$31/32 mean and how is this information useful?

\_\_\_\_\_

5. Is the above O2 sensor good or bad?

\_\_\_\_\_

### Case 3

An O2 sensor equipped vehicle was driven after DTCs were cleared. Answer the questions from the following screens.

#### READINESS TEST

```
MISFIRE MON..... AVAIL
FUEL SYS MON..... AVAIL
COMP MON..... AVAIL
CAT EVAL..... INCMPL
HTD CAT EVAL..... N/A
EVAP EVAL..... INCMPL
2nd AIR EVAL..... N/A
A/C EVAL..... N/A
O2S EVAL..... INCMPL
O2S HTR EVAL..... INCMPL
EGR EVAL..... N/A
```

#### NON-CONTINUOUS TESTS

```
Time#01 CID#01..... Pass
Time#01 CID#02..... Pass
Time#02 CID#01..... Pass
Time#02 CID#02..... Pass
Time#02 CID#03..... Pass
Time#02 CID#04..... Pass
Time#04 CID#01..... Fail
Time#04 CID#02..... Pass
Time#04 CID#10..... Pass
Time#04 CID#20..... Pass
```

#### O2 SENSOR TEST (B1 - S1)

```
LOW SW V..... 0.350V
HIGH SW V..... 0.550V
MIN O2S V..... 0.378V
MAX O2S V..... 0.545V
Time #31..... 1.15s
Time #32..... 1.15s
```

TL874f7w72

1. Do the screens indicate a problem with the vehicle?

2. What area(s) is affected?

3. Will there be DTC(s) and Freeze Frame?

## Section 4: O2 Sensor Response

1. With the engine at operating temperature, go to Data List and note the O2 sensor voltage signal and Fuel Trim. Disconnect a vacuum hose. Was there a change to oxygen voltage signal and Short Term Fuel Trim?

---

2. Reconnect vacuum hose.

3. **Predict** what **will** happen to O2 sensor signal voltage if more fuel is added?

---

4. Go to Injector Volume Active test. Add fuel using the Active Test to increase injector duration. What happened to O2 sensor voltage signal?

---

5. Decrease injector duration. What happened to O2 sensor signal voltage?

---

# O2 Sensor Tests

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Review this sheet as you are doing the worksheet. Check each category after completing the worksheet and instructor presentation. Ask the instructor if you have questions. The comments section is for you to write where to find the information, questions, etc.

*I have questions*

*I know I can*

**Topic**

**Comment**

Locate components using the EWD and RM			
Find wire colors, pin numbers using the EWD and RM			
Check condition of heater circuit with DVOM			
Accurately measure & interpret; oxygen content of the exhaust gases based on sensor signal data			
Describe the primary difference between the O2 sensor and the A/F sensor			
Use Modes 6 and 7 to determine monitored O2 sensor results			