The ECM uses sensors mounted in front of and behind the Three-Way Catalytic Converter (TWC) to monitor its efficiency.

The first sensor, the Air Fuel Ratio (A/F) sensor, sends pre-catalyst information to the ECM. The second sensor, the Heated Oxygen (HO2) sensor, sends post-catalyst information to the ECM. In order to detect any deterioration in the TWC, the ECM calculates the Oxygen Storage Capacity (OSC) of the TWC. This calculation is based on the voltage output of the HO2 sensor while performing active air-fuel ratio control, rather than the conventional detecting method, which uses the locus ratio. The OSC value is an indication of the oxygen storage capacity of the TWC. When the vehicle is being driven with a warm engine, active air-fuel ratio control is performed for approximately 15 to 20 seconds. When it is performed, the ECM deliberately sets the air-fuel ratio to lean or rich levels. If a rich-lean cycle of the HO2 sensor is long, the OSC becomes greater. There is a direct correlation between the OSCs of the HO2 sensor and the TWC.

The ECM uses the OSC value to determine the state of the TWC. If any deterioration has occurred, it illuminates the MIL and sets a DTC.

### DTC DETECTION CONDITIONS CHART

<table>
<thead>
<tr>
<th>DTC No.</th>
<th>DTC Detection Conditions</th>
<th>Trouble Areas</th>
</tr>
</thead>
</table>
| P0420   | OSC value smaller than standard value under active air-fuel ratio control (2 trip detection logic) | • Gas leak from exhaust system  
• A/F sensor(bank 1 sensor 1)  
• HO2 sensor (bank 1 sensor 2)  
• Exhaust manifold (TWC) |
| P0430   | OSC value smaller than standard value under active air-fuel ratio control (2 trip detection logic) | • Gas leak from exhaust system  
• A/F sensor(bank 2 sensor 1)  
• HO2 sensor (bank 2 sensor 2)  
• Exhaust manifold (TWC) |

**HINT:**
- Bank 1 refers to the bank that includes cylinder No. 1.
- Bank 2 refers to the bank that does not include cylinder No. 1.
- Sensor 1 refers to the sensor closest to the engine assembly.
- Sensor 2 refers to the sensor farthest away from the engine assembly.
MONITOR STRATEGY

Related DTCs

- P0420: Catalyst Deterioration
- P0430: Catalyst Deterioration

Required Sensors/Components

(Main)

- A/F sensor and heated oxygen sensor

(Related)

- Intake air temperature sensor, mass air flow meter, crankshaft position sensor and engine coolant temperature sensor

Frequency of Operation

Once per driving cycle

Duration

About 30 seconds

MIL Operation

2 driving cycles

Sequence of Operation

None

TYPICAL ENABLING CONDITIONS

Monitor runs whenever following DTCs not present

- P0011 (VVT System 1 - Advance)
- P0012 (VVT System 1 - Retard)
- P0019 (VVT System 2 - Advance)
- P0021 (VVT System 2 - Retard)
- P0031, P0032, P0051, P0052 (A/F sensor heater - Sensor 1)
- P0037, P0038, P0057, P0058 (HO2 sensor Heater - Sensor 2)
- P0100 - P0103 (MAF meter)
- P0115-P0118 (ECT sensor)
- P0120 - P0223, P2135 (TP sensor)
- P0125 (Insufficient ECT for closed loop)
- P0133, P0156 (HO2 Sensor - Sensor 2)
- P0171, P0172, P0174, P0175 (Fuel system)
- P0300 - P0306 (Misfire)
- P0303 (CPK sensor)
- P0304 (CMP sensor)
- P0351 - P0356 (Ignitor)
- P0500 (VSS)
- P2196, P2198 (A/F sensor - rationality)
- P2A00, P2A03 (A/F sensor - slow response)

- Battery voltage: 11 V or more
- IAT: -10°C(14°F) or more
- Engine coolant temperature sensor: 75°C(167°F) or more
- Atmospheric pressure coefficient: 76 kPa (570 mmHg) or more
- Idling: OFF
- Engine RPM: Less than 3,200 rpm
- A/F sensor status: Activated
- Fuel system status: Closed loop
- Engine load: 10 to 70%
- All of the following conditions are met: Condition 1, 2 and 3
- 1. Mass air flow rate: 5 to 70 g/sec
TYPICAL MALFUNCTION THRESHOLDS

TYPICAL MALFUNCTION THRESHOLDS

| Oxygen Storage Capacity (OSC) of Three-Way Catalytic Converter (TWC) | Less than 0.04g |

MONITOR RESULT

Refer to **CHECKING MONITOR STATUS**.

CONFIRMATION DRIVING PATTERN

HINT:

Performing this confirmation pattern will activate the catalyst monitor. This is very useful for verifying the completion of a repair.

![Diagram](Fig. 144: Identifying Vehicle Speed - Driving Pattern)

**NOTICE:**

This test will not be completed if the vehicle is driven at absolutely constant speed such as with cruise control activated.

(Note: Even if vehicle stops during driving pattern, test can be resumed)

Courtesy of TOYOTA MOTOR SALES, U.S.A., INC.
Fig. 145: Identifying Readiness Test Menu
Courtesy of TOYOTA MOTOR SALES, U.S.A., INC.

a. Connect a Techstream to the DLC3.
b. Turn the ignition switch ON.
c. Turn the tester ON.
d. Clear DTCs (if set) (See DTC CHECK/CLEAR).
e. Select the following menu items: Powertrain / Engine and ECT / Monitor.
f. Check that Catalyst / Status 2 is Incomplete.
g. Start the engine and warm it up.
h. Drive the vehicle at between 40 mph and 70 mph (64 km/h and 113 km/h) for at least 10 minutes.
i. Note the state of the Readiness Tests items. Those items will change to Complete as Catalyst monitor operates.
j. On the tester, select the following menu items: Powertrain / Engine and ECT / Trouble Codes / Pending and check if any DTCs (any pending DTCs) are set.

HINT:

If Catalyst does not change to Complete, and any pending DTCs fail to set, extend the driving time.

CONDITIONING FOR SENSOR TESTING

HINT:

Perform the operation with the engine speeds and time durations described below prior to checking the waveforms of the A/F and HO2 sensors. This is in order to activate the sensors sufficiently to obtain the appropriate inspection results.

![Engine Speed Diagram]

Fig. 146: Identifying Engine Speed - Driving Pattern
Courtesy of TOYOTA MOTOR SALES, U.S.A., INC.

a. Connect a Techstream to the DLC3.
b. Start the engine and warm it up with all the accessories switched OFF, until the engine coolant temperature stabilizes.
c. Run the engine at an engine speed of between 2,500 rpm and 3,000 rpm for at least 3 minutes.
d. While running the engine at 3,000 rpm for 2 seconds and 2,000 rpm for 2 seconds, check the waveforms of the A/F and HO2 sensors using the tester.

**HINT:**

- If either of the voltage outputs of the Air Fuel Ratio (A/F) or Heated Oxygen (HO2) sensor does not fluctuate, or either of the sensors makes a noise, the sensor may be malfunctioning.
- If the voltage outputs of both the sensors remain lean or rich, the air-fuel ratio may be extremely lean or rich. In such cases, perform the following Control the Injection Volume for A/F sensor using a Techstream.
- If the Three-Way Catalytic Converter (TWC) has deteriorated, the HO2 sensor (located behind the TWC) voltage output fluctuates up and down frequently, even under normal driving conditions (active air-fuel ratio control is not performed).

**Fig. 147: Identifying Voltage Variation Graph**

<table>
<thead>
<tr>
<th>Waveform of A/F Sensor in front of TWC</th>
<th>Normal Catalyst</th>
<th>Deteriorated Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage output when active air-fuel ratio control not performed</td>
<td>3.5 V</td>
<td>3.0 V</td>
</tr>
<tr>
<td>1.0 V</td>
<td>0 V</td>
<td></td>
</tr>
</tbody>
</table>

**INSPECTION PROCEDURE**

**HINT:**

Techstream only:

Malfunctioning areas can be identified by performing the Control the Injection Volume for A/F sensor function provided in the ACTIVE TEST. The Control the Injection Volume for A/F sensor function can help to determine whether the Air Fuel Ratio (A/F) sensor, Heated Oxygen (HO2) sensor and other potential trouble areas are malfunctioning.

The following instructions describe how to conduct the Control the Injection Volume for A/F sensor operation using a Techstream.

1. Connect a Techstream to the DLC3.
2. Start the engine and turn the tester ON.
3. Warm up the engine at an engine speed of 2,500 rpm for approximately 90 seconds.
4. Select the following menu items: Powertrain / Engine and ECT / Active Test / Control the Injection Volume for A/F sensor.
5. Perform the Control the Injection Volume for A/F sensor operation with the engine in an idling condition (press the RIGHT or LEFT button to change the fuel injection volume).
6. Monitor the voltage outputs of the A/F and HO2 sensors (AFS B1S1 and O2S B1S2 or AFS B2S1 and O2S B2S2) displayed on the tester.

HINT:
- The Control the Injection Volume for A/F sensor operation lowers the fuel injection volume by 12.5 % or increases the injection volume by 25 %.
- Each sensor reacts in accordance with increases and decreases in the fuel injection volume.

### Standard

#### STANDARD VOLTAGE

<table>
<thead>
<tr>
<th>Tester Display (Sensor)</th>
<th>Injection Volumes</th>
<th>Status</th>
<th>Voltages</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFS B1S1 or AFS B2S1 (A/F)</td>
<td>+25 %</td>
<td>Rich</td>
<td>Less than 3.0</td>
</tr>
<tr>
<td>AFS B1S1 or AFS B2S1 (A/F)</td>
<td>-12.5%</td>
<td>Lean</td>
<td>More than 3.35</td>
</tr>
<tr>
<td>O2S B1S2 or O2S B2S2 (HO2)</td>
<td>+25%</td>
<td>Rich</td>
<td>More than 0.55</td>
</tr>
<tr>
<td>O2S B1S2 or O2S B2S2 (HO2)</td>
<td>-12.5%</td>
<td>Lean</td>
<td>Less than 0.4</td>
</tr>
</tbody>
</table>

**NOTE:** The Air Fuel Ratio (A/F) sensor has an output delay of a few seconds and the Heated Oxygen (HO2) sensor has a maximum output delay of approximately 20 seconds.

#### VOLTAGE OUTPUT DELAY

<table>
<thead>
<tr>
<th>Case</th>
<th>A/F Sensor (Sensor 1) Output Voltage</th>
<th>HO2 Sensor (Sensor 2) Output Voltage</th>
<th>Main Suspected Trouble Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Injection Volume +25% -12.5%</td>
<td>Injection Volume +25% -12.5%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Output Voltage More than 3.35 V</td>
<td>Output Voltage More than 0.55 V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Less than 3.0 V</td>
<td>Less than 0.4 V</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Injection Volume +25% -12.5%</td>
<td>Injection Volume +25% -12.5%</td>
<td>- A/F sensor</td>
</tr>
<tr>
<td></td>
<td>Output Voltage Almost no reaction</td>
<td>Output Voltage More than 0.55 V</td>
<td>- A/F sensor heater</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 0.4 V</td>
<td>- A/F sensor circuit</td>
</tr>
<tr>
<td></td>
<td>Injection +25%</td>
<td>Injection +25%</td>
<td></td>
</tr>
</tbody>
</table>
Following the Control the Injection Volume for A/F sensor procedure enables technicians to check and graph the voltage outputs of both the A/F and HO2 sensors.

To display the graph, select the following menu items on the tester: Powertrain / Engine and ECT / Active Test / Control the Injection Volume for A/F sensor / A/F Control System / AFS B1S1 and O2S B1S2 or AFS B2S1 and O2S B2S2, then press the graph button on the Data List view.

HINT:
Read freeze frame data using a Techstream. Freeze frame data record the engine condition when malfunctions are detected. When troubleshooting, freeze frame data can help determine if the vehicle was moving or stationary, if the engine was warmed up or not, if the air-fuel ratio was lean or rich, and other data from the time the malfunction occurred.

1. CHECK ANY OTHER DTCS OUTPUT (IN ADDITION TO DTC P0420 AND/OR P0430)
   a. Connect a Techstream to the DLC3.
   b. Turn the ignition switch ON and turn the tester ON.
   c. Select the following menu items: Powertrain / Engine and ECT / Trouble Codes.
   d. Read DTCs and write them down.

RESULT REFERENCE

<table>
<thead>
<tr>
<th>Display (DTC Output)</th>
<th>Proceed To</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0420 and/or P0430</td>
<td>A</td>
</tr>
<tr>
<td>P0420 and/or P0430 and other DTCs</td>
<td>B</td>
</tr>
</tbody>
</table>

HINT:
If any DTCs other than P0420 or P0430 are output, troubleshoot those DTCs first.

B: GO TO DTC CHART (See DIAGNOSTIC TROUBLE CODE CHART)
A: Go To Next Step

2. PERFORM ACTIVE TEST USING TECHSTREAM (A/F CONTROL)
   a. Connect a Techstream to the DLC3.
   b. Start the engine and turn the tester ON.
   c. Warm up the engine at an engine speed of 2,500 rpm for approximately 90 seconds.
   d. Select the following menu items: Powertrain / Engine and ECT / Active Test / Control the Injection Volume for A/F sensor.
   e. Perform the Control the Injection Volume for A/F sensor operation with the engine in an idling condition (press the RIGHT or LEFT button to change the fuel injection volume).
   f. Monitor the voltage outputs of the A/F and HO2 sensors (AFS B1S1 and O2S B1S2 or AFS B2S1 and O2S B2S2) displayed on the tester.

HINT:

- The Control the Injection Volume for A/F sensor operation lowers the fuel injection volume by 12.5 % or increases the injection volume by 25 %.
- Each sensor reacts in accordance with increases and decreases in the fuel injection volume.

Standard

STANDARD VOLTAGE

<table>
<thead>
<tr>
<th>Tester Display (Sensor)</th>
<th>Injection Volumes</th>
<th>Status</th>
<th>Voltages</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFS B1S1 or AF SB2S1 (A/F)</td>
<td>+25 %</td>
<td>Rich</td>
<td>Less than 3.0</td>
</tr>
<tr>
<td>AFS B1S1 or AFS B2S1 (A/F)</td>
<td>-12.5%</td>
<td>Lean</td>
<td>More than 3.35</td>
</tr>
<tr>
<td>O2S B1S2 or O2S B2S2 (HO2)</td>
<td>+25 %</td>
<td>Rich</td>
<td>More than 0.55</td>
</tr>
<tr>
<td>O2S B1S2 or O2S B2S2 (HO2)</td>
<td>-12.5%</td>
<td>Lean</td>
<td>Less than 0.4</td>
</tr>
</tbody>
</table>

Result

RESULT REFERENCE

<table>
<thead>
<tr>
<th>Status AFS B1S1 or AFS B2S1</th>
<th>Status O2S B1S2 or O2S B2S2</th>
<th>A/F Condition and A/F and HO2 Sensors Conditions</th>
<th>Misfires</th>
<th>Main Suspected Trouble Areas</th>
<th>Proceed To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lean/Rich</td>
<td>Lean/Rich</td>
<td>Normal</td>
<td>-</td>
<td>• Three-Way Catalytic Converter (TWC) • Gas leak from exhaust system</td>
<td>A</td>
</tr>
<tr>
<td>Lean</td>
<td>Lean/Rich</td>
<td>A/F sensor malfunction</td>
<td>-</td>
<td>• A/F sensor</td>
<td>B</td>
</tr>
<tr>
<td>Rich</td>
<td>Lean/Rich</td>
<td>A/F sensor malfunction</td>
<td>-</td>
<td>• A/F sensor</td>
<td></td>
</tr>
<tr>
<td>Lean/Rich</td>
<td>Lean</td>
<td>HO2 sensor</td>
<td>-</td>
<td>• HO2 sensor • Gas leak from</td>
<td></td>
</tr>
</tbody>
</table>
4. CHECK DTC OUTPUT (DTC P0420 AND/OR P0430)
   a. According to the DTCs output in Step 1 (CHECK ANY OTHER DTCS OUTPUT), proceed to
      the next step, referring to the table below.

   **RESULT REFERENCE**
<table>
<thead>
<tr>
<th>Display (DTC Output)</th>
<th>Proceed To</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0420</td>
<td>A</td>
</tr>
<tr>
<td>P0430</td>
<td>B</td>
</tr>
<tr>
<td>P0420 and P0430</td>
<td>A and B</td>
</tr>
</tbody>
</table>

Lean: During Control the Injection Volume for A/F sensor, the A/F sensor output voltage (AFS) is consistently more than 3.35 V, and the HO2 sensor output voltage (O2S) is consistently less than 0.4 V.
Rich: During Control the Injection Volume for A/F sensor, the AFS is consistently less than 3.0 V, and the O2S is consistently more than 0.55 V.
Lean/Rich: During Control the Injection Volume for A/F sensor of the ACTIVE TEST, the output voltage of the HO2 sensor alternates correctly.
A: Go to step 5

B: Go to step 6

5. REPLACE EXHAUST MANIFOLD SUB-ASSEMBLY RH
   a. Replace the exhaust manifold sub-assembly RH (See REMOVAL).

   NEXT: REPLACE FRONT EXHAUST PIPE ASSEMBLY (See INSTALLATION)

6. REPLACE EXHAUST MANIFOLD SUB-ASSEMBLY LH
   a. Replace the exhaust manifold sub-assembly LH (See REMOVAL).

   NEXT: REPLACE NO. 2 FRONT EXHAUST PIPE ASSEMBLY (See INSTALLATION)