

DTC	P0420	Catalyst System Efficiency Below Threshold (Bank 1)
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MONITOR DESCRIPTION

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.

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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 the DTC.

DTC No.	DTC Detection Conditions	Trouble Areas
P0420	OSC value smaller than standard value under active air-fuel ratio control (2 trip detection logic)	- Front exhaust pipe (TWC) - Gas leakage from exhaust system - A/F sensor (sensor 1) - HO2 sensor (sensor 2)

MONITOR STRATEGY

Related DTCs	P0420: Catalyst Deterioration
Required Sensors/Components (Main)	TWC
Required Sensors/Components (Related)	Air-Fuel Ratio (A/F) sensor, Heated Oxygen (HO2) sensor, Intake Air Temperature (IAT) sensor, Mass Air Flow (MAF) meter, Crankshaft Position (CKP) sensor, Engine Coolant Temperature (ECT) sensor
Frequency of Operation	Once per driving cycle
Duration	20 seconds
MIL Operation	2 driving cycles
Sequence of Operation	None

TYPICAL ENABLING CONDITIONS

The monitor will run whenever the following DTCs are not present	P0011, P0012 (VVT system-Advance, Retard), P0031, P0032 (O2 sensor heater sensor 1), P0031, P0032 (A/F sensor heater sensor 1), P0037, P0038 (O2 sensor heater sensor 2), P0100, P0102, P0103 (MAF sensor), P0115, P0117, P0118 (ECT sensor), P0120, P0122, P0123 (TP sensor), P0125 (Insufficient ECT for closed loop), P0220, P0222, P0223, P2135, P0136, P0137, P0138 (O2 sensor 1), P0136 (O2 sensor 2), P0171, P0172 (Fuel system), P0300, P0301, P0302, P0303, P0304 (Misfire), P0335 (CKP sensor), P0340, P0341 (CMP sensor), P0351, P0352, P0353, P0354 (Igniter), P0500 (VSS), P2196 (A/F sensor (Rationality)), P2A00 (A/F sensor (slow response))
Battery voltage	11 V or more
IAT	-10°C (14°F) or more
Idling	OFF
MAF	2.5 to 33 g/sec
Engine RPM	Less than 4,000 rpm
ECT	75°C (167°F) or more

Estimated TWC temperature	Front catalyst: 650 to 830°C (1,202 to 1,526°F) (M/T) 650 to 840°C (1,202 to 1,544°F) (A/T) Rear catalyst: 400 to 760°C (752 to 1,400°F)
Fuel system status	Closed-loop
A/F sensor	Activated
Engine load	10 to 80 %
EVAP system monitor	The monitor has not run yet or the vacuum introduction has been completed
A/F sensor monitor	Completed
Rear HO2S monitor	Completed
Shift position	3rd or more (A/T), or 4th or 5th gear (M/T)

TYPICAL MALFUNCTION THRESHOLDS

Oxygen Storage Capacity (OSC) of catalyst converter	Less than 0.08 g
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MONITOR RESULT

The monitor result (mode 6) allows the OBD scan tool to display the monitor status, test value and test limit. A problem in this component can be found by comparing the test value and test limit. This procedure is described in "CHECKING MONITOR STATUS" (See page [ES-15](#)).

- TID (Test Identification) is assigned to each emission-related component.
- TLT (Test Limit Type):
If TLT is 0, the component is malfunctioning when the test value is higher than the test limit.
If TLT is 1, the component is malfunctioning when the test value is lower than the test limit.
- CID (Component Identification) is assigned to each test value.
- Unit Conversion is used to calculate the test value indicated on generic OBD scan tools.

TID \$01: Catalyst- Active A/F Control Method

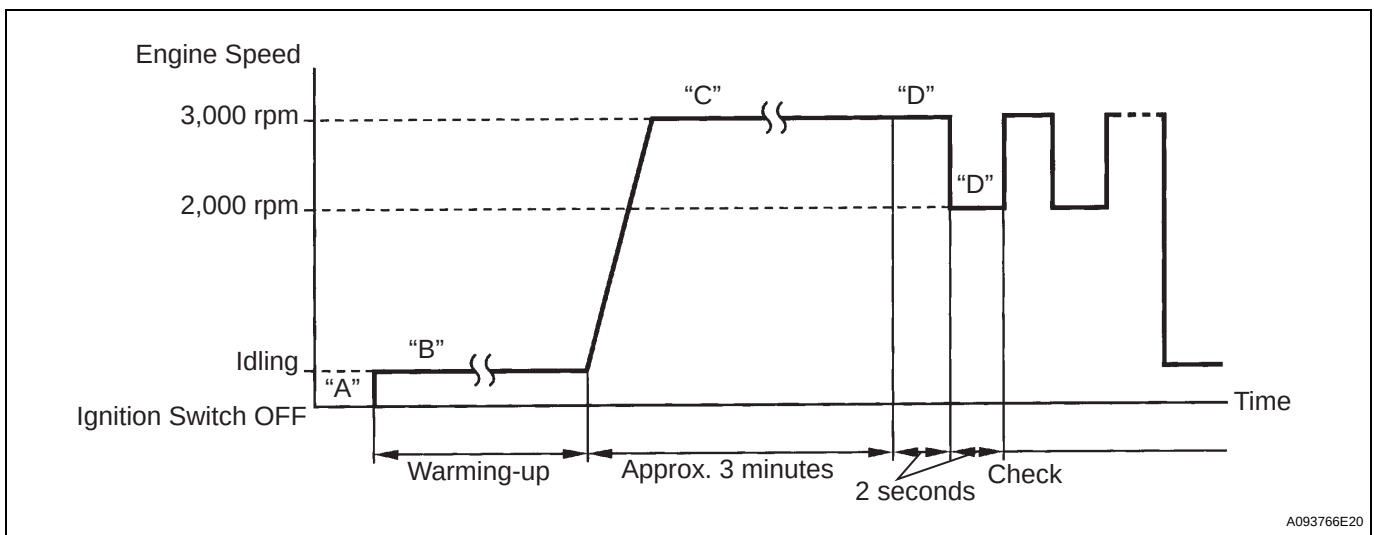
TLT	CID	Unit Conversion	Description of Test Value	Description of Test Limit
0	\$01	Multiply by 0.0078 (no dimension)	Oxygen storage capacity (OSC) bank 1: Determined by HO2S output	Malfunction criterion

CONDITIONING FOR SENSOR TESTING

1. WAVEFORMS OF AIR-FUEL RATIO (A/F) AND HEATED OXYGEN (HO2) SENSORS

HINT:

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



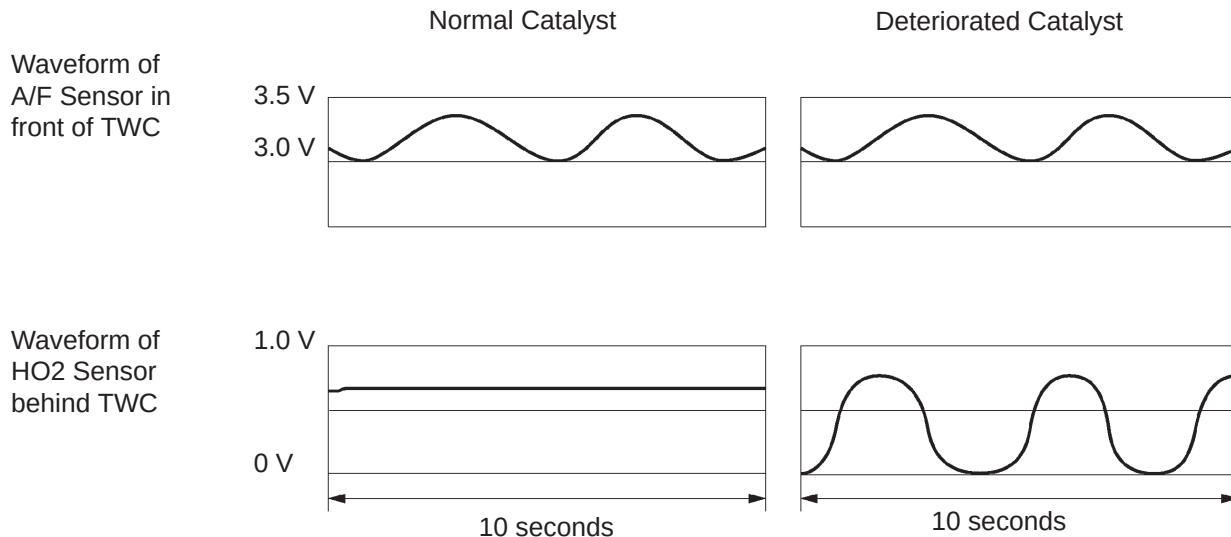
- Connect an intelligent tester or OBD II scan tool to the DLC3 (Procedure "A").
- Start the engine and warm it up with all the accessories switched OFF, until the engine coolant temperature stabilizes (Procedure "B").
- Run the engine at an engine speed of between 2,500 rpm and 3,000 rpm for at least 3 minutes (Procedure "C").
- 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 or scan tool (Procedure "D").

HINT:

- If either of the voltage outputs of the Air-Fuel Ratio (A/F) or Heated Oxygen (HO2) sensors 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 A/F CONTROL using an intelligent tester.
- 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).

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Voltage output when active air-fuel ratio control is not performed



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2. A/F CONTROL**HINT:**

Intelligent tester only:

Malfunctioning areas can be identified by performing the A/F CONTROL function provided in the ACTIVE TEST. The A/F CONTROL 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 A/F CONTROL operation using an intelligent tester.

- Connect an intelligent tester to the DLC3.
- Start the engine and turn the tester ON.
- Warm up the engine at an engine speed of 2,500 rpm for approximately 90 seconds.
- On the tester, select the following menu items: DIAGNOSIS / ENHANCED OBD II / ACTIVE TEST / A/F CONTROL.
- Perform the A/F CONTROL operation with the engine in an idling condition (press the RIGHT or LEFT button to change the fuel injection volume).
- Monitor the voltage outputs of the A/F and HO2 sensors (AFS B1S1 and OS2 B1S2) displayed on the tester.

HINT:

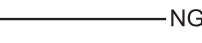
- The A/F CONTROL operation lowers the fuel injection volume by 12.5 % or increases the injection volume by 25 %.
- Each sensor reacts in accordance with increases and decreases in the fuel injection volume.

Standard voltage

Tester Display (Sensor)	Injection Volumes	Status	Voltages
AFS B1S1 (A/F)	+25 %	Rich	Less than 3.0
AFS B1S1 (A/F)	-12.5 %	Lean	More than 3.35
O2S B1S2 (HO2)	+25 %	Rich	More than 0.55
O2S B1S2 (HO2)	-12.5 %	Lean	Less than 0.4

NOTICE:

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.

Case	A/F Sensor (Sensor 1) Output Voltage		HO2 Sensor (Sensor 2) Output Voltage		Main Suspected Trouble Areas
Case 1	Injection Volume +25 % -12.5 %		Injection Volume +25 % -12.5 %		-
	Output Voltage More than 3.35 V Less than 3.0 V	 OK	Output Voltage More than 0.55 V Less than 0.4 V	 OK	
Case 2	Injection Volume +25 % -12.5 %		Injection Volume +25 % -12.5 %		• A/F sensor • A/F sensor heater • A/F sensor circuit
	Output Voltage Almost no reaction	 NG	Output Voltage More than 0.55 V Less than 0.4 V	 OK	
Case 3	Injection Volume +25 % -12.5 %		Injection Volume +25 % -12.5 %		• HO2 sensor • HO2 sensor heater • HO2 sensor circuit
	Output Voltage More than 3.35 V Less than 3.0 V	 OK	Output Voltage Almost no reaction	 NG	
Case 4	Injection volume +25 % -12.5 %		Injection Volume +25 % -12.5 %		• Injector • Fuel pressure • Gas leakage from exhaust system (Air-fuel ratio extremely rich or lean)
	Output Voltage Almost no reaction	 NG	Output Voltage Almost no reaction	 NG	

HINT:

- Following the A/F CONTROL 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: DIAGNOSIS / ENHANCED OBD II / ACTIVE TEST / A/F CONTROL / USER DATA / AFS B1S1 and O2S B1S2, and press the YES button and then the ENTER button followed by the F4 button.

INSPECTION PROCEDURE

HINT:
Read freeze frame data using an intelligent tester or OBD II scan tool. The ECM records vehicle and driving condition information as freeze frame data the moment a DTC is stored. When troubleshooting, freeze frame data can be helpful in determining whether the vehicle was running or stopped, whether the engine was warmed up or not, whether the air/fuel ratio was lean or rich, as well as other data recorded at the time of a malfunction.

When using intelligent tester:

1

CHECK ANY OTHER DTCs OUTPUT (IN ADDITION TO DTC P0420)

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- (a) Connect an intelligent tester to the DLC3.
- (b) Turn the ignition switch to ON and turn the tester ON.
- (c) On the tester, select the following menu items:
DIAGNOSIS / ENHANCED OBD II / DTC INFO /
CURRENT CODES.
- (d) Read DTCs.

Result

Display (DTC Output)	Proceed to
P0420	A
P0420 and other DTCs	B

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

A

B

GO TO DTC CHART

2

PERFORM ACTIVE TEST BY INTELLIGENT TESTER (A/F CONTROL)

- (a) Connect the intelligent tester 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) On the tester, select the following menu items:
DIAGNOSIS / ENHANCED OBD II / ACTIVE TEST / A/F
CONTROL.
 - (e) Perform the A/F CONTROL operation with the engine in an idling condition (press the RIGHT or LEFT button to change the fuel injection volume).
 - (f) Monitor the voltage output of the A/F and HO2 sensors (AFS B1S1 and O2S B1S2) displayed on the tester.
- HINT:
- The A/F CONTROL 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 voltage

Tester Display (Sensor)	Injection Volumes	Status	Voltages
AFS B1S1 (A/F)	+25 %	Rich	Less than 3.0
AFS B1S1 (A/F)	-12.5 %	Lean	More than 3.35
O2S B1S2 (HO2)	+25 %	Rich	More than 0.55
O2S B1S2 (HO2)	-12.5 %	Lean	Less than 0.4

Result

Status AFS B1S1	Status O2S B1S2	A/F Condition and A/F and HO2 Sensors Condition	Misfires	Main Suspected Trouble Areas	Proceed to
Lean/Rich	Lean/Rich	Normal	-	- Three-Way Catalytic Converter (TWC) - Gas leakage from exhaust system	A
Lean	Lean/Rich	A/F sensor malfunction	-	A/F sensor	B
Rich	Lean/Rich	A/F sensor malfunction	-	A/F sensor	B
Lean/Rich	Lean	HO2 sensor malfunction	-	- HO2 sensor - Gas leakage from exhaust system	C
Lean/Rich	Rich	HO2 sensor malfunction	-	- HO2 sensor - Gas leakage from exhaust system	C
Lean	Lean	Actual air-fuel ratio lean	May occur	- Extremely rich or lean actual air-fuel ratio - Gas leakage from exhaust system	A
Rich	Rich	Actual air-fuel ratio rich	-	- Extremely rich or lean actual air-fuel ratio - Gas leakage from exhaust system	A

Lean: During A/F CONTROL, 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 A/F CONTROL, the AFS is consistently less than 3.0 V, and the O2S is consistently more than 0.55 V.

B

CHECK AND REPLACE AIR FUEL RATIO SENSOR

C

CHECK AND REPLACE HEATED OXYGEN SENSOR

A**3****CHECK FOR EXHAUST GAS LEAK****OK:**

No gas leakage.

NG

REPAIR OR REPLACE EXHAUST GAS LEAKAGE POINT

OK

REPLACE THREE-WAY CATALYTIC CONVERTER (BOTH FRONT AND REAR CATALYSTS (FRONT EXHAUST PIPE))

ES

When Using OBD II Scan Tool:

1 CHECK ANY OTHER DTCS OUTPUT (IN ADDITION TO DTC P0420)

- (a) Connect an OBD II scan tool to the DLC3.
- (b) Turn the ignition switch to ON and turn the scan tool ON.
- (c) Read DTCs using the scan tool.

Result

Display (DTC Output)	Proceed to
P0420	A
P0420 and other DTCs	B

HINT:

If any DTCs other than P0420 are output, troubleshoot those DTCs first.

B

GO TO DTC CHART

A

2 CHECK FOR EXHAUST GAS LEAK

OK:

No gas leakage.

NG

REPAIR OR REPLACE EXHAUST GAS LEAKAGE POINT

OK

3 INSPECT AIR FUEL RATIO SENSOR

- (a) Inspect the air-fuel ratio sensor (See page [EC-12](#)).

OK

Test Item	Specific Condition
Confirmation driving pattern	No malfunction is detected
A/F control (Inspection procedure)	Standard value

NG

REPLACE HEATED OXYGEN SENSOR

OK

4 INSPECT HEATED OXYGEN SENSOR

- (a) Inspect the heated oxygen sensor (See page [EC-13](#)).

OK

Test Item	Specific Condition
OS2 test result	Test result is normal
Confirmation driving pattern	No malfunction is detected
A/F control (Inspection procedure)	Standard value

NG

REPLACE HEATED OXYGEN SENSOR

OK

REPLACE THREE-WAY CATALYTIC CONVERTER (BOTH FRONT AND REAR CATALYSTS
(FRONT EXHAUST PIPE))

ES