NTK™ OXYGEN SENSORS

OXYGEN SENSOR Q&A

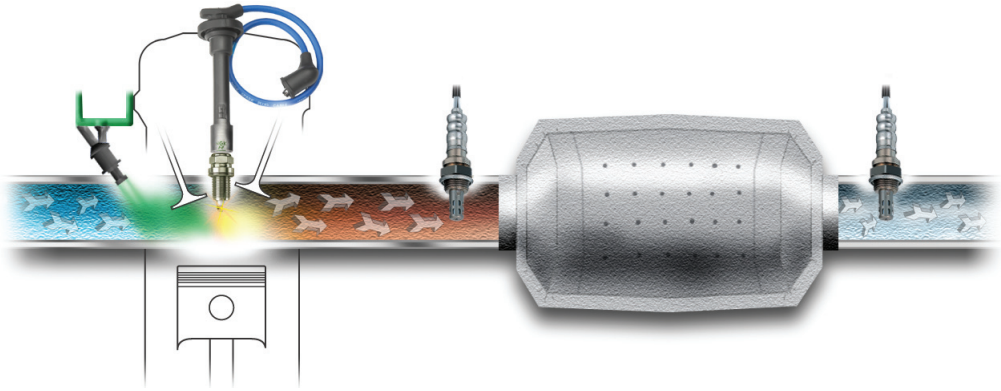
Questions and Answers on Oxygen Sensors

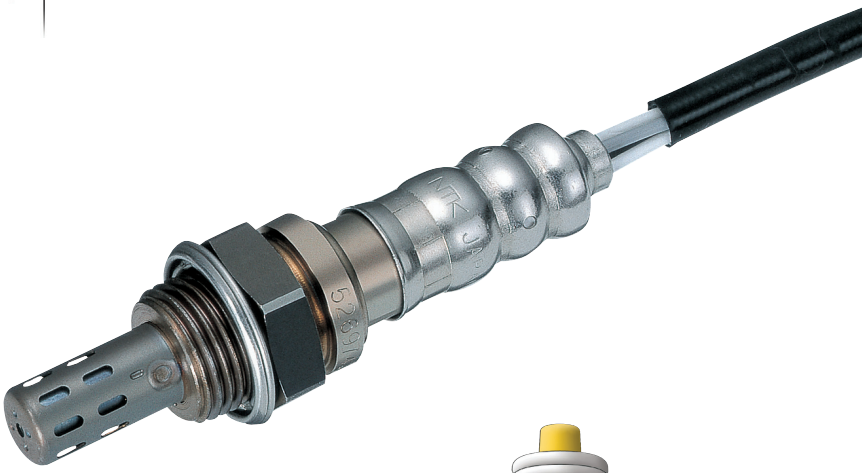
NGK SPARK PLUGS | NTK TECHNICAL CERAMICS

Q1

Q: What is an Oxygen Sensor?

A: An emission control component that senses the presence of oxygen in the exhaust stream.





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Q: Why is an Oxygen Sensor needed?

Q2

A: Vehicles are one of the leading causes of air pollution in the world. As a result, government legislation has enacted regulation in many parts of the world to reduce vehicle emissions and increase fuel efficiency. By more closely controlling a vehicle's air fuel ratio, fuel efficiency can be increased, while tailpipe emissions are reduced.

The oxygen sensor functions as the eyes and ears for the ECU. Its role is to communicate with the ECU whether a vehicle is running rich or lean. The goal is to have the engine run close to 14.7 parts of air to 1 part of fuel. 14.7:1 is known as the Stoichiometric Point. At this point, optimum combustion under normal conditions occurs and the least amount of harmful gases are produced.

Smog filled skyline due to air pollution

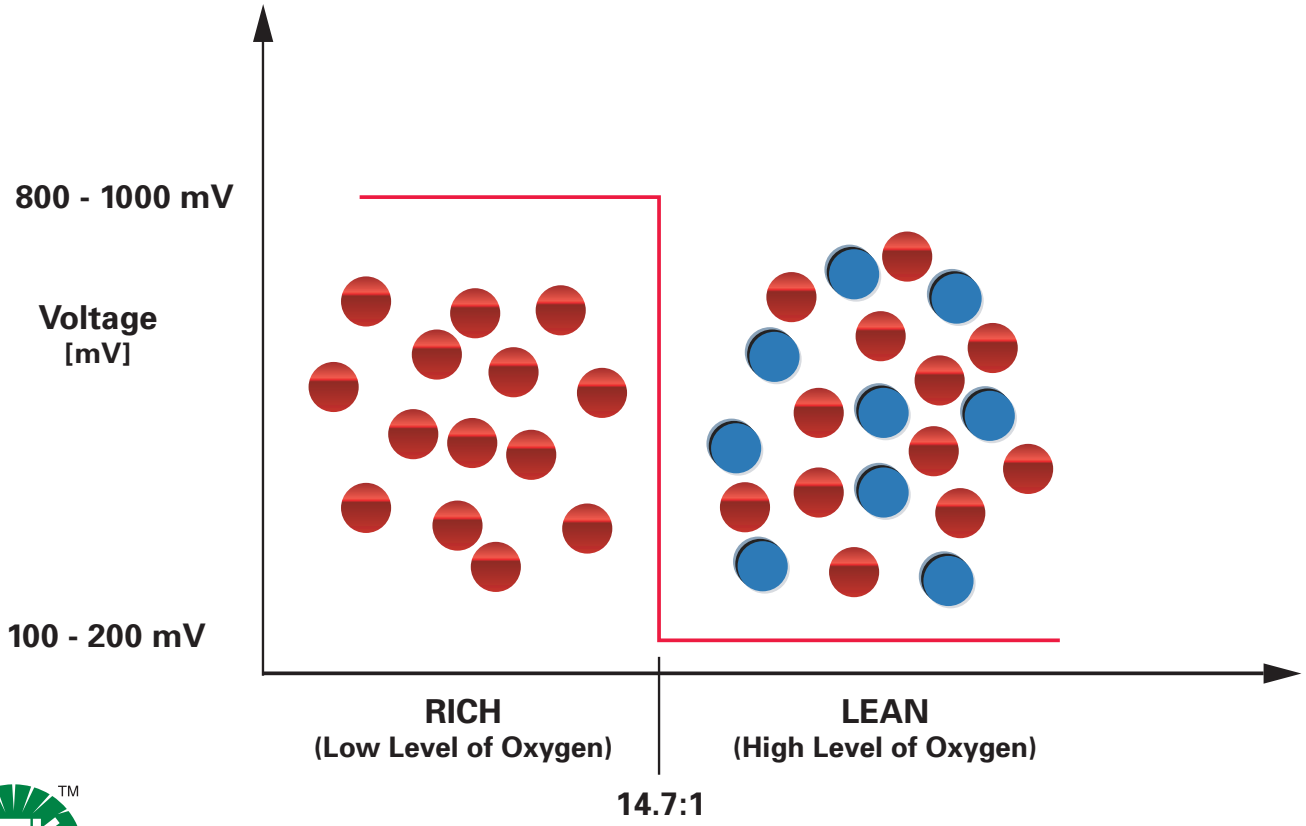
Q3

Q: How does an Oxygen Sensor work?

A: The sensor becomes operational at approximately 350˚C (650˚F).

At this point a chemical reaction occurs producing a high or low voltage based upon high or low levels of oxygen in the exhaust stream.

Output Voltage vs. AFR



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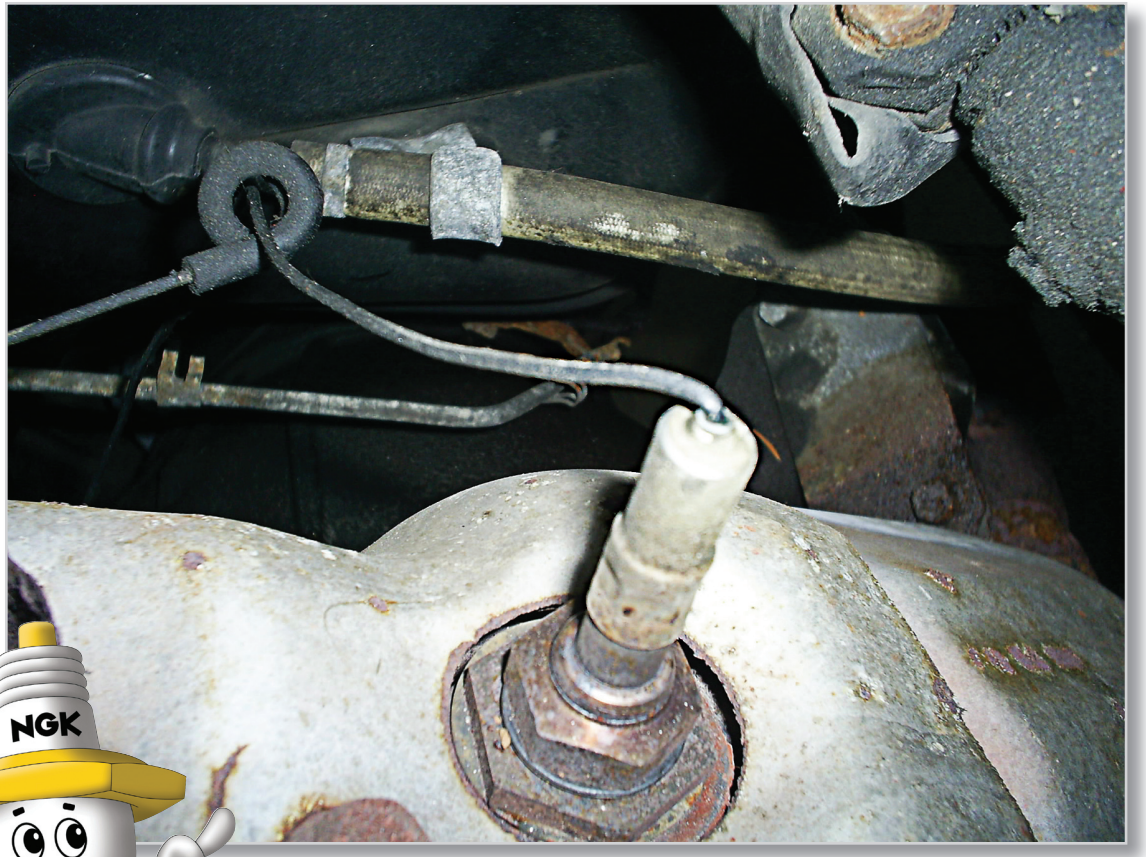
Q4

Q: Does my vehicle have an Oxygen Sensor?

A: Most vehicles produced for the North American market after 1981 have at least one oxygen sensor.

EPA laws required the introduction of oxygen sensors to decrease vehicle tailpipe emissions and improve fuel efficiency.



Early 1 Wire Sensor Design

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Q5

Q: Where are Oxygen Sensors located?

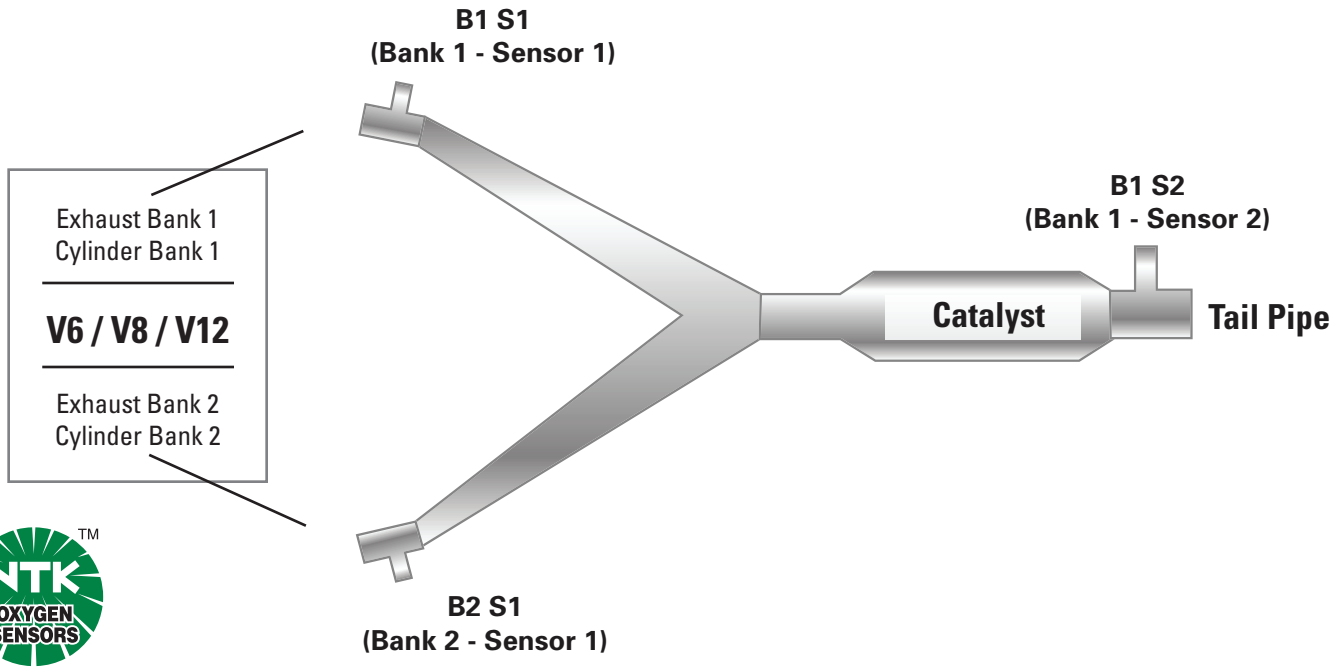
A: Vehicles produced before 1996 (OBDI) will have one or two sensors upstream of the three-way catalyst (catalytic converter). Vehicles produced after the 1995 model year (OBDII) will have oxygen sensors both upstream and downstream of the three-way catalyst.

To explain the sensor locations as found on a scan tool, you must first find the #1 cylinder location. Bank one (1) will always be the side of the engine with the #1 cylinder. Sensor one (1) will always be upstream of the three-way catalyst, while sensor two (2) will be downstream.

To determine left and right, as this is how the sensors are cataloged, you must first establish the front and rear of an engine.

Front will be the side of the engine with the accessory drive belts for alternator, air conditioning, power steering, etc.

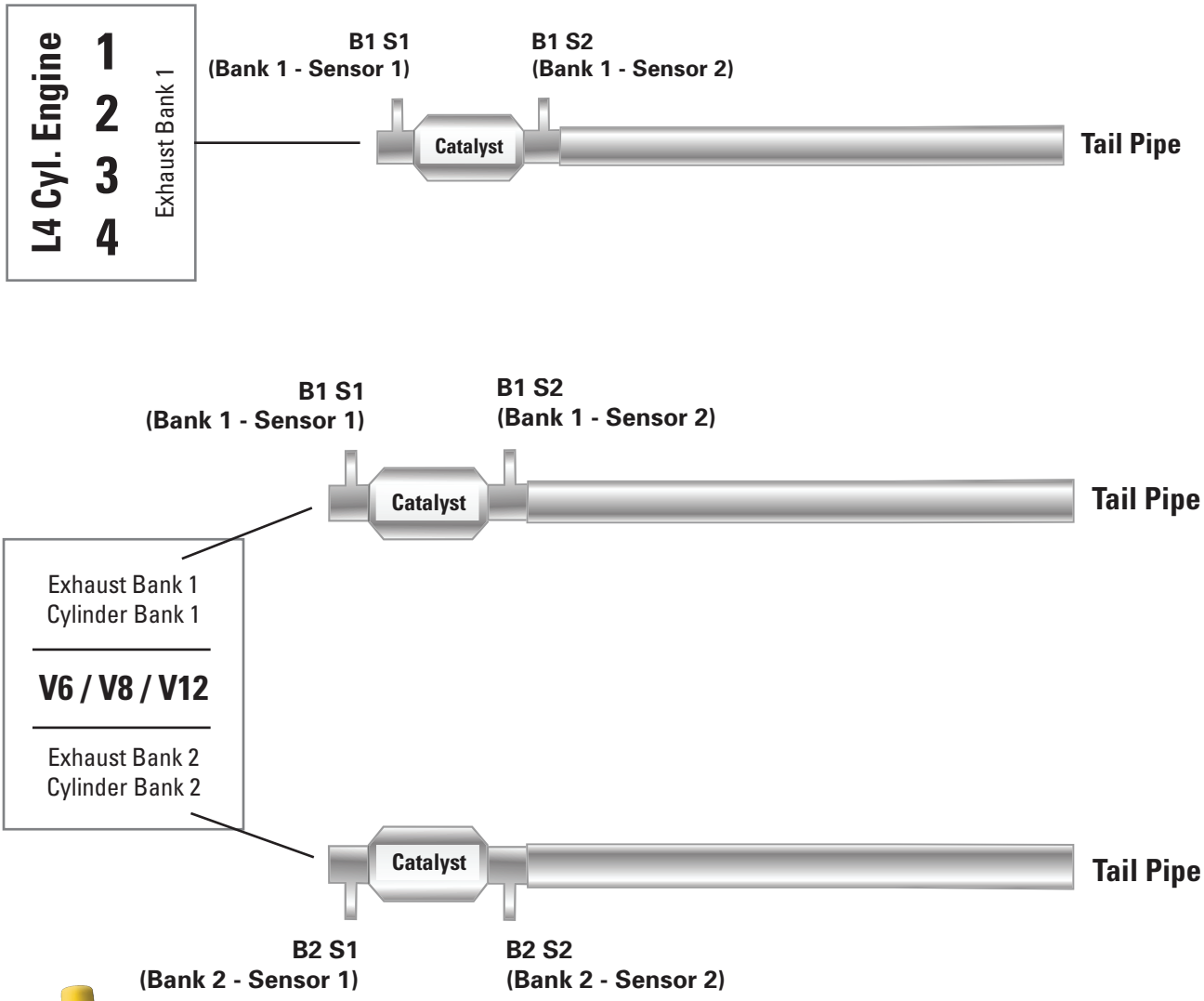
The left side of the engine will be the side to the left of the accessory drive belts when standing behind the engine. The right side of the engine will be the side to the right of the accessory drive belts when standing behind the engine.



NTK™ OXYGEN SENSORS

Q5

Q: Where are Oxygen Sensors located?



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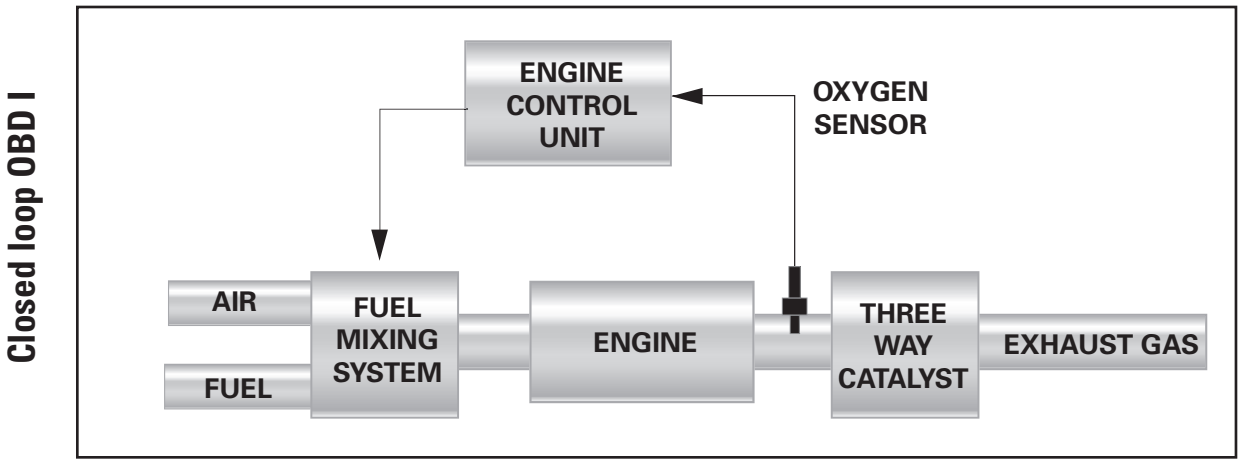
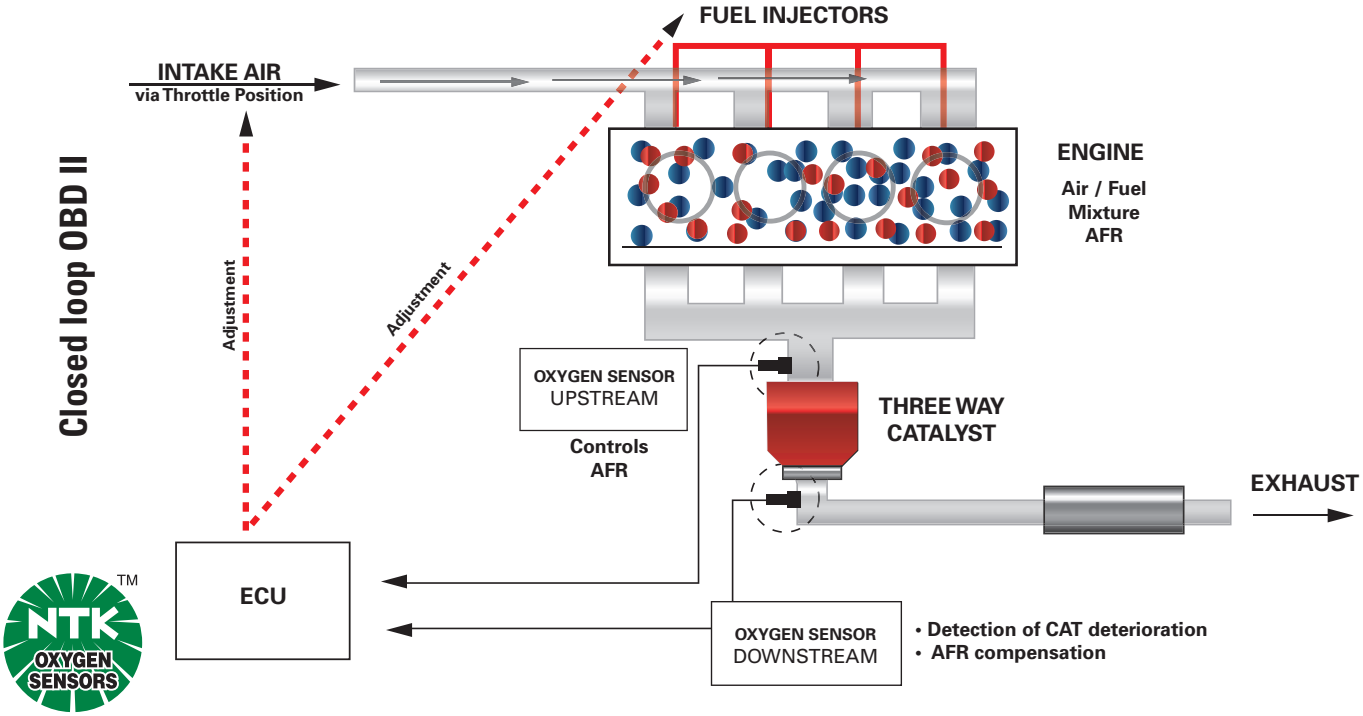
Q6

Q: What are “Open Loop” and “Closed Loop” modes?

A: Open loop mode is the period of time before the oxygen sensor becomes operational, usually at vehicle start up. It is also the default mode should a sensor problem occur.

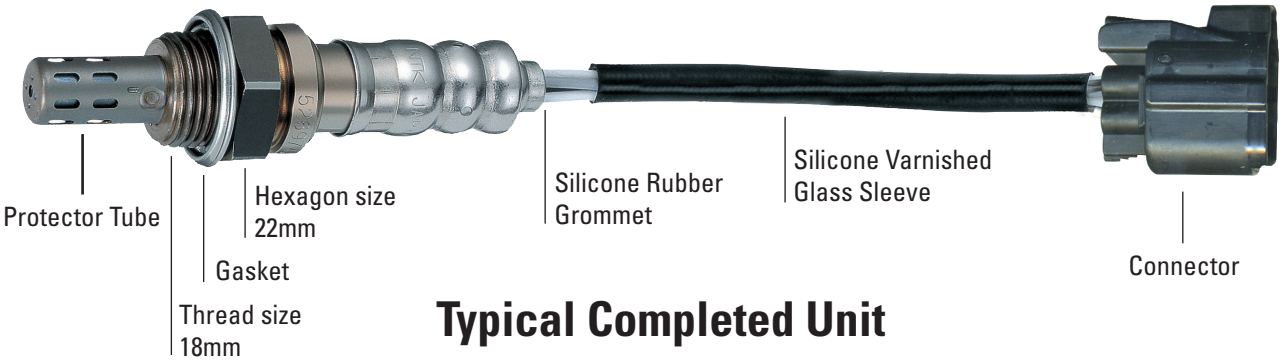
Closed loop mode is the desired mode where the oxygen sensor is operational. At this time AFR and exhaust emissions are being controlled.



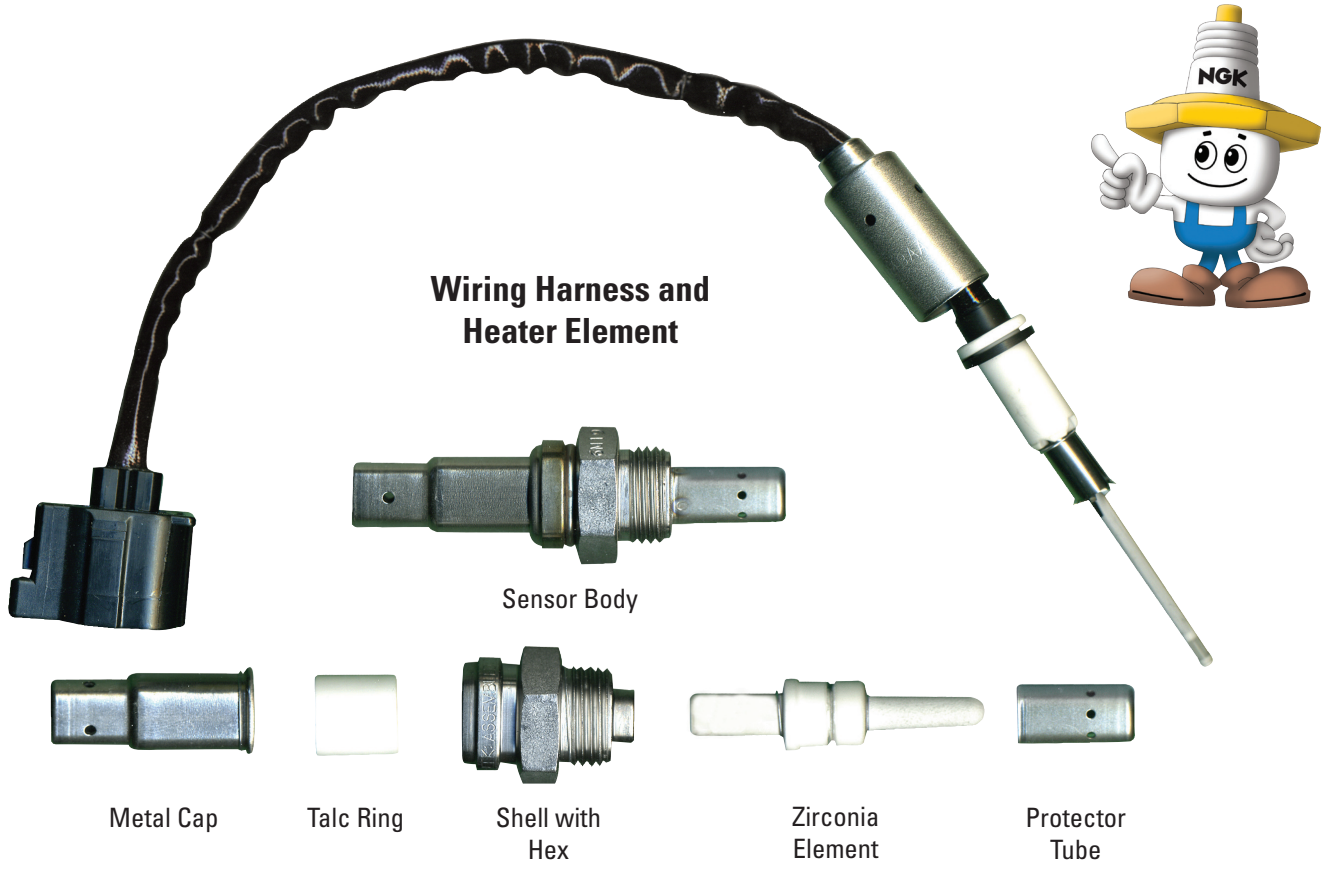


Q7

Q: What are the components of a Zirconia type Oxygen Sensor?



Typical Completed Unit



Typical Components

Note: The images above represent a typical oxygen sensor and its components. Each oxygen sensor part number is unique in its own way and the image's appearance and component vary based on the part numbers specification.

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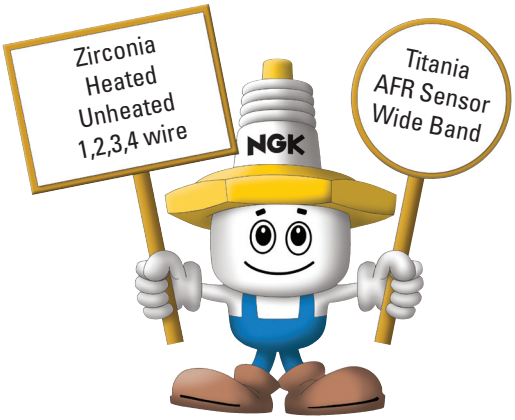
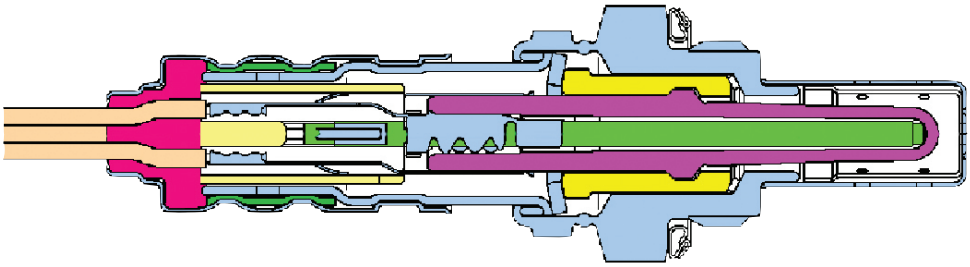
Q8

Q: What are the different types of Oxygen Sensors?



A: Zirconia

- Most popular (90% of the market)
- 1-4 wire configuration
- Heated or unheated
- Thimble or Planar type
- 18mm thread size
- Requires reference air



1 wire (unheated sensor)

- Signal wire
- Ground achieved through sensor body (earth ground)

2 wire (unheated sensor)

- Signal wire
- Ground wire (ground achieved through case or isolated ground)

3 wire (heated sensor)

- Signal wire
- Ground achieved through sensor body (earth ground)
- Two heater wires

4 wire (heated sensor)

- Signal wire
- Ground wire (ground achieved through case or isolated ground)
- Two heater wires

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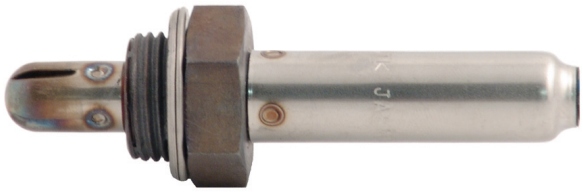
Q: What are the different types of Oxygen Sensors?

Q8

Titania

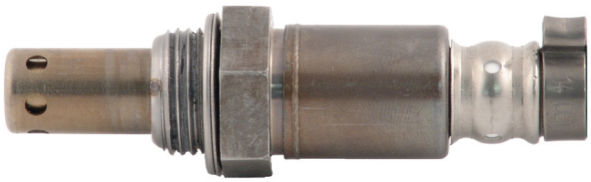


- Always heated (3 or 4 wire)
- Requires no reference air
- Typically 12mm but some 18mm thread sizes

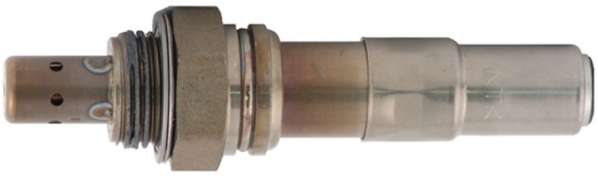
Q Are Zirconia and Titania sensors interchangeable?

A NO - Zirconia produces a voltage (less than 1v) while Titania require a voltage. Resistance is then measured and AFR is controlled accordingly.

AFR Sensor (4 wire)



- Similar structure to conventional (switching) type Zirconia oxygen sensors, but uses limiting current characteristics to measure AFR.
- ECU creates voltage variance across the sensor's electrodes-the potential difference is 300mv and current will be generated as needed to maintain a fixed voltage of 300mv. This limiting current is used for O2 sensing and is linearly proportionate to the amount of oxygen present.
- Thimble or Planar type
- Free of reference air
- Measures air/fuel ratios from 10:1 to 18:1



Wide Band Oxygen Sensor (5 Wire)

- Monitors AFR to a higher degree of accuracy- provides precise control of AFR.
- Wide Band sensors require a controller which is pre-programmed to control AFR at desired point (usually Stoichiometric point)
- Wide Band controller then sends signal to ECU for fuel trim adjustment
- Measures air/fuel ratios from 10:1 to 18:1

Q Are AFR sensors and Wide Band oxygen sensors interchangeable?

A NO

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Q9

Q: What are the obvious signs and impact of worn Oxygen Sensors?

A: The most obvious sign an oxygen sensor is failing or has failed is a check engine light. Vehicles are designed to inform the driver if there is a problem with the emissions system. A check engine light may point to a problem with the emissions system but does not necessarily mean the oxygen sensor is faulty.

Other signs of worn oxygen sensors are increased fuel consumption and an increase in vehicle emissions.

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Q10

Q: How can I check my Oxygen Sensors to ensure they are working properly?

A: There are three (3) ways a sensor can be checked to see if it is functioning properly.

A professional repair shop will have scan tools to check sensor operation.

Advanced shops may have a tool called an oscilloscope. This tool will graphically display oxygen sensor output as it switches voltage from high to low.

Removed from the vehicle, a oxygen sensor can be checked using a common multi-meter to check for heater resistance. In the case of a faulty heater element, the resistance will read as an open circuit.

Scan Tool In Use

Q11

Q: What can shorten the life of an Oxygen Sensor?

A: Common causes for oxygen sensor failure are poisoning from substances such as engine coolant, silicone gasket materials or soot.

Often these problems can point to other mechanical issues with an engine.

Thermal shock from raw fuel or moisture in the exhaust can also cause a sensor heater element to crack.

The root cause of the problem should be addressed along with replacement of the oxygen sensor if needed.

PROBLEM -
Lead Poisoning

SYMPTOM - Shiny deposits are evidence of lead in the fuel. Lead attacks the precious metal of the sensor element & the catalytic converter.

SOLUTION - Sensor needs to be replaced and care taken to use only lead-free fuels.

PROBLEM -
Excessive Carbon / Soot Deposits

SYMPTOM - Thick soot deposits lead to blockage of the sensor protection tube and have a negative effect on reaction time. Causes can be a mixture that is too fuel-rich or the result of damage to the sensor heater.

SOLUTION - Sensor must be replaced in all cases with new sensor.

PROBLEM -
Silicone Contamination

SYMPTOM - White deposits are evidence of silicone poisoning. Silicone based adhesives/products will contaminate the sensor element.

SOLUTION - Sensor must be removed and replaced with new sensor; care must be taken to use ONLY “oxygen sensor-friendly” products.

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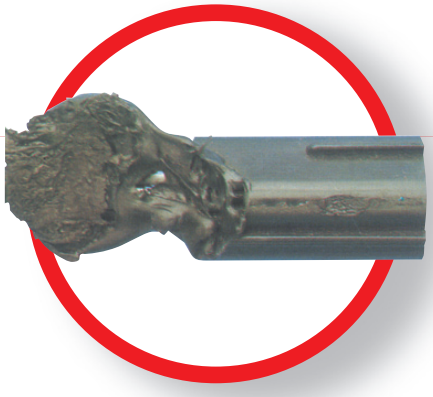
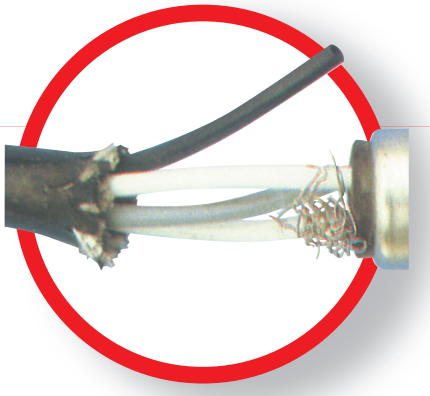
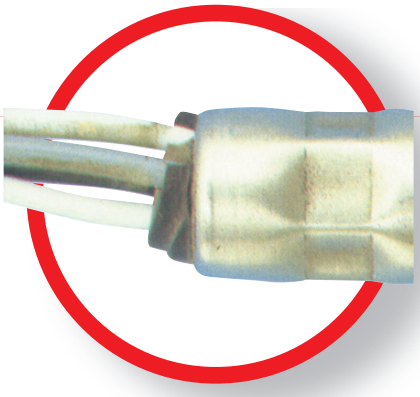
Q12

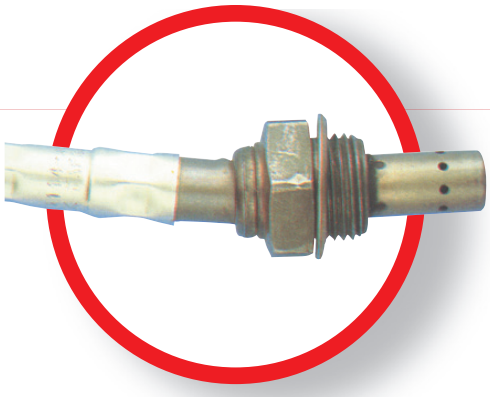
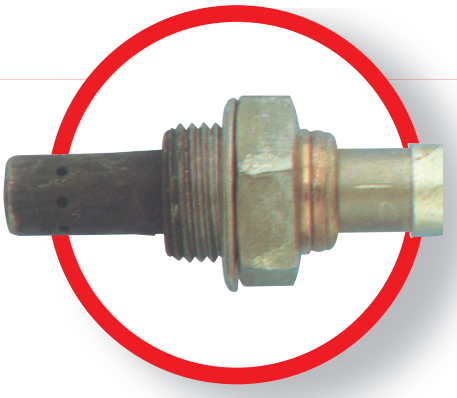
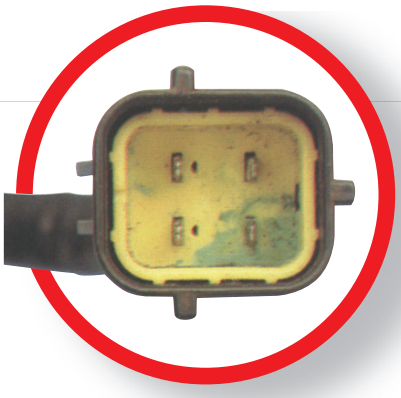
Q: What can I tell from visually inspecting an Oxygen Sensor?

Problem		Solution
Wires melted by contact with exhaust		Replace with new sensor and route without touching the exhaust
Frayed or broken wires		Replace with new sensor and make sure there is some slack in the wires
Wire Grommet is loosened water may enter the sensor		Replace with new sensor and make sure there is some slack in the wires

NTK™ OXYGEN SENSORS

Q12

Q: What can I tell from visually inspecting an Oxygen Sensor?

Problem		Solution
Sensor is bent		Replace with new sensor
Soot deposits are blocking the openings of the protective sleeve, due to fuel-rich mixture or high oil consumption because of wear on engine or valves and leaks in the exhaust system		Diagnose and correct fault. Note: Excessive deposits of soot and oil on the protective sleeve are not caused by the sensor itself
Water in the connector		Replace with new sensor. Check electrical connections to connector seal and also the connection between the sensor and the engine control unit

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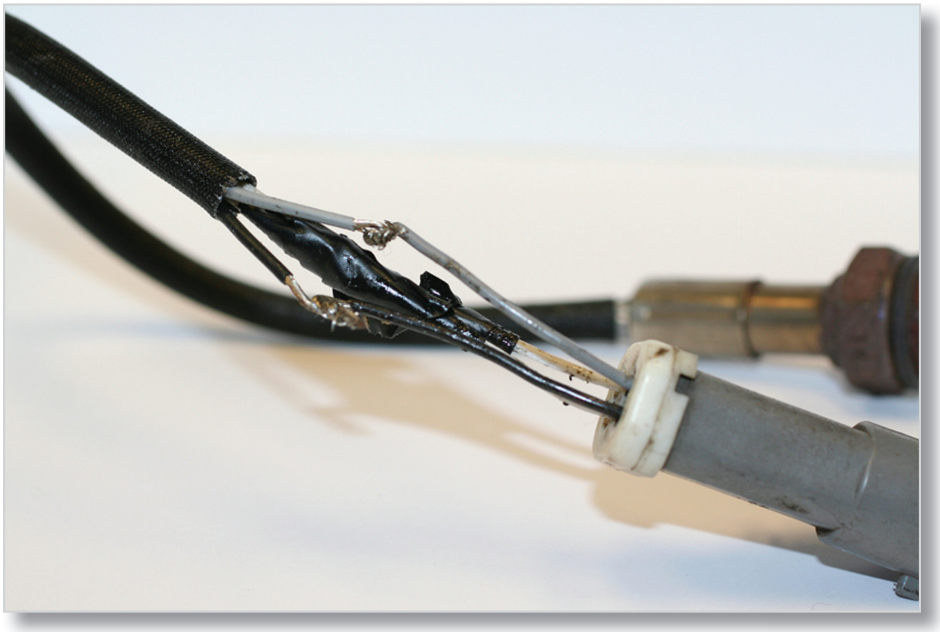
Q13

Q: What is a Universal Oxygen Sensor?

A: Universal oxygen sensors are designed to work on several applications, thereby reducing the number of stocking units needed.

Universal oxygen sensors do not have factory matched connectors and need to be spliced into place using the connector from the old sensor.

The use of universal oxygen sensors are not recommended as compatibility and installation issues often prevent the sensor from performing as well as an OEM matched unit.



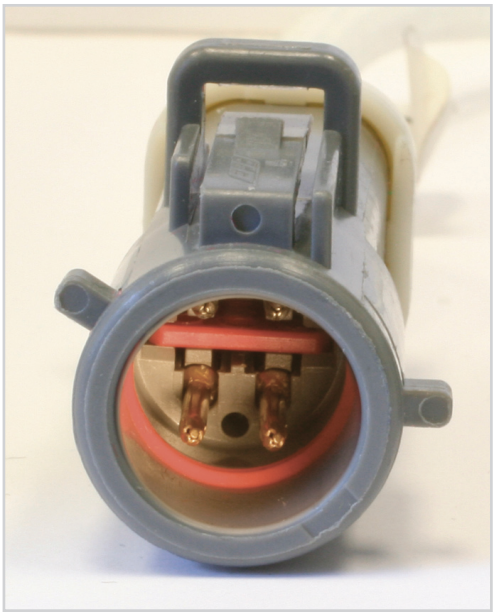
Improper Universal Sensor Installation

Q14

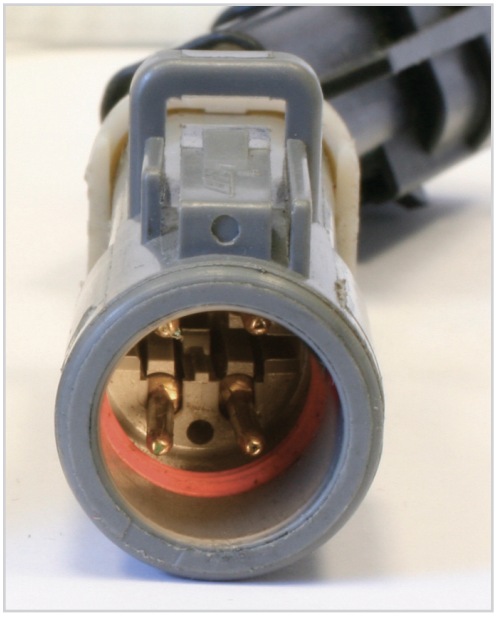
Q: What are the advantages of using a Direct Fit Oxygen Sensor over a Universal Oxygen Sensor?

A: A direct fit oxygen sensor has been engineered to ensure the operating parameters are the same as the OE sensors.

Direct fit sensors will have the correct connectors, hardware and wire length to ensure proper form, fit and function.



OE



Aftermarket

Aftermarket sensor programs may have small variances to the OE sensor to provide wider coverage. For example, the picture above illustrates the elimination of the mounting flanges and allows the aftermarket version to be utilized on both the left and right banks versus having two Aftermarket part numbers, as is the case with the OE part.

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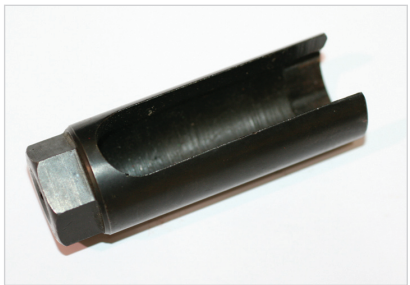
Q: How do I install an Oxygen Sensor?

Q15

A: Sensor installation will first require the proper tools. A specialty oxygen sensor socket is recommended for removal of the old sensor and installation of a new sensor.

1. Disconnect the battery.
2. Disconnect wiring harness from the old sensor.
3. Remove any hardware or clips if applicable.
4. Use the oxygen sensor socket (shown below) to remove the old sensor.
5. Apply anti-seize compound to the threads of the sensor (if not already pre-applied).
6. Use specialty socket to install the new sensor to the recommended torque.
7. Put in place any hardware or clips if applicable.
8. Connect the wiring of the new sensor to the existing vehicle wiring.
9. Reconnect the battery.



NTK OXYGEN SENSORS™

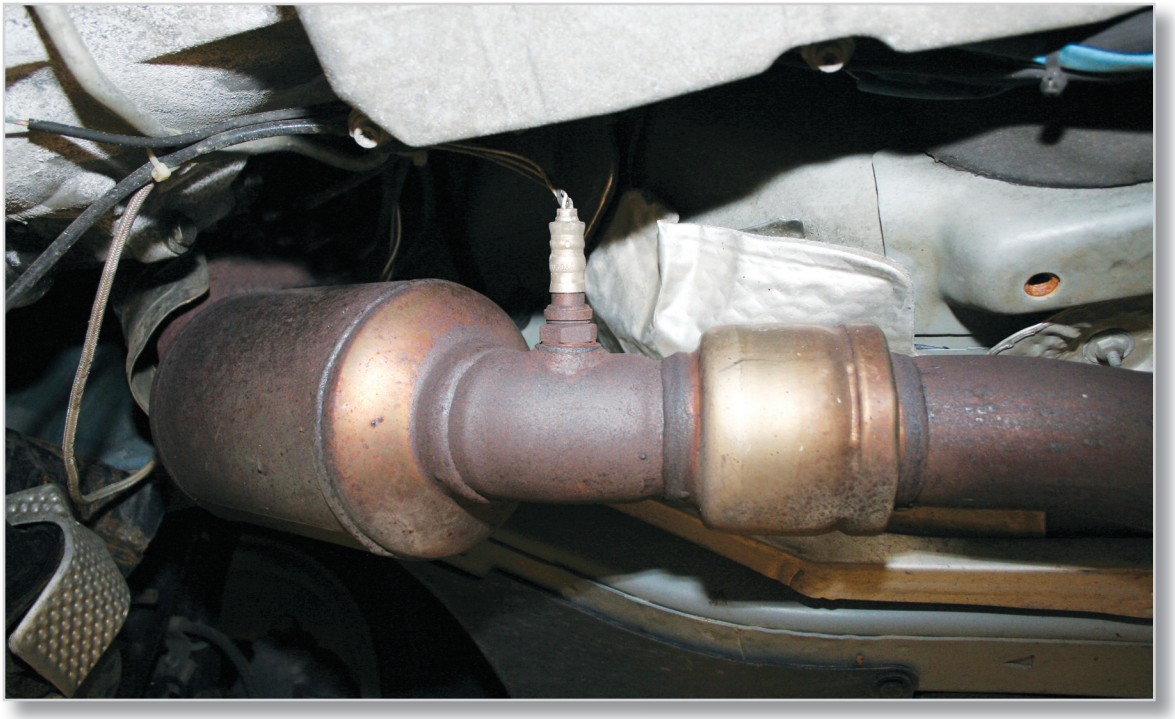
Q16

Q: What is the expanded role an Oxygen Sensor plays in OBDII vs. OBDI ?

A: In OBDII equipped vehicles there is a sensor downstream of the three-way catalyst to monitor catalyst function and can also assist in controlling AFR by adjusting fuel trim.

If a catalyst has failed or there is a problem elsewhere in the system, the downstream sensor may trigger a MIL light or check engine light to warn of a possible problem.

In OBDII, the ECU is also monitoring the condition of the sensor signal response time, heater light-off time and heater resistance.



Downstream Oxygen Sensor

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Q17

Q: What does the future hold for Oxygen Sensors?

A: As future emissions standards become tougher for all engines, even non-automotive applications, NTK is further developing sensor technologies to help provide cleaner, more efficient commercial and recreational engines. In the future, legislation will mandate emission controls on all engines. Today, many motorcycles, snowmobiles, marine and outdoor power equipment applications are using oxygen sensors to limit emissions.

Glossary

Term	Definition
AFR (Air Fuel Ratio)	The measurement or ratio mixture of air to fuel for internal combustion engines.
AFR Sensor	Air Fuel Ratio Sensor. A linear 4 wire oxygen sensor which actually measures air fuel ratio rather than producing a switching voltage. In this type of system, a constant voltage is applied to the sensor to get a desired AFR result.
Three-Way Catalyst (Catalytic Converter)	Emission control component designed to convert harmful poisonous gasses by heat & chemical reaction to non-poisonous environmentally friendly gases. • Converts - CO (Carbon Monoxide) to CO2 (Carbon Dioxide) • Converts - HC (Hydro Carbons) to H2O (Water) • Converts - NOx (Oxides of Nitrogen) to N (Nitrogen)
Closed Loop	Condition after oxygen sensors have reached operating temperature, AFR is controlled and emissions are reduced.
Direct Fit Sensors	Oxygen Sensors that include the wiring connector.
Downstream	Term referring to oxygen sensor position beyond the three-way catalyst located in the exhaust pipe to monitor catalytic converter output.
DTC (Diagnostic Trouble Code)	Code # downloaded from ECU by means of a scan tool identifying emissions related problems.
ECU (Electronic Control Unit)	A vehicle's on-board computer module responsible for controlling and adjusting multiple systems in real time such as fuel management, braking, ignition, etc.
EPA (Environmental Protection Agency)	US governmental agency responsible for federal emission laws & mandates.
HC (Hydrocarbons)	Emission pollutant resulting from incomplete fuel combustion & fuel evaporation.
Lean	Condition of AFR. Too much oxygen is present in the exhaust. AFR is greater than 14.7:1
MIL (Malfunction Indicator Lamp)	Also known as Check Engine Light, a warning lamp on a vehicle's instrument cluster that informs the driver of possible emissions related problem.
NOx (Nitrogen Oxides)	Formed when fuel is burned at high temperatures. Vehicles are the highest producer of NOx

Glossary

Term	Definition
OBDI	Federal emissions standard prior to 1996 model year vehicles. Usually vehicles have one or two oxygen sensors upstream of the catalyst.
OBDII	Federal emissions standard after 1995 model year mandating stricter emission control. Use of downstream oxygen sensors is required.
Open Loop	Condition at start up or wide open throttle where AFR is defaulted to rich, emissions are at its highest. AFR is not controlled by the sensors.
Oscilloscope	Instrument used to measure fluctuations in electrical current where amplitude is graphed as a temporary waveform on a fluorescent cathode screen.
Oxygen Sensor	Vehicle emission control component that senses the presence of oxygen in the exhaust stream.
Rich	Default condition of AFR in open loop mode & also the default condition of an emission related problem. Little oxygen is present in the exhaust. AFR is less than 14.7:1
Stoichiometric Point	Measurement of AFR - where optimum combustion occurs & the least amount of harmful poisonous gases are produced. AFR mixture at this point is 14.7:1
Titania Sensor	Narrow band oxygen sensor made of titanium dioxide that requires a voltage rather than producing one and changes its resistance in response to the oxygen content present in the exhaust stream.
Universal Oxygen Sensor	An oxygen sensor that lacks a wiring connector. Commonly used in the past to reduce SKU count and inventory costs.
Upstream	Term referring to oxygen sensor position in front of the three-way catalyst located in the exhaust manifold or Y pipe.
Wideband Sensor	A linear 5 wire oxygen sensor which measures air fuel ratio. This type of sensor produces a voltage from 0-5V to the ECU. The voltage produced corresponds with a definite air fuel ratio.
Zirconia Sensor	Narrow band O2 sensor made of zirconium dioxide based on an electrochemical fuel cell that produces an output voltage at its two electrodes comparing the amount of oxygen present in the exhaust stream to that of the atmosphere.

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