Check out the new GLCC Website Feature – TECH ARTICLES!!

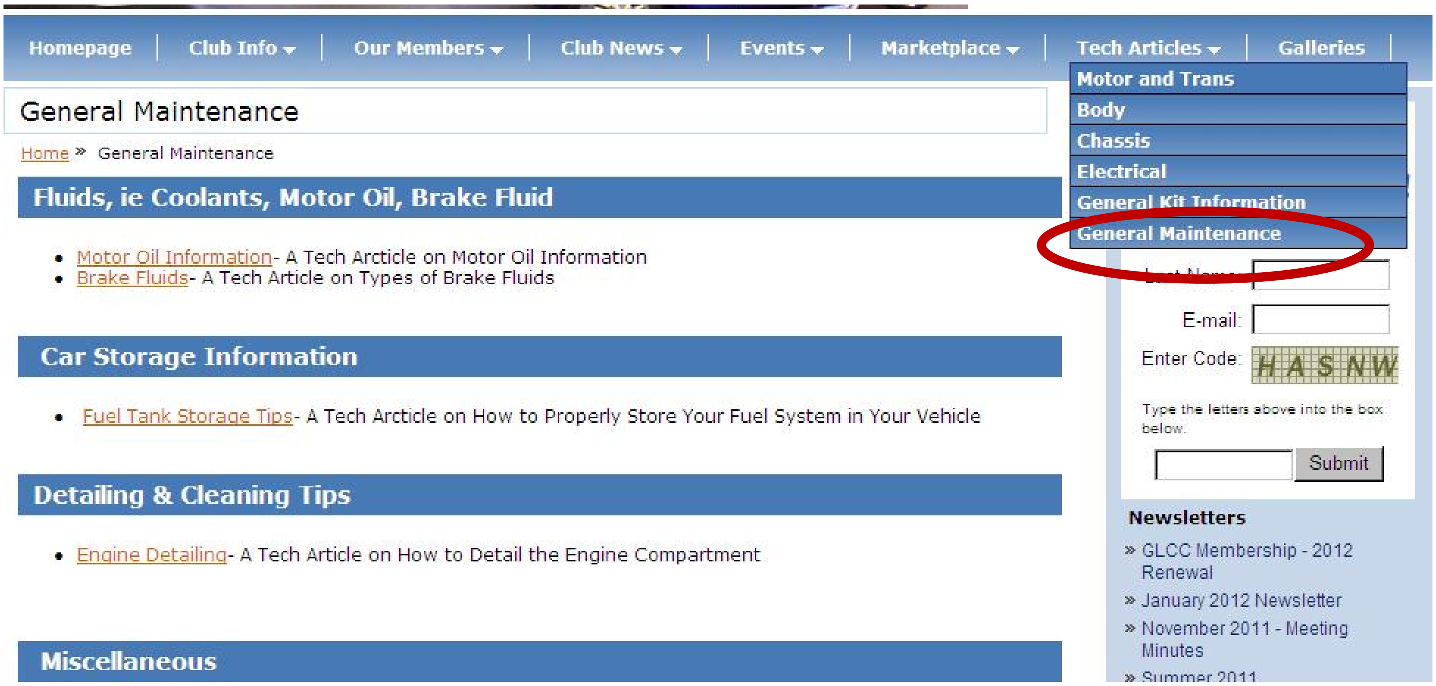
That's right – tech articles have been added. Big thanks to Dave Swanson who has added a terrific new feature to our club's website. This feature is available to members only, and I think you are really going to enjoy.

Go to www.greatlakescobra.com and click on "Sign In" and enter your username and password . If you forgot your password, click on "HERE" at the bottom of the page for a reminder….which will be e-mailed to your e-mail address in your member profile.

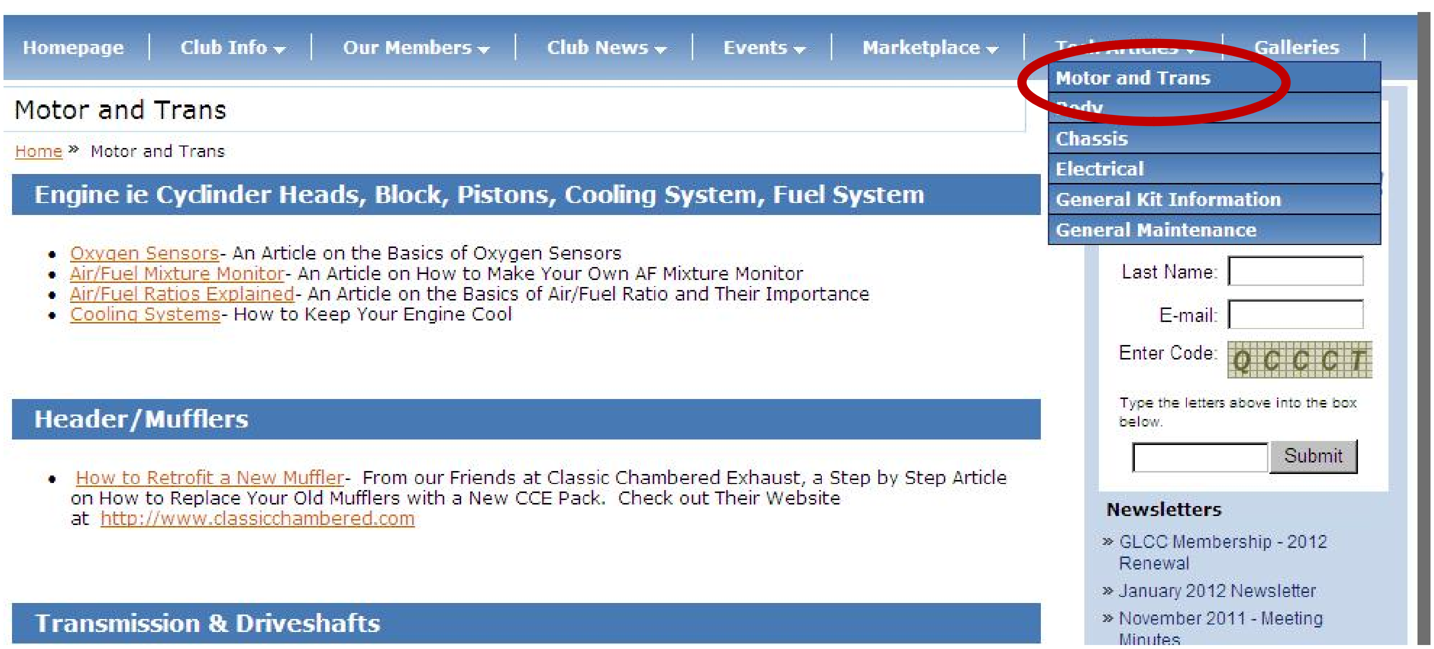
If you are a member and have forgotten your password, please click HERE to get your Username and Password emailed to you. Once you log in, you will be able to change your Username and Password to anything you like.

Once you are logged in go to Tech Articles…..from there you will see several categories….

Each category will then provide links to tech articles in a variety of subsections.



There are a lot of very informative and great articles, courtesy of Robert Jacobs editor of Custom Kit Car Magazine of Australia who gave GLCC permission to use his articles on our site. Thank you Custom Kit Car Magazine and Dave Swanson for setting these up for members to enjoy!



The Oxygen Sensor

What is it and how does it work? You need to know!

The Oxygen Sensor is possibly the most misunderstood and forgotten piece of equipment on your vehicle. It operates out of sight and in silence, so most people never even know of its existence, let alone how it works.

As a driver you would be aware if the engine was running rough or lacked in performance, plus you would be aware if it used more fuel - all these symptoms could be a result of a poorly performing Oxygen Sensor. If you are required to pass an annual inspection and emissions test for registration purposes you will most likely fail the emissions test if your Oxygen Sensor is malfunctioning.

The Oxygen sensor has been fitted to cars and light trucks running on petrol or gasoline since the 1980's. When Governments around the world became sensitive to the needs of the environment, Politicians decided that controlling emission levels on vehicles was a good starting point. After all, there are millions of vehicles travelling around on this planet and many are creating far more pollution than what would now be considered as acceptable.

The removal of leaded fuels and legislated exhaust emission limits were set in countries around the world, and new vehicles manufactured had to meet strict regulations, which would increase even further in the years to come.

Manufacturers took up the challenge with the introduction of the Positive Crankcase Ventilation (PCV) systems - where fumes from inside the rocker cover were sucked back into the engine to be burnt. Fuel mixture screws were limited in their movement, so that changes to optimum settings were restricted. Exhaust Gas Recirculation (EGR) valves were fitted, which recirculated burnt exhaust gasses back into the inlet manifold. This interfered with power outputs, but reduced the dangerous Oxides of Nitrogen produced by the engine.

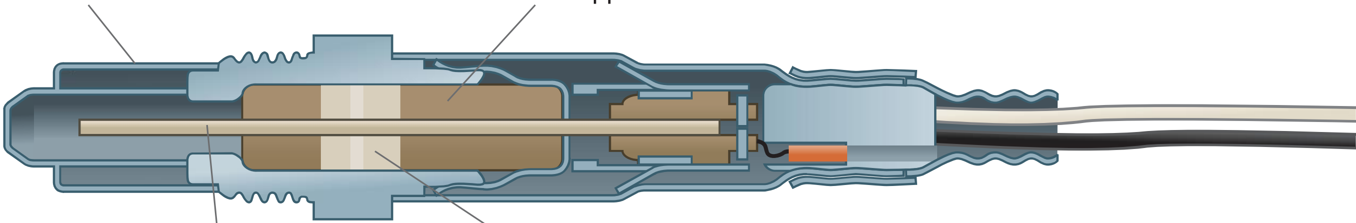


Figure 1:
Shows cut away view of an Oxygen Sensor (early unheated two wire design).

Courtesy of Bosch

Oil vapours were also recirculated and burnt. Fuel tanks were vented to the engine through Charcoal canisters, this mysterious devise was actually good – as fuel vapours previously vented straight from the fuel filler cap to the atmosphere whereas now they are burnt by the engine.

Three main chemicals are considered most harmful to the environment by experts and they had to be controlled, they are Oxides of Nitrogen (NOx), Carbon Monoxide (CO) and Hydrocarbon (HC) from which fuel and oils are made.

Manufacturers were forced to comply with even stricter emission legislation-which stated precisely the quantity of each chemical permitted to exit the vehicles exhaust system.

Introduction

Fuel injection made fuel control very accurate – as adjustments in fuel delivery can be made hundreds of times every second. This far exceeded the limited control ability of the carburettor. Being able to accurately control the fuel injected into the engine was great but manufacturers required a method of determining how much was actually being burnt, and how much ended up unburnt in the exhaust system.

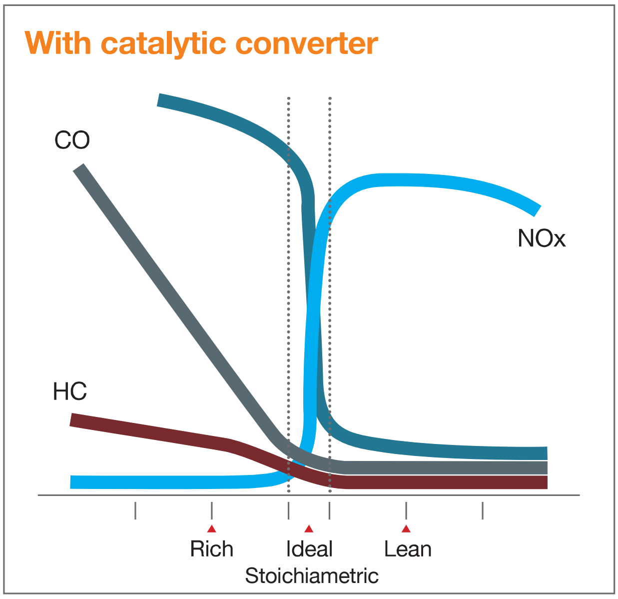
The introduction of catalytic converters provided a method to break down the chemical composition of the unburnt fuel into harmless gasses and water. However, a limitation of the catalytic converter was that it could only work once heated and was damaged by certain fuel types. This presented a need to control fuel composition (unleaded) and quantity in the range between rich and lean, similar to limiting the movement of the mixture screw on a carburettor – however it needed to be fast, and much more accurate.

The oxygen sensor was the answer – it could operate inside the exhaust system, between the engine and the catalytic converter, as it could endure these extreme conditions. One is required in each exhaust manifold, thus a V8 needs two sensors to operate correctly.

These sensors measure the amount of oxygen in the exhaust system (most is burnt during combustion) and determines if the engine is running rich, lean or ideal.

More recently a second Oxygen sensor has been introduced after the catalytic converter in order to sense if the converter is functioning correctly.

The engine could now operate accurately controlling high power and torque levels with low exhaust emissions.



The graph left shows high levels of Carbon Monoxide and Hydrocarbons in the rich area, however, these levels are reduced dramatically using a Catalytic Converter by controlling fuel in the ideal mixture area. During lean mixtures a high level of Oxides of Nitrogen are present even with the Catalytic Converter fitted.

Figure 2:

Graph shows low emissions in ideal mixture range.

Types of 02 Sensors

There are five types of Oxygen sensors currently fitted to vehicles.

1

Planar:

This oxygen sensor was used extensively from 1997-2006 it too uses Zirconia ceramic in its construction. This sensor is smaller and lighter than the other types therefore less electricity is needed for heating. These sensors have four wires.

2

Titania:

These sensors are made from Titanium Oxide (TiO_2) and react by varying their resistance when in contact with Oxygen particles, rather than producing a voltage. They are not as common as the Zirconia types.

3

Unheated Thimble:

First type produced has either one or two wires connected, one for the output voltage and the other an earth wire (can be internally or externally earthed). The Zirconia Oxide (ZrO_2) element can take several minutes to reach an operational temperature of 625°F (300°C) from a cold start.

4

Wideband:

These are the latest design fitted to unleaded vehicles and as the name suggest they operate across a wider fuel mixture. Wideband sensors respond very quickly to changes in oxygen content. Current emission legislation can only be achieved by utilising very accurate control.

These sensors are fitted with five or more wires.

How does it work?

First, to understand the inner workings of the sensor I think we need to understand some associated terminology; Closed Loop and Open Loop.

These are terms used in engine management which make reference to how your engine computer determines the optimum fuel requirement. Different quantities of fuel are required for different circumstances it all depends upon what you, the driver are attempting to do.

If you are starting the vehicle on a cold morning you no longer have to pull out the choke and then push it back in when the engine has warmed up, the computer does this for you. The computer knows the engine is cold from a coolant sensor, it knows your not moving as there is nothing from the speed sensor, so it applies more fuel just as the choke did on earlier carburetted vehicles.

When you drive off from a standing start you need to accelerate quite a bit, so extra fuel is required, you computer reads the information coming back from various sensors like the speed sensor, engine load sensor and throttle position sensor . These values are interpreted by the computer and the fuel quantity is adjusted accordingly.

(I am endeavouring to keep this as simple as possible so that it is easy to understand).

You decide to tow a trailer / caravan or carry a heavy load or perhaps feel the need to accelerate quickly or travel at a higher speed; these activities all require varying amounts of fuel. If the computer gets the calculations wrong your vehicle will run rough, lack power or use larger quantities of fuel. These are all negative outcomes so we need to avoid this from occurring. The computer has a very difficult job monitoring and changing fuel demands as well as other engine functions.

This type of control is called Open Loop.

Closed loop control is where your computer will use only the oxygen sensor to determine fuel requirements. The computer still receives information from other sensors. ▶

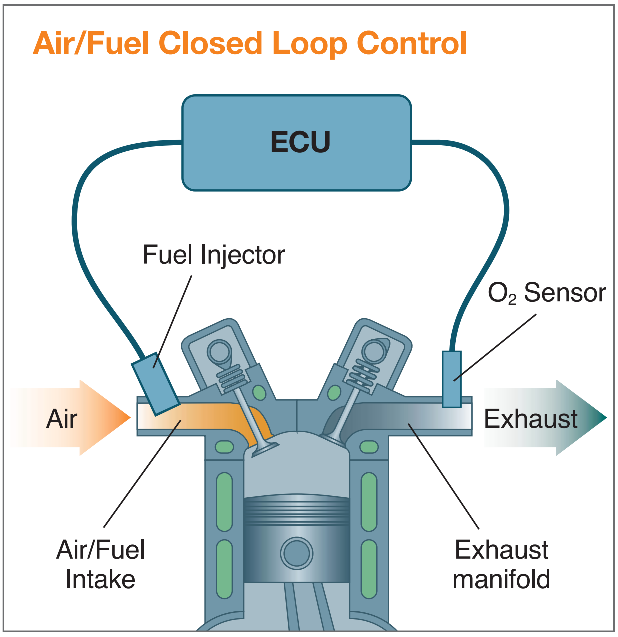


Fig 4: Shows O2 Sensor and Injectors connected to the Computer as in Closed Loop Control.

5

Heated Thimble:

The basic operation is the same as the unheated thimble, although it is fitted with a heater to speed up the time taken to operate correctly (30-60 seconds). This requires a power supply for the heater so it needs either 3 or 4 wires depending on how it is earthed.

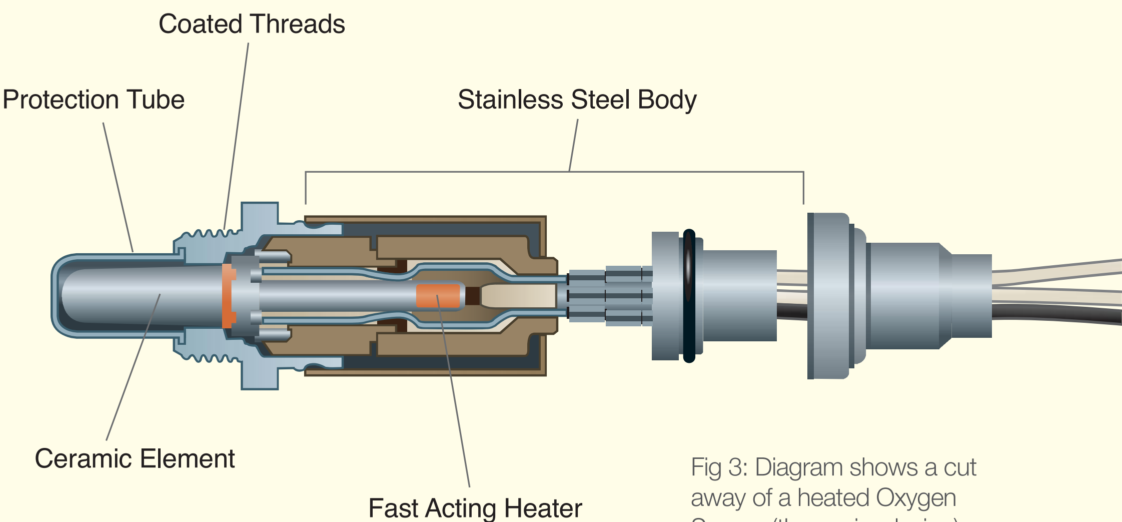


Fig 3: Diagram shows a cut away of a heated Oxygen Sensor (three wire design).

Courtesy of Bosch

Check and double check

The computer in closed loop control will spray fuel via injectors into the engine, and then monitor the oxygen content inside the exhaust system, if there is too much oxygen present it will consider this a lean condition (not enough fuel) so it will increase the quantity of fuel injected. If the oxygen sensor now sees low oxygen content in the exhaust it considers this to be a rich condition (too much fuel) so it will inject less fuel next time until the ideal oxygen content is reached. You must appreciate that this continual fine tuning can happen hundreds of times every second.

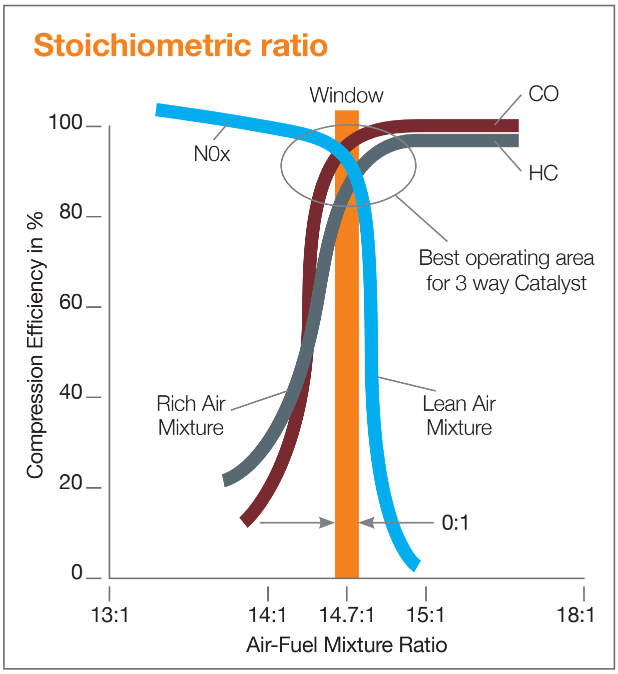
Closed loop control will give your engine the best fuel economy, as well as very good power output, but can only occur if the engine is at operating temperature, and you are driving with a light throttle position and at cruising speed.

The manufacturer determines these settings and enters the information into the computer's memory.

Reference was made to the ideal fuel quantity, this relates to the amount of Fuel and Oxygen present inside the engine to be burnt. This ideal Air/Fuel Ratio (AFR) has been given a name, Stoichiometric. (Try pronouncing it Stoi-key-O-metric).

The Stoichiometric ratio is 14.7:1 (14.7 parts of air to 1 part of fuel).

The Oxygen sensor has another unique name a Lambda sensor, derived from the Greek letter Lambda (_). Lambda will have a value of 1 when the air/fuel ratio is at Stoichiometric. When the air/fuel ratio has too much air (lean) the Lambda value will be greater than 1. When the air/fuel ratio has too much fuel (rich) the Lambda value will be less than 1.



Confused? Don't worry you will not need to remember these values as they are programmed into your computers memory.

Fig 5: Shows Catalytic Converter operating at 95% efficiency while mixture is at Stoichiometric Ratio.

02 Sensor produces a Voltage

Finally, you ask "What has all this got to do with how a sensor works?" It's quite simple really the oxygen sensor produces a voltage (most types) based on how much oxygen is present in the exhaust system. This voltage produced will vary from 0.2 Volt – 0.7 Volt. (Yes, less than 1 volt from beginning to end.)

The voltage produced at the Stoichiometric point should be 0.45 Volt, this information is sent to the engines computer.

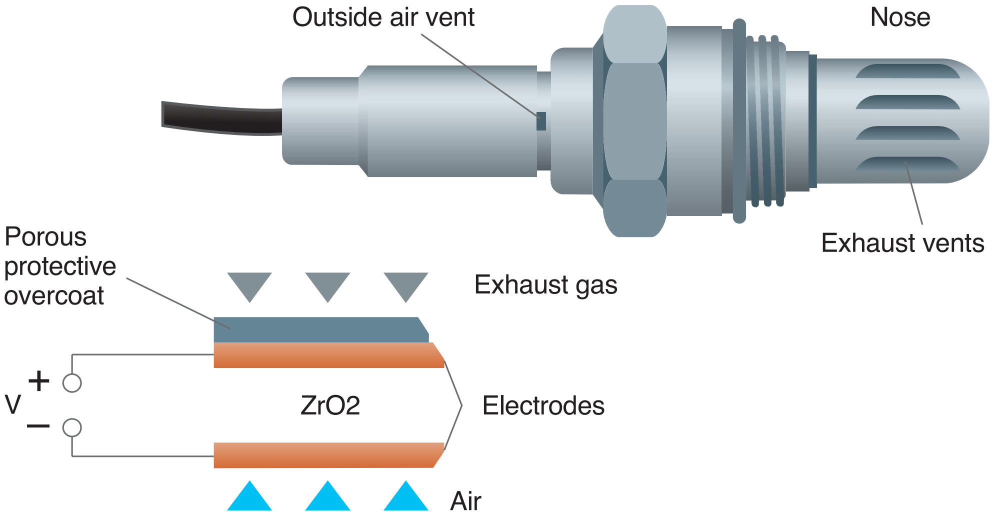
See our technical article on how to build a Fuel Mixture Monitor, page 47.

Precautions

Oxygen sensors operate in a very harsh environment, but they can be damaged quite easily.

- The ceramic Zirconia element is very hard and therefore brittle, be gentle when handling this sensor especially during removal and installation. Do not drop it!
- Damaged electrical connections or wires can cause the signal to be lost or altered prior to it reaching the computer.
- Fuel additives can coat the surface of the element – check the label to make sure it is Oxygen sensor safe.
- Be very careful what gasket glue you use as the fumes can contaminate the sensor. Read the label to ensure it is sensor safe.

Zirconia Oxide



Most Oxygen sensors use Zirconia Oxide (ZrO2) while others use Titanium Oxide (TiO2) as the main element in the sensor. The ZrO2 sensors use two thin Platinum electrodes, one on the inside and one on the outside of the Zirconia element.

The inside electrode is in contact with the outside air via a small vent while the other on the outside of the element is in contact with the exhaust gasses through a porous protective covering.

The Oxygen atoms are attracted to the Zirconia Oxide and accumulate on the outside surface and the platinum electrode. The inside of the Zirconia is in contact with the atmosphere where there is a much higher concentration of Oxygen, this is also attracted the inside surface.

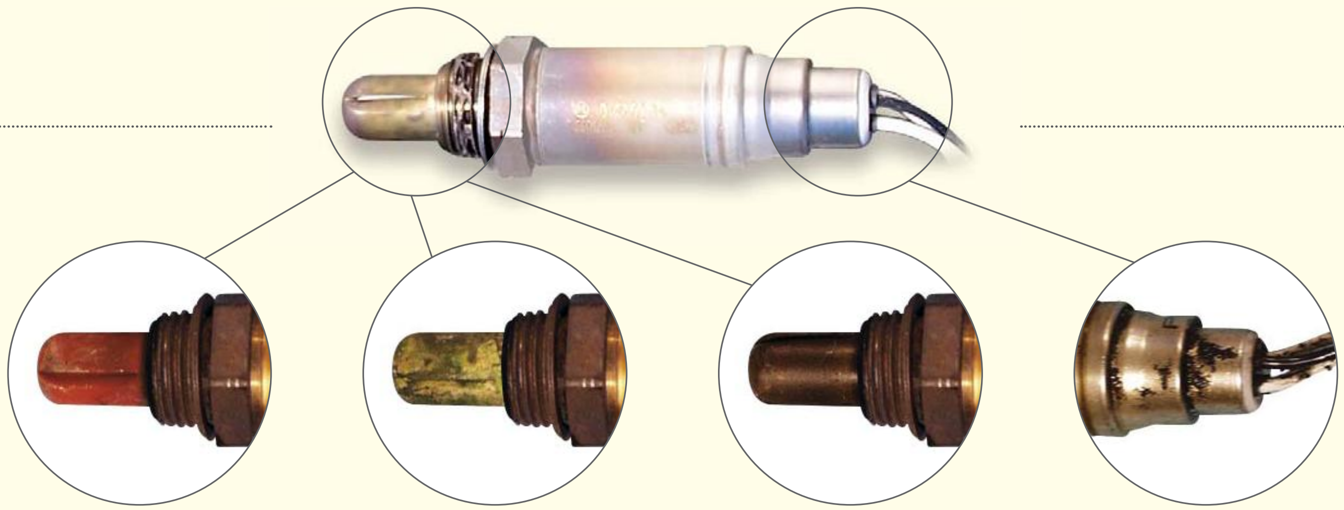
The different amount of Oxygen atoms (Negatively Charged) present inside compared to the outside creates a small magnetic field which produces a small electrical charge or voltage in the platinum electrodes.

(It may be easier to just accept this as true rather than try to work it out).

This voltage will vary based on Oxygen content in the exhaust system and the sensor temperature. This is why most Oxygen sensors are now heated electrically, as it speeds up the time taken to start working properly from a cold start.

Ideally the Oxygen sensor temperature should be between 300°C – 800°C. Therefore, Oxygen sensors do not work when cold. High pollutant levels will be in your exhaust system at this time. It will take between one and two minutes at 1800rpm to bring the catalytic converter and Oxygen sensor up to operating temperature.

Fig 6: Shows cut away view of electrodes connected to the Zirconia Oxide element.



Fuel Contamination

Leaded fuel will coat the element with lead making it useless.

Coolant Contamination

Silicon from coolants can also fill in the holes in the element making it impossible for any oxygen to get through; this can be the result of a corroded head / block or from a blown head gasket allowing coolant to leak into the exhaust system.

Oil Contamination

Excess oil usage from a worn engine, or one with broken rings can also coat the element with oil rendering it useless.

External Oil Contamination

Environmental factors such as mud, dirt, dust, salt, oil and road splash can block the external hole in the sensor so that oxygen can not get inside – which it needs to operate correctly.