



Oxygen/Lambda Sensor

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What is a Oxygen Sensor?



Figure 1
A Oxygen Sensor.

The Oxygen Sensor (OS), which is also commonly know as a Lambda Sensor [Figure 1], is a ceramic device placed in the exhaust manifold [Figure 4] on the engine side of the catalytic converter (CAT). Any car which is injection fuelled and has a CAT, will need a OS fitted to function properly. Without it, performance and idling is poor.

What does the Oxygen Sensor do?



Figure 2
Oxygen Sensor with adapter cable.

The quantity of oxygen remaining after combustion is an excellent indicator of a rich or weak mixture. The oxygen sensor returns a signal to the Electronic Control Unit (ECU), which can almost instantaneously (within 50ms) adjust the fuel injector pulse width. By controlling the engine electronically so that the Air Fuel Ratio (AFR) is always at the Lambda point, no matter the load or speed, almost perfect combustion could be achieved.

The correct control of mixture strength is important not just for the operation of the engine and the exhaust gas emissions, but also to protect the CAT from being contaminated by un-burnt fuel.

What is the Oxygen Sensor made of?



Figure 3
Close up view of a fitted oxygen sensor.

Essentially the oxygen sensor contains two porous platinum electrodes. The outer surface electrode is exposed to the exhaust air and coated in porous ceramic. The inner surface electrode is exposed to ambient atmospheric air.

There are now two different types (functionally method) of oxygen sensor in use. The first and most commonly used oxygen sensor utilises a zirconia element. A voltage signal is generated by the difference in oxygen levels at the two electrodes, and thus is transmitted to the ECU. This voltage is inversely proportional to the level of oxygen in the exhaust manifold. The ECU uses this signal to adjust the injector opening time to maintain $\text{Lambda} = 1.0 \pm 0.02$.



Figure 4
Typical location of a Oxygen Sensor on a down pipe of an exhaust.

What is the "Lambda Point"?

Lambda is the 11th letter in the Greek alphabet written as λ . It is the temperature of any phase transition in which the specific heat capacity regarded as a function of temperature has a logarithmic singularity, the Lambda Point.

The oxygen sensor closed-loop voltage is quite low, and switches between 100mV (weak) to 1v (rich). The signal actually takes the form of a switch and switches very quickly from weak to rich.



The second type of oxygen sensor is made from titania and functions by a change in resistance which alters a digital signal that originates from the ECU. Response of the titania oxygen sensor is much faster than those made from zirconia and the signal is much more stable over a

Figure 5
Internal parts of a Oxygen
Sensor.

range of exhaust temperatures.

Unfortunately driveability would be impaired if the engine was set at Lambda for the entire driving cycle. Controlling the engine to the Lambda ideal would cause hesitation, flat spots and a lack of smoothness that would make a car pretty near undriveable. Therefore when the engine is under Lambda control (i.e. cruising) it is in 'closed-loop' operation. Under acceleration or during the warm up period, the system goes into 'open-loop' operation and a richer mixture is allowed to prevent hesitation.

The oxygen sensor only produces a signal when the exhaust gas has reached a minimum temperature of approximately 300°C. In order that the oxygen sensor will reach optimum operation temperature as quickly as possible after the engine has started, the oxygen sensor contains a heating element [Figure 5]. The oxygen sensor heater supply is usually applied from the fuel pump relay output terminal. This ensures that the heater will only operate whilst the engine is running.

How do I know what type of Oxygen Sensor I need?

For most cars there are three types of build. Each OS has a cable form, comprising of either one wire, three wire or four wire. The single wire type is purely the sensor output itself and has no heater installed. The three wire has the single signal wire plus a positive and ground wire for the internal heater. The four wire type has two internal heaters, two of the wires for the heater and a common ground between them plus the single signal wire yet again.

To tell the type you have either look at the amount of wires coming out of the OS itself or count the pins on the connector that mates with your engine loom.

Typical engine faults:

Although the oxygen sensor method of regulating the AFR works perfectly well within a properly operating engine, things go wrong once faults develop. Almost any problem that affects combustion will see an increase of oxygen in the exhaust. For example a misfire due to an ignition or mechanical problem means that combustion is incomplete and the level of oxygen in the exhaust will rise.

The ECU will interpret this as a lean mixture and increase the fuel injection duration. When the fuel injection method is Multi-point simultaneous injection or single point injection, all cylinders will be enriched. This is a main reason why use of the sequential injection method will almost certainly increase. With sequential injection, only the afflicted cylinder will receive more fuel.

How do I test a Oxygen Sensor?

The switching of the OS is very important to allow correct operation of the injection system. You can measure this switching and determine if the sensor is faulty. The ideal equipment would be to use an oscilloscope as you can actually 'see' the switching and the voltage levels, but this equipment doesn't come cheap. However it is possible to carry out the same tests with a DVM (Digital Volt-a-Meter), but a slow or sluggish sensor is difficult to detect. Do the following test:-

1. Attach a oscilloscope or DVM to the OS switching wire. The connector end would be the best place to monitor this point. Put

- the ground probe to a good earth point on the car (i.e. chassis).
2. Increase the engine speed between 2500 and 3000 RPM for 3 minutes. This allows the OS to heat up and light the CAT.
 3. Allow the engine to fast idle and check for OS switching. The OS voltage should switch high and low from 200mV to 800mV at a very fast rate, typically between 8 to 10 times a second (or 1 Hz).
 4. The oscilloscope will be able to see this transition taking place. But a DVM will only see the average switching voltage (RMS) and will only show about 450mV. A sluggish OS may appear to be functioning correctly and may not reveal the voltage being high. If the DVM has a MAX and MIN function, the range of average switching will be more easily spotted.

How much does a Oxygen Sensor cost?

Well if you go to your Vauxhall dealer, they will typically quote a 3 figure number (i.e. a 2L 16v Calibra sensor is £120). But you can easily get these cheaper as they are nothing particular special. I got my OS from Halfords for £50 and the adapter wire [\[Figure 2\]](#) to fit my Calibra for £11.

Article based on text in the [Haynes Books](#) series and peoples personal experiences.