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Sensor Confusion - What type of sensor is it?

In 1993, it became law in the UK for petrol cars to be fitted with a catalytic converter, or cat, in the exhaust system. This was the demise of the carburetor for mass produced road legal vehicles. But the cat was only just the beginning of a new era of electronic control of the fueling system. The cat had a very narrow fuel ratio in which it could work efficiently. This was known a Lambda 1, or a Stoichiometric ratio of 14.7 parts of air to 1 part of fuel, by weight.

Lambda sensors, a sensor to monitor the amount of oxygen present in the exhaust upstream of the converter, were fitted to all cat equipped vehicles. This was only the beginning. Simple single wire Zirconia sensors provided a basic feedback to the engine electronics, resulting in a closed loop control of the fuel to maintain this narrow air/fuel ratio.

But things did not stop there. It was soon realised lambda sensors required a certain temperature to operate efficiently, usually upwards of 300C. At idle, lambda sensors cooled off and did not provide the signals required, so heated lambda sensors were introduced. Now there were 3 and 4 wire zirconia sensors added to the list.

Then, a new sensor was coming into production, the Titania 4 wire sensor. The difference was Zirconia sensors employed a galvanic element that produced a small voltage in the range of 0 to 1 volts. The newer Titania sensors modified a 5-volt signal sent from the ECM, by changing its internal resistance. This type of lambda sensor is faster in response time, but more expensive to produce.

An old-style oxygen/lambda sensor has one wire

An Air/Fuel (AF) sensor typically has 2 black, 1 blue and 1 white wire

Up to this point, lambda sensors only had the ability to monitor fuel ratios close to 1.00 (lambda 1), so they where considered to be narrow band. With the introduction of lean burn/stratified engines, a new sensor was required that could measure a wider air/fuel ratio that occurs when operating in a stratified mode.

The wide band lambda sensor was introduced as a solution. This sensor employed a completely different internal technology, and the ECM would now be monitoring small pump current changes within the sensor. Reading the sensor was now done via serial data that monitored the equivalence ratio or pump current, to indicate the actual air fuel ratio being measured.

But there is also a 4-wire sensor that can measure a wide air fuel ratio up to 18 to 1. The air/fuel ratio sensor looks like a standard Zirconia sensor, but is considered a wide band sensor and cannot be used as a replacement.

So you can see the confusion that technicians face every time they encounter lambda sensor related faults.

Case Study - Volvo with lambda faults

A Volvo had been diagnosed previously with a lambda sensor fault, and the garage had replaced the upstream sensor. They continued to have more issues with the same faults.

On calling the Helpline for advice, we started with basic signal checks on the new sensor. These seemed to be incorrect for the vehicle in question, so continued with circuit testing back to the ECM.

This vehicle should have been fitted with an air/fuel (AF) sensor, with a bias voltage on the signal line of 2.9 to 3.2 volts.

We asked for the wire colours on the sensor only to find it had 2 white, 1 grey and 1 black wire. This is typical for a Zirconia sensor. It should have been 2 black, 1 blue and 1 white wire, which are typical AF sensor colours. It was then that we realised the garage had fitted a universal sensor, due to the high cost of the OE part. The garage opted for a cheaper option, mistakenly installing the wrong sensor. When the correct AF sensor was fitted, the fault was cleared and the emissions test passed.

5 Wires!

A typical Wide band sensor has 5 wires, as shown here

A typical Narrow band sensor (Zirconia) has 4 wires: 2 whites, 1 grey and 1 black

It is worth noting that an AF sensor signal is around 3.2 volts at lambda 1, and they operate in reverse to conventional sensor signals. A lower voltage is a rich condition, while a high voltage is a lean condition.