POCKET GUIDE

Lambd Sensor

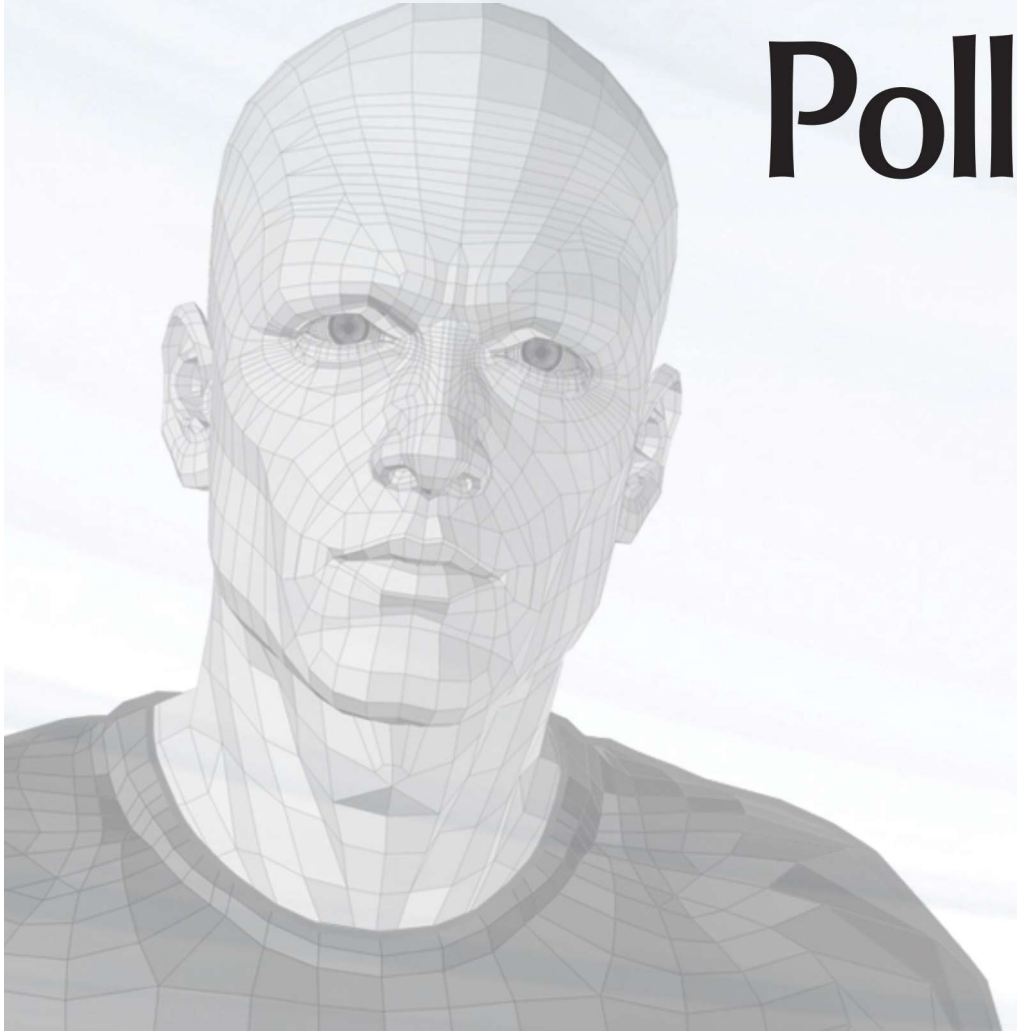
TRUST.

Never settle for second best, always insist on NTK,
the world's No.1 OE fitment.

NTK

TRUST.

The Key to Effective Catalytic Converter Pollution Control



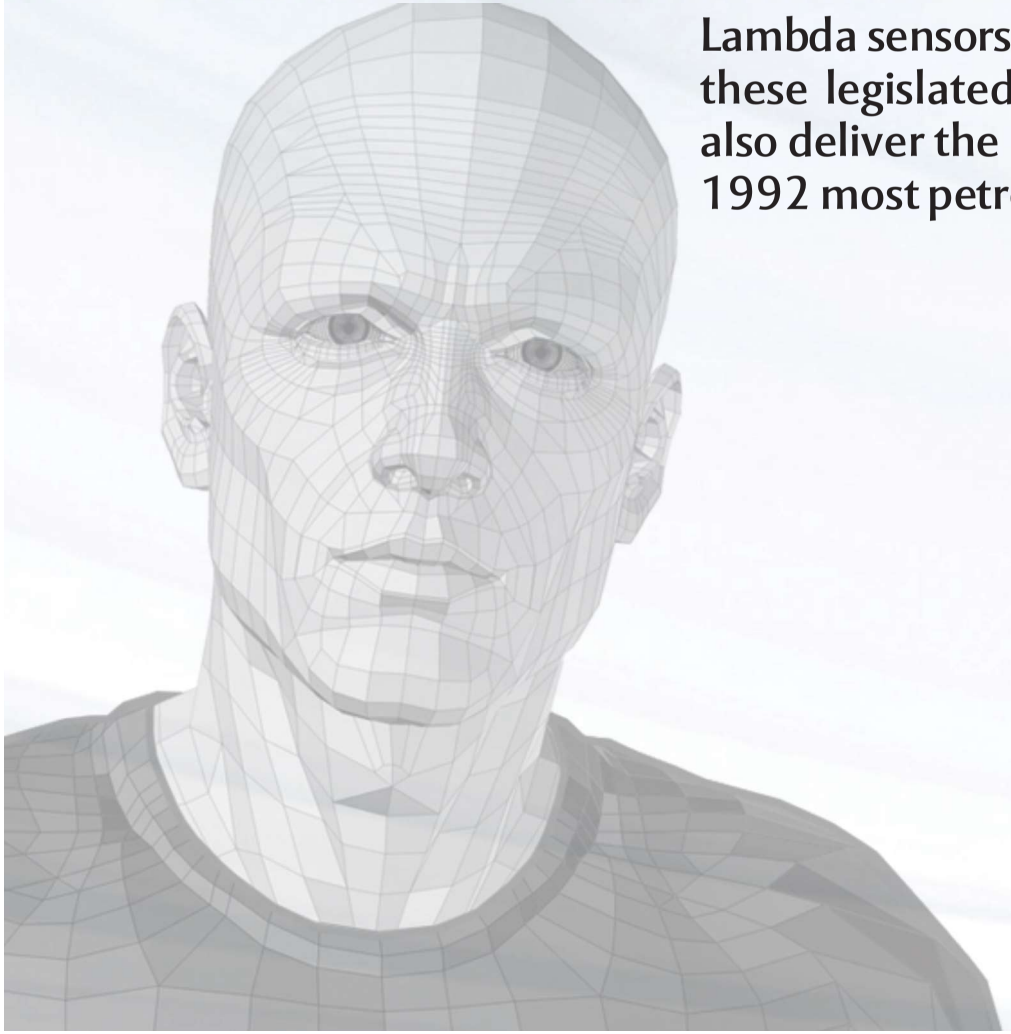
Lambda Sensors

What is a sensor?

A sensor is a device that can detect an analogue signal e.g. movement, chemical composition, temperature etc. We personally use sensors for touch, taste, smell, hearing and sight. The second function of a sensor as discussed here is to convert this analogue signal into an electronic signal that can be sent to a processing device, our brain or for a motor vehicle the electronic control unit (ECU). The processing device can then decide if it needs to change something to compensate for the signal it is receiving e.g. move your hand away from something that is too hot or in the case of a lambda sensor instruct a change to the fuelling system on an engine.

Why are Lambda sensors fitted?

With so many vehicles in use on our roads the reduction of pollutants produced by the internal combustion engine is of ever increasing importance. To encourage advances in technology that can bring this about governments have introduced progressively tougher exhaust gas emission legislation. Lambda sensors are a very important part of the technology used to achieve these legislated targets and as a result of their function the engine can also deliver the best economy and performance available. From the end of 1992 most petrol engine vehicles sold in the UK had Lambda sensors fitted.

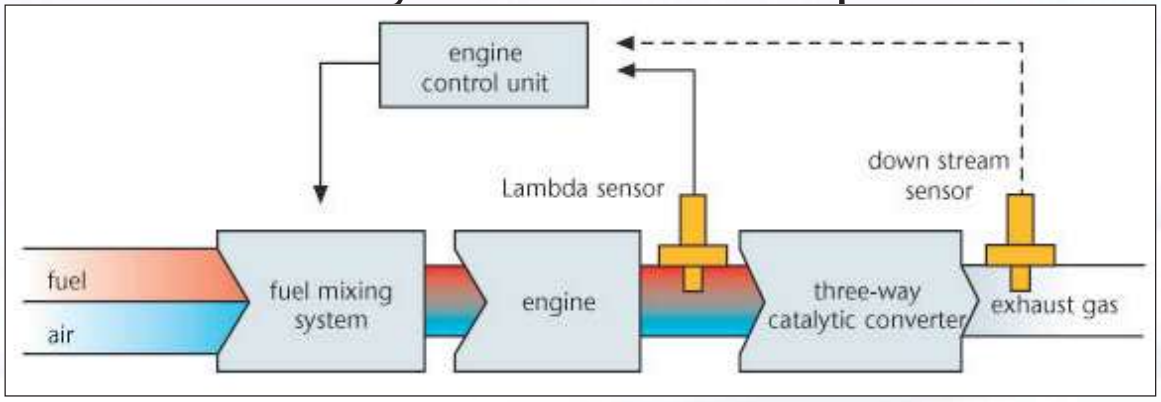


What does the Lambda sensor do?

The most popular method used by vehicle manufacturers to reduce engine emissions is the three-way catalyst (catalytic converter). This device has the ability to take the three main toxic gases produced by an engine which are carbon monoxide (CO), oxides of nitrogen (NOx) and hydrocarbons (HC) and convert them to considerably less harmful, non-poisonous gases: carbon dioxide (CO2), water (H2O) and nitrogen (N2).

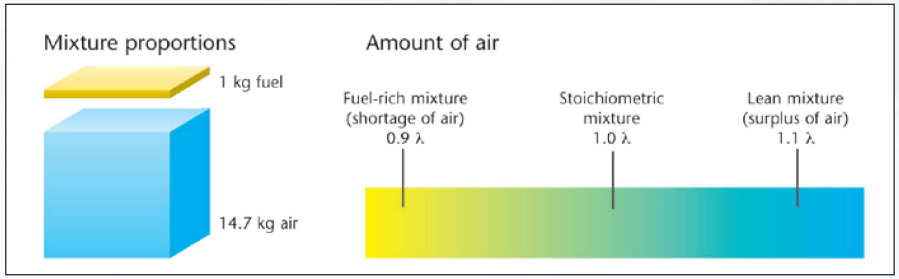
To carry out this conversion of gases efficiently the catalyst must operate within a specified temperature range but also be provided with exhaust gases that are within certain very tight tolerances dependant predominantly on air/fuel ratio. The precise control required to operate this system is provided by the use of an exhaust gas oxygen (Lambda) sensor installed upstream of the catalyst. A Lambda sensor has the ability to precisely measure the air/fuel ratio present in exhaust gases. By sending a signal to the control unit it can initiate a change to keep the fuelling system operating within the very tight tolerances required. This is known as a closed-loop control system.

To further improve control of exhaust emissions most vehicles produced after 2000 have an additional Lambda sensor fitted down-stream of the catalyst that monitors the performance of the catalyst itself.



How does the Lambda sensor work?

Most NTK Lambda sensors can be divided into two non-interchangeable types Zirconia Sensors and Titania Sensors. These are classed as binary or Lambda 1 sensors. They use different types of ceramic element and function in different ways but they have a common goal - to ensure the catalyst works efficiently and harmful gases are kept to a minimum. In order to achieve this an engine needs to attain as close to complete combustion as possible. The ideal ratio of air and fuel to achieve this is around 14.7:1; this means that for 14.7 kg of air 1 kg of fuel would be used. This chemically correct air fuel ratio is known as a stoichiometric ratio or Lambda (λ) 1.0. A fuel rich mixture would have a lower value e.g. 0.8 and a fuel lean mixture would have a higher value e.g. 1.2

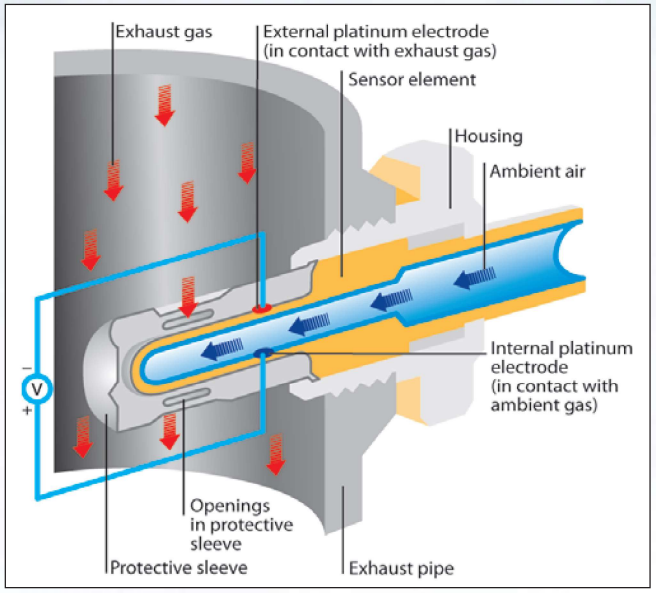


A relatively small but increasing number of vehicles now use sensor types that can precisely measure the air/fuel ratio over a large range of fuel rich and fuel lean conditions. These sensors are called UEGO (Universal Exhaust Gas Oxygen) sensors, wideband, broadband or linear types.

Zirconia Binary type

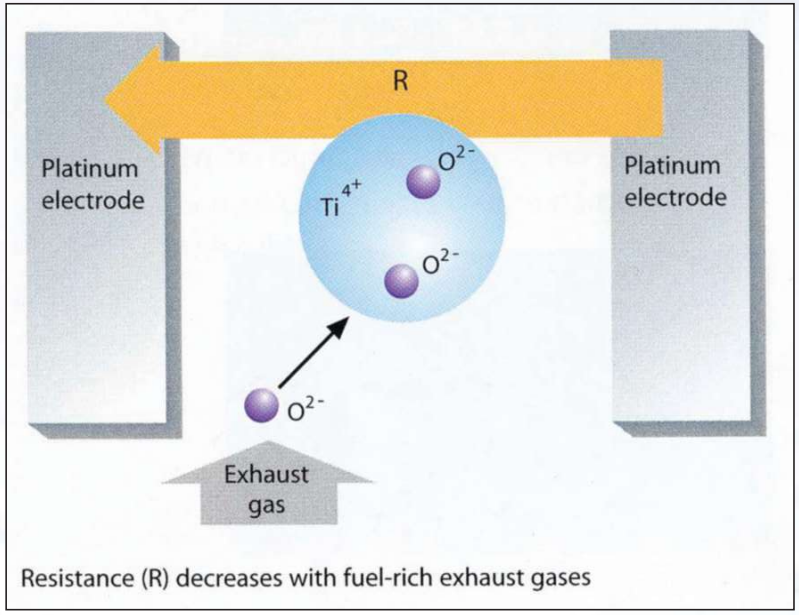
Under the metal protective end of the sensor there is a hollow thimble shaped ceramic body made from zirconium dioxide. The protective metal shell has specially designed holes to allow the exhaust gases to come into contact with the outside of the ceramic element. Both sides of this ceramic element are coated with a thin micro porous layer of platinum. These layers are the electrodes that carry the sensors signal to the wire cables. Over the outside electrode a thin additional layer of porous ceramic is added to protect the platinum from erosion by the exhaust gases. The inside of the thimble is hollow and is used to hold ambient air as a reference gas.

At temperatures in excess of 300°C the zirconia element possesses a property that causes a transfer of oxygen ions. This movement creates a voltage. The greater the difference of oxygen concentration between the exhaust gas and the ambient reference air in the centre of sensor thimble the higher the voltage produced. The voltage produced in the fuel lean position should be approximately 0.1 volt and in the fuel rich position approximately 0.9 volt. The very useful part of this function is that at around the stoichiometric point there is a relatively large change in voltage. This allows the sensor to keep the engine emissions within strict limits by constantly bringing the fuelling system back from a fuel lean or fuel rich position to retain the stoichiometric mixture. The time taken to switch from fuel lean to fuel rich is approximately 300 milliseconds.



Titania Type

Externally these sensors look similar to the zirconia type however the sensor body may be generally smaller. These sensors do not generate a voltage as in the zirconia type but the electrical resistance of the titania changes in relation to the oxygen content of the exhaust gas. If there is a surplus of oxygen in the exhaust gas (fuel lean) the element resistance rises and as the concentration of oxygen decreases (becoming fuel rich) the resistance falls. At the stoichiometric point there is a large change in resistance. The output of an applied voltage will therefore change in relation to the fuelling condition. As there is no need for a pocket of air as a reference gas and due to certain other design differences the sensor can be smaller, stronger and have a faster reaction time. The control system for this type of sensor is very different to that used for the zirconia type. All titania type sensors have internal heating elements.

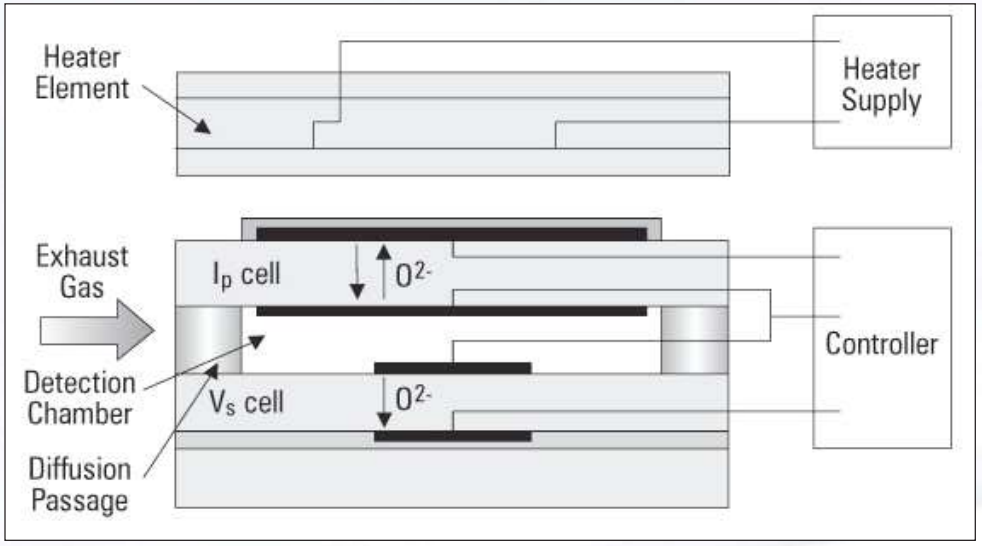


Resistance (R) decreases with fuel-rich exhaust gases

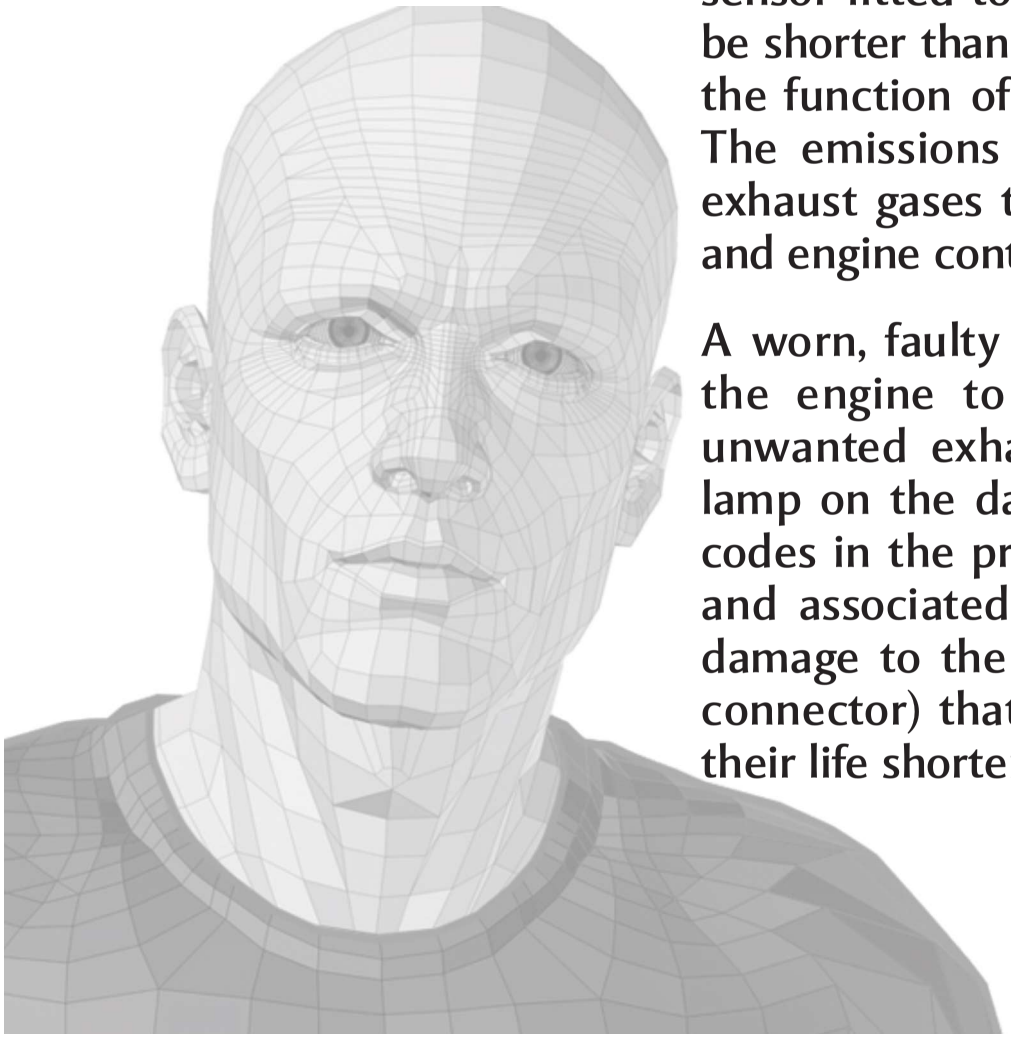
ZFAS-U Type (Air/Fuel Sensor)

Also known as a UEGO, wide band or linear sensor, the easiest way to identify this type of NTK sensor (apart from the part number) is by the number of lead wires - they usually require at least five and are always heated types. The sensor is of layered constructed with two ceramic substrate components, a Zirconia detection element and an Alumina heating element. No external reference air is required as the sensor generates its own. The detecting cavity is exposed to exhaust gas through a gas diffusion layer.

Put very simply the sensor tries to maintain a stoichiometric air/fuel ratio in the detection chamber by pumping oxygen in or out of the chamber. The value of the pumping current required to achieve this corresponds to the air/fuel ratio of the exhaust gas. Not only does this type of sensor have an extended window of measurement and can be used successfully where lean burn strategy is employed, it also provides exceptional accuracy around the stoichiometric point which is useful in the quest for emission reduction. This type of sensor will also be used in conjunction with diesel engines as they operate with an excess air factor.



When should a sensor be renewed?



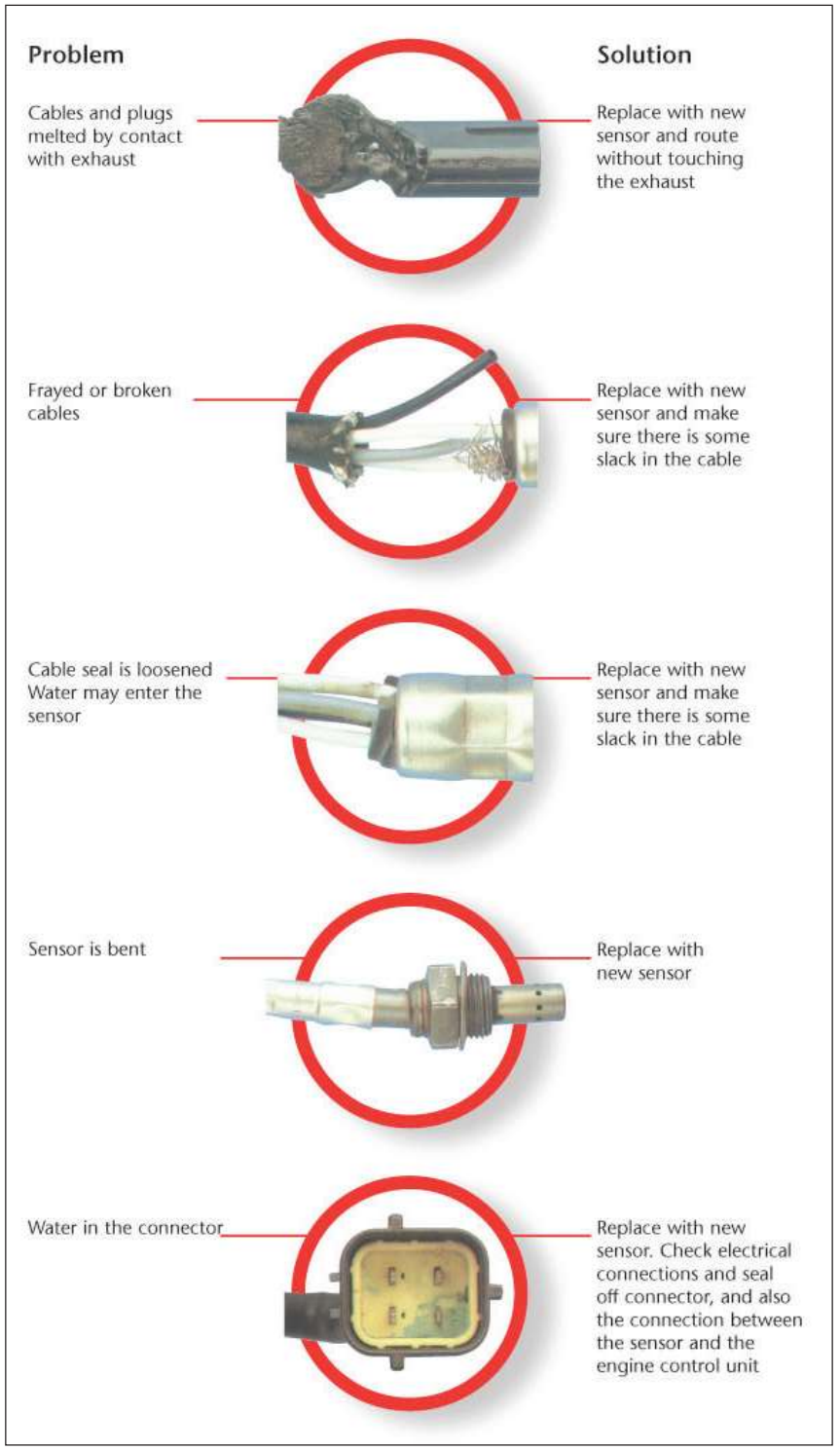
Due to the hostile environment in which they work sensors are subject to a degree of wear and tear and ageing. It would be impossible to say definitively what the service life of a lambda sensor should be due to the very different conditions that each vehicle experiences under different drivers. It would be reasonable to expect that the service life of a lambda sensor fitted to a vehicle used mostly for short in-town journeys would be shorter than one used for steady motorway use. We recommend that the function of the sensor is checked every 20,000 miles or annually. The emissions check as part of the current M.O.T. test samples the exhaust gases to monitor the efficiency of the engine, exhaust system and engine control systems. A lambda sensor is a vital part of this system.

A worn, faulty or failed sensor might make itself apparent by causing the engine to run poorly, increasing fuel consumption, increasing unwanted exhaust emissions or illuminating a malfunction indicator lamp on the dashboard. Newer vehicles have the ability to store fault codes in the processor some of which will relate to the lambda sensor and associated systems. Defective sensors can also cause irreparable damage to the catalyst. Sensors (this includes the wiring harness and connector) that have sustained physical damage will most likely have their life shortened or performance affected and should also be renewed.

How to test Lambda sensors

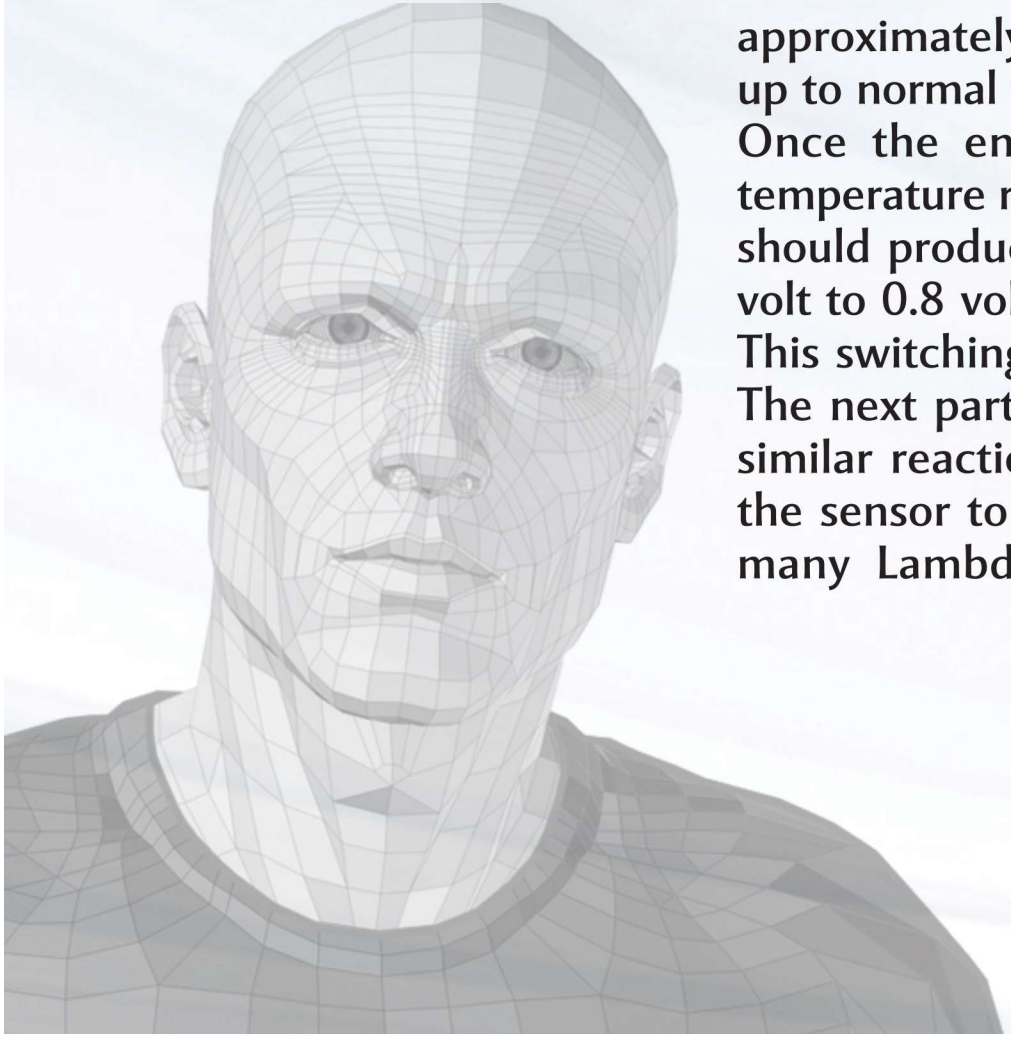
The first step is to carry out a visual inspection of the sensor body, lead and connector. For personal safety this should be done with the engine switched off and ensure that the engine and components are cool enough to touch.

Opposite are some typical examples of sensors that have sustained physical damage and would require renewal. For heated lambda sensors (will have 3 or more wires) another simple test is to check the integrity of the heating element. This can be done using a suitable ohmmeter. Great care must be taken to identify the correct heater element wires. A reading greater than 30 Ω means that the heater is defective and the sensor should be renewed. A reading of infinity ∞ means that the heater coil or wiring is broken, again the sensor must be renewed. Refer to the relevant section for wiring colours.



Testing Zirconia Binary Sensors

Reference to the relevant workshop manual should be made prior to testing. Ideally on the vehicle sensor testing should be carried out using an oscilloscope connected between the sensor and vehicle using an appropriate harness.



As the sensor only functions correctly once it has reached approximately 350°C it is essential that the vehicle is brought up to normal working temperature before checking the readings. Once the engine and sensor have reached normal working temperature raise the engine speed to around 2000 rev/min, this should produce a fluctuation in voltage from approximately 0.2 volt to 0.8 volt as the sensor switches from fuel lean to fuel rich. This switching should occur in approximately 300 milliseconds. The next part of the cycle (fuel rich to fuel lean) should have a similar reaction time. Deviation from these figures will require the sensor to be renewed; a slow switching time is a fault that many Lambda diagnostic tools are incapable of measuring.

A visual inspection of the protection tube when the sensor has been removed can provide valuable clues about conditions in the combustion chamber.

Lead

Shiny deposits are evidence of lead in the fuel. Lead attacks the precious metal of the sensor element and the catalytic converter. The sensor needs to be replaced. After changing the sensor, care should be taken to use only lead-free fuels.

Soot

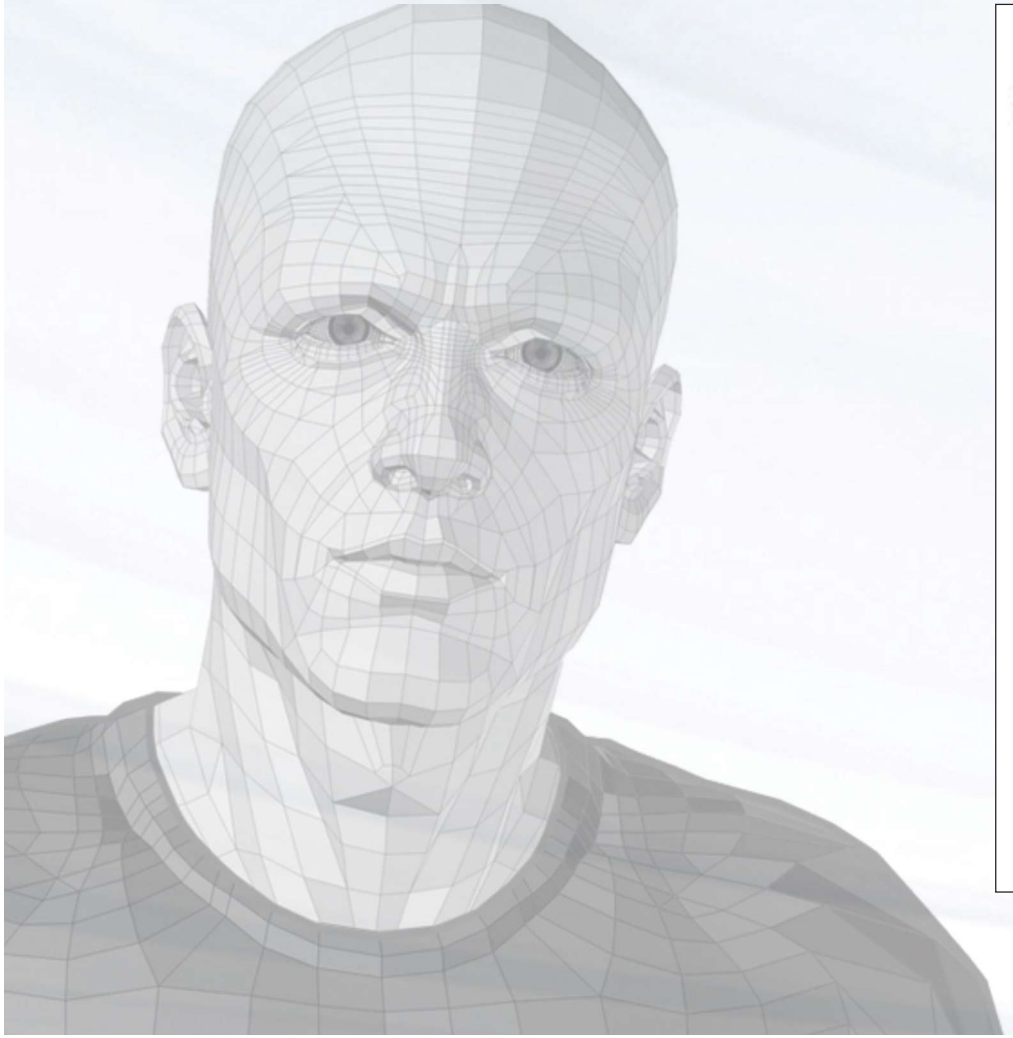
Thick soot deposits lead to blockage of the sensor protection tube and have a negative effect on reaction time. Causes can be a mixture that is too fuel-rich or the result of damage to the sensor heater. The sensor must be replaced in all cases.

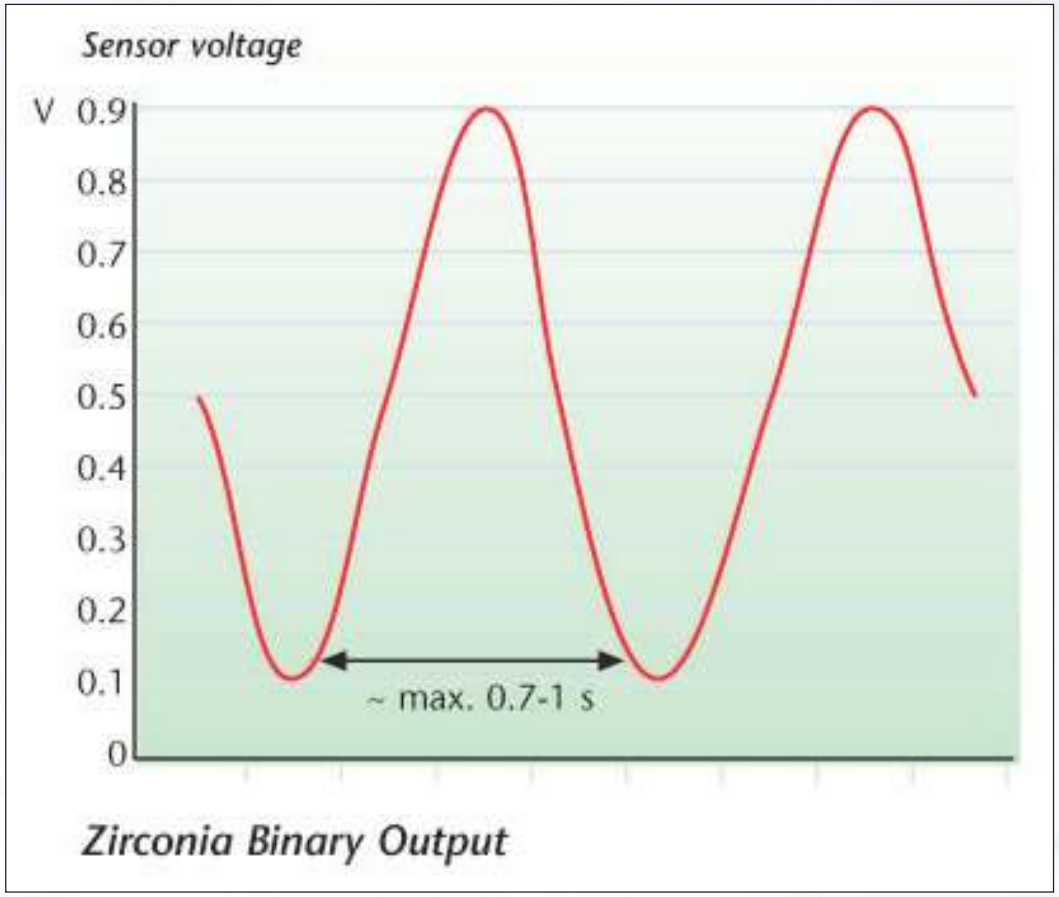
Oil

Thick white or grey deposits are evidence of the use of fuel additives or that the engine is burning oil. Certain components in the fuel additives and the oil contaminate the sensor element. The cause must be removed and the sensor be replaced by a new sensor.

Testing Zirconia Binary Sensors cont

It must be stressed that this testing process does not isolate the sensor from the rest of the vehicle's systems and a fault in another part of the engine, its control system, the exhaust system or fuel used may affect the performance of the sensor. Equipment used in off-vehicle testing uses special heated reference gas and is regularly calibrated.





Zirconia Binary Output

Testing continued

For Titania sensors

As the Titania sensor operates in a similar way to the Zirconia type, the signal characteristic will also be similar but possibly with greater amplitude (depending on the control strategy). Testing can be more difficult and great care must be taken, always referring to the vehicle manufacturer's data and test procedures.

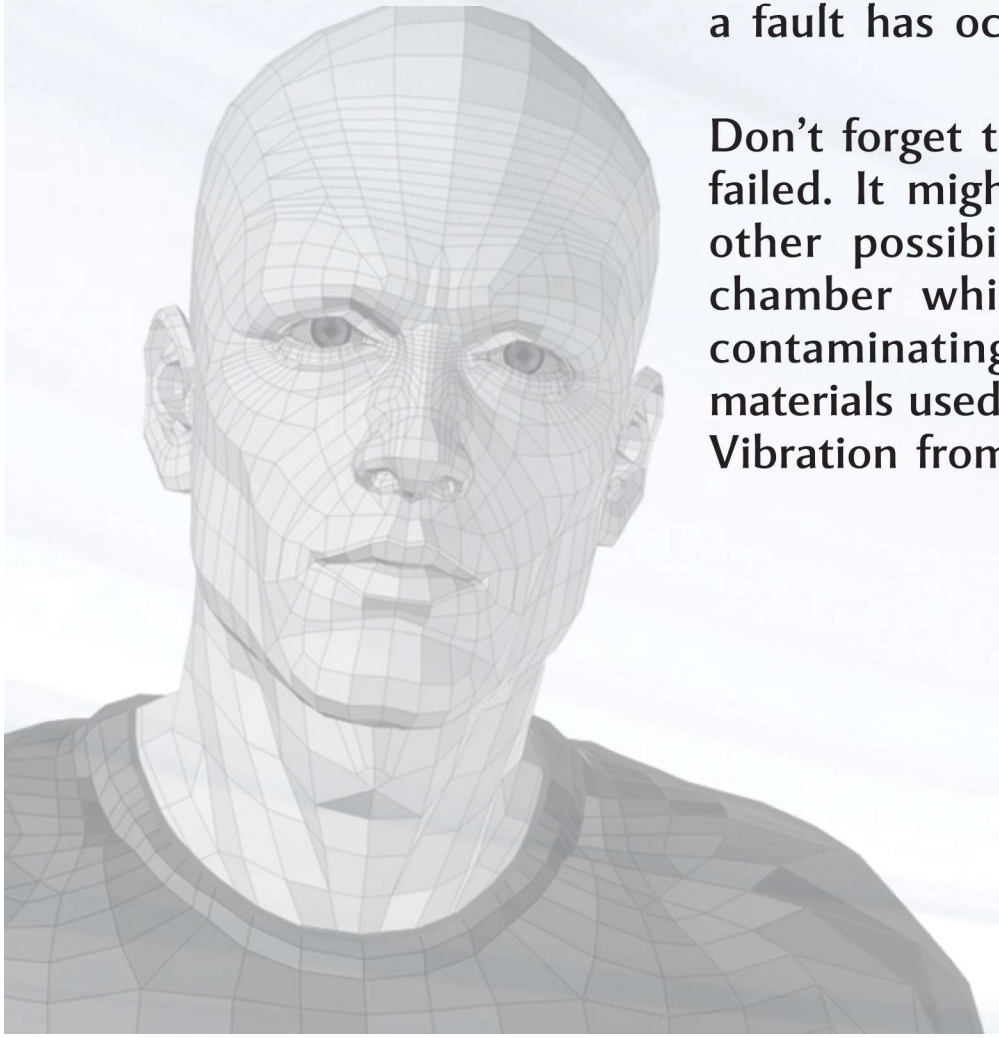
For ZFAS-U type (Air/Fuel Sensor)

Due to the very different way in which these sensors work and the risk of possible damaged to the sensor and associated systems the only test we recommend (other than visual inspection) is to check the heater circuit resistance.

For down-stream, catalyst monitoring sensors

These sensors will usually be of the lambda 1.0, binary switching type. When the exhaust gas treatment system is functioning correctly the output signal will have significantly reduced amplitude. If the amplitude exceeds a certain threshold the management system will identify a potential problem with the catalyst or associated components. Always refer to the vehicle manufacturer's data and test procedures.

OBD (On Board Diagnostics)



Most vehicles are equipped with these diagnostic systems and stored fault codes can be retrieved from the vehicles electronic memory. These fault codes refer to various components on the vehicle and suggest a fault has occurred with the component or associated components.

Don't forget to consider the reasons why the sensor appears to have failed. It might simply be at the end of its service life but consider other possibilities including a coolant leak into the combustion chamber which can lead to anti-freeze reaching the sensor and contaminating it; the solvents of some additional gasket sealing materials used around the engine can also be detrimental to the sensor. Vibration from an unsecured exhaust will shorten the life of a sensor.

Wiring colours

Typical wiring colours for TITANIA types

Type 1

Red = heater (+)

White = heater (-)

Yellow = signal (+) (omitted in 3 x wire types)

Black = signal (-)

Type 2

Grey = heater (+)

White = heater (-)

Yellow = signal (+)

Black = signal (-)

Typical wiring colours for ZIRCONIA BINARY types

1 x wire	Black = signal	**3 x wire**	Black = signal White = heater White = heater
2 x wire	Black = signal Grey = ground	**4 x wire**	Black = signal Grey = ground White = heater White = heater

Typical Wiring colours for ZFAS-U (wide band types)

Blue	Heater +
Yellow	Heater –
White	Ip output (pump current)
Black	Ground
Grey	Icp+

Notes on installation

NB. Always refer to the relevant workshop manuals for special installation procedures.

1. After vehicle has cooled sufficiently to prevent personal injury and where prudent, the battery has been disconnected, unplug the connector and remove the sensor using a suitable tool.

2. Carefully check the vehicle harness and connector for damage or corrosion.

3. Check that the thread in the exhaust system is clean and in good condition before attempting to install the new sensor.

4. Ensure that you have selected the correct part number from the current NTK catalogue.

5. Handle sensors with care to prevent damage - dropping a sensor could inflict damage to the ceramic, which would not be apparent during installation.

6. During production an anti-corrosion compound is applied to threaded portion of the sensor body. This is a sensor friendly grease compound and no other anti-seize compounds should be used as they may contain ingredients that could poison the sensor element.

7. Do not use any other cleaning or anti-rust solvents near the sensor body as this could similarly affect the element.

8. Screw the sensor into place by hand then tighten to the specified torque setting ensuring that the wiring harness is not twisted.

9. Secure the harness using the correct fixings, ensuring that the routing does not produce any kinks in the wires, touch any part of the exhaust system or other hot components and does not foul any rotating parts.

10. Reconnect the harness (and battery if disconnected) and follow the vehicle manufacturers' recommended fault code clearance or other specific procedures.

Why use NTK vehicle specific sensors?

NTK sensors are tailored for each application.

- The specification of each sensor matches or exceeds that of the vehicle manufacturer - even the materials used in the connector pins.

- Every aspect of the sensor should be correct including insertion depth and protection tube design.

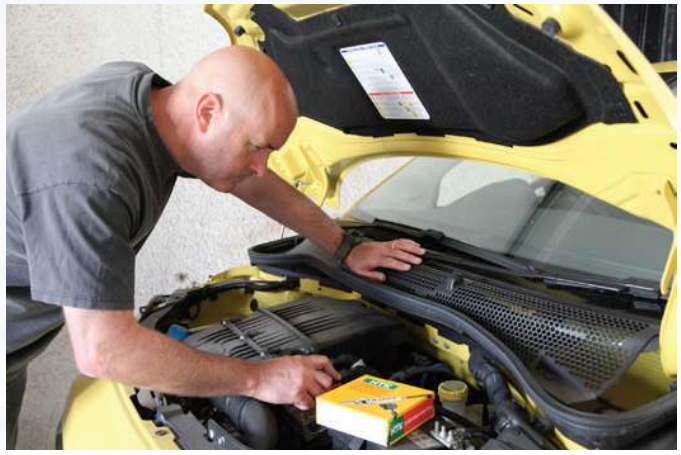
- The dedicated connector block removes the possibility of a wiring error when connecting to the vehicle harness.

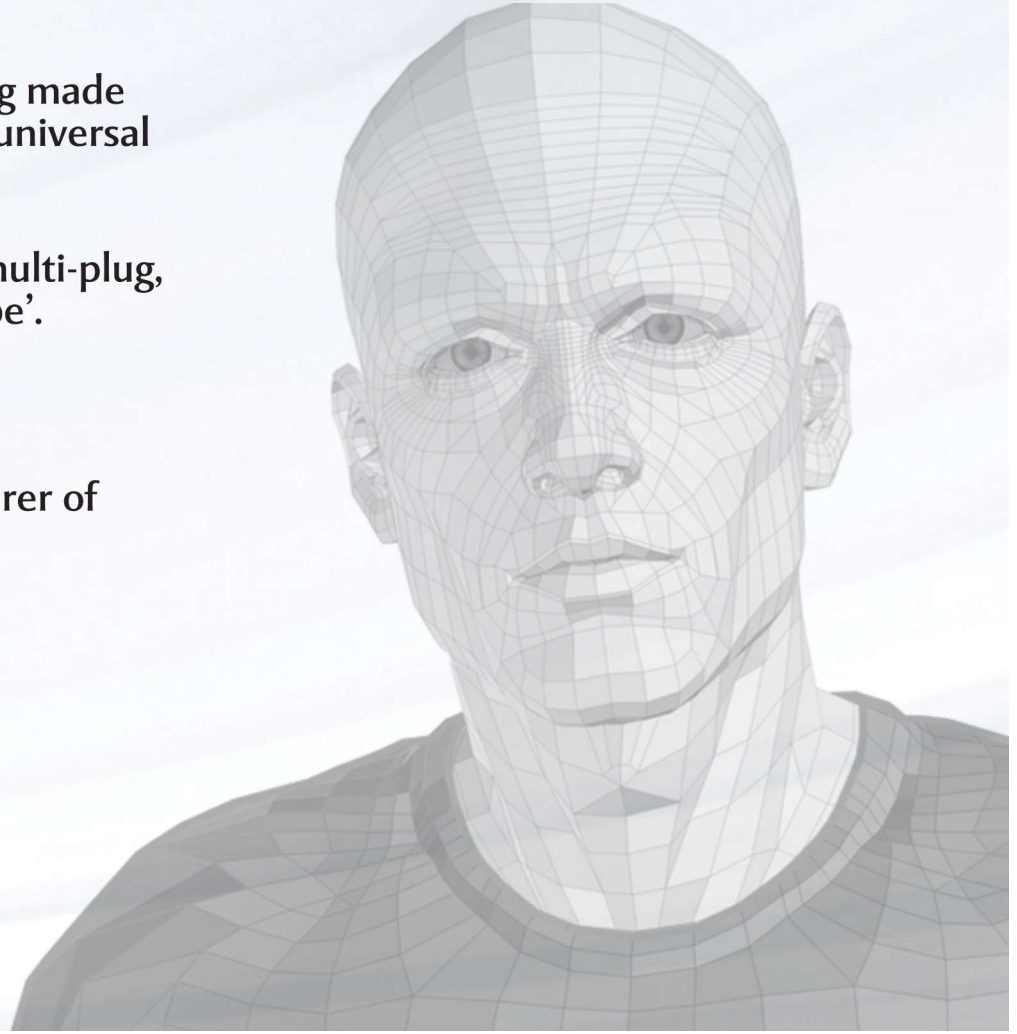
- Removes the possibility of high resistance connections being made or occurring at a later date due to water ingress, when using 'universal types'.

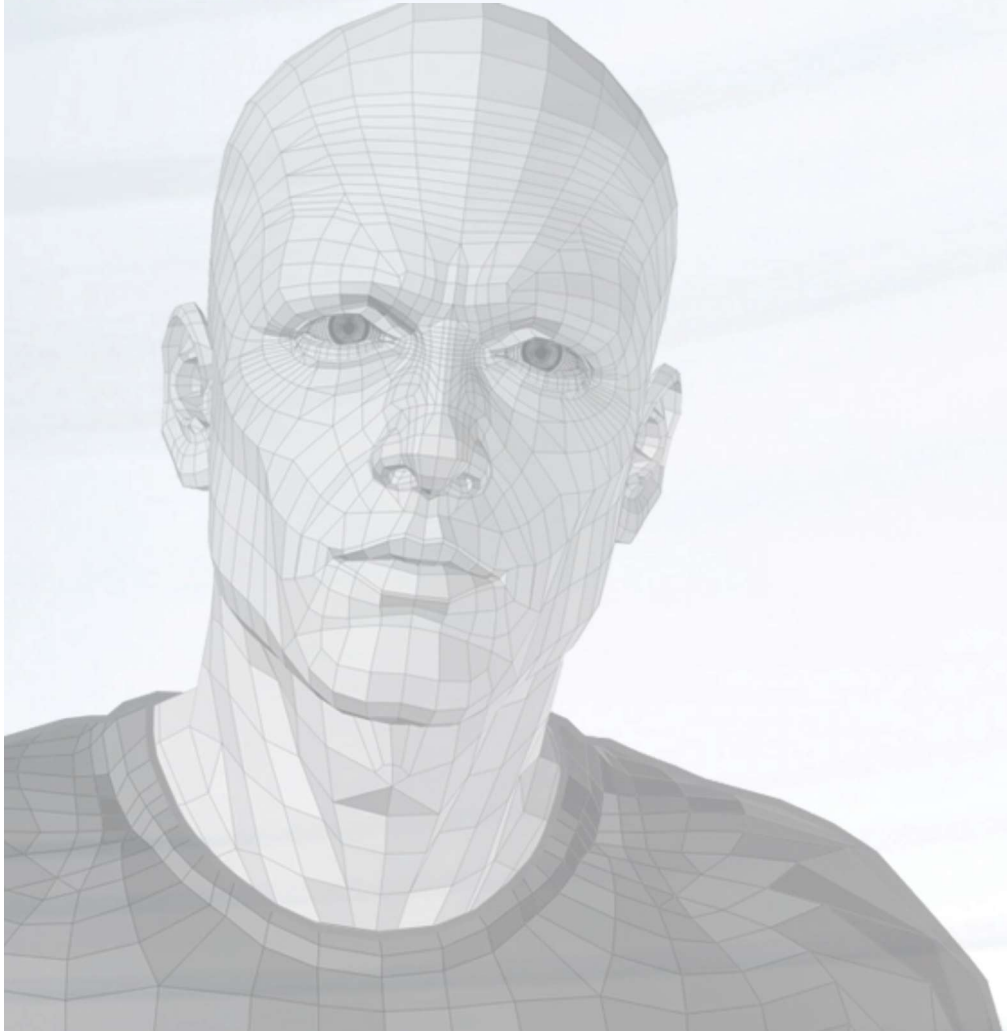
- Removes the possibility of poor connections in the sensor multi-plug, which might go unnoticed if using the spliced in 'universal type'.

- Saves considerable amount of time on fitting.

- Confidence in a product produced by the largest manufacturer of lambda sensors in the world.







TRUST.

NGK Spark Plugs (UK) Ltd
Maylands Avenue
Hemel Hempstead
Herts
HP2 4SD
Tel: 01442 281000
Fax: 01442 281001

www.ngkntk.co.uk