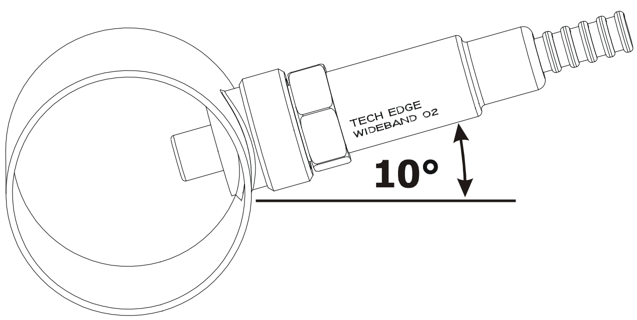
Tech Edge Wideband Oxygen Sensor Installation Guide

General Information on Wideband Sensors

Tech Edge supplies only genuine brand name sensors sourced through OEM channels. Wideband **LSU** sensors manufactured by **Bosch** (or **UEGO** sensors from **NTK**) are designed to last for at least 160,000km (100,000 miles), when installed correctly in a vehicle that has been designed for use with them. After-market applications can approach this life expectancy if certain precautions are taken in their fitment and use. Poor placement, contamination, and rough mechanical handling can destroy a sensor in a very short time.

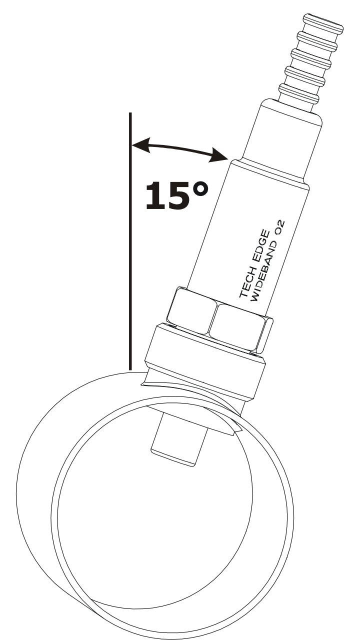


Using leaded fuels reduces the sensor's life expectancy dependant on both the lead concentration and the sensor's placement. The following table, from Bosch, shows how increasing lead concentrations rapidly kills the sensor.

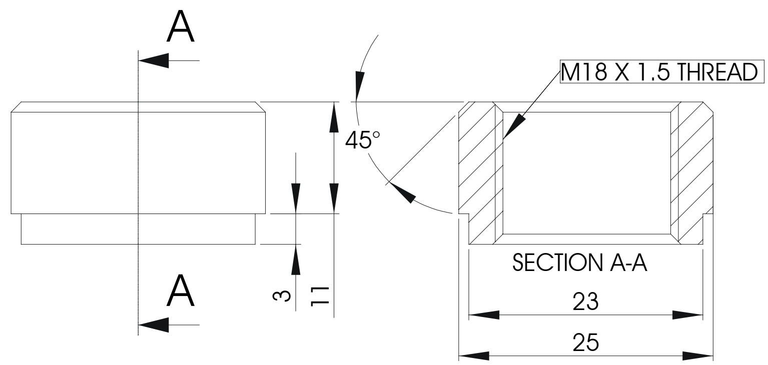
Lead grams/litre	Sensor Life km
0.00	160,000
0.15	60,000
0.40	30,000
0.60	20,000

Other common contaminants include, but are not limited to, **Zinc** (galvanised parts), **Ethylene Glycol** (anti-freeze) & **Silicon** (many gaskets). Other environmental conditions likely to cause a shortened sensor life include:

1. Operating the sensor hotter or cooler than its optimal heat range (see below for more info)
2. Placements where condensation is likely to enter the sensor during warmup or operation. Bosch recommends orientations where the leads point up from the horizontal by at least 10°.
3. Operation in a confined space where heat soak can occur, resulting in elevated sensor body temperatures and subsequent failure of flexible insulation. Operating sensors vertically will exacerbate this situation so, in confined spaces, We suggest you position the sensor away from the vertical by at least 15°.
4. Using the sensor unpowered when in an exhaust stream. The sensor should be powered from a controller whenever it is exposed to exhaust gasses.
5. Excessively rich environments (Lambda 0.75 or richer) will cause more rapid contamination than stoich (Lambda=1.0) operation. Lean and even free-air operation is usually not a problem. Environments devoid of water vapour should be avoided (this is also usually not a problem as H_20 is a by-product of combustion).
6. Excessive oil consumption will rapidly contaminate and physically clog the sensors internal structure. Bosch recommends oil consumption of less than 0.7L/1000km (~2 US-pints/1000 miles).
7. Sensors are designed to be powered when the vehicle is started – this minimises the risk of thermal shock. It is normal practice in a permanent installation to power the controller when the vehicle's ignition is turned on – this sometimes requires an additional relay if a suitable point on the vehicle's wiring cannot be located.

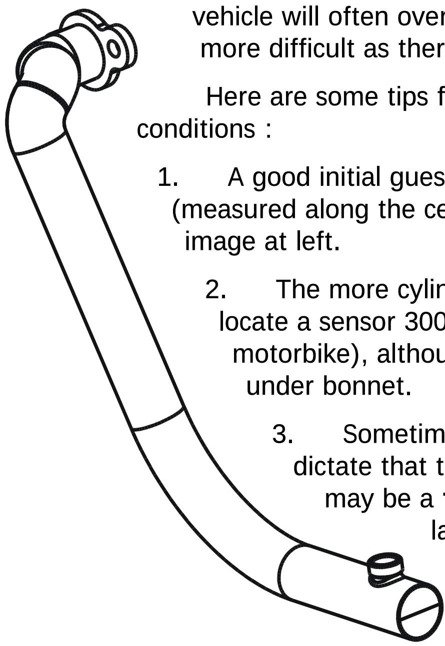


Sensor Typical Mounting Positions



The sensor requires an **M18x1.5** "bung", made from mild steel or even stainless steel, to be welded into the exhaust. Refer to the image for recommended dimensions of the bung. Most exhaust shops carry or can source appropriate bungs. They can usually plasma cut a hole and MIG or TIG them in place. Don't necessarily take their advice as to the best position because most narrowband sensor positions they will be familiar with will be too hot for the average wideband sensor.

Vehicle manufacturers spend a lot of time and money to determine the best position for a Lambda sensor. Most people don't have that luxury and sometimes the final position is a compromise based on where the sensor will fit. Remember however that placing the sensor too far to the rear of a vehicle will often over-cool the sensor, and too close will over-heat the sensor. Turbo vehicles are even more difficult as there are larger variations between boost and non-boost operation.



Here are some tips for good sensor placement, and notes about what to expect under various running conditions :

1. A good initial guess is to locate the sensor 1 metre (40 inches) from the **closest exhaust valve** (measured along the central axis of the exhaust pipe). Often this will result in a location as shown in the image at left.
2. The more cylinders that feed the exhaust pipe, the more heat goes to the sensor. It's possible to locate a sensor 300 mm (12") from a **single cylinder** runner pipe (such as on an air-cooled motorbike), although we would suggest a little further back (500-600 mm = 20-24") if the sensor is under bonnet.
3. Sometimes the requirement for the sensor to see both banks of a split exhaust system dictate that the sensor is located up to 1.5 m (60 inches) or more from the exhaust valve. This may be a **too-cool** borderline position that can be remedied with a recessed sensor – see later.
4. Turbo installations require the sensor to be positioned even further from the exhaust valve. Initially try 1 metre distance from the **turbo outlet**. Don't be fooled by manufacturers placing narrowband sensors right after the turbo outlet – wideband sensor will overheat under boost.
5. So ambient air is not induced back past the sensor at low flow volumes (idle and slow speed), there must be a reasonable amount of pipe after the sensor – at least 500 mm (20 inches) is a starting point. If this cannot be achieved then ignore low speed Lambda indications.
6. If you have any kind of exhaust leak out of the exhaust pipe then it's also possible there is a leak into the exhaust pipe too. Eliminate all exhaust leaks without resorting to sealing compounds as these can often damage the sensor through silicon contamination. Even small leaks may result in meaningless lambda readings. Vehicles with exhaust **air pumps** must be modified so this feature is disabled (caution: doing so may be illegal in some jurisdictions). Remember some vehicles cut fuel on deceleration, so expect to see a "LEAN" indication then.
7. Any temporary or intermittent failure of the ignition, or a very rich or very lean mixture that cannot adequately sustain a spark will result in unburnt fuel particles and excess air passing the sensor. The sensor will see the air but not the raw fuel, and will indicate a much leaner than the actual Lambda than if the cylinder had fired.
8. Remember that a "**hot cam**" with lots of valve overlap can result in air escaping into the exhaust system at lower "off-cam" operation. Be prepared to ignore very lean indications at idle and low power settings.
9. These guidelines also apply to diesel vehicles, but remember diesels often operate at very lean settings.
10. Racing fuel and two stroke motors add the problem of shortened sensor life due to the contamination effects of oil mixed with the fuel. **Recessing** the sensor and using it in a **vertical** position may gain valuable life as the

heavier oil particles find it more difficult to enter the sensor body (see below for more info on recessing the sensor).

Limited Heating, No Cooling

The sensor's internal temperature is closely controlled to aid accuracy. The pump cell wideband technology does not require "temperature compensation" like older style sensors. The controller can only provide limited heating power based on the wattage of the element (around 10 Watts) this is why it's important that the sensor is placed, where possible, close to the motor. However, the controller **cannot** cool the sensor if it gets too hot, so too close to the motor is also a problem.

The controller determines the additional heating required based on indirectly measuring the sensor's pump cell temperature. Under extreme heating/cooling conditions the sensor's internal temperature may not be able to be maintained resulting in:

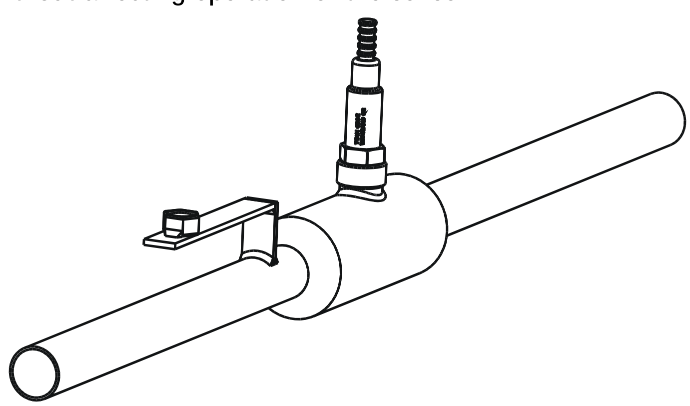
1. Inaccurate Lambda (AFR) measurements.
2. Lowered sensor life due to either sensor degradation at elevated temperatures, or contamination and clogging at lower temperatures.

Tailpipe Sniffing Sensor Location?

Although we don't recommend tailpipe sniffing (ie. placing the sensor at the tailpipe outlet), for many applications this is a necessary evil. For best results we recommend a specially designed sniffer-pipe that minimises the cooling effect in this position. Most dyno shops will have an unsuitable adaptor that is designed for an older style sensor (like the narrowband **LSM-11**) with a higher power heater.

The image shows the general principle. You can use these ideas to make your own version. A small bore take-off pipe opens up into a short length of much larger pipe where the bung is installed. Right after the sensor the diameter is again reduced. The idea is to limit the gas velocity past the sensor by moving it out of the main exhaust stream.

We recommend the two smaller pipes be **at least** 300 mm (12") long and have a diameter **no more than** 20 mm, perhaps even 15 mm (ie. $^5/_8$"- ¾"). The short central section only needs to be 75-100 mm (3-4") long but should be 2.5 to 3 times the smaller pipe's diameter (say 40-50 mm = 1¾"-2"). Longer and thinner inlet and exit pipes reduce exhaust velocity and the cooling effect it has on the sensor without affecting operation of the sensor.



It may be better to rotate the clamp (shown without an attaching bolt) so the clamp does not foul the low plastic skirts found on most new cars. Also, the rear pipe section could be bent at 90^o to limit the length of pipe protruding after the vehicle. Another idea is to have an even smaller diameter pipe after the sensor with two 180^o bends that route the pipe first back past the sensor, then forward past it again, all with the aim of limiting the sniffer's length.

Recess Your Sensor - if it's not in the best position

Moving the sensor out of the hottest part of the exhaust stream, or moving it away from the convective cooling effect of a cool position, can often cure an initially poor choice. One way to do this is by spacing the sensor out from the central part of the exhaust. In effect you are lengthening the bung.

Do this by welding an M18x1.5 nut onto your existing bung. Use a nut at least 10 mm ($^5/_8$") thick to avoid having to align the spacer's new threads with the bung's old threads. Before welding, grinding some of the existing bung so the sensor is not so recessed, can improve the sensor's response speed.

Conventional wisdom says the sensor response may be slower if it's much out of the gas stream. There is a lot of turbulence in the exhaust, particularly where the bung welds affect the smooth pipe walls. So, this is probably not the problem it appears, and besides, a cool or hot sensor may not be as accurate, or may lose PID lock resulting in sluggish response while the sensor cools or heats.

Controller Operation with the Sensor

Tech Edge controllers are designed to operate best at around **13.8** Volts, the voltage provided by a fully charged automotive battery. Most will operate down to **10.5** Volts and up to **19.5** Volts (check your model's specifications). Outside this range, to protect the sensor, the heater will be turned off and the wideband output will not be valid.

Each controller has a status **LED** (or LEDs) that gives an idea of what the controller is doing at any given time. This can provide valuable diagnostic information, so **consult your specific controller's documentation** and become familiar with what each LED flashing sequence means. Some models with bi-colour LEDs should show **GREEN** for normal operation, and **RED** flashing for warming and error codes. Single colour LEDs will show solid RED for normal operation. In general:

1. During initial warm-up there will be a **short sharp ON RED flash** from the status LED. This state should last 25 to 30 seconds and the heater current will slowly ramp up to normal operating values (this provides a "soft start" as specified by Bosch for longest sensor life). The amber LED will show a healthy 30 Hz glow that may be perceived as a steady flicker. An attached display will indicate heating, often by two dots " **..**" or the text "**H..**".
2. If battery voltage is too high, too low, or the sensor-cable or sensor itself is damaged, then the status LED will produce a **medium speed regular RED ON-OFF flash** and the amber LED will have a very dim and pronounced flicker just a few times a second. An attached display should indicate any gross error (bH, bL, ho, hS, hF, etc. - refer to your display's documentation for an explanation).
3. Note that some wideband models with internal logging capability will show different LED indication when they are set to start **logging** – don't confuse logging indications with error codes.
4. During the normal heating cycle, the sensor will rapidly reach operating temperature and the status LED should then come on and **stay solidly lit**.

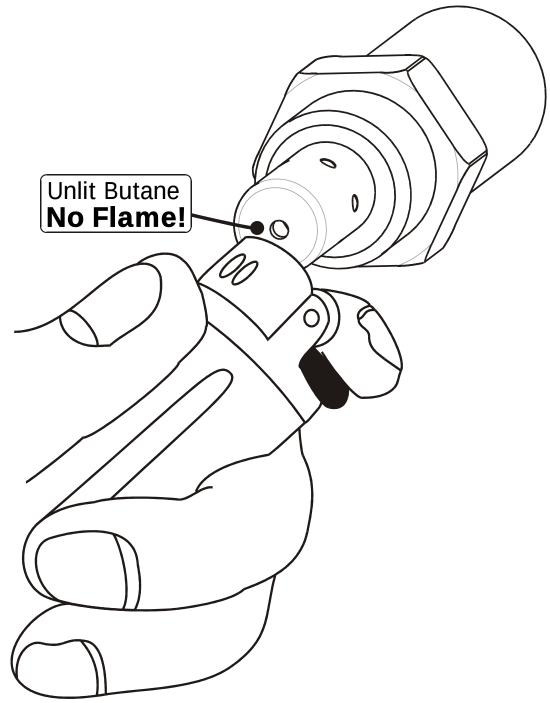
Certain conditions can occur that will result in the status LED not remaining solidly lit. These may be transitory conditions that give an indication of what the sensors is experiencing, or they may be persistent conditions that indicate a problem. The controller uses a software PID algorithm to control both the **heater** and the **wideband** functions of the sensor. We talk about a condition called **PID-unlock** occurring when the software loses control over PID functions (either heater or wideband). PID-unlock is not necessarily an error, but it does indicate either very rapid changes in heating or cooling of the sensor, and/or rapid changes in the monitored Lambda (AFR). If this occurs without an explanation (such as rapid changes in throttle position) then it may be an indication of an intermittent somewhere in the wiring, an aging sensor, or an inappropriately positioned sensor. All digital displays (LD02, LA1, etc.) and the TEWBlog logger indicate these conditions. Each wideband controller also indicates these conditions by flashing the status LED as follows (note: *you may have to update to latest firmware to get these codes*):

1. **Heater** PID-unlock - is a sharp **single-OFF** flash (or sharp RED flash for bi-colour LEDs). This condition indicates the sensor is positioned where it is either too hot, or too cool, or the sensor has become contaminated or has aged. Persistent flashing should be investigated as inaccurate lambda (AFR) readings may accompany this condition.
2. **Wideband** PID-unlock - is indicated by a sharp **double-OFF** flash (or sharp double-RED flash for bi-colour LEDs). It is an early indication of a slowing (aging) sensor. Slow sensor response or rapid inaccurate Lambda (AFR) oscillations may also accompany this condition. It should not occur with a new sensor unless the Lambda is lower than 0.6 – which is usually too rich for normal vehicle operation.

Note: prior to rev firmware Rev-**xx48** the single OFF flash was used to indicate both PID unlock conditions. If you have earlier firmware and need to differentiate between the two conditions then download the latest HXF flash files from the ***Tech Edge*** website and update (see http://wbo2.com/sofware).

Remember, operating the sensor under any error/fault conditions, or undesirable environmental conditions, can drastically shorten the sensor's life. Neither ***Tech Edge*** nor Bosch can be held responsible for sensor failures due to operational issues. If you are unsure of the status of your controller or sensor then remove the sensor and seek technical assistance from ***Tech Edge***. The diagnostic LEDs are there for a purpose. Please read the relevant information, above and on the website, and ensure there are no warnings being displayed.

Initial Confidence Testing



We recommend you test the complete set of wideband components you received, before you begin installation in a vehicle. Often it's easier to test this on a garage bench, and solve any problems, before making difficult-to-reverse changes to your vehicle. You'll also find if there are any unforseen problems, and you'll feel more confident about the unit's operation.

You need a fully charged automotive battery or a regulated power supply. A power supply must be capable of supplying 3 Amps at a DC terminal voltage of at least 12 Volts, and preferably 13.8 Volts. Note: a battery charger will usually **not** be suitable to test the unit.

You'll also need a butane gas source that can be used **without** a flame. A cheap mass-produced plastic cigarette lighter is a very good choice. It should have an exposed nozzle you can hear gas escape from when pressed. Removing its metal wind/heat-shield, which carries the flint you no longer need, will make it easier to get access to the nozzle.

Begin by finding a temporary position to place the sensor – once powered it will heat rapidly and within a few minutes the metal body will become too hot to hold or leave on many bench surfaces. Find a glass container (jam/jelly jar) or an old ceramic mug with a heavy base that will securely hold the sensor.

Now connect all component parts together – the sensor to the sensor-to-controller-cable (this varies with different sensors) and then this cable to the wideband controller unit. Note that the circular 8 pin spin-on connector has a key-way and the matching plug a key, so ensure they are aligned and gently wiggle the two parts together as any force can bend the female mating terminals. If you have a display then connect it as well. If in doubt about anything, the on-line technical information for your controller and display should give you more information.

If you don't have a ***Tech Edge*** display then, for testing purposes, you can install and run the free TEWBlog logging software to connect your PC to the wideband controller using the RJ45 to DB9 cable supplied. If you have a laptop without a DB9 serial connector then you can obtain a USB to serial adaptor quite cheaply from many IT supply places.

Lastly connect power to the controller making sure the battery **positive** goes to the lead with the **red** flash (a heat-shrink red plastic sheath) on the cable supplied. You should cleanly switch power on (and off) to avoid switching transients that could cause the controller to lose its re-programmable memory (it can be reflashed, and memory loss is very rare).

With power applied, the sensor should take **20** to **25** seconds to heat to operating temperature. During this phase the control unit may indicate heating by a slowly flashing red status LED, and a flickering amber LED (shows heater power). The status LED will change to be solidly ON (newer model change to green) when this phase completes. An attached display will indicate heating status and an error code if problems are encountered. Refer to your specific controller's documentation and also display documentation for more information if errors are encountered. The most common problem, with a new controller and sensor, is using an inadequate power supply that cannot supply enough current at the required **12** to **15** Volts (max voltage is 19.5 Volts).

After the heating phase, because the sensor is exposed to air at around 21% oxygen concentration, it should read **LEAN**. PC based software may give you a different indication. Here's where you use the butane lighter. Place the lighter's nozzle close to the hole at the end of the sensor, and press the gas button. Immediately you should see the display change from **LEAN** to a number representing lambda. If you continue to press the gas nozzle the display will change to show **RICH**. What is happening is that the butane (a hydrocarbon fuel) displaces most of the air inside the sensor and approximates the conditions in an exhaust pipe. Depending on the sensor, the gas you squirted in will slowly mix with surrounding air and the display will count up to indicate a leaner and leaner mixture. If you could keep the butane/gas mixture constant you could get a stable display – but this is just a simple test.

Checking the WB_{lin} Output Voltage

One of the most consistent issues reported by customers is getting their **WBlin** output voltage to work with an external logger or with an ECU. Most *Tech Edge* wideband models have a connector with two pins labelled as WBlin+ and WBlin- (or **WB+** & **WB-**). Many loggers have one input only, and this is where some people have problems. But it's quite simple WB+ (or WBlin+) is the output signal that goes to your ECU or the IN (or **IN+**) pin on your logger. This simple one wire connection works but is not ideal, because the WB+ signal will also include some ground switching noise from the controller itself. This noise can make your wideband readings inaccurate, so it's worth understanding.

To solve the noise issue, the WB- input pin is used. WB- connects to the SIGNAL GROUND at the logger or ECU. Sometimes the logger or ECU does not have a SIGNAL GROUND, so WB- should be connected to the GND point physically closest to the WB+ signal. But, and here's the complicated bit, for this to work properly, you need to remove the **WBLIN-GND shunt** inside the unit. If not, then you may as well just use the one wire (and you'll still have the switching noise). You have to refer to your unit's documentation to determine where the WBLIN-GND shunt is found.

If your logger or ECU is a bit fancy then it may have an **IN-** (or similarly named) pin as well. This indicates it has a *differential input*, which can be put to good use by simply connecting WB- to IN-. In this case it's not necessary to remove the WBLIN-GND shunt (and it's best left in!).

The worst possible situation is when the WBLIN-GND is taken out and nothing is connected to the WB- (or WBlin-) input. In this case the WB+ output can float around and give meaningless results. If you find WB+ doing strange things, first make sure the WB- input is connected to GND or the WBLIN-GND shunt is present. If you don't understand the need for WB- or the WBLIN-GND shunt, then more information is on the website at :

http://wbo2.com/sw/wblinout.htm

If you intend using just the unit's voltage output (the WB+ output) hooked up to an ECU or another logger, then you should check that the device is doing what you expect. You need an independent means of measuring this voltage output. We suggest a DVM (Digital Volt Meter) connected between WB+ and WB- and a wire from WB- to GND to ensure WB- has a reference signal.

By measuring the wideband voltage output directly, you can check that the logger or ECU is correctly translating the voltage into a value it logs.

Reasons for Inaccurate Lambda Readings – Exhaust Back Pressure

Wideband Lambda sensors primarily count oxygen atom numbers through measuring the oxygen ion current within the molten electrolyte of the sensor's pump cell. The exhaust gas pressure affects this oxygen ion current – more pressure means more atoms per unit volume and a higher current at the same Lambda. At a higher exhaust gas pressure

- a rich reading will appear richer than it really is, and …
- a lean reading will appear leaner than it really is.

This is the main reason you should position the sensor after the turbo where exhaust back-pressure is lowest.

Other points to note

Route the sensor cable and sensor-to-controller cable to avoid high moisture areas. Particularly ensure the connectors are protected from **moisture ingress** – just a small amount of moisture is enough to provide a conductive path within the connector that will upset measurement from the sensor. Winter and salted roads compound this issue. Always check for cracked or broken connectors when strange results occur.

--- (version 1.0 - edited 26 Oct 20006) ---