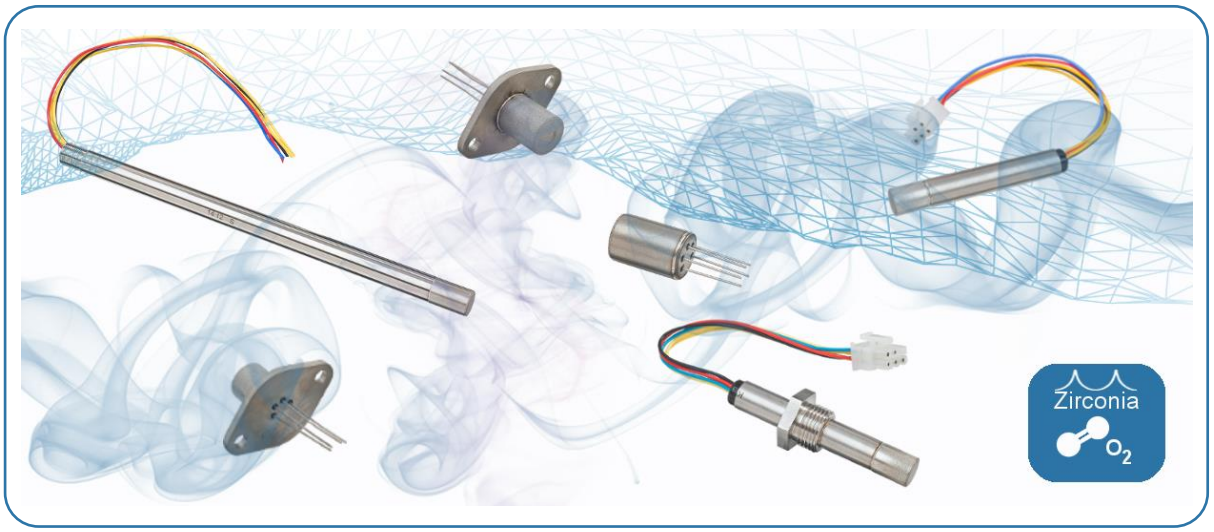
O_2 SENSORS – Zirconium Dioxide (ZrO_2) Oxygen Sensor Installation, Operation and Compatibility Guide

To ensure the best performance from your equipment it is important that the attached oxygen sensor is installed and maintained correctly.



This document provides some useful sensor operating tips and a list of gases and materials that must be avoided to ensure a long sensor life. Typical ZrO_2 sensor lifetime:

- Clean, dry air (e.g. aircraft OBIGGS) applications: 10+ years
- Good quality natural gas (low sulphur): 5+ years
- Biomass (wood chip, pellet, etc.): 2+ years
- Coal (low sulphur): 2+ years
- Composting: 1+ years

NOTE: These lifetimes are typical and are not guaranteed. The lifetime of your sensor can be dramatically reduced if they are physically damaged (high shock or vibration), contaminated with chemicals, or if the heater supply is too low or too high for the chosen sensor and the environment in which it is used.

Contents

1 DEFINITIONS

The following definitions apply to WARNINGS, CAUTIONS and NOTES used throughout this manual.

WARNING:

The warning symbol is used to indicate instructions that, if they are not followed, can result in minor, serious or even fatal injuries to personnel.

CAUTION:

The caution symbol is used to indicate instructions that, if they are not followed, can result in damage to the equipment (hardware and/or software), or a system failure occurring.

NOTE: Highlights an essential operating procedure, condition or statement.

2 SAFETY INSTRUCTIONS

- This equipment may only be installed by a suitably qualified technician in accordance with the instructions in this manual and any applicable standards associated with the country or industry.
- Failure to correctly adhere to these instructions may result in serious injury or death and in this regard the manufacturer will not be held liable.
- This equipment may only be operated and maintained by trained technical personnel. The technical personnel must strictly adhere to the instructions given in this manual, and any prevailing standards/certificates (depending on application).
- Where instructed, you must read the User Guides and Datasheets referenced within this manual. There, you can find detailed information on the equipment.
- The operator may only perform modifications and repairs to the equipment/system with written approval of the manufacturer.
- Do NOT operate damaged equipment.
- If faults cannot be rectified, the equipment must be taken out of service and secured against unintentional commissioning.

3 INSTALLATION

To ensure the best performance from your sensors, they must be installed correctly.

WARNINGS:

All wiring MUST be in accordance with the National Electrical Code and any local codes, ordinances, and regulations.

Disconnect and lock out power before connecting the equipment to the power supply.

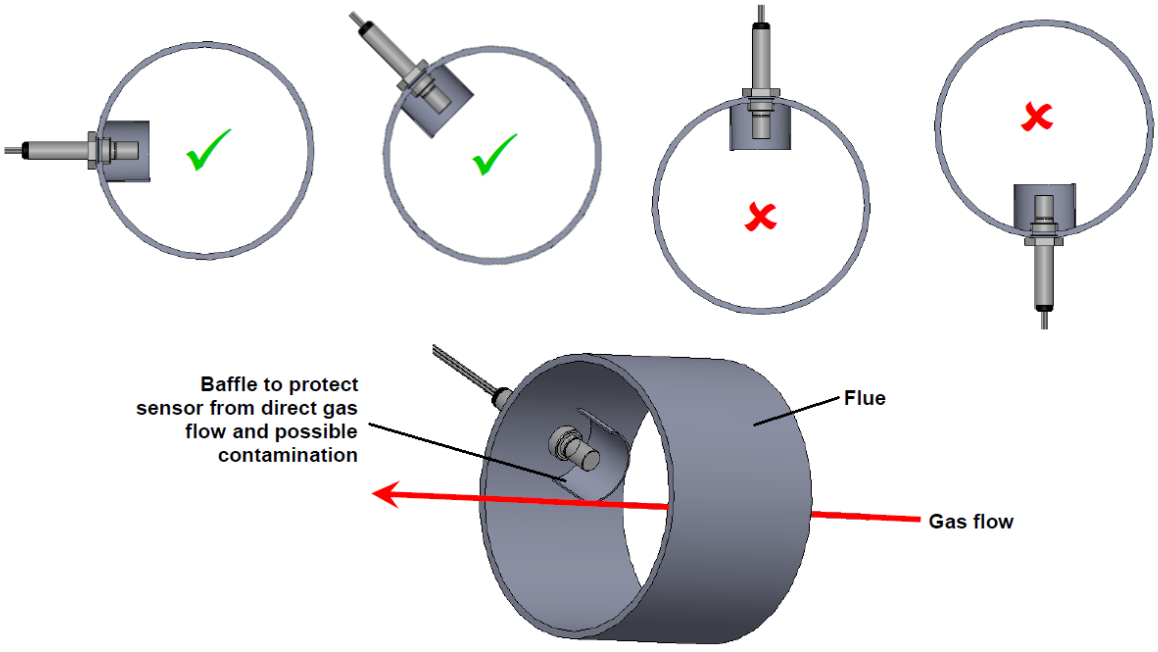
The device wiring should be in a separate conduit. Do NOT install wiring in any conduit or junction boxes with high voltage wiring.

CAUTION: Unless otherwise agreed with SST Sensing, the maximum distance for sensor to electrical interface is 1.1m.
NOTE: Distance is sensor dependent; check the relevant datasheet BEFORE installation. Failure to do so may result in incorrect operation and/or damage to the components.
NOTE: Mounting or dismounting the screw-fit style sensor: hold the sensor body, only turn the hexagonal head while screwing the sensor in or out of the assembly.

3.1 Sensor Placement

Sensors should be installed as per the following mounting recommendations:

- Select the installation location so that there is easy access for later calibration.
- Select an installation location which produces a typical oxygen concentration.
- If mounting in an area where there is a direct gas flow and/or possible contamination, install a baffle as shown to protect the sensor and ensure correct operation.
- Sensors should be mounted horizontally or at a downwards angle to ensure particulates and condensates do not collect on the sensor tip. Do NOT mount vertically.



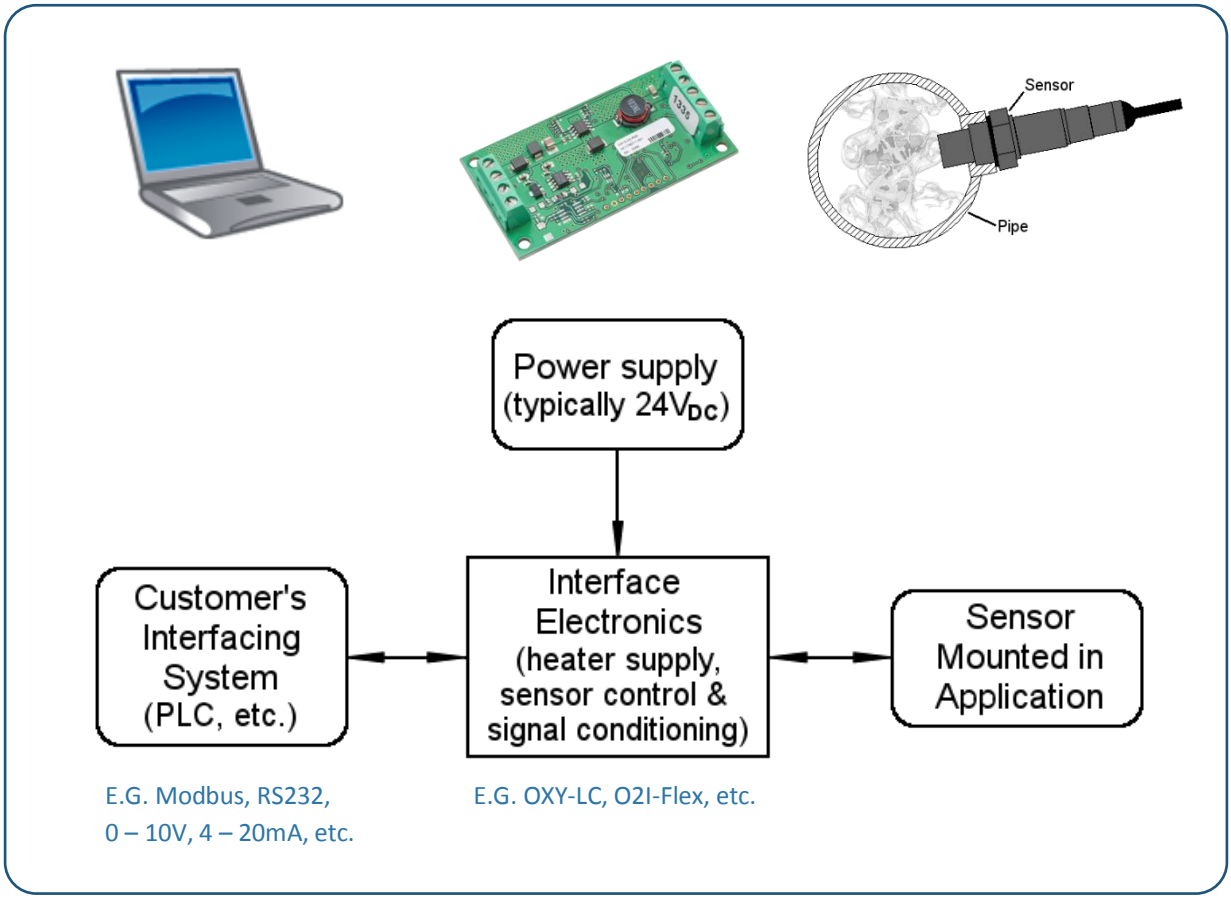
3.2 System Setup

The following diagram shows an example system layout; this shows the minimum requirements.

Always handle the interface board using the correct ESD handling precautions.

Refer to the appropriate interface board User Guide for installation guidance; see REFERENCE DOCUMENTS. If you are not using one of SST Sensing's interface boards, refer to *AN-0113, O_2 Sensors – ZrO_2 Sensor Software and Hardware Design Guide* for guidance.

If you require any assistance configuring your requirements, contact technical@sstsensing.com.



4 INITIAL STARTUP

4.1 Commissioning Checks

Before commissioning the equipment read 2 SAFETY INSTRUCTIONS on page 2-1 of this document.

Complete the following essential tasks BEFORE switching the system ON for the first time:

- Ensure compliance with permissible installation position.
- Verify the sensor unit is mounted securely and sealed correctly if appropriate. Ensure any sealing type used is appropriate (e.g. PTFE tape or gasket; do NOT use silicone based sealants, refer to 5.1.4 Using the Sensor with Silicones on page 5-2 for details).
- If fitted, ensure any baffles are installed in the correct position.
- Verify the device and wiring are all undamaged.
- Ensure the cables are strain-free and not twisted.
- Ensure the sensor is connected properly, with all its inputs and outputs complete. If appropriate, all screw terminals are properly tightened.
- If appropriate, refer to the correct Interface Board User Guide and Datasheet for parameters and control information; see REFERENCE DOCUMENTS.

CAUTION: Test the power supply to ensure it is delivering the correct voltage before wiring to the device.

CAUTION: Failure to test the suitability of the power supply BEFORE first power on could result in irreversible product damage that is NOT covered by warranty.

4.2 First-time Calibration

Calibration, or re-referencing, is required when a sensor is attached to the interface for the first time. Refer to the appropriate Interface User Guide for correct calibration procedure; see REFERENCE DOCUMENTS. Refer also to *AN-0043, O_2 Sensors – ZrO_2 Sensor Operating Principle and Construction Guide* for details.

5 OPERATION

The following sub-sections give an overview of the sensor operation, for more in-depth information regarding the physics and concept behind the zirconium dioxide technology refer to *AN-0043, O_2 Sensors – ZrO_2 Sensor Operating Principle and Construction Guide*.

5.1 Environments

The application in which the zirconium dioxide oxygen sensor is operating influences the life of the sensor. To ensure the sensor does not fail prematurely, the following should be noted:

5.1.1 Fail Safe Operation and Sensor Asymmetry

One of the main benefits of the dynamic and active cell employed within the oxygen sensor is that it is inherently fail safe. The continual cycling and measurement of the generated Nernst voltage is effectively the heartbeat of the sensor, if this stops something fatal has occurred within the cell. This can very quickly be detected by the interface electronics.

Refer to *AN-0043, O_2 Sensors – ZrO_2 Sensor Operating Principle and Construction Guide* for details.

5.1.2 Operating in Aggressive Humid Environments

When operating the sensor in warm, humid environments it is important the sensor remains at a higher temperature than its surroundings, especially if there are corrosive components in the measurement gas. During operation this is less of an issue as the heater operates at 700°C, however this means when the sensor or application is being powered down the sensor heater must be the last thing to be turned off after the temperature of the surroundings have suitably cooled. Ideally the sensor should be left powered or at a lower standby voltage (2V typically) at all times in very humid environments.

Figure 5-1 Internal Corrosive Damage

Failure to adhere to these rules will result in condensation forming on the heater and sensing element. When the sensor is re-powered the condensation will evaporate, leaving behind corrosive salts which very quickly destroy the heater and sensing element as illustrated in Figure 5-1; note how the sensor's external metalwork looks completely normal.

5.1.3 Protecting from Excessive Moisture

In environments where excessive moisture or falling water droplets are likely, the sensor should be protected from water reaching or falling directly onto the very hot sensor cap as this can cause massive temperature shocks to the cell and heater. Popular methods include a hood over the sensor cap or for the sensor to be mounted in a larger diameter cylinder; refer to 3.1 Sensor Placement on page 3-1.

At a very minimum the sensor cap should be angled downwards in the application as this will deflect any falling moisture and prevent the sensor cap from filling with water.

5.1.4 Using the Sensor with Silicones

Zirconium dioxide oxygen sensors are damaged by the presence of silicone in the measurement gas. Vapours (organic silicone compounds) of RTV rubbers and sealants are the main culprits and are widely used in many applications. These materials are often made of cheaper silicones, that when heated still outgas silicone vapours into the surrounding atmosphere. When these vapours reach the sensor, the organic part of the compound will be burned at hot sensor parts, leaving behind a very fine divided Silicon Dioxide (SiO_2). This SiO_2 completely blocks the pores and active parts of the electrodes. If RTV rubbers are used we advise using high quality, well cured materials. Guidance can be provided on request.

A complete list of chemicals and gases that should be avoided can be found in 5.2 Cross Sensitivity below.

5.2 Cross Sensitivity

Gases or chemicals that have an influence on the life of the sensor or on the measuring results are listed in the following sub-sections:

5.2.1 Combustible Gases

Small amounts of combustible gases will be burned at the hot Pt-electrode surfaces or Al_2O_3 filters of the sensor. In general, combustion will be stoichiometric as long as enough oxygen is available, the sensor will measure the residual oxygen pressure which leads to a measurement error. The sensor is not recommended for use in applications where there are large amounts of combustible gases present and an accurate O_2 measurement is required. Gases investigated:

- H_2 (Hydrogen) up to 2%; stoichiometric combustion
- CO (Carbon Monoxide) up to 2%; stoichiometric combustion
- CH_4 (Methane) up to 2.5%; stoichiometric combustion
- NH_3 (Ammonia) up to 1500 ppm; stoichiometric combustion

5.2.2 Heavy Metals

Vapours from metals like Zn (Zinc), Cd (Cadmium), Pb (Lead), Bi (Bismuth) will have an effect on the catalytic properties of the Pt– electrodes. Exposures to these metal vapours must be avoided.

5.2.3 Halogen and Sulphur Compounds

Small amounts (< 100ppm) of Halogens and/or Sulphur compounds have no effect on the performance of the oxygen sensor. Higher amounts of these gases will, in time, cause readout problems or, especially in condensing environments, corrosion of sensor parts. Gases investigated:

- Halogens, F_2 (Fluorine), Cl_2 (Chlorine)
- HCL (Hydrogen Chloride), HF (Hydrogen Fluoride)
- SO_2 (Sulphur Dioxide)
- H_2S (Hydrogen Sulphide)
- Freon gases
- CS_2 (Carbon Disulfide)

5.2.4 Reducing Atmospheres

Long time exposure to reducing atmospheres may in time impair the catalytic effect of the Pt-electrodes and must be avoided. Reducing atmospheres are defined as an atmosphere with very little free oxygen and where combustible gases are present. In this type of atmosphere oxygen is consumed as the combustible gases are burned.

5.2.5 Other

- Fine dust (carbon parts/soot) may cause clogging of the porous stainless steel filter and could have an effect on the response speed of the sensor.
- Heavy shocks or vibrations may alter sensor properties resulting in the need for recalibration.

5.2.6 General

The sensor has been developed for boiler combustion control applications and not for automotive combustion applications. Life tests have been performed in:

- A laboratory atmosphere
- Exhaust gases of natural gas fired boilers
- Exhaust gases of light oil

6 MAINTENANCE

WARNING: BEFORE performing any type of maintenance on the equipment read 2 SAFETY INSTRUCTIONS on page 2-1 of this document.

WARNING: The oxygen sensor is heated to over 700°C (1300°F) and is a source of ignition. Ensure the sensor is cool before attempting to touch or service the equipment.

6.1 Cleaning

Unless your sensors are operating in conditions where excessive contamination occurs, they should not require any cleaning.

NOTE: Where excessive contamination is likely to occur, a suitable hood should be fitted over the sensor (contact SST Sensing for advice).

CAUTION: Never use any of the following for cleaning purposes:

- Chemical cleaning agents
- High-pressure water or steam

6.2 Calibration

SST Sensing's range of zirconium dioxide oxygen sensors do not directly measure the oxygen concentration but instead measure the partial pressure of oxygen within the measurement gas.

Regular calibration removes the effects of application and atmospheric pressure changes and also eliminates any sensor drift[a] that may occur during the first few hundred hours of operation.

Refer to the appropriate Interface User Guide for correct calibration procedure; see REFERENCE DOCUMENTS. Refer also to *AN-0043, O_2 Sensors – ZrO_2 Sensor Operating Principle and Construction Guide* for guidance.

6.3 Disposal

Zirconium dioxide oxygen sensors contain electrical components, for this reason they must be disposed of as electrical waste. Please observe your local regulations.

[a] Refer to APPENDIX A – SENSOR DRIFT on page A-1 for details.

APPENDIX A – SENSOR DRIFT

Zirconium dioxide oxygen sensors drift, or appear to drift, in a number of ways:

Burn-in

New sensors drift as they "burn-in". What's happening here is as follows:

- Minute (and unavoidable) quantities of impurities in the zirconia migrate to the surface of the sensor as it is operated; this is an asymptotic process which levels off after a while.
- The inside of the sensor becomes oxidised and discoloured due to the high internal temperature. This alters how much heat from the heater is reflected back into the centre of the cell and so affects its temperature very slightly. Again, this is an asymptotic process.

In order to quantify this "initial drift", a batch of 50 sensors were tested by measuring their output in a stable environment. Over a 300-hour period, the magnitude and direction of drift was random with a maximum drift of +/- 3.5% of initial reading, i.e. a sensor that started off reading 210mbar, might end up reading 202.6 to 217.4mbar (worst case).
After this initial burn-in drift is complete, the sensor drift is insignificant, all else being equal.

Contamination

Another cause of sensor drift is contamination from chemicals which get into the sensor. Pollutants can poison the sensor in two ways, both resulting in a change in the measured ppO_2. Either the pores in the sensor filters can become blocked, or the boundary between the platinum catalyst and the ZrO_2 substrate can be affected such that the ability of the ZrO_2 to transport O_2 ions is reduced. In small quantities, these pollutants affect the sensor output only minimally and so the result can be considered as "drift".

NOTE: More severe pollution, e.g. from silicone-based materials will seriously affect the sensor behaviour to the point of failure. Obviously every application is different and it is not possible to put numbers to this effect.
Refer to 5.2 Cross Sensitivity starting on page 5-2 which lists gases and chemicals known to contaminate the ZrO_2 sensors.

Cross sensitivity

As described in 5.2 Cross Sensitivity starting on page 5-2, there are gases, such as hydrocarbons, which will combust in the presence of O_2, thereby reducing the amount of O_2 at the sensor cell and resulting in a lower measured value. This is not drift, but it may be perceived as drift if you are not aware of the phenomenon or if the constituents in the gas being used is not fully understood.

Pressure sensitivity

Again, this is not drift, but often confused with drift. Unlike some other O_2 sensors, SST Limited's ZrO_2 products measure ppO_2, not O_2%. The ppO_2 is directly affected by the total pressure of the gas and so can be affected by changes in atmospheric pressure for example.

REFERENCE DOCUMENTS

Other documents in the Zirconium Dioxide product range are listed below; this list is not exhaustive, always refer to the SST website for the latest information.

Part Number	Title
AN-0043	O_2 Sensors – ZrO_2 Sensor Operating Principle and Construction Guide
AN-0076	O_2 Sensors – ZrO_2 Sensor and Interface Selection Guide
AN-0113	O_2 Sensors – ZrO_2 Sensor Software and Hardware Design Guide
DS-0044	Zirconia O_2 Sensors Flange Mounted Series – Datasheet
DS-0051	Zirconia O_2 Sensors Miniature Series – Datasheet
DS-0052	Zirconia O_2 Sensors Probe Series - Short Housing – Datasheet
DS-0053	Zirconia O_2 Sensors Probe Series - Screw Fit Housing – Datasheet
DS-0055	Zirconia O_2 Sensors Oxygen Measurement System – Datasheet
DS-0058	OXY-LC Oxygen Sensor Interface Board – Datasheet
DS-0072	OXY-COMM Oxygen Sensor – Datasheet
DS-0073	Zirconia O_2 Sensors OXY-Flex Oxygen Analyser – Datasheet
DS-0074	O2I-Flex Oxygen Sensor Interface Board – Datasheet
DS-0122	Zirconia O_2 Sensors Probe Series - BM Screw Fit Housing – Datasheet
DS-0131	Zirconia O_2 Sensors Probe Series - Long Housing – Datasheet

CAUTION

Do not exceed maximum ratings and ensure sensor(s) are operated in accordance with their requirements.
Carefully follow all wiring instructions. Incorrect wiring can cause permanent damage to the device.
Zirconium dioxide sensors are damaged by the presence of silicone. Vapours (organic silicone compounds) from RTV rubbers and sealants are known to poison oxygen sensors and MUST be avoided. Do NOT use chemical cleaning agents.

Failure to comply with these instructions may result in product damage.

INFORMATION

As customer applications are outside of SST Sensing Ltd.'s control, the information provided is given without legal responsibility. Customers should test under their own conditions to ensure that the equipment is suitable for their intended application.

For technical assistance or advice, please email: technical@sstsensing.com

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