INSTRUCTIONS FOR USE

CarboProbe HT

CarboProbe DS

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1. Operational principles

The purpose of ECONOX *CarboProbe* oxygen sensors is to measure and regulate atmospheres in heat treatments.

General points

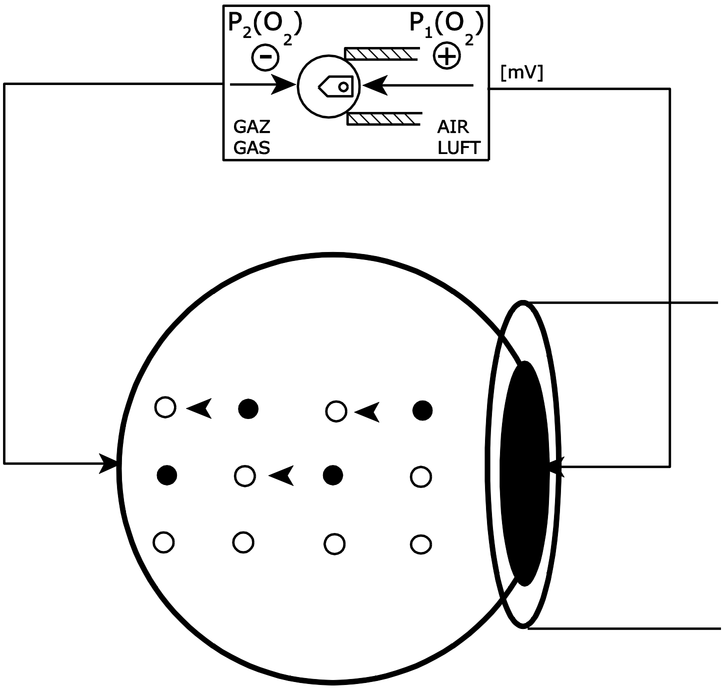
ECONOX uses two different types of electrolyte made of ZrO_2 (zirconium oxide) for its oxygen sensors:

1. A ball made of ZrO_2, an ECONOX-patented system, which may only be obtained from ECONOX. The ball is used in the *CarboProbe ZI pro* sensor.

2. A C-700 ZrO_2 electrolyte.
This is used in the *CarboProbe ZS, DS* and *HT* sensors.

These elements made of zirconium oxide (ZrO_2) placed at work temperature and separating two gaseous areas with differing partial oxygen pressure (pO_2), behave like electrochemical batteries by transferring oxygen ions. At the terminals of both electrodes on the ball, the value of the voltage delivered is linked to the absolute temperature and the difference in partial oxygen pressures, according to the Nernst equation.

The diagram shown below represents the operation of the ZrO_2 ball; the principle is the same for the C-700 ZrO_2 electrolyte.



$$E = 0.0215 \cdot T \cdot \ln \frac{P1 \cdot O_2(référence)}{P2 \cdot O_2(four)}$$

E =	voltage [mV] at terminals
T =	temperature [°K] in the furnace
P1O2 =	partial oxygen pressure of ambient air (20.9%)
P2O2 =	partial oxygen pressure of the atmosphere in the oven

The measuring element in the oxygen sensor is a ceramic composed of zirconium oxide doped with yttrium. The latter presents defects in the crystal lattice. Most parts of the lattice which could be occupied by oxygen ions are incomplete.
The main property of the ceramic is to allow the movement of oxygen ions at temperatures over 700°C. Above that temperature, the zirconium becomes a conductor through the movement of oxygen ions rather than that of electrons. The voltage thus generated is an expression of the relations between the relative difference in oxygen concentrations (ambient air and atmosphere in the furnace) and the temperature of the sensor.
The voltage is expressed in the following equation:

$$E = 0.0215 \cdot T \cdot \ln \frac{P1 \cdot O_2(référence)}{P2 \cdot O_2(four)}$$

By interpreting the voltage measured on exiting the sensor, using the NERNST formula, the oxygen concentration of the atmosphere in the furnace can be read instantly and precisely. By knowing the oxygen concentration, the CO content and the temperature, the carbon potential can be determined using the fixed stoichiometric relations that exist between O_2 – CO – CO_2 concentrations. In this way, the mVs measured on exiting the sensor are a function of the carbon potential for a given temperature and CO level.
The sensor voltage depends solely on the composition of the gas and the temperature.

The carbon potential is then calculated using the following formula:

$$\%C = F(E[mV] \cdot température[°C] \cdot P_{CO})$$

2. Technical specifications

The type HT oxygen probe, based on the ZrO_2 oxygen sensor, is a robust, industrial duty oxygen probe. It is suitable for measurement of oxygen concentration at temperatures from 700°C to 1700°C. The CarboProbe HT, DS is accurate enough for research laboratory use, but robust enough for industrial use.

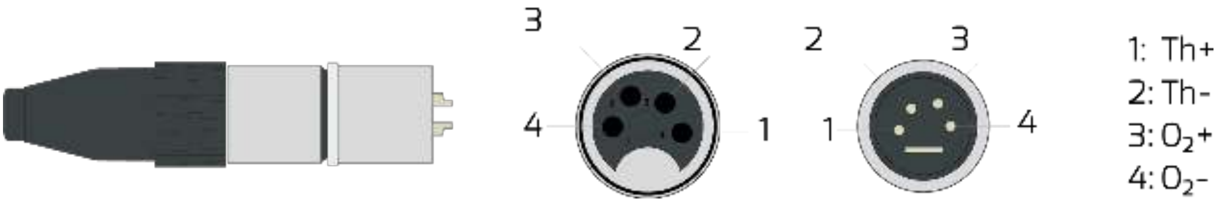
Output	DC millivolt signal, according to Nernst equation
Reading	Oxygen sensors ought to be used with control devices with input impedance of 10 megohms or over.
Insertion depth	10 cm minimum
Response time	Under one second
Standard air	Clean, dry standard air with an output of 0.5 - 1l/hr.
Temperature range	700°C to 1700°C
Thermocouple	R-type
Thermal and mechanical shock	*CarboProbe HT, DS* sensors must be brought up to temperature gradually (over a 10-minute period)..

Electrical plug

Here are the connections for the electrical plug:

Pin 1 – 2 : Thermocouple

Pin 3 – 4 : Oxygen signal



3. Installing the sensor

All our oxygen sensors are tested after assembly. No offset is set when the sensors are shipped.

Points to be followed when installing a sensor:

1. The sensor must never obstruct the loading of the furnace.

2. If the sensor is installed too close to the heating elements or the furnace door, the temperature cannot be measured correctly. Any difference in temperature between the sensor and the regulation thermocouples ought to be avoided.

3. Thermal and mechanical shocks ought to be avoided when installing the sensor, or during the heat treatment cycle (this causes the deterioration of the zirconium oxide measuring element).

4. The temperature of the measuring element must be between 700 and 1700°C

5. The sensor is supplied with a 3/4'' connector. When fitting it to the furnace, ensure that the core temperature of the sensor does not exceed 60°C.

6. The connector linking the sensor to the furnace must be airtight. If necessary, you may check its air tightness using a lighter: when moving it around the connector, no flame should flare up from the connector.

7. The *CarboProbe HT, DS* must be brought up to temperature gradually; otherwise the measuring element may suffer irreversible damage. In order to avoid this problem, the sensor must be inserted slowly into a furnace that is up to temperature. **The sensor must be inserted gradually over a period of 10 minutes**.

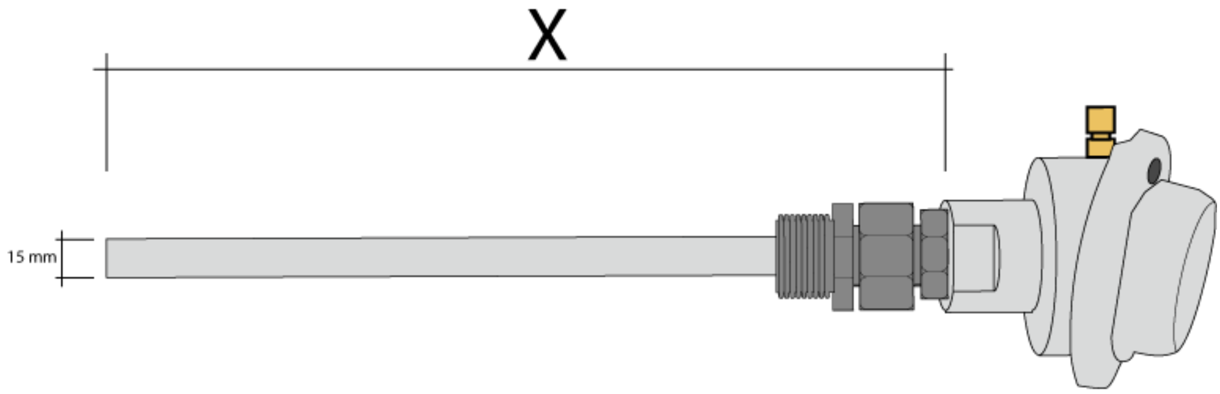
8. Install the probe anywhere in the kiln or furnace where a thermocouple probe could be installed. If the probe is used at temperatures over 1100°C, the probe should hang vertically, to avoid bends caused by high temperature creep. The probe will measure the oxygen concentration at the probe tip, provided that the operating temperature is between 700°C and 1700°C.

4. Construction

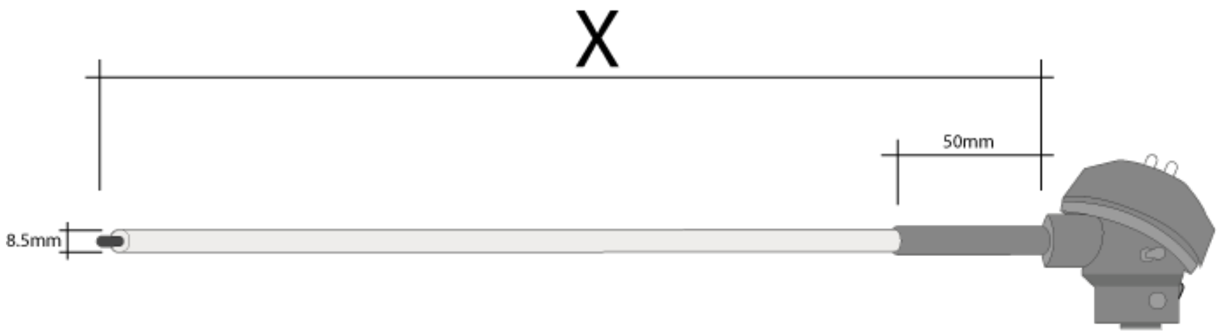
The HT, DS probe consists of a ZrO_2 oxygen sensor, mounted in an industrial thermocouple head with all electrical and reference air connections. Probes are normally supplied with an internal R-type thermocouple.

The sensor is protected by an alumina ceramic sheath of 15 mm outside diameter, open at the end (CarboProbe HT). All wiring and electrodes are platinum, for outstanding corrosion resistance and high temperature application. Probes are supplied with a 4-pin Lemo type cord plug, ready for connection to any suitable 4-conductor cable.

CarboProbe HT



CarboProbe DS



5. Applications

- Control of glaze color and firing ceramics
- Control of air supply in industrial incinerators
- Measurement of fuel/air ratios in combustion
- Combustion and pyrolysis research

6. Maintenance

On request, some probes have a filter consisting of high purity alumina ceramic fiber packed in the end of the sheath. If the filter becomes clogged, pull it out and replace the fiber. The tip of the sensor is about 10 - 15 mm from the tip of the sheath. Do not scrape or pull the end of the sensor. No other routine maintenance is required. There are no user serviceable parts inside the probe. Damaged probes can generally be repaired at our premises.

There are two simple tests that can be performed regularly while the probe is in service. If the probe fails either of these two tests, it should be replaced.

Probe impedance

The impedance of a probe will gradually increase as the probe is used. The impedance of the brand new probe should be measured at the normal operating temperature then at regular intervals, at the same temperature. If the impedance abruptly changes or increases to 10 times more than the initial value, there may be a problem with the probe. Note that the impedance is normally strongly dependent on temperature, so this test must be performed at a consistent temperature.

Reference air response

While the probe is in use, quickly shut off the reference air supply. The probe output signal should gradually fall by a few mV in one minute. If the change is more than 25 mV in one minute, the sensor has probably cracked and may give inaccurate readings.

7. Repairing the sensor

CarboProbe sensors are highly technical measuring instruments subjected to potentially difficult work conditions. The lifespan of a given sensor depends, to a large extent, on the conditions in which it is used. If you suspect that the sensor is malfunctioning, and the troubleshooting section has not helped you in solving the problem encountered, then the sensor probably requires repair.

When sending a sensor for repair, pack it carefully in its original packaging, mark it "Fragile Instrument", and return it to:

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