INSTRUCTIONS FOR USE

CarboProbe HT

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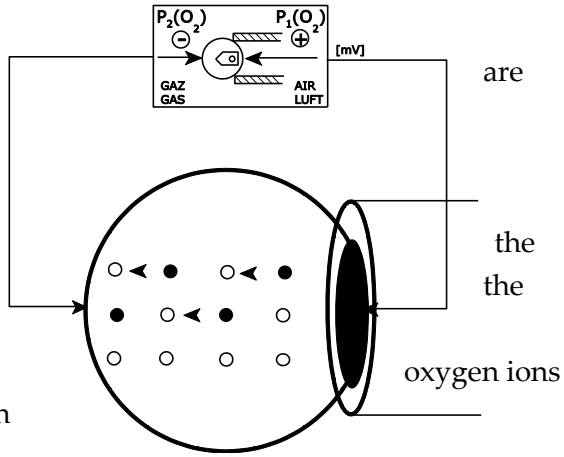
Operating principles

The purpose of ECONOX *CarboProbe* oxygen sensors is to measure and regulate atmospheres in heat treatment furnaces. ECONOX uses two different types of sensors made of ZrO2 (zirconium oxide) for its oxygen sensors:

1. ZrO2 Ball sensor
   The ZrO2 ball used in the *CarboProbe* ZI Pro sensor is an ECONOX-patented system and can only be obtained from ECONOX. The ball is more robust than other sensors and resistant to thermal shock.

2. C-700 sensor
   The C-700 sensor is a rod shaped sensor and is used in *CarboProbe ZS* and *HT* sensors.

The ball sensor and C-700 sensor separate two gaseous atmospheres: the atmosphere of a furnace or oven and the atmosphere of ambient air outside of the furnace. They then act as electrochemical batteries by transferring oxygen ions. Both types of sensors are made of ZrO2 "doped" with yttrium. The yttrium creates defects in the crystal lattice of the ceramic. Portions of the lattice that could be occupied by oxygen atoms are incomplete. When the ceramic sensor is heated over 700C, it allows for the movement of oxygen ions. The zirconium becomes a conductor through the movement of the oxygen ions rather than electrons and the voltage generated is an



expression of the relations between the relative difference in oxygen concentrations between the ambient air and atmosphere in the furnace as well as the temperature of the sensor. Therefore, the voltage in mV can be calculated with the Nernst equation:

$$E = \frac{RT}{nF} \ln\left(\frac{P_{O_2 reference}}{P_{O_2 furnace}}\right)$$

Simplified equation:

$$E = 0.0215\, T \ln\left(\frac{P_{O_2 reference}}{P_{O_2 furnace}}\right)$$

Where $E = voltage\ (mV) at\ terminals\ of\ sensor$

$T = \ temperature\ (°K)$

$P_{O_2 reference} = partial\ oxygen\ pressure\ of\ ambient\ air\ (20.9\%)$

$P_{O_2 furnace} = partial\ oxygen\ pressure\ of\ the\ atmosphere\ in\ the\ furnace/oven$

Sensor voltage depends solely on the composition of the furnace atmosphere and temperature of the furnace. The mVs measured across the sensor are a function of the carbon potential for a given temperature and CO level. The oxygen concentration of the furnace atmosphere can be read instantly and precisely by interpreting the measured voltage across the sensor terminals. When the oxygen content, CO content, and temperature are known, the carbon potential can be determined using the fixed stoichiometric relations that exist between O_2, CO, and CO_2 concentrations.

Applications

The HT probe is primarily used for:

1. Control of glaze color and firing ceramics
2. Control of air supply in industrial incinerators
3. Measurement of fuel/air ratios in combustion
4. Combustion and pyrolysis research

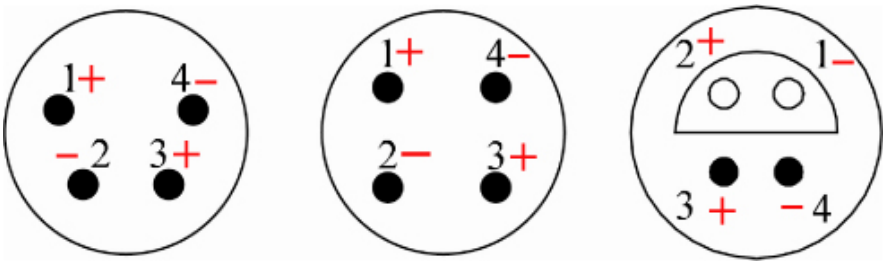
Technical specifications

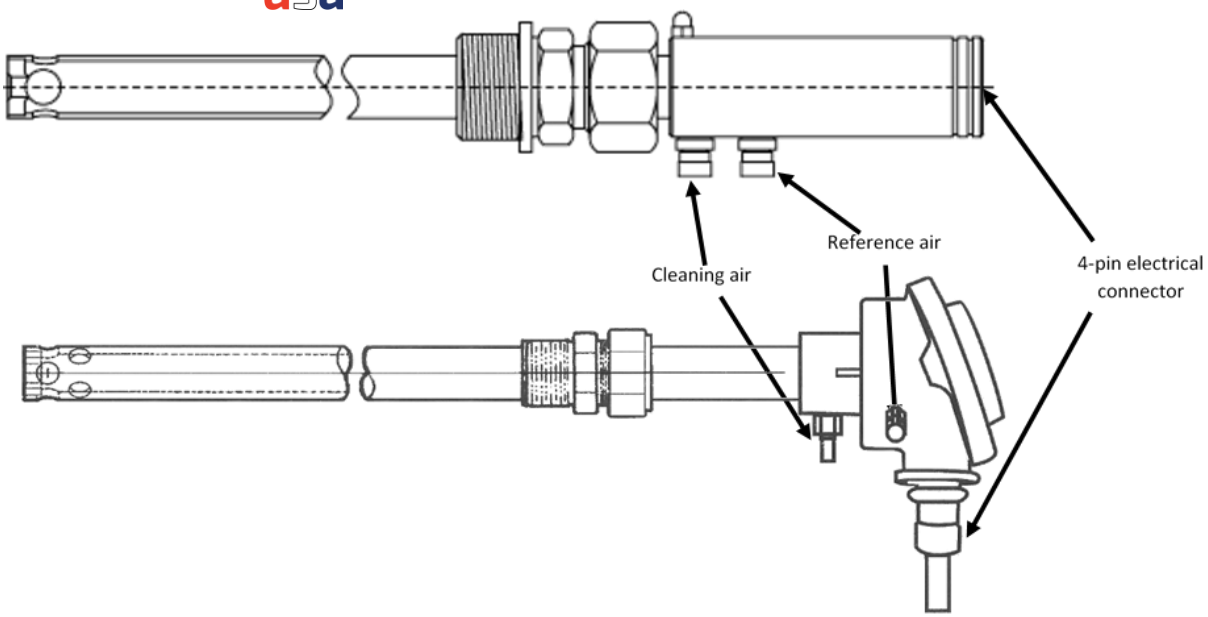
The HT oxygen probe consists of a Zr2 C700 oxygen sensor, mounted in an industrial thermocouple head with all electrical and reference air connections. Probes are normally supplied with an internal R-type thermocouple.

The HT is a robust, industrial duty oxygen probe. It is suitable for measurement of oxygen concentration at temperatures from 1300°F to 3100°F. The accuracy of the CarboProbe HT makes it suitable for laboratory research use, but its robust design makes it suitable for industrial use as well. It is protected by an alumina ceramic sheath of 15 mm outside diameter,

open at one end. 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 Technical Specifications	
Output	DC mV signal, according to Nernst equation
Reading	Oxygen sensors must be used with control devices with input impedance >= 10 megohms.
Insertion depth	10 cm minimum
Precision	.+/- 0.05% °C
Response time	< 1 second
Reference air	Clean, standard air with an output of 0.5-1 l/hr (.018-.035 CFH)
Temperature range	1300°F to 3100°F
Thermocouple	R-type, or no thermocouple
Thermal and mechanical shock	Must be brought up to temperature gradually over a 10 minute period to resist thermal shock.





Installing the sensor

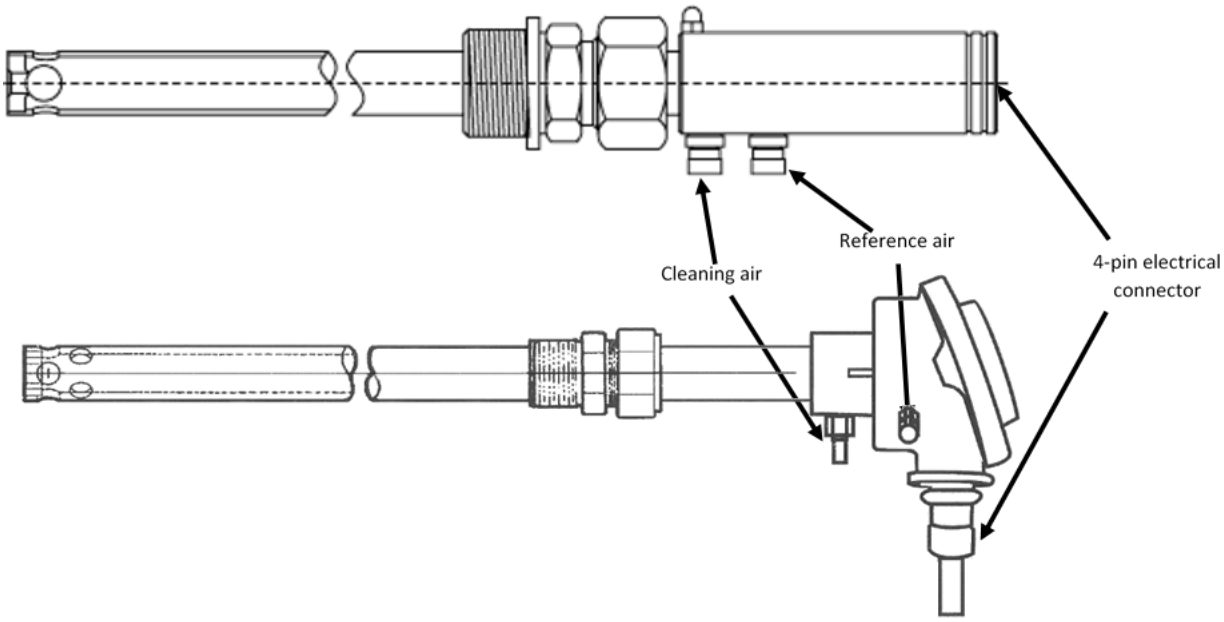
All ECONOX probes are tested after assembly. No offset is set when the sensors are shipped.

1. Sensor placement
    a. The sensor must be placed so that it does not obstruct loading of the furnace.
    b. Place the sensor as close to the load as possible in order to measure the temperature and atmosphere precisely, as these have a direct impact on the load. Placing the sensor close to a turbine will improve readings.
    c. Do not place the sensor too close to heating elements or the furnace door. The temperature will not measure correctly. Placement that creates temperature differences between the sensor and the regulation thermocouples should be avoided.
2. Mechanical shocks must be avoided when installing the sensor and during the heat treatment cycle.
3. The *Carboprobe* HT sensors must be brought up to temperature gradually during installation and heat treatment cycles to avoid thermal shock. Otherwise the measuring element may suffer irreversible damage. To avoid this problem, the probe must be inserted **gradually** into a furnace that is up to temperature **over a period of 10 minutes.**
4. The temperature of the measuring element must be between 1300°F and 3100°F.
5. The sensor is supplied with a ¾" connector. When installing the probe into the furnace wall, ensure that the core temperature of the probe does not exceed 60°C (140°F).
6. The connection between the probe and the furnace must be airtight. The airtightness can be checked using a lighter. Move a lighter around the connection point. If the flame flares up at the edges of the connection, the seal is not airtight.

7. Install the probe anywhere in the kiln or furnace where a thermocouple probe could be installed. If the probe is used at temperatures over 2000°F, the probe should hang vertically, to avoid bends caused by high temperature creep.

Reference and cleaning air

Reference air is supplied to the probe through the red port. Cleaning air is supplied through the blue port and is used to burn off soot that may build up on the probe.



Maintenance

Routine maintenance is not required because there are no user serviceable parts inside the HT probe. Damaged probes generally must be repaired at ECONOX USA.

Two simple tests can be performed regularly while the probe is in service to ensure it is working properly. If the probe fails either of these two tests, it should be replaced. RECYCLE

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 and then again 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. This can be done by pinching the line closed or removing the air line. 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.

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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