TECHNICAL NOTE 1.3:
Accuracy of CO_2-Pro Series Sensors

Introduction

The submersible CO_2-Pro Series of instruments manufactured by Pro-Oceanus provide long-term accuracy and stability for carbon dioxide (CO_2) measurements. The sensors utilize infrared detection to determine the partial pressure of CO_2 in natural waters over a depth range of 0-6000 meters. Many factors must be considered and corrected for to maintain both accuracy and long-term stability. Dectector temperature, water vapour pressure, environmental conditions, other dissolved gases and ageing components can all affect the performance of our instruments. All of these factors are accounted for in the calibration and construction of the CO_2-Pro sensors.

Figure 1.
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CO_2-Pro CV

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Infrared Detection

Non-Dispersive Infrared Detection (NDIR) operates through the measurement of the absorbance of light by specific molecules at particular infrared wavelengths. The main components of an infrared cell are the IR light source, an optical path, a light filter, and a detector (Figure 2). The CO_2-Pro Series of instruments use an internal air pump to circulate gas from behind the gas transfer interface though the IR detector cell where CO_2 is measured (Figure 3). A humidity cell measures the vapor pressure of water and a pressure sensor continually measures the gas stream pressure.

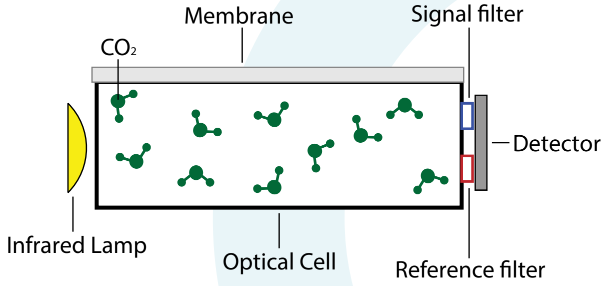


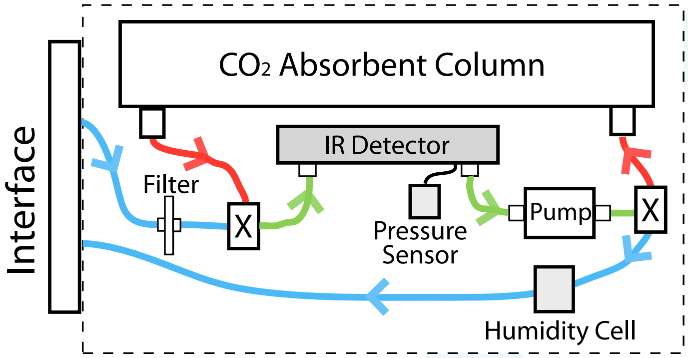
Figure 2.
Diagram of infrared detection cell.

Accuracy and Stability

To maintain both accuracy and long-term stability, several environmental factors must be measured. These measurements are then used to correct the CO_2 data.

Water molecules absorb IR light over a large range of wavelengths, including the IR band used to detect CO_2. As a result, the water vapor pressure is measured and used to correct the CO_2 data through a standard algorithm used for all instruments.

Figure 3.
Diagram of the internal plumbing of the CO_2-Pro Series Instruments.



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The total gas pressure within the detection cell must be measured for two reasons. First, the concentration of CO_2 measured though absorbance of light is dependent on the number of molecules within the path length, and this is a function of the pressure. Second, to determine the partial pressure of CO_2, the total gas pressure must be known.

Temperature of the cell and detector are of critical importance in maintaining accurate measurement of CO_2 using IR. Temperature changes not only affect optical absorbance, but also can affect the performance of the light source the performance of the detector, and the dimensional stability of the optical cell. Because correcting for temperature changes is difficult, Pro-Oceanus CO_2-Pro Series detectors eliminate temperature instability by maintaining a constant detector cell temperature. This allows for calibration and measurement at a single temperature, thereby eliminating the need to correct for changes in temperature.

Accurate measurement and long-term stability are aided by frequent measurement of calibration gases. The ability to have a suite of calibrations gases in a submersible instrument is not an option, however a zero CO_2 reference is used within the CO_2-Pro instruments. The use of an internal CO_2 "scrubber" removes all CO_2 from the detection cell to allow for measurement of a zero CO_2 baseline over periods of a year or longer within the sensors (Figure 3). This operation accounts for ageing of both the detector and the IR light source over time.

Calibration Procedure

Each CO_2-Pro series instrument is individually calibrated using WMO traceable standards. The CO_2 concentration range that each sensor is calibrated to is specified by the requirements of each customer and project. Ranges from 0-600 µatm up to 0 – 1 000 000 µatm are possible. Each sensor is calibrated using "dry" gases and curve fit using a multi-segment polynomial curve-fit. Once fully calibrated and accuracy is within specification, sensors are tested in water to verify performance under "wet" gas conditions.

Using this procedure, CO_2-Pro Series instruments are within 0.5% accuracy over the calibrated range. Yearly maintenance and factory re-calibration are highly recommended for the sensors to maintain optimal accuracy and performance.

Figure 4.
WMO traceable calibration gases.

Figure 2.
Pro-Oceanus CO_2-Pro Instrument.

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