

Underway pCO₂ System Description

Laboratory: RSMAS, University of Miami

Name/Vintage: pCO₂, built by W.T. Hiscock in 2002

Reference: General operating principle described in Wanninkhof and Thoning (1992) and Feely *et al.* (1998)

Where installed: On ships of opportunity

Location of Data: www.rsmas.miami.edu.

Analyzer: LICOR 6262 (digital output) infrared (IR) analyzer

Method of analysis: A zero reference gas flows continuously through the Licor reference cell. Absolute concentration analyses of a “wet” samples measures atmospheric air and a closed loop equilibrator gas. Gas flow is ~200 mL min⁻¹ during IR readings.

Drying method: No drying method employed.

Equilibrator (setup, size, flows):

Equilibrator: Custom Built showerhead equilibrator. Water flow rate: 4L min⁻¹. Re-circulated equilibrator gas flow rate: ~200 mL min⁻¹.

Equilibrator: Liqui-Cell gas exchange membrane. Water flow rate: 1L min⁻¹. Re-circulated equilibrator gas flow rate: ~200 mL min⁻¹.

Standards (number, concentrations, frequency): Measure three standard gases and a zero air, with approximate concentrations of 300, 360, and 420 ppm. In certain areas (coastal), a higher standard is measured, approximately 520 ppm. All four standards are run in sequence every 6 hours, and one of the four standard gases is run once every hour.

Source of calibration and accuracy: All are certified standards from PraxAir.

Standard consumption: Less than a tank per year for each standard.

Operating cycle:

Standard Routine: Every six hours (Default Setting), the three standard gases and a zero air are run in succession. Each gas is flushed for 5-minutes at ~200 mL min⁻¹ and measured for 5-minutes at ~200 mL min⁻¹. Measurements are made every 6-seconds with readings averaged over one minute. During standard measurement phase, the sample output is vented to the lab.

Single Standard Routine: Every hour (Default Setting), one of the three standard gases is measured (High Standard - Default) Setting. The standard gas is flushed for 5-minutes at ~200 mL min⁻¹ and measured for 5-minutes at ~200 mL min⁻¹. Measurements are made every 6-seconds with readings averaged over one minute. During single standard measurement phase, the sample output is vented to the lab.

Atmospheric Air Routine: Every hour (Default Setting), the atmospheric air is measured. The gas is flushed for 5-minutes at ~200 mL min⁻¹ and measured for 5-minutes at ~200 mL min⁻¹. Measurements are made every 6-seconds with readings averaged over one minute. During atmospheric air measurement phase, the sample output is vented to the lab.

Equilibrator Air Routine: The closed-loop of equilibrator air is flushed for 5-minutes at ~200 mL min⁻¹ after a “Standard Routine”, “Single Standard Routine” or “Atmospheric Air Routine”. Then measured continuously at ~200 mL min⁻¹. Measurements are made every 6-seconds with readings averaged over one

minute. Atmospheric pressure (pressure in the laboratory – kPa) is measured every five minutes. During the equilibrator gas measurement phase, the sample is re-circulated from the Li-Cor to the equilibrator.

Parameters recorded/frequency: At the end of each measurement (≈ 1 minute) the following is recorded to disk.

DATE&TIME: UTC time from an independent FURUNO GPS instrument
LATITUDE: position from an independent FURUNO GPS instrument
LONGITUDE: position from an independent FURUNO GPS instrument
SBE_TEMP: temperature measured by a separate SBE sensor inline and immediately before equilibrator
SBE_SAL: salinity measured by a separate SBE sensor inline and immediately before equilibrator
PHASE: “Equil”, “Bow Air”, “Zero”, “Standard 1”, Standard 2” or “Standard 3”
ATM.PRESS.: pressure in laboratory as determined by a Setra Pressure Transducer
XCO2:
XH2O:
LICOR TEMP: Li-Cor temperature output
LICOR PRESS:
ATM.PRESS. (mV):
XCO2 (mV):
XH2O (mV):
LICOR TEMP (mV):
LICOR PRESS (mV):
PC_TIME:
INTERCEPT:
SLOPE A:
SLOPE B:
ROOT MEAN SQUARE:
CO2 ZERO (Intercept):
CO2 SPAN (Slope):

Hardware details

Temperature measurements: SBE flowing thermosalinograph position inline and immediately before equilibrator.

Pressure measurements: Setra model 270-pressure transducer

Circulation pathway: Two Gast pumps (one for equilibrator gas, one for reference air) routed through 1 μm Acro disks and 3-port valves. One KNF pump for Atmospheric Air routed through 1 mm filter/water trap and 3-port valves. The Licor sample output is routed through a solenoid valves that allows it to be directed back to the equilibrator or vented to the atmosphere.

Operating software: CVI Version 4.01

Computer interface boards and sensors read:

Boards: National Instruments FP-1000 RS-232/RS-485 Network Module, FP-RLY-420 8 Channel relay board.

Sensors:

Li-Cor 6262 (communication via RS-232)

Setra model 270 (0-5 V output, communication via Li-Cor)

SBE-45 thermosalinograph (communication via RS-232)

Furuno GPS-31 (communication via RS-232)

Position, Thermosalinograph, fluorometer, wind speed and wind direction may also be read via RS-232 port from shipboard computing system when available.

Approximate Size and Footprint: 21” W x 32” L x 32” H

“Unique” Hardware or operating principles worth highlighting: Fully Automated. Measurement of Atmospheric Pressure every five minutes would relieve any pressure build up in the Liqua-Cell Equilibrator.

What improvements would you incorporate in this system? Decrease size; decrease standard gas consumption.