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](http://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
- 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.