Underway pCO_2 System Description
Laboratory: NOAA/AOML

Name/Vintage: System 3.0B, prototype system which was remodeled by Esa Peltola in 2001

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

Where installed: currently in AOML. Last used on R/V Walton Smith and USCGC Polar Star

Location of Data: **www.aoml.noaa.gov/ocd/oaces.**

Analyzer: LICOR 6252 (analog output) infrared (IR) analyzer

Method of analysis: Differential analyses relative to the low standard gas which flows continuously through the Licor reference cell. Measures dried air and equilibrator headspace gas. Gas flow is stopped prior to IR readings.

Drying method: bow air and equilibrator headspace passes through a water trap cooled to 5 C and subsequently through $Mg(ClO_4)_2$

Equilibrator size, flow and setup: Equilibrator built by David Chipman patterned after design by Weiss, 515 ml water, and 790 ml headspace
Water flow rate 1.5 l/min
Headspace recirculated @ 300 ml/min

Standards: 3 standards spanning expected concentrations up to 530 ppm

Source of calibration and accuracy: All standards come from CMDL traceable to WMO scale. Stated accuracy of the standards is 0.07 ppm from 330 to 420 ppm and 0.2 ppm for higher or lower standards.

Standards: (number, concentration, frequency): Three standards are used with approximate concentrations of 300, 360, and 420 ppm. In certain areas, a high standard of approximately 520 ppm is used instead of 420. All standards are run once an hour.

Standard consumption: 2 tanks a year of low/reference standard; less than 1 tank a year for mid and high standards.

Operating cycle: Hourly cycle with sequence:
Three gas standards (3.5 minute flush @ 50 ml/min, 15 second wait (stop flow), 10 second analysis with average of 5 readings)
4 samples from equilibrator headspace (4 minute flush @ 250 ml/min, 15 second wait (stop flow), 10 second analysis with 5 IR readings averaged)

3 samples of bow air (3.5 minute flush @ 300 ml/min, 15 second wait (stop flow), 10 second analysis with average of 5 readings)
4 samples from equilibrator headspace (4 minute flush, 15 second wait (stop flow), 10 second analysis with 5 IR readings averaged)
During the head space gas measurement phases, gas is recirculated from the Licor sample output back to the equilibrator. During standard and air measurement phases, the sample output is vented to the atmosphere.

Parameters recorded/frequency : At the end of each cycle (≈4.25 minutes) the following is recorded to disk resulting in a data file of less than 1 Megabyte per month
PHASE: water, air or standard
PC_DATE
PC_TIME
YEAR_DAY
IR_VOLTS: analyzer voltage CO2 channel
IR_CONC: concentration determined from 2nd order polynomial fit of preceding standards
PRESSURE: pressure in laboratory
EQ_VOLTS: resistance of thermistor in equilibrator
EQ_TEMP: temperature determined from an empirical polynomial function determined from laboratory calibration for thermistor in equilibrator
EQ_MFM_VOLTS: voltage output from water flow meter in front of equilibrator
EQ_MFM_FLOW: flow (L/min) from water flow meter in front of equilibrator
PRE_MFM_REF_VOLTS: voltage output from reference gas flow meter in front of IR before flow is stopped prior to analysis
PRE_MFM_REF_FLOW: flow (from algorithm with voltage provided by manufacturer)
PRE_MFM_SMP_VOLTS: voltage output from gas flow meter gas sample line in front of IR before flow is stopped prior to analysis
PRE_MFM_SMP_FLOW: flow (from algorithm with voltage provided by manufacturer)
POST_MFM_REF_VOLTS: voltage output from reference gas flow meter in front of IR after flow is stopped prior to analysis
POST_MFM_REF_FLOW: flow (from algorithm with voltage provided by manufacturer)
POST_MFM_SMP_VOLTS: voltage output from gas flow meter gas sample line in front of IR after flow is stopped prior to analysis
POST_MFM_SMP_FLOW: flow (from algorithm with voltage provided by manufacturer)
IR_TEMP_VOLTS: Licor temperature output
IR_TEMP: Licor temperature output

Hardware details
Temperature measurements: Thermistor positioned in top of equilibrator, calibrated against a Hart thermometer once a year

Pressure measurements: Setra model 350 pressure transducer

Circulation pathway: Two KNF pumps (one for head space gas, one for bow air) routed through 1 μm Acro disks and a Valco 6-port valve. The Licor sample output is routed through a solenoid that allows it to be directed back to the equilibrator or to the atmosphere.

Operating software: Labview Version 5.1

Computer interface boards and sensors read:
Boards: National Instruments ATMIO 16 XE-50, National Instruments ER-8 relay board
Sensors: A/D 16 bit- voltage LICOR CO_2 channel (0-5 V)
A/D 16 bit- voltage LICOR temperature (0-5 V)
A/D 16 bit- Data Industrial water flow meter (0-5 V)
A/D 16 bit- Aalborg gas flow meter on reference side of Licor (0-5 V)
A/D 16 bit- Aalborg gas flow meter on sample side of Licor (0-5 V)
A/D 16 bit- resistance, constant current – thermistor equilibrator
A/D 16 bit- Setra model 350 (0-5 V)

Approximate Size and Footprint
Computer box of 21" wide by 19 " deep by 32" high
Equilibrator, condenser, and pump box: size 21" wide by 9 " deep by 25" high
Box with valves, flowmeters, pressure transducer, LICOR, and interface boards: box of 21" wide by 17 " deep by 23" high

"Unique" Hardware or operating principles worth highlighting:

a. Automatic water drains for condensor (operate every 5 hours during standard cycle
b. Short vent lines of equilibrator are in an open chamber flushed with excess bow air

What improvements would you incorporate in this system?
Decrease size: when system uses USB ports, the computer box can be replaced with a notebook computer; Decrease weight: the cases could be made of aluminum or semisoft plastic; Change of the instrument design: the drawer model crimps tubing, the flexible but not corrosive resistant plastic tubing could be replaced with SS tubing in a design of non-moving compartments ; Improve ease of installation; Improve drying to decrease the frequency of changing of $Mg(ClO_4)_2$; Decrease standard gas consumption; Change timing of solenoid that recirculates head space gas to equilibrator.