

# Healy pCO<sub>2</sub> System Installation Report

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## Location on Vessel

The underway pCO<sub>2</sub> system is installed in the vessel's starboard side Wet Lab on the main deck (figure 1). The room is designated as # 1-117-1-Q. The components of the system are mounted near the aft wall on a temporary plywood wall (figure 2) that was installed by the Scripps STS (Shipboard Technical Services) group. The "Main lab" (# 1-117-0-Q) is located diagonally aft of this space and the "Biochem lab" (#1-105-3-Q) is located directly forward from the starboard side of the Wet lab. The Wet lab has direct access to the outside Main deck, just forward of the starboard A-frame. The Biochem lab is the location of the other underway water sensors including the TSG.

Figure 1: Starboard side of USCG vessel Healy, showing location of door to the Wet lab where the underway pCO<sub>2</sub> system is installed in relation to the location of the atmospheric sample air inlet.



Figure 2: View of pCO<sub>2</sub> system from a forward and port side vantage point (looking to the starboard and aft. Calibration gases and Nitrogen cylinders are farthest to the starboard side of the lab, Air sample pumps are located in the small enclosure that is mounted above the small shelf that holds the laptop computer. The analyzer unit is in the clear fronted fiberglass enclosure and finally the air-sea water equilibrator is mounted on its aluminum shelf above the plastic sink.



Behind the plywood wall is a large water tight door that leads aft to the CTD room. Apparently this door is not frequently used so blocking it with the temporary wall was not considered problematic.

### **Calibration Gases and Nitrogen**

The gas cylinders were secured to an existing cylinder rack in the starboard –aft corner of the lab (figure 3). All five aluminum CO<sub>2</sub> in air cylinders are on this rack and raised above the floor. Two Nitrogen cylinders (1 active and 1 spare) are strapped to the rack but are not raised above the floor. The remaining 6 Nitrogen cylinders are secured in the Cargo hold one deck below. The spare Nitrogen cylinders can be brought up to the lab using the ship's elevator. The cylinder information is listed in Table 1 .

Figure 3: Gas cylinders secured to a rack in the starboard –aft corner of the wet lab. Spare nitrogen cylinder is not visible in this view but is located directly aft of the brown gas cylinder.



Table 1: Calibration gas information for Healy system. (Eight Nitrogen cylinders total on board)

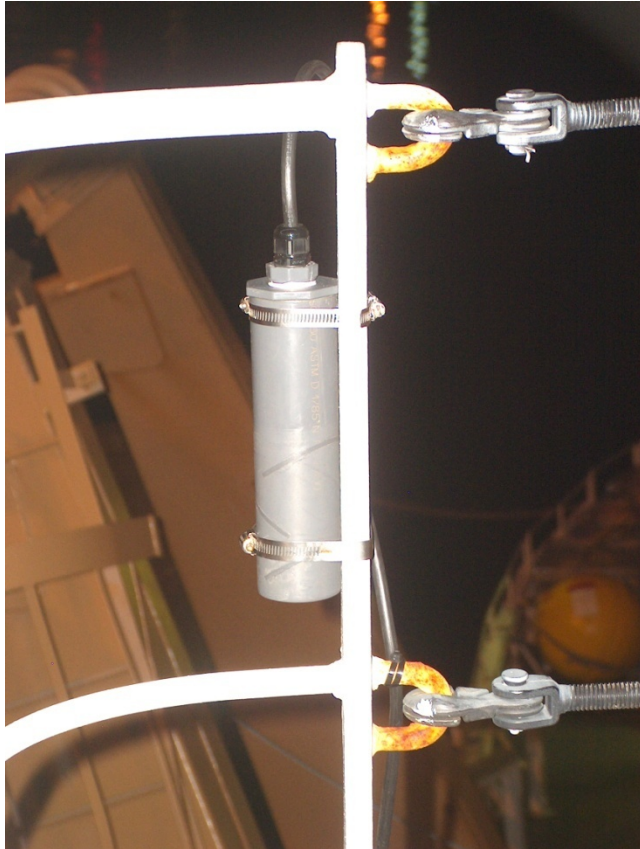
Identifier	Cylinder Pressure (psi)	CO2 (ppm)	Valco Valve Position
Nitrogen	2300	0	1
CC46457	1925	110.22	3
CC58080	1850	700.48	5
CA06650	1840	554.28	7
CC15482	1950	241.31	9
CC104489	1870	386.93	11



### **Atmospheric Inlet.**

A high forward location for an atmospheric inlet appears to be impossible. The bow mast is not very high and is frequently topped by waves and heavy sea spray. A closer location on the starboard side two decks above the main deck was chosen instead (Figure 4). Because all the ship's vents are located on the port side this location may be a good option.

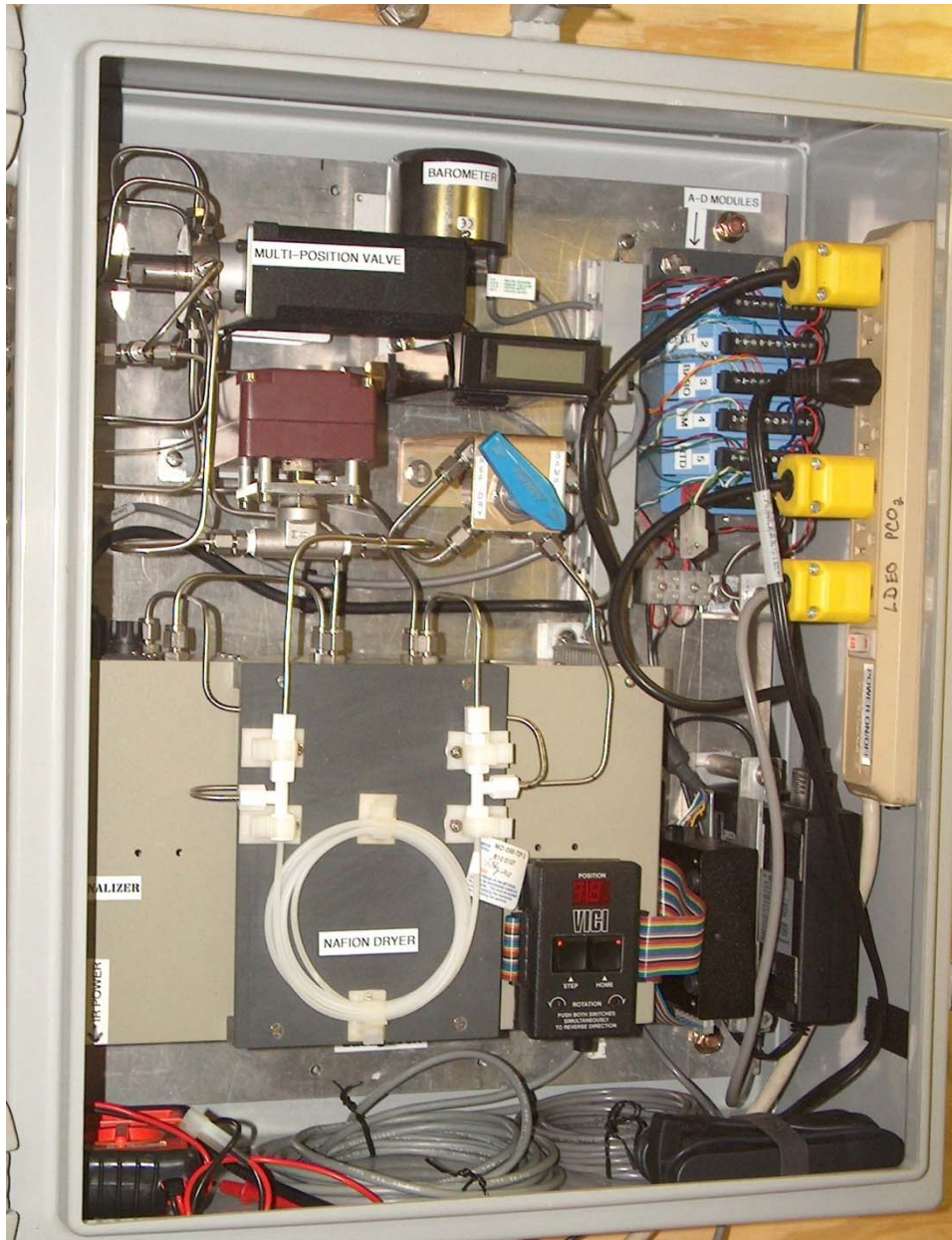
Figure 4: Atmospheric inlet splash guard hose clamped to starboard rail of deck 2 just forward of the Wet lab and Starboard A-frame.



### **Gas Analyzer Unit**

The gas analyzer unit (figure 5) is mounted to the aft wall of the wet lab. It contains most of the electronic components of the system as well as the gas selection valve, gas dryer, flow control valve and flow meter. The A/D modules in this unit allow communications between the system components and the laptop computer

Figure 5. Underway pCO<sub>2</sub> system gas analyzer unit.



### Sample Pumps

The two sample air pumps are housed in a separate metal enclosure (figure 6) one pump for atmospheric samples and one pump for equilibrator (sea water equilibrated air) samples. Valves

for regulation of the gas flows are located on the right side of the enclosure. All sample gas is filtered using 0.1  $\mu\text{m}$  hydrophobic membrane filters. The atmospheric filter is visible in the top center area of figure 5. All sample gas lines that reside outside of the enclosures have been insulated to help prevent condensation from occurring in these gas lines.

Figure 6: Sample air pump enclosure.





## Air Sea Water Equilibrator

The equilibrator is located over a small plastic sink (figure 7) that was temporarily installed in this location. The sink has a 2.5 inch ID drain hose that leads to a 2" ID floor drain to overboard. The drainage capacity of the sink and drain hose was tested and proved more than adequate for the maximum sea water flow rates that are needed for the equilibrator. The sea water source valve is located about 3.5 meters to the right of the equilibrator (figure 8) and the water is supplied from this valve using an insulated  $\frac{1}{2}$  inch ID reinforced tygon hose.

Figure 7: Equilibrator as installed over the sink in the Wet lab.



Figure 8: Seawater source valve, with insulated tubing leading to equilibrator.



## Merged Data File

The Scripps STS group provided the external data that is needed to complete the analysis and interpretation of the raw pCO<sub>2</sub> data. They also have completed the necessary scripting to email each days merged data to Stew Sutherland, [suth@ldeo.columbia.edu](mailto:suth@ldeo.columbia.edu) and to Tim Newberger, [tnewberg@ldeo.columbia.edu](mailto:tnewberg@ldeo.columbia.edu). Also because the pCO<sub>2</sub> computer was wirelessly connected to the vessel's time server the date / time of the local pCO<sub>2</sub> computer will remain synchronized within 1 second of the vessel's GPS date/time.

The data files are comma delimited text, the fields are described below.

### **--the first eleven fields are from the underway pCO<sub>2</sub> system**

Datetime (pco2 laptop computer time sync'ed to ship time server)  
CO<sub>2</sub> (mV) raw CO<sub>2</sub> millivolt reading from gas analyzer  
Cell T. (C) Temperature of gas analyzer cell  
Baro. (mbar) pCO<sub>2</sub> system barometer  
CO<sub>2</sub> (ppm) Calculated dry air mixing ration of CO<sub>2</sub>, in parts per million  
Equil. T (C) Water temperature inside the Air-Seawater equilibrator  
pCO<sub>2</sub> (uatm) partial pressure of CO<sub>2</sub> in Micro atmospheres  
Flow controller (millivolts), control voltage to rotary needle valve  
Flow (ml/min) gas flow rate  
ID# Integer, numeric identifier to distinguish samples from standards  
ID (alpha numeric) another sample or standard identifier

### **-- the next eleven fields are appended to the pCO<sub>2</sub> data string by the ships data logger.**

Lat  
Lon  
COG (Ship's course over ground)  
SOG (ship speed over ground)  
Sea Surf Temp (SBE-3S seawater intake)  
Salinity (PSU)  
Fluorometer (ug/l)  
True Wind Dir  
True Wind Spd (knts)  
Barometric pressure (mbars)  
GPS Date Time (time in seconds since Jan 1 1970)



### **System operation defaults**

The software was set up to analyze the six calibration gases, 60 sequential equilibrator samples and 3 sequential atmospheric samples per cycle. This sampling strategy will result in about 7 to 8 calibration cycles per day.

The computer communicates to the analyzer unit via RS232 protocol on Com1. Com4 is the output port to the RVDAS (ship's data logger). All pCO<sub>2</sub> data is logged locally on the laptop computer as well as on the vessel's data logger.

### **RTD Probe (equilibrator temperature)**

As no thermometer was included in the installation materials the calibration of the RTD probe was limited to checking the readings while the probe was immersed in a well mixed bucket of ice and fresh water. The readings were consistently 0.02 C.

Temperature readings from the first three days of data since the vessel departed Seattle indicate that the equilibrator temperature reads approximately 0.3 C higher than the sea water intake temperature. This 0.3 C offset is typically what we see in our other systems.

### **Preliminary Operation Assessment**

As of 31 May 2011 the vessel has been underway since the afternoon of 27 May 2011. Four data files have arrived by email and system appears to be operating normally. There are many instances in these files that have three nearly identical sequential atmospheric measurements which suggests the starboard location of the atmospheric inlet may have access to uncontaminated air given the right wind conditions. The relatively small offset of the equilibrator temperature from the seawater intake temperature indicates that the sea water residence time in the vessel's plumbing may be similar to what we see in our other systems. All the sea water plumbing on the Healy is well insulated though, unlike the plumbing on most of our other vessels.