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Aerosol Observing System Greenhouse Gas (AOS GHG) Monitor Instrument Handbook

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ARM CLIMATE RESEARCH FACILITY

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Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

AC	alternating current
AMF3	third ARM Mobile Facility
AOS	Aerosol Observing System
ARM	Atmospheric Radiation Measurement
CRDS	Cavity Ringdown Spectrometer
DMF	Data Management Facility
ENA	Eastern North Atlantic
GAW	Global Atmospheric Watch
GHG	Greenhouse Gas Measurement System, also an abbreviation for AOS GHG
IDL	interactive data language
LBNL	Lawrence Berkeley National Laboratory
OLI	Oliktok Point
QC	quality control
RTD	Resistance Temperature Detector
TGP	Tower Gas Processing (System)
USB	Universal Serial Bus
WMO	World Meteorological Organization

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1.0 Instrument Title

Aerosol Observing System Greenhouse Gas (AOS GHG) Monitor

2.0 Mentor Contact Information

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3.0 Vendor/Developer Contact Information

See Section 2.0 Mentor Contact Information.

4.0 Instrument Description

The Greenhouse Gas (GHG) Measurement system is a combination of two systems in series: (1) the Tower Gas Processing (TGP) System, an instrument rack which pulls, pressurizes, and dries air streams from an atmospheric sampling tower through a series of control and monitoring components, and (2) the Picarro model G2301 cavity ringdown spectrometer (CRDS), which measures CO_2, CH_4, and H_2O vapor; the primary measurements of the GHG system.

The TGP is equipped with a cooler and a liquid water detector that will stop pressurized flow from the tower sample line to the Picarro analyzer in the event that liquid water is detected in a sample stream. This prevents liquid water from entering the cell cavity of the Picarro instrument. Prior to entering the Picarro analyzer, the sample stream is further dried by Nafion and Drierite dryers. Sample air and calibration cylinder air pressure to the analyzer is controlled at (800 +/- 0.5) Torr. Operating parameters are monitored and logged, and safety cutoffs are actuated by a Campbell CR1000 datalogger. Sample or calibration stream is selected via Valco multiport valve, and data are logged by the native Picarro software. The CR1000 datastream (aosghgaux) and Picarro datastream (aosghg) are merged post ingest to form the GHG system.

5.0 Measurements Taken

Hourly raw data from the CR1000 logger and Picarro analyzer are automatically transferred to Atmospheric Radiation Measurement (ARM) Data Management Facility (DMF) and Lawrence Berkeley National Laboratory (LBNL) for quality assurance and further analysis. The primary measurements of the GHG system are the greenhouse gases CO_2, CH_4, and H_2O. All other measurements of components in the TGP and Picarro analyzer status are used for Quality Assurance/Quality Control (QC) labeling of the greenhouse gas measurements. These measurements are in line with compatibility goals set by World Meteorological Organization (WMO)/Global Atmospheric Watch (GAW) program for CO_2 and CH_4 observations (see table below, WMO/GAW).

Species	Compatibility Goals	Range in Unpolluted Atmosphere
CO_2	±0.1 ppm	360 – 430 ppm
CH_4	±2.0 ppb	1700 – 2100 ppb

6.0 Links to Definitions and Relevant Information

The datastreams of the TGP (aosghgaux) and Picarro (aosghg) are identical for all deployed systems, with datastream names differing only by geographic location. For example, two systems are deployed at ARM Mobile Facility (AMF3) in North Slope of Alaska and at ENA and each of the respective data streams are named as follows:

oliaosghgauxM1.a1
oliaosghgM1.a1
enaaosghgauxC1.a1
enaaosghgC1.a1
Since raw data from each of these system become meaningful after the datastreams are merged, data at the b0 level and beyond are characterized.

6.1 Data Object Description

Conventions: ARM-1.1
qc_standars_version: 1.0
averaging_interval: 1 minute
averaging_interval_comment: The time assigned to each data point indicates the beginning of any period of averaging data

6.2 Data Ordering

6.2.1 Secondary Variables

BATTERY_MINIMUM
CHILLER_TEMPERATURE
LINE_PRESSURE_TOWER_INLET
EXHAUST_FLOW
CALIBRATION_CYLINDER_1_LINE_PRESSURE
CALIBRATION_CYLINDER_2_LINE_PRESSURE
CALIBRATION_CYLINDER_3_LINE_PRESSURE
NAFION_PURGE_PRESSURE
CALIBRATION_CYLINDER_1_PRESSURE
CALIBRATION_CYLINDER_2_PRESSURE
CALIBRATION_CYLINDER_3_PRESSURE
DRY_PURGE_CYLINDER_PRESSURE
DRY_PURGE_LINE_PRESSURE
FRONT_FAN_FLOW
REAR_FAN_FLOW
DRY_PURGE_FLOW
PRESSURE_CONTROL
LIQUID_ALARM_TOWER_INLET
NAFION_BOX_TEMPERATURE
PUMP_BOX_TEMPERATURE
MP_VALVE_POSITION
CAVITY_PRESSURE_AVG
CAVITY_PRESSURE_STDDEV
CAVITY_TEMPERATURE_AVG
CAVITY_TEMPERATURE_STDDEV
ANALYZER_TEMPERATURE_AVG
ANALYZER_TEMPERATURE_STDDEV
ETALON_TEMPERATURE_AVG
ETALON_TEMPERATURE_STDDEV
WARM_BOX_TEMPERATURE_AVG
WARM_BOX_TEMPERATURE_STDDEV
OUTLET_VALVE_AVG
OUTLET_VALVE_STDDEV

6.2.2 Primary Variables

CO2_AVG
CO2_STDDEV
CH4_AVG
CH4_STDDEV
H2O_AVG
H2O_STDDEV

6.3 Data Plots

Near real-time time series plots at daily, weekly, monthly time scales are generated by mentors at an LBNL server for all deployed systems every hour. The following time series are used for monitoring and diagnosing performance of each of the components in the TGP prior to the sample air entering the Picarro analyzer.

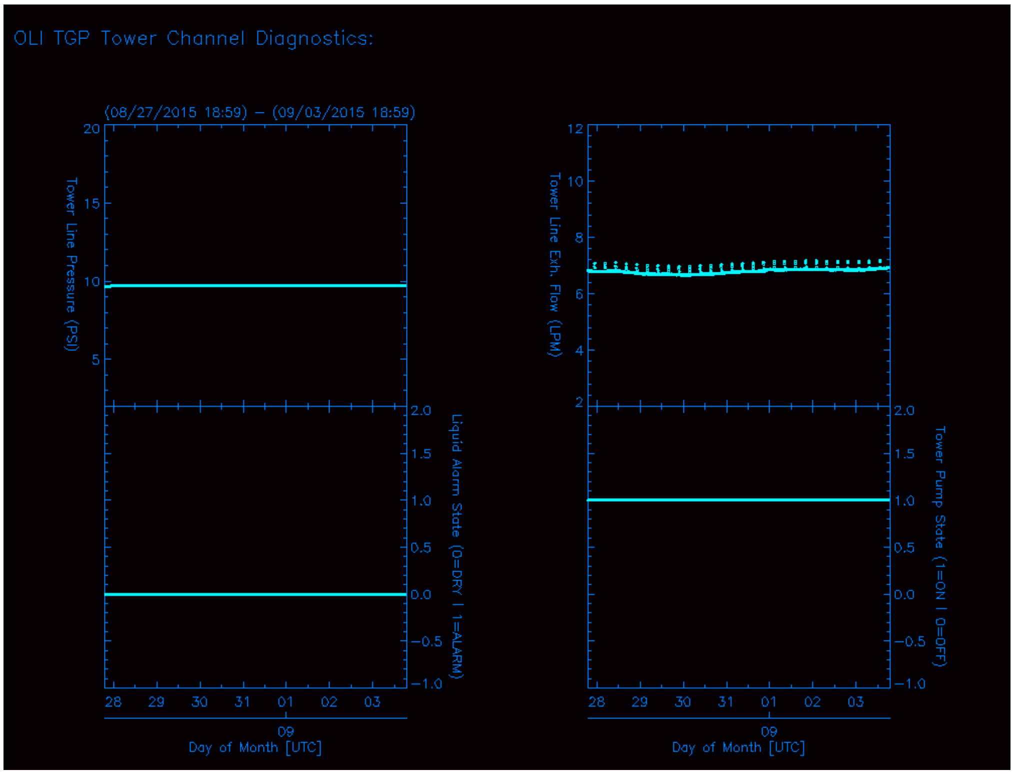


Figure 1. Weekly LBNL time series of TGP tower air sampling diagnostics.

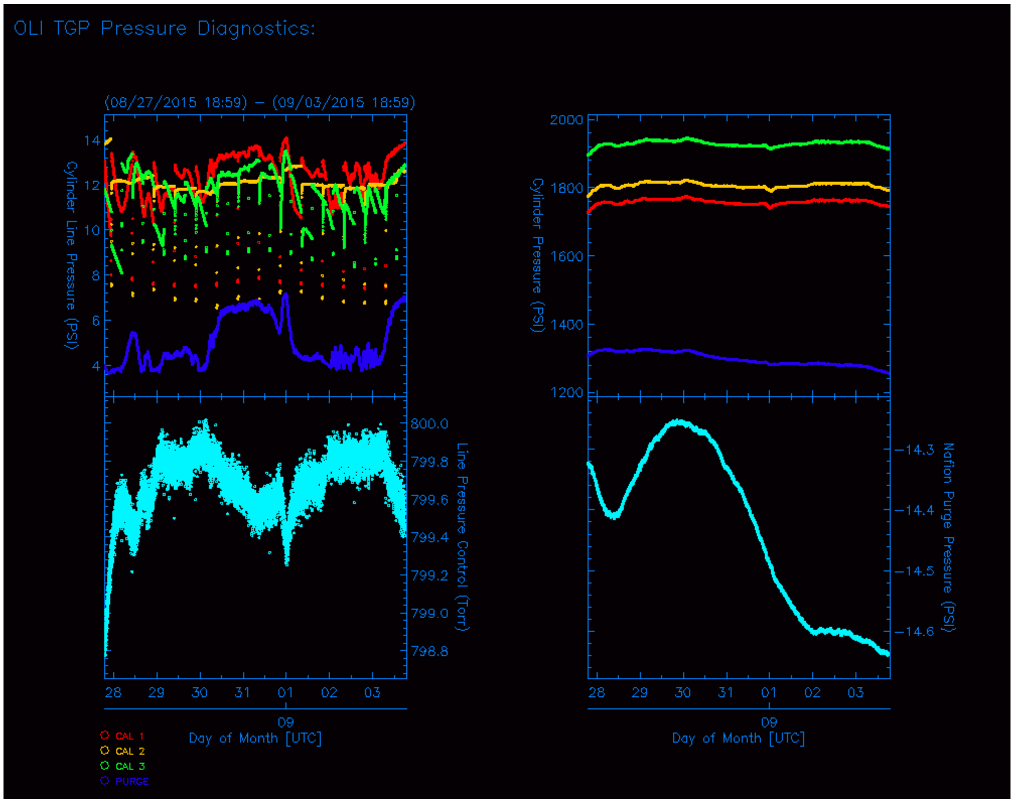


Figure 2. Weekly LBNL time series of TGP system pressure diagnostics.

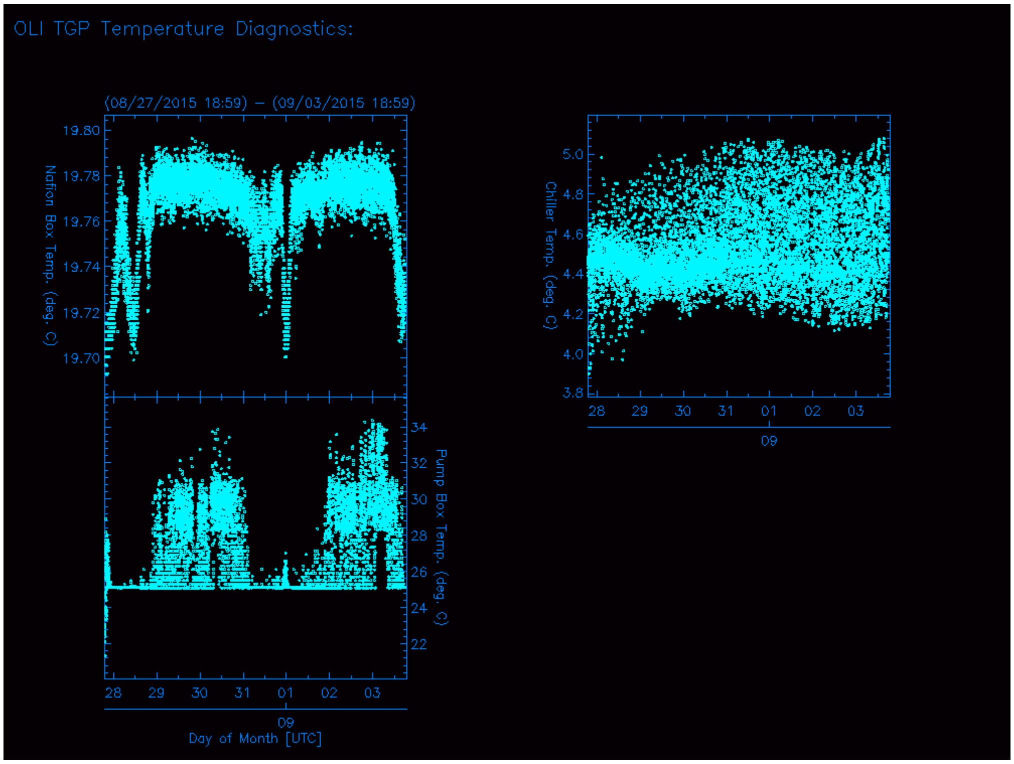


Figure 3. Weekly LBNL time series of TGP system temperature diagnostics.

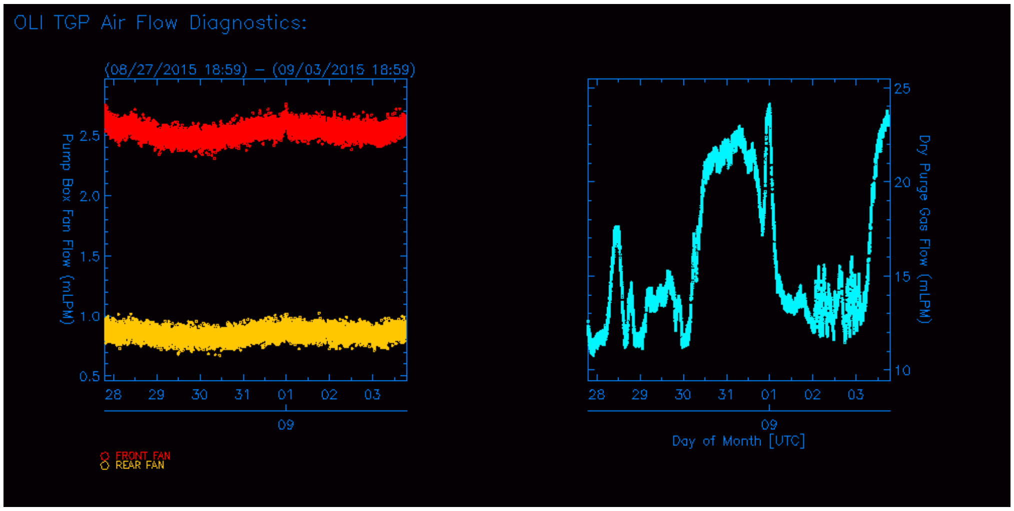


Figure 4. Weekly LBNL time series of TGP system flow diagnostics.

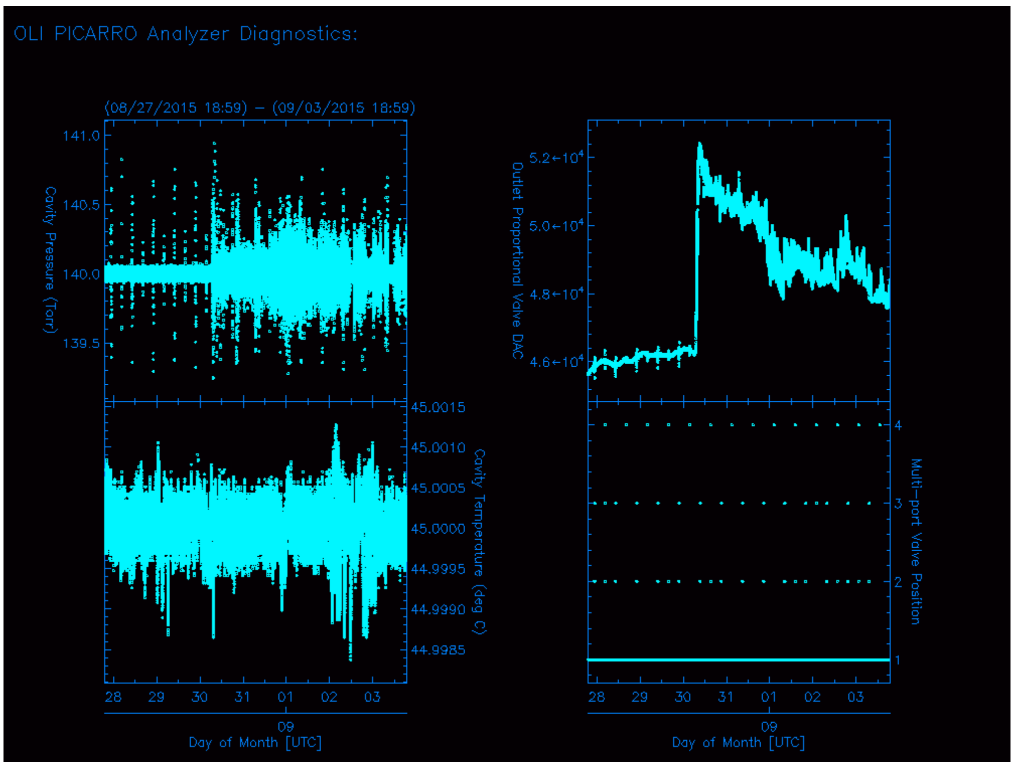


Figure 5. Weekly LBNL time series of Picarro system pressure/temperature/valves diagnostics.

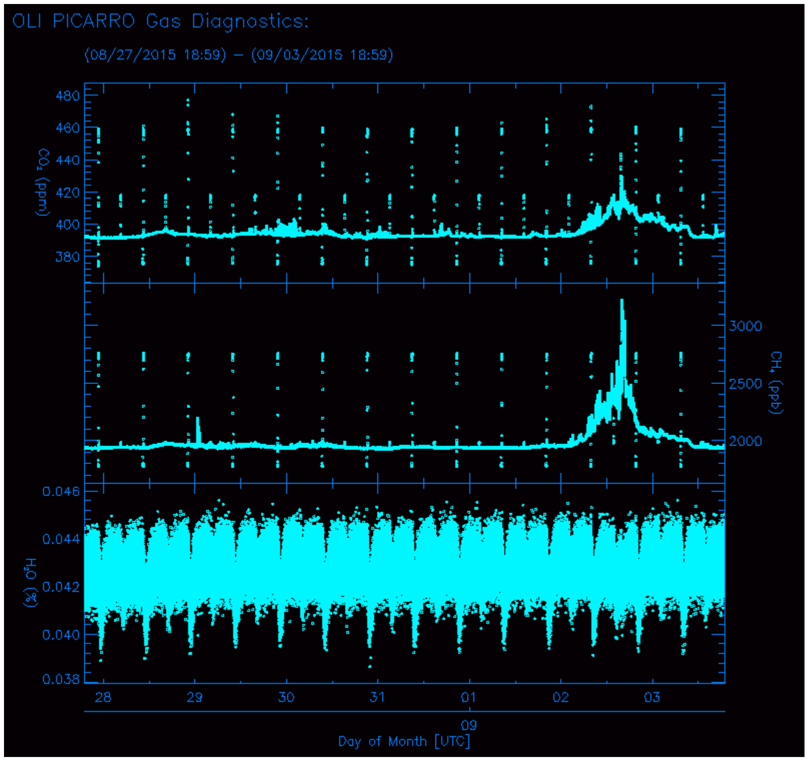


Figure 6. Weekly LBNL time series of Picarro system greenhouse gas diagnostics.

6.4 Data Quality

The b0 and b1 level files contains data quality flags for all variables outlined in Section 6.2; all secondary and primary variables. The variable status (bit values) go as:

- 0x0 = value is within specified range
- 0x1 = value is "suspicious_data"
- 0x2 = value is less than "valid_min"
- 0x4 = value is greater than "valid_max"
- 0x8 = value is equal to "missing_value"

Since bits are added to the initial bit of 0, combination QC states can arise:

- 0x3 = value is suspicious and less than valid_min
- 0x5 = value is suspicious and greater than valid_max

"Suspicious" data refers to data manually labeled by the mentor denoting data that is within the minimum and maximum values but some part or entirety of the system is behaving outside of nominal conditions.

Quality checks on standard deviations of averaged data (where available) are also used as a way to check for sudden and/or unexpected changes in system performance. Quality of primary variables to be used in science should be used only when all secondary variables also have a QC bit of 0.

6.5 Instrument Mentor Monthly Summary

In addition to the ARM automated data quality assessment system, the LBNL team produces a parallel automated data visualization and quality checking system, which includes an automated data quality checking routine.

- Visual QC frequency: hourly to weekly
- QC delay: 1 to 3 hours
- Automated e-mail warnings are sent via LBNL server to instrument mentors for catastrophic system alarms or failures.

QC type: In addition to data QC labeling according to 6.4, instrument mentors routinely views graphic displays of time series plots of daily, weekly, monthly, yearly, total time scales.

6.6 Calibration Database

The primary quantities that are calibrated are the greenhouse gas mixing ratios of the sample air using regular automated measurements of low and high span Calibration Cylinders.

6.6.1 Calibration Cylinders

Each system at each site is assigned low and high span Calibration Cylinders, traceable to WMO scales for CO_2 (WMO-CO2- X2007) and CH_4 (WMO-CH4-X2004). Typically the low and high span mixing ratios bracket ambient concentrations measured at a given site. A "Target" cylinder, close to ambient mixing ratio values is also used. Measurements of the Target cylinder are used to characterize the precision and stability of the aosghg system after calibration is applied.

The following tables are cylinders and their known values for each instrument deployed, as of the revision date of this document. Calibration certificate are valid for three years, and Calibration Cylinders are sent to WMO/GAW Central Calibration Laboratory, when pressure reaches 500 psi or every three years.

CYLINDER_NO	Site	MP_VALVE_ POSITION	CO2 (ppm)	CO2_ERR (ppm)	CH4 (ppb)	CH4_ERR (ppb)
CC302932	ENA	2	373.66	0.03	1761.5	1.0
CA07931	ENA	3	457.83	0.03	2742.6	1.0
CA06632	OLI	2	374.14	0.03	1763.6	1.0
CA08141	OLI	3	456.54	0.03	2720.7	1.0

6.6.2 Calibration Data

Analogous to the process in merging the aosghgaux and aosghg to produce b0 level data for sample tower measurements, measurements of Calibration Cylinders in the a1 level aosghg datastream are split out from the continuous time series and merged with the aosghgaux datastream. Calibration coefficients are calculated from the merged b0 level data and applied to tower data only when calibration measurements as well as calculated coefficients passes quality control standards.

7.0 Instrument System Functional Diagram

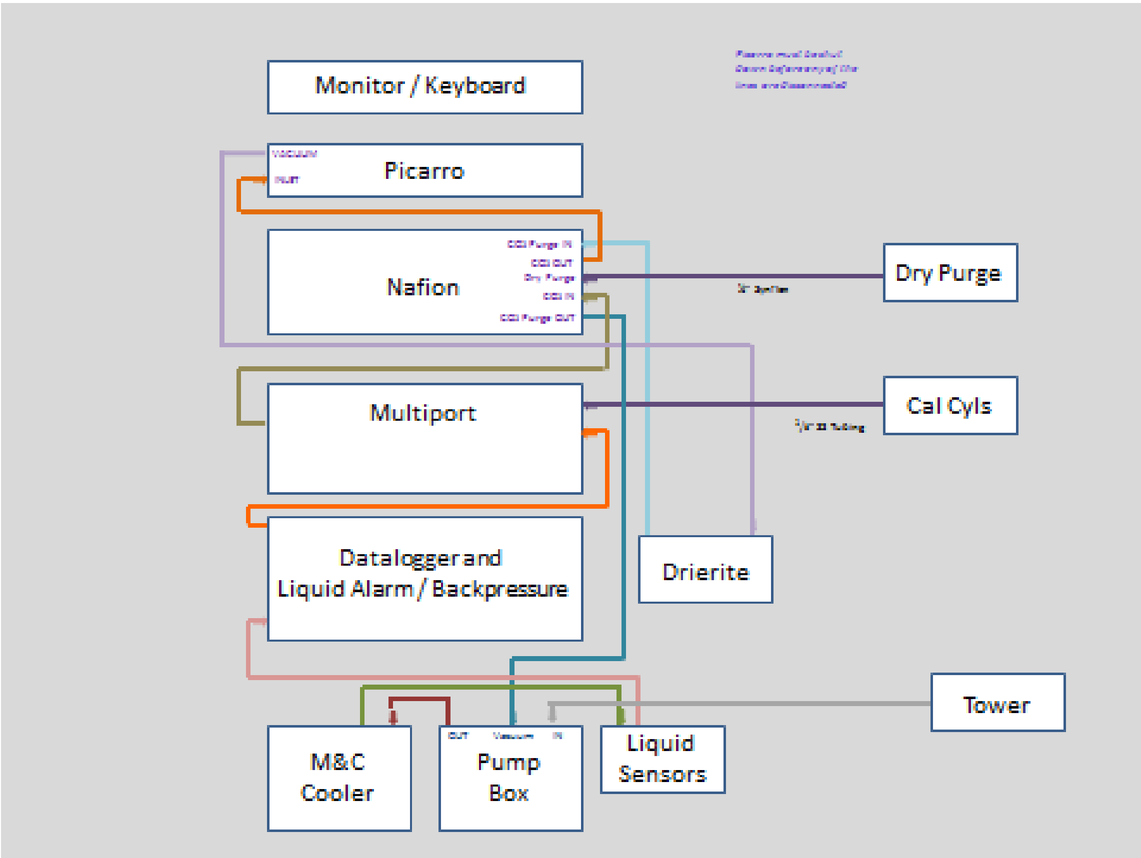


Figure 7. Arrangement of instrument stack, tubing, and cables.

8.0 Technical Specification

The GHG system is described as a series of boxes (rack mounted enclosures), each box with specific functions in processing tower sample air and selecting calibration cylinder air to be measured by the Picarro analyzer.

8.1 Pump Box

- INPUTS:
  - Alternating current (AC) power for vacuum pump, tower pump and fans
  - 1 air channel from tower
  - 3 Calibration Cylinders

- OUTPUTS:
  - 1 air channel to chiller
  - Pump Box temperature signal
  - Fan flow sensor signals

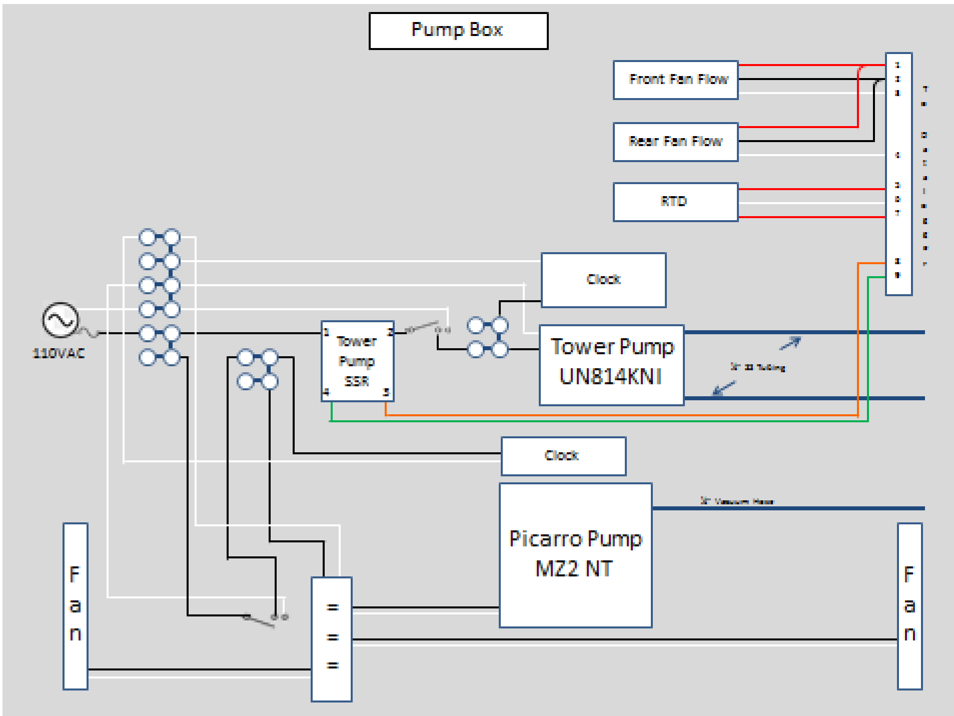
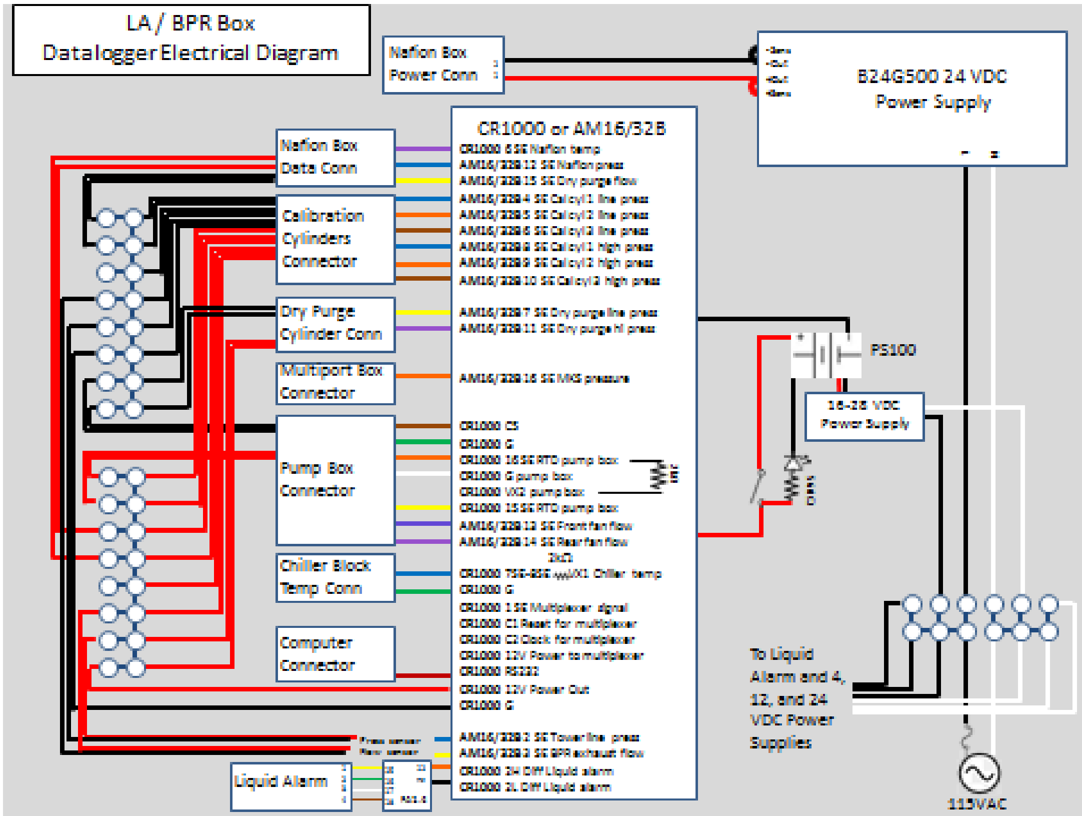


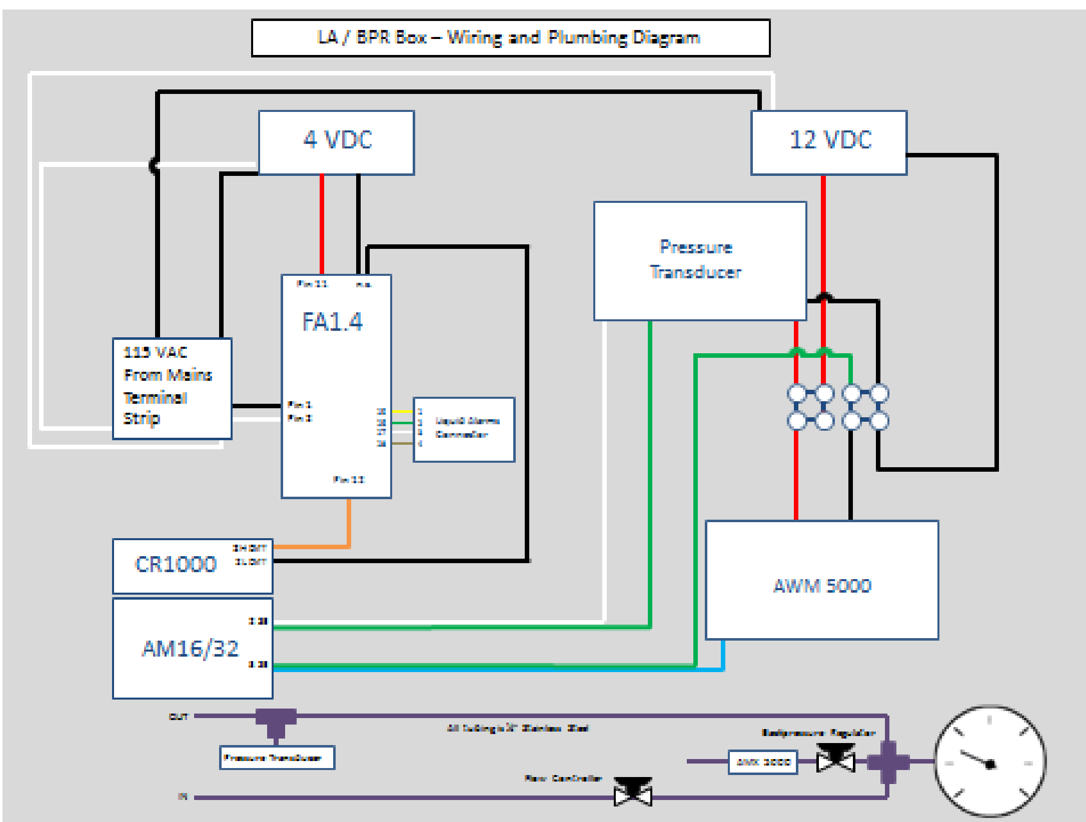
Figure 8. LA/BPR/Datalogger Box.

- INPUTS:
  - 2 AC power for 12 and 24 VDC supplies for the datalogger and Peltier cooler on Nafion Box
  - temperature signal from Pump Box
  - 2 fan flow sensors from Pump Box
  - cold block temperature signal from ECS (Evaporative Condensed Screw) Chiller
  - flow sensor signals from Backpressure vent
  - line pressure signals from tower
  - Liquid Alarm signal
  - line pressure signal from Multiport Box
  - 3 high pressure signals from Calibration Cylinders
  - 3 line pressure signals from Calibration Cylinders
  - high pressure signal from Dry Purge Cylinder
  - line pressure signal from Dry Purge Cylinder

- Dry Purge flow signal from Nafion Box
- purge out pressure from Nafion Box
- temperature signal from Nafion Box
- AC power for 4 and 12 VDC supplies and for power direct to FA1.4 controllers
- 4 air channels from chiller
- 1 signal from flow sensors (0 to 5 VDC)
- 1 signal from liquid alarms (0 or 4 VDC)
- 1 signal from line pressure (0.5 to 5.5 VDC)

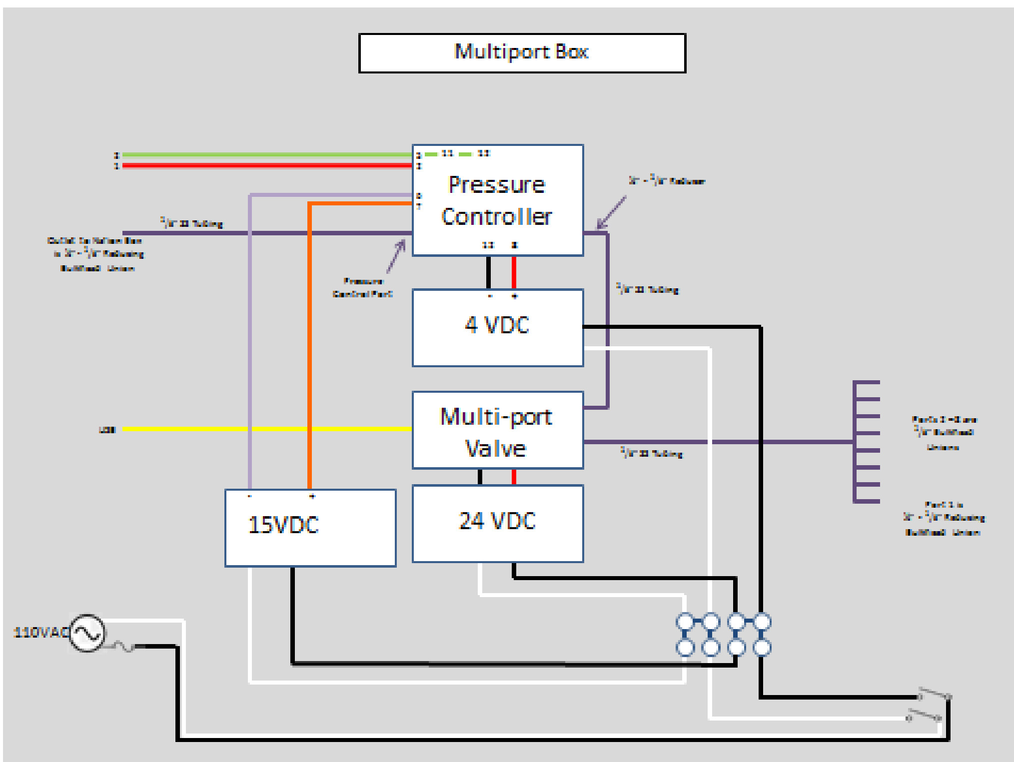
- OUTPUTS:
  - 24 VDC output to Nafion Box
  - 12 VDC output to Dry Purge flow sensor in Nafion Box
  - 12 VDC output to purge out pressure in Nafion Box
  - 12 VDC output to fan flow sensors in Pump Box
  - 12 VDC output to 3 high pressure sensors on Calibration Cylinders
  - 12 VDC output to 3 line pressure sensors on Calibration Cylinders
  - 12 VDC output to high pressure sensor on Dry Purge Cylinder
  - 12 VDC output to line pressure sensor on Dry Purge Cylinder
  - RS232 for logger control and data transmission between Datalogger and Computer
  - 1 air channels to Multiport Box


LA / BPR Box
Datalogger Electrical Diagram
Nafion Box
Power Conn
B24G500 24 VDC
Power Supply
CR1000 or AM16/32B
Nafion Box
Data Conn
Calibration
Cylinders
Connector
Dry Purge
Cylinder Conn
Multiport Box
Connector
Pump Box
Connector
Chiller Block
Temp Conn
Computer
Connector
Liquid Alarm
PS100
16-28 VDC
Power Supply
To Liquid
Alarm and 4,
12, and 24
VDC Power
Supplies
115VAC


LA / BPR Box – Wiring and Plumbing Diagram
4 VDC
12 VDC
Pressure
Transducer
FA1.4
115 VAC
From Mains
Terminal
Strip
CR1000
AM16/32
AWM 5000

8.2 Multiport Box

- INPUTS:
  - AC power for 4, 15, and 24 VDC supplies for the pressure controller and multiport valve
  - Universal Serial Bus (USB) connection from Picarro
  - 1 air channel
  - 3 calibration cylinder channels
- OUTPUTS
  - pressure control sensor to Datalogger Box
  - sample stream out to Nafion Box

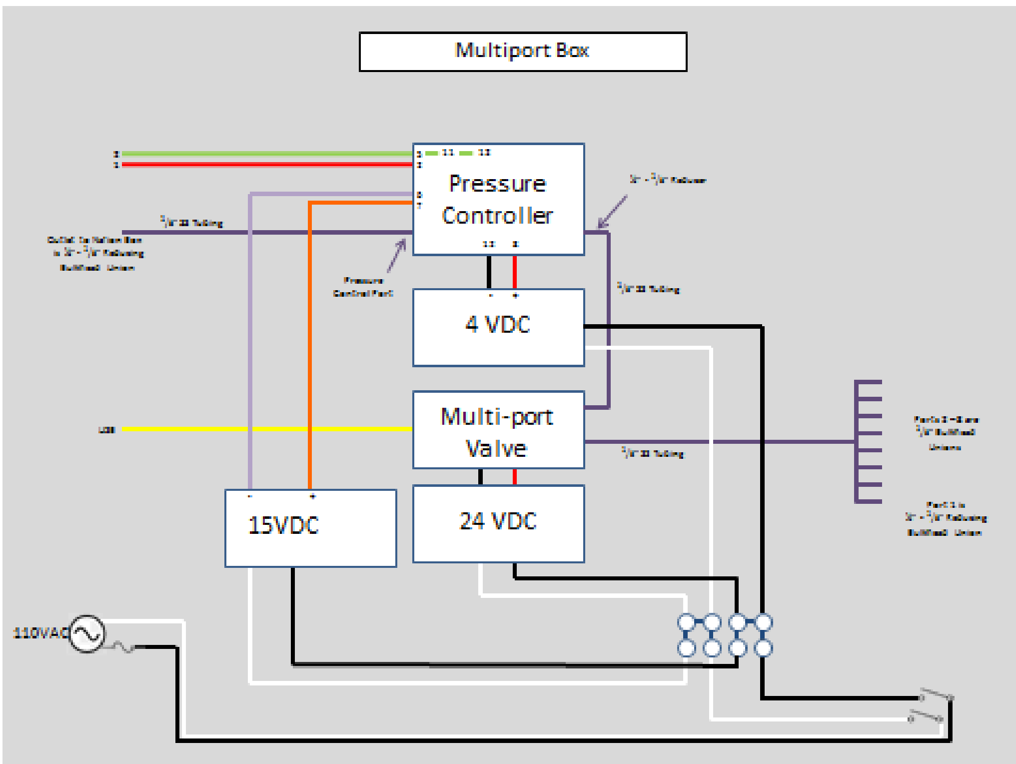


8.3 Nafion Box

- INPUTS:
  - AC power for PID and AC output
  - 24 VDC & GND for Peltier unit
  - +12 VDC & GND for flow sensor
  - +12 VDC & GND for pressure transducer
  - Dry Purge gas

- Air sample stream from multiport
- Purge stream from Drierite

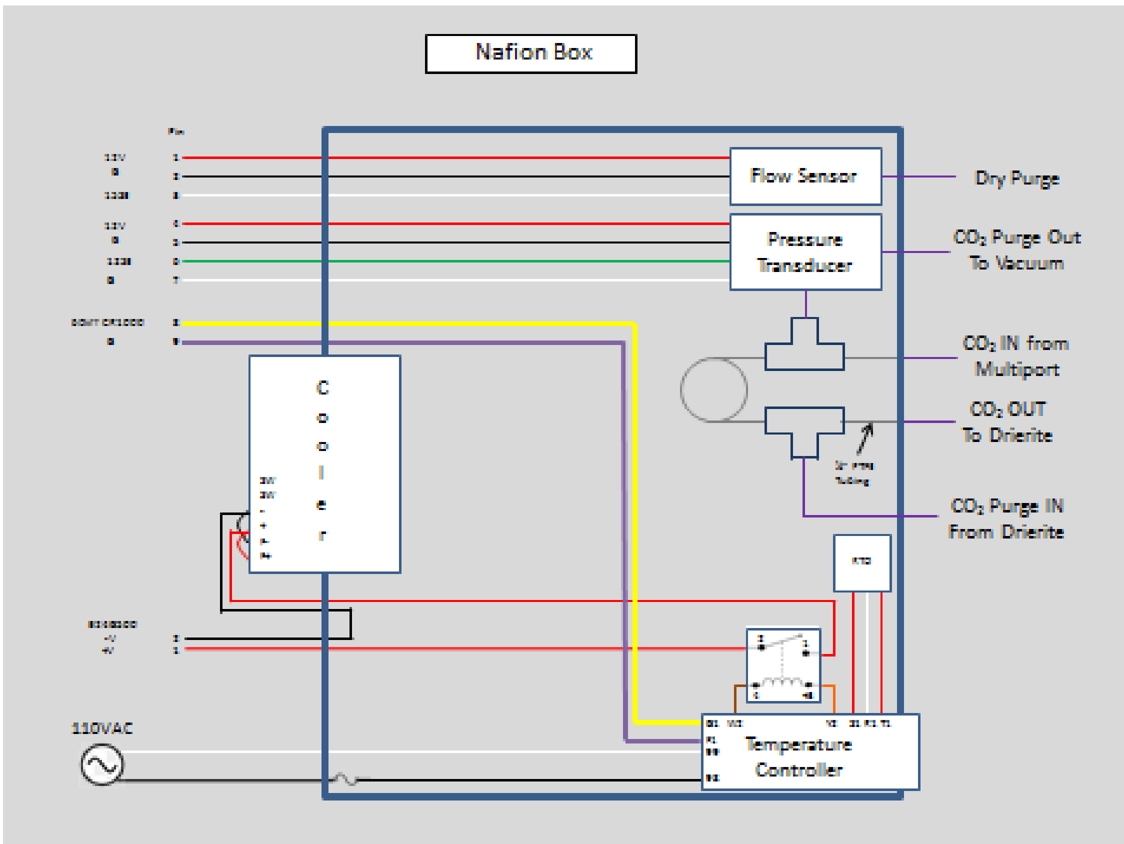
- OUTPUTS:
  - 1 flow sensor signal to datalogger
  - 1 high & 1 low pressure transducer signal to datalogger
  - 1 high & 1 low temperature signal from PID to datalogger
  - Air sample stream to Drierite
  - Purge stream out to vacuum pump in Pump Box



8.4 Nafion Box

- INPUTS:
  - AC power for PID and AC output
  - 24 VDC & GND for Peltier unit
  - +12 VDC & GND for flow sensor
  - +12 VDC & GND for pressure transducer
  - Dry Purge gas
  - Air sample stream from multiport
  - Purge stream from Drierite

- OUTPUTS:
  - 1 flow sensor signal to datalogger
  - 1 high & 1 low pressure transducer signal to datalogger
  - 1 high & 1 low temperature signal from PID to datalogger
  - Air sample stream to Drierite
  - Purge stream out to vacuum pump in Pump Box



8.5 Operational Range

Operational ranges for all measured quantities have been established based on system testing. Low and high limit values noted here are not necessarily the limits established by manufacturers, rather those that are expected during nominal functioning of the system.

Variable Name	Low Limit	High Limit	Units
BATTERY_MINIMUM	11	15	Volts
CHILLER_TEMPERATURE	3	6	deg C
LINE_PRESSURE_TOWER_INLET	2	15	PSI
EXHAUST_FLOW	1	10	LPM
CALIBRATION_CYLINDER_1_LINE_PRESSURE	2	16	PSI
CALIBRATION_CYLINDER_2_LINE_PRESSURE	2	16	PSI
CALIBRATION_CYLINDER_3_LINE_PRESSURE	2	16	PSI
NAFION_PURGE_PRESSURE	-15	-13	PSI
CALIBRATION_CYLINDER_1_PRESSURE	500	3000	PSI
CALIBRATION_CYLINDER_2_PRESSURE	500	3000	PSI
CALIBRATION_CYLINDER_3_PRESSURE	500	3000	PSI
DRY_PURGE_CYLINDER_PRESSURE	200	3000	PSI
DRY_PURGE_LINE_PRESSURE	2	16	PSI
FRONT_FAN_FLOW	0.2	50	mLPM
REAR_FAN_FLOW	0.2	50	mLPM
DRY_PURGE_FLOW	0.2	50	mLPM
PRESSURE_CONTROL	795	805	Torr
LIQUID_ALARM_TOWER_INLET	0	1	Unitless
NAFION_BOX_TEMPERATURE	18	22	deg C
PUMP_BOX_TEMPERATURE	5	40	deg C
MP_VALVE_POSITION	1	8	Unitless
CAVITY_PRESSURE_AVG	139	141	Torr
CAVITY_PRESSURE_STDDEV	0	1	Torr
CAVITY_TEMPERATURE_AVG	44	46	deg C
CAVITY_TEMPERATURE_STDDEV	0	0.05	deg C
ANALYZER_TEMPERATURE_AVG	41	44	deg C
ANALYZER_TEMPERATURE_STDDEV	0	0.05	deg C
ETALON_TEMPERATURE_AVG	44	46	deg C
ETALON_TEMPERATURE_STDDEV	0	0.05	deg C
WARM_BOX_TEMPERATURE_AVG	44	46	deg C
WARM_BOX_TEMPERATURE_STDDEV	0	0.05	deg C
OUTLET_VALVE_AVG	40000	55000	Unitless
OUTLET_VALVE_STDDEV	0	500	Unitless
CO2_AVG	360	700	µmol/mol
CO2_STDDEV	0	20	µmol/mol
CH4_AVG	1600	3800	nmol/mol
CH4_STDDEV	0	50	nmol/mol
H2O_AVG	1	500	µmol/mol
H2O_STDDEV	0	10	µmol/mol

8.6 Picarro Analyzer

Uncertainty in measurements of CO_2 and CH_4 are characterized by the variability in the calibrated Target cylinder measurements.

8.6.1 Calibration

Measurements of CO_2 and CH_4 are calibrated by measuring the low and high span cylinders every 11 hours and 35 minutes (to prevent systematic bias), with a measurement of a Target cylinder in the middle. A linearly interpolated gain and offset time series are applied to the b0 level tower data and Target cylinder measurements.

8.6.2 Uncertainty

The variability in calibrated Target cylinder measurements is used to characterize the relative uncertainty of the analyzer.

9.0 Instrument/Measurement Theory

The method for measuring the primary variables CO_2 and CH_4 is outlined. The text is adapted from the Picarro documentation "Real-Time Atmospheric Monitoring of Stable Isotopes and Trace Greenhouse Gases" available at http://www.picarro.com/assets/docs/isotopes_GHG_article.pdf.

The essential CRDS measurement consists of determining the decay time of light in an optical cavity filled with the gas stream to be analyzed. Light from a semiconductor diode laser is directed into a high finesse optical resonator cavity containing the analyte gas. When the optical frequency matches the resonance frequency of the cavity, energy builds up in the cavity. When the build-up is complete, the laser is shut off. The light circulating in the cavity then decays from the cavity, or "rings down," with a characteristic decay time. When the wavelength of the injected light does not match an absorption feature of any gas in the cavity, the decay time is dominated by mirror loss. However, when the wavelength of the injected light is resonant with an absorption feature of a species in the cavity, the decay time decreases as the reciprocal of the species concentration.

The instrument's electronics include a digital signal processing system for determination of the Ring Down rate, or optical loss, as a function of wavelength, giving it the speed to measure multiple spectral features and accurately detect multiple species.

10.0 Setup and Operation of Instrument

10.1 Tubing and Cables

The sample stream flows from the tower to pump through the heat exchanger in the M&C cooling unit to the liquid sensor mounted in front of the Pump Box to the Backpressure / Liquid Alarm / Datalogger Box to the Multiport Box to the Nafion Box to the Picarro to the Drierite mounted in front of the Datalogger to the Nafion Purge, and out to vacuum. Tubing from the Calibration Cylinders are also attached to the Multiport Box, and from there the calibration gases follow the same stream as the tower samples. Dry air from a compressed air cylinder purges the Nafion Box of condensate that forms on the chiller fins.

1. On the M&C chiller unit, secure the peristaltic pump tube over the pump roller.
2. On the M&C chiller, attach the tubing from the heat exchanger drain to the inlets of the peristaltic pump.
3. On the M&C chiller unit, run drain tubing from the peristaltic pump outlet to a pan for collecting the condensate.
4. Attach the lines from the tower to the IN port on the Pump Box.
5. Attach the tubing from the OUT port on the Pump Box to the inlet of the heat exchanger.
6. Attach the tubing from the outlet of the heat exchanger to the top port of the Liquid Alarm sensor.
7. Attach the tubing from the side port of the Liquid Alarm sensor to the IN port of the Liquid Alarm / Backpressure / Datalogger Box.
8. Attach the tubing from the OUT port of the Liquid Alarm / Backpressure / Datalogger Box to port 1 on the front of the Multiport Box.
9. Attach the tubing from the back of the Multiport Box to the CO2 IN port of the Nafion Box.
10. Attach the tubing from the CO2 OUT port on the Nafion Box to the INLET of the Picarro.
11. Attach the tubing from the VACUUM port of the Picarro to the inlet side of the Drierite canister.
12. Attach the tubing from the outlet side of the Drierite canister to the CO2 Purge IN port of the Nafion Box.
13. Attach the tubing from the CO2 Purge OUT port of the Nafion Box to the From Picarro port of the Pump Box.
14. Attach 1/8” tubing from Calibration Cylinders to ports 2 through 4 of the Multiport Box.
15. Attach tubing from the Dry Purge Cylinder to the Dry Purge port on the Nafion Box.
16. Connect the data cable from the M&C chiller to the “Chiller Temperature” connector on the Datalogger Box.
17. Connect the Liquid Alarm cable to the Backpressure / Datalogger Box.
18. Connect the cable between the Pump Box and the Backpressure / Datalogger Box.
19. Connect the cable between the Multiport Box and the Datalogger Box.
20. Connect the USB cable between the Multiport Box to any USB port on the Picarro.

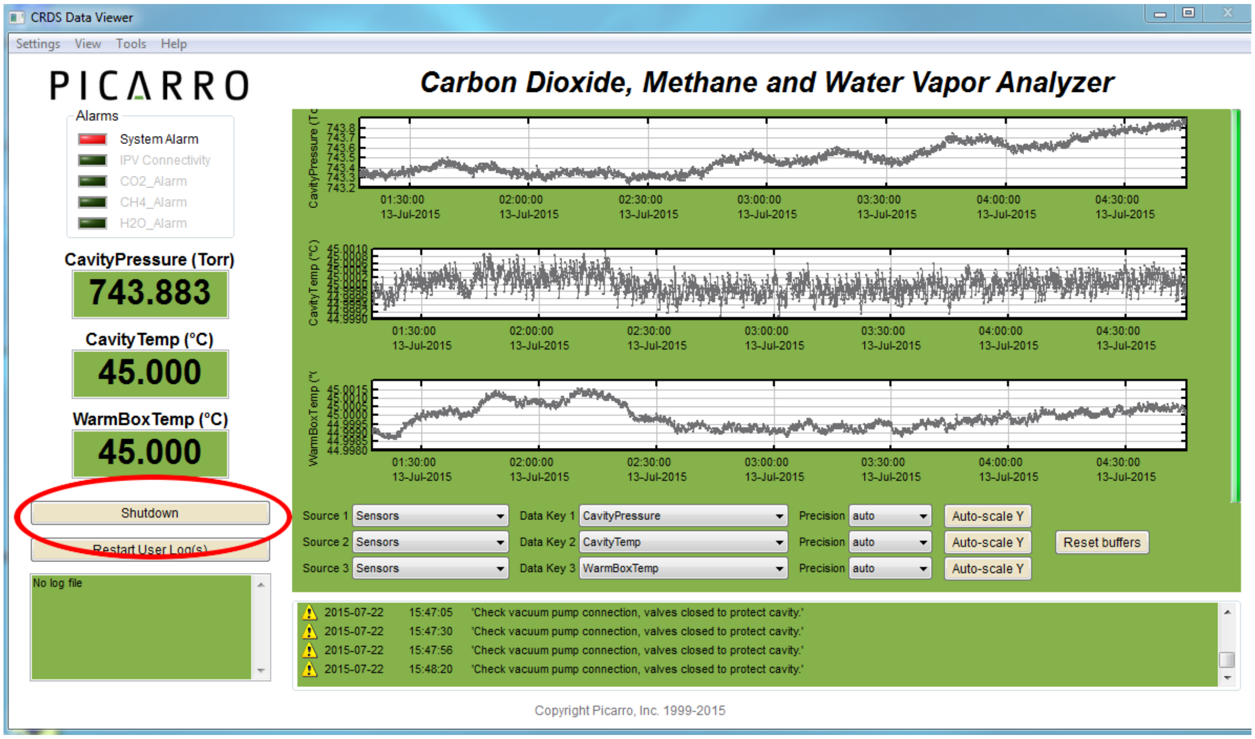
21. Attach the orange connector of the All-In-One cable to the All-In-One connector on the monitor/keyboard console. Attach the blue connector of the All-In-One cable to the VGA port on the Picarro. Attach the green connector of the All-In-One cable to the mouse connector on the Picarro. Attach the USB connector of the All-In-One cable to any USB port on the Picarro.
22. Connect the cable between the 9-pin connector on the Nafion Box and the "Nafion" connector on the Datalogger Box.
23. Connect the 2-pin cable between the Nafion Box and the "Nafion 24VDC" connector on the Datalogger Box.
24. Connect the cable between the RS232 connector on the Datalogger Box to COM2: on the Picarro.
25. Attach the connectors of each of the Calibration Cylinder regulators to the Calibration Cylinders data cable. Attach the Calibration Cylinders data cable to the "Calibration" connector on the Datalogger Box.
26. Attach the connector of the Dry Purge Cylinder regulator to the Dry Purge data cable. Attach the Dry Purge data cable to the "Dry Purge" connector on the Datalogger Box.
27. Plug all power cords into the outlet strip on the instrument cabinet. Plug the outlet strip into a 110 – 120 VAC outlet. Switch the outlet strip ON.

10.2 Measurement

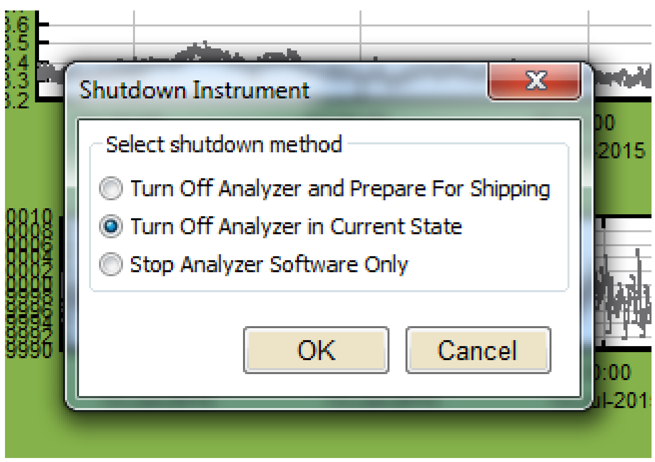
- Once the Picarro data viewer begins displaying trace gas measurements, the Sequencer may be started.
- The Picarro automatically logs data. Data are stored in a text file with a name that will follow a format similar to this filename: "CFADSXXXX-20140813-000014Z-DataLog_User.dat", located in the User_Sync directory. XXXX corresponds to the serial number of the Picarro instrument used. A new file is created each day at midnight Coordinated Universal Time. Data are recorded at 5 second intervals.
- A PID on the back panel of the chiller indicates the status of the chiller. The PID should be set to +4°C. In the event that water makes it past the chiller and is detected in the Liquid Alarm, the datalogger will automatically turn off the tower pump. To clear the alarm, see the Maintenance section of this manual.

10.3 Shutdown

1. Close the Calibration Cylinders.
2. Close the Dry Purge Cylinder.
3. On the Picarro data viewer, click the Shutdown button.



4. This will bring up the Shutdown Instrument pop-up. Select “Turn Off Analyzer in Current State.”



5. When the Picarro has completely shut down, switch off both pumps in the Pump Box, and switch off the Datalogger Box and the Multiport Box.

6. Toggle the rocker switch on the outlet strip to OFF.

11.0 Software

11.1 System Operational Software

As noted in sections 10.2 and 10.3, the Picarro analyzer uses the Python based CRDS Data Viewer software to monitor and control data acquisition, valve sequences for the multiport valve, and system shut down. The same computer runs Campbell Scientific Loggernet to control data acquisition and hardware control of the TGP system components. The configuration of the datalogger is programmed using CRBasic, a Campbell Scientific specific programming language based in Visual Basic which utilizes extensive libraries specific to the CR1000 hardware.

11.2 Data Processing Software

Automated data transmission and processing software was developed by LBNL mentors in R and interactive data language (IDL) programming languages respectively. Raw data processing begins with the creation of hourly files from both TGP and Picarro datastreams

11.2.1 Hourly File Creation

11.2.1.1 Datalogger Files

LoggerNet must be configured to append to the raw data file binary format.

Do this by using “Setup” app in Loggernet to configure the logger file created in:

C:\Campbellsci\LoggerNet\CR1000_raw_60.dat
as binary, or TOB1 format.

Set up Card Convert to convert the continuously appended raw binary data to hourly TOA5 format files by:

1. Loggernet → Card Convert
2. Select Card Drive as C:\Campbellsci\LoggerNet\CR1000_raw_60.dat
3. Change output directory as C:\Campbellsci\LoggerNet\hourly\
4. Edit Destination file options so that:
    a. File format is “ASCII Table Data (TOA5)”
    b. Use Time
    c. Convert Only New Data
    d. Under File Naming, select Time Date Filenames and Use Day of Year
    e. Under TOA5-TOB1 Format, select both Store Record Numbers and Store TimeStamp
    f. Under Time Settings… let the Interval be 1 hour

Both ENA and Southern Great Plain sites run a scheduled task called “createhourlyLoggerfiles”, at 3 minutes past every hour indefinitely, which splits the raw data file into hourly files as:
C:\Campbellsci\Loggernet\hourly\TOA5_CR1000_raw_60_[year]_[day of year].dat
as configured in Card Convert.

Set up the scheduled task to run the program
C:\Program Files (x86)\Campbellsci\CardConvert\CardConvert.exe

with the input as

runfile=C:\Campbellsci\CardConvert\hourly_file.ccf

The scheduled task, once enabled will put hourly files in C:\Campbellsci\LoggerNet\hourly\, the directory from which ATMOS will pull data 5 minutes past every hour.

11.2.1.2 Picarro Data Files

The Picarro analyzer software is configured to parse data files every hour, however, does not produce hourly files consistent with ARM file format standards. As a solution, an R script is used to read the latter 3 hours of data, and parse the most recent 1 hour of data. A Windows Scheduled Task is configured to run every hour to run the batch file C:\sds-scripts\parse_picarro.bat which calls the R script C:\sds-scripts\PARSE_PICARRO_HOURLY.Rn

11.2.2 Data Transmission

Data files are transmitted to ARM DMF by ftp and to LBNL by ssh. The latter utilizes the Cygwin/X software and is configured so that the ssh daemon will run at system start up. The LBNL server then pulls data from the Picarro computer every hour via scp command invoked by IDL.

11.2.3 Data Processing

Hourly raw data for both data streams *aosghgaux* and *aosghg* are read, merged, and processed using IDL at ARM DMF and LBNL during system development. ARM DMF utilizes software based processing software written by the mentor, but modified to operate based on ARM standard procedures.

12.0 Maintenance

12.1 Liquid Alarm (pump switch not illuminated)

Normally the datalogger should indicate LASTATE_1_MAX = 0 and PUMPSTATE_1_MIN = 1 (raw_60). If condensate is detected in one of the liquid alarms, the datalogger will open the circuit to the pump, thereby switching it off. The rocker switch for that pump will not be illuminated, and the datalogger will indicate LASTATE_1_MAX = 1 and PUMPSTATE_1_MIN = 0. To clear this alarm

1. Toggle the rocker switch for the pump to the OFF position.
2. Loosen the 1¼" nut that secures the collection vessel in place, slip the vessel out of the top fitting, invert the vessel and shake out the water. This should reset PUMPSTATE_1_MIN to 1. Then reattach, being careful not to over tighten the 1¼" nut.
3. Toggle the rocker switch to the ON position. With pumpstate(i) = 1, the rocker switch should illuminate and the pump should restart.

12.2 Pump Service

12.2.1 UN814KNI (tower) Pump Maintenance

Diaphragm and valve plates / seals are the only parts of the UN814KNI pumps that are subject to wear. Maintenance intervals is set to 6 months.

To remove a pump for service, first shut down the Picarro (see Section 10.3 above), then disconnect all electrical and tubing connections from the Pump Box. Remove the Pump Box from the cabinet and remove the top lid. Disconnect the tubing from the bulkhead fittings, and note that it may be necessary to loosen the nuts on the bulkhead fittings in order to separate them from the pump. Disconnect spade connectors from the pump, and remove the cable ties that secure the wires to the shelf, if any. Lay the Pump Box on its side and remove the bottom lid in order to access the nuts that secure the pump in place. While supporting the pump, remove the nuts under the shelf using a 5/16" wrench or nut driver, and then lift the pump out of the box.

Perform these steps in reverse order to install the replacement pump. If possible, leak-test the installation at the bulkhead fittings.

12.2.2 MZ2 NT (Picarro vacuum) Pump Maintenance

In normal use, the lifetime of the diaphragms and valves is typically 15,000 operating hours. Refer to the hour meter on the front of the Pump Box, and return the pump for maintenance as the service hours approach 15,000.

The easiest way to remove the vacuum pump from the chassis is to remove the screws that secure its shelf to the chassis, then lift the chassis up off the shelf. This will involve disconnecting the tubing and wires of the tower pump, as well as the vacuum pump.

To remove the pump for service, first shut down the Picarro (see Section 10.3 above), then disconnect all electrical and tubing connections from the Pump Box. Remove the Pump Box from the cabinet and remove the top lid. Disconnect the tubing to and from the tower pump from the bulkhead fittings, and note that it may be necessary to loosen the nuts on the bulkhead fittings in order to separate them from the pump. Disconnect spade connectors from the tower pump, and remove the cable ties that secure the wires to the shelf, if any. Disconnect the power cable and disconnect the vacuum tubing from the male elbow on the pump. Remove the male elbow from the pump and store in a secure place. Lay the Pump Box on a side, and remove the bottom lid.

12.3 Drierite

Indicating Drierite is used to further dry the air samples before reaching the Picarro analysis. Drierite change color from blue to pink when absorbing water. When most the indicating Drierite turns pink for 10 cm or more, it will have to be replaced. Since the Drierite is in line between the Picarro and the vacuum pump, the Picarro and pump must be shut down before breaking any connections.

First shut down the Picarro (see Section 10.3 above). Remove the two quick disconnects from the Drierite canister and pull the canister from the spring clips on the Datalogger Box. Unscrew the top end of the canister, remove the spring and filter pad, and empty the Drierite into a suitably labeled waste container. Pour fresh Drierite into the canister, install the filter pad and spring, screw the top in place, set the canister into the spring clips on the Datalogger Box, and reattach the quick disconnects.

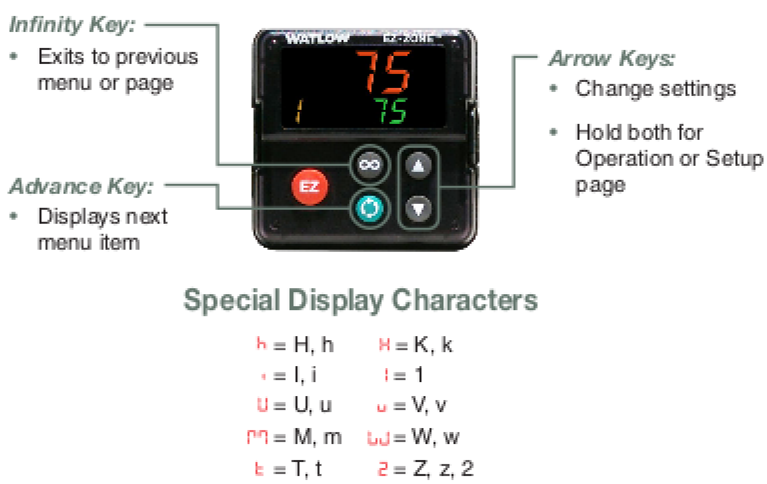
12.4 Chiller Removal

Unplug the chiller's power cord from the outlet strip and its data cable from the Datalogger Box. It may be necessary to remove the Datalogger Box and its shelf in order to access the chiller. Disconnect the two black ¼" tubings from the top of the chiller. (Make a note as to which tubing goes to the left and right fittings so that they can be correctly installed on the replacement chiller.) Unscrew the chiller from the aluminum bracket that secures it to the rack, and then slide the chiller out from the back of the rack. For shipping, the chiller should be packed as is in its original box.

12.5 Configuring the PID for the Watlow Nafion Temperature Controller

This section is only necessary when configuring the temperature controller for the first time, or after the controller has been reset. In all other times, the controller will maintain its settings after shutdown and power up.

12.5.1 User Interface:



Note: use either of the  keys to change the selection in the upper display.

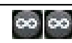
12.5.2 Wiring:

- Resistance Temperature Detector (RTD) red leads to S1 & T1, white lead to R1

- Mains to 98 & 99
- Relay terminal 3 to Y2, terminal 4 to W2
- Temperature output: Datalogger connector pin 8 to G1 and pin 9 to F1

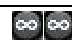
12.5.3 Changing Display from °F to °C:

Press and hold the  keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	9LbL		Enter the Setup Global Menu
C_F	F	C		

12.5.4 Set the Display Precision to 1 Decimal Place:

Press and hold the  keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	Ai		Enter the Setup Global Menu
dEC	0	0.0		

12.5.5 Programming the Input:

Press and hold the  keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	Ai		Enter the Setup Analog Input Menu
SEn	tC	R0.1h		RTD 0.1kΩ
rt.L	2	3		number of leads
Fi.L	0.5	0.5		
i.Er	oFF	oFF		
dEC	0	0.0		
i.CA	0.0	0.0		calibration offset
A.In		-		current input value
i.Er	nonE	-		error status

12.5.6 Programming the Control Loop:

Press and hold the keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	LooP		Enter the Setup Control Loop Menu
h.A9	PID	oFF		heat control
C.A9	oFF	on.oF		cool control
C.hy	1.9	0.1		
db	14.0°C	0.0		
UFA	USEr			
FAiL	USEr			
L.dE	no			
rP	oFF			
L.SP	-1999	-1128		
h.SP	9999	5537		
C.SP	750	10.0		
id.5	75.0	23.9		
SP.Lo	-100.0			
SP.hi	100.0			
o.SP	0.0%			
C.M	AUto			

12.5.7 Programming Output 1 (Analog output to datalogger):

Press and hold the keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	otPt		Enter the Setup Output Menu
otPt	1	1		Output 1
o.tY	Uolt	Uolt		output type set to volts
Fn	heAt	rMt		function set to retransmit
r.Sr	Ai	Ai		
Fi	1	1		
S.Lo	0.00	0.00		lower range of output set to 0V
S.hi	10.0	5.00		upper range of output set to 5V
r.Lo	0	-50°C		lower response range of RTD
r.hi	100	155°C		upper response range of RTD
o.CA	0.0	0.0		calibration offset

12.5.8 Programming Output 2 (Solid State Relay Control):

Press and hold the keys together until the lower display shows Set (about 6 seconds)

Lower Display	Default	Change to	Press	Comment
SEt	Ai	otPt		Enter the Setup Output Menu
otPt	1	2		Output 2
Fn	ALM	CooL		set the output to cool
o.Ct	Ftb	Ftb		fixed time base
o.tb	1.0	1.0		
o.Lo	0%	0%		
o.hi	100%	100%		

12.6 Troubleshooting

12.6.1 Tower Pump Will Not Start

12.6.1.1 Pressurized Line

If the outlet of the pump is pressurized, the motor will not be able to turn against the force of the diaphragm. First verify that the pump is powered, i.e., its rocker switch is illuminated. If that is the case, then toggle the switch to the OFF position and proceed to relieve the pressure. Remove that pump's tubing either from the Liquid Alarm sensor or from the OUT port on the Pump Box. Switch the pump back ON, and reattach the tubing.

12.6.1.2 Pump Failure

In normal operation a pump's rocker switch should be illuminated, and there should be flow (XXX) and pressure (10 psi) indicated on the Backpressure Box. If the rocker switch is illuminated, but no pressure and/or flow indicated on the Backpressure Box, the pump has likely stopped. First try to clear the line (Section 12.6.1.1). If the pump fails to restart, remove the pump (Section 12.2.1) and return it for service.

12.6.2 Picarro Pressure Does Not Come Down to 140 Torr

Disconnect vacuum line from back of Picarro and check for vacuum. If no vacuum, remove and open Pump Box and check that pump is plugged in and switched ON.

12.6.3 Nafion Box Does Not Cool

12.6.3.1 Mains

If the unit is not receiving power (the PID is not illuminated) and the power cable is attached then, check the fuse and replace if necessary.

12.6.3.2 Cooling, but not Achieving Set Point

The Nafion Box may or may not achieve its setpoint, depending upon the operating environment. If the unit is receiving power (the PID is illuminated and displaying measured and set temperatures) and cooling below ambient, but not achieving setpoint, there may be excessive heat sources in the instrument stack or in the room. If this is not the cause, then proceed to Section 12.6.3.3.

12.6.3.3 Not Cooling at All

If the PID is on but the Nafion Box temperature remains around ambient, then the Peltier cooler may not be receiving power. The 24 VDC power supply for the Peltier cooler is located inside the Datalogger Box. Check that the power cable is connected to the power entry module on the Datalogger Box, and that the cable is connected between the 24 VDC OUT on the Datalogger Box and the 24 VDC IN on the Nafion Box. Finally, check the fuse on the power entry module on the Datalogger Box and replace if necessary.

13.0 Safety

13.1 Electrical Hazards

- All components in the instrument stack use 110-120 VAC power. Disconnect power before servicing.
- Observe placarded limits when replacing fuses on fused power entry modules.
- This instrument stack should not be exposed to direct rain or moisture.

13.2 Compressed Gases

- Compressed gases are used for calibration and drying.
- Observe safety precautions when handling compressed gases.

13.3 Lifting

Various components are heavy; observe healthful ergonomic practices when lifting.

14.0 Citable References

Contact instrument mentors for up-to-date reference.

WMO. 2013[2014] 17th WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases and Related Tracers Measurements Techniques. Beijing, China, June 10-13, GAW Report No. 213, July 2014. http://www.wmo.int/pages/prog/arep/gaw/documents/Final_GAW_213_web.pdf

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