NEON SENSOR COMMAND, CONTROL AND CONFIGURATION (C3) DOCUMENT: EDDY COVARIANCE STORAGE EXCHANGE

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/16/2016	ECO-03817	Initial release

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1 DESCRIPTION

Calculation of surface-atmosphere scalar exchange by the aerodynamic or 'eddy flux' approach involves the estimation of two kinds of terms. The first term represents the ***aerodynamic fluxes***, both advective and turbulent, and the second term represents the ***storage***. At NEON tower sites, the ***aerodynamic fluxes*** of CO_2 and H_2O are measured by the Eddy Covariance Turbulent Exchange Assembly, and the ***storage term*** of CO_2 and H_2O will be measured by the Eddy Covariance Storage Exchange Assembly (also referred to as EC profile assembly. The term of "EC profile assembly" will be used in this document from here and below).

On the top of the storage term measurements, the profile assembly also measures the stable isotope of ^{13}C in CO_2, ^{18}O and ^{2}H in water vapor in the atmosphere at each tower measurement level.

The storage term can be determined through CO_2 concentration and H_2O concentration measurements at different measurement levels using a CO_2/H_2O Infrared Gas Analyzer (IRGA). We will use LICOR LI840A in our design. Stable isotope measurement will be done using PICARRO G2131-I Cavity Ringdown Spectrometer (CRDS) for ^{13}C in CO_2 and PICARRO L2130-I CRDS for ^{18}O and ^{2}H in water vapor. For convenience, we will call them G2131-I analyzer or L2130-I analyzer in the document below. This document describes the configuration, command and control related with the instruments, associated accessories, solenoids, manifolds and pneumatics within the Eddy Covariance Storage Exchange Assembly. See Section 13.1 for the Schematic of the EC profile assembly.

Due to the complexity of the whole EC profile assembly, keeping a copy of the EC profile assembly Schematic (Appendix 13.1) handy will enhance your understanding while read through this document.

1.1 Purpose

This document specifies the command, control, and configuration details for operating the EC Profile Assembly. It includes a detailed discussion of all necessary requirements for operational control parameters, conditions/constraints, set points, and any necessary error handling. All Level 0 Data Products generated by the sensor should be identified. Raw data from the sensor are compensated by the DAS, but received at HQ for further processing as a L0 unfiltered and uncorrected data product until its associated algorithms are applied to produce a QA/QC'd L1 data product in Standard Scientific Units.

1.2 Scope

A suite of sensors, solenoids, and manifolds, etc. exist within the EC Profile Assembly. This document is concerned with the operation, configuration, command and control of the sensors, solenoids, manifolds, heater and pneumatics of the assembly.

A complete set of the Level 0 data products generated in this document can be found in appendix 15.6.

The EC Profile Assembly will consist of following Data Generating Device (DGD) based on NEON.DOC.001104.docx:

0330600000	Sensor G2131-i Gas Analyzer for Isotopic CO_2 240VAC, with 125 sccm internal orifice
0328050000	Sensor, L2130-i Analyzer for isotopic water vapor 90 to 240VAC 60HZ
CA07140000	Assembly, Pressure Transducer 0-100psi and Cable Small
CA07150000	Assembly, Pressure Transducer 0-3000psi and Cable Small
0347780000	Remote Thermometer Hygrometer Barometer with PoE
CD06640001	Harness, Grape Digital Out, 8 Solenoid Control
CD06640002	Harness, Grape Digital Out, 4 Solenoid Control
0341500000	Controller, Mass Flow, 5 SLPM, ID EEPROM
0341570000	Controller, Mass Flow, 5 SLPM, Whisper Series, EEPROM
CD08340000	Assembly, IRGA Sensor and EPROM DB9 Serial Adaptor
0341530000	Meter, Mass Flow, 20 SLPM, Whisper Series, ID EEPROM
CA08830000	Assembly, pressure transducer, 0-30 PSI, 4-20MA, enclosure
CD07150000	Assembly, 24VDC Pump and Control

Further detailed sensor info under each DGD is as following:

- Under DGD 0330600000, *Picarro G2131-i Gas Analyzer for Isotopic* CO_2 (NEON P/N 0330600000). It is used to make measurements of high precision CO_2 concentration, H_2O concentration and isotopic CO_2 ($\delta^{13}C$) for air samples drawn from tower profile measurement levels. The reference document for the Picarro G2131-i Analyzer for Isotopic CO_2 is RD [03].
  - Operating System Software: Windows 7 .
  - System Firmware: ver 1.5.0-n
  - Customized design with a critical orifice to allow 125 sccm flow rate through laser cavity
- Under DGD 0328050000, *Picarro L2130-i Analyzer for Isotopic Water Vapor* (NEON P/N 0328050000). It will be used in the measurements of $\delta^{18}O$, $\delta^{2}H$, and H_2O concentration for air samples drawn from tower profile measurement levels. The reference documents for the Picarro L2130-i Analyzer for Isotopic H_2O are RD [04] and RD [05].
  - Operating System Software: Windows 7
  - System Firmware: ver 1.5.0-n
  - Other accessories:
    - A0211 Liquid Sample High Precision Vaporizer [NEON P/N: 0300280001]
    - A0325 HTC-xt Auto Sampler (NEON P/N 0328050001)
    - A0912 Switching valve and accompanying software (NEON P/N 0328050002)
- Under DGD CD08340000, LI840A CO_2/H_2O gas analyzer: LICOR P/N: LI840A-03 (NEON P/N: 0340570000). It will be used to measure the CO_2 and water vapor (H_2O) concentration for air samples drawn from tower profile measurement levels, which will be eventually used to determine the storage term of CO_2 and H_2O. The reference document is RD [08].

- Equip 2 Swagelok fittings (Union, Bulkhead, SS, 0.25" OD Swagelok Part No.: SS-400-61) at the gas inlet and outlet of the sensor per NEON request.
- Firmware version: 2.1.0
- Power Requirements: Input Voltage 12-30 VDC

- Under DGD 0347780000, *Temperature sensor in the instrument hut*: Comet P/N: T7610. Remote Thermometer Hygrometer Barometer with Ethernet. POE Temp Sensor. NEON P/N: 0347780000
- Under DGD 0341530000, *Mass Flow Meter:* Alicat Scientific P/N: MW-20 SLPM-NEON. Meter, Mass Flow, 20 SLPM, Whisper Series, ID EEPROM, NEON P/N: 0341530000. The reference document for this sensor is RD [06]
- Under DGD 0341570000, *Mass Flow Controller* for Li840A IRGA: Alicat Scientific P/N: MCRW-5 SLPM-DS-NEON. Controller, Mass Flow, 5 SLPM, Whisper Series, EEPROM. NEON P/N: 0341570000. The reference document for this sensor is RD [07]
- Under DGD 0341500000, *Mass Flow Controller* for Validation Gas: Alicat Scientific P/N: MC-5 SLPM-NEON. Controller, Mass Flow, 5 SLPM, ID Eeprom. NEON P/N: 0341500000. The reference document for this sensor is RD [07]
- Under DGD CA07150000, *Cylinder Pressure Sensor:* Omega Engineering P/N: PX319-3KGI. Transducer, 0-3000 psi Gage Pressure (PT),3000 psi Gage pressure range, DIN connection style. NEON P/N: 0335480000
- Under DGD CA07140000, *Delivery Pressure Sensor:* Omega Engineering P/N: PX319-100GI. Transducer, 0-100 psi Gage Pressure (PT),100 psi Gage pressure range, DIN connection style. NEON P/N: 0335490000
- Under DGD CA08830000, *Inlet Pressure Sensor:* Omega Engineering P/N: PX319-030AI. 0-30 psi Absolute Pressure Transducer (PT) 30 psi absolute pressure range, DIN connection style. NEON P/N: 0335460000
- Under DGD CD07150000, *Sampling line vacuum pump,* Gast Manufacturing, Inc. P/N: 2032-101-G644. Pump, Rotary Vane Vacuum, 24V DC Brushless, 7.2 Amp, 3000 RPM, 0.13 HP, 0.10 KW, 9 Lbs. NEON P/N: 0334770000

Other important parts:

- *Solenoid Valve*: Components for Automation P/N: C9-211N105-41. Solenoid, 2-Way 24VDC .125 inch NPT Stainless Steel .0945 inch, Orifice Normally Closed. NEON P/N: 0309720000
- *Dehumidifier in the instrument hut:* General Electric P/N: ADEL50LR. Dehumidifier, 23 5/8 x 15 3/8 x 11 inches. NEON P/N: 0347810000

This document specifies the command, control, and configuration that are needed for operating these sensors and accessories. It does not provide implementation details, except for cases where these stem directly from the sensor conditions as described here.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD [01]	NEON.DOC.000001	NEON Observatory Design (NOD) Requirements
AD [02]	NEON.DOC.000291	NEON Configured Sensor List
AD [03]	NEON.DOC.005003	NEON Scientific Data Products Catalog
AD [04]	NEON.DOC.005005	NEON Level 0 Data Products Catalog
AD [05]	NEON.DOC.002058	NEON Eddy Covariance Storage Exchange Assembly SOP [TBW]
AD [06]	NEON.DOC.000822	NEON Eddy Covariance Storage Exchange Assembly ATBD [TBW]
AD [07]	NEON.DOC.002422	Isotopic Water Calibration Fixture Manual L1W200
AD [08]	NEON.DOC.003565	Hut Gas Cylinder Configuration

2.2 Reference Documents

RD [01]	NEON.DOC.000008 NEON Acronym List
RD [02]	NEON.DOC.000243 NEON Glossary of Terms
RD [03]	Picarro G2131-i Analyzer for Isotopic CO_2 - User's Guide Rev 03/06/12. Picarro, Inc. 3105 Patrick Henry Dr. Santa Clara California, 95054 USA.
RD [04]	Installation: L2130-i or L2120-i Analyzer and its Peripherals - User's Manual. Revision B, 8-7-2012. Picarro, Inc. 3105 Patrick Henry Dr. Santa Clara California, 95054 USA
RD [05]	Operation, Data Analysis, Maintenance, Troubleshooting | L2130-*i* or L2120-i analyzer and its Peripherals - - User's Manual. Revision 8-7-2012. Picarro, Inc. 3105 Patrick Henry Dr. Santa Clara California, 95054 USA
RD [06]	Precision Gas Mass Flow Meters Operating Manual. 1/10/2014 Rev. 28. DOC-ALIMAN16. Alicat Scientific. 7641 N Business Park Drive, Tucson, AZ 85743 USA
RD [07]	Precision Gas Mass Flow Controller Operating Manual. 09/18/2013 Rev. 29. DOC-ALIMAN16C. Alicat Scientific. 7641 N Business Park Drive, Tucson, AZ 85743 USA
RD [08]	LI-840A CO_2/H_2O gas analyzer instruction manual. Jan 2011. Publication Number 984-10690. LI-COR, Inc. • 4421 Superior Street • Lincoln, Nebraska 68504 USA

2.3 Acronyms

Acronym	**Explanation**
ATBD	Algorithm Theoretical Basis Document
C^3	Command, Control, and Configuration Document
SOP	Standard Operating Procedures
QA/QC	Quality Assurance/Quality Control
TIS	Terrestrial Instrument System
L0	Level 0
L1	Level 1

ENG	NEON Engineering group
CI	NEON Cyberinfrastructure group
DPS	NEON Data Products group
CVAL	NEON Calibration, Validation, and Audit Laboratory
P/N	Part Number
DGD	Data Generate Device
HQ	Header quarter
IRGA	Infrared Gas Analyzer
CRDS	Cavity Ringdown Spectrometer

3 ANALYZER FOR CO_2/H_2O CONCENTRATION (DGD CD08340000)

3.1 Introduction

LI840A-03 is used for the measurements of CO_2 concentration and H_2O concentration at vertical profile of a tower at NEON tower sites. It is a modified LI-840A sensor to equip 2 Swagelok fittings (Union, Bulkhead, SS, 0.25" OD Swagelok Part No.: SS-400-61) at the gas inlet and outlet of the sensor per NEON request. Its functionality is identical to standard LI840A IRGA. We will call it LI840A here and below. One LI840A IRGA will be deployed at each of NEON terrestrial sites.

Measurements made by LI840A will be switched between sampling mode and field validation mode at scheduled time periods. During sampling mode, the analyzer will measured air samples from different measurement levels on the tower. During the routine field validation, the analyzer will cease measuring the air samples from the tower levels, and measure the known CO_2 gas transfer standards (prepared by CVAL).

The configuration, command and control for the IRGA during sampling mode are described below in section 3.2. The related CO_2/H_2O data products are listed in tables in section 3.2 below. The configuration, command and control related to the field calibration and field validation for the IRGA will be described in Section 12.3.3 in this document. The gas handling during sampling mode and validation mode will be also described in Section 12.2 of this document.

Digital signals from the IRGA will be collected by data acquisition system (DAS) using RS232 communication.

Some descriptions in this document may be more appropriate for SOP documents. But given the complexity of this profile assembly, leaving them in this C3 document will enhance the readers' understanding of the design and context.

3.2 Overview of Sensor configuration

Configuration assumptions: Cal/Val will perform the initial lab calibration and determine calibration coefficients for each LI840A IRGA prior to field deployment, and every 6 months after deployment

The analyzer automatically records all data generated by LI840A using a DAS and the data will be streamed back to NEON headquarter thereafter (see Table 1).

All data output from LI840A should be unfiltered and uncorrected beyond the initial preprocessing by the LI840A IRGA. A description of the working principles and calculations are presented in the associated ATBD (AD[06]).

Table 1. Sensor configuration settings for LI840A IRGA

Parameter	Default Setting
Filtering/averaging	1 s
External vacuum pump	On
Pressure compensation	On
Data output rate	1 Hz

L0 data from LI840A IRGA that will be streamed back to HQ at 1Hz (DGD CD08340000) can be found at appendix 15.6.

3.3 Command and Control

There is no command and control on LI840A sensor.

4 ANALYZER FOR ISOTOPIC CO_2 (DGD 0330600000)

4.1 Introduction

PICARRO G2131-I analyzer is the sensor selected to measure the high precision CO_2 concentration, $\delta^{13}C$ in CO_2, and H_2O concentration in the atmosphere at different tower profile measurement levels. One G2131-I analyzer will be deployed at each of NEON terrestrial sites.

Measurements made by the G2131-I analyzer will be switched between sampling mode and field validation mode at scheduled time periods. During sampling mode, the analyzer will measured air samples from different measurement levels on the tower. During the routine field validation, the analyzer will cease measuring the air samples from the tower, and measure the known CO_2 gas transfer standards (including known $\delta^{13}C$ in CO_2, prepared by CVAL).

Section 4.2 of this document describes the configuration, command and control for the analyzer during sampling mode. The related isotopic CO_2 data products can be found in section 4.2 below. The configuration, command and control related to the field validation for analyzer will be described in Section 12.3.4 in this document. The gas handling during sampling mode and validation mode will be also described in Section 12.2 of this document.

G2131-I analyzer will connect to a local computer in the instrument hut. Selected digital signals from the analyzer will be streamed through Ethernet to CI and also saved in its computer. **This computer should be configured to synchronize timestamp using Local Controller (LC) as time server at that site.**

4.2 Overview of Sensor configuration

Configuration assumptions: Cal/Val will determine and preset the initial calibration coefficients for each G2131-i sensor prior to field deployment, and perform again annually, which shall never be adjusted at field.

When the analyzer power is turned on, the GUI (Graphical User Interface) for the analyzer will start automatically and appear on the computer monitor. **The analyzer automatically records all data and saves in ASCII-format and HD5 format text output files in its computer**. Subset of these data streams and files can be streamed back to NEON headquarter or collected periodically (see Table 4).

All data related to the isotopic CO_2 analyzer should be unfiltered and uncorrected beyond the initial preprocessing by the Picarro G2131-i Analyzer for Isotopic CO_2. A description of the working principles and calculations are presented in the associated ATBD (AD[06]).

Table 2. Sensor configuration settings for Picarro G2131-i analyzer.

Parameter		Default Setting
External vacuum pump		On
G2131-I computer setting and GUI setting	Computer timestamp	Synchronize to LC time stamp
	Picarro Mode Switcher\Select measurement mode	iCO_2-CH4
	Settings menu\GUI Mode	Standard
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\ Data Columns	All parameters shall remain selected
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\Hours of each log file	24 hours
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\Enable Mailbox Archiving	No
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\Archived Directory Structure	YEAR/MONTH/DAY
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\Total User Log Storage Size (GB)	30
	Desktop\Picarro Utilities\ Setup Tool\Data Logger\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\Port Manager\Data Streaming	COM1
	Desktop\Picarro Utilities\ Setup Tool\ Port Manager (Valve Sequencer MPV)	NA; Default value is COM2
	Desktop\Picarro Utilities\ Setup Tool\Port Manager\Commend Interface	TCP
	Desktop\Picarro Utilities\ Setup Tool\Port Manager\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Use SSL	NO
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Use Authentication	NO
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Server	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\User Name	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Password	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\From	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\To	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Subject	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Data Directory	NA
	Desktop\Picarro Utilities\ Setup Tool\Data Delivery\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\GUI Properties\Number of Graphs	4
	Desktop\Picarro Utilities\ Setup Tool\GUI Properties\Enable Control of Valve Sequencer	NA; Valve sequences will be controlled by the DAS location controller: As a default this box is

		grayed out and contains "Yes"
	Desktop\Picarro Utilities\ Setup Tool\GUI Properties\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\Command Interface\Output Data Source	DataLog_User
	Desktop\Picarro Utilities\ Setup Tool\Command Interface\Output data columns	Select columns according to the L0 data product list below.
	Desktop\Picarro Utilities\ Setup Tool\Command Interface\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\Data streaming\Data Stream Source	DataLog_User
	Desktop\Picarro Utilities\ Setup Tool\Data streaming\Data Stream Columns	Select columns according to the L0 data product list below.
	Desktop\Picarro Utilities\ Setup Tool\Data streaming\Mode	iCO_2
	Desktop\Picarro Utilities\ Setup Tool\Electrical Interface	Not Available
	GUI panel\Settings menu\Change GUI mode from standard to service	Standard
	GUI panel\View menu\(Lock/unlock time axis)	Unlocked
	GUI panel\View menu\(Show/hide statistics)	Hide
	GUI panel\View menu\(Show/hide instrument status)	Hide
	Valve sequencer software	NA; Valve sequences will be controlled by the DAS location controller
	Isotopic CO_2 measurements: Acquisition rate	~1 Hz

L0 data product from G2131-i will be collected at the acquisition frequency of ~ 1Hz (DGD 0330600000) and streamed back to HQ. L0 data product list can be found in Appendix 15.6.

There are also some folders and files in the G2131-I computer that contain useful info for the diagnosis, and future data reprocess. They should be copied periodically and sent back to CI for archival before these files are overwritten by new files. These folders and files are:

C:\userdata
C:\Picarro\G2000\AppConfig\; (all directories, not just Config) Will be static except for updates.
C:\Picarro\G2000\Log\Archive\DataLog_Private
C:\Picarro\G2000\Log\Archive\EventLogs
C:\Picarro\G2000\Log\Archive\RDF
C:\Picarro\G2000\Log\Archive \WBCAL
C:\Picarro\G2000\InstrConfig\Calibration\InstrCal ;(Will be static except for updates).

Data streams will be delivered back to HQ during sampling mode and during instrument validation mode will be identical.

REQ: If there is an interruption in measurement (e.g., due to power failure or in other unforeseen circumstances), the sensor shall be automatically returned back to the default settings that is pre-configured by CVAL when the measurement resumes.

4.3 Command and Control

4.3.1 Error handling

Instrument status (INST_STATUS) outputted from the analyzer will be used for later data QAQC, but will not be used to conduct any command and control. The instrument status can be found in the Appendix 15.2.

4.3.2 Sensor <device> controls specification

Human communication with the Picarro G2131-i Analyzer for Isotopic CO_2 will be done through the KVM (keyboard, video and mouse). Additionally, the Picarro G2131-i Analyzer for Isotopic CO_2 requires an external vacuum pump for operation, which comes with analyzer package.

Startup sequence (See flow chart in appendix 15.4 for more details):

- The PICARRO external vacuum pump of the analyzer shall be turned on prior to the analyzer itself. The external vacuum pump shall remain on at all times while the Picarro G2131-i Analyzer for Isotopic CO_2 is running.

Because of the instrument warming up will take a long time, no data within 12 hours after instrument power up should be used for science analysis. A data flag should be generated at HQ and describe in the associated ATBD document.

Shut down sequence (This shut down procedure shall be an automated process. See flow chart in appendix 15.5 for more details):

- During a power failure,
  a. While supported by UPS power systems, 5 minutes prior to the Picarro G2131-i Analyzer shut down command is issued by DAS, a flow of clean dry gas (i.e. < 1000 ppm water concentration at 2.5 psig) should run through the instrument cavity to avoid condensation.
  b. After 5 minutes, DAS issues command to shut down the analyzer properly, then shut down the dry gas
  c. The external pump should be turned off after 30 s of the instrument power off.

Because the dry air runs through analyzer cavity for 5 min prior to shut down command is issued, and because it will take about 5 min for analyzer to fully turn off, no data within 10 min prior to fully turn off should be used for science analysis. A data flag should be generated at HQ and describe in the associated ATBD document.

Table 3. Truth table for controlling sensor (G2131-I, DGD 0330600000)

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Collecting isotopic CO_2	Prior to turning on	Turn external vacuum pump on	NA;

data	analyzer		
Suspending collection of isotopic CO_2 data and shut down	Power failure	Run clean dry gas through instrument cavity for 5 minutes, turn off the analyzer properly, turn off the dry gas; after 30 s of the instrument power off, turn external pumps off.	NA;

5 ANALYZER FOR ISOTOPIC WATER (DGD 0328050000)

5.1 Introduction

The PICARRO L2130-i is the sensor selected to measure the water vapor (referred to as H_2O below) concentration, $\delta^{18}O$ and $\delta^{2}H$ of water vapor in the atmosphere at different tower profile measurement levels, which varies from 4 to 8 levels at different NEON sites. 21 L2130-I units will be deployed at 20 NEON core sites and 1 relocatable site (D18 Barrow).

Section 5 of this document describes the configuration, command and control related to the tower profile measurements of H_2O concentration, $\delta^{18}O$ and $\delta^{2}H$. Measurements made by the L2130-i will be switched between sampling mode and field validation mode at scheduled time periods. During sampling mode, the analyzer will measure the air sample from different tower levels. During the routine field validation, the Picarro analyzer will stop measuring the atmospheric water vapor from the tower profiles, and measure liquid water standards (NEON Tertiary Low, Mid, and High standards, prepared by CVAL) using the autosampler and vaporizer.

Section 5 of this document describes the configuration, command and control on the analyzer during sampling mode and validation mode. The gas handling during sampling mode and validation mode is described in Section 12.2 of this document.

L2130-I analyzer will connect to a local computer. Selected digital signals from the analyzer will be streamed through Ethernet to CI and also saved in its computer. **This computer should be configured to synchronize timestamp using Local Controller (LC) as time server at that site.**

5.2 Overview of Sensor configuration

5.2.1 L2130-i analyzer

Assumptions:

1. Cal/Val will determine and preset calibration coefficients in the its associated computer for each L2130-i sensor prior to the field deployment, which shall never be adjusted during field operations.

2. The Job settings to operate autosampler and vaporizer during instrument field validation are preset by CVAL in its associated computer and described in SOPs (AD [05]) prior to field deployment and shall never be adjusted during field operation.
3. Water standards used in the instrument field validation will be prepared by CVAL.

When the analyzer power is turned on, the analyzer will automatically start, and the GUI (Graphical User Interface) for the analyzer software will appear on the monitor. The analyzer automatically records all data and saves in ASCII-format and HD5 format text output files in the computer. Subset of these data streams and files can be streamed back to NEON headquarter or collected periodically (see Table7).

All data related to the isotopic H_2O analyzer shall be unfiltered and uncorrected beyond the initial preprocessing by the Picarro L2130-i Analyzer for Isotopic H_2O. A description of the calculations performed by the Picarro L2130-i Analyzer is presented in the associated ATBD (AD [06]).

Table 4. Sensor configuration settings for Picarro L2130-i Analyzer during operation

Parameter		**Default Setting**
Regulator at the zero air cylinder\Valve		ON
Regulator at the zero air cylinder\delivery Pressure		2.5 ± 0.5 psig (17.24±3.45 kPa)
External vacuum pumps (analyzer)		ON
Picarro L2130-I Analyzer		ON
Acquisition rate		~1 Hz
L2130-I computer setting and GUI setting	Computer timestamp	Synchronize to LC time stamp
	Picarro coordinator launcher\ Select Coordinator	Dual Liquid/Vapor
	Picarro Mode Switcher	iH_2O Air
	GUI\Setting\Change GUI Mode from Standard to Service	Standard
	GUI\View\Lock\Unlock time axis when zoomed	Lock
	GUI\View\Show\hide statistics	Hide
	GUI\View\Show\hide instrument status	show
	GUI\View\Tools\Show\Hide Valve Sequencer GUI	NA
	GUI\Help Menu	NA
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Data Columns (DataLog_User)	Select all parameters
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Hours of Each Log File (0.01~24)	24 hours
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Enable Mail Archiving	NO
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Archived Directory Structure	YEAR/MONTH/DAY
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Total User Log Storage Size (GB)	30
	Desktop\Picarro Utilities\Setup Tool \Data Logger\Mode	iH_2O Air
	Desktop\Picarro Utilities\Setup Tool \Port Manager\Data Streaming	Off
	Desktop\Picarro Utilities\Setup Tool \Port Manager\Valve Sequencer MPV	N/A (default setting is COM2)
	Desktop\Picarro Utilities\Setup Tool \Port Manager\Command Interface	TCP
	Desktop\Picarro Utilities\Setup Tool \Port Manager\Coordinator (Autosampler)	COM1

	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Use SSL	NO
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Use Authentication	NO
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Server	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\User Name	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Password	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\From	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\To	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Subject	NA
	Desktop\Picarro Utilities\Setup Tool \Data Delivery Setup\Data Directory	NA (Default is C:/Picarro/G2000/Log/Archive/ Datalog_Mailbox\)
	Desktop\Picarro Utilities\Setup Tool \GUI Properties\Number of Graphs	4
	Desktop\Picarro Utilities\Setup Tool \GUI Properties\Enable Control of Valve Sequencer	NA if Valve sequences is controlled by the DAS location controller: As a default this box is grayed out and contains "No"
	Desktop\Picarro Utilities\Setup Tool \Command Interface\Output Data Source	NA (Default is C:\Userdata\DataLog_User\)
	Desktop\Picarro Utilities\Setup Tool \Command Interface\Output Data Columns	Select columns according to the L0 data product list below.
	Desktop\Picarro Utilities\Setup Tool \Data Streaming\Data Stream Source	NA (default is C:\Userdata\DataLog_User\)
	Desktop\Picarro Utilities\Setup Tool \Data Streaming\Data Stream Columns	Select columns according to the L0 data product list below.

L0 data products from L2130-i will be collected at acquisition rate of ~1 Hz (DGD 0328050000) and stream back to HQ. L0 data products list can be found in Appendix 15.6.

There are also some folders and files in the L2130-I computer that contain useful info for the diagnosis, and future data reprocess. They should be copied periodically and send back to CI for archival. These folders and files are:

c:\userdata
c:\isotopedata
C:\Picarro\G2000\AppConfig\\; (all directories, not just Config. Will be static except for updates.)
C:\Picarro\G2000\Log\Archive\DataLog_Private
C:\Picarro\G2000\Log\Archive\EventLogs
C:\Picarro\G2000\Log\Archive\RDF
C:\Picarro\G2000\Log\Archive \WBCAL
C:\Picarro\G2000\InstrConfig\Calibration\InstrCal ;(Will be static except for updates).

REQ: If there is an interruption in measurement (e.g., due to power failure or in other unforeseen circumstances), the sensor shall be automatically returned back to the default settings that haves been pre-configured by CVAL when the measurement resumes.

5.2.2 A0325 HTC-xt Autosampler

The autosampler will be used only in the field validation mode. And **it needs to be restarted manually every two weeks.**

The autosampler settings for Method and Job shall be setup by CVAL and identical to the settings described in AD [07]. Method and Job together will tell autosampler when to start validation, what kind of syringe to use, where to get the liquid standards, how many injections for each standard, what speed to inject standard, etc. Method and Job should not be changed at field unless instructed by CVAL personnel.

5.2.3 A0211 High Precision Vaporizer

The Vaporizer will be used only in the field validation mode. Sensor configuration settings are shown in the table below.

Table 5. High Precision Vaporizer configuration settings

Parameter	Default Setting
Vaporizer Temperature	110 °C
External vacuum pumps (vaporizer)	ON
Raw data measurements	None

5.3 Command and Control

5.3.1 Error handling

Instrument status (INST_STATUS) outputted from the analyzer will be used for later data QAQC, but will not be used to conduct any command and control. The instrument status can be found in the Appendix 15.2.

5.3.2 Sensor <device> controls specification

The interface for the Picarro L2130-i Analyzer for Isotopic H_2O will be through the KVM (keyboard, video and mouse). Additionally, the Picarro L2130-i Analyzer for Isotopic H_2O requires an external vacuum pump for operation.
Startup sequence (See flow chart in appendix 15.4 for more details):

- Assume the compressed gas cylinder valve of zero air has been open and adjusted the output pressure at gas cylinder to 2.5 ± 0.5 psig (17.24±3.45 kPa)

- Turn on both external pumps for analyzer and vaporizer, respectively. The external vacuum pump of analyzer should remain on at all times while the Picarro L2130-i Analyzer operates.
- Turn on autosampler.
- Turn on the vaporizer.
- Turn on L2130-i analyzer. GUI will run automatically.

Because of the instrument warming up will take a long time, no data within 12 hours after instrument power up should be used for science analysis. A data flag should be generated at HQ and describe in the associated ATBD document.

Shut down sequence (This shut down procedure shall be an automated process. See flow chart in appendix 15.5 for more details):

- During a power failure,
    a. While supported by UPS power systems, 5 minutes prior to the Picarro L2130-i Analyzer shut down command is issued by DAS, a flow of clean dry gas (i.e. < 1000 ppm water concentration at 2.5 psig) should run through the instrument cavity to avoid condensation.
    b. After 5 minutes, DAS issues command to shut down the analyzer properly, then shut down the dry gas, shut down the vaporizer and autosampler
    c. The external pump should be turned off after 30 s of the instrument power off.

Because the dry air runs through analyzer cavity for 5 min prior to shut down command is issued, and because it will take about 5 min for analyzer to fully turn off, no data within 10 min prior to fully turn off should be used for science analysis. A data flag should be generated at HQ and describe in the associated ATBD document.

Table 6. Truth table for controlling sensor (L2130-I, DGD 0328050000)

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Collecting isotopic H_2O data	Prior to turning on analyzer	Turn L2130-i external vacuum pump on	NA; The external vacuum pump does not generate a data stream or flag.
Suspending collection of isotopic H_2O data and shut down	Power failure	Run clean dry gas through instrument cavity for 5 minutes, turn off the analyzer properly, turn off the dry gas, turn off the vaporizer and autosampler; after30 s of the instrument power off, turn the L2130-I external pumps off.	NA;

6 TEMPERATURE SENSOR IN THE HUT (DGD 0347780000)

6.1 Introduction

Because of the dependency of the LI840A to its ambient temperature variation, a temperature sensor will be added within 50 cm around the LI840A to monitor the ambient temperature variation. This temperature will be used in the future data flagging. The data collected during the time periods of temperature variation > 10 °C over 1 hour should be flagged due to the possibility of LI840A drift over the requirement of 0.4 ppm for CO_2. This temperature sensor is a smart sensor and can output temperature, humidity and pressure readings.

When the ambient humidity is high (>30, 000 ppmv), the moisture could interfere the performance of L2130-I. The humidity output prom this sensor can also use to flag L2130-I data in the later data process, which will be described in the associated ATBD.

The humidity display on this sensor can also be used to guide field tech to adjust the dehumidifier settings to below 30,000ppmv.

Digital signals from temperature sensor will be collected by DAS using Ethernet protocols.

6.2 Overview of Sensor configuration

The temperature, barometric pressure, humidity, and one computed value can be displayed on LCD display or can be read using an Ethernet connection. The options of the computed quantities included dew point temperature, absolute humidity, specific humidity, mixing ratio and specific enthalpy. We suggest select mixing ratio as this computed value output.

For display, set this temperature sensor to:

a. Enable LCD
b. Show Temperature
c. Show Relative Humidity
d. Show computed value
e. Show atmospheric pressure

For the unit of each measurement, set it to:

a. Temperature: deg C
b. Computed value: Mixing ratio
c. Atmospheric pressure: kPa

Table 7. Default sensor configuration settings for the temperature sensor.

Parameter	Setting
Display	Enable LCD
	Show Temperature
	Show Relative Humidity
	Show computed value

	Show atmospheric pressure
Units	Temperature: deg C
	Mixing ratio (Computed value): g/kg
	Atmospheric pressure: kPa
Default pressure	1013 hPa
Atmospheric pressure offset	0.0 hPa

Note:
The missing ratio above is the weight mixing ratio (water vapor (g)/dry air (kg)), not the mixing ratio of ppmv. PICCARO suggested < 3% (or 30,000 ppm) water vapor by volume (water vapor to dry air as a recommended threshold for operating the WLM purge in moist environments. To leave some safe margin, we suggest adjust the dehumidifier in the hut to achieve the cutoff threshold at **25,000 ppmv** for PICARRO operating environment. The conversion of mixing ratio from g/kg to ppmv is (g/kg readings) *[dry air molecular weight (g)/water molecular weight (g)]*1000*[atmospheric pressure readings (kPa)/103.325 kPa]. Field tech should use this info to set dehumidifier to achieve <25,000 ppmv humidity.

L0 data from temperature sensor that will be streamed back to HQ at 1Hz (DGD 0347780000) can be found in Appendix 15.6

6.3 Command and Control

There is no command and control on temperature sensors themselves.

6.3.1 Error handling

When the error events occur, the sensor LCD will show the error code (see table below), an error code of -9999 should output as values, and a trouble ticket should be generated and sent to field technician.

Table 8. Temperature sensor error codes

Error 0	Err0	Internal memory CRC error. In this state device doesn't work. This is a critical error, contact the distributor.
Error 1	Err1	Measured or computed quantity is over the upper limit. Error code 9999. This state appears in case of: - Measured temperature is higher than approximately +600°C (i.e. high non-measurable resistance of temperature sensor, probably open circuit) - Relative humidity is higher than 100%RH (i.e. damaged humidity sensor or humidity calculation is not possible due to temperature error) - Unable to calculate computed quantity (temperature or humidity measurement error)
Error 2	Err2	Measured or computed quantity is under lower limit or is error in pressure measuring. Error code -9999. This state appears in case of: - Measured temperature is lower than approximately -210°C (i.e. resistance is too small, probably short circuit) - Relative humidity is lover than 0%RH (i.e. damaged humidity sensor or humidity calculation is not

		possible due to temperature error) - Measured atmospheric pressure with offset is over range 300hPa to 1350hPa or the pressure sensor is damaged - Unable to calculate computed quantity (temperature or humidity measurement error)
Error 3	Err3	Internal A/D converter error. Error code -9999. In this state device doesn't work. Contact the distributor.
Error 4	Err4	Internal pressure sensor error. Error code -9999. In this state device not measure pressure. Contact the distributor.

6.3.2 Sensor <unit> controls specification

Table 9. Truth table for controlling sensor <unit>.

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Error codes	When error codes appear	Generate trouble ticket and send to field technician to check this sensor	none

7 DEHUMIDIFIER (NEON P/N: 0347810000, NOT A DGD)

7.1 Introduction

For the PICARRO analyzers, there is a WLM (wave length monitor) purge port on the back of the instrument. PICARRO suggested use dry air to purge WLM through this port at the humid sites. Purging WLM acts to fill the warm box of the analyzer with dry gas. The warm box houses the WLM which is part of the analyzer's laser targeting control loop. The WLM itself enables us to precisely control the wavelength of light being injected into the cavity. Within the warm box there is a distance of about 10 cm which is open path, i.e., the laser light is seeing the ambient atmosphere at 45°C (the temperature at which the warm box is held). Because water is such a strong absorber, and in the case of the isotopic water systems, the laser is specifically tuned to a frequency of water absorption, this open path segment may result in decay of the light prior to entering the WLM. As a result, the performance of the WLM could vary as ambient conditions change. PICCARO recommends drying the gas seen by the laser in the warm box such that any potential decay due to water absorption is limited.

If the analyzer is operating in a very humid environment, such as above 3% water content (30,000 ppmv water vapor to dry air), dry gas is strongly recommended to be supplied to the WLM purge for the aforementioned reasons. Without this dry gas supply, the analyzer may experience more drift. However, due to the high maintenance cost and efforts of using dry gases, NEON elects to use dehumidifier to lower the environmental humidity in the instrument hut at 9 NEON sites (See table below), where the PICARRO L2130-I analyzers locate. PICARRO suggested <3% water content (30,000 ppmv water vapor to dry air). To leave some safe margin, we suggest the cutoff threshold at 25,000 ppm for NEON PICARRO analyzer operating environment. Field tech should follow SOP to use temperature sensor (0347780000) readings to adjust the dehumidifier to achieve ~25,000 ppmv humidity if the default setting cannot provide humidity to that low level.

Table 10. NEON sites that will have a dehumidifier

Domain	Site with L2130-I water analyzer	Site Type	Dehumidifier?
1	Harvard Forest	Core	Y
2	SCBI	Core	Y
3	Ordway-Swisher Biological Station	Core	Y
4	Guanica Forest	Core	Y
5	UNDERC	Core	Y
6	Konza Prairie Biological Station	Core	Y
7	Oak Ridge	Core	N
8	Talladega National Forest	Core	Y
9	Woodworth	Core	N
10	Central Plains Experimental Range	Core	N
11	Caddo/LBJ	Core	Y
12	Yellowstone Northern Range (Frog Rock)	Core	N
13	Niwot Ridge/Mountain Research Station	Core	N
14	Santa Rita Experimental Range	Core	N
15	Onaqui-Ault	Core	N
16	Wind River Experimental Forest	Core	N
17	San Joaquin	Core	N
18	Toolik Lake	Core	N
19	Caribou Creek (CPCRW)	Core	N
20	Olaa	Core	Y
18	Barrow	Relocatable	N

7.2 Overview of Sensor configuration

The default configuration settings of the dehumidifier can be found in the table below:

Table 11. Default sensor configuration settings for the dehumidifier.

Parameter	Setting
Power	On
Humidity control	Initial setting: 50% for D03 Ordway, D04 Guanica, D20 Upper Waiakea, and 60% for rest sites.
Display	Humidity (%)
Fan Speed	Medium
Delay off	none

For the application at NEON, the condensed water will be drained outside the hut through a hose, thus no need to empty the built-in bucket.

The humidity setting above is the initial setting based on the historical data for nearby weather station and our calculations. It can be adjusted to a different value once we have better understanding about the site environment based on the data collected at our sites.

No data need to be streamed back to CI as L0 data products.

7.3 Command and Control

There is no command and control on dehumidifier itself.

7.3.1 Error handling

Follow the manual and SOP to do troubleshooting.

7.3.2 Sensor <device> controls specification

N/A.

8 GAS CYLINDER PRESSURE SENSOR (DGD CA07140000, CA07150000)

8.1 Introduction

Pressure sensors are used to monitor (i) the pressure in the gas cylinders and (ii) the pressure at the supply-side of the pressure regulator for gas delivery to the associated sensors.

There will be 6 gas cylinders used in the EC profile systems for field validation of LI840A IRGA and G2131-I analyzer:

- 3 cylinders of CO_2 at high, middle and low concentration for routine validation of LI840A IRGA and G2131-i analyzer,
- 1 cylinder of Zero air for the routine field validation of LI840A IRGA to determine the sensor zero offset, and used to purge G2131-I cavity prior to the instrument shut down.
- 1 archived CO_2 for validation of LI840A IRGA and G2131-i analyzer at a longer time period (monthly),
- 1 cylinder of Zero air for the field validation and purge for L2130-i analyzer. The zero air for L2130-i field validation will be used to purge the vaporizer and/or dilute the high water vapor concentration to the measurable range, and carry the water vapor to analyzer, as well as purge L2130-I cavity prior to the instrument shut down.

Field validation frequency and command and control will be described below in Section 12.

Each of these 6 gas cylinders will be equipped with a two-stage pressure reduction regulator and two pressure sensors to monitor the cylinder pressure and delivered gas pressure on the supply side. The pressure in the validation gas cylinder (call "**cylinder pressure**" below) should not be lower than **400 psig (2758 kPa)** for CO_2 and zero air validation gas standards used for LI840A IRGA and G2131-i validation, and the delivered gas pressure on the supply side (call "**delivered gas pressure**" below) should be recorded for the purpose of the state of the heath, but will not be used for further scientific data process. The delivered gas pressure should be **2.5±0.5 psig (17.24±3.45 kPa)** for Zero air that will be used for L2130-i validation and purge the laser cavity prior to the instrument shut down. To minimize the waste of CO_2 standard gases during G2131-I validation, the gas flow should be set to 0.3 SLPM, which is controlled by a validation mass flow controller. See "G2131-i Isotope Analyzer Validation" session in this document. It is no need to monitor and flag the delivered gas pressure.

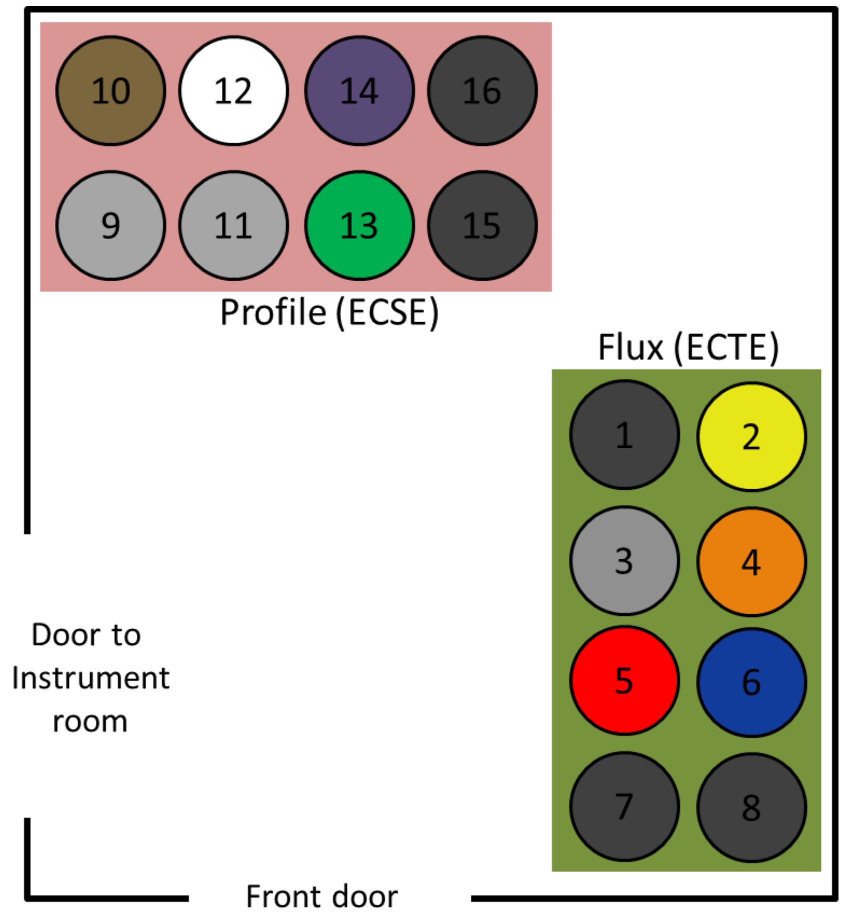
At this time, the Omega Engineering P/N: PX319-3KGI (NEON P/N: 0335480000) and Omega Engineering P/N: PX319-100GI (NEON P/N: 0335490000) will be used to monitor the tank pressure and delivered gas pressure. Here, we describe the configuration, command and control related to the operation of this pressure sensor in session 8.2. A description of how sensor readings shall be converted to pressure units is provided in the associated ATBD (AD [07]). The associated SOP document (AD[06]) explains the procedures for field validation and maintenance.

8.2 Overview of Sensor configuration

The acquisition rate from this sensor shall be once every 1 second (1 Hz). The default sensor configuration settings are given in Table below. When the cylinder gas pressure is lower than 400 psig (2758 kPa), calibration and validation should be discontinued (to preserve the rest of the gas in the cylinder for CVAL traceability analysis), and a flag should be set high to alert the technician and to inform post data process. The flag to alert the field tech should be generated at field and send to trouble ticket center, and the flag to inform post data process should be generated at HQ following the ATBD. When the delivered gas pressure is out of range, i.e. 2-3 psig (13.79-20.68 kPa), for L2130-i validation, a flag should be set high to alert the technician to adjust regulator, and to inform post data process. Again, the flag to alert the field tech should be generated at field and send to trouble ticket center, and the flag to inform post data process should be generated at HQ following the ATBD.

In the hut, the gas cylinder locations are show as following in the figure (AD [8]). Locations from number 9 to 16 are assigned to the cylinders used for profile system.

Gas cylinders will be swapped by field techs when the gas cylinder pressure drops below 400 psig (2758 kPa). The gas concentration inside the cylinder will change after swap. The timestamp when the cylinder is swapped will be provided by field techs. The gas concentration and uncertainties for each cylinder will be provided by CVAL.



Cylinder Number	System Used	Color	Gas Concentration Measured
1	Flux	N/A	Empty
2	Flux	Yellow	Archive CO_2
3	Flux	N/A	Zero Air (Supplied by local vendor)
4	Flux	Orange	Low (~350 ppm CO_2)
5	Flux	Red	Medium (~375 ppm CO_2)
6	Flux	Blue	High (~400 ppm CO_2)
7	Flux	N/A	Empty
8	Flux	N/A	Empty
9	Profile	N/A	Zero Air (Supplied by local vendor)
10	Profile	Brown	Archive (~-8.5 $\delta^{13}C$, 400 ppm CO_2)
11	Profile	N/A	Zero Air (Supplied by local vendor)*
12	Profile	White	Low (~-5 $\delta^{13}C$, 350 ppm CO_2)
13	Profile	Green	Medium (~-8.5 $\delta^{13}C$, 400 ppm CO_2)
14	Profile	Violet	High (~-15 $\delta^{13}C$, 500 ppm CO_2)
15	Profile	N/A	Empty
16	Profile	N/A	Empty

*Note: Cylinder 11 is zero air for the Picarro L2130-i, if the site does not have a Picarro L2130-I, this spot will be empty.

Figure 1. Cylinder layout at instrument hut

Table 12. Default sensor configuration settings for the gas cylinder pressure sensor.

Parameter	Setting
Excitation	Analog, 9–30 V
Output	Analog, 0.004–0.02 A
Data acquisition frequency	1 Hz
Data acquisition streams	Cylinder pressure, delivery pressure

L0 data streams from pressure sensor (GDG CA07150000) for validation gas cylinder pressure at 1 Hz can be found in Appendix 15.6.

L0 data streams from pressure sensor (GDG CA07140000) for validation gas delivery pressure at 1 Hz can be found in Appendix 15.6.

8.3 Command and Control

N/A

8.3.1 Error handling

When the pressure out of range, a trouble ticket should be generated and sent to field technician.

8.3.2 Sensor <unit> controls specification

Table 13. Truth table for controlling sensor <unit>.

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Cylinder pressure	Cylinder pressure < 400 psig (2758 kPa)	Generate trouble ticket and send to field technician to swap gas cylinder	None
Delivery pressure of zero air for L2130-I	Delivery pressure of zero air for L2130-I > 3 psig (20.68 kPa) or < 2 psig (13.79 kPa)	Generate trouble ticket and send to field technician to adjust the hand valve that control delivery pressure	None

9 ABSOLUTE PRESSURE TRANSDUCER (DGD CA08830000)

9.1 Introduction

The absolute pressure sensors are used to monitor the pressure in the sample line behind the critical orifice, which should be 52.8% of ambient pressure or even lower. There will be 1 absolute pressure transducer for each sample line from inlet at different tower measurement levels to the associated pump. Therefore, the number of absolute pressure transducer deployed at each site will vary from 4 to 8. The numbering of the sample line should match with the numbering of measurement levels (ML), i.e., sample line 1 is for ML1, sample line 2 is for ML2, etc.

The absolute pressure readings will be also used to feedback to associated sample line pump to adjust pump speed to maintain the proper pressure drop in the sample line (i.e., 52.8% of ambient pressure or even lower). Ambient pressure used for sample line pump control at each NEON site is presented in the table below. This ambient pressure is calculated using equation below:

$$P = P_b \cdot \left[1 + \frac{L_b}{T_b} \cdot (h - h_b)\right]^{\frac{-g_0 \cdot M}{R \cdot L_b}}$$

where,

P_b = static pressure (pressure at sea level) [Pa]. Here we use ISA standard 101325 Pa

T_b = standard temperature (temperature at sea level) [K]. Here we use ISA standard 15 Celsius (i.e., 288 K)

L_b = standard temperature lapse rate [K/m] = -0.0065 [K/m]

h = height about sea level [m]

h_b = height at the bottom of atmospheric layer [m]

R = universal gas constant = 8.31432 $\left[\frac{N \cdot m}{mol \cdot K}\right]$

g_0 = gravitational acceleration constant = 9.80665 $\left[\frac{m}{s^2}\right]$

M = molar mass of Earth's air = 0.0289644 [kg/mol]

Table 14. Ambient pressure at each NEON sites used for control sample line pump

Domain	Site	Site Type	Latitude	Longitude	Elevation (m)	Barometric pressure (kPa)
1	Harvard Forest	core	42.54	-72.17	348	97.21
1	Bartlett Experimental Forest	relocatable	44.06	-71.29	273	98.08
2	Blandy	relocatable	39.06	-78.07	182	99.16
2	Smithsonian CRC (SCBI)	core	38.89	-78.14	355	97.13
2	Smithsonian ERC	relocatable	38.89	-76.56	10	101.21
3	Ordway	core	29.69	-81.99	48	100.75
3	Jones	relocatable	31.19	-84.47	47	100.77
3	Disney	relocatable	28.13	-81.44	20	101.09
4	Guanica	core	17.97	-66.87	126	99.82

4	Lajas	relocatable	18.02	-67.08	16	101.13
5	Steigerwaldt	relocatable	45.51	-89.58	477	95.72
5	Tree Haven	relocatable	45.49	-89.59	461	95.91
5	UNDERC	core	46.23	-89.54	520	95.23
6	Konza - Core	core	39.10	-96.56	415	96.44
6	Konza - Relocatable	relocatable	39.11	-96.61	323	97.50
6	U Kansas Bio Station	relocatable	39.04	-95.19	321	97.53
7	Oak Ridge	core	35.96	-84.28	342	97.29
7	Great Smokey Mtns	relocatable	35.69	-83.50	661	93.63
7	Mountain Lake	relocatable	37.38	-80.52	1170	88.03
8	Talladega	core	32.95	-87.39	164	99.37
9	Dakota-Coteau	relocatable	47.16	-99.11	575	94.60
9	Northern Great Plains	relocatable	46.77	-100.92	589	94.44
9	Woodworth	core	47.13	-99.24	590	94.43
10	CPER	core	40.82	-104.75	1653	82.97
10	Sterling	relocatable	40.46	-103.03	1365	85.96
10	RMNP Castnet	relocatable	40.28	-105.55	2742	72.43
11	LBJ/Caddo	core	33.40	-97.57	272	98.10
11	Klemme	relocatable	35.41	-99.06	520	95.23
12	Bozeman	relocatable	45.66	-111.05	1503	84.51
12	Yellowstone	core	44.95	-110.54	2129	78.22
13	Niwot	core	40.05	-105.58	3478	65.93
13	Winter Park	relocatable	39.86	-105.86	3526	65.53
13	Moab	relocatable	38.25	-109.39	1800	81.48
14	Santa Rita	core	31.91	-110.84	999	89.88
14	Jornada	relocatable	32.59	-106.84	1321	86.42
15	Onaqui	core	40.18	-112.45	1654	82.96
16	Wind River	core	45.82	-121.95	368	96.98
16	Abby Road	relocatable	45.76	-122.33	367	96.99
17	Soaproot	relocatable	37.03	-119.26	1210	87.60
17	Teakettle	relocatable	37.01	-119.01	2149	78.03
17	San Joaquin	core	37.11	-119.73	397	96.65
18	Toolik	relocatable	68.66	-149.37	827	91.77
18	Barrow	relocatable	71.28	-156.62	7	101.24
19	Caribou-Poker	core	65.15	-147.50	239	98.48
19	Delta Junction	relocatable	63.88	-145.75	504	95.41
19	Healy	relocatable	63.88	-149.21	171	99.29
20	Olaa Forest Reserve	core	19.554785	-155.26	853	91.48

If this pressure is > 55% of ambient pressure, it indicates potential leaks in the sample line or pump loses the capability to maintain the low pressure, or the malfunction of critical orifice. A trouble ticket should be generated and send to field techs.

9.2 Overview of Sensor configuration

The acquisition rate from this sensor shall be once every 1 second (1 Hz). The default sensor configuration settings are given in Table below.

Table 15. Default sensor configuration settings for the absolute pressure transducer.

Parameter	Setting
Excitation	Analog, 9–30 V
Output	Analog, 0.004–0.02 A
Data acquisition frequency	1 Hz
Data acquisition streams	Absolute pressure

L0 data streams from absolute pressure transducers at 1 Hz (DGD CA08830000) can be found in Appendix 15.6.

9.3 Command and Control

N/A

9.3.1 Error handling

N/A

9.3.2 Sensor <unit> controls specification

Table 16. Truth table for controlling sensor (absolute pressure sensor, DGD CA08830000) .

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Absolute pressure in sample line	1 min running average of sample line pressure > 55% of ambient pressure	Generate trouble ticket and send to field technician to check pump conditions, absolute pressure sensor, gas line, etc.	None

10 MASS FLOW METER IN SAMPLE LINES (DGD 0341530000)

10.1 Introduction

Flow meter is used to monitor the flow rate in the sample line from inlet at each tower measurement level to their associated vacuum pump. The flow rate should be within the range of 5-11 SLPM across all NEON sites.

One mass flow meter will be used in one sample line that associated to each tower measurement level. Therefore, the mass flow meter used at NEON tower sites will vary from 4 to 8.

10.2 Overview of sensor configuration

Sensor configuration settings are given in **Error! Reference source not found.**.

Table 17. Mass flow meter configuration settings.

Parameter	Default Setting
Interface	RS–232 or RS–485
Baud rate	38400
Input/output	8 data bits, no parity, 1 stop bit, no flow control
Control valve configuration	Upstream valve
Standard conditions for mass flow calculations	NIST standard conditions (293.15 K, 101.325 kPa)
Gas select	Air
PID parameters	Factory setting
Response time	0.1 s
Positioning	Upright

L0 data streams from mass flow meter (DGD 0341530000) at 1 Hz can be found in Appendix 15.6

Flow rate for each sample line should maintain 5-11 SLMP. Data should be flagged outside the normal operation flow rate ±0.5 SLMP tolerance. These flags will be generated at HQ following the ATBD. The normal operation flow rate will be site specific and measurement level specific, and will be defined in ATBD.

10.3 Command and control

If the flow rate is out of the range, the air plumbing path may be clogging, the tube maybe pinched, or the site may experience power failure (assembly vacuum pump will lost power at this case). To protect the sensors, some command and control on the sample line pump should be done. See the **Sample Line Pumps** section below for details.

10.3.1 Error handling

When the flow rate out of range and the gas pressure flag is set high, a flag will be generated and send to CI.

10.3.2 Controls specification

Table 18. Truth table for controlling sensor <unit>.

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Mass flow rate	Mass flow rate >normal operation flow rate +0.5 SLPM or < normal operation flow rate -0.5 SLPM	Generate a trouble ticket and send to field technician for leak check/clogging	None

11 MASS FLOW CONTROLLER (DGD 0341500000 AND DGD 0341570000)

2 mass flow controllers will be used in the whole profile system assembly:

- 1 to control the validation gases during the validation mode for LI840A IRGA or G2131-I field validation. During LI840A field validation, the flow should be control at 1.5 SLPM; During G2131-I field validation, the flow should be control at 0.3 SLPM; when no validation occurs, the flow controller should be set to 0 SLPM to prevent flow controller overheating. LI840A and G2131-I should never be field validated at the same time. See session 10 for command and control description.
- 1 locates between LI840A IRGA and its pump to maintain the air sample or validation gases to flow through LI840A IRGA cell at the flow rate of 1 SLPM ± 0.2 SLPM at all time.

11.1 Mass flow controller for field validation gases (Val Gas MFC, DGD 0341500000)

11.1.1 Introduction

This mass flow controller (Val Gas MFC) is used to maintain and monitor a constant flow rate of validation gas standards delivered to LI840A IRGA or G2131-I analyzer. 1 mass flow controller will be used at each site for 4 unique CO_2 gas standards and 1 zero air standard. It is located between the Validation Gas Manifold and the tee splitter to CO_2 Sample manifold and IRGA Sample Manifold. At this time, Alicat Scientific P/N: MC-5 SLPM-NEON mass flow controller will be used for this purpose. Below we describe the configuration, command and control related to the operation of this flow controller.

11.1.2 Overview of sensor configuration

Sensor configuration settings are given in **Error! Reference source not found.**.

Table 19. Flow controller (Val Gas MFC) configuration settings (for validation gases)

Parameter	Default Setting
Interface	RS–232
Baud rate	19200
Input/output	8 data bits, no parity, 1 stop bit, no flow control
Control valve configuration	Upstream valve
Standard conditions for mass flow calculations	NIST standard conditions (293.15 K, 101.325 kPa)

Gas select	Air
PID parameters	Factory setting
Response time	0.1 s
Positioning	Upright
Flow set point	1.5 SLPM for LI840A validation 0.3 SLPM for G2131-I validation 0 SLPM when no validation occurs

L0 data streams from mass flow controller (DGD 0341500000) at 1 Hz for validation gases can be founded in Appendix 15.6.

11.1.3 Command and control

N/A

11.1.3.1 Error handling

N/A

11.1.3.2 Controls specification

Table 20. Truth table for controlling sensor (MFC for LI840A validation, DGD 0341500000).

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
Mass flow rate from this mass flow controller during LI840A validation	1 min running average mass flow rate after CO_2 reaches defined absorbtance slope >1.5 SLPM or <1.2 SLPM	Generate a trouble ticket and send to field technician to check MFC setpoint in the codes and MFC conditions, and leak check as needed	None
Mass flow rate from this mass flow controller during G2131-I validation	1 min running average mass flow rate <0.3 SLPM	Generate a trouble ticket and send to field technician to check MFC setpoint in codes and MFC conditions , and leak check as needed	None

11.2 Mass flow controller for LI840A (DGD 0341570000)

11.2.1 Introduction

This mass flow controller is used to maintain and monitor a constant flow rate of sample flow go through LI840A IRGA cell. 1 mass flow controller will be used at each site for this purpose. It is located between LI840A IRGA and its external pump.

11.2.2 Overview of sensor configuration

Sensor configuration settings are given in **Error! Reference source not found.**.

Table 21. Flow controller configuration settings (for LI840A)

Parameter	**Default Setting**
Interface	RS–232
Baud rate	19200
Input/output	8 data bits, no parity, 1 stop bit, no flow control
Control valve configuration	Upstream valve
Standard conditions for mass flow calculations	NIST standard conditions (293.15 K, 101.325 kPa)
Gas select	Air
PID parameters	Factory setting
Response time	0.1 s
Positioning	Upright
Flow set point	1.0 SLPM for LI840A at all time

L0 data streams from mass flow controller at 1Hz (for sample air stream, DGD 0341570000) can be found in Appendix 15.6.

11.2.3 Command and control

N/A

11.2.3.1 Error handling

N/A

11.2.3.2 Controls specification

Table 22. Truth table for controlling sensor (MFC for LI840A sampling, DGD 0341570000).

Control parameter(s)	**Condition**	**Data acquisition system action**	**Flag output to CI as L0 DP**
Mass flow rate from this mass flow controller during LI840A sampling	1 min running average mass flow rate >1.2 SLPM or <0.8 SLPM	Generate a trouble ticket and send to field technician to check MFC setpoint in codes and MFC conditions, and leak check as needed	None

12 EC PROFILE ASSEMBLY INFRASTRUCTURE (DGD CD06640001, CD06640002, CA10210000)

12.1 Introduction of infrastructure

This session describes the configuration, command and control related with the infrastructure, e.g., solenoids, manifolds, pneumatics, etc. within the EC Profile assembly.

12.2 Overview of assembly configuration EC profile assembly

This section is broken into segments which collectively account for the components within the EC profile assembly. This section focuses on the configurations of the Manifold, solenoids, validation manifolds, and heaters. Please refer to appendix for a schematic of the entire EC profile assembly.

Critical flow orifice will be used at each sample line inlet. The air sample pressure will drop to 58.2% of ambient pressure or lower after pass critical flow orifice. This large pressure drop will be sufficient to prevent condensation inside the sampling line at any given environmental conditions found at NEON sites. At this time, same critical flow orifice will be used across all measurement levels at all NEON sites, which will yield flow rate range of 5 to 11 SLPM, but maintain the same laminar flow regime across all measurement levels at all NEON sites

To avoid ice or rime ice to clog the inlet and critical flow orifice, heating should be applied to the screened inlet and critical flow orifice.

Vacuum pump selected should be efficiently enough to provide continuous flow and sufficient pressure drop for each sample line.

From the sample line, a subset of the air sample will be delivered to the analyzers for analysis. To minimize the memory effects of the isotope analysis, the tubing length to deliver this subset of air sample to G2131-I and L2130-I should be as short as possible, ideally < 1 m.

The assembly design should allow LI840A IRGA, G2131-I analyzer and L2130-I analyzer to operate and/or validate independently without interfering each other.

After the interruption of the sensor operation (e.g., after power failure, shut down instrument for maintenance or trouble shutting, etc.), the profile system will resume the operation as following:

1. Calibrate LI840A, validate LI840A, then start normal complete sampling cycle from top most level
2. *Start sampling. When LI840A starts sampling, validation of G2131-I begins if the time elapses beyond 23 hours since last validation, then start normal complete sampling cycle from top most level.*
3. Start normal complete sampling cycle from top most level until field tech starts validation cycle manually, then validate L2130-I, followed by normal complete sampling cycle from top most level

12.2.1 Sample Line Pumps (DGD CD07150000)

Vacuum pump selected should be able to provide continuous flow and sufficient pressure drop for each sample line from inlet to the pump at all NEON terrestrial sites. The absolute pressure readings (DGD CA08830000) behind the inlet critical orifice will be used to feedback to the associated sample line pump and adjust pump speed to maintain the proper pressure drop in the sample line (i.e., 52.8% of ambient pressure or even lower).

Table 23. Default configurations for the Pump

Parameter	Default
Power	on

The default setting for pump will be "on" during normal operation no matter the analyzers are at sampling mode or validation mode. However, when the sample line is clogged, if pump keeps running to pull against vacuum, the pump will eventually be damaged, and can potentially damage other sensors and parts in the system.

The causes of the clog could be i). Ice/hoar frost/rime ice buildup at the screened inlet and clog the orifice; ii). Debris or insects are sucked and stuck at screen inlet; iii). Dirt buildup at the screened inlet and clog the orifice or filter. For the first one, it can be prevented by turning on heater prior to the occurrence of ice/hoar frost/rime ice, which will be discussed in the heater section below. For the second one, if the pump is stopped and pressure is released, the debris or insects should fall off from inlet. If try to stop and restart pump for 3 times, the clog problem is not resolved, the pump should be stop. Similar for the third one, if try to stop and restart pump for 3 times, the clog problem is not resolved, the pump should be stopped.

If flow in the sample line is < 4 SLPM, and dew point temperature (T_d) is above 2 °C (output from both HMP155 sensors at the tower top and at the soil array), stop pump for 2 minutes, then restart and run for 5 min. If the flow rate is still <4 SLPM, repeat again. After third try, if the issue persists, DAS should stop the pump, set pump flag high and send to CI, and also generate a trouble ticket to field tech.

DAS (LC) will control the pump through controlling the voltage applied to the pump. This voltage (0-5 volts) sent to pump will be streamed as L0 DPs and used for post- data process to generate system health flags. 0 volt means pump is stopped. Typical voltage for sampling line pump is around 2.5 to 4.5 volts.

Table 24. Existing data products that will be used in profile system screened inlet heater command and control

Dew/frost point at tower-top (T_{d_t})	NEON.DOM.SITE.DP0.00098.001.01358.000.VER.000 *
Dew/frost point at soil plot (T_{d_s})	NEON.DOM.SITE.DP0.00098.001.01358.003.000.000

*: Vertical measurement level (VER) where the HMP155 locates at tower top varies from site to site.

Table 25. Truth table to control the sample line pumps (DGD CD07150000)

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP

Flow rate in sample line	1 min moving average of the flow rate <4SLPM, and T_{d_t}>2 °C and T_{d_s}>2 °C	Turn off pump for 2 min, and then turn on the pump. If 1 min moving average flow rate < 4 SLPM after 5 min, stop the pump for 2 min and then turn on the pump. If 1 min moving average flow rate < 4 SLPM after 5 min, stop the pump, send trouble ticket to field tech to check inlet clogging and check pump conditions	NA
Flow rate in sample line	1 min moving average of the flow rate <4SLPM, and heater is on (see section 12.3.1 for heater control)	Turn off pump for 2 min, and then turn on the pump. If 1 min moving average flow rate < 4 SLPM after 5 min, stop the pump for 2 min and then turn on the pump. If 1 min moving average flow rate < 4 SLPM after 5 min, stop the pump, send trouble ticket to field tech to check heater and check pump conditions	NA

L0 data products for sample line pumps at 0.2 Hz or faster (DGD CD07150000) can be found in Appendix 15.6.

12.2.2 IRGA sample manifold (CD06640001)

This manifold and its associated solenoid vales control the gas delivered to LI840A IRGA. This manifold shall consist of inlet ports (connected to IRGA sample valves, up to 8, and one additional inlet port to intake validation gas) and 1 outlet port (deliver subset of air sample or validation gas to IRGA). The number of inlet ports on the IRGA Sample Manifold will be used is depended on the number of tower measurement levels, which varies from 4 to 8 (depending on site). Here we use 8 measurement levels as default in this document. During normal sampling operations (default), the configuration of the IRGA sample valves and the IRGA sample manifold is in the table below.

Table 26. Configurations for the IRGA sample manifold

Parameter	Default	Notes
IRGA Sample valves	8 valves, Normally closed	This is to deliver the level specific subset of air sample to IRGA sample manifold.
Inlet ports on IRGA sample manifold (connected to IRGA	8 ports, always open	This is for the level specific subset of air samples to get into the IRGA sample

sample valves)		manifold
Inlet port on manifold (to intake validation gas)	1 port, always open	This is to deliver validation gas through the IRGA sample manifold prior to LI840A IRGA
Outlet port on manifold	1 port, always open	This port is to deliver the level specific subset of air sample or validation gas to LI840A IRGA

12.2.3 H_2O sample manifold (CD06640001)

This manifold shall consist of inlet ports (connected to H_2O Sample valves, up to 8) and 1 outlet port (deliver subset of air sample to analyzer). The number of inlet ports on the profile manifold will be used is depended on the number of tower measurement levels, which varies from 4 to 8 (depending on individual site). Here we use 8 measurement levels as default in this document. There is one additional inlet port on this manifold to allow the zero air to flow through the manifold from the H_2O Manifold Zero Air Valve to L2130-I instrument. During normal sampling operations (default), the configuration of the Sample Level Select Valves and the Isotopic H_2O sample level manifold is in the table below.

Table 27. Configurations for the **H_2O** Sample manifold

Parameter	Default	Notes
H_2O sample valves	8 valves, Normally closed	This is to deliver the level specific subset of air sample to Isotopic H_2O sample level manifold
Inlet ports on manifold (connected H_2O sample valves)	8 ports, always open	This is for air samples to get into the Isotopic H_2O sample level manifold
Inlet ports on manifold (connected to H_2O Manifold Zero Air Valve)	1 port, always open	This is for zero air to get into the H_2O Sample manifold during validation mode.
Outlet port on manifold	1 port, always open	This port is to deliver the level specific subset of air sample or zero air to L2130-I analyzer.

12.2.4 Valves to deliver zero air to L2130-I (DGD CD06640001, DGD CD06640002, CA10210000)

There are four valves in the design to deliver the Zero Air to L2130-I analyzer:

1. H_2O Analyzer WLM Purge Valve (DGD CD06640002)

2. H_2O Analyzer Zero Air Valve (DGD CD06640001)
3. Vaporizer 3-way Valve (DGD CA10210000)
4. H_2O Manifold Zero Air Valve (DGD CD06640001)

During the sampling model, the four valves should be closed to avoid the zero air flow to H_2O Sample Manifold; and H_2O Analyzer WLM Purge Valve, H_2O Analyzer Zero Air Valve, and Vaporizer 3-way Valve should open during the validation mode to allow the zero air to flow to the vaporizer and analyzer. While H_2O Manifold Zero Air Valve should only open before the instrument shut down to allow the zero air to flush the H_2O Sample Manifold and L2130-I laser cavity to prevent water vapor condensation.

See their configuration in the table below. Command and control statements are provided for these sampling / validation solenoids in Section 7.3.

Table 28. Configurations for **H_2O** Analyzer WLM Purge Valve, **H_2O** Analyzer Zero Air Valve, Vaporizer 3-way Valve and **H_2O** Manifold Zero Air Valve

Parameter		**Default**	**Field validation mode**	**Notes**
H_2O Analyzer WLM Purge Valve		Normally closed	Open	
H_2O Analyzer Zero Air Valve		Normally closed	Open	
Vaporizer 3-way Valve	Inlet port 1	Normally open	Closed	Connect to H_2O Sample Manifold
	Inlet port 2	Normally closed	Open	Connect to a Tee between vaporizer purge port and H_2O Analyzer Zero Air Valve
	Outlet port	Always open	Open	Common port, connect to vaporizer Sample port
H_2O Manifold Zero Air Valve		Normally closed	Closed	Only open before instrument shut down to flush H_2O Sample manifold and L2130-I laser cavity

12.2.5 CO_2 sample manifold (CD06640001)

This manifold and its associated solenoid vales control the gas delivered to G2131-I analyzer. This manifold shall consist of inlet ports (connected to CO_2 sample valves, up to 8, and one additional inlet port to intake validation gas) and 1 outlet port (deliver subset of air sample or validation gas to analyzer). The number of inlet ports on the CO_2 sample manifold will be used is depended on the number of tower measurement levels, which varies from 4 to 8 (depending on site). Here we use 8 measurement levels as default in this document. During normal sampling operations (default), the configuration of the CO_2 sample valves and the CO_2 sample manifold is in the table below.

Table 29. Configurations for the Isotopic **CO_2** sample manifold

Parameter	Default	Notes
CO_2 Sample valves	8 valves, Normally closed	This is to deliver the level specific subset of air sample to CO_2 sample manifold.
Inlet ports on CO_2 sample manifold (connected to CO_2 sample valves)	8 ports, always open	This is for the level specific subset of air samples to get into the CO_2 sample manifold
Inlet port on manifold (to intake validation gas)	1 port, always open	This is to deliver validation gas through the CO_2 sample manifold prior to G2131-I analyzer
Outlet port on manifold	1 port, always open	This port is to deliver the level specific subset of air sample or validation gas to G2131-i analyzer.

12.2.6 Validation Gas Manifold (DGD CD06640001)

The Validation Gas Manifold and its associated valves will be used to control the known gas standards to G2131-I analyzer or LI840A for field validation. No validation for these two instruments should occur at the same time. The known gas standards will be used include 3 cylinders of CO_2 at high, intermediate and low concentrations and 1 zero air for routine validation of LI840A IRGA (frequency is every 23 hours between IRGA calibration). Same 3 CO_2 standards will be used for the routine validation of G2131-I (frequency is once every 23 hours), but no zero air will be used. 1 archive cylinder of CO_2 at a concentration around 400 ppm will be used for field validation of LI840A IRGA and G2131-I at a longer time period (monthly).

The Validation Gas Manifold and its associated valves will be used to control the known gas standards to LI840A IRGA for field calibration, which should occur every 6 days or when IRGA cell pressure fluctuation >= 1.2 kPa to minimize the impact of the analyzer drift on data quality. See command and control section below for the sequence of field validation and calibration.

The Val Gas Select valves that are attached to the Validation Gas Manifold will pass a specific flow of CO_2 of known concentration into the Validation Gas Manifold, to the Val Gas MFC, then to the tee splitter to CO_2 Sample manifold and IRGA Sample Manifold, and to either the CO_2 sample manifold during G2131-I field validation or to the IRGA Sample Manifold during LI840A field validation or field calibration. LI840A field validation or field calibration should not occur at the same time with G2131-I validation.

Each span gas line will equip with a Val Gas select valve. The validation sequence should be from low CO_2 concentration to high CO_2 concentration. Only one gas standard is delivered to t either LI840A or G2131-I analyzer at a given time. The Val Gas select valves should be 2-way solenoid valves. Inlet ports of the Val Gas valves are connected to CO_2 gas cylinders, and the outlet ports of the valves are connected to the Val Gas MFC. During normal sampling operations (default), the configuration of this 2-way solenoid valves is normally closed.

Validation Gas Manifold has 5 inlet ports to intake the validation gases, and 1 outlet port to deliver the validation gases to the CO_2 Sample manifold or to the IRGA Sample Manifold. During normal sampling operations (default), the configuration of this manifold is showed in the table below.

Table 30. Default configurations for the Isotopic **CO_2** Validation Gas Manifold

Parameter	Default	Notes
Val Gas select valves	5 valves, Normally closed	This is to deliver the validation gas from gas cylinders to Validation Gas Manifold
Inlet ports on manifold (connected to Val Gas select valves)	5 ports, always open	This is for the validation gas to get into the Validation Gas Manifold.
Outlet port on manifold	1 port, always open	This port is to deliver validation gas from the Validation Gas Manifold to the CO_2 Sample manifold or to the IRGA Sample Manifold.
CO_2 Val Gas Valve	1 port, Normally closed	This is to deliver the validation gas from the Validation Gas Manifold to the CO_2 Sample manifold.
IRGA Val Gas Valve	1 valve, Normally closed	This is to deliver the validation gas from the Validation Gas Manifold to the IRGA Sample Manifold.
IRGA Vent Valve	1 valve, Normally closed	This is not used during sampling mode or calibration/validation mode. It can be used to purge gas through the system when gas cylinder is changed.

12.3 Command and Control

A number of command and control algorithms shall be implemented to monitor and control the functionality of the EC profile assembly. The following command and control statements deal with heating and the control of multiple solenoids within the system. Unfortunately, many errors that may occur within the system, such as leaks, cannot be fixed via command and control and must be manually fixed by a field technician. For more information on the latter please refer to the Standard Operating Procedures document (AD [05]).

12.3.1 Heaters (No DGD)

To avoid ice or rime ice to clog the inlet and critical flow orifice, heating should be applied to the screened inlet and critical flow orifice at each tower measurement levels. Heating should be at low heat (maximum 50 W and not exceed heating of 70 Celsius at any time) to avoid the stable isotopic fractionation.

Heater control is based on the ambient air and the conditions when rime ice could happen (when the air temperature equals or is lower than the dew point temperature, and the air temperature reads close to or below water freezing point (0 °C). So, if air temperature is within 2 °C above the dew point temperature, and air temperature is ≤0°C, then turn on the heater. After heater is on, heating should be maintained at 10 Celsius +/- 5 Celsius above dewpoint temperature. When air temperature is 5 °C higher than dew point temperature, then turn the heater off.

However, since there is multiple measurement levels on the vertical tower profile, and each level has its own temperature measurement and humidity measurement, it will be very complicated to do boom specific heater command and control. Therefore, we decide to only look at the dewpoint temperature and air temperature outputted by HMP155 sensors assembly at the tower top and at the ground level at soil array, which typically bound the worst freezing conditions. The logic is to compare the conditions at tower top and at the ground level, if one of them approaches the frost conditions, then turn on the screened inlet heaters on all profile levels at the same time. When air temperature is 5 °C higher than dew point temperature at both tower top and at ground level, turn off the screened inlet heaters on all profile levels at the same time. To minimize the uncertainty among sampling levels, heating applied to intake tube inlet at all measurement levels at that site shall be triggered on and/or off at the same time (+/- 5 s).

Because heater used in profile system does not have chip, thus is not a data generate device (DGD), therefore the heater on/off status cannot be streamed back to CI as L0 data products. But the heating time period can be flagged during post data process using same algorithms below. See heater command and control below.

Table 31. Existing data products that will be used in profile system screened inlet heater command and control

L0 data product	L0 data product code
Dew/frost point at tower-top (T_{d_t})	NEON.DOM.SITE.DP0.00098.001.01358.000.VER.000*
Dew/frost point at soil plot (T_{d_s})	NEON.DOM.SITE.DP0.00098.001.01358.003.000.000
Aspirated air temperatures at tower top (T_{air_t})	NEON.DOM.SITE.DP0.00098.001.01309.000.VER.000*
Aspirated air temperature at bottom boom (T_{air_b})	NEON.DOM.SITE.DP0.00098.001.01309.003.000.000

*: Vertical measurement level (VER) for the tower top HMP155 varies from site to site, depending on how many measurement levels are at that site.

Table 32. Truth table to control the screened inlet heater (no DGD)*

Control parameter(s)	Condition	Data acquisition system action	Flag output to CI as L0 DP
T_{air_t}, T_{d_t}, T_{air_b}, T_{d_s}	If (T_{air_t} < T_{d_t}+2 °C and T_{air_t}≤ 0 °C) or (T_{air_b} < T_{d_s}+2 °C and T_{air_b}≤ 0 °C)	Turn heater on	NA
T_{d_t}, T_{d_s}	If $T_{d\_t} > T_{d\_s}$	Heater on and maintain inlet heating at 10±5 °C above T_{d_t}	NA
T_{d_t}, T_{d_s}	If $T_{d\_t} < T_{d\_s}$	Heater on and maintain inlet	NA

		heating at 10±5 °C above T_{d_s}	
T_{air_t}, T_{d_t}, T_{air_b}, T_{d_s}	If $T_{air\_t} > T_{d\_t}$+5 °C and $T_{air\_b} > T_{d\_s}$+5 °C	Turn heater off	NA

*: all data in this table is 1 min trailing average from HMP155 humidity sensors

12.3.2 Cycling of Profile Solenoids during sampling mode

The Sample Valves will be used here to subsample and deliver air samples to LI840A, G2131-i and L2130-I analyzers. In order to properly subsample the incoming ambient air at each level of the tower, cycling of the Sample Valves connected to IRGA Sample Manifold, H_2O Sample Manifold and CO_2 Sample Manifold should be completed from highest (vertical height) to lowest level of the tower and consistent among sites.

The tower measurement levels vary from 4 levels to 8 levels. Using the same definition in other NEON document, **measurement level 1 should be the bottom most level. The level number increase with the vertical tower height**.

12.3.2.1 LI840A sampling (DGD CD06640001)

For LI840A, a complete cycle of profile sampling measurements will include all measurement levels from the top most level to the bottom most level at that site. Table below shows the command and control structure for 1 normal complete cycle under sampling mode. Time 0 is the time that the sampling mode starts in a complete cycle. Δt is the time length needed to complete sampling at one measurement level, which include the times for settling (including purge, stabilization, solenoid switching) and measurement. We define Δt is **3 minutes** in the current design. When sampling measurement resumes after interruptions (e.g., power failure, calibration/validation, maintenance, etc.), a complete sampling cycle should start from highest (vertical height) to lowest level of the tower. One measurement cycle should immediately be followed by next measurement cycle without break except for periodical field validation or field calibration.

Table 33. Example of one cycle sequence for IRGA Sample Valves* (1 for open, and 0 for closed, assume 8 levels).

IRGA Sample valve status	Sampling mode								Calibration/validation mode
	0	Δt	2 Δt	3 Δt	4 Δt	5 Δt	6 Δt	7 Δt	
Level 8	1	0	0	0	0	0	0	0	1
Level 7	0	1	0	0	0	0	0	0	0
Level 6	0	0	1	0	0	0	0	0	0
Level 5	0	0	0	1	0	0	0	0	0
Level 4	0	0	0	0	1	0	0	0	0

Level 3	0	0	0	0	0	1	0	0	0
Level 2	0	0	0	0	0	0	1	0	0
Level 1	0	0	0	0	0	0	0	1	0

Note:*: IRGA sample valve at the top most measurement level is open during LI840A calibration/validation to maintain stable IRGA cell pressure.

L0 data streams from IRGA Sample Valves at 0.2 Hz (DGD CD06640001) can be found in Appendix 15.6.

12.3.2.2 G2131-I and L2130-I sampling (DGD CD06640001)

For G2131-I and L2130-I, a complete cycle of profile sampling measurements will include all measurement levels from the top most level to the bottom most level at that site. Table below shows the command and control structure for the normal process under sampling mode. Time 0 is the time that the sampling mode starts in a complete cycle. Δt is the time length needed to complete sampling at one measurement level, which include the times for settling (including purge, stabilization, solenoid switching) and measurement. We define ***Δt* is 10 minutes** in the current design. When sampling measurement resumes after interruptions (e.g., power failure, calibration/validation, maintenance, etc.), a complete sampling cycle should start from highest (vertical height) of the tower. One measurement cycle should immediately be followed by next measurement cycle without break except for periodical field validation.

Table 34. Example of one cycle sequence for **CO_2** Sample Valves or **H_2O** Sample Valves (assume 8 levels).

Sample valve status	**Sampling mode starting time**							
	0	*Δt*	2*Δt*	3 *Δt*	4*Δt*	*5 Δt*	6*Δt*	*7 Δt*
Level 8	1	0	0	0	0	0	0	0
Level 7	0	1	0	0	0	0	0	0
Level 6	0	0	1	0	0	0	0	0
Level 5	0	0	0	1	0	0	0	0
Level 4	0	0	0	0	1	0	0	0
Level 3	0	0	0	0	0	1	0	0
Level 2	0	0	0	0	0	0	1	0
Level 1	0	0	0	0	0	0	0	1

Notes:

a. If a site has both G2131-I and L2130-I analyzers, the cycle sequence above will be identical for Sample Valves connect to **H_2O** Sample Manifold and **CO_2** Sample Manifold.

b. 1 = open valve, 0 = close valve.

L0 data streams from **CO_2** Sample Valves and **H_2O** sample Valves at 0.2 Hz (DGD CD06640001) can be found in Appendix 15.6.

Important notes:

1. **Picarro G2131-I and Picarro L2130-I will always sample at the same level at the same time period while they are not in validation mode; However, although both G2130-I and L2130-I have the same validation interval of 23 hours, because L2130-Ivalidation cannot start until somebody manually initiate the validation process, G2131-I and L2130- I do not have the same field validation schedule. There are two scenario:**
    a. **Both G2131-I and L2130-I sample at the same level at the same time, then G2131-I starts the field validation. L2130-I should proceed for sampling as normal. Once G2131-I finishes the field validation, both G2131-I and L2130-I should start a complete sampling cycle from the top most level.**
    b. **Both G2131-I and L2130-I sample at the same level at the same time, then L2130-I starts the field validation. G2131-I should proceed for sampling as normal. Once L2130-I finishes the field validation, both G2131-I and L2130-I should start a complete sampling cycle from the top most level.**
2. **LI840A should never sample at the same level with Picarro G2131-I and Picarro L2130-I at any given time to avoid the large pressure fluctuation that could exceed instruments' capability to handle. There are two scenarios:**
    a. **Picarro instruments proceeds to a measurement level ahead of LI840A. Under this kind of situation, LI840A should skip this level and move to next level in sequence.**
    b. **LI840A proceeds to a measurement level ahead of Picarro instruments. When Picarro instruments proceed to this level, LI840A should stop measurements at this level immediately and move to next level in sequence.**

12.3.3 LI840A Field calibration and field validation (DGD CD06640001, DGD CD06640002)

Field calibration is only applied to LI840A IRGA CO_2 channel. No H_2O channel will be calibrated at field. The field calibration of the LI840A should occur after LI840A resumes operation from the interruptions (e.g., power failure, periodical instrument shut down for maintenance, etc.) or after IRGA cell experiences pressure fluctuation >= 1.2 kPa. Field calibration should repeat every 6 days thereafter (i.e., day 1, day 7, day 13, ….).

Field calibration should be done at steady-state (i.e., when absorptance slope (based on the regression of last 20 sample points at 1Hz sampling frequency) in moving windows is < $1x10^{-5}$, then perform calibration) using a two-point calibration consisting of a zero air (<0.5 µmol CO_2 mol^{-1}) and a high CO_2 concentration gas standard (450-500 µmol CO_2 mol^{-1}). Since it typically take ~2 min to reach absorptance slope < $1x10^{-5}$, the calibration using one gas standard typically takes < 5 min. To avoid wasting gas, if it takes >5 min to reach absorptance slope < 1x10−5, then force to perform field calibration at the end of 5 min. **Once the zero or span command is sent,**

zero gas or span gas should run for additional 1 min. This will allow us to collect additional measurements with reference gases and with the new calibration applied, which will be used in later ATBD process. Routine field calibration should start at the end of a full sampling cycle at every 143 hour (5 days plus 23 hours), or at the closest possible time after 143 hour expires.

Calibration coefficients results from field calibration should be sent back to CVAL periodically for records. CVAL will then submit this info to CI for archival and for the use in post-data process.

Routine field validation will occur daily (every 23 hours) between field calibrations. File validation should be performed at steady-state (i.e., when absorptance slope (based on the regression of last 20 sample points at 1Hz sampling frequency) in moving windows < $1x10^{-5}$, and trailing 2.5 min average). To avoid wasting gas, if it takes >5 min to reach absorptance slope < 1x10−5, then the 2.5 min averaging time start counting at the end of the 5 min. The validation should start at the end of a full sampling cycle at every 23 hour, or at the closest possible time after 23 hour expires.

Monthly field validation will occur once a month using same gas standards for routine validation plus an additional 'archived' CO_2 gas standard. The strategy to determine the steady-state and trailing 2.5 min average is identical to the field calibration strategy above.

During the sampling model, Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve should be closed. While during the validation mode, these valves should be open to allow selected validation gas flowing to IRGA Sample Manifold. The flag status should be 0 for sampling (valve closed), and 1 for validation/calibration (valve open). During validation mode, only one known gas standard will be delivered at a time to the analyzer to avoid cross contamination. The flow rate is **1.5 SLPM** prior to IRGA Val Gas Valve (controlled by the flow controller). IRGA Vent valve is only used to purge the gas after gas cylinder is replaced.

When zero air is used for LI840A field calibration, the sequence is zero H_2O, then Zero CO_2.

Table 35. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during field calibration of LI840A.

<table>
<tr><th colspan="2" rowspan="2">Validation valves</th><th rowspan="2">Sampling Mode</th><th colspan="2">Field calibration starting time</th></tr>
<tr><th>0</th><th>Δt+1 min</th></tr>
<tr><td rowspan="5">Val Gas Select valves status (0/1)</td><td>Zero Air</td><td>0</td><td>1§</td><td>0</td></tr>
<tr><td>Low CO_2</td><td>0*</td><td>0</td><td>0</td></tr>
<tr><td>Intermediate CO_2</td><td>0*</td><td>0</td><td>0</td></tr>
<tr><td>High CO_2</td><td>0*</td><td>0</td><td>1</td></tr>
<tr><td>Archive CO_2</td><td>0*</td><td>0</td><td>0</td></tr>
<tr><td colspan="2">IRGA Val Gas Valve status (0/1)</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">IRGA Vent Valve status (0/1)</td><td>0</td><td>0</td><td>0</td></tr>
</table>

Notes:

1) 1 = open valve, 0 = close valve.
2) *Δt* = x min, where x min is the purge time depending on the time length to reach steady-state. Max value for x is 5 min); zero or span command is sent once steady-state is reached. Zero or span reference gas should run for additional 1 min after the zero or span commend is sent.
3) *: The status in these cells could be 1 if G2131-I is at validation mode.
4) §:When zero air is used for LI840A field calibration, the sequence is zero **H_2O**, then Zero **CO_2**

Table 36. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during routine field validation of LI840A.

Validation valves		**Sampling Mode**	**Routine validation mode starting time**			
			0	*Δt*	*2 Δt*	*3 Δt*
Val Gas Select valves status (0/1)	Zero Air	0	1	0	0	0
	Low CO_2	0*	0	1	0	0
	Intermediate CO_2	0*	0	0	1	0
	High CO_2	0*	0	0	0	1
	Archive CO_2	0*	0	0	0	0
IRGA Val Gas Valve status (0/1)		0	1	1	1	1
IRGA Vent Valve status (0/1)		0	0	0	0	0

Notes:

a. 1 = open valve, 0 = close valve.
b. *Δt* = x min + 2.5 min, where x min is the purge time depending on the time length to reach steady-state. Max value for x is 5 min); 2.5 min is the time length using for trailing average after reach steady state.
c. *: The status in these cells could be 1 if G2131-I is at validation mode.

Table 37. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during the monthly 'archive' validation of LI840A

Validation valves		**Sampling Mode**	**Monthly validation mode starting time**				
			0	*Δt*	*2 Δt*	*3 Δt*	*4 Δt*
Isotopic CO_2 transfer standard span gas select valves status (0/1)	Zero air	0	1	0	0	0	0
	Low CO_2	0*	0	1	0	0	0
	Intermediate CO_2	0*	0	0	1	0	0
	High CO_2	0*	0	0	0	1	0
	Archive CO_2	0*	0	0	0	0	1
IRGA Validation Gas Solenoid Valve status (0/1)		0	1	1	1	1	1
IRGA Validation Gas Vent Solenoid Valve status (0/1)		0	0	0	0	0	0

Notes:

a. 1 = open valve, 0 = close valve.
b. *Δt* = x min + 2.5 min, where x min is the purge time depending on the time length to reach steady-state. Max value for x is 5 min); 2.5 min is the time length using for trailing average after reach steady state.
c. *: The status in these cells could be 1 if G2131-I is at validation mode.

L0 data products for LI840A field calibration/validation or for G2131-I validation (DGD CD06640001, and DGD CD06640002) at 0.2 Hz can be found in Appendix 15.6.

12.3.4 G2131-I and L2130-I Field Validation

The validation of LI840A, G2131-I and L2130-i analyzers should be performed periodically and independently without impacts to each other. The command and control structure for each of G2131-I and L2130-I Field validation processes are presented in the subsequent sessions.

12.3.4.1 G2131-i Isotope Analyzer Validation (DGD CD06640001)

The G2131-i analyzer should undergo a routine validation at a frequency of **once every ~23 hours** using the CO_2 at 3 different concentrations from ~300 ppm to 600 ppm and with $\delta^{13}C$ of -5 ‰ to -23 ‰, and at a lower frequency of once a month using the archiving CO_2 (~400 ppm). CO_2 gas standards at different concentrations will be routed through Val Gas Select valves, Validation Gas Manifold, a mass flow controller, the CO_2 Val Gas Valve, and CO_2 Sample Manifold prior to the analyzer.

During normal sampling operation, Val Gas Select valves should be closed. During validation mode, only one known CO_2 gas standard will be delivered at a time to the analyzer to avoid cross contamination. There will be 4 valves for 4 CO_2 gases. These valves are normally closed, but are activated to open in sequence during validation. The validation sequence should be from low CO_2 concentration to high CO_2 concentration. Validation with the archiving CO_2 will coincide with an instance of routine field validation. The valve for Zero air should be closed during G2131-I validation. However, the valve for Zero air should be open prior to instrument shut down to prevent the water vapor condensation inside the laser cavity. The zero air used to purge G2131-I cavity during instrument shut down is the same zero air cylinder used for LI840A calibration/validation.

During normal sampling operation, the CO_2 Val Gas Valve should be closed. During field validation, the CO_2 Val Gas Valve will open to deliver the known CO_2 standard gas to G2131-I analyzer. The flag status should be 1 for open, and 0 for close. The flow rate should be controlled at **0.3 SLPM** using a mass flow controller.

The validation should occur every 23 hours. The validation should start at the end of a full sampling cycle that is closest to the 23-hour interval.

Δt is the time length needed to complete a validation using 1 standard gas. It should include the times for settling (including purge, stabilization, solenoid switching) and measurement.

At current design, *Δt* is 10 min (including 2 min flushing time and 8 min averaging time). Therefore, to complete a full cycle of field validation for G2131-I, it will take 40 minutes for a routine field validation, and it will take 50 minutes for a field validation to include the additional "archive" CO_2 standard.

Tables below show the command and control structure for the routine validation process and monthly "archive" validation, respectively.

Table 38. Cycling sequence for the Val Gas Select valves and the **CO_2** Val Gas Valve during routine field validation of G2131-I.

Validation valves		**Sampling Mode**	**Routine validation mode starting time**		
			0	*Δt*	2 *Δt*
Val Gas Select valves status (0/1)	Zero Air	0	0	0	0
	Low CO_2	0*	1	0	0
	Intermediate CO_2	0*	0	1	0
	High CO_2	0*	0	0	1
	Archive CO_2	0*	0	0	0
CO_2 Val Gas Valve status (0/1)		0	1	1	1

Notes:

1) 1 = open valve, 0 = close valve.
2) *Δt* = 10 min
3) *: The status in these cells could be 1 if LI840A is at validation mode.

Table 39. Cycling sequence for the Val Gas Select valves and the **CO_2** Val Gas Valve during the monthly 'archive' validation of G2131-I.

Validation valves		**Sampling Mode**	**Monthly validation mode starting time**			
			0	*Δt*	2 *Δt*	*3 Δt*
Val Gas Select valves status (0/1)	Zero air	0	0	0	0	0
	Low CO_2	0*	1	0	0	0
	Intermediate CO_2	0*	0	1	0	0
	High CO_2	0*	0	0	1	0
	Archive CO_2	0*	0	0	0	1
CO_2 Val Gas Valve status (0/1)		0	1	1	1	1

Notes:

1) 1 = open valve, 0 = close valve.
2) *Δt* =10 min
3) *: The status in these cells could be 1 if LI840A is at validation mode.

L0 data products for G2131-I validation are presented under the section of "LI840A field calibration and field validation".

12.3.4.2 L2130-i Isotope Analyzer Routine Validation (CD06640001, CD06640002)

Validation of the H_2O isotope analyzer should take place every 23 hours using zero air and liquid water standards prepared by NEON CVAL. Only 1 Job will be scheduled by CVAL with 23 hour interval setting, field techs has to restart this validation Job manually at every two weeks while they are at site or after the Job is finished. Otherwise, after the Job is finished, the L2130-i will continue doing ambient air sampling until the Job is manually started again. Therefore, there is no automatic control when the new validation process will start. It really depends on when the field tech will be at field. Given 23 hours validation interval, 45 vials can last longer than 2 weeks of normal field tech visit schedule.

The validation process for this analyzer utilizes four valves (H_2O Analyzer WLM Purge Valve, H_2O Analyzer Zero Air Valve, H_2O Manifold Zero Air Valve, and Vaporizer 3-way Valve), zero air gas, an Auto Sampler and Vaporizer. During the sampling model, the four valves should be closed to avoid the zero air flow to H_2O Sample Manifold; and H_2O Analyzer WLM Purge Valve, H_2O Analyzer Zero Air Valve, and Vaporizer 3-way Valve should open during the validation mode to allow the zero air to flow to the vaporizer and analyzer. While H_2O Manifold Zero Air Valve only open before the instrument shut down to flush the laser cavity to prevent water vapor condensation. The flag status should be 1 for open and 0 for closed.

Table 40. Command and control for **H_2O** Analyzer WLM Purge Valve, **H_2O** Analyzer Zero Air Valve, Vaporizer 3-way Valve and **H_2O** Manifold Zero Air Valve during routine field validation of L2130-I (1 = open valve, 0 = close valve.)

Parameter		Sampling mode	Field validation mode	Notes
H_2O Analyzer WLM Purge Valve status (0/1)		0	1	
H_2O Analyzer Zero Air Valve status (0/1)		0	1	
Vaporizer 3-way Valve status (0/1)*	Inlet port 1	1	0	Connect to H_2O Sample Manifold
	Inlet port 2	0	1	Connect to a Tee between vaporizer purge port and H_2O Analyzer Zero Air Valve
H_2O Manifold Zero Air Valve status (0/1)		0	0	Only open before instrument shut down to flush H_2O Sample manifold and L2130-I laser cavity

* When this 3-way valve is inactive (flag = 0), port1 is NO, and port2 is NC, this is for sampling air to go through; when this 3-way valve is active (flag = 1), port1 is closed, and port2 is open, this is for validation gas to go through.

L0 data streams from IRGA Sample Valves at 0.2 Hz (DGD CD06640001, CD06640002, and CA10210000) can be found in Appendix 15.6.

12.3.4.3 L2130-I Isotope Humidity Dependency Validation

It is known that isotopic analysis using CRDS instruments is sensitive to humidity. The isotope dependency of each L2130-I to humidity will be characterized at CVAL prior to deployment, and should be re-characterized at field prior to operation, and annually thereafter at the same time period when conduct annual field calibration. The functions of isotope dependency to humidity will be used to post correct the data collected from measurements.

Field tech needs to start this process manually while they are at site. It typically last for 3 days. The Jobs for this validation will be pre-coded in the L2130-I analyzer computer by CVAL, but should be triggered by field tech manually. CVAL will provide water standards for this task, and also provide field tech the instructions to conduct this validation as well as provide the templates for data process.

During this validation, the valve settings and data products will be identical to the routine validation.

12.3.4.4 L2130-I Annual field calibration and drift test

Accordingly to currently plan, the L2130-i will not return to CVAL for annual calibration, unless absolutely needed. Instead, annual accuracy test, calibration slope test and drift test will be performed at field to quantify the instrument accuracy and drift.

We proposed this annual field calibration of L2130-I to be done during the time period when G2131-I is sent back to CVAL for lab calibration and the profile system maintenance occurs. Field tech needs to start this process manually while they are at site. It typically last for a week. The Jobs for this validation will be pre-coded in the L2130-I analyzer computer by CVAL, but should be triggered by field tech. CVAL will provide water standards for this task, and also provide field tech the instructions to conduct this validation as well as provide the templates for data process.

During this field calibration, the valve settings and data products will be identical to the routine validation. However, the pump could stop pulling air samples into sample lines during this L2130-I validation. We propose to use this same time period to conduct maintenance to sample line pumps, PICARRO pumps, autosampler, vaporizer, and return G2131-I analyzer back to CVAL for annual calibration. This will maximize the profile data product availability.

Leak test should be conducted after maintenance, but will be described in NEON document, AD [05]).

12.3.5 Error handling

N/A

12.3.6 Sensor <unit> controls specification

N/A

13 ASSEMBLY INTEGRATION

N/A

14 FUTURE DEVELOPMENT

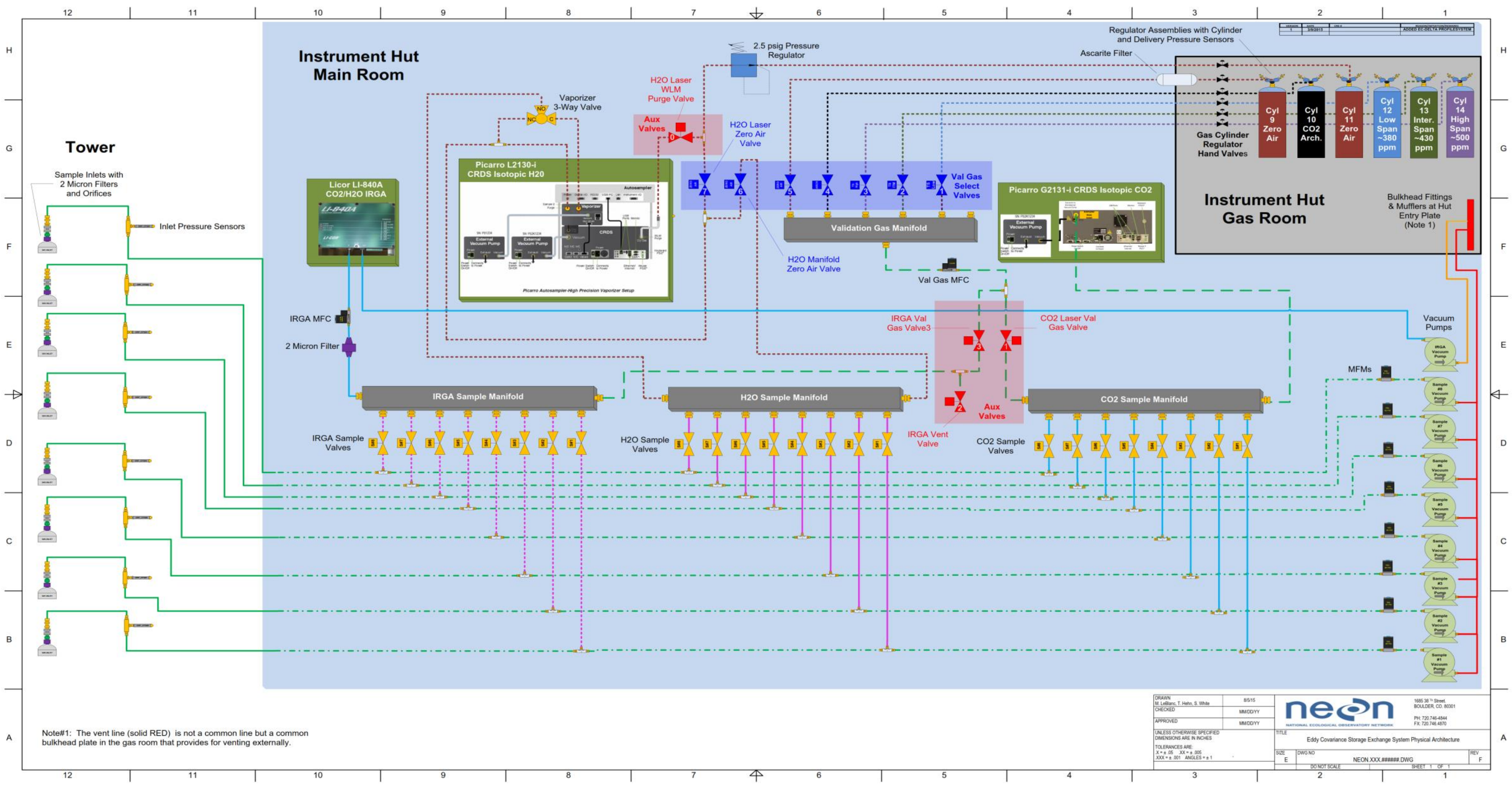
There was suggestion from science community that the profile stable isotopic measurements should not always sampling from top level to the bottom level. Instead, to avoid systematic bias, at least 3 different sampling cycle sequences should be adapted and changed periodically (say, every few days or few weeks). We only include the sequence of top-to-bottom scenario in this document to simplify the process. Once this profile system is successfully implemented and data process is developed, other sampling cycle sequences can be considered per the request from science community. This command, control and configuration document should be revised accordingly then.

There is another suggestion from science community that a reference level should be used for the G2131-I and L2130-I profile measurement. Because it takes over 1 hour to finish a complete sampling cycle for a site with 8 measurement levels, the stable isotope signal may not be suitable to construct a profile. So the suggestion is to include a measurement at reference level between each measurement level so that the measurements over time can have a common comparable reference. The level that is designated to be reference level should be relative stable compared to rest levels. The top most level was suggested due to this reason, which is above canopy in the well mixed surface layer. However, we decided not to include this reference measurement in the current design due to following reasons:

1. Adding a reference level to the measurements will reduce the G2131-I and L2130-I complete sampling cycles to half, which means longer time interval apart between two neighbor cycles and less ideal to develop vertical profile;
2. G2130-I and L2130-I should never take the measurements at the same measurement level at the same time with LI840A, and G2130-I and L2130-I take precedence over LI840A at each measurement level. With G2130-I and L2130-I measurements repeat frequently at the reference level (especially at the top level), it will limit LI840A measurements of CO_2/H_2O concentrations at that level, thus impacts the subsequent CO_2/H_2O storage term calculations;
3. The higher level data products of stable isotope are unknown/unplanned at this moment, thus we do not know how the data will be used to developed higher data products, and not sure if the reference level will be useful or not; Since flux and storage term measurements and calculations are more mature methodology, we decide to give the priority to the good flux and storage measurements and calculation over the stable isotope measurements by not include a reference levels for stable isotope measurements at this moment, but it can be add in the future as needed.

15 APPENDIX & BIBLIOGRAPHY

15.1 EC profile assembly Schematic



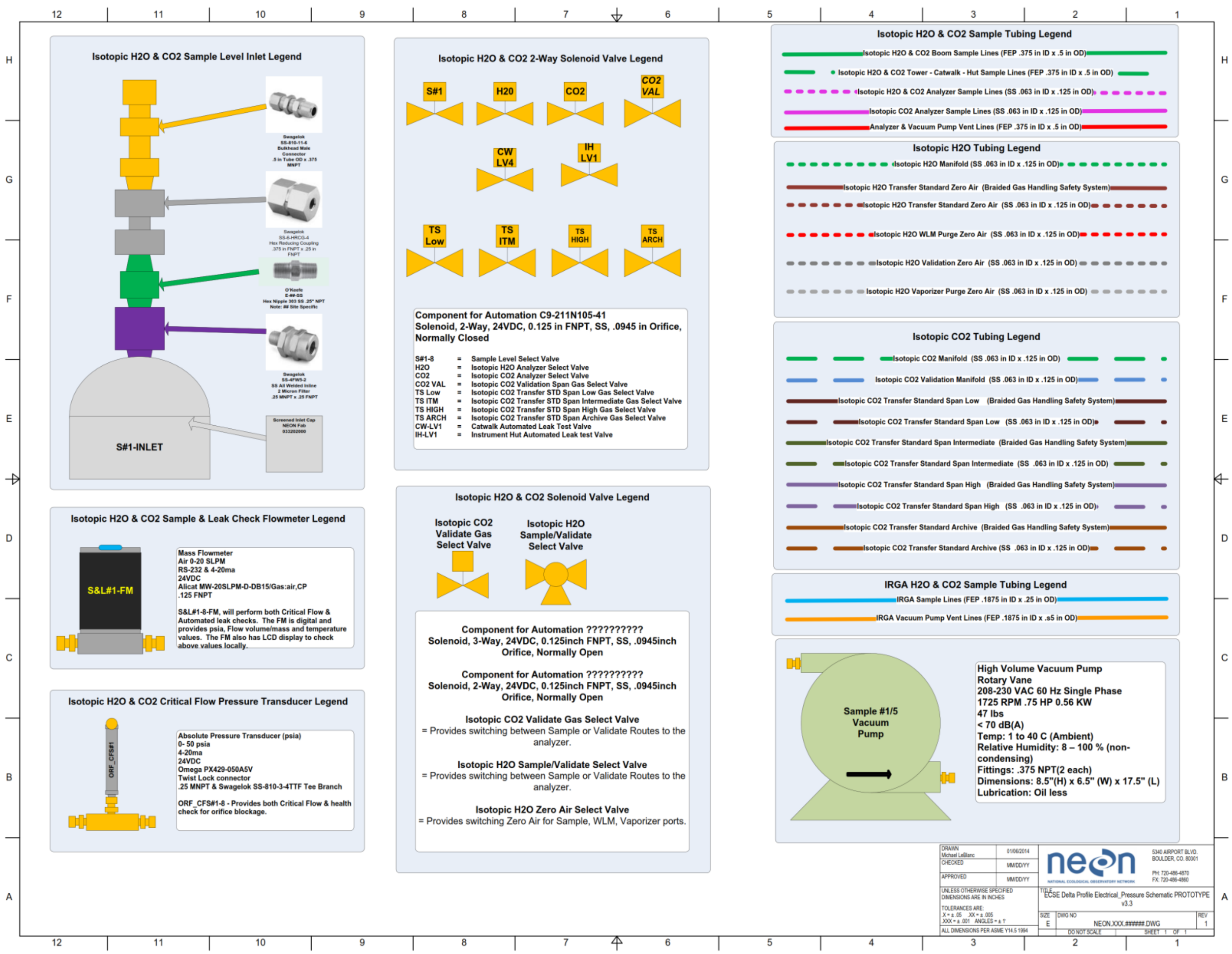


Figure 2. Schematic of the Eddy Covariance Storage Exchange Profile System

15.2 Instrument status (INST_STATUS) information

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408.962.3200 > fax

What does Instrument Status ("INST_STATUS") column in G2000 data log mean? (most of the time its value = 963)

Usually when the instrument is under operational condition and taking measurements, the instrument status value should be 963 (= Bit 0 (ready) AND Bit 1 (measurement active) AND Bit 6 (gas flowing) AND Bit 7 (pressure locked) AND Bit 8 (cavity temperature locked) AND Bit 9 (warm box temperature locked)).

Additional information on each bit follows:

Bit 0 – Ready: Gas measurements are possible as:
- The instrument is warmed up
- The conditions in the sample cavity are acceptable (pressure and temperature controlled within range)
- The instrument is not busy doing something else.

Bit 1 – Measurement inactive/active: is set LOW when the measurement system is inactive, HIGH when measurements are in progress.

If bits 0 and 1 are both set it means the instrument is currently measuring.

Bit 2 – Error in buffer: is set whenever a system error is present in the error buffer. This bit is not cleared until the buffer has been emptied. In general, errors that occur exclusively in the command interface (error codes 1000-1999) do not result in an error being logged in the error queue.

Bit 6 – Gas flowing: is set LOW unless the inlet and outlet valve are both open.

Bit 7 – Pressure locked: is set LOW when the pressure is outside of acceptable operating range, OR gas is not flowing. If the pressure is unable to lock for an extended period when it should, this can be the result of an over or under pressure at the sample input, or a loss of vacuum.

Bit 8 – Cavity temperature locked: is set LOW when the cavity temperature is outside of acceptable operating range.

Bit 9 – Warm box temperature locked: is set LOW when the warm box temperature is outside of acceptable operating range.

Bit 13 – Starting up: is set HIGH immediately after the instrument powers up. This bit clears when the instrument has completed the warmup time (instrument is temperature stabilized) and should then never be set again until the instrument is restarted.

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Bit 14 – System Error: This bit will remain HIGH until error condition no longer exists. All error conditions that cause this bit to be set will also generate an error entry in the error log (and set bit 2 high). However, it is possible for this bit (bit 14) to be high when bit 2 is LOW. This can happen when a persistent error condition exists, the error log is read (clearing bit 2), but the error condition still exists. This bit is not set for errors generated at the RS-232 interface (error codes 1000-1999)

15.3 List of files in analyzers that need to be copied and backup at HQ

All files in the folders listed in the two tables below should be copied (assume manually using CDs) and backup at HQ periodically.

Table 41. Files in G2102-I analyzers that need to be copied and backup at HQ

C:\userdata

C:\Picarro\G2000\AppConfig\\; (all directories, not just Config) Will be static except for updates.
C:\Picarro\G2000\Log\Archive\DataLog_Private
C:\Picarro\G2000\Log\Archive\EventLogs
C:\Picarro\G2000\Log\Archive\RDF

C:\Picarro\G2000\Log\Archive \WBCAL
C:\Picarro\G2000\InstrConfig\Calibration\InstrCal ;(Will be static except for updates).

Table 42. Files in L2130-i analyzers that need to be copied and backup at HQ

c:\userdata
c:\isotopedata

C:\Picarro\G2000\AppConfig\\; (all directories, not just Config) Will be static except for updates.
C:\Picarro\G2000\Log\Archive\DataLog_Private
C:\Picarro\G2000\Log\Archive\EventLogs
C:\Picarro\G2000\Log\Archive\RDF

C:\Picarro\G2000\Log\Archive \WBCAL
C:\Picarro\G2000\InstrConfig\Calibration\InstrCal ;(Will be static except for updates).

15.4 G2131-I and L2130-I power start up sequence flow chart

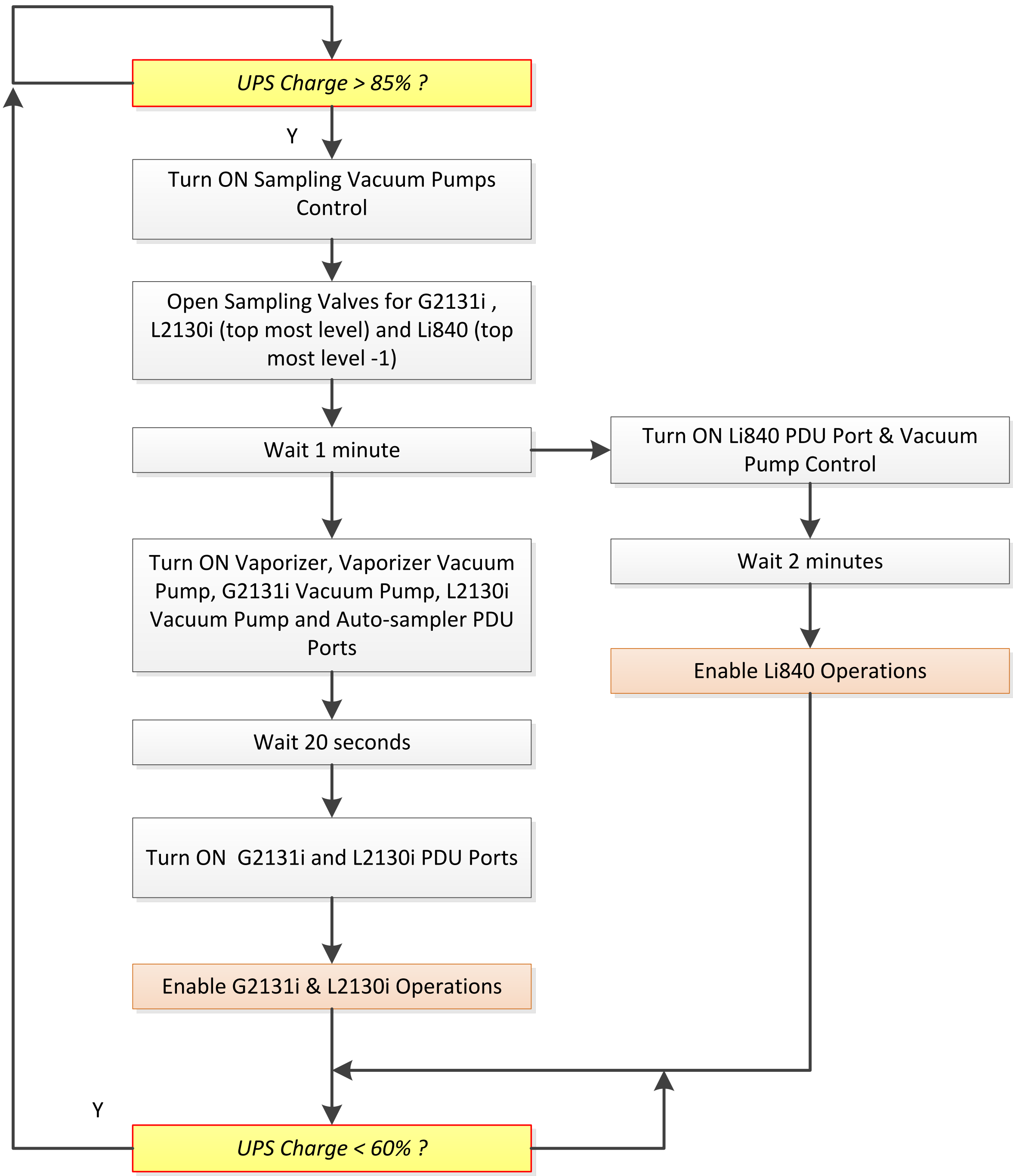

Figure 3. Flow chart for G2131-I and L2130-I power start up sequence

15.5 G2131-I and L2130-I power shut down sequence flow chart

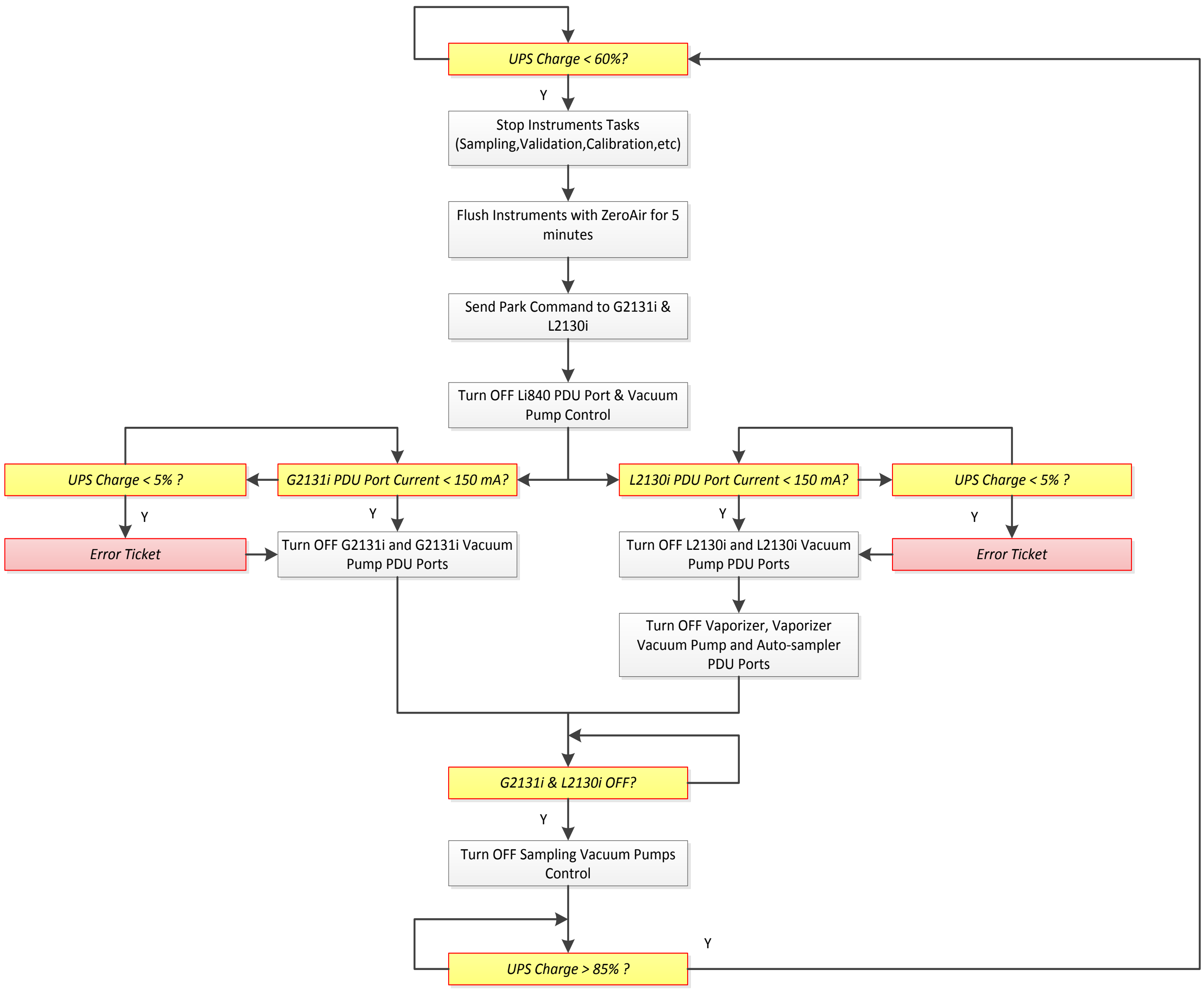

Figure 4. Flow chart for G2131-I and L2130-I power shut down sequence

15.6 List of Level 0 data product

Table 43. List of Level 0 data product for Eddy Covariance Storage Exchange Subsystem

DGD Agile PN	DPName	DPNumber	dpID	fieldName	description	dataType	units	Acquisition frequency (Hz)
CD08340000	profIrga	NEON.DOM.SITE.DP0.00105.001.02316.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	fwMoleCO2	Total wet mole fraction (fw) of CO2 in the air	real	micromolesPerMole	1
	profIrga	NEON.DOM.SITE.DP0.00105.001.02348.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	fwMoleH2O	Total wet mole fraction (fw) of water vapor (H2O) in the air	real	millimolesPerMole	1
	profIrga	NEON.DOM.SITE.DP0.00105.001.02349.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	tempCell	Temperature (temp) of the optical cell	real	celsius	1
	profIrga	NEON.DOM.SITE.DP0.00105.001.02350.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	presCell	Pressure (pres) of the optical cell	real	kilopascal	1
	profIrga	NEON.DOM.SITE.DP0.00105.001.02189.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	asrpCO2	Electromagnetic absorptance (asrp) in the carbondioxide (CO2) absorption band	real	dimensionless	1
	profIrga	NEON.DOM.SITE.DP0.00105.001.02184.HOR.VER.000	NEON.DOM.SITE.DP0.00105.001	asrpH2O	Electromagnetic absorptance (asrp) in the water vapor (H2O) absorption band	real	dimensionless	1
0330600000	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02306.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	instStat	Instrument status bit (963 = good, other values indicate either temperature or pressure is not stable)	integer	NA	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02307.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	presCavi	Pressure of instrument cavity	real	torr	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02308.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	tempCavi	Temperature of instrument cavity	real	celsius	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02309.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	tempDas	Temperature inside chassis	real	celsius	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02310.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	tempEtal	Temperature of Etalon	real	celsius	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02311.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	tempWarmBox	Temperature of the "warm box" - the temperature-controlled electronics and wavelength monitor chamber	real	celsius	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02312.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	posiMPV	State of external rotary valve (if attached), 0-n for an n-port rotary valve	integer	NA	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02313.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	valvOutl	Digitizer value of outlet proportional valve, max open = 65000, closed = 0	real	NA	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02314.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	valvSol	State of external solenoid valves (if attached)	integer	NA	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02315.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	specID	Identity of the spectrum being collected at a point in time; used to identify gas	integer	NA	~1

					species being analyzed			
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02316.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fwMoleCO2	Total wet mole fraction (fw) of CO2 in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02191.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fdMoleCO2	Dry mole fraction (fd) on molar basis (Mole) of carbondioxide (CO2), synonymous with mixing ratio	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02317.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fwMole12CO2	Total wet mole fraction (fw) of 12CO2 in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02318.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fdMole12CO2	Dry molar fraction (fd) of 12CO2 in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02319.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fwMole13CO2	Total wet mole fraction (fw) of 13CO2 in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02320.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fdMole13CO2	Dry molar fraction (fd) of 13CO2 in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02321.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	2Mind13CO2	Measure of the ratio of stable isotopes 13C:12C in CO2, relative to the Vienna Pee Dee Belemnite with 2 minute box averaging	real	permill	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02322.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	30Secd13CO2	Measure of the ratio of stable isotopes 13C:12C in CO2, relative to the Vienna Pee Dee Belemnite with 30 second box averaging	real	permill	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02323.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	5Mind13CO2	Measure of the ratio of stable isotopes 13C:12C in CO2, relative to the Vienna Pee Dee Belemnite with 5 minute box averaging	real	permill	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02324.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	d13CO2	Measure of the ratio of stable isotopes 13C:12C in CO2, relative to the Vienna Pee Dee Belemnite	real	permill	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02325.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	percentFwMoleH2O	Total wet mole fraction (fw) in percent of water vapor (H2O) in the air	real	percent	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02326.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	2MinCO2IsoRatio	The istopic ratio of 13CO2/12CO2 with 2 minute box averaging	real	dimensionless	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02327.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	30SecCO2IsoRatio	The istopic ratio of 13CO2/12CO2 with 30 seconds box averaging	real	dimensionless	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02328.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	5MinCO2IsoRatio	The istopic ratio of 13CO2/12CO2 with 5 minute box averaging	real	dimensionless	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02329.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	CO2IsoRatio	The istopic ratio of 13CO2/12CO2 without any averaging	real	dimensionless	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02330.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fwMoleCH4	Total molar fraction of methane (CH4) in the air; used for correction of the isotopic CO2 measure for methane	real	micromolesPerMole	~1

					crosstalk			
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02331.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fdMoleCH4	Dry molar fraction of methane (CH4) in the air	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02332.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fwMoleHPCH4	High precision total molar fraction of methane (CH4) in the air based on the 12CH4 peak	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02333.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	fdMoleHPCH4	High precision dry molar fraction of methane (CH4) in the air based on the 12CH4 peak	real	micromolesPerMole	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02334.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	peakHeigH2O	Peak height of H2O line, peak height of the H2O feature used for the H2O concentration	real	partsPerBillionPerCentimeter	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02335.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	spliFitCH4	Maximum of the spline fit to the CH4 line, used to calculate methane concentration	real	partsPerBillionPerCentimeter	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02336.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	peakHeig12C	Peak height of 12C line	real	partsPerBillionPerCentimeter	~1
	CO2Iso	NEON.DOM.SITE.DP0.00102.001.02337.HOR.VER.000	NEON.DOM.SITE.DP0.00102.001	peakHeig13C	Peak height of 13C line	real	partsPerBillionPerCentimeter	~1
0328050000	H2OIso	NEON.DOM.SITE.DP0.00103.001.02306.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	instStat	Instrument status bit (963 = good, other values indicate either temperature or pressure is not stable)	integer	NA	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02307.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	presCavi	Pressure of instrument cavity	real	torr	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02308.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	tempCavi	Temperature of instrument cavity	real	celsius	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02309.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	tempDas	Temperature inside chassis	real	celsius	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02310.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	tempEtal	Temperatrue of Etalon	real	celsius	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02311.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	tempWarmBox	Temperature of the "warm box" - the temperature-controlled electronics and wavelength monitor chamber	real	celsius	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02312.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	posiMPV	State of external rotary valve (if attached), 0-n for an n-port rotary valve	integer	NA	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02313.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	valvOutl	Digitizer value of outlet proportional valve , max open = 65000, closed = 0	real	NA	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02338.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	valvMask	State of external solenoid valves if attached, as a decimal representation of valves 1-6 where each valve is a binary bit (e.g., valve 1 = 1, valve 2 = 2, valve 3 = 4, etc. and the values are added)	real	NA	~1

	H2OIso	NEON.DOM.SITE.DP0.00103.001.02339.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	ppmvFwMoleH2O	Total wet mole fraction (fw) of water vapor (H2O) in the air	real	micromolesPerMole	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02369.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	d18OWater	Measure of the ratio of stable isotopes 18O:16O in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02370.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	d2HWater	Measure of the ratio of stable isotopes 2H:1H in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02330.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	fwMoleCH4	Total molar fraction of methane (CH4) in the air. Methane measurement used for correction of the isotopic CO2 measure for methane crosstalk	real	micromolesPerMole	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02340.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	N2Flag	Signal to indicate if the instrument is processing the data for N2 gas or background air. 0=air mode, 1=N2 mode	integer	NA	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02341.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	baseShift	Change in constant term of fitted baseline relative to the empty cavity baseline measured at the factory	real	partsPerBillionPerCentimeter	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02342.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	slopShift	Change in linear term of fitted baseline relative to the empty cavity baseline measured at the factory	real	partsPerBillionPerCentimeter	~1
	H2OIso	NEON.DOM.SITE.DP0.00103.001.02343.HOR.VER.000	NEON.DOM.SITE.DP0.00103.001	resiRMS	Root mean square (RMS) residuals of the least-squares fit	real	partsPerBillionPerCentimeter	~1
0347780000	hutEnv	NEON.DOM.SITE.DP0.00104.001.02344.HOR.VER.000	NEON.DOM.SITE.DP0.00104.001	tempHut	Temperature in the instrument hut	real	celsius	1
	hutEnv	NEON.DOM.SITE.DP0.00104.001.02345.HOR.VER.000	NEON.DOM.SITE.DP0.00104.001	RHHut	Humidity in the instrument hut	real	percent	1
	hutEnv	NEON.DOM.SITE.DP0.00104.001.02346.HOR.VER.000	NEON.DOM.SITE.DP0.00104.001	baroPresHut	Barometric pressure in the instrument hut	real	kilopascal	1
	hutEnv	NEON.DOM.SITE.DP0.00104.001.02347.HOR.VER.000	NEON.DOM.SITE.DP0.00104.001	H2OMixRatioHut	Mixing ratio of water vapor (H2O) in the instrument hut	real	gramsPerKilogram	1
CA07150000	profPresValiRegTank	NEON.DOM.SITE.DP0.00111.001.02196.HOR.VER.000	NEON.DOM.SITE.DP0.00111.001	presGage	Pressure (pres), measured as differential against ambient pressure, synonymous with gage (Gage) pressure (at sea level the gage pressure equals total pressure minus 101.325 kPa)	real	kilopascal	1
CA07140000	profPresValiRegDel	NEON.DOM.SITE.DP0.00110.001.02196.HOR.VER.000	NEON.DOM.SITE.DP0.00110.001	presGage	Pressure (pres), measured as differential against ambient pressure, synonymous with gage (Gage) pressure (at sea level the gage pressure equals total pressure minus 101.325 kPa)	real	kilopascal	1

CA08830000	profPresInlet	NEON.DOM.SITE.DP0.00109.001.02196.HOR.VER.000	NEON.DOM.SITE.DP0.00109.001	presGage	Pressure (pres), measured as differential against ambient pressure, synonymous with gage (Gage) pressure (at sea level the gage pressure equals total pressure minus 101.325 kPa)	real	kilopascal	1
0341530000	profMfm	NEON.DOM.SITE.DP0.00108.001.01951.HOR.VER.000	NEON.DOM.SITE.DP0.00108.001	frt0	Flow rate (frt) at National Institute of Standards and Technology standard conditions (0, which are 293.15 K, 101.325 kPa), synonymous with mass flow rate	real	litersPerMinute	1
	profMfm	NEON.DOM.SITE.DP0.00108.001.01950.HOR.VER.000	NEON.DOM.SITE.DP0.00108.001	frt	Flow rate (frt) at site temperature and pressure, synonymous with volumetric flow rate	real	litersPerMinute	1
	profMfm	NEON.DOM.SITE.DP0.00108.001.01948.HOR.VER.000	NEON.DOM.SITE.DP0.00108.001	presAtm	Pressure (pres), measured as atmospheric (Atm) pressure, synonymous with absolute pressure or total pressure (at sea level the standard atmospheric pressure is 101.325 kPa)	real	kilopascal	1
	profMfm	NEON.DOM.SITE.DP0.00108.001.01949.HOR.VER.000	NEON.DOM.SITE.DP0.00108.001	temp	Temperature (temp)	real	celsius	1
0341500000	profMfcVali	NEON.DOM.SITE.DP0.00107.001.01952.HOR.VER.000	NEON.DOM.SITE.DP0.00107.001	frtSet0	Flow rate (frt) set point (Set) at National Institute of Standards and Technology standard conditions (0, which are 293.15 K, 101.325 kPa), synonymous with mass flow rate set point	real	litersPerMinute	1
	profMfcVali	NEON.DOM.SITE.DP0.00107.001.01951.HOR.VER.000	NEON.DOM.SITE.DP0.00107.001	frt0	Flow rate (frt) at National Institute of Standards and Technology standard conditions (0, which are 293.15 K, 101.325 kPa), synonymous with mass flow rate	real	litersPerMinute	1
	profMfcVali	NEON.DOM.SITE.DP0.00107.001.01950.HOR.VER.000	NEON.DOM.SITE.DP0.00107.001	frt	Flow rate (frt) at site temperature and pressure, synonymous with volumetric flow rate	real	litersPerMinute	1
	profMfcVali	NEON.DOM.SITE.DP0.00107.001.01948.HOR.VER.000	NEON.DOM.SITE.DP0.00107.001	presAtm	Pressure (pres), measured as atmospheric (Atm) pressure, synonymous with absolute pressure or total pressure (at sea level the standard atmospheric pressure is 101.325 kPa)	real	kilopascal	1
	profMfcVali	NEON.DOM.SITE.DP0.00107.001.01949.HOR.VER.000	NEON.DOM.SITE.DP0.00107.001	temp	Temperature (temp)	real	celsius	1
0341570000	profMfcSamp	NEON.DOM.SITE.DP0.00106.001.01952.HOR.VER.000	NEON.DOM.SITE.DP0.00106.001	frtSet0	Flow rate (frt) set point (Set) at National Institute of Standards and Technology standard conditions (0, which are 293.15 K, 101.325 kPa), synonymous with mass	real	litersPerMinute	1

					flow rate set point			
	profMfcSamp	NEON.DOM.SITE.DP0.00106.001.01951.HOR.VER.000	NEON.DOM.SITE.DP0.00106.001	frt0	Flow rate (frt) at National Institute of Standards and Technology standard conditions (0, which are 293.15 K, 101.325 kPa), synonymous with mass flow rate	real	litersPerMinute	1
	profMfcSamp	NEON.DOM.SITE.DP0.00106.001.01950.HOR.VER.000	NEON.DOM.SITE.DP0.00106.001	frt	Flow rate (frt) at site temperature and pressure, synonymous with volumetric flow rate	real	litersPerMinute	1
	profMfcSamp	NEON.DOM.SITE.DP0.00106.001.01948.HOR.VER.000	NEON.DOM.SITE.DP0.00106.001	presAtm	Pressure (pres), measured as atmospheric (Atm) pressure, synonymous with absolute pressure or total pressure (at sea level the standard atmospheric pressure is 101.325 kPa)	real	kilopascal	1
	profMfcSamp	NEON.DOM.SITE.DP0.00106.001.01949.HOR.VER.000	NEON.DOM.SITE.DP0.00106.001	temp	Temperature (temp)	real	celsius	1
CD07150000	profPumpSmp	NEON.DOM.SITE.DP0.00112.001.02351.HOR.VER.000	NEON.DOM.SITE.DP0.00112.001	pumpVoltage	Voltage provided to pump	real	volt	~0.2
CD06640001	profSnd	NEON.DOM.SITE.DP0.00113.001.02360.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd1	Solenoid valve 1 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02361.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd2	Solenoid valve 2 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02362.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd3	Solenoid valve 3 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02364.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd4	Solenoid valve 4 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02365.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd5	Solenoid valve 5 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02366.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd6	Solenoid valve 6 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02367.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd7	Solenoid valve 7 command (0 = close, 1 = open)	integer	NA	0.2
	profSnd	NEON.DOM.SITE.DP0.00113.001.02368.HOR.VER.000	NEON.DOM.SITE.DP0.00113.001	valvCmd8	Solenoid valve 8 command (0 = close, 1 = open)	integer	NA	0.2
CD06640002	profSndAux	NEON.DOM.SITE.DP0.00114.001.02360.HOR.VER.000	NEON.DOM.SITE.DP0.00114.001	valvCmd1	Solenoid valve 1 command (0 = close, 1 = open)	integer	NA	0.2
	profSndAux	NEON.DOM.SITE.DP0.00114.001.02361.HOR.VER.000	NEON.DOM.SITE.DP0.00114.001	valvCmd2	Solenoid valve 2 command (0 = close, 1 = open)	integer	NA	0.2
	profSndAux	NEON.DOM.SITE.DP0.00114.001.02362.HOR.VER.000	NEON.DOM.SITE.DP0.00114.001	valvCmd3	Solenoid valve 3 command (0 = close, 1 = open)	integer	NA	0.2

	profSndAux	NEON.DOM.SITE.DP0.00114.001.02364.HOR.VER.000	NEON.DOM.SITE.DP0.00114.001	valvCmd4	Solenoid valve 4 command (0 = close, 1 = open)	integer	NA	0.2
CA10210000	profSndVapor	NEON.DOM.SITE.DP0.00115.001.02352.HOR.VER.000	NEON.DOM.SITE.DP0.00115.001	valvStat1	Solenoid valve 1 status (0 = close, 1 = open)	integer	NA	0.2

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