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

PREPARED BY	ORGANIZATION	DATE
Hongyan Luo	FIU	Nov 2018
Natchaya Pingintha-Durden	FIU	May 2016
Derek Smith	FIU	Mar 2016

APPROVALS	ORGANIZATION	APPROVAL DATE
Kate Thibault	SCI	03/06/2019
Mike Stewart	PSE	03/06/2019

RELEASED BY	ORGANIZATION	RELEASE DATE
Anne Balsley	CM	03/07/2019

See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/16/2016	ECO-03817	Initial release
B	08/04/2016	ECO-03911	Add gas cylinders and water trays as DGDs in this document
C	12/08/2016	ECO-04291	Update data type for data streams from G2131-I and L2130-I in table 43
D	06/28/2017	ECO-04828	Change 90-vial tray to 12-vial tray, and do some other minor edits
E	03/07/2019	ECO-05977	Add MDP wordings

TABLE OF CONTENTS

1 DESCRIPTION 1
1.1 Purpose 1
1.2 Scope 1
2 Related documents and acronyms 5
2.1 Applicable Documents 5
2.2 Reference Documents 5
2.3 Acronyms 5
3 Analyzer for CO_2/H_2O concentration (DGD CD08340000) 6
3.1 Introduction 6
3.2 Overview of Sensor configuration 7
3.3 Command and Control 7
4 Analyzer for isotopic CO_2 (DGD 0330600000) 7
4.1 Introduction 7
4.2 Overview of Sensor configuration 8
4.3 Command and Control 10
4.3.1 Error handling 10
4.3.2 Sensor G2131-I controls specification 10
5 Analyzer for isotopic water (DGD 0328050000) 11
5.1 Introduction 11
5.2 Overview of Sensor configuration 11
5.2.1 L2130-I analyzer 11
5.2.2 A0325 HTC-xt Autosampler 14
5.2.3 A0211 High Precision Vaporizer 14
5.3 Command and Control 14
5.3.1 Error handling 14
5.3.2 Sensor L2130-i controls specification 14
6 Temperature sensor in the hut (DGD 0347780000) 16
6.1 Introduction 16

6.2 Overview of Sensor configuration 16
6.3 Command and Control 17
6.3.1 Error handling 17
6.3.2 Sensor T7610 controls specification 18
7 Dehumidifier (NEON P/N: 0347810000, NOT A DGD) 18
7.1 Introduction 18
7.2 Overview of Sensor configuration 19
7.3 Command and Control 20
7.3.1 Error handling 20
7.3.2 Sensor <device> controls specification 20
8 Gas cylinder pressure sensor (DGD CA07140000, CA07150000) 20
8.1 Introduction 20
8.2 Overview of Sensor configuration 21
8.3 Command and Control 23
8.3.1 Error handling 23
8.3.2 Sensor PX319-3KGI and PX319-100GI controls specification 23
9 Absolute pressure transducer (DGD CA08830000) 24
9.1 Introduction 24
9.2 Overview of Sensor configuration 26
9.3 Command and Control 26
9.3.1 Error handling 26
9.3.2 Sensor PX319-030AI controls specification 27
10 Mass Flow meter in sample lines (DGD 0341530000) 27
10.1 Introduction 27
10.2 Overview of sensor configuration 27
10.3 Command and control 28
10.3.1 Error handling 28
10.3.2 Controls specification 28
11 Mass flow controller (DGD 0341500000 AND DGD 0341570000) 28
11.1 Mass flow controller for field validation gases (Validation Gas MFC, DGD 0341500000) 29

11.1.1 Introduction 29
11.1.2 Overview of sensor configuration 29
11.1.3 Command and control 29
11.2 Mass flow controller for LI840A (DGD 0341570000) 30
11.2.1 Introduction 30
11.2.2 Overview of sensor configuration 30
11.2.3 Command and control 31
12 EC profile assembly infrastructure (DGD CD06640001, CD06640002, CA10210000) 31
12.1 Introduction of infrastructure 31
12.2 Overview of assembly configuration EC profile assembly 31
12.2.1 Sample Line Pumps and IRGA pump (DGD CD07150000) 32
12.2.2 IRGA sample manifold (CD06640001) 34
12.2.3 H_2O sample manifold (CD06640001) 35
12.2.4 Valves to deliver zero air to L2130-I (DGD CD06640001, DGD CD06640002, CA10210000) 35
12.2.5 CO_2 sample manifold (CD06640001) 36
12.2.6 Validation Gas Manifold (DGD CD06640001) 37
12.3 Command and Control 38
12.3.1 Heaters (No DGD) 38
12.3.2 Cycling of Profile Solenoids during sampling mode 40
12.3.3 LI840A field calibration and field validation (DGD CD06640001, DGD CD06640002) 42
12.3.4 G2131-I and L2130-I Field Validation 45
12.3.5 Error handling 48
12.3.6 Sensor controls specification 48
13 Assembly Integration 49
14 Potential future development 49
15 Appendix & bibliography 50
15.1 EC profile assembly Schematic 50
15.2 Instrument status (INST_STATUS) information 52
15.3 List of files in the analyzers that need to be copied and backed up at HQ 54

15.4 G2131-I and L2130-I power start up sequence flow chart 55
15.5 G2131-I and L2130-I power shut down sequence flow chart 56
15.6 List of Level 0 data product 57
15.7 Bibliography 64

LIST OF TABLES

Table 1. Sensor configuration settings for LI840A IRGA 7
Table 2. Sensor configuration settings for Picarro G2131-I analyzer. 8
Table 3. Truth table for controlling sensor (G2131-I, DGD 0330600000) 10
Table 4. Sensor configuration settings for Picarro L2130-I Analyzer during operation 12
Table 5. High Precision Vaporizer configuration settings 14
Table 6. Truth table for controlling sensor (L2130-I, DGD 0328050000) 15
Table 7. Default sensor configuration settings for the temperature sensor. 16
Table 8. Temperature sensor error codes 17
Table 9. Truth table for controlling sensor T7610 18
Table 10. NEON sites that will have a L2130-i 19
Table 11. Default sensor configuration settings for the dehumidifier. 19
Table 12. Default sensor configuration settings for the gas cylinder pressure sensor. 23
Table 13. Truth table for controlling sensor PX319-3KGI and PX319-100GI. 23
Table 14. Ambient pressure at each NEON site used for control sample line pump 24
Table 15. Default sensor configuration settings for the absolute pressure transducer. 26
Table 16. Truth table for controlling sensor (PX319-030AI). 27
Table 17. Mass flow meter configuration settings. 27
Table 18. Truth table for controlling sensor MW-20 SLPM-NEON 28
Table 19. Flow controller (Validation Gas MFC) configuration settings (for validation gases) 29
Table 20. Truth table for controlling sensor (MFC for LI840A validation, DGD 0341500000). 30
Table 21. Mass Flow controller (MFC) configuration settings (for LI840A) 30
Table 22. Truth table for controlling sensor (MFC for LI840A sampling, DGD 0341570000). 31
Table 23. Default configurations for the Pump 32
Table 24. Existing data products that will be used in profile system screened inlet heater command and control 33
Table 25. Truth table to control the sample line pumps (DGD CD07150000) 33
Table 26. Configurations for the IRGA sample manifold 34
Table 27. Configurations for the H_2O Sample manifold 35
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 36
Table 29. Configurations for the Isotopic CO_2 sample manifold 36

Table 30. Default configurations for the Isotopic CO_2 Validation Gas Manifold 38
Table 31. Existing data products that will be used in profile system screened inlet heater command and control 39
Table 32. Truth table to control the screened inlet heater (no DGD)* 39
Table 33. Example of one cycle sequence for IRGA Sample Valves* (1 for open, and 0 for closed, assume 8 levels). 40
Table 34. Example of one cycle sequence for CO_2 Sample Valves or H_2O Sample Valves (assume 8 levels). 41
Table 35. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during field calibration of LI840A. 43
Table 36. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during routine field validation of the LI840A IRGA. 44
Table 37. Cycling sequence for the Val Gas Select valves, IRGA Val Gas Valve, and IRGA Vent Valve during the monthly 'archive' validation of the LI840A IRGA. 44
Table 38. Cycling sequence for the Val Gas Select valves and the CO_2 Val Gas Valve during routine field validation of G2131-I. 46
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. 46
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.) 47
Table 41. Files in G2130-I analyzers that need to be copied and backed up at HQ 54
Table 42. Files in L2130-I analyzers that need to be copied and backed up at HQ 54
Table 43. List of Level 0 data products for Eddy Covariance Storage Exchange Subsystem 57

LIST OF FIGURES

Figure 1. Cylinder layout at instrument hut 23
Figure 2. Schematic of the Eddy Covariance Storage Exchange Profile System 51
Figure 3. Flow chart for G2131-I and L2130-I power start up sequence 55
Figure 4. Flow chart for G2131-I and L2130-I power shut down sequence 56

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). The specific sensor used in our design is the LICOR LI840A. Stable isotope measurement will be done using a PICARRO G2131-I Cavity Ring Down Spectrometer (CRDS) for ^{13}C in CO_2 and a 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 these instruments, associated accessories, solenoids, manifolds and pneumatics within the Eddy Covariance Storage Exchange Assembly. See Section 15.1 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 15.1) handy will enhance your understanding while reading through this document.

1.1 Purpose

This document specifies the command, control, and configuration details for operating the EC Profile Assembly at all NEON terrestrial sites and Mobile Deployment Platform (MDP) sites (also called as "all NEON sites" or "NEON sites" below). NEON can provide up to 5 MDP systems at a same time period. MDP is a PI driven system; its site location varies depending on PI's decision and research needs. This document 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. L0 data from the sensor received at HQ are unfiltered and uncorrected data products, further processing will be performed using associated algorithms to produce a QA/QC'd L1 data products 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 the following Data Generating Devices (DGD) based on AD [09]:

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
0361660000	Picarro L2130-i tertiary isotopic water standards for field validations
0353710000	Gas Cylinders, High Pressure, Internal Water Volume of 43 liters, with known values of CO2 and Isotopic CO2 to be used for field validations

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 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, *Thermometer Hygrometer Barometer 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 [To be writen]
AD [06]	NEON.DOC.000822	NEON Eddy Covariance Storage Exchange Assembly ATBD [To be writen]
AD [07]	NEON.DOC.002422	Isotopic Water Calibration Fixture Manual L1W200
AD [08]	NEON.DOC.003565	Hut Gas Cylinder Configuration
AD [09]	NEON.DOC.001104	Data Generating Device (DGD) List and Hierarchies

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
WLM	wave length monitor
MFC	Mass flow controller
MFM	Mass flow meter

3 ANALYZER FOR CO_2/H_2O CONCENTRATION (DGD CD08340000)

3.1 Introduction

The LI840A-03 is used for the measurement of CO_2 concentration and H_2O concentration of a vertical profile of a tower at NEON terrestrial and MDP sites. It is a modified LI-840A sensor equipped with 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, referred to as LI840A throughout the document. One LI840A IRGA will be deployed at each of NEON terrestrial and MDP sites.

Measurements made by the LI840A will be switched between sampling mode and field validation mode at scheduled time periods. During sampling mode, the analyzer will measure 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 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 the 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 reader's understanding of the design and context.

3.2 Overview of Sensor configuration

Configuration assumptions: CVAL will perform the initial lab calibration and determine calibration coefficients for each LI840A IRGA prior to field deployment, and annually after deployment

Data generated by the LI840A will be streamed to HQ. See sensor configuration settings in Table 1.

All data output from the 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 the 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 for the LI840A sensor.

4 ANALYZER FOR ISOTOPIC CO_2 (DGD 0330600000)

4.1 Introduction

The 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 and MDP 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 measure 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.

The G2131-I analyzer has an on-board computer. Selected digital signals from the analyzer will be streamed through an Ethernet to CI and also saved on this computer. **This computer should be configured to synchronize timestamp using Location 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 it shall never be adjusted in the field. Annual calibration will be performed by CVAL at headquarters.

When the analyzer is powered 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 ASCII-format and HD5 format text output files in its onboard computer**. Subsets of these data streams and files can be streamed back to NEON headquarters 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 products from the G2131-I will be collected at the acquisition frequency of ~ 1Hz (DGD 0330600000) and streamed back to HQ. The 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 problem diagnosis, and future data reprocessing. They should be copied periodically and sent back to CI for archive 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).

The data streams that will be delivered back to HQ during sampling mode and during instrument validation mode will be identical.

Requirement: 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 are 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 QA/QC, 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 G2131-I 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 powered on.

Because warming the instrument will take a long time, no data within 12 hours after instrument power up should be used for scientific analysis. A data flag should be generated at HQ and described 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 a command is issued by DAS, and 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, the DAS issues a command to shut down the analyzer properly, and then shut down the dry gas flow.
  c. The external pump should be turned off 30 seconds after the instrument powers off.

Because dry air runs through the analyzer cavity for 5 min prior to shut down command being issued, and because it will take about 5 min for the analyzer to fully turn off, no data within 10 minutes prior to full turn off should be used for scientific 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 data	Prior to turning on analyzer	Turn external vacuum pump on	NA;
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, and 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 terrestrial sites, and varies from 2 to 4 at MDP sites. 21 L2130-I units will be deployed at 20 NEON core sites and one relocatable site (D18 Barrow), plus 1 unit will be deployed at each MDP site (up to 5 sites at a same period).

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 air sampled 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. Gas handling during sampling mode and validation mode is described in Section 12.2 of this document.

The L2130-I analyzer has an on-board computer. Selected digital signals from the analyzer will be streamed via Ethernet to CI at Headquarters and also saved in this computer. **This computer should be configured to synchronize timestamp using Location Controller (LC) as time server at that site.**

5.2 Overview of Sensor configuration

5.2.1 L2130-I analyzer

Assumptions:

1. CVAL will determine and preset calibration coefficients in the onboard computer for each L2130-I sensor prior to the field deployment, which shall never be adjusted during field operations.
2. The Job and Method settings in the control GUI to operate the autosampler and vaporizer during instrument field validation are preset by CVAL in the onboard computer and described in SOPs (AD [05]) prior to field deployment. Field adjustment of the Job and Method shall be done according to field training materials (to be written by SIV team and FOPS team).
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 ASCII-format and HD5 format text output files in the onboard computer. Subsets of these data streams and files can be streamed back to NEON headquarters 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
Vaporizer Front display		110 °C
External vacuum pumps (vaporizer)		
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 the L2130-I will be collected at acquisition rate of ~1 Hz (DGD 0328050000) and streamed back to HQ. A L0 data products list can be found in Appendix 15.6.

L0 data for the water standards and associated uncertainty (DGD: 0361660000 for the tray with 12 vials) will be extracted from a CVAL XML file. They can be found in Appendix 15.6. The tray with 12 vials is for 4-week's supplies.

There are also some folders and files in the L2130-I computer that contain useful information for problem diagnosis, and future data reprocessing. They should be copied periodically and sent back to CI for archive. These folders and files are:

C:\userdata
C:\isotopedata

C:\Picarro\G2000\AppConfig\; (copy all directories, not just Config subdirectory. 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 the analyzer's coordinator's GUI (which controls the autosampler) **needs to be restarted manually every four weeks for 12-vial tray.**

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 QA/QC, 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 L2130-i 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. Vaporizer also 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 delivery pressure to 2.5 ± 0.5 psig (17.24±3.45 kPa)
- Power 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 is powered on.
- Power on autosampler.
- Power on the vaporizer.
- Power on L2130-I analyzer. GUI will run automatically.

Because the instrument's warm up takes a long time, no data within 12 hours after instrument power up should be used for scientific analysis. A data flag should be generated at HQ and described 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):

- In response to a power failure,
    a. While supported by UPS power systems, 5 minutes prior to the Picarro L2130-I Analyzer shut down command being 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, the DAS issues a command to shut down the analyzer properly, then shut down the dry gas, then shut down the vaporizer and autosampler
    c. The external pump should be turned off 30 seconds after the instrument is powered off.

Because the dry air runs through analyzer cavity for 5 min prior to shut down command being issued, and because it will take about 5 min for the analyzer to fully turn off, no data within 10 min prior to the system being fully turned 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 on ambient temperature variation, a temperature sensor (Comet T7610 Thermometer Hygrometer Barometer*)* will be added within 50 cm of the LI840A to monitor the ambient temperature variation. This temperature will be used in future data flagging. The data collected during the time periods of temperature variation > 10 °C over one 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), moisture could interfere with the performance of the L2130-I. The humidity output from this sensor can also be used to flag L2130-I data during later data processing, which will be described in the associated ATBD.

The humidity measurement displayed on this sensor's screen can also be used to guide field technicians to adjust the dehumidifier settings to below 30,000ppmv.

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

6.2 Overview of Sensor configuration

The temperature, barometric pressure, humidity, and one computed value can be displayed on the LCD display or can be read via an Ethernet connection. The options of the computed quantities include: dew point temperature, absolute humidity, specific humidity, mixing ratio and specific enthalpy. We 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: °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: °C
	Mixing ratio (Computed value): g/kg
	Atmospheric pressure: kPa
Default pressure	1013 hPa
Atmospheric pressure offset	0.0 hPa

Note:
The mixing ratio above is the mass mixing ratio (water vapor (g)/dry air (kg)), not the ppmv mixing ratio. 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 safety margin, we suggest adjusting the dehumidifier in the hut to achieve the cutoff threshold at **25,000 ppmv** for the 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 technicians should use this info to set the dehumidifier to achieve <25,000 ppmv humidity.

L0 data from the temperature sensor that will be streamed back to HQ at 1Hz (DGD 0347780000) and 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 error events occur, the sensor LCD will show one of the error codes in the table below, and an error code of -9999 will be output to the location controller, 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 T7610 controls specification

Table 9. Truth table for controlling sensor T7610

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 the WLM through this port at humid sites. Purging the 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 precise control of 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 a 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 technicians 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 terrestrial sites that will have a L2130-i

Domain	Site with L2130-I water analyzer	Site Type	Dehumidifier?
1	Harvard Forest	Core	Y
2	Smithsonian Conservation Biology Institute	Core	Y
3	Ordway-Swisher Biological Station	Core	Y
4	Guanica Forest	Core	Y
5	University of Notre Dame Environmental Research Center	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 National Grassland	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	PUUM	Core	Y
18	Barrow Environmental Observatory	Relocatable	N

*Note: MDP is a PI driven system; its site location varies depending on PI's decision, thus cannot determine the deployment of humidifier in this document.

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 PUUM, 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 stations and our calculations. It can be adjusted to a different value once we have a better understanding about the site environment based on the data collected in situ at NEON sites.

No sensor configuration 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 (section 2.1 and 2.2) 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 on the input port of the pressure reduction regulator (Cylinder pressure); and
(ii) the pressure on the output port of the pressure reduction regulator (delivery pressure).

There will be 6 gas cylinders used in the EC profile systems for field validation of the LI840A IRGA, L2130-I and G2131-I analyzers:

- 3 cylinders of CO_2 at high, middle and low concentration for routine validation of both the LI840A IRGA and G2131-I analyzer,
- one cylinder of Zero air for the routine field validation of the LI840A IRGA to determine the sensor zero offset, that is also used to purge G2131-I cavity prior to the instrument shut down.
- one archived CO_2 for validation of the LI840A IRGA and G2131-I analyzer over longer time periods (monthly),

- one cylinder of Zero air for the field validation and purge of the L2130-I analyzer. The zero air for the 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 to purge the L2130-I cavity prior to 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 delivery pressure. The pressure in the validation gas cylinder (called "**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 monitoring state of health, but will not be used for further scientific data processing. 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 purging 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" section in this document. There is no need to monitor and flag the delivered gas pressure.

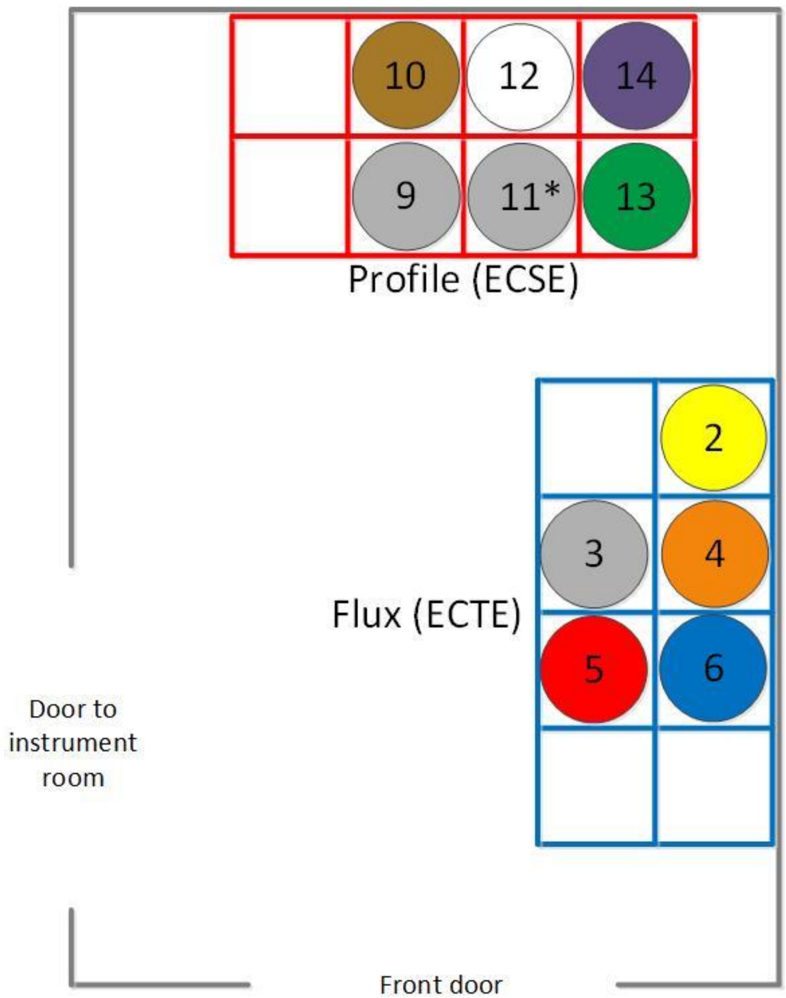
At this time, the Omega Engineering P/N: PX319-3KGI (NEON P/N: 0335480000) and Omega Engineering P/N: PX319-100GI (NEON P/N: 0335490000) will be used to monitor the tank pressure and delivered gas pressure. Here, we describe the configuration, command and control related to the operation of this pressure sensor in section 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 technician should be generated at field and sent 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 technician should be generated at the field site and sent to the trouble ticket center, and the flag to inform post data processing should be generated at HQ (specified in ATBD).

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

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



Cylinder Number	System Used	Color	Gas Concentration Measured
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)
9	Profile	N/A	CO_2 Laser Zero Air (Supplied by local vendor)
10	Profile	Brown	Archive (~-8.5 $\delta^{13}C$, 400 ppm CO_2)
11*	Profile	N/A	H_2O Laser Zero Air (Supplied by local vendor)

12	Profile	White	Low (~-5 δ13C, 350 ppm CO2)
13	Profile	Green	Medium (~-8.5 δ13C, 400 ppm CO2)
14	Profile	Violet	High (~-15 δ13C, 500 ppm CO2)

*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 (DGD: CA07150000) for validation gas cylinder pressure at 1 Hz can be found in Appendix 15.6.

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

L0 data for the gas concentration and associated uncertain for gas cylinders (DGD: 0353710000) will be extracted from CVAL XML file. It 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 PX319-3KGI and PX319-100GI controls specification

Table 13. Truth table for controlling sensor PX319-3KGI and PX319-100GI.

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 one absolute pressure transducer for each sample line between the inlet at each different tower measurement levels and the associated pump. Therefore, the number of absolute pressure transducers deployed at each site will vary from 4 to 8 at terrestrial sites and 2 to 4 at MDP sites. 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 the associated sample line pump to adjust pump speed to maintain the proper pressure drop in the sample line (i.e., 52.8% or less of ambient pressure). Ambient pressure used for sample line pump control at each NEON site is presented in the table below. This ambient pressure is calculated using the 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 site 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

The sensor used to measure the pressure at inlet behind critical orifice is Omega Engineering PX319-030AI 0-30 psi Absolute Pressure Transducer.

If this pressure is > 55% of ambient pressure, it indicates:

(i) potential leaks in the sample line,
(ii) the pump has lost its capability to maintain the low pressure, or
(iii) the malfunction of the critical orifice.

A trouble ticket should be generated and sent to field technicians.

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 PX319-030AI controls specification

Table 16. Truth table for controlling sensor (PX319-030AI).

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

This 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. One mass flow meter will be used in each sample line that is associated with each tower measurement level. Therefore, the number of mass flow meters used at NEON terrestrial sites will vary between 4 to 8, and will vary between 2 to 4 at MDP sites.

10.2 Overview of sensor configuration

Sensor configuration settings are given in table below.

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 the mass flow meter (DGD 0341530000, Alicat Scientific P/N: MW-20 SLPM-NEON) at 1 Hz can be found in Appendix 15.6

Flow rate for each sample line should be maintained at 5-11 SLMP across all NEON sites. 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 normal range:

(i) the air plumbing path may be clogging,
(ii) the tube maybe pinched, or
(iii) the site may have experienced power failure (the assembly vacuum pump will have lost power in this case).

To protect the sensors, some command and control of 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 is out of range and the gas pressure flag is set high, a flag will be generated and sent to CI.

10.3.2 Controls specification

Table 18. Truth table for controlling sensor MW-20 SLPM-NEON

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 profile system assembly:

- one to control the validation gases during the validation mode for the LI840A IRGA or the G2131-I during field validation. During LI840A field validation, the flow should be controlled at 1.5 SLPM; During G2131-I field validation, the flow should be controlled at 0.3 SLPM; when no validation is occurring, the flow controller should be set to 0 SLPM to prevent the flow controller from overheating. **Note: The LI840A and G2131-I should never be field validated at the same time.** See section 10 for command and control description.
- one is located between the LI840A IRGA and its pump to maintain the air sample or validation gas flow through the LI840A IRGA cell at a flow rate of 1 SLPM ± 0.2 SLPM at all times.

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

11.1.1 Introduction

This mass flow controller (Validation Gas MFC) is used to maintain and monitor a constant flow rate of validation gas standards delivered to the LI840A IRGA or G2131-I analyzer. One mass flow controller will be used at each site for the 4 unique CO_2 gas standards and one zero air standard. It is located between the Validation Gas Manifold and the tee splitter to the CO_2 Sample manifold and the IRGA Sample Manifold. At this time, an 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 table below.

Table 19. Flow controller (Validation 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 this mass flow controller (DGD 0341500000) at 1 Hz for validation gases can be found 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 sample flow rate through the LI840A IRGA cell. One 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 table below

Table 21. Mass Flow controller (MFC) 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 the 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 section describes the configuration, command and control related with the infrastructure (e.g., solenoids, manifolds, pneumatics) 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 the appendix for a schematic of the entire EC profile assembly.

A 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 passing the 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, the 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 clogging the inlet and critical flow orifice, heating should be applied to the screened inlet and critical flow orifice.

The vacuum pump selected should be efficient 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 the G2131-I and L2130-I should be as short as possible, ideally < 1 m.

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

After an interruption of the sensor operation (e.g., after power failure, shut down instrument for maintenance or trouble shutting the profile system will resume operation as following to avoid the LI840A and Picarros being calibrated/validated at the same time, or sampling from the same level:

1. Calibrate LI840A, validate LI840A, then start normal complete sampling cycle from the top most level
2. While the LI840A is calibrating/validating the G2131-I will start sampling from top most level. When the LI840A starts sampling, validation of the G2131-I begins if more than 23 hours has elapsed since the last validation, thereafter it starts normal complete sampling cycle from top most level.
3. The L213-I will start normal complete sampling cycle from top most level. Sampling will continue until a field technician starts the validation cycle manually, which be followed by a return to the normal complete sampling cycle from top most level.

12.2.1 Sample Line Pumps and IRGA pump (DGD CD07150000)

The vacuum pump selected for each sample line should be able to provide continuous flow and sufficient pressure drop from inlet to the pump at all NEON terrestrial and MDP 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 a proper pressure drop in the sample line (i.e., 52.8% of ambient pressure or even lower).

The pump selected for LI840A IRGA should be capable of providing flow at 1 SLPM.

At NEON, the pumps selected for sample lines and for IRGA are the same type: Gast Manufacturing, Inc. P/N: 2032-101-G644.

Table 23. Default configurations for the Pump

Parameter	Default
Power	on

The default setting for pump will be "on" during normal operation no matter whether the analyzers are in sampling mode or validation mode.

There is no command and controller on IRGA pump.

However, for sample line pump, when the sample line is clogged, if the pump keeps running, it 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 clogging the orifice,
ii) Debris or insects have been sucked in and are stuck at the screen inlet, or
iii) Dirt buildup at the screened inlet and clogging the orifice or filter.

The first one can be prevented by turning on the 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 after trying to stop and restart the pump 3 times, the clog problem is not resolved, the pump should be stopped. Similarly for the third one, if after trying to stop and restart pump 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 a third try, if the issue persists, the DAS should stop the pump, and also generate a trouble ticket to field tech.

The 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 processing to generate system health flags. 0 volts means the pump is stopped. Typical voltage for the 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 for 2 min and	NA

		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 technician to check inlet clogging and check pump conditions	
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 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 technician 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 valves control the gas delivered to the 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 one outlet port (deliver subset of air sample or validation gas to IRGA). The number of inlet ports on the IRGA Sample Manifold that will be used is dependent on the number of tower measurement levels, which varies from 4 to 8 at terrestrial sites and 2 to 4 at MDP sites: 8 measurement levels are used as a 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 sample valves)	8 ports, always open	This is for the level specific subset of air samples to get into the IRGA sample 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 one outlet port (to deliver a subset of air sample to the analyzer). The number of inlet ports on the profile manifold will be used is dependent on the number of tower measurement levels, which varies from 4 to 8 at terrestrial sites and 2 to 4 at MDP sites. Here 8 measurement levels is the 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 the 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 the 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 sampling mode, the four valves should be closed to avoid zero air flowing to the H_2O Sample Manifold. During validation mode the H_2O Analyzer WLM Purge Valve, H_2O Analyzer Zero Air Valve, and Vaporizer 3-way Valve should be open to allow the zero air to flow to the vaporizer and analyzer. While the H_2O Manifold Zero Air Valve should only be opened before the instrument is shut down to allow the zero air to flush out 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 the 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 (to deliver a subset of air sample or validation gas to the analyzer). The number of inlet ports on the CO_2 sample manifold is dependent on the number of tower measurement levels, which varies from 4 to 8 (depending on site) at terrestrial sites and 2 to 4 at MDP sites. 8 measurement levels is a 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 mass flow rate of the gas standards to the G2131-I analyzer or the LI840A IRGA for field validation. Validation of these two instruments should not occur at the same time. The known gas standards that will be used include 3 cylinders of CO_2 at high, intermediate and low concentrations and one zero air for routine validation of LI840A IRGA (with a frequency of 23 hours between IRGA calibrations). The 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 with a concentration of approximately 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 flow of known gas standards to the LI840A IRGA for field calibration, which should occur every 6 days or when the 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 be equipped 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 either the 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 6 inlet ports to intake the validation gases, and one 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	6 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)	6 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 valve, 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 is just an safety vent used for emergency vent if needed.

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 clogging 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 low (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 the heater is switched 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 are 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, only the dew point temperature and air temperature outputted by HMP155 sensors assembly at the tower top and at ground level at the soil array, which typically bound the worst freezing conditions. The logic is to monitor the conditions at the tower top and at ground level, and 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 the heater used in the profile system does not have a chip, it is not a data generating device (DGD), therefore the heater on/off status cannot be streamed back to CI as an L0 data product. But the heating time period can be flagged during the post data process using same algorithms as 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 the number of tower levels 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 heating at 10±5 °C above T_{d_s}	NA
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 observation measurement 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 the 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 consistently at all sites.

The tower measurement levels vary from 4 to 8 levels at terrestrial sites and 2 to 4 levels at MDP sites. Using the same definition as in other NEON documentation, **measurement level 1 should be the bottommost level. The level number increases with vertical tower height**.

12.3.2.1 LI840A sampling (DGD CD06640001)

For the LI840A IRGA, a complete cycle of profile sampling measurements will include all measurement levels from the topmost level to the bottommost level at that site. The table below shows the command and control structure for a normal complete cycle under sampling mode. Time 0 is the time that the sampling mode starts a complete cycle. Δt is the time length needed to complete sampling at one measurement level, which includes the times for settling (including purge, stabilization, solenoid switching) and measurement. Δt is defined as **3 minutes** in the current design. When sampling measurement resumes after interruptions (e.g., power failure, calibration/validation, maintenance), a complete sampling cycle should start from the highest (vertical height) and continue to the lowest level of the tower. One measurement cycle should immediately be followed by the next measurement cycle without a 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 the 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 the 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. The 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 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. ***Δt* is defined as 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 the next measurement cycle without a 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 connected 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. **The Picarro G2131-I and Picarro L2130-I will always sample at the same level during the same time period while they are not in validation mode; However, although both the G2130-I and L2130-I have the same validation interval of 23 hours, because L2130-I validation cannot start until somebody manually initiates the validation process, G2131-I and L2130-I do not have the same field validation schedule. There are two scenario:**
    a. **Both the G2131-I and L2130-I sample at the same level at the same time, then the G2131-I starts the field validation. The L2130-I should proceed with sampling as normal. Once the G2131-I finishes field validation, both the G2131-I and L2130-I should start a complete sampling cycle from the top most level.**
    b. **Both the G2131-I and L2130-I sample at the same level at the same time, then the L2130-I starts the field validation process. The G2131-I should proceed with sampling as normal. Once the L2130-I finishes the field validation process, both the G2131-I and L2130-I should start a complete sampling cycle from the top most level.**
2. **The LI840A IRGA should never sample at the same level as the Picarro G2131-I and Picarro L2130-I at the same time to avoid the large pressure fluctuation that could exceed the instruments' capability to handle. There are two scenarios:**
    a. **If it is time for the LI840A to switch to a level that is already being sampled by the Picarros, then the LI840A should skip this level and move the next level in the sequence. The Picarros shall continue sampling at this level uninterrupted.**
    b. **If it is time for the Picarros to switch to a level that is already being sampled by the LI840A, then the LI840A shall stop sampling immediately and move the next level, and the Picarros shall continue their sequence and begin sampling at this level immediately.**

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

Field calibration is only applied to the LI840A IRGA CO_2 channel. The H_2O channel will not be calibrated at the field site. The field calibration of the LI840A should occur after the LI840A resumes operation from interruptions or after the IRGA cell experiences pressure fluctuation >= 1.2 kPa. Field calibration should be repeated every 6 days thereafter (i.e., day 1, day 7, day 13, ….).

Field calibration should be done at steady-state (i.e., when the 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 takes ~2 minutes to reach absorptance slope < $1x10^{-5}$, 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 a field calibration at the end of 5 minutes. **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 a later ATBD process.** Routine field calibration should start at the end of a full sampling cycle every 143 hours (5 days plus 23 hours), or at the closest possible time after 143 hours since last calibration expires.

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

Routine field validation will occur daily (every 23 hours) between field calibrations. Field validation should be performed at steady-state (i.e., when the 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 an absorptance slope < $1x10^{-5}$, then the 2.5 min averaging time starts at the end of the 5 min. Validation should start at the end of a full sampling cycle every 23 hours, or at the closest possible time after 23 hours expires.

Monthly field validation will occur once a month using the same gas standards used 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 mode, Val Gas Select valves, and the IRGA Val Gas Valve should be closed. While during the validation mode, these valves should be open to allow selected validation gas to flow to the IRGA Sample Manifold. The IRGA Vent Valve remains closed during sampling mode and validation mode. 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 should be **1.5 SLPM** prior to IRGA Val Gas Valve (controlled by the flow controller). The IRGA Vent valve is only used for emergency vent if needed.

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.

Validation valves		**Sampling Mode**	**Field calibration starting time**	
			0	*Δt+1 min*
	Zero Air	0	1§	0

Val Gas Select valves status (0/1)	Low CO_2	0*	0	0
	Intermediate CO_2	0*	0	0
	High CO_2	0*	0	1
	Archive CO_2	0*	0	0
IRGA Val Gas Valve status (0/1)		0	1	1
IRGA Vent Valve status (0/1)		0	0	0

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 the LI840A IRGA.

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 the LI840A IRGA

Validation valves		**Sampling Mode**	**Monthly validation mode starting time**				
			0	*Δt*	2 *Δt*	*3 Δt*	4 *Δt*
Isotopic CO_2 transfer standard	Zero air	0	1	0	0	0	0
	Low CO_2	0*	0	1	0	0	0

span gas select valves status (0/1)	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 the 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 the G2131-I and L2130-I field validation processes are presented in the subsequent sections.

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 the 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 the G2131-I analyzer. The flag status should be 1 for open, and 0 for closed. 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 one standard gas. It should include the times for both settling (including purge, stabilization, solenoid switching) and measurement.

As currently designed, Δt is 10 min (including 2 min flushing time and 8 min averaging time). Therefore, to complete a full cycle of field validation for the 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 the LI840A is in 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 12.3.3.

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 one Job will be scheduled with a 23-hour interval, field technicians will have to restart this validation Job manually every four weeks (for 12-vial tray) while they are at the 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 technician will be at the field site. Given 23 hours validation interval, 45 vials will last longer than the 2 weeks of normal field technician 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 zero air flow to the H_2O Sample Manifold; and H_2O Analyzer WLM Purge Valve, H_2O Analyzer Zero Air Valve, and Vaporizer 3-way Valve should be open during the validation mode to allow the zero air to flow to the vaporizer and analyzer. While the H_2O Manifold Zero Air Valve is only opened before the instrument is 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 port 2 is NC, this is for sampling air to go through; when this 3-way valve is active (flag = 1), port 1 is closed, and port 2 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

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 the field site prior to operation, and annually thereafter at the same time period when annual field calibration is undertaken. The functions of isotope dependency on humidity will be used to post correct the data.

Field technicians will need to start this process manually while they are at the field site. It will 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 and fine-tuned by field technicians manually. CVAL will provide water standards for this task, and also provide field technicians the instructions to conduct this validation as well as provide the templates for data processing.

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

According to current 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 the field site to quantify the instrument accuracy and drift.

This annual field calibration of the L2130-I should be done during the time period when the G2131-I is sent back to CVAL for lab calibration and profile system maintenance occurs. Field technicians need to start this process manually while they are at the site. It typically will 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 and fine-tuned by the field technicians. CVAL will provide water standards for this task, and also provide field technicians with instructions to conduct this validation as well as provide the templates for data processing.

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

Leak tests should be conducted after maintenance, (see AD [05]).

12.3.5 Error handling

N/A

12.3.6 Sensor controls specification

N/A

13 ASSEMBLY INTEGRATION

N/A

14 POTENTIAL FUTURE DEVELOPMENT

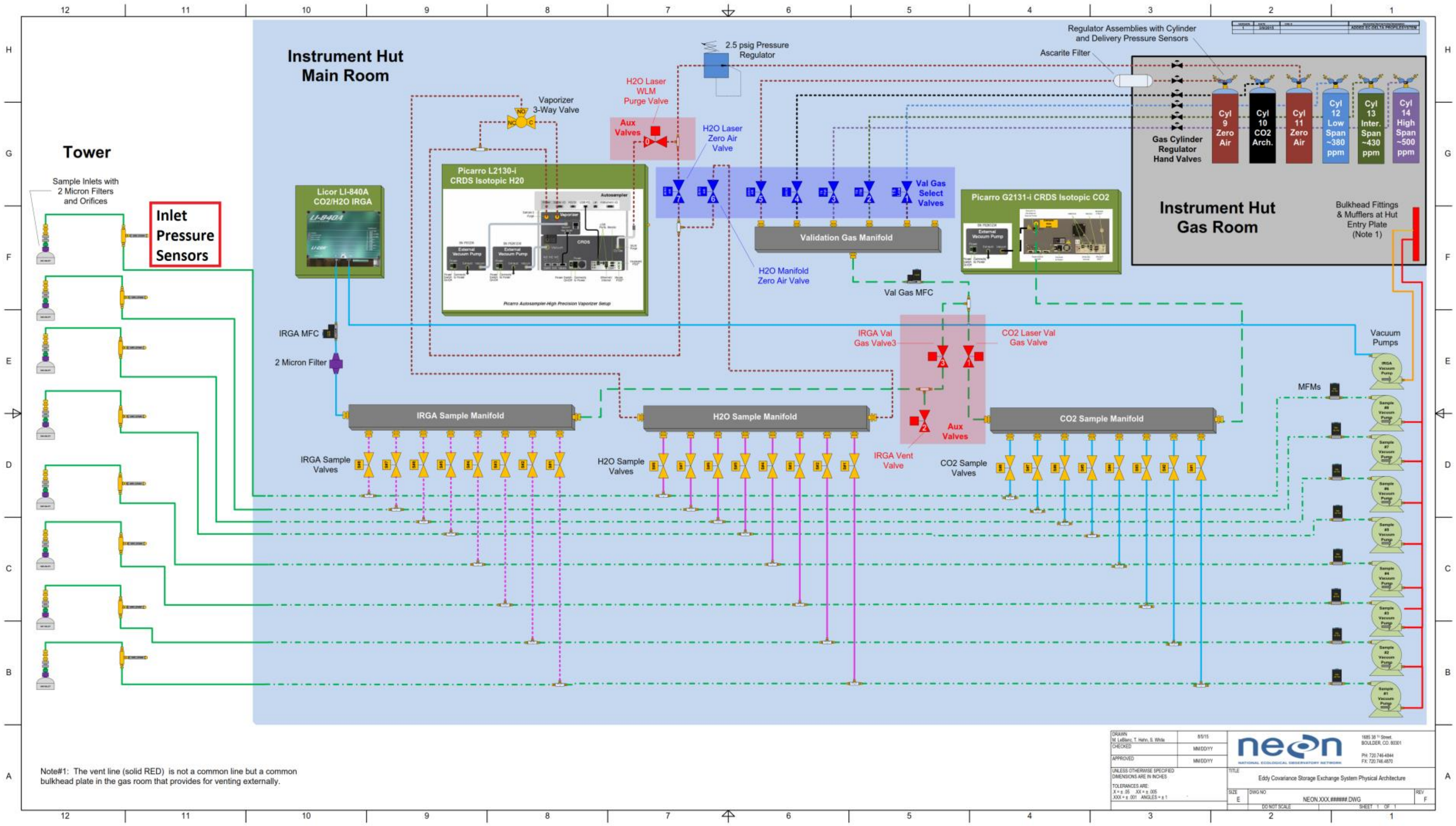
There was a suggestion from the science community (Dave Noone, Todd Downson) that the profile stable isotopic measurements should not always sample from the top level to the bottom level of the profile. Instead, to avoid systematic bias, at least 3 different sampling cycle sequences should be adapted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

There was another suggestion from the science community that a reference level should be used for the G2131-I and L2130-I profile measurement. Because it takes over one 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 a single reference level between measurements made at each measurement level so that the measurements over time can have a common comparable reference. The level that is designated to be the reference level should be the level where atmospheric conditions (i.e. relative humidity, temperature, CO2 concentrations, isotope composition etc.) have been found to be least variable. The top most level was suggested as it 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 by half, which means longer time interval apart between two neighbor cycles, making it less suitable for developing a vertical profile;
2. The G2130-I and L2130-I should never take the measurements at the same measurement level at the same time as the LI840A, and the G2130-I and L2130-I take precedence over LI840A at each measurement level. With G2130-I and L2130-I measurements being repeated frequently at a single reference level (especially at the top level), this will limit LI840A measurements of CO_2/H_2O concentrations at that level, thus impacting the subsequent CO_2/H_2O storage term calculations;
3. Higher level data products for stable isotope measurements are currently unplanned. Thus it is unknown how the data will be used to develop higher data products, and if the reference level will be useful or not; since flux and storage term measurements and calculations have a more mature methodology, the priority is given to these storage measurements and calculations over the stable isotope measurements by not including a reference levels for stable isotope measurements at this time, but this can be reassessed in the future as needed.

15 APPENDIX & BIBLIOGRAPHY

15.1 EC profile assembly Schematic



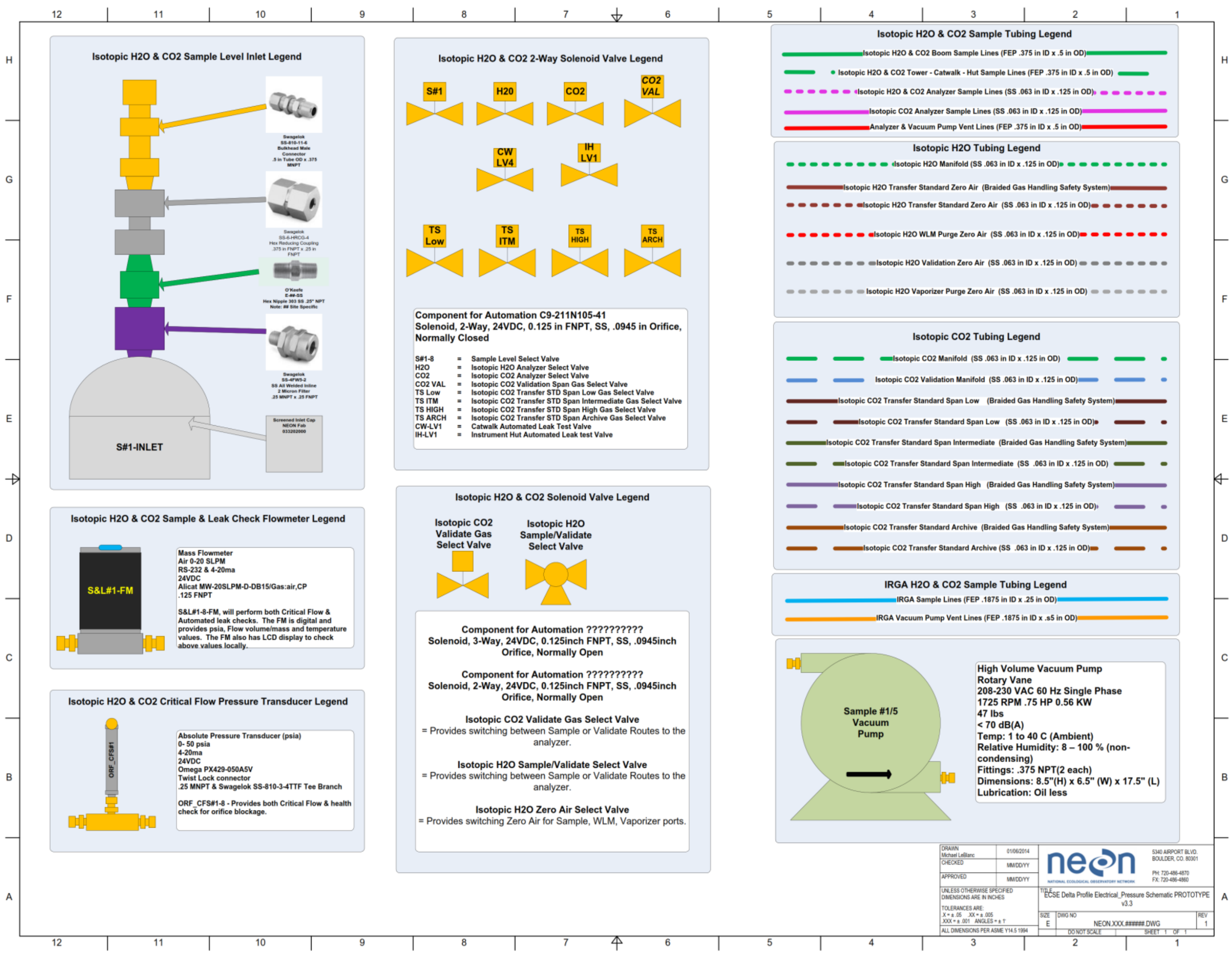


Figure 2. Schematic of the Eddy Covariance Storage Exchange Profile System

15.2 Instrument status (INST_STATUS) information

PICARRO | The World's Highest Performing and Easiest to Use Analyzers

3105 Patrick Henry Drive
Santa Clara, California 95054

408.962.3900 > tel
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.

PICARRO | The World's Highest Performing and Easiest to Use Analyzers

3105 Patrick Henry Drive
Santa Clara, California 95054

408.962.3900 > tel
408.962.3200 > fax

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 the analyzers that need to be copied and backed up at HQ

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

Table 41. Files in G2130-I analyzers that need to be copied and backed up 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 backed up 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

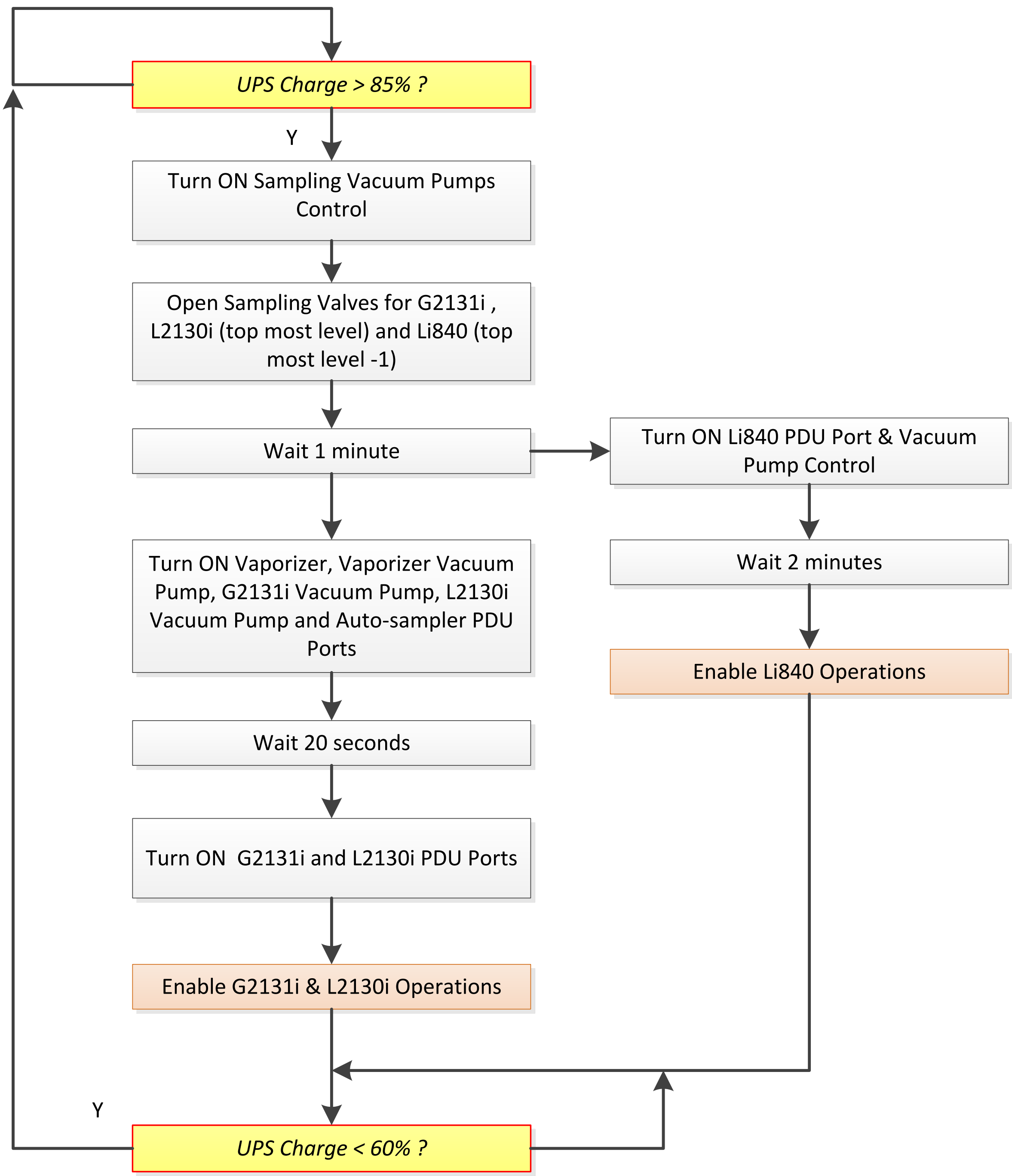


Figure 3. Flow chart for G2131-I and L2130-I power start up sequence

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

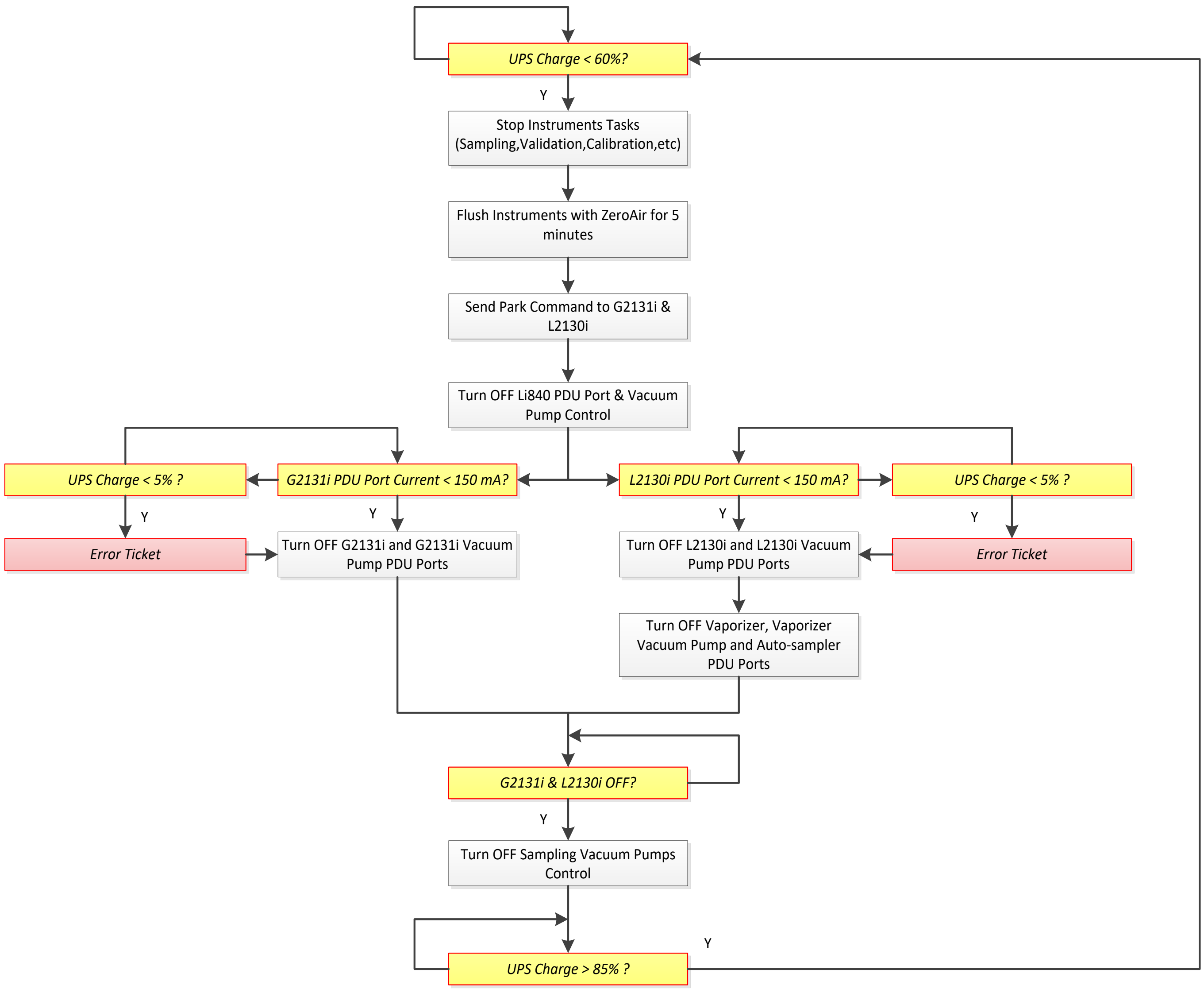


Figure 4. Flow chart for G2131-I and L2130-I power shut down sequence

15.6 List of Level 0 data product

Table 43. List of Level 0 data products 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	real	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)	real	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 species being analyzed	real	NA	~1
	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 isotopic 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 isotopic 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 isotopic 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 isotopic 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 crosstalk	real	micromolesPerMole	~1
	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.DP0.00103.001.02311.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.DP0.00103.001.02309.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	Temperature of Etalon	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	real	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	real	NA	~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.DP0.00103.001.02341.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.DP0.00103.001.02343.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

CA07140 000	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
CA08830 000	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
0341530 000	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
0341500 000	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
0341570 000	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 flow rate set point	real	litersPerMinute	1
	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
CD07150 000	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
CD06640 001	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
CD06640 002	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
0361660000	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02850.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d2HWaterLow	Measure in the low standard of the ratio of stable isotopes 2H:1H in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02851.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d18OWaterLow	Measure in the low standard of the ratio of stable isotopes 18O:16O in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02852.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d2HWaterMed	Measure in the medium standard of the ratio of stable isotopes 2H:1H in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02853.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d18OWaterMed	Measure in the medium standard of the ratio of stable isotopes 18O:16O in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02854.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d2HWaterHigh	Measure in the high standard of the ratio of stable isotopes 2H:1H in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
	profRefeH2oVali	NEON.DOM.SITE.DP0.00120.001.02855.HOR.VER.000	NEON.DOM.SITE.DP0.00120.001	d18OWaterHigh	Measure in the high standard of the ratio of stable isotopes 18O:16O in H2O, relative to the Vienna Standard Mean Ocean Water	real	permill	1
0353710000	profGasCyl	NEON.DOM.SITE.DP0.00118.001.02191.HOR.VER.000	NEON.DOM.SITE.DP0.00118.001	fdMoleCO2	Dry mole fraction (fd) on molar basis (Mole) of carbondioxide (CO2), synonymous with mixing ratio	real	micromolesPerMole	1
	profGasCyl	NEON.DOM.SITE.DP0.00118.001.02324.HOR.VER.000	NEON.DOM.SITE.DP0.00118.001	d13CO2	Measure of the ratio of stable isotopes 13C:12C in CO2, relative to the Vienna Pee Dee Belemnite	real	permill	1
	profGasCyl	NEON.DOM.SITE.DP0.00118.001.02318.HOR.VER.000	NEON.DOM.SITE.DP0.00118.001	fdMole12CO2	Dry molar fraction (fd) of 12CO2 in the air	real	micromolesPerMole	1

	profGasCyl	NEON.DOM.SITE.DP0.00118.001.02320.HOR.VER.000	NEON.DOM.SITE.DP0.00118.001	fdMole13CO2	Dry molar fraction (fd) of 13CO2 in the air	real	micromolesPerMole	1

15.7 Bibliography

- 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
- 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
- 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
- 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
- LI-COR2011_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