NEON PREVENTIVE MAINTENANCE PROCEDURE: EDDY COVARIANCE SYSTEMS

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See configuration management system for approval history.

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Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/30/2017	ECO-04540	Initial Release
B	01/16/2017	ECO-05273	Documentation update: Expanded upon Critical and Non-Critical Preventive Maintenance specific to the Extended Battery Modules in the Instrument Hut. Clarified Autosampler Sample Volume (uL) pulse rate and added procedures to start, restart, and modify for the Picarro H_2O monthly validation process. Moved CVAL Calibration process from Chapter 5 to Chapter 6. Incorporated a summary table for annual calibration and validation tests in Chapter 6. Edited some minor errors and added additional clarifications to sections from lessons learned since initial publishing. Added two additional appendixes.
C	05/21/2018	ECO-05544	Updated the PICARRO L2130-I Analyzer for Isotopic H2O procedure (monthly validations with 12 vials instead of 90 vials) and add instructions on how to use Remote Desktop Connection to access the PICARROs from the Domain. Incorporated information from NEON-8426, NEON-12735, NEON-13155, and NEON-12376. Made updates/ corrections, and clarifications to Section 2, Section 5, and Section 6. Added additional instructions to power down procedures for the tower to align with the TIS Electrical Safety Training NEON Safety initiative. Incorporated additional feedback from Field Science TIS Technicians from April 2018 TIS Training Palooza, etc. Added additional Sensor Refresh information and packaging requirements in Section 6. Changed Hut Summer Set Point for D04 LAJA and GUAN from 77F to 85F and D05 UNDE to 80F.
D	08/24/2022	ECO-06843	Reorganized content: moved removal, and replacement to sensor/infrastructure sections, reorder of Picarro autosampler training steps. Added sensor prioritization from KB0012900. Updated guidance for instrument hut temperatures. Updated gas cylinder exchange procedure

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
			using IS Control and Monitoring Suite software. Removed troubleshooting for MFMs, GRAPES and rotary vane pumps due to scope limitations. Removed redundant tools and consumables table in inspection and preventative maintenance section. Revised and updated Windows Remote Desktop Connection for Picarro remote access. Guidance added on Ascarite II CO2 scrubber. Updated guidance for ECTE and ECSE pump replacement parameters. Added instructions for adjusting ECTE intake tube heater and taring MFMs. Added improved guidance for ECTE inlet rebuild via KBA0012880 and instructions for cleaning inlet tube. Updated and added info for remote monitoring expectations and resources. Clarified preventive maintenance requirements for both PICARRO sensors internal filter and orifice. Added KB0011752 in the Appendix. Updated formatting, branding, and fixed typos, and bad links. Incorporated information from CHG0035987.
E	12/01/2022	ECO-06923	Moved Appendix C contents to Section 2, to align with document template Renamed Section 2 to: Related Documents and Acronyms Minor formatting fixes

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1 DESCRIPTION

1.1 Purpose

Routine preventive maintenance is imperative to ensure the proper functional and operational capability of National Ecological Observatory Network (NEON) systems, and the preservation of NEON program infrastructure. This document establishes the mandatory procedures and recommended practices for preventive maintenance of the **Eddy Covariance Systems: Eddy Covariance Storage Exchange (ECSE) and Eddy Covariance Turbulent Exchange (ECTE)** sensors and infrastructure to meet the objectives of the NEON program, and its respective stakeholders and end users.

1.2 Scope

Preventive Maintenance is the planned maintenance of infrastructure and equipment with the goal of improving equipment life by preventing excess depreciation and impairment. This maintenance includes, but is not limited to, inspecting, adjusting, cleaning, clearing, lubricating, repairing, and replacing, as appropriate. The procedures in this document are strictly preventive.

This document specifically addresses the preventive procedures to maintain the Eddy Covariance Storage Exchange (ECSE) and Eddy Covariance Turbulent Exchange (ECTE) for all NEON terrestrial instrumentation sites (TIS). This covers the ECSE and ECTE subsystems and infrastructure in the Instrumentation Hut and Tower.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

The following applicable documents (AD) contain mandatory requirements and/or supplementary information that are directly applicable to the topic and/or procedures herein. Visit the NEON Document Warehouse for electronic copies of these documents.

AD [01]	NEON.DOC.004300	Environmental, Health, Safety and Security (EHSS) Policy, Program and Management Plan
AD [02]	NEON.DOC.004301	EHSS Environmental Protection Manual
AD [03]	NEON.DOC.004316	Operations Field Safety and Security Plan
AD [04]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
AD [05]	NEON.DOC.003636	Preventive Maintenance Procedure: Environmental Enclosure
AD [06]	NEON.DOC.001436	TIS Comm Interconnect Map
AD [07]	NEON.DOC.003565	Hut Gas Cylinder Configuration
AD [08]	NEON.DOC.000807	Eddy-covariance Turbulent Exchange Subsystem Level 0 Prime Data Products ATBD
AD [09]	NEON.DOC.001427	TIS Hut, Rack DAS and PDS Interconnect
AD [10]	NEON.DOC.000465	NEON Sensor Command, Control and Configuration (C3) Document: Eddy Covariance Storage Exchange
AD [11]	NEON.DOC.000456	Neon Sensor Command, Control and Configuration (C3) Document: Eddy-Covariance Turbulent Exchange Subsystem
AD [12]	NEON.DOC.004163	Location Controller (LC) Command and Control User Manual
AD [13]	NEON.DOC.002768	TIS Subsystem Architecture, Site Configuration and Subsystem Demand by Site - SCMB Baseline
AD [14]	NEON.DOC.003775	ECSE Compressed Gas Cylinder Change and Dilution Pressure Purge Procedure for Pressure Reduction Regulator
AD [15]	NEON.DOC.004273	ECTE Compressed Gas Cylinder Change and Dilution Pressure Purge Procedure for Pressure Reduction Regulator
AD [16]	NEON.DOC.002422	Isotopic Water Calibration Fixture Manual L1W200
AD [17]	NEON.DOC.004887	How-To: Field Microsoft Windows Operating System (OS) Software Update Procedure for the PICARRO G2131-I and L2130-I Analyzers
AD [18]	NEON.DOC.004482	TIS DAS-Hut Subsystems Formal Verification Procedures
AD [19]	NEON.DOC.004637	TIS Verification Checklist
AD [20]	NEON.DOC.004980	NEON Preventive Maintenance Procedure: Site Infrastructure
AD [21]	NEON.DOC.005241	NEON Standard Operating Procedure: Eddy Covariance Storage Exchange (ECSE) Gas Line Cleaning Procedure
AD [22]	NEON.DOC.XXXXXX	Command and Control (CNC) Configuration Values Template
AD [23]	KB0012946	Mandatory Information Requirements for Returning Instrument System (IS) Items to HQ via ServiceNow
AD [24]	KB0012702	Sensor Refresh Command and Control (CNC) Program Reporting Requirements
AD [25]	NEON.DOC.005038	NEON Standard Operating Procedure (SOP): Sensor Refresh

2.2 Reference Documents

The Reference Documents (RD) listed below may provide complimentary information to support this procedure. Visit the NEON Document Warehouse for electronic copies of these documents.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.050005	Field Operations Job Instruction Training Plan
RD [04]	NEON.DOC.004879	TIS Site Complete Power Shut Down Procedure
RD [05]	NEON.DOC.004100	Instruction, Assembly, Air Intake, EC-SES, Orifice 42
RD [06]	NEON.DOC.003637	Instruction, Assembly, Air Intake, EC-SES, Boom 42
RD [07]	NEON.DOC.003065	Instruction, Tube Fitting Installation
RD [08]	NEON.DOC.003701	Instruction, Assembly, Heated Inlet Tube, IRGA
RD [09]	NEON.DOC.004257	All Systems Standard Operating Procedure: Decontamination of Sensors, Field Equipment, and Field Vehicles
RD [10]	NEON.DOC.000705	NEON Bolt Torque Specification
RD [11]	NEON.DOC.003066	Instruction, Teflon Pipe Tape Application
RD [12]	CD0715003	Assembly 24VDC Pump and Control Gusset Mounting Brackets, .025 inch Tube Connectors
RD [13]	NEON.DOC.000769	Electrostatic Discharge Prevention Procedure
RD [14]	NEON.DOC.004882	NEON Installation Procedure: Environmental Enclosure Power Cover
RD [15]	NEON.DOC.001599	Schematic, Environmental Enclosure
RD [16]	NEON.DOC.004458	Hut Dehumidifier (ECSE) Formal Verification Procedures
RD [17]		NEON IS Tools Consumables and Parts List v3.0
RD [18]	NEON.DOC.005329	HOW-TO CAP UNUSED GAS LINES ON ECSE GAS PLATES CD08330000 AND CD08330010

2.3 External References

The external references (ER) listed below may contain supplementary information relevant to maintaining specific commercial products that make up the infrastructure of the ECSE/ECTE systems. External references contain information pertinent to this document, but are not NEON configuration-controlled. Examples include manuals, brochures, technical notes, and external websites. If an issue with a product requires the involvement of the manufacturer, NEON Headquarters (HQ) will contact the manufacturer or provide Field Operations (FOPS) the authority to contact via the NEON Issue Management System.

ER [01]	Department of Labor, Occupational Safety and Health Administration (OSHA), General Industry Standard 29 Code of Federal Regulations (CFR) 1910.101, Compressed Gas Association's (CGA) Pamphlets C-6-1993, C-8-1997, and P-1-1999. *https://www.osha.gov/*
ER [02]	National Fire Protection Association (NFPA) 55: *Compressed Gases and Cryogenic Fluids Code*, 2016. *http://www.nfpa.org/*
ER [03]	Department of Health & Human Services (HHS), National Institute for Occupational Safety and Health (NIOSH), *Compressed Gases Self-Inspection Checklist*, June 14, 2014. *https://www.cdc.gov/niosh/docs/2004-101/chklists/r1n29c~1.htm*

ER [04]	GAST, *GAST 31, 32, 33, & 34 Series Oil-Less Vacuum Pumps and Compressors Operation and Maintenance Manual*, http://gastmfg.com/uploads/manuals/70-205-H.pdf
ER [05]	GAST Rotary Vane Pump Rebuild (to maintain and repair pumps, as appropriate), https://www.youtube.com/watch?v=1h6pj4wrJIU
ER [06]	Swagelok, Inc. YouTube Channel for Tech Tips and Training Procedures for Maintenance, https://www.youtube.com/channel/UC0DJ35LbnayzW-bJsH6bthA
ER [07]	General Electric, *Model ADEL50LR Dehumidifier Use and Care Owner's Manual*, http://products.geappliances.com/MarketingObjectRetrieval/Dispatcher?RequestType=PDF&Name=49-7707-2.pdf
ER [08]	Comet Systems, Transmitters and Regulators, *T7310 Industrial Temperature, Humidity, Bar. Pressure Transmitter - RS232 Output*, http://www.cometsystem.com/products/temperature-humidity-pressure-transmitters-and-regulators/t7310-industrial-temperature-humidity-bar-pressure-transmitter-rs232-output/reg-T7310#technical_dataa
ER [09]	PICARRO Inc., *Picarro G2101-I Analyzer for Isotopic CO_2 User's Guide/Manual*. Rev. March 6, 2012. www.picarro.com
ER [10]	Swagelok Inc., *An Installer's Pocket Guide for Swagelok Tube Fittings*, www.swagelock.com. http://www.swagelok.com/downloads/webcatalogs/EN/MS-13-151.PDF
ER [11]	AMPROBE, *TMULD-300 ULD-300 Ultrasonic Leak Detector User's Manual*, Rev002, English. http://content.amprobe.com/manualsA/TMULD-300_ULD-300_Ultrasonic-Leak-Detectors_Manual.pdf
ER [12]	Campbell Scientific, CSAT3 Three Dimensional Sonic Anemometer Instruction Manual, Revision 2/15. https://s.campbellsci.com/documents/us/manuals/csat3.pdf
ER [13]	JIRA, NEON-5151. D03-DSNY: LI-7200 - Dirty Optical Windows and Low Measured Values/Signal Strength, 13/Dec/16. https://neoninc.atlassian.net/browse/NEON-5151
ER [14]	LI-COR, LI-840 CO_2/H_2O GAS ANALYZER Instruction Manual. https://www.licor.com/documents/y10gor2jal2p3t8ev4hm
ER [15]	LI-COR, LI-7200 CO_2/H_2O Analyzer, Instruction Manual. Publication No. 984-10564. ftp://195.37.229.5/pub/outgoing/okolle/For_Divino/Manuals/Licor/LI-7200_Manual.pdf
ER [16]	PICARRO, INSTALLATION L2130-i or L2120-i Analyzer & Peripherals 8-7-2012.pdf *SHA1: 1ab3ad5f33bb7249599a41d70bfb1c777a99806d*
ER [17]	PICARRO, OPERATION, DATA ANALYSIS, MAINTENANCE, TROUBLESHOOTING L2130-i or L2120-i Analyzer & Peripherals 8-7-2012.pdf *SHA1: e946d4da9d3d55a6c49a27efb116146a93d3802c*
ER [18]	PICARRO, Picarro Autosampler User's Manual rev 8-7-2012.pdf *SHA1: 8888d5bec77a7bbd3d73049baf0f20741344324c*
ER [19]	PICARRO, L2130-i High Precision Isotopic Water Analyzer Data Sheet *SHA1: a293c85e07b91c097d8c1ac6aae58283723c25fa* http://hpst.cz/sites/default/files/attachments/data-sheet-l2130-i-high-precision-isotopic-water-analyzer-102615.pdf
ER [20]	SharperTEK, Ultrasonic Cleaners, User Manual, SH-Series http://lib.store.yahoo.net/lib/yhst-42112424359421/SH-Series-Manual.pdf
ER [21]	Fluke Corporation, 80 Series V Multi-meter Quick Reference Guide, May 2004, www.fluke.com
ER [22]	Xsens, MTi 10-series and MTi 100-series User Manual, Rev 1, MT0605P, 20 December, 2016 SHA1: e342a14581e689a6f5bc42221d493ea12b2d0d16 https://www.xsens.com/download/usermanual/MTi_usermanual.pdf
ER [23]	PICARRO Inc., G2131-i Analyzer for Isotopic CO_2 Data Sheet SHA1: 29bb6ba6e5694aee26ca2303e19223ffe79f8e48

	http://hpst.cz/sites/default/files/attachments/datasheet-g2131-i-crds-analyzer-isotopic-co2-oct15.pdf
ER [24]	Swagelok, Inc. An Installers Pocket Guide for Swagelok Tube Fittings. https://www.chem.purdue.edu/docs/chemsafety/chem/SwageLokPocketInstallerGuide.pdf
ER [25]	Comtrol PortVision DX for PoE Switches: http://www.comtrol.com/resources/product-resources-white-papers/additional-resources/portvision-dx
ER [26]	Eaton. 9PX 8000, 9PX 11000, 9PX Extended Battery Module 240V Installation and User Manual, 8-11kVA US_EN. 2013. http://lit.powerware.com/ll_download.asp?file=614-09275-02_EN%20(web).pdf
ER [27]	NEON Science, YouTube: *Eddy Covariance: Measuring an Ecosystem's Breath*. April 18, 2017. https://youtu.be/CR4Anc8Mkas

2.4 Acronyms

Acronym	Description	Acronym	Description
^2H	Deuterium (Isotope of Hydrogen)	KVM	Keyboard, Video and Mouse
^{13}C	Isotope of Carbon	LC	Location Controller
^{18}O	Isotope of Oxygen	LCD	Liquid Crystal Display
3D	Three Dimensional	LED	Light-Emitting Diode
A/R	As Required	LPM	Liters Per Minute
AHRS	Attitude and Heading Reference System	MFC	Mass Flow Controller
AMRS	Attitude and Motion Reference System	MFM	Mass Flow Meter
ARC	Assembly, Repair and Calibration Laboratories	MFR	Mass Flow Rate
CH_4	Methane	ML	Measurement Level
CFG	Configured	MSDS	Material Safety Data Sheet
CGA	Compressed Gas Association	NEMA	National Electrical Manufacturers Association
CGC	Compressed Gas Cylinder	NMP	1-methyl-2-pyrrolindinone
CNC	Command and Control	P/N	Product Number
CO_2	Carbon Dioxide	PDU	Power Distribution Unit
CRDS	Cavity Ring-Down Spectroscopy	PoE	Power over Ethernet
CVAL	Calibration, Validation, and Audit Laboratory	PPE	Personal Protective Equipment
DMM	Digital Multi-Meter	PPM	Parts Per Million
DOT	Department of Transportation	PPMV	Parts Per Million by Volume
DPress	Differential Head Pressure (LI-7200/RS)	PRT	Platinum Resistance Thermometer
ECTE	Eddy Covariance Turbulent Exchange	PSI	Pounds Per Square Inch
ECSE	Eddy Covariance Storage Exchange	PSIA	Pounds Per Square Inch Absolute
EHSS	Environmental Health Safety and Security	PSIG	Pounds Per Square Inch Gauge
ENG	Engineering	SCCM	Standard Cubic Centimeters Per Minute
FEP	Fluorinated Ethylene Propylene	SHA1	Secure Hash Algorithm
FTP	File Transfer Protocol	SLPM	Standard Liter Per Minute
GPS	Global Positioning System	SPD	Surge Protection Device
GUI	Graphical User Interface	SS	Stainless Steel
H_2O	Water	TEP	Terminal Emulator Program

HQ	Headquarters	TIS	Terrestrial Instrumentation Site
IP	Internet Protocol	UPS	Uninterruptable Power Supply
IRGA	Infrared Gas Analyzer	USB	Universal Serial Bus
JSA	Job Safety Analysis	UV	Ultraviolet
KPa	kilopascal	WLM	Wavelength Monitor
kPaA	Kilopascal – Absolute Pressure	XML	Extensible Markup Language
kPaG	Kilopascal – Gauge Pressure		

2.5 Terminology

The use of common names for NEON instrumentation and subsystems varies across departments and Domains. The aim of this section is to consolidate terminology so Field Ecologists are aware of the component referenced in the procedures herein, but also aware they may be called another term in a group discussion with HQ or training staff.

SYNONYMOUS COMMON NAME(S)	NEON TECHNICAL REFERENCE NAME
Attitude and Heading Reference System (AHRS), Accelerometer, Inclinometer	**Accelerometer, Attitude and Motion Reference System (AMRS)**
CO_2 Laser, CO_2 Analyzer, CO_2 Isotopic Laser, Isotopic CO_2, Analyzer Module	**PICARRO G2131-I CO_2 Analyzer for Isotopic CO_2**
CSAT, Sonic, 3D Wind, 3D Sonic	**Campbell Scientific CSAT3 3D Sonic Anemometer**
ECSE IRGA, ECSE Delta, LI-840/850 Non-Dispersive Infrared (NDRI) Gas Analyzer	**LICOR LI-840/850 Infrared Gas Analyzer (IRGA)**
ECTE Control Box	**LICOR LI-7550 Interface Unit for the LI-7200/RS**
ECTE IRGA, IRGA 7200 or Heated Inlet Tube Assembly, IRGA, CO_2/H_2O Infrared Gas Analyzer	**LICOR LI-7200/RS Infrared Gas Analyzer (IRGA)**
Environmental Probe, Platinum Resistance Thermometer (PRT), ECSE Rack PRT, COMET	**COMET T7610 Temperature Monitor**
National Electrical Manufacturers Association (NEMA) Enclosure, Environmental Enclosure (EE), Environmental Chamber, Enviro Chamber/Enclosure	**Tower Top Environmental Enclosure**
NEMA Enclosure, Device Post	**Tower Power Box**
NEMA Enclosure, Device Post	**Tower Communications (Comm) Box**
NEMA Enclosure, Gas Breakout Box	**Gas Junction Box, Tower Base**
Profile System	**Eddy Covariance Storage Exchange**
Septum	**Septa**
Water (H_2O) Laser, H_2O Analyzer, H_2O Isotope Laser, Isotopic H_2O, Analyzer Module	**PICARRO L2130-I Analyzer for Isotopic H_2O**
Vaporizer	**PICARRO Vaporization Module**
Maximo, AssetWorks	**Asset Lifecycle Management System**

3 SAFETY AND TRAINING

Personnel working at a NEON site must be compliant with safe fieldwork practices in AD [03] and AD [01]. The Field Operations Manager and the Lead Field Ecologist have primary authority to stop work activities based on unsafe field conditions; however, all employees have the responsibility and right to stop work in unsafe conditions.

All Field Ecologists must complete safety training and procedure-specific training to ensure the safe implementation of this protocol per AD [03]. Refer to the site-specific EHSS plan via the NEON Safety document portal for electronic copies.

Preventive maintenance of the Eddy Covariance Systems may require the use of a special equipment to access the sensor subsystem assemblies. Follow Domain site-specific EHS plans and NEON safety training procedures when conducting maintenance activities. Conduct a Job safety Analysis (JSA) prior to accessing the sensor subsystems onsite. Reference the My NEON Safety Office SharePoint website for JSA templates and additional hazard identification information.

In the event the current method to conduct the procedures herein are no longer safe for use due to unforeseen or unknown site dynamics, consult with the NEON Safety Office via the NEON Program's Issue Management and Reporting System (ServiceNow) for alternative methods to conduct TIS preventive/corrective maintenance and Sensor Refresh procedures.

Note: Compressed Gas Safety guidelines are in AD [01] under Section 23 of the NEON.DOC.004300 EHSS Policy, Program and Management Plan.

4 EDDY COVARIANCE TURBULENT EXCHANGE AND STORAGE EXCHANGE OVERVIEW

4.1 Description

4.2 Eddy Covariance Science: A Brief Introduction

Eddy Covariance is a micrometeorological measurement technique for directly quantifying the exchange of mass, momentum, and energy between the biosphere and the atmosphere. It measures the net exchange (i.e., flux) of scalar entities like CO_2, CH_4, N_2O, water vapor, heat, and other gases between the earth's surface (within canopies) and the atmosphere (above canopies).

This exchange occurs by "eddies" in the wind. As wind blows across the surface of the earth, the surface roughness causes wind to tumble and create various eddies that entrain heat and trace gases into the air. These eddies transport the heat and trace gases along with the wind across the landscape (see **Figure 1**).

Figure 1. Wind Flow Transporting Heat and Trace Gases Across Landscape (Burba 2013).

Eddy Covariance Turbulence Exchange (ECTE) is the covariance between the turbulent fluctuations of the vertical wind, and the concentration fluctuations of the scalar entity of interest. Quickly collecting accurate measurements of the vertical wind, while simultaneously taking measurements of a scalar entity (e.g., CO_2, CH_4, H_2O), enables capturing measurement rates and magnitudes between the biosphere and the atmosphere.

The ECTE system instruments aim to measure the exchange of heat and gases in a region above canopies, the inertial sublayer, or the constant flux layer. This is one of the reasons the NEON program requires tower heights to reach a certain height above canopy. The optimal mixture of air via turbulence occurs within this layer; the flux value within the constant flux layer is constant (hence the name). It remains constant regardless of the tower height for measurement collection within the layer (see **Figure 2**). NEON can collect the same flux value from below the mixed layer from above the roughness layer.

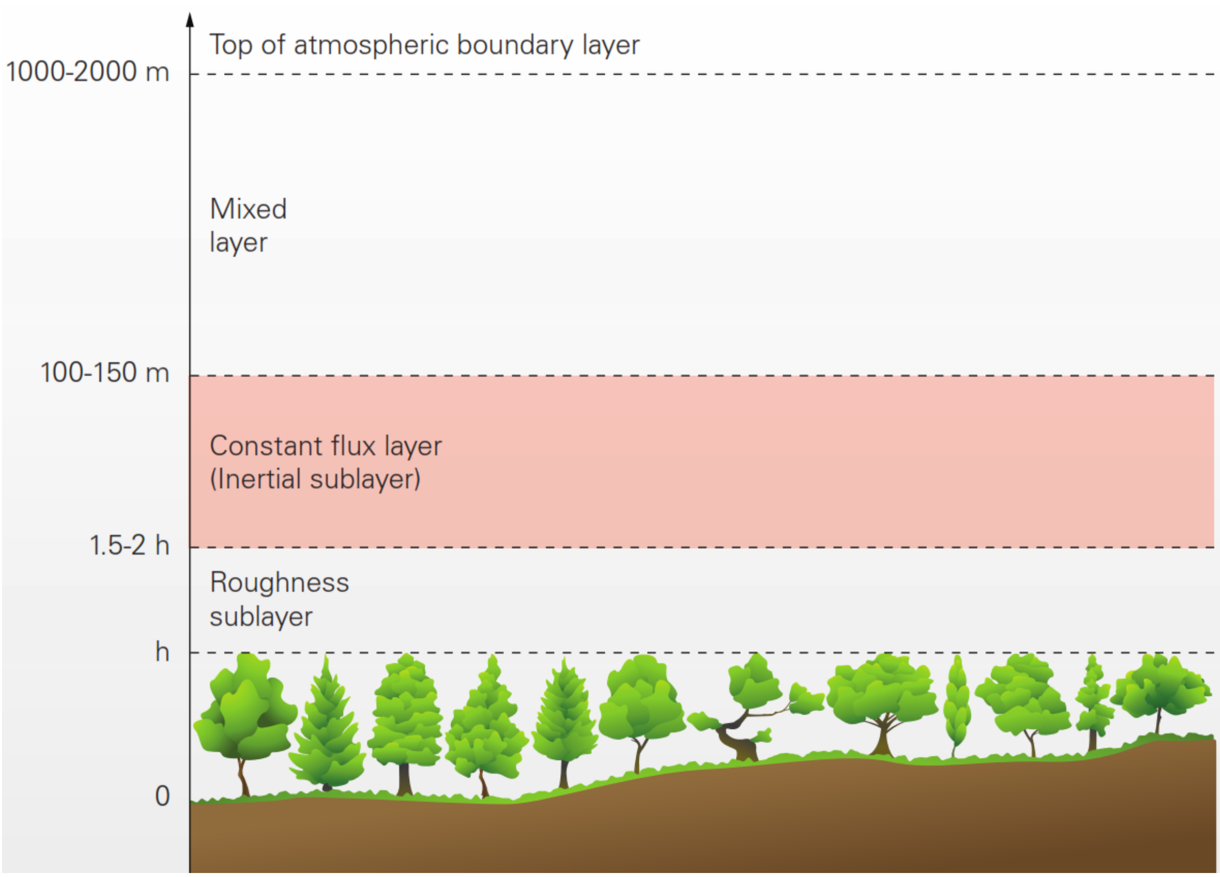


Figure 2. Optimal Measurement Level for ECTE: Constant Flux Layer (Inertial Sublayer) (Burba 2013).

Immediate surroundings, such as trees, may influence the measurements deriving from the canopy surface; too close to the surface (the roughness sublayer in **Figure 2**). Collecting measurements from high above the canopy, where the air disperses amongst a wider area (the mixed layer in **Figure 2**), may fail to represent the ecosystem (too high above the surface). In summation, both layers above and below the constant flux layer vary in flux value due to external variables. These biosphere and atmospheric constraints make the constant flux layer ideal for collecting ECTE measurements.

The NEON program's ECTE system measures surface exchange using specific sensors per standard NEON science requirements, which include installation and implementation within the inertial sublayer using custom designed terrestrial instrumentation system (i.e., NEON TIS Towers). However, employing accurate sensor technology and adapting infrastructure to achieve the optimal height are only two pieces of the equation. *Successful measurement is dependent on the sufficient turbulent mixing of the air.*

Conditions exist where insufficient turbulent mixing occurs, such as during calm winds, still nights, or within forest canopies. During these conditions, the ECTE system fails to quantify the measurement of the biospheres surface exchange of the scalar entities (i.e., CO_2, CH_4, N_2O, water vapor, heat, and other gases) because there is either an accumulation or depletion within the air below the height of the canopy top, and subsequently the ECTE system. The accumulation or depletion within the canopy is the "storage" effect of the scalar entities within the air of the canopy, which is an instrumental measurement in determining accurate estimations of both the biosphere and atmosphere surface exchange. Unfortunately, the ECTE system cannot measure this effect within a canopy; it must accompany an additional measurement system to capture the surface exchange occurring beneath the canopy. *Accurate measurement of surface exchange requires measurements in nearly all atmospheric conditions.*

The Eddy Covariance Storage Exchange (ECSE) system (or Profile System) measures the "storage" of scalar entities within a canopy. The NEON program's ECSE system measures gas concentrations at different tower measurement levels, from the ground surface to above the canopy. This allows NEON to capture measurements of gas concentrations over time (i.e., measuring the gas concentration profile), and calculate the amount of "storage" occurring within each measurement level. Combining these measurements from the ECSE system with the measurements from ECTE system enables NEON to capture more complete and accurate estimations of the true surface exchange (flux) amongst a NEON TIS Tower site ecosystem.

A summary video from NEON about Eddy Covariance is available at the following link [Eddy Covariance: Measuring an Ecosystem's Breath]

ECTE INSTRUMENTS (SENSORS)

The ECTE system uses the following instrumentation to measure turbulent fluctuations of three dimensional wind, CO_2, and water vapor concentrations.

Campbell Scientific CSAT3 3D Sonic Anemometer with Accelerometer, Attitude and Motion Reference System (AMRS) (AMRS not shown)

LICOR LI-7200/*RS* IRGA with the LI-7550 Analyzer Interface Unit

ECSE INSTRUMENTS (SENSORS)

The ECSE system uses the following instrumentation to measure gas (CO_2 and water vapor) concentrations and stable isotope ($\delta^{13}C$ in CO_2, $\delta^{18}O$ and $\delta^{2}H$ in water vapor) concentrations along the vertical profile throughout the canopy.

PICARRO G2131-I Analyzer for Isotopic CO_2

PICARRO L2130-I Analyzer for Isotopic H_2O, Vaporizer, and Autosampler

LICOR LI-840/*850* IRGA

The ECSE and ECTE systems reside on common infrastructures. Preventive maintenance procedures for these common infrastructures are applicable to both systems, which are addressed first herein, following a logical order of operations (e.g., conduct remote condition monitoring prior to arriving onsite; perform maintenance in the Hut; perform maintenance on the Tower; verify operations in the Hut/Tower; continue remote conditioning monitoring and repeat the cycle), unless stated otherwise.

4.3 Sensor Specific Handling Precautions

4.3.1 Compressed Gas Cylinders

All compressed gases present physical hazards due to their high pressure. A sudden release of pressure may cause a cylinder to become a missile-like projectile. If handled properly, compressed gas cylinders are safe. If handled improperly, the same cylinders can present a severe hazard to Field Ecologists and the surrounding infrastructure and environment. Domain staff must complete the requisite safety training prior to handling compressed gas cylinders. Always conduct a Job Safety Analysis (JSA) as needed and wear the appropriate Personal Protective Equipment (PPE) (refer to AD [01]).

- Always transport cylinders using wheeled cylinder carts with retaining straps or chains, or secure with spacers between cylinders in sleds.
- Do not bang, drop, slide, drag or allow a cylinder to strike another cylinder or other hard surface.
- Store cylinders upright and secure them with a chain, strap, or cable to a stationary building support (i.e., Structural Beam) or to a cylinder cart to prevent cylinders from tipping or falling.
- Store cylinders in a dry, well-ventilated area away from flames, sparks, or any source of heat.
- Place cylinders in a location where they are not subject to mechanical or physical damage, heat, or electrical circuits to prevent potential explosions or fires.
- Do not use the valve cover to lift cylinders; they may damage and/or separate from the cylinder, causing the cylinder to drop on a hard surface, possibly resulting in an explosion.
- Always keep valve protection caps on the cylinders, except when the cylinder is in use.
- Never plug, remove, or tamper with any pressure relief device.
- Never expose cylinders to an open flame or to any temperature above 125 degrees Fahrenheit (52°C).

4.3.2 PICARRO Sensor Instrumentation

The PICARRO sensor systems contain electrostatic discharge (ESD) sensitive parts. Protect the analyzers from mechanical shocks and extreme temperatures (temperatures outside of its operating and storage temperature range of 10 to 35°C (operating) -10 to 50°C (storage)). Failure to do so may compromise its performance. When conducting maintenance on a PICARRO analyzer, wear an anti-static wristband (with cord tied to the ground/grounding mechanism).

4.3.3 LICOR Sensor Instrumentation

The optical sources are sensitive to vibration; they may incur damage via strong vibrations and jarring movements. Do not drop the LI-7200/RS and LI-840/850 or expose it to severe mechanical shock.

The LI-840/850 is sensitive to rapid temperature fluctuations and high temperatures (above 45°C). Avoid direct exposure to sunlight or extremely high temperatures (temperatures conditions outside of the operating range set for the instrument by the manufacturer). Store in an environment with a controllable temperature; do not leave the instrument in a vehicle or in an environment with an uncontrollable temperature for long durations.

4.3.4 CSAT3 3D Sonic Anemometer Instrumentation

Please refrain from handling the CSAT3 transducers (i.e., fingers), arms or strut between the arms. The transducers must maintain their precise orientation and distance; alterations to their position affects measurement collection and requires a re-calibration of the instrument to resolve. Always hold the sensor by the block or main body where the sensor upper and lower arms connect.

4.3.5 Grapes and Power over Ethernet (PoE) Switches Subsystems

Grapes and PoEs contain ESD sensitive parts; therefore, all Grapes and PoEs require ESD (antistatic) packaging and handling during inter- and intra-site transport, reception, and storage. *Reference AD [18] for additional information.* As a rule, when handling (installing, removing, and servicing) these electrical components, all technicians must ground themselves. Reference RD [13] for electrostatic discharge prevention procedures. ***Never plug or unplug sensor connections when the Grapes are powered (also known as hot swapping). Always remove the RJF Cable (Cable that connects to the PoE Switch in the Comm Box) first to de-energize the Grape and prevent damage.***

5 INSPECTION AND PREVENTIVE MAINTENANCE

5.1 Subsystem Location and Access

The ECSE instrumentation and subsystem is located on each Terrestrial Instrumentation System (TIS) Tower Measurement Level (ML) and within the Instrumentation Hut.

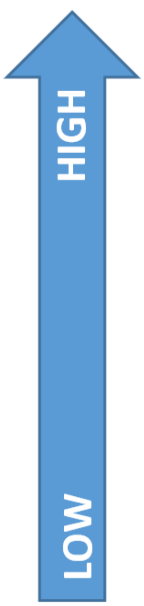
The ECTE instrumentation is located on the Tower Top ML (boom or boom arm). A portion of the ECTE subsystem is in the Environmental Enclosure located on the Tower Top and in the Instrumentation Hut. *Reference AD [05] for preventive maintenance procedures on equipment within the Tower Top Environmental Enclosure.*

Note: Refer to site-specific As-Built documentation in the NEON SharePoint Document Warehouse to verify site-specific TIS ECSE and ECTE Infrastructure and Sensor subsystems.

5.2 Prioritization of Maintenance Activities

Use the following guidance to prioritize maintenance at TIS sites (**Figure 3**).

Priority Overview:



System	Sensor	Rationale
ECTE System	LI-7200, CSAT3, AMRS	80-90% of flux measurement, no redundancy
EC Storage Exchange (ECSE)	LI-840	Key part of storage flux measurement
ECSE	Picarro G2131-i	Making vertical profile measurements of CH_4 (methane), high precision CO_2 concentration and ^{13}C isotope in CO_2
ECSE	Picarro L2130-i	Making vertical profile measurements of ^{2}H and ^{18}O isotope in H_2O
Storage Exchange Measurement Levels (MLs)	First priority is tower top ML. Second priority is ML1.	Top level needed for flux calculation. Bottom level has the higher CO_2 concentration.
Others	All other TIS sensors	Many have redundancies elsewhere or have lower importance compared to EC system

Figure 3. TIS Sensor System Prioritization Overview for Maintenance Activities.

The top priority at all TIS sites is the ECTE measurements, if needed a ML pump should be swapped in to replace a non-functional ECTE pump. The ECTE sensors accounts for 80-90% of flux measurements and the LI-7200/RS is the only sensor in the Observatory that collects this measurement at each site. The second most top priority is the ECSE system sensors. Contact the TIS Science Support Team via ServiceNow with any questions in the application of these guidelines in **Figure 3**.

5.3 Maintenance Frequency

Table 1 is an interval schedule of each infrastructure component requiring preventive maintenance.

Table 1. ECSE & ECTE Common Preventive Maintenance Tasks Interval Schedule**.**

Maintenance	Bi-Weekly	Monthly	Quarterly	Annual	Biennial	As Needed	Type
Pump Infrastructure & Pneumatics *(the gas system)*							
Remote Monitoring	***CONDUCT REMOTE MONITORING OF ECSE AND ECTE SYSTEM DAILY.***						
Visual Inspection	X						P
Compressed Gas Cylinder Pressure, Pump, and Mass Flow Remote & Onsite Condition Monitoring	X					X	P/R
Leak Check Compressed Gas Cylinders						X	P
Replace Compressed Gas Cylinders				X*		X	P/R
Mass Flow Meter & Controller Remote & Onsite Diagnostic Monitoring	X						P
Taring Mass Flow Meters			X				P
Replace ECSE Rotary Vane Pump Mufflers				X		X	P/R
Replace ECTE Rotary Vane Pump and Mufflers					X	X	P/R
Replace FEP Tubing, Inlet Valves, Fittings and/or Connectors						X	R
Replace Regulators, Manifolds, Gauges, and Relief Valves						X	R
MISCELLANEOUS EQUIPMENT							
Temperature Monitoring							
Visual Inspection	X						P

Maintenance		Bi-Weekly	Monthly	Quarterly	Annual	Biennial	As Needed	Type
	Verify Comet Temp Relative Humidity Setting/Values						X	P
	Hut Temperature Range/Set Point	X						P
Dehumidifier (High-Humidity Sites Only)								
	Visual Inspection			X				P
	Humidity Set Point/Range for Hut			X				P
	Clean Grille and Case						X	P
	Clean Water Bucket			X				P
	Clean Air Filter			X			X	P
Subsystem Support Structure								
	Visual Inspection	X						P
	Verify Structural Integrity Bolt Connections and Unistrut			X			X	P
NOTE: P = Preventive, R = Repair. **Archive cylinders are scheduled to be swapped every three (3) years.*								

Table 2 contains preventive maintenance tasks specific to the ECTE sensors and subsystems. This includes the Campbell Scientific CSAT3 3D Sonic Anemometer and the LICOR LI-7200/RS IRGA air inlet and LI-7550 interface on the tower top boom.

Table 2. ECTE Preventive Maintenance Tasks Interval Schedule.

Maintenance		Bi-Weekly	Monthly	Quarterly	Annual	As Needed	Type
Campbell Scientific CSAT3 SD Sonic Anemometer							
	Remote Monitoring	*CONDUCT REMOTE MONITORING ON THE ECTE SYSTEM DAILY.*					
	Visual Inspection	X				X	P
	Remove spider webs from Transducers					X	P
LICOR LI-7200/RS Infrared Gas Analyzer (IRGA)							
	Visual Inspection	X					P
	Clean Inlet Filter Cap, Gas Delivery Path & Orifice Surfaces					X	P

Maintenance	Bi-Weekly	Monthly	Quarterly	Annual	As Needed	Type
Replace 2-micron Inlet Filter					X	P/R
Optical Path Cleaning					X	P
Verify Inlet/Critical Flow Orifice Heater					X	P
Replace Internal Chemicals*				X		P*
Sensor Head Cable (P/N 0303030005)	*Replace Every 5 Years*					*P*
NOTE: P = Preventive, R = Repair. **Completed by CVAL*						

Table 3 contains preventive maintenance tasks specific to the ECSE sensors and subsystems. This includes the PICARRO L2130-I Analyzer for Isotopic H_2O (i.e., "Water Laser") with the PICARRO A0211 (Vaporizer) and PICARRO A0325 Autosampler, the PICARRO G2131-I Analyzer for Isotopic CO_2 (i.e., "CO2 Laser"), and the LICOR LI-840/850.

Table 3. ECSE Preventive Maintenance Tasks Interval Schedule.

Maintenance	Bi-Weekly	Monthly	Quarterly	Bi-Annual	Annual	As Needed	Type
PICARRO L2130-I Analyzer for Isotopic H_2O							
Remote Monitoring	*CONDUCT REMOTE MONITORING OF ECSE SYSTEM DAILY.*						
Visual Inspection	X						P
Replace Inlet Particulate Filter						X	P
External Analyzer Pump Maintenance*						X	P/R
Replace Internal Filter and Orifice*						X	P
External Pump Replacement					X		P/R
Replace Validation Vials		X					P
Adjust Sample Volume						X	P
Replace Syringe		X				X	P
Replace Septa		X					P
Clean Analyzer Exhaust Fan Screen					X	X	P
PICARRO A0211 Vaporizer							
Visual Inspection	X						P

Maintenance		Bi-Weekly	Monthly	Quarterly	Bi-Annual	Annual	As Needed	Type
	External Vaporizer Pump Replacement					X		P/R
	External Pump Maintenance*						X	R
PICARRO A0325 Autosampler								
	Visual Inspection	X						P
	Train Autosampler	X					X	P
PICARRO G2131-I Analyzer for Isotopic CO_2								
	Visual Inspection	X						P
	Replace Inlet Particulate Filter						X	P
	Replace Internal Filter and Orifice*						X	P
	External Analyzer Pump Maintenance*					X	X	P/R
	External Pump Replacement					X	X	P/R
	Clean Analyzer Exhaust Fan Screen					X	X	P
LICOR LI-840/850								
	Visual Inspection	X						P
	Clean MFC 2-micron Filter						X	P
ECSE Air Inlets on Tower, Heated/Unheated Assembly								
	Verify Orifice Heater (Heated Sites Only)						X	P**
	Clean Inlet Filter Cap, Gas Delivery Path & Orifice Surfaces						X	P/R
	Replace 2-micron Inlet Filter						X	P/R
NOTE: P = Preventive, R = Repair. **The NEON Program HQ, Assembly Repair Lab and/or CVAL responsibility, as applicable.* ***Verification must occur more frequently during seasonal freezing/ice accumulation.*								

5.4 Remote Monitoring

Remote monitoring is a vital component of preventative maintenance for both ECTE and ECSE systems. This Section contains a summary of commonly used applications/software for monitoring these systems and the frequency (**Table 5**) Field Science should use them. *See Table 4. Software/Application Resources for Remote Monitoring for a list of links for each tool.*

1. The NEON Sensor Health application (**Figure 4**) and email reports allow for continuous and automated monitoring of the ECTE and ECSE systems, as well as other IS sensors. Use this application to monitor sensor uptimes and ranges. Click the help icon in the app menu on the left for assistance in using and interpreting data.

*Note: Use the "Alert Management App" to sign up and configure email reports. See "Sign up for Alerts" in the left hand column in **Figure 4**.*

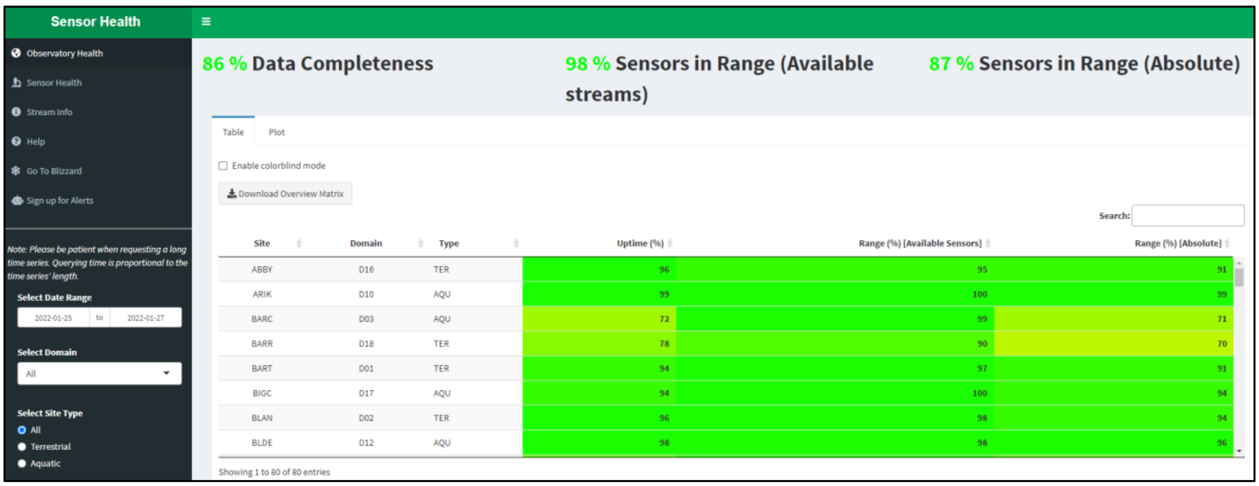


Figure 4. NEON Sensor Health Application.

2. The Eddy Covariance Domain Reports (**Figure 5**) provide relevant timeseries plots for the most recent 2 weeks of data to monitor EC system ranges. This tool that was developed specifically for TIS by the TIS Science team. Instructional guidance is linked to each section of the report to help users interpret plots.

Note: See https://den-prodissom-1.ci.neoninternal.org/swift-reports/how-to/domain_tutorial.html to learn more.

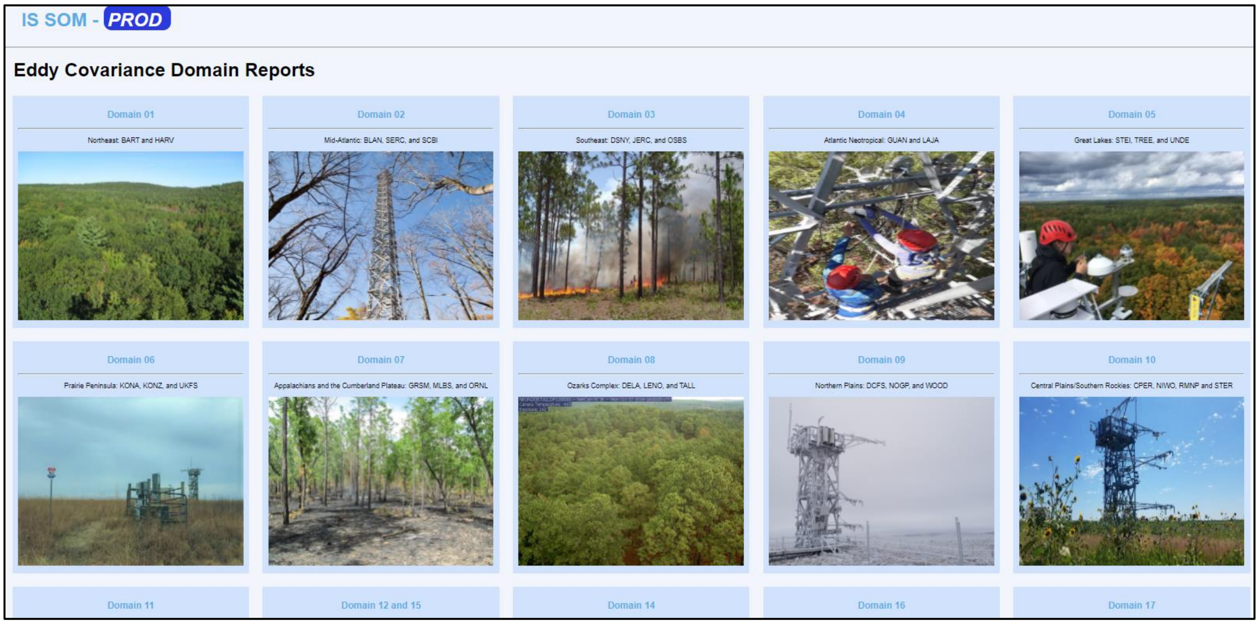


Figure 5. Eddy Covariance Domain Reports (The Aviary).

3. The DQ (Data Quality) Blizzard application, also developed by the Science team, is another monitoring tool available for use that contains monthly data summaries, which includes data quality metrics and the ability to produce plots of level 0 (raw) and level 1 (processed) data (**Figure 6**).

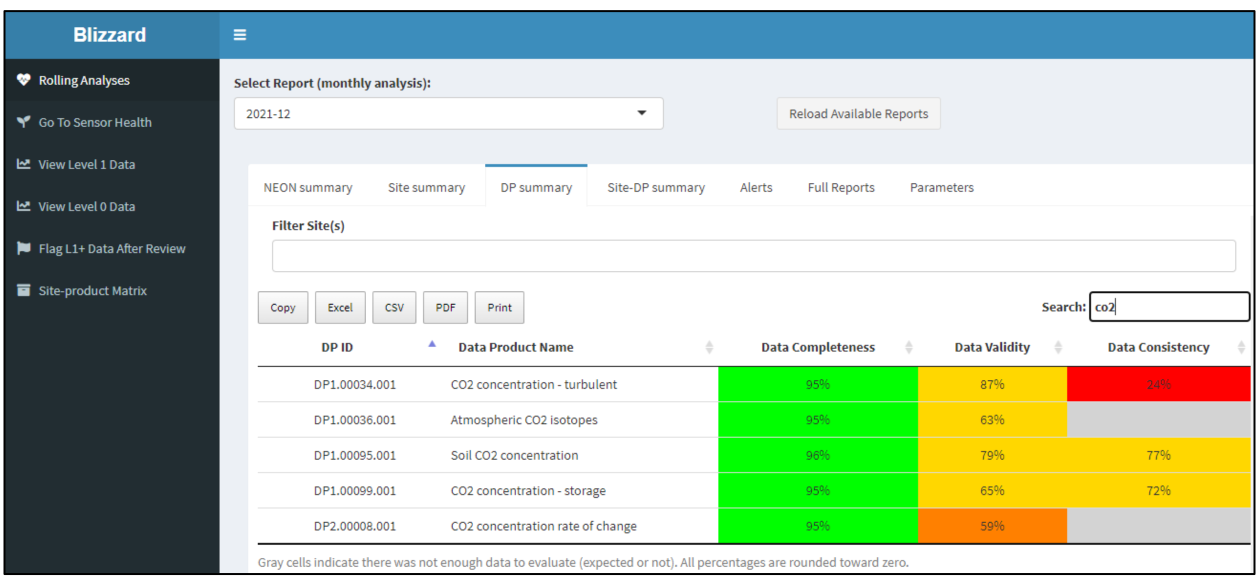


Figure 6. DQ Blizzard Application.

4. The IS Control and Monitoring Suite software is a tool developed by the NEON Engineering team that is available for use for both TIS and AIS sites (**Figure 7**).

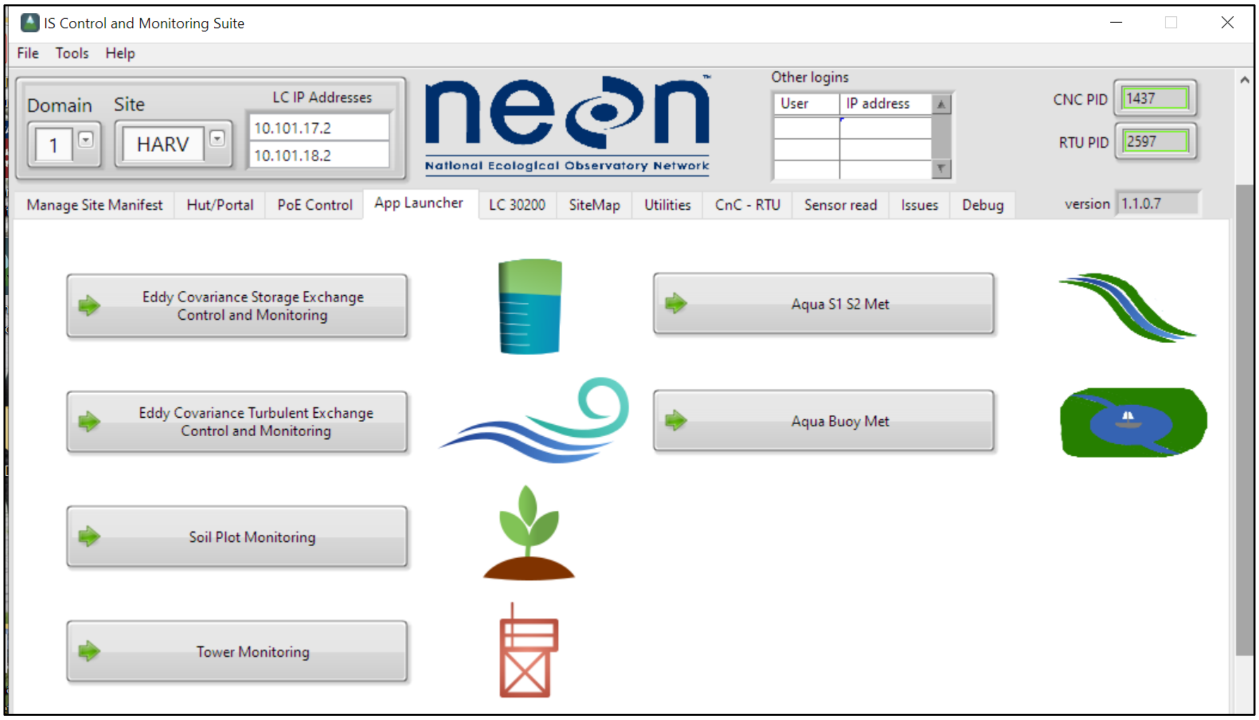


Figure 7. IS Control and Monitoring Suite.

5. A Terminal Emulator Program (TEP) connection to site Location Controller (LC) is the quickest way to monitor real time data and the program recommended by SCI and ENG if any of the applications above are down/unavailable. See Table 4 for the link to two TEP options.

6. Lastly, users may directly connect to the Picarro gas analyzers directly via Windows Remote Desktop, when applicable/necessary (see **Table 4** below).

Use these monitoring resources (**Table 4**) to be **preventative** in conducting maintenance by addressing issues **before** they impact data quality. For example, monitoring ECSE flow rates and replacing a clogging inlet before it falls below the flowrate threshold or verifying data streams are streaming and are within range. This is important and vital to the long-term success of the Observatory.

Table 4. Software/Application Resources for Remote Monitoring.

Software Resources
IS-SOM Production Server: https://den-prodissom-1.ci.neoninternal.org/
Domain EC Reports "How-To" Instructional Guidance: https://den-prodshiny-1.ci.neoninternal.org/TheAviary/IS/Eddy-Co/Investigation/Eddy_Co_Domain_Reports_How_To.html
NEON IS Control and Monitoring Suite & SSH/TEP Software Resources: N:\Common\CVL\Field_Calibration\Required Directory\Test_Data TEP Login for Location Controller (LC) Username: **user** | Password: **resuresu** *See APPENDIX A: Using TEP for Real-Time Monitoring.*
TEP Programs - PuTTy: http://www.putty.org/ or MobaXterm: https://mobaxterm.mobatek.net/

Software Resources
Windows Remote Desktop for Picarro - **Username:** .\Picarro | **Password:** Extreme_Science! *See detail in APPENDIX B: Connecting to Picarro ANALYZERS via Windows Remote Desktop.*
Site Configuration Static Internet Protocol (IP) Device List: N:\Common\SYS\Site Network Configurations *These are unchanging IP addresses created when a site was built, i.e., underwent verification, before it was commissioned. Any device in a computer network that uses the Internet Protocol for communication must have an IP address. Site infrastructure, such as the network switches and PDUs, are assigned static (or unchanging) addresses. In contrast, sensors and grapes are assigned dynamic (or changing) IP addresses.*
Command and Control (CNC) Program Resources: N:\Common\ENG\Location Controller\CommandAndControl\Documents To stop CNC, type "**/etc/init.d/cncctl stop**". This enables maintenance mode which disables auto-restart of CNC. To restart CNC, type "**/etc/init.d/cncctl start**". *This serves numerous functions including controlling the Eddy Covariance system daily gas validation process, sensor/subsystem heating, solenoids, and vacuum pumps.*

Reference **Table 5** for general guidance of when to use the tools listed above. As needed basis means it is at your discretion and when deemed necessary (which may happen during an investigation of an issue or during remote troubleshooting).

Table 5. ECTE and ECSE Expected Remote Minimum Monitoring Frequency.

Monitoring Resource/Tool	Daily	Weekly	As Needed
Sensor Health Domain Report Email	X		
Sensor Health App (uptime and range)		X	
EC Domain Report		X	
DQ Blizzard Application			X
IS Control and Monitoring Suite		X	X
TEP (PuTTY or MobaXterm)			X
Picarros via Windows Remote Desktop			X

Best practice is to thoroughly check each Eddy Covariance system operation remotely via the IS Control and Monitoring Suite and/or a TEP before conducting a site visit. For example, verify sensors/other components are streaming reasonable values and solenoid valves are switching between MLs, as expected. This allows you to plan site visits accordingly and bring along any additional tools, parts or other needed items for any necessary corrective maintenance, repairs and/or troubleshooting.

*PRO TIP: Check the system for proper operation any time (1) changes are made (such as replacing a sensor or data logger), (2) when CNC is restarted, and (3) always **before** leaving the site. This allows you to catch a mistake that may have been made onsite or any errors from system startup. For example, a hand valve was left closed on a gas cylinder, or a data logger (Grape) was left unplugged after troubleshooting.*

Figure 8 below is an example of the ECSE system operating optimally in sampling mode, as seen through IS Control and Monitoring Suite.

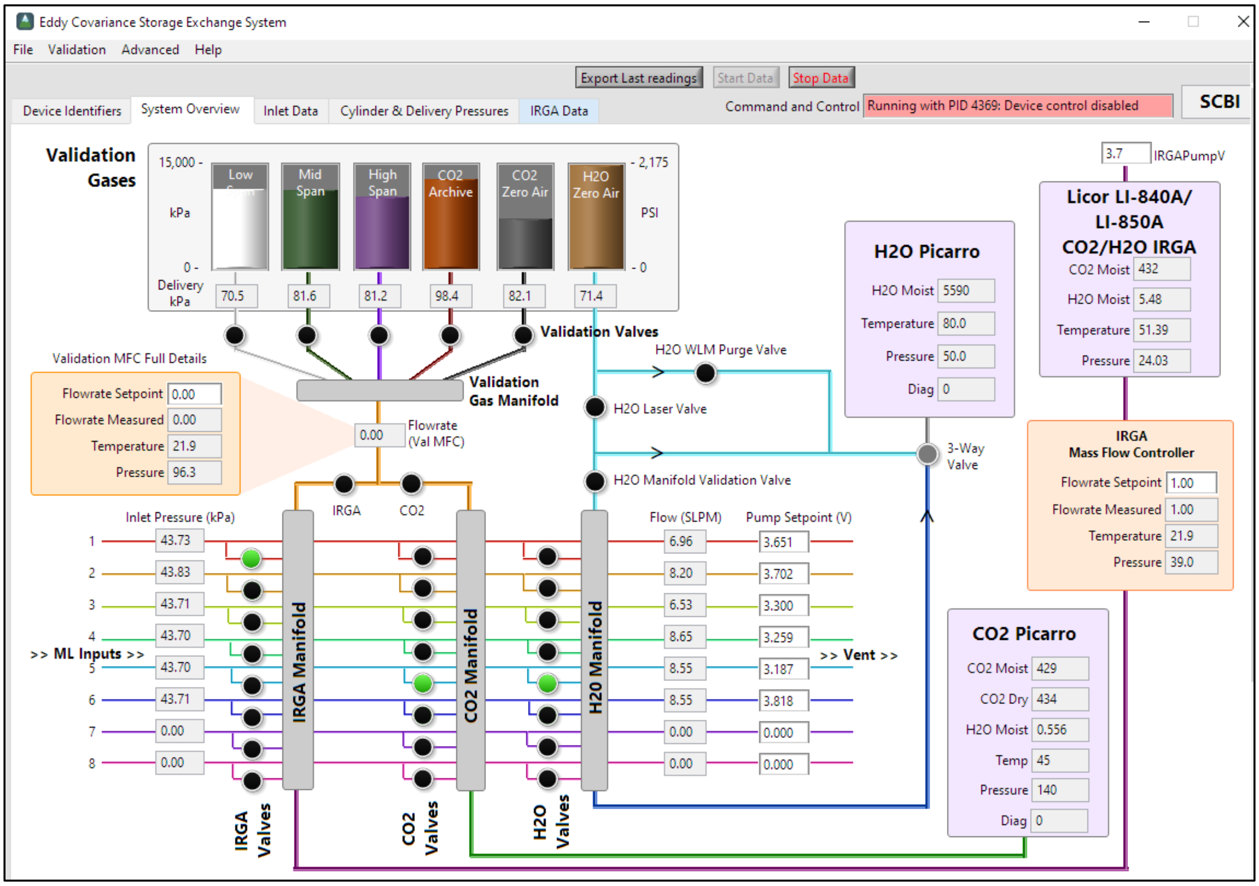


Figure 8. Example of Proper Operation of the ECSE System via the IS Control and Monitoring Suite.

Note: All sensors streaming reasonable data (in accordance with ***Table 6*** *parameters), all ML flowrates/inlet pressures are OK for the site, the LI-840 flowrate is at 1 SLPM (standard liter per minute), and gas cylinder pressures and delivery pressures/sensor readings are within range.*

5.4.1 Expected Data Values

Below is a list of sensors and other EC system components with expected ranges and how to respond to deviations. In most cases, if operating outside these ranges enter an incident ticket into ServiceNow and reach out to ENG and/or TIS Science for assistance in interpretation or troubleshooting.

NEON HQ data quality personnel may flag the data with the help of Field Ecologists reporting onsite events or abnormal data ranges. Use ServiceNow using the Request Data Quality Review process on applicable incidents.

Table 6 is a list of ECSE and ECTE instruments and subsystem components that may provide a logical (electronic/online application) or physical indication of its state of health for offsite and onsite condition monitoring. This table is subject to change as the implementation of NEON program sensors and subsystems mature.

Table 6. ECSE & ECTE Condition Monitoring Operating Value Ranges.

INSTRUMENT/ SUBSYSTEM	NORMAL OPERATING RANGE	ABNORMAL OPERATING RANGE	ACTIONS/ CONSIDERATIONS
Zero Air Compressed Gas Cylinders (ECSE/ECTE)	>2758kPaG (>400psig)	<2758kPaG (<400psig) *May indicate a leak or cylinder has run the course of its life.*	Conduct leak test and request replacement from local supplier.
Compressed Gas Pressure Delivery for PICARRO H_2O Validations (ECSE)	2.5 ± 0.5psig (17.24 ± 3.45kPa)	>3psig (20.68kPa) or <2psig (13.79kPa) *May indicate a leak or cylinder has run the course of its life.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance immediately.
Compressed Gas Cylinder Usage Rate for Validation Gas & Zero Air (ECSE/ECTE)	*4– 6 psi / day* **Note: Exception is the ECSE H2O zero air when validations are occurring*	> 6 psi / day.	Conduct leak tests and/or request replacements.
CO_2 Compressed Gas Cylinders (ECSE/ECTE)	>2758kPaG (>400psig)	<2758kPaG (<400psig) *May indicate a leak if the cylinder was recently replaced or has run the course of its life.*	Conduct leak test procedures and request a replacement from CVAL.
Compressed Gas Cylinders Delivery Pressure (ECSE/ECTE)	Set for 70kPa when validation gas flows at 1.5 SLPM for ECTE and 1.3 SLPM for ECSE	<70kPa *May indicate a leak or a kink in the line to the tower.*	Check the lines on the tower for leaks/damage to tubing. *Delivery pressure rises to ̃80 kPa when validation gas is not flowing.*
Mass Flow Meters (MFMs) for ECSE System	Expected Flow Rate = 9.46*P Amb./ 101.325 This flow rate varies by site from 5-9.46 SLPM *The expected flow rate measured by the MFM in the instrument hut should be as follows: Flow Rate= 9.46*P Amb./101.325. P Amb. = Ambient pressure in kPa measurement from the tower PTB330 barometric pressure sensor. For example, the ambient barometric pressure is 82kpa, thus the flow rate calculated per the equation above should be 7.66 SLPM.*	5 SLPM < mass flow rate (MFR) < 9.46 SLPM (At high altitudes the MFR may be < 5 SLPM, but no < 2.5 SLPM) 70% of expected flow rate < MFR < expected flow rate + 0.3 SLPM (if MFR > expected flow rate +0.3 SLPM, leak exceeds acceptable level; if MFR < 70% of expected flow rate, inlet clogging or kinked/blocked gas line) *Pump motors may be running at maximum RPM; may indicate a clog in the IRGA air inlet (screen or filter orifice), an obstruction /kink in the tubing or a leak in the system.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance. Clean and replace the corresponding ML air inlet filter on the Tower. **Note:** Technicians may see a minor reduction to the flow rate of the MFMs when an analyzer is sampling that level: • *PICCARO CO_2: <0.125 SLPM* • *PICCARO H_2O: <0.035 SLPM* • *LICOR LI-840/850: <1.0 SLPM*
LICOR LI-840/850 Sample Mass Flow Controller (MFC) (ECSE)	Maintain a flow rate of 1 ± 0.2 SLPM	1.2 SLPM< MFR <0.8 SLPM	MFC may need replacement.

INSTRUMENT/ SUBSYSTEM	NORMAL OPERATING RANGE	ABNORMAL OPERATING RANGE	ACTIONS/ CONSIDERATIONS
ECSE Validation Gas (ValGas) MFC (ECSE LICOR Li-840/850 Use)	1.3 SLPM during calibration/validation 0 SLPM in Sampling Mode	<<1.2 SLPM >>1.3 SLPM *Less than may indicate a kinked tube, or delivery pressure is too low. Greater than may indicate an issue with the ValGas MFC.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance immediately.
ECSE ValGas MFC (PICARRO Analyzer for Isotopic CO_2)	<0.25 SLPM to <0.188 SLPM MAX in validation mode (depending on altitude and pressure of the site) 0 SLPM in Sampling Mode	<0.125 SLPM *May indicate a low ValGas delivery pressure.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance.
Sample MFC for LICOR LI-7200/RS IRGA (ECTE)	Flow rate of 12 ± 0.2 SLPM 0 SLPM during Validation <0.1 SLPM during Leak Checks	<11.8 SLPM on MFC *Pump motors may be running at maximum RPM; may indicate a clog in the IRGA air inlet (screen or filter orifice) or an obstruction /kink in the tubing.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance. Clean the IRGA air inlet filter on the Tower.
ValGas MFC for LICOR LI 7200 IRGA (ECTE)	1.5 SLPM during calibration/validation 0 SLPM in Sampling Mode	<<1.4 SLPM >>1.5 SLPM *Less than may indicate a kinked tube, leak or delivery pressure is too low. Greater than may indicate an issue with the Val Gas MFC.*	If discovering abnormal values, execute troubleshooting/ corrective maintenance.
GAST Rotary Vane Pumps (ECSE)	Associated MFM 5-9.46 SLPM, operating 3-4 V	>4 V Pump Setpoint/Voltage Range Associated MFM <4 SLPM <5 SLPM at higher altitudes, but should maintain no less <2.5 SLPM *May indicate a clog in the system or requires a rebuild.*	Verify associated MFM SLPM to rule out a filter/muffler clog in pump. If it is not an issue with either of these, request a replacement.
Absolute Pressure Transducer on Tower Inlet ML (ECSE)	45% of ambient pressure or lower	>50% of ambient pressure *May indicate leaks in the sample line or pump has lost its ability to maintain the low pressure.*	Verify inlet pressure and conduct leak check procedures.
PICARRO H_2O Autosampler (ECSE)	Consistent data pattern in validation mode	Witnessing saw-tooth or inconsistent data pulses in CRDS Data Viewer *May indicate a sticky injection syringe needle.*	Change injection syringe.
PICARRO H_2O Vaporization Module (ECSE)	Measurement varies per site in validation mode	Greater amount of noise in the water measurement in CRDS Data Viewer	Change septa.
PICARRO H_2O Vaporization Module Temperature Set Point (ECSE)	Stabilizes at 110°C	Unable to reach 110°C	Power vaporizer off/on. If problem persists, generate a ticket for a replacement Vaporizer.

INSTRUMENT/ SUBSYSTEM	NORMAL OPERATING RANGE	ABNORMAL OPERATING RANGE	ACTIONS/ CONSIDERATIONS
PICARRO Analyzer Module (for Isotopic H_2O or CO_2)	Warm box ambient air set point 45°C	Unable to reach set point *May indicate a PICARRO software CNC issue.*	Shut down & restart software (not instrument, select Software Only from shutdown options per Section 5.7.2.3.1. If problem persists; request a replacement.
PICARRO Analyzer Module for Isotopic CO_2 (ECSE)	CO_2 concentration similar to LI-7200/RS, LI-840/850 readings	CO2 ppm values steadily increasing above ambient air concentration while personnel are in instrument hut *May indicate a leak in CO2 sampling line.*	Conduct leak checks on associated subsystem.
ECSE Air Inlet Assembly, Heater Set Point (Heated Sites Only)	*ON set point:* Air temperature within 2°C above dew point temperature & air temperature ≤0°C at either ground or tower top ML *OFF set point:* Air temperature >5°C above dew point temperature at either ground or tower top ML *While ON:* 10°C ± 5°C above dew point temperature at either ground or tower top ML	No heat to orifice, inconsistent heat pattern or orifice heater >70°C Outside of site dependent set point from dew point and air temperature range *May indicate a malfunction in the heating component.*	If heater temperature range is outside of site dependent set points, verify if the HMP155 at the soil plot and tower top ML is functioning properly. If not, or if there is no heat to the orifice or >70°C, conduct corrective actions; submit a ticket in ServiceNow.
LICOR LI-840/850 Instrument (ECSE IRGA)	No significant cell pressure fluctuation	Instrument requires calibration if pressure falls below 23.5kPa or above 24.5kPa) *May occur after a Grape reset, system restart or defective vacuum pump.*	Requires calibration. Calibration occurs via CNC automatically when the software detects a pressure spike in the instrument.
LICOR LI-7200/RS Instrument (ECTE IRGA) Differential Head Pressure (DPress)	Between 0 and -5 kPa Parameter 9 is DPress via the command: `“vd -s 0x[MAC ADDRESS] -r 9”`	< -5 kPa or > 0 kPa If less than, it may be due to a clogged inlet, disconnected sample line or a failed pressure transducer	***Do not use the LI-7200/RS Software.*** The configuration may change/disable portions of the configuration, which affects data products.
LICOR LI-7200/RS Instrument (ECTE IRGA)	Diagnostic Value of 8191 This diagnostic value is via the command: `“vd -s 0x[MAC ADDRESS] -r 1”`	Different diagnostic value. If signal strength is $\leq$ 85% the analyzer cell should be cleaned *May indicate a dirty optical path or analyzer cell.*	Clean optical path and windows. Clean analyzer cell (*See Section 5.6.2.2*). ***Do not use the LI-7200/RS Software.***
LICOR LI-7200/RS with LICOR LI-7550 Interface	Temperature varies with ambient conditions	Inlet/outlet thermocouple temperature reads -65 (or so)	***Do not use the LI-7200/RS Software.***

INSTRUMENT/ SUBSYSTEM	NORMAL OPERATING RANGE	ABNORMAL OPERATING RANGE	ACTIONS/ CONSIDERATIONS
(ECTE IRGA)	**TempIn** is via the command: "`vd -s 0x[MAC ADDRESS] -r 13`" **TempOut** is via the command: "`vd -s 0x[MAC ADDRESS] -r 14`"	*May indicate the internal temperature sensor is defective.*	
CSAT3 3D Sonic Anemometer Level	Most are 0 ± 1 degree in pitch and roll; *see Figure 94 for exceptions*	The mean streamlines are tilted **more than 5 degrees**.	Level the CSAT3 3D Sonic Anemometer when > 5 degrees to realign the pitch and roll to align with the mean streamline.
ECSE Hut Rack Temperature Monitor (COMET) Set Range	Temperature variation of <10° C over a 1 hour period	Temperature variation of ≥10° C over a 1 hour period *May indicate an open door during seasonal weather changes or hut temperature setpoint issues.*	Conduct an inspection on Hut temperature and HVAC system; ensure the Hut door is closed.
Instrumentation Hut Temperature Set Points	80F cooling setpoint, 65F heating See *Section 5.5.1.1.*	Temperature ranges outside of 50° F (10° C) - 95° F (35° C)	Shut down gas analyzers in the hut, troubleshoot HVAC
Instrumentation Hut Humidity Set Range	Best: <25,000ppmv (<2.5% water content) Max: <30,000ppmv (<3% water content) Varies per site. See below for %RH.	Max: >30,000ppmv (>3% water content)	Turn on dehumidifier and set it to reduce humidity to normal operating range.
Instrumentation Hut Dehumidifier for ECSE Instrumentation Set Point**	50%-60% Medium fan speed	Not able to maintain normal operating set point range/ fan speed *May indicate a clogged or faulty humidifier.*	Conduct preventive maintenance/basic troubleshooting and/or acquire a replacement, if necessary.

5.4.1.1 To Determine Relative Humidity (RH)

Use the ECSE Temperature Monitor to determine these values (Comet 7610):

- Best: mixing ratio *air pressure*15.59 <25,000ppmv
- Max: mixing ratio *air pressure*15.59 <30,000ppmv

The Comet 7610 displays both the mixing ratio and air pressure. Collect the two data points and multiply them together then times 15.59 to get the result. The calculation result should be < 25,000 ppmv. If the result is higher than 30, 000 ppm, then adjust the dehumidifier to reduce humidity further. When the humidity is stable, collect the data and do the calculation again to confirm.

5.5 Physical infrastructure

5.5.1 Instrumentation Hut

The Instrumentation Hut housing the compressed gas cylinder's physical structure. Preventive maintenance includes a visual inspection of the support structure (entire Unistrut frame and its associated attachments to the wall, other Unistrut frames, and floor via L brackets, to include bolts, washers, screws, etc.) structural integrity, and identification of damage, natural or otherwise. Verify the mounts for the MFMs, MFCs, manifolds and pumps are secure to the supporting Unistrut; ensure all fasteners are tight and temperature range in the room is accurate (to include the dehumidifier set point).

5.5.1.1 TIS Hut Temperature Set Points

Instrument hut temperatures are a primary concern for the gas system analyzers and other hut infrastructure. The thermostat should be **set at 80° F for cooling setpoint** and **65° F for heating setpoint** at all TIS instrumentation huts year-round. This will help maximize the lifespan of the hut HVAC units, maintain the hut at temperatures within suitable operating ranges of analyzers and other equipment and generally avoid issues with condensation. However, gas lines should be inspected frequently in the hut to detect any issues here.

Figure 9. Typical Hut Thermostat - ICM Controls SC4011 Non-programmable Thermostat.

Note: Refer to NEON Preventative Maintenance Procedure: Site Infrastructure (NEON.DOC.004980) for additional details and requirements for HVAC and Instrument Hut Preventative Maintenance.

If the HVAC unit is unable to maintain the hut temperature above 50° F (10° C) or below 95° F (35° C), submit a ServiceNow incident ticket and power off the gas system analyzers (PICARRO/LICOR Analyzers in the hut) to prevent damage. Hut temperatures can be monitored via the COMET sensor (see Section 5.4 Remote Monitoring for more information).

There are two specific concerns to watch for regarding the temperature of the operating environment for the ECSE system: **Rapid Temperature Fluctuations** and **Condensation**. If the Instrumentation Hut fails to maintain operating temperatures, these issues may cause significant damage to the ECSE instrumentation and subsystems.

- ***Rapid fluctuations:*** *The LICOR LI-840/850 is sensitive to rapid changes in temperature, which may result in unreliable data. As a result, NEON requires* ***no changes to the hut operating environment temperature greater than 10°C over a one hour timeframe*** *(i.e., do not leave the Hut door open in extreme temperatures). Do not reset the thermostat frequently and do not introduce any other forms of heating/cooling without prior approval from NEON HQ.*

- ***Condensation:*** *The PICARRO Analyzer Modules are sensitive to condensation. Each instrument is equipped with an alarm to detect minimal amounts of condensation. If large amounts of condensation occur, the instruments are vulnerable to serious damage, resulting in minimal or total loss of data. Condensation occurs when the Hut is cooler than the outside environment. This may cause condensation to form in the ECSE tubing. Is it cooler in the Hut than it is outside? If so, inspect the tubing for both systems in the Hut (specifically in lower points and areas of accumulation) and maintain awareness of the temperature variances.*

Figure 10. T7610 Temperature Sensor (Environmental Probe).

If additional guidance is needed, or if the set point range is causing condensation inside the Hut, submit a ticket in the NEON program's Issue Management and Reporting System for NEON HQ evaluation to determine site-specific Hut temperature guidance.

5.5.1.2 ECSE Temperature Monitor

The Comet T7610 in **Figure 10** is an industrial temperature model that measures relative humidity, temperature, and atmospheric pressure with a measuring range of -30 to +80ºC. An LCD screen displays the measurement values.

To maintain the temperature monitor, verify it is functioning correctly and displaying measurements clearly via the LCD screen. Ensure the cables are free of damage and the sensor location is where the cables will not incur damage. *Reference AD [10] for Command, Control and Configuration parameters of this platinum resistance thermometer (PRT).*

Use a TEP such as PuTTY or MobaXterm and **`nc localhost 30200`** command via the LC to retrieve the dynamic IP address. Use the IP as a URL in a web browser or use the following command prompt to see the data streams in real time to monitor the temperature measurement remotely: **`vd -s 0x[mac address]`**

5.5.1.3 Dehumidifier

Preventive maintenance procedures within this section are for sites employing a General Electric Model ADEL50 dehumidifier (**Figure 11**) only. Supplying high humidity sites with dehumidifiers mitigates variances in the data deriving from the PICARRO Analyzer for Isotopic H_2O. Excessive water absorption from changes in ambient environmental conditions or continuously operating in high humidity conditions (over 3% water content or 30,000 parts per million by volume (ppmv) water vapor to dry air ratio), may affect the wavelength monitor (WLM) and warm box ambient air (45°C) in the PICARRO Analyzer Module for Isotopic H_2O. Maintaining consistent, low humidity ambient environmental conditions is imperative for optimal performance of the PICARRO Analyzer Module. **Figure 12** on the next page is a visual representation of the dehumidifiers residing at sites subject to high humidity conditions.

Figure 11. Dehumidifier.

A control panel directly on top of the unit operates the dehumidifier. This area provides several indicators if maintenance is necessary via lit status indicators. Please turn off the dehumidifier using the power button and remove the plug from the wall outlet prior to conducting preventive maintenance.

Note: The dehumidifier turns off automatically when the bucket is full (which may occur if the hose incurs a clog or kink) or when the bucket is not in the proper position.

- Conduct a physical inspection and remove dust/dirt build-up by vacuuming the grille and cleaning the case with a cloth and a mix of water and mild detergent. Do not use bleach or abrasives.

5.5.1.3.1 Air Filter

The dehumidifier’s air filter resides behind the front grille. The manufacturer recommends cleaning the filter every 250 hours of runtime, which equates to approximately 10 days. A “clean the filter” indicator light will glow as a reminder to change the filter. However, technicians at terrestrial sites are to clean the filter every 14 days (a biweekly basis) to align with the site preventative maintenance schedules, unless directed otherwise at the discretion of NEON HQ.

- To clean the air filter, remove the water bucket.
- Grasp the filter edge and pull it straight down as illustrated in **Figure 12**.
- Clean the filter with warm, soapy water/mild detergent.
- Rinse clean and allow the filter to dry before inserting it back into the dehumidifier.

DO NOT OPERATE THE DEHUMIDIFIER WITHOUT A FILTER.
Obstructions/clogs from dirt and lint reduces its performance.

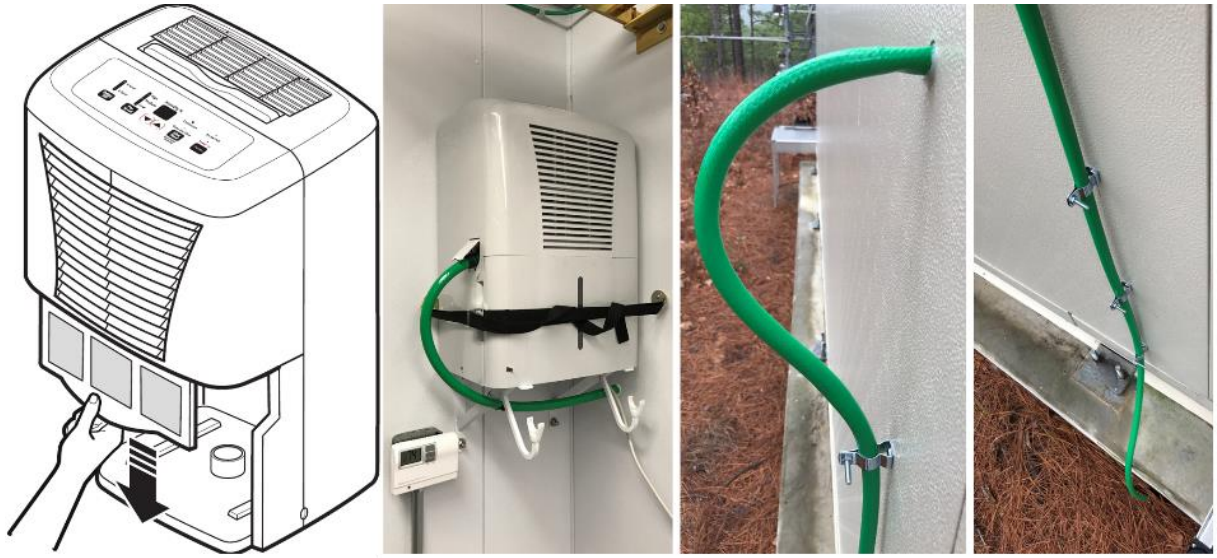


Figure 12. Hut Dehumidifier Filter Removal, Placement and Components.

Inspect hose connections, retaining strap, and mount to ensure the dehumidifier is functioning properly and secure in its position in the Hut corner (**Figure 12**). *See RD [16] to for additional information on the Dehumidifier.*

5.5.1.4 Pneumatics and Pump Infrastructure

5.5.1.4.1 Compressed Gas Cylinders Overview

The ECSE and ECTE system each employ five compressed gas cylinders, comprising 10 compressed gas cylinders in the Hut for TIS sites. TIS sites that host the PICARRO L2130-I Analyzer for Isotopic H_20 instrumentation have one more compressed gas cylinder in the Hut, comprising of 11 cylinders total. Conduct the following preventive maintenance (see **Table 1** for maintenance intervals/frequency):

- Conduct a visual inspection of gas cylinders, each component, and their subsystems, and ensure the following:
  - Cylinders are secure in the rack to prevent any motion.
  - Correct placement and labeling of each gas cylinder are in accordance with AD [07].

MAINTAIN SENSOR MAPPING: REGULATORS MUST CORRESPOND WITH CYLINDER.

  - Valve covers are in place when cylinders are not in use.
  - Integrity and tightness of connections, such as pressure regulators, manifolds, hoses/tubing, gauges, and relief valves.
    - Ensure the correct regulator is in use for the compressed gas contained in the cylinder and pressure rating. The ECSE system uses a high purity regulator and the ECTE system uses a standard regulator. **Figure 13** and **Figure 14** display these differences in **Table 7** below.

Table 7. ECSE & ECTE System Regulator Overview & Comparison.

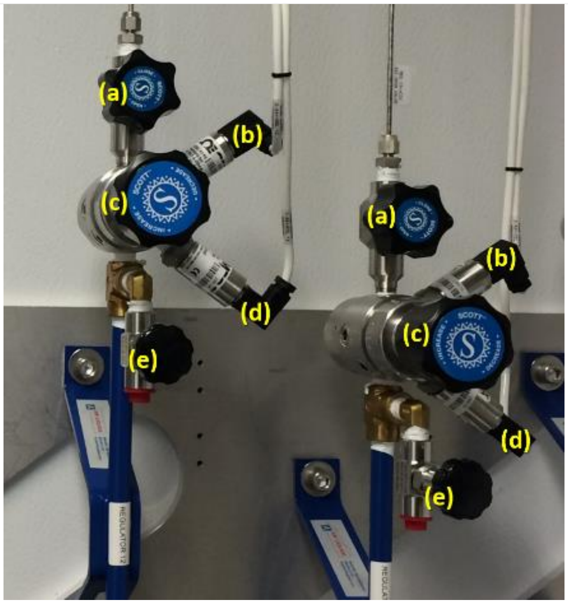


Figure 13. High Purity Regulator for ECSE System.

Figure 13 displays a high purity regulator, which mounts horizontally, and affixes to the ECSE compressed gas cylinders in the Hut.

(a) Shut-off valve
(b) Delivery pressure transducer
(c) Pressure adjusting knob / regulator
(d) Regulator inlet (cylinder) pressure transducer
(e) Regulator inlet pressure sensor validation port

Note: Do not use (e) to bleed off pressure. This is a safety hazard and may cause damage to the operator/regulator. Reference Section 5.5.1.4.3 for ECSE and ECTE Compressed Gas Cylinder Change and Dilution Pressure Purge Procedure.

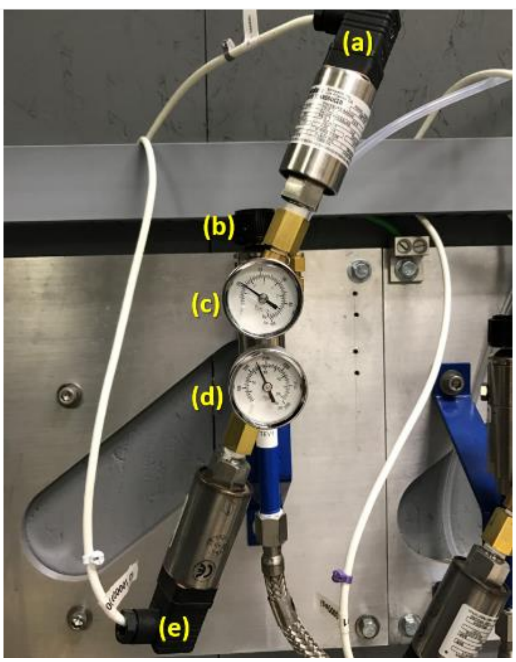


Figure 14. Standard Regulator for ECTE System.

Figure 14 displays a standard regulator, which mounts vertically, and affixes to the ECTE compressed gas cylinders in the Hut.

(a) Delivery pressure transducer
(b) Pressure adjusting knob
(c) Delivery pressure gauge
(d) Cylinder pressure gauge
(e) Regulator inlet (cylinder) pressure transducer

- The high-pressure (inlet) gauge has 1.5x the rating of the cylinder.
- The low-pressure (output/discharge) gauge has approximately twice the pressure rating of the regulator, which is on the regulator label.

        - Ensure there are accurate and clear labels for each gas tube line.
    - Cylinders are not displaying evident tampering/defects or damage (i.e., from rusting/corrosion, pitting, cuts, gouges, dings, bulges, neck defects and general distortion). Rusting and corrosion may occur from leak testing. Rust damages the cylinder and may cause the valve protection cap to stick.

DO NOT USE LUBRICANTS ON CYLINDAR CAP, VALVE, OR FITTINGS.

- Verify gas cylinder pressure gauges.
    - These cylinders must never fall below 100 PSIG.
        - Reference AD [12] for procedures on this and other applications involving the LC (location controller).
- Perform leak testing as needed to mitigate gas losses or system pressure issues and monitor the system remotely for any abnormal values that may reflect a leak. See *Section 5.5.1.5 Leak Test/Detection for Compressed Gas Cylinders*.
- Ensure cylinders are installed in correct Configured (CFG) location in the NEON program's Asset Lifecycle Management System (i.e., Maximo or AssetWorks) and align with labeling (color-coded tape or labels from a third party supplier).

5.5.1.4.2 Important Notes

- The gas cylinder pressure **should not be allowed to drop below 100 PSIG** to avoid re-conditioning the gas cylinders.
- Zero air is needed to flush and dry out the PICARRO cavity before shutting down PICARRO instruments to prevent the damage and/or contamination by condensation. Shut down the PICARROs when the zero air cylinder pressure drops <150 PSIG. This will help prevent PICARRO instrument damage.
- Validations of gas analyzers **should not use the gas cylinders with pressure lower than 400 PSIG**. If the pressure of an individual gas cylinder falls below 400 PSIG, exchange the cylinder as soon as possible. If not possible, close the hand valve and inform ENG to disable that gas cylinder in CNC.
- If an individual gas cylinder is below 400 PSIG, do not turn off the entire validation. Validations are still valid to use for post-data correction, if at least two gas cylinders are above 400 PSIG and running.
- Keep the gas analyzers running in sampling mode even if validation is disabled for a reason, unless otherwise directed by NEON HQ ENG or SCI to stop sampling.

5.5.1.4.3 Compressed Gas Cylinder Swap Procedures

Table 8. Gas Cylinder Swap Tools & Consumables.

Equipment & Consumables	Quantity
Torque Wrench	1
1-1/8 Crowfoot Adapter	1
1-1/8 Open Ended Wrench (longest one as possible within space limitations of Hut to use for leverage)	1
Black Rubber Caps (EPDM Caps - Chemical-Resistant Push-On Round Caps)	A/R

DO NOT ALLOW FOR THE UNCONTROLLED RELEASE OF HIGH PRESSURE.

1. Shut off Command and Control (CNC). To stop CNC, type "**/etc/init.d/cncctl stop**".
    a. Close the hand valve on the cylinder and depressurize the line as directed below.
2. For the ECSE system (**Figure 15** on the next page):
    a. Set the IRGA pump voltage (1) and IRGA MFC setpoint (2) to zero by typing 0 (zero) into the field, open the three valves on ML1 (3) by clicking on the black circles (they will turn green when open), open the IRGA valve (4) and set the Validation MFC flowrate setpoint (5) to 2 SLPM. Finally open the validation valve (6) for the cylinder that you are replacing.
    b. The Flowrate Measured on the Validation MFC will increase to 2 SLPM, and the cylinder pressure (represented by the colored bars) will decrease. Leave as is with software open until cylinder pressure shows zero and the flowrate decreases to zero. At this point the pressure has been bled from the system and you can close the software (this will close all valves) and proceed with the removal and replacement of the cylinder. Repeat as needed for additional cylinders.

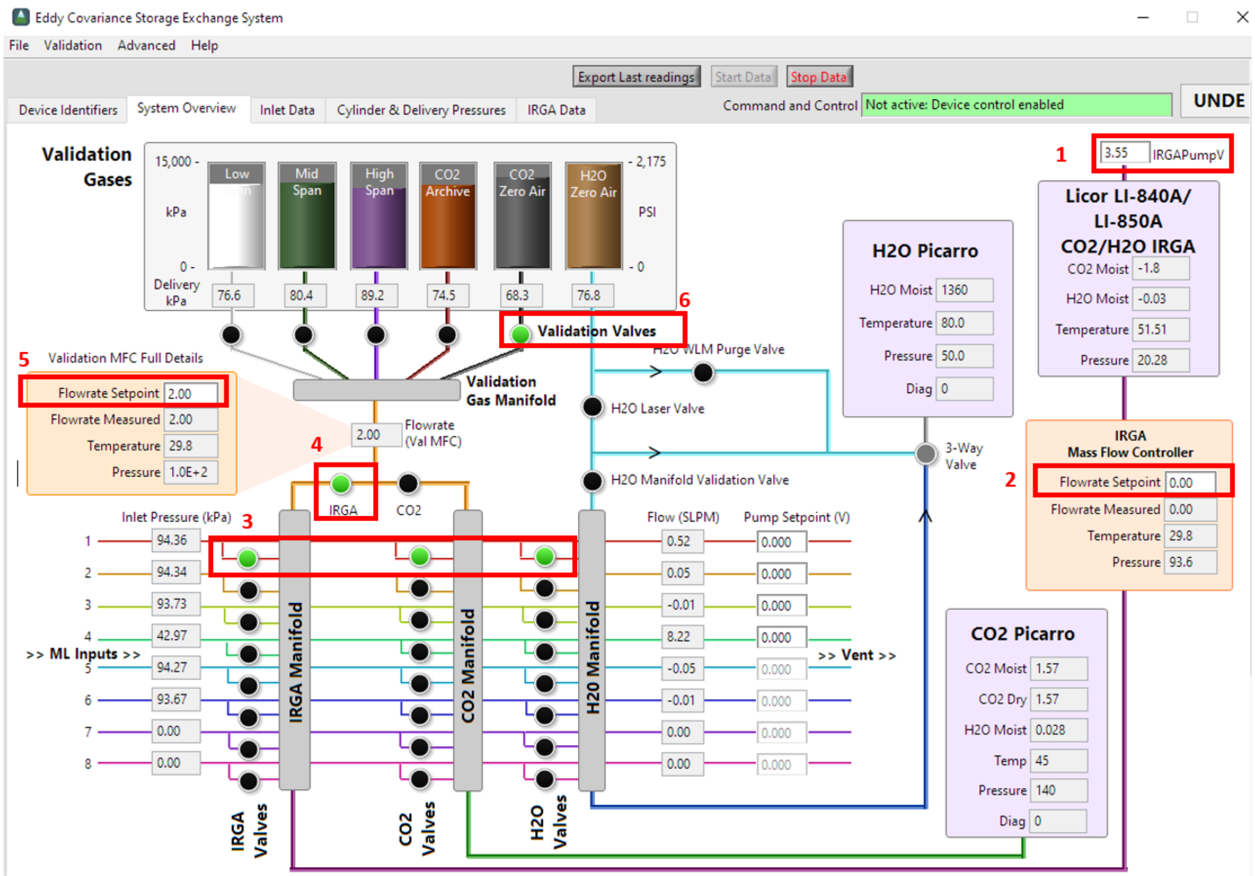


Figure 15. ECSE IS Control and Monitoring Suite Software.

3. For the ECTE system (**Figure 16** on the next page):

    a. Set the IRGA pump voltage (1) and sample MFC setpoint (2) to zero by typing 0 into the field, set the tower validation MFC (3) to 1.5 SLPM, open the tower top validation valve (4) for the line that you are bleeding pressure from. Then open the hut validation valve (5) for the corresponding line.

    b. The tower validation MFC flowrate will increase to 1.5 SLPM and the cylinder pressure (represented by the colored bars) will decrease. Leave as is with software open until cylinder pressure shows zero and the flowrate decreases to zero. At this point the pressure has been bled from the system and you can close the software (this will close all valves) and proceed with the removal and replacement of the cylinder. Repeat as needed for additional cylinders.

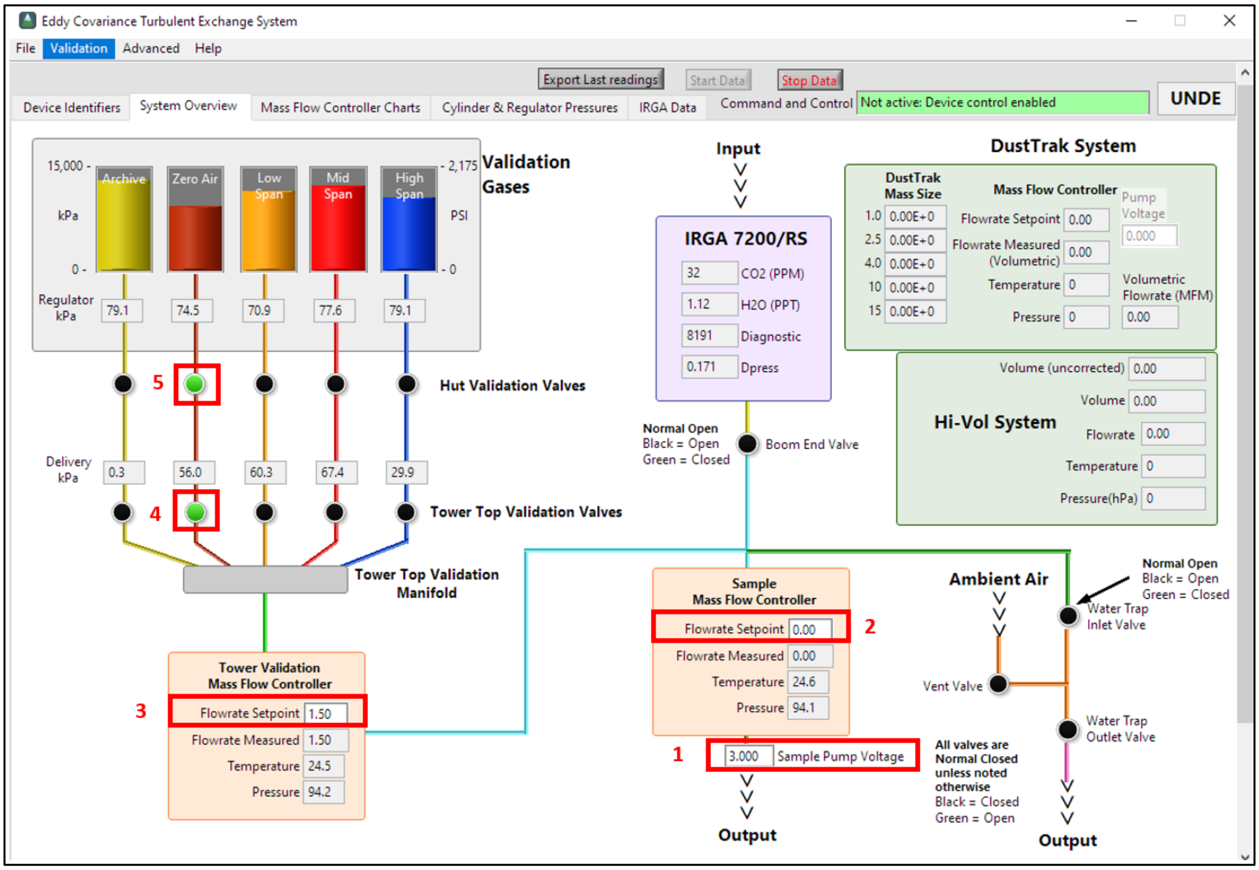


Figure 16. ECTE IS Control and Monitoring Suite Software.

4. Disconnect the braided steel hose from the cylinder.

   a. The fitting for this is reverse threaded (as indicated by notches in **Figure 22**). <u>Turn clockwise to loosen.</u>

Note: If a cylinder in the back of the rack requires replacement, remove the cylinder in the front to access it. Follow steps 2-4 for the front cylinder and place in a safe spot while removing/replacing the back cylinder. Conduct the same purge procedures on both cylinders after reinstallation.

5. Protect the smooth sealing surface on the end of the braided steel hose from damage by capping it with a black rubber protector cap (the metal is easy to damage and can lead to leaks).

6. Secure the cylinder cap for removal. Tighten in the clockwise direction as viewed from above the cylinder until the rotation stops.

   a. Note the orientation of the old cylinder's valve outlet for when the new cylinder is installed.

   b. Do not use oil or any other form of lubricant on the threads of the cylinder's valve, valve protection cap or CGA fitting threads.

7. Remove the old cylinder from rack and replace it with a new cylinder.

    a. Loosen the Socket Head Cap Screws that secures the 1.25” square tubing that secures the cylinder in the cylinder rack.

8. Secure the new cylinder in the rack. Replace the 1.25” square tubing that secures the cylinder in the rack and tighten the two Socket Head Screws finger tight.

9. Remove the cylinder valve protection cap. Inspect the valve seat (**Figure 17**) inside the cylinder’s valve (see **Figure 26**) for damage or contamination. Clean contamination with a lint free microfiber cloth. If damage is present or unable to remove/clean contamination, replace the cylinder with another cylinder, if available, or stop and submit an incident ticket in ServiceNow.

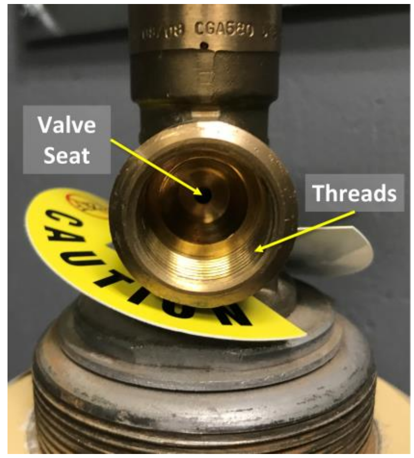


Figure 17. Inspect Valve Seat.

10. These Compressed Gas Cylinders (CGC) can have more than 1800 pounds per square inch of internal pressure and can cause serious injury and/or death. **Please be very careful and ensure everyone in the vicinity is wearing eye and ear protection**. Very carefully and very slowly, rotate the gas cylinder’s valve handle in the counterclockwise direction as viewed from above the cylinder to **slightly open the valve** and close it again very quickly. This will allow a very small amount of gas to bleed out of the cylinder and blow out any debris that may have collected in the valve outlet, keeping it out of the cylinder’s check valve and pressure reduction regulator.

11. Insert the regulator’s CGA 590 nut into the cylinder’s outlet valve and thread in by hand to finger tight (reattaching the braided steel hose to the new cylinder).

    a. Again, the fitting for this is reverse threaded. Turn counterclockwise to tighten.

    b. Tighten the two SHCS that secure the 1.25” square tube on to the cylinder and cylinder rack to secure the cylinder in place. Use the 1.125” open-end torque wrench and tighten the CGA 590 nut first to 40 foot-pounds then 50 foot-pounds.

12. Slowly open the CGC valve on the top of the cylinder to pressurize the inlet side of the regulator by rotating the valve handle first in the counterclockwise direction and then a ¼ turn in the clockwise direction when viewing the valve handle from above. This will pressurize the high-pressure section of the gas line.

13. Conduct leak checks on connection(s) to new cylinder. Follow procedures in Section 5.5.1.5.

    a. If the cylinder fitting leaks after performing the procedures in the section above, the cylinder and/or the regulator assembly will need replacing. Submit an incident ticket in ServiceNow.

14. For the ECSE system, with CNC off, set the validation MFC to 0.3 SLPM and open the CO_2 validation valve via the IS Control and Monitoring Suite (**Figure 18**). Adjust the regulator's pressure adjusting knob (turn clockwise) until the delivery pressure reads 70 kPa, then proceed to Step 16.

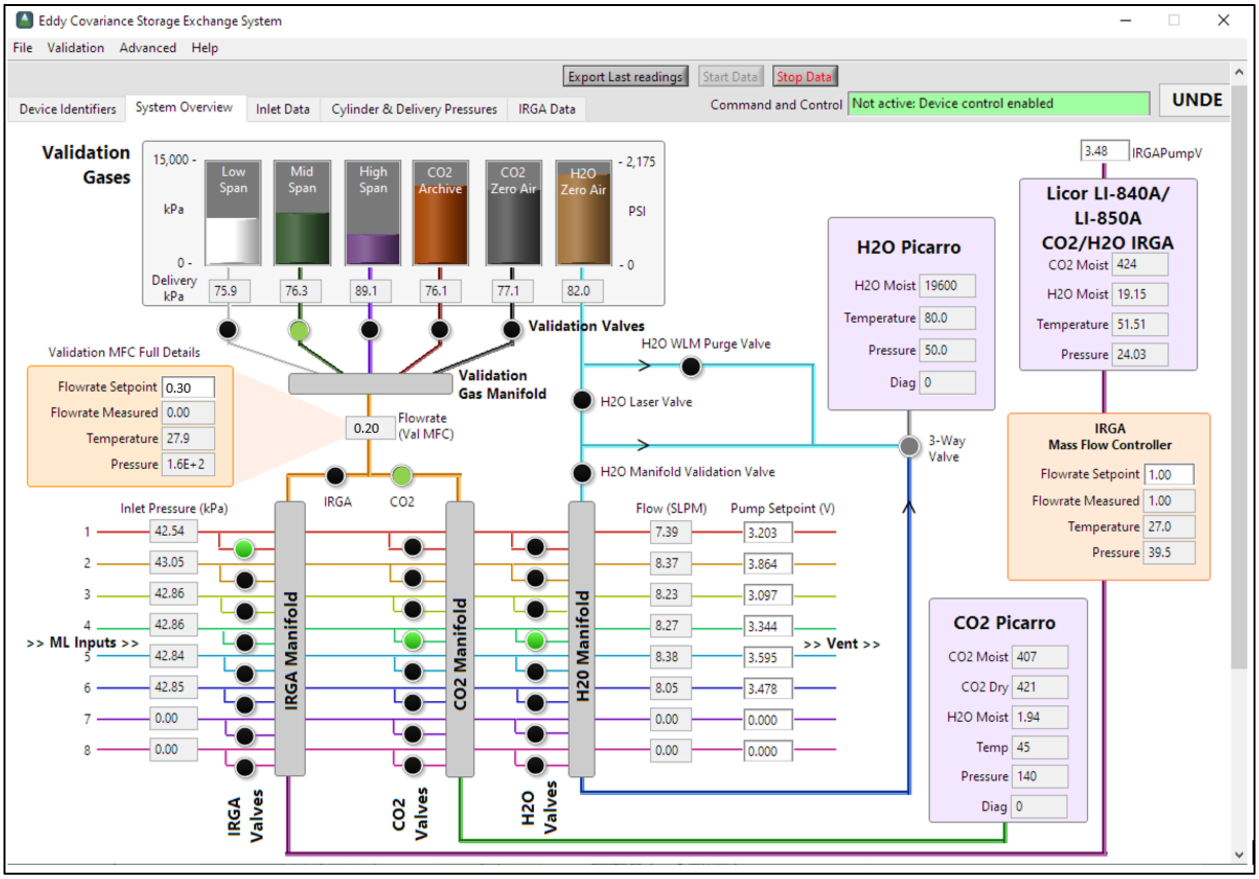


Figure 18. Set the validation MFC set point to 0.5 SLPM with gas flowing at 0.2 SLPM via the IS Control and Monitoring Suite.

15. For the ECTE system, set the validation MFC set point to 1.5 SLPM with gas flowing at 1.5 SLPM via the IS Control and Monitoring Suite in **Figure 19** on the next page. Adjust the regulator's pressure adjusting knob (turn clockwise) until the delivery pressure reads 70 kPa. (Ensure the Instrument Hut/Environmental Enclosure valves are open, or IRGA/cylinder valves are open.)

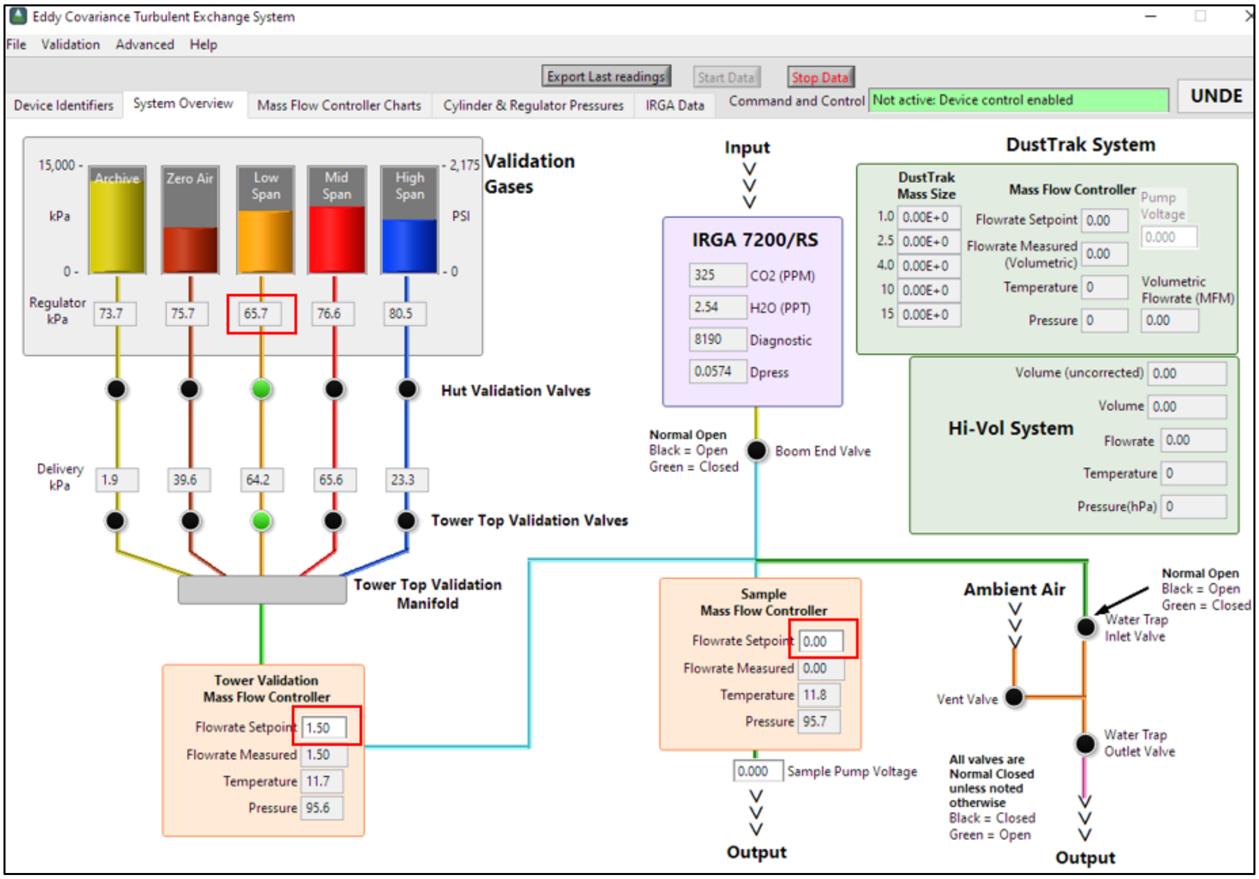


Figure 19. Set the validation MFC set point to 1.5 SLPM with gas flowing at 1.5 SLPM via the IS Control and Monitoring Suite.

16. Close the solenoid valves associated with this CGC valve.

17. Set the Validation MFC set point to zero and restart CNC.

18. Inform ENG of the new asset tag number for the **ECSE High Span Concentration** cylinder replacements to update CNC programming for the site. This ensures proper calibration of the LI-840/850 instrumentation.

19. Update the CFG location for the cylinder via the NEON program's Asset Lifecycle Management System (e.g., Maximo/AssetWorks).

    - Monitor usage rates.

PRO TIP: If Field Science notices delivery pressures of < 50 kPa while CNC is on (except for archive cylinders), it may indicate a leak exists in a gas line, fitting, or a failure in the automated validation procedures. Gas pressure may fluctuate with temperature changes. Conduct these procedures under or near ambient normal operating conditions in the Instrumentation Hut gas room.

5.5.1.5 Leak Test/Detection for Compressed Gas Cylinders Swap Procedures

Most leaks occur at the valve on the top of the cylinder and may involve the valve threads, valve stem, valve outlet, or pressure relief devices. Significant leaks may occur on the pressurized portion of the system between the cylinder valve and the first valve on the output side of the regulator. **Leak testing must occur after the installation/swap of compressed gas cylinders** for both the ECSE and ECTE systems. Reference the procedure below to complete this task (**Table 9** and **Table 10** below).

Table 9. Gas Cylinder Leak Testing Tools & Consumables.

Equipment & Consumables	Quantity
Squirt Bottle Commercial Leak Check Fluid	1
Cloth/Towel	1
1-1/8 Torque/Crowfoot Wrench	1

Note: A commercial brand leak testing solution is preferred in lieu of a soapy water mixture.

Table 10. Cylinder Swap & General Compressed Gas Cylinder Leak Test Procedures.

Figure 20. Squeeze out any Bubbles in the Mixture.

STEP 1 | Prior to applying leak check fluid on the cylinder valve, squeeze the mixture onto a cloth to clear bubbles (**Figure 20**).

Adding the mixture with bubbles may cause confusion over whether a leak exists on the valve.

Figure 21. Squeeze Soapy Water Mixture over Valve.

STEP 2 | Lightly squeeze the all-purpose leak detector solution over the valve connecting the cylinder (**Figure 21**).

Figure 22. Example of a Small Leak on Cylinder Valve.

STEP 3 | **Figure 22** is an example of a minor leak.

To resolve this type of leak, dry off leak check fluid and torque the nut at a higher specification.

Increase the torque in sets of five until reaching 60ft-lb at this connection.

Figure 23. Large Leak on Cylinder.

STEP 4 | **Figure 23** is an example of a larger leak.

To resolve this type of leak, dry off leak check fluid and increase the torque in sets of five at this connection. Do not torque over 60ft-lb.

If leaks are still occurring, then follow the next three steps to inspect the cylinder valve fitting.

Figure 24. Remove the Valve.

STEP 5 | Prior to conducting this step (**Figure 24**), dry off the area that is wet from the leak testing solution.

Bleed off the pressure before removing the valve. *Reference Section 5.5.1.4.3 to conduct compressed gas system purge pressure procedures for installing and removing cylinders.*

Examine the condition of the threads and fittings. Clean off dust or dirt.

Figure 25. Inspect the Curved Surface of Fitting.

STEP 6 | Inspect the nipple seat (the curved surface in **Figure 25**) for damage, dirt, or dust.

Handle this fitting with care; it easily incurs damage from impact.

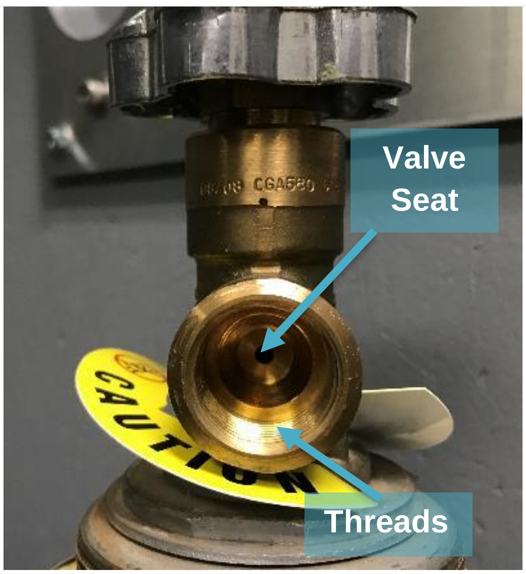


Figure 26. Inspect the Cylinder Valve Seat Fitting.

STEP 7 | Inspect associated seat fitting inside the valve for damage (**Figure 26**).

Figure 27. Reassemble the Fitting.

STEP 8 | Reassemble the fitting with a 1-1/8 wrench (**Figure 27**). *To measure torque, use a 1-1/8" crowfoot wrench. Please be aware, these are reverse threaded fittings.*

Use a 40ft-lbs. torque specification. If leaks continue to occur, then use 45ft-lbs., 50ft-lbs., 55ft-lbs., and 60ft-lbs. torque max. Leverage gravity by using body weight on the wrench when torquing (in a controlled fashion).

After adjusting for leaks, check for leaks again on all previously leaking connections found during leak checking.

If unable to remedy a compressed gas cylinder leak by tightening the valve to 60ft.-lbs., bleed the pressure and disconnect the gas cylinder from the regulator. Reseat the regulator and repeat the process once more in **Table 10** to rule out installation errors.

If the cylinder continues to leak after performing this procedure a second time, the cylinder and/or regulator requires replacement. Cap the cylinder and notify the NEON HQ Engineering (ENG)/ Calibration, Validation and Audit Laboratory (CVAL) via ServiceNow to receive further instructions to return/swap the cylinder or to switch a stainless steel CGA fitting for a brass CGA fitting. If the cylinder is from a local supplier, request a replacement. *Reference AD [14] and AD [15] for additional information.*

5.5.1.5.1 Ascarite II

The gas systems also have a housing in-line with the G2131 Picarro and LI7200 zero air supply in the gas room containing Ascarite II as a CO_2 scrubber (**Figure 28**). It is not expected to require frequent replacement since the zero air has already had most hydrocarbons removed. Ascarite is also hygroscopic and will serve as a desiccant if exposed to humid air. However, it should still be checked periodically for issues in case of a leak or a problematic zero air cylinder.

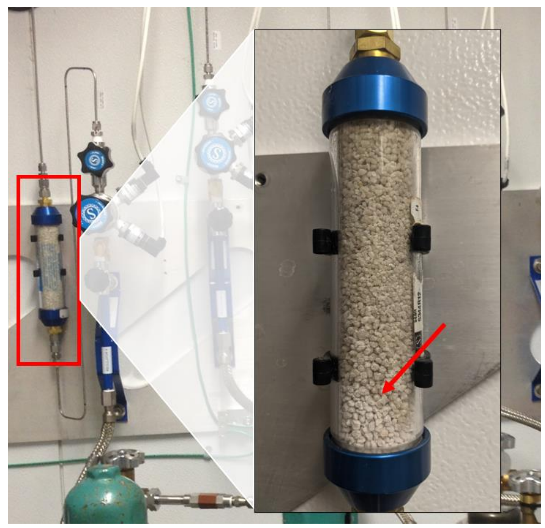


Figure 28. Ascarite II housing for G2131 Picarro Zero Air Supply (*Note the Material turning Whiter/Brightening at the Base of the Housing).*

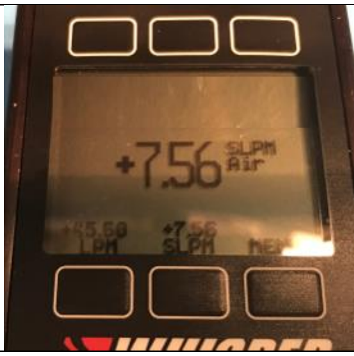
Ascarite II contains soda lime, sodium hydroxide and potassium hydroxide. When new will be creamy white in color. If exposed to CO_2, it will form calcium carbonate and turn white (**Figure 28**). If >50% of the Ascarite has turned white it should be replaced with fresh Ascarite within the fume hood at the Domain lab.

> **CAUTION: Ascarite II is corrosive. Do not breathe, touch, or ingest Ascarite II. Review its Safety Data Sheet. Replacement of material should be completed in a fume hood, preferably into a spare housing.**

5.5.1.6 Mass Flow Meters (MFMs) and Controllers (MFCs)

The hut contains Mass Flow Meters (MFMs) for the ECSE system. If an issue occurs with the rotary vane pumps in the Hut, the MFM readings generally provide the first indicator. Conduct condition monitoring of the inlets and rotary pumps using the MFMs to prevent major issues in airflow and/or damage to the system via an obstruction in the tubing, MFM or pump. If the MFM flow rate readings are <5 SLPM, it may indicate an obstruction in the screen, orifice and/or 2-micron filter in the air inlet. **Table 11** provides a few examples of the various MFM readings a site may encounter for ECSE system.

Table 11. Example MFM Readings for ECSE Flow Rate.

		
Normal MFM Reading *Normal reading for Boulder, CO. 82kPa*	Normal High-Altitude MFM Reading (above 10000ft.) *Normal reading for D10 Niwot Ridge Mountain Research Station.*	Abnormal MFM Reading *May indicate a leak in the sample line.*

The ECTE system uses two Mass Flow Controllers (MFCs) in the Environmental Enclosure for the LI-7200/RS IRGA. The difference between an MFC and an MFM is the valve; MFMs do not have a valve. Reference **Table 12** provides a few examples of the various MFC readings a site may encounter for the ECTE system.

Table 12. Example Sample MFC Readings for ECTE Flow Rate.

		
Normal Sample MFC Reading at Sea-level	Concerning Sample MFC Reading *This is in LPM, not SLPM. It is a normal MFC reading in SLPM. Always check the measurements to prevent a false alarm.*	Abnormal Sample MFC Reading *May indicate a clog or kinked tubing.*

5.5.1.6.1 Taring Mass Flow Meters (MFM) Quarterly

The Mass Flow Meters (MFM) used in the Eddy Covariance Storage Exchange system are subject to drift over time. The Alicat manual states "Taring is an important practice that ensures that your flow meter is providing the most accurate measurements possible". Drifts of over 0.7 SLPM have been observed and large drifts may create the appearance of leaks or clogs. Conduct this procedure quarterly. Follow Steps 1-5 with **Figure 29** below.

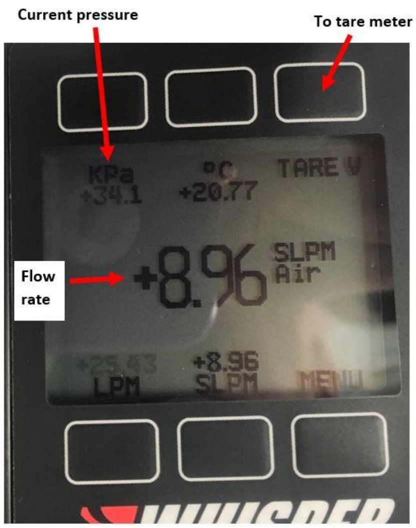


Figure 29. Tare MFMs Quarterly.

1. Ensure pumps are shut off and there is no flow though the meter (it is best to switch the pump to manual and set the dial to zero volts).
2. Check the display to see if the flowrate displayed is 0.00 ± 0.1 SLPM. The pressure reading in the upper left should read ambient barometric pressure.
3. If it is greater than ± 0.1 SLPM, then press the Tare V button on the MFM in the upper right corner (reference **Figure 29**).
4. The display should now read a flow rate of 0.00 ± 0.1 SLPM.
5. Repeat for remaining MFMs.

5.5.1.6.2 Sample Mass Flow Controller (MFC) Filter Cleaning for LICOR LI-840/850 Instrumentation

The filter that connects to Sample MFC to the LI-840/850 (**Figure 30**) requires preventive maintenance on an "as required" basis per the MFC reading indicators (see **Table 6**). Procedures for cleaning the 2-micron filter are the same as the 2-micron filter cleaning procedures for the ECSE and ECTE air inlets, with exception to the location since this MFC resides in the Hut (therefore, no need to retract the boom).

Table 13. Sample MFC Filter Cleaning Tools & Consumables List.

Equipment & Consumables	Quantity
9/16" Wrench	1
Swagelok 2-Micron Stainless Steel Filter	1 per ML
Brush, Stainless (If Teflon Tape is on any of the fittings requiring cleaning)	1
Hydrogen Peroxide, Concentration 3.00%, Capacity 16 oz., Container Type Bottle	1
Cleaner, Ultrasonic, Heated, 6" x 5.25" x 6" (L x W x H) with Sweep and Degas	1
Detergent, Anionic (Alconox) Detergent	1
Air Canned, Filtered to 0.2 Microns	1
Powder-free Nitrile Gloves	1 Pair

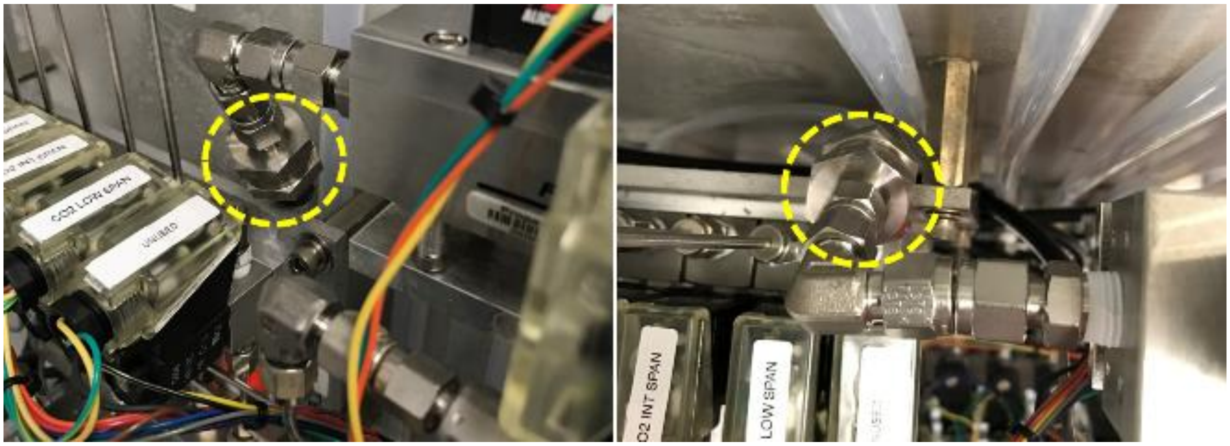


Figure 30. Sample MFC to LI-840/850 Filter Location in Hut.

Conduct the following preventive maintenance procedures for this filter (in **Figure 30**):

1. Shut down CNC. **The LI840/850 vacuum pump must be off for this procedure**. See AD [12] for additional information.
    a. To stop cnc, type "**/etc/init.d/cncctl stop**" #
    b. # This enables maintenance mode which disables auto-restart of CnC #
2. Remove the fittings using a 9/16" Wrench.
3. Cap/Plug the openings to the sample line and MFC to prevent dirt/dust from accumulating in the system.
4. Follow the maintenance cleaning procedures for the stainless steel filter, screen, and fittings in *Section 5.7.3.5.1 ECSE Heated/Unheated Sample Air Inlet Cleaning & Replacement.*
5. Follow the reverse order to reinstall the filter and fittings.

5.5.1.7 Rotary Vane Vacuum Pumps

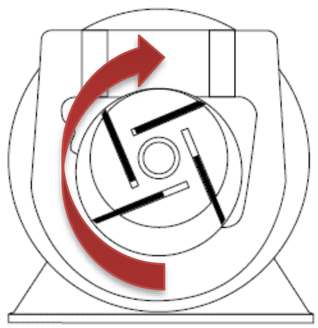


Figure 31. Rotary Vane Pump Diagram

The hut houses up to nine (dependent on MLs per site for ECSE system in Hut) rotary vane vacuum pumps, which bolt to linear vertical/horizontal steel Unistrut lining the interior wall. A vacuum pump draws sample air through the air inlets on the tower MLs for ECSE and ECTE.

Rotary vane compressors and vacuum pumps work by producing a pumping action using a series of sliding, flat graphite vanes, as they rotate in a cylindrical housing. As shown in **Figure 31**, a mounted rotor turns, and the individual vanes slide in and out of their slots by centrifugal and pressure-loading forces. This creates a series of air compartments of unequal volume against the wall of the housing.

These compartments increase during the suction part of the cycle, creating vacuum at the intake port and decrease during the discharge portion of the cycle, creating pressure at the exhaust port (**Figure 32**).

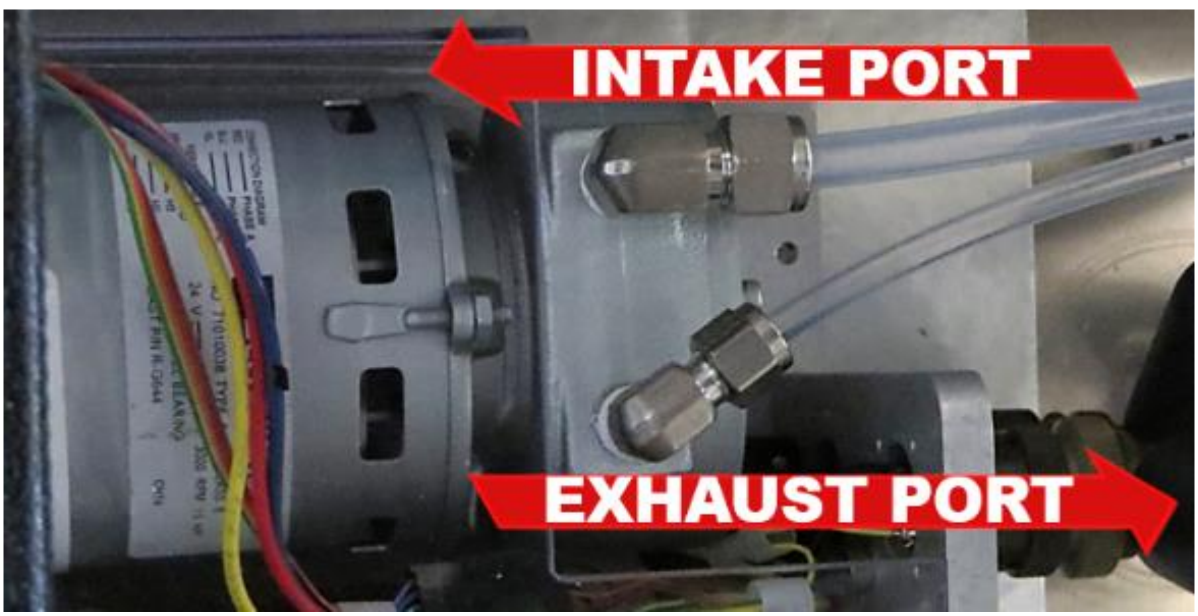


Figure 32. Intake Port and Exhaust Port Locations.

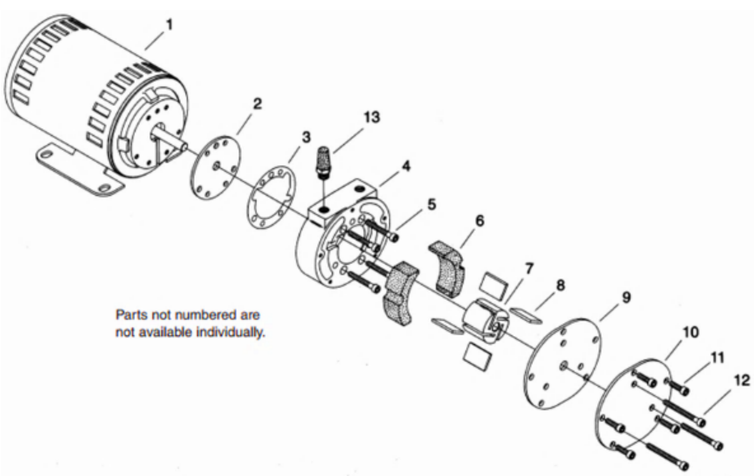
The vacuum and pressure flows are free of pulsation because the inlet and exhaust ports do not have valves, and the air moves continuously rather than intermittently.

Many variables determine the life expectancy of a rotary vane pump. These are the ambient temperature (lower temperatures affect the pump's ability to start and higher temperatures affect its lifespan), duty level, operating cycle, operating speed, condition of air handled (i.e., cleanliness, humidity, heat, chemical vapors present (corrosive, noncorrosive)), and most importantly, pump preventive maintenance. This includes rebuilding the pump due to the graphite or carbon vanes wearing down and/or break over time or internal filter replacement and/or muffler (airline silencer) maintenance. If an issue occurs with the rotary vane pumps in the Hut, the MFM readings generally provide the first indication. Data from Observatory operations to date have shown that once a pump has exceeded 4 Volts to generate the required flow rate a pump is likely to fail shortly after. Due to this, you should monitor pump voltages and **replace a pump that is operating at or above 4 volts** to reduce system downtime. For the ECTE system pump, which operates on a static voltage setting, the **pump and exhaust muffler should be replaced biannually (Table 1).**

Submit an incident ticket in ServiceNow to report any noticeable degradation or inconsistencies in function via the MFM or other monitoring mechanism. NEON HQ Repair Lab provides a functional pump to swap out the dysfunctional pump. Once NEON HQ receives the broken pump, the Repair Lab then conducts a root-cause analysis to determine if the pump requires a rebuild or retirement. **Figure 33** displays the components of a GAST pump for reference and understanding of its internal mechanism.

Note: For vacuum pumps, lubrication is ***not*** *required. Use of petroleum or hydrocarbon products reduces Carbon Vane service life.*

CAUTION: Protect all surrounding items from exhaust air; it may become very hot. Pump surfaces become very hot during operation; allow product surfaces to cool before handling. Air stream from product may contain solid or liquid material that can result in eye or skin damage, wear proper eye protection. Clean this product in a well-ventilated area.



#	Description	QTY
1	MOTOR	1
2	INSERT PLATE	1
3	GASKET	1
4	BODY	1
5	BODY BOLT	4
6	FOAM	2
7	ROTOR	1
8	VANES	4
9	INSERT PLATE	1
10	RETAINER PLATE	1
11	RETAINER BOLT	5
12	RETAINER BOLT	3
13	SILENCER	1
	REBUILD KIT (NOT SHOWN)	1

Figure 33. GAST Model 2032 Rotary Vane Pump Exploded View Diagram.

5.5.1.7.1 ECSE Rotary Vane Vacuum Pump Removal and Replacement

The NEON program HQ Repair Lab conducts the repairs, rebuilds, or replacements of the votary vane pumps for Field Science. These pumps (CD07150000 *| Assembly 24VDC Pump and Control, Gusset Mounting Brackets*) may require annual maintenance, depending on site characteristics and system use (if the pump voltage is above 4 Volts or not working otherwise). If a pump requires maintenance, reference the following procedure in **Table 15** to remove and replace a pump for the ECSE system. *Reference AD [05] to remove and replace a pump for the ECTE system in the Environmental Enclosure.*

Table 14. Hut Pump Removal and Replacement Tools & Consumables List.

Equipment & Consumable List	Quantity
3/16” Hex Key/Allen Wrench	1
Crescent Wrench	1
Flathead Screwdriver	1
Plugs/Caps for Tubes	1-2

Acquire the necessary tools and consumables via Table 14 and conduct the procedures in **Table 15**.

Table 15. ECSE Rotary Vane Vacuum Pump Removal and Replacement Procedure.

STEP 1 | Shut down CNC. Disconnect the RJF to the Grape that controls the pump.

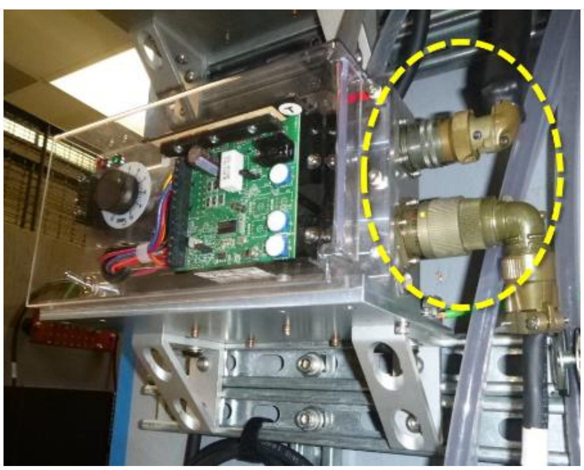


Figure 34. Disconnect Pump Cables.

STEP 2 | Remove the two cable connections from the Pump(s) in **Figure 34**. One connects the pump’s speed control via an ECSE Hut Grape and one to a Power Supply unit below the pumps on the same hut wall. The power supply unit(s) for the pumps connect to PDU4.

Reference AD [06] and AD [09] for Grape maps and PDU/PSU interconnects.

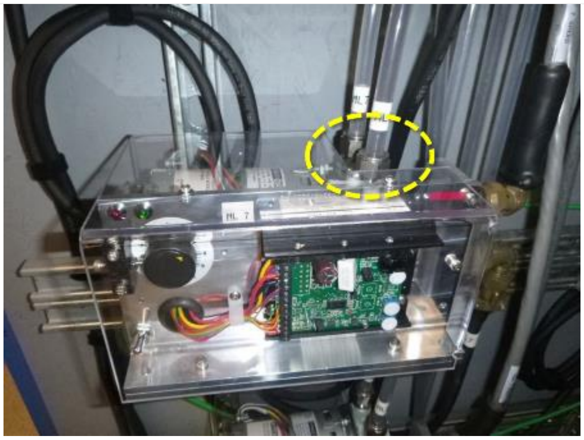


Figure 35. Disconnect Gas Lines from Top of Pump.

STEP 3 | Use a crescent wrench and 7/8" end wrench to disconnect the fittings connecting the gas lines (**Figure 35**).

Figure 36. Remove Four Screws from Mounting Bracket.

STEP 4 | Use a 3/16" hex key/Allen wrench to remove the four black screws on the underside of the pump mounting plate. (**Figure 36**).

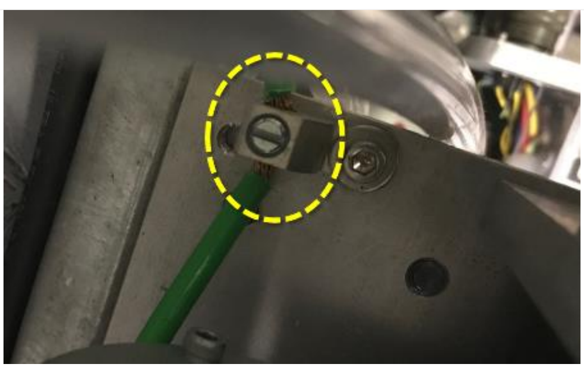


Figure 37. Release Ground Wire from Clamp.

STEP 5 | Use a flat head screwdriver to release the ground wire (if present) from the ground clamp.

In **Figure 37**, the ground clamp resides on the right hand side corner of the pump base plate, closest to the Unistrut on the wall.

Figure 38. ECSE Vacuum Pumps in Hut.

STEP 6 | Remove the pump from the gusset mounting bracket.

Figure 38 displays the ECSE pumps on the hut wall.

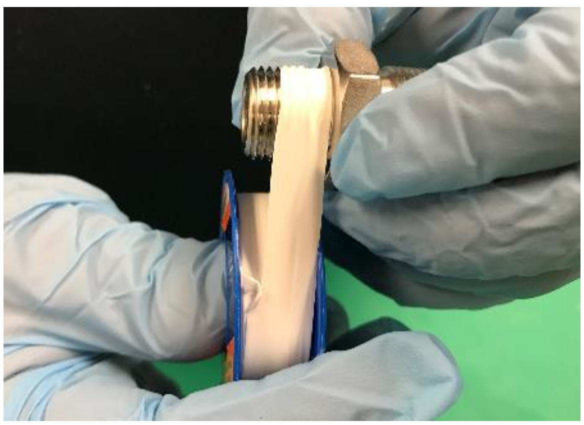


Figure 39. Wrap the Threads with Teflon Tape.

STEP 7 | Unpack the new replacement pump assembly and move gas connection fittings from the pump removed in Step 6. The fittings will need to have all Teflon tape removed and re-wrapped with 2-3 layers of Teflon tape following the direction of the threads (**Figure 39**).

Next, use a flat head screwdriver to secure the ground wire under the ground clamp (Step 5) and a 3/16" hex key/Allen wrench to secure pump to the gusset-mounting bracket.

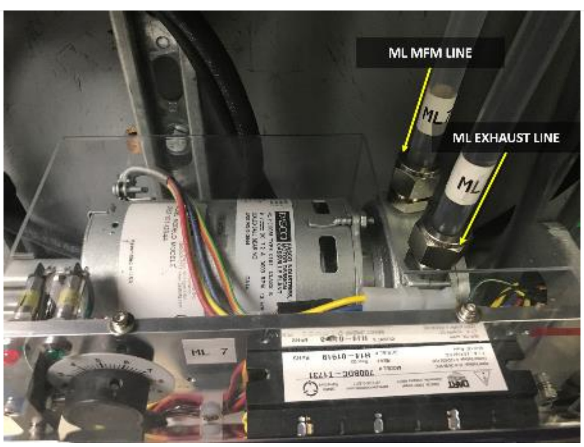


Figure 40. Reconnect Gas Lines.

STEP 8 | Reconnect the exhaust gas lines to the MFM/ML and the exhaust (the exhaust line is usually darker from the graphite in the pump). See **Figure 40** for orientation.

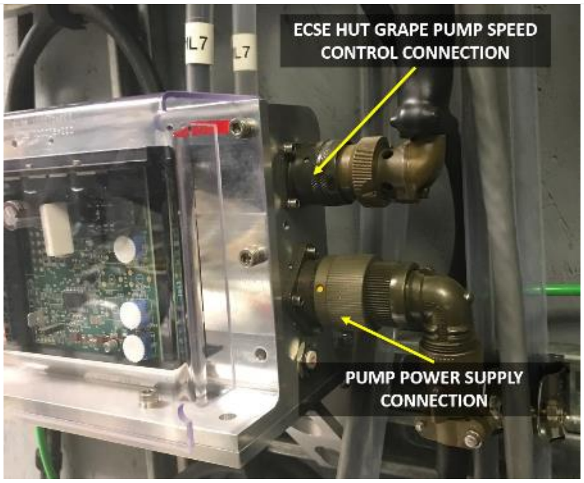


Figure 41. Reconnect Power Cables.

STEP 9 | Reconnect the Grape connections (pump connection first then Ethernet) and then the power cables that directly connect to the pump. See **Figure 41**.

*Note: Prior to restarting CNC, ensure the pump switch is in **remote mode**, not manual mode.*

STEP 10 | Currently CNC will need to be updated with replacement pump EEPROMs. Contact ENG for assistance as needed. Restart CNC and verify the function of the pump(s).

5.5.1.7.2 ECTE Rotary Vane Vacuum Pump Removal and Replacement

For ECTE pump replacement, which resides in the Environmental Enclosure on tower top, reference AD [05]. (The steps for this procedure are like the procedure for the ECSE pump replacement.)

5.5.1.7.3 Muffler (Airline Silencer) Maintenance

Each pump exhaust tube is fitted with a muffler (airline silencer), which is located on the side of the Hut for the ECSE system pumps (see **Figure 42**) and on the bottom of the Environmental Enclosure for the ECTE system. *Reference AD [05] for the Tower Top Environmental Enclosure preventive maintenance procedures.*

If a muffler becomes clogged, the flow rate may be below the thresholds (**Table 6**) and/or pump may be operating at a high voltage or trip the pump internal breaker.

For preventive maintenance of these mufflers, verify the operating conditions of the pump and ensure the silencer is not clogged or loose.

1. If clogged, Technicians may clean the mufflers in a sonic bath (reference the cleaning process for the ECSE Air Inlets. In summation, rinse in the opposite direction of airflow, place in an ultrasonic bath, rinse again, allow to air-dry, and reinstall. **Do not use Hydrogen Peroxide.**). Having spares of this part at the Domain allows Field

Figure 42. ECSE Pump Mufflers on side of Hut.

Science to swap out mufflers to clean, if the muffler is in good condition. Repeat the cleaning process if there is no improvement.

2. Replace mufflers as needed or at least on a bi-annual basis. *See Spreadsheet for muffler part numbers.*
3. If loosened by vibration or other means, retighten using a torque wrench.
   a. Recommended tightening torque is approximately 13 Nm = 115 In-lbs.
4. Black residue is normal in the exhaust lines to the muffler. Monitor exhaust build up in tubing. *Note: An obstruction in the muffler from pump exhaust particles from the graphite vanes may affect the flow rate.*

5.5.1.8 Pressure Transducer

Each compressed gas cylinder is equipped with two stainless steel pressure transducers (also known as pressure sensors) to monitor the compressed gas cylinder pressure (Omega Engineering Model PX319-3KGI) and the delivery of gas pressure (Model PX319-100GI). A pressure transducer (Omega Engineering Model PX319-030AI) also services the inlets on each tower measurement level (ML). This pressure sensor resides in a small enclosure to protect it from the environment, which mounts on the tower near each ML and connects to a corresponding Catawba Grape. The pressure sensor on each measurement level monitors the pressure between the measurement level inlet (on the boom arm) and the gas breakout or junction box (gas tubing NEMA enclosure near ML1 communication box).

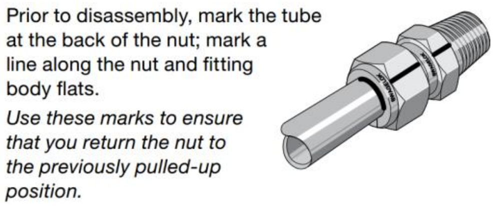
Remotely monitor the pressure transducers using NEON data monitoring software and applications to maintain awareness on any abnormal output values. *Reference AD [10] for more information on the command, control, and configuration of the ECSE system components.*

5.5.1.9 Swagelok and Tylok Fittings

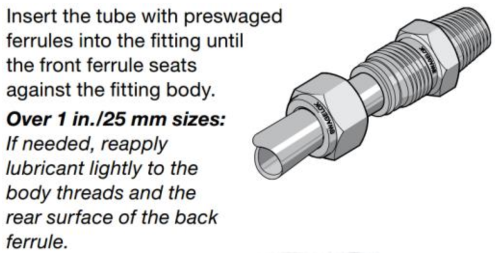
The NEON program primarily employs Swagelok and Tylok fittings, which requires specific tools and additional steps for reassembling. For preventive maintenance, ensure tube fittings are secure (Swagelok, Tylok or other). For Swagelok specific fittings, follow the instructions in **Table 16**.

Note: You may disassemble and reassemble Swagelok tube fittings many times; however, reassembly requires additional steps. Refer to ER [06] and ER [10] for additional guidance on Swagelok fitting installations and assemblies.

Table 16. Swagelok Fitting Disassembly & Reassembly Guidance.



STEP 1 | Prior to disassembly, mark the tube at the back of the nut; mark a line along the nut and fitting body flats. Use these marks to ensure that you return the nut to the previously pulled-up position.



STEP 2 | Insert the tube with pre-swaged ferrules into the fitting until the front ferrule seats against the fitting body.

STEP 3 | While holding the fitting body steady, rotate the nut with a wrench to the previously pulled-up position, as indicated by the marks on the tube and flats. At this point, you will feel a significant increase in resistance. Tighten the nut slightly further – about a 1/8 turn.

5.5.1.10 Grapes (Data Acquisition Device or Data Logger)

The Grapes are data acquisition and control mechanisms (also known as data loggers) for the sensors and their subsystems. The hut contains three Catawba Grapes for the ECTE system and up to six Catawba Grapes for the ECSE system, depending on the number of designated tower MLs per TIS site. **Figure 43** is an example of Catawba Grapes set up for five MLs. *Reference AD [06] for specific guidance on TIS Comm Interconnect Mapping (a map of the of Grape connections).*

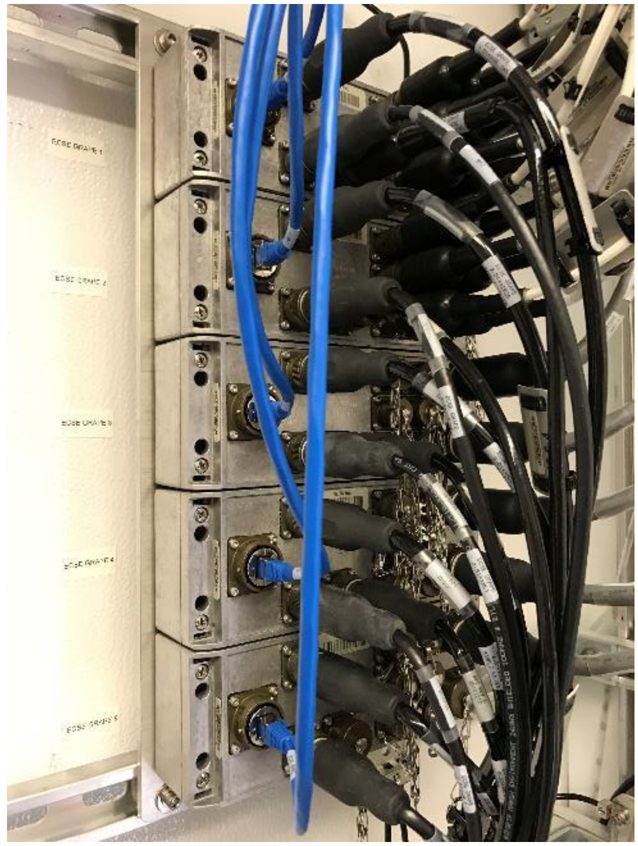


Figure 43. ECSE Catawba Grapes for Five MLs.

The Tower Top Environment Enclosure contains the Grapes for the ECTE system on the top ML. *Reference AD [05] for more information on the ECTE subsystem in the Tower Top Environmental Enclosure.*

Conduct the following preventive maintenance tasks for the ECSE and ECTE Grapes:

1. Ensure connector caps on unused Grape connections are secure (locked in place).
2. Inspect and remove any dust and/or debris by vacuum or by dabbing areas with a lint-free cloth. **Do not use compressed air.**

Note: Remove the Ethernet plug prior to removing any connectors on the Grape. After all connections are secure on the Grape, plug the Ethernet cable (must occur last). Cap any connector not in use. ***NEVER HOT SWAP SENSOR CONNECTIONS!***

For TIS, only three Grape models require annual calibration via CVAL: Catawba, Merlot, and Concord. *Reference Section 5.4 Remote Monitoring to conduct remote monitoring on the Grapes for each Eddy Covariance system.*

Note: Certain Catawba Grapes has a specific CNC configuration. ***Do not swap or change Grapes for the ETCE or ECSE Catawba Grapes unless CNC configuration is updated***

5.5.2 Tower

ECSE system tower components are on each Tower ML. ECTE system tower components are on the tower top ML. FEP and stainless steel tubing connects these components on the tower and to the Hut. To maintain awareness of structural integrity of these two systems on the Tower, conduct the following preventive maintenance tasks:

Figure 44. Tubing Secured via Zip Ties and Cushioned Tube Clamps.

- Conduct a physical inspection of the gas lines from the gas box to each measurement level on the tower, to include the tubing to the Environmental Enclosure on the tower top.
- Label tubes by corresponding measurement level and gas cylinder. Maintain the labeling of these gas lines. Replace labels if they are no longer easy to understand or inaccurate. Accurate and clear labels for each gas tube line is important for maintenance.
- Ensure the tubing is secure on each tower measurement level to the Unistrut via zip ties or 1/2” or 1/4” cushioned and swiveling tube clamps (**Figure 44**).
- Visually examine all tubing runs from the air inlet along the ML boom. Look for kinks, obstructions, or hindrances during retraction and extension of the boom.
- Verify the installation of tubing management clips, clamps, or other devices and are properly routing and guiding the tubing along the Tower and each ML.
- Inspect Swagelok and Tylok fittings from gas breakout/junction box (gas tube NEMA Enclosure) to each measurement level pressure sensor enclosure and sample collection lines, to include the fitting on the bottom of the Environmental Enclosure on the tower top. **Figure 45** displays connections on the right of the gas breakout box graphic.
- Inspect the inside of the gas breakout box on the tower and under the boardwalk for any standing water, corrosion, biologics, or debris (the left side graphic in **Figure 45** provides a good example of a clean gas breakout box on the tower).

Figure 45. Gas Breakout/Junction Box and Top Connections from Box to Tower MLs.

5.6 Eddy Covariance Turbulent Exchange (ECTE) Instrumentation – Sensor Systems

The ECTE system measures the three dimensional (3D) structure of "eddies" within the wind, while simultaneously measures the scalar entities (CO_2, water vapor, and heat) entrained within those eddies. By rapidly measuring (at a frequency of 20Hz) the 3D structure of the eddies and the scalar entities over a fixed timeframe of 30 minutes, the calculation of the fluxes of CO_2, water vapor, and heat may occur.

The NEON ECTE system comprises of the Campbell Scientific CSAT3 3D Sonic Anemometer and LICOR LI-7200/RS IRGA. The CSAT3 uses three pressure transducers to measure orthogonal wind speeds (streamwise (u), horizontal (v) and vertical (w)) and computes a virtual temperature. The LI-7200/RS measures the mole fraction concentrations of CO_2 and H_2O. The NEON ECTE system is unique as it adds several components that are not common in an ECTE system. Outside of the main instrumentation (the Campbell Scientific CSAT3 3D Sonic Anemometer and the LICOR LI-7200/RS IRGA), our system includes heated customizations to the air inlet (Metzger et al. 2016) and sampling tube, an Attitude and Motion Reference System (AMRS), and an automated *in-situ* gas validation system.

Using the measurements from the ECTE system, NEON can compute the covariance of various meteorological parameters that quantify the energy balance ratio equation of the environment, in conjunction with Soil Heat Flux measurements. The closer the energy balance ratio is to unity, the greater the confidence in the covariance computations of the vertical wind speed and CO_2 concentration (mass transfer between the atmosphere and ecosystem, e.g., flux).

The ECTE subsystem consists of span gas cylinders, a rotary vane vacuum pump, MFCs, solenoids, regulators, pressure transducers, stainless steel and brass Swagelok/Tylok fittings, and FEP tubing. A portion of the subsystem resides in the Tower Top ML Boom, Tower Top Environmental Enclosure, and in the Hut. **Figure 46** displays the ECTE system instrumentation in the field.

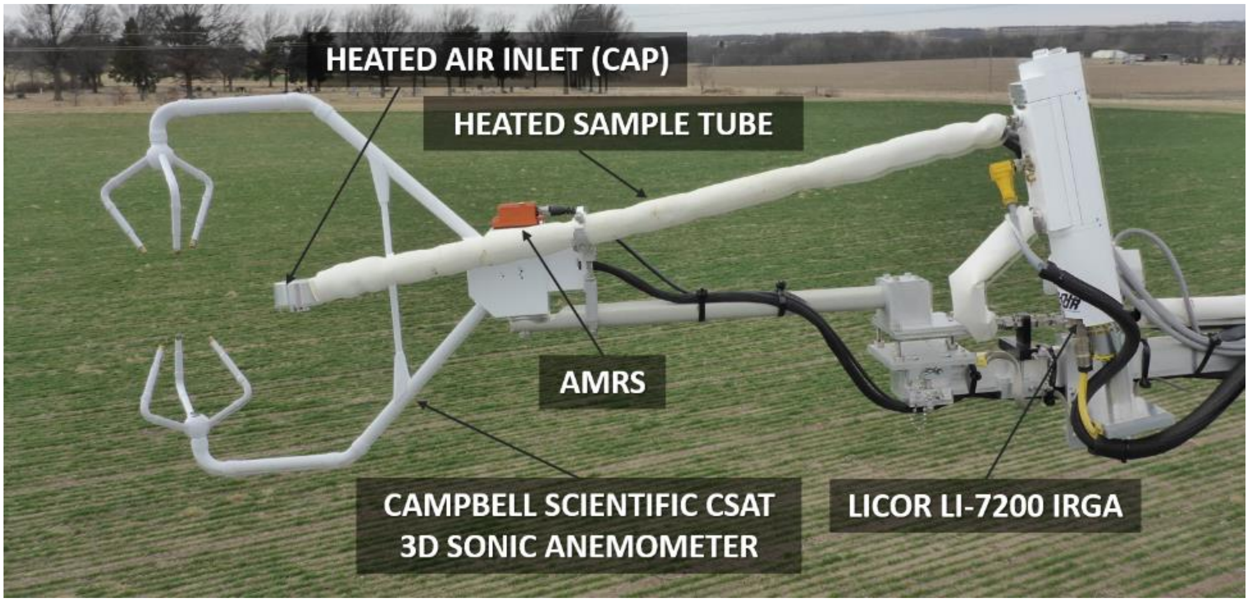


Figure 46. ECTE Instrumentation on Tower Top ML Boom (Domain 06, KONA).

Measurement instrumentation for the ECTE system is, as follows:

- **0300010000 | SENSOR, CAMPBELL SCIENTIFIC CSAT 3D SONIC ANEMOMETER**
    - Electronics Box
    - 0346850000 | Xsens Attitude and Motion Reference System (AMRS) and Cable
- **0303030001 | SENSOR, GAS ANALYZER CO2 / H2O LI-7200**
- **0340220000 | SENSOR, GAS ANALYZER, CO2 / H2O LI-7200, EXTREME COLD**
- **0303030010 | SENSOR, GAS ANALYZER CO2 / H2O LI-7200RS**
    - LI-7550 Analyzer Interface (Control Box)
    - Heated Sampling Tube
    - Heated Air Inlet

5.6.1 Campbell Scientific CSAT3 3D Sonic Anemometer and Xsens AMRS

The CSAT3 (also known as the Sonic, 3D Sonic or 3D Wind) is an ultrasonic anemometer and thermometer for measuring wind speed in three dimensions and virtual temperature. It uses three pairs of non-orthogonally oriented transducers to sense the streamwise (u), horizontal (v) and vertical (w) winds (**Figure 47**). Each transducer alternates transmitting and receiving ultrasonic pulses in pairs. It measures the time of flight (wind speed along the sonic transducer axis) of each ultrasonic pulse and calculates the difference between the pairs to compute wind speed and virtual temperature along each transducer axis. Quantifying the wind speed via the three transducers with the mean wind vector allows for the calculation of the virtual temperature.

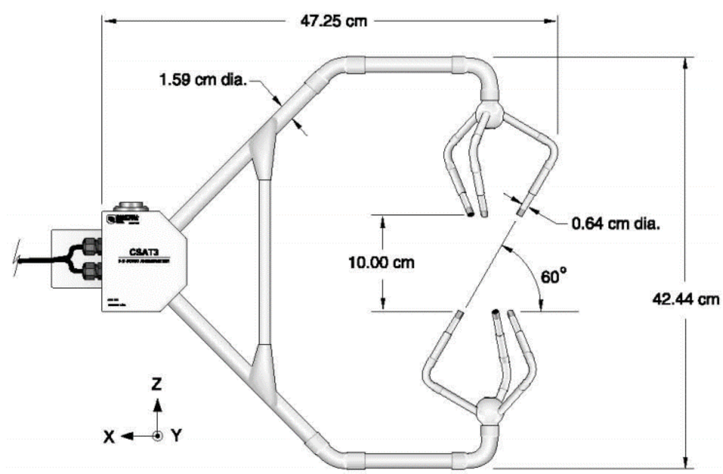


Figure 47. CSTAT 3D Sonic Anemometer Head.

An Xsens AMRS attaches to the top of the CSAT3 support body and integrates the capabilities of a gyroscope, magnetometer, and several accelerometers to measure pitch, roll, and yaw of the ECTE tower top ML boom. NEON uses the data from the AMRS to assess the influence of the boom motion and sensor alignment on the 3D wind measurements from the CSAT3, as well as detecting boom vibrations that affect the CO_2 and H_2O concentration measurements of the LICOR LI-7200/RS. The AMRS pairs with a cable as an assembly (**Figure 48**).

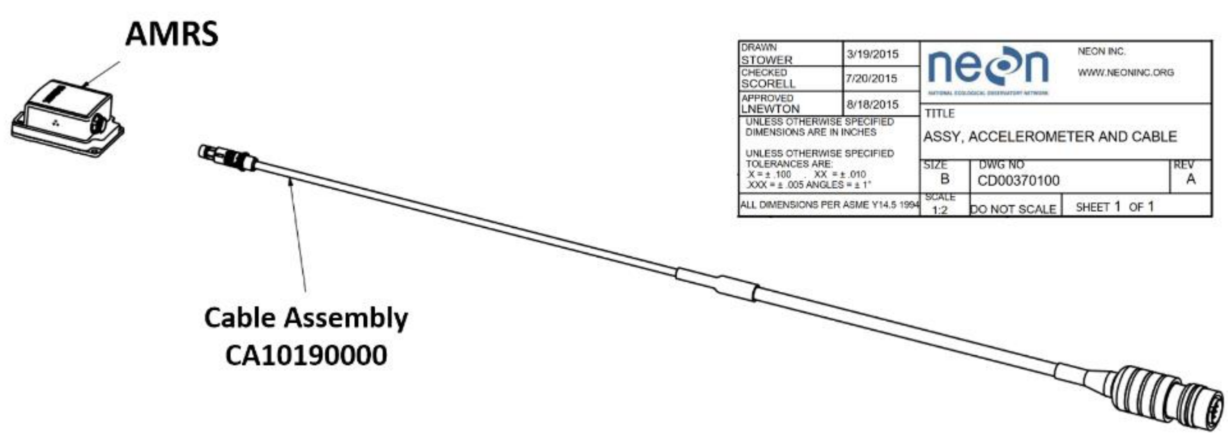


Figure 48. AMRS and Cable Assembly (CD00370100).

5.6.1.1 CSAT3 & AMRS Maintenance

Table 17. CSAT3 Tools & Consumables List.

Equipment & Consumables	Quantity
3D Wind Alignment Tool	1
Boomtron or Equivalent	1

The CSAT3 requires minimal preventive maintenance (**Table 17**). On a biweekly basis, ensure there are no spider webs on the transducers. Webbing may cause a variance in data collection. If spider webs exist, pull the boom in to remove them. Carefully conduct a quick sweep to break apart the webbing **without touching the transducers**.

Conduct visual inspections to check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions. Periodically check electrical connections to the sensor and Grape. Ensure the sensor head is free of any surrounding environmental obstructions, especially after high wind/storm events (e.g., ensure no branches or other debris are obstructing/damaging the sensor head).

Positioning for the CSAT occurs via the AMRS, which resides on top of the sensor head. The level requirement is +/- 1.0 degrees **on install** with some sites having non-zero site-specific orientations. Ensure alignment of the sensor is accurate, specifically after the discovery of obstructions and/or severe weather events. See *Section 5.6.3 Removal and Re-Installation of the LI-7200/RS IRGA, Heated Inlet and Sample Tube Assembly, CSAT3 3D Sonic Anemometer* and *Section 5.6.3.1* for additional guidance on leveling the CSAT3. **If the AMRS drifts outside of the +/- 1.0 degree requirement over time, it should only be re-leveled if > 5.0 degrees.** A Data Quality Trouble Ticket should be submitted in ServiceNow.

Note: Whenever retracting the ECTE boom, the AMRS and CSAT GRAPE should be unplugged from the PoE connector to prevent bad data from being collected and prevent issues with AMRS heading readings. Remember to plug back in when maintenance is complete

The AMRS contains no user serviceable components for preventive maintenance. At a minimum, inspect sensor cables and mounting hardware for wear and tear, corrosion and/or other environmental damage. If the sensor malfunctions, request a replacement.

Note: It is recommended NOT to disconnect the cable from the AMRS. Remove the cable at the Grape along with the unit since they are one assembly, if intending to replace a defective AMRS. The connecting pins to the AMRS are fragile and damage can occur when reseating the connector.

5.6.2 LICOR LI-7200/RS IRGA (ECTE Tower Top)

The LI-7200/RS is a non-dispersive, closed path infrared CO_2/H_2O analyzer for use in Eddy Covariance Flux measurement systems (see **Figure 49.** LICOR LI-7200/RS IRGA Overview Diagram). The NEON program selected this instrument to capture fast (turbulent-scale) measurements of H_2O and CO_2 concentrations across all Domain TIS sites. The fast H_2O and CO_2 concentration measurement collects through the combination of an optical sample cell in the LI-7200/RS sensor head and a separate electronics box for digital signal processing (i.e., the LICOR LI-7550 Analyzer). Air samples flow through the LI-7200/RS via a rotary vane vacuum pump, which resides in the Environmental Enclosure (see AD [05]).

DO NOT USE THE LICOR LI-7200/RS SOFTWARE TO CALIBRATE THE SENSOR. DO NOT ATTEMPT TO REPLACE THE INTERNAL CHEMICALS INSIDE THE IRGA HEAD

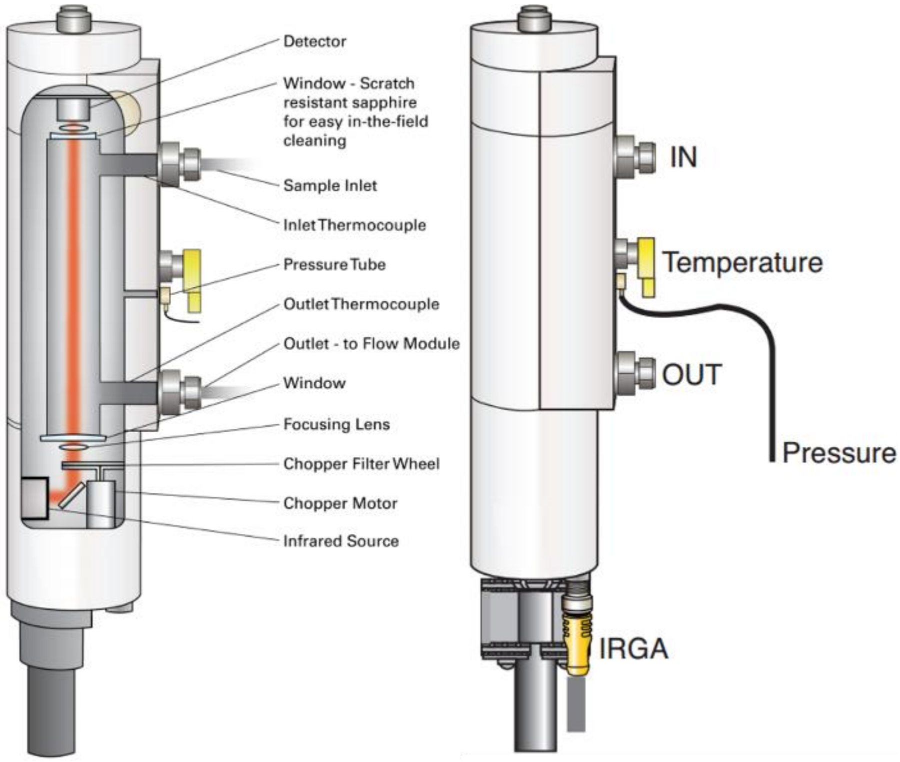
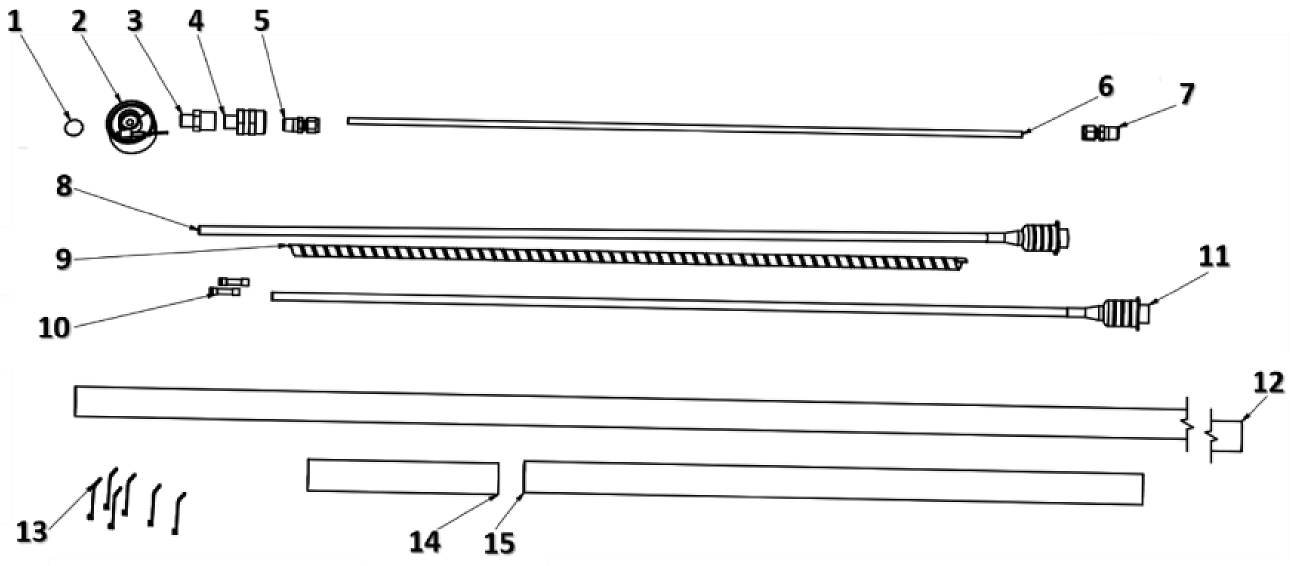


Figure 49. LICOR LI-7200/RS IRGA Overview Diagram.

5.6.2.1 LI-7200/RS IRGA Air Inlet Filter Cleaning & Replacement

The ECTE IRGA air inlet sits on the Tower Top ML boom arm with the LI-7200/RS and LI-7550 instrumentation to collect and process sample air measurements. Its subsystem components reside in the Tower Top Environmental Enclosure (see AD [05]).



DRAWN STOWER	5/5/2014	neon	
CHECKED ACOOPER	9/8/2014		
APPROVED LNEWTON	9/8/2014	TITLE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		ASSY HEATED INLET TUBE, IRGA	
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X = ± .100 .XX = ± .030 .XXX = ± .010 ANGLES = ± 1°		SIZE B / DWG NO CD06880000	REV B
ALL DIMENSIONS PER ASME Y14.5 1994		SCALE / DO NOT SCALE	SHEET 1 OF 1

#	Description
1	Screen, 316 SS, 0.75" Dia., 100 x 100 Mesh, .0055" Opening, .0045" Wire Dia.'
2	Assembly, Inlet Cap and Heater
3	Adapter, 1/4"FNPT, 1/4"MNPT, PFA
4	In-Line Filter Welded, Stainless Steel, 0.25 inch MALE NPT - FEMALE NPT Pleated Mesh Element 2 Micron Pore Size
5	Connector, Male Stainless Steel 0.25 inch OD, 0.25 inch MNPT
6	Tube, Stainless Steel, .25 Inch OD x .18 Inch ID x 28.3 Inch length
7	SS Swagelok Tube Fitting, Bored-Through Male Connector, 1/4 in. Tube OD x 1/4 in. Male NPT
8	Assembly, Heater Tube Inlet 50W @ 48vDC
9	Spiral Wrap, Black Polyethylene, 0.375 inch OD, Wall Thickness 0.052 inch, 100 foot Spool
10	Heat Shrink, Butt Splice Insulated, reducing, 16-14 to 22-18 AWG 600V
11	Assembly Cable12-4 Inline Receptacle Clocked W Single End 3 feet
12	Insulation, Pipe, Unslit Foam Rubber, 3/8 inch Thick, 1/2 inch ID, 6 foot Length
13	Cable Tie - UV Black Nylon 5.75" x 14"
14	Heat Shrinkable Tubing, Polyolefin, 2:1 Shrink Ratio, White, 1.5" Dia., 8" Lg
15	Heat Shrinkable Tubing, Polyolefin, 2:1 Shrink Ratio, White, 1.5 Inch Dia., 26.0 Inches Lg

Figure 50. ECTE IRGA Heated Air Inlet Exploded View and Build of Materials.

The ECTE IRGA air inlet, like the ECSE air inlet, uses a stainless steel 2-micron filter (#4 in **Figure 50**). The cleaning procedures for the filter and orifice fittings are the same as the ECSE air inlet (**Table 45**).

The ECTE IRGA plugs directly into the LI-7550 control box on the tower top and two heat transformers. Reference **Table 18** and **Table 19** to conduct preventive maintenance on the ECTE IRGA.

Table 18. ECTE IRGA Air Inlet Tools & Consumables List.

Equipment & Consumables	Quantity
LI-7200/RS Spares/Cleaning Kit	1
In-Line Filter Welded, Stainless Steel, 0.25 inch MALE NPT - FEMALE NPT Pleated Mesh Element 2 Micron Pore Size	1
Heat Shrinkable Tubing, Polyolefin, 2:1 Shrink Ratio, White, 1.5" Diameter	1 @ 6"
Screen, 316 SS, 0.75" Dia., 100 x 100 Mesh, .0055" Opening, .0045" Wire Dia.	1
Tear-Resistant Silicone Foam Pipe Insulation, 3/4" Insulation ID, 1/4" Thick	1 @ 6"
Tape, Thread, Low Density, PTFE Tape, Thread	1

Equipment & Consumables	Quantity
Brush, Tube, Black Nylon, Diameter: 1/4", Length 36"	1
Brush, Tube, White Nylon, Diameter: 1/6", Length 32"	1
Brush, Sieve, Black Polypropylene, Dia. 1 3/4", Lg. 6 1/4"	1
Tape, Kapton HN Polyimide Film, 1/2" x 36 yds., x 1 Mil, Silicone Adhesive, -269°C to 260°C	1
Brush, Stainless	1
Hydrogen Peroxide, Concentration 3.00%, Capacity 16 oz., Container Type Bottle	1
Wrench, Strap, 3.000 (76.2) Dia. Max., 12" Strap	1
Cleaner, Ultrasonic, Heated, 6" x 5.25" x 6" (L x W x H) with Sweep and Degas	1
Gun, Heat, 120VAC, 12.5 A	1
Detergent, Anionic (Alconox)	1
Air Canned, Filtered to 0.2 Microns (or other compressed air supply)	1
Powder-Free Nitrile Gloves	1 pair
Cable Ties for Re-Installation of Inlet to ML	A/R
Scissors	1
½" Wrench	1
9/16" Wrench	1
Digital multimeter	1

General Rules When Handling the ECTE Inlet:

1. Never bend the inlet tube for any reason.

2. Take extra care when cutting away white shrink tubing; do not cut/nick/chip the cap heater wire.

3. When loosening and tightening fittings, never grip the tube itself, use a wrench to hold onto adjacent fittings for leverage (gripping the tube can cause the tube heater wrap to spin and overlap itself causing hotspots that eventually burn up/short out).

4. Be careful when handling the cap; a small drop/hit can cause the switch epoxied inside the cap to fail.

5. Always make sure to re-screw the plastic fitting into the cap at an angle, take your time to get this right, as once the threads are stripped there is no fixing it! *Note that a plastic fitting is used in place of stainless steel as a thermal break to separate the heaters in the cap and on the tubing.*

6. Never use Teflon tape on swage fittings or between steel and plastic fittings.

7. When retightening swage fittings, you do not need to over tighten. Overtightening causes the fitting to swage even further, closing off more of the opening and making it nearly impossible to remove.

Table 19. ECTE IRGA Air Inlet Cleaning Procedures.

STEP 1 | Acquire the equipment and consumables in **Table 18**.	
STEP 2 | Shut down CNC. Reference AD [12] for additional information.	

Figure 51. Disconnect Gas Line on Tower Top Boom.

STEP 3 | Retract the tower top pivot boom.

Always disconnect (and plug/cap the gas line fitting if the pump is off or during long durations of having the tubing disconnected) when retracting the tower top boom (**see Figure 51**). When reconnecting after extension of the boom, hand tighten first, and then tighten with a 9/16" wrench.

Note: Whenever retracting the ECTE boom, the AMRS and CSAT grape should be unplugged from the PoE connector to prevent bad data from being collected and prevent issues with AMRS heading readings. Remember to plug back in when maintenance is complete

Reference AD [20], NEON.DOC.004980 NEON Preventive Maintenance Procedure: Site Infrastructure for procedures to retract and extend the tower top ML ECTE/SE boom.

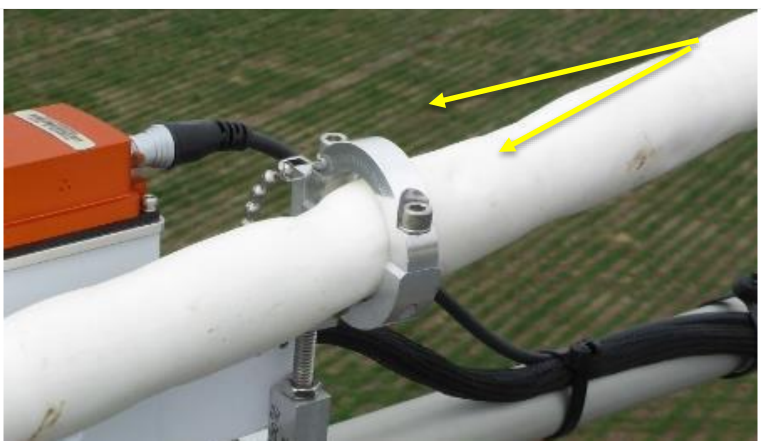


Figure 52. Remove Captive Screws from ECTE Support Clamp.

STEP 4 | Disconnect the IRGA heated air Inlet and sample tube from the LI-7200/RS. Remove two captive screws from the ECTE sample tube support clamp at the end of the tower top boom shown in **Figure 52**.

Cap/plug the sample tubing if you are not conducting a one-for-one swap of the components. Employ care with the new air inlet. If swapping, use ESD handling precautions.

Conduct the remaining preventive maintenance steps on the ECTE IRGA air inlet at the Domain Office.

STEP 5 | Remove the 6" shrink-wrap nearest the cap by cutting it off with scissors, being careful not to cut the small wire for the heated cap (**Figure 53**).

Figure 53. Shrink Wrap Removed from End of ECTE Inlet.

STEP 6 | Carefully slit the tape with scissors and open the 6" piece of black silicone insulation being careful not to damage small heater wire.

STEP 7 | Using two 9/16" wrenches, loosen the Swagelok nut until free (see "**Wrench here**" in **Figure 54**). Unthread the in-line filter from the PFA adaptor by hand if possible. Separate the inline filter from taped fitting with a crescent wrench and 9/16" end wrench. Unthread PFA adaptor from cap by hand if possible.

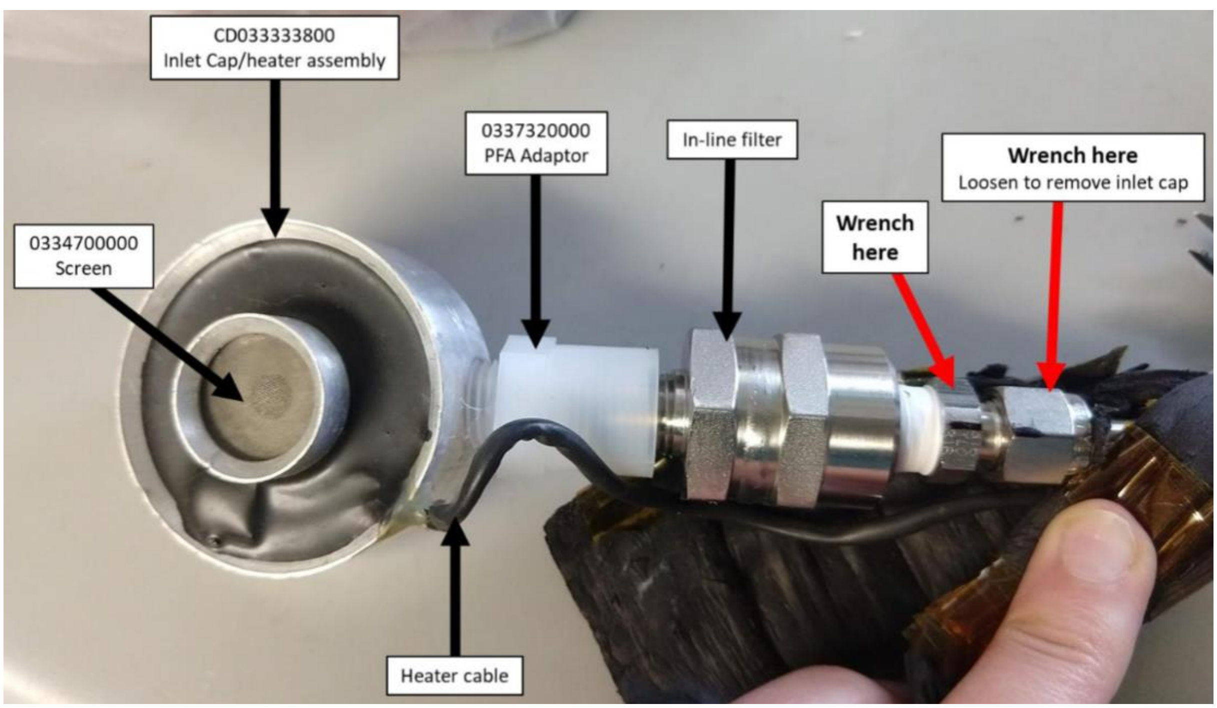


Figure 54. ECTE Inlet Fittings with Insulation Pulled Back.

Figure 55. Secure Inlet Cap to Prepare for Inlet Tube Cleaning.

STEP 8 | Prior to cleaning, secure the inlet cap to the inlet tube using rubber bands or tape to help prevent damage while cleaning the inlet tube (**Figure 55**).

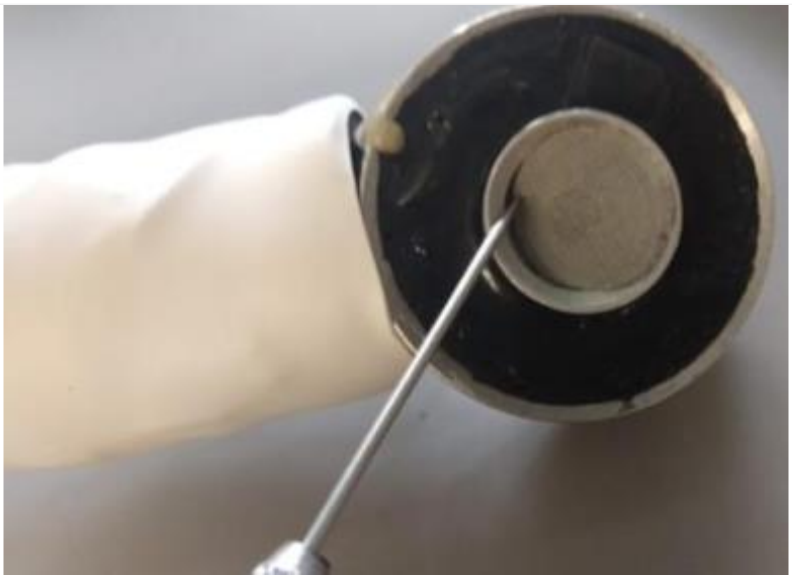


Figure 56. Removing Screen with a Dental Pick or Equivalent**.**

STEP 9 | Push the inlet cap screen out of the grooved cap using a dental pick or equivalent (**Figure 56**).

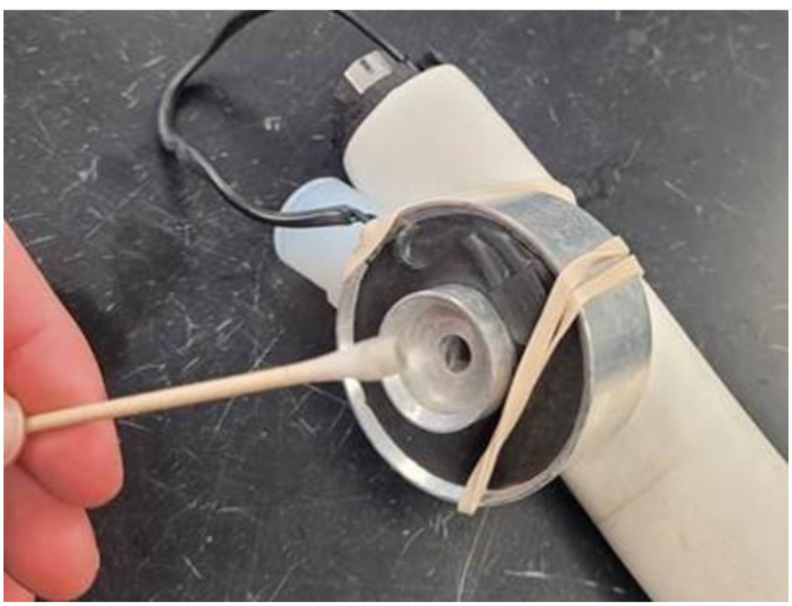


Figure 57. Use a Q-tip to Clean Debris from Inlet Cap.

STEP 10 | Conduct the same cleaning procedure on the inline filter for the ECSE heated air inlet in *Section 5.7.3.5.1,* **Table 45***, Step 21-28.*

In addition, use a Q-tip soaked in 95% ethanol to clean the inlet cap from both the screened and PFA adaptor end (**Figure 57**).

Compressed air may also be helpful in cleaning the inlet cap.

STEP 11 | Use compressed air to blow out the inlet tube for approximately 20 seconds. Repeat from the opposite end.

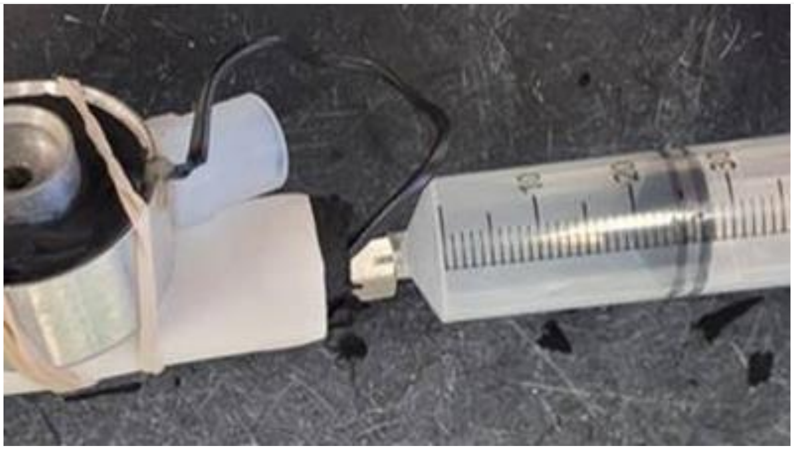


Figure 58. Use a Syringe to Rinse the Inlet Tube from each End.

STEP 12 | Using tap water and a syringe force water through the tube in each direction for approximately 10 seconds to remove any larger particulates (**Figure 58**).

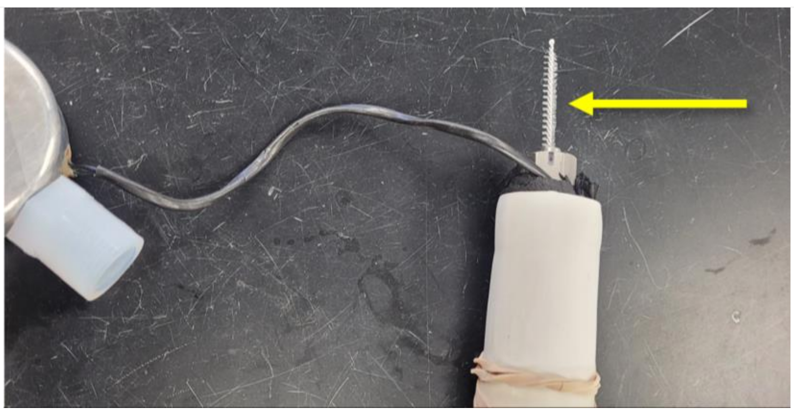


Figure 59. Long Nylon Tube Brush inserted through Inlet Tubing.

STEP 13 | Use a long, narrow bottle brush (1/6" diameter, 32" long) that has been soaked in Alconox (2 oz/gal water) and run the tube brush back and forth all the way through the inlet tube at least 5 times (**Figure 59**).

Repeat the previous step (Step 12) to rinse.

STEP 14 | Rinse the bottle brush thoroughly with tap water and soak in 95% ethanol. Run the tube brush through the inlet tube as in the previous step (Step 13).

STEP 15 | Dry the tubing by applying compressed air to the tube for approximately 30 seconds prior to proceeding with reassembly

STEP 16 | Reapply Teflon tape to stainless steel adapter fitting and follow the reverse order to reassemble (**Figure 60**). Reference RD [11] for Teflon Pipe Tape Application instructions. **The PFA adaptor (compression) fitting should be hand tightened only** (over tightening will damage threads). carefully thread the PFA adaptor into the cap at a slight angle. Go slow and be careful to avoid cross-threading.

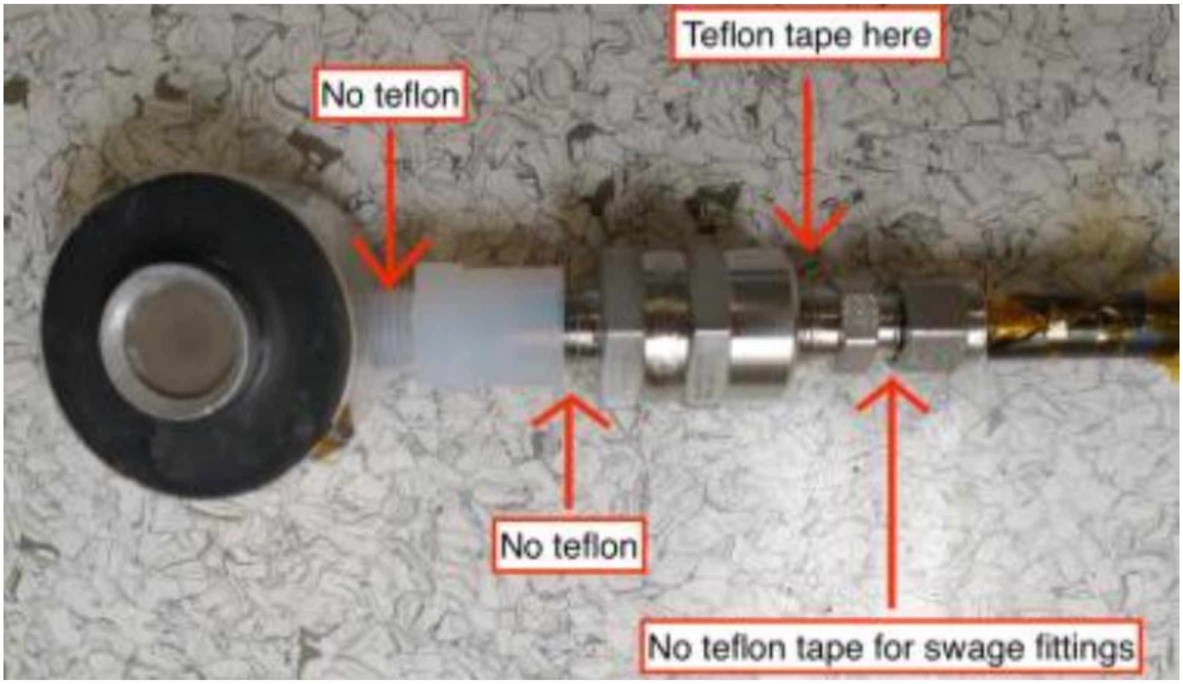


Figure 60. ECTE Air Inlet Sample Tube without Insulation.

STEP 17 | Cut and reapply foam to the fitting assembly (~6" piece). You can reuse the foam if still in good condition and tuck heater wire into the foam, avoiding any sharp bends or edges (**Figure 61**).

Figure 61. Cut or Use a 6" Piece of Insulation.

Figure 62. Wrap the Insulation with Tape.

STEP 18 | Wrap and tape the 6" piece of insulation from the end of the cap over the in-line filter, wire, and Swagelok fitting at the end of tube (**Figure 62**). Use Kapton HN Polyimide Film Tape, 1/2" x 36 yards, x 1 Mil, Silicone

Adhesive, -269°C to 260°C for this step.

STEP 19 | If reassembling the entire assembly, cut and slit a 26” piece of insulation. Wrap and tape the insulation around the cables and rod from the end of the initial 6” piece of insulation to the Swagelok nut at the end of the rod. **Figure 63** is the result of this step. (***Skip this step if only addressing the 6” portion of the air inlet.)***

Figure 63. Sample Tube Full Insulation.

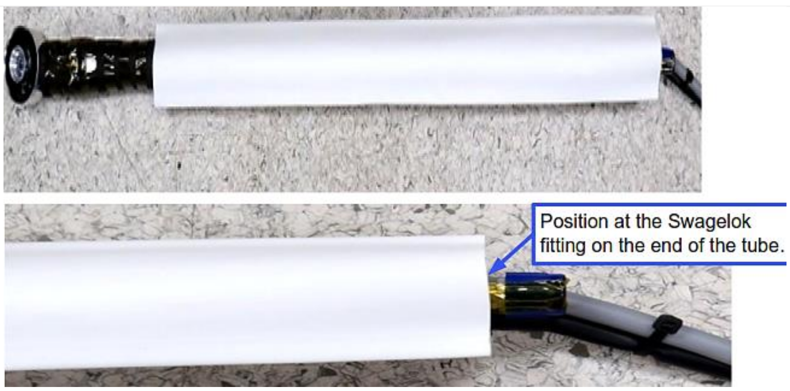


Figure 64. Position Shrink Wrap at Swagelok Fitting.

STEP 20 | Slide a 26” piece of white heat shrink-wrap over the cables and insulation. Position exactly as displayed in **Figure 64**.

Skip this step if only addressing the 6” portion of the air inlet.

Figure 65. Heat the Shrink Wrap.

STEP 21 | Heat the white shrink-wrap onto the assembly using a heat gun (**Figure 65**).

Skip this step if only addressing the 6” portion of the air inlet.

STEP 22 | Slide an 8” piece of white heat shrink-wrap over the remaining portion of the insulation. Allow a portion of the shrink-wrap to overlap onto

Figure 66. Slide on Shrink Wrap.

the cap to ensure the wrap covers the wires (**Figure 66**).

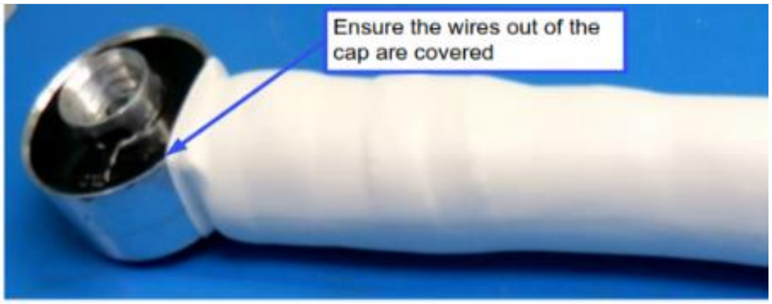


Figure 67. Heat the Shrink Wrap.

STEP 23 | Heat the white shrink-wrap again using a heat gun (**Figure 67**). Move quickly over areas to prevent overheating areas/creating hotspots that may cause damage to the components.

Figure 68. Trim Heat Shrink.

STEP 24 | Use a sharp blade to trim the white heat shrink to fit around the exterior of the cap. Use caution when cutting to prevent cutting any wires or body parts.

Follow the red line for reference in **Figure 68**.

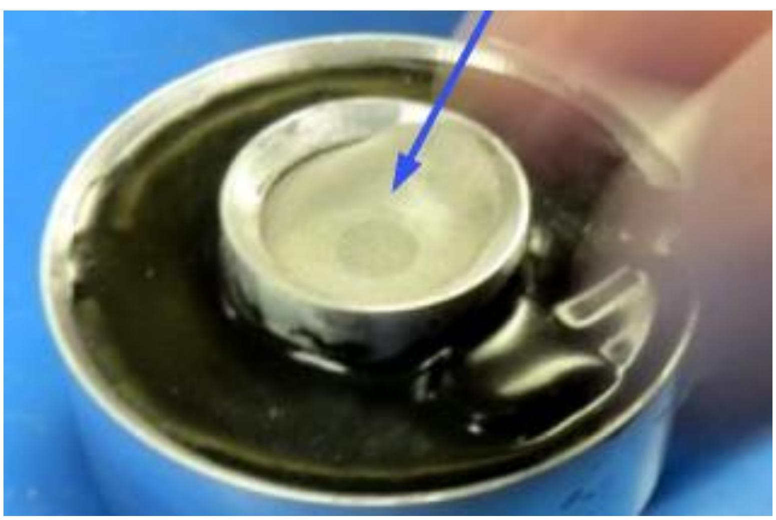


Figure 69. Stainless Steel Screen Installation.

STEP 25 | Gently install the new and/or clean stainless steel screen using a dull/blunt object or tweezers to carefully push into the groove of the interior cap (**Figure 69**).

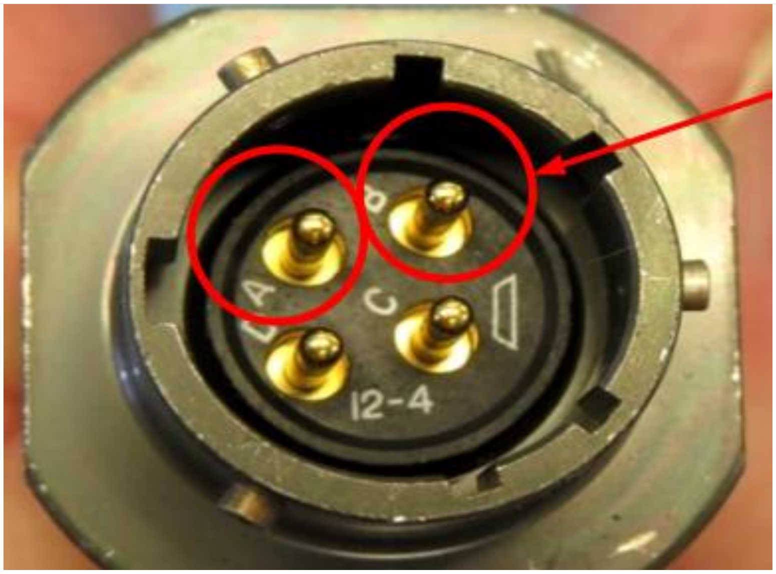


Figure 70. Use a DMM to Measure the Resistance.

STEP 26 | Use a digital multi-meter to measure the resistance of the two cables between pins A and B (circled in red in **Figure 70**) on the cables that connects the heating components.

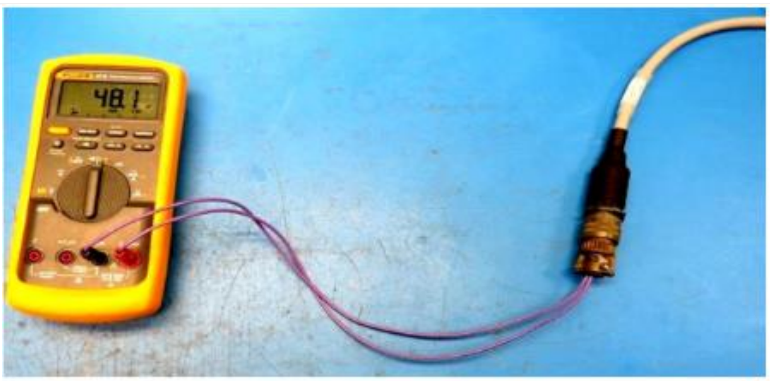


Figure 71. Measure Resistance of the ECTE Heater Cables.

Note: The heater component rates at 100W at 48V. Checking heating components is to ensure the heaters and wires are not damaged and which cable is which. Best practice is to label the cables both on the inlet assembly and on the tower.

STEP 27 | Measure resistance (**Figure 71**). Measurement for the ECTE cap heater component is 23±5 ohms (**Figure 72**). Measurement for the sample tube heater is 48±5 ohms.

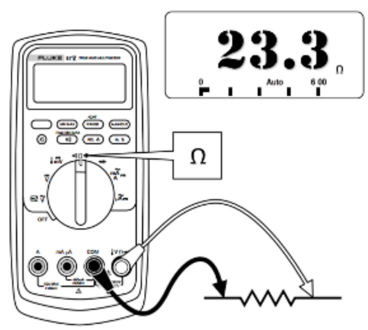


Figure 72. DMM for ECTE Cable.

Figure 73 is an example of packaging the sample tube for transporting from locations to protect the tube using a generic plastic bag (left) from external dust/debris and electric shocks using an electrostatic discharge bag (right) for the two cables.

Figure 73. Sample Tube Packaging for Transporting.

5.6.2.2 LI-7200/RS IRGA Optical Path Cleaning

The LICOR LI-7200/RS IRGA is tolerant of small particulates on the windows, if they are small, and spectrally neutral (the windows are sapphire, which are durable and resistant to scratches). The LI-7200/RS optical path and windows require maintenance when the sensor produces low signal strength/values**. If signal strength is < 85% the analyzer cell should be cleaned as specified below.** LI-COR suggested to reset signal strength to 100% after window cleaning. But at NEON, field staff do not perform this reset, and only CVAL will do the signal strength reset when this IRGA is back to HQ for re-calibration. Therefore, occasionally, the signal strength could be slightly higher than 100% (but typically <105%) after a careful window cleaning at field. Other contaminants such as dust and pollen can also affect signal strength. Pollen is a problem because it is sticky and accumulates.

Monitor the signal strength via the diagnostic value 8191 (stream number) for changes to determine if optical path/windows require cleaning. The diagnostic value is a binary representation that changes when the instrument incurs a variety of issues. If the number is other than 8191, it may mean that the lens requires cleaning, or another issue exists with the sensor. To prevent an optical path/window cleaning that may not be necessary (nor resolve the issue), submit a ticket in the Issue Management System for help in identifying the issue that relates to the diagnostic code. A diagnostic code calculator has been developed that will help interpret coded values.

The LI-7200 detector is sensitive to sunlight/UV (ultraviolet) radiation. Opening the optical cell must occur indoors for cleaning to prevent contamination or damage.

Remove the optical bench from the instrumentation and clean the optical path with any mild detergent or glass cleaner. NEON HQ recommends the following cleaning consumables in **Table 20**.

Table 20. Optical Path Cleaning Tools & Consumables List.

Equipment & Consumables	Quantity
Kimwipes	A/R
Bower 6 In 1 Digital Camera Cleaning Kit Model	1
Squirt Bottle (125ml Nalgene Translucent Economy Wash Low-density Polyethylene Bottle)	1
3/16" Hex Wrench	1

Equipment & Consumables	Quantity
Plier/Towel (if the thumb screws are too tight to remove, use pliers or a towel for leverage)	1

1. Acquire the appropriate equipment and consumables via **Table 20**.
2. Shut down CNC. Reference AD [12] for additional information.
3. Retract the tower top pivot boom to access the LI-COR LI7200 to clean the optics. *Reference AD [20], NEON.DOC.004980 NEON Preventive Maintenance Procedure: Site Infrastructure for procedures to retract and extend the tower top ML ECTE/SE boom for instructions.*
4. Disconnect the temperature cable, sensor head cable and pressure tube (see **Figure 49**). Cover open tubes left on the boom with tape to keep out bugs and/or dirt.
5. Remove the LI-7200/RS instrumentation from the boom by removing its boom arm mount clamp. Use a 3/16" hex wrench to remove the two captive screws from the mount clamp. (Be careful not to lose the spacers and washers.)
6. Return to the Hut with the assembly to conduct the preventive maintenance procedures. **Do not open the optical cover unless indoors.**
7. Loosen the two knurled knobs on the top of the LI-7200/RS sensor head, and then pull the top of the sensor head out away from the optical bench (see **Figure 74**).

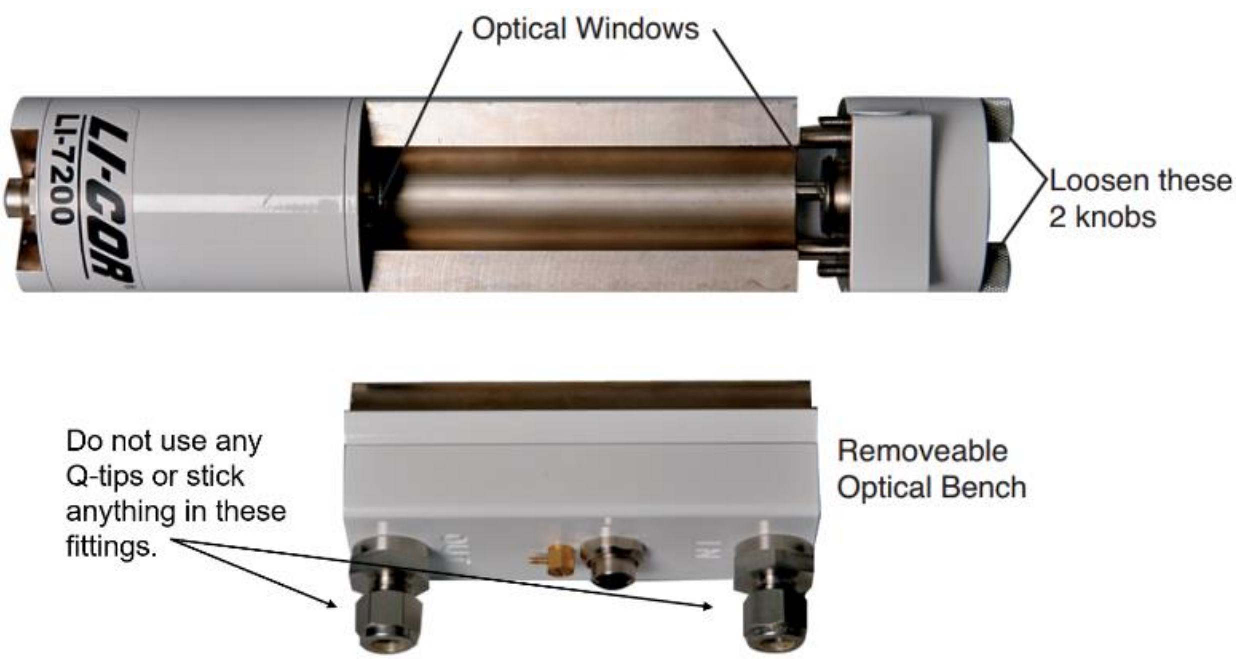


Figure 74. LI-COR LI-7200/RS Optical Window Location and Access.

Note: The optical bench has a PVC insert as the optical path. You can use mild soap and water, isopropyl alcohol, vinegar, or distilled/deionized water to clean the optical path. ***Do not use acetone, ammonia, chlorine, compressed air, or wire brushes to clean the path, as irreparable damage to the PVC insert may occur.***

CAUTION: DO NOT USE Q-TIPS TO CLEAN THE FITTINGS ON THE REMOVEABLE OPTICAL BENCH. THESE FITTINGS CONTAIN DELICATE THERMALCOUPLES TO MAINTAIN TEMPERATURE MEASUREMENTS. IF THESE THERMALCOUPLES INCUR DAMAGE FROM Q-TIPS, THE SENSOR LOSES ITS ABLITY TO TAKE TEMERATURE MEASUREMENTS.

8. Conduct the following preventive maintenance procedures to clean the LI-7200/RS optical path in **Figure 74**.
   a. Remove as much loose dust and dirt as possible from the lens with a hand squeeze blower/soft-bristled brush.
   b. Spray a stream of water from a Nalgene bottle (squirt bottle) on the lens to remove lodged dust and dirt.
   c. Apply a few drops of lens cleaning solution to a lens tissue/kimwipe cleaning cloth.
   d. Using a lateral motion (not circular) and gently clean contaminants from the lens surfaces.
9. Once complete, reassemble the sensor head.
10. Reinstall the sensor on the tower top boom.
11. Reconnect sensor connections.
12. Initiate CNC and verify function before leaving site.

5.6.2.3 LI-7200/RS IRGA Inlet Tube Heating Adjustment

Regularly monitor the LI-7200/RS cell temperature differential (reference Section 5.4 Remote Monitoring) to determine proper functioning of the inlet tube heater. The proper functioning of the heated inlet will minimize condensation in the sample line and within the IRGA. The temperature difference between the inlet and outlet of the LI7200 should be within 2-6° C. If not, you may need to adjust the potentiometer in the transformer box mounted to the tower top railing.

There are two heater boxes, one for the inlet tube heater and one for the inlet cap heater (**Figure 75**). Ensure that you know which is for the inlet tube before making heater adjustments. Trace the cables to the inlet tube heater to help identify each, if necessary. Label each box, if not already labeled, for future reference.

<u>PRO TIP</u>: The tube heater cable on the ECTE inlet is the longer of the two grey cables coming out of the inlet tube.

Figure 75. Inlet and Tube Heater Boxes.

Follow Steps 1-5 below to make heater adjustments. Further troubleshooting is available in the following guide on Sampling Support Library (Guide – Checking the LI-7200 Tube Heater Temperature Differential)

1. With CNC on to activate the relay and cables still attached to the box and inlet, loosen the four captive screws holding the lid and circuit board.

2. Use a digital multimeter to check the voltage across the "V out +" and "V out –" (**Figure 76**), this should read approximately 14.5 V DC. (Alligator clip probes can be helpful for this step.)

3. If not, carefully turn the potentiometer screw "V out adjust" (**Figure 76**) small increments to adjust output voltage until it is approximately 14.5 V DC.

   a. Turn clockwise to increase voltage out and counterclockwise to decrease.

4. After making the adjustment, wait several minutes and then verify by streaming the LI-7200/RS and comparing **Stream 13 (TempIn)** with **Stream 14 (TempOut)**.

   a. In a TEP, type: **vd -s 0xZZZZZZZ**, where **ZZZZZ=MAC** address of LI7200.

b. **CTRL+C** stops the stream so you can compare.

5. Apply Krytox grease to the box gasket and reinstall onto mounting, ensuring gasket is not twisted and cables are securely attached.

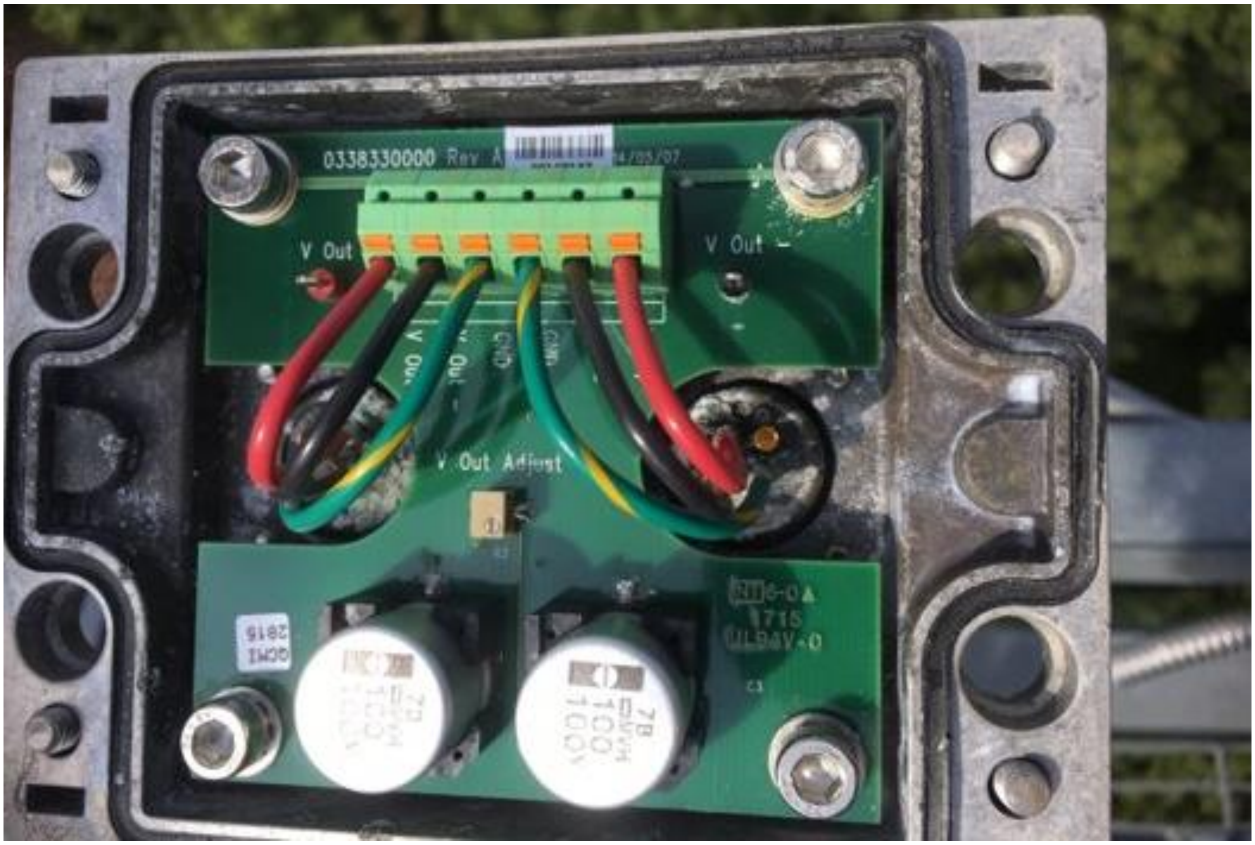


Figure 76. Inside of a Heater Box.

5.6.3 Removal and Re-Installation of the LI-7200/RS IRGA, Heated Inlet and Sample Tube Assembly, CSAT3 3D Sonic Anemometer

Use the following Tables (**Table 21** and

Table 22) to remove/replace ECTE tower top instrumentation. Note: The following is an outline of the basic steps, a Field Science Guide has also been developed with additional details to support field replacement.

Table 21. Campbell Scientific CSAT 3D Sonic Anemometer, LICOR LI-7200/RS IRGA Replacement Tools & Consumables List.

Equipment & Consumables	Quantity
10” Torpedo Level	1
2’ Bubble Level	1
3/16” Allen Wrench	1
3/16” Hex Socket	1

Flush Cut Diagonal Cutters	1
Soft Grip Pliers	1
Crescent wrench	
Thread Lubricant	1
Cable Ties	A/R
9/16" Wrench	1

Table 22. ECTE Tower Top Pivot Boom Arm Removal/Replacement Procedures.

STEP 1 | Acquire the appropriate equipment in **Table 21**.

STEP 2 | Shut down the CNC via the LC.

Figure 77. CSAT3 and AMRS Grapes on Tower Top Rail.

STEP 3 | De-energize the two Grapes for the CSAT 3D Sonic Anemometer by removing the Ethernet cable for both Grapes:

- AMRS Concord grape (24V)
- CSAT3 Merlot Grape (12V)

Note that the LI-7200/RS plugs directly into a control box and does not use a Grape. Both Grapes mount to the Tower top railing under the protection of a Grape shield (**Figure 77**).

STEP 4 | Retract the tower top pivot boom to reach the instrumentation. *Reference AD [20], NEON.DOC.004980 NEON Preventive Maintenance Procedure: Site Infrastructure for procedures to retract and extend the tower top ML ECTE/SE boom.*

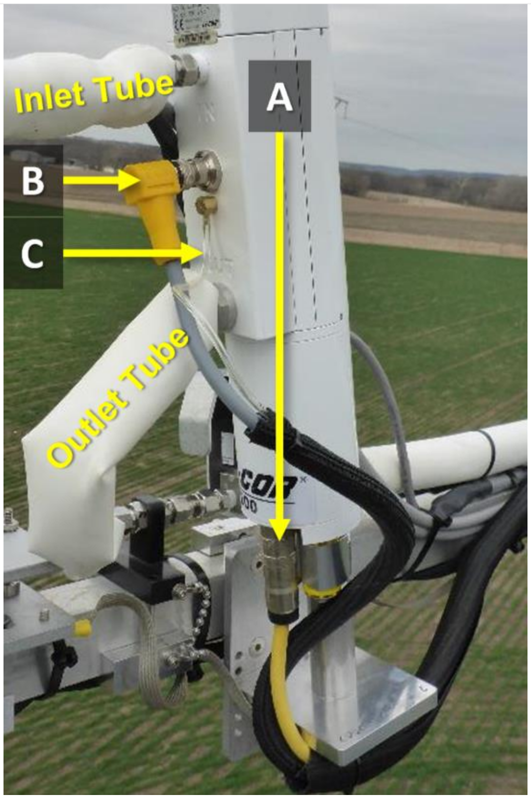


Figure 78. LICOR LI-7200/RS IRGA Sensor Head Connections.

STEP 5 | Disconnect the sensor in the following order of operations.

A. Remove the Sensor Head Control Cable using soft grip pliers from the base of sensor (**Figure 78**). The other end of this cable attaches to the analyzer interface unit at the connector labeled **IRGA**. The removal of interface box connections is covered in later steps.

B. Disconnect right angle temp cable in Figure 78. The other end of this cable connects to the interface box labeled **SENSOR**.

C. Disconnect the pressure tube (**Figure 78**) from the barbed tube fitting on the LICOR LI-7200/RS. Pull firmly downwards to disconnect.

Lastly, remove the inlet and outlet tube (**Figure 78**) swage connections to the IRGA by loosening them with a crescent wrench.

Figure 79. Remove Bolt from LI-7200 Boom Clamp.

STEP 6 | Remove the LI-7200/RS IRGA by removing the bolt into the standoff on the underside of the boom clamp (**Figure 79**).

Note: The LI-7200/RS IRGA leans forward slightly to prevent rain and precipitation from ascending the tube.

Figure 80. Remove Screws to Remove ECTE Inlet Tube.

STEP 7 | To remove and/or reinstall the ECTE Sample Inlet, remove the two bolts on the top of the mount. Reference **Figure 80**.

Unplug heater cable (gray) from cables on the boom and remove any zip ties.

Reinstall replacement ECTE inlet and secure bolts in **Figure 80**.

STEP 8 | Install replacement LI7200/RS sensor head following the reverse of removal, first fastening the IRGA to the mounting bracket with the large mounting bolt. Reinstall the Sensor Head Control and Temperature Cables to finger tight. Ensure the connectors are not cross-threaded and they form a good seal. Reattach the small clear pressure tube attaches to the brass hose barb fitting under the temp cable connector (**Figure 81** on the next page). If the end of the tube is damaged, cut off the damaged end before reconnecting.

Reattach inlet and outlet tubing to the LI7200/RS. Thread carefully by hand and then tighten with a crescent wrench. Do not over-tighten swage connections. Fasten the bolts securing inlet tube (reference **Figure 81** and **Figure 80**).

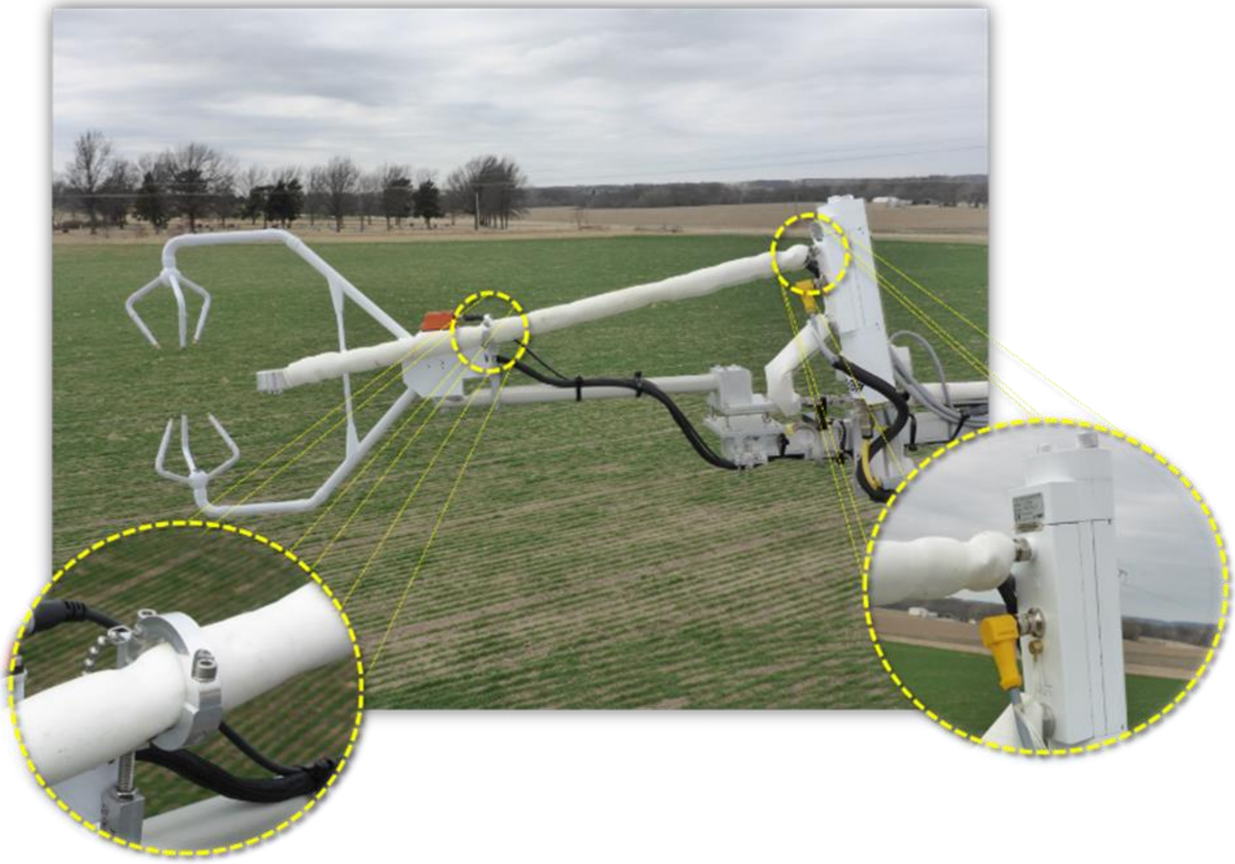


Figure 81. ECTE Air Inlet Mounting Bracket and LI-7200/RS Connection.

Figure 82. CSAT3 Electronic Control Box.

STEP 9 | The CSAT has a control box, sensor and "y-cable". These are coupled into an assembly. Do not mix and match them.

First, remove the CSAT Control Box (**Figure 82**) by unplugging cables and loosening 2 bolts on the mounting bracket.

Install replacement box and route cable to grape.

*Note: When reinstalling, placement of the electronic control box and cables is important; **it must not interfere with the function of the pivot boom.***

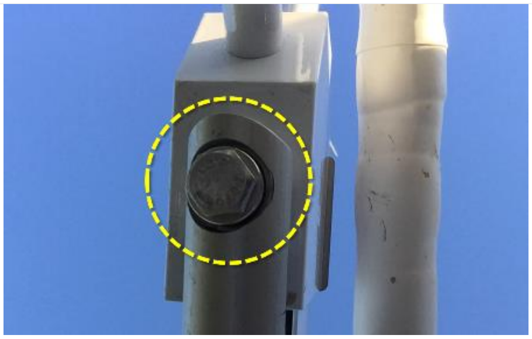


Figure 83. CSAT3 Ball Mount (Nut).

STEP 10 | Next, for CSAT removal, disconnect the ARMS Cable from the Grape connection. For reinstallation, connect the AMRS cable after installation of the CSAT3 on the ball mount.

Remove/re-install the CSAT3 from the ball mount via the single nut at the end of the boom arm from the mounting/leveling bracket (**Figure 83**).

*PRO TIP: It is helpful to mark current CSAT position on the mounting before removal to assist in positioning of replacement (see **Figure 96**).*

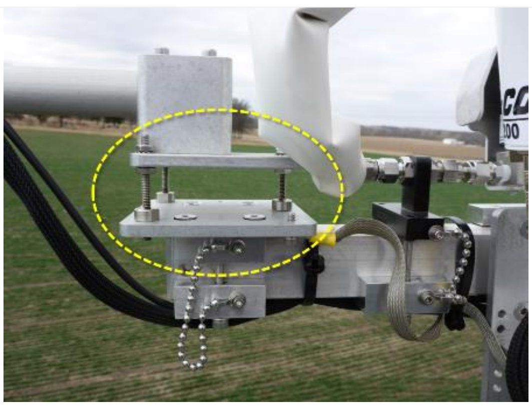


Figure 84. CSAT3 Leveling Plate.

STEP 11 | For reinstallation, level the CSAT3 3D Sonic Anemometer by adjusting nuts on levelling plate (**Figure 84**). Additional details are in the following section

- Over flat level terrain, adjust the CSAT3 anemometer head so that the horizontal surface is level.
- Over sloping terrain, see site-specific requirements.

*Note: Eight TIS sites employing a Campbell Scientific CSAT3 Sonic Anemometer haves site-specific Pitch and Roll requirements. **See Figure 94 for information on these sites and their requirement.***

Figure 85. CSAT3 Leveling Plate Alternate Viewpoint.

STEP 12 | **Figure 85** is an alternate view of the leveling plate for reference. Leveling terminology for the CSAT3 is, as follows:

- **Pitch:** is any angle around the CSAT3 cross-axis. Positive pitch is a rotation above the horizon as viewed from behind the CSAT3.
- **Roll:** is any angle around the CSAT3 long axis. Positive roll is defined as clockwise rotation as viewed from behind the sonic anemometer.

Figure 86. Measure/Level Components.

STEP 13 | The requirements for this install position are very tight (+/- 0.5cm). The sample tube must sit 15 cm back from the CSAT3 sensing volume. Slide inlet tube mounting bracket along CSAT3 mounting arm to center the intake head vertically within the CSAT3 (**Figure 86**).

Note: Use the AMRS to level the CSAT. See Section 5.6.3.1 for leveling procedures.

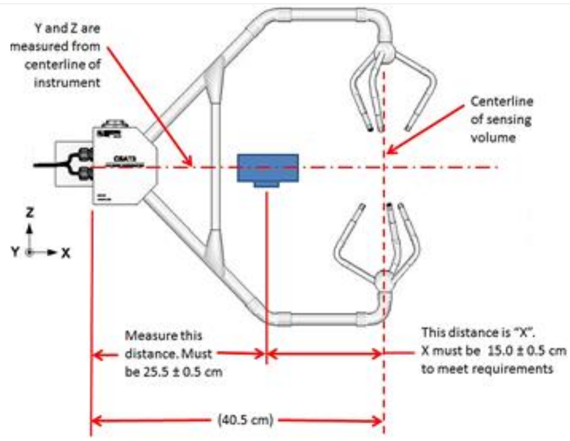


Figure 87. Measure Installation of Components.

STEP 14 | Measure and level installations of each component using a level and measuring tape. Measure from the center of the inlet (**Figure 87**). *Reference TIS Site-Specific As-Built documents in the Document Warehouse.*

Note: Employ care when measuring and adjusting orientation of installation locations to match site-specific "as-built" requirements; do not touch, knock, or damage the transducer probes on the CSAT3.

STEP 15 | CSAT3 cable plugs into port marked "Transducer Head". Connect RS-232 and +12V Cables into labeled ports in CSAT3 Control Box (**Figure 88**).

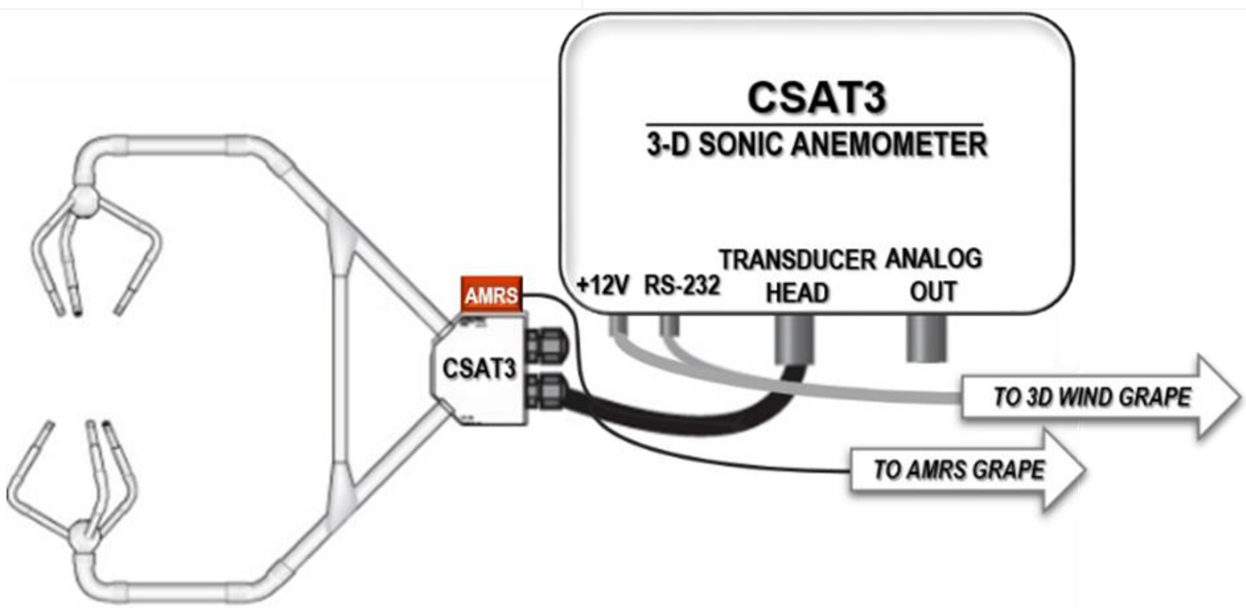


Figure 88. CSAT3 3D Sonic Anemometer Connections.

Figure 89. Be Aware of Tube Pinch Points.

STEP 16 | Return the boom out into operational position, checking for any cable/tube pinch points while pivoting (**Figure 89**).

Figure 90. LI-7550 Control Box Mounts to Tower Top ML.

STEP 17 | The LI-7550 control box mounts to Unistrut on the top tower with 4 bolts (see Figure 90). Remove/Install three LICOR LI-7200/RS IRGA cables (see **Figure 91**):

- The sensor head control cable for the IRGA plugs into the connector labeled **IRGA**.
- The temperature cable plugs into the connector labeled **SENSOR**.
- The small clear tubing with quick connect pushes into the connector labeled **PRESSURE**.

Note: LICOR recommends when tightening the control cable connector, rock the connector back and forth 4 or 5 times to compress the gasket. Connect appropriate cables to Power and Ethernet ports.

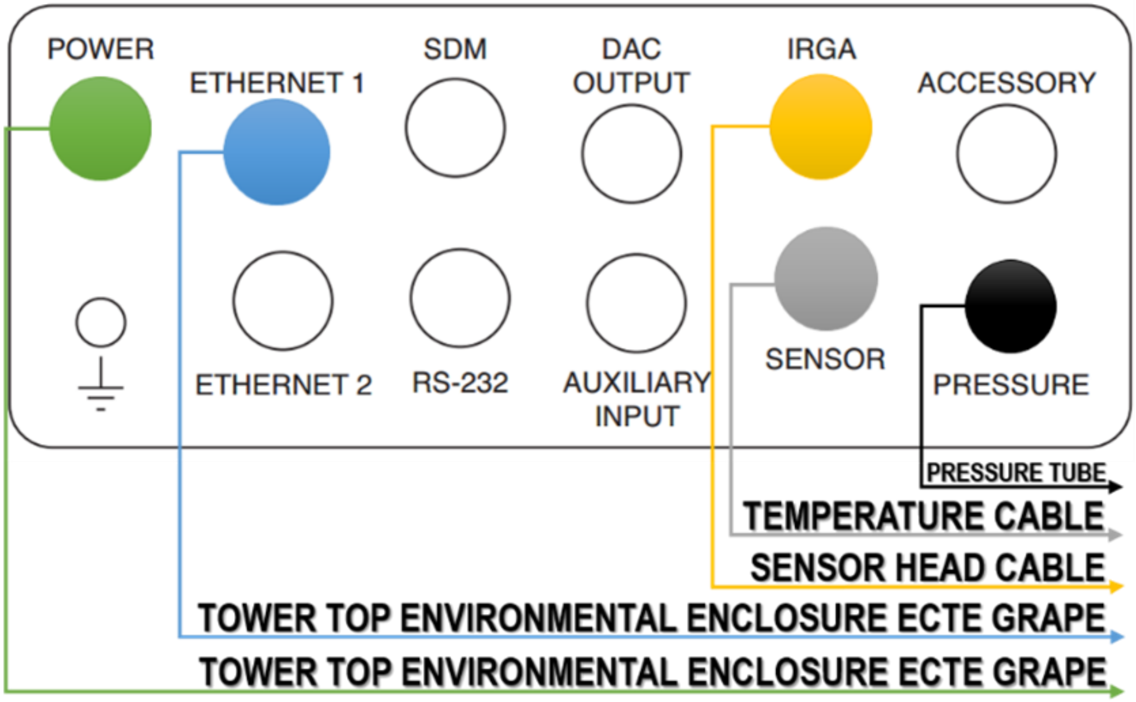


Figure 91. LICOR LI-7550 Analyzer Interface Unit Connections.

STEP 18 | Use AD [06] to unplug/plug in connections to the communications box base/environmental enclosure and Grapes, as applicable. Check connections/cable for faults before re-energizing the ML. Always plug the Grape Ethernet cable in after sensor connections before re-energizing, too (RJF, Ethernet -> Comm Box).
STEP 19 | The two heater cables that connect to the sample air inlet cap and tube connect to two transformers next to the two Grapes on the tower top ML railing. These cables should be labeled as a best practice to ensure the cap heater and inlet tube heater are connected to the right transformer box.
STEP 20 | Check system function via the LC and IS Control and Monitoring Suite, level the CSAT3 per Section 5.6.3.1.

5.6.3.1 Leveling the CSAT3 and Site-Specific Leveling Requirements

Follow the instructions in **Table 23** to level the CSAT3 at your site.

Table 23. Leveling the CSAT3.

STEP 1 | Use the AMRS, measuring pitch, roll, and yaw to level the CSAT3 sensor head by viewing its associated data streams. Open the IS Control and Monitoring Suite and select the Tower Monitoring App. Open the Tab for **ML Top** (shown in **Figure 92** below). *Note: An alternative option is to use a TEP with the command:* ***vd -s [EEPROM] -r26*** *for Roll and* ***-r27*** *for Pitch.*

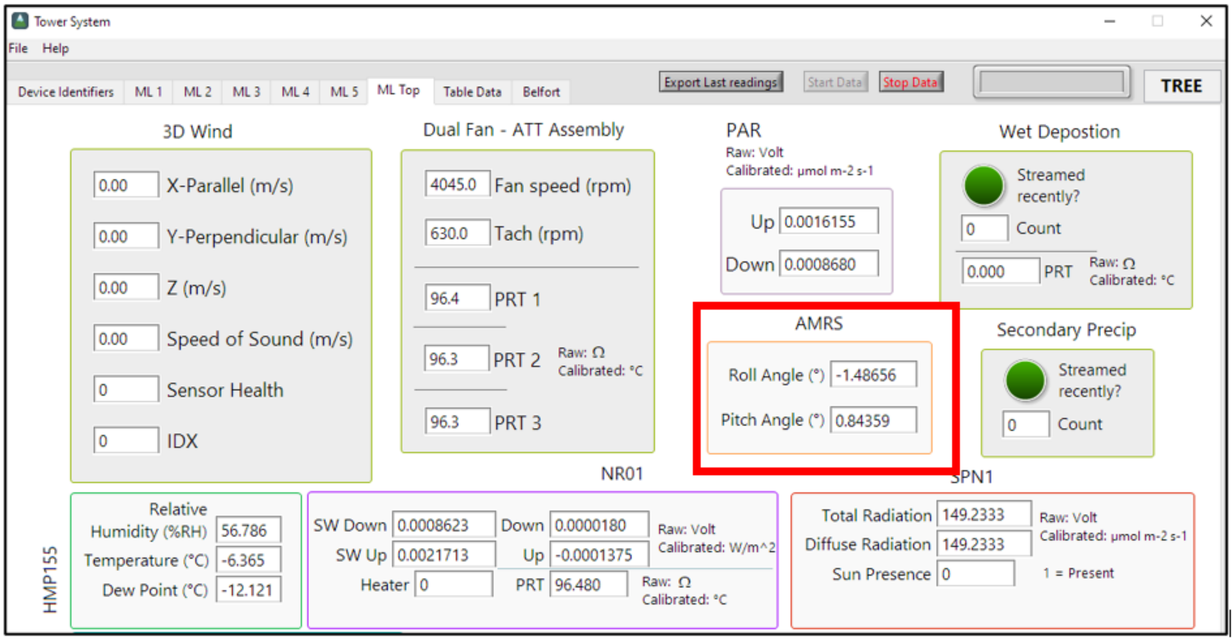


Figure 92. The IS Control and Monitoring Suite AMRS Values.

PRO TIP: It is important to pay attention to scientific notation of the displayed pitch and role values. If a large jump in pitch or role is noted, be sure the scientific notation has not changed.

STEP 2 | With the boom extended, observe the live values for Pitch and Roll. With exception of the sites listed in **Figure 94** below, the Pitch and Roll should be 0 ± 1 degree upon installation.

*Note: The AMRS (**Figure 93**) measures rotation around defined axes. The ECTE boom extends in line with the AMRS x-axis, the Roll, and the y-axis measures the Pitch. Clockwise (or right-handed) movement from level (0°) is positive. Counterclockwise is negative.*

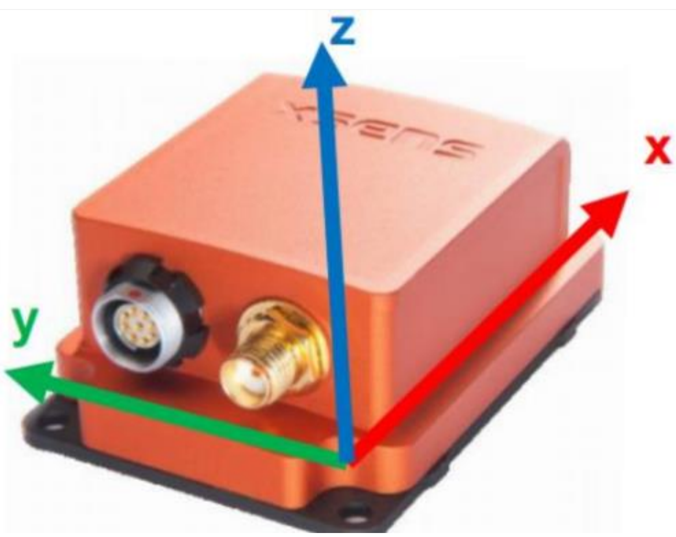


Figure 93. The AMRS Axes: The X Axis Aligns with the ECTE Boom.

Domain Site	Pitch° (±1.0°)	Roll° (±1.0°)
D02 SCBI	-11.0	-14.0
D04 GUAN	0.0	+11.0
D06 UKFS	-7.0	-10.0
D08 TALL	-6.0	0.0
D10 RMNP	+7.0	+8.0
D13 NIWO	-8.0	-9.0
D17 SOAP	-18.0	-7.0
D17 TEAK	-6.0	+7.0

Figure 94. Site-Specific Leveling Requirements for CSAT3 (Sites not listed are to be Installed Level).

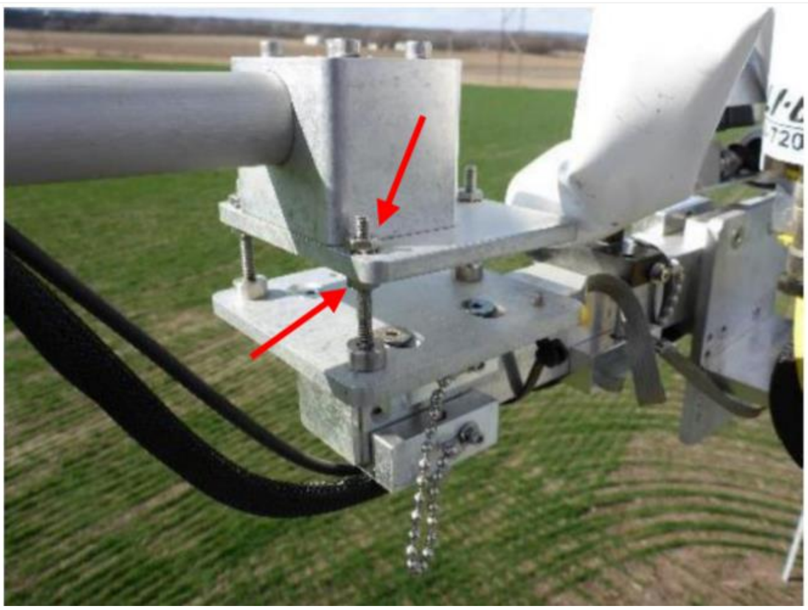


Figure 95. Adjust Roll by Loosening the Lower Nut on Leveling Plate and by Tightening the Upper Nut and Adjust Pitch with the Back (Closest to Tower when Boom is Extended) Threaded Stud.

STEP 3 | If the CSAT3 position needs adjustment, make note of magnitude and direction for adjustment. Retract the boom and adjust as follows:

- For larger adjustments (>2 degrees), loosen the nut for ball mount (**Figure 95**) and shift as needed.
- If <2 degrees of adjustment or less are needed, adjust using the leveling plate displayed in **Figure 95**.

*<u>PRO TIP</u>: It helps to mark the current position of the CSAT on the mount before moving, a sling is useful as a spacer (**Figure 96**).*

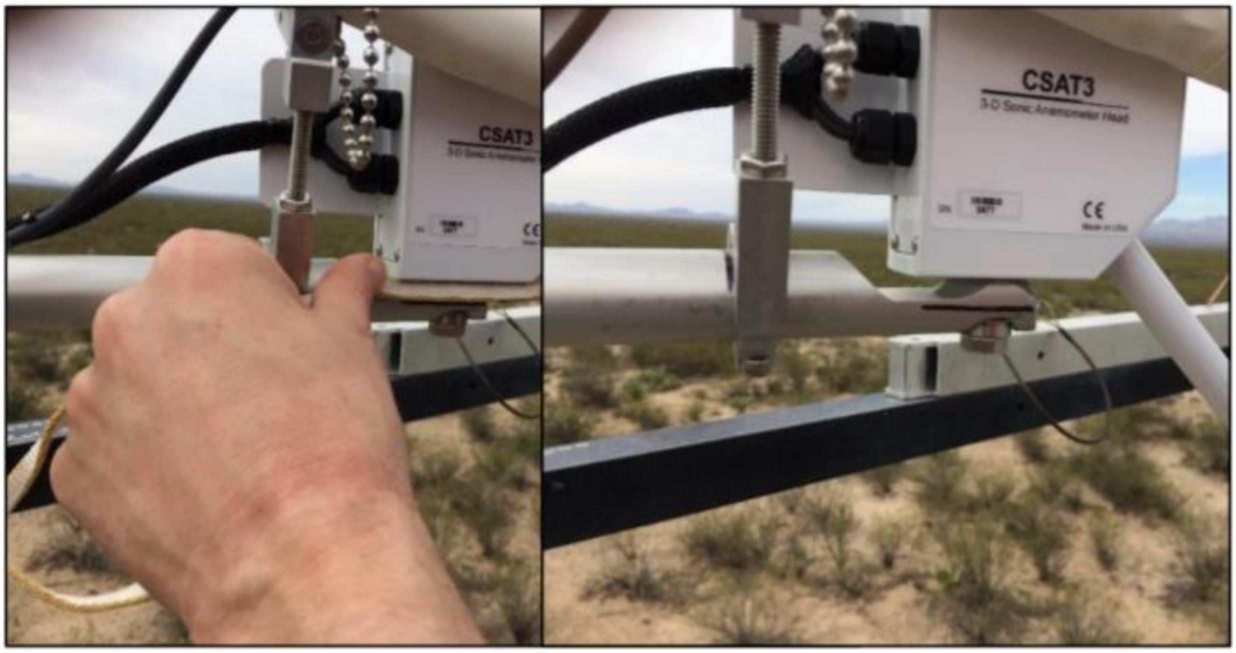


Figure 96. Using a Sling to Mark CSAT Position on Mounting for Reference before Moving.

STEP 4 | Extend the boom and view data streams from AMRS as in Step 1. Repeat Step 3, as needed.

STEP 5 | Once within specifications, ensure all hardware is adequately tightened and re-verify inlet position as in **Figure 96**.

STEP 6 | Remotely monitor the CSAT3 post-installation. After initial installation, if the CSAT3 drifts **< 5 degrees** outside specifications **DO NOT re-level.** Continuity is more important than the 1 degree positioning of the requirement. However, if the drift **EXCEEDS 5 degrees,** the CSAT **should be re-leveled** at the next site visit and a field science staff must submit Data Quality Trouble Ticket via ServiceNow.

5.7 Eddy Covariance Storage Exchange (ECSE) Instrumentation – Sensor Systems

The ECSE system measures the gas concentration profiles of CO_2, CH_4 and water vapor from the ground to tower top. It also measures the profile of stable isotopes of ^{13}C in CO_2, and ^{18}O and ^{2}H in water vapor. The number of ECSE system air inlets are dependent on canopy and tower height (4-8 measurement levels). The ECSE subsystem consists of span gas cylinders, rotary vane vacuum pumps, MFMs, Validation and Sample MFCs, solenoids, regulators, pressure transducers, stainless steel and FEP tubing, and Swagelok or Tylok fittings.

Measurement instrumentation for the ECSE system in **Figure 97** in **Table 24** is, as follows:

- **0328050000 | PICARRO L2130-I ANALYZER for ISOTOPIC H_2O**
  - Analyzer Module
  - Two External Vacuum Pumps
  - 0328050001 | Autosampler, A0235

    - 0300280001 | Vaporization Module, A0211
- **0330600000 | PICARRO G2131-I ANALYZER for ISOTOPIC CO_2**
    - Analyzer Module
    - External Vacuum Pump
- **CD08360000 | LICOR LI-840/850 IRGA**

The ECSE system employs two modes of operation: a sampling mode that measures the *in-situ* air via each ML, and a field validation mode where each analyzer ceases measuring *in-situ* air samples to cycle through a series of calibrated standards (span gasses for G2131 and LI840/850; water vials for the L2130) every 23.5 hours.

5.7.1 PICARRO L2130-I Analyzer for Isotopic H_2O

The PICARRO L2130-i Analyzer for Isotopic H_2O is a high-precision, and high-accuracy gas analyzer that uses Cavity Ring-Down Spectroscopy (CRDS) to measure stable isotopes of H_2O (^{18}O and ^{2}H) in atmospheric and liquid H_2O samples while simultaneously measuring concentrations of H_2O vapor. The instrumentation comprises of five units: the Analyzer Module, a robotic Autosampler, a high-precision Vaporization Module, and two External Vacuum Pumps. The PICARRO L2130-i Analyzer for Isotopic H_2O also contains no user serviceable components except the particulate filter. See **Table 24** for an overview of the PICARRO L2130-I Analyzer for Isotopic H_2O components.

Table 24. ECSE Instrumentation Rack in Hut: PICARRO L2130-I Analyzer for Isotopic H_2O.

	**Figure 97.** The equipment rack that houses the gas analyzers for the ECSE system. (a) Isotopic H_2O analyzer (PICARRO L2130-I) (b) Isotopic CO_2 analyzer (PICARRO G2131-I) (c) CO_2/H_2O analyzer (LICOR LI-840/850)

Figure 98. The main components of the PICARRO L2130-I Analyzer for Isotopic H_2O.

(a) Autosampler, A0235
(b) Vaporization Module, A0211
(c) Analyzer Module (PICARRO L2130-I)
(d) Vacuum Pump to Analyzer Module
(e) Vacuum Pump to Vaporization Module

Figure 99. View of the back of the PICARRO L2130-I Analyzer for Isotopic H_20, as see on the equipment rack.

(a) Vaporization Module, A0211
(b) Analyzer Module (PICARRO L2130-I)
(c) Vacuum Pump to Vaporization Module
(d) Vacuum Pump to Analyzer Module

5.7.1.1 PICARRO Analyzer Module

The PICARRO Analyzer Module is a self-contained unit that includes a custom configured Windows 7-based computer and hard drive that acts as the data acquisition system for spectral collection and analysis, the CRDS spectrometer, the optical sample cavity, and the control and communications hardware and firmware. See **Table 25** for an overview of the PICARRO Analyzer Module. This Table displays the same components for the PICARRO G2131-I Analyzer Module for Isotopic CO_2.

Table 25. PICARRO Analyzer Module for Isotopic H_2O.

Figure 100. Front of the PICARRO L2130-I Analyzer for Isotopic H_2O.

(a) Power button
(b) UBS port

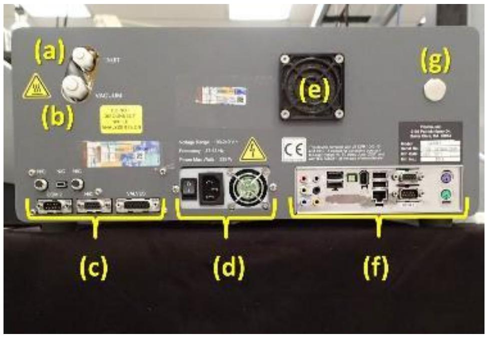


Figure 101. Rear of the PICARRO L2130-I Analyzer for Isotopic H_2O.

(a) Sample inlet port
(b) Connection to the External Vacuum Pump
(c) communications and control ports
(d) power supply
(e) fan inlet
(f) computer ports
(g) Wavelength Monitor (WLM) Purge Port *(only on H_20 Analyzer Module; not on the CO_2 Analyzer Module)*

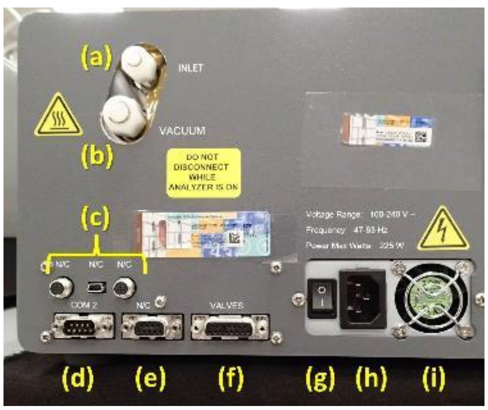


Figure 102. Rear left side of the PICARRO L2130-I Analyzer for Isotopic H_2O.

(a) Sample inlet port
(b) External Vacuum Pump connector
(c) Unused ports
(d) Communications port (COM 2)
(e) Unused 15-pin port
(f) Valve control port
(g) Power button
(h) Power cable input
(i) Power supply fan

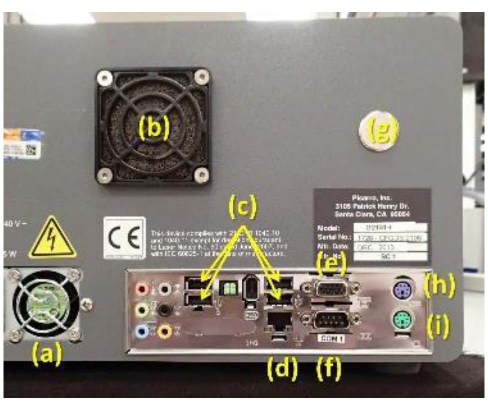


Figure 103. Rear right side of the PICARRO L2130-I Analyzer for Isotopic H_2O.

(a) Power supply fan
(b) Fan inlet
(c) USB ports
(d) Ethernet port
(e) External video port
(f) Communications port (COM 1)
(g) WLM Purge Port
(h) PS/2 port – keyboard
(i) PS/2 port – mouse

5.7.1.2 PICARRO Vacuum Pumps for Analyzer and Vaporizer Module

An External Vacuum Pump is an enclosed diaphragm pump that connects to the Analyzer Module or the Vaporization Module to pull the samples through each system. The Vacuum Pump for the Analyzer Module is interoperable with the PICARRO L2130-I Analyzer for Isotopic H_2O and G2131-I Analyzer for

Isotopic CO_2 (**Figure 106** (a) – the one with the silver handle). A newer revision pump (A2000) is being phased in and is pictured in **Figure 104** and can be used for the G2131, L2130 or the vaporizer unit.

The vacuum pump does not currently contain serviceable components for Field Science; pumps are rated to last a year before service. Send faulty pumps to NEON HQ, Repair Lab to conduct repairs, rebuilds and/or requisition a new pump for the site, as appropriate. **Figure 104** displays both types of Picarro vacuum pumps.

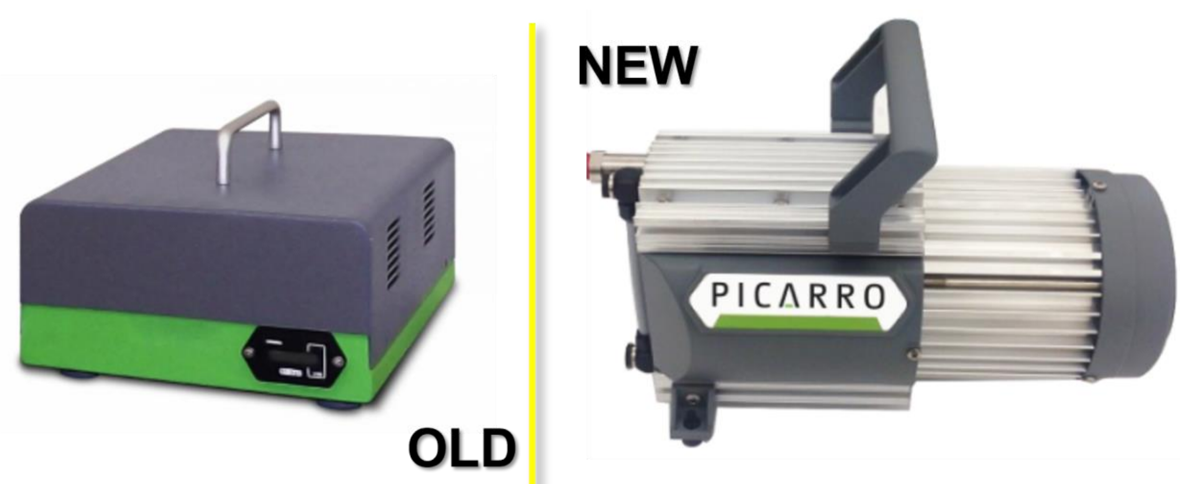


Figure 104. Earlier Picarro Diaphragm Pump (Left), New Picarro A2000 Diaphragm Pump (Right).

See **Table 26** for an overview of the PICARRO external vacuum pumps.

Table 26. PICARRO External Vacuum Pump Overview.

	**Figure 105.** The PICARRO L2130-I Analyzer for Isotopic H_2O requires two External Vacuum Pumps. (a) Connected to the Analyzer Module, L2130-I (b) Connected to the Vaporization Module, A0211 ***Note: Do not allow these Vacuum Pumps to lean against or touch each other. Vibration may cause issues over time.***

Figure 106. Front view of the External Vacuum Pump.

(a) Silver handle (Indicates pump is interchangeable between both PICARRO Analyzer Modules)
(b) Hour meter

Figure 107. Rear view of the External Vacuum Pump.

(a) Power switch
(b) Fuse
(c) Power plug
(d) Exhaust port with muffler
(e) Vacuum port

5.7.1.3 Connecting to Picarro Instruments via Windows Remote Desktop

See Section 9 APPENDIX B: Connecting to Picarro ANALYZERS via Windows Remote Desktop on page 184.

5.7.2 PICARRO G2131-I Analyzer for Isotopic CO_2

The PICARRO Analyzer G2131-I (**Figure 108**) contains no user serviceable components except the fan filter (see **Table 27.** PICARRO Analyzer Module Fan Screen Cleaning Procedure) and the particulate filter, which is serviced by CVAL.

Figure 108. PICARRO Analyzer G2131-I.

5.7.2.1 PICARRO Analyzer Module Fan Maintenance Procedure

Table 27 is the procedure for removing and cleaning the PICARRO Analyzer Module cavity ring down spectrometer (CRDS) fan filters. This procedure applies to both PICARRO Analyzer Modules for both Isotopic CO_2 and H_2O (G2131 and L2130).

Table 27. PICARRO Analyzer Module Fan Screen Cleaning Procedure.

STEP 1 | Stop CNC. Power down the instrument. *See Section 5.7.2.3.1 for additional information to power down the analyzer modules.*

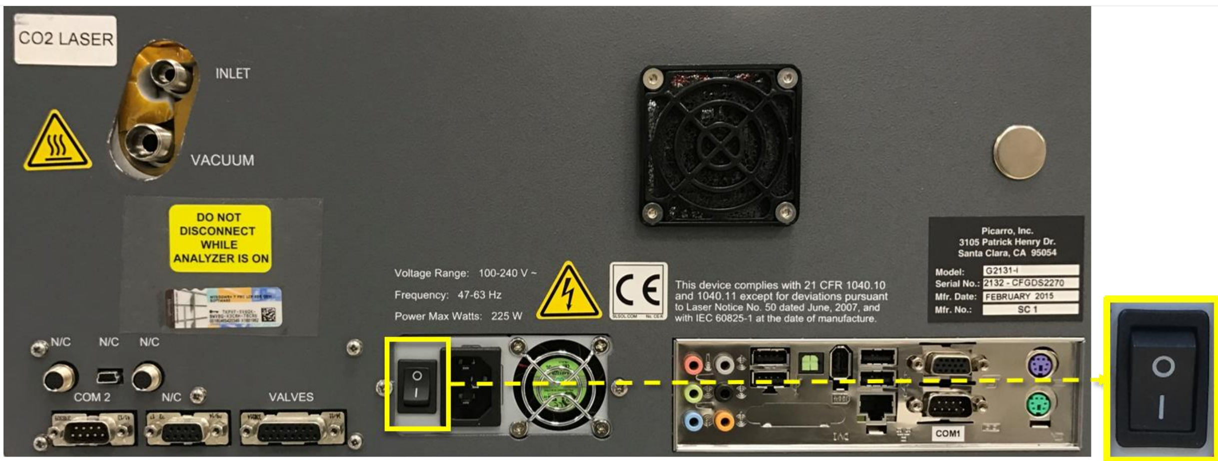


Figure 109. Flip the O/I switch to "I".

STEP 2 | After shutdown, on the back of the Analyzer Module, flip the O/I switch to "O" (**Figure 109**) and disconnect the power cable.

STEP 3 | Use a 2.5 mm hex key and remove the 4 Socket Head Flat screws securing the fan screen to the Analyzer Module (**Figure 110** circled in yellow).

Figure 110. Analyzer Module Fan Screen/Filter.

Figure 111. Clean Fan Screen/Filter with Compressed Air.

STEP 4 | Use a clean, dry compressed air source with the pressure adjusted no higher than 30 PSIG and on both sides. Blow the debris from the fan guard and filter assembly (**Figure 111**).

STEP 5 | Reinstall the fan screen/filter using a hex key. Ensure the pump is turned back on. Reconnect the power cord and flip the I/O switch back to "I". These actions power up the pump and analyzer. Ensure that the analyzer enters measurement mode (See Section 5.7.2.3.1). Restart CNC.

5.7.2.2 PICARRO Analyzer Module Particulate Filter and Orifice Replacements

Both PICARRO Analyzer Modules (G2131 and L2130) require periodic replacement of the internal particulate filter and orifice. For the G2131, this service occurs (and is tracked) at HQ when the instrument is in the CVAL lab. The frequency is set for every two (2) years for NEON program instruments since an inline filter at the inlet should prevent frequent contamination.

Since the L2130 only returns to HQ upon failure (it is not part of sensor refresh), Field Science must complete the internal filter and orifice replacements for this analyzer every two (2) years to coincide with an annual calibration. Instructions and procedures for conducting this on the PICARRO L2130-I Analyzer for Isotopic H_2O are in Section 5.7.3.3.1.

5.7.2.3 PICARRO Analyzer and Pump Removal and Replacement Instructions

This section applies to both PICARRO Analyzer Modules, the PICARRO L2130-I Analyzer for Isotopic H_2O and the PICARRO G2131-I Analyzer for Isotopic CO_2.

Always disconnect the power prior to removing or replacing any components. To do this, turn off the sensor via its software using the following instructions below, then power down the pumps that connect to the PICARRO.

WARNING: Do not attach electrical power or start the analyzers until after attaching and turning on the External Vacuum Pump. Do not disconnect the vacuum line while the analyzers are running. Failure may result in damage to the optics.

1. To remove the Analyzer Module(s), shut down CNC via the LC. Reference AD [12] for additional information. Connect to Picarro via Windows Remote Desktop via *Section 9 APPENDIX B: Connecting to Picarro ANALYZERS via Windows Remote Desktop*. From the CRDS Data Viewer Program, click Shutdown and select "**Turn off Analyzer and Prepare for Shipping**", then click **OK** (**Figure 112**). Once the green power light goes off on the front of the analyzer, you are OK to proceed.

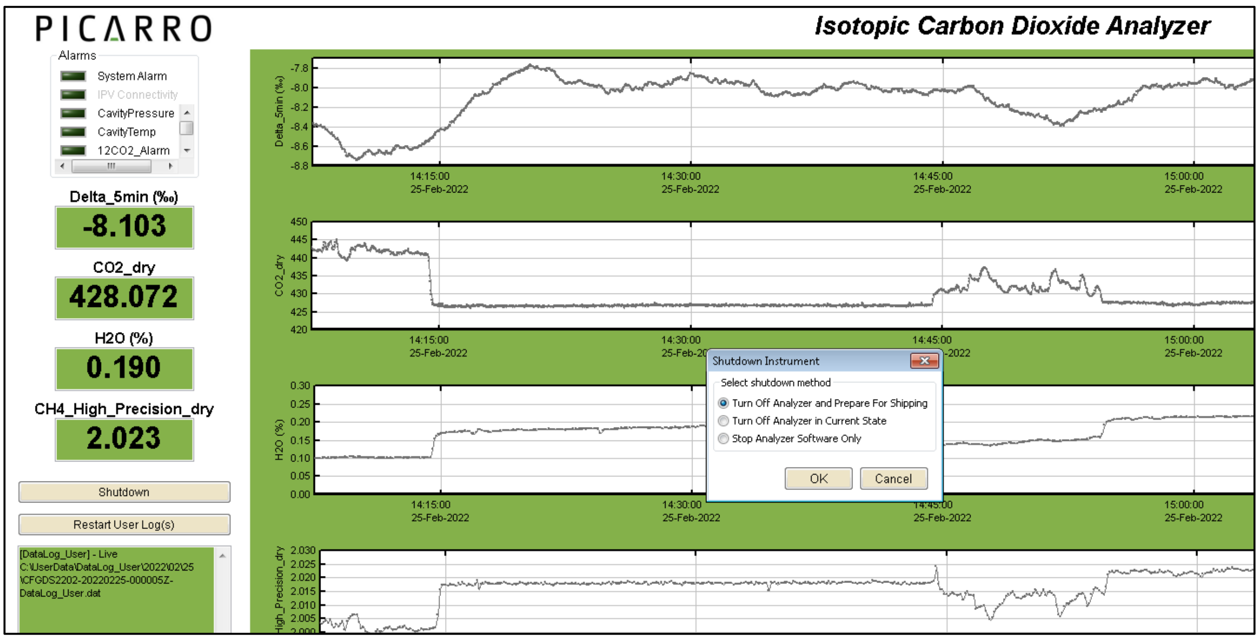


Figure 112. CRDS Data Viewer Program: Select "Turn off Analyzer and Prepare for Shipping".

2. Once the analyzer is powered down, shut off the vacuum pump via the switch on the pump.

3. Disconnect all tubing and electrical connections from the analyzer, making note of their locations so that everything is connected back correctly upon install of a replacement. Please exercise caution with the tubing to the vaporizer as the tubing is small and can be damaged if bent sharply.

5.7.2.3.1 PICARRO Analyzer and Pump Replacement Instructions

Table 28. PICARRO Analyzer Replacement Tools & Consumables List.

Equipment & Consumables	Quantity
11/16" Wrench	1
9/16" Wrench	1
Screwdriver	1

1. Acquire the equipment in **Table 28**.

2. Remove the Analyzer and the External Vacuum Pump from their respective shipping containers. Save the original packaging.

3. Install the analyzer and pumps in the instrument rack.

4. Remove the caps from the Analyzer gas connections and vacuum pump. These caps should be placed on the analyzer and pumps being returned.

5. Attach the gas line between the Analyzer vacuum port and the External Vacuum Pump. Hand tighten the nut and then make an additional 1/8th turn with an 11/16” wrench.

6. Ensure pump switch is off and connect the AC power cable to the External Vacuum Pump.

7. Attach the KVM connections, Ethernet cable, and a VGA monitor display cable to the computer connections on the back of the Analyzer (see **Figure 114**).

8. **<u>Turn on the power in the following order</u>:**

    1. ***External Vacuum Pump***

    2. ***The Analyzer Module Power Switch***

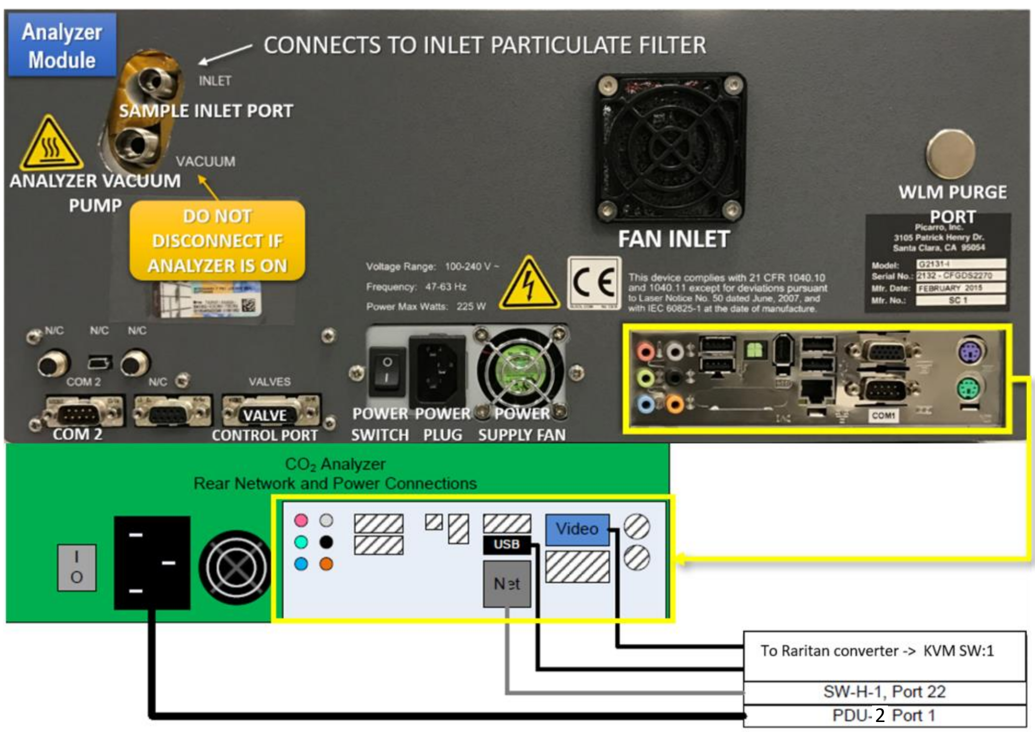


Figure 113. CO2 Analyzer Rear Connections *(*Note There is No WLM Purge Port for CO_2).*

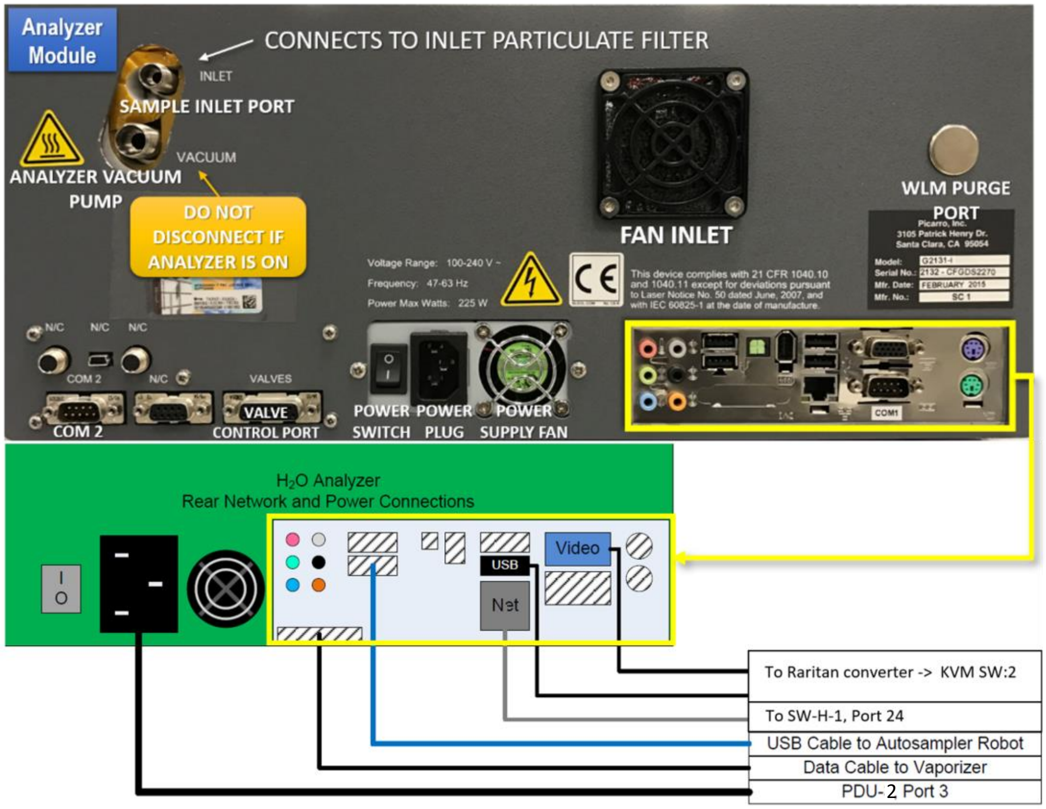


Figure 114. H2O Analyzer Rear Connections.

Note: As the instrument is starting up, it is normal for there to be a delay in reporting data. This can take several minutes depending on how long it takes the internal temperature to reach its operating point, and it is normal during this time for some concentration readings to be negative or constant. Additionally, the data selection pull-down menus will not populate with the appropriate items until data is displaying in the graph. This is typically less than 30 minutes, but depending on ambient temperature, the analyzer can take up to 1 hour to stabilize (for extreme cold sites it may take even longer).

5.7.3 PICARRO L2130-I Analyzer for Isotopic H_2O Autosampler and Vaporization Module Operations and Validations

This section consists of the following procedures to operate the PICARRO Autosampler and Vaporization Module for daily validations sampled by the PICARRO L2130 Analyzer.

1. PICARRO Autosampler, Training (bi-weekly) and Syringe Exchange (monthly / as needed)
2. Picarro Vaporization Module and Septa Change (monthly)
3. PICARRO L2130-I Analyzer for Isotopic H_2O Validation Process and Adjustment of Sample Volume
4. How to Adjust for Broken Validation Vials

5. Restarting Isotopic H_2O Validation Process

5.7.3.1 PICARRO Autosampler, A0235

The PICARRO Autosampler, A0235 works in conjunction with the Vaporization Module, and both sit atop the PICARRO L2130-I Analyzer for Isotopic H_2O. The Autosampler at terrestrial tower sites is a validation mechanism to maintain the calibration of the Analyzer Module using traceable water standards. These water calibration standards contain high, medium, and low isotope water mixtures, which replicates standards from the International Atomic Energy Agency. CVAL provides these water calibration standards in trays of 12 preloaded vials in four-week intervals.

The Autosampler comprises of an XYZ-arm (see **Figure 115**(a)), a syringe and needle (see **Figure 115**(b)), a wash and waste station (see **Figure 115**(c)), and a sample vial tray (see **Figure 115**f). The Vaporization Module (see **Figure 115**(g)) attaches to the Autosampler XYZ-arm via mounting bracket underneath the horizontal portion of the XYZ-arm (see **Figure 117**(g)).

At regular intervals, a validation sequence activates. The Autosampler activates and collects a liquid water sample from the vial tray using a syringe. It injects the sample into the Vaporization Module's injection port (see **Figure 115**(i)) to vaporize the liquid water sample. The Analyzer Module then pulls the water vapor sample to collect and record measurements. Once the validation sequence finalizes, the Autosampler is in a suspended state until the next validation sequence. See **Table 29** for an overview of the Autosampler.

Table 29. PICARRO Autosampler, A0235 Overview.

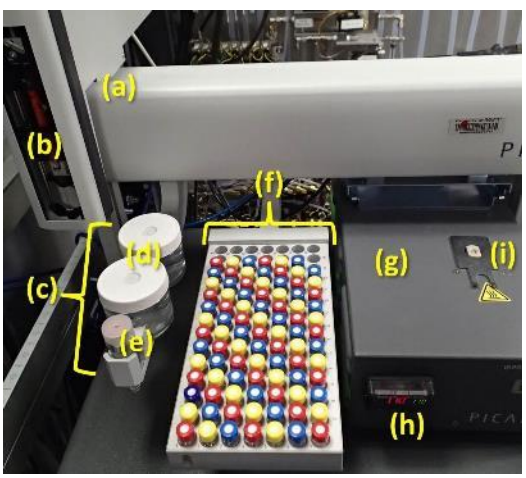


Figure 115. Top view of the PICARRO Autosampler and the Vaporization Module.

(a) XYZ-Arm
(b) Syringe and needle
(c) Wash and waste station*
(d) Wash 1 & Wash 2*
(e) Wash waste*
(f) Sample vial tray holder and vials**
(g) Vaporization Module body
(h) Vaporization Module temperature monitor and control
(i) Injection port

**The Autosampler requires the wash bottles (d) for placement for Autosampler Training. The Autosampler may slam down on the wash/waste station without the bottles or incur damage to the needle if training to the wash/waste station fails to occur.*
***Only 12 vials are currently used for monthly validations, see Section 5.7.3.1.1.*

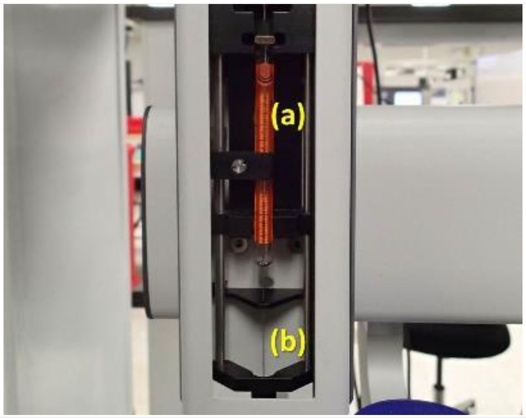


Figure 116. The syringe and needle within the XYZ-arm of the Autosampler.

(a) Syringe
(b) Needle

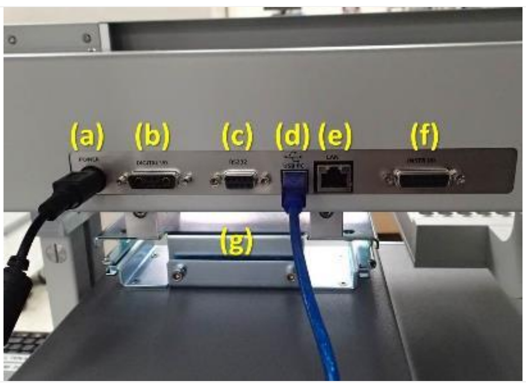


Figure 117. View of the back of the Autosampler.

(a) Power plug
(b) Digital I/O port (not used)
(c) RS-232 port (not used)
(d) USB port
(e) Ethernet port (not used)
(f) Instrument I/O port (not used)
(g) Mounting bracket for the Vaporization Unit

5.7.3.1.1 PICARRO Autosampler, Vials

The NEON headquarters (HQ) Calibration, Validation and Audit Laboratory (CVAL) provides vials of International Atomic Energy Agency traceable water standards for the PICARRO daily validation process and yearly calibration and validation process. Each process requires a specific set of vials: a tray of 12 vials for validation (see **Figure 118**), and a tray of nine vials for annual calibration (six vials for the calibration and three vials for the calibration validation in **Figure 119**) to all sites with exception of YELL, BONA, BARR and TOOL sites (see end of this section for information on these sites).

Each vial contains an isotopic water mixture (tap water mixtures of a known value). These values align with the coloring and labeling of the trays. CVAL provides applicable Field Science Domain Offices with a tray of validation vials every 30 days and a tray of calibration and calibration validation vials annually.

Note: Validation Vial trays expire after 40 days unpunctured and 10 days punctured. In the event Field Science receives broken vials, reference Section 0 for additional guidance.

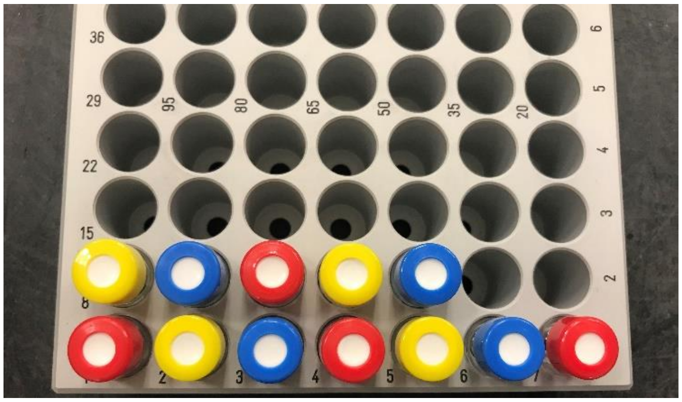


Figure 118. PICARRO H2O Analyzer Tray of 12 Validation Vials.

VALIDATION VIALS (12)

12 vials must be in the following order for validation (**Figure 118**):

1. Red
2. Yellow
3. Blue
4. Red
5. Yellow
6. Blue
7. Red
8. Yellow
9. Blue
10. Red
11. Yellow
12. Blue

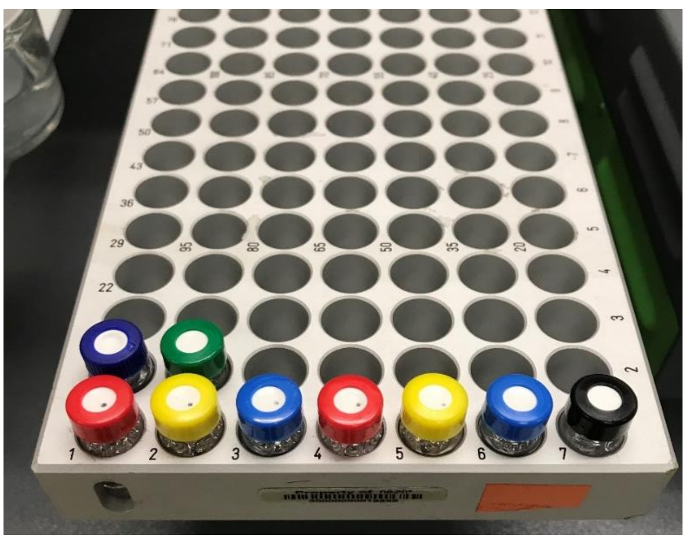


Figure 119. An Example of Two Trays containing Six Calibration and Three Calibration Validation Vials (9 Total).

CALIBRATION VIALS (6) & CALIBRATION VALIDATION VIALS (3)

Six vials must be in the following order for calibration (**Figure 119**):

1. Red
2. Yellow
3. Blue
4. Red
5. Yellow
6. Blue

Three vials must be in the following order for calibration validation:

1. Black
2. Dark Blue
3. Green

Due to site access considerations in Alaska and Montana, the following sites receive a vial tray set of 36 instead of 12, plus 2 additional vials for drift quantification, and run validations for a period of three months, instead of one. As of writing, these sites include: Toolik Field Station (TOOL), Utqiaġvik in Charles Etok Edwardsen Barrow Environmental Observatory (BARR), Caribou-Poker Creeks Research Watershed (BONA), and Yellowstone National Park (YELL). The process remains the same with exception of the number of vials and duration of validation.

5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures

Training the Autosampler aligns to the instrumentations main components to conduct syringe exchanges, collect samples, and rinse syringes. NEON HQ, CVAL recommends manually training the Autosampler on a biweekly basis to verify alignment, function and to prevent drift. Training the Autosampler primarily occurs in manual mode with exception of a step to set sample depth. Sample depth is best set using a digital adjustment via teach mode in the software. Open the KVM (keyboard, video, and mouse) and select the switch for PICARRO H_2O or connect via Windows Remote Desktop (*See Section 9 APPENDIX B: Connecting to Picarro ANALYZERS via Windows Remote Desktop*). Reference **Table 30** and **Table 31** for systematic procedures on how to train the PICARRO Autosampler, A0235 to the Vaporization Module and the PICARRO L2130-I Analyzer Module for Isotopic H_2O.

Table 30. Equipment and consumables for Training & Exchanging the Syringe on the PICARRO Autosampler.

Equipment & Consumables	Quantity
Injection Syringe (Fisher PN 03350172, TRAJAN SGE™ 002976)	1
Powder-Free Nitrile Gloves	1 pair
DI water	1

Table 31. How-To Train and Exchange Syringe on the PICARRO Autosampler, A0235.

STEP 1 | Acquire the equipment listed in Table 30.

STEP 2 | Ensure that no current autosampler jobs are running by…

(**1**) Clicking on the Autosampler UI Window and clicking on the "**End**" button
(**2**) Closing the window Autosampler UI Window, and
(**3**) Closing the CRDS Coordinator Window

See **Figure 120**. If these windows are not open, proceed to the next step (Step 3).

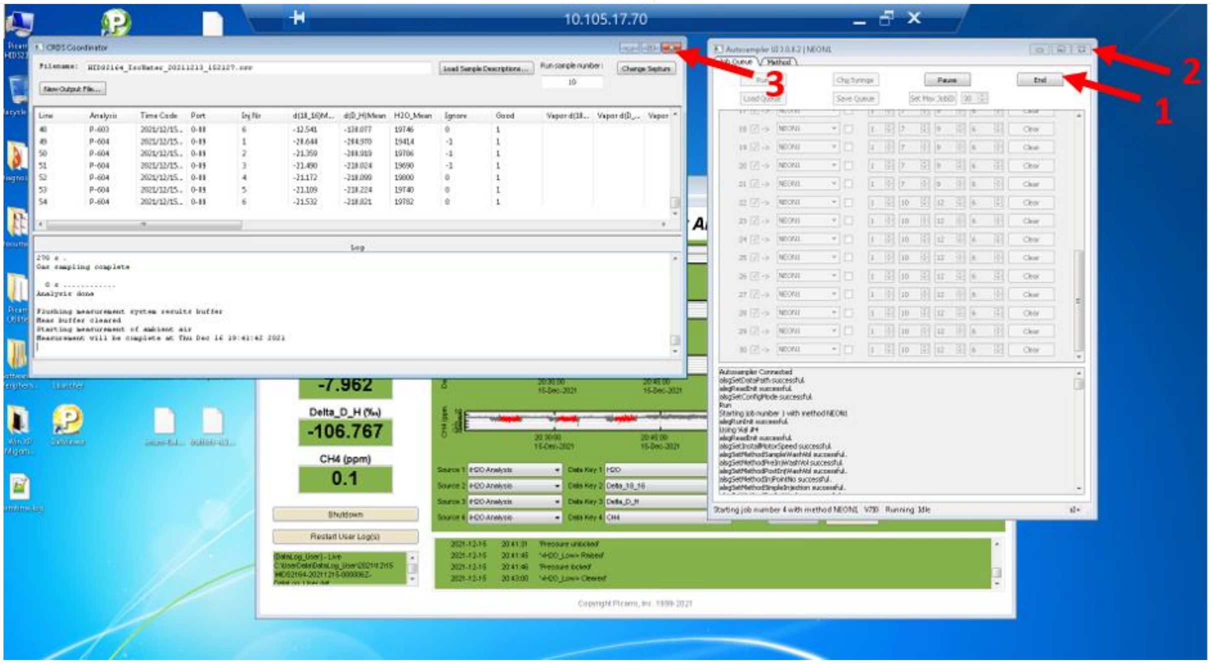


Figure 120. Close Autosampler UI and CRDS Coordinator Programs.

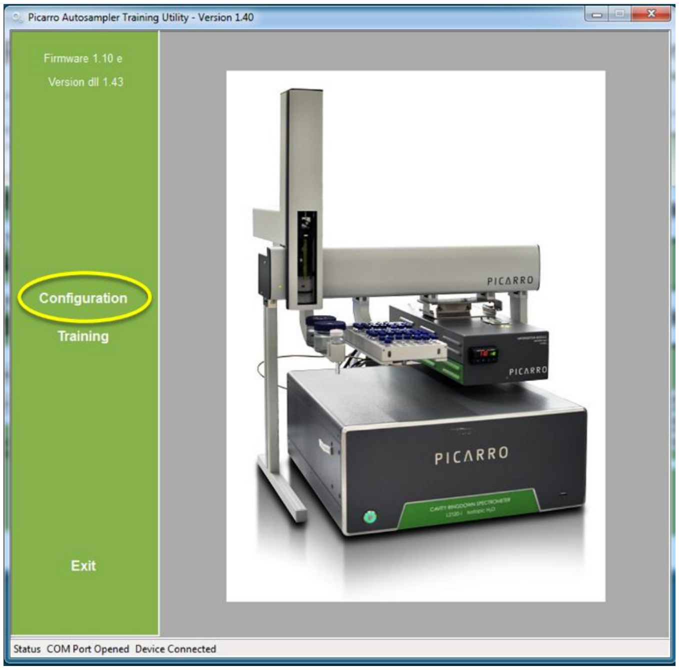


Figure 121. Open the Autosampler Training Program Window.

STEP 3 | Open the PICARRO Autosampler Training icon via Desktop and select "**Configuration**" (**Figure 121**).

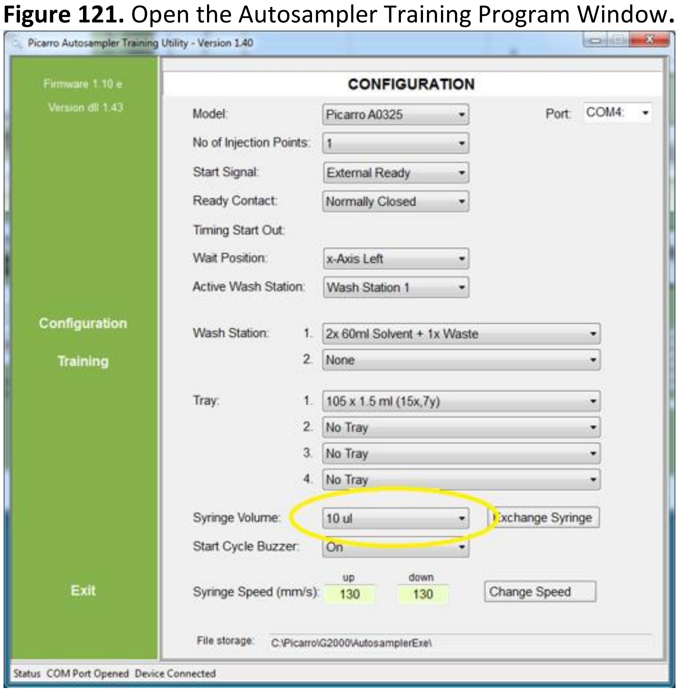


Figure 122. Select Syringe Volume for Red Syringe (10uL).

STEP 4 | Under Syringe Volume, ensure "**10 ul**" is selected from the drop-down options if using a 10uL Syringe (**Figure 122**).

Figure 123 displays a 10uL syringe.

Figure 123. 10uL Syringe (Red).

PRO TIP: CVAL recommends ordering two (2) boxes of six (6) syringes. Syringes do not store well in high-humidity climates; syringes are likely to degrade (corrode) before use. This is seen when the syringes are sticky. Store in a sealed box with dessicant if possible. Test fresh syringes prior to installation by drawing a small amount of DI water into the syringe from the wash station. Eject the water, and repeat once more, if *necessary, to evaluate integrity of syringe*. ***Wear gloves whenever handling/installing new syringes in the autosampler.***

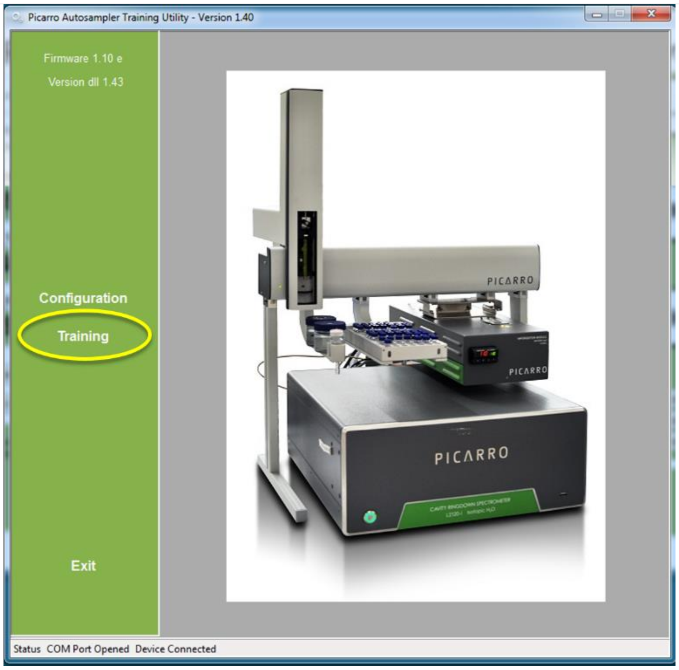


Figure 124. Select the Training Option in the same Window.

STEP 5 | Select "**Training**" (**Figure 124**).

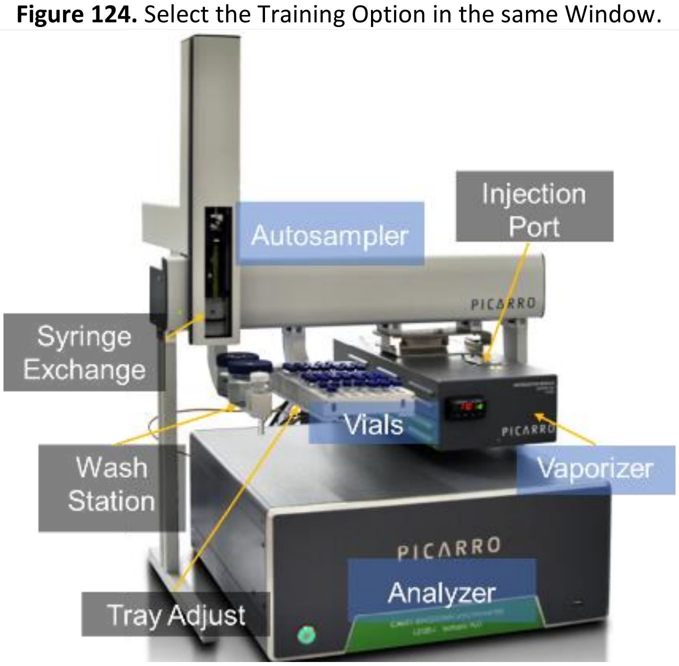


Figure 125. PICARRO H_2O Laser Main Components.

The Training Window populates with selections for **Injection Port**, **Syringe Exchange**, **Tray Adjust** and **Wash Station**. This graphic provides an overview of the components that require training (gray labels).

Figure 125 illustrates the Picarro instrumentation main components.

Note: Field Science must train the Autosampler to the Wash Station to prevent a mishap from syringe misalignment (e.g., breaking the syringe on the wash station). Fill the ***middle jar*** *with DI water to prevent dry cycling the syringe.*

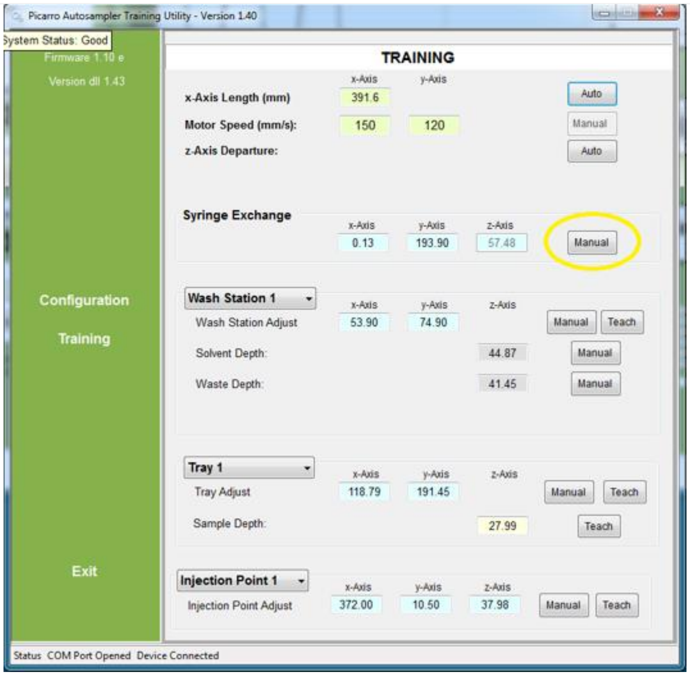


Figure 126. Select the "Manual" button for Syringe Exchange.

STEP 6 | Select the "**Manual**" button for **Syringe Exchange** to manually train the Autosampler to present the Syringe for exchanging (**Figure 126**).

Wait for the pop-up window (**Figure 127**) to proceed.

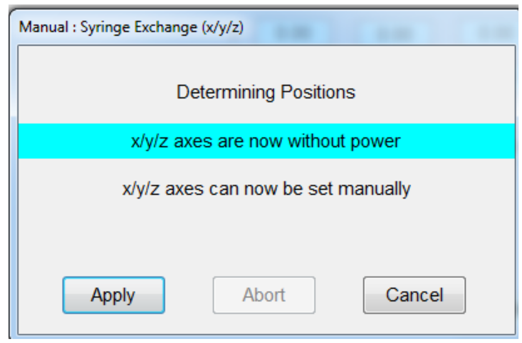


Figure 127. Syringe Exchange Pop-Up Window.

STEP 7 | Move the Autosampler head to the right of the vials. Pull it forward to a convenient location to exchange the syringe where it will not interfere with the frame of the rack. This location should make it easier to exchange syringes.

Figure 128. Upper & Lower Syringe Locks in Open Position.

STEP 8 | Carefully remove the old syringe by lowering the syringe carriage. Carefully lower the black syringe carriage pulling gently downwards until free from magnetic catch. Be careful of the syringe needle tip.

Remove the syringe by unlocking the upper and lower locks counter-clockwise.

Figure 128 displays the upper and lower locks in the open position.

CATCH THE SYRINGE CARRIAGE IMMEDIATELY AFTER THE MAGNET RELEASES IT!

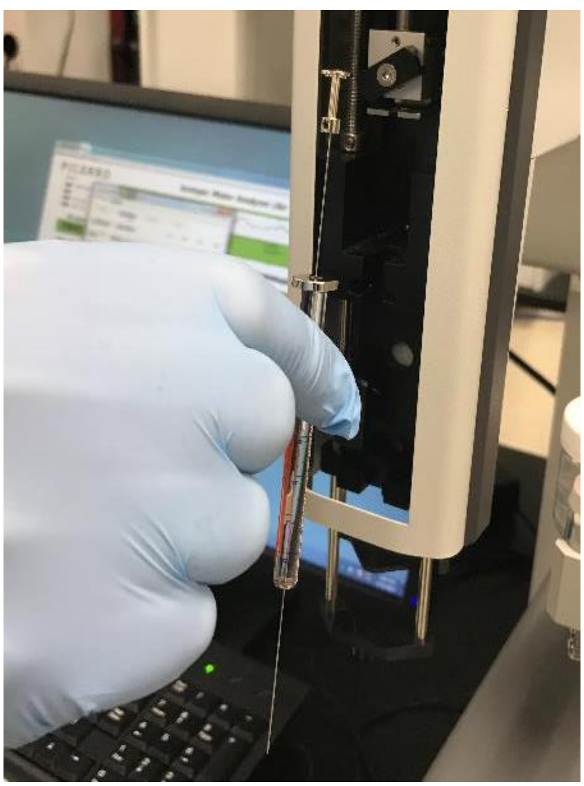


Figure 129. Handle by the Syringe Body.

STEP 9 | Handling by the syringe body (**Figure 129**), carefully remove the old syringe, sliding the plunger head and top body flange from their recesses.

Note: Wear gloves when handling new syringes. (It is only necessary to wear gloves with new syringes.)

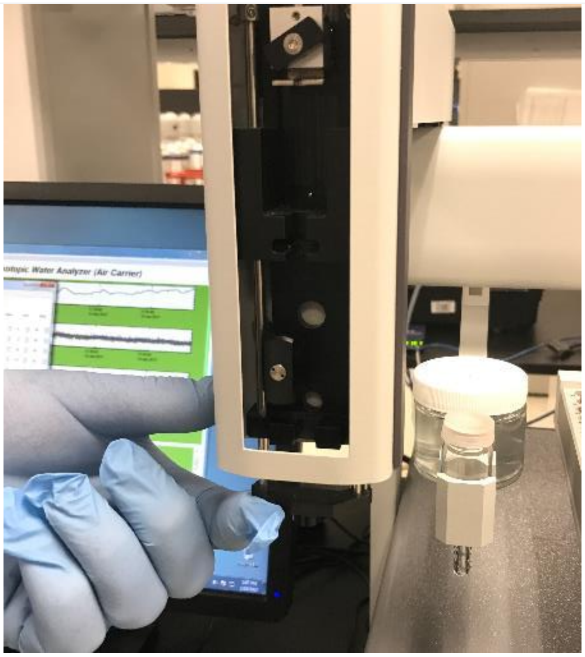


Figure 130. Lift the Supports to Align the Syringe Holes.

STEP 10 | Prior to installing a new syringe, wear gloves to prevent contaminating the needle or plunger.

Remove a new syringe from its packaging, handling the syringe by the glass body. Test the syringe as described in Step 4. Syringes that are "sticky" should be disposed of, as they will cause issues with injections down the road.

Gently lift the lower black needle support vertically until it contacts the upper support to align the two needle holes (**Figure 130**).

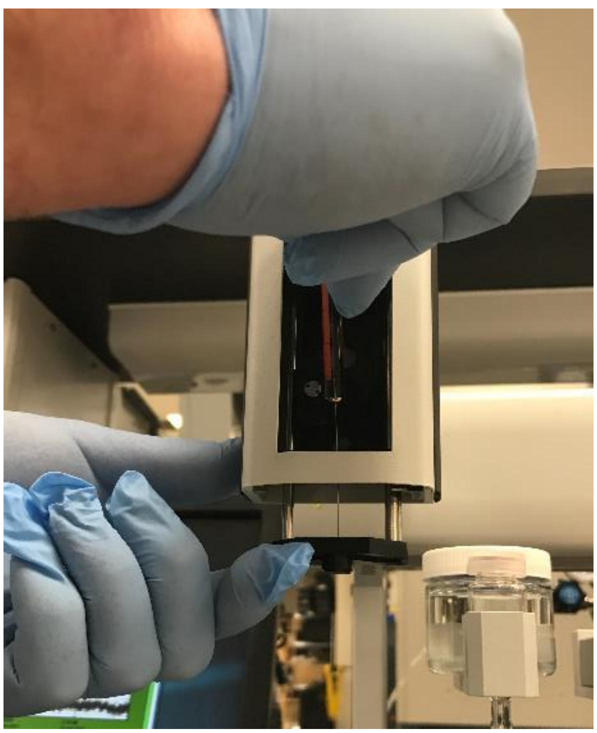


Figure 131. Insert the New Syringe.

STEP 11 | Insert the new needle tip into the two holes (**Figure 131**).

Figure 132. Lift the Plunger Head to Align with the Cavity.

STEP 12 | Swivel the syringe body in towards the holder and lift the plunger head out of the syringe body enough to align it with the cavity (**Figure 132**).

Figure 133. Syringe body in autosampler head.

STEP 13 | Gently slide the top body flange of the syringe into its cavity in the holder while guiding the plunger head into place in the upper lock.

Rotate the syringe body as necessary to align the body flange sideways in the cavity (**Figure 133**).

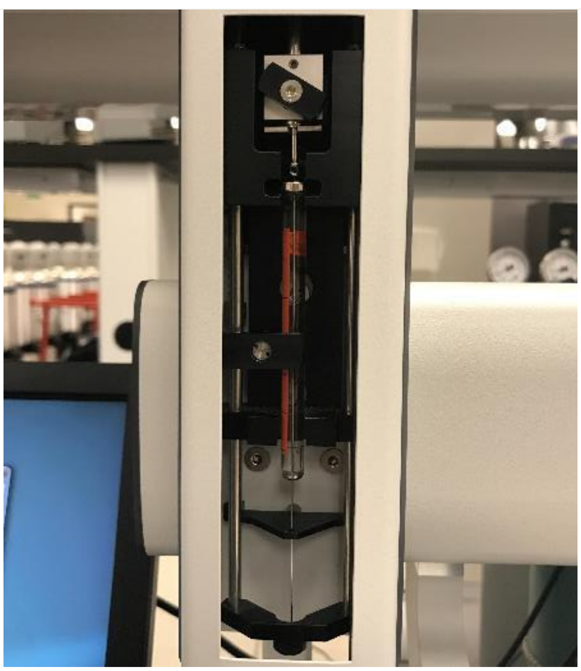


Figure 134. Upper and Lower Lock in Closed Position.

STEP 14 | Rotate the upper lock clockwise to lock the plunger head. Carefully pull out the lower lock against its light spring pressure enough to turn it clockwise and lock against the syringe body.

Figure 134 shows the upper and lower lock in their locked position.

Verify that the needle has engaged both holes in both needle supports before continuing. Gently push the carriage back up to the sampling head until it is engaged with the magnets that hold it up.

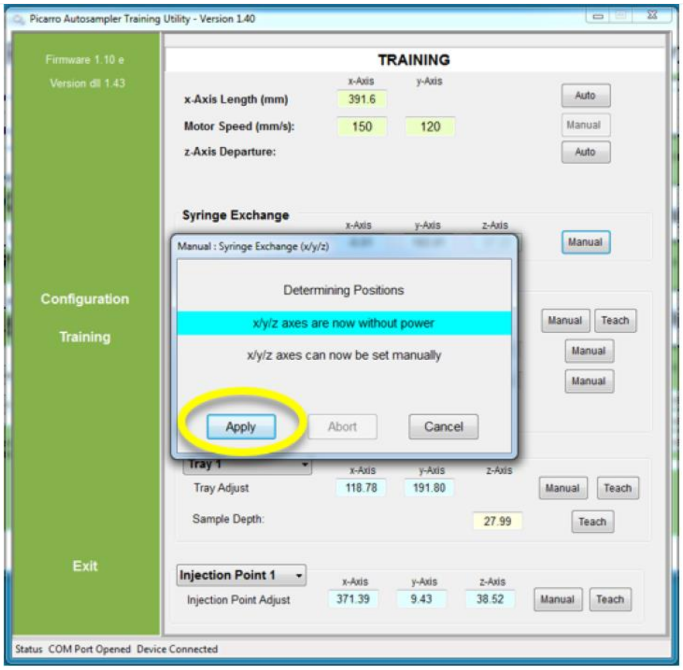


Figure 135. Click apply for Syringe Exchange.

STEP 15 | Return to the application and click "**Apply**" on the pop up window to activate the test run of the Syringe Exchange manual setting (**Figure 135**).

Keep clear as the autosampler will turn and move now to the home position.

ENSURE NO OBJECTS, TOOLS, OR HANDS ARE ON THE AUTOSAMPLER PRIOR TO CLICKING "APPLY"!

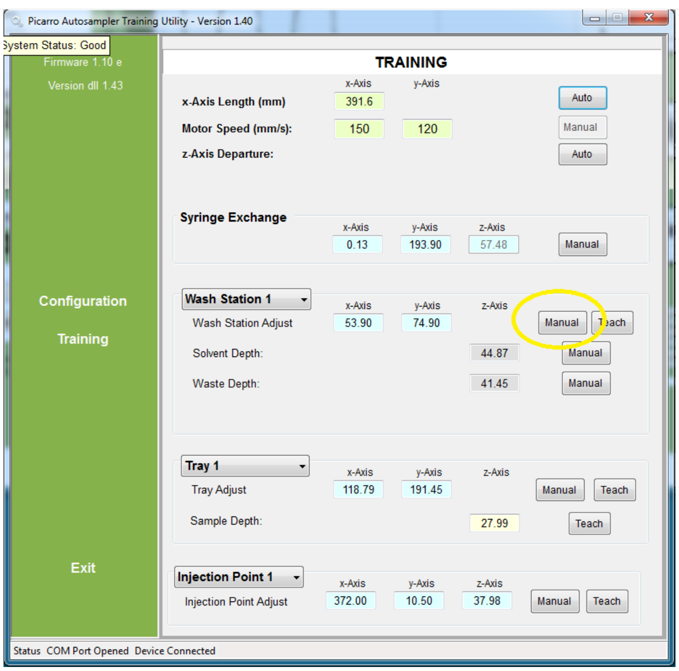


Figure 136. Select Manual for Wash Station.

STEP 16 | Select the "**Manual**" button for **Wash Station** to manually train the Autosampler to align with Waste Port/Wash Station area (**Figure 136**).

Wait for the pop-up window (**Figure 137**) to proceed.

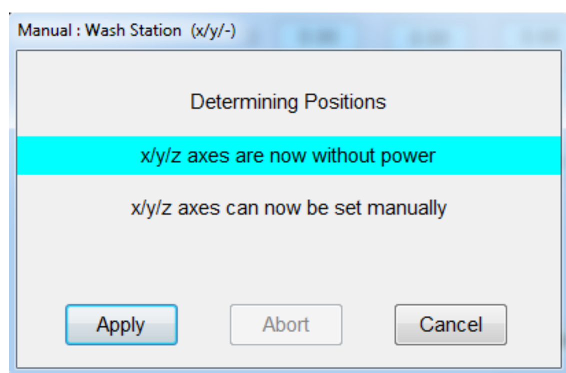


Figure 137. Wash Station Pop-Up Window.

STEP 17 | Ensure the wash station components are in place and the middle jar contains DI water. Move the Syringe to the Wash Station and lower it over the **MIDDLE JAR** (**Figure 138**).

Note: Field Science must train to the wash station to prevent a mishap from syringe misalignment (e.g., breaking the syringe on the wash station). Adding DI water prevents dry cycling the needle when in use and may increase needle lifespan or resolve issues with the needle occurring in the field.

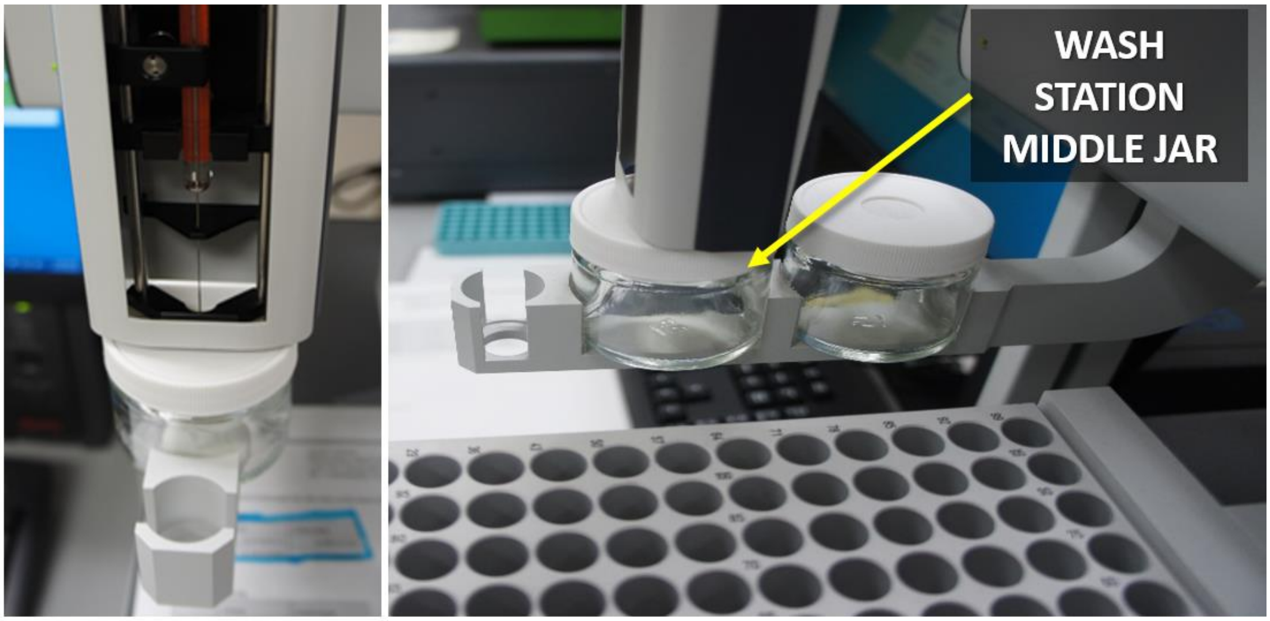


Figure 138. Wash Station: Train Manually to Middle Jar.

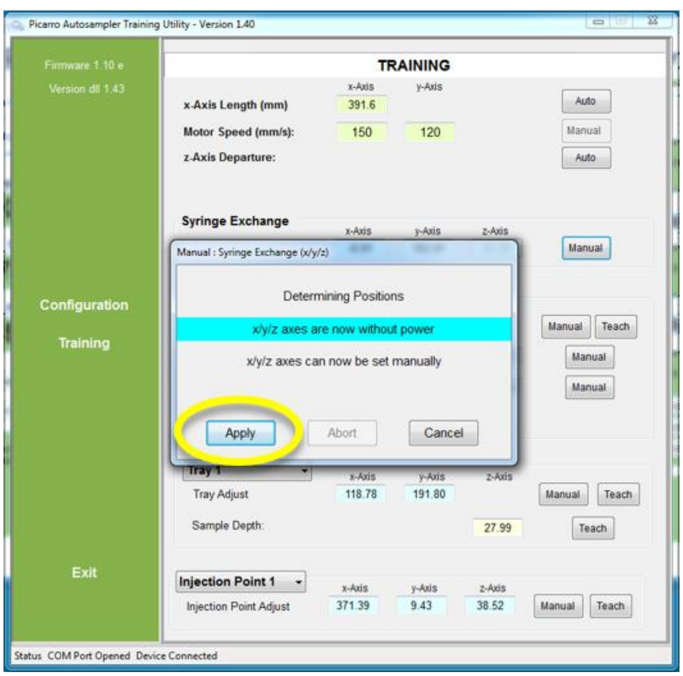


Figure 139. Click Apply for Wash Station.

STEP 18 | Return to the application and click "**Apply**" on the pop up window to activate the test run of the Wash Station manual setting (**Figure 139**).

Note: Clicking "Apply" activates a test run of the manual setting in this and all subsequent steps.

ENSURE <u>NO</u> OBJECTS, TOOLS, OR HANDS ARE ON THE AUTOSAMPLER PRIOR TO CLICKING "APPLY"!

STEP 19 | Select the "**Manual**" button for **Tray Adjust** to manually train the Autosampler to align with Vial 1 on the tray (**Figure 140**).

Wait for the pop-up window to proceed (**Figure 141**).

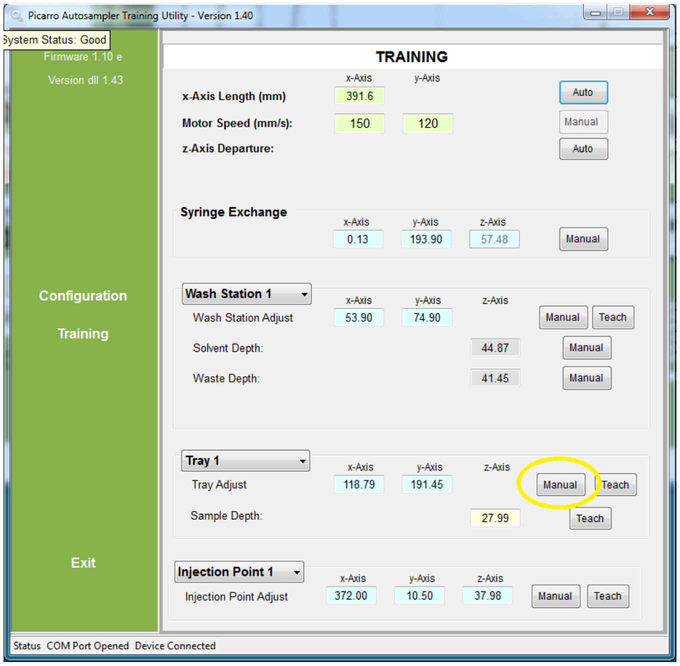


Figure 140. Select Manual for Tray Adjust.

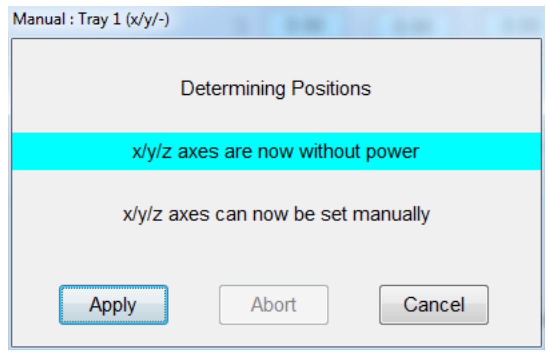


Figure 141. Tray 1 - Tray Adjust Pop-up Window.

Figure 142. Vial Tray contains Numerical Labels for Vial Placement.

*Note: The vial tray in **Figure 142** is set in a specific numerical order. The white circle identifies the start number under the "**NEON1**" configuration in the program.*

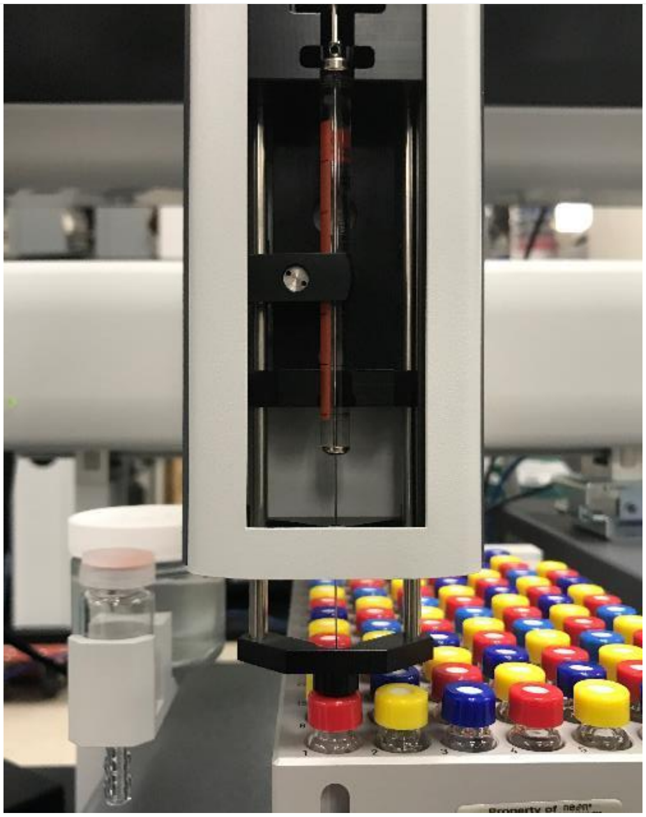


Figure 143. Train the Autosampler: Manual Tray Adjust.

STEP 20 | Move the Syringe to the Tray Adjust area and pull it forward to align with Vial 1 on the tray. Carefully lower the black syringe carriage pulling gently downwards until free from magnetic catch.

CATCH THE SYRINGE CARRIAGE IMMEDIATELY AFTER THE MAGNET RELEASES IT!

Center the Syringe needle over Vial 1 (**Figure 143**). Leave the carriage in the lowered position, resting on the top of the vial. Proceed to the next step.

Note: A strong magnet holds the syringe cavity in the Autosampler. ***To prevent the syringe from hitting the vial; catch it immediately after the magnet releases to lower the syringe needle over the vial.***

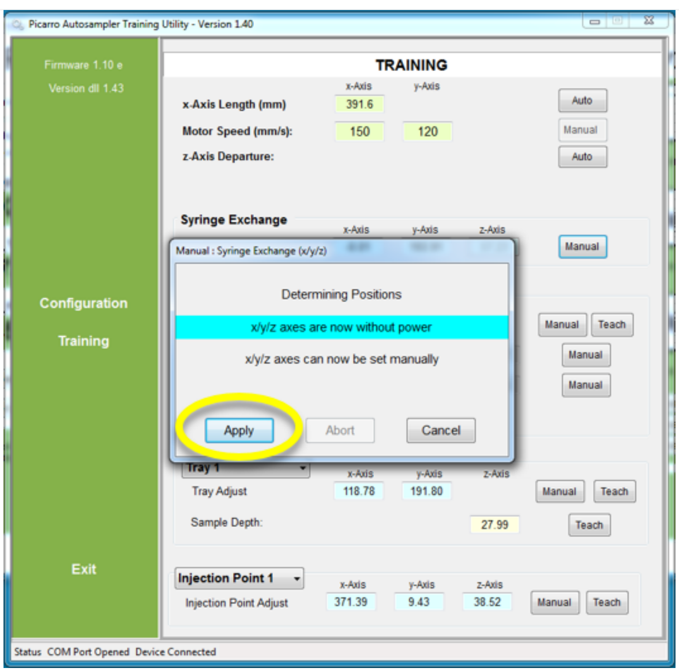


Figure 144. Click Apply for Tray Adjust.

STEP 21 | Return to the application and click "**Apply**" on the pop-up window to activate the test run of the Tray Adjust to Vial 1 manual setting (**Figure 144**).

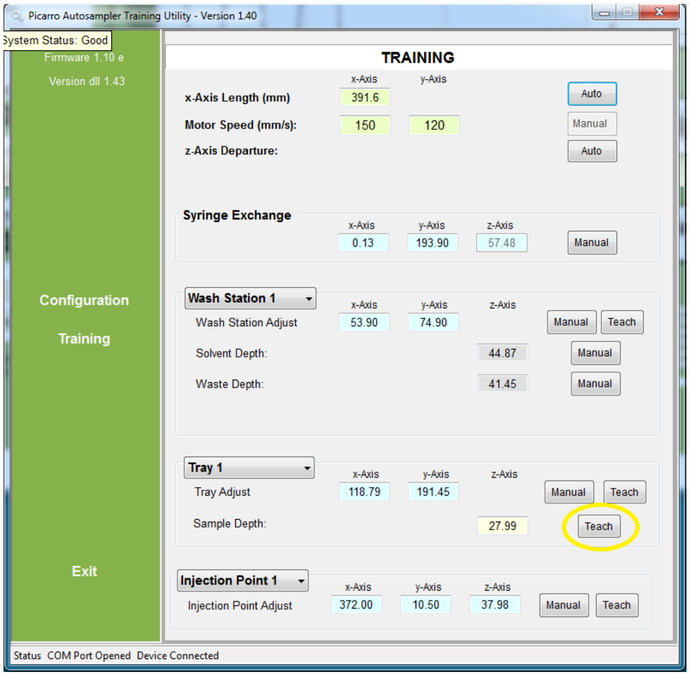


Figure 145. Select "Teach" for Sample Depth.

STEP 22 | Select the "**Teach**" for **Sample Depth** to train the Autosampler to achieve the appropriate sample depth for sampling (**Figure 145**). NOTE: Sample head will move to vial 1 position

*<u>PRO TIP</u>: Rotating the vial in position 1 as shown in **Figure 147**, so hash marks and numbers are visible. This makes adjusting for depth easier.*

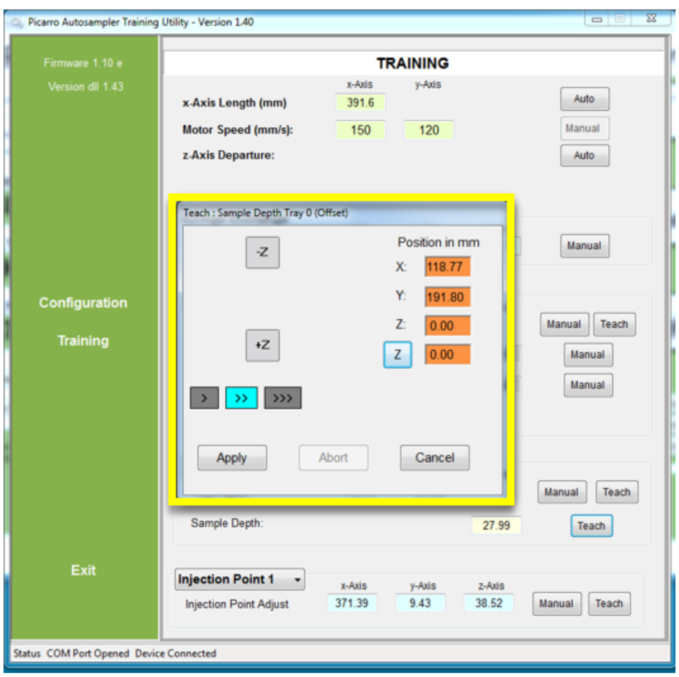


Figure 146. Train the Sample Depth using the Selections.

STEP 23 | The pop up window displays three speed modes to train **Z** in **Figure 146**:

> | >> | >>>

Technicians should use the slowest mode to make incremental adjustments for the needle to reach the sample depth threshold.

Select "**>**" in **Figure 146** then click "**+Z**" to slowly lower the needle in short movements until it reaches depth (about ¾ down, 27 - 30 position in mm field for Z). Use "**-Z**" to raise the needle if the sample depth is too low. Click "**Apply**" when complete.

Figure 147. Needle at Sample Depth.

***Figure 147** is an example of a needle at accurate sample depth.*

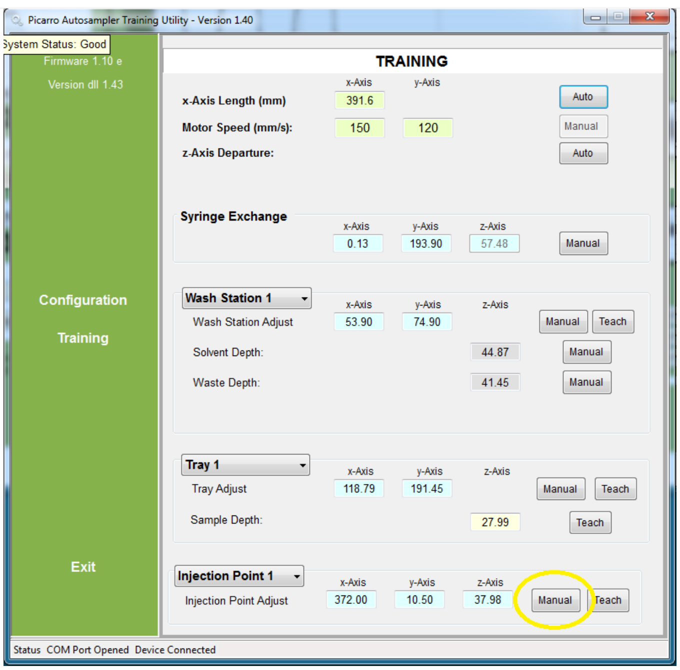


Figure 148. Select Manual for Injection Point.

STEP 24 | Select the "**Manual**" button for **Injection Point** to manually train the Autosampler to align with the Vaporization Module injection port (**Figure 148**).

DO NOT USE TEACH FOR INJECTION POINT! IT CLEARS THE AXIS DATA. USE MANUAL MODE!

Wait for the pop-up window (**Figure 149**) to proceed.

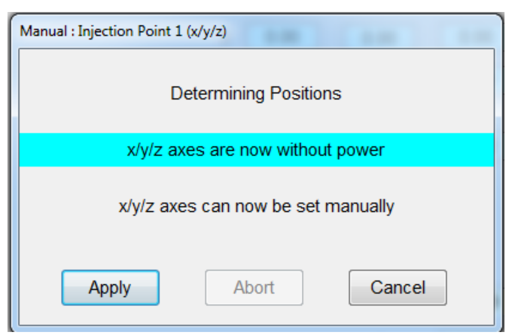


Figure 149. Injection Point Pop-Up Window.

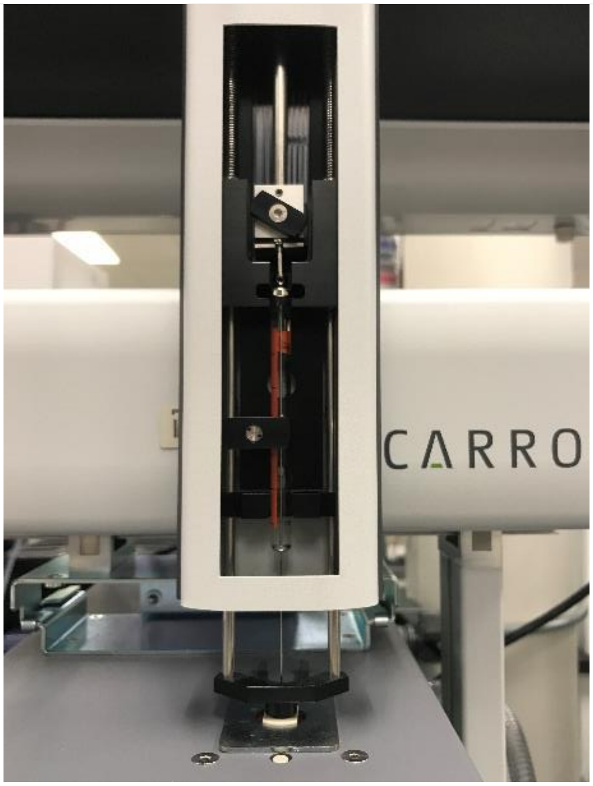


Figure 150. Train the Autosampler: Injection Port.

STEP 25 | Move the Syringe (Autosampler injection head) to the Vaporization Module injection port. Carefully pull down the syringe and lower it over the port (**Figure 150**).

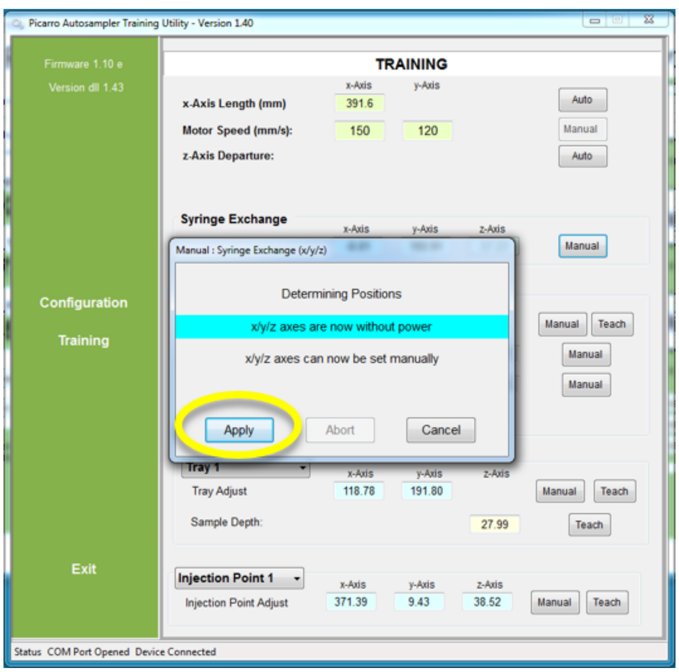


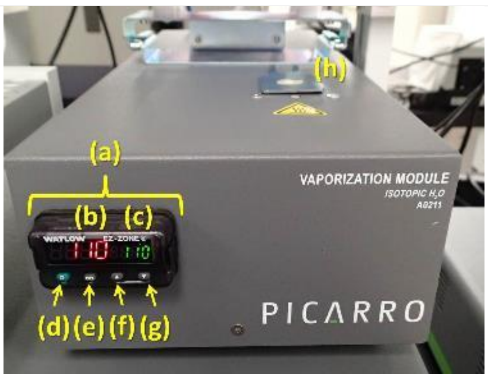
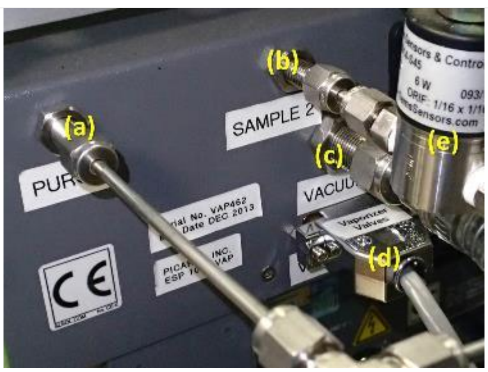
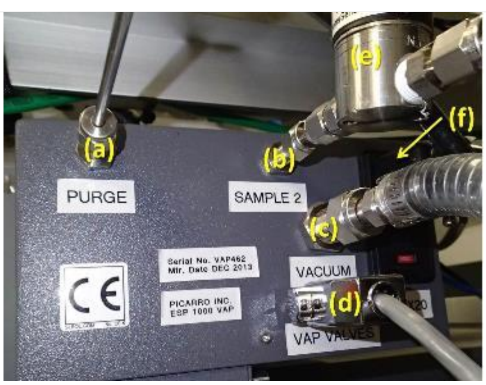
Figure 151. Click Apply on the Pop-up Window for Injection Point.

STEP 26 | Return to the application and click "**Apply**" on the pop up window to activate the test run (**Figure 151**). You can now close the training program window

5.7.3.2 PICARRO Vaporizer Module

The Vaporizer Module, A0211, attaches to the right side of the Autosampler XYZ-Arm. The module vaporizes liquid water samples before sending the sample to the Analyzer Module for sampling and analysis. The Vaporization Module has a temperature set point of 110°C. The vaporizer does not require preventive maintenance. Use water to clean the vaporizer exterior, if necessary. See **Table 32** for an overview of the Vaporization Module.

Table 32. PICARRO Vaporizer Module, A0211 Overview.

 	**Figure 152.** Front of the Vaporizer Module, A0211. (a) Temperature controller (b) Vaporizer current temperature (c) Temperature set point (d) Menu (provides a list of selection options) (e) Sub-Menu (provides further options of a selection) (f) Temperature increase (g) Temperature decrease (h) Injection port where Septa resides
 	**Figure 153.** The rear of the Vaporization Module, A0211. (a) Purge port (b) Sample 2 port (c) Vacuum port (d) Vaporizer valves control port (connects to L2130 analyzer) (e) 3-way valve (solenoid)
 	**Figure 154.** Alternate view of the rear of the Vaporization Module, A0211. (a) Purge port (b) Sample 2 port (c) Vacuum port (d) Vaporizer valves control port (connects to L2130 analyzer) (e) 3-way valve (solenoid) (f) Power plug, power switch, and fuse

5.7.3.2.1 PICARRO Septa Change Procedures

NEON recommends replacement of the injector port septa around every 500 injections (which is about a month of normal validations). The more closely grouping of the needle piercing on the septa, the sooner the septa requires replacement. Failing to change the septa may make it difficult to maintain the vacuum inside the vaporizer, which may degrade the quality of the data. The NEON program requires Domain TIS sites employing this instrumentation to change the septa monthly (typically when installing a new validation tray). Reference **Table 33** and **Table 34** to conduct the septa change procedures.

Table 33. Septa Change Tools & Consumables.

Equipment & Consumables	Quantity
Septa (Fisher PN 03-100-023)	1
Needle-nose Pliers or Tweezers	1
Powder-free Nitrile Gloves	1

Table 34. PICARRO Analyzer for Isotopic H_2O, Vaporizer Module, A0211 Septa Change Procedures.

STEP 1 | Acquire the necessary tools and consumables in **Table 33**.

STEP 2 | Ensure that no current autosampler jobs are running by clicking on the Autosampler UI Window and clicking on the "End" button (**1**), closing the window Autosampler UI Window (**2**) and closing the CRDS Coordinator Window (**3**). Use **Figure 155** as reference for each of these steps. If these windows are not open, then proceed to the next step.

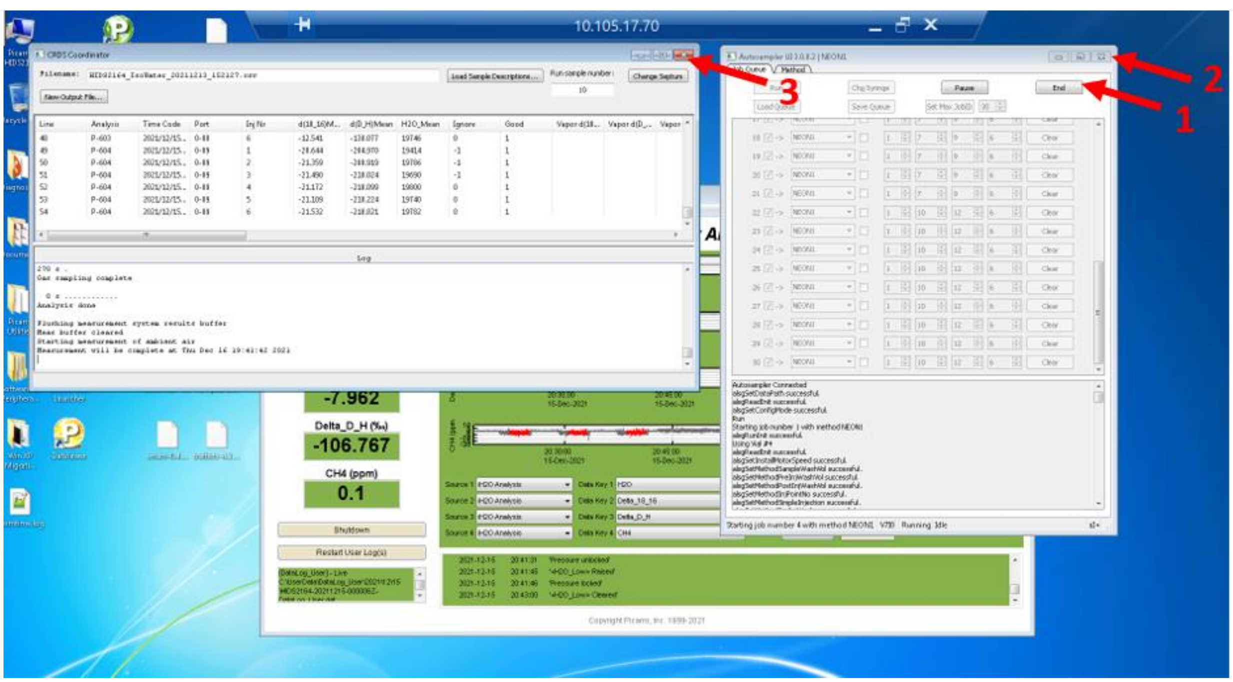


Figure 155. Close Autosampler UI and CRDS Coordinator Programs.

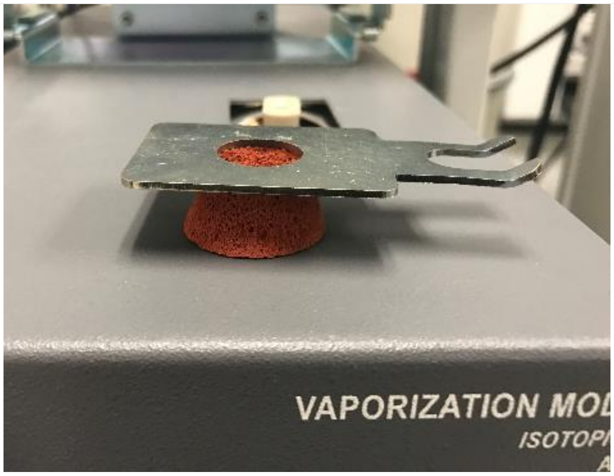


Figure 156. Septa Tool that acts as a Protective Cover.

STEP 3 | Remove the protective metal cover around the injection port.

This is a built-in septa tool to unscrew the cap of the port (**Figure 156**). Beneath this cap is the septa. Use caution as the tool can become hot.

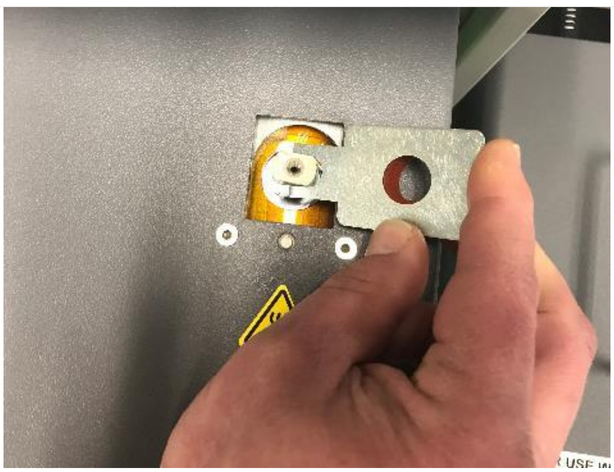


Figure 157. Move the Septa Tool Counter-Clockwise.

STEP 4 | Use the septa tool to unscrew the cap. Move the tool counter-clockwise, as shown in **Figure 157**.

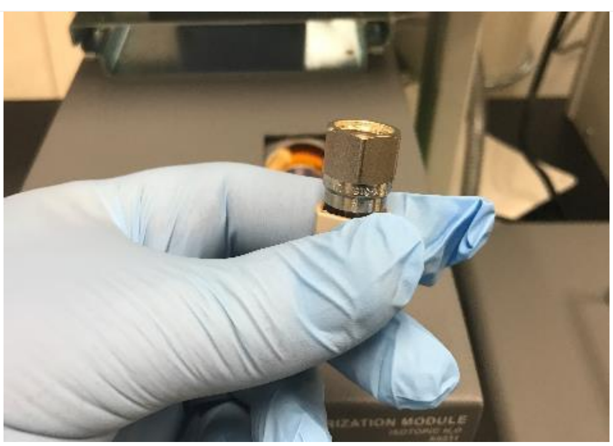


Figure 158. Remove the Cap from the Port.

STEP 5 | Remove the cap grasping the plastic portion of the cap, which can be hot (**Figure 158**).

WARNING: DO NOT TOUCH THE METAL PORTION OF THE CAP (BOTTOM OF THE CAP) WITH BARE HANDS – IF IN OPERATION THE VAPORIZER IS VERY HOT, PLEASE EMPLOY CAUTION TO PREVENT INJURY.

Gloves are recommended, but optional until handling the new septa in Step 7.

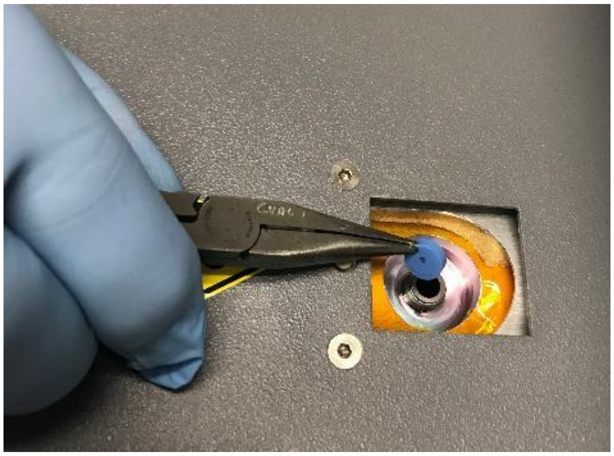


Figure 159. Remove the Septa from the Port.

STEP 6 | The old septa may stick to the port. Remove the septa using needle-nose pliers or similar tool, if necessary (**Figure 159**).

If the instrument is operational, removing the septa may cause a suction noise.

If there is no visible septa to remove, look on the inside of the cap to see if it is stuck. Remove with needle-nose pliers or tweezers.

Note: Figure 160 is an example of a septa stuck in the cap upon removal.

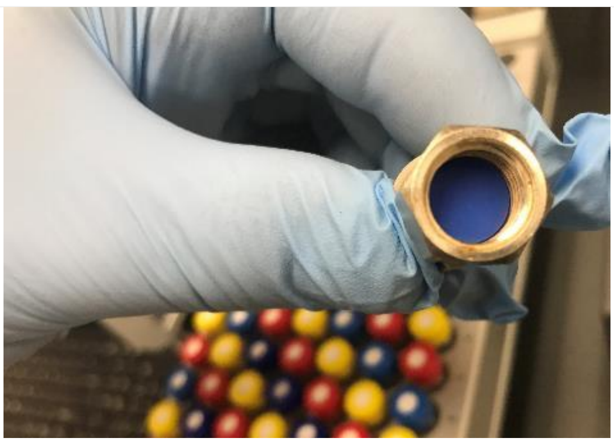


Figure 160. Insert the New Septa into the Cap.

STEP 7 | Apply gloves prior to handling a new septa to prevent contamination.

Insert the new septa into the cap. Conduct a swift replacement of the septa since the vacuum pump is on (prevents dust accumulation in the Vaporizer).

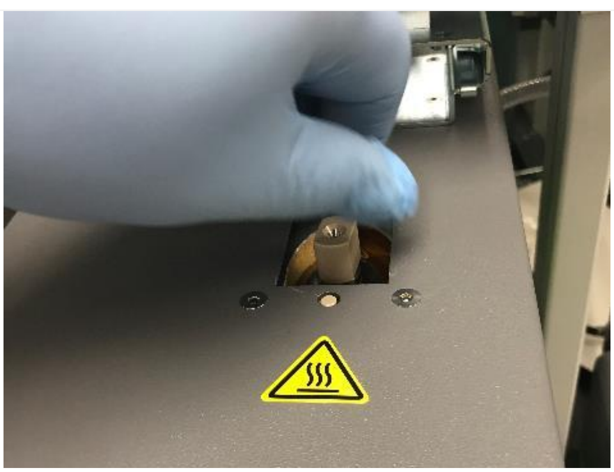


Figure 161. Screw the Cap onto the Port by Hand.

STEP 8 | Screw the cap onto the port by hand until it comes to a hard stop (**Figure 161**).

Tighten to finger tight only.

DO NOT OVER-TIGHTEN OR USE A WRENCH, THIS DAMAGES THE INJECTOR PORT.

Return the tool to its original position above the injection port, providing a protective metal cover over the port.

5.7.3.2.2 PICARRO L2130-I Analyzer for Isotopic H_2O Validation Process

CVAL provides Field Science with trays stocked with validation vials of known isotopic water every 30 days. The vials on the tray can be used for daily validation up to 30 days. Conduct the procedure in **Table 35** to exchange validation trays.

Table 35. Initiate PICARRO L2130-I Analyzer Module for Isotopic H2O Monthly Validation Procedure.

STEP 1 | Acquire a new tray of validation vials from CVAL. (CVAL aims to send out the vials the 3rd week of every month. This is subject to change depending on the availability of spare trays/tray reuse.) For YELL, TOOL, BARR, and BONA, validation vials are sent from CVAL every 3 months.

Prior to starting validations, train the autosampler, and replace the syringe and the septa. CNC must be running on the LC prior to starting validations.

Note: Validation Vial trays expire after 40 days unpunctured & 10 days punctured.

Figure 162. Validation Vial Tray (12 Vials).

STEP 2 | Install a new tray of 12 isotopic water sample vials **Figure 162** displays a validation vial tray containing 12 isotopic water samples.

Return the old validation vial tray to CVAL wrapped in bubble tape/padding (how Field Science receives a vial tray from CVAL is how Field Science should return to CVAL).

Figure 163. Autosampler Control Program Icon.

STEP 3 |Open the KVM (keyboard, video, and mouse) and select the switch for PICARRO H_2O or connect via Windows Remote Desktop (*See Section 9 APPENDIX B: Connecting to Picarro ANALYZERS via Windows Remote Desktop*).

When ready to start, double-click on the Autosampler Control Program icon (**Figure 163**).

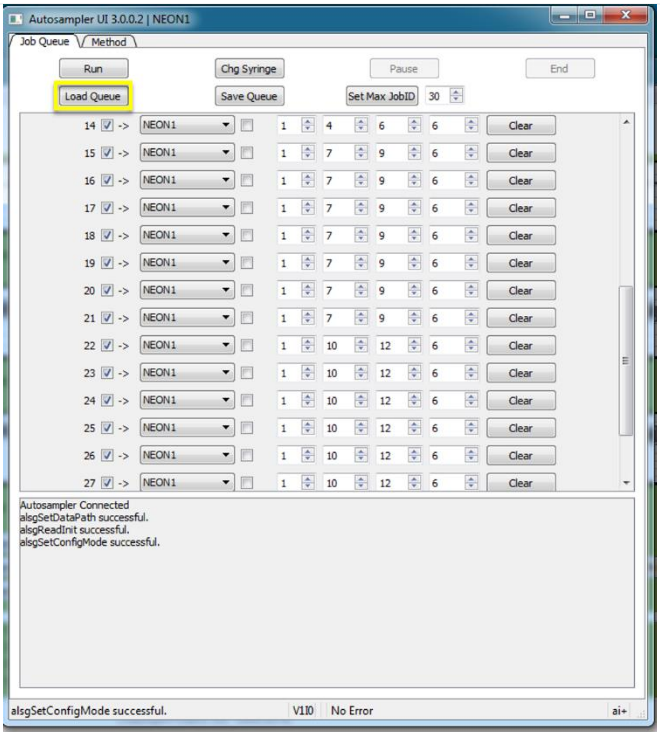


Figure 164. Select Load Queue.

STEP 4 | Select **Load Queue** (**Figure 164**) and load "**NEON1.Que**".

STEP 5 | In the Autosampler Control program, adjust and confirm the **NEON1** settings under the **Job Queue** tab. **Figure 165** displays **NEON1** default configuration.

Verify the following settings:

- Verify **Set Max JobID** is set to **30**.
- Each line is set to **Tray 1**
- Verify the number of injections (**#inj**) are **six**.

In **Figure 165**, each line in the Autosampler Control program is set for a day of validation injections.

- Vials **1-3** are for the first seven days.
- Vials **4-6** are for days 8-14.
- Vials **7-9** are for days 15-21.
- Vials **10-12** are for the remaining nine days.

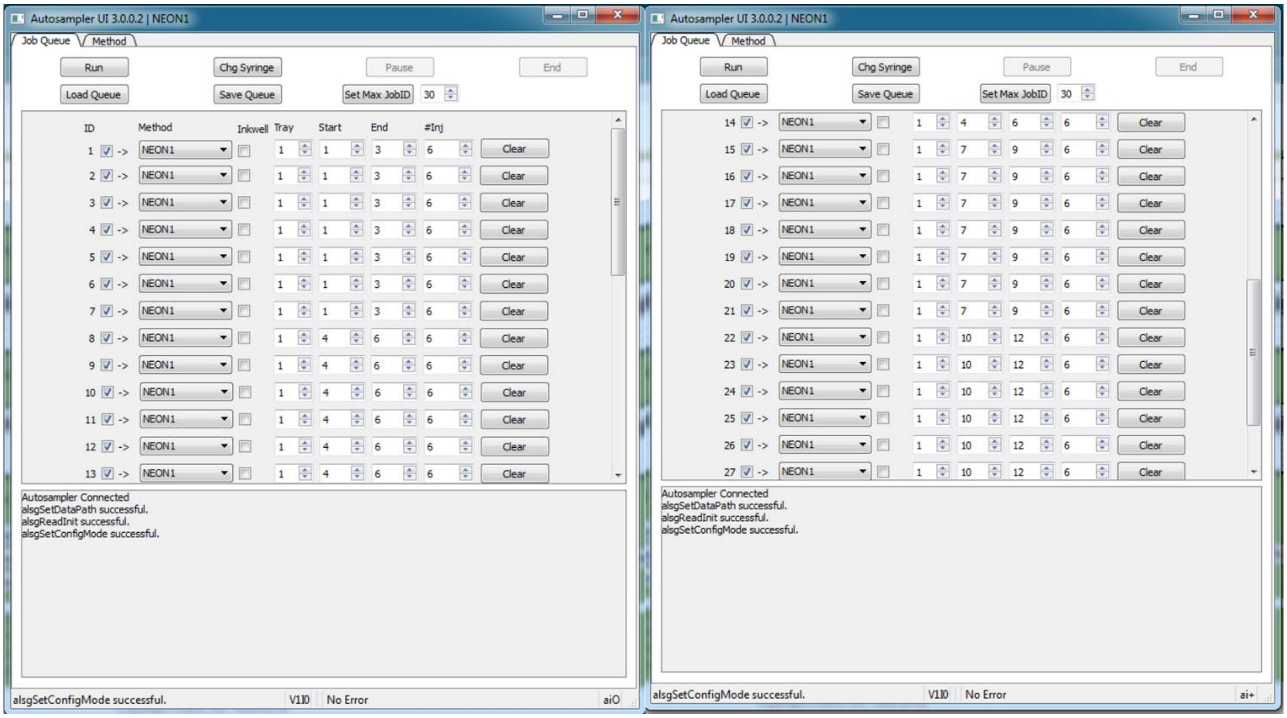


Figure 165. NEON1 Configuration.

NEON1 default configuration starts with vials 1-3 and ends with vials 10-12, in accordance with the physical sample vial tray numbering ***UNLESS*** sample vials break during shipping/handling **OR** the initial validation process stopped, and Technicians must restart the process.

*Note: If vials broke during shipping/handling, the "**Start**" and "**End**" vial number changes in the **NEON1** configuration. See the procedure in **Table 36** If Technicians have paused or stopped the validation process, see the procedure in **Table 37** to restart the validation cycle for the remaining vials.*

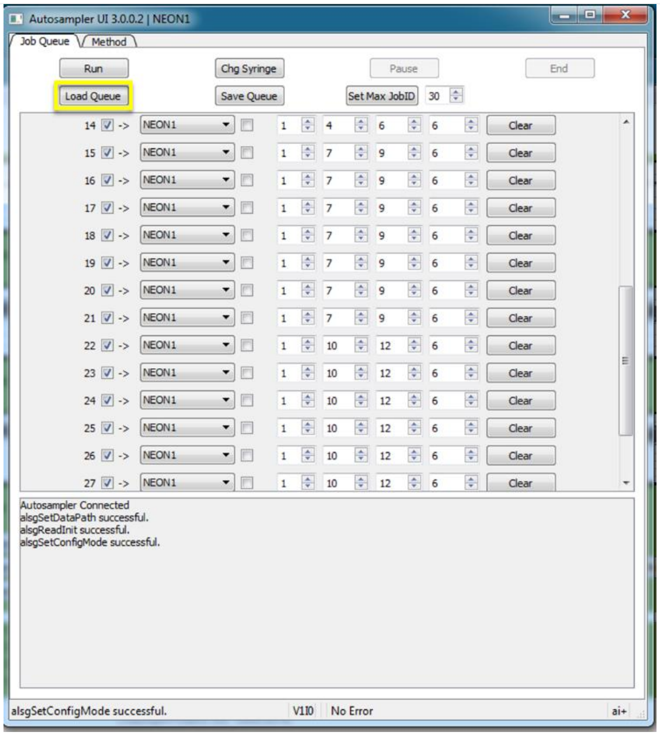


Figure 166. Select Load Queue again IF lines are Missing.

STEP 6 | If lines are missing, click **Load Queue** (**Figure 166**), again, and select "**NEON1.Que**", again.

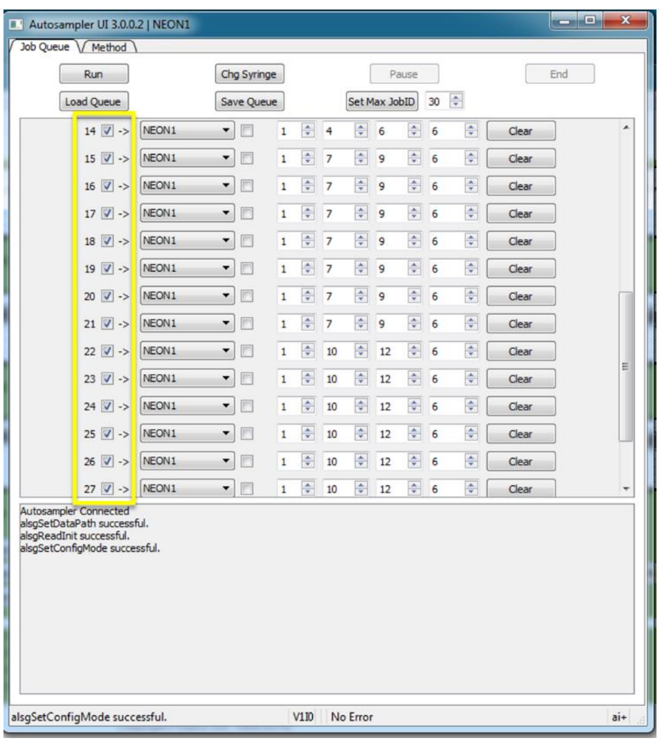


Figure 167. Select the Lines 1-30 under the NEON1 Method.

STEP 7 | Ensure the boxes for lines 1-30 are checked under the ID column (**Figure 167**).

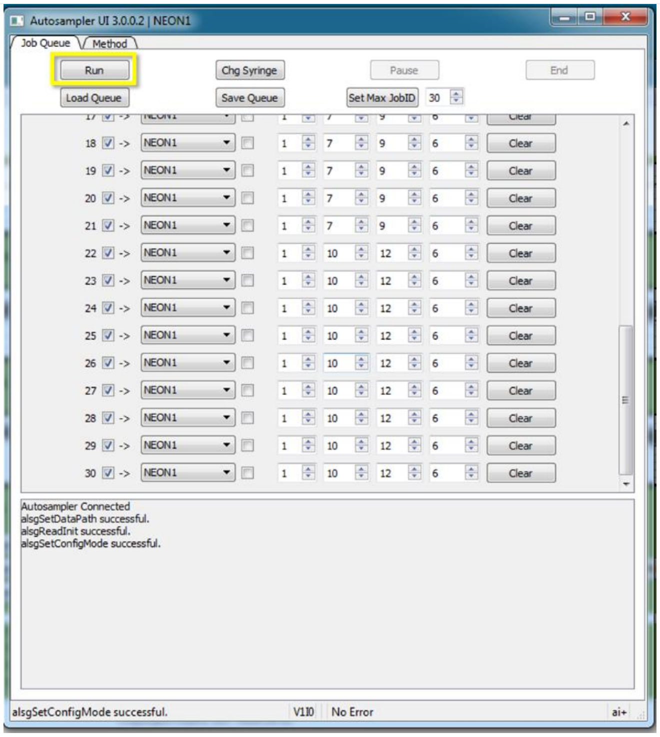


Figure 168. Select Run.

STEP 8 | Click **Run** to initiate the validation process using the 12 vial tray (Figure 168).

☆THE AUTOSAMPLER CONTROL GUI MUST BE OPEN AND THE RUN BUTTON CLICKED PRIOR TO STARTING THE COORDINATOR LAUNCHER GUI IN STEP 8 OR PICARRO SOFTWARE WILL FREEZE AND REQUIRE CVAL TO RE-DOWNLOAD NEON1.QUE.☆

Figure 169. Open Picarro Coordinator Launcher.

STEP 9 | Open the **Coordinator Launcher**. Select **Dual Liquid/Vapor** from the dropdown options and click **Launch** (**Figure 169**).

STEP 10 | Set **User Editable Parameters** to the following parameters and click **OK** when complete (**Figure 170**).

- Number of liquid injections for calibration: **18**
- Vapor measurement time (hours): **23**
- Include ambient measurement in output file (0=no 1=yes): **0**

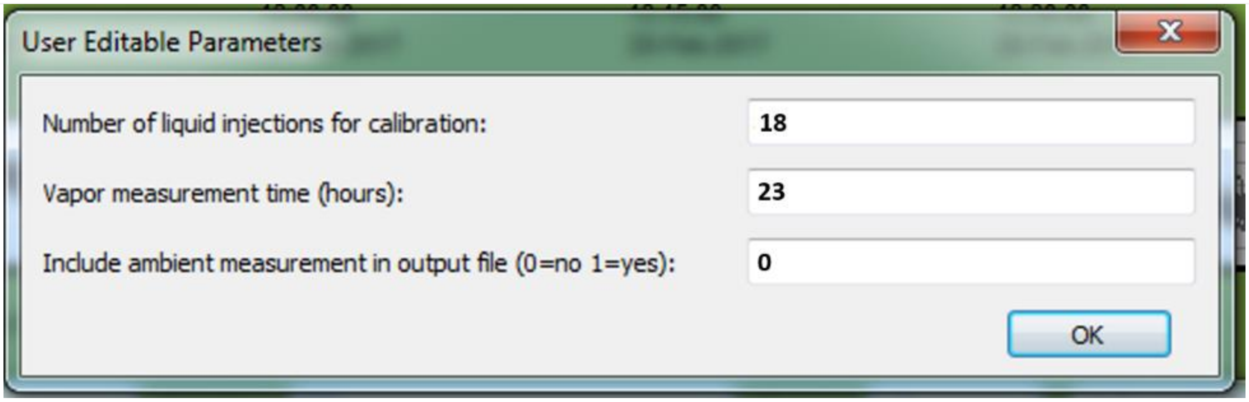


Figure 170. Edit User Editable Parameters.

STEP 11 | Verify the needle is picking up water samples and injecting them into the vaporizer. It takes several minutes to compete an Injection and analysis. Injection pulses should be **20,000 ppm (±1,000)** H2O via the Digital Readout area on the CRDS Data Viewer (see note below and **Figure 171**).

This process may take up to about nine minutes an injection. As a result, the overall process to adjust the sample volume may take a while to complete. Allocate some buffer room when planning to make these adjustments. *Once Technicians reach **~20,000ppm (±1,000) concentration**, conduct 3 additional injections to verify.*

The Coordinator Launcher screen will show a summary of injections as they are completed. Technicians may also view injection data logs via **C:/IsotopeData**. Each file contains a timestamp to review injections over time.

Important: If the pulses are over or under the thresholds, proceed to STEP 13 to adjust sample injection volume. *The first several injections are sometimes inaccurate; wait until at least three (3) injections are complete before assessing.*

Note: If the Picarro is not picking up water samples, the syringe may be faulty. Replace and if issues remain, submit a ticket in the NEON Issue Management and Reporting System to conduct corrective action under the guidance of NEON HQ.

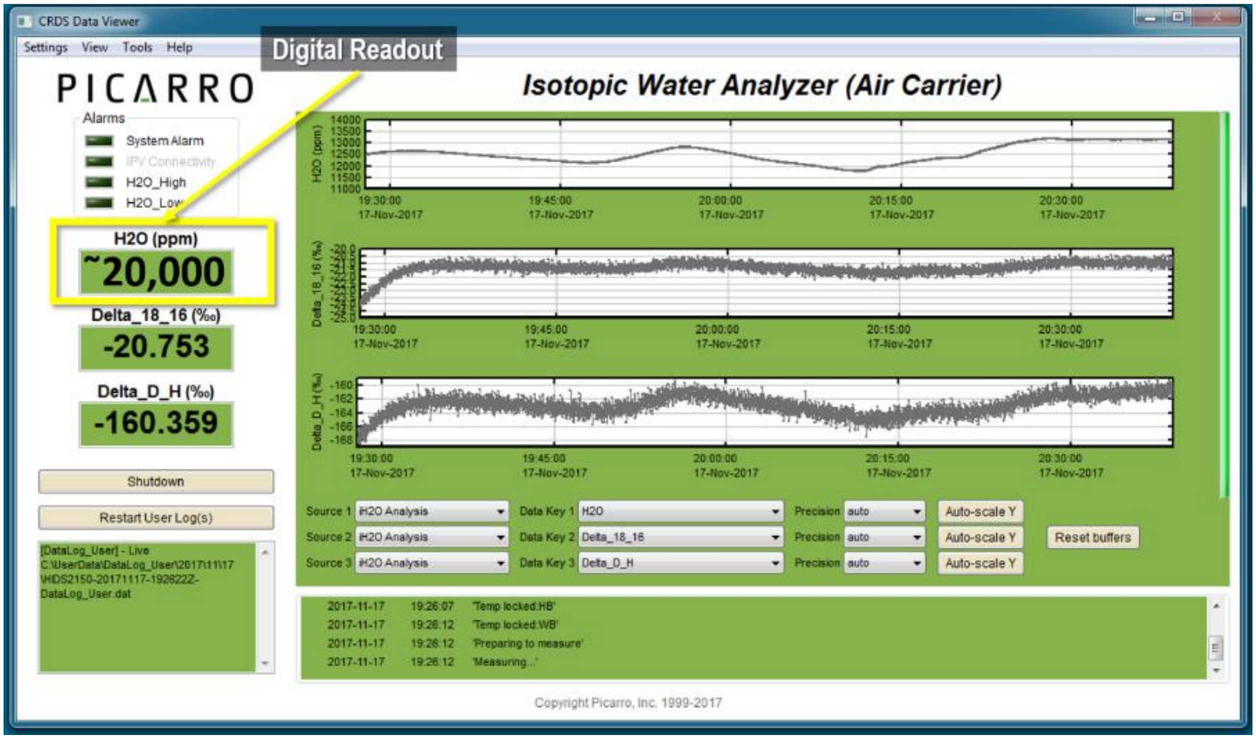


Figure 171. Monitor H20 PPM Digital Readout.

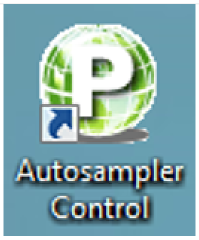


Figure 172. Autosampler Control Icon.

STEP 13 | If pulses are not reaching the **20,000 ppm (±1,000)** H2O via the Digital Readout area on the CRDS Data Viewer, you may need to adjust the sample volume being injected. Once this has been set initially it should only need rare minor adjustments if any.

Close the Autosampler UI Window and CRDS Coordinator Programs. Then reopen the Autosampler UI by double-clicking the Autosampler Control icon (**Figure 172**).

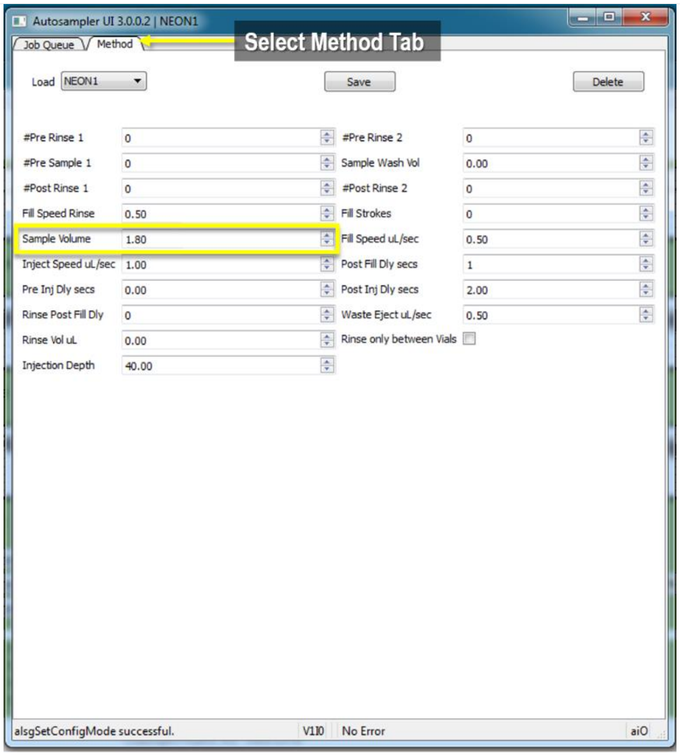


Figure 173. Select Method and Adjust Sample Volume (uL).

STEP 14 | Under the **Method** Tab, select the **NEON1** configuration (**Figure 173**).

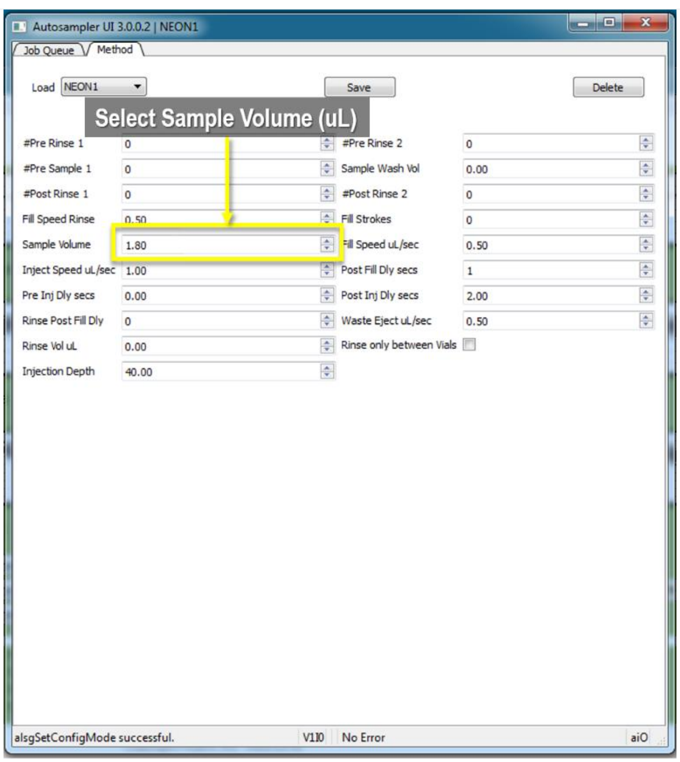


Figure 174. Adjust Sample Volume Field.

STEP 15 | Adjust the **Sample Volume (uL)** (**Figure 174**). Use the arrows to toggle the number up and down to adjust sample volume.

PRO TIP: Adjust the sample volume (uL) micro liter using the following information as a rule of thumb: 0.1 = 1000ppm change.

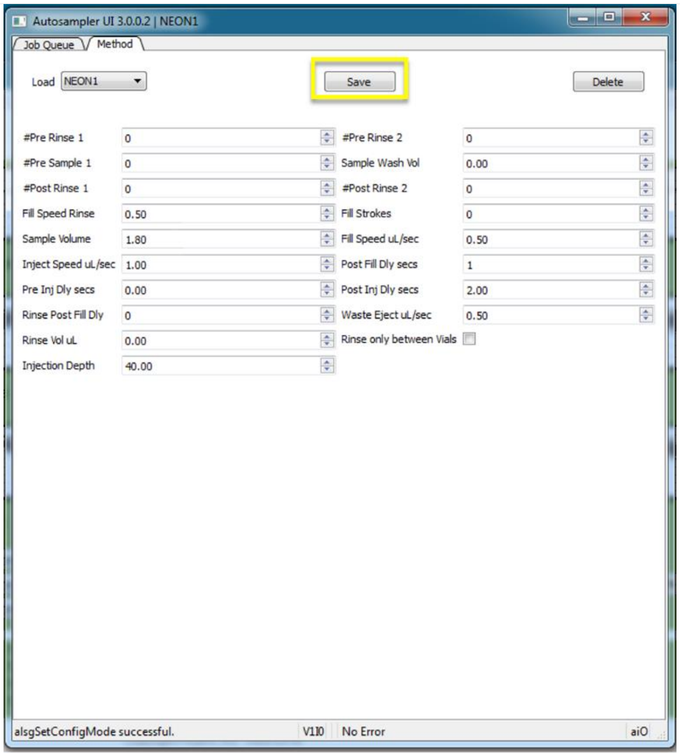


Figure 175. Save Adjustment under NEON1 Configuration.

STEP 16 | **Save** adjustment to Sample Volume (uL) in the NEON1 configuration (**Figure 175**).

A pop-up window will appear asking to overwrite NEON1 configuration. ***Select OK and continue this procedure.***

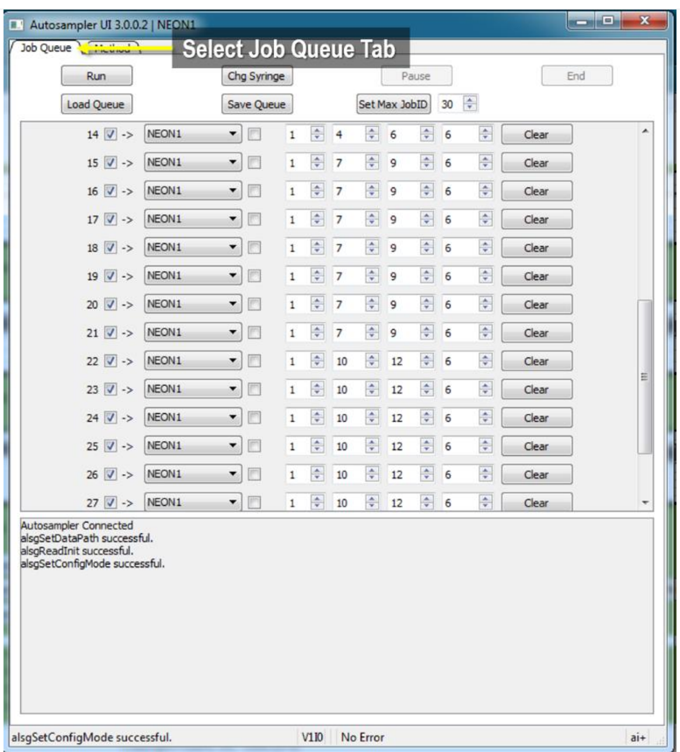


Figure 176. Return To Job Queue Tab.

STEP 17 | Return to the **Job Queue** Tab (**Figure 176**).

STEP 18 | In the **NEON1** configuration, select only the first row (**Figure 177**).

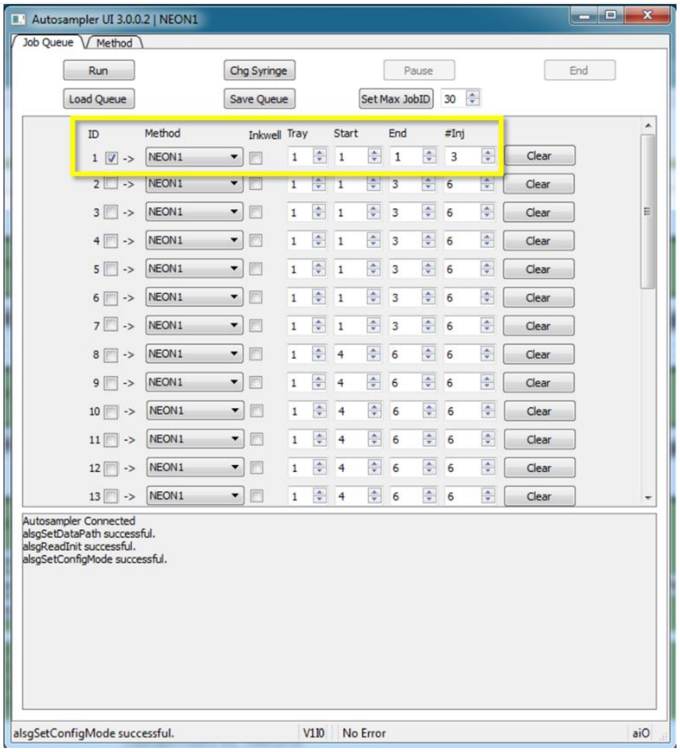


Figure 177. Select the First Row only.

STEP 19 | Select **Run** to test the Sample Volume (uL) adjustment (**Figure 178**).

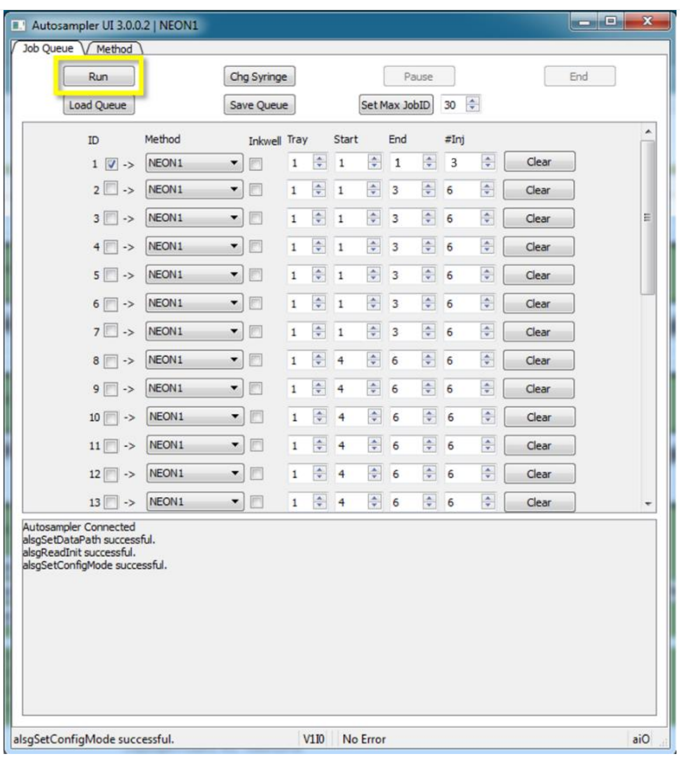


Figure 178. Select Run to Run NEON1 Configuration.

Figure 179. Coordinator Software Icon.

STEP 20 | Open the PICARRO **Coordinator Launcher** software (see Coordinator Launcher Icon in **Figure 179**).

Figure 180. Select Coordinator Mode: Dual Liquid/Vapor.

STEP 21 | Select Coordinator Mode "**Dual Liquid/Vapor**" from the dropdown options and click **Launch** (**Figure 180**).

<u>'Dual Liquid/Vapor':</u> Used for measurement of ambient vapor coupled with automated injection of liquid calibration standards. Before operating in Dual Mode, ensure temperature is set to 110 C°.

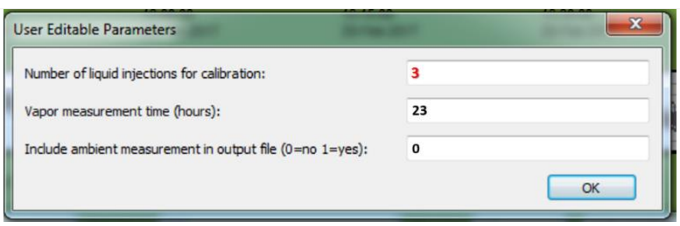


Figure 181. Edit User Editable Parameters.

STEP 22 | Set **User Editable Parameters** to the following parameters and click **OK** when complete (**Figure 181**).

- *Number of liquid injections for calibration: **3***
- *Vapor measurement time (hours): **23***
- *Include ambient measurement in output file (0=no 1=yes): **0***

STEP 23 | Monitor CRDS Output as in Step 9 and repeat adjustment of sample volume as needed (see note below). Begin at Step 11 above to start the validations. If unable to reach required thresholds for injections, submit a ticket in ServiceNow to conduct corrective action under the guidance of NEON HQ.

Note: The first several injections are sometimes inaccurate; wait until at least three (3) injections are complete before assessing.

5.7.3.2.3 How to Adjust for Broken Validation Vials

In the event Field Science receives broken vials, use the procedure in **Table 36** to amend the process.

Table 36. Modify PICARRO L2130-I Analyzer Module for Isotopic H_2O Validation Procedure.

STEP 1 | If validation vails break in the tray during shipping/handling; replace the broken vials with the identical color cap vials from the end of the tray. Follow the color pattern and use the last three vials on the tray to replace the broken vials as needed (**Figure 182**). Ensure there are no empty spots in the ordering; adjust vials accordingly to follow the color pattern. See below for more information.

Note: Sampling must always start the sequence with a red capped vial. Replace broken vials with vials with the identical color cap. Ensure that locations 1-6 at a minimum have vials (2-week validation run). Each line in the control software is a day!

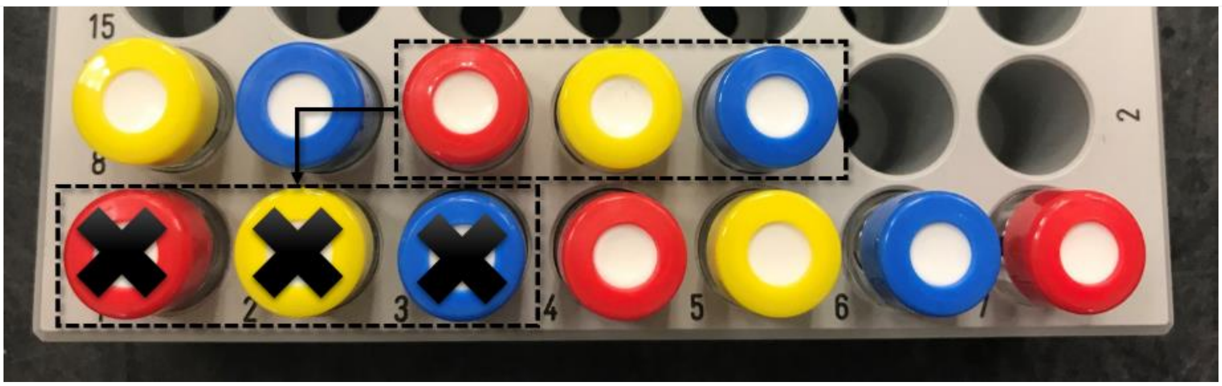


Figure 182. Replace Broken Validation Vials from Back - Follow Color Cap Pattern.

STEP 2 | **Report # of broken vials and cap color to CVAL immediately!** Ensure locations 1-6 have vials to ensure a two-week validation run. In the Autosampler control window, select lines 1-14 only and continue the process to start validations.

After receiving replacement vials from CVAL, fill the empty slots with the good vials, following the color sequence above (red, yellow, blue) and restart the validation run. When restarting, under the **Job Queue** tab, adjust for the difference in vials in the **NEON1** Configuration.

For example, if conducting a validation run for 6 good vials, check lines 1-14 only (see **Figure 183** below). During this validation run, CVAL sends replacement vials for Field Science to install. 14 Days of validations run.

When received, place vials in remaining slots, following the color order and restart validations. When restarting, under the **Job Queue** tab, select lines 15 to 30 only.

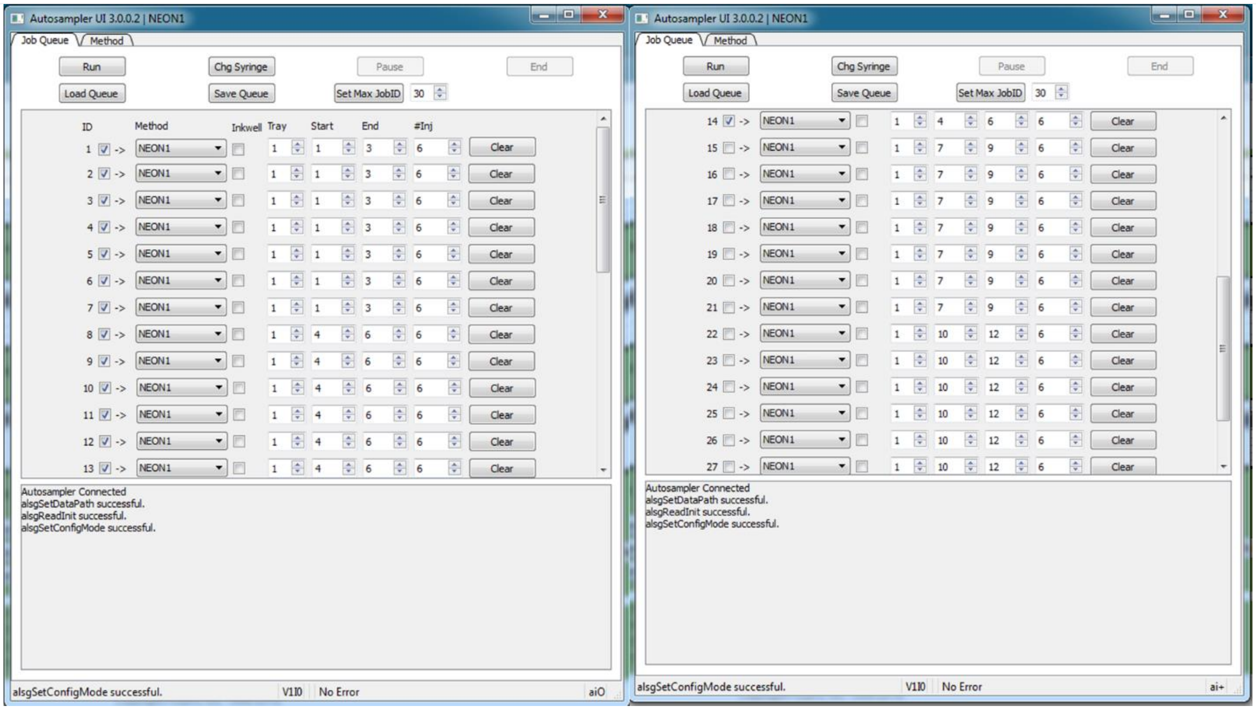


Figure 183. Example Scenario: First 6 Vials for 2 Week Validation Run Settings.

STEP 3 | Verify changes, that the correct boxes are checked, and select **Run** (**Figure 184**).

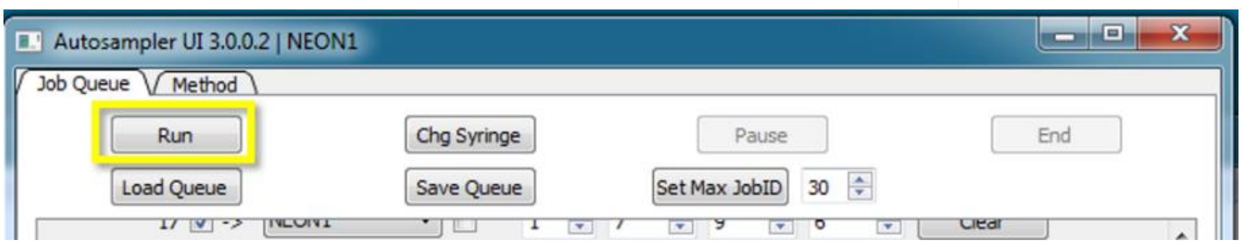


Figure 184. Select Run in Autosampler UI.

Figure 185. Coordinator Launcher.

STEP 4 | Open the **Coordinator Launcher**. Select **Dual Liquid/Vapor** from the dropdown options and click **Launch** (**Figure 185**).

STEP 5 | Set **User Editable Parameters** to the following parameters and click **OK** when complete (**Figure 186**).

- Number of liquid injections for calibration: **18**
- Vapor measurement time (hours): **23**
- Include ambient measurement in output file (0=no 1=yes): **0**

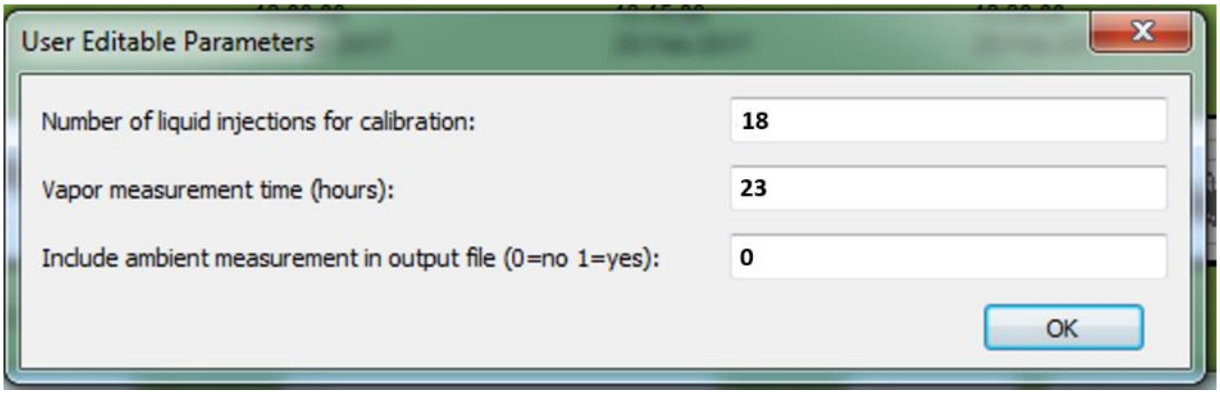


Figure 186. Edit User Editable Parameters.

STEP 6 | Verify that the needle is picking up water samples and injecting them into the vaporizer. Pulses should be **~20,000 ppm** H2O via the Digital Readout area on the CRDS Data Viewer. *Reference Section 5.7.3.2.2 Step 15 to adjust pulses, if pulses are failing to reach ~20,000 ppm.* Field Science may also view injection data logs via **C:/IsotopeData**. Each file contains a timestamp to review injections over time.

If the PICARRO Analyzer/Autosampler is not picking up water samples, submit an incident ticket in ServiceNow to conduct corrective action under the guidance of NEON HQ.

5.7.3.3 How to Restart the Validation Process

In the event an issue arises, and the validation process stops, or maintenance required ceasing validations, use the procedure in **Table 37** to restart the validation process.

Table 37. Restart PICARRO L2130-I Analyzer Module for Isotopic H_2O Monthly Validation Procedure.

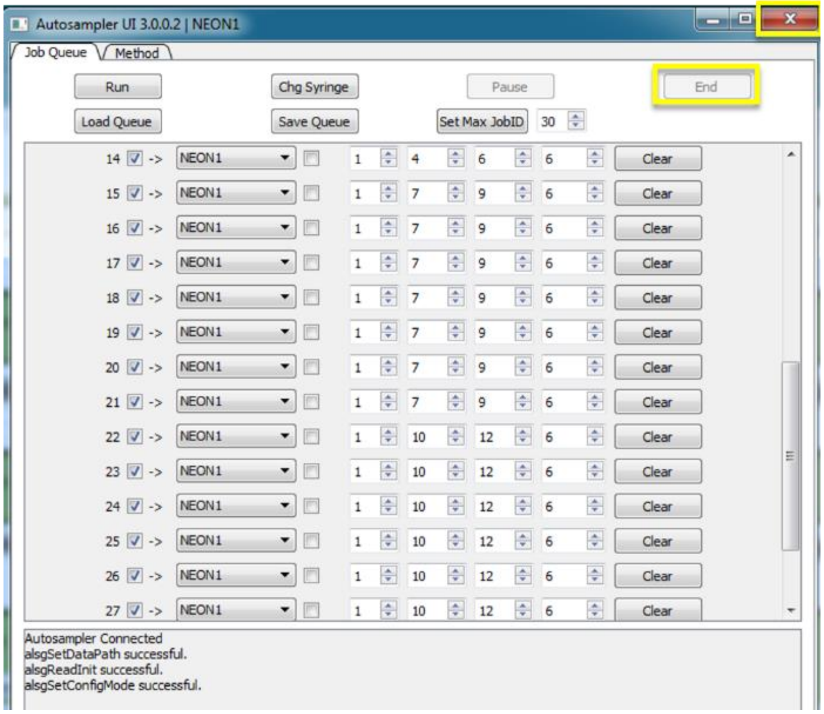


Figure 187. Close Autosampler Control Program**.**

STEP 1 | Close the Autosampler Control Program (**Autosampler UI 3.0.0.2**).

- Skip step if this program is not open. Continue to the next step.
- Click '**End**', if button is enabled to end the run, and click '**X**' in the upper right hand corner of **Figure 187**.
- If '**End**' is not enabled, click '**X**' to close in the upper right hand corner of **Figure 187**.

Figure 187 displays the '**End**' button not enabled.

STEP 2 | Close the **CRDS Coordinator** window. Click '**X**' in **Figure 188** below. Skip this step if the program is not open. The green **CRDS Data Viewer** may remain open for this process.

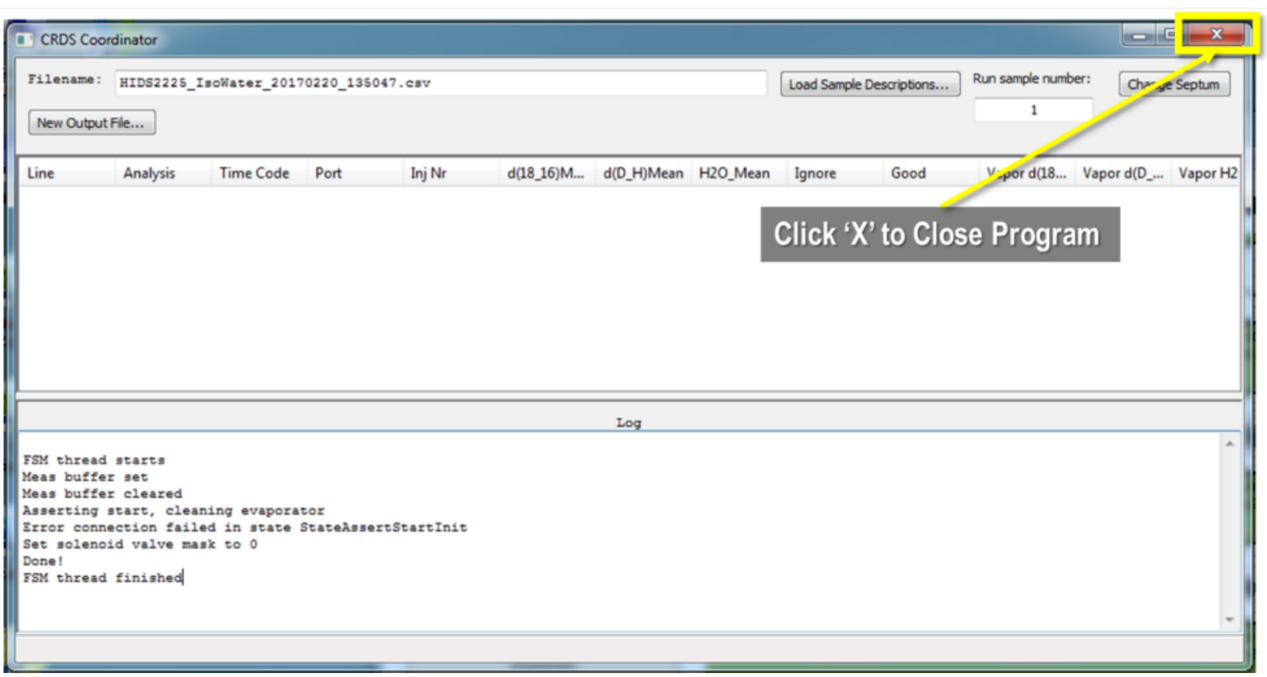


Figure 188. Close CRDS Coordinator.

STEP 3 | Restart the validation cycle from the first line in the **NEON1** configuration that was not ran.

For example, if you installed on the 1st day of the month and the validations ran ok for 4 days and then stopped. Restart validations by selecting lines 5-30 in the Autosampler Control Program.

If you are uncertain when the validations were started or when they stopped, you can open **C:\IsotopeData** (**Figure 189**) and select the most recent file (**.csv** file). Open the file in Notepad.

Note: Each line is a set of injections (the needle punctures red, yellow, and blue/three vials daily) in the NEON1 configuration.

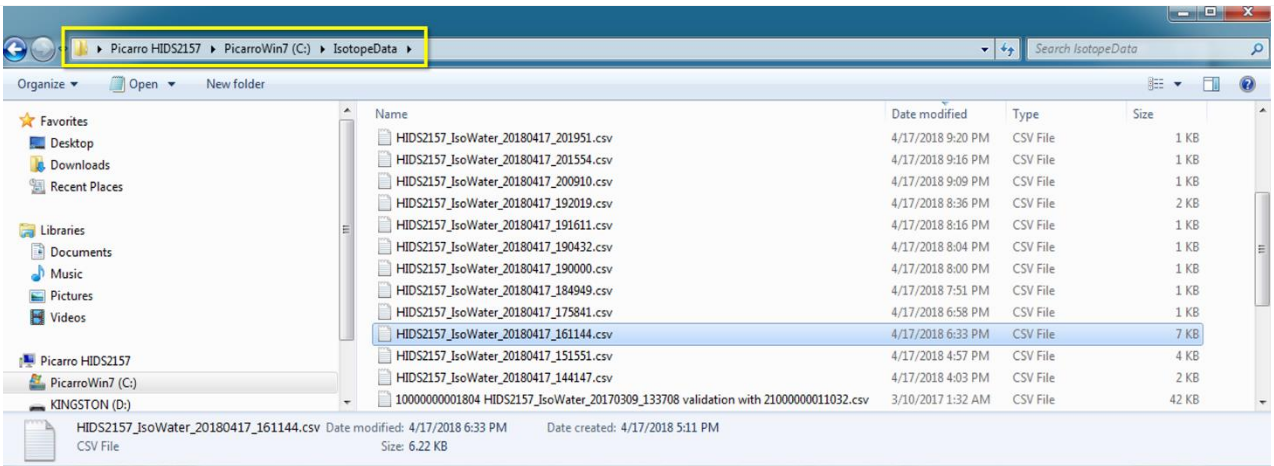
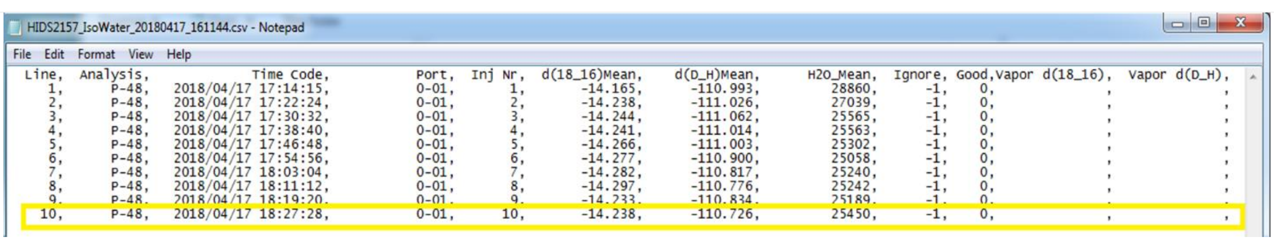


Figure 189. Picarro C:\IsotopeData .csv Validation Files.

STEP 4 | In the most recent *.csv IsoWater validation file, the last line indicates the last time the Autosampler Control program GUI ran. Reference **Figure 190** as an example. Be aware that a new file is generated each time that the injections are started.

Note: Port = Vial # - Visually check vial tray to verify last punctured cap to ensure it aligns with file Port #.



Line	Analysis	Time Code	Port	Inj Nr	d(18_16)Mean	d(D_H)Mean	H2O_Mean	Ignore	Good	vapor d(18_16)	vapor d(D_H)
1	P-48	2018/04/17 17:14:15	0-01	1	-14.165	-110.993	28860	-1	0		
2	P-48	2018/04/17 17:22:24	0-01	2	-14.238	-111.026	27039	-1	0		
3	P-48	2018/04/17 17:30:32	0-01	3	-14.244	-111.062	25565	-1	0		
4	P-48	2018/04/17 17:38:40	0-01	4	-14.241	-111.014	25563	-1	0		
5	P-48	2018/04/17 17:46:48	0-01	5	-14.266	-111.003	25302	-1	0		
6	P-48	2018/04/17 17:54:56	0-01	6	-14.277	-110.900	25058	-1	0		
7	P-48	2018/04/17 18:03:04	0-01	7	-14.282	-110.817	25240	-1	0		
8	P-48	2018/04/17 18:11:12	0-01	8	-14.297	-110.776	25242	-1	0		
9	P-48	2018/04/17 18:19:20	0-01	9	-14.233	-110.834	25189	-1	0		
10	P-48	2018/04/17 18:27:28	0-01	10	-14.238	-110.726	25450	-1	0		

Figure 190. IsoWater .csv file Open in Notepad Highlighting Last Validation Run.

STEP 5 | Open the **Autosampler Control** program (**Figure 192**).

Figure 192. Autosampler Control Program.

Under the **Job Queue** Tab for the **NEON1** configuration (**Figure 191**), adjust the configuration to start on the next line in the queue for validation.

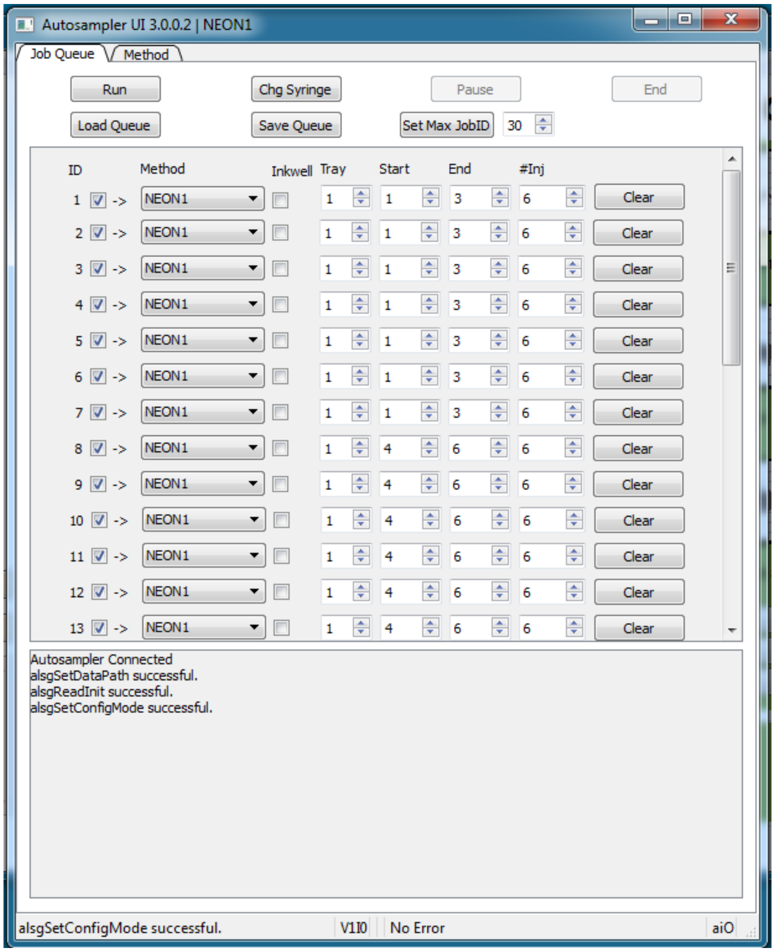


Figure 191. Autosampler Control Program GUI.

STEP 6 | Verify changes, that the correct boxes are checked, and select **Run** (**Figure 193**).

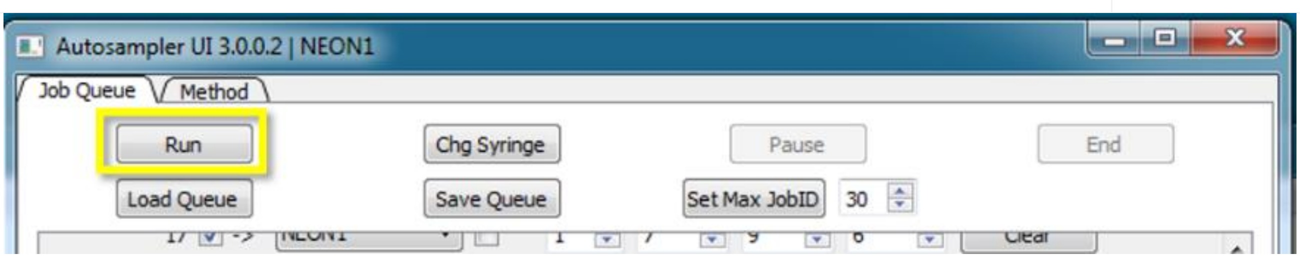


Figure 193. Select Run in Autosampler UI.

Figure 194. Open Coordinator Launcher.

STEP 7 | Open the **Coordinator Launcher**. Select **Dual Liquid/Vapor** from the dropdown options and click **Launch** (**Figure 194**).

STEP 8 | Set **User Editable Parameters** and click **OK** when complete (**Figure 195**).

- Number of liquid injections for calibration: **18**
- Vapor measurement time (hours): **23**
- Include ambient measurement in output file (0=no 1=yes): **0**

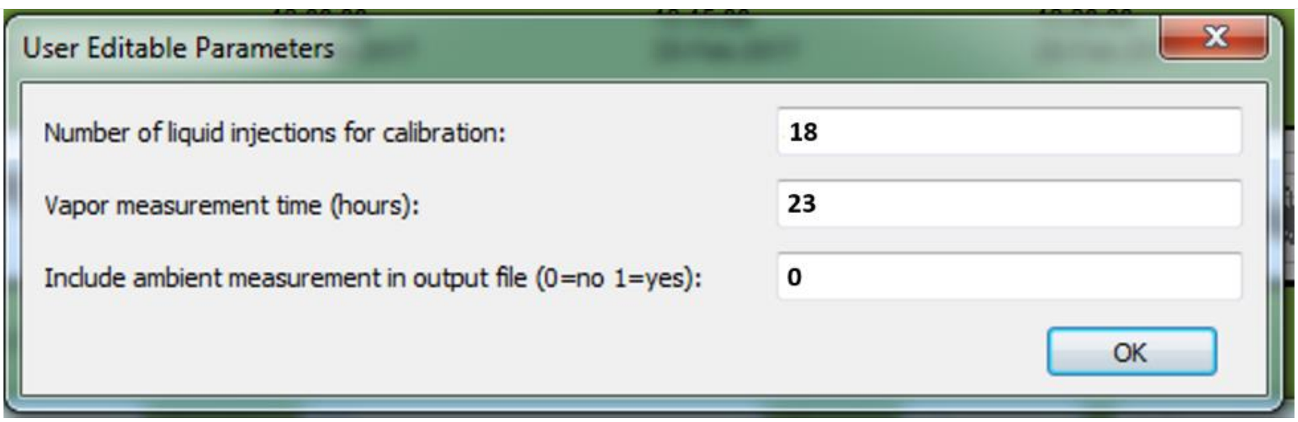


Figure 195. Edit User Editable Parameters.

STEP 9 | Verify the needle is picking up water samples and injecting them into the vaporizer. Pulses should be **~20,000 ppm** H2O via the Digital Readout area on the CRDS Data Viewer. *Reference Section 5.7.3.2.2 Step 15 to adjust pulses, if pulses are failing to reach ~20,000 ppm.* Ecologists may also view injection data logs via **C:/IsotopeData**. Each file contains a timestamp to review injections over time.

If the PICARRO Analyzer/Autosampler is not picking up water samples, submit an incident ticket in ServiceNow to conduct corrective action under the guidance of NEON HQ.

5.7.3.3.1 PICARRO L2130i Analyzer Module Particulate Filter and Orifice Replacement Procedure

Follow the procedure in

Table 39 per the direction of HQ.

Table 38. PICARRO L2130-I Analyzer Module Particulate Filter and Orifice Replacement Tools and Consumables.

Equipment & Consumable List	Quantity
11/16" end wrench	1
9/16" end wrench	2
5/8" end wrench	1
Crescent wrench	1
2 mm Allen wrench (or hex driver)	1
¼" FEP tubing (17') with1/4" male Swagelok fitting on each end	1
Squirt Bottle Commercial Brand Leak Check Fluid	1
Particulate filter	1
Orifice	1

Table 39. PICARRO Particulate Filter Maintenance Procedure.

STEP 1 | Acquire the necessary equipment and consumables from **Table 38**.

STEP 2 | Turn off CNC and log into PICARRO Analyzer via Windows remote desktop (see Section 9) or KVM.

STEP 3 | Power down the Analyzer per Section 5.7.2.3.

STEP 4 | Once instrument is powered off, shut off pump and disconnect all gas/vacuum lines, ethernet, and video cables. Be aware that the connection to the vaporizer has a very small line, exercise caution as it can be easily damaged.

STEP 5 | Carefully move the Analyzer to a flat, stable working surface, such as the Lista cabinet in the Instrument Hut.

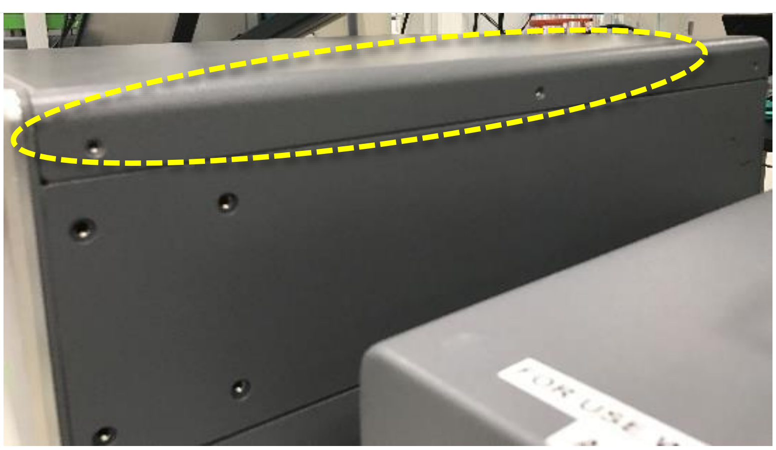


Figure 196. Remove Lid.

STEP 6 | Using a 2 mm hex driver, remove the top lid of the analyzer by removing six M3 x 6mm socket flathead screws.

There are three screws lining the top of each side on each side of the analyzer module (**Figure 196**). Place these screws in a secure location

Figure 197. Inside View of Picarro Analyzer Module.

STEP 7 | Remove the lid.

Figure 197 is an internal view of the Picarro Analyzer module.

Note: Do not touch the compartment on the right side of module in Figure 197.

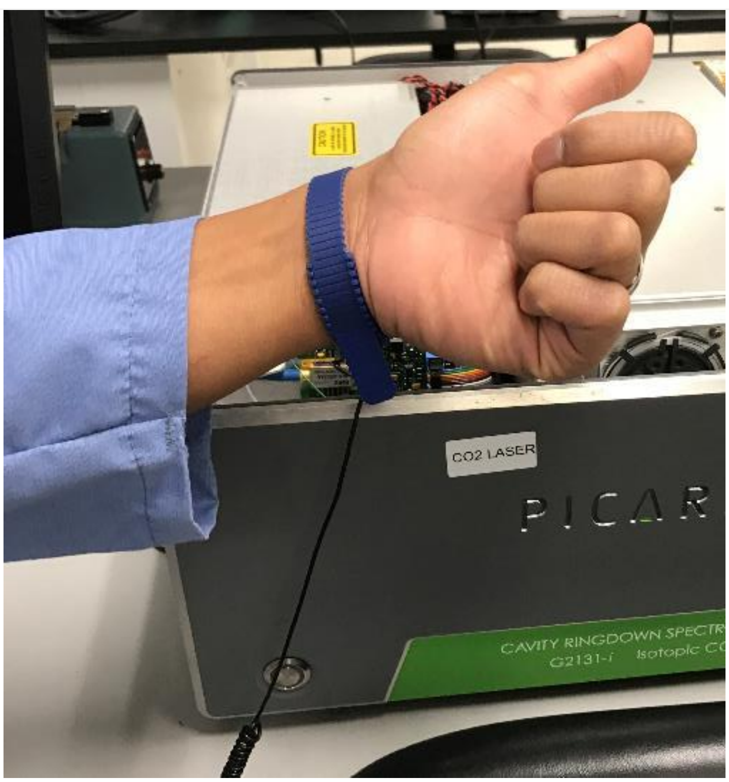
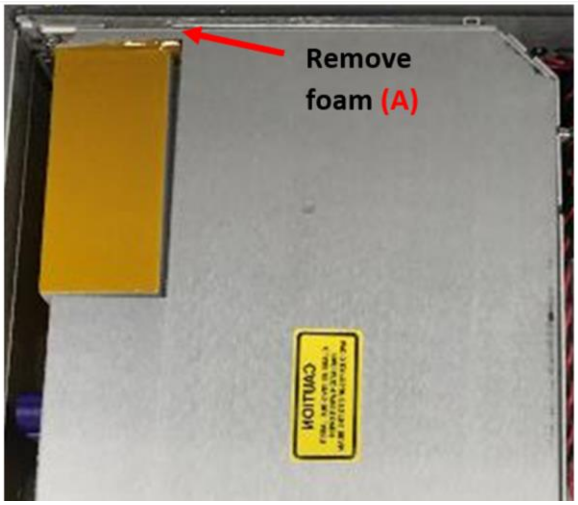


Figure 198. Wear an Anti-Static Wristband.

STEP 8 | **Wear an anti-static wristband tied to ground.**

Figure 198 provides an example of wearing an anti-static wristband connected to a grounding source.

STEP 9 | Remove the small foam **(A)** piece covering the bulkhead nut near the Picarro inlet. Loosen the bulkhead nut counter-clockwise using a 5/8" wrench, and then remove the second foam cover **(B)** by sliding towards the outside of the analyzer case. Reference **Figure 199** for this Step.



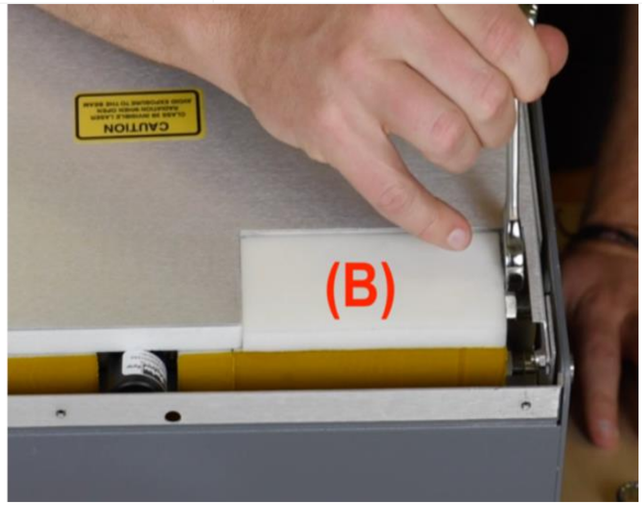


Figure 199. Remove Foam and Loosen Retaining Nut.

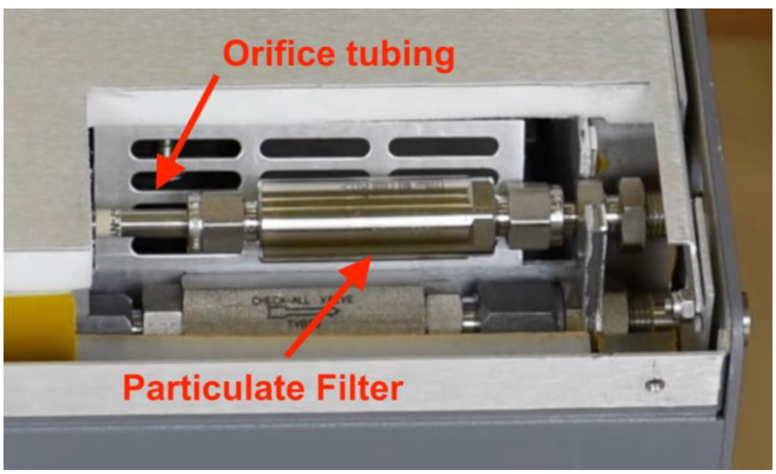


Figure 200. Foam cover removed.

STEP 10 | Removing the foam cover exposes the internal particulate filter and critical orifice fitting (**Figure 200**). These can be hot, exercise caution when handling these components

STEP 11 | Using the 11/16" and 9/16" end wrench. Loosen the nut at the right (inlet side) securing the particulate filter. Thread the nut off by hand once loosened by the wrench.

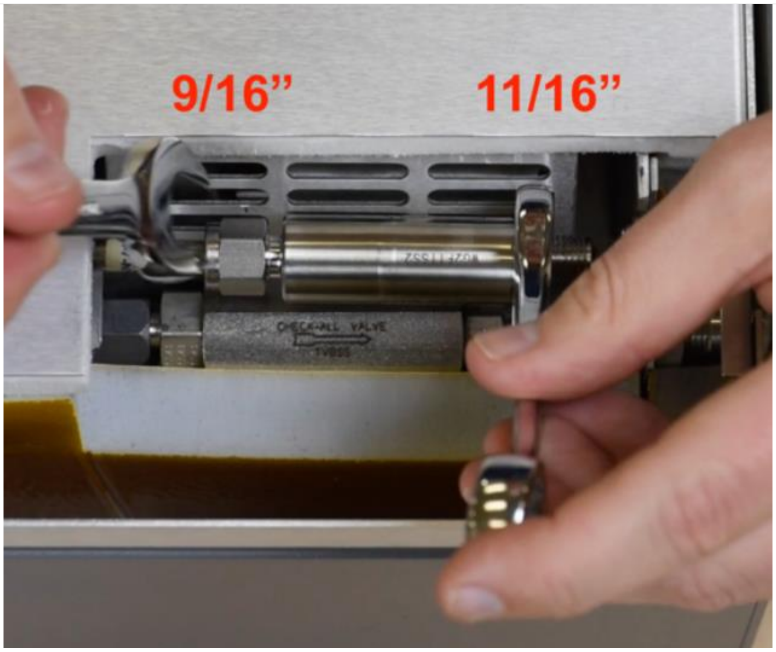


Figure 201. Remove Nut Securing Particulate Filter.

STEP 12 | Use the 11/16” on the flats of the filter (Fig 42) and loosen the other nut (9/16”) securing the particulate filter (**Figure 201**). Thread the nut off until you can remove the particulate filter. Set this aside.

If only replacing filter skip to **step 16.**

PRO TIP: Mark the old filter/orifice to prevent accidentally reinstalling them (mixing them up with the new one, since they look the same).

Figure 202. Loosen the Two Nuts Connecting to the Filter.

STEP 13 |Loosen the two nuts on the lid of the hot box – just enough to lift the lid (**Figure 202**).

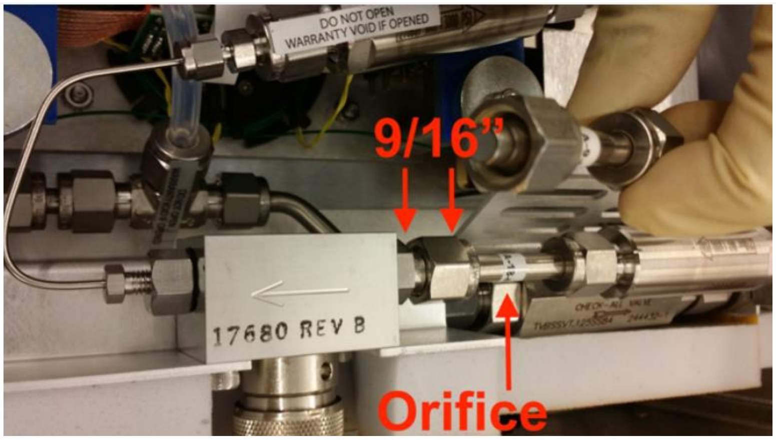


Figure 203. Loosen Orifice Nut to Remove Critical Orifice.

STEP 14 | Using **two** 9/16" wrenches, loosen the nut to remove the critical orifice (**Figure 203**).

Note: ***Observe the orientation of the lettering on the orifice, this is necessary to properly orient the replacement orifice in the next step.***

STEP 15 | Install the replacement orifice, matching the orientation of the lettering with the orifice that was removed in Step 14. Finger thread all fittings first, then tighten using a second wrench as a backer.

STEP 16 | Install the replacement particulate filter. An arrow etched onto the filter indicates the orientation of the filter with air flow (**Figure 204**). **The arrow will point towards the front of the analyzer when installed.** Finger thread all fittings first, then tighten using a second wrench as a backer.

Figure 204. The Arrow on the Particulate Filter must Point to the Front.

STEP 17 | Leak check the new installation of the particulate filter and critical orifice. *Reference Section 5.7.3.3.2 on Page 144 to complete this step.*

STEP 18 | Close the hot box and tighten the nuts to secure lid.

STEP 19 | Reinstall the foam cover to the filter and tighten retaining nut.

STEP 20 | Replace lid/screws and reinstall into instrument rack.

STEP 21 | Restart Analyzer and CNC. See Section 5.7.2.3 for Analyzer start-up instructions.

STEP 22 | Return used filter and orifice to CVAL HQ, C /O Doug Kath.

PRO TIP: A helpful video from PICARRO is currently available for replacing the internal filter (unfortunately the video does not include the orifice replacement): *https://www.picarro.com/videos/replacing_your_inlet_particulate_filter*

5.7.3.3.2 How to Leak Check the PICARRO Analyzer Particulate Filter/Critical Orifice

This procedure provides instructions on how to leak check the PICARRO Particulate Filter and Critical Orifice. Conduct this procedure every time the filter and/or orifice is replaced.

Table 40. Leak Check PICARRO Analyzer Particulate Filter and Critical Orifice Tools and Consumables.

Equipment & Consumable List	Quantity
¼" FEP Gas Line (to connect to ECTE Zero Air and PICARRO Analyzer Gas Inlet)	1
Squirt Bottle Commercial Brand Leak Check Fluid	1
NEON Laptop with latest version of the IS Control and Monitoring Suite Software	1
Sharpie Marker	1

Note: Field Ecologists must be able to access *https://www.picarro.com/videos/replacing_your_inlet_particulate_filter* *to complete this procedure.*

Table 41. How to Leak Check the PICARRO Analyzer Particulate Filter/Critical Orifice.

STEP 1 | Acquire the necessary equipment and consumables from **Table 40**.

STEP 2 | With **CNC still OFF**, open the IS Control and Monitoring Suite Software and select applicable site and Domain.

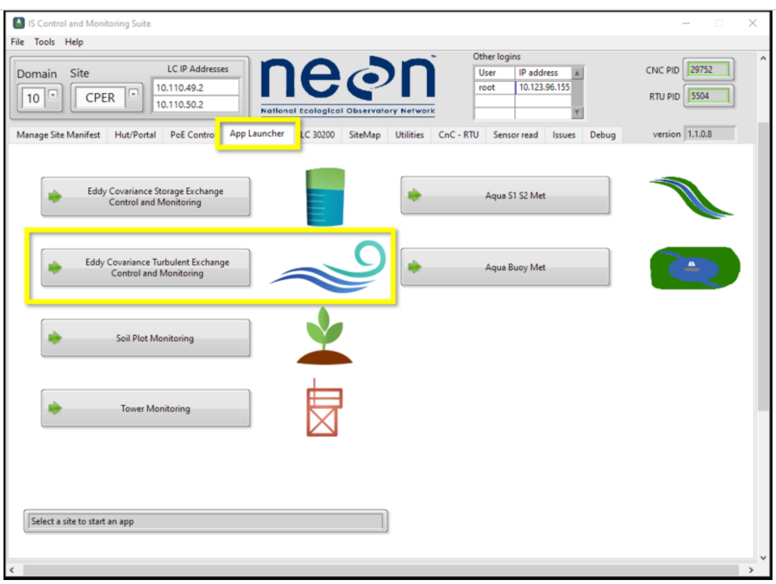


Figure 205. App Launcher Tab: ECTE Control & Monitoring Button.

STEP 3 | Open the **App Launcher** tab and select **Eddy Covariance Turbulent Exchange Control and Monitoring** button (**Figure 205**).

STEP 4 | To set the delivery pressure for leak checking, follow the 1-5 numbering in **Figure 206**.

1. Set the sample MFC setpoint to zero by typing 0 into the field.

2. Set the tower validation MFC to 1.5 SLPM.
3. Open the tower top validation valve for the zero air.
4. Then open the hut validation valve for zero air.
5. Reduce delivery pressure down to ~20 kPa by slowly turning knob by small increments on regulator counterclockwise. Wait between changes until it is stable.

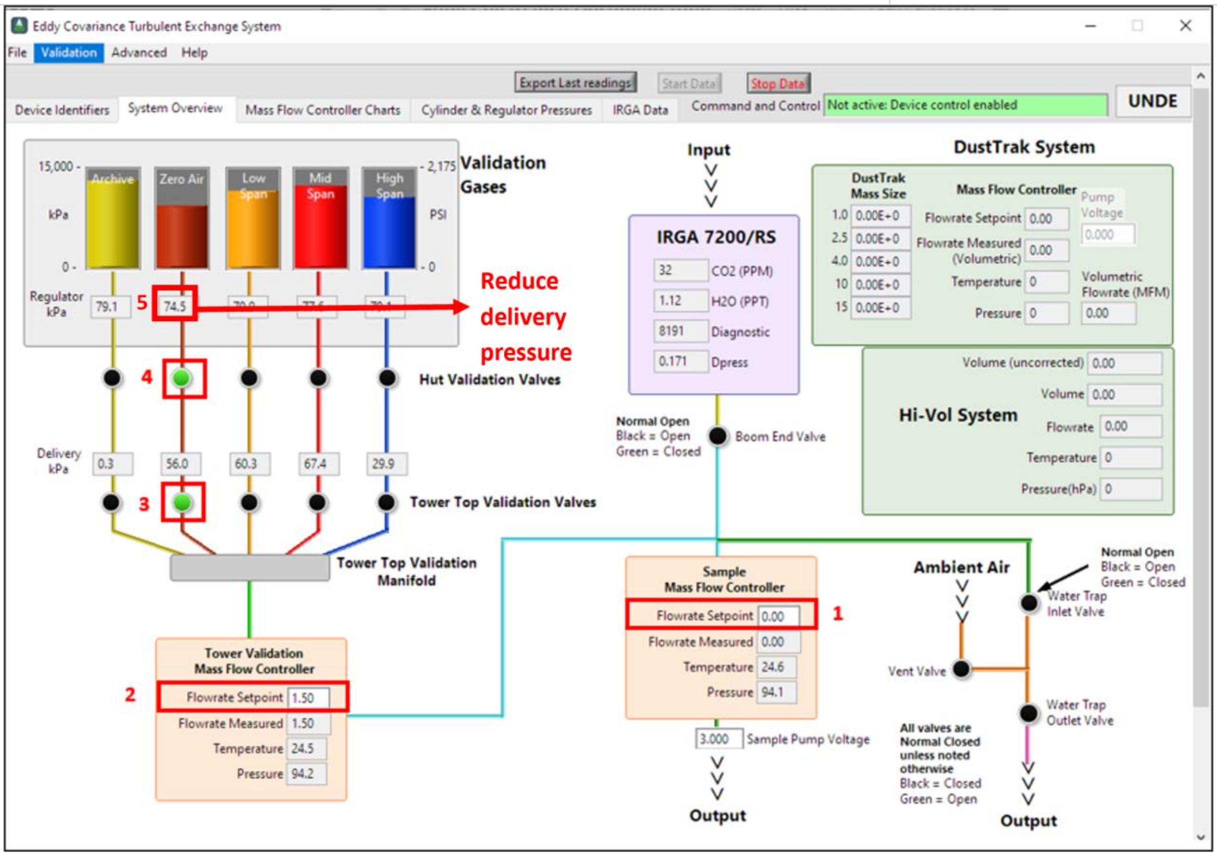


Figure 206. To Set Delivery Pressure for Leak Checking: Follow the 1-5 Numbering in Red.

STEP 5 | Once delivery pressure has stabilized at 20 kPa, close the cylinder hand valve by **turning it clockwise** until it stops.

Wait a few minutes while the remaining pressure bleeds from the system (flowrate measurement will read zero on the tower validation MFC).

STEP 6 | Mark the nut and fitting body with a sharpie and disconnect the ¼" gas line with 9/16" wrench on the ECTE regulator. (See **Table 16** in Section 5.5.1.9 for an illustration of this mark.)

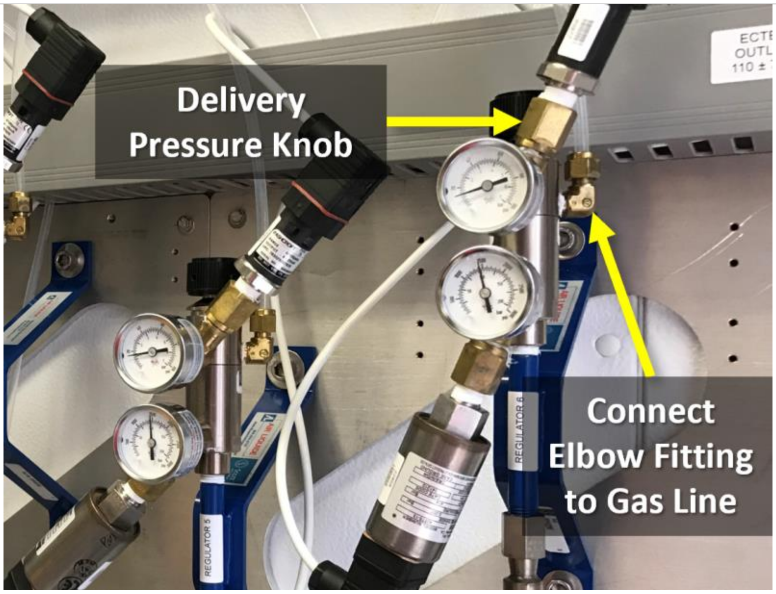


Figure 207. Connect Supplied Line to Regulator.

STEP 7 | Connect the supplied line to the fitting on the regulator (**Figure 207**) and the other end to the Picarro inlet fitting (**Figure 208** below).

Figure 208. Connect Supplied Gas Line to PICARRO Inlet to Leak Check.

STEP 8 | Once both ends of the gas line are secure, slowly open (**counterclockwise**) the hand valve on the zero air cylinder.

STEP 9 | Leak check the filter and orifice fittings by carefully placing several kimwipes under the fitting and applying a few drops of leak check fluid. If bubbles or foam appear after several minutes, carefully tighten fitting until leak free.

PRO TIP: Video of this available from Picarro at 5:20 minute mark: *https://www.picarro.com/videos/replacing_your_inlet_particulate_filter*.

STEP 10 | When complete, close the hand valve on the cylinder. Disconnect the temporary gas line from the Picarro and ECTE regulator. Low pressure air will bleed out when nut is loosened on either end.

STEP 11 | Reinstall the cover as specified in Step 5 in **Table 38** and reinstall the Picarro into the rack making all gas, vacuum, and other required connections.

Note: As a reminder, always turn on the PICARRO pump FIRST, then power on the Analyzer when power the system back up.

STEP 12 | Reconnect the ECTE zero air validation line to the regulator, tightening to just past the match marks made on the fitting (Step 6).

STEP 13 | Open the cylinder hand valve, readjust the delivery pressure to ~70kPa per instructions in Steps 3 and 4 above and leak check the fitting.

STEP 14 | Turn on the Picarro pump on FIRST, then power the instrument back up. Be aware, it may take up to an hour for the Analyzer to warm up.

STEP 15 | Log back into the Picarro via Remote Desktop (*see Section 9 for instructions on remotely logging into a PICARRO Analyzer*) and monitor startup. The instrument will display no alarms orCO_2 dry concentration values when entering measurement mode (**Figure 209**).

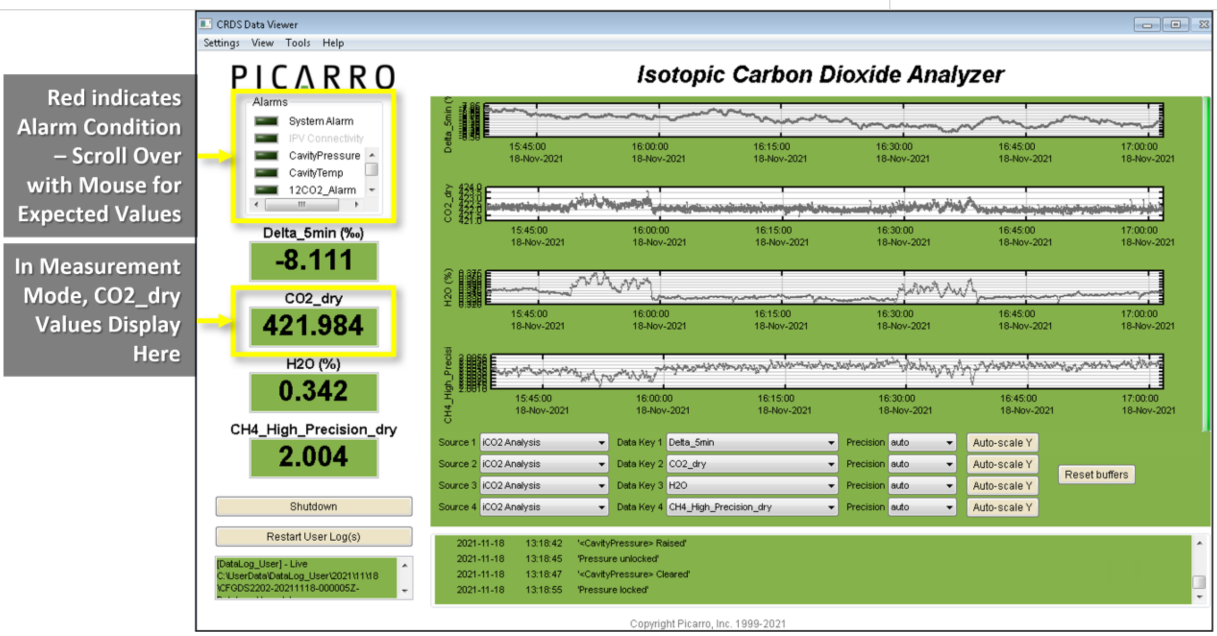


Figure 209. PICARRO Alarms and CO2_dry Values.

*Note: If issues arise after adequate warm up time, click **Shutdown -> Stop Analyzer Software Only -> Ok.** Wait at least a minute. Then double-click the **Start Instrument** icon on the desktop. If issues remain, contact Advanced Engineering for assistance.*

STEP 16 | Once the PICARRO is streaming, restart CNC.

5.7.3.3.3 PICARRO Analyzer Module Fan Maintenance Procedure

See Section 5.7.2.1 PICARRO Analyzer Module Fan Maintenance Procedure. This procedure applies to both PICARRO Analyzer Modules for both Isotopic CO_2 and H_2O.

5.7.3.4 PICARRO L2130-I Analyzer for Isotopic H_2O Replacement Instructions

Use the following procedures to replace the PICARRO L2130-I Analyzer for Isotopic H_2O.

Table 42. PICARRO L2130-I Analyzer Module for Isotopic H_2O Replacement Tools & Consumables List.

Equipment & Consumable List	Quantity
11/16" wrench	1
9/16" wrench	1
Screwdriver	1

1. Acquire the equipment in Table 42.

2. Follow the steps in Section 5.7.2.3 to replace the analyzer and the pump. Then proceed to Step 3.

3. Connect the electrical connections from the back of the Autosampler to the back of the Analyzer and power source.

   a. Connect the blue cord from the Autosampler into the USB port on the back of the Analyzer Module (see Autosampler to Analyzer connection in **Figure 211**).

   b. The black Autosampler power cable connects to the Autosampler with the flat side facing up. Attach the cable to the AC/DC Transformer, which will connect to a power source. **DO NOT connect to power.**

4. Mount the vaporizer holder to the X Axis Stage: Check that it is the required 3" (76mm) distance from the outer edge of the right hand leg (from the front). Slide the vaporizer onto the vaporizer holder and tighten the screws (**Figure 210**). (If the vaporizer is in its holder, disconnect the vaporizer holder from the vaporizer by loosening the two and sliding it out before mounting.)

Figure 210. Mounting the Vaporizer to the Bracket on the Autosampler.

5. Attach the zero air gas Line to the Vaporizer. Attach the gas line to the open third leg of the gas line that connects the vaporizer purge and the sample ports (which ships connected to the vaporizer).

6. Attach the (zero air) Gas Line to the Analyzer. Attach a Gas line from the “**WLM Purge**” Port on the Analyzer, which connects to a zero air gas cylinder. To connect 1/4” dry gas tube to the Wavelength Monitor Purge (WLM Purge) Port on the Analyzer, use the Push Connector that is attaches to the port. The connector is in two pieces: The Outer Flap and the Inner Flap.

    a. To connect the tube to the port, simply push the tube into the connector and then pull the tube back. If there is a space between the inner flap and the outer flap, this means that the tube locked to the port. Do not twist and turn.

    b. To take the tube out of the port, push the Outer Flap in against the Inner Flap, and while doing this, pull out the tube. This will cause the gripping mechanism to release from the tube.

7. Attach the External Vacuum Pump to the Vaporizer. An additional External Vacuum Pump, a hose with fittings attached, and a power cord come with the vaporizer.

    a. Attach the hose at the vaporizer’s vacuum port and connect to the External Vacuum Pump.

    b. Attach the power cable to the External Vacuum Pump, **but DO NOT apply power**.

8. Connect the Vaporizer and the Analyzer using a Grey Cable (in dark blue in **Figure 211**).

    Attach the 15-pin end of the grey valve cable to the port labelled “**Vap Valves**” on the vaporizer and connect to the port labeled “**Valves**” on the analyzer (third connector from the left at the bottom row of the Analyzer).

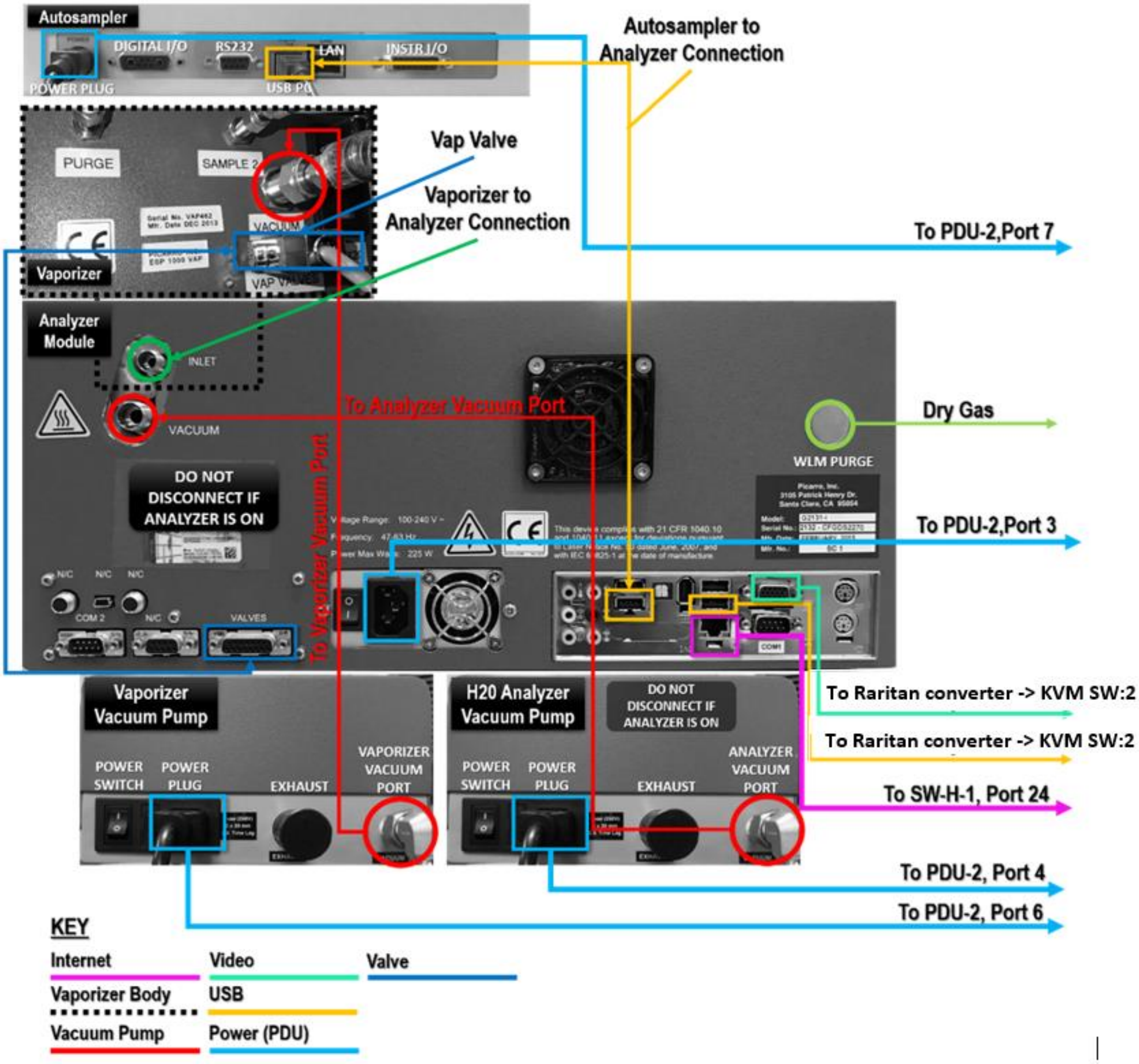


Figure 211. Rear Connections for Autosampler, Vaporizer, and the Analyzer *(Not Shown: Vaporizer Power Plug (the Vaporizer connects to PDU-2, Port 5) & Power Switch to the right of the Vacuum Port and Vap Valve).*

9. Connect the Vaporizer and the Analyzer with a 1/16th" tube. Carefully align the analyzer and the Autosampler relative to each other such that the 1/16th inch tube hanging from the vaporizer connects to the "**Inlet**" port on the analyzer (in dark green in **Figure 211**). There is a small cover that protects this line, as it is fragile (**Figure 212**).

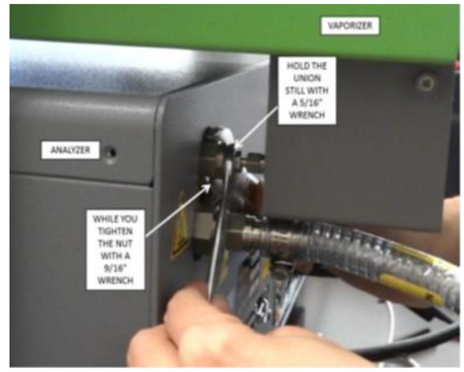


Figure 212. Inlet Port of the Analyzer with narrow diameter tubing and cover.

    a. Do not bend the 1/16th inch tube to achieve this connection. If the 1/16th inch tube is not horizontal with the DAS inlet port, then gently move the position of the vaporizer on the Autosampler by loosening the clamps and retightening them after alignment. Connect the vaporizer to the analyzer by hand tightening the locking screw first, and then using a 9/16" wrench to tighten it further. **It is important to seat the vaporizer properly and tightly so that the injector port on the vaporizer does not move relative to the rest of the elements on the Autosampler.**

10. Carefully slide the complete system into position: small movement of the components relative to one another is OK, the units lock. Do not overly force movement and check for obstacles if the unit does not slide easily.

11. **Turn on the power in the following order**:

    1. ***Both External Vacuum Pumps***
    2. ***The Autosampler Power Supply***
    3. ***The Vaporizer Module***
    4. ***The Analyzer Module Power Switch***

Note: As the instrument is starting up, it is normal for there to be a delay in reporting data. This can take several minutes depending on how long it takes the internal temperature to reach its operating point.. Additionally, the data selection pull-down menus will not populate with the appropriate items until data is reports in the graph. This is typically less than 30 minutes, but depending on ambient temperature, the analyzer can take up to 1 hour to stabilize (for extremely cold sites it may take even longer).

5.7.3.5 ECSE Heated/Unheated Sample Air Inlet Cap (Tower System, Measurement Levels)

The NEON program equips the TIS Tower sites with heated or unheated air inlets to pull sample air into the ECSE system sensor instrumentation per site characterization requirements. Heat application for sites with colder temperatures prevents the accumulation of ice or potential rime ice obstructions to the inlet and critical flow orifice. The heating set point is low at a maximum 50 Watts, not to exceed heating of 70 Celsius to prevent stable isotope fractionation of the sample due to gas emission from the FEP tubing.

Note: Gases (CO_2, water vapor, CH_4, etc.) under snow cover or during seasonal changes (fall, winter, and winter spring) may be important for some researchers. Therefore, please keep the ECSE ML1 inlet in situ and do not remove it along with 2D Wind and other ML1 sensors when preparing for winter operations.

5.7.3.5.1 ECSE Heated/Unheated Sample Air Inlet Cleaning & Replacement

Depending on environmental and atmospheric conditions, the 2-micron filter may require replacement. The replacement interval varies per site (it may be as often as every two weeks for sites with high pollen and particulate matter). Clean the air inlet orifice with every filter cleaning (reference **Figure 213** and **Table 43.** ECSE Heated Air Inlet for orifice and filter locations); obstructions may build up in the orifice or the process to clean the filter may stir up dirt/dust/pollen in the orifice and release into the system, which may cause obstructions in other areas of the system. Cleaning the stainless steel 2-micron filter and orifice is a multi-step, time-consuming process; therefore, NEON Engineering recommends having a spare air inlet to enable a one-for-one swap to conduct the procedures offsite at the discretion of the Domain schedule.

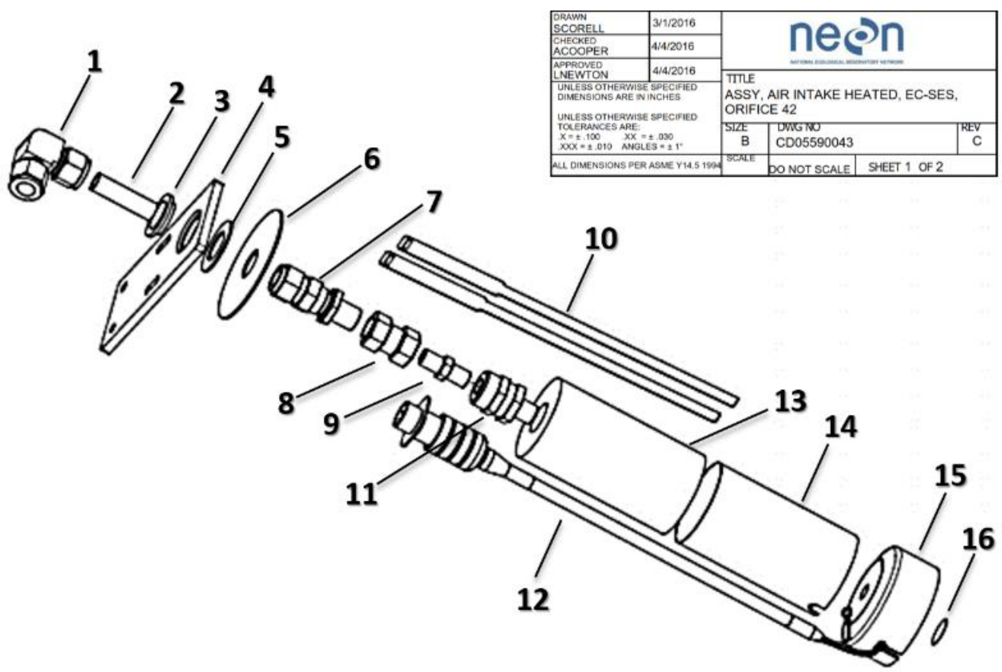


Figure 213. ECSE Heated Air Inlet.

Table 43. ECSE Heated Air Inlet Bill of Materials.

#	Description
1	Union Elbow, Stainless Steel Swagelok Tube Fitting
2	Tube, Seamless, .50” OD x .43” ID x 1.80” long, Stainless Steel
3	Spacer Teflon
4	Bracket, EC-SES Air Intake Assembly
5	Washer, Flat, 7/8” Screw Size, 1.5” OD, .057” -.067”, Thick Teflon (Spacer)
6	Rain Shield, Insulation, EC-SES Heated Air Intake
7	Fitting, Tube, Stainless Steel Bulkhead Male Connector, ½” Tube OD x 3/8” Male NPT
8	Fitting, Pipe, Stainless Steel, Hex Reducing Coupling, 3/8” Female NPT x ¼ Female NPT
9	Orifice Number 42, Hex Nipple, Size 0.042” Dia., ¼” MNPT Stainless Steel
10	Tie, Cable, .5” Wide x 3” Cable Dia., Aluminum
11	Inline Filter Welded, Stainless Steel, 0.25” Male NPT – Female NPT, Pleated Mesh Element 2 Micron Pore Size
12	Heated Inlet Cable, 12-3 Receptacle (part of Inlet Cap assembly)
13	Insulation, Pipe, Flexible, EC-SES Heated Air Inlet
14	Shield, Rain, Insulation, Wrapped, EC-SES Heated Air Inlet, Aluminum
15	Heated Air Inlet Cap
16	Screen, 316 Stainless Steel, 0.75” Dia., 100 x 100 Mesh, .0055” Opening, .0045” Wire Dia.

The inlet design aims to prevent condensation inside the sample tube for a range of environmental conditions our system may encounter at NEON TIS Tower sites by incorporating a critical flow orifice within the fittings of the inlet. A critical flow orifice is a tiny circular hole inside a tube or fitting that restricts and maintains a constant mass airflow. Its restriction is like that of an hourglass with the flow of sand through a small orifice in the middle; if the sand stays constant, the flow output is always the same. **Figure 214** is the critical flow orifice for the ECSE system air inlet.

Figure 214. ECSE Critical Flow Orifice.

A result of using a critical flow orifice is a drop in pressure from the ambient pressure flowing into the orifice (in comparison to pressure leaving the orifice). The critical flow orifice in the ECSE inlet creates an incoming pressure drop of 58.2% ambient pressure. This decrease in pressure sufficiently prevents the forming of condensation within the sample tubing.

An inlet resides close to the end of each tower ML boom arm. Conduct the following procedures to maintain the Tower ML ECSE air inlets, referencing **Table 44** and

Table 45.

Table 44. ECSE Heated/Unheated Sample Air Inlet Tools & Consumables List.

Equipment & Consumables	Quantity
In-Line Filter Welded, SS, 0.25 in MALE NPT - FEMALE NPT Pleated Mesh Element 2 Micron Pore Size	1 per ML
Screen, 316 SS, 0.75" Dia., 100 x 100 Mesh, .0055" Opening, .0045" Wire Dia.	1 per ML
Orifice Number 42, Hex Nipple, Size 0.042 inch diameter 1/4 inch MNPT Stainless Steel	1 per ML
Tape, Thread, Low Density, PTFE Tape, Thread	1
Brush, Sieve, Black Polypropylene, Dia. 1 3/4", Lg. 6 1/4"	1
Brush, Stainless	1
Hydrogen Peroxide, Concentration 3.00%, Capacity 16 oz., Container Type Bottle	1
Wrench, Strap, 3.000 (76.2) Dia. Max., 12" Strap	1
Cleaner, Ultrasonic, Heated, 6" x 5.25" x 6" (L x W x H) with Sweep and Degas	1
Detergent, Anionic (Alconox)	1
Air Canned, Filtered to 0.2 Microns or other compressed air supply	1
Powder-free Nitrile Gloves	1 Pair
95% Ethanol	1
Cable Ties for Re-Installation of Inlet to ML	A/R
7/8" Wrench	1
15/16" Wrench	1
9/16" Wrench	1
DMM	1
Crescent wrench	2
3/4" Ratchet Wrench	1

Table 45. ECSE Heated Sample Inlet Filter, Orifice, and Fitting Cleaning & Replacement.

STEP 1 | Collect the tools and consumables to conduct this procedure via **Table 44**.

STEP 2 | Shut down CNC and ensure the ECSE ML Pump for the ML is not running. You can turn the pump to manual mode and adjust to zero once CNC is off. Reference AD [12] for additional information.

Figure 215. Disconnect ECTE Tubing on Tower Top ML.

STEP 3 | *For the Tower Top pivot boom arm only:* Use a 9/16" wrench to disconnect the ECTE tubing fitting (**Figure 215**). Retract the boom.

Reference AD [20] for information on retracting the tower top boom.

The ECTE pump should also be shut off to avoid bringing any debris into the ECTE system.

Skip this if retracting a profile boom. This step <u>only</u> applies to the tower top pivot boom arm.

For the profile boom arms, use a 3/4" ratchet wrench and cable winch to pull inlet toward tower.

Reference AD [20], NEON.DOC.004980 NEON Preventive Maintenance Procedure: Site Infrastructure for procedures to retract and extend the tower top ML pivot boom or profile boom.

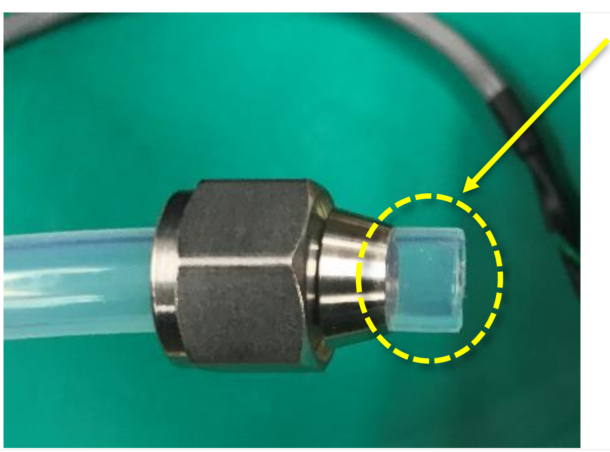
Figure 216. Remove ECSE Heated Air Inlet from Tower.

STEP 4 | Carefully cut any zip ties securing the heater cable and tubing on the boom arm necessary to remove the inlet.

Figure 216 is an example of an ECSE air inlet on the tower ML boom arm.

Figure 217. Remove Swagelok Fittings/Connections.

STEP 5 | Using two wrenches, remove the Swagelok fitting connecting the FEP tubing to the inlet (**Figure 217**).



STEP 6 | Cap/plug tube to prevent dirt/dust collecting in tube while conducting maintenance if a one-for-one swap did not occur.

NEON HQ recommends using the following Swagelok plug and cap:

- *SS-810-P 316 SS Plug for 1/2 in. Tube Fitting*
- *SS-810-C 316 SS Cap for 1/2 in. OD Tubing*

Nylon is sufficient in place of SS and in a pinch tape is OK to use, but do not use on a regular basis.

Figure 218. Cap/Plug FEP Tubing Post-Removal.

Figure 218 is an example of tubing without a cap or plug. Do not leave tubing without a cap or plug. If swapping the air inlet, disregard capping/plugging.

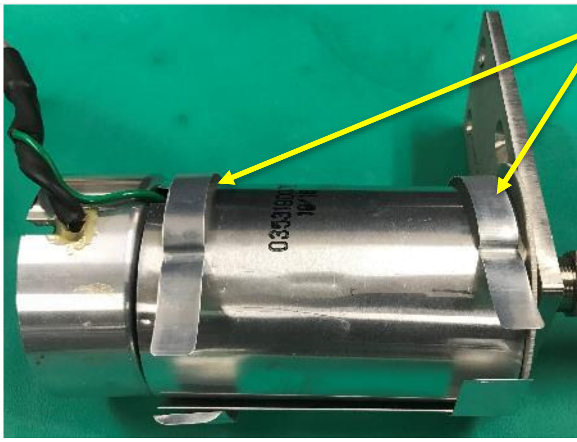


Figure 219. Remove Aluminum Cable Ties.

STEP 7 | Unlatch aluminum cable ties from the aluminum rain shield (**Figure 219**).

THIS STEP DOES NOT APPLY TO UNHEATED SITES.

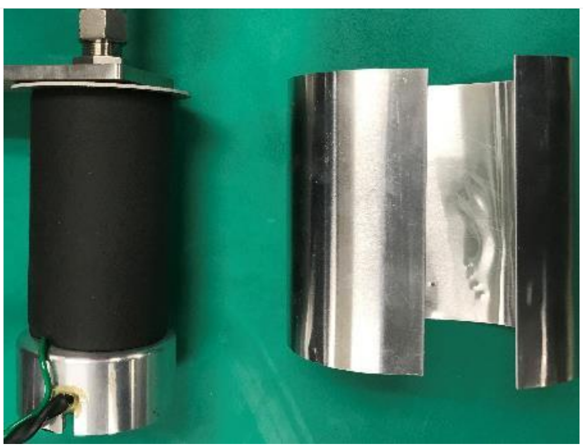


Figure 220. Remove Aluminum Rain Shield.

STEP 8 | Remove aluminum rain shield (**Figure 220**).

THIS STEP DOES NOT APPLY TO UNHEATED SITES.

Figure 221. Remove the Elbow Bracket.

STEP 9 | Remove elbow bracket using the two wrenches (**Figure 221**).

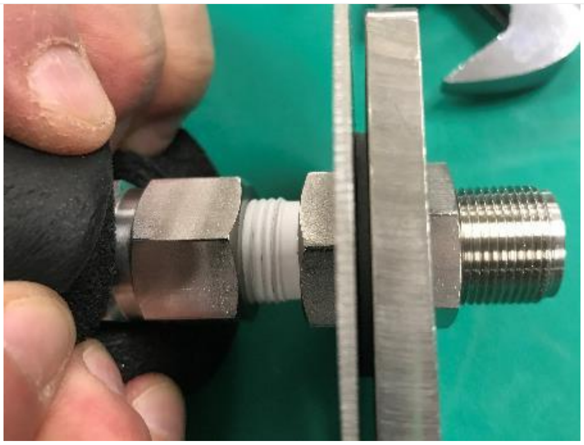


Figure 222. Pull Back the Black Insulation.

STEP 10 | Pull back the black insulation to fit the wrench to remove the nut securing the bracket (**Figure 222**). For unheated sites, ignore the parts regarding the insulation in these next few steps.

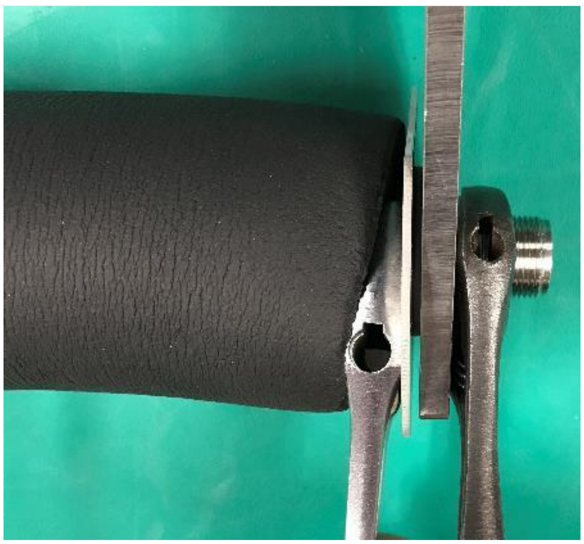


Figure 223. Remove the Bracket.

STEP 11 | Remove the bracket using a wrench to stabilize the right side and wrench to remove the nut on the left side (**Figure 223**).

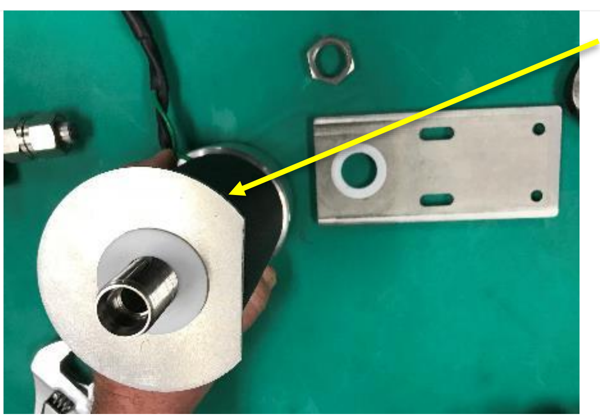


Figure 224. Remove Shield and Washer.

STEP 12 | Slide off the rain shield and washer and set it aside (**Figure 224**).

Note: To prevent loss of parts, collect and place parts of the inlet that do not require maintenance in tray/bucket for easy retrieval upon re-assembly.

THIS STEP DOES NOT APPLY TO UNHEATED SITES.

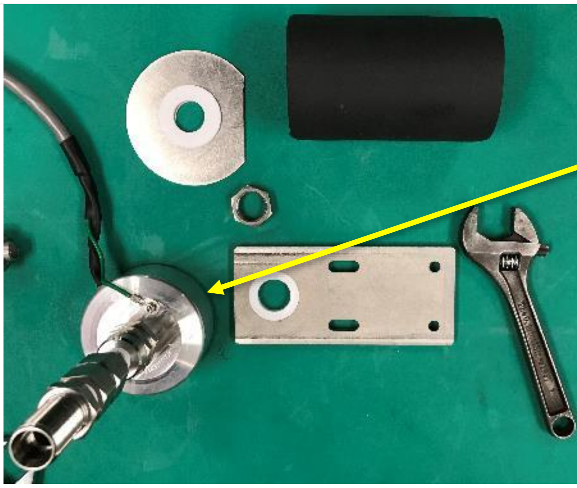


Figure 225. Remove the Black Insulation.

STEP 13 | Slide the insulation off the inlet assembly and set aside (**Figure 225**).

Note: The heated inlet assembly is identical to an unheated inlet with exception of the heated cap (unheated cap is smaller and does not a cable to connect to power the heating component).

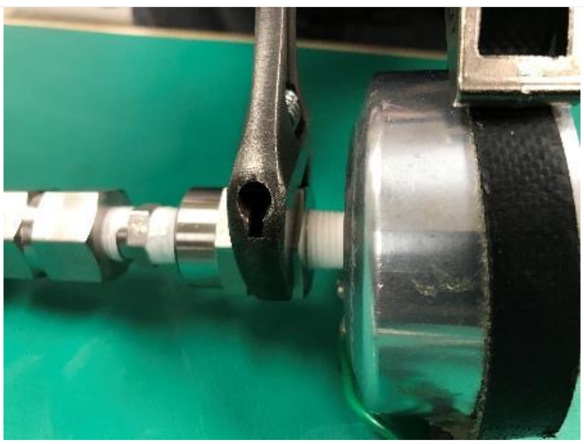


Figure 226. Remove the Heated Cap.

STEP 14 | Using a wrench strap to secure the cap, remove the nut with a wrench to separate the orifice from the heated cap. Reference **Figure 226**.

USE CARE WHEN UNSCREWING THE CAP ASSEMBLY FROM THE FILTER.

DO NOT ALLOW THE CABLE TO TWIST OR BEND EXCESSIVELY WHILE REMOVING THE CAP.

Figure 227. The Orifice and the Cap.

STEP 15 | Separate the orifice and the cap (**Figure 227**).

These two components of the air inlet require preventive maintenance.

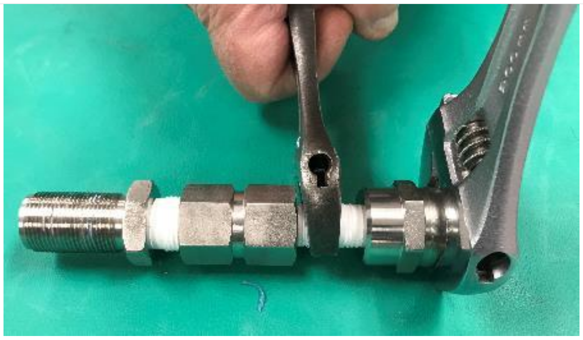


Figure 228. Disassemble the Orifice.

STEP 16 | Using two wrenches, disassemble the orifice fittings and nuts (**Figure 228**).

Figure 229. A Disassembled ECSE Orifice.

STEP 17 | Collect each piece of the inlet orifice for cleaning (**Figure 229**).

Do not lose any of these parts.

Figure 230. Use a Blunt Object to Remove Screen.

STEP 18 | Pop the screen out using a dull instrument from the cap.

Figure 230 displays a cable tie is sufficient.

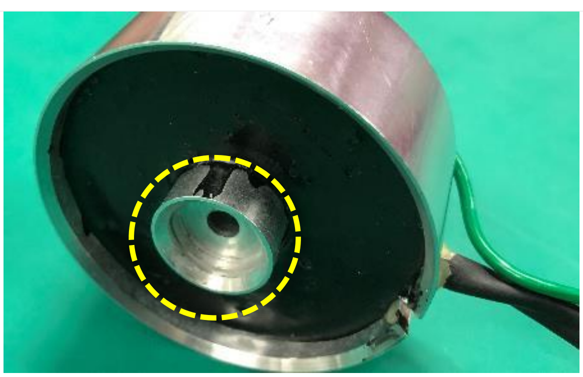


Figure 231. A Heated Inlet Cap without a Screen.

STEP 19 | Replace the screen with a new screen.

If a new screen is not available, clean the previous screen along with the fittings in an ultrasonic bath.

Figure 231 displays a cap without a screen.

Figure 232. Swagelok Filter with Flow Direction.

IMPORTANT NOTE: This is a Swagelok stainless steel in-line filter, 0.25 inch MALE NPT – FEMALE NPT pleated mesh element 2 micron pore size.

THIS PART MUST ALIGN WITH THE FLOW DIRECTION.

An arrow directly on the Swagelok part identifies the flow direction in **Figure 232**.

Figure 233. Use Compressed Air to Clean Filter and Fittings.

STEP 20 | Use compressed air to blow out any debris in the filter against the flow direction (**Figure 233**).

Conduct the same process with each orifice fitting.

Figure 234. Use Water to Clean Filter and Fittings.

STEP 21 | Remove the handle ring from a tube brush and slide the non-brush end through the fittings. Pull the brush through; do not push the brush through the tube.

After, spray a water stream against the flow direction (**Figure 234**). Conduct the same process with each orifice fitting.

Clean the tube brush with warm soapy water.

Figure 235. Remove Teflon Tape (If Applicable).

STEP 22 | Remove any traces of old Teflon pipe sealing tape from the threads of the filter and orifice (**Figure 235**). A brush with stainless steel bristles may be used to help remove the old tape.

Conduct the same process with each orifice fitting, as applicable.

Figure 236. Remove Remaining Pieces of Teflon Tape.

STEP 23 | Pick off any remaining pieces of Teflon tape the brush was not able to remove (**Figure 236**).

Conduct the same process with each orifice fitting, as applicable.

Figure 237. Soak Fittings in 3% Hydrogen Peroxide Solution.

STEP 24 | Place filter, orifice, and 100-mesh screen in a solution of standard hydrogen peroxide (3% or diluted down to 3%) in a container (**Figure 237**) and soak for 2-3 days.

Figure 238. Rinse the Fittings and Filter Post-Soak.

STEP 25 | Rinse with a hot water spray in both directions post-hydrogen peroxide soak (**Figure 238**).

Rinse each orifice fitting and filter. Place filter in a small Nalgene (~100 mL) that is half full of hydrogen peroxide and shake vigorously for one minute.

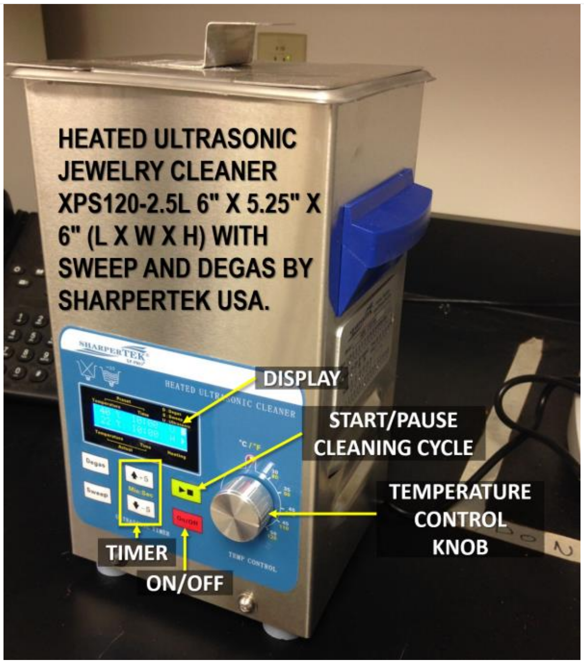


Figure 239. Clean Fittings and Filter in Ultrasonic Bath.

STEP 26 | Place filter, orifice, and 100-mesh screen in an ultrasonic bath (*0353770000*) containing a 2 oz. /gallon solution of Alconox (*0353840000*). Fill ultrasonic cleaner with cleaning materials and items requiring cleaning and close the lid. Plug in the system and set it to clean at a temperature of 45°C (115°F) for 60 minutes.

Figure 239 is a heated ultrasonic cleaner XPS with sweep and degas. Specifications:

- Ultrasonic Frequency: 40,000 Hz
- Tank Material: Stainless Steel
- Tank Capacity: 2.5 Liter, 2.7 Quarts
- Tank: 6"(L) x 5.25"(W) x 6"(H)
- Unit: 7"(L) x 6.43"(W) x 12"(H)
- Power Supply AC 100 ~ 120V, 50 / 60Hz
- Weight: 6 lbs.

For more information on this cleaner (how to use it), please reference ER [20]. Do not place parts or containers directly on the bottom of the cleaning tank; use tray/wire to suspend items.

Figure 240. Rinse the Fittings and Filter with Hot Water, Inspect Filter for Remaining Debris.

STEP 27 | Post-ultrasonic bath, rinse the filter, orifice and 100-mesh with a hot water spray in both directions (**Figure 240**).

Soak the filter briefly in de-ionized water, if available. Inspect each filter by shining a light into the inlet side of the filter (**Figure 240**).

If any debris remains on the pleated mesh filter, repeat Steps 25-28.

Figure 241. Place Fittings and Filter Vertically to Dry.

STEP 28 | Using compressed air, thoroughly dry the filter by blowing in both directions into the fittings and filter openings.

Place each fitting and the filter vertically, such as in **Figure 241**, and allow to dry overnight.

STEP 29 | Clean the channel in the inlet cap using a small wire tube brush (**Figure 242**), followed by a cotton swab soaked in 95% ethanol. You may need to apply ethanol to the opening from both sides and let sit for a few minutes. Continue until all debris is removed. Allow to dry before reassembly.

Figure 242. Clean Channel in Inlet Cap using a Small Wire Tube Brush.

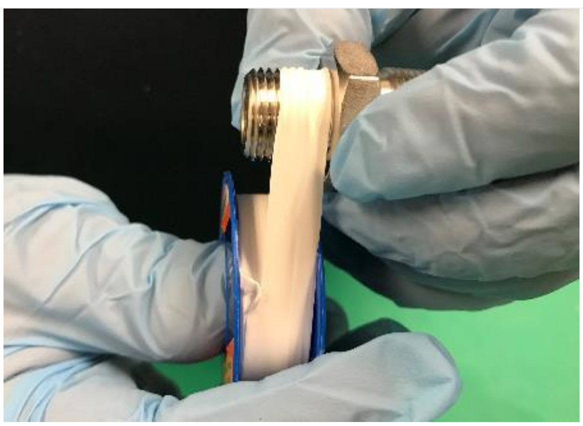


Figure 243. Wrap the Threads with Teflon Tape.

STEP 30 | Re-wrap the threads with Teflon tape, as necessary (**Figure 243**). Wrap in the direction of the threads to prevent the tape from unwrapping, as the fitting is threaded in.

Reference RD [05] or RD [06] for additional assembly instructions for heated and unheated air intakes.

Figure 244. Leave the Last Two Threads Bare.

STEP 31 | Leave taping within a half thread to two threads bare.

Figure 244 displays a fitting taped properly, leaving the last two threads free of tape. Leaving at least a half to two threads bare ensures remnants of tape do not enter the orifice and get trapped in the ECSE system MFMs, etc.

Figure 245. An Example of Bad Thread Taping.

Figure 245 is a consequence of taping all the threads of a fitting. A piece of tape has come off the end of the fitting and is laying directly in the middle of the air inlet orifice. This is a risk to the system as it may cause an obstruction in the system.

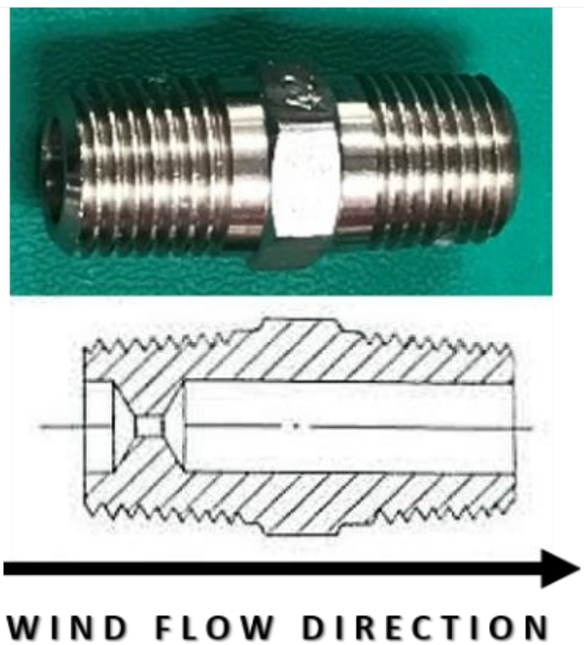


Figure 246. Air Flow Direction for Critical Flow Orifice.

STEP 32 | Reassemble the fittings, filter, and orifice. Maintain awareness of the direction of the airflow for the filter and orifice.

See **Figure 232** to reference the orientation of the filter and **Figure 246** to reference the orientation of the orifice.

If appropriate, reinstall the air inlet on the ML boom. (If a one-for-one swap did not occur.)

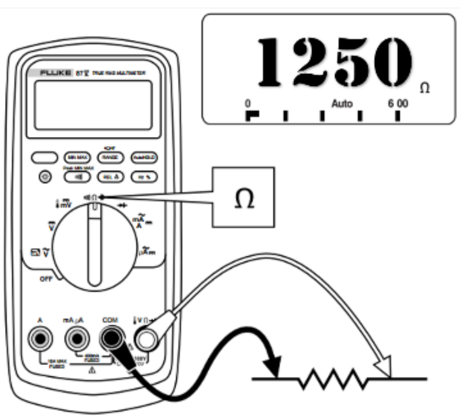


Figure 247. Use a Digital Multi-Meter to Measure Resistance.

STEP 33 | After installation/swap of a clean inlet, use a digital multi-meter (DMM) to measure the resistance of the heater element (cable), reading must be 1250 ± 15 ohms (**Figure 247**).

Insert red probe into A and black probe in B on the heater cable.

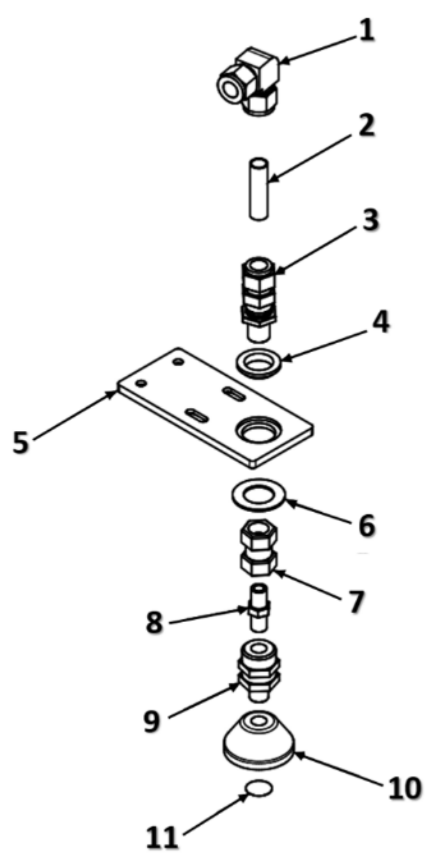
This is to verify the heaters function per NEON requirements to prevent the fractionation of sample air.

	THIS STEP DOES NOT APPLY TO UNHEATED SITES.
STEP 34 | Use the reverse order of this process to reassemble the heated or unheated air inlet.	

The cleaning procedure of the filter, fittings and inlet are the same for both the ECSE and the ECTE systems; however, the disassembly and reassembly of these systems differ. These filters can have an indefinite lifespan if maintained in accordance with the procedure.

Note: If one filter at a lower tower ML requires replacement, additional filters at upper levels may require immediate attention/replacement.

For the unheated ECSE air inlet, the same procedure above is applicable with exception of the heating components. The heater cable, aluminum cover and clamps, and foam cover are items not applicable to the unheated air inlet assembly. Reference **Figure 248** and continue the procedure skipping the applicable steps with heater components within the procedure.



DRAWN RMONTGOMERY	8/14/2014	neon	
CHECKED STOWER	8/14/2014		
APPROVED LNEWTON	8/14/2014	TITLE	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		ASSY, AIR INTAKE, EC-SES BOOM 42	
UNLESS OTHERWISE SPECIFIED TOLERANCES ARE: .X = ± .100 .XX = ± .030 .XXX = ± .010 ANGLES = ± 1°		SIZE B, DWG NO CD05560042	REV B
ALL DIMENSIONS PER ASME Y14.5 1994		SCALE, DO NOT SCALE	SHEET 1 OF 2

#	Description
1	Union Elbow, SS, Swagelok Tube Fitting
2	Tube, Seamless, .50" OD x .43" ID x 1.80" long, Stainless Steel
3	Fitting, Tube, Stainless Steel Bulkhead Male Connector, ½" Tube OD x 3/8" Male NPT
4	Spacer, Teflon
5	Bracket, EC-SES Air Intake Assembly
6	Washer, Flat, 7/8" Screw Size, 1.5" OD, .057"-.067", Thick Teflon
7	Fitting, Pipe, SS, Hex Reducing Coupling, 3/8 inch Female NPT x 1/4 inch Female NPT
8	Orifice Number 42, Hex Nipple, Size 0.042 inch diameter 1/4 inch MNPT Stainless Steel
9	In-Line Filter Welded, Stainless Steel, 0.25 inch MALE NPT - FEMALE NPT Pleated Mesh Element 2 Micron Pore Size
10	Cap, Screened Inlet
11	Screen, 316 SS, 0.75" Dia., 100 x 100 Mesh, .0055" Opening, .0045" Wire Dia.'

Figure 248. Exploded View of Unheated Air Inlet for ECSE System.

5.7.4 LICOR LI-840/850 IRGA

The LI-840/850 (Figure 249) is an absolute, non-dispersive infrared (NDIR) gas analyzer based upon a single path, dual wavelength infrared detection system. It is a closed-path gas analyzer with a 14cm (5.5") thermally stable optical path. It comprises of a detection range of 0-20,000ppm or µmol/mol (0-2%) for CO_2 and 0-80µmol/mol for H_2O (dry air to 36 °C dew point). It has internal thermistors and pressure transducers for temperature and pressure compensation and band broadening corrections. However, due to its dependance on the temperature, it is recommended to keep the hut door close all the time to maintain stable operating temperature for this IRGA.

Figure 249. LI-840/850 IRGA for ECSE System.

The NEON program uses the LI-840/850 as part of the ECSE system, for the vertical profile measurement of CO_2 and H_2O concentration for the ECSE system via TIS towers.

Please do not attempt to open and clean the LI840/850 IRGA optical bench. Only CVAL or repair lab should open and clean the optical bench, and then follow by a careful calibration thereafter under a controlled environment.

TECHNICAL SPECIFICATION	LICOR LI-840/850 IRGA
System Firmware	Version 2.1.0
Power	12-30VDC (14W maximum)
Operating Temperature	–20°C to +45°C; maintain optical bench at a constant of ~50°C
Relative Humidity Range	0 to 95% RH, Non-Condensing
Additional Components	Two Swagelok Fittings (on gas IN/OUT) and a Dongle

Note: Avoid direct exposure to sunlight or extremely high temperatures that may elevate the temperature inside the LI-840/850 case.

Why does NEON use the LI-840/850 in the ECSE system?

To understand the whole picture of carbon and water balance over an ecosystem, the ECTE flux data and the ECSE data collection rates must occur within a half hour period. The ECTE system sensor instrumentation collects CO_2/H_2O concentration measurements at a frequency of 20 Hz (a quicker frequency rate than most of the ECSE instrumentation). The incorporation of these data calculates into half hour timeframes.

Although PICARRO G2131-I instrument can also measure high precision CO_2/H_2O concentrations, due to the pneumatic purge and the Allan variance (or stabilization period) settling time for Isotopic CO_2/H_2O, it may take an upwards of ~10 minutes per ML or ~80 minutes to cycle back to the same ML for a site with eight MLs. Thus, the PICARRO instrumentation is unable to produce storage exchange flux in a half-hour timeframe.

The LICOR LI-840/850 has a faster pneumatic purge and Allan variance settling time than the PICARROS. Integration of the LI-840/850 into the profile system enables measurement collections on all eight levels on the tower within a half hour, and generation of storage exchange flux may occur in a half hour timeframe. This enables compatible surface exchange measurements between the ECSE and ECTE system for accurate bio-meteorological science modeling.

In summary, the LI-840/850 calculates the storage of CO_2 and H_2O within the canopy in a faster response time to align with the ECTE instrumentation measurements. As a result, each ML can sample multiple times within a flux calculation period (30 minutes).

The LI-840/850 requires minimal preventive maintenance; it contains a user serviceable optical bench. NEON HQ does not anticipate field preventive maintenance for this component currently. Please do not open this sensor and clean the optical bench in the field. The sensor should be recalibrated at CVAL lab if opened. LICOR estimates these instruments may last up to 2+ years in continuous operation. Monitor the system for abnormal values, function, and report any discrepancies in function or spikes in data collection.

5.7.4.1 LICOR LI-840/850 IRGA Removal and Replacement Procedures

Table 46. LICOR LI-840/850 IRGA Tools & Consumables List.

Equipment & Consumables	Quantity
Crescent wrench	1
Flat head precision screwdriver	1

1. Acquire the equipment in **Table 46**.

2. Shut down the ECSE IRGA Pump. Reference AD [12] for additional information.

3. Disconnect the Grape Ethernet cable (ECSE Grape #2),

4. Disconnect cable from the EEPROM adaptor by loosening the two screws securing the RS-232 cable to the adaptor. **Keep EEPROM adaptor connected and with the IRGA**

5. Disconnect power supply from the IRGA by pulling the green terminal strip out of the socket on the IRGA.

6. Disconnect the inlet and outlet (vacuum) lines with crescent wrench. **Ensure these lines are labeled "In" and "Out" to avoid mistakes when attaching lines to the replacement IRGA.**

7. Cover the air inlet and outlet ports with the dust caps or attached to a sample line when the instrument is not in use. This will prevent dust from entering the instrument downstream from the filters where it can enter the optical path.

8. Remove the caps from the LI-840/850 input and output flow connection ports and place into location on the instrument rack

9. Connect the RS-232 cable to the EEPROM adaptor and secure screws

10. Connect sample and vacuum lines and carefully tighten.

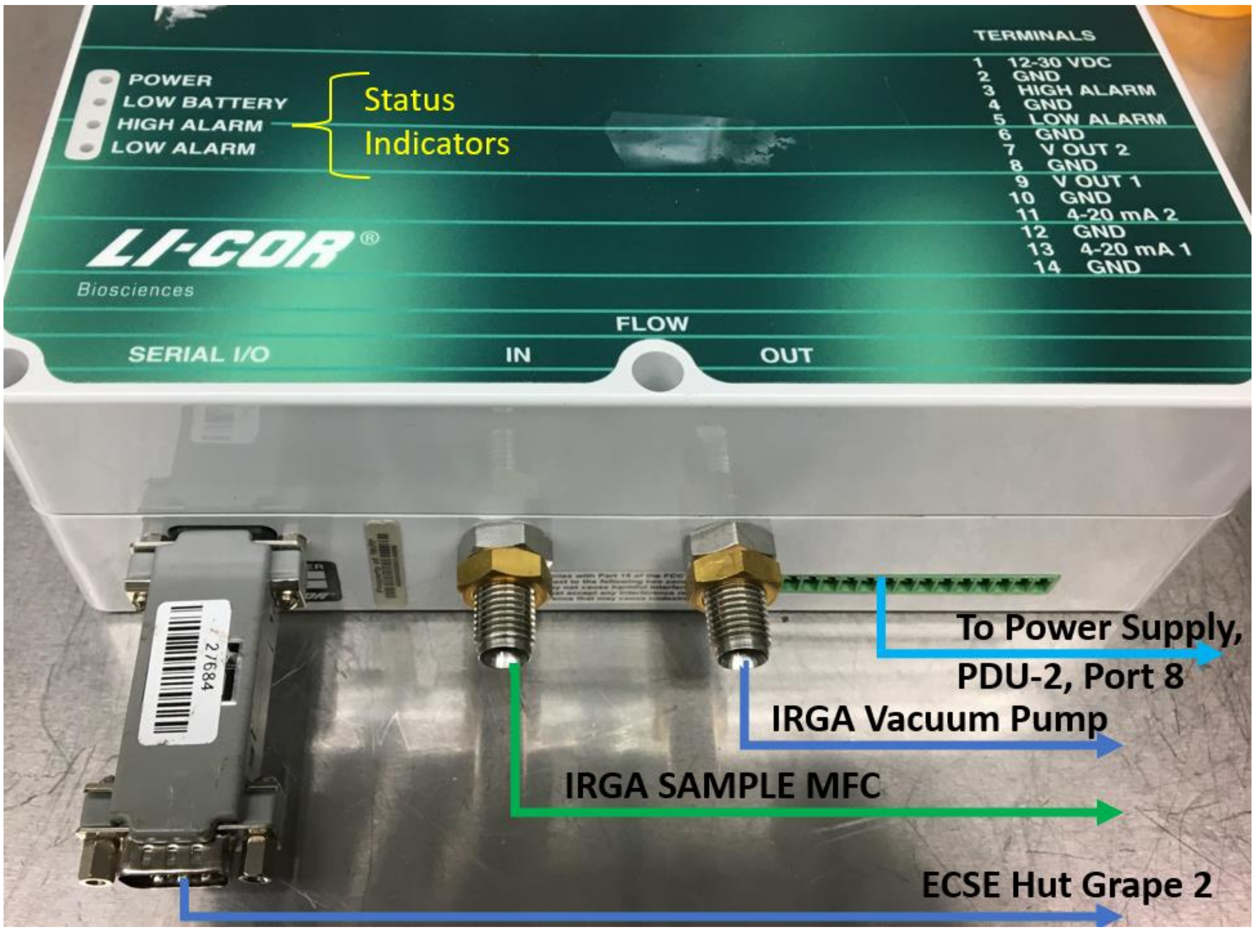
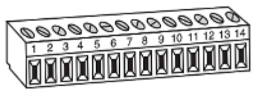


Figure 250. LICOR LI-840/850.

11. Connect external power source via the Terminal Strip (**Figure 251**). The LI-840/850 requires an input voltage of 12-30 VDC. The supply must source a maximum current drain of 1.2A (at 12 VDC). (After the instrument warms up, it draws about 0.3A (at 12 VDC) with the heaters on.)

12. Reconnect the ethernet cable to the ECSE Grape #2 and confirm the instrument is streaming via the LC.



The terminal positions are as follows, reading from left to right:

Terminal	Label	Description
1	12-30 VDC	Voltage In, 12-30 VDC
2	GND	Ground
3	High Alarm	High Alarm
4	GND	Ground
5	Low Alarm	Low Alarm
6	GND	Ground
7	V OUT 2	Voltage output channel 2
8	GND	Ground
9	V OUT 1	Voltage output channel 1
10	GND	Ground
11	4-20 mA 2	Current output channel 2
12	GND	Ground
13	4-20 mA 1	Current output channel 1
14	GND	Ground

Figure 251. LI-840/850 Terminal Strip Labels, Locations & Descriptions (only pins 1 and 2 are used for power, others unused).

5.8 Eddy Covariance System Calibration and Validation Processes

To minimize data downtime and optimize the availability of viable data, coordinate instrumentation and subsystem **annual** calibration, validation, and preventive maintenance requirements to occur within the same timeframe. **Table 47** provides a summary of the ECSE and ECTE instrumentation and subsystems ***calibration requirements*** (below). **Table 48** provides a summary of the ECSE and ECTE instrumentation and subsystems ***validation requirements*** (also below). Validation of calibration must occur after annual calibrations of all instrumentation and on a biweekly basis for the PICARRO L2130-I Analyzer for Isotopic H_20, Autosampler in the field.

Table 47. ECSE & ECTE Instrumentation Calibration Requirements.

	LOCATION		TIMEFRAME			
	CVAL	***FIELD***	***BIWEEKLY***	***ANNUAL***	***NA[1]***	**COMMENTS**
PICARRO L2130-I Analyzer for Isotopic H_2O		**X**		**X**		See Table 49 for annual calibration requirements.
PICARRO A0211 (Vaporizer)					**X**	
PICARRO Auto-Sampler					**X**	
PICARRO G2131-I Analyzer for Isotopic CO_2	**X**			**X**		Requires ESD packaging, see AD [24] for packing requirements. Cap inlet and vacuum pump ports prior to packing/shipping.
LICOR LI-840/850 (IRGA)	**X**	**X***		**X**		*LC CNC maintains and monitors zero and high span for LI-840/850

[1] Initial calibration set via manufacturer or CVAL; no continuing calibration requirements are necessary for preventive maintenance. Calibration or validation may be necessary for corrective action purposes (this is determined on a case-by-case basis via the NEON HQ Issue Reporting/Management System).

	LOCATION		TIMEFRAME			
	CVAL	***FIELD***	***BIWEEKLY***	***ANNUAL***	***NA***[1]	**COMMENTS**
						via a weekly-automated calibration process or after the detection of a pressure spike. Requires ESD packaging, see AD [24] for packing requirements. Do not send the instrument to CVAL without its Dongle and Swagelok connectors on IN/OUT ports.
Campbell Scientific CSAT3 with Cable and Electronic Box					**X**	CVAL conducts annual validations on this sensor. *See Table 48.* Reference AD [24] for Sensor Refresh Packing Requirements. Always send the CSAT3 to CVAL with its cable and the Electronics Box with its mount clamp.
Attitude and Motion Reference System (AMRS)					**X**	The AMRS and cable together are one assembly. Never remove its cable.
LICOR LI-7200/RS (IRGA) and LI-7550 Analyzer Interface Unit	**X**			**X****		**Sensor swaps occur on a **biannual basis** for this instrument. ***NEVER use the LICOR Software.*** Requires ESD packaging, see AD [24] for packing requirements. Always send the LI-7200/RS and LI-7550 together.
COMET T7610 Temperature Monitor					**X**	
						INSTRUMENTATION SUBSYSEM
Associated Sensor Grapes	**X**			**X**		Concords, Merlots, and Catawbas only. Follow ESD Protocols.

Table 48. ECSE & ECTE Instrumentation Validation Requirements.

	LOCATION		TIMEFRAME			
	CVAL	***FIELD***	***BIWEEKLY***	***ANNUAL***	***NA***	**COMMENTS**
PICARRO L2130-I Analyzer for Isotopic H_2O		**X**				23.5 hour Routine Validation, Humidity Dependency Validation Field Test *(Source: AD [10]). See Table 49 for validation requirements. See Communication Protocols with CVAL per Section 10, Appendix C.*
PICARRO A0211 (Vaporizer)					**X**	
PICARRO Auto-Sampler		**X**	**X**			Field Science trains the Autosampler, adjusts the Sample Volume (uL) and changes the injection needle and Septa every 30 days, at a minimum.
PICARRO G2131-I Analyzer for Isotopic CO_2		**X**		**X**		CNC 23.5 hour Routine Validation in the field. Requires ESD packaging, see AD [24] for packing requirements. Cap inlet and vacuum

	LOCATION		TIMEFRAME			
	CVAL	***FIELD***	***BIWEEKLY***	***ANNUAL***	***NA***	**COMMENTS**
						pump ports prior to packing/shipping.
LICOR LI-840/850 (IRGA)		**X**				CNC 23.5 hour Routine Validation in the field.
Campbell Scientific CSAT3 with Cable and Electronic Box	**X**			**X**		See AD [24] for Sensor Refresh Packing Requirements. Always send the CSAT3 to CVAL with its cable (contains the sensor's 1-wire chip) and the Electronics Box with its mount clamp.
LICOR LI-7200/RS (IRGA) LI-7550 Analyzer Interface Unit		**X**				CNC 23.5 hour Routine Validation in the field. ***NEVER*** ***use the LICOR Software.*** Requires annual calibration via CVAL, *see Table 47.*
COMET T7610 Temperature Monitor					**X**	
						INSTRUMENTATION SUBSYSEM
Associated Sensor Grapes	**X**			**X**		Concords, Merlots, and Catawbas only. Follow ESD Protocols.

5.8.1 ECTE Routine Validation Process

Figure 252 charts an overview of the gas flow for the ECTE Validation.

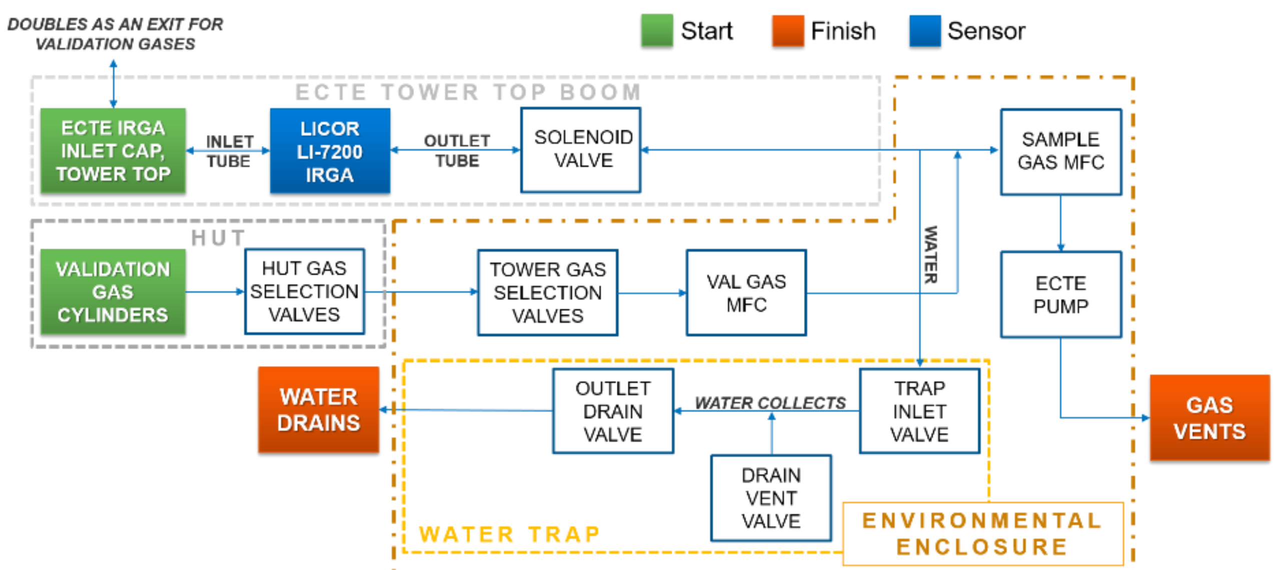


Figure 252. ECTE Validation Gas Flow Chart.

5.8.2 ECSE Routine Validation Process

Figure 253 charts an overview of the gas flow for the ECSE Validation for sites employing a PICARRO G2131-I Analyzer for Isotopic CO_2 **only**.

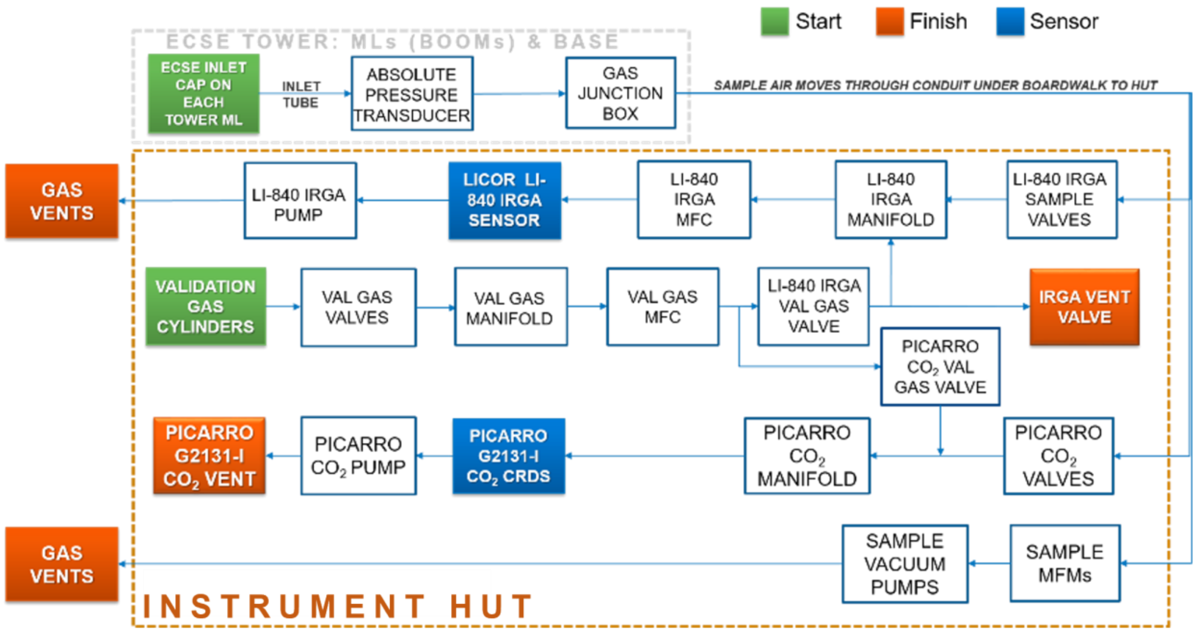


Figure 253. ECSE Validation Gas Flow Chart (No PICARRO Analyzer for Isotopic H_20).

Figure 254 charts an overview of the gas flow for the ECSE Validation for sites employing a PICARRO G2131-I Analyzer for Isotopic CO_2 **and** a PICARRO L2130-I Analyzer for Isotopic H_20.

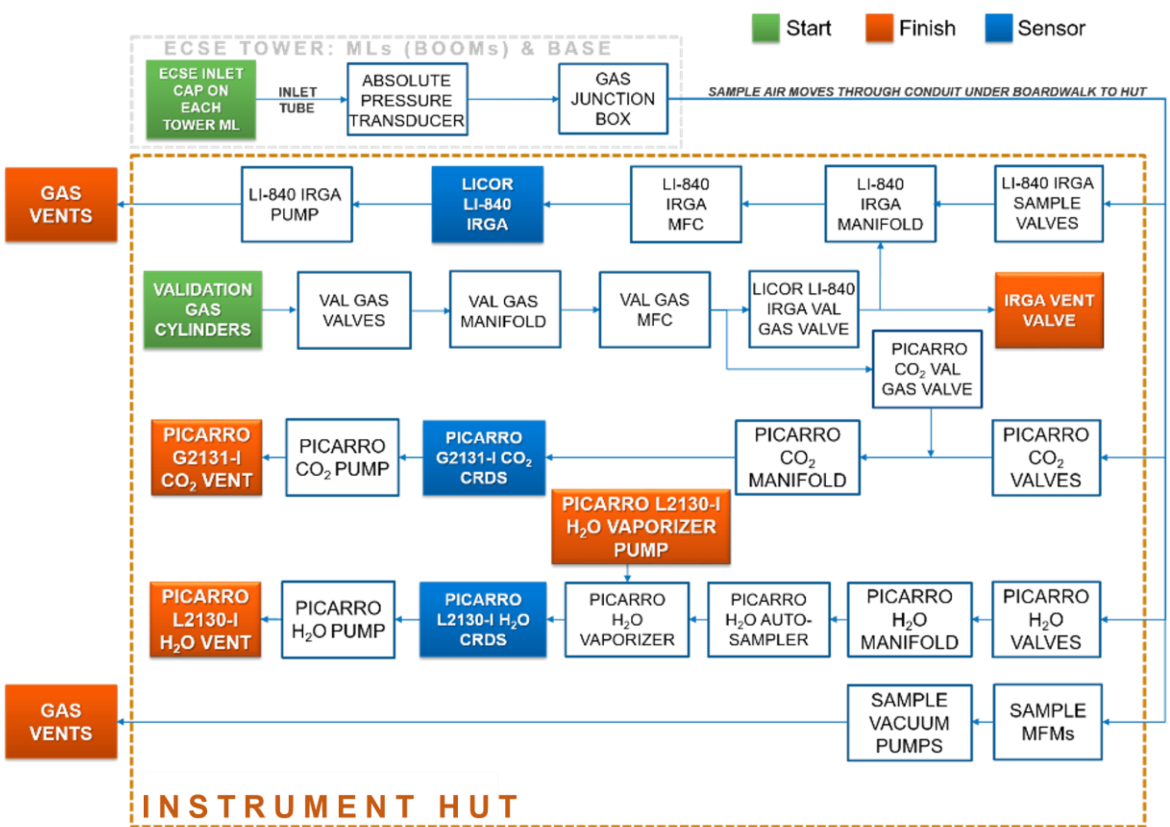


Figure 254. ECSE Validation Gas Flow Chart (Including PICARRO Analyzer for Isotopic H_20).

Note: The LC calibrates the LICOR LI-840/850 with zero and high span gases via a weekly-automated calibration process or after a pressure spike in the cell due to a Grape reset, system restart or any other reason that may cause a high-pressure spike. The LC CNC system continuously checks the LICOR LI-840/850 pressure and determines if there is a need for calibration anytime the pressure is below 23.5kPa or above 24.5kPa.

5.8.3 ECSE Calibration and Validation Procedures

This section applies to the PICARRO L2130-I Analyzer for Isotopic H_2O. **Table 49** provides a summary of the procedures, role, frequency and clarifying notes for quick reference of this section's contents.

Table 49. ECSE Calibration and Validation Procedures.

Section	Procedure	Responsibility	Frequency	Comments
5.8.3.1 ECSE Annual Calibration and Calibration Validation Process for the PICARRO L2130-I Analyzer for Isotopic H2O	Annual Calibration	Field Science Technicians under CVAL Oversight	Annual	Uses calibration vials. FIELD SCIENCE preps the instrument and CVAL remotely conducts Calibration.
5.8.3.1 ECSE Annual Calibration and Calibration Validation Process for the PICARRO L2130-I Analyzer for Isotopic H2O	Annual Calibration Validation	Field Science Technicians under CVAL Oversight	Annual	Uses calibration validation vials to validate annual remote calibration from CVAL. This is different from the validation vials for daily routine validations.
5.8.3.1.2 Field Validation Test for the PICARRO L2130-I Analyzer for Isotopic H2O	Field Test: Validation Test	Field Science Technicians under TIS SCI Oversight	Annual	Uses 2 sample vials: a red and blue vial (or one vial containing a low isotopic water sample and one containing a high isotopic water sample).
5.8.3.1.3 Humidity Dependency Test for the PICARRO L2130-I Analyzer for Isotopic H2O	Field Test: Humidity Dependency Test	Field Science Technicians under TIS SCI Oversight	Annual	Uses 2 sample vials: yellow or red depending on site requirements

5.8.3.1 ECSE Annual Calibration and Calibration Validation Process for the PICARRO L2130-I Analyzer for Isotopic H_2O

This procedure calibrates and validates calibration of the PICARRO L2130-I Analyzer for Isotopic H_2O with NEON isotopic water standards. This procedure requires Field Science participation under the oversight of CVAL. It takes approximately four days to complete the process. Prior to CVAL initiating annual calibration and calibration validation remotely, ensure the following process steps occur:

1. Train the Autosampler. See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*
    a. **DO NOT USE THE CALIBRATION VIALS TO TRAIN THE AUTOSAMPLER.** ***Use an existing tray of daily routine validation vials or a vial of deionized water.***
2. Insert a new tray containing six Calibration Vials and three Calibration Validation vials. See *Section 5.7.3.1.1 PICARRO Autosampler, Vials.*
3. Change Needle (Syringe Exchange). See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*
4. Change Vaporizer Septa (Injection Point). See *Section 5.7.3.2.1 PICARRO Septa Change Procedures.*
5. Adjust Sample Volume, if needed. **Injection pulses should be 20,000 ppm (±1,000).** See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*
6. *Provi*de notification to **WG-ENG CalVal** listserv via email to alert CVAL that the PICARRO L2130-I Analyzer for Isotopic H_2O is ready for CVAL to initiate calibration with the IP address.
7. The remainder of the process occurs by remote access via CVAL. CVAL reaches out to the site to provide direction during this process, when necessary. Upon completion of the process, CVAL remotely inputs the proper slopes and offset values for the instrument.

5.8.3.1.1 ECSE Annual Field Validations for the PICARRO L2130-I Analyzer for Isotopic H_2O

The PICARRO L2130-I Analyzer for Isotopic H_2O requires a series of annual characterization tests post annual calibration in the field. These must occur for new installations of this instrumentation, as well. Please ensure the following items are set prior (**24 hours in advance**) to initiating any of these validation tests:

1. If the system was offline for some reason, allow the system to run for 24 hours (sampling ambient air) to stabilize. This enables the instrument to establish performance data.
2. Install a new syringe on the Autosampler component of the PICARRO L2130-I Analyzer for Isotopic H_2O. See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*
3. Install new septa on the Vaporization Module component of the PICARRO L2130-I Analyzer for Isotopic H_2O. *Reference Section 5.7.3.2.1.*
4. Train the Autosampler. See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.* Set to **NEON1** (use NO SPACES in-between **NEON1**) method in the PICARRO Coordinator Launcher software and adjust sample size to achieve ~20,000 ppm via the PICARRO GUI during validation.

a. ***Adjust the sample volume (uL) micro liter using the following information as a rule of thumb: 0.1 = 1000ppm change.*** This may take up to 3-4 injections, which run up to nine minutes an injection. As a result, the overall process to adjust the sample volume may take several hours to complete. See *Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*

5.8.3.1.2 Field Validation Test for the PICARRO L2130-I Analyzer for Isotopic H_2O

The Field Validation test characterizes the calibration of the instrument across a range of isotopic content. This test may take up to four hours to complete.

Table 50. Field Validation Test for PICARRO Analyzer for Isotopic H_2O.

Equipment & Consumable List	Quantity
Red Vial (Low Isotopic Content)	1
Blue Vial (High Isotopic Content)	1
USB Drive	1

1. Gather the consumables from **Table 50**. Do not return the red and blue vial to the tray after use in this test.
2. Place the Red Vial in position #1 and Blue Vial in position #2 in the vial tray.
3. Open the PICARRO Autosampler Control program.
4. Verify **NEON1** configuration and sample volume for the PICARRO Analyzer Module to read ~20,000 ppm. *See Section 5.7.3.2.2 Step 15 to complete this step.*
5. Set the Job Queue to **NEON1** and click **Run** (see **Figure 255**). Minimize window.

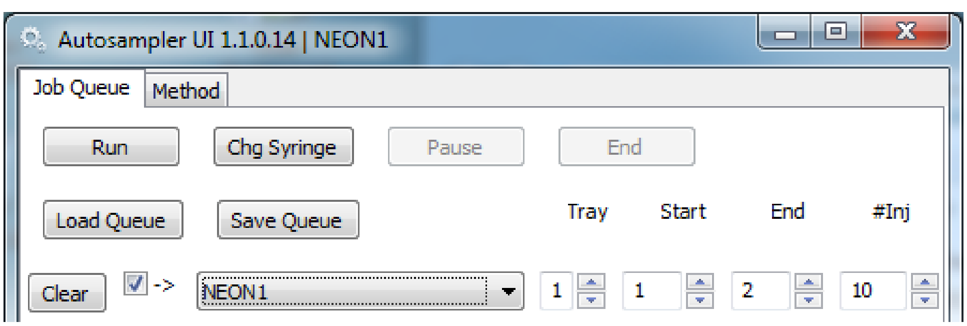


Figure 255. NEON1 Configuration for Field Validation**.**

6. Open the PICARRO Coordinator Launcher.
7. Select **Dual Liquid/Vapor**. Click **Launch**.
8. Set the User Editable Parameters to **20**, **23** and **0** (**Figure 195**) and click **OK**.

9. Verify the Autosampler pulls 10 liquid injections from Vial 1 and injects them into the Vaporizer injection port. Same for Vial 2. Monitor progress visually and via the PICARRO Coordinator application. Each run of 10 injections takes ~2 hours.

10. Copy and save the results file from the PICARRO application via a USB drive from ***C:/Piccaro/Isotope***

11. Update the Excel file with the Field Validation test per NEON Science below, update the template file name with the PICARRO 14-digit asset number, and test date (i.e., **H2OLASERASSET_Field_Validation_Test_yyyymmdd.xlsx**).

    a. Open the file from Step 10.

    b. Copy all the data (not the full sheet; only the data), to include the header, and paste into the Template file in the "**Calculations**" tab starting at cell **A5**.

    c. Fill in the name of the water standard, machine serial number, and asset tag in the "**Standards_Samples**" tab.

    d. Fill in the name of the water standard again in the "**Run_sheet**" tab.

    e. Fill in the Sample Volume and Injection Depth in the "**PAL_Progamming**" tab.

    f. Check the results in the "**Summary**" tab. If the results appear erroneous, rerun the test one more time. If this situation persists, contact CVAL.

    g. Save the template file name with the PICARRO 14-digit asset number, and test date (i.e., **H2OLASERASSET_Field_Drift_Test_yyyymmdd.xlsx**).

12. Save the files (both the .xlsx and .csv file) on the NEON Network Drive via ***N:/Common/Picarro L2130-i Annual Validation Data***. A folder exists for each Domain with a PICARRO L-2130-I Analyzer.

13. If the instrument passes the Field Validation test, please continue to the next characterization test (Humidity Dependency Test).

5.8.3.1.3 Humidity Dependency Test for the PICARRO L2130-I Analyzer for Isotopic H_2O

This characterization should be done at the time when a replacement unit arrives to the field prior to normal operations, as well as annually after field calibration. The Humidity Dependency test characterizes the instrument performance at low humidity levels. The isotopic determinations made by the Picarro CRDS instrument can vary slightly depending upon the specific humidity of the water vapor introduced to the instrument, creating water concentration dependence. The instrument measures the water concentration in units of parts per million (PPM) and reports that along with the isotope data. At concentrations between 5,000 and 25,000 ppm, the instruments tend to be approximately linear. Therefore, corrections of isotopic measurements for water concentration dependence are generally not needed. However, at water concentration below 5,000 ppm, the isotopic measurements are greatly dependent on the water concentration (**Figure 256**). Therefore, there is a need to characterize this water concentration dependence curve for future correction. This characterization is the Low Humidity Dependency Test or LHD test.

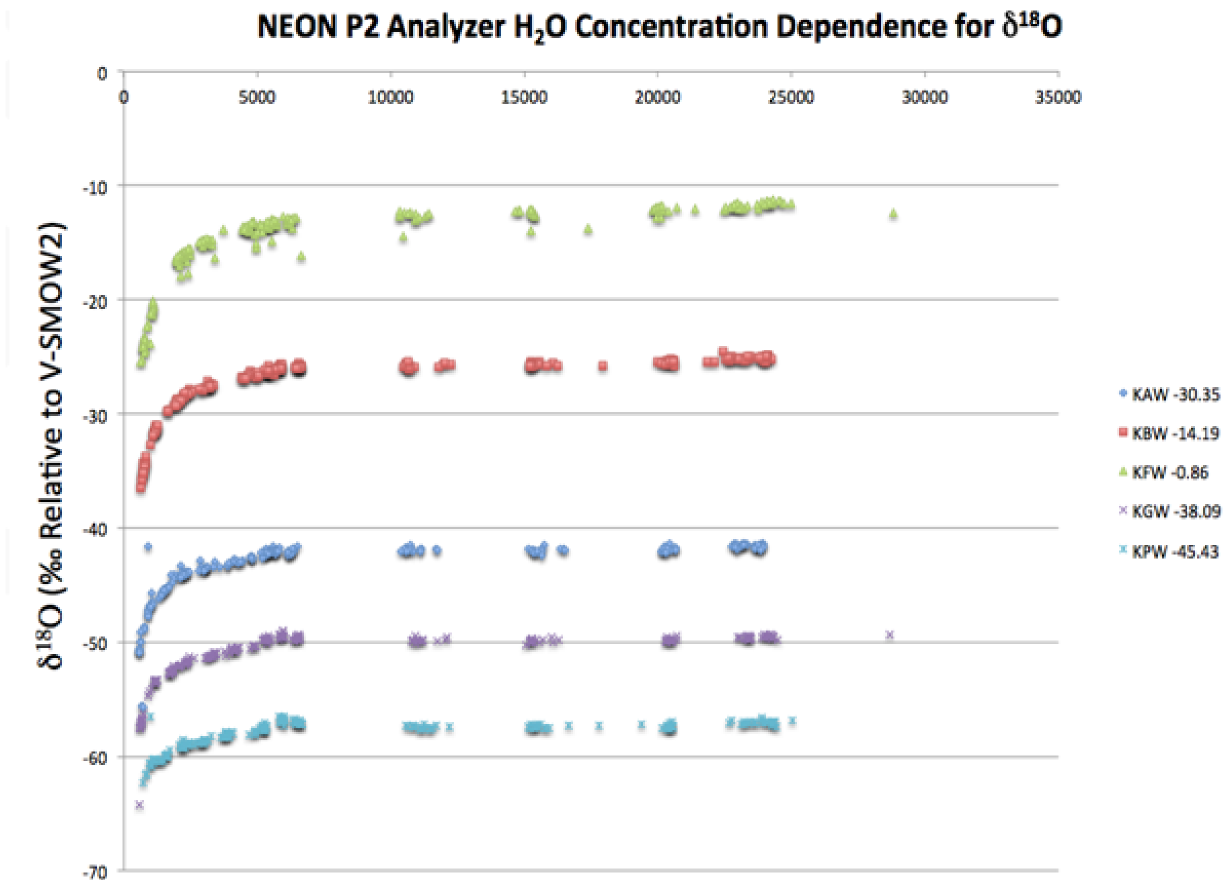


Figure 256. Water Concentration below 5,000 ppm: Isotopic Measurements are greatly dependent on Water Concentration.

The humidity dependency test collects multiple samples from two vials with site-specific isotope concentrations at different humidity levels (500 - 25,000 ppm).

For this procedure, the **Sample Volume (uL)** field in the **Method Tab** must change to achieve the correct water concentration levels for each segment of the Humidity Dependency Test. This test takes 24 to 48 hours to complete.

Table 51. Humidity Dependency Test for PICARRO Analyzer for Isotopic H_20.

Equipment & Consumable List	Quantity
Low Humidity vials (yellow or red depending on site)	2

1. Gather the consumables from **Table 51**.

2. Place the low humidity vials in locations #20 and #21 on the installed tray.

3. Train the Autosampler. *See Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*

4. **DO NOT USE THE CALIBRATION VIALS TO TRAIN THE AUTOSAMPLER.** Use an existing tray of daily routine validation vials or a vial of deionized water.

5. Change Needle (Syringe Exchange). See Section *See Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*

6. Change Vaporizer Septa (Injection Point). *See Section 5.7.3.2.1 PICARRO Septa Change Procedures.*

7. Adjust Sample Volume if needed. Injection pulses should be 20,000 ppm (±1,000). See Section *See Section 5.7.3.1.2 PICARRO Autosampler, Training and Syringe Exchange Procedures.*

8. Provide notification to WG-ENG CalVal listserv via email to alert CVAL that the PICARRO L2130-I Analyzer for Isotopic H_2O is ready for CVAL to initiate humidity dependency test with the IP address.

The remainder of the process occurs by remote access via CVAL. CVAL reaches out to the site to provide direction during this process, when necessary. Upon completion of the process, CVAL remotely inputs the proper slopes and offset values for the instrument.

6 SENSOR REFRESH AND REPLACEMENT

6.1 Additional Sensor Replacement Procedures

Field Science is responsible for managing the removal and replacement of the sensors onsite for preventive or corrective maintenance and/or Sensor Refresh and manages field calibration and validation of sensors, as appropriate. The NEON, HQ CVAL is responsible for the calibration and validation of select sensors and manages Domain Sensor Refresh schedules.

6.2 Equipment

RD [17] contains a list of equipment to conduct work at TIS sites for specific instrumentation and/or subsystem components that require maintenance, calibrations, and validations. Equipment recommendations and applicability may adjust over time as the implementation of NEON sensors and subsystems mature.

Note: Maintain original product packaging, if possible, for use in future sensor swaps (calibration and validation), temporary storage, or to return faulty equipment.

Note: Save the any gas connection inlet/outlet and vacuum connection port caps for later use. Reinstall the caps to connections for storage, moving and/or shipping.

6.3 Cleaning & Packaging of Returned Sensor

Field Science staff clean, package, and ship the sensors back to the CVAL at the NEON program HQ in Boulder, CO for sensor swap/calibration requirements. (Please note: if a sensor is defective, submit a trouble ticket and affix a red tag with the trouble ticket number on it. See *Section 7* for additional guidance). Conduct decontamination and remove biologics from the devices. Reference RD [09] for decontamination procedures. Follow the guidance outlined in AD [23] and AD [25] for this section.

Note: For any Non-CVAL initiated sensor returns, please notify CVAL of the return via ServiceNow.

6.4 Sensor Refresh Record Management of Assets

In addition to the physical movement of devices, the sensor refresh process requires dedicated and accurate record management of asset movement and location.

6.4.1 NEON Asset Management and Logistic Tracking System Requirements

Technicians must update the instrumentation records via the NEON program's Asset lifecycle Management System as soon as possible. NEON HQ and Field Science must maintain accurate record keeping on the location, date, and time of an instrument installation to ensure NEON HQ, Computer

Infrastructure, Data Products, and CVAL are able to apply correct algorithms, calibrations, and processing factors. Report replacements using the NEON Asset Tag Number via the Asset Management and Logistic Tracking System, which is the 14-digit Property Tag ID ("Property of") number on the sensor/subsystem and EPROM ID Ensure the CFG location reflects the current install site and location. *Reference AD [25] NEON.DOC.005038 NEON Standard Operating Procedure (SOP): Sensor Refresh for additional information.*

6.4.2 CNC Program Update Requirements

Appropriate management and updates to digital records is vital to proper system functioning and data ingest. In addition to asset management records, numerous EC system sensors and supporting assets also need to be properly configured on the local CNC software running on the site LC. See AD [22] and AD [24]. Route and/or add Advanced Engineering to the ticket to notify the appropriate points of contact. *Reference AD [25] NEON.DOC.005038 NEON Standard Operating Procedure (SOP): Sensor Refresh for additional information.*

7 ISSUE REPORTING OUTPUTS

Field Science must report issues encountered while conducting preventive maintenance in ServiceNow. To ensure a quick response and remedy to an issue, please include as much information and detail, as possible. This includes, but is not limited, to the following:

- Domain and Site name
- Issue Narrative (detailed narrative of the issue, specific location of issue on tower infrastructure, relevant 2nd/3rd order effects to infrastructure, possible cause [e.g., weather event, obstruction, human activity]).
- Multiple Photographs (to capture vantage points/perspectives for remote diagnostic)
- Provide Part Number/Manufacturer Information, EPROM ID, Asset Tags, IP/MAC Address, etc.
- Provide Diagnostic Information (from firmware, if applicable), such as error codes, values, etc. Provide screenshots.
- Additional guidance outlined in AD [23].

Conduct the following tasks to ensure the proper management of the asset between sites:

1. For each issue where NEON, HQ is replacing a defective instrument/subsystem at a TIS site, please create a sub-task in ServiceNow for the defective asset from the reported issue. Resolution of an issue does not occur with the installation of a replacement, but with the root cause analysis of the issue deriving from the defective asset. Field Science may resolve the ticket upon installation of the replacement if a sub-task exists for the defective asset for NEON HQ to conduct root cause analysis.

2. Ship all defective equipment/assets with a red "Rejected" tag. **Figure 257** displays the minimum information requirements for each tag.

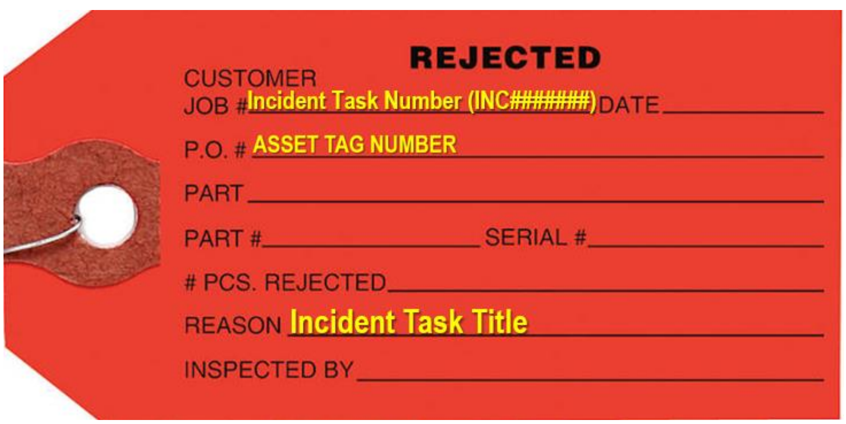


Figure 257. Red Rejected Tag for Defective Assets (MX104219).

8 APPENDIX A: USING TEP FOR REAL-TIME MONITORING

This appendix provides additional information from Section 5.4. Conduct the following procedure in **Table 52** to set-up a Terminal Emulator Program (TEP) for real-time instrument monitoring.

Table 52. Using TEP for Real-Time Monitoring.

STEP 1 | Navigate and install a TEP, either PuTTY or MobaXterm will suffice.

1. https://www.putty.org/
2. https://mobaxterm.mobatek.net/

 Session	**STEP 2** | Connect to the LC by clicking on the Session icon in the upper left corner of the screen.
 SSH	**STEP 3** | Then click on the SSH key icon in the Session Settings.

STEP 4 | Enter the LC IP address into the Remote Host Dialog Box (**Figure 258**) and click OK. No need to input a username at this step.

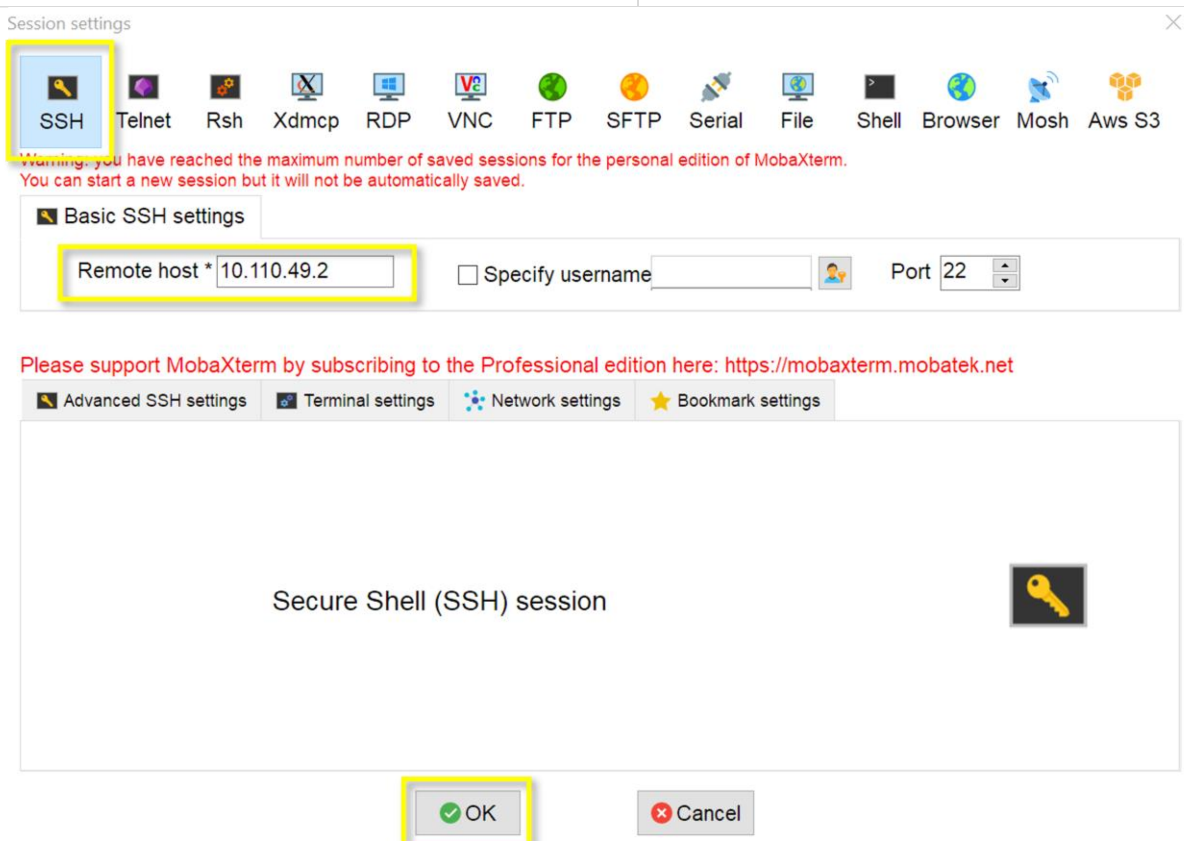


Figure 258. Enter the LC IP address into the Remote Host Dialog Box and Click OK.

STEP 5 | Enter the following username and password into the password prompt:

- Username: **user** | Password: **resuresu**

STEP 6 | Reference **Figure 259** for commands to stream real-time data from the LC.

Press the **Enter** key to execute the command and **ctrl+C** to stop streaming and return to command prompt.

*PRO TIP: To perform the functions in **Figure 259**, ecologists must acquire the Grape MAC address and/or the EEPROM ID (from Maximo/AssetWorks) of the sensor. Use to verify function of Grapes and Sensors post-Sensor Refresh or via the IS Control and Monitoring Suite.*

Remote Monitoring TEP Commands	Description
vd -s 0x[MAC address]	This displays the data from the grape (or smart sensor) with the MAC Address entered.
vd -s [sensor EEPROM]	This displays live data stream for sensor EEPROM entered
vd -s [sensor EEPROM] -r [stream number]	To view data from a sensor and specific data stream
nc localhost 30200	Stream list of dynamic network IP addresses (e.g. Picarro analyzers, grapes)
nc localhost 30200 | grep [search term]	Search for specific device IP address . For example. user@D23-HQTW-LC1:~$ nc localhost 30200 | grep 0f1a This returns the grape IP address for grape with MAC address ending in "0f1a". **NOTE:** search term is case sensitive

Figure 259. Remote Monitoring TEP Commands & Descriptions.

Figure 260 is an example of streaming data from a PICARRO G2131-I Analyzer for Isotopic CO_2.

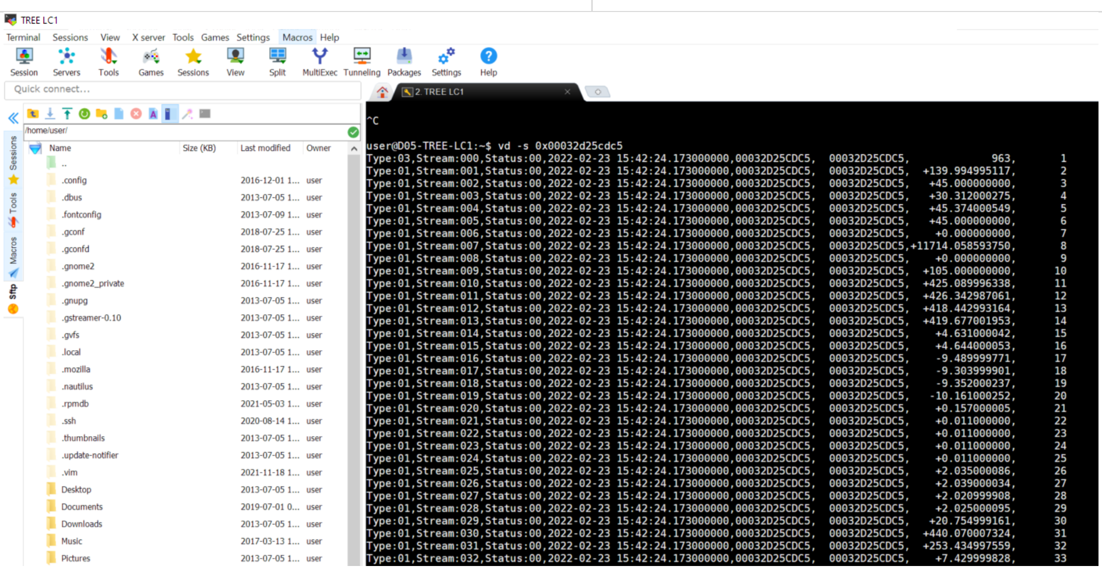


Figure 260. Example of a Live Data Stream of a PICARRO G2131-I Analyzer for Isotopic CO_2.

9 APPENDIX B: CONNECTING TO PICARRO ANALYZERS VIA WINDOWS REMOTE DESKTOP

This appendix provides additional information from Section 5.4. Conduct the following procedure in **Table 53** to connect to a PICARRO Analyzer via the Windows Remote Desktop application.

Table 53. Using Windows Remote Desktop to Connect to a PICARRO Analyzer.

STEP 1 | Log into the LC using a TEP, such as PuTTY or MobaXterm via Section 8.

Note: These next two steps are to acquire the IP addresses of the PICARROs at your sites. If you already have this information, then proceed to Step 3.

STEP 2 | In the command line prompt, use the following command to get the information displayed in **Figure 261**: `nc localhost 30200 | grep Picarro`

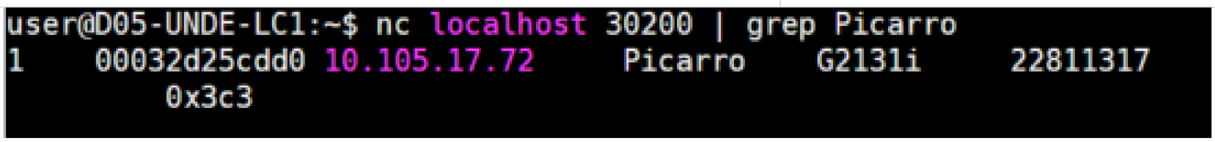


Figure 261. IP Address of a of a PICARRO G2131-I Analyzer for Isotopic CO_2 (Example).

STEP 3 | Returning to your desktop/laptop screen, in the Windows Search Bar, type **Windows Remote Desktop** and open the application.

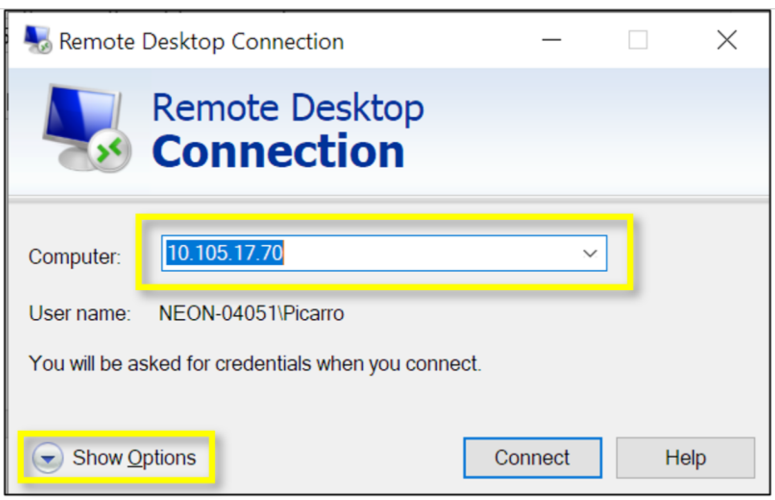


Figure 262. Windows Remote Desktop Connection Pop-up Window.

STEP 4 | Enter the IP address to the PICARRO Analyzer into the Dialog Box and click **Show Options** (**Figure 262**).

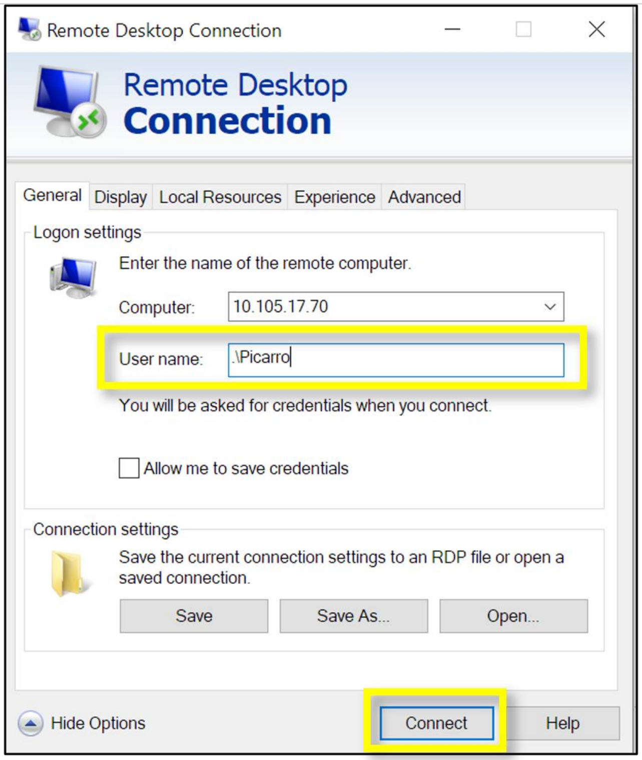


Figure 263. Show Options Screen.

STEP 5 | Enter **.\Picarro** in the **User name** field, then click **Connect** (**Figure 263**).

This opens a screen that will allow you to view and interact with the Windows 7 PC running on the PICARRO Analyzer.

If you have an error in connecting, see the info below to resolve

STEP 6 | If you were able to access the Picarro with no issue, please disregard this step. However, if you encounter either of the following errors, follow Steps 1-4 below.

- "The user name or password is incorrect."
- "The trust relationship between this workstation and the primary domain failed."

1. Press the "OK" button to acknowledge the error.
2. When the login password box appears, press the "Switch User" button below the password box.
3. Select the "Other User" icon from the selection screen.
4. Log in as ".\Picarro" with the normal password.

10 APPENDIX C: CVAL COMMUNICATION PROTOCOL FOR THE PICARRO L2130-I ANALYZER FOR ISOTOPIC H_2O ANNUAL CALIBRATION

The PICARRO L2130-I Analyzer for Isotopic H_2O Annual Calibration occurs at the following 21 TIS Sites:

- D01 HARV
- D02 SCBI
- D03 OSBS
- D04 GUAN
- D05 UNDE
- D06 KONZ
- D07 ORNL
- D08 TALL
- D09 WOOD
- D10 CPER
- D11 CLBJ
- D12 YELL
- D13 NIWO
- D14 SRER
- D15 ONAQ
- D16 WREF
- D17 SJER
- D18 TOOL
- D18 BARR
- D19 BONA
- D20 PUUM

The communication protocol goals are to (1) establish downward and parallel communication channels between HQ, CVAL and Field Science stakeholders (Domain Managers and TIS Field Ecologists), and (2) supplement these communication channels with a redundancy to mitigate single points of failures (e.g., if a technician is on vacation) or establish a contingency option to ensure messages reach their intended audiences (via ServiceNow and Email).

Figure 264 on the next page outlines the communication protocol: the message, the distribution method, the frequency of distribution, the communication goals/objectives of the message, the owner that is responsible for distributing the message, and the audience for the message.

Figure 264 aligns with the process flows displayed in **Figure 265** and **Figure 266**.

Message (What)	Method (Where)	Frequency (When)	Communication Goals/Objectives (Why)	Owner (who is responsible)	Audience (who)
Calibration Start/Initiation	Email	Sensor Calibration Scheduled Date	To verify start dates, confirm function of Picarro onsite, and initiate calibration coordination taskings.	CVAL	FOPS Domain Manager (DM)
Change Request (CR) to track process	ServiceNow	Sensor Calibration Scheduled Date	Create a CR Task to track process milestones and for project record management purposes.	CVAL	FOPS DM
Calibration Start Confirmation	Email	Upon Receipt of CVAL Email	To confirm receipt of the Calibration Start Email, Sensor Refresh schedule, and sensor statuses. This is also when the DM communicates an estimation of time, notifies stakeholders of potential delays/hindrances, and provides direct contact information for TIS personnel conducting the onsite preparation of the sensor (for CVAL to coordinate with personnel onsite, if issues are encountered).	FOPS DM	CVAL TIS Field Ecologist
Provide Direct TIS POCs	ServiceNow	Upon Receipt of CR Task	Assign TIS Personnel to CR Task (Work Notes and/or assign task responsibility) that will prepare the Picarro for CVAL remote calibration.	FOPS DM	CVAL TIS Field Ecologist
Ship Calibration Tray	ServiceNow	Upon Receipt from CVAL	Provides shipping information (tracking number) on the ServiceNow CR for the shipped cal vial tray. This notifies the Domain that the tray is on its way.	Logistics	FOPS DM TIS Field Ecologist
Calibration Vial Tray Confirmation	Email and ServiceNow	Upon Receipt of Vial Tray	Confirms the Domain has received the calibration vial tray. The tray expires after 30 days (the calibration process is time-sensitive).	FOPS DM TIS Field Ecologist	CVAL
Picarro Ready for Calibration	Email and ServiceNow	After Installation of Vial Tray	Notify CVAL that the Picarro is ready for calibration (the Picarro has had its syringe and septa changed, autosampler trained, pulses adjusted to 20K ppm, calibration vial tray installed, and the zero air cylinder is above 500psi). Provide instrument IP Address. This gives CVAL the green light to start the remote calibration process.	FOPS DM TIS Field Ecologist	CVAL
Picarro Calibration Process Status/Analyses	Email and Discussion	At Process Milestones	Provides calibration and validation, pass/fail determinations, and share progress updates and conduct analyses, as necessary.	CVAL	CVAL
Update Calibration File	Network File Transfer	Ongoing	Throughout the calibration process, update the XML file with the coefficients and associated quality flagging (R1 flagging = 1 or 0).	CVAL	CI TIS Science Staff
Calibration End	Email and ServiceNow	At end of Process	If the Picarro passes Cal: Notify stakeholders that the "unit passes calibration and is good for normal operations" via Email. Update status of the unit in the CR Task work notes.	CVAL	FOPS DM TIS Field Ecologist
Troubleshooting Guidance	Email and Phone	As Required	If the Picarro fails Cal: Provide information for FOPS and create Incident Task in ServiceNow. CVAL will assess the data to provide any insights and follow-up instructions, as necessary.	CVAL	TIS Field Ecologist
Picarro Incident	ServiceNow Meeting	As Required	If the Picarro fails Cal: Inform additional stakeholders (Assignment Groups) outside of the Domain to support in the resolution of the issue. Attach failed calibration data files and insights from CVAL analyses on the data.	CVAL	Advanced ENG, FOPS DM, TIS Field Ecologist, & Repair Lab
Return Vial Tray	Email and Service Now	At end of Process or upon expiration	Complete ETR form and ship calibration vial tray with vials back to HQ, CVAL. Update ServiceNow ticket with shipping information/tracking number to inform Logistics/CVAL that the tray is returning to HQ.	TIS Field Ecologist	CVAL, Logistics

Figure 264. CVAL Communication Protocol for the PICARRO L2130-I Analyzer for Isotopic H_2O Annual Calibration.

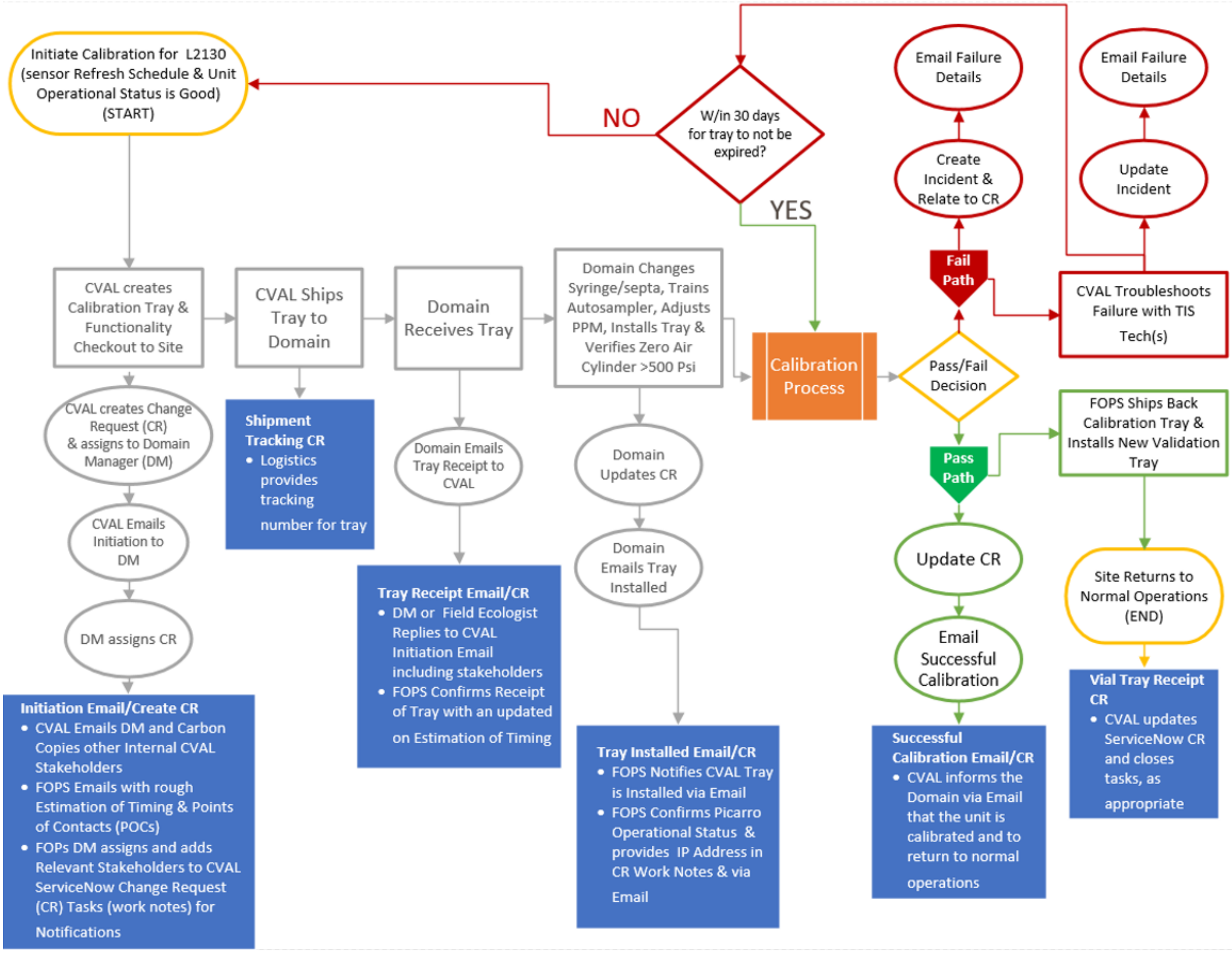


Figure 265. CVAL Communication Requirements Process Flow.

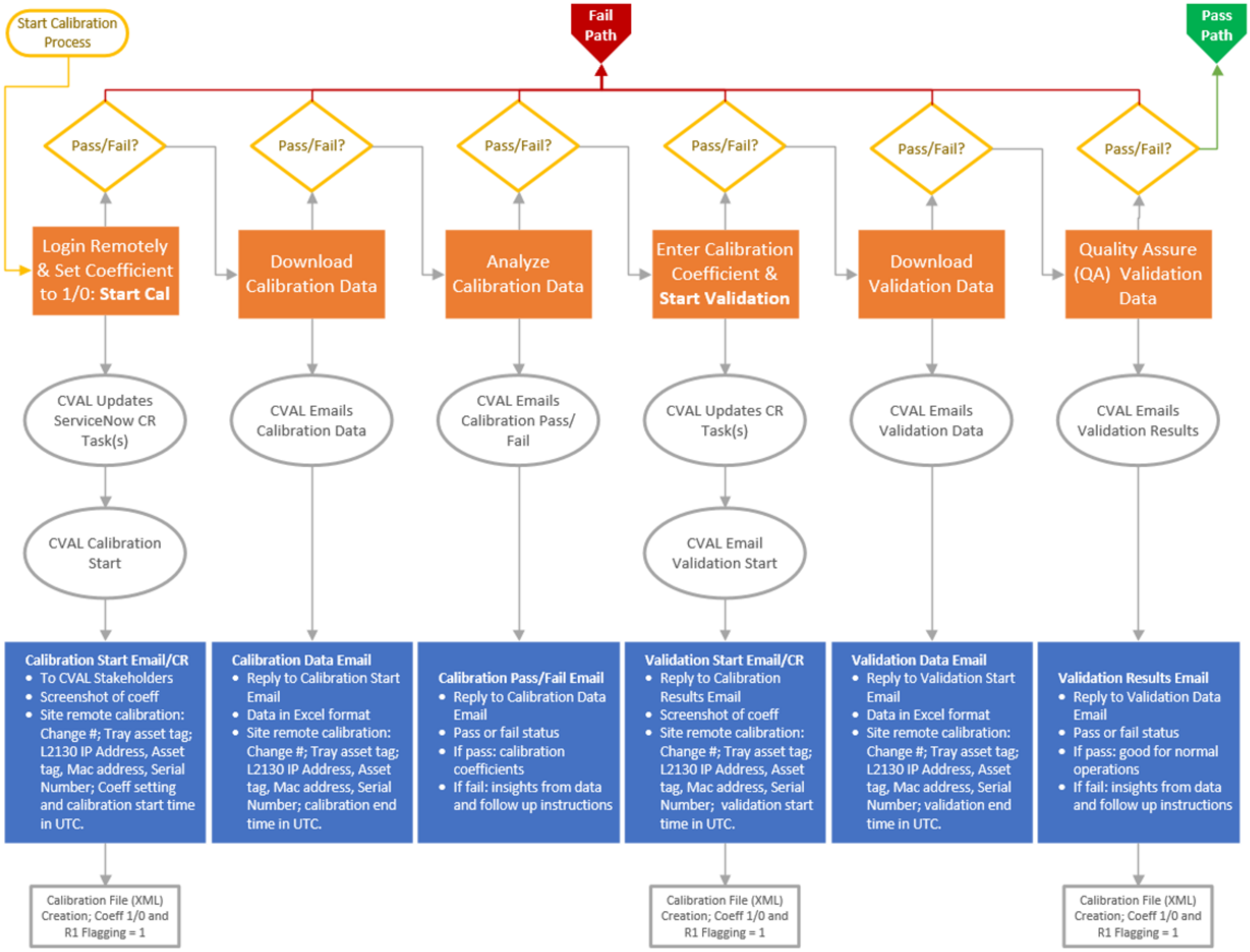
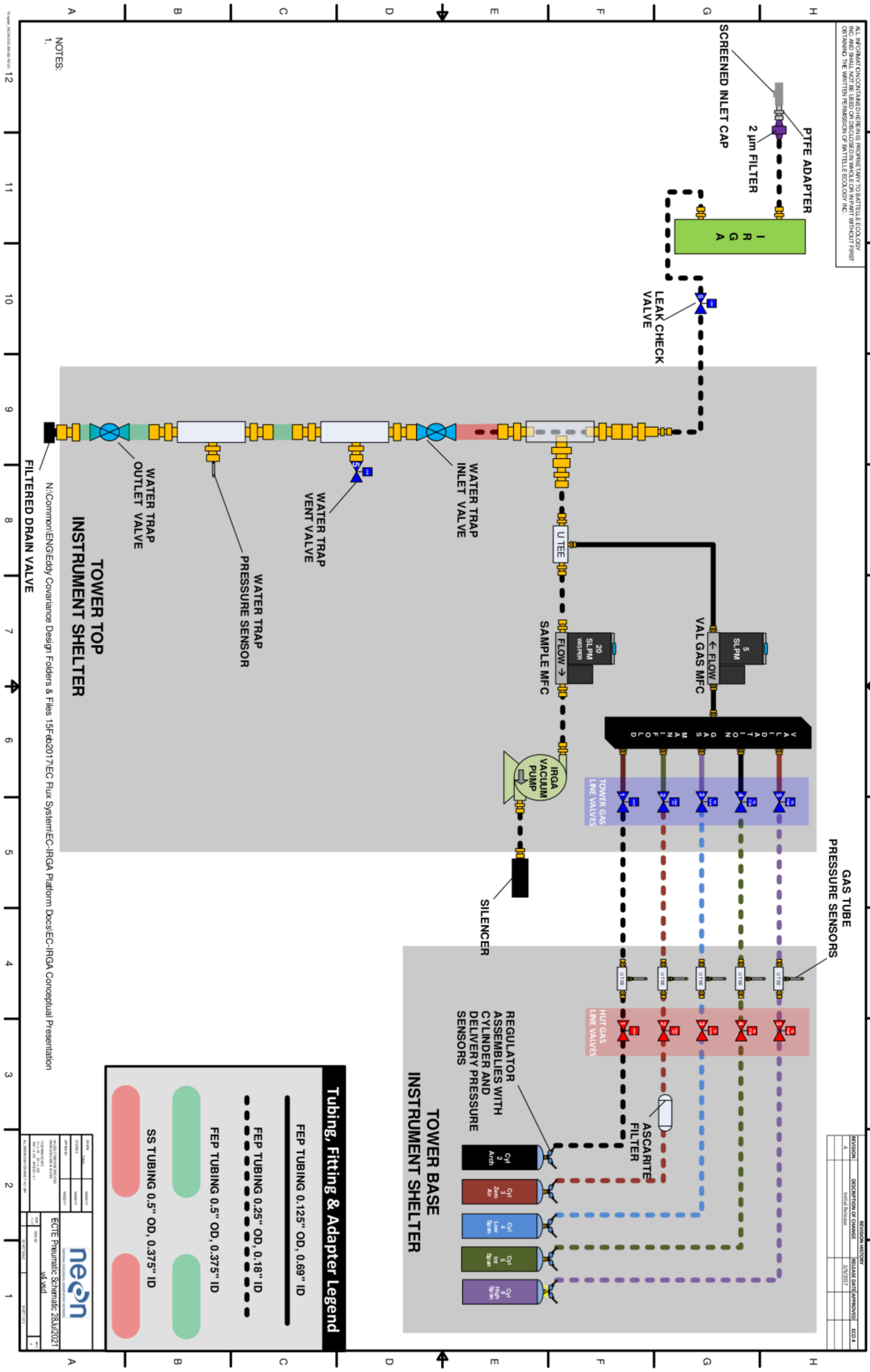


Figure 266. CVAL Calibration Sub-Process Communication Approach.

11 APPENDIX D: EDDY COVARIANCE TURBULENT EXCHANGE SCHEMATIC



12 APPENDIX E: EDDY COVARIANCE STORAGE EXCHANGE SCHEMATIC