Using the LI-8250 Multiplexer

for Soil Gas Flux Measurements

LI-COR®

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for Soil Gas Flux Measurements

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Notice

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Printing History

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Notes on Safety

This LI-COR product has been designed to be safe when operated in the manner described in this manual. The safety of this product cannot be assured if the product is used in any other way than is specified in this manual. The product is intended to be used by qualified personnel. Read this entire manual before using the product.

Equipment markings:	
	The product is marked with this symbol when it is necessary for you to refer to the manual or accompanying documents in order to protect against injury or damage to the product.
	The product is marked with this symbol when a hazardous voltage may be present.
	The product is marked with this symbol if a Chassis Ground connection is required.
⎓	The product is marked with this symbol to indicate that a direct current (DC) power supply is required.
WARNING	Warnings must be followed carefully to avoid bodily injury.
CAUTION	Cautions must be observed to avoid damage to your equipment.
Manual markings:	
Warning	Warnings must be followed carefully to avoid bodily injury.
Caution	Cautions must be observed to avoid damage to your equipment.
Note	Notes contain important information and useful tips on the operation of your equipment.

CE Marking:

This product is a CE marked product. For conformity information, (typically EMC, Safety, RoHS, and/or Wireless) contact LI-COR Support at envsupport@licor.com for a Declaration of Conformity. Outside the U.S., contact your local sales office or distributor.

For ReaCH (Regulation (EC) n.1907/2006) related questions, information is available on the European Chemicals Agency maintained website for the Waste Framework Directive SCIP database.

You can search by product name (for this product “LI-8200”), or request an “SCIP number” from the email above.

LI-COR scientific products are for professional use (non-consumer products). These products do not fall within the voluntary scopes of regulations: UNI EN ISO 14024, TCO Certified, EPEAT 2018, Blue Angel, TÜV Green Product Mark, Energy Star, EU GPP, or other similar regulations. The typical scope for these regulations is lighting, furniture, copiers, mobile phones, televisions, computer/servers, home appliances, to name a few. As such, our products do not use any labeling that indicates adherence thereof.

California Proposition 65 Warning

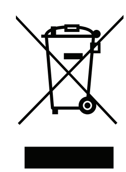
WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Federal Communications Commission Radio Interference Statement

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC rules, which are designed to provide a reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

Waste Electronic and Electrical Equipment (WEEE) Notice

This symbol indicates that the product is to be collected separately from unsorted municipal waste. The following applies to users in European countries: This product is designated for separate collection at an appropriate collection point. Do not dispose of as household waste. For more information, contact your local distributor or the local authorities in charge of waste management.



Wi-Fi Warning

When powered on for the first time, this device will broadcast a wireless local area network (WLAN) signal.
The use of WLAN is restricted in some regions and countries, and the illegal use of WLAN may be punishable under these regulations. Check your local regulations to determine if WLAN is permitted.

If WLAN is not permitted in your area, it is your responsibility to disable the WLAN signal. LI-COR, Inc. cannot be held liable for any problems arising from the use of WLAN in any countries or regions where it is not permitted. Legal penalties may result from failing to disable or re-enabling the wireless network where it is not permitted, modifying or altering the product, or removing the certification labels from the product.

Instructions for disabling the WLAN signal are provided in this manual.

ROHS Information

LI-8250 多路器, 8250-01 扩展模块, 8200-104/C 测量室, 9982-074 瓶子套件 LI-8250 Multiplexer, 8250-01 Extension Manifold, 8200-104/C Chamber, 9982-074 Flask Kit						
零件名称 Part Name	有毒有害物质或元素 Toxic and Hazardous Substances or Elements					
	铅 (PB)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
印刷电路板 (PCBs)	X	O	O	O	O	O
机电零件 (Electromechanical)	X	O	O	O	O	O
电缆和电线 (Cables and Wires)	X	O	O	O	O	O
金属零件 (Metal Parts)	X	O	O	O	O	O
塑料零件 (Plastic Parts)	O	O	O	O	O	O
电池 (Batteries)	O	O	O	O	O	O

该表是根据SJ / T 11364的规定编制的。

O = 表示该有毒有害物质在该部件所有均质材料中的含量低于GB/T 26572规定的限量。

indicates that the content of the toxic and hazardous substance in all the Homogeneous Materials of the part is below the concentration limit requirement as described in GB/T 26572

X = 表示该有毒有害物质至少在该部件的某一均质材料中的含量高于GB/T 26572规定的限量。

indicates that the content of the toxic and hazardous substance in at least one Homogeneous Material of the part exceeds the concentration limit requirement as described in GB/T 26572

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Section 1.
Introduction to the LI-8250

This section provides an overview of what's included with your LI-8250 Multiplexer as well as the software used to interact with the instrument and process data.

What's what

After you receive your LI-8250 Multiplexer, check the packing list to verify that you have received everything ordered, including:

- LI-8250 Multiplexer (part number LI-8250)
- Indoor AC to DC power supply (part number 8250-772)
- Bare-leads power cable (part number 8150-706)
- Ethernet cable (part number 616-06116)
- Spares kit (part number 9982-072)

With each 8250-01 Extension Manifold ordered, you should have received:

- Cable assembly (part number 9982-056)
- Spares kit (part number 9982-072)

And with each 8200-104 Opaque Long-Term Chamber or 8200-104C Clear Long-Term Chamber ordered, you should have received:

- Two soil collars (part number 6581-044)
- Spares kit (part number 8100-613)
- Replacement gasket kit (part number 8100-612)

LI-8250 Multiplexer

Part number: LI-8250

The LI-8250 Multiplexer is an automated system for multiplexing measurements of soil gas flux.

The central role of the LI-8250 Multiplexer is to facilitate the connection of one or more gas analyzers with multiple chambers. Data from this system is useful for characterizing spatial and temporal variation of soil gas flux.

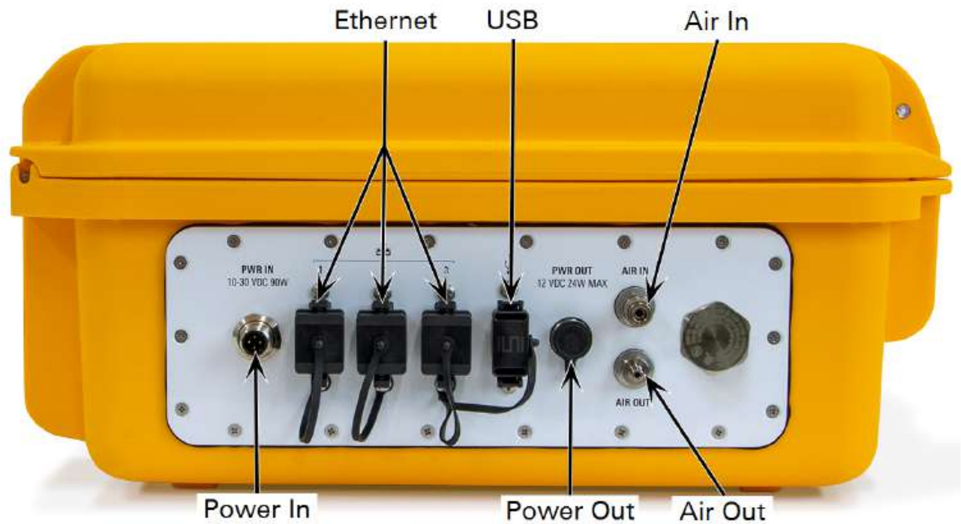
Featuring embedded flux processing software, GPS, and internal storage, the LI-8250 Multiplexer can be configured with LI-COR gas analyzers for real-time flux calculations. The LI-8250 can also be configured and time-matched with many non-LI-COR gas analyzers to measure fluxes of your particular gases of interest.

By itself, the LI-8250 Multiplexer can connect with eight chambers. Through the use of multiple 8250-01 Extension Manifolds, the maximum number of chambers can be increased to 36.

Interaction with the LI-8250 is done by connecting to the built-in web server using the browser of your SmartPhone, tablet, or computer. The web server may be reached by Ethernet connection or using the onboard Wi-Fi network.

Analyzer connection panel overview

The LI-8250 Multiplexer can connect to your site Ethernet network or cellular modem, and can integrate many types of gas analyzers.

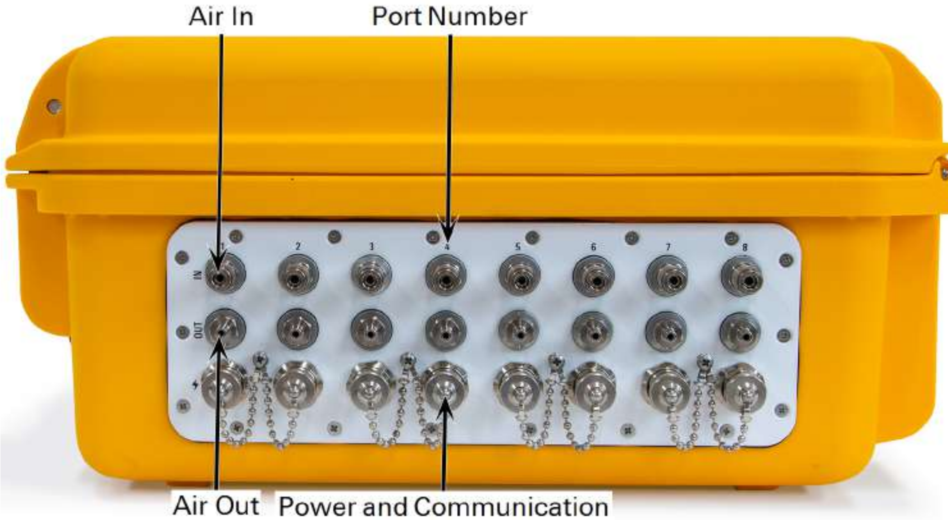


Component	Description
Power In	Connects to the bare-leads power cable (8150-706) or the optional outdoor AC to DC power supply (8250-770).
Power Out	Provides power to the LI-870 CO_2/H_2O Analyzer.
Ethernet	Connects to LI-COR LI-78xx Trace Gas Analyzers, site Ethernet network, or cellular modem (RJ-45).
USB	Connects to the LI-870 CO_2/H_2O Analyzer.
Air In	Connects to the air outlet of analyzer(s).
Air Out	Connects to the air inlet of analyzer(s).

Caution: The power output is 12 VDC ⎓ with a center-positive pin (⊖-☾-⊕). The output has a 2 A maximum and is designed to only power the LI-870 CO_2/H_2O Analyzer. Only use the power cable supplied with the LI-870 cable assembly (part number 9982-010), and do not attempt to power any other analyzers with the LI-8250. Drawing a current in excess of 2 A will trip the self-resetting breaker. If you trip the self-resetting breaker, you will need to power the LI-8250 off and back on to reset the LI-870 power output.

Chamber connection panel overview

The LI-8250 has ports to connect with up to eight devices at a time, including the 8250-01 Extension Manifold, the 8200-104 Opaque Long-Term Chamber, the 8200-104C Clear Long-Term Chamber, and user-built custom chambers.



Component	Description
Air In	Connects to the air outlet of an extension manifold or chamber.
Air Out	Connects to the air inlet of an extension manifold or chamber.
Port Number	The designated port number for the connected device.
Power and Communication	Provides power to and communication with an extension manifold or chamber (RS-422).

Internal overview

The internal components control the flow of air between analyzers, extension manifolds, and chambers.

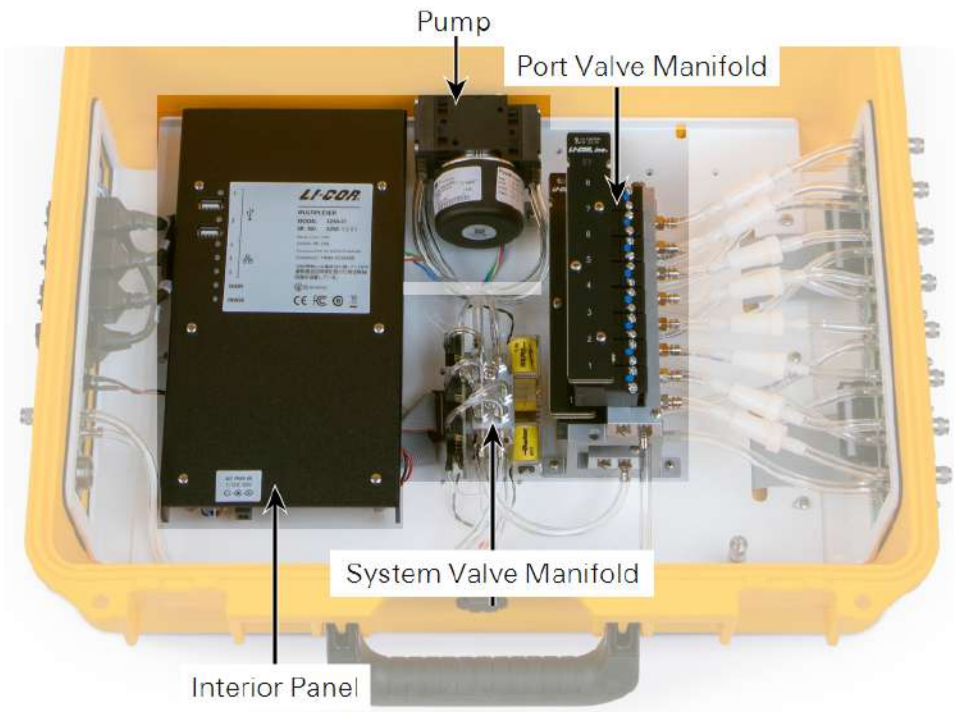


Figure 1-1. Components inside the multiplexer include the pump, interior panel, port valve manifold, which controls flow to individual ports (chambers, typically), and the system valve manifold, which controls flow through the subsample loop and attached gas analyzers.

Component	Description
Pump	Provides a steady flow of air through the system.
Port Valve Manifold	Controls the flow to and from each port.
Interior Panel	See the *Interior panel overview* on the next page.
System Valve Manifold	Controls the flow to and from the valve manifold and gas analyzers using two valves.

Interior panel overview

The interior panel provides options for mass data storage and removal, an input for powering the multiplexer indoors, and status indicators for the multiplexer.

Component	Description
USB Port	For connecting to an external Wi-Fi adapter or USB mass storage.
USB Activity	LED indicator that provides a steady light when connected and blinks when sending/receiving communication.
Ethernet Activity	LED indicator that provides a steady light when connected and blinks when sending/receiving communication.
Ready	LED indicator that provides a steady light when the LI-8250 Multiplexer has finished booting up.
Power	LED indicator that illuminates when the LI-8250 Multiplexer is receiving power.
Alternate Power Input	For connecting to the indoor AC to DC power supply (8250-772).

What's included

Listed below are the items included with every LI-8250 Multiplexer.

Bare-leads power cable

Part number 8150-706

The bare-leads power cable is a 3 m cable with bare wire leads that allows you to connect the LI-8250 Multiplexer to a user-supplied DC power source that reliably meets your power requirements. See *Power requirements and consumption* on page 2-2 to estimate your total system power requirements.

Indoor AC to DC power supply

Part number 8250-772

The indoor AC to DC power supply provides a constant 24 VDC 80 W power source using mains power. It is intended for indoor use only, such as in the lab.

Ethernet cable

Part number 616-06116

This cable has two unsealed RJ-45 connectors and is used to connect your LI-8250 Multiplexer to a computer. Because the connectors are unsealed, this cable is not intended for field use. Ethernet cables may also be included in the optional cable assemblies, but these cables are sealed and strain-relieved for field use.

Spares kit

Part number 9982-072

This kit includes additional components and spare parts for your LI-8250 Multiplexer and 8250-01 Extension Manifold.

Description	Quantity	Part Number
Urethane Tubing (0.9 m)	1	222-00303
Balston Disposable Air Filter	1	300-01961
Hose Barb T-Fitting	2	300-02627
Hosebarb Replacement	2	300-17717
Vinyl Cap for Quick-Connect Plug	16	620-08298
Vinyl Cap for Quick-Connect Coupler	16	620-08299
Valve Manifold Air Inlet Filter	8	9981-123

LI-8250 user interface

The LI-8250 includes a built-in web server that can be accessed using a wireless or wired connection (see *Connecting to the LI-8250 Multiplexer* on page 2-7). From the user interface, you can view and manage flux data, run diagnostics, or configure and control your long-term system. See *User interface* on page 6-1 for details about how to use the user interface.

SoilFluxPro™ Software

SoilFluxPro is a free Windows- and macOS-compatible application for advanced analysis of soil flux datasets. Features include recomputation of datasets with altered parameters, graphs and charts, summary statistics, GPS data visualization with Google Earth, and more. Download SoilFluxPro from the LI-COR support site (licor.com/8250-software). Navigate to **SoilFluxPro Software** and find the installer for your operating system.

Optional accessories

Listed here are products that are not included with the LI-8250 Multiplexer but that are available from LI-COR for your soil gas flux system.

Outdoor AC to DC power supply

Part number 8250-770

When used with the LI-8250, the outdoor AC to DC power supply provides a constant 12 VDC 80 W power source. It is weather-resistant, O-ring sealed, and is designed for long-term outdoor deployment.

Sealed to standard Ethernet cables

Part numbers: 392-19109 or 392-19110

Sealed to standard Ethernet cables are available in lengths of 5 m (part number 392-19109) or 25 m (part number 392-19110). These cables have one sealed RJ-45 connector and one unsealed RJ-45 connector. They are used to connect the LI-8250 (sealed) to your site network (standard).

LI-190R Quantum Sensor and leveling stake

Part number 190R-8200

The LI-190R Quantum Sensor can be connected to the 8200-104/C Long-Term Chambers to measure photosynthetically active radiation at the chamber to supplement your data. The leveling stake is used to mount and level the LI-190R Quantum Sensor.

LI-200R Pyranometer and leveling stake

Part number
200R-8200

The LI-200R Pyranometer can be connected to the 8200-104/C Long-Term Chambers to measure global solar radiation at the chamber to supplement your data. The leveling stake is used to mount and level the LI-200R Pyranometer.

Stevens HydraProbe II

Part number
900-19016

A Stevens HydraProbe soil moisture, temperature, and electrical conductivity probe with SDI-12 connection cable is available to connect to the 8200-104/C Long-Term Chambers. Ancillary data from the probe is captured alongside soil gas flux data.

Sensor connector to cable with flying leads

Part number
392-18518

LI-COR offers an optional 2 m sensor connector (Turck) to cable with flying leads to connect an SDI-12 sensor to the 8200-104/C Long-Term Chambers.

Sensor T-split fitting

Part number
310-18516

The sensor T-split fitting multiplies the number of sensors that can connect to the 8200-104/C Long-Term Chambers. The sensor T-split fitting connects directly to a chamber port and serves as a junction for the connectors from two sensors, such as a light sensor and chamber thermistor or multiple SDI-12 sensors.

T-split tubing

Part number
9982-073

Pre-assembled T-split tubing is available for connecting multiple gas analyzers. The T-split tubing connects directly to the LI-8250 Multiplexer and serves as a junction for the air in and air out lines from the analyzers.

Cable assembly

Part number
9982-056

This cable assembly for the includes a 15 m RS-422 cable (part number 392-18852) and two 15 m lengths of Bev-A-Line® tubing with quick-connect fittings. This assembly provides power, communication, and gas flow between the LI-8250 Multiplexer, 8250-01 Extension Manifolds, and long-term chambers.

8250-01 Extension Manifold

Part number 8250-01

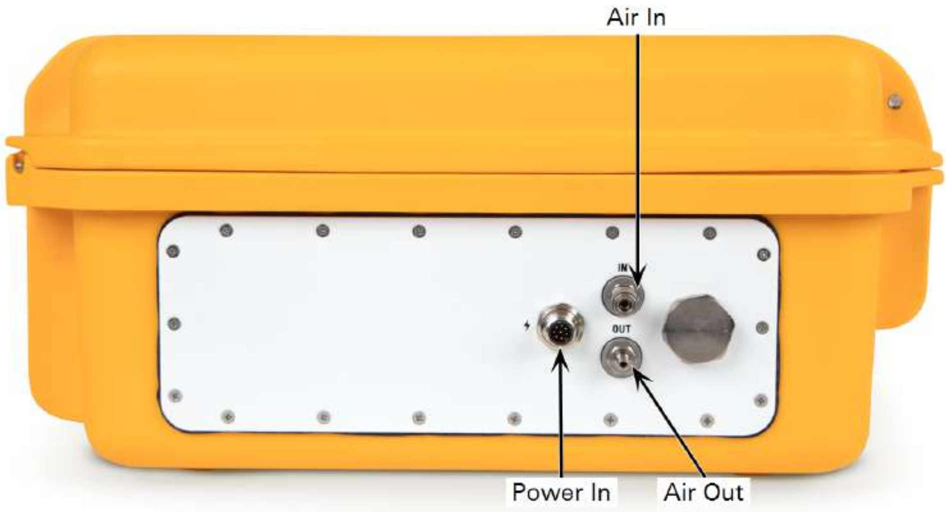
The 8250-01 Extension Manifold increases the number of chambers you can have in your long-term system by allowing up to eight chambers to share one multiplexer port.

The multiplexer can support up to four extension manifolds, bringing the maximum number of chambers to 36 (four extension manifolds connected to eight chambers and four additional chambers connected to the multiplexer). With each extension manifold you ordered, you should have received the following:

- Cable assembly (part number 9982-056)
- Spares kit (part number 9982-072)

Multiplexer connection panel overview

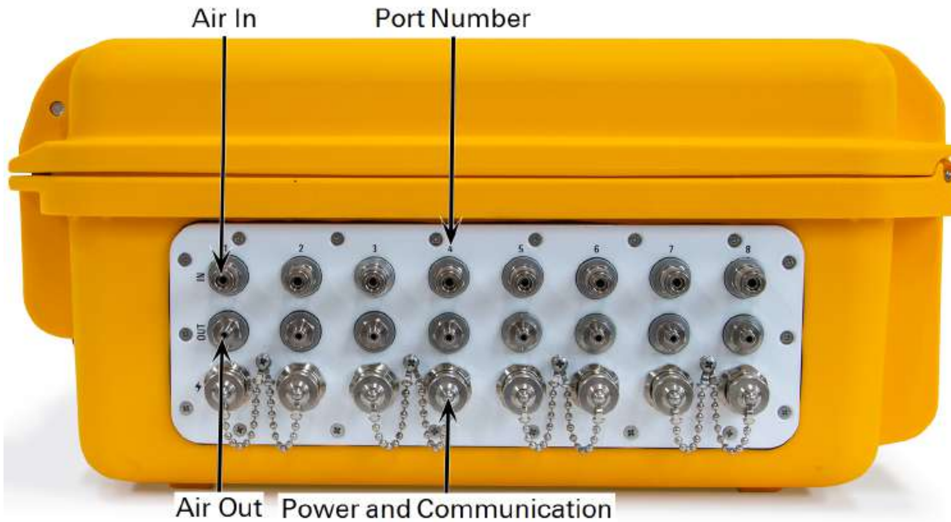
The 8250-01 Extension Manifold connects to the LI-8250 Multiplexer for power, communications, and the transfer of air.



Component	Description
Power and Communication	Connects to the LI-8250 Multiplexer for power and communications (RS-422).
Air In	Connects to the air outlet of the LI-8250 Multiplexer.
Air Out	Connects to the air inlet of the LI-8250 Multiplexer.

Chamber connection panel overview

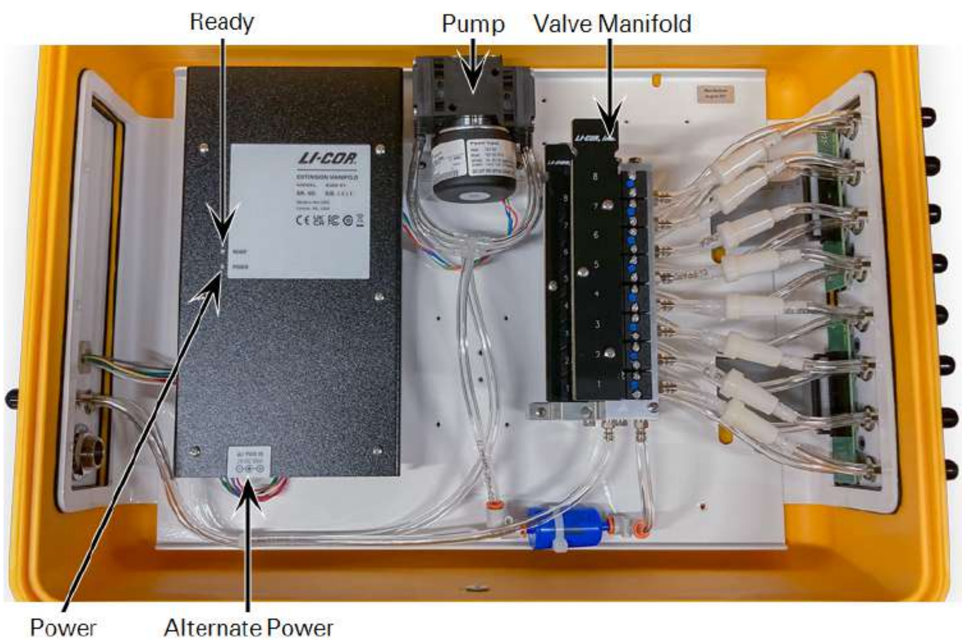
An 8250-01 Extension Manifold connects to one port on the LI-8250 Multiplexer, and each extension manifold can connect to eight chambers.



Component	Description
Air In	Connects to the air outlet of a chamber.
Air Out	Connects to the air inlet of a chamber.
Port Number	The designated port number for the connected device.
Power and Communication	Provides power to and communication with a chamber (RS-422).

Internal overview

The internal components control the flow of air between the LI-8250 Multiplexer and chambers. The interior panel includes an input for powering the extension manifold and status indicators for the extension manifold.



Component	Description
Pump	Provides a steady flow of air through the system.
Valve Manifold	Controls the flow to and from each chamber.
Ready	LED indicator that provides a steady light when the 8250-01 Extension Manifold has finished booting up.
Power	LED indicator that illuminates when the 8250-01 Extension Manifold is receiving power.
Alternate Power Input	For connecting to the indoor AC to DC power supply (8250-772).

> **Note:** The 8250-01 Extension Manifold only requires an alternate power source when using the purge pump for the Flask Sampling Kit (part number 8250-660).

Gas analyzers

The LI-8250 Multiplexer can integrate a variety of gas analyzers, including the LI-870 CO_2/H_2O Analyzer and LI-78xx Trace Gas Analyzers from LI-COR. Below are brief descriptions of each of these analyzers and the components necessary to connect them to the multiplexer.

LI-870 CO_2/H_2O Analyzer

Part number
LI-870

The LI-870 CO_2/H_2O Analyzer is a durable, weatherized gas analyzer that provides CO_2 data to the LI-8250 Multiplexer for soil CO_2 flux measurement.

The LI-870 measures CO_2 in air at concentrations from 0 to 20,000 ppm using non-dispersive infrared gas analysis technology. Water vapor measurements are used in corrections to report CO_2 dry mole fraction with high accuracy. Power to the LI-870 is supplied from the LI-8250 Multiplexer.

LI-870 CO_2/H_2O Analyzer cable assembly

Part number
9982-010

Included with the LI-870 Analyzer, this cable assembly includes a 1.2 m USB-A to USB-B cable (part number 392-17654), a 1.2 m 2.5 × 5.5 mm IP68 power cable (part number 9982-008), and two lengths of Bev-A-Line® tubing with quick-connect fittings. This assembly provides power, communications, and gas flow between the LI-8250 Multiplexer and the LI-870 CO_2/H_2O Analyzer (see *Connecting an LI-870 CO2/H2O Analyzer* on page 5-1).

LI-78xx Trace Gas Analyzer

Part numbers: LI-7810, LI-7815, or LI-7820

LI-COR Trace Gas Analyzers are high-precision, high-stability, laser-based instruments that use Optical Feedback-Cavity Enhanced Absorption Spectroscopy (OF-CEAS) to measure gas concentration in air.

LI-COR Trace Gas Analyzers provide data to the LI-8250 Multiplexer that is used to compute fully-processed fluxes in the field for gases beyond CO_2, like CH_4 with the LI-7810 $CH_4/CO_2/H_2O$ Trace Gas Analyzer or N_2O with the LI-7820 N_2O/H_2O Trace Gas Analyzer. LI-78xx Trace Gas Analyzers are powered separately from the LI-8250 Multiplexer.

LI-78xx Trace Gas Analyzer cable assembly

Part number 9982-011

This optional cable assembly comes in a 2 m length and includes an Ethernet cable with two sealed RJ-45 connectors and Bev-a-Line® tubing with compression fittings for connecting to LI-78xx Trace Gas Analyzers (see *Connecting an LI-78xx Trace Gas Analyzer* on page 5-3).

Long-term chambers

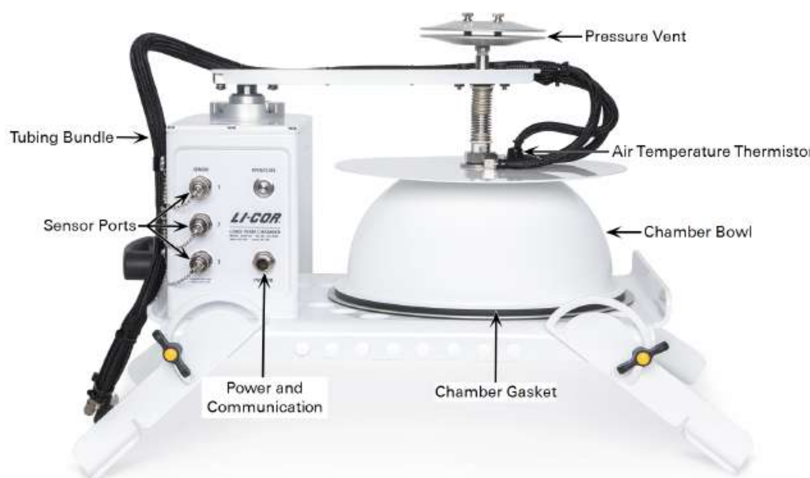
Depending on the system you ordered, you may have one or more of the following chambers. With each chamber you ordered, you should have received the following:

- Two soil collars (part number 6581-044)
- Spares kit (part number 8100-613)
- Replacement gasket kit (part number 8100-612)

8200-104 Opaque Long-Term Chamber

Part number 8200-104

The 8200-104 Opaque Long-Term Chamber has a reflective white enamel chamber bowl which rotates to and away from the soil collar. The 8200-104 is weatherized and intended to be left outdoors for extended periods of time to make automated measurements.



8200-104C Clear Long-Term Chamber

Part number 8200-104C

The 8200-104C Clear Long-Term Chamber has a clear chamber bowl which rotates to and away from the soil collar. The 8200-104C is weatherized and intended to be left outdoors for extended periods of time to make automated measurements. The clear chamber allows sunlight to reach plants in the collar, making this chamber suitable for measurement of net carbon exchange.

Soil collars

Part number 6581-044

Soil collars are a short section of pipe that provides a seal between the chamber and the soil and should be installed at the measurement site at least 6 hours prior to measurements (although 24+ hours is better). Additional collars can be purchased from LI-COR or made in a shop if you have access to suitable materials (see *Making your own soil collars* on page 4-3).

Spares kit

Part number 8100-613

This kit includes additional components and spare parts for each 8200-104/C Long-Term Chamber.

Description	Quantity	Part Number
Thumb nut	4	165-00140
Bumper	4	191-08069
Cable tie	9	218-08499
Urethane tubing (1.8 m)	1	222-00303
Cap plug	5	620-08297

Replacement gasket kit

Part number 8100-612

This kit, included with each 8200-104/C Long-Term Chamber, contains the components needed to replace the chamber gasket.

Description	Quantity	Part Number
Collar gasket	2	6581-060
Chamber gasket trim (1.8 m)	1	224-07606
Loctite adhesive	1	208-05786
6-32 x 3/8" screw	4	122-00009
4-40 x 3/8" screw	18	122-01578

Bulkhead flying lead for custom chambers

Part number 310-19090

A bulkhead flying lead is available to connect the LI-8250 Multiplexer or 8250-01 Extension Manifold to a custom chamber for communication (see *Integrating a custom chamber* on page B-1).

Custom chamber control kit

Part number 8200-402

LI-COR offers a custom chamber control kit that can simplify integrating your custom chamber with the LI-8250 Multiplexer or 8250-01 Extension Manifold.

Description	Quantity	Part Number
Bulkhead flying lead for custom chambers	1	310-19090
Cable assembly	1	9982-056
Quick-connect bulkhead (female)	1	300-07126
Quick-connect bulkhead (male)	1	300-07127
Seal washer	2	167-07256

Flask Sampling Kit

Part number 8250-660

LI-COR offers a Flask Sampling Kit for measuring gas fluxes from discrete samples, such as soil samples, fruits, or small animals, in flasks.

Description	Quantity	Part Number
Thermistor input module	1	9982-079
Purge pump	1	9982-077
Purge pump mount	1	9982-042
Bev-A-Line® tubing (15 m)	2	8150-250
M3-0.5 x 6 mm mounting screw	10	150-14477
M3-4.5 x 14 mm standoffs	4	161-18848
Seal washer	20	167-07256
Quick-connect bulkhead (female)	8	300-07126
Quick-connect bulkhead (male)	8	300-07127
Barbed quick-connect plug (male)	16	300-07124
Barbed quick-connect plug (female)	16	300-07125
Quick-connect plug	1	300-08151
Quick-connect fitting	2	300-08251
3/32" hex wrench	1	610-04290

Section 2.
Initial setup

In this section, we begin with the basic instrument setup, including connecting and powering on the LI-8250 Multiplexer, connecting to the multiplexer, and more.

Deploying a long-term system

Instruments deployed outdoors for long periods of time are bound to experience a wide range of elements and challenges inherent to working in remote locations. While LI-COR instruments are intended to withstand rigorous field research, there are steps you can take to ensure your equipment continues to perform at its peak.

Protection from the elements

The LI-8250 Multiplexer, 8250-01 Extension Manifold, and the LI-870 CO_2/H_2O Analyzer are weatherproof. However, we do still recommend you take the conditions of your site into consideration. Some sites may require you to place these instruments on a pallet or other object to protect them from flooding or heavy snow events. Other sites may subject these instruments to significant solar loading. At these sites, the instruments may benefit from a cover to provide shade and ensure they remain within their operating temperature range.

The LI-78xx Trace Gas Analyzers are weather-resistant, but they are not weatherproof. For an LI-78xx Trace Gas Analyzer to be deployed in the field for extended periods, they **must** be covered and elevated. The cover can be something simple, such as a doghouse or pup tent.

Figure 2-1. An example long-term system setup with an LI-78xx Trace Gas Analyzer, LI-8250 Multiplexer, and LI-870 CO_2/H_2O Analyzer.

Power requirements and consumption

A LI-8250 Multiplexer long-term system deployed in the field can be run on mains power using the outdoor AC to DC power supply (part number 8250-770) or on a user-supplied external DC power source, such as solar panels or a fuel cell.

Table 2-1. Typical long-term system power consumption (Wi-Fi off) based on the number of chambers and additional consumption for the LI-870.

Chambers	Extension Manifolds	Idle (W)	Active (W)
1	0	4.9	20.1
2	0	5.2	20.4
4	0	6.0	21.2
8	0	7.5	22.7
15	1	10.9	36.4
22	2	14.3	39.8
29	3	17.8	43.3
36	4	21.2	46.7
Additional for LI-870	–	5.0	5.0

The LI-8250 Multiplexer has three power supply options discussed in more detail in *Powering the LI-8250 Multiplexer* on the facing page. The LI-870 CO_2/H_2O Analyzer is powered by the multiplexer as are each of the 8250-01 Extension Manifolds and 8200-104/C Long-Term Chambers. The *Table 2-1* above shows typical power consumption based on the number of chambers, extension manifolds, and whether an LI-870 is included.

Each LI-78xx Trace Gas Analyzer requires its own connection to your power source. Either mains power of 100 to 240 VAC, using the universal power supply (part number 9968-232), or a user-supplied external DC power source of 10.5 to 33 VDC, using the auxiliary power supply adapter (part number 9968-242), will work.

Warning: The universal power supply (part number 9968-232) is not weatherized and should not be exposed to the elements. Using the universal power supply where it may become wet or damaged may shock the user or damage the Trace Gas Analyzer.

LI-78xx Trace Gas Analyzers include rechargeable lithium-ion batteries. These batteries should be installed even when connected to an external power source. The *Table 2-2* below shows the power consumption for the LI-78xx Trace Gas Analyzers.

Table 2-2. Power consumption for the LI-78xx Trace Gas Analyzers.

Steady state operation (W)	Universal power supply during warmup (W)	Auxiliary power supply during warmup (W)
22	Up to 100 with batteries charging	Up to 65

For additional details on powering your LI-78xx Trace Gas Analyzer, see the instruction manual provided with your instrument. A complete copy of the manual can be found at licor.com/env/support.

Powering the LI-8250 Multiplexer

Three options are available to power the LI-8250: a standard, bare-leads power cable (part number 8150-706) to connect to a user-supplied DC power source, an indoor AC to DC power supply (part number 8250-772) for connecting to mains power, or an optional outdoor AC to DC power supply (part number 8250-770) for connecting to mains power.

Using the bare-leads power cord

The bare-leads power cord (part number 8150-706) is used to connect the LI-8250 Multiplexer to a DC power source supplied by the user. To make long-term measurements, you will require a dependable power supply, such as a solar power system or a deep cycle marine battery bank, that reliably meets your power requirements. See *Power requirements and consumption* on page 2-2 to estimate your total system power requirements.

> **Note:** Higher DC input voltages result in less power cable voltage and power loss. For example, nominal 24 VDC input voltage would be preferred over nominal 12 VDC input voltage.

To connect the power cable to your system, connect the red wire lead to the positive side of your power source and the black wire lead to the negative side. Then connect the power cord into the **PWR IN** port of the LI-8250 Multiplexer. Once connected, the LI-8250 will automatically power on.

Using the indoor AC to DC power supply

The indoor AC to DC power supply (part number 8250-772) provides power to the LI-8250 Multiplexer using mains power (100 to 240 VAC). This power supply is also used to power the 8250-01 Extension Manifold when running the purge pump with the Flask Sampling Kit (part number 8250-660). This power supply plugs into the **ALT PWR IN** barrel jack inside the case. Once connected, the LI-8250 Multiplexer will automatically power on.

Alternate Power

The indoor power supply can be used to power the multiplexer, so that you can configure your system before field deployment. The lid of the case must be left open to use the indoor power supply.

Alternatively, you can route the power supply connector through the analyzer connection panel for long-term indoor use. To route the power supply connector through the analyzer connection panel, remove the metal seal from the panel (see

Figure 2-2 below) and connect the power supply into the **ALT PWR IN** barrel jack (*Figure 2-3* below).

Figure 2-2. The metal seal can be removed to access the alternate power jack.

Figure 2-3. Routing the indoor AC to DC power supply through the analyzer connection panel after removing the metal seal.

> **Warning:** The indoor AC to DC power supply is intended for indoor use only and should not be exposed to the elements. Using the indoor power supply where it may become wet or damaged may shock the user or damage the multiplexer.

Using the optional outdoor AC to DC power supply

The outdoor AC to DC power supply (part number 8250-770) can be used to power the LI-8250 Multiplexer using mains power (100 to 240 VAC).

Before plugging the power supply into a power outlet, first connect the cord between the power supply and the LI-8250 Multiplexer. Connect one end to the power supply and the other to the **PWR IN** port of the multiplexer. The fittings of the power connectors are keyed. Be sure to align the key with the slot before tightening until snug. The connection will not fit if the key is not aligned.

Once the power supply is connected to the multiplexer, connect the power supply AC cord into the power supply and then plug it into an outlet. You will hear a click when the cord is connected to the power supply. If you do not hear a click, your connection may not be fully sealed.

The LI-8250 Multiplexer will automatically power on once power is connected.

Warning: To protect against electrical shock, the power supply must be connected to a grounded AC receptacle. We recommend that the mains power to the instrument be supplied by a ground-fault circuit interrupter (GFCI).

Connecting to the LI-8250 Multiplexer

You can connect to your LI-8250 Multiplexer using either the Wi-Fi network broadcast by the multiplexer or Ethernet.

Connecting over Wi-Fi

Your LI-8250 Multiplexer is capable of broadcasting its own Wi-Fi network and takes just a few steps to connect. These steps can be performed using a computer, tablet, or smart phone in the Chrome, Safari, Firefox, or Edge web browsers.

1 Connect your computer or smart phone to the LI-8250 Wi-Fi network

On your computer or mobile device, follow your standard procedure for identifying Wi-Fi networks. The network name is the serial number of the LI-8250 Multiplexer (`82m-nnnn`). Your serial number can be found on the label inside the case of the multiplexer (see *Figure 2-4* below). Select the network and connect to it. Enter the password `licorenv` to complete the connection.

Figure 2-4. The serial number can be found on the interior label of the multiplexer.

2 Enter the hostname or IP Address in the browser address bar

One of the following will work.

- Hostname: Enter `http://82m-nnnn.local`, where `82m-nnnn` is the hostname (and the serial number) of your LI-8250 Multiplexer.
- Alternate Hostname: Some Android OS devices do not support multicast Domain Name Service (mDNS). You may need to enter the hostname in this format instead: `http://82m-nnnn.li8250.licor.com`
- Fixed IP address: Enter `192.168.46.1`

The LI-8250 Multiplexer user interface will load in your browser window.

> **Note:** Broadcasting a Wi-Fi signal is not permitted in all locations. LI-COR, Inc. cannot be held liable for use of Wi-Fi/WLAN where it is prohibited. If WLAN is restricted in your area, and you are interested in other options for Wi-Fi, please contact LI-COR technical support.

Connecting over Ethernet

In some cases where Wi-Fi is not allowed, or if Wi-Fi has been disabled through the software, you will need to make a wired connection to interact with the LI-8250 Multiplexer. After completing this process, you can re-enable Wi-Fi or continue to use the wired connection.

1. Connect your computer directly to the multiplexer using the Ethernet cable included with your instrument (part number 616-06116).

   Plug one end of the Ethernet cable into the Ethernet port or Ethernet port adapter of your computer and the other into one of the three available Ethernet ports on the LI-8250 Multiplexer. Alternatively, you can connect to the multiplexer if it is on the same local area network (LAN) as your computer.

2. Enter your serial number into the address bar of an internet browser using the following: `http://82m-nnnn.local`

   where `82m-nnnn` is the serial number of your multiplexer. If you do not know your serial number, see *Figure 2-4* on the previous page. Chrome, Safari, Firefox, and Edge are the recommended browsers to connect to the multiplexer.

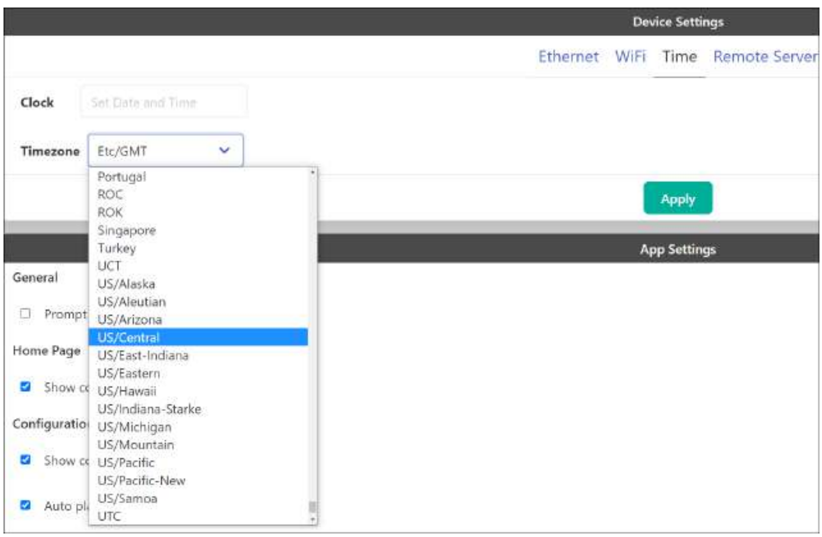
If the URL and serial number have been entered correctly, the LI-8250 user interface will load in your browser window.

Setting the timezone

The date and time are logged in your data files and are used to distinguish observations. Setting the timezone is not only important for accurate data, but also for any time-matching that may need to be done in SoilFluxPro Software. You should only need to set your timezone once, unless you have moved your research site to a new timezone.

To set the timezone:

1. Connect to the LI-8250 Multiplexer user interface and go to the Device Settings page.
2. Select your **Current Timezone** from the drop-down.



3. Click **Apply** to save the timezone.

> **Note:** You must always **Apply** after changing the timezone. If you navigate to other pages without clicking **Apply**, your changes will not be saved.

Disabling Wi-Fi

If Wi-Fi is not permitted in your country, you will need to disable it.

You may disable and re-enable Wi-Fi using a wired connection. Connect your multiplexer to your computer using the included, unsealed RJ-45 Ethernet cable (part number 616-06116). After connecting, launch the LI-8250 Multiplexer user interface using the same address listed above. Select the Wi-Fi settings icon and toggle the **Status** to **off**. Then click **Apply**.

> **Note:** You must always **Apply** after changing Wi-Fi settings. If you navigate to other pages without clicking **Apply**, your changes will not be saved.

Re-enabling Wi-Fi

To re-enable Wi-Fi, connect to the LI-8250 Multiplexer using the instructions in *Connecting over Ethernet* on page 2-8.

Select the Wi-Fi settings icon and toggle the **Status** to **on**. Then click **Apply**. Leave **Channel** on the default option (this may be used to troubleshoot connectivity issues if necessary).

> **Note:** You must always **Apply** after changing Wi-Fi settings. If you navigate to other pages without clicking **Apply**, your changes will not be saved.

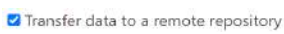
After pressing **Apply**, your LI-8250 Multiplexer will begin broadcasting a Wi-Fi signal. You can then connect to your LI-8250 from your computer, tablet, or smartphone using the steps in *Connecting over Wi-Fi* on page 2-7.

> **Note:** Broadcasting a Wi-Fi signal is not permitted in all locations. LI-COR, Inc. cannot be held liable for use of Wi-Fi/WLAN where it is prohibited. If WLAN is restricted in your area, and you are interested in other options for Wi-Fi, please contact LI-COR Technical Support.

Configuring a remote server

The LI-8250 Multiplexer can push daily summary files and .82z files from the previous day to a remote server. All .82z files from the same day are uploaded as a single .zip file, whereas daily summary files are uploaded as a single .csv file. The LI-8250 Multiplexer maintains a queue of files to be uploaded to the server. If connectivity is lost before an upload is complete, the multiplexer will continue the upload when connectivity is restored.

> **Note:** If your multiplexer is deployed in the field without an available internet connection, see *Connecting to a cellular modem* on page E-1 for instructions on connecting the multiplexer to a cellular modem.

1. Connect to the LI-8250 Multiplexer user interface and go to the Device Settings page. Then open the **Remote Server** settings.
2. Check the box for **Transfer data to a remote repository.**
3. 

4. Enter a **Username**, **Password**, and **URL**. You will need to enter the URL in a way that works for both the server and the transfer protocol used. For example:
   - https://server-address
   - sftp://server-address/path/$(filename)
   - ftp://server-address/path/$(filename)

   In the examples above, **server-address** is the URL of the server where the multiplexer will send data.

   Depending on your server setup, you may want to add information to the URL. When any of the items below are added to the URL, the LI-8250 Multiplexer will replace **$(variable)** with the corresponding value. For example, $(hostname) is replaced with the hostname of the multiplexer.

   - $(checksum) MD5 sum of the file being uploaded
   - $(filename) Name of the file being uploaded
   - $(fullname) Name of the file including the path
   - $(hostname) Multiplexer hostname
   - $(md5sum) MD5 sum of the contents of the file begin uploaded
   - $(md5) Same as md5sum

> **Note:** Even if the server you are using does not require a username and password, the multiplexer expects that information will be required. In this case, you can use a generic username and password.

5 Add a transfer **Start Time** and **End Time**.

This step is optional. By entering a time, you can choose when files are uploaded. For example, if you want the files to transfer between 1:00 AM and 4:00 AM, set **Start Time** to 01:00 and **End Time** to 04:00. If both fields are set to 00:00, the multiplexer will attempt to transfer every 30 minutes until the upload of all files is complete.

6 Check the box for **Upload only Summary Files**.

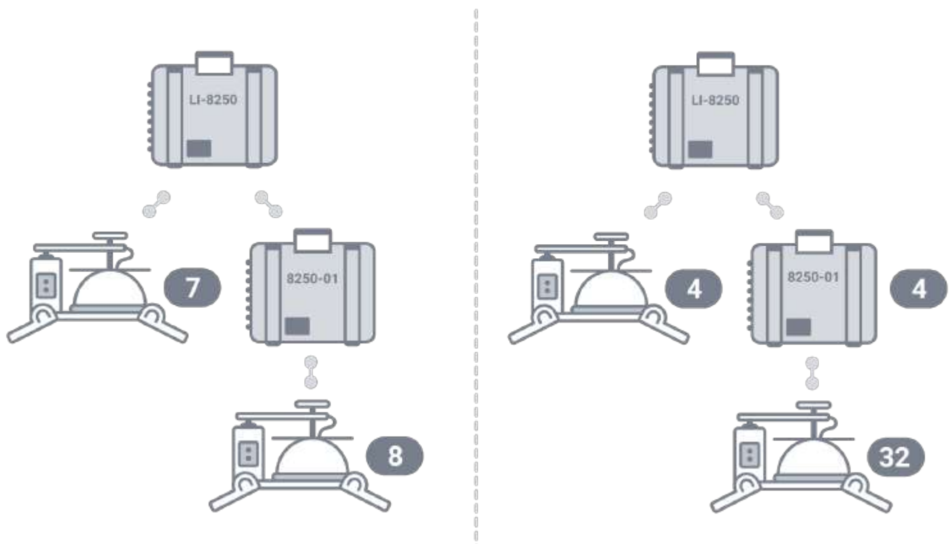
Use this box if you only want to receive the daily summary files. With this box checked, the .82z files will not be transmitted. Since the summary files are small compared to the .82z files, this will reduce the bandwidth needed to transfer.

7 Click **Apply**.

> **Note:** You must always **Apply** after changing remote server settings. If you navigate to other pages without clicking **Apply**, your changes will not be saved.

Section 3.
Extension manifolds

The LI-8250 Multiplexer can connect one chamber on each of its eight ports, resulting in a maximum of eight chambers. The 8250-01 Extension Manifold increases the number of chambers you can have in your long-term system by enabling up to eight chambers to share a single multiplexer port.



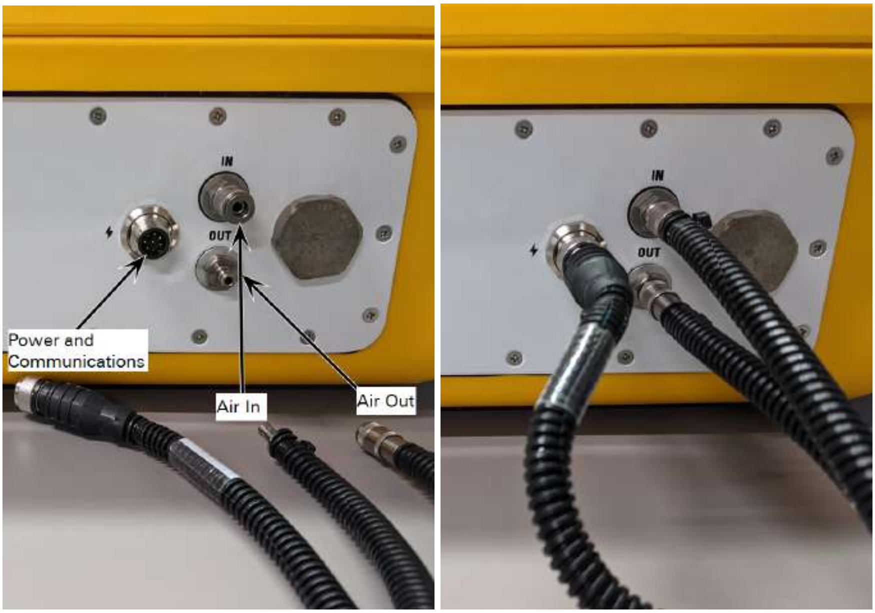
Connecting an extension manifold

Part number: LI-8250, 8250-01, and 9982-056

Connecting an 8250-01 Extension Manifold to your LI-8250 Multiplexer takes just a few steps. The multiplexer provides power to the extension manifold and to any 8200-104/C Long-Term Chambers connected to the extension manifold.

The multiplexer and extension manifold use metal quick-connect fittings for air tubing. A male and female fitting comes factory-installed on both ends of the cable assembly (part number 9982-056).

First, connect the air tubing quick-connect fittings from the cable assembly to the multiplexer connection panel of the extension manifold. Then connect the power and communications (RS-422) connector to the ⚡ port. The fitting for the power and communications connector is keyed. Be sure to align the key with the slot before tightening until snug. The connection will not fit if the key is not aligned.



Complete the connection by connecting the air tubing quick-connect fittings and the power and communications connector to the ⚡ port of the chamber connection panel on the LI-8250. Ensure that all connections for an extension manifold are made to the same port number.

Determining extension manifold needs

Because an extension manifold occupies a port, each 8250-01 Extension Manifold effectively adds another seven chambers to your system. The multiplexer can support four extension manifolds, which allows you to grow your system to up to 36 chambers. *Table 3-1* below details how many extension manifolds are needed for each range of chambers.

Table 3-1. Maximum number of chambers based on number of 8250-01 Extension Manifolds in the system.

Extension Manifolds	Chambers on Extension Manifold Ports	Chambers on Remaining Multiplexer Ports	Total Chambers
0	0	8	8
1	8	7	15
2	16	6	22
3	24	5	29
4	32	4	36

Section 4.
Long-term chambers

With the use of multiple 8250-01 Extension Manifolds, the LI-8250 Multiplexer can connect with any combination of up to 36 chambers at a time, including the 8200-104 Opaque Long-Term Chamber, the 8200-104C Clear Long-Term Chamber, custom-built chambers, and flasks. For details on how to use a custom chamber, see *Integrating a custom chamber* on page B-1. For more about the Flask Sampling Kit (part number 8250-660), see *Measuring gas fluxes in a flask system* on page D-1.

Each chamber occupies a single port number on the chamber side panel with an air inlet, air outlet, and power and communication connection. LI-COR long-term chambers can integrate many different kinds of sensors, including the LI-190R Quantum Sensor, the LI-200R Pyranometer, the thermistor, and sensors with an SDI-12 interface, such as the Stevens HydraProbe.

Installing soil collars

To install a soil collar, lay a piece of wood across the collar and hit the wood using a hammer or mallet to drive the collar into the soil. Aim to hit the wood near the collar and move the wood to high spots as needed. In hard or compacted soils, you may need to create a channel around the collar with a knife or trowel before installing the collar. Check the collar to ensure it is level.

> **Note:** After installing a soil collar it may take up to 24 hours for the soil gas flux to return to normal, undisturbed levels.

Insertion depth

Optimal collar height will depend upon site conditions and the length of time the collars will be used at a given site. At a minimum, the collar should be inserted into the soil to a depth that gives a solid foundation so the collar does not move when placing the chamber on the collar.

As insertion depth is increased, lateral diffusion of trace gases in the soil column below the chamber will be reduced. The advantage of this is that lateral diffusion can be a source of error in the measurement, but the disadvantage is that as insertion depth increases, the possibility of root shearing increases. Collars may become loose over time and should be moved if this occurs.

Collars should extend 3 cm or more above the soil surface. With greater extension there is increased shading and perturbation of air movement. Over the long term, these perturbations could result in changes of evaporation rate, soil temperature, and soil moisture.

Measuring the collar height

The collar height is used to the determine the volume of air inside the soil collar, which is in turn used to calculate the total system volume. Total system volume is an important parameter of the flux calculation and should be determined as accurately as possible. The collar height is measured by the distance between the soil surface and the upper edge of the chamber base plate. You will enter the collar height measurement into the chamber block on the **Configuration** page (see *Configuring the LI-8250 Multiplexer block* on page 6-7).

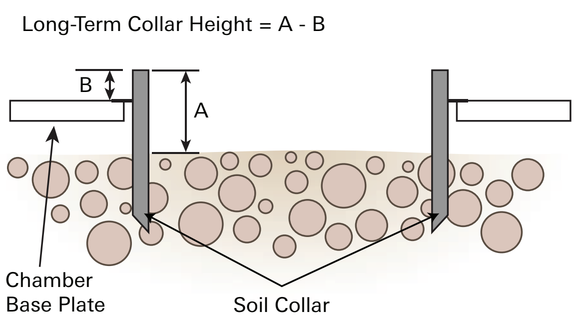


Figure 4-1. Collar height is the distance from the soil surface to the top of the chamber base plate.

For the most accurate measurements, it is recommended that you measure collar height in at least 3-4 places and average these numbers. This is especially important when collars are installed in uneven or sloping soil.

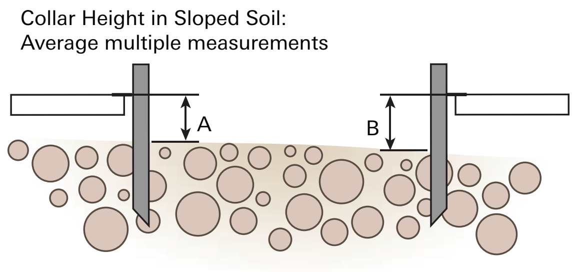
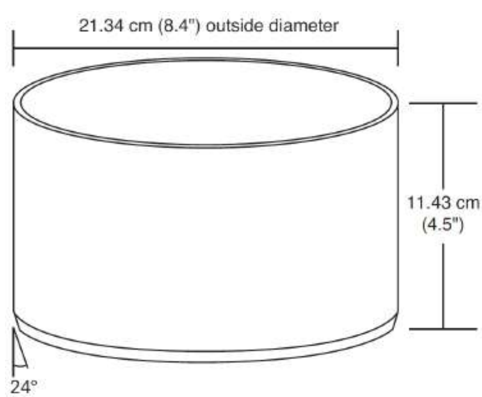


Figure 4-2. Collar height offset in sloped soil should be computed from an average of the offsets.

Making your own soil collars

Although some collars are included with your LI-8250 Multiplexer, you can create your own collars. We recommend making your own collars with materials that are widely available in the United States. In other countries you may need to special order materials.

- **Inside Diameter:** 20.1 cm ± 0.03 cm
- **Outside Diameter:** 21.34 cm
- **Height:** 11.43 cm



LI-COR soil collars are constructed from thick-walled, 8-inch SDR 35 PVC pipe. Begin by cutting a length of pipe to approximately 11.43 cm. Then, use a grinder, coarse file, or large lathe to bevel the bottom edge to a 24° angle. The bevel is optional but does allow for easier insertion of the collar into the soil.

Installing and connecting a long-term chamber

The 8200-104 Opaque Long-Term Chamber and 8200-104C Clear Long-Term Chamber are used to make continuous measurements of soil gas flux at a single location for weeks or months at a time.

These chambers uses a motor-driven strut system to automatically move the chamber bowl away from the soil collar when not taking a measurement. This ensures that the sample location is subjected to normal, undisturbed precipitation, temperature, and shading between measurements. A patented pressure vent at the top of the chamber prevents pressure spikes when the chamber closes and maintains chamber pressure at ambient levels under calm and windy conditions.

Each chamber has two gaskets: the chamber bowl seals to the base plate with a flexible gasket, and the base plate seals to the soil collar with a second gasket.

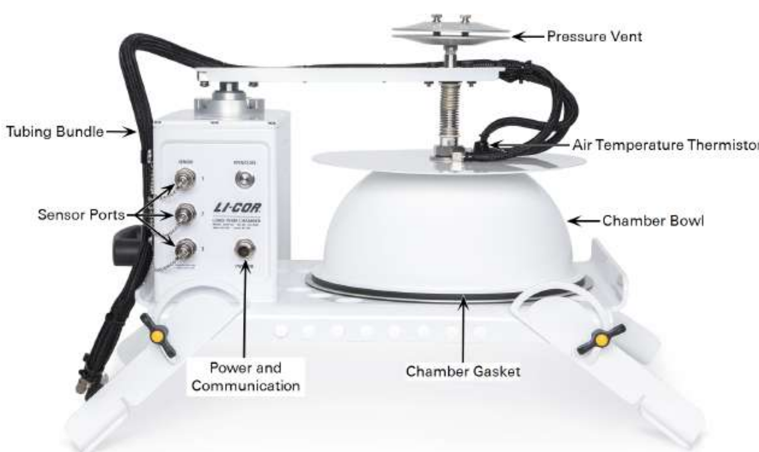


Figure 4-3. The 8200-104 Opaque Long-Term Chamber.

Positioning considerations

When installing the 8200-104 Opaque Long-Term Chamber or the 8200-104C Clear Long-Term Chamber it is important to first consider the positioning of the chamber. You will want to ensure there is sufficient clearance for the chamber arm and bowl to swing away. The default open position is 180° from the closed position. See *Changing the open position* on page 4-7 for details on chamber clearance requirements and changing the open position.

You will also want to orient the chamber so that the LI-COR logo stamped on the motor housing faces the equator. This ensures that most of the shadows from the chamber structure are cast away from the collar area to prevent shading effects. This is especially important when making net carbon exchange measurements. See *Measuring net carbon exchange* on page A-13 for details. Even with this orientation, the collar and chamber may still shade the sample area.

Leveling the chamber

Make sure the soil collar does not shift when placing the chamber on it. The chamber edge should be as close to the soil surface as practical, so that air flow within the chamber causes mixing near the soil surface, while minimizing the amount of the collar that extends into the chamber. Each of the four legs should be adjusted so that the chamber sits evenly over the soil collar.

To adjust a leg, loosen the knob and reposition the leg. Then tighten the knob securely.

Connecting a long-term chamber

Part number:
LI-8250 or 8250-01,
8200-104/C, and
9982-056

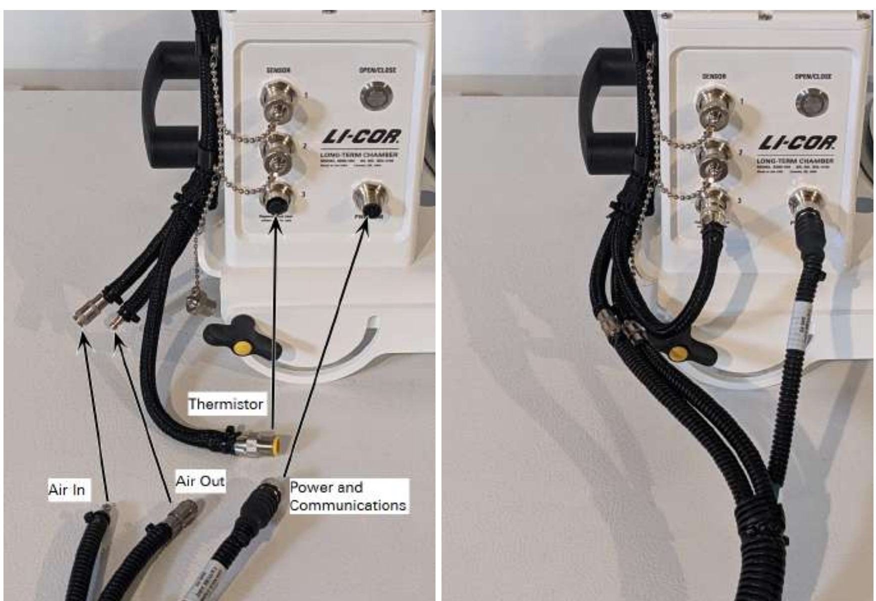
The components needed to make this connection are the LI-8250 Multiplexer or 8250-01 Extension Manifold, a long-term chamber (part number 8200-104 or 8200-104C), and the cable assembly (part number 9982-056).

Connecting either the 8200-104 Opaque Long-Term Chamber or the 8200-104C Clear Long-Term Chamber requires the same steps. The multiplexer provides power to the 8200-104/C Long-Term Chambers directly or indirectly via an extension manifold.

The multiplexer, extension manifolds, and long-term chambers all use metal quick-connect fittings for air tubing. A male and female fitting comes factory-installed on the tubing bundle of the 8200-104/C and the cable assembly.

The chambers use a built-in thermistor for a chamber air temperature measurement used in flux calculations. The connector for the thermistor will occupy one of the **SENSOR** ports on the chamber and is part of the chamber tubing bundle.

First, connect the air tubing quick-connect fittings from the cable assembly to the tubing bundle on the chamber and connect the thermistor to one of the available **SENSOR** ports. Then, connect the power and communications (RS-422) connector to the **PWR/COM** port on the housing of the 8200-104/C. The fittings for the thermistor and power and communications are keyed. Be sure to align the key with the slot before tightening until snug. The connection will not fit if the key is not aligned.



Complete the connection by connecting the air tubing quick-connect fittings and the power and communications connector to the ⚡ port of the chamber connection panel on the LI-8250or 8250-01 Extension Manifold. Ensure that all connections for a long-term chamber are made to the same port number.

Once the RS-422 cable is connected (and if the system is powered on) the **OPEN/CLOSE** button of the 8200-104/C will illuminate with a green light to indicate it is powered on.

Repeat the steps above for each chamber you need to connect.

Changing the open position

You may program each long-term chamber with one of six open positions ranging from 30° to 180° as shown in *Figure 4-4* on the next page. The default open position is approximately 180° from the closed position. Five other open positions are available to avoid terrain or obstructions that interfere with the full 180° of movement. Be sure to consider possible shading effects when choosing an open position.

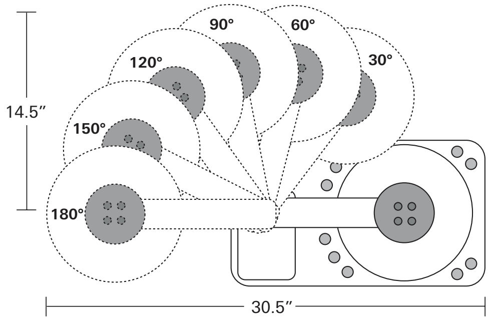


Figure 4-4. The long-term chambers have six programmable open positions.

To change the open position:

1. Connect to your LI-8250 Multiplexer and open the user interface.

   See *Connecting to the LI-8250 Multiplexer* on page 2-7 for instructions on how to connect.

2. Open the **Configuration** tab and select the chamber by serial number to have the open position changed.
3. Add the **Open Position** block to the chamber if it is not already present.

   Select LI-COR Chambers in the Toolbox and find the **Open Position** block. Then click and drag the Open Position block to the chamber block.

4. Under **Open Position** of the chamber you can manually enter the new open position into the field in 30° increments, or you may use the mouse over the dial to select the new open position.

   See *Figure 4-5* below. The multiplexer will store this setting as the open position for this port until it is changed. If a different chamber is placed on that port, the chamber will use the open position assigned to that port.

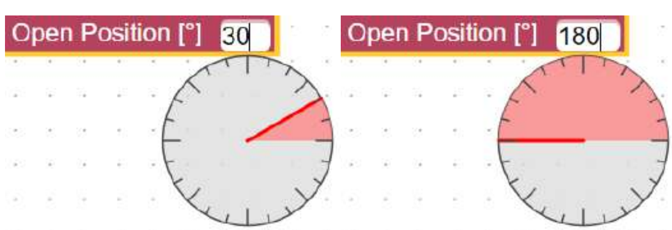


Figure 4-5. The open position can be set in 30° increments from 30° to 180°.

Parking the chamber

You can manually change the position of the chamber using the **OPEN/CLOSE** button on the motor housing. This button has a few different uses but the most common use is to place the chamber into the park position. When in park, the chamber will raise slightly to prevent compressing the chamber gasket. This is the position you will want the long-term chamber in before transporting it, performing maintenance, or storing it.

To place the chamber into park, quickly press the **OPEN/CLOSE** button twice. If the chamber was open, it will first fully close and then it will raise to the park position.

Below is a complete list of the **OPEN/CLOSE** button functions.

- A single press will close the chamber if it is open and open the chamber if it is closed.
- Two quick presses will park the chamber.
- Pressing and holding the button will move the chamber slowly in the opposite direction of its last movement.

CAUTION: Be sure to park the chamber before transporting it, performing maintenance, or placing it in long-term storage. Handling the chamber while it is not parked can strain and potentially damage the shaft and sealing mechanism.

Tips for using the 8200-104C Clear Long-Term Chamber

Here are some tips that will help you use the clear long-term chamber.

Shading effects

Shading effects from the structure of the 8200-104C Clear Long-Term Chamber can alter the rate of photosynthesis. To minimize the effect shading has on your results, the 8200-104C should always be oriented so that the LI-COR logo stamped into the motor housing faces the equator. This ensures that most of the shadows from the chamber structure are cast away from the collar area. Even with this orientation, the collar and chamber may still shade the sample area.

Temporal variations in light intensity inside the collar area will occur due strictly to shading from both the chamber and foliage in and around the collar, as the sun moves across the sky. It is important to consider these temporal variations when examining flux data.

Measuring photosynthetically active radiation

When using the clear chamber for net carbon exchange (NCE) measurements, you will want to measure photosynthetically active radiation (PAR) to supplement your measurements. The LI-190R Quantum Sensor can be connected to the 8200-104C Clear Long-Term Chamber to measure PAR at the chamber. This sensor is available in a package (part number 190R-8200) that includes an LI-190R Quantum Sensor and leveling stake to mount and level the sensor.

Figure 4-6. The 190R-8200 package includes a leveling Stake to mount and level the LI-190R Quantum Sensor for measuring PAR near the 8200-104C Clear Chamber.

Using sensors

The 8200-104 Opaque Long-Term Chamber and 8200-104C Clear Long-Term Chamber can integrate many different kinds of sensors for the collection of ancillary data. Compatible sensors include: the chamber thermistor, the LI-190R Quantum Sensor, the LI-200R Pyranometer, and sensors with an SDI-12 interface, such as the Stevens HydraProbe.

	Chamber Connection Allowances
Sensor Type	Number of Sensors
Light	1 (the LI-190R Quantum Sensor or the LI-200R Pyranometer)
Chamber air temperature	1 (the integrated chamber thermistor)
SDI-12	Up to 9 with T-split fitting

Note: SDI-12 sensors require some configuration before they can be used. Sensor configuration is done using the SDI-12 console in the user interface. See *SDI-12 console* on page 6-21 for details on configuring an SDI-12 sensor.

Connecting a sensor

LI-COR long-term chambers use a keyed Turck fitting to connect to a sensor. Sensors can be connected to any port of the chamber or T-split fitting. To connect a sensor, insert the female fitting of the sensor into the male fitting of the chamber or sensor T-split, then thread the connector until snug. The fittings are keyed, so be sure to align the key of the sensor fitting with the slot on the chamber or T-split fitting. The connection will not fit otherwise.

Using the sensor T-split fitting

The sensor T-split fitting (part number 310-18516) expands the number of sensors you may have connected to a LI-COR long-term chamber. Each T-split fitting can connect two sensors, including the chamber thermistor. Using the sensor T-split fitting is similar to connecting a sensor itself. One fitting of the T is a female fitting that you connect to the chamber and the additional fittings are male to connect to the sensors (see *Figure 4-7* below). The fittings are keyed, so be sure to align the key on one fitting with the slot on the other before tightening the threads.

Figure 4-7. One end of the sensor T-split fitting connects to the chamber and the other two fittings are available to connect to a sensor.

Light sensors

Below are instructions for installing and maintaining the LI-190R Quantum Sensor and the LI-200R Pyranometer. Both sensors use the same instructions, except each has its own sensor block in the configuration. The quantum sensor package (part number 190R-8200) and the pyranometer package (part number 200R-8200) include a mounting plate and leveling stake used to mount and level the sensor.

> **Note:** The LI-190R Quantum Sensor and LI-200R Pyranometer are the only light sensors compatible with the 8200-104/C Long-Term Chambers. Only one light sensor may be connected to a chamber at a time.

LI-190R Quantum Sensor

The LI-190R Quantum Sensor can be connected to the 8200-104/C Long-Term Chambers to measure photosynthetically active radiation at the chamber to supplement your data.

Quantum Sensor Specifications	
Spectral Response:	400 to 700 nm
Energy Range:	0 to 2000 μmol/m^2/s
Absolute Calibration:	±5%
Output Signal:	0 to 15 μA
Linearity:	Max. deviation of 1% up to 10,000 μmols^{-1}m^{-2}
Cosine Correction:	Up to 82° angle of incidence
Azimuth Error:	<1% over 360° at a 45° elevation angle

LI-200R Pyranometer

The LI-200R Pyranometer can be connected to the 8200-104/C Long-Term Chambers to measure global solar radiation at the chamber to supplement your data.

Pyranometer Specifications	
Spectral Response:	400 to 1100 nm
Energy Range:	0 to 1000 W/m^2
Absolute Calibration:	±5%
Output Signal:	0 to 75 µA
Linearity:	Max. deviation of 1% up to 3,000 $W\ m^{-2}$
Cosine Correction:	Up to 82° angle of incidence
Azimuth Error:	<1% over 360° at a 45° elevation angle

Installing the sensor

Installing the sensor takes just a few steps.

1. Choose a position for the sensor so that it will not be shaded, from either the surrounding landscape or the chamber itself, and so that the sensor and its cable will not interfere with the chamber opening and closing.
2. Push the leveling stake into the soil keeping it as upright as possible.

   Leave at least 5 cm of clearance between the soil and the bottom of the mounting plate to prevent the sensor from being submerged in heavy rain. If the soil is difficult to push the stake into, you can drive the stake into the soil. Set a scrap piece of wood into the opening between the arms and tap the wood using a hammer or mallet. Be careful not to bend the stake.
3. Attach the mounting plate to the leveling stake using the three Phillips-head screws.

   Do not fully tighten the screws at this point.
4. Mount the sensor in the fixture on the mounting plate by placing the sensor into the fixture and tightening the mounting screw against the sensor base.

5 Level the sensor by adjusting the three hex-head leveling screws until the bubble is centered in the bubble level.

6 Fully tighten the Phillips-head screws from step 3 to lock the mounting plate in place.

7 Connect the sensor to the chamber using the instruction in *Connecting a sensor* on page 4-11.

Configuring the sensor

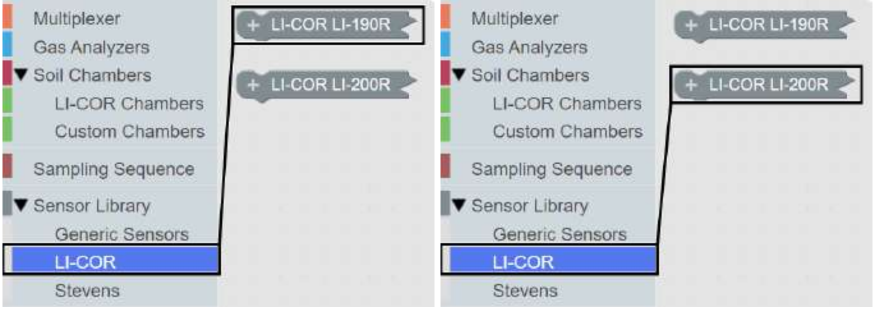
LI-COR sensors require little configuration to work with the LI-8250 Multiplexer.

1 To add a sensor to a LI-COR chamber block, first navigate to **Configuration** in the LI-8250 Multiplexer user interface.

If you do not have an existing configuration, see *Configuring the LI-8250 Multiplexer block* on page 6-7 for details on how to do this.

2 Expand the **Sensor Library** drop-down and select **LI-COR**.

3 Click and drag the **LI-COR LI-190R** or **LI-COR LI-200R** block under the chamber where it will be added.



4 You will then need to add the **Serial Number** and **LI-COR Light Sensor Multiplier** for your sensor.

Each LI-COR radiation sensor is shipped with a certificate of calibration. The certificate can also be found at licor.com/env/support/. Enter your sensor's serial number in the calibration search box at the bottom of the page. The calibration multiplier is listed on the certificate under **For use with LI-COR handheld meters and loggers.**

Maintaining the sensor

- Keep the surface and vertical edge of the acrylic diffuser clean.
- Clean the diffuser sensor with water, mild detergent, or vinegar dilute using a soft, lint-free cloth as needed.
- Do not use alcohol, organic solvents, strong detergents, abrasive solvents, or abrasive cloth on the diffuser.
- Return the sensor to LI-COR for factory recalibration every two years. Contact technical support for more information.

Stevens HydraProbe II

The Stevens HydraProbe provides ancillary soil moisture and temperature data from the probe measured alongside soil gas concentration data. The probe communicates with the LI-8250 Multiplexer using the SDI-12 communications protocol. Provided are some basic instructions for installing and using the Stevens HydraProbe. For more information about using the Stevens HydraProbe, see the operation instructions at: https://stevenswater.com/products/hydraprobe/

	Stevens HydraProbe II Specifications	
	Operating Temperature Range:	-10 to 60 °C
	Voltage Range:	9 to 20 VDC
	Measurement Range:	0 to saturation
	Accuracy:	±0.03 m^3/m^3
	Power Requirements:	<1 mA idle; 10 mA active

Installing the sensor

Install the probe by burying it in soil that is representative of your site.

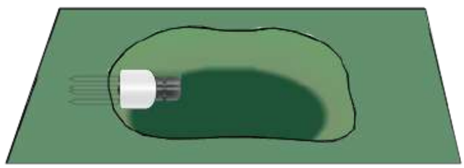
1 Choose a position for the probe so that the probe cable will not interfere with the chamber opening and closing.

2 Dig a small hole with a smooth, undisturbed side.

Try to keep the excavated soil as an intact block if possible.

3 At a depth of 5 cm below the soil surface, press the probe into the soil until the base of the tines are flush with the side.

Be especially careful to avoid creating air pockets when inserting the probe. Air pockets around the tines will reduce the accuracy of measurements.



4 Replace the excavated soil, burying the probe.

5 Connect the sensor to the chamber using the instruction in *Connecting a sensor* on page 4-11.

Configuring the sensor

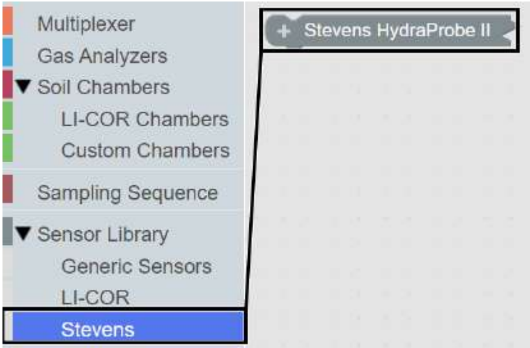
Before you can configure a Stevens HydraProbe, it is recommended that you first change the address and the soil type and verify the measurement configuration using the instructions in *Configuring a Stevens HydraProbe* on page 6-23. Once you have done this, you can add the sensor to your configuration.

1 To add a sensor to a LI-COR chamber block, first navigate to **Configuration** in the LI-8250 Multiplexer user interface.

If you do not have an existing configuration, see *Configuring the LI-8250 Multiplexer block* on page 6-7 for details on how to do this.

2 Expand the **Sensor Library** drop-down and select **Stevens**.

3 Click and drag the **Stevens HydraProbe II** block under the chamber where it will be added.



4 Change the **Sensor Address** to the address you assigned the sensor using the SDI-12 console.

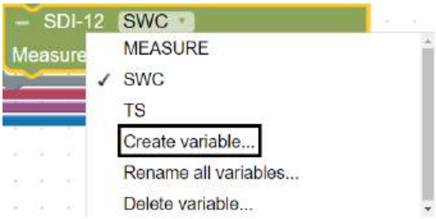
The **Measurement Set** should be left at its default settings: **SWC** is measurement # **1** (for soil moisture) and **TS** is measurement # **3** (for soil temperature).

One measurement block is needed for each variable logged by the probe. Two default blocks are included and do not need to be changed: **SWC** is for soil moisture (the first default output) and **TS** is for soil temperature (the third default output).

5 To add more blocks, select the current block and duplicate it by pressing `Ctrl + Shift + D` or `Cmd + Shift + D`, or right-click the block and select **Duplicate**.

6 **Create a variable** for the new measurement using the drop-down menu.

The variable name you choose is how this measurement will be labeled in the files.



Then select the **Measurement #** and the **Units** for the variable being logged.

Maintaining the sensor

The Stevens HydraProbe is sealed after calibration and does not require routine maintenance. However, be mindful of the following points.

- Read and understand the manufacturer’s instructions provided with this product.
- Do not attempt to disassemble the probe. This will damage the factory seal and invalidate the warranty.
- Do not remove the HydraProbe from the soil by pulling on the cable.
- Do not attempt to straighten a bent tine while it is attached to the probe.

Generic sensors

The LI-8250 Multiplexer can integrate data from nearly any sensor that uses an SDI-12 interface. LI-COR offers an optional 2 m sensor connector (Turck) to cable with flying leads (part number 392-18518) to connect an SDI-12 sensor to the 8200-104/C Long-Term Chambers. See *Sensor connector pin assignments* on page G-3 for a diagram and details of the cable pin assignment.

Caution: Be certain when wiring an SDI-12 sensor using the sensor connector to cable with flying leads not to connect, short, or allow water to make contact with the white or gray wires. If the white or gray wires are connected, shorted, or make contact with water, all sensor communications may be corrupted, including the light sensor and thermistor temperature measurements.

Installing the sensor

Install the sensor according to the manufacturer's instructions choosing a position for the sensor so that the sensor and its cable will not interfere with the chamber opening and closing. Then connect the sensor to the chamber using the instruction in *Connecting a sensor* on page 4-11.

Configuring the sensor

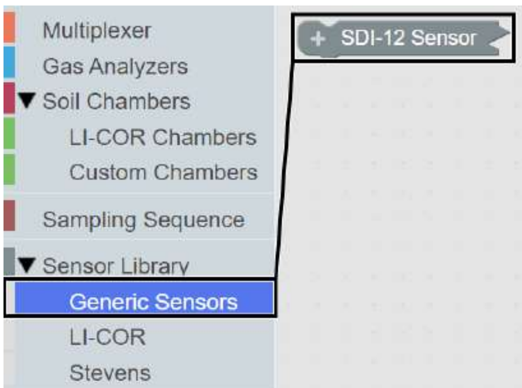
Before you can configure an SDI-12 sensor, it is recommended that you first change the address and configure the sensor using the SDI-12 console. Using the console to configure sensors is detailed in *SDI-12 console* on page 6-21. Refer to the documentation provided with your sensor for details on configuring it. Once you have done this, you can add the sensor to your configuration.

1 To add a sensor to a LI-COR chamber block, first navigate to **Configuration** in the LI-8250 Multiplexer user interface.

If you do not have an existing configuration, see *Configuring the LI-8250 Multiplexer block* on page 6-7 for details on how to do this.

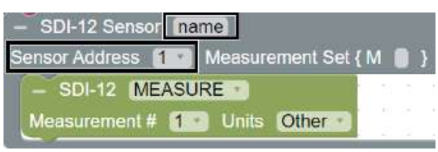
2 Expand the **Sensor Library** drop-down and select **Generic Sensors**.

3 Click and drag the **SDI-12 Sensor** block under the chamber where it will be added.

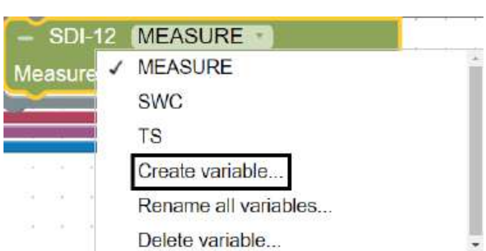


4 Give the sensor a **name** and change the **Sensor Address** to the address you assigned the sensor using the SDI-12 console .

The **Measurement Set** represents the measurement configuration chosen for the sensor in the SDI-12 console.



Within the measurement block, use the **MEASURE** drop-down to **Create a variable** to be measured. The variable name you choose is how this measurement will be labeled in the files.



One measurement block and variable is needed for each variable logged by the sensor. To add more blocks, select the current block and duplicate it. To duplicate a block, select it and press `Ctrl + Shift + D` or `Cmd + Shift + D`, or right-click the block and select **Duplicate.**

5 Select the **Measurement #** of the variable you would like logged.

The Measurement # is a numbered output based on the Measurement Set you configured in the SDI-12 console. For example, on the Stevens HydraProbe Measurement # 1 is soil moisture when using the default configuration.

6 Select the **Units** for the variable being logged.

Viewing live data from the instruments

Sensor data can be viewed live in the LI-8250 Multiplexer user interface under Real Time Variables. It is good practice to verify that the sensor and sensor measurements are behaving as expected after you have configured your sensor.

To see sensor data, go to the Home page. In the **Real Time Variables** pane, expand the drop-down menu and choose the variable(s) from the sensor you would like to see. Selecting a variable from the drop-down menu will add that variable to your Real Time Variables list. Clicking on the trashcan of a variable will remove that variable from your list.

With the variable(s) added to your list, use the **Active Port** drop-down menu to select the chamber with the sensor. Data, including sensor data, will begin streaming from the chamber on that port. This data can also be seen when a sequence is running but only from the currently active port.

Note: Different sensors have different measurement rates, so the time will vary for when you can begin to see data. For example, the thermistor and light sensors are measured once per second but some SDI-12 sensors provide one measurement per minute.

Section 5.
Gas analyzers

The LI-8250 Multiplexer can integrate with LI-COR gas analyzers, non-LI-COR gas analyzers, and even multiple analyzers at once. This way you can measure a variety of gases, such as CO_2, CH_4, N_2O, and isotopologues, using one system.

Connecting an LI-870 CO_2/H_2O Analyzer

Part numbers: LI-8250, LI-870, and 9982-010

The components you will need to make this connection are the LI-8250 Multiplexer (part number LI-8250), the LI-870 CO_2/H_2O Analyzer (part number LI-870), and the LI-870 CO_2/H_2O Analyzer cable assembly (part number 9982-010).

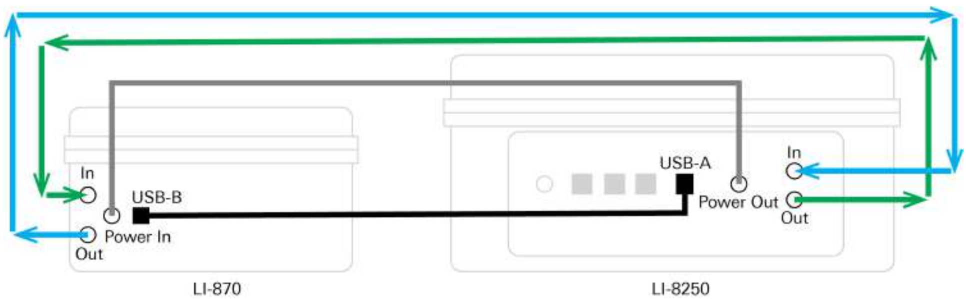
The LI-870 CO_2/H_2O Analyzer offers precise measurements of CO_2 concentration for flux measurements with the LI-8250 Multiplexer. Connection is simple, and power is supplied to the LI-870 directly from the LI-8250 Multiplexer.

A complete user manual is sent with the LI-870 CO_2/H_2O Analyzer, and the material can also be found at the LI-COR support site at licor.com/env/support. This section demonstrates connecting the cable assembly. Instructions for configuring a measurement are detailed in *An overview of configurations* on page 6-5.

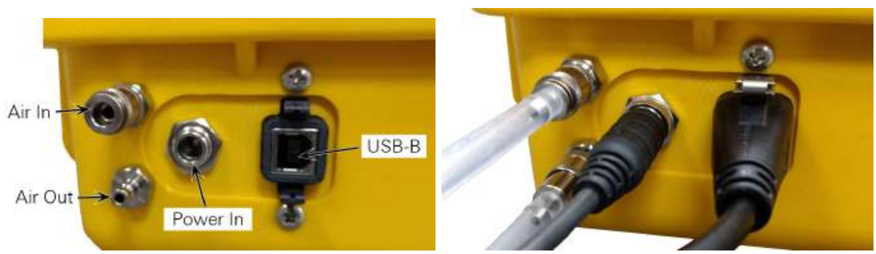
Caution: The LI-870 CO_2/H_2O Analyzer is water-resistant, but it is not waterproof. It should not be allowed to sit in standing water or be directly exposed to driving rain. In hot environments, the LI-870 CO_2/H_2O Analyzer may require a cover for shade to stay within its operating temperature range (-20 to 45 °C, without solar loading).

Making the connection

Connecting the LI-8250 Multiplexer and the LI-870 takes just a few steps.



The LI-8250 Multiplexer and the LI-870 CO_2/H_2O Analyzer each use metal quick-connect fittings for air tubing. A male and female connector comes factory-installed on each end of the LI-870 cable assembly.



First, connect the air tubing quick-connect fittings, male USB-B connector, and power cable connector to the LI-870.

For both ends of the power connector, note that the cable end consists of the power connector itself and an outer nut that must be threaded onto the LI-870 and multiplexer.

Complete the connection by connecting the air tubing quick-connect fittings, male USB-A connector, and power cable connector to the multiplexer.

Note: For a fully seated and sealed connection, ensure the clips above and below the USB connector have locked over the connector and the power cable is fully tightened.

Note: Only use the supplied USB-A to USB-B cable from the LI-870 cable assembly.

Warning: *Only use the power cable supplied with the LI-870 cable assembly (part number 9982-010).*

Powering on the LI-8250 Multiplexer will also power up the LI-870 (assuming you are properly connected). The optical bench of the LI-870 needs to warm up and achieve a steady state temperature and pressure before making measurements. This step may take up to 10 or 15 minutes, depending on ambient temperature.

Connecting an LI-78xx Trace Gas Analyzer

Part numbers: LI-8250, LI-78xx, and 9982-011

The components you will need to make this connection are the LI-8250 Multiplexer (part number LI-8250), an LI-78xx Trace Gas Analyzer, and the LI-78xx Trace Gas Analyzer cable assembly (part number 9982-011).

This section will provide you with what you need to know to connect a LI-78xx Trace Gas Analyzer to your LI-8250 Multiplexer. Instructions for configuring a measurement are detailed in *An overview of configurations* on page 6-5.

Caution: LI-COR LI-78xx Trace Gas Analyzers are water-resistant, but they are not waterproof. They should not be allowed to sit in standing water, be directly exposed to driving rain, or be deployed outdoors without weather protection.

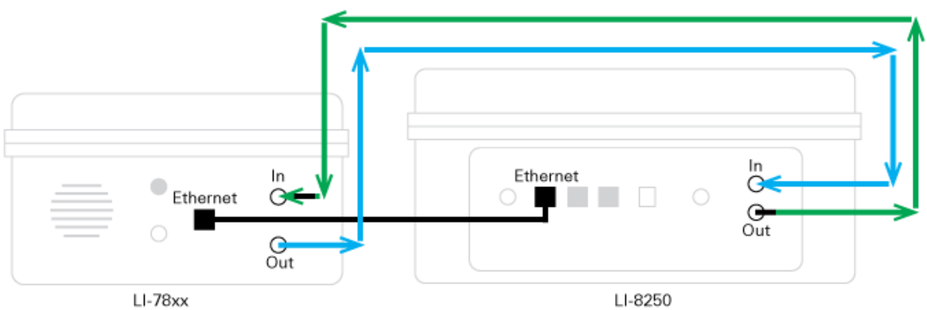
Network cable connector

The LI-8250 communicates with LI-78xx Trace Gas Analyzers using an RJ-45 Ethernet cable. This cable is part of the LI-78xx Trace Gas Analyzer cable assembly (part number 9982-011). The cable assembly must be ordered separately.

> **Note:** Only use the supplied 2 m Cat5e RJ-45 Ethernet cable from the LI-78xx Trace Gas Analyzer cable assembly (part number 9982-011).

Making the connection

Connecting the LI-8250 Multiplexer and an LI-78xx Trace Gas Analyzer takes just a few steps.



> **Note:** The LI-8250 Multiplexer air out to Trace Gas Analyzer air in tubing is distinguished on each end with black plastic shrink wrap. Take care to ensure this tubing and your assembled connectors are installed to the **AIR OUT** port of the LI-8250 Multiplexer and the **IN** port on the Trace Gas Analyzer. Mixing up the connection will cause incorrect mixing and unexpected results in your data.

LI-78xx Trace Gas Analyzers use a 1/4"compression fitting for tubing at both the air in and air out ports.

The LI-78xx Trace Gas Analyzer cable assembly comes pre-assembled with a knurled nut (part number 300-05896), stainless steel insert (part number 300-18126), and stainless steel ferrule (part number 300-15024) at one end to connect to the analyzer.

Thread the nut onto the compression fitting of your analyzer until finger tight and tighten the nut an additional 1/4 turn to ensure a good seal. Then connect the RJ-45 Ethernet cable to the Ethernet port of the Trace Gas Analyzer.

Complete the connection by connecting the air tubing and RJ-45 Ethernet connector to the multiplexer. Any available Ethernet port will work.

> **Note:** For a fully seated and sealed connection, ensure the clips above and below the Ethernet connector have locked over the connector.

Connecting multiple gas analyzers

The LI-8250 Multiplexer can simultaneously connect to both an LI-870 CO_2/H_2O Analyzer and an LI-78xx Trace Gas Analyzer, or two Trace Gas Analyzers. The power and communications connections are the same as those used in *Connecting an LI-870 CO2/H2O Analyzer* on page 5-1 and *Connecting an LI-78xx Trace Gas Analyzer* on page 5-3. You will need the T-split tubing (part number 9982-073) to connect the tubing.

Connect the long leg (15 cm) to the respective **IN** or **OUT** port on the LI-8250 Multiplexer. Then connect the short legs (8 cm) to the respective ends of the analyzer air in and air out tubing.

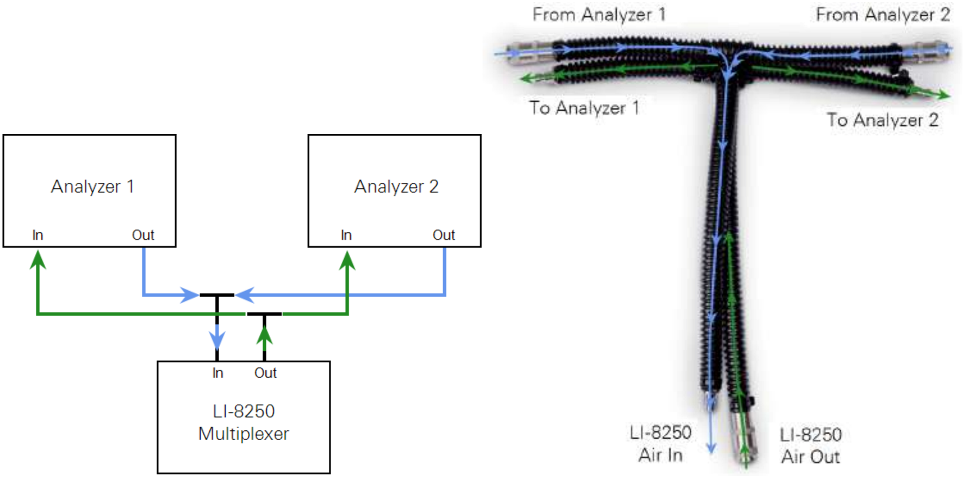


Figure 5-1. If using two gas analyzers, such as an LI-870 and a LI-COR Trace Gas Analyzer, or two trace gas analyzers, connect the tubing as shown using the T-split tubing (part number 9982-073).

The T-split tubing will add 30 cm to the analyzer tubing that must be evenly split between the tubing lengths of both analyzers (add 15 cm to each). Instructions for setting tube volume in the software and establishing communication between the gas analyzers and the LI-8250 are in *Configuring the LI-8250 Multiplexer block* on page 6-7.

Section 6.
User interface

This section will explain the LI-8250 Multiplexer user interface in detail, beginning with a tour of the interface. This section will also cover configuring and starting a measurement, viewing your data, transferring your data, performing a leak test, and includes a data dictionary that describes the different LI-8250 Multiplexer variables.

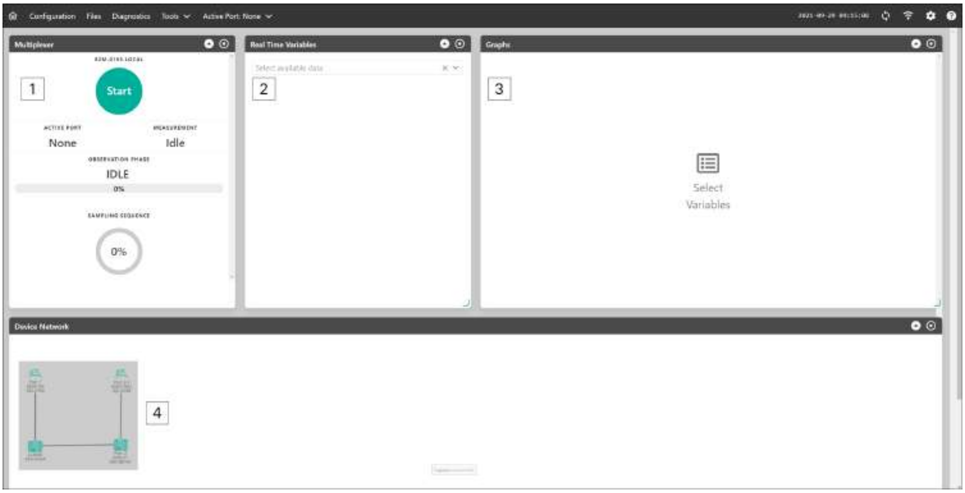
A tour of the user interface

The LI-8250 Multiplexer user interface is made up of several pages:

- The Home page, where you can start and monitor your measurements, view real time variables, and see your data graphed live.
- The **Configuration** page, where you can add chambers, gas analyzers, and sensors, and configure your sampling sequence.
- The **Files** page, where you can view, download, and transfer files and chart summary file data.
- The **Diagnostics** page, where you can see the details of the LI-8250 Multiplexer and connected equipment.
- The **Tools** drop-down, where you can perform the leak test, program sensors, manually control the system, and update firmware.
- The Wi-Fi Settings page, where you can toggle the Wi-Fi signal on and off and select the Wi-Fi channel.
- The Device Settings page, where you can see Ethernet settings, set your timezone, and toggle the other device settings.
- The Help page, where you can find resources related to your LI-8250 Multiplexer and long-term system.

Home

Whenever you first connect to your LI-8250 Multiplexer you will find yourself on the Home page. This is the primary page you will interact with and consists of four major panes.



1 The **Multiplexer** pane is where you will begin a sampling sequence and receive information about the status of the sampling sequence, including which port is active in the sequence, what phase the sequence is in, and the percentage of the sequence that is complete.

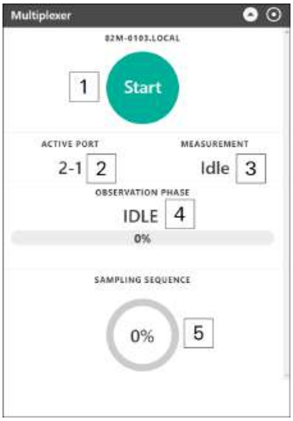
2 The **Real Time Variables** pane allows you to search for and select which variables you would like to monitor and provides real-time updates to those variables.

3 The **Graphs** pane provides real-time graphing of the variables you selected from the **Real Time Variables** pane.

4 The **Device Network** pane provides an overview of your networks, including configured and non-configured devices and their status.

Multiplexer

The Multiplexer pane is also made up of several separate components.



1 **Start** is where you can start or stop a sampling sequence. The sampling sequence will run as configured until you choose to stop it.

2 **Active Port** will display the port that is currently being sampled.

3 **Measurement** shows the current status of the sampling sequence. **Preparing** is when the chamber is closing, **Active** is when a sampling sequence is in progress, and **Idle** indicates that a sampling sequence has not been started.

4 **Observation Phase** indicates where the current observation is according to the configuration. A sampling sequence may be **Active** while the observation may be in a **Waiting** phase. Other typical phases include prepurge, postpurge, chamber closing, delay, and observation.

5 **Sampling Sequence** indicates what percentage of the sequence is complete at this time. This section also provides an estimate of the time complete and the total time of the sequence.

Real Time Variables

The **Real Time Variables** pane lets you select from multiple variables provided by the LI-8250 Multiplexer, LI-COR long-term chambers, LI-COR gas analyzers, and sensors to view them in real time. Selecting a variable from the drop-down menu will add that variable to your Real Time Variables list and clicking on the trashcan will remove the variable. You can change the order of your variables by clicking and dragging them to a different level in the list.

Graphs

The **Graphs** pane allows you to add any of the variables from your Real Time Variables list (up to two at a time) to graph the variable in real time. To graph a variable, click anywhere on the variable. The variable will turn gray and will begin being graphed in the **Graphs** pane. Clicking on the same variable again will deselect it and remove it from the graph.

The Graphs pane will only allow you to plot two variables at a time. To replace one of the variables in the graph, delete one of the variables being plotted. Then add the new variable you would like plotted.

Device Network

The **Device Network** pane gives an overview of the devices that are currently connected to your network. This pane will also show the different states of instruments.


Green icons indicate normal operation.


Yellow icons indicate that there is a problem.


A red icon indicates that communication between the LI-8250 Multiplexer and that device is not established.

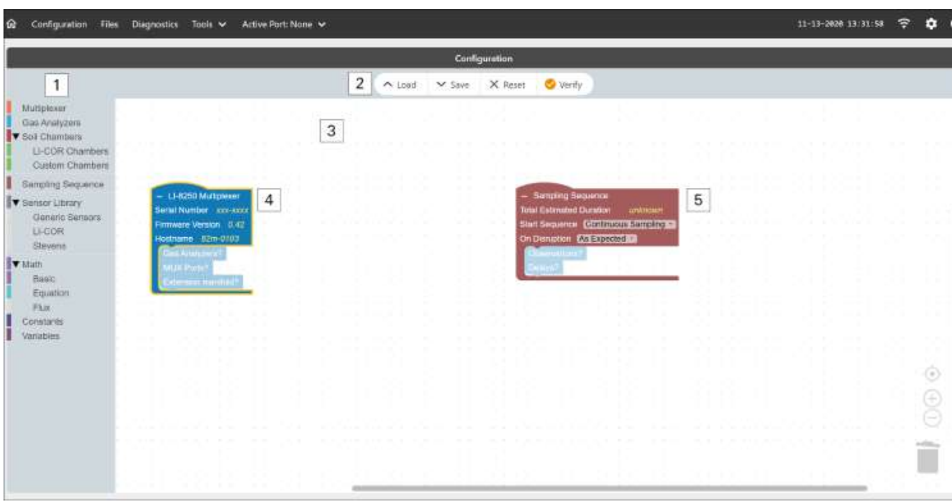

A circle with an exclamation mark indicates a conflict between what device is connected to the port and how the port is configured in the user interface.

Hovering over a green chamber icon will provide you with flux readings from that chamber, while hovering over yellow or red icons provides you with some information about the issue with that device. Visiting the **Diagnostics** page can help you learn more about these issues.

The LI-870 CO_2/H_2O Analyzer, 8250-01 Extension Manifold, and 8200-104/C Long-Term Chamber icons are automatically added to the graphic once the data cables from those devices are connected to the LI-8250. Trace Gas Analyzers are added by connecting the tubing and data cable between the Trace Gas Analyzer and the LI-8250 (see *Gas analyzers* on page 5-1), and then adding the block and selecting the Trace Gas Analyzer hostname. See *Configuring the LI-8250 Multiplexer block* on page 6-7.

An overview of configurations

The **Configuration** page uses a visual program editor where you drag interlocking blocks to build your configuration. This page offers a lot of flexibility to customize your system and your observations. Before we get into how to configure your system, let's first get familiar with the different areas of the Configuration page.



1 The **Toolbox** is the menu from which you can drag the many different types of blocks used to configure your system.

2 The **Configuration Bar** is where you can **Load** a configuration previously saved to your computer, **Save** your current configuration to your computer, **Reset** your configuration back to only the LI-8250 Multiplexer and Sampling Sequence blocks, or **Verify** your current configuration. Verifying your configuration provides feedback in three different states. Clicking Verify will provide you with details about what may be missing or incorrect in your configuration.

Means your configuration is complete and valid–all systems go.

Means there may be something missing from your configuration but the sampling sequence will still run.

Means the configuration is invalid. The configuration will not be remembered by the multiplexer if you navigate away from the Configuration page and the sampling sequence will not run. However, you can Save the configuration to your computer

3 This large white field is called the **Workspace**. This is where you will arrange and manage the various block in your configuration. The Workspace has many different actions you can perform with your blocks. See *Workspace actions* below for details.

4 The **LI-8250 Multiplexer** block is the root block under which the physical components (gas analyzer, extension manifold, chamber, etc.) are added to your configuration. This block may not be deleted and is not nested under any other blocks.

5 The **Sampling Sequence** block is the root block under which the events of your sampling sequence are laid out. This block may not be deleted and is not nested under any other blocks.

Workspace actions

The workspace allows you to perform many basic actions.

- **Drag and snap/drop:** If a block is compatible with another block, it will snap into place below it. If it is not compatible it will not snap but can be dropped to the workspace for later use.
- **Delete:** To delete a block, drag it to the trash (lower right hand corner), select it and press `Delete` or `Backspace`, or right-click it and select **Delete Block**.
- **Cut:** To cut a block, select it and press `Ctrl + X` or `Cmd + X`.
- **Copy:** To copy a block, select it and press `Ctrl + C` or `Cmd + C`.
- **Paste:** To paste a block, select it and press `Ctrl + V` or `Cmd + V`.
- **Undo:** To undo the previous action press `Ctrl + Z` or `Cmd + Z`.
- **Redo:** To redo the prior action `Ctrl + Y` or `Cmd + Y`.
- **Duplicate:** This works like copy and paste, but in one action. To duplicate a block, select it and press `Ctrl + Shift + D` or `Cmd + Shift + D`, or right-click the block and select **Duplicate**.
- **Collapse/expand:** Clicking the (-) or (+) buttons in the upper left-hand corner of a block toggles the block between a collapsed and expanded view. This can also be done by selecting the block and pressing `Ctrl + Shift + E` or `Cmd +`

`Shift + E`, or by right-clicking the block and selecting **Collapse Block/Expand Block**. This is useful for hiding blocks you are not currently configuring.

- **Pan:** To pan around the workspace, click and drag on the open space, use the scroll button on your mouse, or use the scroll bars in the workspace pane.
- **Zoom:** To zoom in and out, hold `Ctrl` or `Cmd` and scroll the mouse wheel or you can use the ⊕ and ⊖ buttons above the trash.
- **Center:** To center your view, click the button above the trash. This button centers the view and returns the zoom to 100%.

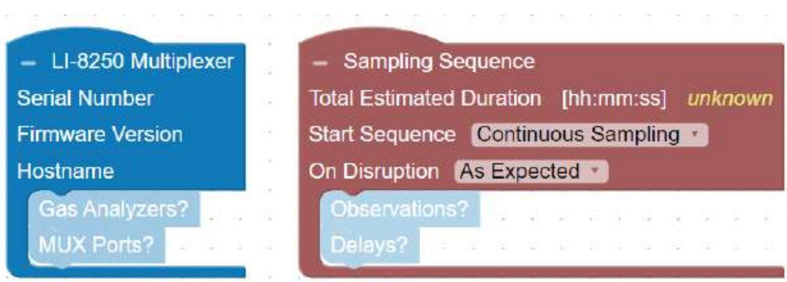
You can also right-click on a block and the following options will pop up:

- **Add/Remove Comment:** Adding a comment will flag a block with a blue question mark (?) indicating that there are comments. Comments are added to a pop-up bubble for your records. Removing a comment removes the comment.
- **Inline/External Inputs:** Changes the arrangement of the block options from vertical to horizontal.
- **Help:** Opens the help system.

Configuring the LI-8250 Multiplexer block

When you first open the **Configuration** page, you will see two empty root blocks: the **LI-8250 Multiplexer** block and the **Sampling Sequence** block. This section covers how to configure the LI-8250 Multiplexer block. For details on how to configure the Sampling Sequence block, see *Configuring the Sampling Sequence block* on page 6-14.

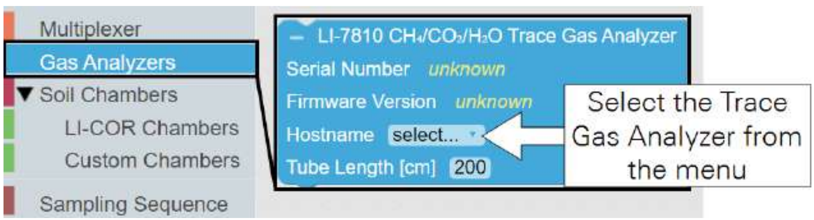
> **Tip:** When configuring a system with multiple chambers and extension manifolds, you can copy/paste or duplicate blocks to speed things up (see *Workspace actions* on the previous page).



1

Add a gas analyzer

Select **Gas Analyzers** from the Toolbox to open the drawer. Then select the gas analyzer model (LI-870, LI-7810, and so on) to add it to the configuration. Repeat this for each analyzer on the system. For Trace Gas Analyzers, you also need to click the **Hostname** menu and select the analyzer.



All gas analyzer blocks are nested under the LI-8250 Multiplexer block.

- If you are using a LI-COR cable assembly for the Trace Gas Analyzers (part number 9982-011) or the LI-870 CO_2/H_2O Analyzer (part number 9982-010), the tubing length is set automatically.
- If you have multiple gas analyzers connected using the T-split tubing (part number 9982-073), you will need to add 15 cm to the tube length for each analyzer.

2

Add a port

Before you can add an extension manifold or chamber, you will need to add the port that the device is connected to. To do this, select **Multiplexer** from the Toolbox, then click and drag **Port #** to place the block under the LI-8250 Multiplexer block.

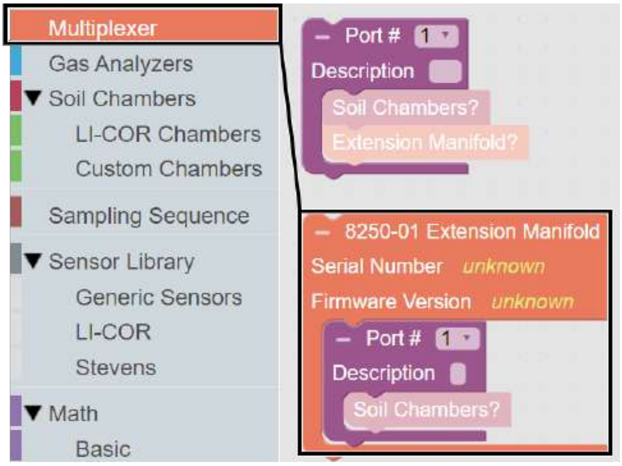
You can assign a port number or the user interface will automatically assign a port number as these blocks are added. You can also provide a description of the devices on that port that will appear in the data file.

3

Add an 8250-01 Extension Manifold (optional)

This step is only necessary when an 8250-01 Extension Manifold is connected to your LI-8250 Multiplexer. If you do not have an extension manifold, skip to step 4.

To add an 8250-01 Extension Manifold, select **Multiplexer** from the Toolbox, then click and drag **Extension Manifold** to place the block under its respective Port # block. For example, if you have an extension manifold connected to port 2 of the multiplexer, place the extension manifold block under the Port # 2 block at the multiplexer level. Repeat this for each extension manifold.

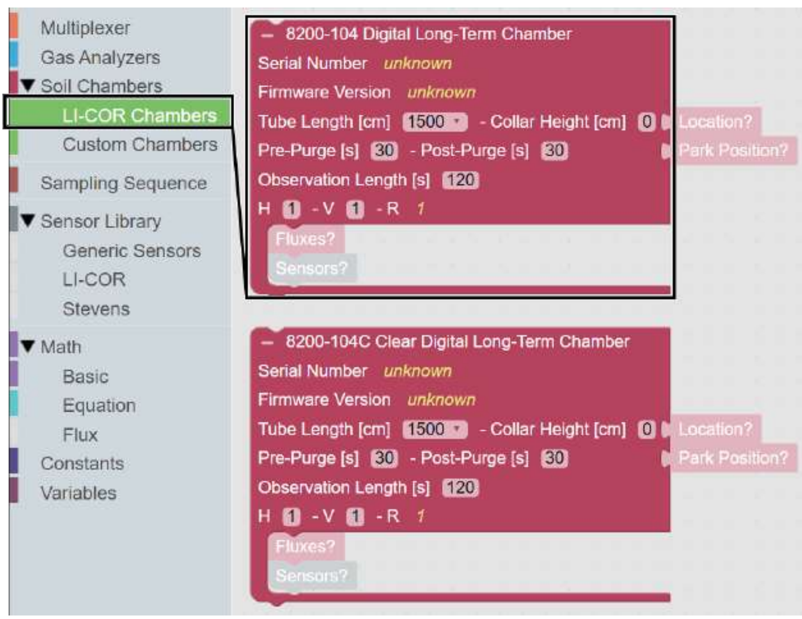


> **Note:** The 8250-01 Extension Manifold block will default to having one Port # block nested. If you have more than one chamber on that extension manifold, you will need to add additional Port # blocks under that extension manifold block.

4 Add a chamber

After you have added a port to the LI-8250 Multiplexer or 8250-01 Extension Manifold block, you can add a chamber to that port. The LI-8250 Multiplexer can interface with LI-COR long-term chambers and user-built custom chambers. This section will focus on adding LI-COR long-term chambers. For information about configuring a custom chamber see *Integrating a custom chamber* on page B-1.

To add an 8200-104 Opaque Long-Term Chamber or 8200-104C Clear Long-Term Chamber, expand the **Soil Chambers** drop-down in the Toolbox and select **LI-COR Chambers**. Then click and drag either the **8200-104 Digital Long-Term Chamber** or **8200-104C Clear Digital Long-Term Chamber** block under the Port # block where you would like to add the chamber. Repeat this for each chamber on each port of the multiplexer and all extension manifolds.

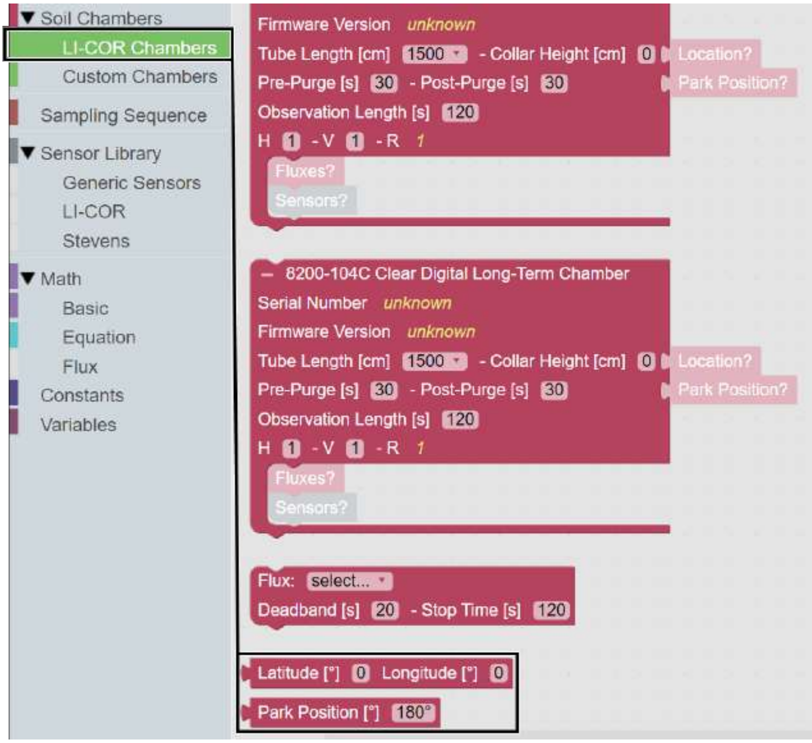


Each LI-COR chamber block allows you to change several parameters. If you are using the cable assembly from LI-COR (part number 9982-056), the **Tube Length** of 1500 cm is correct. **Collar Height** must be measured and entered using the steps outlined in *Measuring the collar height* on page 4-2. You can also adjust the **Pre-Purge**, **Post-Purge**, and **Observation Length** according to your needs. See *Terminology* on page A-3 for additional details on these parameters. If the parameters chosen were not optimal, SoilFluxPro Software offers several tools to improve flux calculations in post-processing.

The LI-COR chamber block also allows you to attach a few other parameters. **Location** allows you to enter the location of the chamber and **Open Position** changes the position of the chamber when it is not taking a measurement. For details on changing the open position see *Changing the open position* on page 4-7.

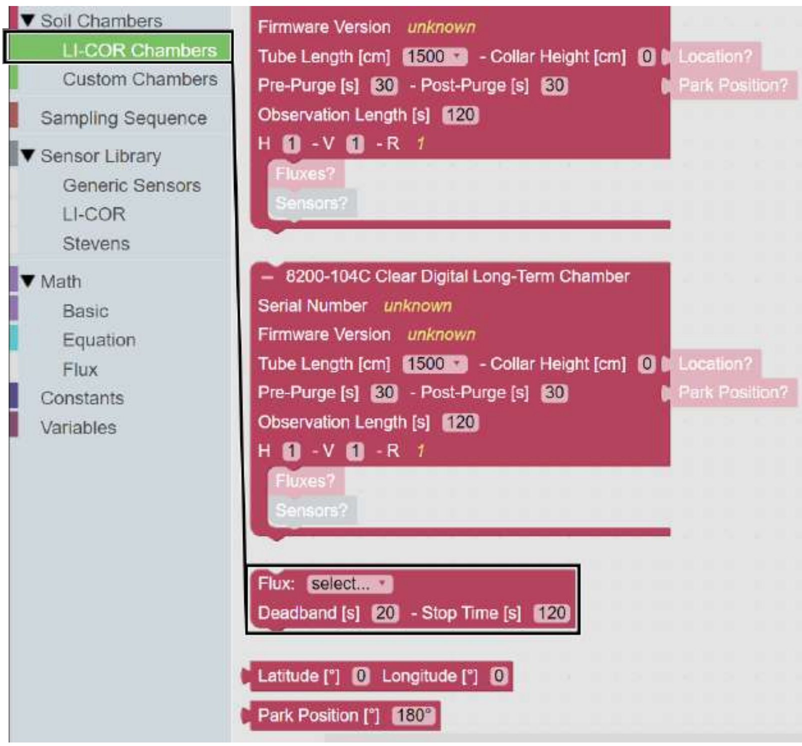
> **Note:** If a location is not defined, the multiplexer will use the GPS location of the LI-8250 Multiplexer as the chamber location in the data file.

To add these, select LI-COR Chambers in the Toolbox and find the **Latitude/Longitude** or **Open Position** blocks. Then click and drag the Latitude/Longitude or Open Position block to the chamber block.

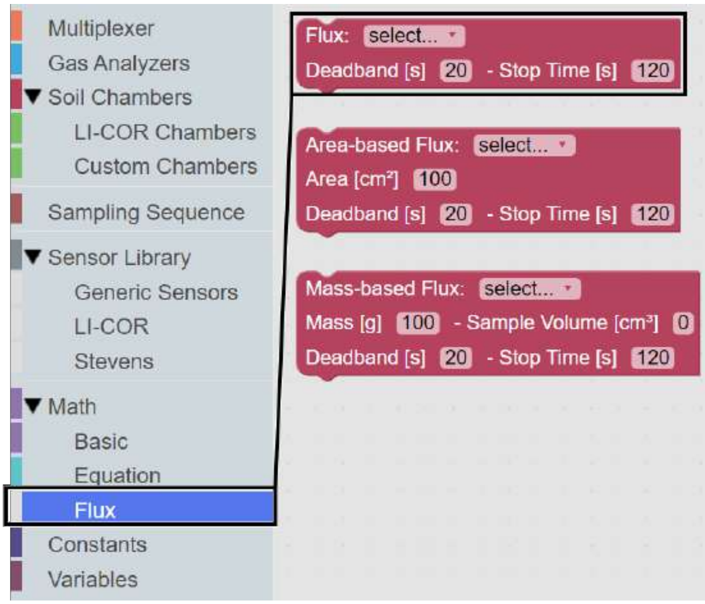


5 Add a flux

Adding a flux to a LI-COR chamber block can be done in two ways. The first way is to select LI-COR Chambers from the Toolbox and find the **Flux** block. Then click and drag the Flux block under the chamber block you would like to add the flux to.



The other way to do so is to expand the **Math** drop-down and select **Flux** from the Toolbox. From the Flux drawer click and drag the block called Flux under the chamber you would like to add the flux to. For area-based flux enter the sample area (cm^2). For mass-based flux, enter the sample mass (g) and volume (cm^3). The sample volume is subtracted from the system volume.



The **Flux** block allows you to customize three additional parameters. The drop-down menu allows you to select the type of gas and the source for flux calculations. You can have multiple Flux blocks under each chamber depending on the analyzer(s) you are using and the gases you would like recorded.

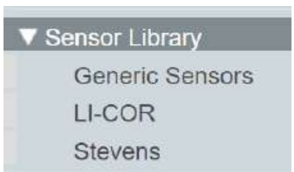
You can also adjust the **Deadband** and **Stop Time** as needed. The Deadband and Stop Time are parts of the total **Observation Length.** Stop Time can be any time desired so long as it is beyond the Deadband and does not exceed the Observation Length. See *Terminology* on page A-3 to see how Deadband is defined.

Note: You will need one Flux block for each gas flux you would like to have computed. Without a Flux block, no flux will be calculated for that gas. If a Flux block was not added for a gas, a flux can still be calculated later using SoilFluxPro Software.

6 Add a sensor

LI-COR chambers can integrate various sensors for ancillary data, including the LI-190R Quantum Sensor, the LI-200R Pyranometer, the Stevens HydraProbe, and other SDI-12 sensors. How to install and configure a sensor is covered in detail in *Using sensors* on page 4-10. Here we will cover how to add the sensor to your chamber block.

To add a sensor to a LI-COR chamber block, expand the **Sensor Library** drop-down.



Generic Sensors allows you to add a generic SDI-12 sensor, **Stevens** allows you to add a Stevens HydraProbe II sensor, and **LI-COR** lets you add the LI-190R Quantum Sensor and the LI-200R Pyranometer. Click and drag the sensor under the chamber where it will be added.

Configuring the Sampling Sequence block

This section will cover the steps needed to configure the elements under the **Sampling Sequence** block. If you have just opened the Configuration page, you will see two empty parent blocks: the **LI-8250 Multiplexer** block and the **Sampling Sequence** block. It may be helpful to first configure the physical components under the LI-8250 Multiplexer block before configuring your Sampling Sequence. See *Configuring the LI-8250 Multiplexer block* on page 6-7.

The Sampling Sequence has three different events that can be added: **Observation**, **Delay**, and **Disable Sampling Pumps.** Each block added will update the **Total Estimated Duration** of the sequence which must be taken into consideration when choosing when to start the sequence.

The Sampling Sequence runs in sequential order from top to bottom and completes when it reaches the bottom.

> **Tip:** When configuring a system with multiple chambers and extension manifolds, you can copy/paste or duplicate blocks to speed things up (see *Workspace actions* on page 6-6).

1 Choose when to start the sequence

The **Start Sequence** in the Sampling Sequence block defines when the LI-8250 Multiplexer will begin its sequence after you click **Start** on the Home page.

- **Continuous Sampling** will immediately start the sequence, run through all events, and will begin again once finished.
- **15 [min]** starts the sequence on the next quarter-hour. For example, if you set the Start Sequence to 15 [min] and click Start at 12:07 AM, the sequence would begin at 12:15 AM.
- **30 [min]** starts the sequence on the next half-hour. For example, if you set the Start Sequence to 30 [min] and click Start at 12:07 AM, the sequence would begin at 12:30 AM.
- **1 [hr]** starts the sequence on the next hour. For example, if you set the Start Sequence to 1 [hr] and click Start at 12:07 AM, the sequence would begin at 1:00 AM.
- **2 [hr]** starts the sequence on a 2-hour interval from midnight. For example, if you set the Start Sequence to 2 [hr] and click Start at 12:07 AM, the sequence would begin at 2:00 AM.
- **4 [hr]** starts the sequence on a 4-hour interval from midnight.
- **6 [hr]** starts the sequence on a 6-hour interval from midnight.
- **12 [hr]** starts the sequence on a 12-hour interval from midnight.
- **Daily** will start the sequence at midnight of each day.

2 Set behavior after a disruption

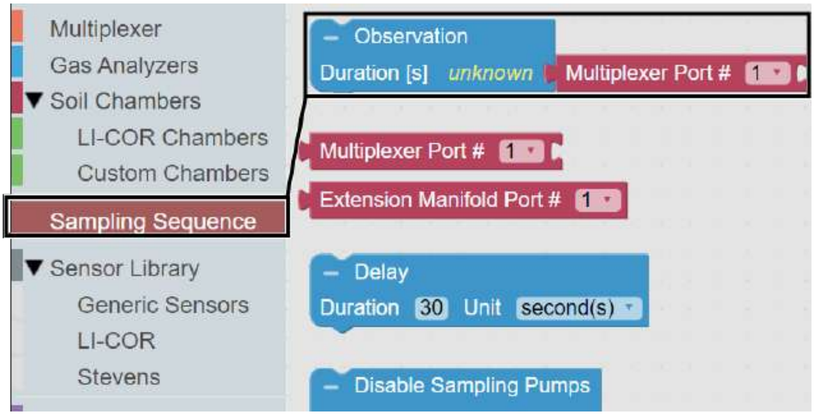
In the event the system experiences a disruption, such as a power outage, you can define how the Sampling Sequence will behave when it comes back online through the **On Disruption** field.

- **Beginning** will restart the Sampling Sequence over from the beginning.
- **Next** tells the LI-8250 Multiplexer to see where it was in the Sampling Sequence and start from the next event.
- **As Expected** will cause the LI-8250 Multiplexer to assess the length of the disruption and to pick up where it **should** be at in the Sampling Sequence.

3 Add an observation

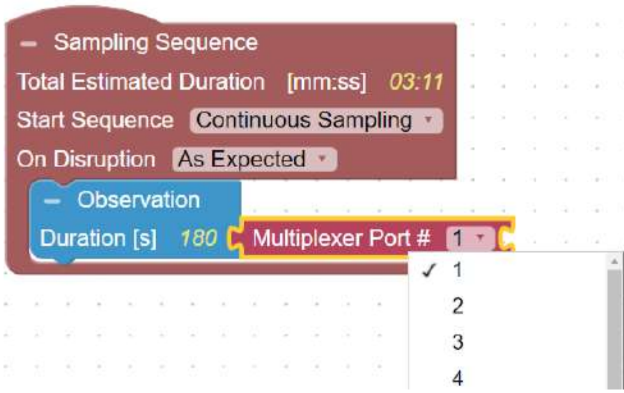
An **Observation** includes all the time that a port is selected and active, including purges and measurement. Adding an Observation block to the Sampling Sequence block tells the multiplexer to perform an observation on a specified port. Several observations can be strung together for a single port or multiple ports. Each observation **Duration** is determined by the combined Pre-Purge, Post-Purge, and Observation Length for the chamber on that port.

To add an **Observation** to the Sampling Sequence, select Sampling Sequence from the Toolbox. Then click and drag an Observation block to where you would like it placed in the sequence.



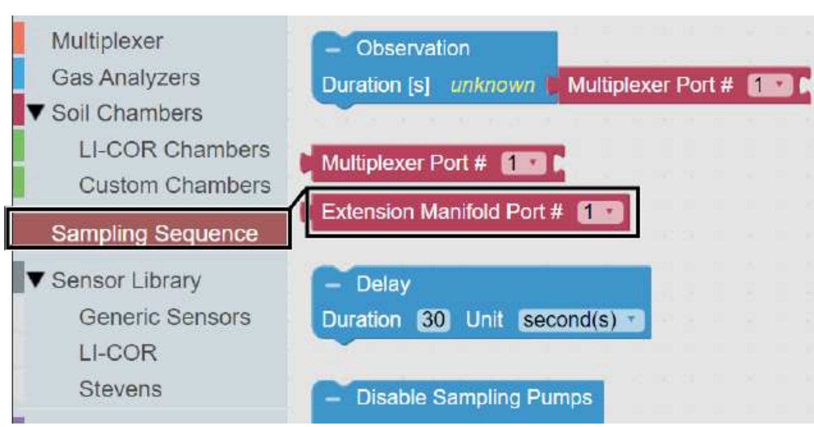
4 Set the port

Setting the port tells the multiplexer which chamber should be active during the observation. Adding an Observation block automatically includes a **Multiplexer Port #** block. To begin, change the **Multiplexer Port #** to the port you would like to observe in this Observation.



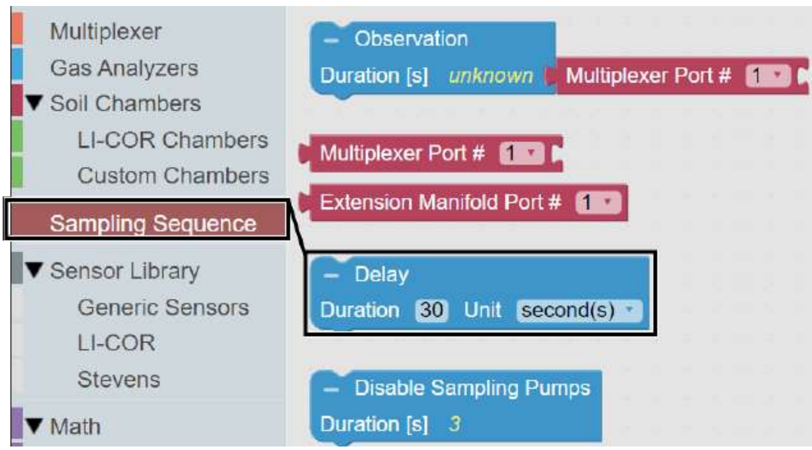
If you do not have an 8250-01 Extension Manifold, you can skip to step 5. If your system does include chambers connected to one or more extension manifolds, then you will need to add an **Extension Manifold Port #** block.

To add an Extension Manifold Port # block, select Sampling Sequence from the Toolbox, then click and drag an Extension Manifold Port # block and connect it to a Multiplexer Port # block. Verify that the port number set on the Multiplexer Port # block has an extension manifold physically connected to it.

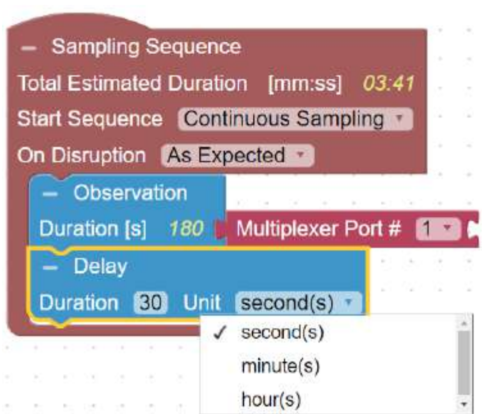


5 Add a delay

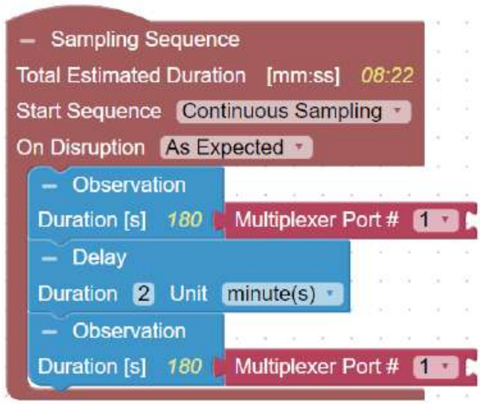
Delay is simply a pause in the Sampling Sequence. You can place a Delay wherever it is needed, for as long as is needed. To add a Delay , select Sampling Sequence from the Toolbox, then click and drag a Delay block to where you would like to add the Delay in your sequence.



Then set the **Duration** and **Unit** to suit the length of Delay you would like.



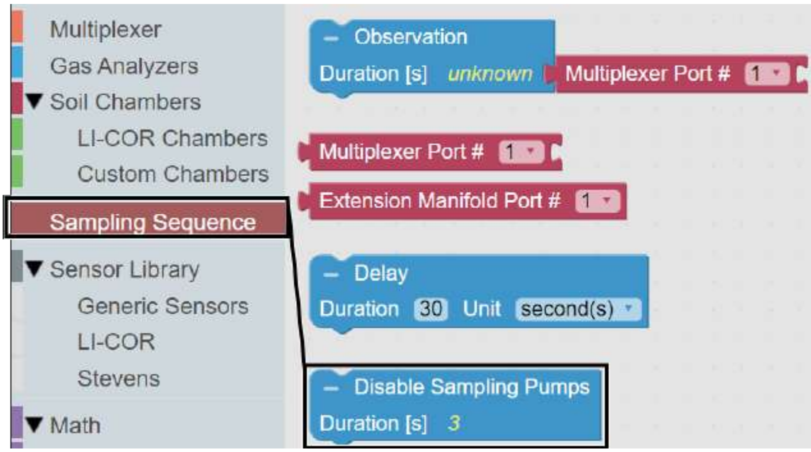
Two observations on a single port with a 2-minute delay between observations would appear as such.



6 Disable sampling pumps

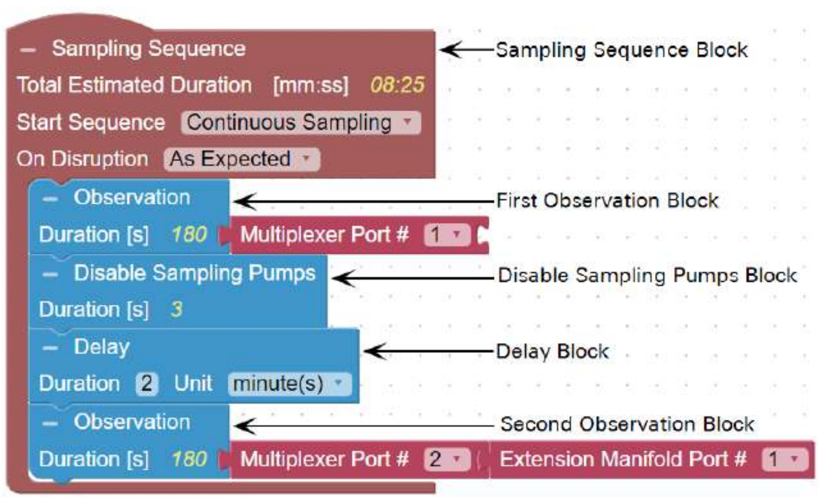
There may be times where you will want to disable the sampling pumps. This would typically be during an extended Delay where you would not want the pump running the entire time. Disabling the pumps is less noisy and preserves the life of your pumps. A **Disable Sampling Pumps** block should appear immediately before a Delay block.

To add a Disable Sampling Pumps block, select Sampling Sequence from the Toolbox, then click and drag the Disable Sampling Pumps block before the Delay block that needs the pumps disabled.



So, if you wanted to disable the pumps during a 2-minute delay between observations, this is how you would do that.

Note: Although the Disable Sampling Pumps block only shows a Duration of 3 seconds, the pumps will be disabled for the entire Duration of the following Delay block.



SDI-12 console

You will use the SDI-12 console to configure connected sensors with an SDI-12 interface, such as the Stevens HydraProbe. This may include setting the address for the sensor or configuring the variables. Here we use commands for a Stevens HydraProbe. You can connect and configure nearly any SDI-12 sensor, but you will need to refer to the documentation of that sensor for details on configuring it.

To use the SDI-12 console to configure a sensor, you must be connected to the LI-8250 Multiplexer user interface, the sensor must be connected to a port on an 8200-104/C Long-Term Chamber, and that chamber must be connected to a port on the multiplexer or an extension manifold. You can connect multiple sensors to a port on a LI-COR long-term chamber using the sensor T-split fitting (part number 310-18516).

Note: It is advised to connect and configure the sensors on each chamber one at a time. Often, but not always, the default address of a sensor is 0. If multiple sensors on the same chamber have the same address, communication with either sensor will not be possible. Related to this, the console does allow you to change the address of one sensor to the address of another. If more than one sensor is assigned the same address, you will need to disconnect all but one of the sensors and change the addresses.

To open the SDI-12 console, first connect to the LI-8250 Multiplexer user interface. Then expand the **Tools** drop-down and click **SDI-12 Console**.

You will then need to change the active port. The active port will need to be the same multiplexer port number or multiplexer/extension manifold port number combination that the chamber with the sensor is on. For example, if you would like to configure a Stevens HydraProbe connected to a chamber on an 8250-01 Extension Manifold, you will:

1 Determine which port of the LI-8250 Multiplexer the 8250-01 Extension Manifold is on.

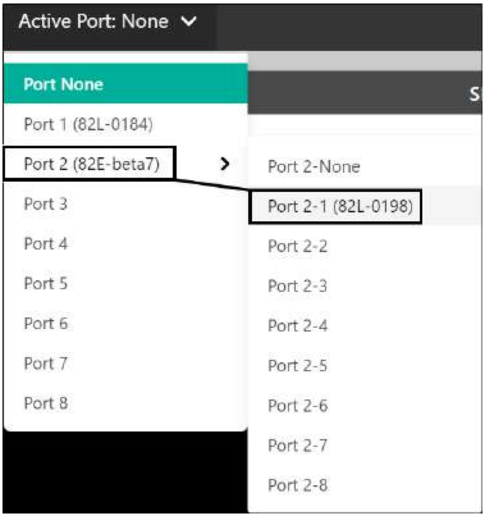
In this case, it's port 2.

2 Determine which port of the 8250-01 Extension Manifold the chamber with the sensor is on.

In this case, it's port 1.

3 Change the active port to 2-1.

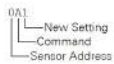
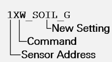
To change the active port, expand the **Active Port** drop-down and click the port number to make it the active port. Remember to change the active port before attempting to configure a sensor on a different chamber.



Anatomy of a command

The first character in a command is the sensor address. Whenever you would like to communicate with a sensor, your command will begin with the address of that sensor. In the example in this section, we change the address from 0 to 1, but the address could be any number from 0 to 9. While the full SDI-12 protocol does allow for a wider range of addresses, the LI-8250 Multiplexer uses a partial implementation and can only accept numeric addresses.

> **Note:** Typically, device specific SDI-12 commands are followed by an exclamation mark (!). In the SDI-12 Console, you do not need to add the exclamation mark as it is added automatically.

Command	Definition
	The command `0A1` changes the address for sensor 0 to 1.
	The command `1XW_SOIL_G` changes a setting on the sensor. In a Stevens HydraProbe, **1XW_SOIL_G** changes the soil type for sensor 1 to general (see *Table 6-1* on the next page).
	(Version 3 and older) The command `1XM=0` changes the measurement for sensor 1 to the first default set.

Configuring a Stevens HydraProbe

Here we provide a basic overview of how to configure a Stevens HydraProbe. Some of the commands, such as changing the address, may be similar for other sensors. Refer to the documentation of that sensor for details.

> **Note:** We recommend that you keep the Stevens HydraProbe in its default configuration for everything except the address and soil type.

With the first sensor you would like to configure connected and the active port set, click **Query All** at the bottom of the page. A query will search the active port for any connected devices. Devices that are found will report back the model number, serial number, and address of the sensor.

Changing the address

The first thing you will want to do with any sensor is to change its address. The address is used to communicate with the sensor. Choose a number between 0 and 9 unique for that chamber. For example, each chamber may have a sensor with an address of 1, but having more than one sensor on the same chamber with the same address will disable communication with any sensor using that address on that chamber. If you will be using more than one sensor, it is not recommended that you use 0 as many sensors use that as the default address.

To change the address from 0 to 1, enter the command `0A1`, then click **Send** or press `Enter`. This command tells the sensor with the address `0` to set the address (`A`) to `1`. You should receive a response of **1** as confirmation from the sensor that the address was changed.

Changing the soil type

The Stevens HydraProbe offers support for various types of soil, and you should change the soil type to reflect the type of soil representative of your site. This updates the calibration coefficient the probe uses to convert signal to soil moisture/temperature/electrical conductivity values. The different soil types and their corresponding commands can be found in*Table 6-1* below and *Table 6-2* on the facing page

To change the soil type for sensor 1 to silt, enter the command `1XS2`, then **Send**. This command tells the sensor with the address `1` to set the soil type (`XS`) to silt (`2`). Choose the soil type that best represents the soil at your site.

Table 6-1. Stevens HydraProbe (v4 and newer) soil type commands.

Command	Which means...
1XW_SOIL_G	Sensor 1 soil type is now general
1XW_SOIL_O	Sensor 1 soil type is now organic
1XW_SOIL_R	Sensor 1 soil type is now rockwool

Table 6-2. Stevens HydraProbe (v3) soil type commands and definitions.

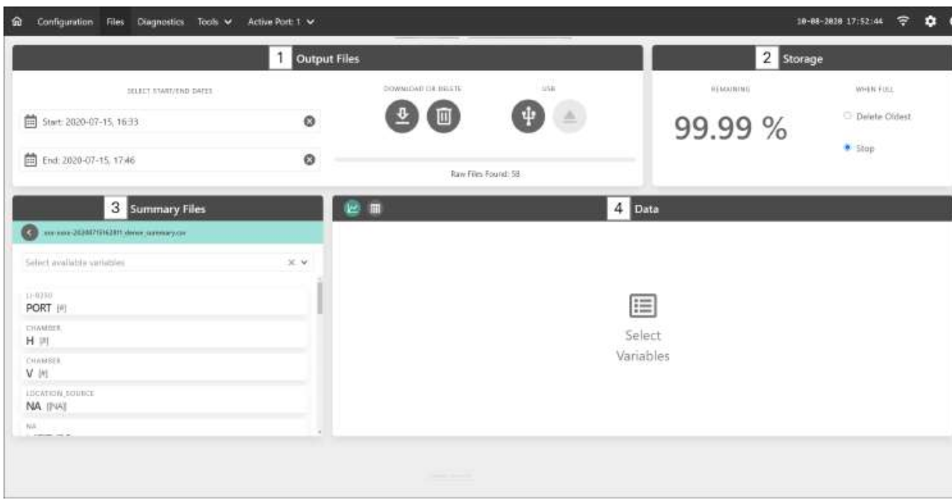
Command	Sensor returns...	Which means...
1XS1	1S1=SAND	Sensor 1 soil type is now 1 or sand
1XS2	1S2=SILT	Sensor 1 soil type is now 2 or silt
1XS3	1S3=CLAY	Sensor 1 soil type is now 3 or clay
1XS4	1S4=LOAM	Sensor 1 soil type is now 4 or loam

Files

The **Files** page is used to view, access, and download data from measurements. The LI-8250 Multiplexer stores two different kinds of files:

- Each observation is stored into an `.82z` file and includes all metadata and high-frequency data that was collected during a chamber closure.
- Daily summary files are stored in `.csv` files using a subset of metadata and summary data with calculated fluxes.

The **Files** page is made up of four panes:



1 The **Output Files** pane allows you to set a date range of files and to download those files to your computer, to transfer them to a user-provided USB drive connected to the multiplexer, or to delete the files within that range.

2 The **Storage** pane shows how much of the LI-8250 Multiplexer onboard storage is remaining and gives you options for how the multiplexer should behave if its storage should become full. When storage is full, you can have the multiplexer **Stop** taking measurements or **Delete Oldest** files to make room for new ones. The LI-8250 Multiplexer contains 8 GB of onboard storage which should record several months worth of data.

3 The **Summary Files** pane displays a list of daily summary files that fall within the range chosen in the **Output Files** pane. Selecting one of the summary files expands that summary file, providing you with multiple variables you can view or chart in the **Data** pane.

4 The **Data** pane offers two ways to view the contents of a summary file. You can view all the data in a table format by selecting the table icon or you can view two of your variables charted together based upon the variables chosen in the **Summary Files** pane by selecting the chart icon.

Data file structure

This section describes the structure of files downloaded from your LI-8250 Multiplexer. Two kinds of files can be downloaded from the LI-8250 Multiplexer.

- Daily summary files
- Raw data for a single observation in .82z files

Daily summary files

Summary data from each observation are collected into a daily summary file that can show you if your system is working properly. File names for summary files are formatted with the instrument serial number and date (`serial-number-YYYYMMDD_dense_summary.csv`).

Daily summary files are .csv files that contain summary values–fluxes, means, and initial values–representing a subset of all available variables in the system(see *Table 6-13* on page 6-39). These files include a header made up of 3 lines.

- The device that is the source of the measurement (e.g., LI-8250)
- The variable name (e.g., DATE)
- The units for the variable (e.g., YYYYMMDD)

.82z files

Raw data for a single observation are received in .82z files. These files are intended for use in SoilFluxPro Software to simplify the management and processing of your large soil gas flux datasets.

File names for .82z files are formatted with the instrument serial number and a time stamp (`serial-number-YYYYMMDDHHMMSS.82z`). These files are zip archives that include represent all measurements that occur at a given port for one observation. .82z files include two files: a **data.csv** file and a **metadata.json** file.

The **data.csv** file uses the same 3-line header structure as the daily summary files but includes raw time series data from one observation with every variable collected by the system. See the tables in *Data dictionary* on page 6-30 for a complete list of variable definitions.

The **metadata.json** file is a text file containing all the observation, instrument, and flux calculation metadata. See the tables in *Data dictionary* on page 6-30 for a complete list of metadata variable definitions.

> **Note:** The .82z files do not include fluxes or summary values for any variable.

Downloading files

You can retrieve files from the LI-8250 Multiplexer in three ways:

- Download directly from the user interface
- Transfer to USB storage from the user interface
- Automatic transfer to a remote server

Download from user interface

To download the files from the LI-8250 Multiplexer user interface:

1. Connect to the LI-8250 Multiplexer user interface.
2. Go to the **Files** page.
3. Select a **Start Date and Time** and an **End Date and Time** for the range of files to download.
4. Click the Download button.

The daily summary files and .82z files will then be downloaded to your device as a .zip file. The file name will use the serial number, the start date and time, and the date and time of download (`serial-number-YYYYMMDDHHMM-YYYYMMDDHHMM`).

Opening the .zip file will provide all the summary files for the dates in range and a directory. The directory contains all the .82z files separated into subdirectories, first by year, then month, then day.

Transfer to USB storage

To transfer files from the multiplexer to a USB storage device:

1. Connect to the LI-8250 Multiplexer user interface.
2. Go to the **Files** page.
3. Select a **Start Date and Time** and an **End Date and Time** for the range of files to download.

4 Insert a USB storage device into one of the two USB ports on the multiplexer interior panel.

> **Note:** The USB storage device must be connected to the multiplexer. The user interface will not recognize a USB device connected to your computer.

5 Click the USB button.

The daily summary files and .82z files will then be downloaded to your device as a .zip file. The file name will use the serial number, the start date and time, and the date and time of download (`serial-number-YYYYMMDDHHMM-YYYYMMDDHHMM`).

Opening the .zip file will provide all the summary files for the dates in range and a folder. The folder contains all the .82z files separated first by year, then month, then day.

Automatic transfer to remote server

The LI-8250 Multiplexer can be configured to automatically transfer daily summary files and .82z files containing raw observation data from the previous day to a remote server using FTP, SFTP, or HTTP. This will require the multiplexer to be connected to a LAN or cellular modem via Ethernet.

For instructions on transferring files to a remote server using a LAN connection, see *Configuring a remote server* on page 2-11.

For instructions on transferring files to a remote server using a cellular modem, see *Connecting to a cellular modem* on page E-1.

Data dictionary

The data dictionary describes variable names from the files and how those variables are displayed in the user interface.

LI-8250 Multiplexer variables

Table 6-3. LI-8250 Multiplexer data definitions. The **DEVICE** for these variables will be **LI-8250.**

Interface variable	Units	Data file variable	Description
Temperature	C	T_CASE	Internal temperature of the multiplexer
Pressure	kPa	PA	Atmospheric pressure
Pressure Temperature	C	T_PA	Atmospheric pressure sensor temperature
Pump Positive Pressure	kPa	PUMP_ POSITIVE_ PRESSURE	Pressure sensor on the positive pressure side of the sampling pump
Pump Negative Pressure	kPa	PUMP_ NEGATIVE_ PRESSURE	Pressure sensor on the negative pressure side of the sampling pump
Flow	$L\ M^{-1}$	FLOW	Flow rate through the multiplexer to the active port.
Pump Time	H	PUMP_TIME	Hours of sampling pump operation
Pump Setpoint		PUMP_ SETPOINT	Drive setting for the sampling pump
Pump Current	A	PUMP_ CURRENT	Current draw by the sampling pump
Purge Pump Time	H	PURGE_PUMP_ TIME	Hours of purge pump operation
Purge Pump Setpoint		PURGE_PUMP_ SETPOINT	Drive setting for the purge pump
Purge Pump Current	A	PURGE_PUMP_ CURRENT	Current draw by the purge pump
Purge Pump Pressure	kPa	PURGE_PUMP_ PRESSURE	Pressure sensor on the positive pressure side of the purge pump

Table 6-3. LI-8250 Multiplexer data definitions. The DEVICE for these variables will be LI-8250. (...continued)

Interface variable	Units	Data file variable	Description
Subsample Pressure	kPa	SUB_PRESSURE	Ambient to subsample loop pressure differential
Subsample Flow	L M^{-1}	SUB_FLOW	Flow through the subsample loop
VSO Flow Setpoint[1]		VSO_FLOW_ SETPOINT	Setting for the inlet side of the system valve manifold (*Figure 1-1* on page 1-5)
VSO Pressure Setpoint		VSO_ PRESSURE_ SETPOINT	Setting for the outlet side of the system valve manifold (*Figure 1-1* on page 1-5)
VSO Flow Control Voltage	V		Voltage to the inlet valve on the system valve manifold
VSO Pressure Control Voltage	V		Voltage to the outlet side of the system valve manifold
Port *n* Current	A	PORT*n*_ CURRENT	Current draw through the port number listed
Solenoid Current	A	SOL_CURRENT	Current supplied to valves and VSOs
12 VDC Current	A	12VDC_ CURRENT	Current draw on the 12 VDC power output supply
Voltage	V	VIN	Input voltage to multiplexer
Voltage Out	V	VOUT	Output voltage on the nominal 24 VDC supply
12 VDC Voltage	V	12VDC_ VOLTAGE	12 V supply voltage
5 VDC Voltage	V	5VDC_VOLTAGE	5 V supply voltage
Flow Pressure	kPa	FLOW_ PRESSURE	Pressure measurement used to determine flow rate
Subsample Flow Pressure	kPa	SUB_FLOW_ PRESSURE	Pressure measurement used to determine subsample flow rate
Port		PORT	Active port being sampled
Latitude	°	LATITUDE	Latitude reported by GPS
Longitude	°	LONGITUDE	Longitude reported by GPS
Altitude	m	ALTITUDE	Altitude reported by GPS

[1] VSO® is a Voltage Sensitive Orifice. VSO® is a registered trademark of Parker Intangibles LLC (Parker Hannifin Corporation).

Table 6-3. LI-8250 Multiplexer data definitions. The DEVICE for these variables will be LI-8250. (...continued)

Interface variable	Units	Data file variable	Description
Satellites		SATELLITES	Number of satellites
Date	YYYY-MM-DD	DATE	Timestamp of year-month-day
Time	HH:MM:SS	TIME	Timestamp of hours-minutes-seconds

8250-01 Extension Manifold variables

Table 6-4. 8250-01 Extension Manifold data definitions. The **DEVICE** for these variables will be **8250-01 Extension Manifold.**

Interface variable	Units	Data file variable	Description
Temperature	C	T_CASE	Internal temperature of the extension manifold
Pump Time	H	PUMP_TIME	Hours of sampling pump operation
Pump Setpoint		PUMP_SETPOINT	Drive setting for the sampling pump
Pump Current	A	PUMP_CURRENT	Current draw by the sampling pump
Purge Pump Time	H	PURGE_PUMP_TIME	Hours of purge pump operation
Purge Pump Setpoint		PURGE_PUMP_SETPOINT	Drive setting for the purge pump
Purge Pump Current	A	PURGE_PUMP_CURRENT	Current draw by the purge pump
Purge Pump Pressure	kPa	PURGE_PUMP_PRESSURE	Pressure sensor on the positive pressure side of the purge pump
Port *n* Current	A	PORT*n*_CURRENT	Current draw through the port number listed
Solenoid Current	A	SOL_CURRENT	Current supplied to valves and VSOs
Voltage	V	VIN	Input voltage to multiplexer
12 VDC Voltage	V	12VDC_VOLTAGE	12 V supply voltage
5 VDC Voltage	V	5VDC_VOLTAGE	5 V supply voltage
3.3 VDC Voltage	V	3.3VDC_VOLTAGE	3.3 V supply voltages
Port		PORT	Active port being sampled
Diag Code		DIAG_CODE	Diagnostic flag bits

Table 6-5. Multiplexer and extension manifold metadata definitions. The **DEVICE** for these variables will be **LI-8250** or **8250-01 Extension Manifold.**

Interface variable	Data file variable	Description
Start Time	TIMESTAMP_START	Timestamp at the start of an observation
Volume	VOLUME	Device volume
Total Volume	VOLUME_TOTAL	Total volume used in flux calculations
Port	PORT	Port number the observation was made on
Port Label	PORT_LABEL	User entered description associated with the port
Prepurge	PREPURGE	Prepurge length
Observation Length	OBSERVATION	Observation length
Post Purge	POST_PURGE	Post purge length
Horizontal	HORIZONTAL	Numerical value of H from chamber's HVR field
Vertical	VERTICAL	Numerical value of V from chamber's HVR field
Latitude	LATITUDE	Multiplexer latitude in decimal degrees
Longitude	LONGITUDE	Multiplexer longitude in decimal degrees
Serial Number	SERIAL_NUMBER	Device serial number
Firmware	FIRMWARE	Device firmware version

LI-COR chamber variables

Table 6-6. LI-COR chamber data definitions. The **DEVICE** for these variables will be **CHAMBER.**

Interface variable	Units	Data file variable	Description
Temperature	C	TA	Chamber air temperature
Board Temperature	C	TB	Chamber control board temperature
Voltage	V	VIN	Chamber input voltage
Motor Current	A	MOTOR_CURRENT	Current draw by chamber drive motor
State		STATE	There are eight chamber states: 1 = closing; 2 = opening; 3 = parking; 4 = manual move; 5 = closed; 6 = open; 7 = parked; 8 = unknown

Table 6-7. LI-COR chamber metadata definitions. The **DEVICE** for these variables will be **CHAMBER**.

Interface variable	Units	Data file variable	Description
Volume	cm^3	VOLUME	Device volume
Tube Length	cm	TUBE_LENGTH	Length of tubing associated with the chamber used to calculate total volume
Collar Height	cm	COLLAR_ HEIGHT	Collar height
Area	cm^2	AREA	Soil area
Closing Time	s	CLOSE_TIME	Time it took the chamber to close
Park Position	°	PARK	Chamber park position
Latitude	°	LATITUDE	Chamber latitude in decimal degrees
Longitude	°	LONGITUDE	Chamber longitude in decimal degrees
Serial Number		SERIAL_ NUMBER	Device serial number or chamber type
Firmware		FIRMWARE	Device firmware version

LI-870 CO_2/H_2O Analyzer variables

Table 6-8. LI-870 CO_2/H_2O Analyzer data definitions. The **DEVICE** for these variables will be **LI-870**.

Interface variable	Units	Data file variable	Description
Date	YYYY-MM-DD	DATE	Timestamp of year-month-day
Time	HH:MM:SS	TIME	Timestamp of hours-minutes-seconds
CO_2	µmol mol^{-1}	CO2	Carbon dioxide mole fraction
CO_2 Dry	µmol mol^{-1}	CO2_DRY	Carbon dioxide dry mixing ratio
H_2O	mmol mol^{-1}	H2O	Water vapor mole fraction
Cell Temperature	C	T_CELL	Optical bench temperature
Cell Pressure	kPa	PA_CELL	Pressure in the optical bench
CO_2 Absorption		CO2_ABS	Absorption by carbon dioxide
H_2O Absorption		H2O_ABS	Absorption by water vapor
Voltage	V	VIN	Input voltage to the LI-870
Flow	L M^{-1}	FLOW	Flow rate through the LI-870

Table 6-9. LI-870 metadata definitions. The **DEVICE** for these variables will be **LI-870.**

Interface variable	Units	Data file variable	Description
Volume	cm^3	VOLUME	Device volume
Tube Length	cm	TUBE_LENGTH	Length of tubing associated with the analyzer used to calculate total volume
Serial Number		SERIAL_ NUMBER	Device serial number
Firmware		FIRMWARE	Device firmware version

LI-78xx Trace Gas Analyzer variables

Table 6-10. LI-78xx Trace Gas Analyzer data definitions. The **DEVICE** for these variables will be **LI-7810**, **LI-7815**, or **LI-7820.**

Interface variable	Units	Data file variable	Description
Date	YYYY-MM-DD	DATE	Timestamp of year-month-day
Time	HH:MM:SS	TIME	Timestamp of hours-minutes-seconds
CO_2 Dry	$\mu mol\ mol^{-1}$	CO2_DRY	Carbon dioxide dry mixing ratio (LI-7810 and LI-7815 only)
H_2O	$mmol\ mol^{-1}$	H2O	Water vapor mole fraction
CH_4 Dry	$nmol\ mol^{-1}$	CH4_DRY	Methane dry mixing ratio (LI-7810 only)
N_2O Dry	$nmol\ mol^{-1}$	N2O_DRY	Nitrous oxide dry mixing ratio (LI-7820 only)
Diagnostic		DIAGNOSTIC	Diagnostic value indicating the quality of the data and state of the instrument
Cavity Temperature	C	T_CAVITY	Optical cavity temperature
Cavity Pressure	kPa	PA_CAVITY	Optical cavity pressure
Laser Pressure	kPa	PA_LASER_ PHASE	Pressure used to control the laser phase
Laser Temperature	C	T_LASER	Temperature of the laser

Table 6-10. LI-78xx Trace Gas Analyzer data definitions. The DEVICE for these variables will be LI-7810, LI-7815, or LI-7820. (...continued)

Interface variable	Units	Data file variable	Description
Residual		RESIDUAL	Residual of absorption spectrum fit
Ring Down	μs	RING_DOWN	Ring down time
Enclosure Temperature	C	T_THERMAL_ ENCLOSURE	Temperature of the optical cavity enclosure
Phase Error		PHASE_ERROR	Error between setpoint and actual laser phase in counts
Shift Temperature	C	T_LASER_SHIFT	Difference between factory set laser temperature and operating laser temperature
Voltage	V	VIN	Input voltage to the LI-78xx

Table 6-11. LI-78xx metadata definitions. The **DEVICE** for these variables will be **LI-7810**, **LI-7815**, or **LI-7820**.

Interface variable	Units	Data file variable	Description
Volume	cm^3	VOLUME	Device volume
Tube Length	cm	TUBE_LENGTH	Length of tubing associated with the analyzer used to calculate total volume
Serial Number		SERIAL_ NUMBER	Device serial number
Firmware		FIRMWARE	Device firmware version

Flux variables

Table 6-12. Flux metadata definitions. The **DEVICE** for these variables will be **FLUX.**

Interface variable	Units	Data file variable	Description
Deadband	s	DEADBAND	Deadband length
Stop Time	s	STOP_TIME	Length of data used for the flux computation
Dilution Source		DILUTION_ SOURCE	Name of the device that provided the water vapor measurement used for dilution correction (NONE for a dry gas)
Dilution Units		DILUTION_UNIT	Units of water vapor measurement (NONE for a dry gas)
Temperature		TEMPERATURE	Label of the temperature measurement used in flux calculation
Temperature Source		T_SOURCE	Device of temperature measurement used in flux calculation
Gas		GAS	Name of the gas species the flux was computed for
Gas Source		GAS_SOURCE	Name of the device that measured the gas for which the flux was computed
Replicate		REPLICATE	Numerical value of R from the chamber's HVR field

Summary file variables

In *Table 6-13* on the facing page you will find the variables included in a summary file. Under the **Label** column, variables listed with F*gas* will vary based upon the gas species measured by the analyzer. Under the **Device** column, variables listed with FLUX_*source* vary based upon the device (instrument) used. For example a flux of CO_2 calculated using an LI-870 CO_2/H_2O Analyzer would appear as: FLUX_LI-870, FCO2_DRY, [µmol mol^{-1}].

Table 6-13. Summary file variables.

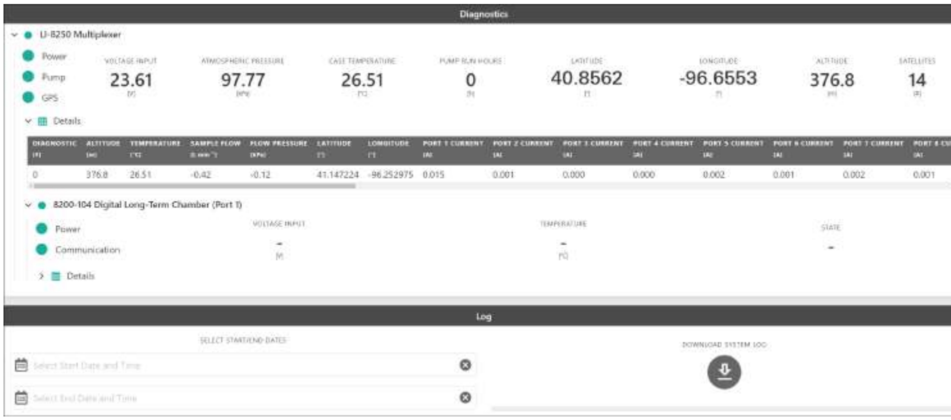
Label	Units	Device	Description
F*gas*	nmol m^{-2}s^{-1}, µmol m^{-2}s^{-1}, or mmol m^{-2}s^{-1}	FLUX_*source*	Flux of the gas species based on exponential fit
F*gas*_dCdt	nmol mol^{-1}s^{-1}, µmol mol^{-1}s^{-1}, or mmol mol^{-1}s^{-1}	FLUX_*source*	Slope used to compute flux
F*gas*_CV		FLUX_*source*	CV for flux calculation
F*gas*_R2		FLUX_*source*	Regression coefficient of fit to accumulation curve
F*gas*_SEI		FLUX_*source*	Standard error for the intercept
F*gas*_SES		FLUX_*source*	Standard error for the slope
F*gas*_A		FLUX_*source*	Curvature parameter of exponential fit
F*gas*_Cx	nmol mol^{-1}, µmol mol^{-1}, or mmol mol^{-1}	FLUX_*source*	Asymptotic gas concentration
F*gas*_C0	nmol mol^{-1}, µmol mol^{-1}, or mmol mol^{-1}	FLUX_*source*	Gas concentration at time zero
F*gas*_T0	s	FLUX_*source*	Time zero for fitting accumulation curve
F*gas*_ITER		FLUX_*source*	Number of iterations required to fit the exponential model
F*gas*_N		FLUX_*source*	Number of data points used in the flux calculation
DATE	YYYY-MM-DD	LI-8250	Date at the start of the observation
TIME	HH:MM:SS	LI-8250	Time at the stat of the observation

Table 6-13. Summary file variables. (...continued)

Label	Units	Device	Description
DOY		LI-8250	Decimal day of the year at the start of the measurement
PORT		LI-8250 or 8250-01	Port being sampled
H		CHAMBER	Horizontal value from HVR
V		CHAMBER	Vertical value from HVR
LATITUDE	°	CHAMBER	Chamber or multiplexer latitude
LONGITUDE	°	CHAMBER	Chamber or multiplexer longitude
TA	C	CHAMBER	Air temperature used in flux calculation
PA	kPa	LI-8250	Pressure used in flux calculation
CO2_DRY	$\mu mol\ mol^{-1}$	LI-870 or LI-78xx	Carbon dioxide dry mixing ratio
CH4_DRY	$nmol\ mol^{-1}$	LI-7810	Methane dry mixing ratio
H2O	$mmol\ mol^{-1}$	LI-870 or LI-78xx	Water vapor mole fraction
N2O_DRY	$nmol\ mol^{-1}$	LI-7820	Nitrous oxide dry mixing ratio
Ancillary SDI-12 or light sensor data		CHAMBER	Data from connected sensors

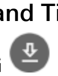
Diagnostics

The Diagnostics page provides various details about your long-term system. The page includes two panes: **Diagnostics** and **Log**.



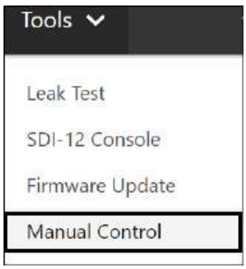
The **Diagnostics** pane gives real-time feedback about the status of the LI-8250 Multiplexer and connected LI-COR devices, such as gas analyzers and long-term chambers. Indicators along the side of each device show you if there are any issues. Expanding the device drop-down will let you see which component is experiencing the issue.

Below each device is an additional **Details** drop-down. Expanding Details opens a table with more information about the device. The information in this table can be valuable for troubleshooting.

The **Log** pane allows you to download a system log (.syslog) file of the multiplexer's performance. To download the system log file, use the fields **Select Start Date and Time** and **Select End Date and Time** to choose a start and end date. Then click the **DOWNLOAD SYSTEM LOG**  button. This option should be used in consultation with LI-COR Technical Support in order to resolve performance issues.

Manual Control

The Manual Control page lets you control certain functions within the system. To open the manual controls, first connect to the LI-8250 Multiplexer user interface. Then expand the **Tools** drop-down and click **Manual Control**.



From this page you can turn the LI-8250 Multiplexer pump on and off or reset the pump hours after a pump replacement. You can also open and close individual chambers.

Figure 6-1. The Manual Control page lets you control certain functions within the system.

Section 7.
Maintenance

In this section we will go over how to maintain your LI-8250 Multiplexer, 8250-01 Extension Manifold, and 8200-104/C Long-Term Chambers to keep your system running smoothly.

Updating the firmware

The firmware that runs on the LI-8250 Multiplexer, 8250-01 Extension Manifold, and the 8200-104/C Long-Term Chambers may need to be updated periodically. Firmware updates include new features and bug fixes. We recommend that you always run the most current firmware on your instruments.

To update the firmware:

1. Acquire the latest updater application from licor.com/8250-software and install it on your computer.

   The updater is available for both Windows and macOS computers.
2. Power on the LI-8250 Multiplexer, 8250-01 Extension Manifolds, and your LI-COR long-term chambers.
3. Connect the LI-8250 Multiplexer to your computer or your local network using an Ethernet cable.
4. Launch the updater application on your computer.

   The updater will display a list of all the LI-8250 Multiplexers on your network by serial number. If you need to find the serial number for a multiplexer, see *Figure 2-4* on page 2-7.
5. Select the multiplexer to update and then click **Update LI-8250**.

   The next window shows the connected instruments that need updating.
6. Click **Update** and the application will load the new files onto the selected instruments.

Depending on the size of your system, updating the firmware may take several minutes or may take up to a couple of hours. Be sure that the computer and the multiplexer are powered on until the update is finished.

Note: Do not allow your computer to enter sleep mode while updating.

LI-8250 Multiplexer and 8250-01 Extension Manifold maintenance

The LI-8250 Multiplexer and 8250-01 Extension Manifold are designed to require little routine maintenance. Most of the components are modular and are intended to be easily replaced if needed.

Note: Before doing any maintenance or repairs to the components, first disconnect the instrument from the power source.

Replacing the air filters

The multiplexer and extension manifold include nine air filters. Eight of these filters are associated with the IN port on the chamber connection panel and there is one blue Balston filter between the valve manifold (inlet) and the system manifold or pump. These filters should be replaced if you are experiencing low (below 1.9 LPM) or no flow rate.

One Balston air filter (part number 300-01961) and eight valve manifold air inlet filters (part number 9981-123) are provided in the spares kit (part number 9982-072) and additional filters can be ordered from LI-COR.

Replacing the air inlet filter

Air filters are located inline with the tubing between each of the eight air inlets and the valve manifold.

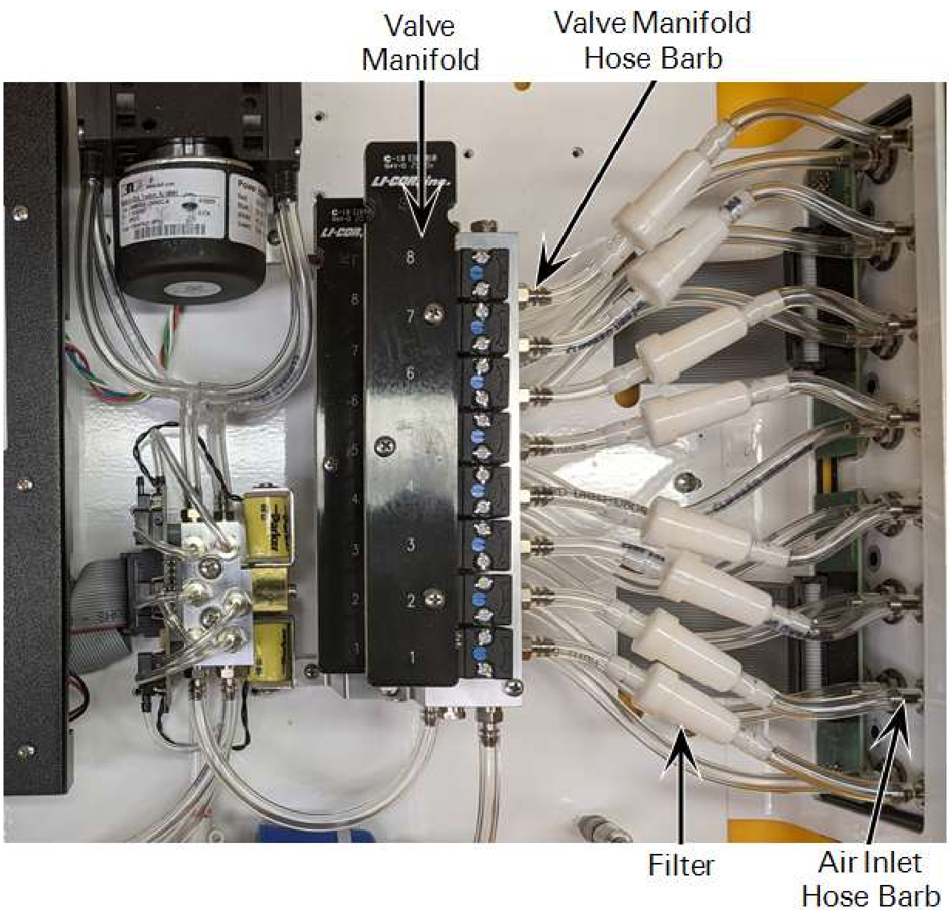


Figure 7-1. The air inlet filter is located inline with the tubing between each of the eight air inlets and the valve manifold.

The tubing is attached with barbed fittings found at the air inlet and the valve manifold. This provides a secure, long-term connection. A good way to remove the filter is to cut a small, wedge-shaped section out of the tubing behind the hose barb. Small, general-purpose diagonal, flush, or shear cutters work well. Position the cutters so that you will not scratch or damage the hose barb as you cut.

> **Caution:** Using a knife to cut along the hose, across the hose barb is not recommended and should be avoided. Cutting across the hose barb may damage the sealing surface of the barb.

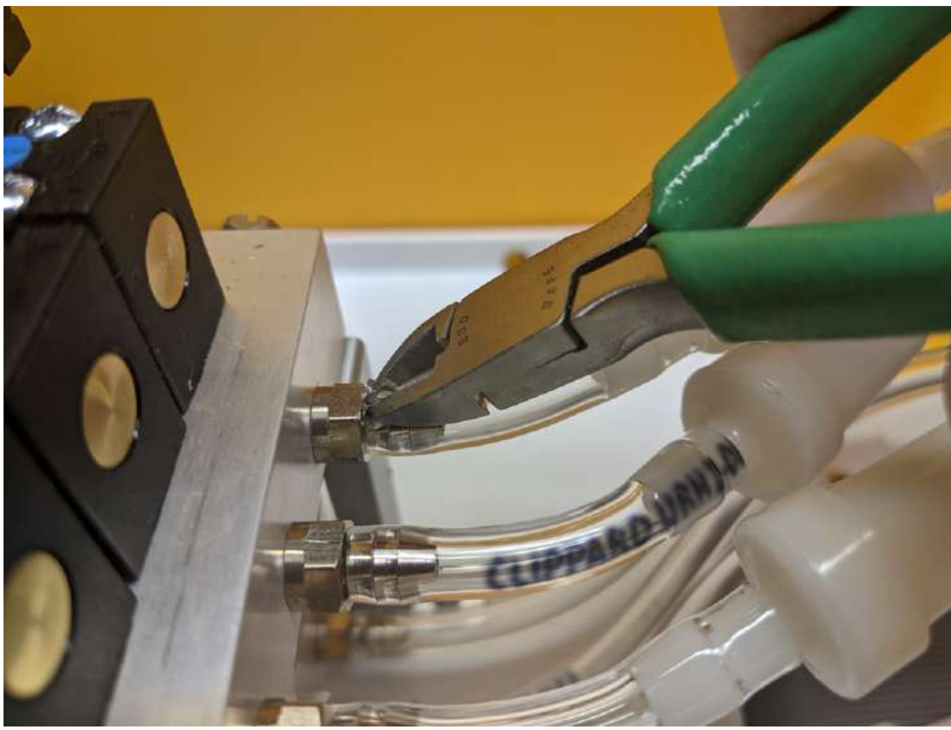


Figure 7-2. Cut a small, wedge-shaped section out of the tubing behind the hose barb.

After cutting the wedge out of the tubing, pull the tubing firmly to the side (perpendicular to the fitting). The tubing will slide off with relative ease. Still, be careful to avoid injuring your knuckles when removing the tubing. Discard the old tubing and filter.

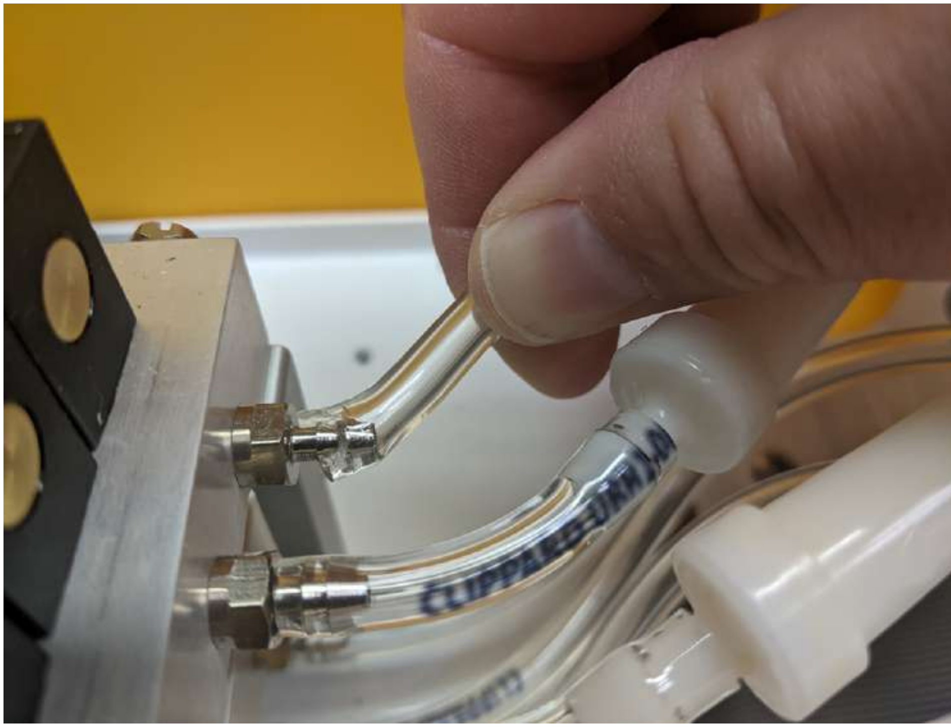


Figure 7-3. Remove the tubing from the hose barb by pulling firmly to the side (perpendicular to the fitting).

Attach the tubing to the hose barb on the valve manifold. Pay careful attention to the orientation of the new filter. There is a raised arrow on the outside of the filter. This arrow should point toward the valve manifold so that the wider end is toward the valve manifold.

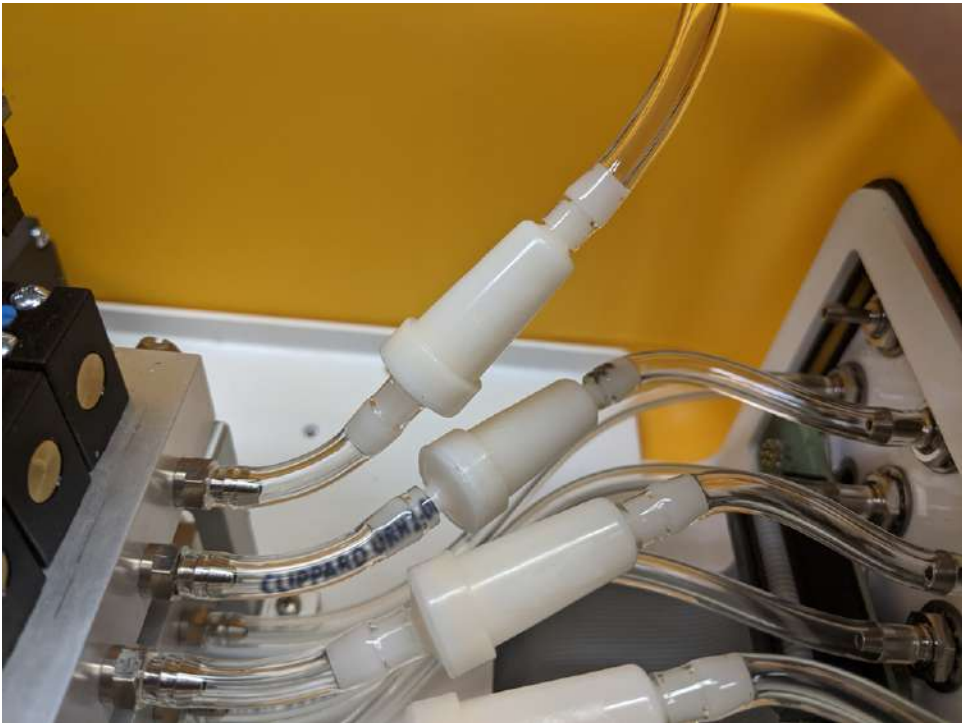


Figure 7-4. Attach the tubing to the hose barb on the valve manifold with the wide end of the filter toward the valve manifold.

The tubing on the other end of the filter is longer than required. Route the tubing to the hose barb at the air inlet. Leave a little slack and trim the hose to length before sliding it over the hose barb.

Figure 7-5. Route the tubing to the hose barb at the air inlet, trim the hose, and connect.

Replacing the Balston air filter

A blue Balston air filter is located between the valve manifold (inlet) and the system manifold (multiplexer) or pump (extension manifold).

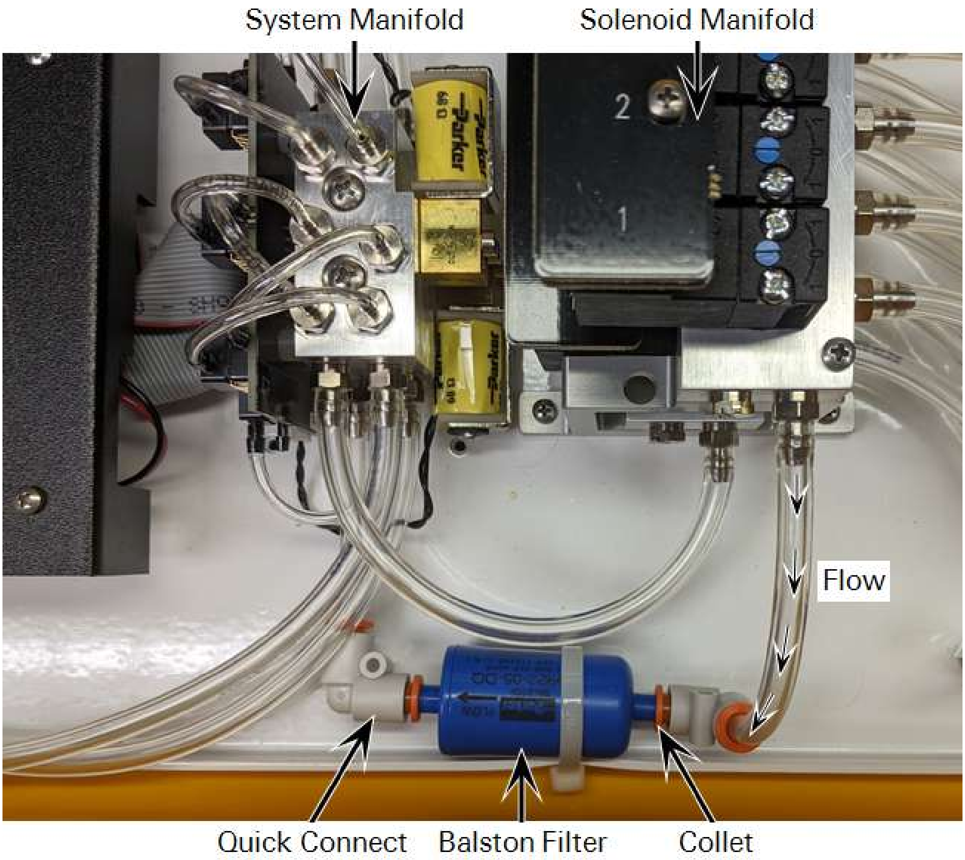


Figure 7-6. In the LI-8250 Multiplexer, the Balston air filter is located between the valve manifold and system manifold. Note the orientation of the filter and the direction of the flow.

To remove the air filter, press in on the orange collets of the quick-connect fittings on both sides of the filter. Pull the quick-connect fittings off and slide the filter out of the strap.

Figure 7-7. Press in on the orange collets to remove the quick-connect fittings and slide the old filter out.

Slide the new filter into the strap. Note the direction of the flow from *Figure 7-6* on the previous page, and ensure the arrow on the filter is pointed with the direction of the flow. Then reconnect the quick-connect fittings to each side of the new air filter.

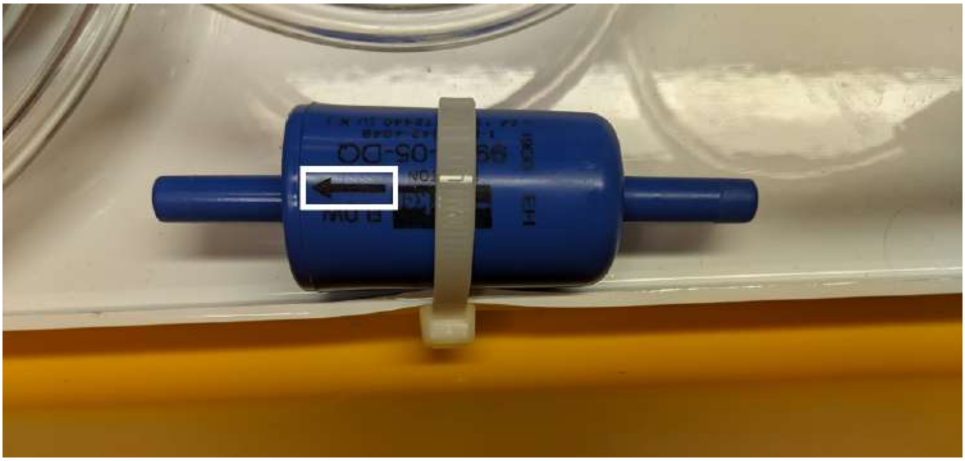


Figure 7-8. Slide the new filter into the strap and reconnect the quick-connect fittings.

Long-term chamber maintenance

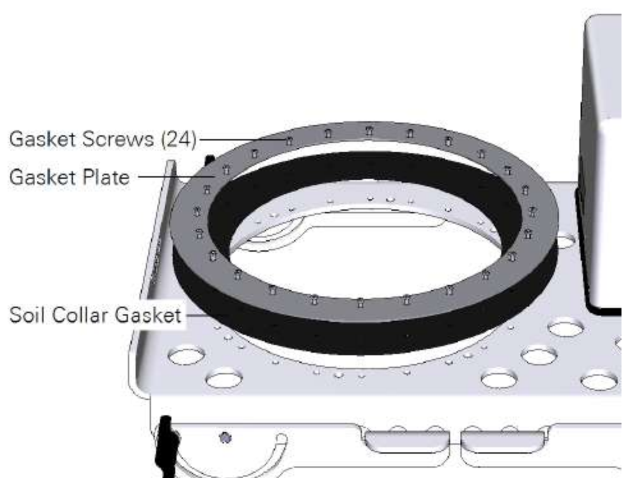
Both the 8200-104 and 8200-104C Long-Term Chambers are designed to require minimal maintenance. Most of the components are modular and are intended to be easily replaced if needed.

> **Note:** Before doing any maintenance or repairs to a long-term chamber first disconnect the **PWR/COM** cable from the chamber.

Replacing the collar gasket

Around the opening of the chamber base is a black neoprene collar gasket that seals around a soil collar. This gasket should not need to be replaced unless it has become cracked, brittle, or otherwise damaged. Two spare collar gaskets (part number 6581-060) are included in the replacement gasket kit (part number 8100-612) and additional gaskets can be ordered from LI-COR.

Before you disconnect the **PWR/COM** cable from the chamber, you will first need to move the chamber to its open position. If the open position does not allow you to fully access the gasket, you will need to change the open position. See *Changing the open position* on page 4-7.



To replace the gasket, loosen the 24 screws around the gasket plate and remove the plate and gasket. Be careful not to lose the screws, but if you do there are spares in the chamber gasket kit. Then line up the new collar gasket with the screw holes on the plate and screw the plate to the chamber base. Torque each screw to 0.45 Newton meters.

Performing the leak tests

With the large amount of tubing and connections in a multiplexed system, leaks may develop over time. This is especially true as the system ages. Fortunately, it is relatively easy to check for any leaks using the System leak test and to further narrow down where the leak is with the Component leak test.

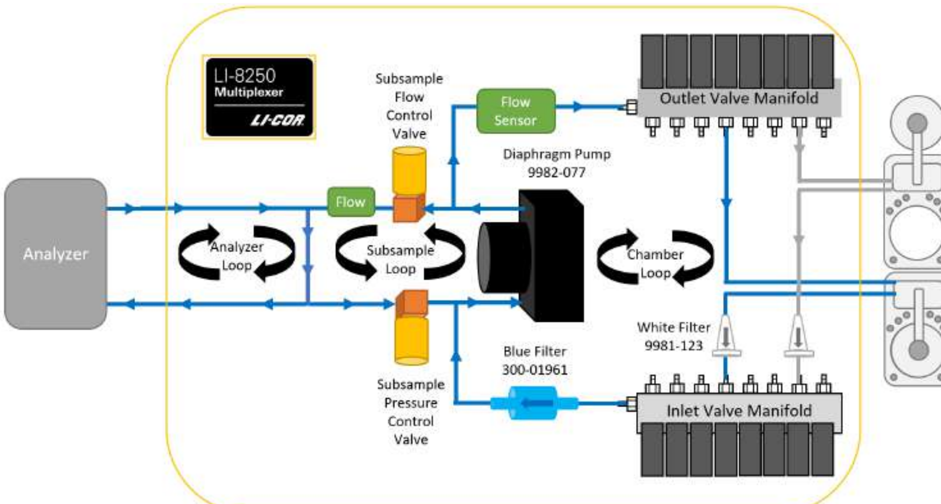
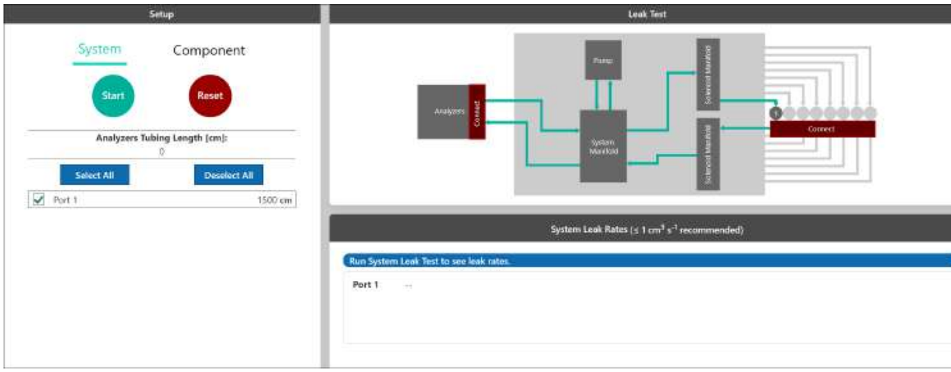


Figure 7-9. A diagram showing the flow of air through the LI-8250 Multiplexer and the various loops.

System leak test (without 8250-01 Extension Manifolds)

The following steps will walk you through the leak test without an 8250-01 Extension Manifold. These steps can be used in situations where you either do not have an extension manifold or you will not be testing the port with an extension manifold.

During the System leak test, the LI-8250 Multiplexer pump draws a vacuum on the system for each port selected. Pressure is monitored to determine the total leak rate for that port. Before moving to the next port, the system is purged to prepare for the next port to be evacuated. The recommended leak rate for each port is ≤ 1 $cm^3 s^{-1}$ to minimize error in your measurements.



The System leak test requires you to seal the analyzer tubing and each tested port to form a closed loop. To do this, disconnect the chamber and analyzer tubing, then connect the male and female ends together.

> **Note:** At least one port must be left open to allow the system to purge itself. The port left open will need to be checked for leaks after testing the others.

Performing the test

To perform the System leak test:

1. Connect to the LI-8250 Multiplexer user interface.
2. Expand the **Tools** drop-down and click **Leak Test**.

3. Disconnect the analyzer tubing from your analyzer or analyzers.
4. Connect the disconnected ends together.

   Leave the tubing connected to the multiplexer.

> **Note:** For analyzers with Swagelok fittings, such as the LI-78xx Trace Gas Analyzers, use the Swagelok Union (part number 300-15249) found in the Spares Kit (part number 9982-072) to connect the ends.

5 Disconnect the chamber tubing from each chamber.

6 Connect the ends of the chamber tubing together for each port you would like to test.

Leave the tubing connected to the multiplexer.

> **Note:** At least one port must be left open to allow the system to purge itself.

7 Select the ports you would like to have tested in the user interface.

Verify the tubing lengths for the analyzer tubing and the chamber tubing are correct. These lengths can be found on your **Configuration** page under their respective blocks. If you are using cable assemblies provided by LI-COR, see *Table 7-1* below for tubing lengths.

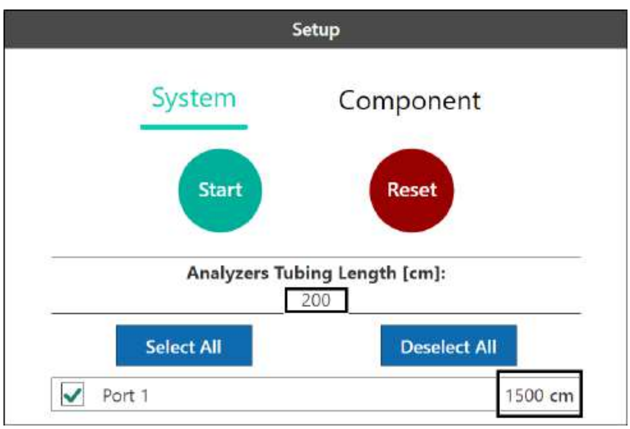


Table 7-1. Tubing lengths for LI-COR cable assemblies.

Instrument	Cable assembly part number	Tubing length (cm)
LI-870 CO_2/H_2O Analyzer	9982-010	120
LI-78xx Trace Gas Analyzer	9982-011	200
8200-104/C Long-Term Chamber or 8250-01 Extension Manifold	9982-056	1500
T-split tubing	9982-073	30

8 Click **Start**. You will then receive two warnings to verify you have plumbed your system correctly for the leak test. To begin the test click **Start Test**.

The multiplexer will then run through the System leak test port by port. After the leak test, you will receive a report on the leak rate of each port tested. If the report has no warnings, as in *Figure 7-10* below, no ports exceeded the 1 $cm^3\ s^{-1}$ threshold. You are finished or you can move on to testing any additional ports that were not tested before.

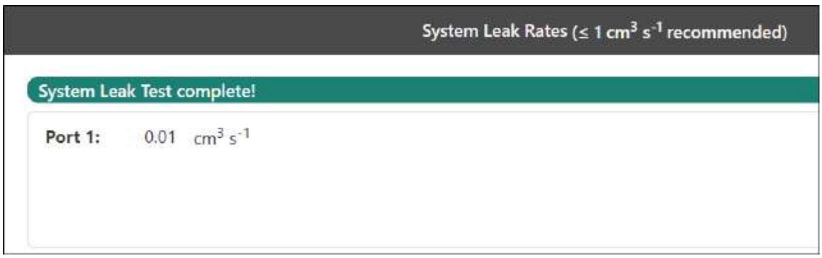


Figure 7-10. Leak test results with no warnings.

Any port that exceeds the 1 $cm^3\ s^{-1}$ threshold for a leak will provide you with a high leak rate warning and advise you to run the Component leak test to troubleshoot where the leak may be occurring, see *Figure 7-11* below.

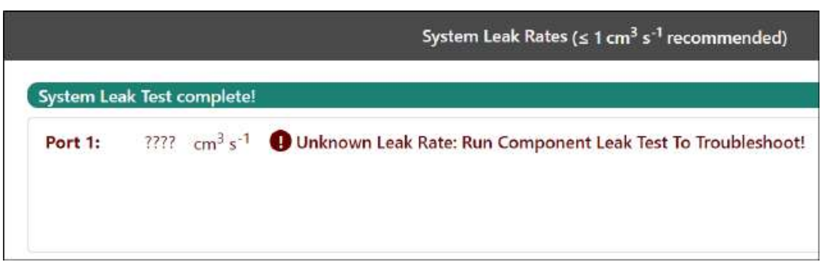


Figure 7-11. Leak test results indicating a high leak rate on port 1.

Component leak test (without 8250-01 Extension Manifolds)

If the System leak test indicates that one of the ports has a high leak rate, you can use the Component leak test to narrow down the location of the leak on that port. You will need the leak test plug (part number 300-18823), see *Figure 7-12* below, for this test. The LI-8250 Multiplexer user interface will guide you through when to use the plug.

Figure 7-12. The leak test plug.

The leak test plug is stored inside the multiplexer case. It is connected to post on the lower right side, see *Figure 7-13* below.

Figure 7-13. The leak test plug is found connected to a post in the lower right side.

The Component leak test requires you to seal the analyzer tubing and the tubing of each tested port to form a closed loop and to leave at least one port open. This test will check six components for leaks:

- Analyzer tubing
- Multiplexer tubing
- Tubing from IN to valve manifold
- Tubing from OUT to valve manifold
- Tubing from IN to chamber
- Tubing from OUT to chamber

Each subsequent step of the test relies on the previous steps to estimate the leak of that component. If one component exceeds the 1 cm^3 s^{-1} threshold, you will receive a warning message under **Component Leak Rates**. The test will stop and indicate the component with the high leak rate that needs to be addressed. Address the component with the high leak rate to continue the test.

Performing the test

To perform the Component leak test:

1 Connect to the LI-8250 Multiplexer user interface.

Expand the **Tools** drop-down and click **Leak Test**.

2 Disconnect the analyzer tubing from your analyzer or analyzers and connect the disconnected ends together.

Leave the tubing connected to the multiplexer.

3 Disconnect the chamber tubing from each chamber you would like to test and connect the ends of the chamber tubing together.

Leave the tubing connected to the multiplexer.

Note: At least one port must be left open to allow the system to purge itself.

4 Click **Component** at the top of the **Setup** pane.

5 Select the port you would like to have tested.

6 Verify the tubing lengths for the analyzer tubing and the chamber tubing are correct.

These lengths can be found on your **Configuration** page under their respective blocks. If you are using cable assemblies provided by LI-COR, see *Table 7-1* on page 7-13 for tubing lengths.

7 Click **Start**.

You will then receive a warning to verify you have plumbed your system correctly for the leak test. To begin the test click **Start Test**.

After the analyzer tubing is tested, the user interface will ask you to connect the leak test plug into the port **IN** connection, the port **OUT** connection, and between the ends of the chamber tubing.

At the end of the Component leak test, you will receive a **Total Leak Rate** calculation. If the Total Leak Rate exceeds the 1 cm^3 s^{-1} threshold, you will see a warning to address the areas with a high leak rate. It is possible to have no individual components exceed the threshold but to have a cumulative total that requires components to be addressed.

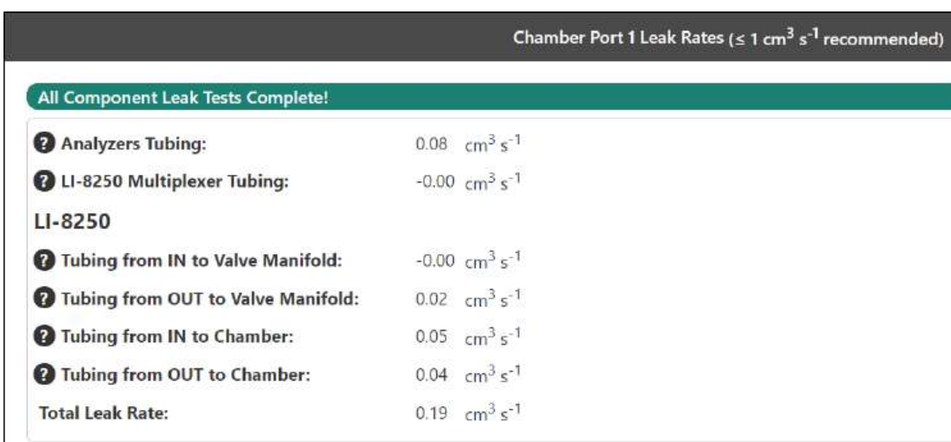


Figure 7-14. A Total Leak Rate calculation is given at the end of the Component leak test.

Note: The Component leak test total leak rate may differ from the System leak test leak rate because the System leak test is more accurate.

System leak test (with 8250-01 Extension Manifolds)

The following steps will walk you through the leak test with an 8250-01 Extension Manifold.

During the System leak test, the LI-8250 Multiplexer pump draws a vacuum on the system for each port selected. Pressure is monitored to determine the total leak rate for that port. Before moving to the next port, the system is purged to prepare for the next port to be evacuated. The recommended leak rate for each port is ≤ 1 cm^3 s^{-1} to minimize error in your measurements.

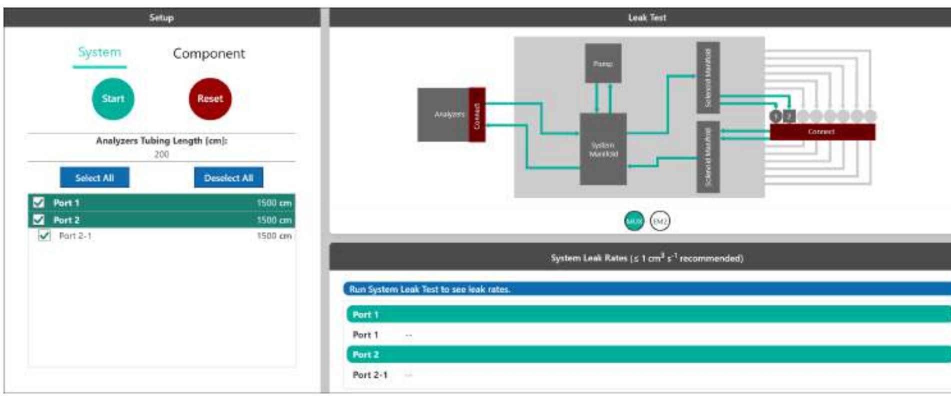


Figure 7-15. The system leak test with an extension manifold on port 2.

The System leak test requires you to seal the analyzer tubing and each tested port to form a closed loop. To do this, disconnect the chamber and analyzer tubing, then connect the male and female ends together.

Note: At least one port must be left open to allow the system to purge itself. The port left open will need to be checked for leaks after testing the others.

Performing the test

To perform the System leak test:

1. Connect to the LI-8250 Multiplexer user interface. Expand the **Tools** drop-down and click **Leak Test**

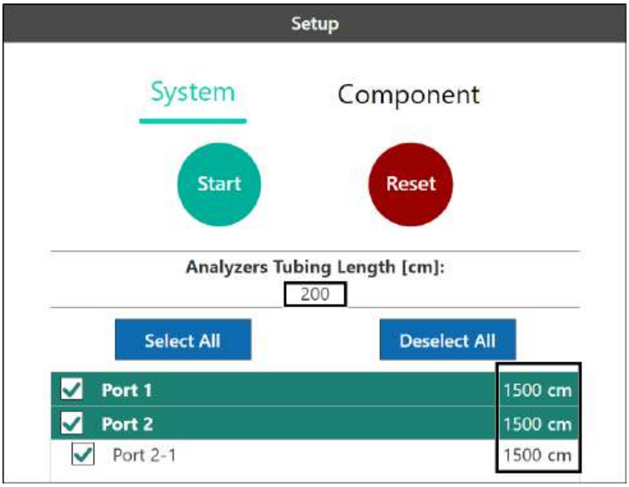
2. Disconnect the analyzer tubing from your analyzer or analyzers. Connect the disconnected ends together. Leave the tubing connected to the multiplexer.

> **Note:** For analyzers with Swagelok fittings, such as the LI-78xx Trace Gas Analyzers, use the Swagelok Union (part number 300-15249) found in the Spares Kit (part number 9982-072) to connect the ends.

3. Disconnect the chamber tubing from each chamber connected to the multiplexer. Connect the ends of the chamber tubing together for each port you would like to test. Leave the tubing connected to the multiplexer.

> **Note:** At least one port must be left open to allow the system to purge itself

4. Disconnect the chamber tubing from each chamber connected to all extension manifolds. Connect the ends of the chamber tubing together for each port you would like to test. Leave the tubing connected to the extension manifold.
5. Select the ports you would like to have tested in the user interface.
6. Verify the tubing lengths for the analyzer tubing, extension manifold tubing, and the chamber tubing are correct. These lengths can be found on your **Configuration** page under their respective blocks. If you are using cable assemblies provided by LI-COR, see *Table 7-1* on page 7-13 for tubing lengths.



7 Click **Start**. You will then receive three warnings to verify you have plumbed your system correctly for the leak test. To begin the test click **Start Test**.

The multiplexer will then run through the System leak test port by port. After the leak test, you will receive a report on the leak rate of each port tested. If the report has no warnings, as in *Figure 7-16* below, no ports exceeded the 1 $cm^3\ s^{-1}$ threshold. You are finished or you can move on to testing any additional ports that were not tested before.

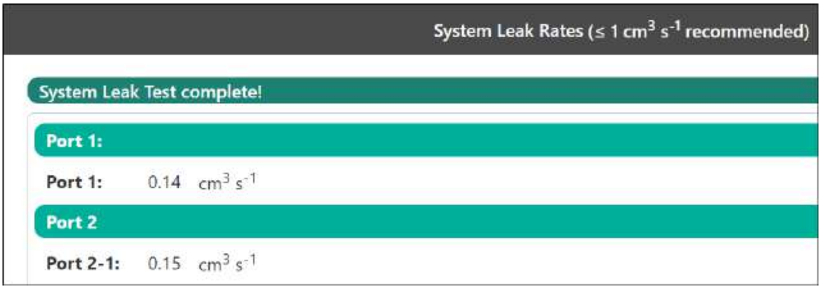


Figure 7-16. Leak test results with no warnings.

Any port that exceeds the 1 $cm^3\ s^{-1}$ threshold for a leak will provide you with a high leak rate warning and advise you to run the Component leak test to troubleshoot where the leak may be occurring, *Figure 7-17* on the facing page.

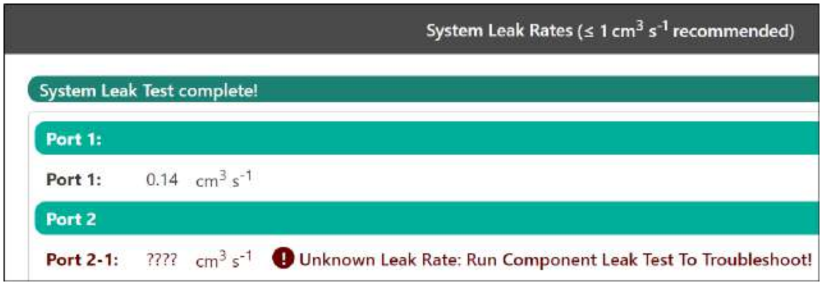


Figure 7-17. Leak test results indicating a high leak rate on port 1.

Component leak test (with 8250-01 Extension Manifolds)

If the System leak test indicates that one of the ports has a high leak rate, you can use the Component leak test to narrow down the location of the leak on that port. You will need the leak test plug (part number 300-18823), see *Figure 7-12* on page 7-15, for this test. The LI-8250 Multiplexer user interface will guide you through when to use the plug.

The leak test plug is stored inside the multiplexer case. It is connected to post on the lower right side, see *Figure 7-13* on page 7-15.

The Component leak test requires you to seal the analyzer tubing and the tubing of each tested port to form a closed loop and to leave at least one port open. This test will check 12 components for leaks:

Multiplexer Components

- Analyzer tubing
- Multiplexer tubing
- Tubing from IN to valve manifold
- Tubing from OUT to valve manifold
- Tubing from IN to 8250-01 Extension Manifold
- Tubing from OUT to 8250-01 Extension Manifold

Extension Manifold Components

- Pump tubing
- Extension manifold tubing
- Tubing from IN to valve manifold
- Tubing from OUT to valve manifold
- Tubing from IN to chamber
- Tubing from OUT to chamber

Each subsequent step of the test relies on the previous steps to estimate the leak of that component. If one component exceeds the 1 $cm^3\ s^{-1}$ threshold, you will receive a warning message under **Component Leak Rates**. The test will stop and indicate the component with the high leak rate that needs to be addressed. Address the component with the high leak rate to continue the test.

Performing the test

To perform the Component leak test:

1. Connect to the LI-8250 Multiplexer user interface. Expand the **Tools** drop-down and click **Leak Test**.

2. Disconnect the analyzer tubing from your analyzer or analyzers. Connect the disconnected ends together. Leave the tubing connected to the multiplexer.
3. Disconnect the chamber tubing from each chamber you would like to test. Connect the ends of the chamber tubing together. Leave the tubing connected to the multiplexer.

> **Note:** At least one port must be left open to allow the system to purge itself

4. Click **Component** at the top of the **Setup** pane.
5. Select the port combination you would like to have tested.
6. Verify the tubing lengths for the analyzer tubing and the chamber tubing are correct. These lengths can be found on your **Configuration** page under their respective blocks. If you are using cable assemblies provided by LI-COR, see *Table 7-1* on page 7-13 for tubing lengths.
7. Click **Start**. You will then receive a warning to verify you have plumbed your system correctly for the leak test. To begin the test click **Start Test**.

After the analyzer tubing is tested, the user interface will ask you to connect the leak test plug into the LI-8250 port **IN** connection, the LI-8250 port **OUT** connection, between the ends of the extension manifold tubing, the 8250-01 port **IN** connection, the 8250-01 port **OUT** connection, and between the ends of the chamber tubing.

At the end of the Component leak test., you will receive a **Total Leak Rate** calculation. If the Total Leak Rate exceeds the 1 $cm^3\ s^{-1}$ threshold, you will see a warning to address the areas with a high leak rate. It is possible to have no individual components exceed the threshold but to have a cumulative total that requires components to be addressed.

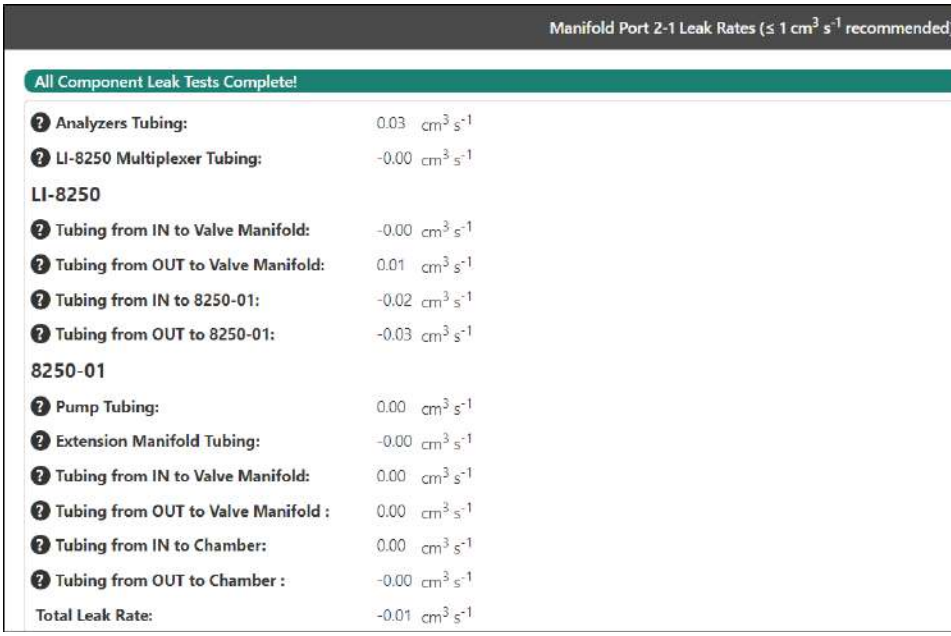


Figure 7-18. A Total Leak Rate calculation is given at the end of the Component leak test.

Note: The Component leak test total leak rate may differ from the System leak test leak rate because the System leak test is more accurate.

Section 8.
Troubleshooting

Eventually, we all run into situations where things just do not go according to plan. This section will (hopefully) help you find a solution to some common issues. Should you run into an issue you cannot resolve, you can visit licor.com/env/support or you can reach LI-COR Technical Support at envsupport@licor.com.

System will not power on or powers on incompletely

- Is the power supply strong enough? The system power supply should be capable of powering the entire system. Verify that your power supply provides enough current for all connected instruments. See *Table F-1* on page F-2 to see total system power requirements.
- Are the cables properly tightened? Some of the threaded connections can appear to be connected but may require a little extra effort to fully seat them. Ensuring these cables are properly tightened is also important for achieving a weather-tight seal. Push in on the cable while giving it a little wiggle and turn the threaded nut and see if the system does not power on then.

Connection and communication problems

This section addresses problems communicating with the LI-8250 Multiplexer.

Cannot connect to the LI-8250 Multiplexer over Wi-Fi

If you are using Chrome, Firefox, or Safari, and are having trouble connecting, first try the steps outlined in *Connecting over Wi-Fi* on page 2-7. If you are still having trouble here are some potential solutions.

- Has the system finished powering up? The system takes about a minute to fully power up. During this powering up period the **Ready** light on the interior panel will flash and the multiplexer will not broadcast a Wi-Fi signal. Once the **Ready** light is steady, you can try to connect.
- Is Wi-Fi enabled? If Wi-Fi has been previously disabled for any reason you will need to re-enable it before connecting, or perhaps you did re-enable the Wi-Fi previously but did not press **Apply**. Instructions for re-enabling Wi-Fi can be found in *Re-enabling Wi-Fi* on page 2-10.
- Have you entered the correct password? To connect to the LI-8250 Multiplexer Wi-Fi network enter the password `licorenv` to connect. Some devices may first prompt you to enter a PIN. In this case, select **Use a security key instead.**
- You can try switching the Wi-Fi channel. This can be especially helpful where multiple wireless networks are available. To switch the Wi-Fi channel, you will first need to connect to the multiplexer user interface using an Ethernet connection (see *Connecting over Ethernet* on page 2-8). From the user interface, open the Wi-Fi settings and use the **Channel** drop-down menu to switch the Wi-Fi to another channel.
- Using a Windows PC? We recommend using Windows 10, Version 1809 or higher. If you are using an older version, you may consider updating.

Cannot connect to the LI-8250 Multiplexer over Ethernet

If you are using Chrome, Firefox, or Safari, and are having trouble connecting, first try the steps outlined in *Connecting over Ethernet* on page 2-8. If you are still having trouble here are some potential solutions.

- Has the system finished powering up? The system take about a minute to fully power up. During this powering up period the **Ready** light on the interior panel will flash and the multiplexer will not accept a connection. Once the **Ready** light is steady, you can try to connect.
- Is your computer using Wi-Fi? You may need to disable Wi-Fi on your computer as the computer may default to this as the preferred connection.
- Did you change networks? Network settings persist on the LI-8250 and require a restart before the settings will update. If you have changed networks, such as disconnecting the multiplexer from a LAN to connect via Ethernet cable, reboot the multiplexer and try connecting again.

- You can also try to connect using the LI-8250 updater. Open the updater software, select your multiplexer from the list, and click **Connect to LI-8250.**

Cannot connect to the user interface

- Ensure that you are connected to the LI-8250 Multiplexer Wi-Fi network. If you are somewhere where your device is set to automatically connect to a Wi-Fi network, the multiplexer connection may have been overridden and would require you to reconnect. You should also note that some devices will automatically disconnect themselves from a Wi-Fi network if they cannot access the Internet. This is an option that must be disabled on your device.
- Make sure you have entered the correct serial number in the correct format in the browser address bar. See *Connecting to the LI-8250 Multiplexer* on page 2-7 for details on where to find your serial number and how to enter that information into the address bar.
- Are you using an Android device? The Android operating system does not support multicast Domain Name Service (mDNS), so you must use an alternative address to connect wirelessly with Android devices: http://82m-nnnn.li8250.licor.-com.

A note on mDNS and IPV6

For speed and security, the LI-8250 Multiplexer was designed with the latest networking technology, which includes mDNS and IPV6. These technologies are not fully supported by all devices and operating systems. There are two main cases where mDNS and IPV6 limitations create LI-8250 Multiplexer connection issues:

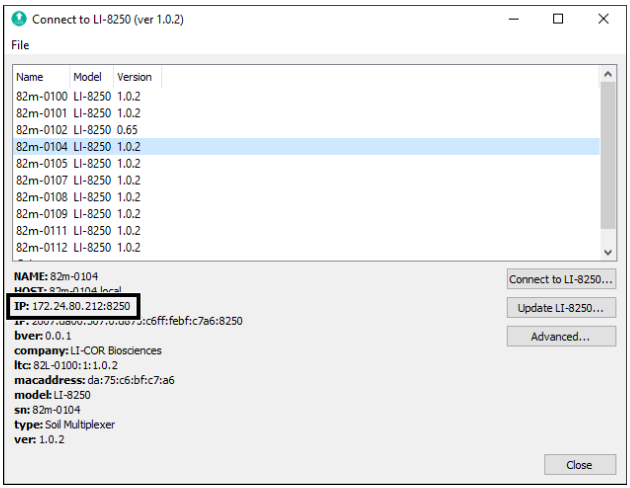
1. Android devices, which do not support mDNS.

   Connecting to the multiplexer using the localhost requires mDNS, which is not currently supported by the Android OS. The fix for this is simple: use a different address: http://82m-nnnn.li-8250.licor.com, where 82m-nnnn is the serial number of your multiplexer.

2. Windows operating systems.

   Windows officially began supporting IPV6 with Windows 10 version 1809. You may encounter issues connecting via localhost to your LI-8250 Multiplexer if you are using an older version. In this case, we recommend updating your operating system, though this is not absolutely required for connection.

If you are not able, or choose not, to update your operating system, you may also connect using the multiplexer IP address. An easy way to identify your multiplexer IP address is through the software updater. Follow the instructions in *Updating the firmware* on page 7-1 to download and install the updater. Connect your LI-8250 Multiplexer to your computer via Ethernet, and open the updater software. Click the serial number of your multiplexer, and the IP address will be displayed.



Write this address down for your records. It can be a useful backup if you run into issues connecting using the localhost. Enter the IP address directly into your browser to connect to the user interface.

If you cannot identify your multiplexer with the updater software, you should check to ensure the multiplexer is being recognized by your network. With your LI-8250 Multiplexer connected to your computer via Ethernet, open a command-line terminal and use the ping or nslookup commands, where 82m-nnnn is the serial number of your multiplexer.

- `ping 82m-nnnn.local` (macOS)
- `nslookup 82m-nnnn.local` (Windows)

If you receive a message like "Ping request could not find host 82m-nnnn.local. Please check the name and try again," your multiplexer is not being recognized by your network. In this case:

- Is your Ethernet cable damaged or not connected properly?
- Are you using the RJ-45 Ethernet cable supplied with your LI-8250 Multiplexer?
- Is the Ethernet port and/or dongle of your computer working properly?
- Are there any settings on your computer that would prevent you from connecting to devices via Ethernet?

LI-COR long-term chamber problems

See this section for issues related to the 8200-104 Opaque Long-Term Chamber and the 8200-104C Clear Long-Term Chamber.

Chamber will not open or close

- Is there debris in the chamber? First check for and clear any debris that may be blocking the movement of the chamber.
- Are the cable connections tight? Check that the **OPEN/CLOSE** button on the chamber is lit with a green light. If this light is not lit, check the cable connections to the **PWR/COM** port of the chamber and the ⚡ port of the LI-8250 Multiplexer. Press in and tighten each connector or try to disconnect and reconnect the chamber, then try to open or close the chamber.
- If the light around the **OPEN/CLOSE** button on the chamber is still not lit and you have checked the connections, try connecting the chamber to a different ⚡ port on the multiplexer. You can also try a different cable assembly to see if the cable is damaged.
- Try to open or close the chamber using the user interface. While connected to the LI-8250 Multiplexer user interface, go to **Tools** drop-down and select **Manual System Control**. Find the port number that the chamber is on and toggle between closed and open.

Chamber appears as orange in the Device Network

- Has the chamber and all components connected to it been configured? If the chamber or its components have not been configured, it will appear in the device network as orange. See *An overview of configurations* on page 6-5 for details.

Chamber appears as red in the Device Network

This indicates that the chamber and the LI-8250 Multiplexer are not communicating. First go to the **Diagnostics** page in the user interface. There may be a code or some indicator there as to why the instruments are not communicating.

- Try disconnecting the power and communications cable from the chamber for 30 seconds and reconnecting.
- Reboot the multiplexer by going to the Device Settings page and clicking **Reboot** at the bottom of the page.
- Try connecting the chamber to a different port on the multiplexer.
- If the problem persists, contact LI-COR Technical Support.

Chamber temperature readings are unreasonable

- Is the thermistor connector fully seated in the sensor port? The thermistor connector may not be fully tightened. Try to fully tighten the thermistor connector and see if the problem persists.
- Disconnect any other sensors from the chamber and see if the problem persists. An incorrect connection or short circuit in another sensor can cause a corrupted temperature measurement.
- Have you tried connecting the thermistor to a different sensor port? If you are getting unreasonable readings from one port, try moving the thermistor to a different port and see if the problem persists. If the problem persists regardless of sensor port, the chamber thermistor may be damaged or malfunctioning. Contact LI-COR Technical Support.

Data and measurement problems

This section can help you address problems related to measurements and the quality of data.

Measurements stop immediately after starting

- Is the power supply adequate? Be sure that your power supply is capable of running the entire system. If your power supply is not sufficient, the instruments will shut down when they attempt to draw a load. See *Table F-1* on page F-2 to see total system power requirements.

Data is noisy

- Check the **IN** and **OUT** connections at the LI-8250 Multiplexer and the chamber to be sure the connections are complete. Also, inspect the tubing for any damage or leaks, especially near the connections.
- Is the soil collar leaky? If the soil collar wobbles or if there are gaps between the soil and the bottom of the collar, there is likely a leak allowing ambient air into the chamber during a measurement. Reinstall the soil collar in another location. See *Installing soil collars* on page 4-1 for how to install a soil collar.
- Is the chamber sealing around the collar well? Look for any obstructions around the chamber and collar seals that may be interfering with a complete seal. If there are no obstructions, inspect the gaskets around the chamber and replace any damaged or hardened gaskets.

Initial gas concentrations are high

- Is the prepurge long enough? One possible cause of a high initial gas concentration may be that the prepurge duration is not set long enough. Try to lengthen the prepurge and see if that corrects the problem. See *An overview of configurations* on page 6-5

Low/no flow during measurement

- Is the filter on that port clogged? If the filter on that port has not been changed in a while, it may have become clogged and may need to be replaced. See *Replacing the air filters* on page 7-2 to see how to change the filters. This may also be a good time to consider when you last changed the filter on the other ports or your car.
- Is there a blockage or liquid water in the tube? Inspect the tubing for blockages, kinks, or liquid water in the tubing. If you can see a blockage, clean or replace the tubing using the spares kit as needed. If you see water, take off the tubing immediately and power off the LI-8250 Multiplexer. Try to get the water out as soon as possible, and consider contacting LI-COR Technical Support.
- Has the pump gone bad? The pump on the LI-8250 Multiplexer and the 8250-01 Extension Manifold should run from the prepurge through the postpurge. Disconnect the tubing from the chamber and attempt an observation. Feel the ends of the tubing for air movement. If you do not feel air movement or if you cannot hear the pump, it may have failed. Contact LI-COR Technical Support.

Assessing GPS data accuracy

The LI-8250 Multiplexer reports the accuracy of GPS data (latitude, longitude, altitude) by providing horizontal dilution of precision (HDOP). HDOP is closely related to the number of satellites and represents the preciseness of data based on the relative geometries of the available satellites.

HDOP Value	Description
1	Perfect. This is the highest possible HDOP value and indicates the highest quality data.
1-2	Excellent
2-5	Good
5-10	Moderate
10-20	Fair. This data provides a very rough estimate of position.
>20	Poor. Data with an HDOP of >20 has the lowest possible precision and may be inaccurate by as much as 300 meters.

Appendix A.
Soil gas flux measurement theory

Soil gases are produced by a variety of biological processes, including root respiration, organic matter decay, and microbial activity. Rainwater interacting with calcareous soils can also create soil gases.

Soil gases primarily diffuse into the atmosphere via air-filled pores and cracks in the soil, but they can also be displaced by rain and are very sensitive to changes in pressure. Pressure gradient changes can be driven by wind, or by mechanical influences, such as chamber placement. The air-filled porosity of the soil varies with soil type and moisture content, so these characteristics can have a significant effect on the movement of gas through soils.

Because soil gas fluxes are dependent on soil temperature, organic content, moisture content, pressure, and precipitation, they exhibit a great deal of temporal and spatial variability.

For soil gas flux measurements to be most accurate, conditions within the chamber must be similar to conditions outside the chamber. These conditions include the concentration gradient driving diffusion, barometric pressure, temperature, and moisture of the soil.

LI-COR long-term chambers are designed to minimize the effect the chamber has on the flux of soil gases and to maintain ambient conditions before, after, and during a measurement. Some of these design considerations include:

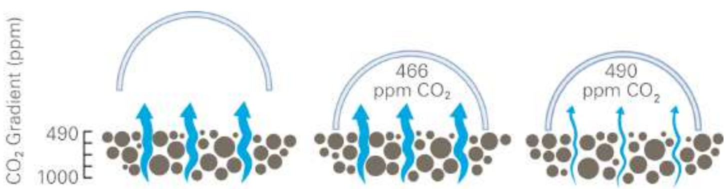
- A patented chamber vent that maintains ambient pressure inside the chamber—even in windy conditions.
- A uniform chamber shape and air inlet and outlet positioning within the chamber to mix of chamber air without fans.

- A perforated base to allow the natural exchange of gas, sunlight, and precipitation between the atmosphere and soil.

Soil gas flux varies substantially in both space and time. A long-term soil gas flux system with the LI-8250 Multiplexer allows you to observe both spatial and temporal variability. Up to 36 chambers may be connected at once and configured to take automated measurements at defined intervals year-round. This allows you to examine how periodic events, such as rainfall, influence soil gas flux, and to characterize diurnal, seasonal, and annual flux patterns.

Accounting for an altered diffusion gradient

While the above design considerations can minimize artificial effects, they cannot eliminate them. Upon chamber closing, there is an increase in the mole fraction of the gas being measured inside the chamber—suppressing the efflux. Because of this, the gradient of gas diffusion between the soil surface layer and the air is not the same inside and outside the chamber.



To account for the altered diffusion gradient, the diffusion rate is estimated using an exponential function. This technique reduces errors in flux estimates by taking into account the effect of increasing chamber gas concentration on the diffusion gradient and allows for the estimation of flux at the time of chamber closing—when gas concentration is nearest to ambient levels.

Measurement length

For CO_2, CH_4, and N_2O it is generally recommended to limit measurements to between 90 and 180 seconds. This is an important consideration to ensure that the moisture and temperature of the soil within the measurement collar are similar to the surrounding soil and to minimize the effect of altered diffusion.

For example, a 2-minute measurement made once every 30 minutes leaves the soil fully exposed to sun, wind, and precipitation more than 93% of the time. This keeps gas concentration changes due to the chamber to a minimum. However, some gases, such as H_2O, may need measurements up to 15 minutes or longer to reliably calculate their flux.

The measurement cycle

The measurement cycle begins with an optional prepurge period with the chamber open, after which the chamber closes. Upon closing, the deadband starts. The LI-8250 Multiplexer begins logging data and continues to do so for the duration of the observation. When the observation is finished the postpurge begins. Then the cycle repeats as configured.

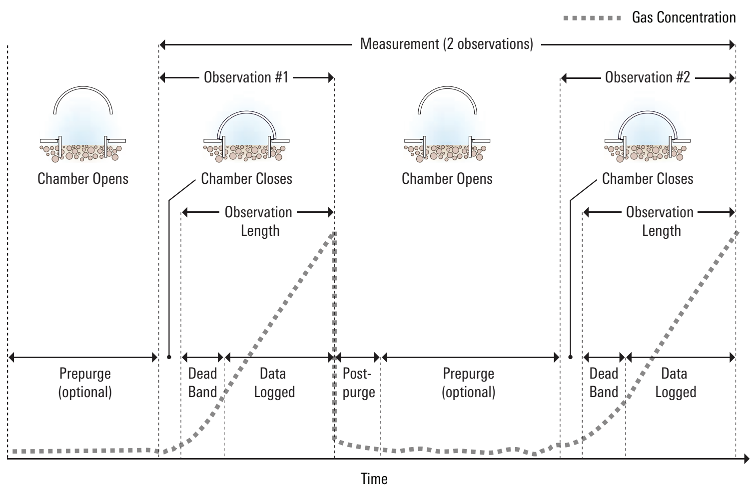


Figure A-1. A typical measurement cycle.

Terminology

Provided is a list of various terms used in a measurement and in the user interface.

Collar height

Defined as the distance from the soil surface and the upper edge of the chamber base plate. The measurement is used to compute the volume of the system. See *Measuring the collar height* on page 4-2 for instructions.

Deadband

The period, usually between 10 and 30 seconds, from complete chamber closing until steady mixing is achieved and the measurement begins. Deadband requirements change based on chamber geometry, system flow rate, collar height, and site characteristics and should be optimized in post-processing using SoilFluxPro Software.

Tubing volume

The volume of the tubing from the multiplexer to the chamber, including any tubing to an extension manifold. To determine tubing volume, measure the combined length of all tubing (**AIR IN** and **AIR OUT**) and use the following information to make your calculations: 1 cm of 1/4" outer-diameter Bev-A-Line® tubing adds approximately 0.079 cm^3 of volume or 7.9 cm^3 per meter.

To simply calculate extension tube volume, multiply the total length in meters by 7.91 for both the **AIR IN** and **AIR OUT** tubing. For example:

$$15 \text{ m} \times 7.91 \times 2 = 237 \text{ cm}^3 \tag{A-1}$$

Measurement start

The start of a measurement. You can begin a measurement using the **Start** button on the Home page. This will begin the sampling sequence based on the configuration you outlined in *Configuring the Sampling Sequence block* on page 6-14.

Observation length

The period from complete chamber closing until just before it opens, including the specified deadband. You will need to optimize the observation length for the conditions of your site. For example, if you are measuring fluxes in poor soil (low organic matter) or dry conditions, you may need to extend the observation length to allow more gas to build-up and improve the signal-to-noise ratio.

Note: The LI-8250 Multiplexer begins logging data when the chamber starts to close and continues throughout the entire observation length. The elapsed time does not begin until the chamber is closed.

Prepurge

In multiplexed systems, gases may accumulate in open chambers. Prepurge turns on the pump to mix the air in an open chamber and bring conditions closer to ambient. You will need to optimize the prepurge time for your site. For example, a slightly longer prepurge may be needed in very sandy or soft soils where the chamber movement may disturb the flux.

After an observation, the chamber will automatically rise off the soil collar. If there is more than one observation specified for that chamber, the prepurge sets the time during which the chamber is open. Under still conditions, it may take 2 minutes or more for the chamber air to return to ambient conditions. Under windy conditions, the chamber air may return to ambient levels in as little as 20 or 30 seconds.

Postpurge

The period of airflow through the chamber after the measurement is complete and as the chamber opens. This is important where environmental factors may influence the amount of greenhouse gases, such as CO_2, or moisture present in the gas sampling lines. For example, in hot, moist conditions, you may want to increase the postpurge to ensure that the gas sampling lines are purged of moisture that may condense in the lines. In most cases, a postpurge of about 45 seconds is adequate.

Soil area

The surface area of soil in the chamber. For a 20 cm soil collar, the soil area is 317.8 cm^2. For home-made soil collars, you will need to compute surface area.

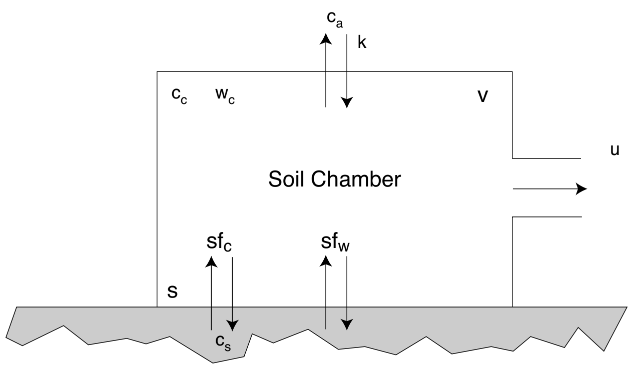
Total system volume

The total calculated volume for all components of the system, including the chamber, multiplexer, extension manifold, gas analyzer(s), and tubing.

Deriving the flux equation

The LI-8250 Multiplexer can be used to measure fluxes of many trace gases that can be reliably detected with compatible gas analyzers. The flux equation remains the same for all gases.

At constant pressure, the total rate at which water evaporates into the chamber sf_w (mol s^{-1}) is balanced by a small flow rate of air out of the chamber u (mol s^{-1}). The gas mole fraction of the air outside the chamber is c_a, inside the chamber is c_c, and in the soil is c_s, all in mol mol^{-1}. The chamber air water vapor mole fraction is w_c (mol mol^{-1}). The rate constant k (s^{-1}) characterizes leaks (if any) due to diffusion of gas between the soil chamber and outside air. The chamber volume v includes the volume of the pump and measurement loop.



A chamber of volume v (m^3) and surface area s (m^2) sitting over the soil, which has a gas efflux rate f_c (mol m^{-2} s^{-1}) and water evaporation flux rate f_w (mol m^{-2} s^{-1}).

The mass balance equations for the gas of interest, water vapor, and air take the form

storage = flux in - flux out A-2

We neglect the effects of leaks for now, but we will consider them later.

Gas mass balance

$$\nu \frac{\partial \rho_c^c}{\partial t} = sf_c - c_c u \qquad \text{A-3}$$

H_2O mass balance

$$\nu \frac{\partial \rho_c^w}{\partial t} = sf_w - w_c u \qquad \text{A-4}$$

Air mass balance

$$\nu \frac{\partial \rho_c}{\partial t} = sf_c + sf_w - u \qquad \text{A-5}$$

ρ_c^c is the number density of gas in the chamber, ρ_c^w is the number density of water vapor in the chamber, and ρ_c is the total number density of air in the chamber (all in mol m^{-3}); $\rho_c = \rho_c^a + \rho_c^c + \rho_c^w$, where ρ_c^a is the number density of dry air in the chamber.

The number density of air is given by the ideal gas law, $\rho_c = p(RT_K)^{-1}$, where *R* is the gas constant (8.314 Pa m^3 K^{-1} mol^{-1}), and T_K is the absolute temperature (K). From equation A-5, with ρ and T_K constant, and $sf_w >> sf_c$,

$$u = sf_w \qquad \text{A-6}$$

Combining equations A-4 and A-6, and noting that $\rho_c^w = \rho_c w_c$, we find

$$sf_w = \frac{\nu\rho_c}{1-w_c}\frac{\partial w_c}{\partial t} \qquad \text{A-7}$$

Combining equations A-3, A-6 and A-7 gives

$$f_c = \frac{\nu\rho_c}{s}\left(\frac{\partial c_c}{\partial t} + \frac{c_c}{1-w_c}\frac{\partial w_c}{\partial t}\right) \qquad \text{A-8}$$

Equation A-8 can be simplified by defining $c_c{}' = c_c(1-w_c)^{-1}$, which is the chamber dry mixing ratio, corrected for water vapor dilution, reported in units of µmol/mol. This is different from C_{dry}, the dry mole fraction, reported in units of parts-per-million (ppm) in the data output.

Differentiating $c_c{}'$ we find,

$$(1-w_c)\frac{\partial c_c{}'}{\partial t} = \frac{\partial c_c}{\partial t} + \frac{c_c}{1-w_c}\frac{\partial w_c}{\partial t} \qquad \text{A-9}$$

Substituting this into equation A-8 gives

$$f_c = \frac{\nu\rho_c}{s}(1-w_c)\frac{\partial c_c{}'}{\partial t} \qquad \text{A-10}$$

Equation A-10 has an important advantage over equation A-8 because it is not necessary to estimate the rate of increase in water vapor mole fraction. In most measurements, the water vapor mole fraction increases in a highly non-linear fashion, and the rate is estimated with a linear function. Thus, in effect, equation A-8 forces us to use average values for $\partial w_c/\partial t$ and w_c. But with equation A-10, the dilution correction is made point-by-point, and estimates of the initial values at time zero are used to estimate f_c at the instant the chamber closed. This is both easier and more accurate than the procedure required to implement equation A-8.

In order to use equation A-10 the initial values must be known for ρ and T_K (to compute ρ_c), as well as the initial values for w_c and $\partial c_c'/\partial t$. After the chamber closes, the LI-8250 Multiplexer performs a linear regression with time on the first 10 values of each measured variable. The initial values of ρ, T_K and w_c are obtained from the time zero intercepts of these regressions; however, finding the initial value for $\partial c_c'/\partial t$ requires a little more work.

To do this, f_c is defined in terms of the mole fraction gradient across the soil- to-chamber interface and a transfer coefficient, to obtain

$$f_c = \rho_c g\,(c_s - c_c) \qquad \text{A-11}$$

where c_s is the mole fraction in the soil surface layer communicating with the chamber (mol mol^{-1}), g is conductance to the gas of interest (m s^{-1}), and ρ_c is the density of air (mol m^{-3}). The soil and chamber must be isothermal for equation A-11 to hold.

Combining equation A-11 with equation A-10, considering all variables except c_c' to be constant, and rearranging, gives

$$\frac{dc_c'}{dt} + \frac{sg}{\nu}c_c' = \frac{sg}{\nu}c_s' \qquad \text{A-12}$$

where $c_s' = c_s(1 - w_c)^{-1}$. When $w_c = w_s$, c_s', gives the water vapor dilution-corrected mole fraction in the soil layer communicating with the chamber. We do not expect w_c to equal w_s exactly, but most of the time they will differ by less than 0.02 mol mol^{-1} or so, which introduces only a small uncertainty in c_s'. If c_s' is taken as a constant, then equation A-12 can be integrated to give

$$c_c'(t) \;=\; c_s' \;+\; [c_c'(0) \;-\; c_s']e^{-\alpha t} \qquad \text{A-13}$$

where $\alpha = sg\,v^{-1}$ is a rate constant (s^{-1}) and $c_c'(0)$ is the initial value of the dilution-corrected mole fraction when the chamber closes. The rate of change in $c_c'(t)$ at any time can be computed from the derivative of equation A-13.

$$\frac{dc_c'}{dt} \;=\; \alpha\,[c_s' \;-\; c_c\,(0)]e^{-\alpha t} \qquad \text{A-14}$$

Calculating the flux from measured data

In the LI-8250 Multiplexer, equations A-10, A-12 and A-13 are implemented in a form that presents the variables in more familiar and intuitive units. Equation A-10 is computed as

$$F_c = \frac{10VP_0\left(1-\frac{W_0}{1000}\right)}{RS(T_0+273.15)}\frac{\partial C'}{\partial t} \quad \text{A-15}$$

where F_c is the soil gas efflux rate (µmol m^{-2} s^{-1}), V is volume (cm^3), P_0 is the initial pressure (kPa), W_0 is the initial water vapor mole fraction (mmol mol^{-1}), S is soil surface area (cm^2), T_0 is initial air temperature (°C), and $\frac{\partial C'}{\partial t}$ is the initial rate of change in water vapor dilution corrected mole fraction (µmol mol^{-1} s^{-1}) of the gas of interest.

Examine *Figure A-2* on the next page to see *C'(t)* vs *t* data that were obtained from a soil CO_2 flux measurement with two observations. The data are marked to show when the chamber closed and when it opened.

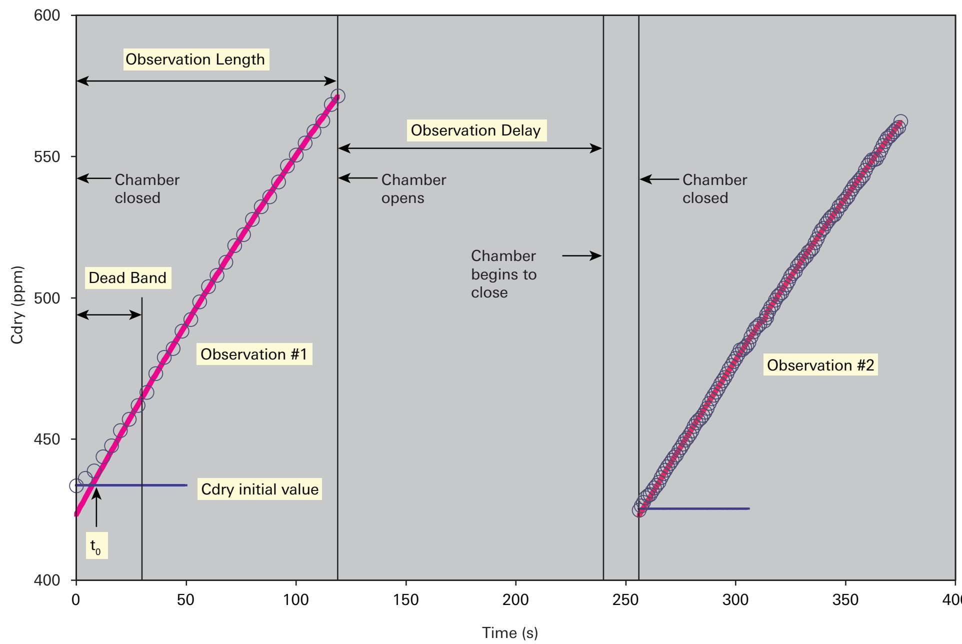


Figure A-2. Soil CO_2 flux data were collected on bare soil in a tropical greenhouse near Lincoln, NE. Two observations are shown. About 60% of the data from the first observation has been removed for clarity. For both observations, the observation length was 120 seconds, deadband was 30 seconds, and prepurge was 120 seconds. The chamber begins to close at the end of the prepurge and the first data point used in the analysis is collected after the chamber touches down; the difference represents the time required for the chamber to close. Observation #1: t_0 =7.3s, C_0' = 434 ppm, C_x' = 1016 ppm, flux = 6.4 µmol m^{-2} s^{-1}; observation #2: t_0 = 2.0s, C_0' = 425 ppm, C_x' = 1145 ppm, flux = 6.0 µmol m^{-2} s^{-1}.

The deadband is the time until steady chamber mixing is established, and typically lasts 10s to 30s. After mixing is stable, the data are fit with an empirical equation that has a form similar to equation A-13:

$$C'(t) = C_x' + \left(C_0' - C_x'\right)e^{-\alpha(t-t_0)} \qquad \text{A-16}$$

where $C'(t)$ is the instantaneous water-corrected chamber mole fraction of the gas of interest, C_0' is the value of $C'(t)$ when the chamber closed, and C_x' is a parameter that defines the asymptote, all in µmol of gas per mol dry air (µmol mol^{-1}); a is a parameter that defines the curvature of the fit (s^{-1}).

The initial value of $C'(t)$, called C_0' in equation A-16, is computed from the intercept of a linear regression of the first 10 points after the chamber closes. This is used as a parameter in the non-linear regression that fits equation A-15 to the $C'(t)$ vs t data between the end of the deadband and the end of the observation. This regression yields values for the parameters C_x', a and t_0. $t = t_0$ represents the time when $C'(t)$ in equation A-16 equals its initial value when the chamber closes, or $C'(t_0) = C_0'$. The delay between the instant the chamber closed and t_0 gives the time required to establish steady mixing. Gas offsets or time delays can occur when the chamber closes, and these events can cause t_0 to be positive or negative in value.

All the initial values needed to obtain the soil gas efflux rate, F_c, in equation A-15 can now be computed. The initial values P_0, T_0 and W_0 are all obtained from the intercepts of linear regressions of the first 10 measurements of P, T and W after the chamber closes. The rate of change of dilution-corrected chamber mole fraction can be computed at any time from

$$\frac{dC'}{dt} = \alpha\left(C_x' - C_0'\right)e^{-\alpha(t-t_0)} \qquad \text{A-17}$$

When $t = t_0$,

$$\left.\frac{dC'}{dt}\right|_{t=t_0} = \alpha\left(C_x' - C_0'\right) \qquad \text{A-18}$$

Equation A-18 gives an estimate of the rate of change in C' at the instant the chamber closed. This value must be estimated mathematically. It cannot be measured directly at any time during the measurement because imperfect mixing prevents an accurate estimate early in the measurement cycle, and later in the cycle, the increasing chamber gas concentration continuously reduces the gradient between soil and chamber. This suppresses the rate, as can be seen from equation A-17 and also in *Figure A-2* on the previous page.

Relationship between the model and the empirical equation

The diffusion model provides an equation with a form that allows correction for the effect of changing gradients on the rate, which in turn, makes it possible to estimate the initial rate. It is worthwhile to distinguish between the model function given in equation A-13 and the empirical function in equation A-16. As just described, the units are different in the two expressions; but more important, for the parameters c_s and A in equation A-13 to have their defined meaning, the assumptions underlying the derivation must be true. By contrast, equations A-16 through A-18 are treated as empirical functions and are used only to estimate the rate of change, *dC'/dt*. The parameters C_x', a and t_0 do not depend upon a specific theoretical interpretation, and may or may not provide reliable estimates of soil parameters.

Evaluating other methods for computing soil gas flux

Other approaches have been used for computing gas flux in transient measurements. One commonly used method is to fit a linear function to what is sometimes referred to as "the linear portion" of the curve. Unfortunately, there is no linear portion, as can be seen from careful inspection of *Figure A-2* on page A-10. The slope is meaningless in the initial phase before steady mixing is established, and after steady mixing is established, the extent of the non-linearity depends upon the soil surface-to-chamber volume ratio and the flux rate. During this time, gas vs time curves are always concave in a downward direction, meaning that linear regression over this portion of the dataset will give an underestimate of the rate of change. In every case we have tested so far, the average rate measured by linear regression is less than the initial rate measured by non-linear regression. Nevertheless, linear regression is a robust numerical approach. We recommend you use these only for comparison to the initial values, which are obtained by fitting equation A-16 to the data using a non-linear regression method.

Another approach that has been used to estimate the initial rate is to fit a polynomial to the gas concentration vs time data. This approach is theoretically sound inasmuch as a power series can be generated from a Taylor series approximation to equation A-16. Usually, the data are fit with a quadratic equation. We tested this approach and found that while it can be justified on theoretical grounds, it does not work very well in practice. The shape of even a second order polynomial is sensitive to small perturbations in the data. This makes initial rate calculations subject to much larger variations than when the same data are analyzed by nonlinear regression using equation A-16.

Effects of high chamber gas concentrations

Finally, we consider the importance of choosing appropriate observation times and prepurge times. We do not have experience on all soil types, and cannot give absolute recommendations for the best observation length in all situations.

Nevertheless, our experience so far suggests that 60 to 120 seconds will often work well, though flux measurements of some trace gases may require longer measurements. A measurement of 60 to 120 seconds prevents large build-ups in chamber gas concentration at typical change rates such as 0.5 ppm s^{-1}. We have found that optimal deadband length can vary from about 10 to 60 seconds, with 30 seconds being a good value to use as a first estimate.

Deadbands and observation times can be adjusted after the fact, using SoilFluxPro Software. This program provides curve fit analysis tools that can be used to find the optimal deadband lengths and observation lengths. Therefore, it is not critical to choose the right deadband and observation length in the field; as long as the observation lengths are long enough, they can be optimized later, if necessary.

Long observations can have the effect of capping the soil and causing the gas concentration to build up in the soil under the chamber. This phenomenon can be observed by performing a sequence of observations in which the chamber concentration is allowed to increase several hundred ppm during each observation. When the prepurge is set to be just long enough to allow the chamber atmosphere to come back to the ambient gas concentration, the initial rates in sequential observations can often be observed to increase as the soil gas concentration increases. This is expected according to equation A-18, $dC_c'/dt = a(C_x' - C_{ambient}')$, if it is assumed that $C_x' = C_{soil}'$. Thus, long observation lengths may perturb the very process we wish to measure.

Another effect of high chamber gas concentrations is to promote leaks between the chamber and atmosphere. Leaks can be ignored when the gradient between the chamber atmosphere and ambient atmosphere are small. But when the gradient is not small, leaks cannot be neglected and it can be shown that the parameters in equation A-13 are altered to become

$$\alpha = \left(\frac{gs}{v} + k\right) \text{ and } c_x{}' = \left[\left(\frac{gs}{v}\right)c_s{}' + kc_\alpha{}'\right]\left(\frac{gs}{v} + k\right)^{-1} \qquad \text{A-19}$$

where k and c_a' are the leak rate time constant and water-corrected ambient gas concentration, respectively, and the expression for c_x' replaces c_s' in equation A-13. Thus, when chamber gas concentrations are high, the rate constant and asymptote will reflect leaks from the system.

Measuring net carbon exchange

At the ecosystem level, carbon (CO_2) is fixed through photosynthetic carbon metabolism. Fixed carbon is then used for growth and development of plants, and some of the fixed carbon is lost through respiration. Net carbon exchange (NCE) is defined as the carbon exchange between an ecosystem and the atmosphere. This is calculated as the photosynthesis uptake minus the total respiration, including above ground respiration and soil respiration.

NCE is a key variable for understanding the carbon balance of an ecosystem. NCE can be readily measured over a large uniform field using the eddy covariance method or with clear chambers, such as the 8200-104C Clear Long-Term Chamber, for short and small canopies. If no plants are present inside a clear chamber, then the measured NCE is the soil respiration.

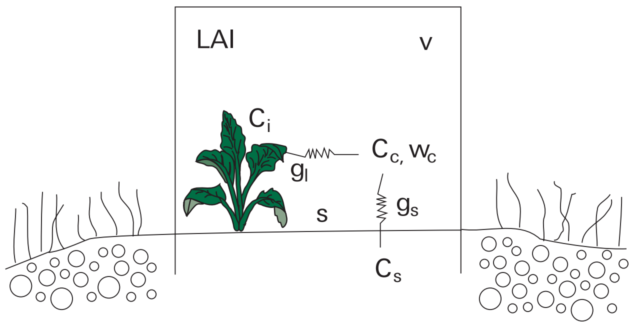


Figure A-3. Diagram showing a chamber volume of v *(m^3) and surface area* s *(m^2) sitting over the soil with plants inside. The leaf area inside chamber is LAI.* g_s *and* g_l *are soil conductance and leaf conductance ($m\ s^{-1}$).* C_i *is the intercellular CO_2 mole fraction (mol mol^{-1}),* C_s *is the CO_2 mole fraction of soil air (mol mol^{-1}).* C_c *is the CO_2 mole fraction inside chamber (mol mol^{-1}).*

For a clear chamber, the mass balance for CO_2 inside the chamber would be (see equation A-10 for more information);

$$NCE = \frac{V_{\rho_c}}{S}(1 - w_c)\,\frac{\partial c_c'}{\partial t} \qquad \text{A-20}$$

where ρ_c is the air number density inside the chamber (mol m^{-3}), S is the surface area inside the chamber (m^2), and w_c is the chamber air water vapor mole fraction (mol mol^{-1}). C_c' is chamber CO_2 mole fraction corrected for water vapor dilution.

For soil CO_2 flux f_c:

$$f_c = \rho_c g_s\,(C_s - C_c) = \rho_c g_s\,(1 - w_c)\,(C_s' - C_c') \qquad \text{A-21}$$

Where f_c is soil CO_2 flux (mol $m^{-2}s^{-1}$), and all variables have the same definitions as described in the section for opaque chambers.

When you have living plants with leaf area index, (LAI, defined as the ratio of total one-sided leaf area inside the clear chamber to ground area), the CO_2 uptake rate via photosynthesis (f_p) would be:

$$f_p = \rho_c g_l \left(C_c - C_i\right) = \rho_c g_l (1 - w_c) \left(C_c{'} - C_i{'}\right) = \rho_c g_l (1 - w_c) C_c{'} (1 - \alpha) \qquad \text{A-22}$$

Where f_p is the photosynthesis rate (mol $m^{-2}s^{-1}$), g_l is the total leaf conductance (mol $m^{-2}s^{-1}$) including stomatal and leaf boundary layer conductance, $C_i{'}$ is intercellular CO_2 mole fraction (mol mol^{-1}), is C_i/C_a ratio. We assume α to be constant over a wide range of CO_2 concentrations (around 0.6 for C3 species, and 0.3 for C4 species) (Wong et al., 1979; Morison, 1987; Xu and Hsiao, 2004).

$$\frac{V_{\rho_c}}{s}\left(1 - w_c\right)\frac{\partial c_c{'}}{\partial t} = \rho_c g_s (1 - w_c)(C_s{'} - C_c{'}) - LAI \rho_c g_l (1 - w_c) C_c{'} (1 - \alpha) + R_h \qquad \text{A-23}$$

where R_h is total above-ground biomass respiration. Rearranging equation A-23, we have

$$\frac{\partial c_c{'}}{\partial t} + \frac{S}{V}\left[g_s + LAI g_l \left(1 - \alpha\right)\right] C_c{'} = \frac{S}{V}\left(g_s C_s{'} + R_h\right) \qquad \text{A-24}$$

Let $N = \frac{S}{V}\left[g_s + LAI g_l \left(1 - \alpha\right)\right]$ and $M = \frac{S}{V}\left(g_s C_s{'} + R_h\right)$

$$\frac{\partial c_c{'}}{\partial t} + N C_c{'} = M \qquad \text{A-25}$$

Equation A-25 can be integrated to have

$$C_c{'}(t) = \frac{M}{N} + \left(C_0{'} - \frac{M}{N}\right) e^{-Nt} \qquad \text{A-26}$$

Let $C_m{'} = \frac{M}{N}$, we have

$$C_c{'} = C_m{'} + \left(C_0{'} - C_m{'}\right) e^{-Nt} \qquad \text{A-27}$$

The following equation will be used to fit the time series of $C_c{'}$ (see earlier in this section for an explanation of the origin of t_0)

$$C_c{'} = C_m{'} + \left(C_0{'} - C_m{'}\right) e^{-N(t - t_0)} \qquad \text{A-28}$$

Equation A-25 is exactly the same as equation A-13 for opaque chambers. For the LI-8250 Multiplexer, we use a generic exponential equation to fit the time series of chamber CO_2 concentration. For a clear chamber, when $C_m' < C_0'$, net carbon uptake is observed. When $C_s' > C_0'$ from fitted equation A-25, net carbon release is observed.

The net carbon exchange can then be estimated using equation A-10, with the information from the initial slope of the time series of Cc' (equation A-26). Negative flux values will be reported for the cases of net carbon uptake and positive flux will be reported for the cases of net carbon release. Note that C_m represents the CO_2 compensation point at which photosynthesis rate is equal to total respiration rate inside the chamber.

The above derivation involved some assumptions to be able to solve the differential equation A-26 analytically. Not all assumptions are valid for all cases. For example, we assume stomatal conductance is independent of air CO_2 level, which clearly is not the case. The purpose of this exercise is to provide a general view on how the time series of chamber CO_2 concentration behaves after the chamber is closed.

The considerations for setting up the configuration (deadband, observation length, observation count, prepurge) for the clear chamber measurement are the same as for LI-COR opaque chambers (part number 8200-104).

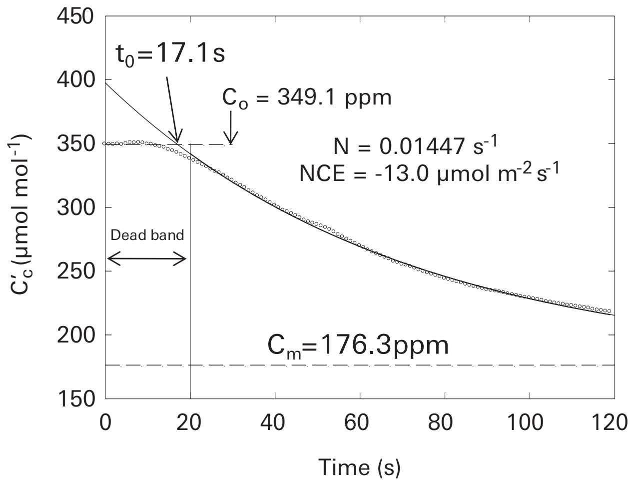


Figure A-4. Example of time series of C_c' from one observation from the clear chamber over a short grassland on the LI-COR campus. Values for various fitted parameters (t_0, C_m, and N) from equation A-28 are also shown. The observation length was 120 s with a deadband of 20 s. The NCE is -13 µmol $m^{-2}s^{-1}$.

Appendix B.
Integrating a custom chamber

The LI-8250 Multiplexer and 8250-01 Extension Manifold can be connected to a user-built custom chamber. Digital communication enables data integration and affords the multiplexer some basic control over the chamber. Data integration allows custom chambers to take full advantage of the file structure features of the LI-8250 Multiplexer, trace gas analyzers compatibility, and the data processing tools of SoilFluxPro Software.

Here we outline some general design considerations for closed transient chambers and details how to use the LI-8250 user interface. Some example scripts are provided for the Arduino IDE and Python to help facilitate communication. Example hardware configurations for connecting to the multiplexer's digital communication interface are also provided.

Design considerations

When designing a custom chamber for use with the LI-8250 Multiplexer, some key design considerations need to be addressed related the chamber headspace concentration between measurements, chamber volume, and air mixing inside the chamber.

Chamber headspace

The headspace concentration is important because of the way the system is applied to measure soil gas flux. The LI-8250 Multiplexer is designed to use a closed transient method for flux measurement. Here, air is circulated in a fixed volume between the chamber and gas analyzer. As the sample interacts with the air in this volume, the gas concentration changes proportionally to the flux into or out of the sample and the size of the volume. In a closed system, the flux for a particular gas species is given by:

$$f = \frac{PV}{RTS}\frac{dc'}{dt} \quad \text{B-1}$$

Where f is the flux in mol m^{-2} s^{-1}, P is pressure in Pa, V is volume in m^3, R is the Ideal Gas Constant (~8.314 Pa m^3 k^{-1} mol^{-1}), T is temperature in K, and S is sample surface area in m^2. dc'/dt is the rate of change in the dry mixing ratio of the gas species of interest in mol mol^{-1} s^{-1}.

In the LI-8250 Multiplexer system, dc'/dt is calculated for the moment of chamber closure using a non-linear diffusion-based model that accounts for the progressive suppression of the diffusive flux while the chamber is closed. Where the flux is truly diffusive in nature, as the chamber headspace concentration changes during the measurement, the diffusive gradient between the chamber and the sample also changes and, in turn, changes the flux. For CO_2 emitted from soils, for example, the flux becomes progressively reduced as the chamber headspace concentration increases during the measurement. If the chamber is left closed long enough, the flux will eventually be reduced to zero. For this reason, a chamber must include some mechanism to return the chamber headspace to ambient conditions after an observation.

In a LI-COR long-term chamber, such as the 8200-104 Opaque Long-Term Chamber, the headspace is returned to ambient conditions after an observation by lifting the chamber bowl and rotating away from the collar. This ensures free air exchange between the chamber and the atmosphere between measurements.

The LI-8250 Multiplexer can trigger the opening and closing of a custom chamber timed with sampling. It is up to the user to design the actual mechanism the chamber will use to open and close.

Chamber volume

Chamber volume, or particularly the surface-area-to-volume ratio, should be carefully considered in the context of expected flux rates when designing a chamber. As chamber volume increases for a given surface area and a given flux, the observed dc'/dt will decrease. With a very large chamber relative to a very small flux, it is quite possible to drive dc'/dt well below the peak-to-peak noise for the analyzer used for measurements. In this case, long observation times will be required to make a measurement and uncertainty in the final computed flux will be high.

A simple sensitivity analysis using equation *B-1* on the previous page should be done to optimize the chamber surface-area-to-volume ratio. This should be based on the expected minimum and maximum fluxes and the precision of the gas analyzer. The goal is to ensure that for the selected chamber volume and measurement area, dc'/dt for the minimum expected flux is sufficiently large relative to the analyzer's peak-to-peak noise and that the chamber headspace concentration at the end of the observation for the largest expected flux is below the analyzer's maximum detection limit.

Air mixing

Volume and chamber shape are also important for turbulent air mixing within the chamber. A measurement inherently assumes that the gas sample pulled from the chamber and routed through the LI-8250 Multiplexer to the gas analyzer, is representative of the conditions in the chamber at the moment the sample is pulled. If the chamber volume is well mixed, this assumption is valid. The observed gas concentration will change predictably as a function of the sample flux rate.

If mixing is poor, the observed gas concentration can change independently of the sample flux. These changes may appear as oscillations or sudden steps in the observed gas concentration during the observation. Or they may simply cause erroneous measurements that represent the combined effects of the sample flux and diffusion into or out of pockets of air trapped in the chamber that are at a different concentration than the bulk chamber air.

In general, conditions are favorable for mixing when the chamber air is turbulent and few flow obstructions are present in the chamber. When flow from the LI-8250 Multiplexer drives turbulence in the chamber, smaller chamber volumes are more favorable for mixing. LI-COR chambers are bowl-shaped with a volume of approximately 5 liters. For larger or more irregularly shaped chambers, it may be necessary to include fans inside the chamber to aid in mixing.

Pneumatics

The LI-8250 Multiplexer, the 8250-01 Extension Manifold, and the cable assembly (part number 9982-056) use quick-connect fittings to attach pneumatic lines. On this assembly, the male quick-connect fitting provides airflow into the chamber. See *Table B-3* on page B-6 for suggested quick-connect fittings.

The flow through the chamber provided by the LI-8250 Multiplexer, 8250-01 Extension Manifold, and the cable assembly is ~2.8 SLPM. The actual flow rate through the chamber flow loop is measured inside the multiplexer and is reported in the data file and user interface.

Power

The LI-8250 Multiplexer provides a regulated 24 VDC power supply via the power and communications port. This power supply is passed down through the 8250-01 Extension Manifold. The supply is electronically fused, limiting peak current to a single chamber at ~1.8 A, and is shared between all ports. We strongly recommended that you keep total steady-state power consumption for all connected custom chambers at or below 1 A. If the chamber(s) will require more power than this, you should provide a separate power supply to the chamber(s) directly. In this case, the multiplexer and chamber grounds should remain separate.

For custom chambers built off platforms with limited input voltage ranges, such as Arduino or Raspberry Pi, direct connection to the 24 VDC supply is not possible. In these cases, you will need to step down the voltage to an acceptable level (typically 5.0 or 3.3 VDC) using a DC-DC converter. For the best protection, use a DC-DC converter that provides ground isolation between the input and output sides and leave the input and output grounds unconnected from each other.

For connection between the chamber and the multiplexer or extension manifold, an 8-pin bulkhead flying lead adapter is available (part number 310-19090). This adapter provides a direct, water tight connection to the standard 15 m cable assembly. A description of the flying leads from this connector and pin assignment is provided in *Table G-3* on page G-3.

Serial interface

The LI-8250 Multiplexer uses full-duplex RS-422 operating at 115,200 baud to communicate with the chamber. Few off-the-shelf platforms typically used in custom chambers offer native hardware support for RS-422. For these platforms, you will need an adapter to convert between RS-422 and a supported hardware communication interface.

There are several such adapters available through third-party suppliers that you can use to convert RS-422 to RS-232, USB, or TTL. We have tested adapters from CommFront (commfront.com) and Zihatec (hwhardsoft.de) and have verified compatibility with the LI-8250 Multiplexer and these adapters. See Table B-1 and *Table B-2* on the next page for the configuration and wiring of the Zihatec adapters.

For those interfacing to platforms such as Arduino or Raspberry Pi, an RS-422 to TTL adapter is recommended. The TTL output from the adapter should be connected to a physical serial UART on these devices. Note that for Arduino specifically, the software emulated serial ports (such as those provided by the AltSoftSerial library) are not fast enough at the LI-8250 Multiplexer's baud rate, leading to message corruption. For making a TTL connection to the platform's serial port, be mindful of the TTL voltage levels supplied by the adapter. Raspberry Pi for example, only supports a 3.3 VDC maximum input on its GPIO pins, whereas the high logic level for many TTL devices will be 5 VDC.

Table B-1. DIP switch settings for the Zihatec RS-422/RS-485 Arduino Shield or Raspberry Pi Hat.

SW1		SW2		SW3	
Channel	Setting	Channel	Setting	Channel	Setting
1	On	1	On	1	On
2	Off	2	On	2	Off
3	On	3	Off	3	Off
4	Off	4	Off	4	Off

Table B-2. Bulkhead flying lead (part number 310-19090) to Zihatec RS-422/RS-485 Arduino Shield or Raspberry Pi Hat connections.

Input Terminal Strip Pin	Flying Lead Wire Color
B	Brown
A	Green
Z	White
Y	Blue
Shield	Red and gray if not used to power the chamber, empty otherwise

Custom chamber control kit

Part number 8200-402

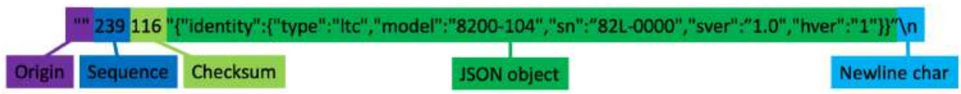
LI-COR offers a custom chamber control kit that can simplify integrating your custom chamber with the LI-8250 Multiplexer.

Table B-3. Parts included in the custom chamber control kit.

Part number	Name	Description	# per chamber
310-19090	Bulkhead flying lead for custom chambers	An 8-pin Turk bulkhead with flying leads used to connect a custom chamber to the multiplexer or extension manifold for power and communication	1
9982-056	Cable assembly	Includes a 15 m RS-422 to RS-422 cable and two 15 m lengths of Bev-A-Line® tubing with quick-connect fittings. Provides power, communication, and gas flow between the multiplexer or extension manifold and the chamber.	1
300-07126	Quick-connect bulkhead (female)	Connects a custom chamber to the male end of the Bev-A-Line® tubing on the cable assembly.	1
300-07127	Quick-connect bulkhead (male)	Connects a custom chamber to the female end of the Bev-A-Line® tubing on the cable assembly.	1
167-07256	Seal washer	Used to create a seal between the quick-connect bulkheads and the panel they are inserted through.	2

Messaging

Messages sent between the LI-8250 Multiplexer and a chamber have a five-part structure. Each message begins with an origin identifier, followed by a sequence number, checksum, and JSON object. All messages are terminated with a newline character (ASCII 10).



Origin

The origin defines the source of the message. For messages originating from a chamber, the origin will always be null (`""`). For messages arising from the LI-8250 Multiplexer, general communication on the port will have a null origin. Port specific commands will include the port number in the origin. Where a non-null origin is sent, the custom chamber does not need to do anything with it. Though this information does tell the chamber what port it is connected to on the multiplexer.

Sequence

The sequence is an integer (-1 or 1 to 32767) used to track messages. For each message received with a sequence number greater than zero, an acknowledgment should be returned by the receiving device. For the example above sent by an 8200-104 Opaque Long-Term Chamber, the multiplexer would respond with:

```
"" 239 -1 "{"ack":""}"
```

This acknowledges receipt of message 239 from the chamber. For messages using a sequence of -1, no acknowledgment is expected.

Checksum

The checksum is a bitwise XOR of the JSON object. For acknowledged messages, it should always be included. The checksum is calculated by the receiving device (LI-8250 Multiplexer or chamber) and compared to the checksum in the original message. This ensures the message has not been corrupted. For acknowledged messages where the checksums do not match, a non-acknowledgment would be sent:

```
"" 239 -1 "{"nak":""}"
```

Example functions for computing the checksum using Python and the Arduino IDE are given in *Figure B-1* below. These functions accept the JSON object as a string and return the checksum as an integer value.

```
//XOR checksum function for Arduino
int checkSumXOR(const String& message){
  int b=message.length()+1;
  byte m[b];
  message.getBytes(m,b);
  int c=0;
  for(int i=0;i<b;i++){c^=m[i];}
  return c;
}
```

```
#XOR checksum function for Python
def checkSumXOR(message):
    m=bytearray(message)
    c=0
    for b in m:
        c^=b
    return c
```

Figure B-1. Example functions for computing the checksum using Python and the Arduino IDE.

JSON object

The JSON object contains the data items passed between the chamber and LI-8250 Multiplexer. Each data item is composed of a key:value pair. For a custom chamber, there are four general message types expected from the chamber with specific JSON objects associated with each.

- Acknowledgments as described above
- Identity messages containing information about the chamber
- Status messages containing the chamber state
- Data messages containing measurements made by the chamber

Identity messages are sent in response to an identity request from the LI-8250 Multiplexer. The identity message consists of an identity object, containing type, model, serial number (`sn`), and software version (`sver`). The type for a custom chamber will always be the string `dcc`. Model, serial number, and software version are all free-form strings. Other data items can be included in the identity message if desired but are not used by the multiplexer. The request for a chamber identity by the multiplexer is an unacknowledged message:

```
"" -1 -1 "{"identify":""}"
```

Once received, the chamber should respond with its identity as in the example below:

```
"" 78 53 "{"identity":{"model":"User_Cham-
ber","type":"dcc","sn":"UC-01","sver":"0.1"}}"
```

Status messages should be issued by the chamber with each identity message, when the chamber initiates a move operation, and upon reaching a new position. Status messages contain three objects: the model and serial number (`sn`), the chamber state (`chamber_status`), and a diagnostic value (`diag_code`).

- Chamber state is a string where valid values are open, opening, closed, closing, and unknown.
- Model and serial number are the same as they appear in the identity.
- Diagnostic value is a bit field containing error flags.

A diagnostic value of 0 indicates normal operation. Other values indicate an error. The bits in *Table B-4* on the next page are those used by the 8200-104/C Long-Term Chambers and are interpreted in the same way by the LI-8250 Multiplexer for a user-built custom chamber. Additional bits can be set in the diagnostic code and are defined by the user.

Table B-4. Diagnostic code (`diag_code`) bit fields used by the 8200-104/C Long-Term Chambers. These can be used to indicate errors from a user-built custom chamber, but they will be interpreted by the multiplexer following the error description here.

Bit	Error description
1	Message error
2	Motor error, motor does not move or stalled during a move
4	Issue with EEPROM
8	Issue with SDI-12 sensor or its configuration
16	Issue with light sensor or its configuration
32	Problem with chamber temperature sensor
64	Problem with temperature sensor on chamber control board
128	Input voltage issue
256	Fatal error occurred

Here is an example status message indicating that the chamber is currently open:

```
"" 77 53 "{"type":"dcc","sn":"UC-01","chamber_
status":"open","diag_code":0}"
```

The LI-8250 Multiplexer sets the chamber status at the start and end of an observation and when using the manual controls in the LI-8250 user interface. The multiplexer sends a message containing a chamber object with the new desired chamber state as a string. Here is an example message requesting the user chamber to open:

```
"" 1002 90 "{"chamber":"open"}"
```

or to close:

```
"" 1003 56 "{"chamber":"close"}"
```

The chamber sends data messages continuously during an observation and when you set the port to active in the LI-8250 user interface. The multiplexer will send a message requesting the chamber to start and stop sending data. These messages are port-specific and, as such, include a non-null origin value. To request the start of data messages, the multiplexer sends:

```
"1" 1004 54 "{"measurement":"start"}"
```

or to request the end of data messages:

```
"1" 1005 78 "{"measurement":"stop"}"
```

The data message itself contains three objects: data, source, and a diagnostic code (`diag_code`). Diagnostic code is analogous to that used in the status message.

The source object includes a type and serial number (`sn`), as in the identity message. The data object, at a minimum, must contain the temperature measured in the user chamber (`temperature`) since this is required for flux calculations. The data object can include other measurements as desired. All values reported for measurements in the data object must be interpretable as floating point numbers. Mapping to associate user-specific keys with appropriate units and variable names is done in the LI-8250 Multiplexer configuration described later. Here is an example data message:

```
"" 79 96 "{"data":{"temperature":24.1},"source":
{"type":"dcc","sn":"UC-01"},"diag_code":0}"
```

Tools exist in Python and the Arduino IDE for constructing and parsing JSON objects. For Python, the standard json library includes manipulation of JSON. For the Arduino IDE, the third-party library ArduinoJson (arduinojson.org) provides an efficient implementation. Both environments also provide built-in functions for serial communications.

The examples in *Listing B-1* on the next page and *Listing B-2* on page B-13 show how to serialize and deserialize JSON in both environments and how to publish a response to an identity request.

Note: The code for these scripts may be copied from below or downloaded from licor.com/documents/9t2om4h11d6rg4xuus3la3d293yfkayr.

Listing B-1. An example of the Python script.

```
#Example Python script for publishing identity responses to the <span class="text-nowrap product_names.LI-8250 mc-variable">LI-8250</span>
import json
import serial

ser=serial.Serial('/dev/serial0', 115200)
sequence=0

def checkSumXOR(message):
    m=bytearray(message)
    c=0
    for b in m:
        c^=b
    return c

def publishResponse(message):
    message= '"'+message+'"'
    global sequence
    sequence+=1
    if sequence>32767:
        sequence=1
    ser.write(bytes('"" '+str(sequence)+' '+str(checkSumXOR(message))+' '+message+'\n'))
    return True

while True:
    if ser.inWaiting()>0:
        request=ser.readline()
        j=json.loads(request[request.find('{'):-2])
        if 'identify' in j:
            publishResponse(json.dumps({'identity':{'type':'dcc','model':'User_Chamber','sn':'UC-01','sver':'0.1'}}))
```

Note that in the Arduino IDE example, the choice to declare the buffers for working with the JSON objects inside a function separate from the main loop is deliberate and stems from how these buffers are handled by ArduinoJson. Please refer to the library's documentation for more details.

Listing B-2. An example of the Arduino IDE script.

```
//Example Arduino script for publishing identity responses to the <span class="text-nowrap product_names.LI-8250 mc-variable">LI-8250</span>
#include "ArduinoJson-v5.13.3.h"
int sequence=0;

int checkSumXOR(const String& message){
  int b=message.length()+1;
  byte m[b];
  message.getBytes(m,b);
  int c=0;
  for(int i=0;i<b;i++){c^=m[i];}
  return c;
}

bool publishResponse(const String& message){
  sequence++;
  if(sequence<0){sequence=1;}
  Serial.println("\"\" "+String(sequence)+" "+String(checkSumXOR(message))+" \""+message+"\"");
  return true;
}

void requestHandler(const String& message){
  StaticJsonBuffer<200> recieveBuffer;
  JsonObject& mux_json = recieveBuffer.parseObject(message.substring(message.indexOf("{"),message.lastIndexOf("}")+1));
  if(mux_json.success()){
    if(mux_json.containsKey("identify")){
      StaticJsonBuffer<100> sendBuffer;
      JsonObject& root = sendBuffer.createObject();
      JsonObject& id = root.createNestedObject("identity");
      root["identity"]["type"].set("dcc");
      root["identity"]["model"].set("User_Chamber");
      root["identity"]["sn"].set("UC-01");
      root["identity"]["sver"].set("0.1");
      String jstr;
      root.printTo(jstr);
```

```
        publishResponse(jstr);
        sendBuffer.clear();
      }
    }
    recieveBuffer.clear();
  }

  void setup() {
    Serial.begin(115200);
  }

  void loop() {
    if(Serial.available()){requestHandler(Serial.readStringUntil('\n'));}
  }
```

Configuring a custom chamber

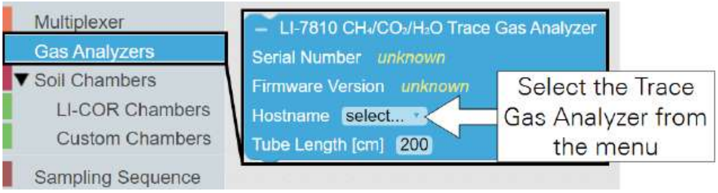
The LI-8250 Multiplexer is capable of communicating with custom chambers using the Configuration page of the user interface. For the most part, configuring a custom chamber is identical to configuring a LI-COR long-term chamber. Those steps are described in *An overview of configurations* on page 6-5. Where custom chambers differ is that they use the **Digital Custom Chamber** block and require different inputs to this block. Also, the Configuration page does not allow for the integration of sensors to collect ancillary data with custom chambers.

When you first open the **Configuration** page, you will see two empty root blocks: the **LI-8250 Multiplexer** block and the **Sampling Sequence** block. This section will cover the steps needed to configure the elements under the LI-8250 Multiplexer block. For details on how to configure the Sampling Sequence block, see *Configuring the Sampling Sequence block* on page 6-14.

> **Tip:** When configuring a system with multiple chambers and extension manifolds, you can copy/paste or duplicate blocks to speed things up (see *Workspace actions* on page 6-6).

1 Add a gas analyzer

If you are using a LI-COR gas analyzer, the first step is to add the gas analyzer(s) your system is using. Select **Gas Analyzers** from the Toolbox to open the drawer. Then find one of the gas analyzers you will be using and click to add it. In this case, we added an LI-7810 $CH_4/CO_2/H_2O$ Trace Gas Analyzer. Repeat this for each analyzer on the system.

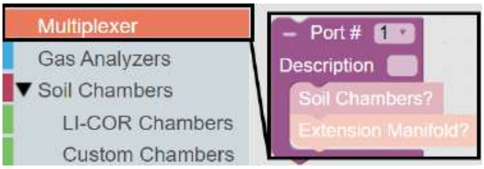


All gas analyzer blocks are nested under the LI-8250 Multiplexer block. If you are using a LI-COR cable assembly for the Trace Gas Analyzers (part number 9982-011) or the LI-870 CO_2/H_2O Analyzer (part number 9982-010), the tubing length is already entered. If you have multiple gas analyzers connected using the T-split tubing (part number 9982-073), you will need to add 15 cm to the tubing length of each analyzer.

Note: If you are using an LI-870 CO_2/H_2O Analyzer or have added the gas analyzer to the **Device Network** previously, the analyzer will automatically be added to the LI-8250 Multiplexer block when you open the Configuration page.

2 Add a port

Before you can add an extension manifold or chamber, you will need to add the port that the device is connected to. To do this, select **Multiplexer** from the Toolbox, then click and drag **Port #** to place the block under the LI-8250 Multiplexer block.

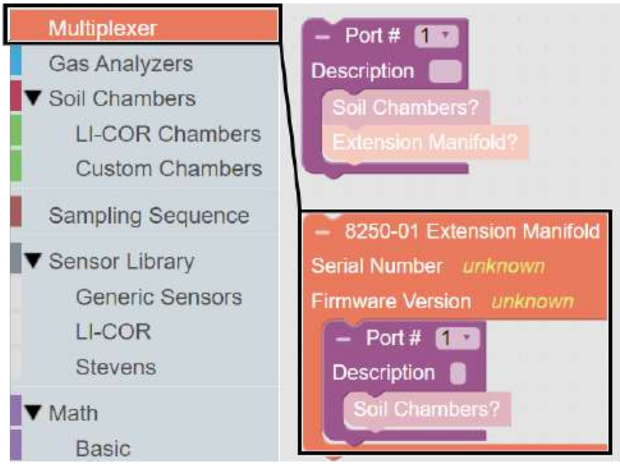


You can assign a port number or the user interface will automatically assign a port number as these blocks are added. You can also provide a description of the devices on that port that will appear in the data file.

3 Add an 8250-01 Extension Manifold (optional)

This step is only necessary when an 8250-01 Extension Manifold is connected to your LI-8250 Multiplexer. If you do not have an extension manifold, skip to step 4.

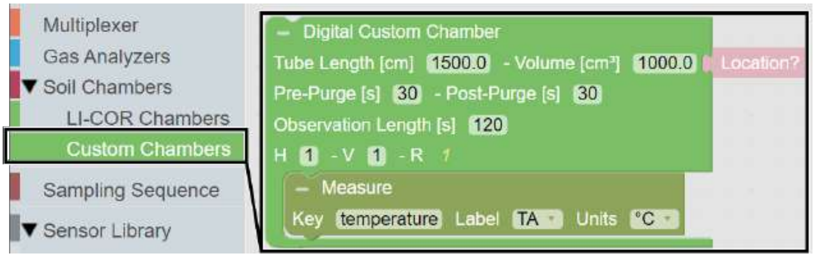
To add an 8250-01 Extension Manifold, select **Multiplexer** from the Toolbox, then click and drag **Extension Manifold** to place the block under its respective Port # block. For example, if you have an extension manifold connected to port 2 of the multiplexer, place the extension manifold block under the Port # 2 block at the multiplexer level. Repeat this for each extension manifold.



Note: The 8250-01 Extension Manifold block will default to having one Port # block nested. If you have more than one chamber on that extension manifold, you will need to add additional Port # blocks under that extension manifold block.

4 Add a custom chamber

After you have added a port to the LI-8250 Multiplexer or 8250-01 Extension Manifold block, you can add a custom chamber to that port. To add a custom chamber, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Digital Custom Chamber** block under the Port # block. Repeat this for each chamber on each port.

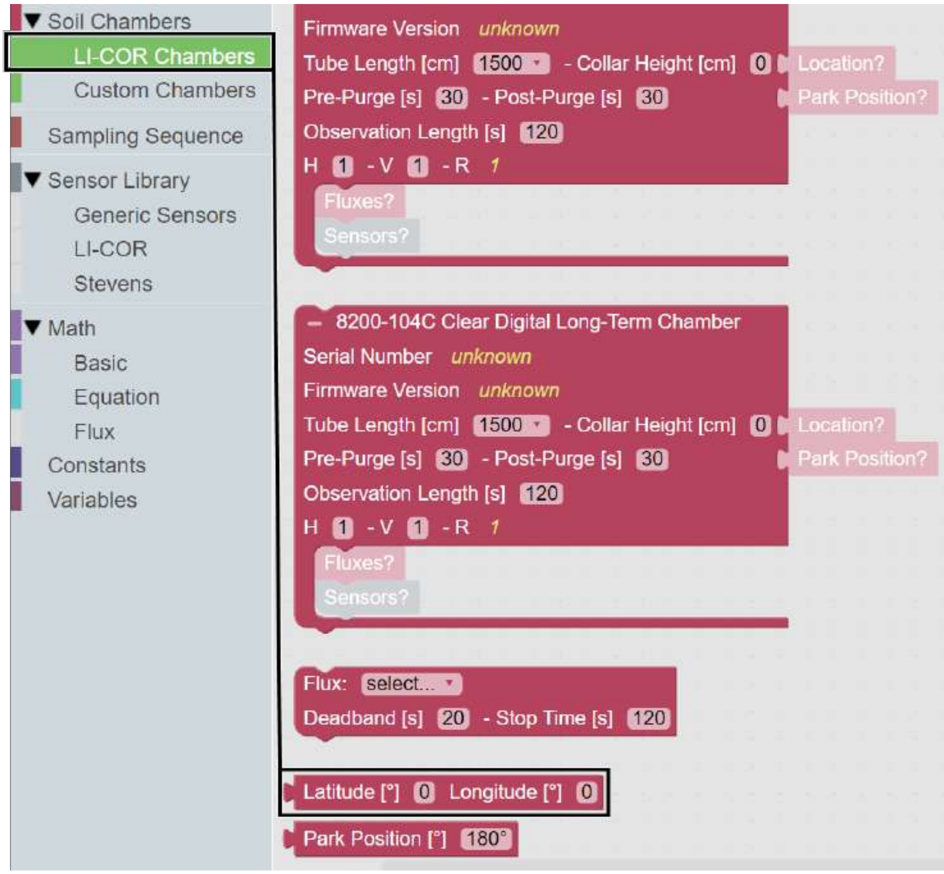


Each custom chamber block allows you to change several parameters. If you are using the cable assembly from LI-COR (part number 9982-056), the **Tube Length** of 1500 cm is correct. You can also adjust the **Volume**, **Pre-Purge**, **Post-Purge**, and **Observation Length** according to your needs.

The custom chamber block also allows you to enter the location of the chamber under the **Location** block.

> **Note:** If a location is not defined, the multiplexer will use the GPS location of the LI-8250 Multiplexer as the chamber location.

To add the Location block, select **LI-COR Chambers** in the Toolbox and find the **Latitude/Longitude** block. Then click and drag the Latitude/Longitude block to the chamber block.

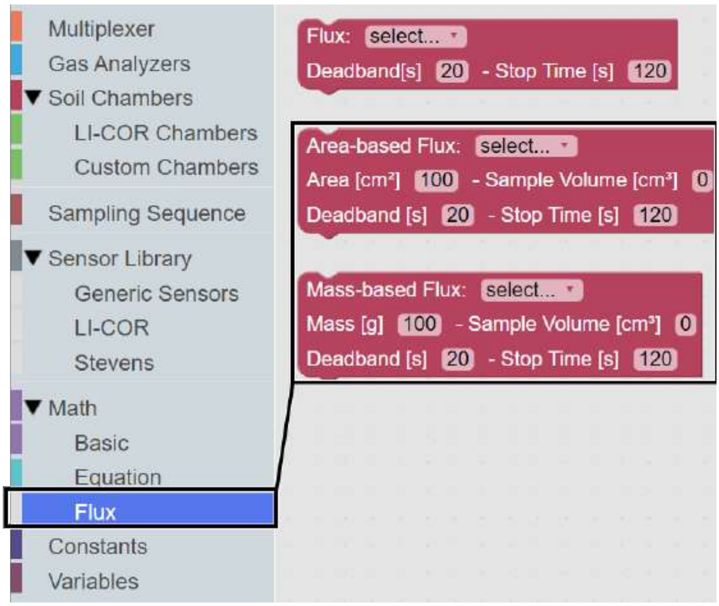


5 Add a flux

Two different flux calculations are available to be added to a custom chamber configuration: Area-based Flux and Mass-based Flux. The Area-based Flux is used to specify a flux calculated on a per area basis and the Mass-based Flux is used to specify a flux calculation on a per mass basis.

To add a flux block to your custom chamber block, expand the **Math** drop-down and select **Flux** from the Toolbox. From the Flux drawer click and drag either the **Area-based Flux** block or the **Mass-based Flux** block under the chamber you would like to add the flux to. You can have multiple Flux blocks under each chamber depending on the analyzer(s) you are using and the gases you would like recorded.

Note: Only one type of flux block (area or mass) may be placed inside a Digital Custom Chamber block. Multiple flux blocks may be placed under the Digital Custom Chamber block to accommodate different gas species, but they must be of the same type.



Each flux block allows you to customize additional parameters required for the flux calculation.

Area-based flux

The drop-down menu allows you to select the type of gas and the source for flux calculations. Under **Area** you will enter the sample surface area in cm^2. You can also adjust the **Deadband** and **Stop Time** as needed. The Deadband and Stop Time are parts of the total **Observation Length**. Stop Time can be any time desired so long as it is beyond the Deadband and does not exceed the Observation Length.

Mass-based flux

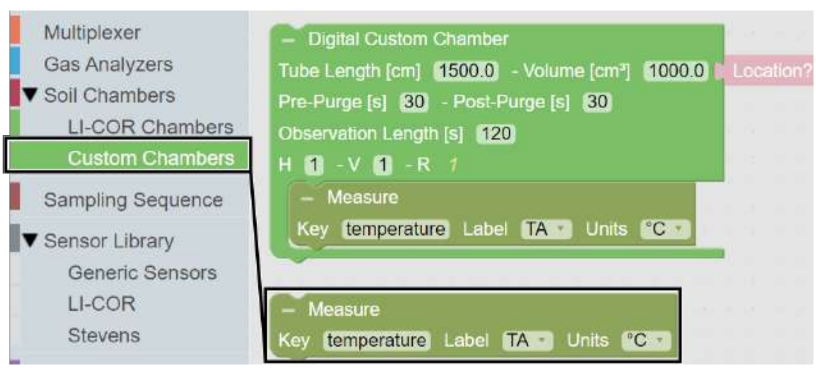
The drop-down menu allows you to select the type of gas and the source for flux calculations. Under **Mass** you will enter the sample mass in grams. Under **Sample**

Volume you will enter the calculated volume of the sample in cm^3. This is used to correct the total volume for sample displacement. You can also adjust the **Deadband** and **Stop Time** as needed. The Deadband and Stop Time are parts of the total **Observation Length.** Stop Time can be any time desired so long as it is beyond the Deadband and does not exceed the Observation Length.

> **Note:** You will need one Flux block for each gas flux you would like to have computed. Without a Flux block, no flux will be calculated for that gas. If a Flux block was not added for a gas, a flux can still be calculated later using SoilFluxPro Software.

6 Add a measured variable

The LI-8250 Multiplexer can include measured variables from a custom chamber. This block defines an expected measurement in each data message sent by the chamber. By default, the Digital Custom Chamber block includes one measured variable block. To add another measured variable, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Measure** block under the custom chamber you would like to add the variable to.



This block allows you to select from several predefined variables, including soil moisture (**SWC**), air temperature (**TA**), and soil temperature (**TS**), or you can add a variable of your own using **Create variable.** You must include an air temperature measurement for the configuration to work. If temperature is not included, flux calculations will not be performed by the LI-8250 Multiplexer. Multiple measured variable blocks can be added under one custom chamber block. Within this block:

- **Key** identifies the key used for the measured variable in the data message's JSON object.
- **Label** specifies the data label used for this measured variable in the .82z file.
- **Unit** provides a selection of supported units used for this measured variable.

Appendix C.
Connecting to non-LI-COR gas analyzers

While the LI-8250 Multiplexer is optimized for use with LI-COR gas analyzers, it can be configured with non-LI-COR gas analyzers.

The LI-8250 Multiplexer logs timestamp, soil temperature and moisture, location, and other data alongside the analyzer. The datasets can then be merged using SoilFluxPro Software to calculate fluxes.

Making the connection

Configuring the LI-8250 Multiplexer with a non-LI-COR gas analyzer requires two things.

1. The analyzer must be able to query the LI-8250 Multiplexer network time protocol (NTP) server for timestamp synchronization.
2. Exhaust flow from the analyzer must not exceed 5 slpm to be compatible with the LI-8250 Multiplexer pneumatics. ≤ 2 slpm is strongly recommended.

Currently, these features are supported by several models from Picarro, LGR (ABB - Los Gatos Research), Gasmet, and Aerodyne.

If you intend to use the LI-8250 Multiplexer with a non-LI-COR gas analyzer, an optional 2 m cable assembly with two sealed RJ-45 Ethernet connectors and Bev-a-Line® tubing (part number 9982-011) is available. The sealed RJ-45 connectors will not connect to a standard Ethernet port without an adapter (part number 309-17612). This adapter includes one sealed and one unsealed RJ-45 connector.

If you choose to make your own air tubing, 5 m (part number 392-19109) and 25 m (part number 392-19110) sealed to standard Ethernet cables are also available. It is strongly recommended that you use these cables with the LI-8250 Multiplexer, and not cables from a different manufacturer.

Timestamp synchronization

The LI-8250 Multiplexer includes a GPS receiver for high-precision GPS time data. For LI-8250 Multiplexer data files to be merged with non-LI-COR gas analyzer data files in SoilFluxPro Software to calculate fluxes, the timestamps must match. For this, the LI-8250 Multiplexer contains a network time protocol (NTP) server which can be queried by other devices to sync the device's clock to the LI-8250 Multiplexer's GPS time, so that the same timestamps are being logged by both devices.

Generally, this synchronization is completed using the following steps.

1. Connect the LI-8250 Multiplexer and gas analyzer.
2. Identify the LI-8250 Multiplexer NTP server location through the analyzer interface.

   Different analyzers have different ways of identifying the location of the LI-8250 Multiplexer NTP server. Picarro analyzers, for example, have a Windows operating system embedded in the analyzer as a graphical user interface. In the file directory for the analyzer software, a "remote access" .ini configuration file allows users to identify NTP servers for time syncing. In this file, the LI-8250 Multiplexer server is identified by the LI-8250 Multiplexer serial number, and a similarly-named "remote access" executable (.exe) file performs the synchronization with the server locations indicated in the .ini configuration file.
3. Manually query the NTP server to sync the devices, or set a task or scheduled job to automatically query the NTP server.

   Querying the LI-8250 Multiplexer NTP server depends on how you interface with your analyzer and locate the LI-8250 Multiplexer NTP server. Because the Picarro file structure provides an executable file to perform the query, users can manually run the .exe file through the Windows interface command prompt. Alternatively, CRON jobs, shell scripts, or scheduled tasks can also be configured to run the executable at specified times such as desired intervals, at instrument startup, etc.

Plumbing considerations

The exhaust from all connected analyzers must not exceed 5 slpm.

Determining effective volume

When using non-LI-COR gas analyzers, you must calculate the volume of the analyzer used and the length of your tubing.

First, you will need to calculate the effective volume that the non-LI-COR analyzer adds to your system. The volume of the analyzer will have at least two kinetic effects: 1) it brings additional air to the system, which dilutes trace gas entering the system from the soil surface and reduces the measured trace gas mole fraction rate of change (*dC/dt*); and 2) it creates a time delay in the onset of a monotonic concentration increase or decrease.

The quantitative impact of the added volume on *dC/dt* can be evaluated by considering the equation used to calculate flux F (mol $m^{-2}s^{-1}$). This equation is derived based on the assumption of a single fixed volume V (m^3) with homogeneous air density ρ. For simplicity, in this discussion the effects of water corrections are neglected. This, however, does not change the conclusions. Thus,

$$F = \frac{(\rho V)}{S}\frac{dC}{dt} \qquad \text{C-1}$$

where F is the flux of trace gas (mol $m^{-2}s^{-1}$), ρ is air density (mol m^{-3}), dC/dt is the time rate of change in mole fraction of the gas being measured (s^{-1}), and S (m^2) is the soil surface area over which the flux occurs. For a flux F, the trace gas mole fraction rate of change dC/dt is proportional to the total number of molecules in the system ρV.

For a well-mixed system, when an additional volume V_{added} that contains a gas of density ρ_{added}, is inserted into the system, equation Appendix C. becomes

$$F = \frac{(\rho_{system} V_{system} + \rho_{added} V_{added})}{S}\frac{dC}{dt} \qquad \text{C-2}$$

But $\rho_{system} = P_{system}/RT_{system}$, where R is the universal gas constant, and similarly for the added volume. Substituting these expressions and factoring gives,

$$F = \frac{\rho_{system}\left(V_{system} + V_{added}\frac{P_{added}}{P_{system}}\frac{T_{system}}{T_{added}}\right)}{S}\frac{dC}{dt} \qquad \text{C-3}$$

For data processing using SoilFluxPro, an effective volume $V_{effective}$ for the addition can be defined for the added analyzer and entered into the software.

$$V_{effective} = V_{added}\frac{P_{added}}{P_{system}}\frac{T_{system}}{T_{added}} \qquad \text{C-4}$$

Thus, the total volume used in equation C-1 becomes simply $V_{system} + V_{effective}$ and the density is ρ_{system}. There are inherently small variations in $V_{effective}$ due to changes in T_{system} and P_{system}, but these are generally small and subsequently neglected. In many cases, the impact of an added volume on flux calculations will be modest as $V_{effective}$ for many modern trace gas analyzers is small.

In cases where the volume of the addition operates at a non-uniform temperature or pressure or is not well known, $V_{effective}$ can be estimated experimentally by plumbing the non-LI-COR analyzers in a closed loop and injecting a known volume $V_{injection}$ (m^3) of pure CO_2 into the loop. The gas concentrations in the loop pre-injection C_1 (mol mol^{-1}) and post-injection C_2 (mol mol^{-1}) are defined as:

$$C_1 = \frac{N_{CO2}}{N_{added}} \tag{C-5}$$

$$C_2 = \frac{N_{CO2} + N_{injection}}{N_{added} + N_{injection}} \tag{C-6}$$

where N_{CO2} is the number of moles of CO_2 in the additional volume pre-injection, N_{added} is the total number of moles in the additional volume pre-injection, and $N_{injection}$ is the number of moles of CO_2 injected into the loop. Substituting equation C-5 into C-6 and rearranging to solve for N_{added} yields:

$$N_{added} = \frac{N_{injection}(C_2 - 1)}{(C_1 - C_2)} \tag{C-7}$$

where

$$N_{added} = \frac{P_{added}V_{added}}{RT_{added}} \tag{C-8}$$

and

$$N_{injection} = \frac{P_{injection}V_{injection}}{RT_{injection}} \tag{C-9}$$

$T_{injection}$ (K) and $P_{injection}$ (Pa) are the temperature and pressure, respectively, of the gas injected into the closed loop. Substituting these into equation C-7 and following from equation C-4 yields:

$$V_{effective} = \frac{P_{injection}T_{system}V_{injection}(C_2 - 1)}{P_{system}T_{injection}(C_1 - C_2)} \tag{C-10}$$

In practice it is difficult to know $T_{injection}$ and $P_{injection}$ with great certainty. Making the assumption that $P_{injection} = P_{system}$ and $T_{injection} = T_{system}$ introduces some error in determining $V_{effective}$ experimentally, but it allows equation C-10 to be simplified, eliminating the need to know temperature or pressure:

$$V_{effective} = \frac{V_{injection}(C_2 - 1)}{(C_1 - C_2)} \qquad \text{C-11}$$

You will need to follow this protocol to calculate the effective volume of a non-LI-COR gas analyzer. LI-COR Technical Support is happy to assist you with this configuration.

Appendix D.
Measuring gas fluxes in a flask system

The LI-8250 Multiplexer system is typically used to measure fluxes of trace soil gases *in situ* with actuated chambers. However, with the Flask Sampling Kit (part number 8250-660), the system can be adapted to measure gas fluxes from discrete samples, such as soil samples, fruits, or small animals, in non-actuated, user-designed chambers, referred to as flasks.

The Flask Sampling Kit contains two major components: a thermistor input module (part number 9982-079) and a purge pump (part number 9982-077). The thermistor input module allows thermistors to be attached directly to the LI-8250 Multiplexer or an 8250-01 Extension Manifold to measure air temperature inside the flasks. The purge pump serves to continuously flush the flasks with ambient (or user-conditioned) air between observations, providing a pneumatic analog to an actuated chamber.

The purge pump connects directly to the valve manifold of the instrument providing flow and uses the normally open side of the valve manifold as a vent (see *Figure D-1* on the next page). The unpowered valves connect the normally open channel of each manifold to the pneumatic connections on the side of the instrument, such that the flow from the purge pump is divided over all inactive ports (green arrows) and isolated from the active port (blue arrows).

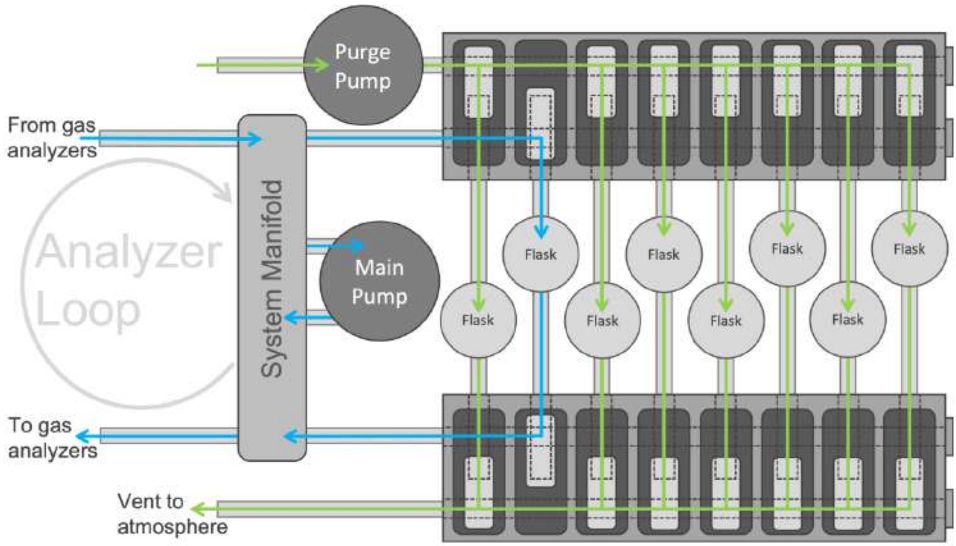


Figure D-1. Flow diagram for the multiplexer configured for flask measurements. Purge flow through all inactive ports is shown in green. Sample flow shown in blue for an observation being made on port 2.

Figure D-2 on the facing page shows what happens to flow and gas concentrations for a single flask over the course of multiple sampling sequences. When the sequence is inactive and no observations are being made on any port (e.g., between the dashed and solid black vertical lines), the total purge flow is divided over all eight ports.

Once the sequence starts (solid black vertical line) and an observation is being made on one port, the purge flow increases slightly as it is now only being divided over seven of the eight ports. In both cases, the flask is in an open loop and the concentration inside the flask is relatively constant and relatively close to the concentration of the purge air.

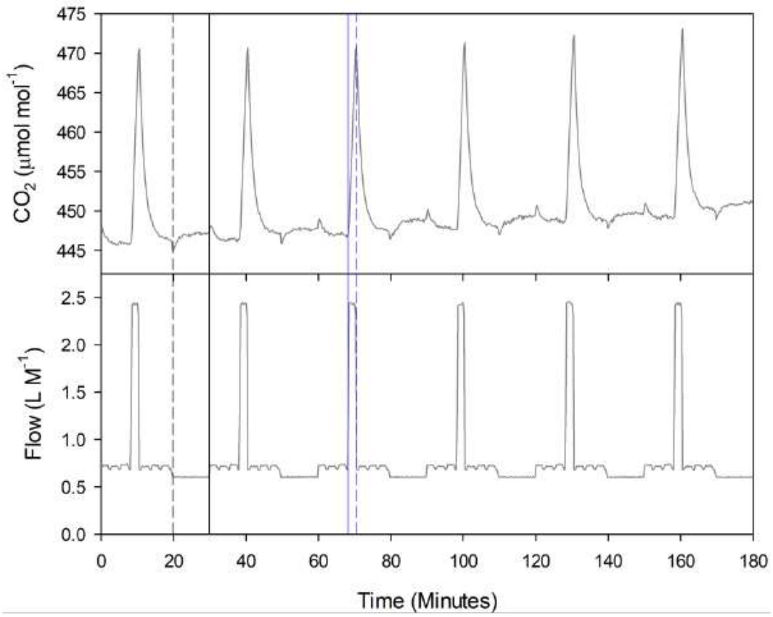


Figure D-2. Continuous time series of flow and CO_2 concentration for one flask. Flow and CO_2 were measured in parallel to the LI-8250 Multiplexer at one flask in a system configured with flasks on seven ports and one port as an analyzer loop purge. The dashed black vertical line represents the end of one sampling sequence and the solid black vertical line represents the start of another sampling sequence. The solid blue vertical line represents the start of an observation on this flask and the dashed blue vertical line represents the end of that observation.

When the flask is being sampled (e.g., between the solid and dashed blue vertical lines), flow increases significantly as the flask is now the active port. At this point, the flask is in a closed loop with the measurement system. The concentration over time will change proportional to the flux. In the example shown in *Figure D-2* above, the sample is evolving CO_2 and CO_2 concentration increases during the observation.

When the observation ends (dashed blue vertical line), the flask is purged and the concentration returns to the pre-observation levels. Note that the concentration does not instantly return to the pre-observation level. There is some wash out period primarily governed by the flask headspace volume and the purge flow rate. If perfect mixing in the flask is assumed, this washout time can be described by a time constant, τ:

$$\tau = \frac{V_h}{U_v} \tag{D-1}$$

Where V_h is the headspace volume and U_v is the volumetric flow rate while purging, both with matching volume units. One τ is the time it takes to achieve ~ 63% of the concentration change. For a well-mixed headspace volume, at least three times τ is required to return to the pre-observation state. For the example data in *Figure D-2* on the previous page, the headspace volume was approximately 1.6 L and the purge flow after the observation was approximately 0.7 L M^{-1}, suggesting that it should take at least 6.8 minutes for the headspace to return to the pre-observation concentration, which fits the observed data well.

Because a flask needs to return to pre-observation conditions before another observation can be made, this time determines the minimum time between repeat observations on a flask. Depending on the nature of the sample material in the flask, some additional time may be required to allow the sample material to re-equilibrate with the headspace.

Flask design considerations

The LI-8250 uses a closed transient method for flux measurements. A fixed volume of air is circulated between the flask and gas analyzer(s). As the sample interacts with the air in this volume, gas concentrations change proportionally to the flux into or out of the sample and the volume. In a closed system, the flux velocity for a particular gas species is given by:

$$f = \frac{PV_s}{RT}\frac{dc'}{dt} \tag{D-2}$$

Where f is the flux velocity in mol s^{-1}, P is pressure in Pa, V_s is system volume in m^3, R is the ideal gas constant (~8.314 Pa m^3 k^{-1} mol^{-1}), and T is temperature in K. dc'/dt is the rate of change in the dry mixing ratio of the gas species of interest in mol mol^{-1} s^{-1}.

Flux velocity is standardized by the sample surface area (s in m^2) or the sample mass (g in kg), to yield an area-based flux (F_s) in mol m^{-2} s^{-1} or a mass-based flux (F_g) in mol kg^{-1} s^{-1}:

$$F_s = \frac{f}{s} \tag{D-3}$$

$$F_g = \frac{f}{g} \tag{D-4}$$

Flask volume

Volume, or particularly the volume-to-unit standardization ratio (V:US), should be considered carefully in the context of expected flux rates when constructing a flask. As the volume increases for a given unit standardization and a given flux, the observed *dc'/dt* will decrease. With a very large flask relative to a very small flux, it is quite possible to drive *dc'/dt* well below the peak-to-peak noise for the analyzer used to make concentration measurements. In this case, long observation times will be required to make a measurement and uncertainty in the final computed flux will be high.

A simple sensitivity analysis using equation *D-2* on the previous page should be done to optimize the V:US, based on expected minimum and maximum fluxes and the precision of the gas analyzer. The goal is to ensure that for the selected flask volume and expected sample area or mass, *dc'/dt* for the minimum expected flux is sufficiently large relative to the analyzer's peak-to-peak noise and that the headspace concentration at the end of the observation for the largest expected flux is below the analyzer's maximum detection limit.

Air mixing

Volume (and flask shape to some degree) is also important for turbulent mixing within the headspace. A measurement inherently assumes that the gas sample pulled from the headspace and routed through the LI-8250 Multiplexer to the gas analyzer, is representative of the conditions in the flask at the moment the sample is pulled. If the headspace volume is well mixed, this assumption is valid. The observed gas concentration will change predictably as a function of the sample flux rate.

If mixing is poor, the observed gas concentration will change independently of the sample flux. These may appear as oscillations or sudden steps in the observed gas concentration during the observation. Or they may simply cause erroneous measurements that represent the combined effects of the sample flux and diffusion into or out of pockets of air trapped in the headspace that are at a different concentration than the bulk air.

In general, conditions are favorable for mixing when the headspace is turbulent and few flow obstructions are present in the flask. When flow from the LI-8250

Multiplexer drives turbulence in the headspace, smaller headspace volumes are more favorable for mixing. For larger or more irregularly shaped flasks, it may be necessary to include fans inside the headspace to aid in mixing.

Analyzer loop carryover

Due to the flow scheme of the LI-8250 (see *Figure D-1* on page D-2), a small volume of gas in the analyzer loop is carried between measurements. In both datasets in *Figure D-3* below, the carryover is evident by the small concentration step change at Elapsed Time zero. The measured concentration before this point is dominated by the gas already in the analyzer loop. After Elapsed Time zero, the measured concentration reflects what is happening in the flask. This carryover has two practical implications for measurements in the system:

- Observed gas concentrations at the very start of an observation do not necessarily represent initial headspace concentrations in the flask.
- Gas from a previous observation is carried into the current observation.

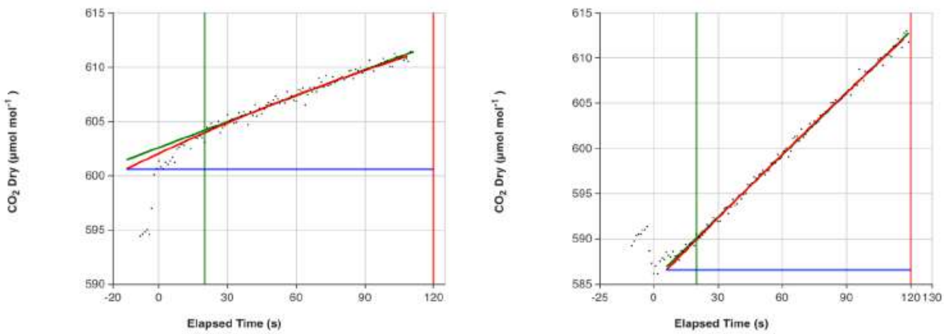


Figure D-3. Example accumulation curves measured following a short analyzer loop purge using a port open to ambient (left) and measured immediately following an observation on another flask (right). In both cases, there is a small jump in concentration at the start of the observation due to carryover in the analyzer loop.

The LI-8250 Multiplexer fits an exponential model to derive the flux. For fluxes where there is strong feedback with changes along the diffusion gradient, this model better estimates the real flux before chamber closure disturbed the diffusion gradient. The exponential model relies on measurement of ambient concentration prior to chamber closure. This is the concentration the flux is regressed to.

In a flask system, the inherent carryover means the starting concentration does not necessarily represent the initial headspace concentration in the flask. Consequently, a sudden change is often observed some time into the observation, as shown in *Figure D-3* on the previous page. If this sudden change is not accounted for, it will impact the initial gas concentration estimate and, subsequently, the derived exponential flux. Analyzer loop carryover can be accounted for by configuring a prepurge time (see *Configuring flask measurements* on page D-20).

For flasks, the prepurge time is not a purging or flushing period as it is for traditional chambers. Instead, it delays the point the system considers time zero and when the initial concentration is taken (blue lines in *Figure D-3* on the previous page). In *Figure D-3* on the previous page, data was collected using a 10-second prepurge. In both cases, the result is an initial concentration estimate that fits well with the subsequent data. To determine the prepurge time, we suggest making some preliminary measurements using your specific setup before collecting any meaningful data.

Note: The prepurge is not adjustable in SoilFluxPro™ Software like the other fit parameters are, making it difficult to recover the correct exponential flux from data collected using an inappropriate prepurge. SoilFluxPro fits both an exponential and linear model (red and green fit lines respectively of *Figure D-3* on the previous page) and provides a flux estimate from both fits. The linear model is mostly unaffected by where time zero is set (prepurge time). Meaning that the linear flux can often be used to get a reasonable flux estimate for data collected with an inappropriate prepurge.

For studies where mixing of gas between flasks is undesirable, a port can be dedicated as an analyzer loop purge. This will flush the analyzer loop with ambient (or user-conditioned) air between observations and will greatly reduce or eliminate flask-to-flask gas mixing. However, the air in the analyzer loop from the purge will still be carried over to the next flask observation.

Hardware requirements

Both the purge pump and thermistor input module are required for flask measurements, and both must be installed in any instrument (LI-8250 Multiplexer or 8250-01 Extension Manifold) that connects to a flask. For example, if you have a system with a multiplexer and two extension manifolds and you would like to connect flasks to each, three flask kits are needed (one for each instrument). If, for example, you will not be connecting any flasks to the multiplexer, only two flask kits are needed (one per extension manifold).

Because the current draw for a purge pump in an extension manifold exceeds what the multiplexer can supply, each extension manifold used for flask measurements must be powered via the alternate power input. You will need one indoor AC to DC power supply (part number 8250-772) for each extension manifold with a flask kit. You can power the multiplexer using the indoor AC to DC power supply or the outdoor AC to DC power supply (part number 8250-770).

Flask measurements require at least one temperature measurement. The temperature measurement must be made using a thermistor connected to the same instrument as the flask. Up to eight thermistors can be connected to each thermistor input module, and a thermistor can be mapped to one or more flasks.

In our example system above, if flasks are connected to the multiplexer and both extension manifolds, a minimum of three thermistors are required (one per instrument). If each flask had a thermistor, there could be up to 22 thermistors (eight on each extension manifold and six on the multiplexer). Where temperatures are relatively uniform across the system, such as in a temperature-controlled growth cabinet, one thermistor per instrument may be sufficient. Where temperatures differ across the system, multiple thermistors will be required.

Preassembled, weatherized thermistors are available from LI-COR (part number 9982-081). These thermistors are potted into a stainless-steel housing, fit to a sealed cable gland, and include a 15 m shielded cable. The cable gland mounts through a 12.5 mm diameter hole in materials up to 3 mm thick and is held in place by a nylon hex nut. Alternatively, the gland may be threaded directly into a PG 7 (steel conduit threading per DIN 40430) threaded hole.

Note: For a proper seal, the gland shoulder must compress against the mounting surface, where the gasket is located.

User-provided thermistors can also be used in the system. The thermistor input module is optimized for 10 kOhms at 25 °C nominal NTC thermistors. Steinhart-Hart coefficients for the user-provided thermistor must be known and set in the instrument configuration. No provision is included in the flask kit to seal a user-provided thermistor into a flask.

Pneumatic connections

Each Flask Sampling kit includes fittings and 30 m of Bev-A-Line® tubing to connect the user flask to the instrument (see *Figure D-4* below). You may cut the tubing to your desired length, and additional tubing can be ordered in 15 m rolls using part number 8150-250.

The tubing connects to fittings installed on the flask and to the instrument using barbed quick-connect fittings (part numbers: 300-07124 [male] and 300-07125 [female]). These fittings have a barb on one side that you press into the end of the tubing. Ensure you have cut the tubing end square and cleanly before inserting the barb. Install one male and one female barbed quick-connect fitting per tube.

Figure D-4. Pneumatic fittings and tubing are used for flask measurements.

Bulkhead quick-connect fittings (part numbers: 300-07126 [female] and 300-07127 [male]) provide a connection at the flask. These fittings mount through materials up to 4.5 mm thick (accounting for seal thickness) via an 8.5 mm diameter through-hole. Seal washers (part number 167-07256) provide a gas-tight seal. Slide the washer over the threads of the fitting with the rubber side away from the quick-connect end. Install one male and one female bulkhead quick-connect fitting per flask using an 11 mm wrench for the fittings and accompanying nuts.

> **Note:** To properly seal, the rubber side of the washer must compress against the mounting surface.

Installing the Flask Sampling Kit

The following instructions will guide you through installing the Flask Sampling Kit into an LI-8250 Multiplexer or 8250-01 Extension Manifold.

Caution: Before installing the Flask Sampling Kit, power down your system and disconnect all power inputs. Keep the system powered off until you have installed all flask hardware.

Run power to the instrument

1 Using a pair of 24 mm wrenches, remove the metal seal from the analyzer connection panel (multiplexer) or multiplexer connection panel (extension manifold) to access the cable port.

With this plug removed, tubing and cables can pass through the panel and the case can be closed.

2 If you are using the indoor AC to DC power supply (part number 8250-772), pass its connector through the cable port and connect it to the **ALT PWR IN** barrel jack on the interior panel (see *Figure 2-3* on page 2-5).

Be sure the power supply and multiplexer are not connected to mains power when making this connection.

Note: You must use the indoor AC to DC power supply to power 8250-01 Extension Manifolds for flask measurements.

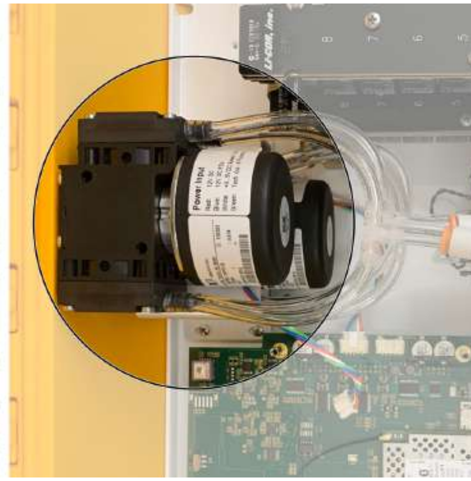
Install the purge pump

Caution: Be careful not to touch the exposed board, as electrostatic discharge can damage it.

1. Remove the six Phillips-head screws from the interior panel cover over the mainboard and lift the cover off.

2. Attach the mounting bracket (part number 9882-042) to the purge pump as shown below using two Phillips-head screws from the kit (part number 150-14477).

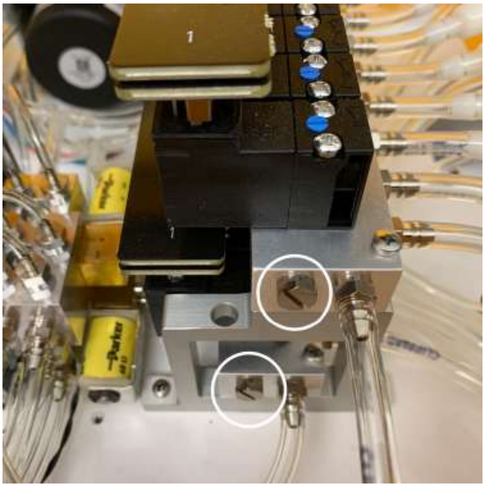
3 Position the pump and bracket assembly over the main pump as shown and mount it to the base plate using four Phillips-head screws from the flask kit (part number 150-14477).

4 Connect the power cable from the purge pump to the main board as shown.

The purge pump connects to the connector closest to the main pump connector.

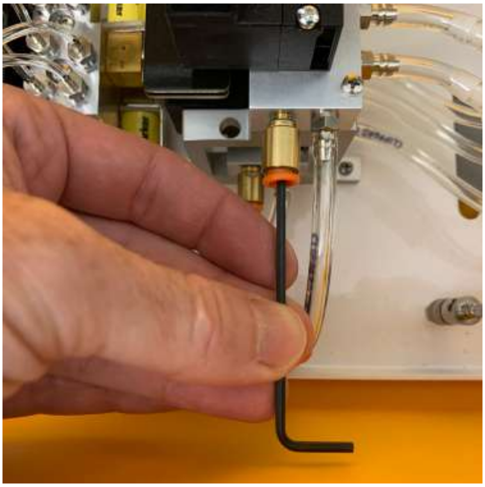
5 Remove the plugs from the upper and lower valve manifold using an 8 mm wrench or a flat-head screwdriver.



6 Install two brass quick-connect fittings (part number 300-08251) into the plug openings of the upper and lower valve manifolds.

7 Slide the fitting onto the included hex key (part number 610-04290).

Use the hex key to thread the fitting, then finish tightening the fitting by hand to compress the gasket against the manifold.



8 Connect the tubing with the tee fitting from the purge pump to the brass quick-connect fitting on the lower valve manifold.

9 Push the tubing into the fitting and pull back slightly to seat it in place.

10 Route the tubing with the filter from the purge pump through the cable port of the analyzer connection panel (multiplexer) or multiplexer connection panel (extension manifold).

If desired, route a length of tubing from the upper valve manifold through the cable port of the analyzer connection panel (multiplexer) or multiplexer connection panel (extension manifold). Push the tubing into the brass quick-connect fitting and pull back slightly to seat it in place.

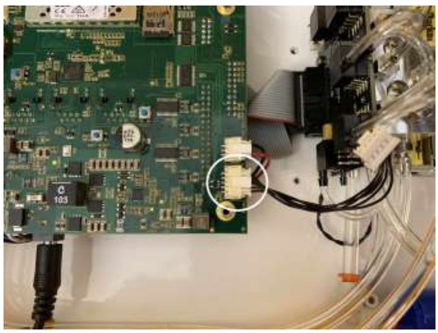
Note: This is recommended if moist air will be returned from the flasks.

Install the thermistor input module

> **Caution:** When not installed, the module is ESD sensitive. Handle it only by the edges and after touching a ground connection.

1 Connect the cable for the thermistor input module to the main board.

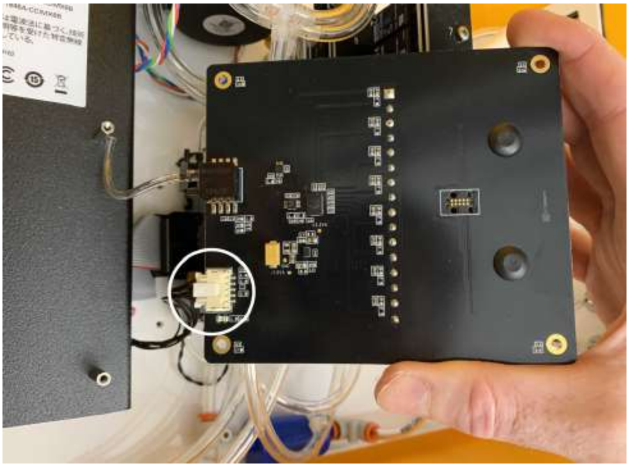
Align the keys on the white connectors and press in until they are seated. It does not matter which end you connect.



2 Replace the cover using two Phillips-head screws in the holes furthest from the **ALT PWR IN** jack (top of the cover).

3 Install standoffs (part number 161-18848) in the four remaining holes. Be careful not to over-tighten the screws or standoffs.

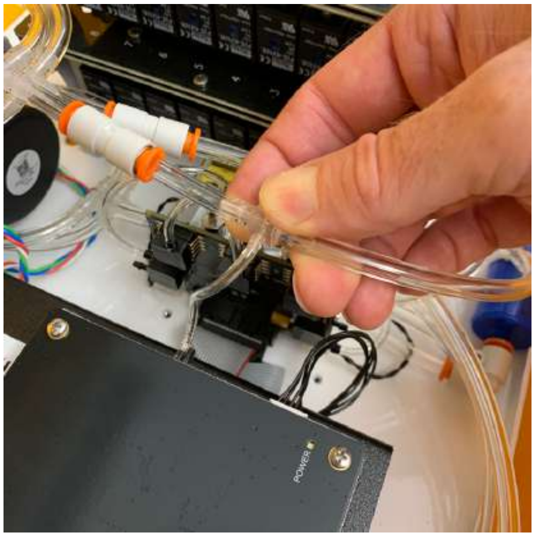
4 Connect the other end of the cable for the thermistor input module to the thermistor input module.



5 Install the thermistor input module onto the standoffs using the four remaining cover screws you removed previously.

6 Connect the pressure sensor tubing from the thermistor input module to the tee fitting on the purge pump tubing.

The tee fitting is on the tubing that connects to the brass quick-connect fitting on the lower valve manifold.



7 Connect the air tubing quick-connect fittings to the flasks and the chamber connection panel.

There should be two connections per port and flask.

Connect thermistors

Thermistor channels and flask port numbers do not have to match. However, the thermistor and flask must be connected to the same instrument (i.e., LI-8250 Multiplexer or 8250-01 Extension Manifold).

1 Pass the thermistor cable through the cable port.

2 If you are using a LI-COR thermistor (part number 9982-081), connect the brown wire to a numbered input terminal (**T1** through **T8**) on the green terminal strip at the center of the thermistor input module.

Twist the ends of the blue wire and the uninsulated shield wire together. Connect these to the ground (**GND**) terminal adjoining the numbered input terminal you selected.

3 Secure the thermistor cable to one of the strain relief posts on the thermistor input module using a wire tie if desired.

Repeat steps 1-3 for all thermistors.

4 If you will be using a port to purge the analyzer loop, choose which port you will use now.

Connect a length of tubing to the **OUT** port of that port. The length should be equivalent to the total tubing length (to and from) for one flask. This ensures that the back pressure on this port is comparable to the others and prevents excess purge flow when not being sampled.

5 Cap the **OUT** port of any ports not used for a flask or purging.

To do this, place a black vinyl cap (part number 620-08298) from the spares kit over the quick-connect fitting of the **OUT** port.

6 Connect all power supplies to mains power. At this point, the system will turn on.

7 Verify all **POWER** lights illuminate for all instruments, including the thermistor input module.

Calibrating the purge pump

Before configuring the flask system, you will need to calibrate the pressure sensor in the purge pump. To open the manual controls, first connect to the LI-8250 Multiplexer user interface. Then expand the **Tools** drop-down and click **Manual Control**.

Each instrument with a purge pump installed will have a **Purge Pump** panel. Click **Calibrate Pressure Sensor** for each purge pump.

Note: For each 8250-01 Extension Manifold with a purge pump, you will need to expand the tool panel to access its Purge Pump panel.

Configuring flask measurements

For the most part, configuring a flask system is identical to configuring a LI-COR long-term chamber. Those steps are described in *An overview of configurations* on page 6-5. Where flasks differ is that they use the **Flask** block and require different inputs to this block.

When you first open the **Configuration** page, you will see two empty root blocks: the **LI-8250 Multiplexer** block and the **Sampling Sequence** block. This section will cover the details relevant to configuring a flask system for measurements. For details on how to configure other system components, see *An overview of configurations* on page 6-5.

Tip: When configuring a system with multiple flasks and extension manifolds, you can copy/paste or duplicate blocks to speed things up (see *Workspace actions* on page 6-6).

1 Add a purge pump

You will first need to add a Purge Pump block to the root block of each instrument (i.e., LI-8250 Multiplexer or 8250-01 Extension Manifold) used for flask measurements.

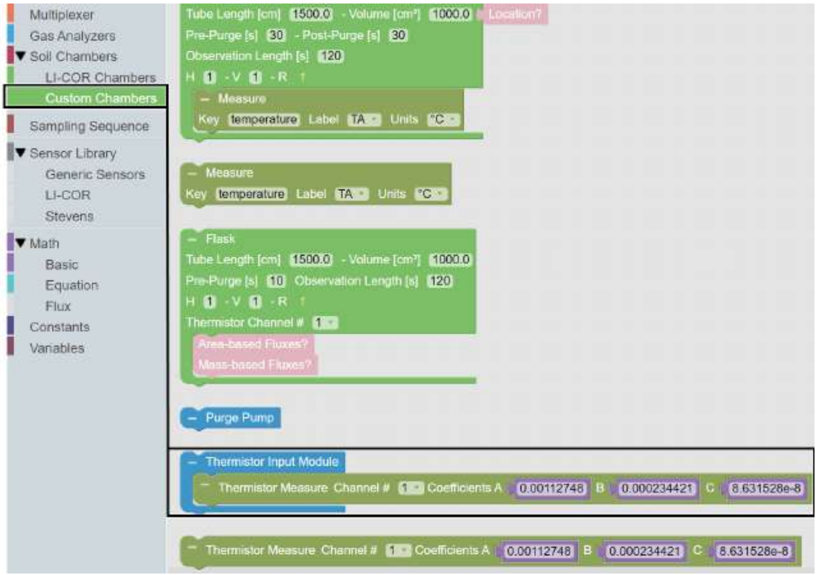
To add a Purge Pump block, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Purge Pump** block under the instrument where you would like to add the purge pump.

This block specifies that the instrument should enable the purge pump. When this block is present, the purge pump runs by default.

2 Add a thermistor input module

Next, add a Thermistor Input Module block to the root block of each instrument (i.e., LI-8250 Multiplexer or 8250-01 Extension Manifold) used for flask measurements.

To add a Thermistor Input Module block, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Thermistor Input Module** block under the instrument where you would like to add the thermistor input module.



This block allows you to add up to eight thermistors to each instrument.

3 Add another thermistor measurement (optional)

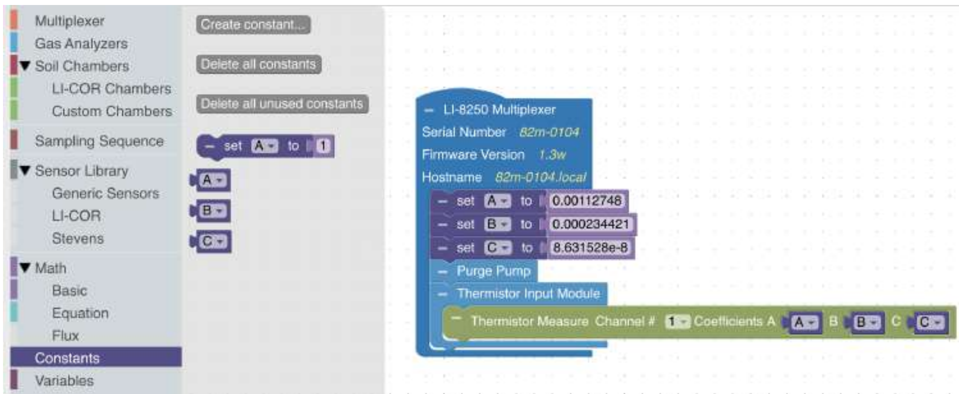
By default, each Thermistor Input Module block includes a Thermistor Measure block. If you have more than one thermistor on an instrument, you will need to add a Thermistor Measure block for each additional thermistor.

To add a Thermistor Measure block, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Thermistor Measure** block under the **Thermistor Input Module** block where it is to be added. Then set the **Channel** to the numbered input on the module where the thermistor is connected.

4 Configure thermistor measurements

If you are using the LI-COR thermistor assembly, the **A**, **B**, and **C** values can be left as is. The default values are the Steinhart-Hart coefficients for these sensors.

If you are using a user-provided thermistor, set the values to match the coefficients of that sensor. You can do this for each block individually, or you can create a set of **Constants** blocks, as shown.



5 Add a port

Before you can add an extension manifold or flask, you will need to add the port that the device is connected to. To do this, select **Multiplexer** from the Toolbox, then click and drag **Port #** to place the block under the LI-8250 Multiplexer or 8250-01 Extension Manifold block.

You can assign a port number or the user interface will automatically assign a port number as these blocks are added. You can also provide a description of the devices on that port that will appear in the data file.

6 Add a flask

After you have added a port to the LI-8250 Multiplexer or 8250-01 Extension Manifold block, you can add a flask to that port. To add a flask block, expand the **Soil Chambers** drop-down in the Toolbox and select **Custom Chambers.** Then click and drag the **Flask** block under the Port # block. Repeat this for each flask.

7 Configure the flask

Each flask block allows you to change several parameters. Set the **Tube Length** and flask **Volume.** The Tube Length is the one-way length of the tubing from the instrument to the flask. For example, if your flask is connected by 1.5 meters of tubing to the flask and another 1.5 meters of tubing returning from the flask, the tube length would be 150 cm.

Set the **Thermistor Channel #** to the thermistor this flask will use for flux calculations. This could be a thermistor installed in the flask or outside of it, and multiple flasks may reference the same thermistor.

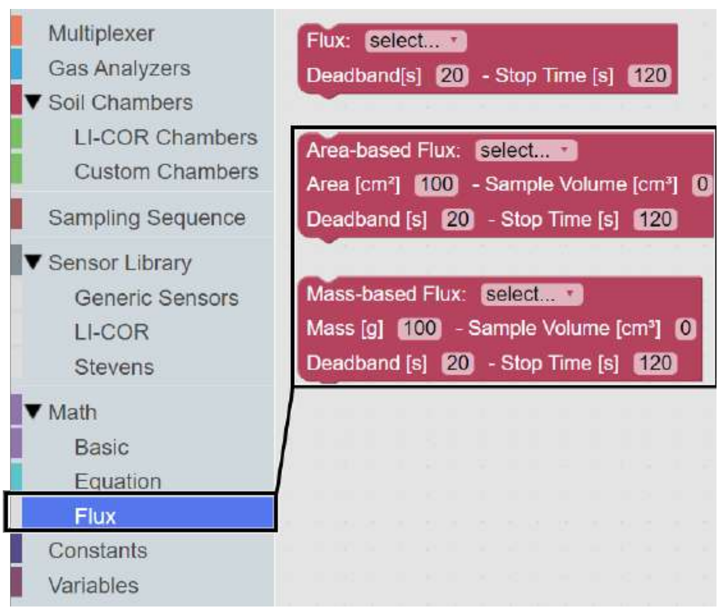
Then, set the **Observation Length** and **Pre-Purge** according to your needs. Ten seconds is a good place to start for a prepurge. Additional details about the prepurge and how it can influence fluxes can be found in *Analyzer loop carryover* on page D-6.

8 Add a flux

Two different flux calculations are available to be added to a flask configuration: Area-based Flux and Mass-based Flux. The Area-based Flux is used to specify a flux calculated on a per area basis and the Mass-based Flux is used to specify a flux calculation on a per mass basis.

To add a flux block to your custom chamber block, expand the **Math** drop-down and select **Flux** from the Toolbox. From the Flux drawer click and drag either the **Area-based Flux** block or the **Mass-based Flux** block under the flask you would like to add the flux to. You can have multiple Flux blocks under each flask depending on the analyzer(s) you are using and the gases you would like recorded.

> **Note:** Only one type of flux block (area or mass) may be placed inside a Flask block. Multiple flux blocks may be placed under the Flask block to accommodate different gas species, but they must be of the same type.



Each flux block allows you to customize additional parameters required for the flux calculation. If a sample occupies some volume inside the flask, enter a **Sample Volume.** This value is subtracted from the system volume to provide a more accurate total volume estimate for the flux calculation.

> **Note:** If multiple flux blocks for different gases are included under a Flask block, the sample volume and area/mass values for all flasks must be consistent or your configuration will not **Verify**.

Area-based flux

The drop-down menu allows you to select the type of gas and the source for flux calculations. Under **Area** you will enter the sample surface area in cm^2. You can also adjust the **Deadband** and **Stop Time** as needed. The Deadband and Stop Time are parts of the total **Observation Length**. Stop Time can be any time desired so long as it is beyond the Deadband and does not exceed the Observation Length. A good Deadband to start with is 15 to 20 seconds, but this can be adjusted in post-processing using SoilFluxPro Software.

Mass-based flux

The drop-down menu allows you to select the type of gas and the source for flux calculations. Under **Mass** you will enter the sample mass in grams. Under **Sample Volume** you will enter the calculated volume of the sample in cm^3. This is used to correct the total volume for sample displacement. You can also adjust the **Deadband** and **Stop Time** as needed. The Deadband and Stop Time are parts of the total **Observation Length.** Stop Time can be any time desired so long as it is beyond the Deadband and does not exceed the Observation Length. A good Deadband to start with is 15 to 20 seconds, but this can be adjusted in post-processing using SoilFluxPro Software.

> **Note:** You will need one Flux block for each gas flux you would like to have computed. Without a Flux block, no flux will be calculated for that gas. If a Flux block was not added for a gas, a flux can still be calculated later using SoilFluxPro Software.

Finding leaks

Flask measurements require that the system be leak-free. This means that there are no volumetric gains or losses independent of the gas flux. You can use the built-in leak test to determine leaks between the multiplexer, extension manifold(s), and all tubing, but this test will not determine if a flask leaks. Large flask leaks may be evident in the time series of gas concentrations. Small leaks may be less obvious in the concentrations but may still be detectable in the positive and negative pressures reported for the main LI-8250 Multiplexer pump.

If these pressures consistently vary by a significant amount (greater than 1 kPa) over each observation, there may be a leak in the flask. When used with an 8250-01 Extension Manifold, these pressures may show sudden changes during an observation as the main pump adjusts flow.

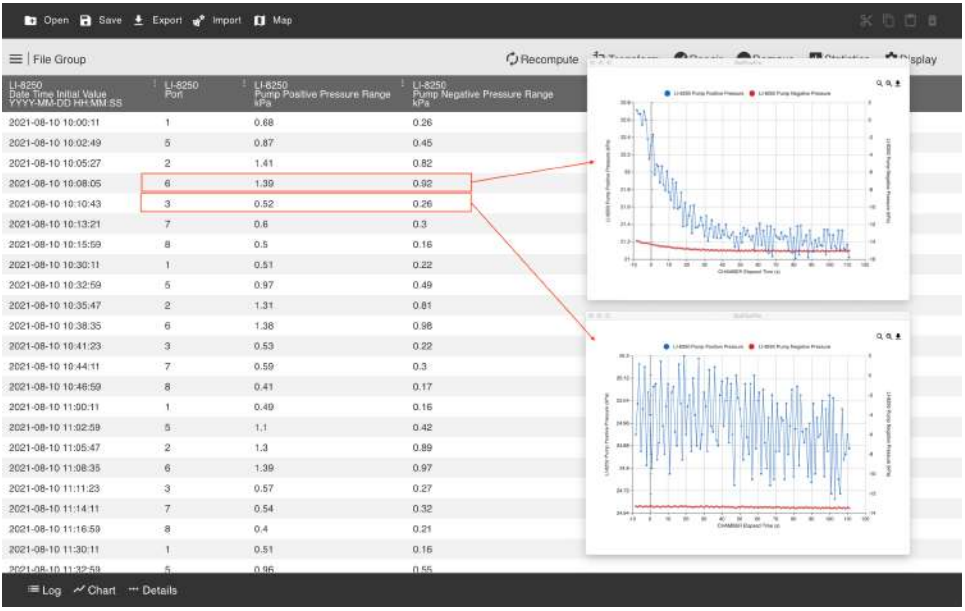


Figure D-5. An example dataset showing sample pump positive and negative pressure ranges for some leaky and leak free flasks. In the data shown here, the flasks on LI-8250 port 2, 5, and 6 had small leaks where the thermistor was inserted into the flasks. The flasks on all other ports appeared to be leak free.

Appendix E.
Connecting to a cellular modem

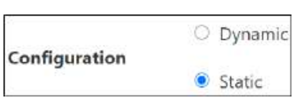
You can connect the LI-8250 Multiplexer to a cellular modem to remotely control and monitor your system through the user interface. Connecting your multiplexer to a cellular modem also lets you configure the multiplexer to push daily summary files and .82z files containing raw observation data from the previous day to a server (see *Configuring a remote server* on page 2-11).

You will need a cellular modem and an active data plan with a cellular service provider in your area. Your data plan should include a fixed public IP address for direct access to the user interface. The multiplexer must be connected to the modem using an Ethernet connection. Sealed to standard Ethernet cables are available in lengths of 5 m (part number 392-19109) or 25 m (part number 392-19110) to make this connection.

Configure Ethernet settings

The first step is to configure the LI-8250 Multiplexer with a static IP address.

1. Connect to the LI-8250 Multiplexer user interface and go to the Device Settings page.
2. Open the **Ethernet** settings and change the **Configuration** from **Dynamic** to **Static** by selecting the radio button.



3. Enter the static settings for the **IP Address**, **Subnet Mask**, and **Default Gateway**.

   These are entered as a string up to 3 digits ranging from 1 to 254 (the exception to this is the Subnet Mask, which will use 0 or 255). The settings provided below are for the Sierra Wireless AirLink RV50X cellular modem.

- **IP Address:** Enter a static IP address for the multiplexer, such as 192.168.13.200
- **Subnet Mask:** Typically 255.255.255.0
- **Default Gateway:** Set this to the local IP address used to connect to your cellular modem (e.g., 192.168.13.31)

4 Click **Apply** and then click **Reboot** at the bottom of the page to restart the multiplexer and verify the new settings.

> **Note:** You must always **Apply** after changing Ethernet settings. If you navigate to other pages or reboot without clicking **Apply**, your changes will not be saved.

Configure port forwarding and filtering

To enable remote connectivity, you will need to configure the cellular modem so that it forwards requests to the static IP address of the LI-8250 Multiplexer. We also recommend blocking port 22 through inbound port filtering. Doing so can protect your site instruments from nefarious hacking attempts over the network. More information on how to configure port forwarding, port filtering, and other modem related settings can be found in the documentation provided with your modem. The Sierra Wireless Airlink RV50X manual can be found at licor.com/documents/i8pb9t0f0521e5fv26ec07postsd2sgp.

Port forwarding allows remote computers and devices to connect to a specific device within a local area network. For the multiplexer, you will want to forward ports 80 and 8080. Since these are commonly used ports in web servers, it is recommended that these ports be forwarded using different ports. The LI-8250 Multiplexer user interface assumes that if you are using one public port for port 80, the next public port in the sequence will be for port 8080.

Port 22 is required to use SFTP with the LI-8250 Multiplexer. If you have blocked port 22, you will want to forward that port with a public start port as well. See *Table E-1* on the facing page for complete example settings.

Table E-1. Example port forwarding settings for the LI-8250 Multiplexer.

Public Start Port	Public End Port	Protocol	Host IP Address	Private Start Port
8200	0	TCP	192.168.13.200	80
8201	0	TCP	192.168.13.200	8080
8222	0	TCP	192.168.13.200	22

Connecting remotely

To remotely connect to your LI-8250 Multiplexer user interface using the example port settings provided in *Table E-1* above

1 Open a web browser.

2 Enter the fixed public IP address of the modem followed by the port number.

For this example, you would enter `http://xxx.xxx.xxx.xxx:8200` where `xxx.xxx.xxx.xxx` is the fixed public IP address of your modem.

3 Press `Enter` to connect to the multiplexer.

Appendix F.
Specifications

All specifications are subject to change without notice.

LI-8250 Multiplexer

General

Dimensions: 38.5 cm L × 52 cm W × 18.5 cm H
Weight: 7.7 kg
Weatherproof Rating: Tested to IEC IP55 standard
Operating Range
- **Temperature:** -20 to 45 °C
- **Humidity:** 0 to 95% RH, non-condensing

User Data Storage: 8 GB total non-volatile
GPS: Accuracy 2.5 m CEP
Coverage Area
- **Maximum radius from LI-8250 to chambers:** 15.0 m with one cable assembly or 30.0 m with an extension manifold and two cable assemblies
- **Maximum diameter of measurement circle:** 30.0 m with two cable assemblies or 60.0 m with two extension manifolds and four cable assemblies.

Plumbing
- **Flow rate to/from chambers:** ~2 to 3 lpm
- **Pump type:** Diaphragm (pumps in the analyzers subsample air stream in the LI-8250)

Barometric Pressure Sensor
- **Measurement Range:** 20 to 110 kPa
- **Sensor Accuracy:** ±0.4 kPa from 50 to 110 kPa
- **Resolution:** 0.006 kPa

Communication

Seven LED Indicators: Power, Ready, Ethernet activity (3), USB activity (2)
Connectivity: Three Ethernet Ports, Wi-Fi (not available in some countries)
Wi-Fi Compatibility: 2.4 GHz, 802.11 a/b/g/n/ac
Connectivity Ports:

One sealed and strain-relieved USB-A: For connection to LI-870 CO_2/H_2O Analyzer

Two standard, internal USB-A: For USB mass storage (file transfer) or a country-specific Wi-Fi adapter.

Three sealed and strain-relieved RJ-45 Ethernet: For connection to LI-COR LI-78xx Trace Gas Analyzers, site Ethernet network, or cellular modem. Connectors also accept standard, non-sealed RJ-45 Ethernet cables for lab use.

Output Port Connector: Full-duplex RS-422 communication, 115,200 baud, plus 24 VDC power. Each output port is current-limited to ~1.8 A. Combined steady state power consumption for all chambers should not exceed 1 A. For details about pin assignments see *Pin assignments* on page G-1.

Power

Power Requirements: 10 to 30 VDC up to 80 W (120 VAC and 240 VAC when using a power supply). The LI-8250 powers the 8200-104/C chambers, the 8250-01 Extension Manifold, and the LI-870 CO_2/H_2O Analyzer. Other analyzers are powered separately. See *Table F-1* below for total system power requirements.
Output Voltage: 12 VDC, 2 A
Alternate Power Input: 21.9 to 26.5 VDC 80 W

Table F-1. Total system power requirements.

Typical Power Consumption (W)			
Instrument	**Idle**	**Sampling/Moving**	**Max/Warm-up**
LI-8250	4.8	15.6	18.2
8250-01 (each)	0.8	9.2	11.0
8200-104/C (each)	0.36	4.8	N/A
LI-870	5.0	5.0	14.0

Note: The maximum listed for the LI-8250 is a typical maximum, there is no additional warm-up power. Chamber power reaches 4.8 W only when opening or closing, not the entire time of sampling.

8250-01 Extension Manifold

General

Dimensions: 38.5 cm L × 52 cm W × 18.5 cm H
Weight: 7.4 kg
Weatherproof Rating: Tested to IEC IP55 standard
Operating Range
 Temperature: -20 to 45 °C
 Humidity: 0 to 95% RH, non-condensing
Plumbing
 Flow rate to/from chambers: ~2 to 3 lpm
 Pump type: Diaphragm

Communication

Two LED Indicators: Power, Ready
Input Port Connector: Full-duplex RS-422 communication, 115,200 baud, plus 24 VDC power.
Output Port Connector: Full-duplex RS-422 communication, 115,200 baud, plus 24 VDC power. Each output port is current-limited to ~1.1 A. Combined steady state power consumption for all chambers should not exceed 1 A.

Power

Power Requirements: Input voltage range is supplied by LI-8250 Multiplexer. Typical 24V and 1.8A max. See *Table F-2* below for 8250-01 power requirements.
Alternate Power Input: 21.9 to 26.5 VDC 80 W

Table F-2. 8250-01 Extension Manifold power requirements.

Typical Power Consumption (W)			
Instrument	**Idle**	**Sampling/Moving**	**Max/Warm-up**
8250-01 (each)	0.8	9.2	11.0
8200-104/C (each)	0.36	4.8	N/A

> **Note:** The max listed for the 8250-01 is a typical maximum, there is no additional warm-up power. Chamber power reaches 4.8W only when opening or closing, not the entire time of sampling.

Indoor AC to DC Power Supply (8250-772)

Dimensions: 14.5 cm L x 6 cm W x 3.2 cm H
Weight: 0.5 kg
Power requirements: 100 to 240 VAC, 1.3 A, 50/60 Hz, 120 VA
Output Voltage: 24 VDC, 3.75 A

Outdoor AC to DC Power Supply (8250-770)

Dimensions: 15 cm L × 12.5 cm W × 8.5 cm H
Weight: 1.3 kg
Weatherproof Rating: Tested to IEC IP55 standard
Environmental Operating Conditions: Tested to IP55 for dust and water ingress
Operating Range: -20 to 50 °C
Power Requirements:
Serial number 82P-0364 and earlier: 100 to 240 VAC, 50/60 Hz, 120 VA
Serial number 82P-0365 and later: 100 to 240 VAC; 50/60 Hz, 140 VA
Output Voltage:
Serial number 82P-0364 and earlier: 12 VDC, 6.67 A
Serial number 82P-0365 and later: 12 VDC, 8.0 A

Opaque Long-Term Chamber (8200-104)

Dimensions: 48.3 cm L × 38.1 cm W × 33.0 cm H
Weight: 7.3 kg
Chamber Volume: 3955 cm^3
Soil Area Exposed: 317.8 cm^2
Weatherproof Rating: Tested to IEC IP55 standard
Air Temperature Thermistor
Operating Range: -20 to 50 °C
Accuracy: ±0.3 °C from -20 to 50 °C
Light Sensor Current Input
Range: 0 to 90 µA
Resolution: 1.5 nA
Accuracy: ±(0.37 % of Reading + 8 nA) from -20 to 50 °C
SDI-12 Communications Interface
Max Number of Devices: 10
Output Voltage: 12 VDC, 200 mA

Clear Long-Term Chamber (8200-104C)

Dimensions: 48.3 cm L × 38.1 cm W × 33.0 cm H
Weight: 7.3 kg
Chamber Volume: 3955 cm^3
Soil Area Exposed: 317.8 cm^2
Weatherproof Rating: Tested to IEC IP55 standard
Air Temperature Thermistor
Operating Range: -20 to 50 °C
Accuracy: ±0.3 °C from -20 to 50 °C
Light Sensor Current Input
Range: 0 to 90 µA
Resolution: 1.5 nA
Accuracy: ±(0.37 % of Reading + 8 nA) from -20 to 50 °C
SDI-12 Communications Interface
Max Number of Devices: 10
Output Voltage: 12 VDC, 200 mA

Flask Sampling Kit (8250-660)

Power

Power Requirements: Input voltage is supplied by the LI-8250 Multiplexer or the 8250-01 Extension Manifold. When a Purge Pump is configured to an extension manifold, the extension manifold must be connected to a power supply, such as the Indoor Power Supply (8250-772), via the Alternate Power Input. See *Table F-3* below for 8250-660 power requirements.

Table F-3. 8250-660 Flask Sampling Kit power requirements.

Typical Power Consumption (W)			
Instrument	**Idle**	**Sampling/Moving**	**Max/Warm-up**
9982-079 Thermistor Input Module (each)	0.12	0.12	N/A
9982-077 Purge Pump (each)	5.8	5.8	7.0
Flask Sampling Kit Total (each)	5.92	5.92	7.12

Note: The power requirements for the 9982-077 Purge Pump are based on the pump being configured to run in the user interface. If the pump is not configured to run, it will use no power.

Thermistor

Thermistor Input Module (**9982-079**)

Operating Range: -20 to 70 °C

Optional Thermistor Assembly (**9982-081**)

Operating Range: -20 to 70 °C

Accuracy: ±0.3 °C from -20 to 70 °C

Appendix G.
Pin assignments

The pin assignments for the RS-422 connectors and SDI-12 sensors are provided below.

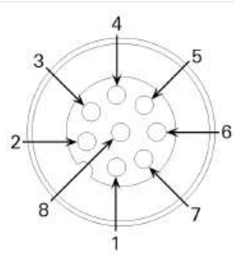
RS-422 pin assignments

Round Turck connectors are used for RS-422 serial output between the LI-8250 Multiplexer and chambers. The RS-422 pin assignments are as follows:

LI-8250 Multiplexer power and communication port

This connection allows the LI-8250 Multiplexer to provide power and communication to LI-COR long-term chambers and to communicate with custom chambers. The pin assignment shown in *Table G-1* below represents the female end of the power and communication port on the multiplexer.

Table G-1. Pin assignment for the power and communication ports on the multiplexer.

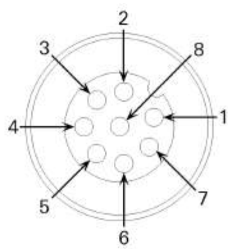


Connector Pin #	LI-8250 Signal Name
1	RS422_RX-
2	RS422_TX-
3	RS422_TX+
4	+24VDC
5	Ground
6	+24VDC
7	RS422_RX+
8	Ground

8200-104/C Long-Term Chamber power and communication port

A 15 m RS-422 to RS-422 cable (part number 392-18852) is used to connect the LI-8250 Multiplexer to the 8200-104 Opaque Long-Term Chamber and the 8200-104C Clear Long-Term Chamber. This cable is included in the optional cable assembly (part number 9982-056). The pin assignment shown in *Table G-2* below represents the male end of the power and communication port on the chamber.

Table G-2. Pin assignment for the power and communication port on LI-COR long-term chambers.

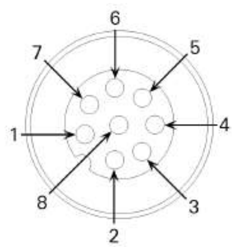


Connector Pin #	Chamber Signal Name	Wire Color
1	RS422_TX-	White/Blue
2	RS422_RX-	White/Brown
3	RS422_RX+	Brown
4	+24VDC	Orange
5	Ground	White/Green
6	+24VDC	White/Orange
7	RS422_TX+	Blue
8	Ground	Green

Bulkhead flying lead for custom chambers

A bulkhead flying lead (part number 310-19090) is available to connect the LI-8250 Multiplexer or 8250-01 Extension Manifold to a custom chamber for communication. The pin assignment shown in *Table G-3* on the facing page represents the male end of the bulkhead.

Table G-3. Pin assignment for the bulkhead flying lead that connects to a custom chamber.



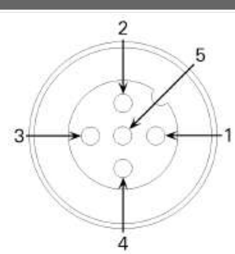
Connector Pin #	Chamber Signal Name	Bulkhead Wire Color
1	RS422_TX-	White
2	RS422_RX-	Brown
3	RS422_RX+	Green
4	+24VDC	Yellow
5	Ground	Gray
6	+24VDC	Pink
7	RS422_TX+	Blue
8	Ground	Red

Sensor connector pin assignments

To connect your own SDI-12 sensor to a 8200-104/C Long-Term Chamber, LI-COR provides an optional 2 m sensor connector to cable with flying leads (part number 392-18518). The pin assignment shown in *Table G-4* below represents the male end of the Turck connector.

Caution: Be certain when wiring an SDI-12 sensor not to connect, short, or allow water to make contact with the white or gray wires. If the white or gray wires are connected, shorted, or make contact with water, all sensor communications may be corrupted, including the light sensor and thermistor temperature measurements.

Table G-4. Pin assignment for the sensor connector.



Connector Pin #	Function	Wire Color
1	+12 VDC power	Brown
2	Thermistor input	White
3	SDI-12 data	Blue
4	Ground	Black
5	Light sensor input	Gray

Appendix H.
References

Morison, J.I.L., 1987. Intercellular CO2 concentration and stomatal response to CO_2. In: Zeiger, E., Farquhar, G.D. and Cowan, I.R. (Eds.), Stomatal Function. Stanford University Press, Stanford, California, pp. 229-251.

Wong, S.C., Cowan, I.R., Farquhar, G.D., 1979. Stomatal conductance correlates with photosynthetic capacity. Nature 282, 424-426.

Xu, L-K and Hsiao TC, 2004. Predicted vs. measured photosynthetic water-use efficiency of crop stands under dynamically changing field environments. Journal of Experimental Botany. 55:2395-2411.

Standard Terms and Conditions

1. General. LI-COR Inc. ("LI-COR") is delivering these goods and products ("Products") subject to these Terms and Conditions of Sale ("Conditions"). Buyer will be deemed to have assented to these Conditions upon Buyer's placement of order. Notwithstanding the above, failure of LI-COR to object to provisions contained in any purchase order or other form or document from Buyer shall not be construed as a waiver of these Conditions nor an acceptance of any such provision.

2. Buyer's Use Only/No Resale. The purchase of Products only conveys to Buyer the non-transferable right for only Buyer to use the quantity of Products and components of Products purchased in compliance with the applicable intended use statement, limited use statement or limited label license, if any, in LI-COR catalogues or on the label or other documentation accompanying the Products (all such statements or licenses being incorporated herein by reference as if set forth herein in their entirety). Buyer has no right to resell the Products, or any portion of them, and any such resale is strictly prohibited unless LI-COR first accepts and approves a purchase order and acknowledges in writing that the Products may be resold by Buyer and the terms of such resales.

3. Prices/Taxes. All prices are quoted for delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA. Accordingly, unless otherwise specified by LI-COR, prices are exclusive of shipping, insurance and installation charges, all of which are Buyer's sole responsibility. All prices are exclusive of all sales, use, excise, value added, withholding and other taxes, and all customs, duties, documentation charges, and freights forwarder charges now or hereafter claimed or imposed by any governmental authority upon the sale of the Products. Any such charges will be added to the product invoice or subsequently invoiced to the Buyer. In the event LI-COR is required to pay any such tax, duty or charge, Buyer will promptly reimburse LI-COR.

4. Payment Terms. All payments shall be made in immediately available U.S. Dollars net thirty (30) days from the date of invoice for qualified accounts, without set-off, deduction or withholding of any kind, unless otherwise stated by LI-COR in writing and may be paid by check (drawn on a U.S. bank), wire transfer or major credit card. All open account invoicing must be pre-approved. Any amounts not paid when due will accrue interest at the rate of 1 1/2% per month, or the maximum amount allowed by law, if lower. In the event that any payment is more than thirty (30) days late, LI-COR shall have the right to suspend doing business with Buyer until all past due balances are made current. Buyer shall pay for all costs (including reasonable fees) incurred by LI-COR in connection with the collection of late payments. Each accepted purchase order is a separate, independent transaction, and Buyer has no right of set-off against other purchase orders or other transactions with LI-COR. Buyer hereby grants LI-COR a security interest in the Products in the amount of the unpaid balance of the purchase price until paid in full. LI-COR may file a financing statement for such security interest and Buyer shall sign any such statements or other documentation necessary to perfect LI-COR security interest.

5. Return Policy. Buyer may return non-consumable Products to LI-COR within forty-five (45) days of invoice date only with prior authorization by LI-COR, the Product(s) being returned in new and unused condition and must be resalable as new. Any returned Product(s) are subject to payment of a fifteen percent (15%) re-stocking fee on all items returned. Buyer shall be responsible to make payment to LI-COR for any and all expenses related to deinstallation of the Product(s), including but not limited to shipping, duties, and taxes. All payments subject to this provision shall be made to LI-COR within thirty (30) days of return, or de-installation, of the Product(s).

6. Delays In Performance. LI-COR shall not be liable for any delay in performance hereunder due to unforeseen circumstances or due to circumstances beyond its control including, but not limited to, acts of nature, acts of government, labor disputes, delays in transportation, delays in customs clearance and delays in delivery or inability to deliver by LI-COR's suppliers.

7. Shipment and Packing. All Product prices exclude costs of shipping and handling and insurance, in accordance with delivery terms designated by LI-COR. Unless otherwise agreed in writing, such costs will be paid by the Buyer and will appear as a separate item on LI-COR invoice. LI-COR shall ship in accordance with LI-COR standard practices. Buyer may specify different shipping instructions, subject to agreement by LI-COR. Unless otherwise agreed to in writing by LI-COR, all products shall be packaged, if appropriate, for shipment and storage in accordance with standard commercial practices. All packing shall conform to carrier requirements.

8. Partial Shipments. Any Products delivered in partial shipments may be invoiced individually. Additional shipping and handling charges may apply.

9. Title/Risk of Loss. All domestic shipments are made FOB per Uniform Commercial Code. All international shipments are made per INCOTERMS 2000 designated by LI-COR. LI-COR title to the Products and the risk of loss of or damage to the Products ordered by the Buyer will pass to Buyer at time of LI-COR delivery of Products to the carrier. The carrier shall be deemed Buyer's agent, and any claims for damages in shipment must be filed with the carrier. LI-COR is authorized to designate a carrier pursuant to LI-COR standard shipping practices unless otherwise specified in writing by Buyer.

10. Intellectual Property Rights. Title to and ownership of the documentation, and any improved, updated, modified or additional parts thereof, and all copyright, patent, trade secret, trademark and other intellectual property rights embodied in the Products, shall at all times remain the property of LI-COR or LI-COR licensors.

11. Acceptance. All sales are final and all Products shall automatically be deemed accepted upon delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA. Buyer may not return any Products to LI-COR except as provided for by LI-COR warranty or as provided herein.

12. Product Warranties. Unless otherwise specified by LI-COR:

(a) LI-COR warrants that, for a period of twelve (12) months from the date of shipment of the Products from LI-COR (the "Warranty Period"), unless otherwise specified for individual Products or extended by a Support Contract or Extended Warranty Contract, the Products sold hereunder will be free from material defects in materials and workmanship and will conform to LI-COR published specifications in effect as of the date of manufacture. LI-COR SPECIFICALLY DISCLAIMS ANY INDIRECT,SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF USE OR LOST PROFITS) WHICH MAY RESULT FROM THE USE OF PRODUCTS PURCHASED HEREUNDER, AS FURTHER SET FORTH IN SECTION 13 OF THESE CONDITIONS OF SALE. This limited warranty extends only to Buyer as original purchaser unless otherwise agreed upon in writing by LI-COR.

(b) The foregoing warranty shall not apply if the defective Product (i) has been subjected to abuse, misuse, neglect, negligence, accident, improper testing, improper installation, improper storage, improper handling or use contrary to any instructions issued by LI-COR, (ii) has been repaired or altered by persons other than LI-COR, (iii) has not been installed, operated, repaired and maintained in accordance with the documentation or operated outside of the environmental specifications for the Product; (iv) has failed due an Act of God, including but not limited to fire, flood, tornado, earthquake, hurricane or lightning or (v) has been used with any devices, accessories or products not manufactured by or approved by LI-COR. In addition, the foregoing warranty shall not apply to Products (i) LI-COR Standard Terms and Conditions of Sale – rev. 5/15/2009 marked or identified as "sample," (ii) loaned or provided to Buyer at no cost, or (iii) which are sold "as is."

c) If during the Warranty Period: (i) LI-COR is notified promptly in writing upon discovery of any defect in the Product, including a detailed description of such alleged defect, (ii) such Product is returned, transportation charges prepaid, to LI-COR designated manufacturing facility subject to the prior approval of LI-COR with a valid Return Material Authorization ("RMA") number, and (iii) LI-COR inspections and tests determine that the Product is indeed defective and the Product has not been subjected to any of the conditions set forth above, then, as Buyer's sole remedy and LI-COR sole obligation under the foregoing warranty, LI-COR will, at LI-COR option, repair or replace without charge the defective Product. In no event will the Buyer itself nor will the Buyer allow any party other than LI-COR or a third party authorized in writing by LI-COR to perform any service on the Products.

(d) During the Warranty Period, LI-COR will provide on-site warranty repair for Odyssey® Infrared Imager, Aerius Automated Infrared Imager, Pearl® Imager and/ or 4300 DNA Analyzer Products including travel costs, repair parts, and labor to maintain the hardware in proper operating condition. At LI-COR discretion, the Buyer may be required to run certain diagnostic procedures to help determine the source of the problem before on-site warranty repair is rendered. If an on-site service call is initiated, LI-COR will dispatch a service technician to the Buyer site. On-site service will be provided 8:00 a.m. to 5:00 p.m. (Buyer local time), Monday through Friday, excluding LI-COR holidays. The cost of a repair/service call for an instrument malfunction caused by third party hardware and/or software will be billed to Buyer on a time and material basis.

(e) Any Product that has either been repaired or replaced under this warranty shall have warranty coverage (parts only) for the longer of ninety (90) days or the remaining original warranty period. Replacement parts used in the repair of Products may be new or equivalent to new.

(f) EXCEPT FOR THE WARRANTIES SET FORTH IN THIS SECTION, LI-COR MAKES NO OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, WITH RESPECT TO ANY PRODUCTS OR OTHER PRODUCTS PROVIDED IN CONNECTION WITH THESE CONDITIONS, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NONINFRINGEMENT, OR ARISING FROM COURSE OF PERFORMANCE, DEALING, USAGE OR TRADE.

(g) Notwithstanding anything herein to the contrary, LI-COR makes no warranty with respect to any third party products provided under these Conditions. Buyer's sole remedy with respect to such third party products shall be pursuant to the original manufacturer's or licensor's warranty, if any, to Buyer, to the extent permitted by the original manufacturer or licensor.

13. Limitation of Liability. IN NO EVENT SHALL LI-COR, ITS LICENSORS OR ITS SUPPLIERS BE LIABLE TO BUYER OR ANY THIRD PARTY FOR COSTS OF PROCUREMENT OF SUBSTITUTE PRODUCTS OR SERVICES, LOST PROFITS, DATA OR BUSINESS, OR FOR ANY INDIRECT, SPECIAL, INCIDENTAL, EXEMPLARY OR CONSEQUENTIAL DAMAGES OF ANY KIND ARISING OUT OF OR IN CONNECTION WITH THE USE OF THE PRODUCTS OR THESE CONDITIONS, HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY (WHETHER IN CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, PRODUCTS LIABILITY OR OTHERWISE). LI-COR TOTAL AND CUMULATIVE LIABILITY ARISING OUT OF OR IN CONNECTION WITH ANY PRODUCTS PURCHASED BY BUYER HEREUNDER SHALL IN NO EVENT EXCEED THE PURCHASE PRICE PAID BY BUYER FOR SUCH PRODUCTS. THE LIMITATIONS SET FORTH IN THIS SECTION SHALL APPLY EVEN IF LI-COR OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, AND NOTWITHSTANDING ANY FAILURE OF ESSENTIAL PURPOSE OF ANY LIMITED REMEDY.

14. Authorized Use of Biotechnology Products. Unless otherwise expressly indicated in LI-COR catalogues, LI-COR website or on the label or other documentation accompanying Biotechnology Products, the LI-COR Biotechnology Products are intended for RESEARCH USE ONLY and are not to be used for any other purposes including, but not limited to, unauthorized commercial purposes, in vitro diagnostic purposes, ex vivo or in vivo therapeutic purposes, investigational use, in foods, drugs, devices or cosmetics of any kind, or for consumption by or use in connection with or administration or application to humans or animals. Buyer acknowledges that the Biotechnology Products have not necessarily been tested for safety or efficacy, unless expressly stated in LI-COR catalogs or on the label or other documentation accompanying the Biotechnology Products.

15. Authorized Use of Biotechnology Products. Unless otherwise expressly indicated in LI-COR catalogues, LI-COR website or on the label or other documentation accompanying Biotechnology Products, the LI-COR Biotechnology Products are intended for RESEARCH USE ONLY and are not to be used for any other purposes including, but not limited to, unauthorized commercial purposes, in vitro diagnostic purposes, ex vivo or in vivo therapeutic purposes, investigational use, in foods, drugs, devices or cosmetics of any kind, or for consumption by or use in connection with or administration or application to humans or animals. Buyer acknowledges that the Biotechnology Products have not necessarily been tested for safety or efficacy, unless expressly stated in LI-COR catalogs or on the label or other documentation accompanying the Biotechnology Products.

16. Severability. If any portion of these Conditions is held invalid, the parties agree that such invalidity shall not affect the validity of the remaining portions of these Conditions.

17. Export Control. Buyer acknowledges and agrees that the Products purchased under these Conditions may be subject to restrictions and controls imposed by the United States Government and the regulations thereunder. BUYER WARRANTS THAT IT WILL NOT EXPORT OR RE-EXPORT ANY PRODUCTS PURCHASED WITHOUT PRIOR WRITTEN NOTIFICATION AND APPROVAL OF LI-COR.

18. Assignment. Buyer shall not assign or transfer these Conditions or any rights or obligations under these Conditions, whether voluntary or by operation of law, without the prior written consent of LI-COR. LI-COR may assign or transfer these Conditions to any successor by way of merger, acquisition or sale of all or substantially all of the assets relating to these Conditions. LI-COR or any successor may assign all or part of the right to payments under these Conditions. Any assignment or transfer of these Conditions made in contravention of the terms hereof shall be null and void. Subject to the foregoing, these Conditions shall be binding on and inure to the benefit of the parties' respective successors and permitted assigns.

19. Entire Agreement. These Conditions of Sale take precedence over Buyer's additional or different terms and conditions, to which notice of objection is hereby given. Acceptance by Buyer is limited to LI-COR Conditions of Sale. Neither LI-COR commencement of performance nor delivery shall be deemed or construed as acceptance of Buyer's additional or different terms and conditions. These Conditions supersede all prior communications, transactions, and understandings, whether oral or written, and constitute the sole and entire agreement between the parties

pertaining to the referenced quotation or purchase order, provided that: (1) these Conditions shall not, without LI-COR prior written consent, supersede any conflicting terms of: (a) prior written agreements duly executed by LI-COR, or (b) governmental purchase orders, terms of purchase, requests for quotation or acquisition regulations relative to governmental purchasers; and (2) to the extent not in conflict with any such prior or governmental terms, these Conditions shall supplement them. No modification, addition or deletion, or waiver of any of the terms and conditions of these Conditions shall be binding on either party unless made in a non-preprinted agreement clearly understood by both parties to be a modification or waiver, and signed by a duly authorized representative of each party.

20. Entire Agreement. These Conditions of Sale take precedence over Buyer's additional or different terms and conditions, to which notice of objection is hereby given. Acceptance by Buyer is limited to LI-COR Conditions of Sale. Neither LI-COR commencement of performance nor delivery shall be deemed or construed as acceptance of Buyer's additional or different terms and conditions. These Conditions supersede all prior communications, transactions, and understandings, whether oral or written, and constitute the sole and entire agreement between the parties pertaining to the referenced quotation or purchase order, provided that: (1) these Conditions shall not, without LI-COR prior written consent, supersede any conflicting terms of: (a) prior written agreements duly executed by LI-COR, or (b) governmental purchase orders, terms of purchase, requests for quotation or acquisition regulations relative to governmental purchasers; and (2) to the extent not in conflict with any such prior or governmental terms, these Conditions shall supplement them. No modification, addition or deletion, or waiver of any of the terms and conditions of these Conditions shall be binding on either party unless made in a non-preprinted agreement clearly understood by both parties to be a modification or waiver, and signed by a duly authorized representative of each party.

21. Force Majeure. Shipping dates are approximate and may be delayed absent prompt receipt from Buyer of all necessary information. LI-COR shall not be responsible for any failure to perform or delay attributable in whole or in part to any cause beyond its reasonable control, including but not limited to Acts of God, government actions, war, civil disturbance, insurrection, sabotage, labor shortages or disputes, failure or delay in delivery by LI-COR suppliers or subcontractors, transportation difficulties, customs clearance, shortage of energy, raw materials or equipment, or Buyer's fault or negligence. In the event of any such delay the date of delivery shall, at the request of LI-COR, be deferred for a period equal to the time lost by reason of the delay.

22. Governing Law and Venue. These Conditions and performance by the parties hereunder shall be construed in accordance with the laws of the State of Nebraska, U.S.A., without regard to provisions on the conflicts of laws.

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