



FL23 Algal CO2 Package Manual



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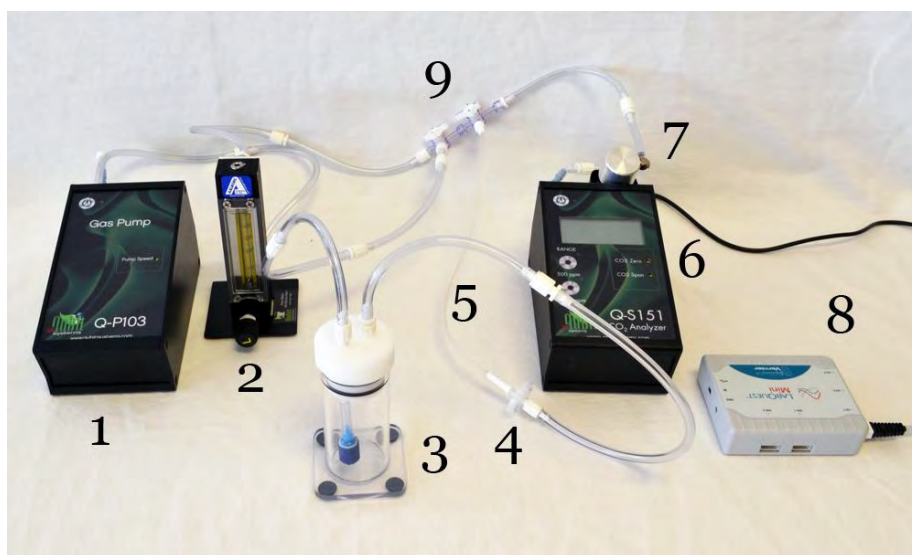
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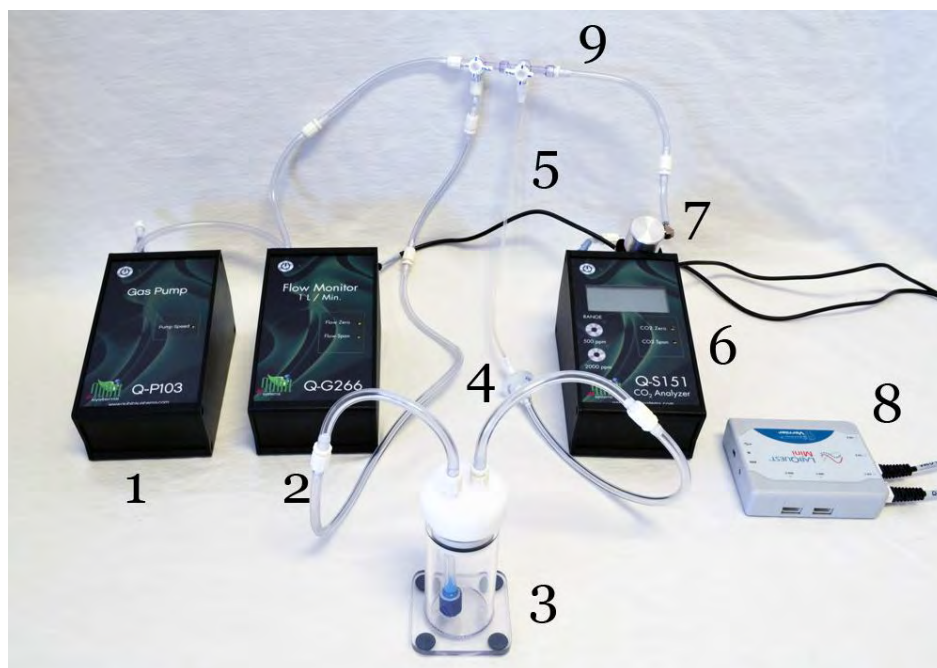
Introduction

The FL23 Algal CO₂ package is designed for measurements of CO₂ exchange from the head space above an algal suspension inside a flow-through chamber. The system uses an infrared CO₂ gas analyzer for measurements of CO₂ in the 0-2000ppm range. A carrier gas with constant CO₂ concentration is supplied to the algal chamber via a gas pump and a flow meter (or Flow Monitor; optional) at a known flow rate. The gas inlet of the chamber is attached to tubing with an air stone that is placed below the level of the liquid. The bubbling of the gas through the algal suspension releases dissolved CO₂ from the liquid to the head space of the chamber. Gas from the head space exits through the outlet of the chamber. The PTFE filter prevents liquid from entering the CO₂ analyzer. The water content of the wet effluent gas is first reduced by passing through the Nafion RH equilibrator. Next, the gas is dried further by the drying column before entering the CO₂ analyzer. The FL23 Algal CO₂ package can be used for measurements of photosynthetic CO₂ consumption when the algal suspension is illuminated. Also the package can measure CO₂ production during dark respiration. An optional calibrated LED light source (A113) can also be purchased from Qubit Systems.

System Outline

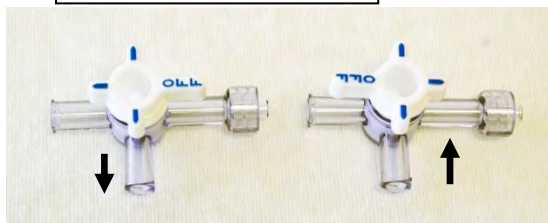
The photos below show the components of the FL23 Algal CO₂ Standard Package (with rotameter style flow meter) or enhanced package with the optional Flow Monitor. In the standard FL23 package, the flow of gas through the system is set and measured with the rotameter flow meter and therefore is not recorded in the software. In the enhanced FL23 Package the flow of gas is set and monitored by the Q-G266 Flow Monitor (1LPM) and it is recorded in the software.



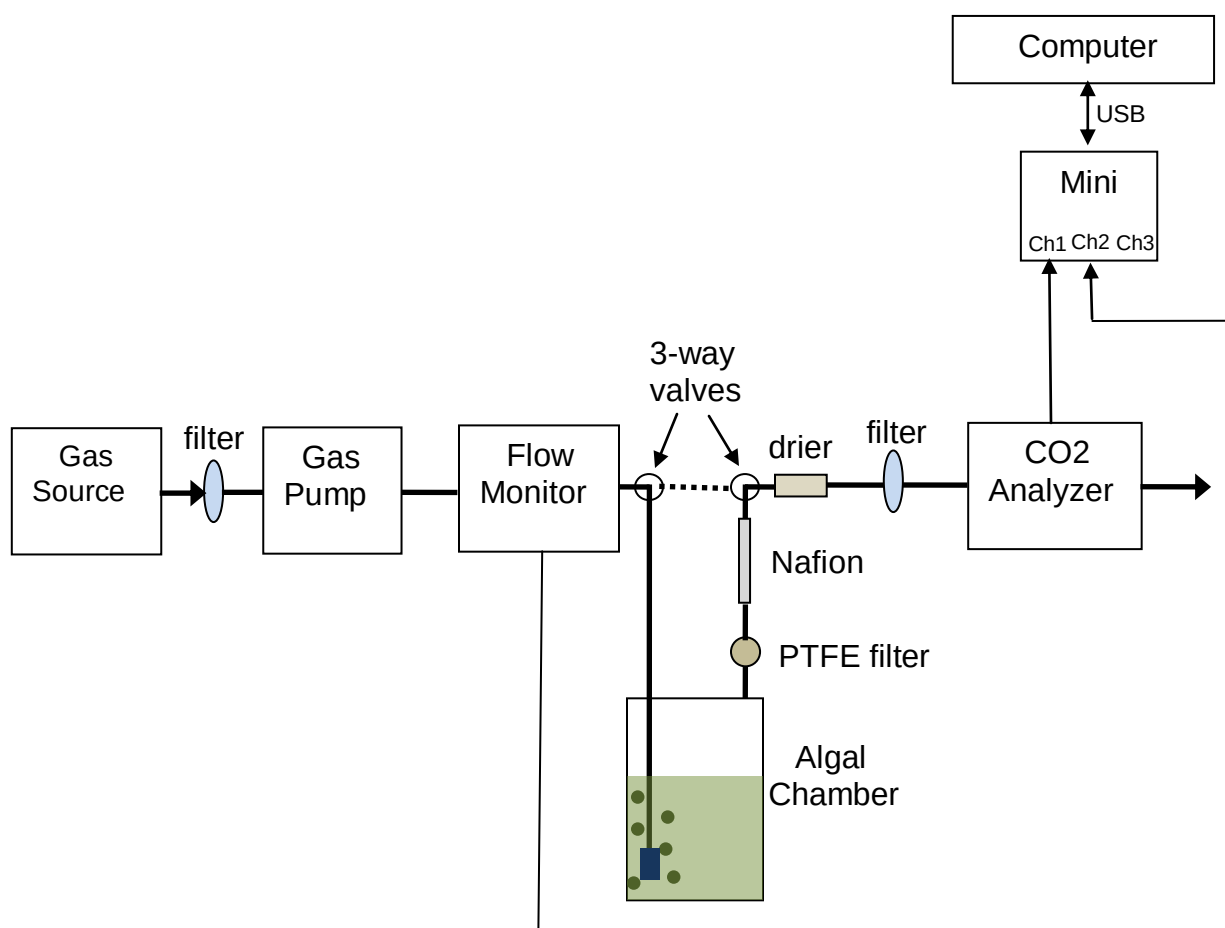
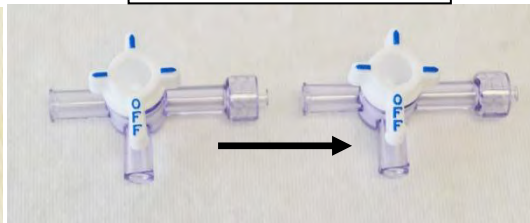


The carrier gas requires a constant CO₂ level such as in a commercial mixture or outside air (400 ppm). For calibration or short experiments, a gas bag filled with carrier gas can be connected to the gas pump Q-P103 (1) via the blue particulate filter (25um). For longer experiments, a direct line to outside air is suitable. If using a pressurized tank mixture, reduce the pressure to 1-2 psi with the regulator, bypass the pump and control the flow with the valve on the flowmeter (F-500) (2) or optional flow monitor (Q-G266) (2). When the Flow Monitor is used the flow rate will be recorded in the software. From the Flow Monitor or the Flow Meter, gas enters the Algal chamber (3). Gas exits the algal chamber via the PTFE filter (4) which stops any liquid getting into the CO₂ analyzer. The humidity of the wet headspace gas is equilibrated to atmospheric RH by the Nafion RH equilibrator (5). Nafion has a membrane permeable to water vapour but not to other gases such as CO₂. Equilibrated gas is further dried by the drying column filled with Drierite (7) before it enters the CO₂ analyzer. The drierite column is mounted on the back of the CO₂ analyzer. From the drying column, gas enters the Q-S151 CO₂ Analyzer (6) via the blue particulate filter where the level of CO₂ in the effluent gas is measured. This is a flow through system, hence gas vents from the CO₂ analyzer via the gas outlet. The analog signal from the Q-S151 CO₂ Analyzer (and the Flow Monitor Q-G266 if included) is digitized by the C610 LabQuest Mini data acquisition interface (8) under control of C901 Logger Pro software in the computer. The system also includes two three way valves (9) that can be used to re-direct the gas flow from going through the algal chamber (in sample position) or bypass the algal chamber (in reference position).

Valves deactivated gas
supplied to sample



Valves activated gas
bypassing sample

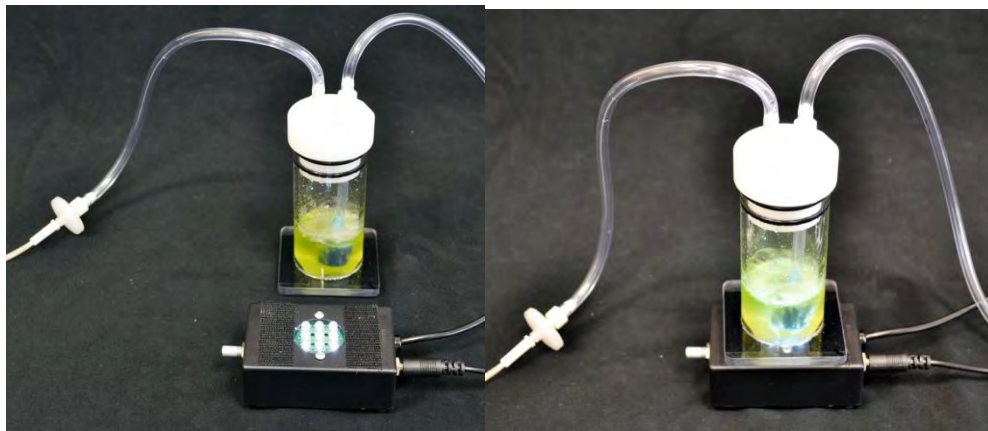


FL23 Algal CO₂ Components

1. Q-P103 Gas Pump (1LPM no load)
2. FL500 Flow Meter (40-500ml/min) or Q-G266 Flow Monitor (1LPM) (optional)
3. G211 Algal Chamber with an air stone
4. PTFE filter for trapping liquid that may enter the system (extra filter provided).
5. B301 Nafion RH equilibrator
6. Q-S151 CO₂ Analyzer (0-2000ppm) (soda lime CO₂ scrubber included)
7. Drying column (Drierite)
8. Data Interface (C610 LabQuest Mini; 3 channel)
9. Manual Three way valves (2)
10. C901 Logger Pro Data Acquisition Software
11. C404 Qubit Custom Set up Files
12. G122 Gas bags (2 x 30L)
13. Accessory Kit (tubing, connectors, wrench, screwdriver)
14. Instruction Manual

Other **optional components** include 1) the LED Light source (A113) calibrated in software for use with the alga chamber or 2) Halogen Light (A111) for illuminating the algal culture during measurements of photosynthesis as CO₂ fixation rate, and 3) the absolute pressure sensor (S181) for measurements of atmospheric pressure (used in calculations of the molecular flow).

Algal chamber with the optional A113 LED light source



C610 LabQuest Mini Data Interface

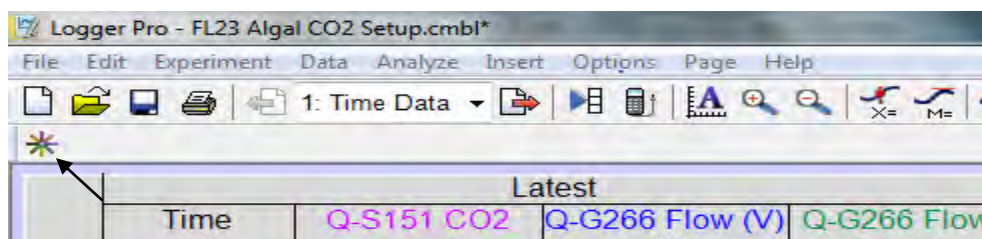
The C610 LabQuest Mini data acquisition interface works in conjunction with the C901 Logger Pro software. A LabQuest Mini can be used with a PC or Macintosh computer. The Mini interface has 5 independent channels: 3 analog and 2 digital. The digital channels can be programmed in Logger Pro in conjunction with a Digital Control Unit, for instrument control. The complete guides to the LabQuest Mini and Logger Pro are included in the package on the C404 disk.

To conduct measurements with the FL23 Algal CO₂ package, connect the C610 LabQuest Mini to a computer with the supplied USB cable. The Lab Quest Mini is powered from the computer via USB. When the connection is successful the LED on the interface turns orange first and then green once logger pro has been activated.

Installing and Running Logger Pro 3

PC Users:

- (1) To start, a complete copy of Logger Pro 3 must be installed on the computer. Before starting the installation, make sure all USB cables are disconnected from the computer. Failure to do so may cause an error in the installation of the USB drivers.
- (2) Run the installation and do not change the default destination directory. Logger Pro 3 will be installed in C:/Program Files/Vernier Software/Logger Pro 3.
- (3) The installation will automatically load the USB drivers for connecting the LabQuest Mini or other interfaces to the computer.
- (4) If QuickTime 6 (or greater) is not installed on the computer, install it when prompted. QuickTime will allow use of the picture and movie features of Logger Pro 3.
- (5) You will be prompted to connect the LabQuest Mini or other interfaces to the computer via the USB connection.
- (6) Click 'Finish' to complete the installation process.
- (7) Proceed to C404 installation (below) before opening the Logger Pro with the "FL23 Algal CO₂ Setup" file.
- (8) Double click the "FL23 Algal CO₂ Setup" file (create a shortcut on the desktop once moved from the C404 disk for easy access) to start Logger Pro and data collection. If Logger Pro detects the LabQuest Mini interface, the Logger Pro screen will appear with a star (icon for LabQuest Minis) in the top left corner.



- (9) If Logger Pro cannot detect the LabQuest Mini Interfaces a message will appear “no device connected”. Check that the LabQuest Mini is connected to the computer directly via USB. The LED on the Mini should be green. No LED light indicates that power is not supplied to the Mini - check power connections. A red LED indicates that power is on but there is no communication between the interface and the computer. In this case, exit the “FL23 Algal CO2 Setup” file and unplug the USB cable from the computer. Reconnect the USB. Allow the computer to recognize the Mini (bell tone) and then re-open the “FL23 Algal CO2 Setup” file.

Macintosh Users:

- (1) To start, a complete copy of Logger Pro 3 must be installed on the computer (Use at least OS 9.2). Run the “Complete Installation” and ensure all TI GRAPH_LINK and USB cables are disconnected . The most recent version of Logger Pro (3) is included with this package. The following instructions are the same as those for PC users.

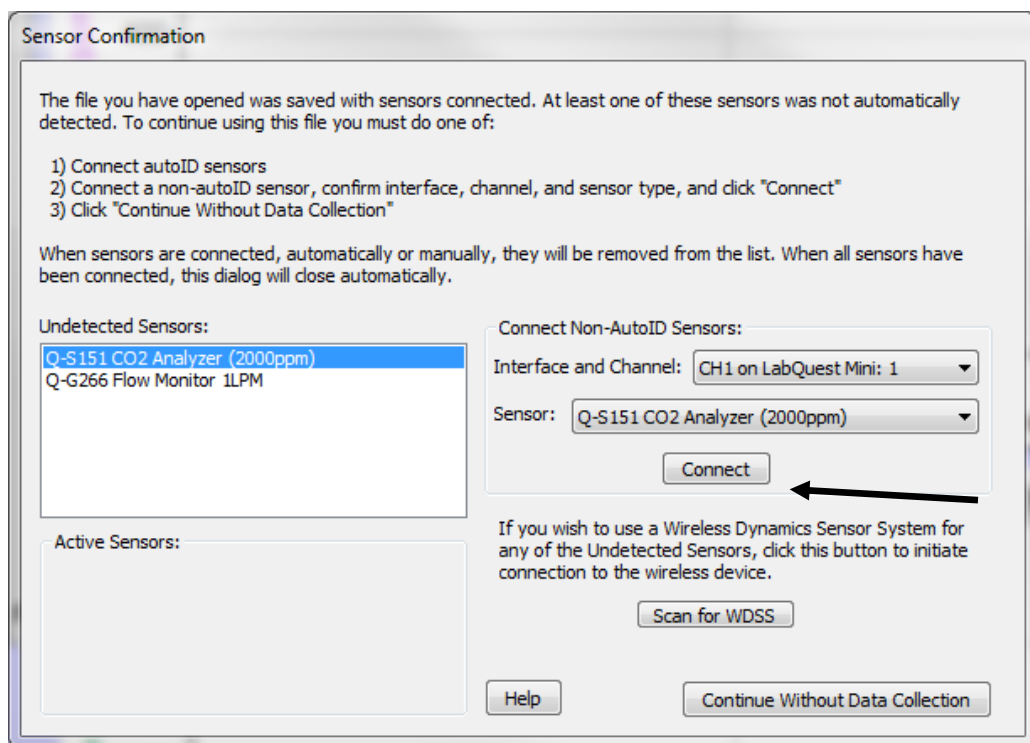
C404 Custom Setup Files Installation:

Qubit Systems’ C404 Custom Setup Files disk contains all of Qubit Experiment files (designed by Qubit Systems) including the “FL23 Algal CO2 Setup”. The Experiment files contain the setup (i.e. graphs, table, calculations etc) for the various experiments, as well as the calibration constants for the Qubit sensors. The C404 disk also contains manuals for the different Qubit sensors and packages. These files can be copied to a user specified location on the computer. The experimental file of interest, “FL23 Algal CO2 Setup”, should be placed in an accessible location or have a shortcut created on the desktop. It is recommended the user to make a copy of the original file and keep it in a safe place on the computer, in case the original is accidentally altered.

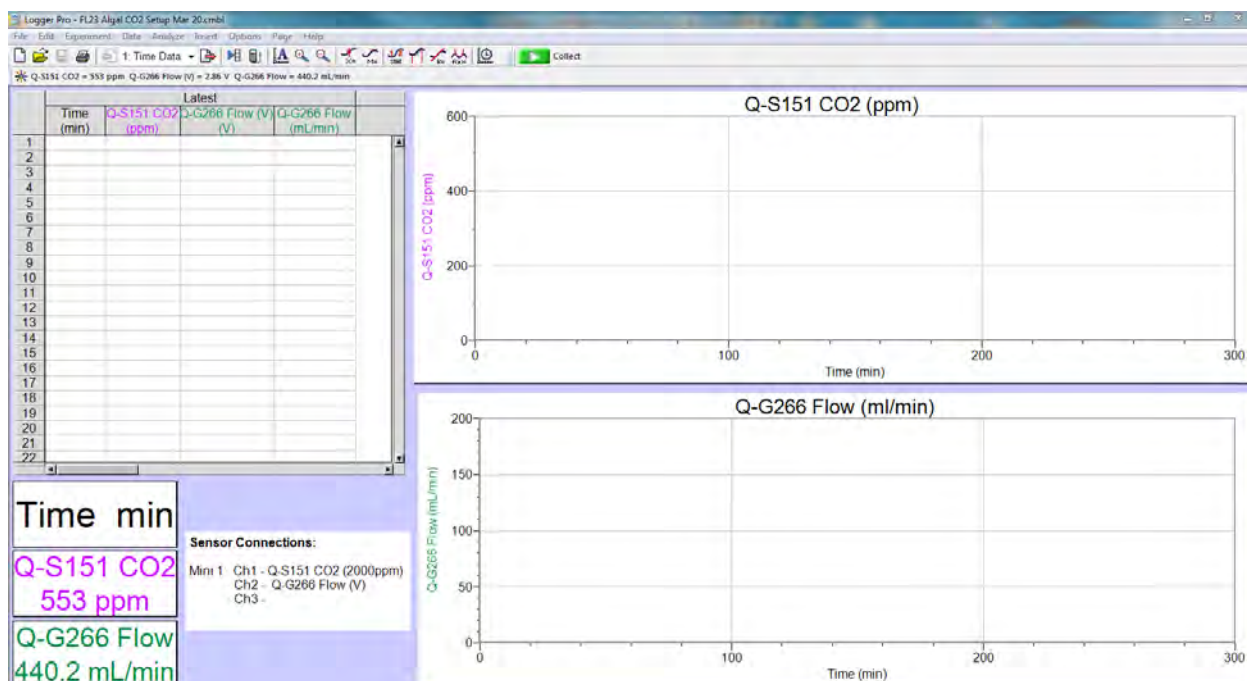
Data Collection with the FL23 Algal CO2 Package

To start data collection, the Logger Pro software and C404 Custom files must be loaded (see page 7 for instructions). Ensure the Q-S151 CO₂ Analyzer and Q-G266 Flow Monitor (optional) are connected into channels 1 and 2, respectively, of the C610 LabQuest Mini interface. Open the “FL23 Algal CO2 Setup”

file to start Logger Pro and “connect” the Q-S151 and Q-G266 sensors to channels 1 and 2, respectively (as shown in the window below).



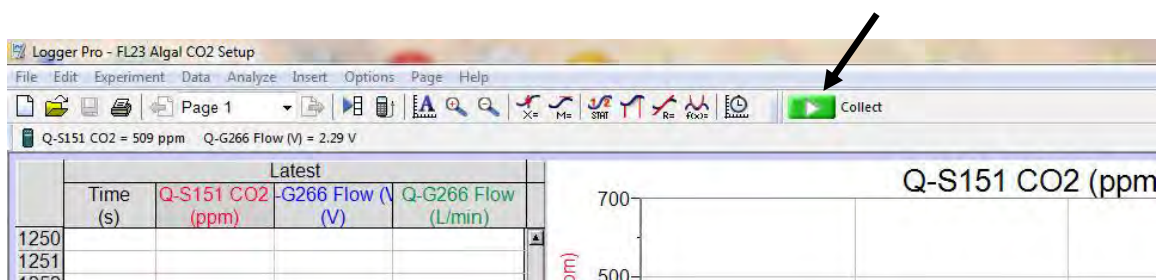
Once the Q-S151 CO2 Analyzer and Q-G266 Flow Monitor are selected, the following software screen will be displayed:



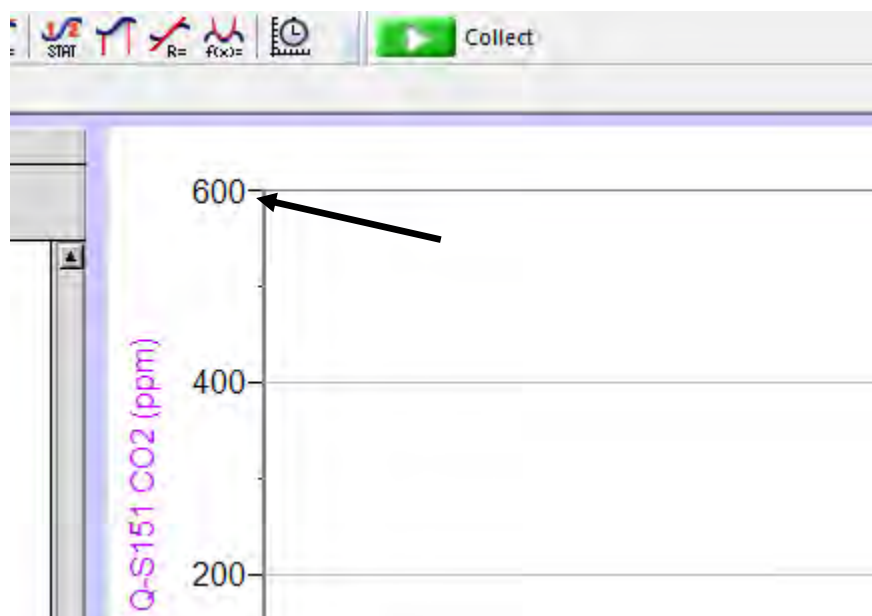
The meters in the left bottom corner will display values of CO₂ measured in ppm and flow rate (ml/min) adjusted with the gas pump and the flow monitor needle valves. These values are also displayed graphically and in a table.

Before collecting data, the user should save the file under a new name in a user specified location to ensure that the “**FL23 Algal CO2 Setup**” file is not overwritten. Before starting the experiment, the Q-S151 CO₂ analyzer should be checked for calibration. See detailed instructions on the calibration procedure below on page 14.

To start data collection, click the green “collect” button. To stop data collection manually, click the red “stop” button (the green button turns red once data collection starts). Otherwise collection will stop automatically when the experiment duration is reached, as selected below.

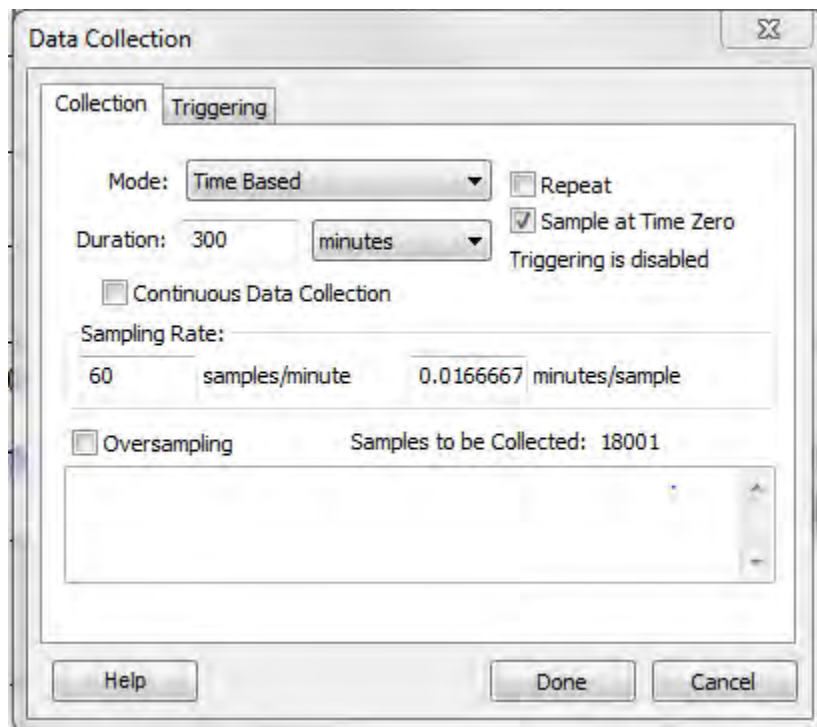


To manually modify the range of the x and y-axes, click on the maximum and/or minimum values of the graph and type in the new values.



To alter the duration of the experiment, or the rate of data sampling, select **Experiment>Data Collection** (or the clock icon in the menu). Enter the **length** of the experiment and select the units of time. Next,

select the **sampling rate** (default is 60 samples per minute). **Note the Experiment Duration limits the time for a particular run.**



If the experiment exceeds the allotted time, select **Experiment>Store Latest Run**. Then restart data collection. Data from the first part of the experiment will remain on the screen as a faint trace, and new data will be plotted in a bolded shade of the same colour. Numerous runs can be collected in this way, with each run written to a separate table. When the data is saved, all of the runs will be saved under the same file name.

Data Analysis with C901 Logger Pro

Logger Pro software has numerous analysis tools so data can be analyzed without exporting it into spreadsheet programs such as Excel. For more detailed instructions on how to perform data analysis in Logger Pro software, see the LoggerPro quick guide included with the software. Brief instructions follow:

- Position the cursor at the beginning of the data set that is to be analyzed, then click and hold with the mouse. See data figure below.
- Drag the cursor across the data set and unclick. A greyed box will appear on the screen to show the data range to be analyzed.

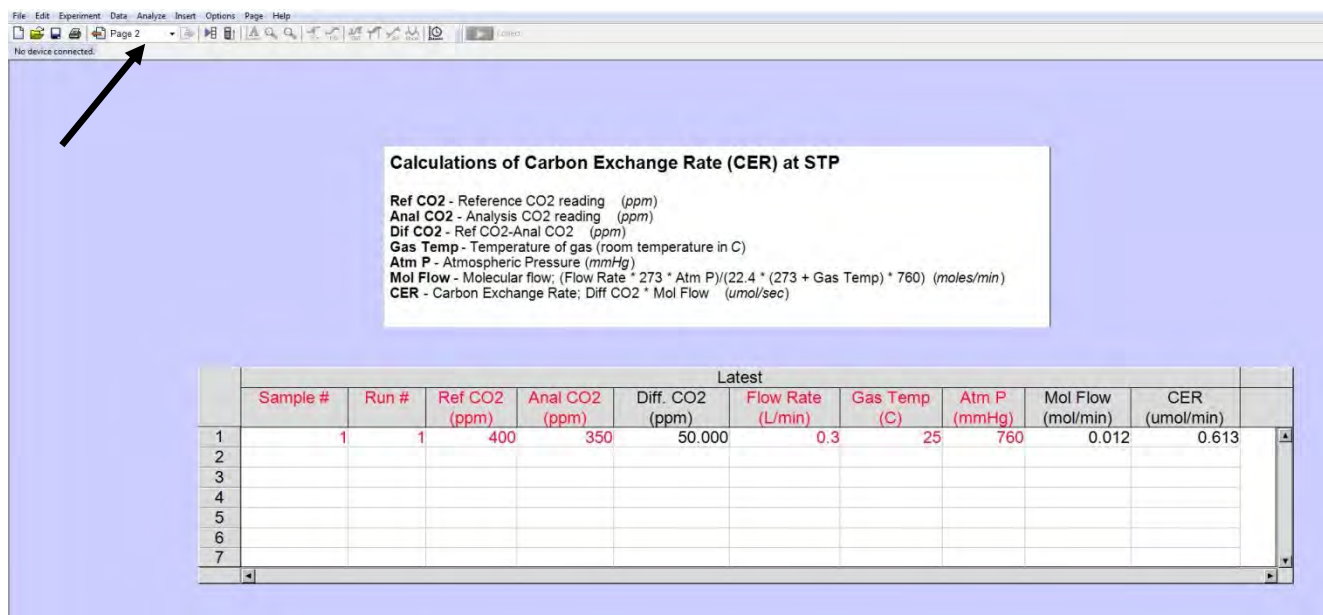
- Select “Analyze”, and then choose from a wide variety of analysis options or select from the shortcut icons in the main menu bar. For example, use:
- “Examine” to scroll through the data points at specific time intervals.
- “Integral” to integrate the selected data - no background subtraction.
- "Peak Integration" to integrate with background subtraction.
- “Statistics” to perform a variety of statistical analyses.



To export collected data from Logger Pro software for further analysis go to the main menu **File>ExportAs>Text** and provide it a file name. The text file created can be opened in any spreadsheet program for further analysis and manipulation.

Calculations of Carbon Exchange Rate (CER)

Calculations of the carbon exchange rate from the algal solution can be performed on page 2 of the **FL23 Algal CO2 Setup** file.



To calculate the carbon exchange rate (CER) in $\mu\text{mol CO}_2/\text{min}$, the values in red columns must be entered first. These can be obtained from page 1 where raw data is displayed, using the various analysis tools of Logger Pro described above.

The reference CO_2 level (*Ref CO₂*) is the background CO_2 in the gas that is supplied to the algal chamber. This can be measured at the beginning or end of the experiment by bypassing the algal chamber with the 3-way valves shown in the system diagram on page 5. The analysis CO_2 (*Anal CO₂*) is the level of CO_2 that is measured in the effluent gas from the algal chamber. With the algal culture illuminated, the Anal CO_2 will drop below the reference level since CO_2 is being fixed by the algae during photosynthesis. The difference between the Ref and Anal CO_2 (*Diff. CO₂*) is the differential CO_2 . A positive number indicates CO_2 uptake and negative number indicates CO_2 production (i.e. during respiration of the culture in the dark). The flow through the system, as measured by the F500 Flow meter (or recorded in the software by the Q-G266 Flow Monitor), is entered next along with the Gas Temperature (*Gas Temp*) (room temperature), and Atmospheric pressure (*Atm P*). The atmospheric pressure can be obtained from a local weather station via the internet, or the user may add an absolute pressure sensor (S181) to the package. The molecular flow (*Mol Flow*) calculation converts the flow from units of volume/min to units of moles/min at Standard Temperature and Pressure (0 °C, 760 mm Hg) using the following formula:

$$\text{Mol Flow} = (\text{Flow Rate} \times 273 \times \text{Atm P}) / (22.4 \times (273 + \text{Gas Temp}) \times 760)$$

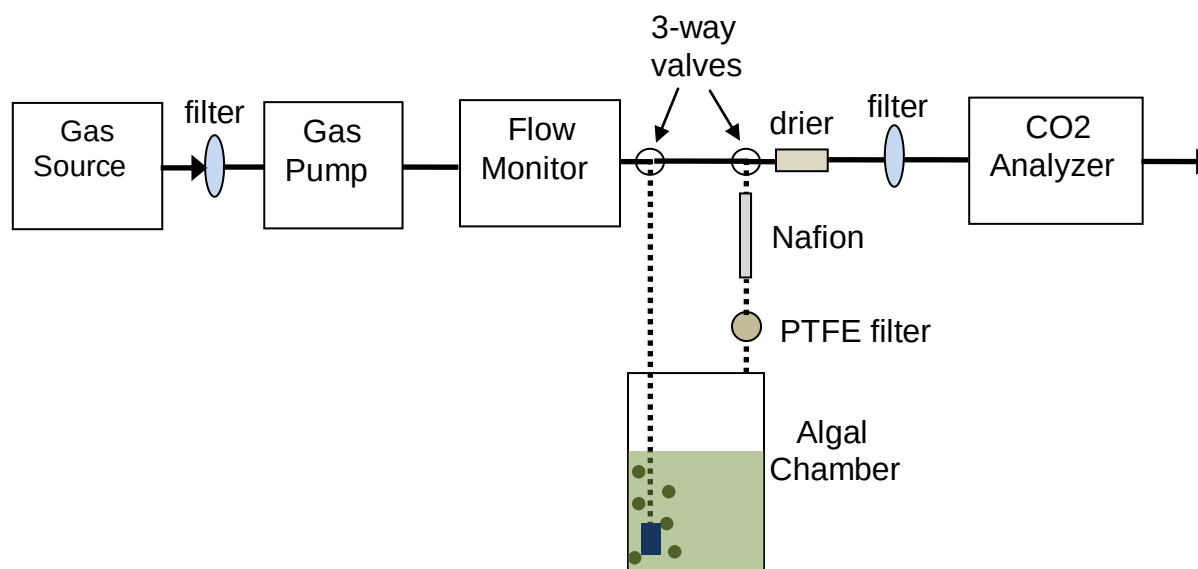
Where Flow Rate is in L/min, 273 is the absolute Temperature in °K, Gas Temp is the room temperature in °C, Atm P is atmospheric pressure in mm Hg, 760 is the standard pressure in mm Hg and 22.4 is the moles of gas/L under STP. CER in $\mu\text{moles}/\text{min}$ is then calculated as:

$$\text{CER} = \text{Diff CO}_2 \times \text{Mol Flow}$$

To calculate the CER per unit of chlorophyll, the chlorophyll content of the algal culture in the experiment must be determined and the calculation can be done by adding another column to the table.

Calibration of the Q-S151 CO₂ Analyzer:

The Q-S151 CO₂ analyzer is factory calibrated, however the analyzer output may drift over time. Therefore, regular calibrations checks and re-calibration are recommended. Gas with a known pCO₂ can be attached to the pump inlet and the 3-way valves adjusted to bypass the algal chamber, as shown in the diagram below.



The Q-S151 output is linear, therefore 2 points are sufficient for calibration. The zero CO₂ point can be obtained by using the white soda lime column provided with the analyzer, otherwise N₂ gas can be used for zeroing. Air is pumped through the column before it enters the drier and CO₂ analyzer to scrub CO₂ from the air. The second point of the calibration should be a standard gas of known CO₂ concentration near the highest concentration where the CO₂ analyzer will be used. Calibration gases containing a certified level of CO₂ may be obtained from gas supply companies. During factory calibration, the CO₂ Analyzer has been given an offset voltage of approximately 0.8 V at zero CO₂.

If the Q-S151 CO₂ analyzer is to be used regularly, it is recommended to keep it powered at all times. Allow the analyzer to warm up at least 15 min before use. When using the analyzer for the first time or after a storage period, a longer warm up time is recommended. The CO₂ analyzer is provided with the soda lime column (white) for scrubbing CO₂ and drierite column (blue) for drying the gas before it enters the analyzer. The blue filter (25µm) keeps particulates out of the CO₂ analyzer's optics. The soda lime column is used during calibration to scrub CO₂ from the air and obtain the zero reading. Place the drierite drying column in the holder on the back of the analyzer. Using the drying column ensures that

the gas entering the analyzer is dry, which will prevent water vapour in the gas from diluting CO₂. It is recommended that the Q-S151 CO₂ analyzer is calibrated at the flow rate that will be used during the experiments. **Ensure that the flow through the CO₂ Analyzer never exceeds 650ml/min.** Follow the steps outlined below during calibration:

- a) First, set the CO₂ analyzer in the 0 – 2000 ppm which is the default range for this package.



- b) Establish a zero CO₂ reading by pumping CO₂-free air through the Q-S151. This can be achieved by pumping room air through the soda lime column (white) and drying column (blue). If the Zero reading on the display of the CO₂ Analyzer does not read 000, the “CO₂ Zero” potentiometer on the front panel should be adjusted, using the small screwdriver provided. Turning the potentiometer clockwise will increase the reading on the analyzer and counter clockwise will decrease the reading.
- c) If the zero reading is highly out of range (by more than 40 ppm), or if the maximum or minimum position of the “CO₂ Zero” has been reached (i.e. turning the control has no effect), use the “Coarse Zero” on the back of the instrument to bring zero within range. **Use the “Coarse Zero” with caution since very small adjustments result in large changes and there is a delay in response to changes in “Coarse Zero”.** Use the Coarse Zero to bring the reading close to Zero. Then use the “CO₂ Zero” on the front of the analyzer to make the final zero adjustment. If it is necessary to use the Coarse Zero, it is best to first adjust the fine zero to the middle of its range. Do this by turning the “CO₂ Zero” potentiometer on the front of the analyzer clockwise or counter-clockwise by as many turns as is required to maximize its range (it will click when this is reached). Then turn the potentiometer twelve complete turns in the opposite direction. The CO₂ Zero control is then centered.

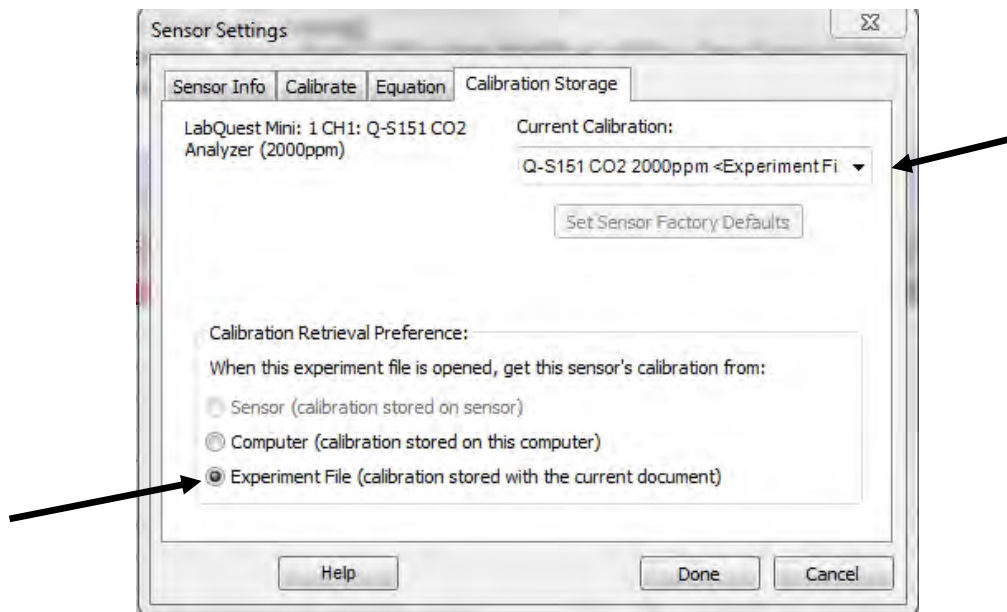


- d) Once the zero CO₂ level has been adjusted, remove the soda lime column from the gas line “IN” and attach a known CO₂ concentration, such as a gas bag, to the inlet of the gas pump. The known CO₂ level should be near the upper range of CO₂ to be measured. Outside air (400 ppm CO₂) can serve as this span gas. Once the CO₂ display becomes stable, this reading should match the concentration of the span gas. If the reading is not the same, adjust the “CO₂ Span” until the display corresponds to the concentration of CO₂ supplied.
- e) Following “CO₂ Span” adjustments, the zero CO₂ reading should be rechecked. If this still reads zero, the calibration is complete. If it no longer reads zero, reset it and recheck the span reading by supplying the calibration gas to the CO₂ Analyzer. Adjust the span and the zero until correct values are displayed.

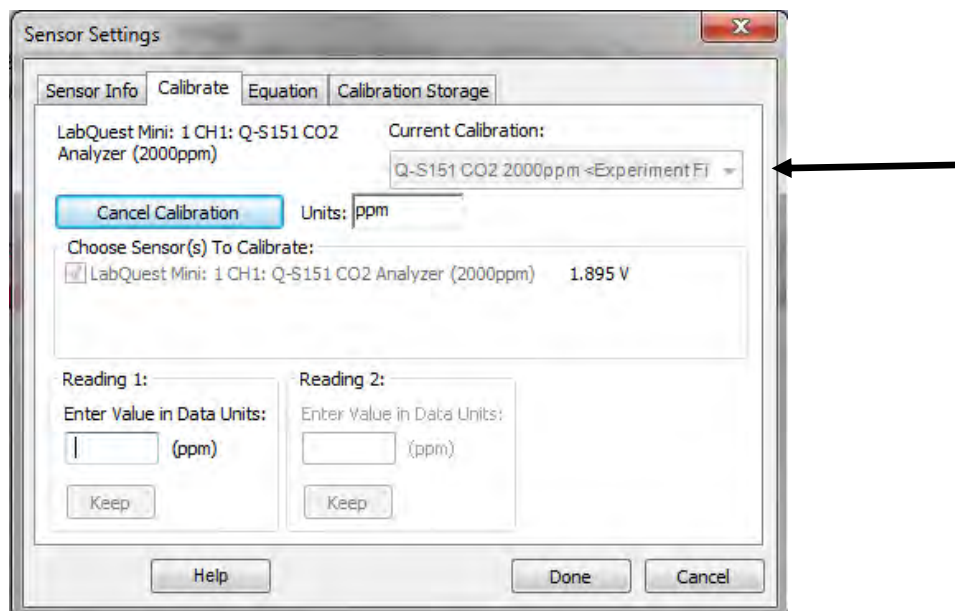
Calibration of Q-S151 CO₂ Analyzer in Logger Pro Software:

When the Q-S151 CO₂ Analyzer is used with a data acquisition interface and Logger Pro software, the calibration of the analyzer should be checked while the analyzer is connected with the Logger Pro Software. Refer to instructions on how to load Logger Pro software and custom set up files from the C404 disk before logging Q-S151 data or calibration. Follow the steps outlined below for calibration of the Q-S151 in Logger Pro.

- a) Set the CO₂ analyzer in 0 – 2000 ppm range which is default range is 0-2000 ppm.
- b) Supply CO₂ free – air to the analyzer by attaching the soda lime column to the CO₂ analyzer as described above to obtain the first point of the calibration – zero CO₂.
- c) From the main menu in LoggerPro Software select **Experiment>Calibrate>LabQuest Mini Q-S151 CO₂ Analyzer 200ppm**. A dialog box will appear as shown below. Select the calibration storage as “Experiment File” so the calibration is saved with the current file.



- d) Proceed to **“Calibrate”** in the same window (see below). Ensure the Current Calibration is selected as **“Q-S151 CO₂ Analyzer 2000ppm <Experiment**. This selection will ensure that the calibration is saved with the experiment file.



- e) When the reading on the CO₂ analyzer is stable, use the small green screwdriver provided to adjust the “CO₂ Zero” control on the analyzer and set the digital display to read 000 CO₂.
- f) In software, enter “**Reading 1**” as 0. Click “Keep”



- g) If the zero reading is highly out of range (by more than 40 ppm), or if the maximum or minimum position of the “CO₂ Zero” has been reached (i.e. turning the control has no effect), use the “Coarse Zero” on the back of the instrument to bring zero within range. Follow the instructions above for adjusting the coarse zero.
- h) Once the zero CO₂ (reading 1) has been recorded, remove the soda lime column and attach known CO₂ gas to the “In” port of the Gas Pump.
- i) If the Q-S151 display does not show the concentration of CO₂ in the calibration gas, adjust the display using “CO₂ Span” control. When the Q-S151 CO₂ analyzer display shows the correct CO₂ concentration, enter that concentration as “**Reading 2**” in software and click “**Keep**” then “**Done**”. **Save the file under a new name so the new calibration is saved with the current experiment file.** The CO₂ reading in the Logger Pro CO₂ meter should now be the same as those on the digital display of the CO₂ analyzer.
- j) If a significant adjustment had to be made to “CO₂ Span”, go back to the zero check and ensure the zero reading on the analyzer has not shifted. It is not necessary to do this zero check while in the calibration mode of the software.

- k) If the readings on the Q-S151 display match the readings in Logger Pro for CO₂, then calibration of the CO₂ analyzer can be done without being in the calibration mode of the software. That is, only the Q-S151 CO₂ analyzer requires calibration as described above.

Q-P103 Gas Pump

The Q-P103 Gas Pump is a 1L/min (no load) pump. It is used to pump the carrier gas from the gas source in to the Algal Chamber and the Q-S151 CO₂ Analyzer.



The Q-P103 Gas Pump is delivered with a pre-set pump speed. The two needle valves on the back of the pump are locked to maintain that speed. The flow through the system should be adjusted with either the needle valve of the Flow Meter (F500) or the needle valve of the Q-G266 Flow Monitor (optional).

If the pump is used in a stand-alone mode and the pump speed needs to be adjusted, this can be done with the two needle valves on the back. To set the flow rate with the gas pump, fully open both needle valves (turn counter-clockwise). Adjust the flow to about twice the required rate using the valve beside the pump outlet (“out”). Next, reduce the flow the required rate with the needle valve beside the “in” gas port (see photo below).



Once the flow is adjusted to the desired rate, use the small wrench provided in the accessory pack to lock both valves of the gas pump in place.



F500 Flow Meter

The F500 Flow meter is a rotameter which can monitor and adjust the flow in the range of 50 to 500 ml/min. This flow meter is supplied with the standard FL23 Algal CO₂ package. It is placed between the pump and Algal Chamber. To adjust the flow through the system, turn the needle valve on the bottom of the Flow Meter clockwise to reduce the flow, and anti-clockwise to increase the flow. The flow measured by the F500 flow meter is not logged, therefore this flow meter needs to be monitored throughout the experiment for any changes to the pre-set flow rate.



Q-G266 Flow Monitor 1L/min (optional)

The Q-G266 Flow Monitor is a mass flow meter with a 0-5V analog output that can be logged in software. It has been factory calibrated and should not require additional calibration. However, with time the zero may drift. To reset zero, adjust “Flow Zero” with no gas running through the system until a zero value is reached in Logger Pro. **Do not accidentally adjust the “Flow Span”**. If “Flow Span” needs adjusting, a known flow of a standard gas is required



When the Q-G266 Flow Monitor (optional) is included in the FL23 Algal CO₂ package, it should be used to adjust and record the flow. When adjusting the flow with the flow monitor, use the needle valve on the back of the monitor. Once the flow is set to the desired rate, lock the needle valve in position with the locking nut using the small wrench provided.



G122 Large Gas Bags

The 30 L gas bags are made from a gas-impermeable nylon-polyethylene laminate and are heat-sealed. Tygon tubing is attached to each bag by a luer-lock fitting. These bags can be filled with outside air to provide a constant source of CO₂ (400 ppm). Alternatively, a gas mixture with a suitable CO₂ concentration can be used. Bags should not be over-inflated, since this can weaken the seams and cause leakage. After use, the bags should be fully deflated, preferably by attachment to a vacuum-line. Note: do not use room air directly as the gas supply to the system as the CO₂ levels are not stable in room air. Fill the gas bag with room air first and then use it to supply gas to the algal chamber. Gas bags can be filled with room air or outside air by attaching the gas pump outlet to open gas bag inlet and running the gas pump backwards.

Using the Q-S151 CO₂ Analyzer

The Q-S151 CO₂ Analyzer is a non-dispersive infrared gas analyzer (IRGA). The gas supplied to the IRGA passes through a sealed wave guide and vents from the outflow port. The Q-S151 can be used as a stand-alone analyzer in an open or closed-circuit gas exchange system, and can be used with other gas analyzers downstream. However, ensure placement of an analyzer downstream does not cause a significant increase in backpressure in the Q-S151. Increasing pressure significantly beyond that at which the IRGA was calibrated, produces erroneous readings since it is not pressure corrected.

The maximum flow of gas through the Q-S151 should not exceed 650 mL/min. It is recommended that the Q-S151 is calibrated at the flow to be used during experiments.

Gases entering the Q-S151 must be clean and dry, since particulate matter may absorb infrared radiation and cause erroneous readings. Water vapour will not interfere with the IR absorption by CO₂, but it will dilute the CO₂ concentration. Most of the water vapour in the sample gas may be removed by passing it through a tube placed in an ice-water bath (not included). The remainder may be removed by flowing the gas through a drying column containing DRIERITE (included). Poly wool plugs at the ends of the column are required to filter particulate matter.

The FL23 Algal CO₂ Package is provided with the Nafion RH equilibrator which will reduce the high water content of the gas exiting the Algal chamber to the ambient room level. The gas is dried further by the Drierite column.

The Q-S151 CO₂ Analyzer requires 12 Volts DC power to operate. A 120/220 AC power adaptor (included) provides 12 Volts DC. For continuous use or regular, leave the Q-S151 powered

Caution: Use the 12 V DC adapter with the correct AC line voltages. A 120/220 VAC 50/60 Hz 12 VDC adapter is supplied by QUBIT SYSTEMS.

The unit requires 2-3 minute warm-up before the CO₂ level will be displayed. During warm-up, the LCD will flash numbers briefly, then display a "1". After warm up, the LCD will display a very high reading, which will slowly decline to the CO₂ level in the gas stream provided to it. For most accurate and stable readings, Q-S151 should be warmed up for a minimum of 15 min to 1 hour before use

Altitude and Barometric Pressure Correction

The Q-S151 is factory calibrated at sea level. When using the IRGA at elevations other than sea level, **calibrate at the elevation at which the analyzer will be used.** If this is impossible, correct the CO₂ reading according to the table below. For example, when using a factory-calibrated unit at an altitude of 2,500 feet, multiply the displayed CO₂ reading by 90%. For example, with a reading of 1000 ppm, the corrected CO₂ concentration is $1,000 \text{ ppm} \times 0.90 = 900 \text{ ppm}$.

Altitude (feet)	Pressure (inches Hg)	Pressure (mm Hg)	Pressure (psia)	% Display Reading
0 sea level	29.92	759.78	14.70	100
500	29.38	746.04	14.43	97.97
1000	28.86	732.84	14.18	95.94
1500	28.34	719.64	13.92	93.91
2000	27.82	706.43	13.66	91.88
2500	27.32	693.73	13.42	89.84
3000	26.82	681.04	13.17	87.81
3500	26.32	668.34	12.93	85.78
4000	25.82	655.65	12.68	83.75
4500	25.36	643.96	12.46	81.72
5000	24.90	632.28	12.23	79.69

For other altitudes, use the following equation:

Percentage of measured CO₂ = [1 - (4.06234 x 10⁻⁵ x Altitude in feet)] x 100

Drying Column

The Q-S151 is designed to analyze dry gas. A desiccant column is provided which is filled with DRIERITE to dry the gas before analysis. The column is supplied ready for use and should be mounted **vertically** on the back of the Q-S151 to ensure maximal contact of the flowing gas with the DRIERITE. DRIERITE contains a cobalt indicator that is blue when it is functional and pink when it has absorbed moisture. When spent, the DRIERITE should be replaced or reconditioned. To recondition, remove the DRIERITE from the column and place it in a thin layer in a drying oven at 210°C for 1 hour, or until the pink coloration disappears.

The replacement DRIERITE is #8 mesh order #23005 from drierite.com.

Magnesium perchlorate is an alternative drying agent which is more effective than Drierite. However, magnesium perchlorate will harden and then liquefy if it absorbs too much moisture, so it must be monitored and changed when it hardens. It is recommended that a trap is installed downstream if using magnesium perchlorate. A PTFE filter is supplied with the FL23 Algal Package for this purpose.

Note: Qubit Systems is not responsible for any damage caused to any components due to magnesium perchlorate entering any part of the system.

Soda Lime Column

CO₂ free gas for zeroing during calibration, is obtained by pumping air through the supplied column containing soda lime. The column should also be used in a **VERTICAL** position, as for the drying column. The soda lime has a coloured indicator to show when it is spent. The soda lime should be replaced when most of it has changed from its original white colour to a pale purple. This colour change is subtle, and the purple coloration often does not persist, but appears as a band in the column at the junction between active and inactive soda lime.

Replacement supplies may be obtained from **Fisher Scientific (product #S200I-3)**.

When refilling the column, a glass wool plug should be placed towards the outlet of the column. Refill with soda lime using a spatula or funnel. When the column is full, tap it on a hard surface to settle the soda lime, and then top off with further soda lime. Insert a second wool plug and close the column. When not in use, the two ends of the column should be reattached with short tubing to prevent depletion of the soda lime by room air diffusing into the column.

Note: remove the soda lime column from the system once calibration has been completed.

Warning: Soda lime can cause severe burns. Users should read and comply with the Material Safety Data Sheet on soda lime.

Troubleshooting the Q-S151:

The LCD display will not stabilize during operation:

This may indicate the unit is not getting the required 12V power. Unplug the power cord from the unit and measure the DC voltage at the plug; it should measure 12 Volts DC. If using an alternative DC power source, the unit will operate with 12 to 15 Volts. If the provided power supply is not supplying 12 Volts DC, contact QUBIT SYSTEMS.

Insufficient power may cause a “1” to appear on the display:

Check that the power supply is properly connected and is delivering +12 Volts (Centre Positive). Confirm that +12 Volts DC is being provided by measuring the voltage with a meter at the plug that connects to the CO₂ analyzer. Once proper power is restored, give the unit 7 minutes to warm up and start displaying meaningful CO₂ readings.

Span or zero out of range may cause “1” to appear on the display:

Use the “Coarse Zero” on the back of the CO₂ analyzer to display a zero reading with zero CO₂ gas flowing through the analyzer. Once a zero display is achieved, attach a known CO₂ concentration span

gas to the system and use “CO₂ Span” to adjust the display on the CO₂ analyzer to the correct CO₂ concentration. Recheck the CO₂ zero with zero CO₂ gas flowing through the analyzer, and if necessary make small adjustments with the fine “CO₂ Zero”.

Ensure no material (liquid or dust) has entered the analyzer:

If material (eg. liquid or dust) has entered the analyzer it will block the internal IR path and a “1” will be shown on the display. The unit will need to be returned to QUBIT Systems for repair.

Ensure the Gas Flow Path in the Analyzer is Open:

Check that there are no internal leaks in the analyzer. If the analyzer is exposed to extreme pressures a leak can result. Connect a 10mL syringe to a tube connected to the ‘OUT Port’ of the CO₂ analyzer and plug the ‘IN Port’. Pull a slight vacuum with the syringe. If there are no leaks the vacuum should persist as felt at the plunger. If there is an internal leak contact QUBIT Systems for further instructions.

Ensure the Soda Lime CO₂ Scrubbing Column is used to provide Zero CO₂ gas to the analyzer:

Do not confuse the soda lime column with the drying column filled with Drierite. Soda Lime is white. Drierite is blue and turns pink when it is spent. If unsure of the condition of the Soda Lime in the column, replace it with new Soda Lime or use an alternate Zero CO₂ source such as pure N₂ gas.

Check Calibration

If the CO₂ Span control has been adjusted without following a full calibration procedure, the analyzer must be recalibrated using a span gas mixture with a known CO₂ level. See the CO₂ analyzer calibration section of this manual for the correct procedure.

Specifications of Q-S151 CO2 Analyzer:

- Operating principle - Non-dispersive infrared
- Gas sampling mode - Flowing gas stream, sealed chamber
- Maximum gas flow - 650 mL/min
- Measurement range (LCD display)- 0 – 1999 ppm
- Two ranges of Analog output, 0 – 2000 ppm and 0 – 500 ppm
- Accuracy - ± 1 ppm
- Repeatability (at stable atm press and temp)- Better than ± 1 ppm
- Maximum drift (per year) - ± 100 ppm
- Response time (@ 250 mL/min; to 95% of final value) - ca. 25 sec
- Warm up time (@ 22°C) – ca. 15 min
- Output (linear) for Low Sensitivity setting – 0 – 5 VDC for 0 – 2000 ppm
- Output (linear) for High Sensitivity setting – 0 – 5 VDC for 0 – 500 ppm
- Calibration adjustments – Zero and Span
- Operating temperature range – 0 to 50°C
- Storage temperature range - -40 to 70°C
- Operating pressure range - $\pm 1.5\%$ local mean pressure
- Humidity range - 5 to 95% RH, non-condensing (recommend drying gas stream)
- Pressure dependence – $+0.19\%$ reading per mm Hg
- Power requirements- 12 VDC via 120 VAC/60 Hz adapter
- Current requirements – 125 mA average, 450 mA peak
- Dimensions (cm) – (H x W x D: 5.5 to 9.5 x 9.5 x 17)
- Weight - 1kg
- Warranty - 1 year limited

Qubit Systems Warranty Information

QUBIT warrants all its instruments to be free from defects in materials or workmanship for a period of **one year** from the date of invoice/shipment from QUBIT.

If at any time within this warranty period the instrument does not function as warranted, return it and QUBIT will repair or replace it at no charge. The customer is responsible for shipping and insurance charges (for the full product value) to QUBIT. QUBIT is responsible for shipping and insurance on return of the instrument to the customer.

No warranty will apply to any instrument that has been (i) modified, altered, or repaired by persons unauthorized by QUBIT; (ii) subjected to misuse, negligence, or accident; (iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions supplied by QUBIT.

The warranty is return-to-base only, and does not include on-site repair charges such as labour, travel, or other expenses associated with the repair or installation of replacement parts at the customer's site.

QUBIT repairs or replaces the faulty instruments as quickly as possible; maximum time is one month.

QUBIT will keep spare parts or their adequate substitutes for a period of at least five years.

Returned instruments must be packaged sufficiently so as not to assume any transit damage. If damage is caused due to insufficient packaging, the instrument will be treated as an out-of-warranty repair and charged as such.

QUBIT also offers out-of-warranty repairs. These are usually returned to the customer on a cash-on-delivery basis.

Wear & Tear Items are excluded from this warranty. The term Wear & Tear denotes the damage that naturally and inevitably occurs as a result of normal use or aging even when an item is used competently and with care and proper maintenance.

Return Procedure

Before returning any instrument to QUBIT:

Consult the operating manual or contact Qubit to ensure that the instrument(s) is in fact faulty and has not just been set up improperly.

Contact QUBIT before sending anything back. We will issue an RMA number and provide shipping instructions. QUBIT will refuse any goods that are returned without an RMA number, or which are sent in a manner outside of QUBIT'S stipulations.

If you have encountered a program failure, we need a printed copy of any faults you have seen, including how to reproduce them. Include these in the return package along with your mailing address.

Include a copy of the Invoice on which the product was shipped to you.

All returns must be shipped prepaid. Unpaid packages will not be accepted.

In case of questions contact QUBIT by

E-mail: info@qubitsystems.com,

by phone: (01)-613 384 1977,

or by fax: (01)-613 384- 9118.