Q-Box RP2LP High Range Respiration Package

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Overview of Q-Box RP2LP High Range Respiration Package:

The Q-Box RP2LP package provides the user with all the materials required to measure the metabolic rate of medium-sized animals such as mammals, reptiles, and amphibians in an open-flow gas exchange system.

The concentration of CO_2 and O_2 in the gas supplied to the flow-through animal chamber or flask is measured using a Q-S153 infrared CO_2 gas analyzer (IRGA; 0 to 10%) and a fuel cell Q-S102 O_2 Analyzer (0 to 100KPa). The gas is pumped at a measured flow rate (adjusted by the Q-P651 Gas Pump and Q-G265 Flow Monitor) through the chamber containing the subject material. The concentration of CO_2 and O_2 in the outflow gas is determined using the Q-S153 CO_2 Analyzer and Q-S102 O_2 Analyzer. Analog signals from all the sensors are converted to digital signals via two integrated interfaces (6 available channels). Data are displayed, recorded and manipulated on a PC or Macintosh computer using Logger Pro software. Changes in the concentrations of CO_2 and O_2 in the outflow gas are monitored in real time. Metabolic rate is calculated from the change in O_2 and CO_2 and the flow rate directly in the software using provided calculation templates.

The Q-Box RP2LP also includes a temperature sensor (S132) which can be placed inside the animal chamber and allows investigations into the effect of temperature on metabolic rate. Metabolic rates measured at different temperatures can be corrected to a standard temperature, assuming a given Q_{10}.

The Q-Box RP2LP Package can be used to investigate animal metabolic responses to exercise, to different diets, to the administration of pharmaceuticals and to various concentrations of O_2 and CO_2 in the gas supplied to the sample chamber. Gas mixtures can be supplied via 2 large gas bags (G122 included with the system) or, for longer term experiments such as hibernation studies, from a compressed gas source.

Other potential applications for the RP2LP package include measurements of human respiration and metabolic activity. This requires the addition of a pneumotach spirometer, exercise heart rate monitor, face masks and accessories as supplied in the Q-Box HR1LP Human Respirometry Package.

Components of Q-Box RP2LP:

Q-S153 CO_2 Analyzer (Range: 0-5% and 0-10%)

Q-S102 O_2 Analyzer with pressure sensor (Range: 0-25KPa and 0-100KPa)

Drying columns for Q-S153 and S102 with Drierite (blue) (x3) (Q11784)

CO_2 scrubbing column with soda lime (white) (Q13025)

Q-G265 Flow Monitor (Range: 0 -2 LPM)

Q-P651 Gas Pump (3 LPM no load)

G114 Flow-through Animal Chamber (8.5 cm ID x 20 cm)

S132 Stainless Steel Temperature Probe

2 x G122 Large Gas Bag (30 Litres)

G127 T-Piece Assembly (T-Piece, needle valve, tubing)

F250 Flow meter

Integrated C610 LabQuest Mini Data Acquisition Interfaces, 6 analog channels (x2)

C901 Logger Pro Data Acquisition Software

C404 Customized Setup Software

Q-Box Accessory Kit (includes tubing, filters, connectors, wool, wrench for needle valve adjustment, small screwdriver for adjustment of analyzers, Qubitac sealant, vacuum grease, two-way valves x2 for switching between ref. and sample)

Manual

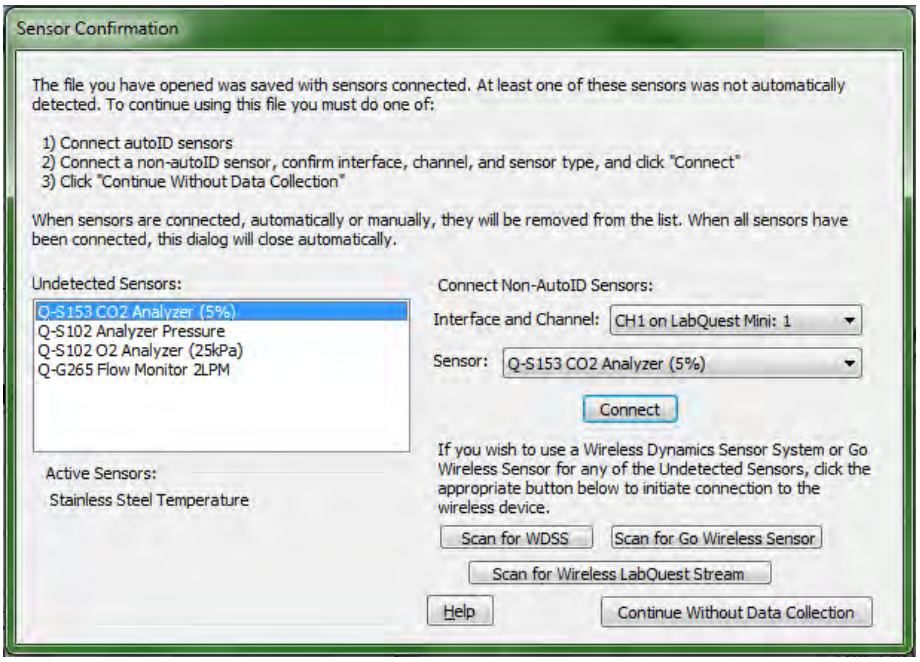
Individual power supplies for all the sensors (for use in stand-alone mode outside of the Q-Box)

Rugged weather-proof case

A249 Battery Pack for field work (**OPTIONAL**)

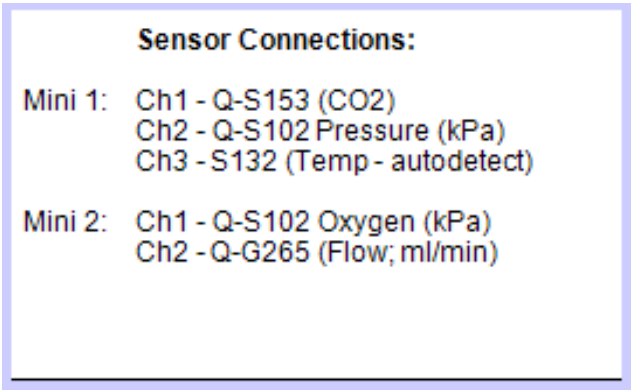
Quick Start Up Steps:

1. Load Logger Pro 3 software onto the computer (follow instructions on pg. 22).
2. Load C404 customized files (follow instructions from pg. 24)
3. Plug the Q-Box into a power supply (or into an optional A249 Battery pack for field use)
4. Turn on the Q-P651 pump, Q-G265 flow monitor, Q-S153 CO_2 analyzer and Q-S102 O_2 analyzer
5. Ensure that the Q-S153 is set for 5% range and Q-S102 is set for 25KPa range.
6. Allow the Q-S153 CO_2 and Q-S102 analyzers to warm up for at least 30 min or longer.
7. Connect two USB cables from the Q-Box frame to the computer. Two audible sounds from the computer may be heard as the two interfaces are recognized. **Ensure that USB1 is plugged in first and USB2 is plugged in second. This is critical in ensuring that the two interfaces are recognized in the correct order.**
8. Open the "**Q-Box RP2LP Setup**" file to start Logger Pro software. The following screen will appear.



9. Assign the sensors to appropriate channels on the 2 interfaces as follows:
    a. Ch. 1 LabQuest Mini 1 = Q-S153 CO_2 Analyzer (5%)
    b. Ch. 2 LabQuest Mini 1 = Q-S102 Analyzer Pressure (kPa)
    c. Ch. 1 LabQuest Mini 2 = Q-S102 O2 Analyzer (25kPa)
    d. Ch. 2 LabQuest Mini 2 = Q-G265 Flow Monitor 2LPM

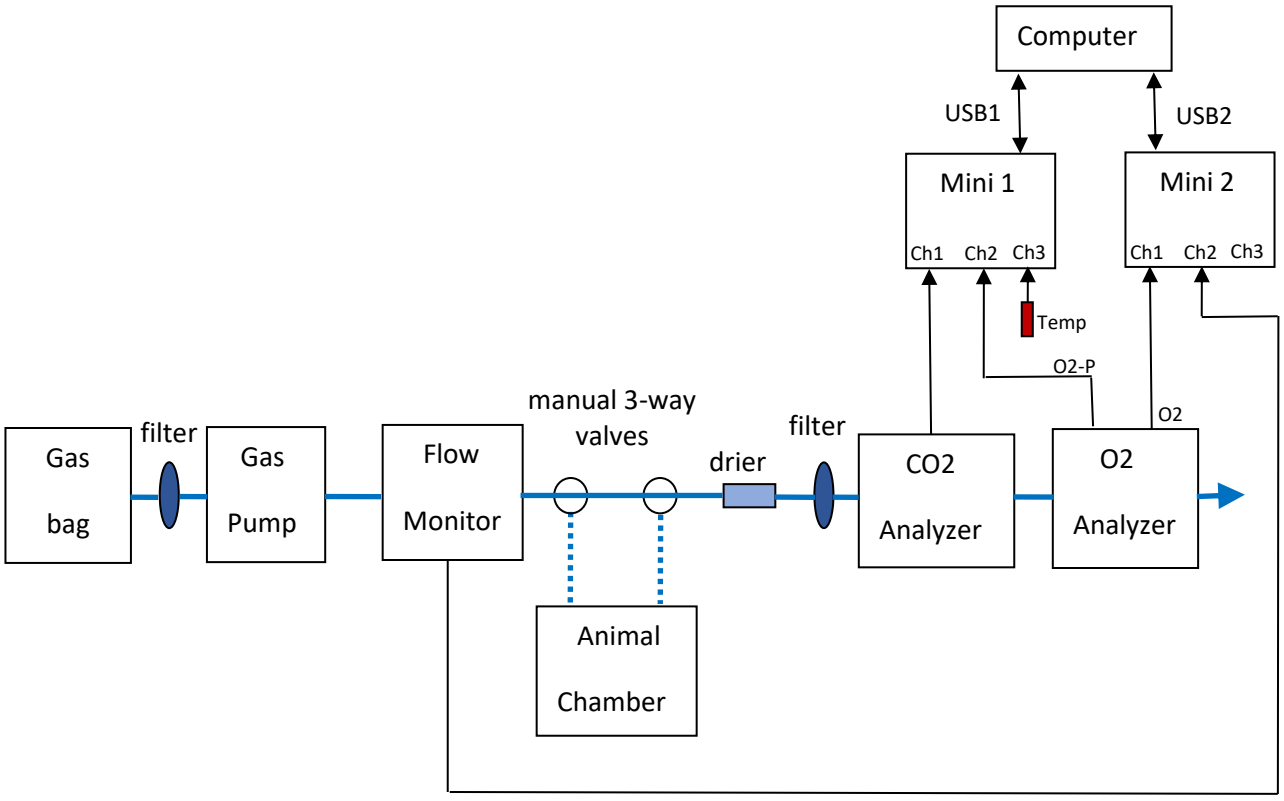
Note: Ch. 3 LabQuest Mini 1 automatically recognizes the stainless steel temperature sensor (S132 Temperature). The configuration of the sensor connections is shown in the software at the bottom of page 1.



Check the system plumbing by removing the tray with all the sensors from the Q-Box and place it outside of the box as shown in the photo below. The system should be configured for calibration before it is used in experiments. Ensure that a blue tubular filter is connected to the gas pump and Q-S153 “In” ports to prevent any particulate debris from entering the system.

Component Set-Up for Calibration

Note: heavy blue lines indicate gas flow; thin black lines indicate electrical connections

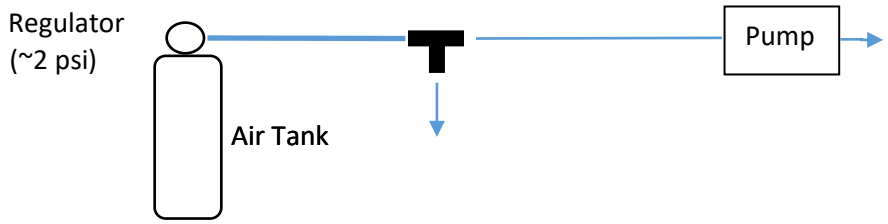


10. The gas supply tubing from the gas source (gas bag or other constant source of CO_2) is attached to "In" port on the Q-P651 Gas Pump via a blue particulate filter.

    When studying the animal in air, the gas source can be a gas bag of CO_2-free air (filled from a commercial tank) to **avoid the significant fluctuations of CO_2 in room air due to human breath.**

An alternative is to use **outside air** which **has a constant CO_2 level of ~ 400 ppm.** Outside or inside air can be scrubbed of CO_2 using the soda lime column if CO_2-free air is needed.

Note: If the gas source is pressurized (e.g. tank) do not force pressurized gas into the pump. Instead, reduce the regulator pressure to 2-3 psi and connect the gas line to a luer "T" piece. Connect the pump to one of the other T ports and let excess gas vent from the third port of the T-piece. The pump then supplies gas at atmospheric pressure.

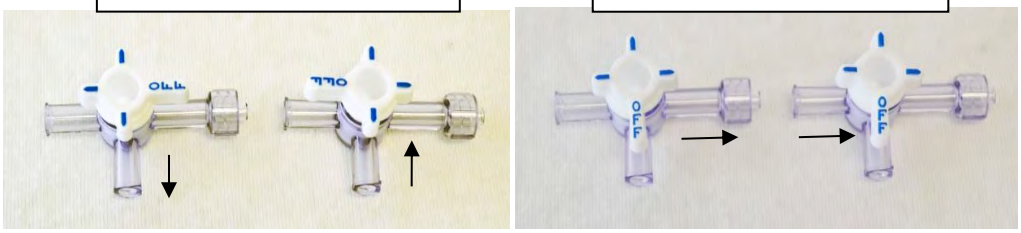


11. The "Out" port of the Gas Pump connects to the "In" port of the Q-G265 Flow Monitor.

Note: The manual 3-way valves are installed as in the above diagram to direct the flow of gas either through the animal chamber to obtain a measurement, or to bypass the chamber to obtain reference levels. The two valves can be connected directly to each other as a unit to make valve turning easier. Tubing with male luer connectors at both ends is required for connecting the left valve to the chamber in the above diagram.

Valves deactivated - gas supplied to sample for **analysis measurements**

Valves activated - gas bypassing sample for **reference measurements**



12. The "Out" port of the Flow Monitor initially (in the calibration mode) connects to the "In" port of the Q-S153 CO_2 Analyzer via the Drying Column (blue DRIERITE) and a blue filter.

Note that only one drying column needs to be used when Q-S153 and Q-S102 are used in series unless gas entering the CO_2 analyzer is high in water vapour.

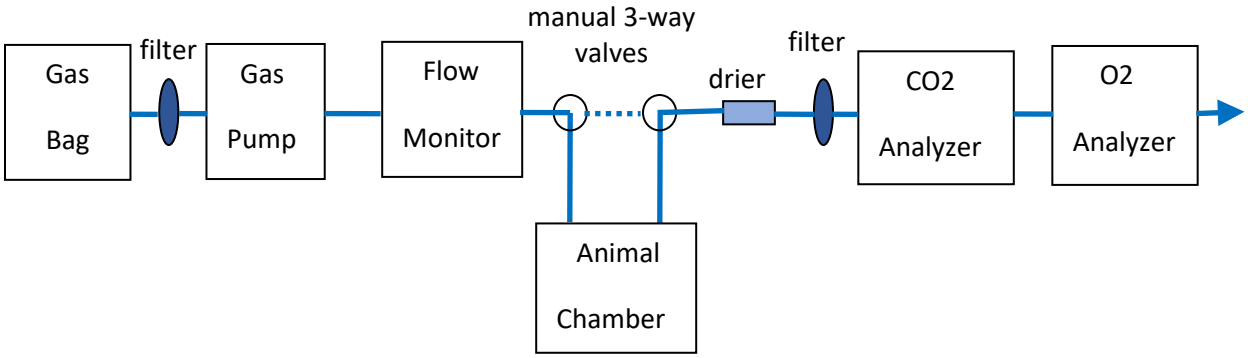
i The "Out" port of the Q-S153 CO_2 Analyzer connects to the "In" port of the Q-S102 O_2 Analyzer.

ii Gas vents from the O_2 analyzer via the "Out" port.

iii Two blue filters (25µ) should be placed in the gas line, one before the pump and one before the CO_2 analyzer, to prevent particulate matter from entering the analyzers.

13. After initial calibration of the gas analyzers (see pg. 10 for instructions), configure the system for measurements of animal respiration in an **open-flow system** as outlined in the diagram below. When studying the animal in air, the gas source can be a gas bag of air (filled from a compressor) to **avoid the significant fluctuations of CO_2 in room air due to human breath. If possible, use outside air which has a constant CO_2 level of ~ 400 ppm.**

*Component Set-up for sample measurements in an **Open-Flow** system with flow rates < 650 ml/min:*



a. Attach the "Out" port of the Flow Monitor to the inlet of the animal chamber.

b. Attach the outlet of the animal chamber to the inlet of the drying column

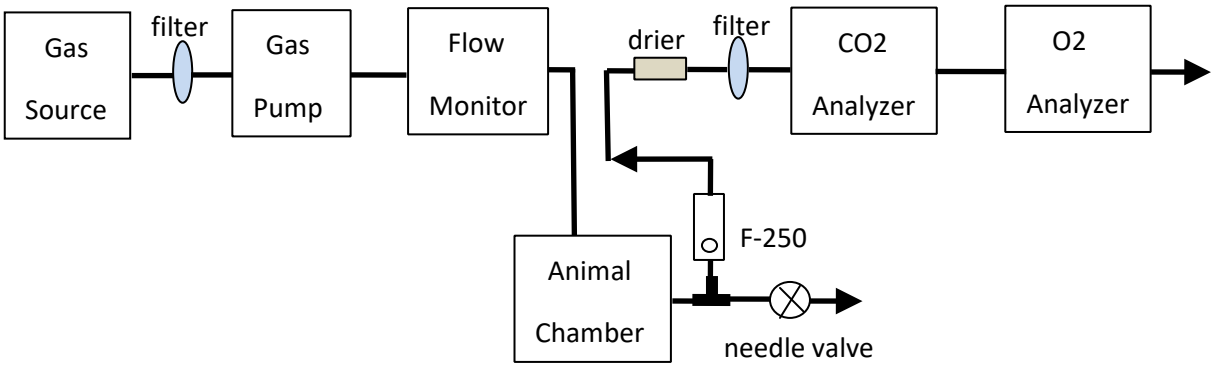
c. Attach the outlet of the drying column to the "In" port of the Q-S153 CO_2 analyzer via the blue filter.

d. Attach the "Out" port of the Q-S153 CO_2 analyzer to the "In" port of the Q-S102 O_2 Analyzer.

e. The "Out" port of the O_2 Analyzer vents the gas in the Open-Flow System.

f. For experiments in which flow rates through the animal chamber need to be higher than 650 ml/min, the system should be configured with a T-Piece flow bypass. Note that flow rates higher than 650 ml/min through the CO_2 and O_2 analyzers can damage the analyzers. See the diagram below for the set up with the T-piece bypass.

*Component set-up for sample measurements in **Open-Flow** system with flow rates **> 650ml/min***

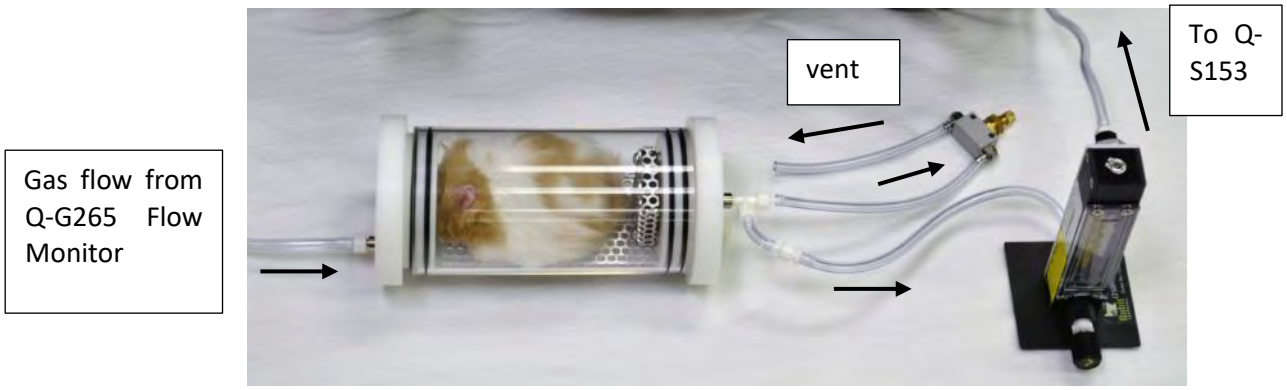


14. Set the gas flow through the system. It is recommended that the **system be calibrated at the same flow as that used in experimental measurements** (with or without the T-piece bypass). The **flow** through the Q-S153 CO_2 and Q-S102 analyzers **should not exceed 650 ml/min. In the open loop mode, signal intensity depends inversely on flow.**

    To set the flow rate through the system It is recommended that both needle valves on the Q-P651 Gas Pump are partially restricted (as set at the factory, 1/3 of the way) and flow through the system is adjusted using the single valve on Q-G265 Flow Monitor. Unlock the valve locking nut with the wrench provided before adjustments. Turn the valve counter clockwise to increase flow or clockwise to reduce flow. Once the flow is adjusted to the desired rate, use the small 8mm wrench provided in the accessory pack to lock the valves in place on the Flow Monitor and the Gas Pump to avoid accidental changes in the flow rate during experiments. Note that flow is recorded in software. The tray holding all the sensors can then be placed back in the Q-Box.

    If higher flow through the animal chamber is required to avoid hypercapnic levels of CO_2, it is recommended to set up the T-piece bypass whereby a portion of the gas leaving the animal chamber is sub-sampled through the gas analyzers at a known rate (as set with the needle valve and the F250 Flow meter in the above diagram). The excess gas from the animal chamber vents through the needle valve. To use the T-piece bypass, attach one side of the T-Piece to

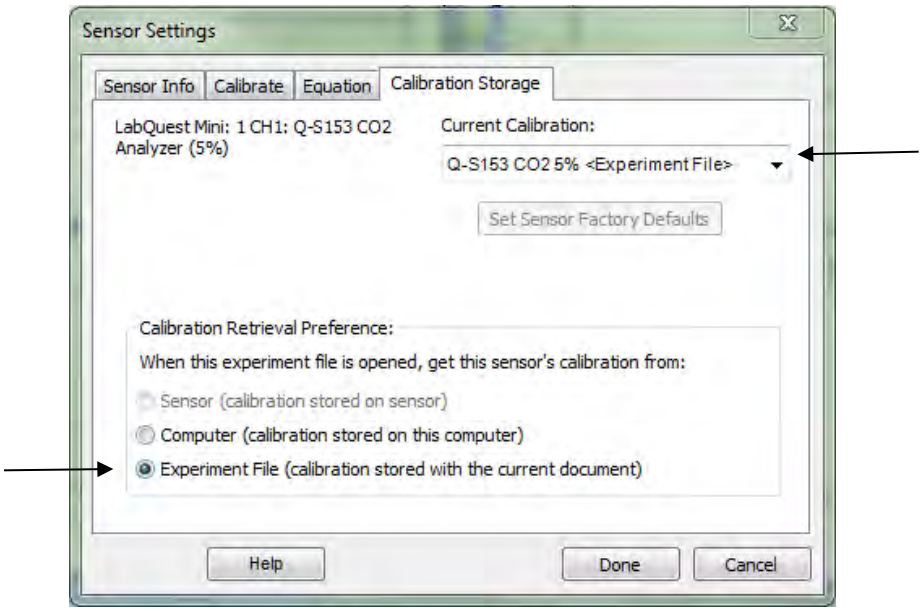
the outlet of the animal chamber. Attach the other side of the T-piece to the needle valve. Attach the 3rd outlet of the T-piece to the inlet of the F250 flow meter and attach the outlet of the flow meter to the drying column in front of the Q-S153 CO_2 analyzer. Refer to the diagram above and the photo below. Once the flow rate through the animal chamber is set (as described above) fully open the needle valve and the F250 flow meter. Proceed to close the needle valve while monitoring the flow through the F250 flow meter until the flow of about 200 ml/min is reached (2x the final flow rate). Next, adjust the valve on the F250 flow meter to reduce the flow rate further until the desired value is reached i.e. 100 ml/min.



15. The Q-G265 and S132 Sensor are factory calibrated and no additional calibrations are required. The Q-S153 CO_2 Analyzer and Q-S102 O_2 Analyzer should be calibrated at the start of each day of experiments. Both analyzers have linear responses, hence they require only 2-point calibrations. The first point should be zero and the second point should be a standard CO_2 or O_2 concentration near the upper part of the range at which the analyzer will be used.

Calibration of the Q-S153 CO_2 analyzer (two-point calibration):

a. Set the CO_2 analyzer in the 0-5 % range. This is the default range for respirometry measurements.
b. Supply CO_2-free air to the analyzer by attaching the soda lime column (white) to the outlet of the flow monitor. Attach the outlet of the soda lime column to the inlet of the drying column. Both the soda lime and drying columns should be in a vertical position. The outlet of the drying column should already be attached to the inlet of the CO_2 analyzer. Soda lime will scrub the CO_2 from the gas before it enters the CO_2 analyzer and provide the zero reading (the first point of the calibration).
c. From the main menu in LoggerPro Software select ***Experiment>Calibrate>LabQuest Mini 1>Q-S153 CO2 Analyzer>Calibration Storage***. A dialog box will appear as shown below. Select the calibration storage as "Experiment File" so the calibration that was saved with the setup file included on the C404 disk is used. Click "Done".



d. When the reading on the CO_2 analyzer is stable, use the small screwdriver provided to adjust the "CO_2 Zero" control on the analyzer to set the digital display to read 0.00 CO_2. Clockwise turns increase the value and counter clockwise turns decrease the value. The reading on the CO_2 analyzer display should match the reading in the software on the Q-S153 meter.

e. If the zero reading is highly out of range (by more than 0.06%), or if the maximum or minimum position of the "CO_2 Zero" has been reached (i.e. turning the control has no effect), use the "Coarse Zero" adjustment 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 "CO_2 Zero" on the front of the analyzer to make the final zero adjustment. If use of the coarse aero is necessary, it is best to first adjust the fine zero to the middle of its range. Do this by turning the "CO_2 Zero" potentiometer on the front of the analyzer clockwise or counter clockwise to the end of its range (it will click when this is reached). Then turn the potentiometer twelve complete turns in the opposite direction. The CO_2 Zero control is then centered.

f. Remove the long soda lime column (white) from the gas line. Attach the "In" port of the Q-P651 Gas Pump to a known CO_2 source (e.g. gas bag with known CO_2 concentration).

g. Wait until the CO_2 analyzer shows a steady reading. If the Q-S153 display does not show the concentration of CO_2 in the calibration gas, adjust the display using "CO_2 Span" control. Turning the potentiometer clockwise will increase the reading and counter clockwise will reduce the value displayed.

h. If a significant adjustment was made to "CO_2 Span", return to the zero check and ensure the zero reading has not shifted. It is not necessary to do the zero check while in the calibration mode of the software.

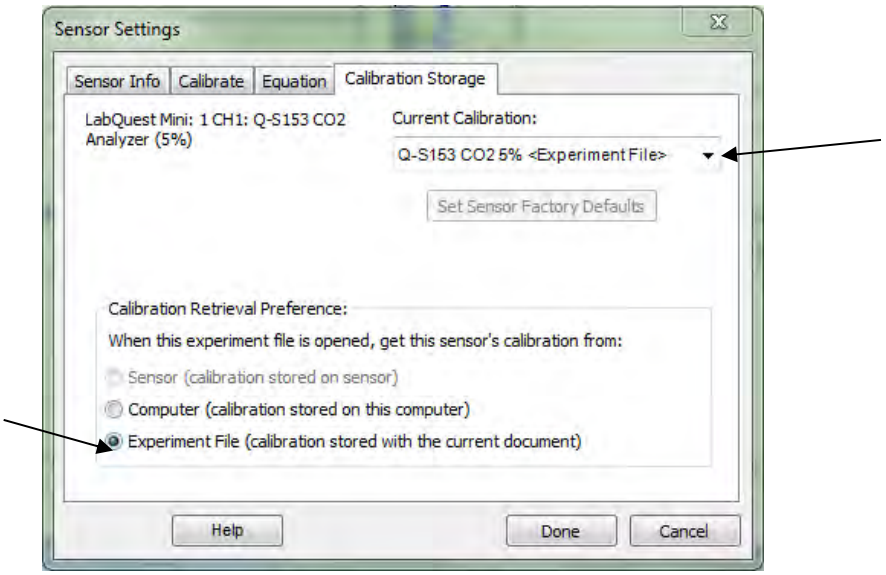
i. If the readings on the Q-S153 digital display are significantly different from those on the Q-S153 CO_2 meter in the software, first check that the correct range (5%) is still selected on the CO_2 analyzer and the correct CO_2 analyzer (Q-S153 CO_2 Analyzer 5%) has been selected in the experimental file. If these are correct and the readings are mis-matched, then proceed to calibration of the CO_2 analyzer in the software as described below.

Calibration of the CO_2 analyzer in the software (to be used only if display readings on the analyzer and software readings are significantly mismatched)

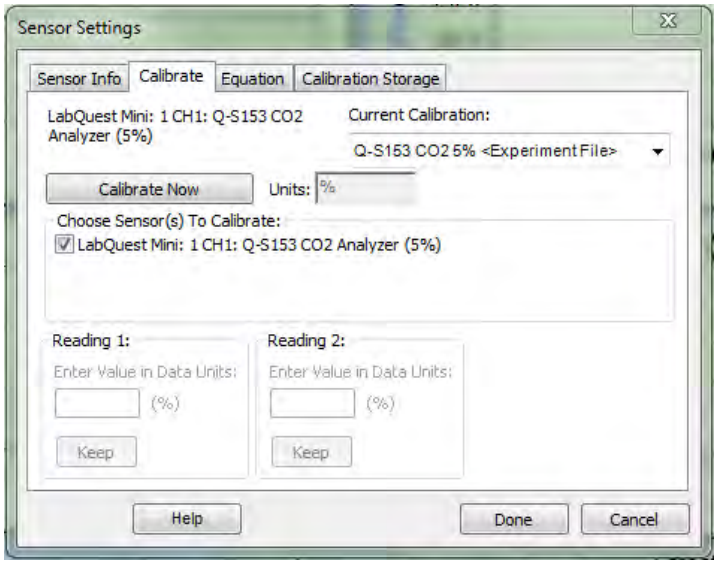
a. Supply CO_2-free air to the analyzer by attaching the soda lime column to the outlet of the flow monitor. Attach the outlet of the soda lime column to the inlet of the drying column. Both the soda lime and drying columns should be in a vertical position to ensure maximal

contact of the gas with the particles. The outlet of the drying column should already be attached to the inlet of the CO_2 analyzer. Soda lime will scrub CO_2 from air and provide the zero reading (the first point of the calibration).

b. From the menu in Logger Pro Software, select ***Experiment>Calibrate>LabQuest Mini 1>Q-S153 CO2 Analyzer (5%)***. A dialog box will appear as shown below. Select the calibration storage as "Experiment File" so the new calibration is saved with the current file.



c. Proceed to "Calibrate Now" in the same window (see below). Ensure the Current Calibration is selected as ***Q-S153 CO_2 Analyzer 5%<Experiment>***.



d. When the reading on the CO_2 analyzer is stable, use the small screwdriver provided to adjust the "CO_2 Zero" control on the analyzer (if needed) to set the digital display to read 0.00 CO_2. In software, enter "Reading 1" as 0 and click "Keep".

e. Remove the soda lime column from the gas line. Attach the "In" port of the Q-P651 Gas Pump to a gas bag with known CO_2 concentration.

f. If the Q-S153 display does not show the correct concentration of CO_2 in the calibration gas, adjust the display using the "CO_2 Span" control. When the Q-S153 CO_2 display shows the correct CO_2 concentration, enter that concentration as "Reading 2" in software and click "Keep" then "Done". **Save the experimental file under a new name so the new calibration is saved with the current file.** The CO_2 readings in Logger Pro software should now be the same as those on the digital display of the CO_2 analyzer.

Calibration of the Q-S102 O_2 analyzer:

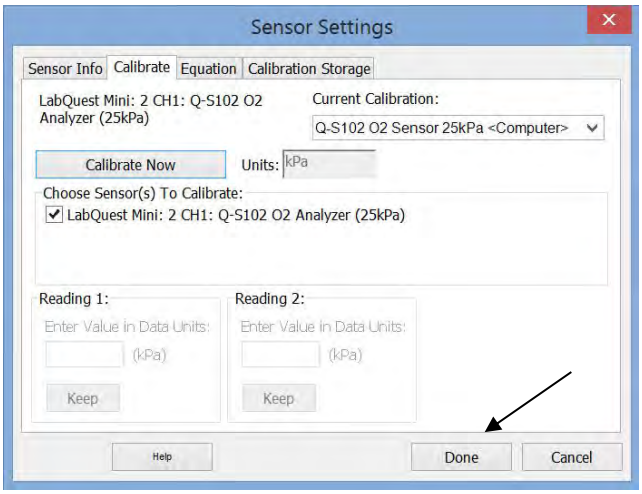
Note the Q-S102 analyzer measures partial pressure (kPa) of O_2 in a gas and total gas pressure in the system. The partial pressure of O_2 will follow atmospheric pressure changes whereas the concentration is constant and independent of pressure variation. The analyzer O_2 partial pressure reading is corrected in software for changes in total gas pressure to produce O_2 (Pcor) reading in % units. These corrected readings (see calculation below) are displayed in the software in a meter and in the graph as shown below.

$$O2\ (Pcor) = ((Q\text{-}S102\ O2\ )/(Q\text{-}S102\ P))*100$$

Where Q-S102 O2 is the O_2 partial pressure, and *Q-S102 P* is the (total) gas pressure measured inside the QS102 O_2 analyzer.

To check and adjust the calibration of the Q-S102, follow these steps:

a. Set the O_2 analyzer in the 0-25 kPa range. This is the default range for measurements of respiratory O_2 consumption with the Q-Box RP2LP. Ensure the current calibration is selected as Q-S102 O2 Sensor 25kPa <Computer> then click "Done".



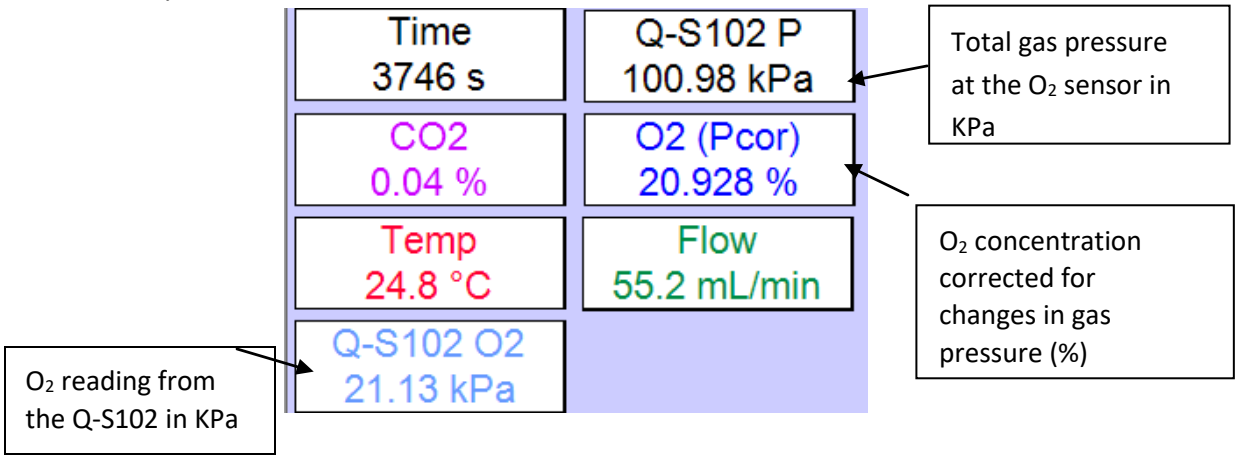
b. Supply O_2 free-gas (e.g. N_2) to the analyzer by attaching the O_2-free gas source (i.e. gas bag) to the "In" port of the Q-P651 Pump. As the O_2-free gas enters the Q-S102 O_2

Analyzer, the reading in the software on page 1 - (**O2(Pcor)**) will decrease towards zero (the first point of the calibration).

c. When the reading in the software (O2(Pcor) window) is stable, use the small screwdriver provided to adjust the "O_2 Zero" control on the analyzer until this meter display in the software reads 0.00 O_2.

d. Attach the "In" port of the Q-P651 Gas Pump to a source of gas with known O_2 concentration (i.e. gas bag with a known concentration of O_2). Alternatively, dried room air contains 20.95% O_2.

e. When the **O2 (Pcor)** reading in software becomes stable, adjust the "O_2 Span" control on the analyzer until this reading corresponds to the O_2 concentration supplied to the analyzer.



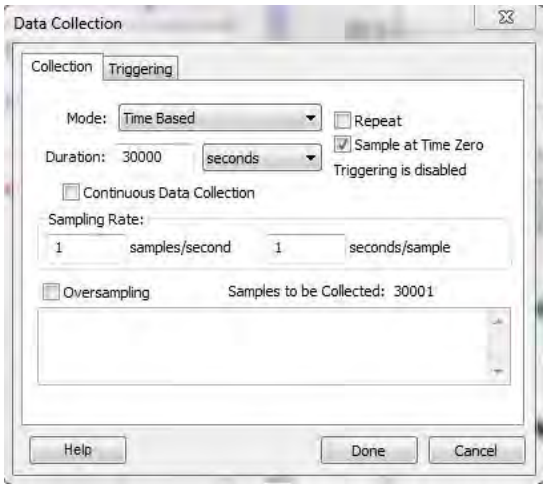
f. If a significant adjustment had to be made to "O_2 Span", return to the zero check and ensure that the zero reading on the analyzer has not shifted. It is not necessary to do the zero check while in the calibration mode of the software.

The Q-Box RP2LP system is now ready for use.

16. Assemble the flow-through animal chamber (coating the o-rings of the end cap with some grease is recommended for easy assembly). Place the temperature probe (with O-rings) in the opening of the end cap as shown. If the temperature probe requires additional sealing around the opening use the blue Qubitac sealant provided in the animal chamber accessory kit. If the temperature probe is not used, ensure the hole is plugged with the stainless-steel rod stopper provided. The out-flow end cap contains a fan (blowing counter current to the gas flow) for mixing of gases in the animal chamber. Attach the power supply to the fan.

17. Place the animal in the chamber. Attach the chamber to the system as shown below and as explained in item #9 above for an Open-Flow system, or for an Open-Flow system with the T-piece by-pass (larger or more active animals will most likely require this set up).

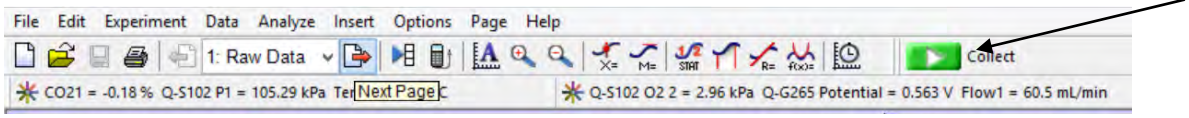
18. Before collecting data with LoggerPro software, select ***Experiment > Data Collection*** in the main menu. The following dialog box will appear:



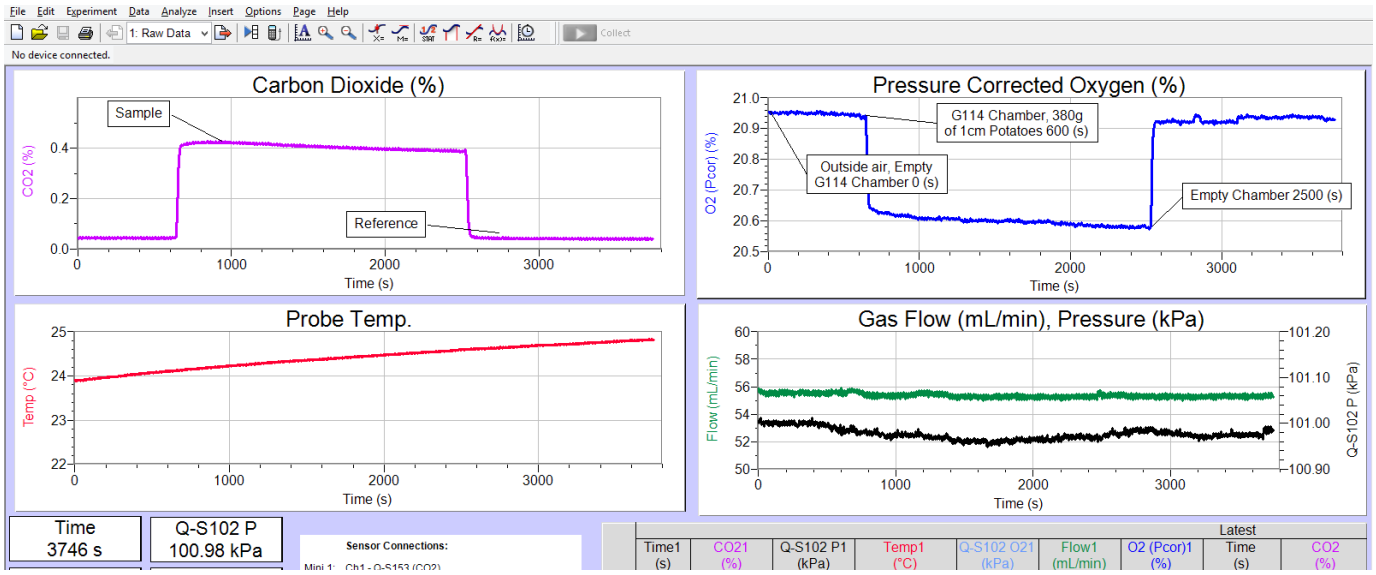
Input experiment length and data sampling rate as required. The default is 1 sample per sec or 60 samples/min. Click "Done".

Select: ***File> Save As*** to save the experiment settings under the file name selected during calibrations of Q-S153, so that the original set up file (Q-Box RP2LP Setup) is not over-written.

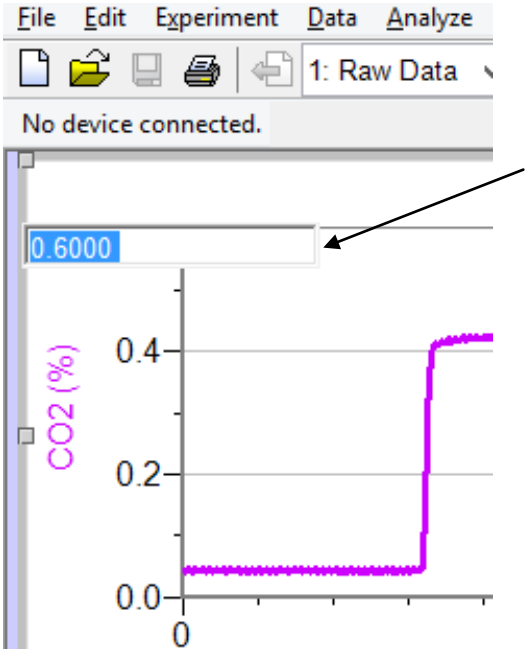
19. Start data collection by clicking the green "Collect" button, and stop data collection by clicking the red "Stop" button (green turns red during data collection)



20. Logger Pro software displays data on page 1 as they are collected in graphs, meters and spreadsheet columns. Sample data from an experiment with potatoes in a 660 ml G114 chamber (380 g chopped into 1 cm cubes to induce wound respiration) in an open-flow system with a T-Piece bypass are shown below. Note the close inverse relationship between the O_2 and CO_2 readings.



21. During the experiment, the x and y axis ranges can be adjusted by clicking on the lowest or highest number and typing in the desired new value as shown in the following screen.



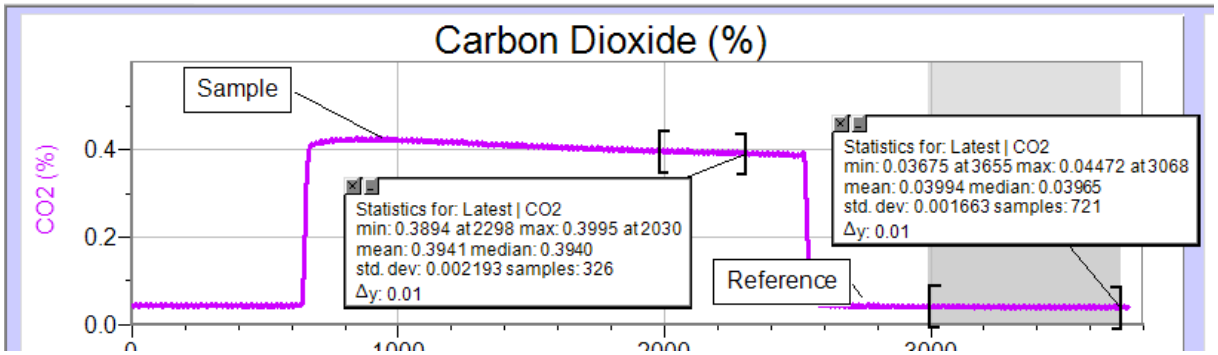
22. Upon completion of the experiment, the data can be analyzed directly in Logger Pro using the various analysis tools in the ***Analyze*** menu, or using icons selected in the top menu bar. Further calculations can be done directly in Logger Pro on **page 2 (Calculations of $\dot{V}CO_2$ only, assuming RQ) or page 3 (Calculations of $\dot{V}CO_2$ and $\dot{V}O_2$ with correction for O_2 and CO_2 concentrations).** The data can also be directly exported as a CSV file (***File > Export As > CSV***), which can then be opened in any spreadsheet program for further analysis and calculations.

Calculations of Metabolic Rates ($\dot{V}CO_2$ and $\dot{V}O_2$):

Measurements of metabolic rates can be expressed as rates of CO_2 produced per unit time ($\dot{V}CO_2$) or as O_2 consumed per unit time ($\dot{V}O_2$). The most common units are µl/min or µl/hr. Respiratory Quotient, RQ, is the ratio of CO_2 produced to O_2 consumed (i.e. RQ=$\dot{V}CO_2/\dot{V}O_2$). It is directly related to the animal's diet and metabolic condition. RQ is usually less than 1.0, which means that more O_2 is consumed than CO_2 is produced. Calculations of $\dot{V}O_2$ and $\dot{V}CO_2$ in the software account for this imbalance**.** The "Q-Box RP2LP Setup" file includes two pages for calculations of metabolic rates. **Page 2 is for calculations of $\dot{V}CO_2$ only, and requires assumptions of respiratory quotient (RQ). When only $\dot{V}CO_2$ is measured (small animal in an open flow system) an assumption about the RQ value has to be made**. The assumed RQ value is assigned on Page 2 of the Experiment file. **When differential pCO_2 and pO_2 can both be measured accurately in an open flow system, (larger or more active animal) $\dot{V}CO_2$ and $\dot{V}O_2$ are calculated according to equations on page 3** of the "Q-Box RP2LP Setup" file. These equations account automatically for RQ values that differ from 1.0.

Flow rate is measured by the Q-G265 Flow Monitor. The Q-G265 is a mass flow meter, so readings are not affected by temperature and pressure changes. Therefore, the **flow rate does not need to be corrected for standard temperature and pressure (STP).**

The incurrent and excurrent CO_2 and O_2 concentrations are measured by the Q-S153 CO_2 Analyzer and Q-S102 O_2 Analyzer during the reference and sample set up of the system, respectively. These are used to calculate the fractional concentrations (incurrent - Fi; excurrent - Fe) of CO_2 and O_2 that enters and exits the animal chamber. These values are obtained directly from the raw data by manually highlighting the data collected in the reference mode and in the sample mode then obtaining the average number from the statistics window as shown in the image below:



There are two options for calculating metabolic rates. On page 2, calculations of $\dot{V}CO_2$ are made assuming a user assigned RQ. This option is chosen when O_2 measurements are not possible or deemed inaccurate. On page 3, $\dot{V}CO_2$ and $\dot{V}O_2$ are calculated based on the measured CO_2 and O_2 differentials. Since the **flow monitor** in the Q-Box RP2LP package is **upstream** of the CO_2 and O_2 analyzers, and **CO_2 or O_2 are not removed from the excurrent gas** stream at any point, the following equations are used to calculate $\dot{V}CO_2$ and $\dot{V}O_2$:

References:

(http://warthog.ucr.edu/WartHogPage/LAX%20website/respirometry.html)

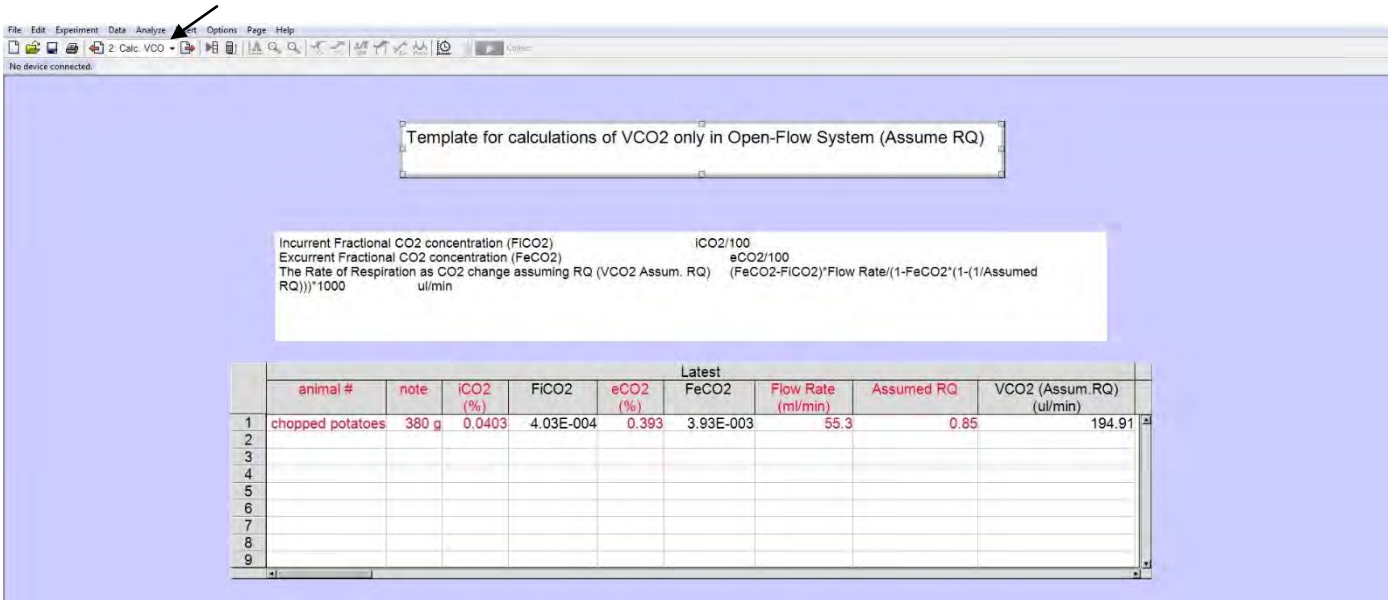
Lighton, J.R.B. "Measuring Metabolic Rates: A manual for Scientists" Oxford University Press, 2008

Page 2 – Calculations of $\dot{V}$CO2 only in Open-Flow System. An assumed RQ has to be assigned. If the diet of the animal is not known, an **assumed RQ of 0.85** is most appropriate.

$$\dot{V}CO_2 = (FeCO_2 - FiCO_2) * FR/(1 - FeCO_2 * (1-(1/Assumed\ RQ)))$$

Where **$FeCO_2$** is the **fractional** excurrent CO_2 concentration, **$FiCO_2$** is the **fractional incurrent CO_2** concentration and FR is the gas flow rate in mL/min.

$$FeCO_2 = eCO_2 \text{ in } \%/100$$
$$FiCO_2 = iCO_2 \text{ in } \%/100$$



Page 3 – Calculations of $\dot{V}$CO2 and $\dot{V}$O2 in an Open-Flow System. To account for dilution, measured differential O_2 is used in the $\dot{V}CO_2$ calculation and measured CO_2 differential is used in the $\dot{V}O_2$ calculations as shown in the following equations:

$$\dot{V}CO_2 = FR * ((FeCO_2 - FiCO_2) - FeCO_2 * (FiO_2 - FeO_2))/(1 - FeCO_2)$$

$$\dot{V}O_2 = FR * ((FiO_2 - FeO_2) - FeO_2 * (FeCO_2\text{-}FiCO_2))/(1 - FeO_2)$$

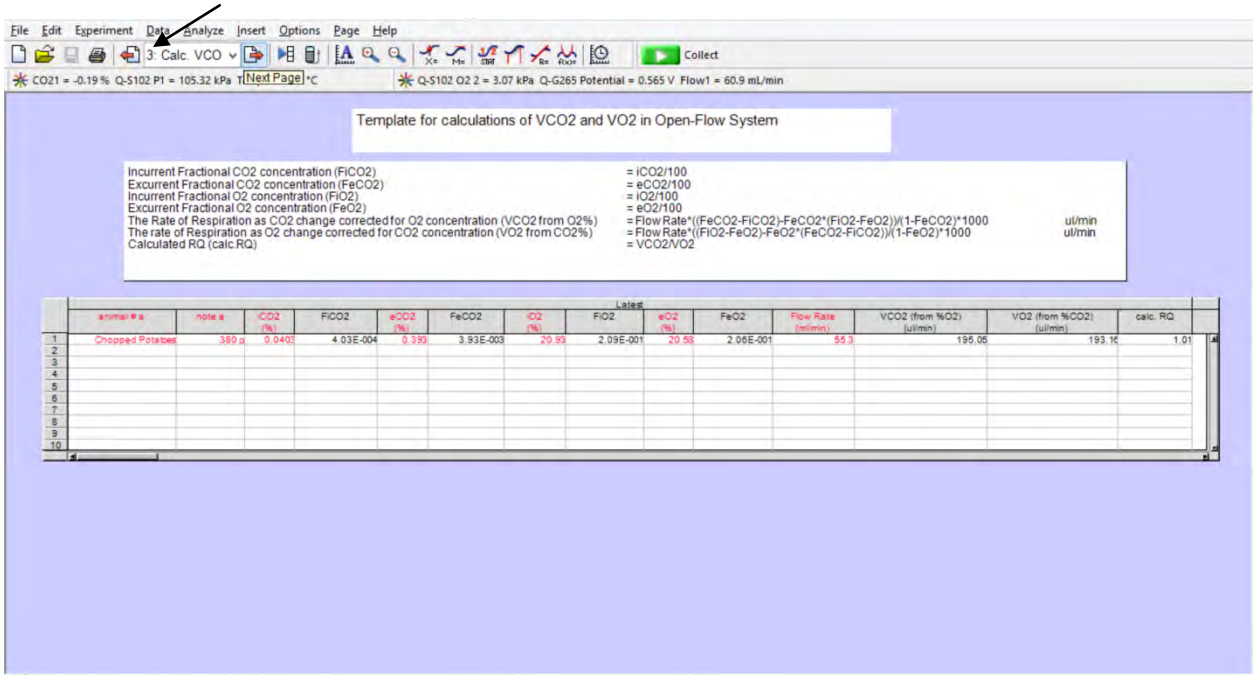
Where FeO_2 is the fractional excurrent O_2 concentration, FiO_2 is the fractional incurrent O_2

$$FeO_2 = eO_2 \text{ in } \%/100$$

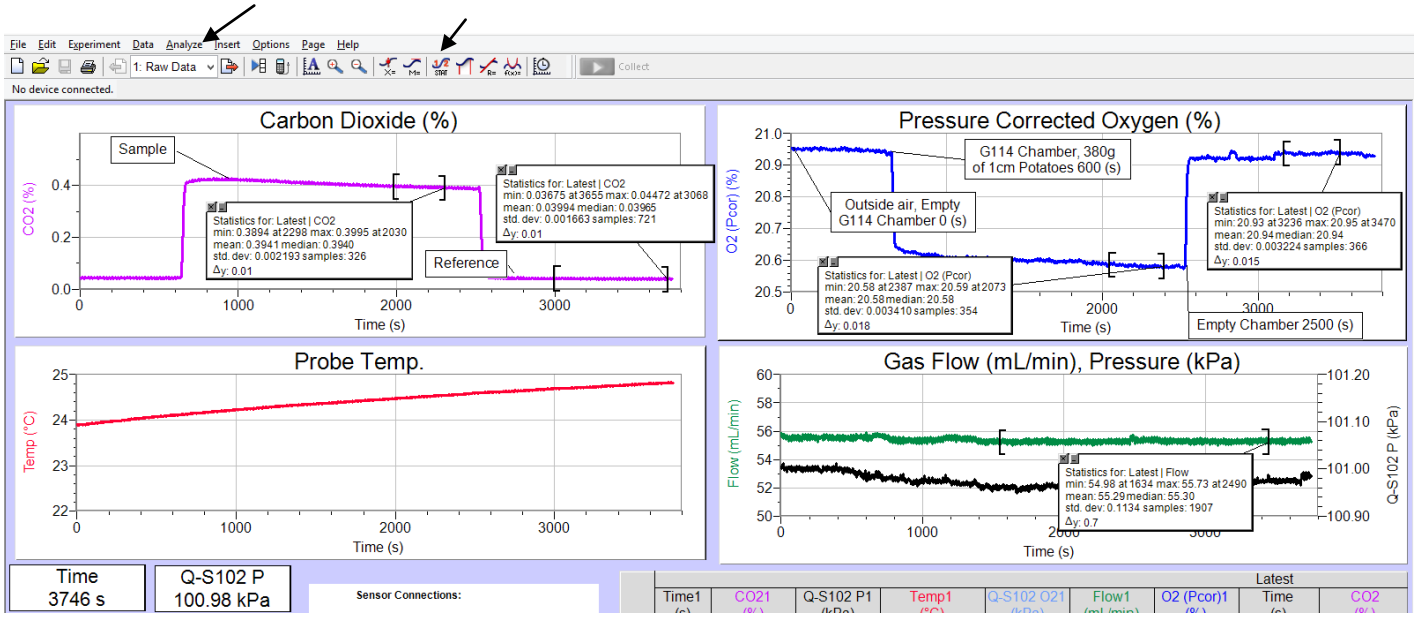
$$FiO_2 = iO_2 \text{ in } \%/100$$

$$\text{Calculated RQ} = \dot{V}CO_2/\dot{V}O_2$$

The following screen shows the calculations of both $\dot{V}CO_2$ and $\dot{V}O_2$ as well as RQ in software on Page 3 for 380 g of chopped potatoes where both CO_2 and O_2 were measurable in open flow mode.

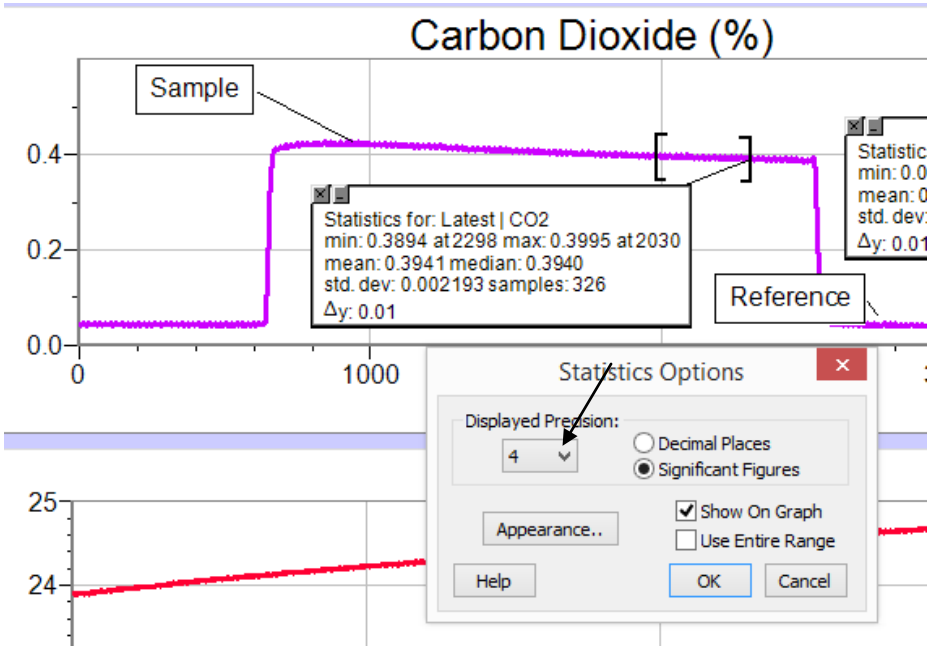


To use calculation pages 2 and 3 the values in **red columns** (iCO2, eCO2, iO2, eO2, Flow Rate) must be **entered manually**. These values are obtained from the appropriate sections of the **graphs on Page 1** showing the raw data. To select the raw data for the calculation page, use the numerous analysis tools available in Logger Pro. These are: Examine, Tangent, Statistics, Integral etc. which can be selected from the icons in the menu at the top of the screen. Also, they can be obtained from the ***Analyze*** menu.



All graphs can be selected by clicking on each graph while holding down the shift key. Then select the data of interest on one of the graphs (e.g. Q-S153 CO_2 values during the steady state response of the

animal) by holding down the shift key and dragging the mouse over the region of interest on that graph. Note that data on the other selected graphs for that time period will also be highlighted. When the data have been selected on all the graphs, the appropriate analysis tool can be chosen (i.e. "Statistics" analysis) while still holding the shift key. The statistics will then be shown in a separate window for the selected data on each of the graphs. The number of decimal places or the size of the font to be displayed can be changed by right clicking on the analysis window as shown below.



The mean values for each of the parameters can then be copied from the statistics windows into the calculation pages in the appropriate red columns. Once the red columns with the input parameters are filled, the calculation columns (black) will fill automatically.

In long experiments, it is important to measure the incurrent (reference) levels of CO_2 and O_2 periodically to account for possible sensor drift. This is done by employing the two 3-way valves that are shown on the diagram on pg. 6 for the calibration mode setup. The excurrent levels of CO_2 and O_2 for a sample are obtained with the 3-way valves switched to direct flow through the chamber.

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 setup process will automatically load the USB drivers for connecting the LabQuest Mini or other interfaces to the computer.

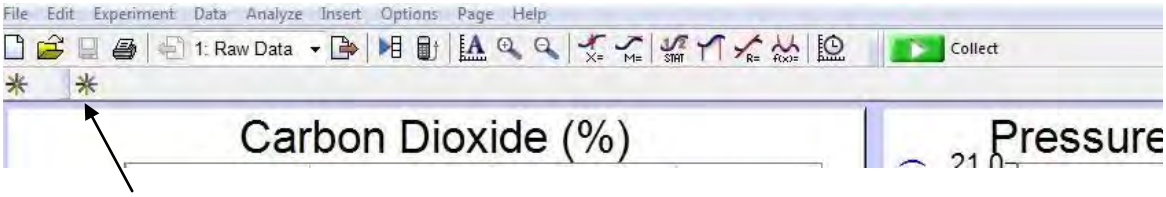
(4) If QuickTime 6 (or greater) is not installed on the computer, install it when prompted. QuickTime will allow use of the picture and movie features of Logger Pro 3.

(5) You will be prompted to connect the LabQuest Mini or other interfaces to the computer via the USB connection. The LabQuest Minis can be connected to the computer by connecting the USB1 and USB2 cables **(in that order)** from the Q-Box frame into the computer.

(6) Click 'Finish' to complete the installation process.

(7) Proceed to C404 installation (below) before opening Logger Pro with the "**Q-Box RP2LP Setup**" file.

(8) Double click the "**Q-Box RP2LP 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 two LabQuest Mini interfaces, the Logger Pro screen will appear with two stars (icons 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" or if only one interface is detected then only one star will be shown in the software. Check that the LabQuest Minis are connected to the computer directly via USB plugs 1 and 2 on the frame of the Q-Box. Check if the USB cables are connected to the minis. The LED power lights on the Minis should be green. No LED light indicates that power is not supplied to the Minis - check power connections. A red LED indicates that power is on but there is no communication between the interfaces and the computer. In this case, exit the "**Q-Box RP2LP Setup**" file and unplug the USB cables from the computer. Reconnect the USB cables with **USB1 connected first and USB2 second**. This order is important as **the computer will assign the LabQuest Minis as 1 or 2 according to the order in which they were connected**. Allow the computer to recognize the Minis individually by waiting a few seconds between plugging the minis to the computer and then re-open the "**Q-Box RP2LP Setup**" file. If the computer is having problems with assigning the LabQuest Mini interfaces in the correct order, then try plugging Mini 1 first then opening the experimental file and once it is open, plugging in Mini 2.

Macintosh Users:

To start, a complete copy of Logger Pro 3 must be installed on the computer (You must be using 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:

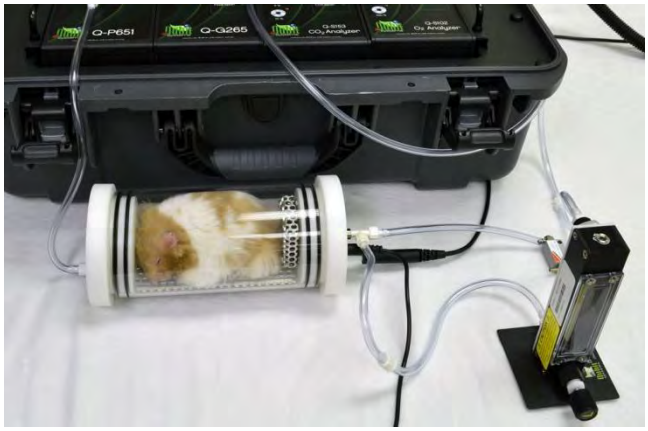
Qubit Systems' C404 Custom Setup Files disk contains Experiment file (designed by Qubit Systems) for this package (**Q-Box RP2LP Setup**) and the manual. In addition, the manual for the LabQuest mini data interface is also included. These files can be copied to user specified location on the computer and the experimental file "**Q-Box RP2LP Setup**" should be placed in an accessible location or have a shortcut created on the desktop to the file. We highly recommend for 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.

Using the Q-S153 CO_2 Analyzer

The Q-S153 CO_2 Analyzer is a non-dispersive infrared gas analyzer (NDIR IRGA). It has a gas "In" port with a female luer-lock connector and a gas "Out" port with a male luer-lock connector. A length of Bevaline tubing with a luer-lock connector is provided to join the Q-S153 to the rest of the gas exchange system. The gas supplied to the IRGA passes through a sealed wave guide and vents from the "out" port. The Q-S153 can be used as a stand-alone analyzer in an open or closed-circuit gas exchange system. It can be used with other gas analyzers downstream. However, ensure that the placement of an analyzer or instrument downstream from the Q-S153 does not cause a significant increase in backpressure. Increasing pressure significantly beyond that at which the IRGA was calibrated produces erroneously high readings.

The maximum flow rate of gas into the Q-S153 should not exceed 650 ml/min. This, or lower flow rates, should be provided by the Q-P651 Gas pump and monitored by the Q-G265 Flow Monitor. It is recommended that the user calibrate the Q-S153 at the flow rate intended to be used during the experiments. If the flow rate through the animal chamber has to be maintained higher than 650 ml/min to avoid hypercapnic levels of CO_2 in the chamber, use the T-Piece by-pass configuration whereby the T-Piece is connected to the outlet of the animal chamber, and the outlets of the T-piece are connected to the needle valve and the F250 flow meter, as shown in the photo below and on pg. 8 and 9. This will allow

the user to sub-sample the gas exiting the animal chamber at a lower flow rate and supply it to the CO_2 and O_2 analyzers while most of the gas vents via the needle valve.



Gases entering the Q-S153 must be clean and dry, since particulate matter may absorb infrared light and cause erroneous readings. Water vapour will not interfere with the IR absorption measurement of CO_2, but water vapour will dilute the CO_2 concentration. The Q-S153 CO_2 analyzer is supplied with a drying column containing DRIERITE. This drying agent removes moisture from the analysis gas before it enters the CO_2 analyzer. Wool plugs at the base and top of the column prevent particulate matter from leaving the column.

The Q-S153 CO_2 Analyzer requires 12 Volts DC power to operate. A 120/220 AC power adaptor (included) provides 12 Volts DC. For continuous use, leave the Q-S153 CO_2 analyzer powered all the time. Keeping the Q-S153 powered up will maintain the calibration constant.

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

The Q-S153 requires a 2 to 3 minute warm-up period before the CO_2 level will be displayed. During warm-up, the LCD will flash numbers briefly and display the number 1. After the unit has warmed up, the LCD will display a very high reading, which will slowly decline to the CO_2 level in the supplied gas stream.

For most accurate and stable readings, it is recommended that the Q-S153 be warmed up for minimum of 15 min to 1 hour before use. If the Q-S153 is to be used on a regular basis, it should be powered continuously.

Altitude and Barometric Pressure Correction

The Q-S153 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 not possible, correct the CO_2 reading of the analyzer according to the table below. For example, when using a factory-calibrated unit at an altitude of 2,500 feet, multiply the displayed CO_2 reading by 89% (1,000 ppm x 0.89 = 890 ppm actual).

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 CO_2 = [1- (4.06234 x 10^{-5} x Altitude in feet)] x 100

Using the Drying Column and Soda Lime Column

The Q-S153 is designed to analyze dry gas samples. A desiccant column is provided which is filled with DRIERITE to dry the gas before analysis. The column has glass wool at both ends to prevent particulates from being carried through the system. It is supplied ready for use. The column should be mounted **vertically** on the Q-S153.

DRIERITE contains an indicator that is blue when the column is functional and pink when the DRIERITE is saturated with absorbed water vapour. When spent, the DRIERITE should be replaced or reconditioned. To **recondition**, remove the **DRIERITE** from the column and place it in a drying oven at **210 ˚C for 1 hour**,

or until the blue coloration reappears. 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 turn into liquid with time, so it must be changed frequently. It is recommended that a trap or liquid filter is installed downstream if using magnesium perchlorate. **Qubit Systems is not responsible for any damage caused to any components of the Q-Box RP2LP due to magnesium perchlorate entering any part of the system.**

CO_2-free gas can be obtained by pumping air through a column containing soda lime. A small amount of glass wool should be placed at the ends of the column, and the column should then be filled with soda lime using a spatula. When the column is full, it should be tapped to settle the soda lime, and then topped off. The soda lime column should be used in a **vertical** position to ensure the gas has maximal contact with the crystals when flowing through the column**.**

The soda lime provided with the Q-S153 has a coloured indicator to show when it is saturated with absorbed CO_2. 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).

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-S153:

The LCD display will not stabilize during operation:

This may indicate that the unit is not getting power. Unplug the power cord from the unit and measure the DC voltage at the plug; it should be 12 Volts DC. If using an alternate DC power source, the unit will operate with 12 to 19 Volts DC. 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). Check that the unit has been sufficiently warmed up.

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

Turn the "CO_2 Span" all the way down (counter clockwise) and use the "Coarse Zero" on the back of the CO_2 analyzer to display 0 with zero CO_2 gas flowing through the system. Once the zero display is read, attach a known CO_2 concentration to the system and use "CO_2 Span" to adjust the display on the CO_2 analyzer to the correct CO_2 concentration. Return to the zero CO_2 check with zero CO_2 gas running through the system, and if necessary, make small adjustments with the "CO_2 Zero".

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

If material has entered the analyzer, it will block the internal light path and "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. Connect a 10ml syringe to a tube on the "Out" port of the CO_2 analyzer and plug the "In" port. Pull a slight vacuum with the syringe. If there is no leak, the plunger should not move. If there is an internal leak, contact QUBIT Systems for further instructions.

If the analyzer is exposed to extreme pressures, a leak can result.

Ensure the Pump is not leaking.

A faulty pump can leak room air (possible high ppm CO_2) and increase the CO_2 reading. To test the pump, turn it on and plug the inlet. Connect a tube to its outlet and place the tube in a glass of water. There should be no bubbles. If there are bubbles, the pump is leaking internally and should be repaired or replaced.

Ensure the Soda Lime CO_2 Scrubbing Column is used to provide Zero CO_2 gas to the analyzer:

Do not confuse the soda lime column with the drying column filled with DRIERITE. Soda Lime is white, whereas DRIERITE is blue. If the drying column is mistaken as the CO_2 scrubbing column, CO_2 may enter the analyzer since **DRIERITE absorbs some CO_2 and can release it slowly thereby slowing response** time. If unsure of the condition of the Soda Lime in the column, replace it with new Soda Lime or use an alternate zero CO_2 source such as pure N_2 gas.

Check Calibration

If the CO_2 Span control has been adjusted without following a full calibration procedure, the analyzer must be recalibrated using a zero gas mixture and a gas mixture with a known CO_2 level. See the CO_2 analyzer calibration section of this manual for the correct procedure.

The CO_2 readings on the display of Q-S153 are different from those in Logger Pro

If the CO_2 values displayed on the Q-S153 CO_2 Analyzer are very different from those displayed in the Logger Pro file, first check that correct range for the CO_2 analyzer has been selected both in software and on the analyzer - the default should be 5 %. If the ranges are selected correctly, check that the LabQuest Mini interfaces have not been reversed (check that values displayed in LoggerPro software for other sensors are correct). If the LabQuest Minis have not been reversed, then the CO_2 Analyzer requires a new calibration in software. Proceed with calibration instructions outlined above on pg. 12. If the LabQuest Minis have been reversed follow the instructions below on pg. 34 on how to fix the problem.

Using the Q-S102 O_2 Analyzer

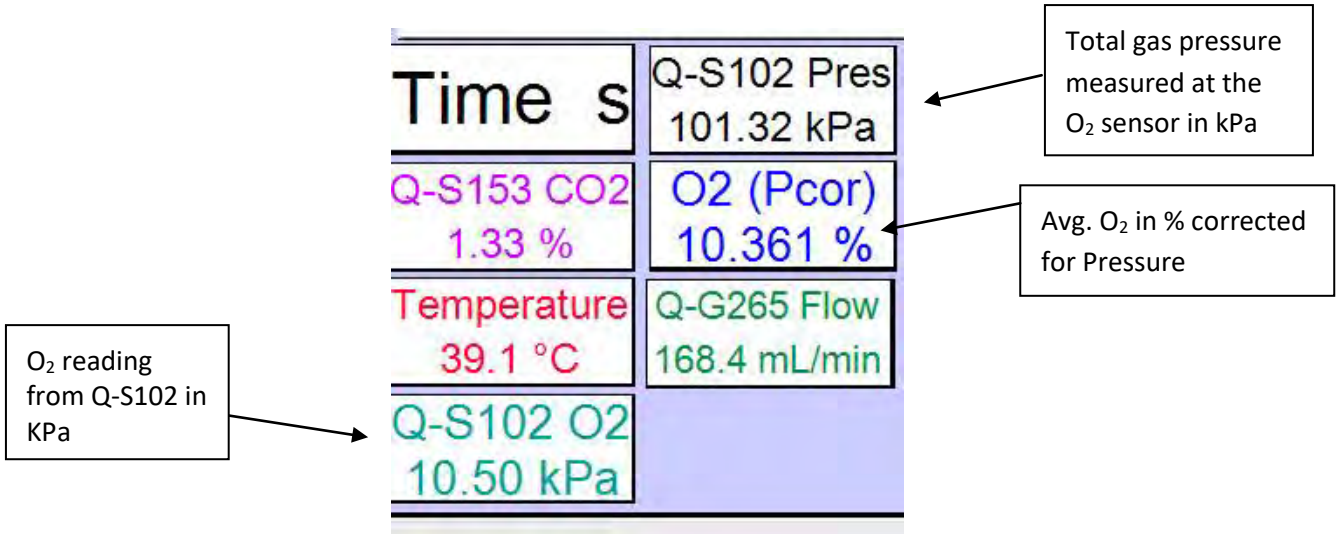
The Q-S102 O_2 Analyzer contains an O_2 sensor which is a galvanic cell (a lead-oxygen battery) consisting of a lead anode, an O_2 cathode, and an acid electrolyte. It also incorporates an O_2-permeable Teflon FEP

membrane with a gold electrode bonded to its surface. Oxygen diffusing through this membrane is reduced electrochemically at the gold electrode. A resistor and a thermistor (for temperature compensating diffusion across the Teflon membrane) are connected between the anode and the cathode. The output of the instrument is proportional to the current flowing through the resistor and thermistor. This current is proportional to the partial pressure of O_2 in contact with the Teflon FEP membrane. The signal from the oxygen sensor is transmitted to the computer via the LabQuest Mini (i.e. Q-S102 O2). The Q-S102 O_2 Analyzer has two analog signal outputs, one for O_2 and one for total gas pressure at the O_2 sensor. The total gas pressure reading from Q-S102 are used in correction of the O_2 signal in kPa to O_2 in % (O2 (Pcor)). This is done automatically in the software.

The galvanic cell is housed in a brass cylinder for greater temperature stability and more stable O_2 signal. Pressure (Q-S102 P) is measured at the O_2 cell and is displayed on page 1 in a meter and a graph. This pressure value is then used in software to convert the partial pressure (kPa) of O_2 (Q-S102 O2) to a concentration (%) (O2 (Pcor)) which is independent of pressure.

O2 (Pcor)=((Q-S102 O2)/(Q-S102 P))*100

The pressure corrected concentration is displayed in a meter and a graph.



The maximum **flow** through the Q-S102 O_2 analyzer **should not exceed 650 ml/min**. The minimum **flow** through the O_2 analyzer **should not decrease below 5mL/min** to avoid local depletion of O_2 at the membrane of the sensor. The analyzer should not be exposed to pressures that are above 20 PSIG or below 10 PSIG, or the damage to the sensor can result. The expected **life** of the O_2 Analyzer's galvanic cell is **3-5 years**. If it is impossible to adjust the O_2 signal amplitude by adjusting the span, a new sensor is necessary. Contact Qubit Systems to obtain the replacement galvanic cell and instructions on its replacement.

The Q-S102 is supplied with its own drying column filled with DRIERITE. When used in series with the Q-S153 CO_2 Analyzer, only one drying column is necessary (in front of the Q-S153) unless the sample gas is very wet. When using the Q-S102 in a stand-alone mode, gas should be dried before entering the O_2 Analyzer to avoid dilution by the water vapour. Place the drying column in the bracket mounted on the analyzer and connect it to the "In" port via the blue particulate filter (25µm). Check the filter frequently to ensure that it is not plugged. Plugged filters will result in reduced gas flow to the analyzer and should be replaced.

Troubleshooting Q-S102 O_2 Analyzer

If the O_2 **signal can no longer be adjusted** with the "O_2 Span" and the analyzer has been used for 3-5 years, the galvanic cell should be replaced. Contact Qubit Systems for instructions on ordering the new cell and on the replacement procedure.

If **significant periodic jumps** (0.5-1kPa) in the O_2 readings are observed, this may indicate pressure damage to the Teflon membrane inside the sensor cell. If the signal shows unexpected drift, check for other damage to the membrane by removing the Q-S102 O_2 Analyzer from the Q-Box tray by unscrewing the two bolts on the back that hold the analyzer in place. While monitoring the O_2 readings, tilt the analyzer 90 degrees. If there is a large change in the signal following the tilt, the Teflon membrane is likely damaged. In case of damage to the membrane, the galvanic cell should be replaced. Contact Qubit Systems for replacement instructions.

If **small pulses in the O_2 readings** are observed when passing a stable O_2 gas through the analyzer, this may indicate pressure changes in the system resulting from unstable gas delivery. First, check the system for obstructions or restriction in the gas lines. Second, check the O_2 analyzer by unplugging the gas supply line from it. The reading should become stable after detaching the gas supply line. A stable reading when no gas is flowing through the analyzer, indicates that gas delivery to the analyzer is the problem.

Unstable gas delivery may be due to the Q-P651 Gas Pump. In an open-flow system, both needle valves on the Q-P651 Gas Pump should be partially restricted (as set at the time of manufacture, about 1/3 closed from the fully open position) and the flow should be adjusted via the needle valve of the Q-G265 Flow Monitor.

Using the S132 Temperature Probe

The temperature sensor is a semi-conductor device mounted on the end of a stainless-steel probe. It is inherently linear with an operational range from –40°C to +125°C. The temperature sensor should not require calibration; however, it is possible to calibrate it in the Logger Pro software using the menu commands **Experiment>Calibrate**. The sensor is recognized automatically, and calibration is loaded when the "**Q-Box RP2LP Setup**" file is opened. The sensor is mounted on a stainless-steel support, which fits through the temperature sensor port of the animal chamber. The temperature sensor port in the chambers must be plugged with the provided plug when the sensor is not in use.

Using the G122 Gas Bags

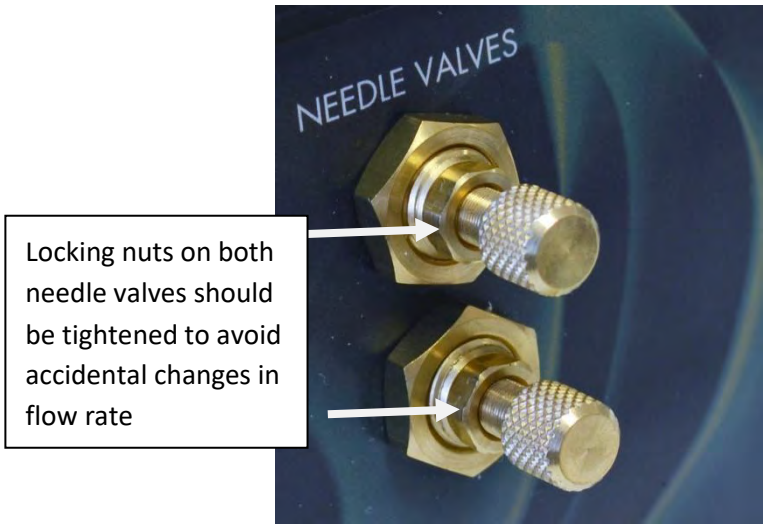
The heat-sealed, 30 L gas bags are made from a gas-impermeable nylon-polyethylene laminate. Tygon tubing is attached to each bag by a luer-lock fitting. The fitting on the other end of the tubing attaches directly to the fittings on the Q-P651 Gas pump. These bags can be filled with air from a compressor (or another gas mixture) to provide a **constant source of CO_2.** For long experiments, outside air (constant 400 ppm CO_2) should be used since compressor refills may have variable CO_2 concentration if room air is used. **Inside air can vary several hundred ppm in CO_2 due to human activity.** Bags should not be overinflated, as this can cause weakening of the seams and eventual leakage. After use, the bags should be fully deflated, preferably by attachment to a vacuum-line or pump.

Using Q-P651 Gas Pump

The Q-P651 Gas Pump is a 3L/min (no load) pump. It is used in this Package to carry gas through the system. The Q-P651 Gas Pump is delivered with pre-set pump speed of 2L/min as part of the Q-Box system, and together with the Flow Monitor it delivers the gas at a flow of about 600mL/min. The two needle valves on the back of the pump are locked in position to maintain this flow of air through the system. The flow rate through the system should be adjusted with the needle valve of the Flow Monitor Q-G265. Please remember that if flow rates higher than 650ml/min need to be used then the By-pass T-Piece needs to be employed as described on pg. 7-10.

If the pump is used in a stand-alone mode and the pump speed needs to be adjusted, it can be done with the two needle valves on the back. To set the flow rate with the gas pump, initially fully open both needle valves on the back of the Q-P651 Gas Pump (turn counter-clockwise). Adjust the flow rate down to about twice the required rate using the valve beside the pump outlet ("Out"). Second, reduce the flow further to the required rate with the needle valve on the Gas Pump across from the "In" gas port (see photo below).

Turn the valves on the gas pump clockwise to reduce the flow or counter clockwise to increase the flow. 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 with the outside nut in place to avoid accidental changes in the flow rate during experiments.



A249 Battery Pack (optional)

The A249 battery pack is composed of two Voltaic V88 Universal Batteries. The batteries are Lithium Polymer and can be charged directly via an AC charger or from a car battery via a DC charger (included). The two batteries that power the Q-Box supply a maximum of 177 Watt hours of power. Both batteries together, or one at a time are hooked up to the Q-Box power outlet via the split cable provided. The use of A249 Battery Pack allows field operation of the Q-Box RP2LP or any other Q-Box package for up to 11hr (without the lap top computer). Each Voltaic battery has one "Out" port for plugging in the Q-Box power cable and an "In" port for plugging in the AC or DC charging adaptor. **The voltage output from the battery to the Q-Box has to be set to 12V.** This is selected by pressing the black button on the top of the batter for 3 sec and then again for selection of 12V. **It is important to set up 12V output before the battery pack cable is plugged into the Q-Box. Settings higher than 12V may damage the Q-Box.**

Once the battery pack is connected to the Q-Box the output voltage cannot be accidently changed.

Troubleshooting LabQuest Minis

LabQuest Mini 1 and 2 are switched

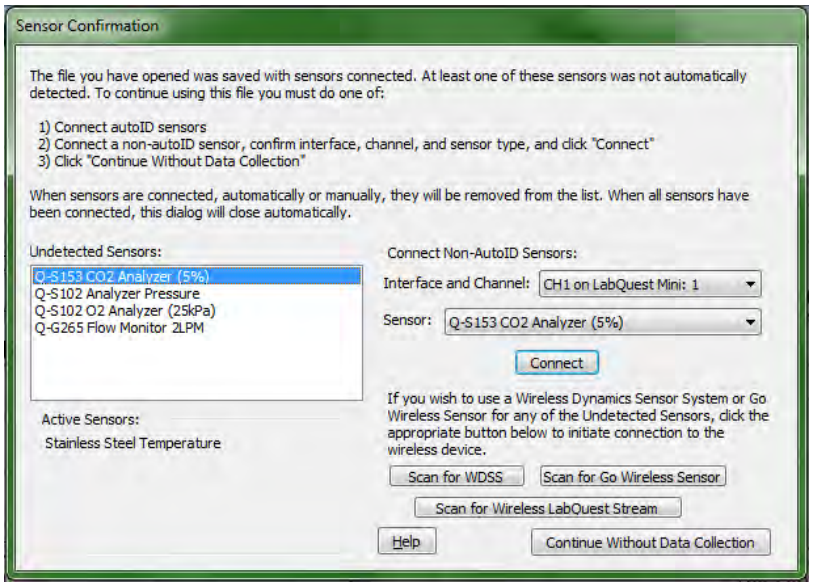
If the sensors show unusual values, Logger Pro software may have confused LabQuest Mini 1 with LabQuest Mini 2. To rectify this situation, follow these steps:

Close the "**Q-Box RP2LP Setup**" file. Unplug the two USB cables from the frame of the Q-Box.

First, reconnect one cable into the USB 1 outlet on the frame, then plug the second cable into the USB 2 outlet. As each LabQuest Mini is recognized by the drivers, there may be an audible beep and the indicator LED light on the LabQuest Minis will change from red to orange. Reopen the "**Q-Box RP2LP Setup**" file and proceed to assigning the sensors to appropriate channels on the two LabQuest Mini interfaces as follows:

a. Ch. 1 LabQuest Mini 1 = Q-S153 CO_2 Analyzer 5%
b. Ch. 2 LabQuest Mini 1 = Q-S102 Analyzer pressure
c. Ch. 1 LabQuest Mini 2 = Q-S102 O_2 sensor (25kPa)
d. Ch. 2 LabQuest Mini 2 = Q-G265 Flow Monitor 2LPM

Note: The LabQuest Mini 1 automatically recognizes the Stainless Steel Temperature probe (S132) in channel 3.



If the computer continues to assign the Lab Quest mini interfaces in the wrong order, then follow these steps to fix the problem: first plug in USB 1 cable to the computer and open the experimental file **Q-Box RP2LP Setup**, once the single star is observed in the top menu then plug in USB 2 cable to the computer and wait for the second star to appear as the software recognizes the second mini. The system should now be set up correctly to select the individual sensors as shown in the window above.

Using Q-G265 Flow Monitor

The Q-G265 Flow Monitor has been factory calibrated and should not require further calibration. However, if after extended use the flow values appear erroneous, the zero may have drifted. To reset zero, adjust "Flow Zero" on the front of the instrument using the small screwdriver provided with the package when no gas is flowing through the flow monitor. Make this adjustment with no gas running through the system, until a zero flow value is displayed in Logger Pro. **Do not accidentally adjust the "Flow Span". If "Flow Span" needs adjusting, a calibrated flow standard must be used (for example a Mass flow Controller set at a known flow rate of air).**

It is recommended to adjust the flow rate through the Q-Box using the needle valve on the back of the flow monitor. The flow is increased by turning the valve counter clockwise and decreased by turning it clockwise. Once the flow is set lock the ring on the needle valve with the small wrench provided to avoid accidental changes to the flow rate. The data cable from the analog output labeled "Flow" is plugged into the data interface and the flow data is displayed in the software.

Specifications of Q-S153 CO_2 Analyzer

Operating principle	Non-dispersive infrared
Gas sampling mode	Flowing gas stream, sealed chamber
Maximum gas flow rate	650 ml/min
Measurement range (LCD display)	0-10 %

Analog output, low sensitivity	0-10 %
Analog output, high sensitivity	0 -5 %
Accuracy (assumes accurate recent calibration)	0.3% of FS
Resolution	0.01%
Repeatability (assumes stable atm press and temp)	Better than ±1%
Maximum drift (per year)	±0.5%
Response time (@ 250 ml/min; to 95% of final value)	ca. 20 sec
Warm up time (@ 22^{o}C)	ca. 5 min
Output (linear) for Low Sensitivity setting	0-5 VDC for 0-10 %
Output (linear) for High Sensitivity setting	0 -5 VDC for 0-5 %
Calibration adjustments	Zero and Span
Operating temperature range	0 to 50^{o}C
Storage temperature range	-40 to 70^{o}C
Operating pressure range	±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	175 mA average, 450 mA peak
Dimensions (cm)	(H x W x D: 5.5 to 9.5 x 9.5 x 17cm)
Weight	1kg
Warranty	1 year limited

Specifications of Q-S102 O_2 Analyzer:

Operating principle	Acid Electrolyte, Teflon Diffusion Membrane
Detection Range	0-25kPa and 0-100 kPa O2 (Linear)
Resolution	±40 ppm
Accuracy	± 0.21% of Full Scale
Response Time (90%)	12 Seconds
Life Expectancy of O_2 sensor	3-5 years
Easy sensor replacement	
Influence by Other Gases	Ammonia and Ozone
min flow	5 ml/min
max flow	650 ml/min
Built in total gas pressure reading at the sensor (for pressure correction in the software)	
Pressure Range	0.5 atm to 1.5 atm
Pressure Effect	Output voltage changes proportionally
Shock Resistant	to 2.7 G
Avoid strong vibration	
Operating Temperature	5 to 40^{o}C (Effective range)
Weight	1.35 kg
Dimensions (cm)	(H x W x D: 5.5 to 9.5 x 9.5 x 17)

Output	0 to 5 volt
Power Supply	12 Volts
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.