CI-900 Portable Ethylene Analyzer

Operation Manual

CID Bio-Science Inc.

Portable Instruments for Precision Plant Measurement

DECLARATION OF CONFORMITY

Manufacturer:

CID Bio-Science, Inc.
1554 NE 3rd Ave
Camas, WA 98607

Declares that the CE-marked Product:

Product Models (s):

Model CI-900

Complies With:

89/336/EEC Electromagnetic Compatibility Directive
73/23/EEC Low Voltage Directive

Compliance Standards:

EN 55027	RF Emissions Information Technology Equipment
EN 50082-1	EMC Immunity Standard
EN 60950	Safety of Information Technology Equipment Including Electrical Business Equipment

December 18, 2013

Leonard Felix
President

DOCUMENT OVERVIEW

This instruction manual is written for firmware version 4.5.26

Introduction

Congratulations on the purchase of your new CI-900 Portable Ethylene Gas Analyzer. The CI-900 provides accurate real-time measurement of ethylene gas concentrations in a compact instrument suitable for field and laboratory use. At the core of the instrument is an electrochemical sensor that offers extraordinary sensitivity to ethylene, at levels as low as 0.04 ppm (40 ppb) in air.

Ethylene production is known to increase in response to plant stress and during fruit ripening and maturity, and until recently, sensitive ethylene measurements were available only through elaborate and expensive gas sampling and gas chromatography analysis. The intent of the CI-900's portable design is to aid the research community in developing real-world ethylene management applications for the benefit of growers, processors, and consumers.

The CI-900 analyzes the concentration of ethylene in a gas sample for the purpose of research or ethylene management. The CI-900 employs electro-chemical sensors as well as several other sensors for temperature, humidity, GPS location, and optionally carbon dioxide (CO_2: high and low range) and oxygen (O_2). During a sample, the subject gas travels across the surface of the electrode and diffuses into the electrochemical cell where ethylene is oxidized. The current created by the oxidation is measured and interpreted as the concentration of ethylene (reported in parts per million or ppm).

We hope you enjoy using your CI-900 Portable Ethylene Gas Analyzer.

Figure 1: The CI-900 Portable Ethylene Analyzer front panel and display.

Features

- High sensitivity to C_2H_4 (0 ppm – 200 ppm)
- CO_2 and O_2 sensing capability (optional)
- Compact portable form factor (2.43 kg)
- Real time continuous monitoring
- Internal data logging and storage (4 GB SD card included)
- Automatic data logging with adjustable interval
- User adjustable flow rate
- Transflective display enables easy viewing in direct sunlight
- Rechargeable Li-Ion battery provides 4 hours of monitoring in the field
- Multiple configurations to accommodate *in situ* research and controlled atmosphere monitoring
- Instantaneous and accumulated measurement modes (Monitor and Graph View)
- Quick connect sampling ports
- Data saves in .csv (commas separated value) file
- Configured for domestic and international operation: 110 VAC, 60 Hz or 230 VAC, 50 Hz
- Non-destructive measurements
- Mini-USB chargeable and mini-USB data download
- Time-date stamped data records
- External wire terminals for fixed location monitoring or control applications
- GC emulation mode for small sample volumes (optional)

Figure 2: The removable SD card on the CI-900 makes data transfer quick and simple.

Specifications

CI-900 Specifications	
Display	Sunlight visible transflective graphic LCD
Operating environment	0°C - 45°C (0-90% humidity non-condensing)
Battery Capacity	4 hours - Rechargeable Li-Ion (5000 mAh)
Dimensions	183.5 mm x 111 mm x 120 mm
Weight	2.43 kg
Enclosure	Anodized aluminum
Air Sampling Rate	0.2 Liters/minute
Sample Rate	Open Loop - Monitoring @ 5 sec intervals Closed loop < 3 min
Warm-up time	<5 minutes
C_2H_4 PPB Sensor	Electrochemical
Nominal Range	0- 2 ppm
Resolution	0.001 ppm
Lower Detection Limit	0.04 ppm (40 ppb)
Accuracy	±10 %; adjusted for temperature and humidity
Offset Recalibration	Daily
Span Recalibration	Weekly (calibration gas required)
C_2H_4 PPM Sensor	Electrochemical
Nominal Range	0- 200 ppm
Resolution	0.1 ppm
Lower Detection Limit	0.5 ppm
Accuracy	±5 %; adjusted for temperature and humidity
Offset Recalibration	Bi-annually
Span Recalibration	Bi-annually (calibration gas required)

Optional Sensors	
CO_2 PPM Sensor	Low-Power Non-Dispersive Infrared Gas Analyzer
Chopping Frequency	1Hz
Source Life	5000 Hours
Nominal Range	1 – 2000 ppm (Standard)
	0 – 3000 ppm (Optional)
Zero Scale Resolution	0.1 ppm
Full Scale Resolution	1 ppm
Repeatability	±0.1 ppm (short term)
Accuracy	< ±2% up to 3000 ppm
Sample Cell	100 mm x 10.2 mm (3.94" x 0.4" diameter)
Warm-up time	<3 minutes
Weight	172.6 g
Offset Recalibration	Daily
Span Recalibration	Bi-annually (calibration gas required)
CO_2 Percent Sensor	Infrared Sensor, Pyroelectric detector
Nominal Range	0 – 20% (200,000 ppm) (optional: 0-5%)
Full scale resolution	0.01%
Zero repeatability	±10 ppm
Full scale Repeatability	±500 ppm
Accuracy	1.5% of Full Scale
Lifetime	>5 years
Warm-up time	<3 minutes
Weight	7 g
O_2 Percent Sensor	Electrochemical
Nominal Range	0-100%
Resolution	0.1%
Operating environment	0°C - 55°C (5-95% humidity non-condensing)
Weight	7 g

Theory of Operation

The ethylene sensors in the CI-900 are electrochemical. With this type of sensor, the gas sample travels across the surface of the electrode and diffuses into the electrochemical where ethylene is oxidized. The current created by the oxidation is measured and converted to parts per million (ppm) of ethylene.

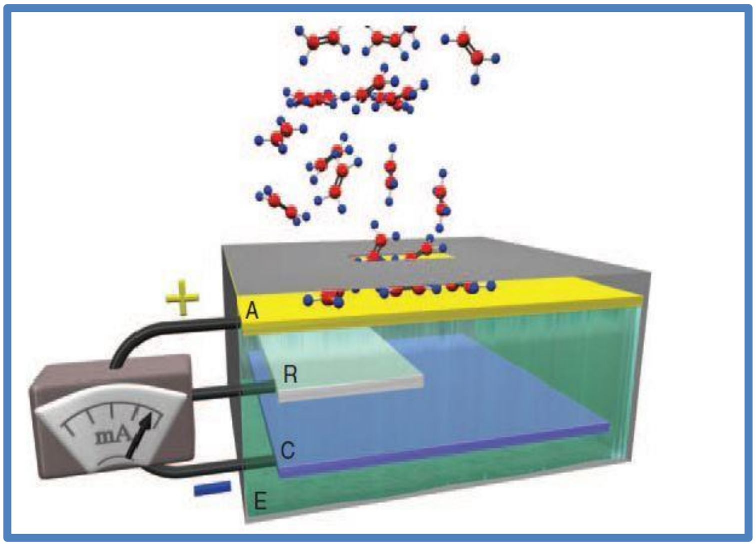


Figure 3: Diagram of an electrochemical sensor. A: working electrode R: reference electrode C: counter electrode E: electrolyte. Image credit: doi:10.1093/aob/mcs259.

The CI-900 flow rate is regulated by a pump and a flow meter. Additional optional sensors are enabled/disabled in the Setup Menu (see page 31), as well as "conditioning chambers" on the back of the instrument (see page 44).

The temperature and relative humidity sensors are located inside the instrument. Therefore, the temperature sensor is subject to heating by the CI-900 internal electronics. The temperature reading is often 4-5^{o}C above ambient and in turn, relative humidity readings are affected. The use of water in Chamber In (PolarCept, see page 7), will also affect relative humidity readings.

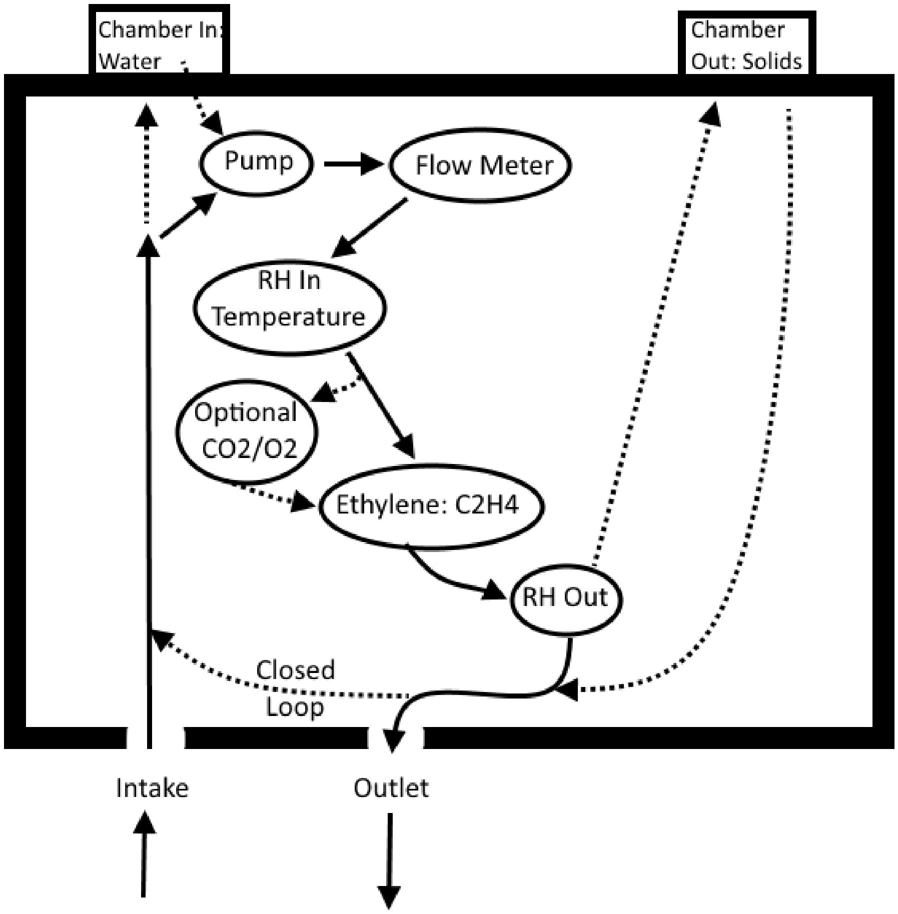


Figure 4: Flow path diagram of the CI-900 ethylene analyzer. Dashed line indicates optional flow path capabilities.

Interfering Gases

No analytical method is completely specific. Gases present in the environment, other than the “target” gas of a measurement, may affect instrument response. Interferences are not necessarily linear, and may also exhibit time dependent characteristics.

The following table details the approximate concentration in parts per million of interfering gas required to cause a 1 ppm detection in the ethylene analyzer. Please note that the response values given are not absolute.

Table 1: Interfering Gas and the CI-900 sensor

INTERFERING GAS	acetone	acetylene	Cl_2	CO	CO_2	ethyl alchohol	ethylene glycol	EtO	Freon	glutaral-dehyde	H_2	isopropyl alcohol	N_2O	NH_3
C_2H_4 (ethylene) ANALYZER	300	4	15 [N]	8	>10^4	150	0.3	0.2	> 10^4	1	500	0.4	> 10^5	200

[N] = Negative interference

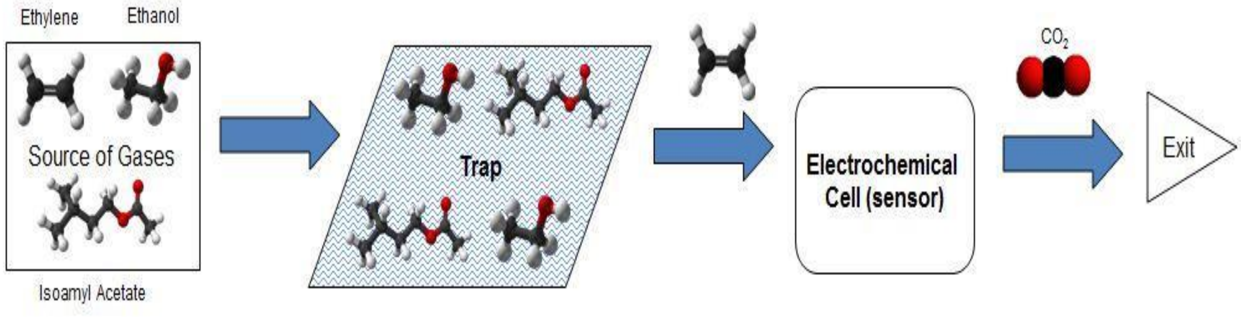
Ripening fruit emit a complex mixture of hydrocarbons, including ethylene. Oxidation of these other gases in the electrochemical sensor cannot be readily distinguished from ethylene. This causes the ethylene value to be falsely high in the presence of interfering gas. CID Bio-Science has tested a method to absorb some of the competing gases and provide better ethylene measurements. This method, PolarCept, uses distilled water in conditioning Chamber In and has been shown to filter out alcohols and produce less interference.

PolarCept

PolarCept is the use of distilled water in conditioning Chamber In to filter out or trap some of the interfering gases. Gas from the sample environment is passed through the water trap. Some of the polar molecules are held in the trap, while ethylene passes through the water trap to the sensor, where oxidation occurs. CO_2 is released as the oxidation product from the sensor. The water being used can become saturated after several minutes, so it must be cleaned of the trapped interfering gas molecules. Trapped interfering gases are driven out of the water during the cleaning time by a concentration gradient.

It is recommended to always use the PolarCept filter when measuring a gas mixture or interfering gases present will be reported by the instrument.

PolarCept: Measure



PolarCept: Clean

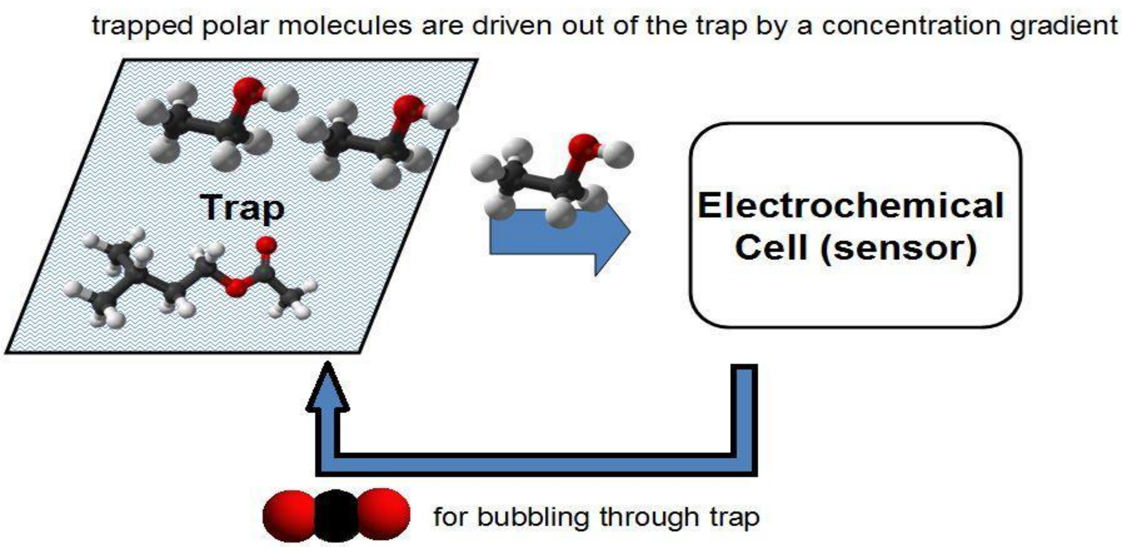


Figure 5: Top: diagram of measure period during use of PolarCept. Bottom: diagram of cleaning period of PolarCept.

Unpacking the CI-900

The CI-900 base unit arrives with the CI-900, strap and several accessory parts to use with the instrument. Included are the heavy duty USB cable, charger, tubing accessory kit, potassium permanganate ($KMnO_4$) and a CI-900 Instruction Manual. Several different styles of connector pieces and various lengths of tubing that **do not outgas (ex: Viton or Teflon)** are provided as part of the tubing accessory kit. Male and female quick connectors can be added to tubing and used to connect sample bags or custom chambers to the CI-900.

Figure 6: Accessories and parts that arrive with the CI-900, clockwise from top center: CI-900 ethylene analyzer, power supply and heavy duty USB cable, Viton tubing, Teflon tubing with quick connects, GC emulation port, assorted quick connects, GC emulation sampling syringe, Silica gel in conditioning chamber

The CI-900 includes the consumable potassium permanganate, which is used to scrub ethylene and other hydrocarbons from the gas stream. If the instrument has an optional CO_2 sensor, soda lime is included, which is used to scrub carbon dioxide from the gas stream and to create a 0 ppm CO_2 gas for the CO_2 zero calibration.

CI-900 Research Kit Accessories

The CI-900 Research Kit (CI-900RK) includes parts to non-destructively sample fruit in the field. The CI-900RK arrives in a hard-sided carrying case with a fruit chamber and wand with flexible tubing to sample fruit or plants. The fruit chamber includes a closed chamber lid and a lid with a seal to allow sampling of fruit still intact on the plant. The CI-900RK includes all the parts and accessories that arrive with the CI-900, as well as an external conditioning tube, sample bag, injection port assembly, glass syringe, needle, and a jar of silica gel which can be used to dehumidify the gas.

Figure 7: The CI-900RK arrives with a fruit chamber and two lids: closed chamber lid (left) and slit chamber lid (right).

Operating Instructions

To turn the instrument on, press the green power button. The top of the display reads CI-900 and the current firmware version the unit is running. For information on the latest firmware version, please visit the CI-900 software webpage (http://cid-inc.com/support/ci-900-support/900software). The line underneath this states "CID Bio-Science". Below this, a menu will appear on the display with the following options: Measure, Setup, View and File. This is the CI-900 Main Menu. After the instrument is powered on, the uptime and battery life remaining will be displayed on the bottom line. The uptime, or time the instrument has been powered on, is displayed in hours: minutes, followed by the battery life in percent.

Note: If the CI-900 does not power on, eject the SD card or disconnect the mini-USB cable from the front of the instrument. Then, power the CI-900 on. Re-insert the SD card or reconnect the charger.

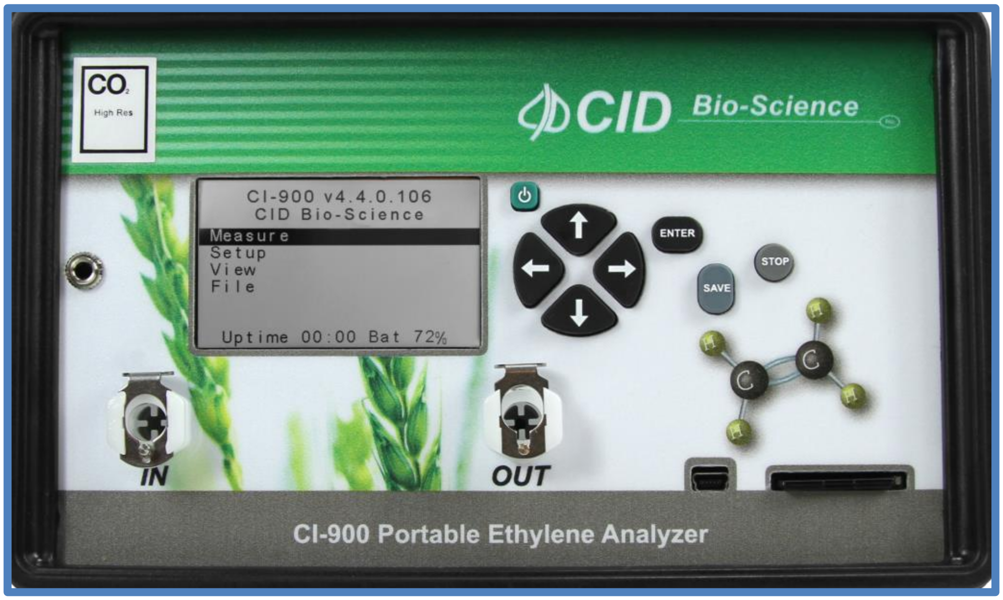


Figure 8: The options on the Main Menu of the CI-900.

From the Main Menu, there are four menu options: Measure, Setup, View and File. Use the UP and DOWN arrows to switch between menu options and the RIGHT arrow to select. Press the POWER button to power off the CI-900.

Note: To force a power off and reset of the CI-900 at any point, a user may press and hold the POWER button for 10 seconds. This "emergency hard shut-down" feature exists to address hardware or software problems and should not be used except when needed.

Charging the Internal Battery

The CI-900 arrives with a wall charger that can be used to recharge the CI-900 battery, as well as for continually powering the unit during long-term monitoring.

To charge the CI-900:

- Connect the mini-USB cable to the front panel of the CI-900
- Plug the charger into the wall
- Check the charge status (on/off) at the "View>Battery" menu

Figure 9: The battery charger setup of the CI-900.

The display will flash "powering off" on the top line when you hit the power key. "Power Off" will flash on the display as the instrument is powered off. **For fastest charging of the CI-900, use the highest rated port on the charger and do not connect any other USB devices to the charger.**

To use the CI-900 in Monitor Mode to continuously monitor fruit storage rooms or other locations, or to run the instrument for days or weeks at a time, connect the mini-USB cable to the charger cable and to the connection port on the front panel. Plug the charger into an electricity source.

CI-900 CO_2 PPM Sensor and Battery Power

The CO_2 PPM sensor draws a lot of power; if trying to conserve battery life, the sensor should be turned off when not being used. The CO_2 PPM sensor will draw power when turned on, even if the CI-900 is not actively measuring.

- Always turn the CO_2 PPM sensor to "off" for the fastest recharge, either using the mini-USB cable and computer or with a wall charger.
- The CO_2 PPM sensor ranges from 0-2000 ppm. The CO_2 PCT sensor is from 0-20% and does not have the same power draw.

To turn off/on the CO_2 PPM sensor:

1. Go to Setup>Sensor>Sensor Selection.
2. When asked "Are you sure you want to continue?" press Enter.
3. Press the DOWN arrow to highlight CO_2 PPM.
4. Press the RIGHT arrow key to highlight ON/OFF.
5. Press the UP/DOWN arrow key to toggle ON/OFF the sensor.
6. **Press SAVE** when the desired setting is highlighted. This will turn off the CO_2 sensor until you come back to this menu and turn it back on.
7. If you press ENTER, the CO_2 sensor setting will only be temporarily saved. When the instrument is turned off and then back on, the CO_2 sensor will be enabled.

Setup Sensor	
C2H4 PPB	On
C2H4 PPM	On
CO2 PPM	Off
CO2 PCT	Off
O2	Off

Measure Menu: Taking a Measurement

To begin taking measurements, select the Measure Menu by **pressing the RIGHT arrow** key when Measure is highlighted on the Main Menu display. Make sure the IN and OUT ports on the front panel of the instrument are clear from any obstructions. Create and open a file before starting a measurement, otherwise the default filename on the SD card is File01.

If sampling ambient air, turn the unit on and leave the front ports free of obstruction. If sampling a container or pallet, connect the Viton tubing to the "In" port and place the end of the tubing into the container or pallet to be sampled. If using the CI-900RK, place the fruit to be sampled in the fruit chamber, and connect it to the IN port on the unit. It is up to the specific setup whether the OUT tubing is connected to the OUT port with Chamber Out filled with potassium permanganate ($KMnO_4$) and set to "on". If left disconnected from the OUT port, the fruit chamber is allowed to replenish with ambient air.

Sensor Stability

The CI-900 will begin to warm-up. The CI-900 will display the "Sensor Stability" screen after pressing the RIGHT arrow to get into the Measure Menu. The display will show the File that is open and the Flow of gas being pumped through the instrument. Below this will be whether the initialization is automatic or manual. **If the initialization is automatic, the CI-900 will precede directly to the measurement (Graph Mode) once the sensors have stabilized**. If the initialization is manual, Monitor Mode will not be triggered until the user presses the right arrow to enter Monitor Mode.

- Press the DOWN arrow key to switch between automatic and manual initialization.
- Press the RIGHT arrow to skip the Sensor Stability screen and proceed to the Graph Mode display.

If the **offset autocorrection** feature is enabled, then the unit will run the set zero process automatically every 24 hours (or at the user defined time interval). The offset autocorrection utilizes Chamber Out, which should be left full of $KMnO_4$ even if Chamber Out is set to "off" during normal measurements. For more details on the offset autocorrection, see the Setup>Calibration menu on page 34.

NOTE: The CI-900 ethylene analyzer sensors should be given 24 hours to stabilize after being on an airplane. Start a measurement and enable the closed loop (ON) and allow the instrument to measure for 24 hours.

Graph Mode

Graph Mode will be entered automatically when the unit has stabilized in Sensor Stability mode. Or to enter Graph Mode, press the RIGHT arrow when the CI-900 is at the Sensor Stability screen. This view graphically displays the measured C_2H_4 value over time. To switch Graph Mode into Monitor Mode, press the right arrow. **To exit the measurement, press stop.**

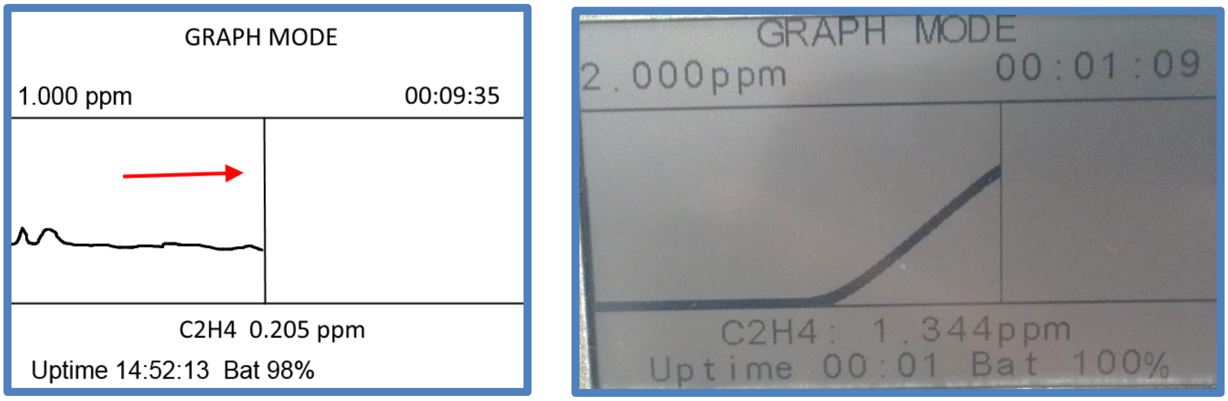


Figure 10: Graph Mode with red arrow indicating direction of movement.

Directly below the graph is the current ethylene value. Above the graph is the dynamic range (on the left it is 1.000 ppm, on the right it is 2.000 ppm). The y-axis scale is set by the highest value shown in the buffer. This range will scale vertically, dependent on the highest concentration of ethylene measured. If the concentration is small, the dynamic range will reflect this. For example, the initial value was 0.162 ppm and there is a sudden peak to 7.578 ppm. As the spike or peak occurs, the graph will scale to 10.000 ppm. If the sample returns to 0.168 ppm, the scale will remain at 10.000 ppm until the graph and the buffer are cleared.

The scale of the graph can be increased or decreased by using the up and down keys. Pressing the up arrow will zoom in on the data, minimizing the visible range. Using the down key will increase the scale, up to 200 ppm. Note that the minimum range of data visible (down to 0.150 ppm) depends on the current data being graphed. For example, if the current data is 3.486 ppm, the user may use the up key to zoom in to the 5 ppm range, but cannot zoom in to a narrower 2 ppm range.

The graph begins on the left side and moves with the vertical line towards the right as more data points are added. Once the time line reaches the right side of the display, the data will be compressed to the far left.

The time scale relates directly to the vertical position line. In other words, the line moves to the right as new data points are added. Every time a data point is added, the time scale is incremented. For time under 10 minutes, the graph is updating almost every second. The bottom of the display shows the uptime of the CI-900 and current battery level.

Monitor Mode

The large bold value on the top line is the digitally filtered value of the raw ethylene measurements. Next, the HUMIDITY, or relative humidity in percent, of the gas stream in the instrument is displayed followed by the TEMPERATURE in degrees. The PRESSURE or atmospheric pressure, is displayed. Press the DOWN arrow to view the FLOW in milliliters per minute. The default flow rate is 200 mL per minute. If the unit has a high resolution CO_2 sensor on board, the CO_2 value in ppm will be displayed below the ethylene value. If the unit has a low resolution CO_2 sensor, or O_2 sensor on board, the value will be displayed in percentage (%).

MONITOR
3.26 ppm

Humidity	47.0%
Temperature	28.7C
Pressure	101.0 kPa
Flow	200 mL
Det Rate	0.03 nmol/s

Uptime 01:17 Bat 95%

- If Autosave is enabled, "saved" will flash at the top of the display each time the data is automatically saved to the file.
- Press the STOP key to stop the measurement and exit to the Sensor Status display.
- Press the LEFT arrow to enter GRAPH Mode.
- Press the RIGHT arrow to get to the Measurement Settings menu.

The temperature and relative humidity sensors are located inside the instrument. Therefore, the temperature sensor is subject to heating by the CI-900 internal electronics. **The temperature reading is often 4-5^{o}C above ambient and in turn, relative humidity readings are affected. The use of water in Chamber In (PolarCept, see page 7), will also affect relative humidity readings.**

The detection rate (Det. Rate) in nmol/second is calculated by the following formula, based on ethylene being an ideal gas.

- Detection rate (n') = (V*P)/(R*T).
- Where volume (V)= flow rate * concentration (L/s)*(ppb) = **nL/s**
- P = pressure (atm) = (kPa)*0.0098692
- R= constant = 0.0821
- T = absolute t (K)

The detection rate starts calculating the ethylene emission rate from the fruit. Emission rate is typically calculated with the following parameters and the weight of the fruit.

- Flow rate: 0.2L/min = 15.0L/hr
- Sensitivity to C_2H_4: 0.1 µL/L or 100 nL/L

Therefore, the CI-900 optimally detects around 1500 nL/hr. If the specimen weighs 50 grams, then the emission rate is: 30 nL C_2H_4/gfw/h. The unit is nanoliters of ethylene per gram fresh weight per hour.

Measurement Settings

The **Settings** screen is accessed by using the RIGHT arrow from Monitor Mode, and provides a short list of variables which may be manipulated while measurements are being made. The exterior Conditioning Chambers are turned On/Off, valves are closed causing gas to circulate internally (Closed Loop On/Off), or the ethylene zero calibration (Set Zero) can be initiated. Chamber Out is primarily used with potassium permanganate ($KMnO_4$) for cleaning water and setting the instrument's offset. **It is recommended to use Chamber In with distilled water for most ethylene measurements.**

The Set Zero procedure begins by automatically closing the Intake and Outtake valves on the front of the instrument (Closed Loop) and enabling Chamber Out (On) with $KMnO_4$. The instrument will continue to record data to the file, with the mode listed as "offset". The instrument will allow time for ethylene to be scrubbed from the internal environment, wait for a stable point to be reached, and then set a new zero calibration point. Stability is reached when there is no more than a 40 ppb change in ethylene for 10 minutes. The limit of 40 ppb is the same as the noise. The set zero process takes about 25 minutes to complete.

The ethylene sensor zero calibration should be performed every 24 hours to compensate for daily baseline drift. To perform the C_2H_4 Set Zero:

1. Place potassium permanganate ($KMnO_4$) in Chamber Out.
2. Power on the instrument and allow adequate warm-up time (3 min).
3. Press the Right arrow when Measure is highlighted to begin a measurement.
4. Let the sensor stabilize and automatically begin measuring.
5. Once the measurement begins, press the right arrow until you access the "settings" menu.
6. Scroll down to "Set Zero".
7. Press the Right arrow to highlight "C_2H_4".
8. Press Enter.
9. A message appears asking "zero selected sensors?"
    a. Press enter to confirm.
10. A message appears asking to "Place $KMnO_4$ in CH_Out.'"
    a. If $KMnO_4$ is in Chamber Out, press enter to confirm.
11. The display will switch to Monitor mode and "correcting offset" is shown at the bottom.
    a. The settings will automatically change to turn on Chamber Out, turn off Chamber In and turn on the Closed loop.

12. The instrument will wait until no more than a 40 ppb change is detected for 10 minutes before setting the zero calibration point.
13. The instrument will make a “beep” sound twice to indicate that the offset correction is complete. **The entire set zero process takes about 25 minutes**.
14. The measurement will continue with the original settings for the conditioning chambers and close loop on/off.

SETTINGS

Chamber OUT	On
Chamber IN	Off
Closed Loop	On
Set zeros	C2H4

Uptime 01:15 Bat 75%

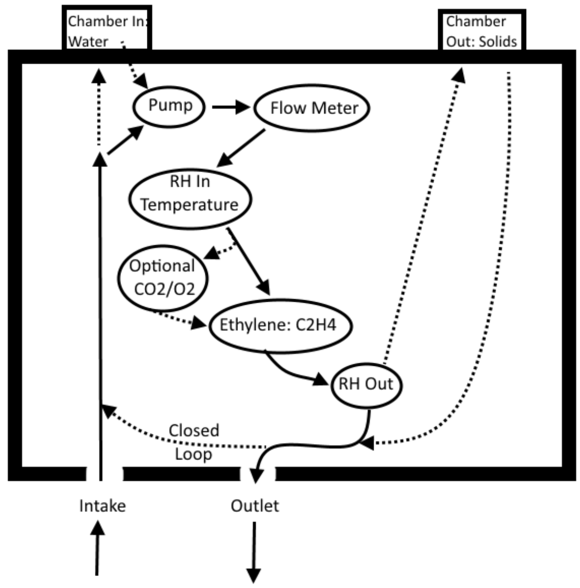


Figure 11: Measurement Settings menu display (left); flow path of internal gas stream (right).

Electrochemical Sensor Response

The lag in sensor response is a natural phenomenon for charged porous membrane electrodes. The platinum electrode can be thought of as a series of cylindrical pores. Each of these pores will have a double layer in the radial direction. The interactions between the molecules, convection from air movement, electric fields and the concentration gradient result in a lag following a change in concentration[1]. Additionally, a lag is created due to the volume of internal tubing the instrument contains. Because of the volume of internal tubing, it takes about **120 seconds** to see a response by the sensor.

[1] Kontturi et al., “Ionic Transport Processes: In Electrochemistry and Membrane Science.” (Oxford University Pess) 2008

Auto-Escape Feature

An upper limit auto-escape feature acts as a safety feature of the unit. This safety feature is always on. If the sensor detects over 200 ppm ethylene, the CI-900 will auto-escape from monitor mode to prevent poisoning of the electrode. This will stop the measurement. If the sensor becomes poisoned, it will continually auto-escape with the error message "sensor out of bounds". If this happens, use potassium permanganate ($KMnO_4$) in Chamber Out and set the instrument to Closed Loop. This will begin to clean the gas inside the instrument. If possible, the CI-900 ethylene analyzer should be removed from the high concentration environment.

Flow Block Error

The display may show “flow blocked” and a very low flow rate (less than 40 ml/min) for several reasons. If this message appears on the display of the CI-900, ensure that the intake on the front of the CI-900 is free from obstruction and not covered. If connected to tubing or a fruit chamber, disconnect and reconnect the tubing from the In port.

If using water in Chamber In, remove the top panel of the CI-900 and ensure no water has entered the CI-900. There is a white hydrophobic filter directly down the flow path Chamber In to be checked for water, as well as a hydrophobic filter near the in port on the front of the CI-900. If water is found inside the tubing or filters, STOP the measurement and allow the instrument to dry out. Be careful no further water damage occurs when turning the pump back on.

No SD card Present

If the autosave is enabled and no SD card is present, the user will be notified by seeing “INSERT SD CARD OR HIT ENTER KEY”. After enter is pressed, “NO SD CARD” is visible on the Sensor Status display where the FILE and filename usually are. Pressing any other button besides ENTER, will return to the main menu. Each time the CI-900 tries to autosave, the unit will flash “write error” instead of “saved” at the top of the display.

CI-900RK: Using the Research Kit Fruit Chamber

To use the CI-900 Research Kit in the field or laboratory, attach a hose of the chamber wand to the IN port on the front panel. Slide the end of the wand into the chamber and tighten the thumb-screw. Make sure the connection is snug. The fans inside the chamber will begin to spin when the connection is established. The fruit chamber available is 2L in volume. The chamber either has a flat-bottom or a bottom-slit to allow for non-destructive sampling. A fruit stem or petiole that is attached to the plant is passed through the slit and then closed in the chamber. This allows C_2H_4 levels to be recorded during ripening without damaging the fruit. Leaf chambers available for the CI-340 Photosynthesis System, from CID Bio-Science, Inc. are compatible and interchangeable with the CI-900 Research Kit.

If the tube is not connected to the OUT port, ambient air will be used to replenish the fruit chamber.

If the gas returning to the fruit chamber needs to be conditioned, consumables should be placed in Chamber Out and it should be turned on. Possible reasons to condition the air returning to the fruit chamber include scrubbing humidity (with silica gel) or scrubbing CO_2 (with soda lime). Build-up of carbon dioxide may inhibit fruit respiration at high concentrations. At high concentrations, the sensor fails to consume all the ethylene, so $KMnO_4$ could be used to scrub ethylene and not return it to the sample system.

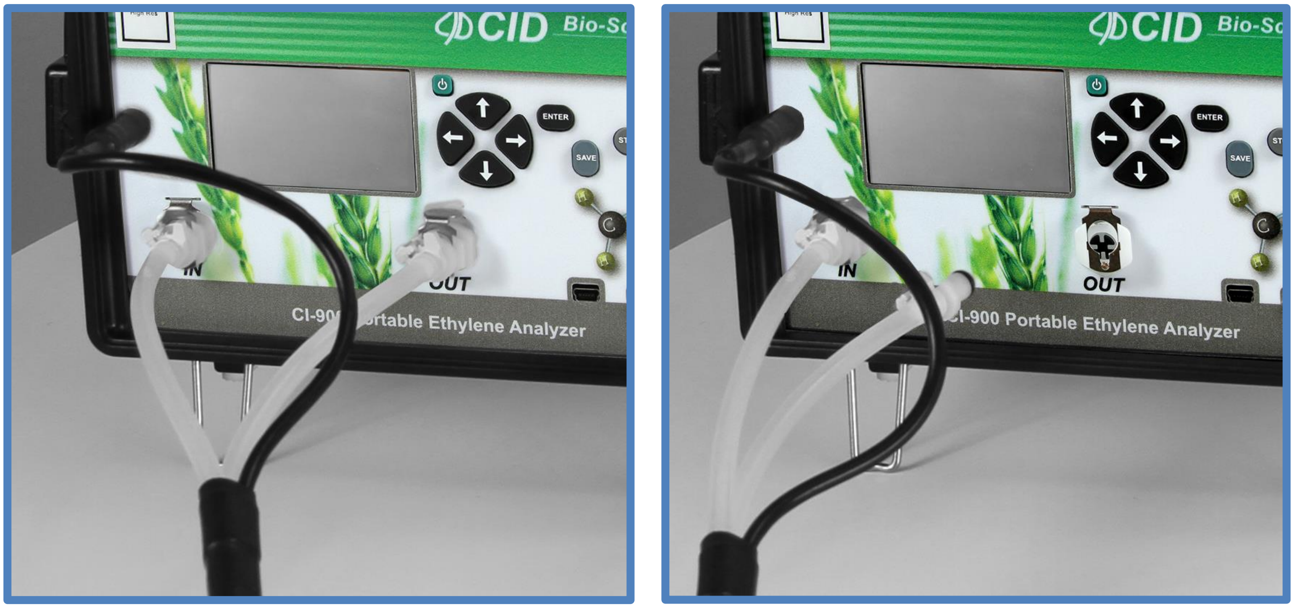


Figure 12: Using conditioned air to replenish the fruit chamber by connecting the IN and the OUT (left); using ambient air to replenish the fruit chamber by disconnecting the OUT (right).

To sample a fruit:

- Open a data file to save the measurements to.
- Attach the chamber to the CI-900 by screwing on the wand to the top of the chamber.
- Next, connect one of the tubes from the wand to the Intake port on the front of the CI-900.
- Connect the black power chamber cable to the left of the display to power the fans in the fruit chamber.
- Place the fruit inside the chamber and close it.
- Observe and record the rate of change of ethylene over time with the CI-900 Monitor Mode.

GC Emulation Mode

To use the CI-900 to analyze a small sample in a syringe, the GC Emulation Mode should be used. With the simple addition of our inline injection port, small volumes of analyte can be accurately measured. The use of GC emulation mode requires an ethylene standard, preferably in the same concentration range of the sample to be measured. GC Emulation Mode is available for the optional sensors for CO_2 and O_2. Calibration standard gas is not required for CO_2 or O_2 in this mode, only for ethylene. Simultaneous results can be collected for all enabled sensors.

Figure 13: GC emulation port connected to front of instrument for small volume samples.

The GC emulation mode employs a patent pending Flow Inject Analysis method to determine ethylene concentrations ranging from 0.2-20 ppmv with **sample volumes from 10-15ml.** Just like a GC, a simple estimation accurate up to +/-0.1ppmv is made by comparing the area counts of the unknown sample to a known concentration. As shown by Equation 1 below, the injection volume is determined by the expected concentration of ethylene and the detection limits of the sensor. If interfering gases are expected, their expected concentrations must be subtracted from the reported ethylene concentration.

Equation 1: $$0.2\ ppmv \leq \frac{Injection\ Volume * Expected\ Ethylene\ Concentration}{30mL} \leq 20\ ppmv$$

Exceeding the lower limit of Equation 1 will decrease the accuracy and precision of the result. **Exceeding the upper limit will affect the sensitivity of the instrument and will cause the instrument to under-estimate measurements for up to 24 hours.** A new calibration point may be required.

How GC Emulation Mode Works

The patent pending Flow Injection Analysis method integrates the signal from the ethylene sensor for 120 seconds. The resulting value, reported as area counts, is then compared against a user-definable calibration point and an estimated concentration is determined. **Using GC emulation mode requires the use of a standard ethylene gas.** The user-definable calibration point should be determined on a technician by technician basis as injection technique will alter the result. Additionally, setting the calibration point near the expected ethylene concentration will provide the most accurate estimation. There are several improvements compared to a Gas Chromatograph:

- No need for N_2, H_2, or bottled air.
- Portable.
- No heating or ovens required.
- Predicts ethylene concentration without chromatography.

GC Emulation Mode Tips

- If injection port does not have pressure-release valves, please disconnect and reconnect port at end of each measurement (when "Results" displayed) to prevent pressure build-up.
- **If the expected C_2H_4 sample's concentration is > 2 ppm, use a higher flow rate to increase signal detection. Recommended flow rate is 250 mL/minute, and can be set in Setup>Flow menu.**
- In general, higher injection volume will also increase signal detection. Recommended injection volume is **10-15 ml**. Once injection volume is set, please make sure to maintain the same volume of injection throughout all measurements.
- The CI-900 requires some warm-up time when using GC emulation mode. It is recommended to **verify your calibration point** after it is set for the first time. Inject the same sample and compare the displayed result with the calibration concentration. Reset the calibration point if needed. For example, if the calibration point is 5.0 ppm and your verifying sample read 5.9 ppm, reset the calibration point by pressing Enter. Repeat calibration/verification injections until samples are reported consistently.

C2H4: 5.9 ppm Set as Calibration? Yes: Enter, No: Stop

Note: Injection mode standard error (at two sigma) is ±10% of calibration concentration.

GC Emulation Mode Operation Procedure

Section 1: Warm up

1. Turn on GC Emulation mode in the Setup>Measure menu. Press **Save** to save changes and exit to the main menu.

Setup	Measure
Mode	GC Emulation

2. Enter the measure menu and wait for the instrument to stabilize.

SENSOR STABILITY

File	file01
Flow	200 mL
Initialization	Automatic

Environment Stabilizing
Please Wait...42%

Uptime 00:11 Bat 98%

3. Follow the instructions on the display and connect the inline injection port. Press **Enter**.

Setup injection tube
then press Enter

Uptime 00:13 Bat 98%

4. Enable or disable the Water Chamber to increase selectivity of C_2H_4 measurement. Enable the chamber only if CO_2 and O_2 measurements are NOT involved. Chamber In should be filled at least half full with fresh distilled water. The distilled water in Chamber In should be replaced with fresh DI water **every 10 injections**. Alternatively, monitor mode can be used to clean the water.

Use Water Chamber?

(C2H4 only)

Yes: Enter, No: Stop

5. Wait 10 minutes (600 sec) for the environment to stabilize, or press Enter to skip and continue to the next step.

Stabilizing environment	
Enter Skip	
C2H4	484ppm
CO2	0.03%
O2	20.6%
Humidity	51.3%
Temperature	21.4C
Flow	202mL
Ready in 600 sec	
Uptime 00:45 Bat 92%	

Section 2: Calibration Injection

6. Enter the volume of sample gas that will be injected in cc (1 ml = 1 cc). Recommended sample volume ranges from 10-15 ml. Press **Save**.

Setup gas	
Then press Save	
Volume	000015cc

7. Inject calibration gas, then press **Enter**. Next, remove the syringe from injection port.

Initial count	1609543
current count	1609383
peak count	1609616
CO2	0.03%
O2	20.6%
Processing…120	
Uptime 00:40 Bat 90%	

8. Wait for processing countdown to complete from 120 seconds.
9. Set the sample as your **calibration** standard by pressing **Enter** for Yes when asked "set as calibration"?
10. Enter the concentration of the calibration gas in ppb (1 ppm = 1000 ppb). The concentration of the calibration gas is printed on a tag or sticker on the bottle of gas. Press **Save** to see ethylene value in ppm on display.

Results	
Enter: Repeat	Stop: Done
peak count	2729747
2.00ppm	
CO_2	0.03%
O_2	21.1%
Uptime 00:52	Bat 90%

11. Press **Enter** to repeat and inject a sample or press Stop to exit to main menu. There is a "cleaning" time between samples, which can be skipped by pressing Enter. During cleaning, the ethylene sensor is consuming the ethylene from the sample. The instrument will wait until the ethylene signal is less than 100 ppb before finishing the cleaning. Cleaning will take longer with high concentration samples.

Note: if injection port does not have a pressure-release valve on the OUT side, briefly remove and replace the injection port from the CI-900 to manually release the internal pressure build-up between injections.

Section 3: Sample Injection

12. Follow the same steps, but this time, inject the sample gas using the same volume of sample as for the calibration gas.
13. Choose "No" by pressing Stop when asked "Set as calibration?" to view the ethylene concentration on the display.

peak count	2729747
1.92ppm	
CO_2	0.05%
O_2	20.4%
Uptime 00:58	Bat 85%

14. Press the **Enter** to start another measurement. Press Stop to exit to the Main Menu.
15. For ethylene readings, the procedure should be calibration injection, verification injection, sample injection, then repeat, for most accurate measurements.

Section 4: Optional Setting GC Emulation Mode Calibration Manually

If performing a calibration injection and verifying the accuracy of the calibration, it is no longer necessary to carry out the following steps. If questions arise as to how the calibration is working and what the area being used for the peak counts is, they can be found here. However, it is recommended to run the standard calibration injection protocol (previous GC emulation sections 1-3) and have the CI-900 automatically provide the peak counts.

1. Take 3 measurements of a calibration gas standard.
2. Determine the average of the 3 peak counts.
3. Set the value for peak counts to the average and enter the ppb concentration in the calibration menu. (Setup > Calibration > press Enter to continue > C_2H_4 > Standard > Injection parameters).

Injection parameters	
peak counts	1103698
concentration	0001000
calibrated Volume	50.0

Ethylene Sensor Zero Calibration

The baseline or zero of the ethylene sensor is known to drift, especially the C_2H_4 ppb sensor. The zero calibration should be performed daily. This can be done manually or automatically, as described below. In both cases, **potassium permanganate ($KMnO_4$)** is used to scrub ethylene from the gas and set the zero. Using PolarCept (water in Chamber In) is not necessary during the zero calibration.

It is not recommended to use N_2 gas to zero the C_2H_4 sensors. N_2 gas typically has hydrocarbon impurities which could create signal for the ethylene sensor. Standard ethylene gas (0 ppm) can be used to perform the zero calibration.

Manually Set Zero

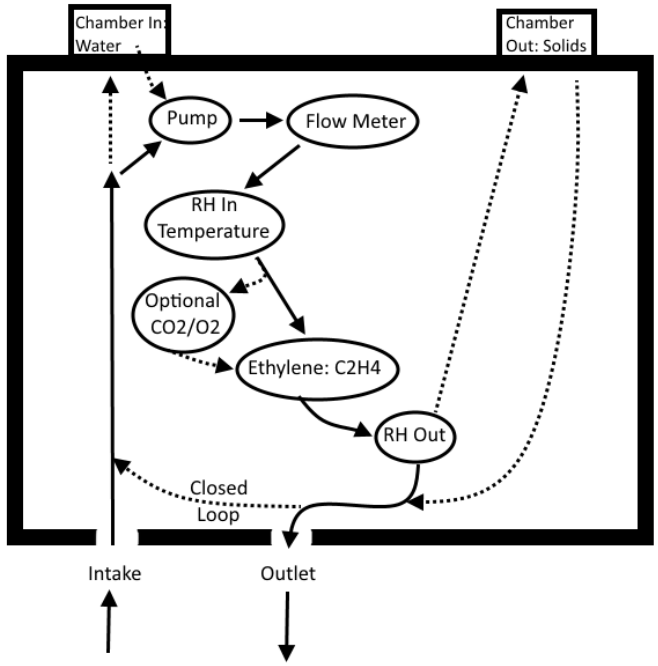
Please see Measurement>Settings menu on page 17 for additional information.

1. Place potassium permanganate ($KMnO_4$) in Chamber Out.
2. Power on the instrument and allow adequate warm-up time (3 min).
3. Press the Right arrow when Measure is highlighted to begin a measurement.
4. Let the sensor stabilize and automatically being measuring.
5. Once the measurement begins, press the right arrow until you access the “settings” menu.
6. Scroll down to “Set Zero”.
7. Press the Right arrow to highlight “C_2H_4”.
8. Press Enter.
9. A message appears asking “zero selected sensors?”
   a. Press enter to confirm.
10. A message appears asking to “Place $KMnO_4$ in CH_Out.’”
    a. If $KMnO_4$ is in Chamber Out, press enter to confirm.
11. The display will switch to Monitor mode and “correcting offset” is shown at the bottom.
    a. The settings will automatically change to turn on Chamber Out, turn off Chamber In and turn on the Close loop.
12. The instrument will wait until no more than a 40 ppb change is detected for 10 minutes before setting the zero calibration point.
13. The instrument will make a “beep” sound twice to indicate that the offset correction is complete. **The entire set zero process takes about 25 minutes**.
14. The measurement will continue with the original settings for the conditioning chambers and close loop on/off.

SETTINGS

Chamber OUT	On
Chamber IN	Off
Closed Loop	On
Set zeros	C2H4

Uptime 01:15 Bat 75%



Automatically Set Zero: Offset Autocorrection

Please see Setup>Calibration>Offset Autocorrection on page 34 for additional information or to enable/disable the automatic set zero feature. The automatic offset will stop a measurement to set the zero, and then re-start the measurement automatically. **This should be used during continuous monitoring or experiments longer than 24 hours.**

The offset autocorrection duration is adjustable (default: 30 minutes) and happens during "Sensor Stability", the first screen when measurement mode is initiated. The default interval between offset autocorrections is 24 hours for continuous use, or during the next start-up for units that are not running continuously. If the unit is exposed to concentrations greater than 200 ppm during the measurement period, the offset autocorrection will be initiated the next time the user enters "Sensor Stability", even if less than 24 hours have passed.

Setup Menu

The CI-900 has a number of utility functions that allow the user to manage the instrument's capabilities. These functions are accessed by pressing the RIGHT arrow when Setup is highlighted on the Main Menu. The setup utility options are: Measure, Autosave, Sensor, Calibration, Time, Flow, Chamber, Terminals, Board and Connection. Use the UP/DOWN arrows to select the desired option and then press the RIGHT arrow to enter the choice. Press the LEFT arrow to exit to the Main Menu.

Setup Menu
Measure
Autosave
Sensor
Calibration
Time
Flow
Chamber
Terminals
Board
Connection

Setup Measure

The Setup>Measure menu allows the user to setup a measurement in 1 of 2 different modes: Monitor Mode or GC Emulation Mode. Instructions to use Monitor Mode are found on page 16. GC Emulation Mode is available with the CI-900 Research Kit and requires the use of the inline injection port with septum. To save changes in the Setup>Measure menu, press **SAVE**. Use the UP and DOWN arrows to toggle between options.

Setup Autosave

To select the Autosave feature, press the RIGHT arrow key when Autosave is highlighted. This allows the user to setup the instrument to automatically store measurements, and to start a new measurement without explicitly saving the old one. This mode is convenient when taking fast, repetitive measurements, as well as when it is not necessary to review each measurement immediately after taking it. The files created by the CI-900 are saved in .csv (comma separated value) format, to be opened with Microsoft Excel or other spreadsheet program.

In the Setup>Autosave menu, the top line of the display will read "enter" and "save" and the directional arrows. Next to Autosave and "Yes" or "No" indicating whether this feature is turned on or off. Below Autosave is the "Interval" option where the user can set the time interval. This is the length of time in seconds between saves, when the autosave feature is selected. The default autosave interval is 10 seconds.

Autosave	Menu
Autosave	Yes
Interval	010

- To set the instrument up to automatically store measurements press the RIGHT arrow key to highlight the word "no" on the display, then press the UP/DOWN arrow to switch to "yes". Press the SAVE key to save the configuration. After saving, it will exit to the Setup Menu.
- To set the instrument up to **not** automatically save measurements, toggle the UP/DOWN arrow key until "no" is on the display, then press the SAVE key to save the configuration. To save data when Autosave is disabled, press the "save" button during the measurement.
- When Autosave is highlighted, press the UP/DOWN arrow to get to the Interval line and then use the RIGHT arrow key to highlight the time interval value. Press the UP/DOWN arrow key to change the time interval. Press SAVE to save changes.
- To avoid changing any configuration, press the STOP key to exit back to the Setup Menu.

Setup Sensor

The Setup>Sensor Menu has three options, **Sensor Selection**, **Sensor Voltammetry** and **Cell Hydration**. Sensor Selection allows the user to turn on/off the different sensors of the CI-900. After selecting any of the menu options from the Setup>Sensor menu, the display will prompt "Are you sure you want to continue?" Press **Enter** to continue to the selection.

Not all CI-900's are built with all sensors, so see the Production Check Sheet at the end of the manual to see which sensors are included in your unit. All units are equipped with a High Resolution C_2H_4, ethylene sensor (PPB) and an extended range C_2H_4, ethylene sensor (PPM). The C_2H_4 PPB measures from 0-2 ppm. The C_2H_4 PPM measures from 2-200 ppm, but is capable of reading as low as 0 ppm. Optional sensors available for carbon dioxide are the PPM or the PCT, which gives values in percent (%). There is also an additional sensor available for O_2 (percent oxygen). The optional sensors are in series, meaning the gas sample will flow to the CO_2 PPM, then CO_2 PCT sensor, then O_2 sensor. The C_2H_4 sensors are parallel, meaning a valve changes the gas flow between the C_2H_4 sensors, again depending on the current concentration.

Sensor Selection: Press the RIGHT arrow when Sensor Selection is highlighted to see the list of sensors.

Setup	Sensor
C_2H_4 PPB	On
C_2H_4 PPM	On
CO_2 PPM	Off
CO_2 PCT	Off
O_2	Off

- Use the UP/DOWN arrows to select the sensor to adjust and then the LEFT/RIGHT arrow keys to switch between columns. Once in the column with the On/Off, use the UP/DOWN arrow to turn the sensor On/Off.
- **Both ethylene sensors should always be turned "On" for measurements. The firmware will control which ethylene sensor is used to measure the gas sample.**
- If sensors are not included in your instrument, please set them to "Off".
- If not actively using the CO_2 PPM sensor, set it to "Off" to conserve battery life.
- Press SAVE to save any changes.
- Press STOP to exit to the Setup Menu.

Sensor Voltammetry should only be used if instructed by a CID technician.

Sensor voltammetry is the electrode recovery mode and is a useful tool if the electrochemical cell has been poisoned. However, running Sensor Voltammetry may cause the calibration to shift, changing the data displayed on the screen.

During this process the pump will be turned off and a series of voltage changes will occur on the sensor. First, voltage changes serve to oxidize anything on the electrode, followed by reduction and finally, a re-stabilization period for the sensor. The cleaning will take about 40 minutes to complete, and the sensor may be very sensitive and noisy for a period of time following the cleaning.

If Sensor Voltammetry is selected by mistake, please press the STOP key to exit, as instructed on the display.

Cell Hydration menu features options and details about the water status of the electrochemical sensor. The weight is set to 0.00 grams when the electrochemical cell is completely full, prior to it being shipped from CID Bio-Science, Inc. As the cell loses water, the weight will become a negative value. If the weight is greater than -10.0 g, the instrument should be hydrated by 10 cc (1cc = 1 g). A positive value indicates hydration, a negative value indicates dehydration of the cell.

A message on the display to **"check cell hydration"** indicates 2 possibilities: the ethylene sensor is dehydrated or overhydrated. Rehydrating the ethylene sensor is critical to maintain the instrument and accurate readings.

Cell Hydration	
Weight (g)	-000.297709
RH sync	
RH reset	

When this message appears, weigh the entire CI-900 (with no water or consumables in the conditioning chambers). Compare this weight to the weight on the Production Check Sheet on the last page of this manual.

To rehydrate the electrochemical sensor, the instrument should be in the closed loop mode. Distilled water should be placed in Chamber In and it should be enabled. Let the instrument run for 12 hours to rehydrate the ethylene sensor. Press stop to exit this mode and return to the Setup Sensor Menu. Re-weigh the instrument to determine if more hydration is needed. **Always have fresh distilled water in Chamber In when rehydrating the electrochemical cell.**

To dehydrate the sensor, place the instrument in closed loop mode with silica gel (humidity scrubber) in one of the conditioning chambers. Enable the chamber with the silica gel and let run overnight. Press stop to exit this mode and return to the Setup Sensor Menu. Re-weigh the instrument to determine if more hydration is needed.

Finally, reset the hydration value in the Cell Hydration menu to the current weight minus the shipped weight using the Up/Down arrows to adjust the value for weight. (Current weight – original weight).

RH Sync feature will synchronize the two relative humidity sensors inside the instrument (upstream and downstream of the ethylene sensor). This should only be done at the instruction of a technician.

RH reset serves to calibrate the relative humidity sensor. This calibration requires N_2 gas and should only be done by a technician. The calibration has two parts. The first part of the calibration will set the zero or baseline for each relative humidity sensor. The second part of the calibration will set the span (known value) for both RH sensors. This requires precise control of temperature and humidity of the entire instrument.

Setup Calibration

Current Calibration Parameters and re-calibration steps for C_2H_4, CO_2, and O_2 sensors can be found in the Calibration Menu. Press **Enter** to confirm and get into the menu. The options at the Setup>Calibration menu are C_2H_4, CO_2, O_2, system DAC and flow.

C_2H_4 Calibration

****Re-calibration or changes to any of the Calibration Parameters for C_2H_4 must be performed under the supervision of a CID Technician only.****

The options from the C_2H_4 Calibration menu are for the C_2H_4 PPM sensor, C_2H_4 PPB, offset autocorrection or sensitivity correction. Calibration Parameters are set by a CID Technician during factory calibration and are specific to each instrument. The internal offset is the ADC voltage output from the sensor when no ethylene is present, and gain describes the linear increase in the ADC voltage output from the sensor in the presence of ethylene. The RH, T slope and offset are applied to the ADC voltage to correct for shifts in relative humidity and temperature that may occur during the sample period.

Calibration	Parameters
Internal offset	
Internal gain	
Calibrated RH	
Calibrated t	
RH slope	
RH offset	
t slope	
t offset	

The ethylene sensor calibration will drift over time. Occasional recalibration of the sensors can be carried out using calibration gas in the range of each ethylene sensor. For example, 1 ppm C_2H_4 gas can be used to adjust the internal gain reading for the C_2H_4 PPB sensor. To adjust the internal gain of the C_2H_4 PPM sensor, standard gas between 5-100 ppm could be used. The timeframe for adjusting the gain depends on the specific sensor and its use. The C_2H_4 PPB sensor may require weekly gain adjustments, while the C_2H_4 PPB sensor may require gain adjustments every 6 months.

Manual Gain (Span) Calibration

It is recommended to use the more automated calibration of the CI-900 sensors, as described in the Setup>Connection section on page 50. **Always perform a zero calibration of the ethylene sensors using $KMnO_4$ before adjusting the gain.** Run the calibration gas for at least 15 minutes to ensure correctly reading calibration standard. Use the following formula to find the new internal gain and update it in the Calibration Parameters menu, where solving for "x" is the new internal gain. The measured concentration is what the CI-900 is reading the calibration gas as. Do not use the Chamber In with water when performing calibrations.

Enter the temperature on the display of the CI-900 as the “calibrated T” when the gain is adjusted. Press **Save** to save the new internal gain calibration value.

$$\frac{X}{\text{Original gain}} = \frac{\text{measured concentration}}{\text{standard gas concentration}}$$

Injection Parameters

With additional sensors added to the CI-900, additional internal volume is added and the amount of volume becomes specific to each instrument and the amount of tubing used. In order to determine the calibration volume for GC emulation mode using either CO_2 or O_2 sensors, the following formula is used. The results are saved on your ethylene analyzer and in the Production Test Check Sheet in this manual.

$$V= \frac{((X_i-X_o)*V_i)}{(X_f-X_o)}$$

- X_i: Injected gas concentration (%)
- X_o: Initial concentration (%)
- X_f: Final concentration (%)
- V_i: Injected gas volume (mL)
- V: Volume of gas stream in instrument (mL)

In GC emulation mode, start a measurement and setup the injection port (chambers off, closed loop off). Record stabilized value of target gas. This value is X_o. Next, prepare injection gas (such as 4% CO_2 or 50% O_2), record V_i and X_i, then inject gas. Record stabilized value “X_f” of target gas. Calculate V using the formula above. This should be repeated several times, and the average should be taken. The average calibrated volume (V) has been determined and entered in the Setup>Calibration> press enter>CO_2 or O_2>Injection Parameters menu by a technician at the factory.

Offset Autocorrection

Offset autocorrection allows the unit to adjust the baseline, or zero, for the ethylene sensors, which may drift from the zero set at the time of calibration. The offset autocorrection procedure typically takes about 25-30 minutes and takes place during “Sensor Stability”, the first screen when measurement mode is initiated. The default interval between offset autocorrections is 24 hours for continuous use, or during the next start-up for units that are not running continuously. If the unit is exposed to concentrations greater than 200 ppm during the measurement period, the offset autocorrection will be initiated the next time the user enters “Sensor Stability”, even if less than 24 hours have passed. **The offset autocorrection relies on there being $KMnO_4$ in Chamber Out.**

Offset Autocorrection	
Adjust enable	Yes
interval (hour)	024
requesting	Yes

Adjust enable: If "Yes" is selected, the unit will automatically adjust the offset every 24 hours or upon startup if more than 24 hours have passed between uses. The offset will be corrected when the user first enters measurement mode and is in the "Sensor Stability" screen. To enable the automatic offset adjustment, and to ensure that the latest offset adjustment so that the unit is using the most recent zero, change the "Adjust enable" line to "Yes". To return to factory calibration parameters, select "No".

Interval: The offset autocorrection interval can be changed from 24 hours (default) to any user selected interval in hours.

Requesting: If "Requesting" is reading "No" while adjust enable is on, the unit has recently set the offset and will not enter the offset autocorrection the next time the "Sensor Stability" screen is entered. If "Requesting" reads "Yes", the unit will begin resetting the offset the next time measurement mode is initiated and "Sensor Stability" is entered.

Sensitivity Correction

The sensitivity correction is for adjusting the internal gain value of the C_2H_4 sensors. Ethylene gas standards are required. The Sensitivity Correction feature is currently in process and will be completed in a future version of firmware.

CO_2 Calibration

To access the Calibrate CO_2 feature of the CI-900, press the RIGHT arrow key when Calibration is highlighted on the Setup Menu. Press enter to continue to the Calibration mode. Select the CO_2 sensor to be calibrated (PPM or PCT).

CO2 CALIBRATION

CO2 PPM

CO2 PCT

The CO_2 sensor needs to be enabled in the Setup>Sensor menu to access the Setup>CO_2 menu. To calibrate the CO_2 PPM sensor, 400 ppm or 600 ppm standard CO_2 gas is recommended. To Calibrate the CO_2 PCT, 4-20% CO_2 is recommended. Allow the gas to run for 20-30 minutes before calibration.

Calibration Parameters will display the coefficients from the previous calibration.

Re-calibration allows the user to re-calibrate the sensor, setting a new zero and span for the selected sensor. **CO_2 PPM zero calibration is recommended daily. CO_2 PCT zero calibration is recommended every six months.** However, if the unit is in an environment where the temperature fluctuates frequently, zero calibration may be necessary more often than the recommended intervals. Alternatively, a CO_2 scrubber such as soda lime can be placed in Chamber OUT.

Turn the ethylene sensors on for the CO_2 calibration. Directions for using a buffer system in place of a standard gas may be found at the end of the section.

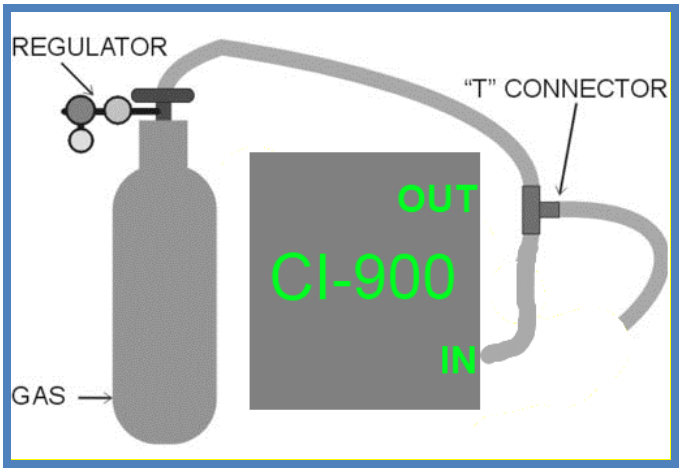


Figure 14: Calibrating the CO_2 sensor using standardized gas.

The CO_2 PPM zero calibration will drift with time and temperature therefore daily zero calibration is recommended for the CO_2 PPM sensor. If performing the CO_2 span calibration, it should be carried out immediately after the CO_2 zero calibration. The span calibration is required every 6 months. **The CO_2 span or gain calibration does NOT need to be performed every time the CO_2 zero is set.**

When performing the CO_2 span calibration, use standardized gas with at least 100 ppm CO_2, but not over the range of the CO_2 sensor (2000 ppm or 3000 ppm, check the production test check sheet at the end of the manual for CO_2 sensor information). The recommended standard gas concentration for the CO_2 PPM sensor is between 400 and 600 ppm. The recommended concentration for the CO_2 PCT sensor is 4-20% CO_2.

Calibrating the CO_2 sensor with standardized gas is fairly simple and takes 20-30 minutes. **Remember, to always use a "T" connection to vent excess gas and prevent damage to the internal components.**

1. Go to Setup>Calibration, press enter, then select CO_2. Select the CO_2 sensor to calibrate.
2. Go to Re-calibration and press the right arrow. You will hear the valves open and the pump begin to run.
3. The display will read Setup N_2 and press enter. If you have pure N_2 gas (0 ppm CO_2), connect it to the inlet of the device. Be sure to have a "T" in the line so that the instrument and seals are not over pressurized. Use the regulator on the gas tank to set the flow to just over 1 PSI. This will ensure the unit is provided with a bit more than the necessary gas for it to operate at 200 ml/min (wasting calibration gas will happen at over 2 PSI).

   If N_2 gas is not accessible, use the Soda Lime provided with the research kit. Create a 0 ppm CO_2 environment by filling the external conditioning tube with

soda lime and connecting it to the inlet. This will generate CO_2 free air, allowing the instrument to set the zero as it would with the N_2 gas.

4. Once the N_2 gas or soda lime is connected, press Enter. The instrument will enter a screen that reads "Internal Offset" and count down from 99.

5. When the offset is obtained, the instrument will pause and allow you to calibrate to either the 20% range or 100% range. For example, if you need the instrument to read 50%, press "Save" to calibrate to the 100% range.

6. In the Setup Gas screen, connect the CO_2 (use a "T" connection to not over pressurize the instrument) and change the value to 00050 %. Press "Save".

7. The instrument will now set the internal gain and count down from about 46.

8. The final calibration values will then be displayed. Press "Save" to save the values, completing the calibration and returning to the Calibration Menu.

Calibration Results	
zero	0
span	(600) 0000

If access to standardized CO_2 gas is limited, ambient air can be used to calibrate the CO_2 span. Ambient air should only be used if a buffer tank system is implemented. The buffer tank system will help stabilize fluctuations in CO_2 levels, providing an ambient air with approximately 400 ppm CO_2 (depending on proximity to urbanized areas).

Tips for Calibrating the CI-900 CO_2 Sensor with a buffer system:

- The operator should stand away from the CI-900.
- Use extra tubing to get the intake source away from human breath.
- Use a buffer tank system to stabilize the intake source.

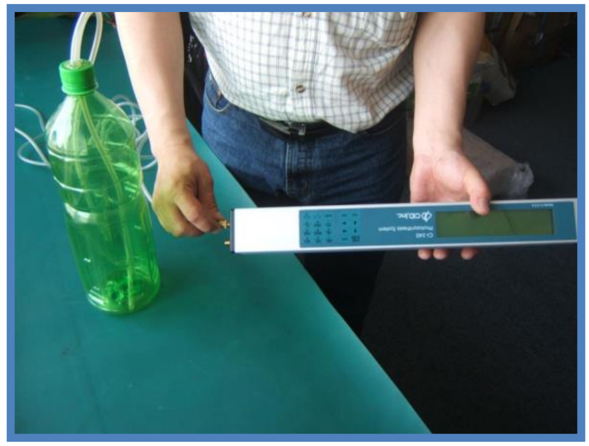
CO_2 Span Buffer Tank System Instructions

1. Find and clean an empty bottle with cap, which is at least 3L in volume.
2. Drill two small holes in the cap of the buffer bottle: 1 hole is for the intake tube and 1 hole is for the out tubing.
3. Insert a short plastic tube into the cap of the buffer bottle for the “out”.

4. Insert a longer plastic tube into the cap of the buffer bottle that will connect to the “IN” of the instrument. Use hot glue or otherwise seal the tubing to the cap, with no leaks.

5. Make sure that the tube and cap has no leaks.

6. Connect the “in” tubing to the intake port on the instrument.



7. To use the buffer bottle, make sure that the tubing is clear from obstruction. Connect the In tubing to the unit. Place the buffer bottle in a location that has stable CO_2 concentration (away from operator, cars, furnace, photosynthesizing plants). Here, ambient air CO_2 levels should be approximately 400 ppm.

Note: The instrument shown in these images is a CI-340 Photosynthesis Analyzer (CID Bio-Science, Inc). The buffer tank system technique can be used to help stabilize the ambient intake of any IRGA CO_2 sensor (images courtesy of ZealQuest, China).

O_2 Calibration

The offset and gain from the previous calibration can be seen under Calibration Parameters. These values are achieved by setting a zero and a span for the unit. To re-calibrate, pressurized N_2 gas and O_2 gas will be needed. If O_2 gas is not available, ambient air may be used. **Annual re-calibration is recommended**, but if the environment changes frequently, re-calibration may be required more often. To set the zero of the O_2 sensor, follow the same instructions for the CO_2 sensor zero calibration, with the following changes:

1. Use 0 ppm O_2 gas.

2. Highlight O_2 in the Measure>Settings menu and press ENTER twice when it is time to set the zero.

Calibrating the O_2 sensor with standardized gas is fairly simple. **Remember, to always use a "T" connection to vent excess gas and prevent damage to the internal components.**

1. Go to Calibration, hit enter, then O_2.
2. Go to Re-calibration and press the right arrow. You will hear the valves open and the pump begin to run.
3. Use pressurized N_2 to create zero O_2 gas. When the gas is flowing and connected to the unit, press Enter.
4. The unit will count down as it sets the zero for the O_2 sensor. The humidity, Temperature, and Flow are displayed. The flow should continue to read 200 mL throughout the calibration- if it does not you may have a leak or obstructed tube. (Pressing enter at any time will move you into the next step. Only do so if you want to use the previous zero calibration).
5. Setup Calibration gas: Enter the percent concentration, where 1000 E-3 = 100% and 210 E-3= 21%. Use the LEFT/RIGHT arrow keys to switch between placeholders, and the UP/DOWN arrows to change the values.
6. Press save to initiate the calibration.
7. The unit will count down from 19 as it sets the span for the O_2 sensor. (Pressing enter at any time will move you into the next step. Only do so if you want to use the previous span calibration).
8. After the unit has set the zero and the span for the O_2 sensor, the Calibration Results are displayed. Press Save to save the values and return to the Calibration Menu.

Setup Time and Date

To change the time and date on the CI-900, press the RIGHT key when "Time" is highlighted on the Setup menu. This utility allows the user to set-up the instrument in different time zones or to adjust the time after daylight savings.

- To change the time on the instrument, use the UP/DOWN arrows to change the values. Use the LEFT/RIGHT arrow to highlight the appropriate column. Then, make the appropriate shift in time and press SAVE.

Setup	Time
03 28 2013	16 : 33 : 24

Setup Flow

The air flow of the CI-900 is an important factor for taking good measurements. The default flow rate is 200 ml/min. Flow rate is adjustable from 100-500 ml/min.

A flow value below 100 ml/min can negatively impact sensor functionality. If measuring bottled gas, a lower flow rate may be used in order to reduce gas waste. If measuring open air, a higher flow rate (~300 ml/min) is acceptable. **The default flow rate is 200 ml/min**.

Setup	Flow
Set Flow	200
Actual Flow	200

To make adjustments:

1. Go to Setup>Flow and press the RIGHT arrow.
2. Use the UP/DOWN arrows to adjust the value.
3. The Set Flow value is found in ml/min to the far right.
4. The Actual Flow value will change to match the set flow.
5. Press SAVE to save changes and exit back to the Setup Menu.
6. Press STOP to exit back to the Setup Menu without saving.

Setup Chamber

The Setup>Chamber menu allows you to turn on/off the in-line conditioning columns on the back of the instrument. **The settings in Setup>Chamber are the default settings to be used to start a measurement.** Once a measurement is in process, conditioning chambers can be turned on/off in the Measurement>Settings menu. The removable plastic containers are used to hold the consumables potassium permanganate, distilled water, soda lime, and silica gel. **Keep the plastic containers on the CI-900, even when empty, to protect the brass intakes. Always ensure the conditioning chamber is seated properly when screwing it on the CI-900.**

The purpose of the inbound chamber, Chamber In is to condition the air before it reaches the sensor. Chamber In additionally provides a “special mode” where distilled water is used to filter out alcohols before the electrochemical sensor. The use of distilled water in the Chamber In is referred to as PolarCept. **It is recommended to use PolarCept (Chamber In: Special) for most ethylene measurements. PolarCept is intended for distilled or deionized water only.**

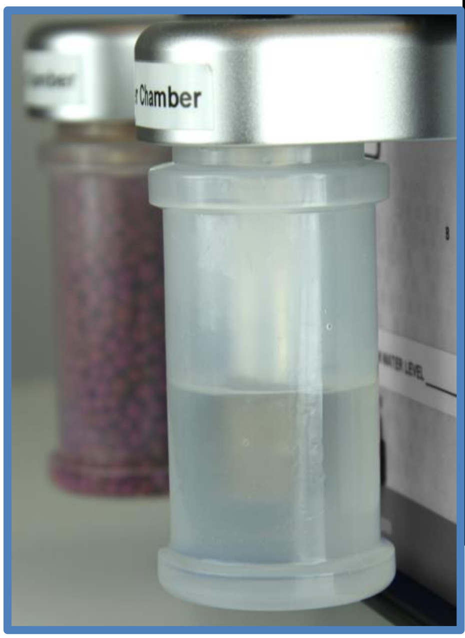
Figure 15: Solids Chamber and Water Chamber on back of instrument.

Chamber Out is on the left of the back panel. Chamber Out is the last chamber before the gas OUT port. If the Outlet gas stream is connected to the field kit chamber or to the inlet of the unit, it can be used to condition the incoming gas after it leaves the sensor. **Chamber Out is used with potassium permanganate ($KMnO_4$) for cleaning water and zero calibration of ethylene sensors.**

Enabling Chamber Out, the CI-900 can use soda lime to remove CO_2 from the gas stream. Similarly, silica gel is used to scrub water from air and create a 0% relative humidity gas. Most commonly, potassium permanganate is used to remove hydrocarbons from the gas stream. $KMnO_4$ beads (not dust) should be sourced locally by the user.

$KMnO_4$ will turn from purple to brown when it expires and needs replacement. The silica gel has an added color indicator that changes from blue to pink when replacement is necessary.

To use Chamber Out to condition the air replenishing the fruit chamber, enable Chamber Out in the Setup>Chamber menu and fill Chamber Out with the appropriate consumable. Connect the fruit chamber hoses to both the IN and OUT ports on the front of the CI-900.



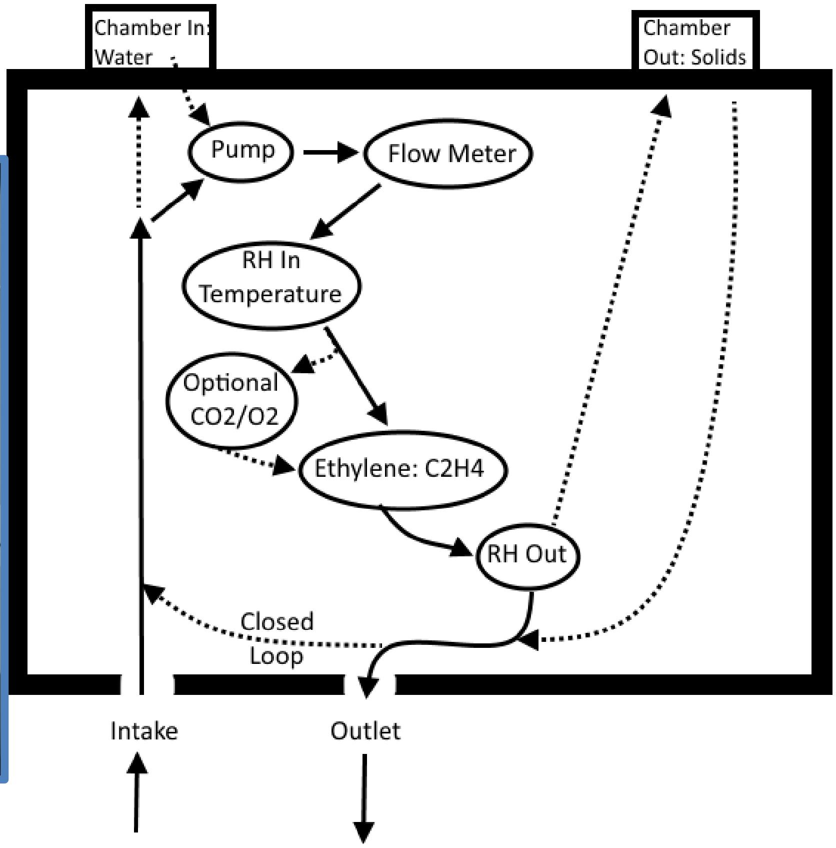


Figure 16: The back of the CI-900 with removable and refillable containers for distilled water and $KMnO_4$ (left) and a diagram showing the flow path of the gas stream (right).

Chamber In is on the right side of the back panel. This chamber can be enabled in 2 different modes. Chamber In should be filled with distilled water to help filter out interfering gases in the air stream. By passing the gas sample through the water, polar molecules are trapped or filtered from the airstream. Using Chamber In with distilled water as a filter can help reduce the interference measured when alcohol or other light polar molecules (known interfering gases for the CI-900 electrochemical sensor) are present. Also, using the water trap can help keep the electrochemical cell hydrated, with longer periods of time between needing to refill the electrochemical sensor.

There are 3 options for Chamber In in the Setup>Chamber menu.

1. Chamber In set to OFF.
2. Chamber In set to ON.
3. Chamber In set to **SPECIAL**. This is the setting for **PolarCept**.

Use the UP/DOWN arrows to select Chamber Out or Chamber In. Use the RIGHT arrow to get to Off/On. Next, use the UP/DOWN arrow to switch between on or off, or set the measure or cleaning period in minutes. If Chamber In is set to Special, you will see Measure or Cleaning Period appear below.

Chamber	Menu
CHAMBER_A OUT	Off
CHAMBER_B IN	SPECIAL
MEASURE PERIOD	3 MIN
CLEANING PERIOD	17 MIN

To use soda lime or silica gel to condition the air stream before it is measured, turn Chamber In to ON and place the consumable in the conditioning chamber.

- Fill Chamber In less than half full with distilled water.
- The water level of Chamber In should to be inspected **every 120 hours** when using PolarCept. This mode may not be applicable at high ethylene concentrations.
- When the CI-900 is using the water to filter out alcohol, the water must be cleaned by running a longer cleaning period than the measure period.

To use the PolarCept water trap, set Chamber In to SPECIAL. Fill Chamber In less than half full with distilled water. There is a fill line on the back of the instrument. Next, set the length of the measuring period in minutes. This is the time the CI-900 will take to do a measurement. When using the water trap, a settling time of at least 3 minutes is required before being able to record a measurement. At a measuring time of 5 minutes, the reading is settled, but the overall measurement will take longer. A measuring period of 3-5 minutes is sufficient to achieve an accurate reading. After 5 minutes you run the risk of reaching saturation. Actual times will depend on application/environment.

The length of time required for cleaning will be dependent on the make-up of the gas(es) being sampled. The more interfering gases that are present, the longer the water will need to be cleaned. The main reason for the cleaning step is to keep the water in the maximum adsorption range. As the water becomes polluted with alcohols, it will not filter as effectively. This results in an increase in signal from interfering gasses escaping the filter. A small measurement to cleaning time ratio is suggested because the longer the measure time with the filter, the longer it will take to clean. A recommendation of **5 minutes of measure and 12 minutes of cleaning** is better than 20 minutes of measure and 60 minutes of cleaning. For long-term monitoring, cleaning time may need to be extended upwards of 50-60 minutes. At the end of the cleaning time, the C_2H_4 reading should be low (less than 0.2 ppm). If not, lengthen the cleaning time and repeat the test.

When the CI-900 has conditioning Chamber In turned on, the Monitor Mode display top line will indicate CH_IN, meaning that Chamber In is enabled. Next, the current state (measure or cleaning) will be shown. If the CI-900 is in a state of Measure, the data will reflect the current measurement. If the CI-900 is in a state of Cleaning, "Clean" is shown in the upper right corner of the display. The CI-900 has two hydrophobic filters in-line with the internal tubing. This is to protect the CI-900 in case any water is sucked into the instrument when using PolarCept.

B_SPEC	MEASURE
0.160 ppm	
HUMIDITY	47.0%
TEMPERATURE	28.7C
PRESSURE	100.4KPa

To avoid drawing water into the internal tubing of the CI-900 when using PolarCept:

1. Fill conditioning Chamber In only to the fill line and **never completely fill** the conditioning chamber with water.
2. Always keep the top panel of the CI-900 facing up and **do not tilt the instrument** when there is water in the conditioning chamber. When operating in SPECIAL mode, do not operate the instrument with the display panel facing upwards.
3. **Do not transport or tip the CI-900 if moisture is in Chamber In**. Before transport or moving the CI-900, Chamber In should be completely dry to prevent even small drops of liquid from entering the unit.
4. If the Relative Humidity sensor reads high, open the top panel of the unit and inspect hoses for liquid. If liquid has accumulated at the hydrophobic (blue) filter, it should be disconnected and drained. If liquid has penetrated the hydrophobic filter the unit will need to be serviced to prevent circuit board failure. Contact support@cid-inc.com with any questions.

Setup Terminals

The Setup>Terminals Menu is where the CI-900 can be setup to have an external fan or gas control connected to the terminal block. The terminal block is located between the chambers for consumables on the back panel of the CI-900. The CI-900 can turn on and off the gas based on the measured ethylene concentration of the room (or chamber). Other control applications using the terminal block are possible, such as controlling ethylene scrubbers or connection to an external control system.

The CI-900 will perform action at the high and low levels, when set. If the concentration of ethylene rises above the Gas_Hi, the gas will be shut off. If the ethylene concentration is lower than the Gas_Lo, the gas will be turned on.

Setup	Terminals
VALUE	PPB
GAS_HI	00000
GAS_LO	00000
CONTL_OUT	DISABLE
CONTL_IN (Clean)	DISABLE

- Press the UP/DOWN arrow to switch between parameters.
- Press the RIGHT arrow to switch to the column containing the values in **ppb** (parts per billion).
- Use the UP/DOWN arrow keys to set the desired level.
- Press the LEFT arrow or SAVE to exit back to the Setup Menu. Any changes made will automatically be saved.
- Enabling **CONTL_OUT** will turn on the standard terminal control, using the output of the pins to control turning on or off the gas and/or the exhaust fan.
- Enabling **CONTL_IN (Clean)** allows use of the analog input pin to supply a voltage to control the cleaning mode (input signal). This terminal control mode was developed for using the CI-900 with other external advanced control systems. When this mode is not being used, set to DISABLE.
    - Note: if Setup>Chamber: *CHAMBER _IN* is currently set to *Special*, enabling *CNTL_IN (CLEAN)* will overwrite *CHAMBER_IN* to *OFF.*
    - Terminal Connections:
        - Pin 1: Ground
        - Pin 10: Control voltage. Control voltage could be applied during Measure>Monitor mode to control cleaning mode. Specifically:
            - 0.0-1.0V: Cleaning disable (closed loop OFF, chamber IN OFF)
            - 1.5-5.0V: Cleaning enable (closed loop ON, chamber IN ON)

To connect a gas control to the terminal block of the CI-900, first pull off the removable portion of the terminal block (pull straight out). The piece in the figure below will separate from the CI-900. Slide the wire from what is going to be controlled through the opening for pin 4 or pin 5. Use a screw driver to tighten and clamp onto the wire, creating a connection. The removable section of the terminal block is designed to stay with the fan or gas control so, if the CI-900 needs to be moved, the terminal block can be disconnected easily.

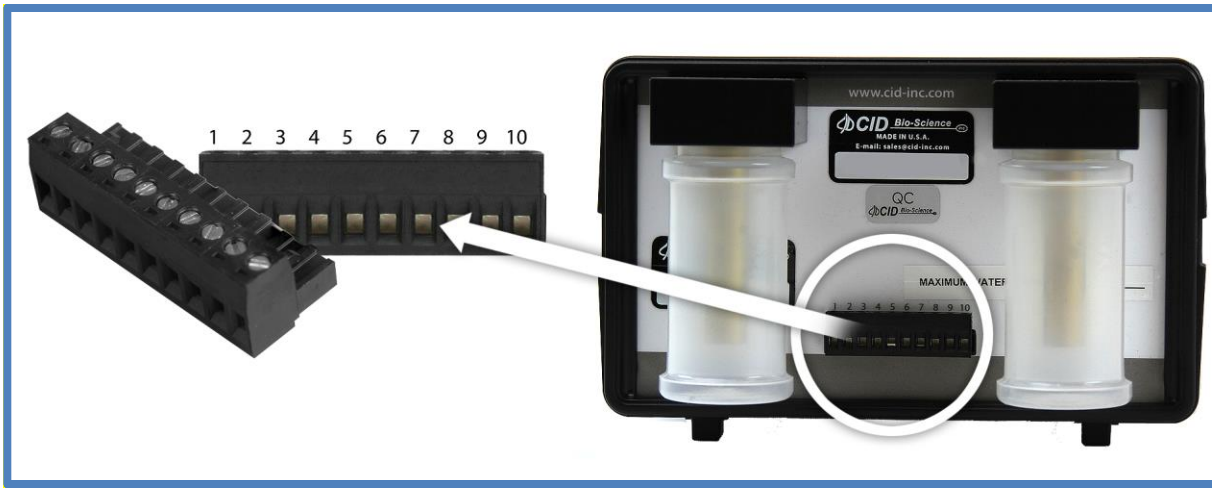


Figure 17: The removable piece of the CI-900 terminal block.

The 10 pins of the terminal block have the following designations:

PIN	Function
1 and 2	Ground
3	Plus 5 volts (limited through 4.7 ohm resistor)
4	Gas valve control (5 V)
5	Ready signal (5V)
6	Alarm or error indicator
7 and 8	Analog outputs (4-20 mA)
9 and 10	Analog inputs(4-20 mA)

Setup Board

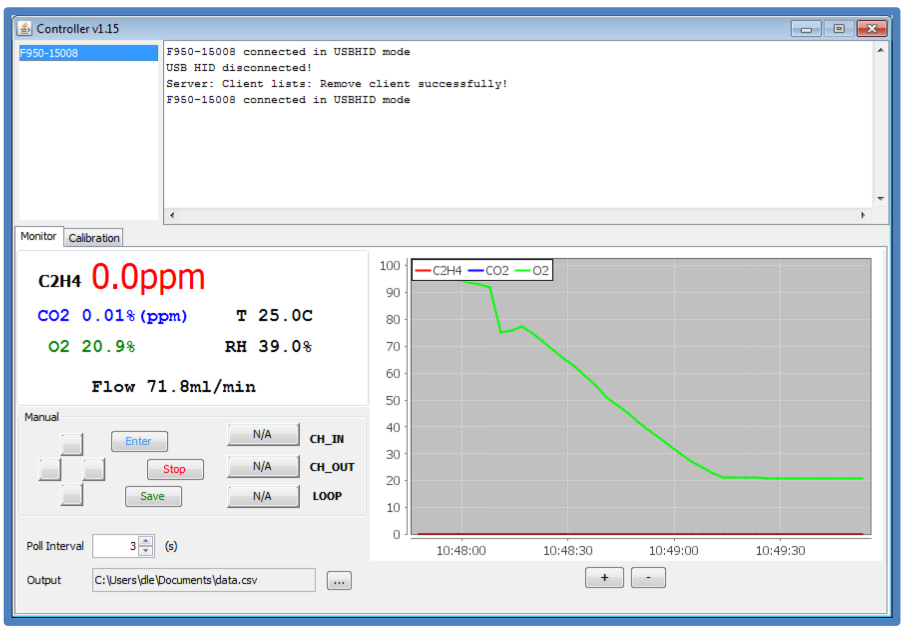
The Setup Board Menu should only be changed by a CID Technician. This menu allows the user the select the type of hardware platform that the unit operates on, and should only be changed at installation, or if hardware is upgraded.

Setup Connection

Setup>Connection feature will be fully available in the next version of firmware. This feature allows a connection to a computer via USB or WiFi (mode). Highlight "Connect" and press **Enter** to establish a connection. "Not connected!" will appear if the connection is not successful. Currently, the USB connection can be established.

Mode	USB
Group	STAB/CALI
Connect	

The **CI-900 Controller Software** offers real-time monitoring, controlling as well as calibrating multiple CI-900/F-950 devices from standard USB connection. The CI-900 Controller Software is included as part of the firmware update package (http://cid-inc.com/support/ci-900-support/900software), named CI-900 Controller. Once the package is downloaded, the CI-900 Controller software can be found in the Windows start menu.



Instructions:

1. Open the CI-900 Controller software
2. Connect the CI-900 to the computer using the mini-USB to USB cable.
3. In Controller software, the device series should show up in the device list at top-left corner. Click on the device series to select device. *Note: when connecting device to your computer for the first time, it may take a minute for the device to show up in the left panel.*
4. Monitoring information from your device should display in monitor tab.

View Menu

The View Menu can be accessed from the main menu screen by pressing the RIGHT arrow key when "View" is highlighted on the display. This menu allows the user to navigate to and see the files, as well as check on many features of the CI-900. Options from the View menu are: Files, Voltage, Battery, Flash, Time, GPS, and SD card.

View Files

The View>Files menu allows the user to review the filenames and file size of any files on the CI-900. To view collected and saved data, either download files via USB or eject the SD card and insert it in a computer. In the View>Files mode, the top line of the display will show the word "View" on the left and "Files" on the right. Below this, the column on the left contains the filename and the column on the right contains the file size.

The options are:

- use the UP or DOWN arrow keys to scroll through the files
- press the LEFT arrow or STOP to exit to the View Menu

View	Files
File01	3201
RoomA2	1022
Fruit7	0

Note: A file with a negative number for the file size is corrupt. This file should be deleted and re-created.

View Voltage

The View>Voltage screen shows the current voltage of the instrument. Press the RIGHT arrow when Voltage is highlighted to check the unit's voltage. If any of these numbers are rapidly changing after the instrument has warmed up, please contact technical support at support@cid-inc.com. Press the LEFT arrow or STOP to exit back to the View Menu.

Voltage is set for each individual unit before leaving the CID Bio-Science factory and is board specific. For default voltage values, please see the Production Test Check Sheet at the end of the Instruction Manual for factory voltage settings. V_System is the voltage of the control board. The voltage for V_Charger should increase when you connect the USB charger. V_3volt is the digital voltage from the CPU and the V_Analog is the converted analog voltage.

View		Voltages
V_System	=	5.98v
V_Charger	=	4.64v
V_3volt	=	3.31v
V_Analog	=	2.07v

View Battery

The View>Battery menu displays indicates on the top line if the unit's Charging is On or Off, or if the unit is connected via USB cable to a computer. The QBAT value shows the battery level in hexadecimal follow immediately by the battery level in percent. VBAT shows the voltage of the battery and TBAT indicates if the temperature of the battery is ok. The Charge shows the output status of the battery charger. Press the LEFT arrow or STOP to exit to the View Menu.

Charge	Off
QBAT:	a413 60%
VBAT:	3.840V
TBAT:	OK
Charge:	Off
Board:	v6

When the instrument is connected to the charger, the top line will indicated Charge On. Charge Off indicates that the unit is not charging. USB Host in the upper left corner indicates that the unit is connected to the computer or that the power supplied by the charger is not full charging voltage (unplug any other devices using the same charger).

The QBAT hexadecimal number should be changing and the battery percent increasing. Also, the voltage will begin to increase slowly. The Charge will read "off" when no charger is plugged in and "Complete" when finished charging. The Board refers to the hardware version of the unit. Features described in this manual are associated with all versions of hardware. When discrepancies occur, they are listed, along with the version that they are associated with.

Other View Menu Options

The View>Flash option is only accessible by CID Bio-Science technicians.

The View>Time screen displays the current time on the instrument. Press the LEFT arrow or STOP to exit back to the View Menu. The View>SD card screen indicates if an SD card is present in the unit, as well as other information about the SD card. If no SD card is in the instrument, or if the SD card is not fully inserted, “no SD card” will appear on the display.

```
          <stop>

SDcard              Present
CardSize  =      3935MB
NumSectors  =  8058880
BlockSize  =     512B
```

GPS System Features

The CI-900 has a built-in GPS system which can relay the longitude, latitude and altitude of the instrument when performing measurements. The View>GPS screen displays the mode of the GPS sensor (SEN= $GPGGA), as well as the values for latitude, longitude, altitude and indicates the number of satellites currently connected to. Press the UP/DOWN arrow to display the latitude, longitude and altitude information only.

```
<stop>    <save>           ←→↑↓

SEN =                    $GPGGA
SAT =                        05
TIM =                015546.806
LAT =                 45.58792
LON =                -122.37459
ALT =                     10.6
```

The GPS uses GMT or Greenwich Mean Time for a standardized time. The GMT is displayed as the time (TIM) on the GPS menu and is synchronized with minute and second alignment. Often, when the instrument is turned on indoors, the latitude, longitude and altitude will be blank. This occurs when no satellite signal can be obtained by the instrument. Powering up the CI-900 outdoors will correct this problem and allow latitude, longitude and altitude readings to be taken.

File Menu

The File Menu is accessed by highlighting "File" on the Main Menu and pressing the RIGHT arrow key. Here, the user can manipulate files on the CI-900, with options to clear, delete, create and open files.

The CI-900 uses an SD card to store all measurements. This means the user is able to create, clear and delete any measurement file.

To view data on a computer, simply insert the SD card into the computer's SD card reader. The computer should automatically detect the SD card as a new storage device and mount the drive so that measurement data will be accessible by any computer application. The mini-USB port can also be used to establish a USB connection with a computer to transfer data from the CI-900.

Clear a File

Pressing the RIGHT arrow key when "Clear" is highlighted on the display enters the menu to clear files. This mode allows the erasure of the file contents without changing the file name or set-up. This feature is useful if it is necessary to do a number of similar measurements. The user can take these measurements to a particular file, copy the results, clear the file, and be ready to take a new set of measurements to that file.

Clear	File
File01	3201
RoomA2	1022
Fruit7	0

The top line of the display reads "Clear" on the left and file on the right. Filenames are listed on the left and the file size is listed in the right column. An empty file will have a zero as the file size.

- Use the UP or DOWN keys to select the file to clear.
- Press the RIGHT arrow to clear the file.
- Press ENTER to confirm.
- The display will indicate "Done!" when the file is erased.
- Press STOP or the LEFT arrow to go back to the File Menu.

Delete a File

Press the RIGHT arrow when "Delete" is highlighted on the display to get the unit into the *delete file* mode. This mode will erase a file (and filename) completely from the memory/SD card. In this mode, the top line of the display reads "Delete" on the top left line and file on the right. Below this, the filename is listed on the left and the file size is listed on the right.

Delete	File
File01	3201
RoomA2	1022
Fruit7	0

- To delete a file, use the UP or DOWN arrow keys to select a file.
- Once a file is selected to be deleted, press the RIGHT arrow key to delete the file.
- Press ENTER to confirm. Or, to escape without deleting the file, press the LEFT arrow or STOP key.
- The display will indicate "Done!" when the file is erased.
- Press STOP or the LEFT arrow to go back to the File Menu.

Create a File

Press the RIGHT arrow when "Create" is highlighted on the display to get the unit into the *create files* mode. The top line of the screen will read "Name" on the left, and a file name (e.g. "file00") on the right.

Name:	file00
ENTER TO CREATE A FILE	
STOP TO CANCEL	

NOTE: The STOP key can be pressed at any time to abort the file creation process and to return to this point.

Pressing the arrow keys will allow the user to enter an alpha or numeric selection for a six-character file name. The RIGHT/LEFT arrow keys select which character in the file name to edit and the UP/DOWN arrow keys are used to choose a character.

The chart lists the available characters. Although special characters are seen as options while creating a filename, it is currently recommended not to use special characters when naming files. **The filename must end in a number**, or else the file will be corrupt and no data will be saved to it.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n o p q r s t u v w x y z
0 1 2 3 4 5 6 7 8 9

Pressing the SAVE key in the "Create" mode saves the file. Should the file name be identical to another file name, the instrument will display the message “duplicate name” on the top line of the display and “enter” on the bottom.

Fruit01	Create
<enter>	<stop>

The CI-900 will save all parameters for each measurement on the SD card. Once finished creating the file name, press the ENTER key, or press STOP to abort the process. The CI-900 will exit to the File Menu.

Open File

Press the RIGHT arrow when "Open" is highlighted on the display to get the unit into the *open files* mode. The top line of the screen will read "Open" on the left, and File on the right. Filenames are listed on the left and the file size is listed in the right column.

The default file on the instrument is File01. Data will be saved into File01 unless another file is created and opened. Data can be appended to the end of a file, so files that were previously used can be re-opened.

Open	File
File01	3201
RoomA2	1022
Fruit7	0
Fruit9	-2

An empty file will have a zero as the file size. If the file is corrupt, the file size will be a negative number. Any file with a negative file size should be deleted and re-created. Only files with positive numbers or a zero for the file size can be opened to save data too.

- Use the UP or DOWN keys to select the file to open.
- Press the RIGHT arrow to open the file. "Done!" will flash across the screen if the file was opened successfully.
- Press STOP or the LEFT arrow to go back to the File Menu.
- Moving the cursor to another file after opening a file and then exiting the menu by pressing either STOP or the LEFT arrow opens the second file (the last file highlighted on the menu is opened).
- Note: After a file is created, it must be opened in order to start saving data to it.

Data Transfer to a Computer

To view the collected data on a computer, remove the SD card and insert it in an SD card reader on the computer. Or, use the supplied USB cable and connect the instrument to the USB host (computer). The user can only view/manipulate data on a computer via the USB connection, or with the removable SD card. Data cannot be viewed after it is saved on the CI-900.

Once the instrument is connected to the computer via USB cable, it is strongly recommended that the user copy and re-save the files and images to the hard drive of the computer. The computer application used to view the files can also be used to re-save them. It is recommended that the user does not work from the original file on the SD card after the measurement has been made, because if any changes are made to the original file, it can break the alignment of the file causing error and data loss.

In order to keep the file system in sync, perform any editing or further calculations on the copied file saved to the computer hard drive. **Do not edit the files directly on the SD card!**

Do not connect the USB cable to the instrument and the computer while performing measurements. If the user tries to operate the instrument through the computer, the files are subject to becoming out of sync, breaking alignment and causing errors in the files. This can also lead to problems with saving data.

If an error occurs in a specific data file, it can be deleted and created again. Go to the File Menu on the instrument; clear the file where the error has occurred. If the file has been transferred to the computer, delete it on the computer also. Once the corrupted files have been deleted, create the file again (if it has been properly cleared, the same file name can be used) and re-take the measurement.

Data Files

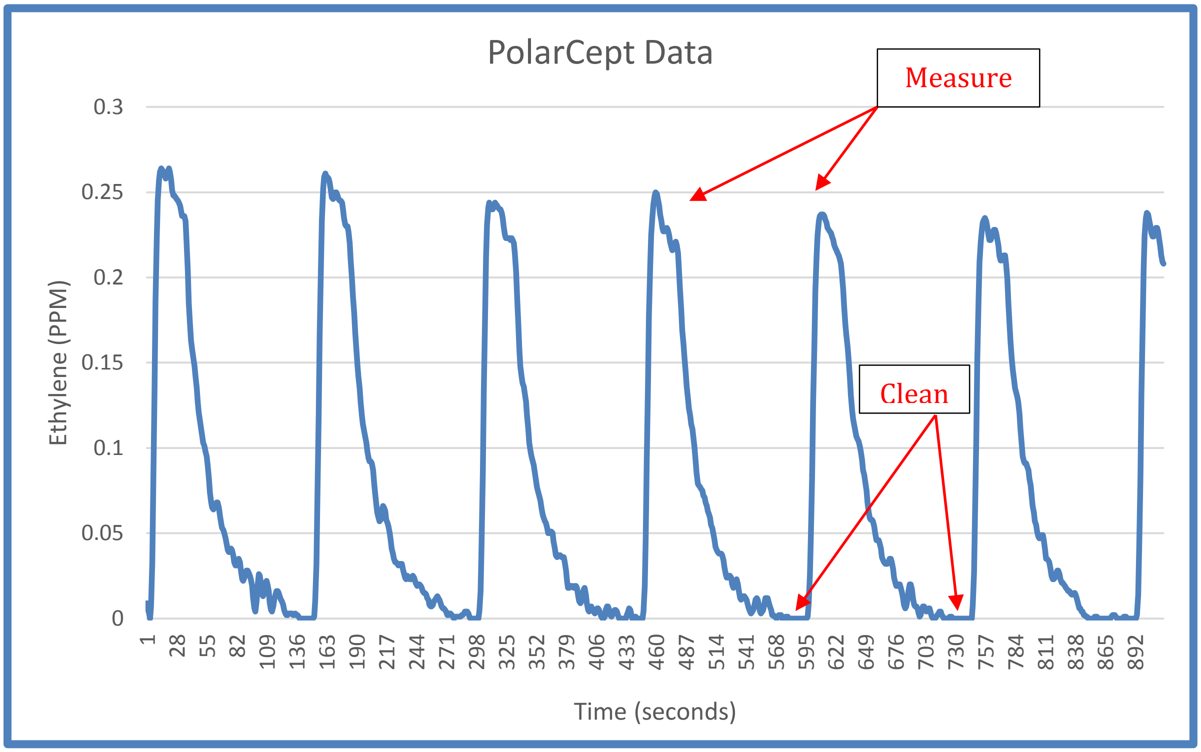
Open the data files saved on the SD card on the computer using Microsoft Excel or Notepad. The figure below is an example data spreadsheet. Data values included are the date and time of the measurement, the ethylene level in ppm, the mode (monitor, measure or cleaning, offset or GC emulation), the CO_2 and O_2 concentration, the temperature of the gas stream in degrees Celsius, the relative humidity (RH) of the gas stream in percent, the atmospheric pressure (KPa) and the flow rate of the gas stream in ml/min. In this example, when the CO_2 or O_2 sensors are not being used, the concentration values are zero. For the mode, monitor indicates measurements without PolarCept, measure/cleaning indicate PolarCept, and offset indicates zero calibration.

	A	B	C	D	E	F	G	H	I	J
1	Date	Time	C2H4 (ppmv)	Mode	CO2 (ppm	O2 (%)	Temp (C)	RH (%)	Pressure KPa	Flow (mL/min)
2	9/11/2014	16:49:59	0.849	monitor	1978.1	20.37	23.5	87.4	101.6	201
3	9/11/2014	16:50:20	0.843	monitor	1656	20.41	23.6	87.1	101.6	201
4	9/11/2014	16:50:41	0.835	monitor	1411.9	20.46	23.7	86.8	101.6	201
5	9/11/2014	16:52:07	0.833	monitor	1368.2	20.43	24	85.8	101.6	201
6	9/11/2014	16:52:28	0.796	monitor	1027.6	20.55	24.1	85.5	101.6	201
7	9/11/2014	16:54:26	0.785	monitor	954.7	20.49	24.5	84.3	101.6	201
8	9/11/2014	16:54:47	0.776	monitor	872.3	20.54	24.5	84.1	101.6	201
9	9/28/2014	14:55:48	0	GC emulation	0	0	24.6	42.2	100.4	201
10	9/28/2014	14:56:09	0	GC emulation	0	0	24.6	42.1	100.4	201
11	9/28/2014	14:56:30	0	GC emulation	0	0	24.7	42	100.4	201
12	9/28/2014	15:45:57	0.164	sm_measure	253.1	0	22.9	59.3	100.4	94
13	9/28/2014	15:46:18	0.796	sm_measure	228.1	0	23	64.4	100.4	201
14	9/28/2014	15:46:39	1.198	sm_measure	248.8	0	23.1	66	100.4	201
15	9/28/2014	15:47:00	1.289	sm_measure	286.7	0	23.3	66.7	100.4	201
16	9/28/2014	15:47:21	1.281	sm_measure	347	0	23.4	67.1	100.4	201
17	9/28/2014	15:47:42	1.248	sm_clean	368.4	0	23.5	67.2	100.4	201
18	9/28/2014	15:48:03	1.026	sm_clean	372.2	0	23.6	67.1	100.4	201
19	9/28/2014	15:48:24	0.952	sm_clean	388.8	0	23.7	67.2	100.4	201
20	9/28/2014	15:48:45	0.752	sm_clean	422.2	0	23.8	67.2	100.4	201

Figure 13: Example data spreadsheet for a CI-900 measurement.

REMEMBER: Always save the data files to the computer before making changes or starting analysis.

Below is an example of ethylene data plotted for PolarCept, that shows the typical peaks and valleys for the measure/cleaning cycle. At the end of the cleaning time, the ethylene level should be low (below 0.2 ppm). If a low ethylene concentration is not seen at the end of the cleaning period, lengthen the cleaning time in Setup>Chamber and test again.



Firmware Update

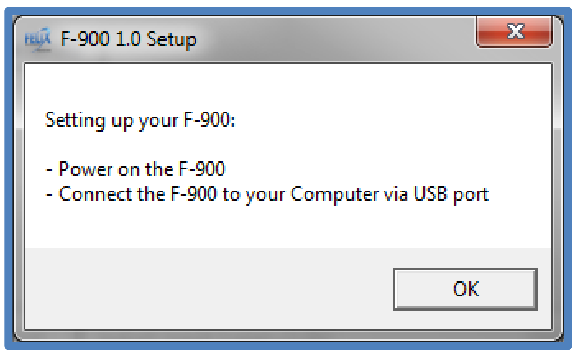
Transfer all data files from the SD card and DELETE all data files on SD card before doing the firmware update! Leaving data files from older firmware versions may corrupt the SD card.

Several files should be accessed from the software CD or downloaded from the CI-900 software webpage (http://cid-inc.com/support/ci-900-support/900software). Always double-check the webpage for the latest compatible firmware version depending on the serial number of the CI-900. Please contact CID Bio-Science technical support with questions about firmware updates.

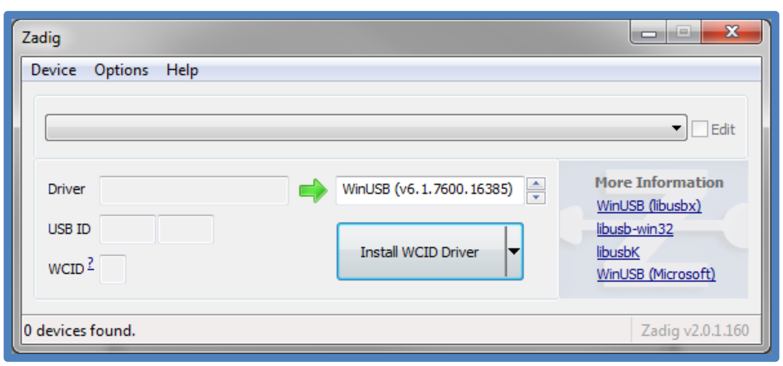
- Setup application: CI-900_Package_Setup32.exe or CI-900_Package_Setup64.exe
- Firmware code file: CI-900-ver-x.xx.bin

CI-900 Driver Installation Procedure

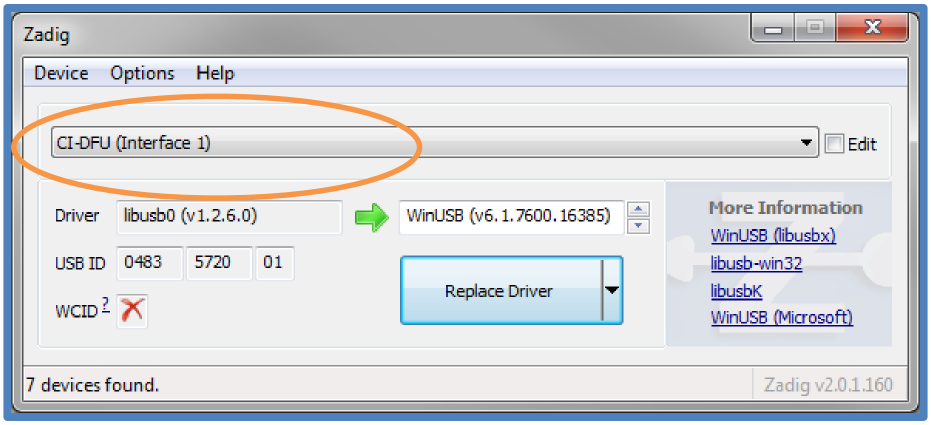
1. Connect the CI-900 to the computer using the mini-USB to USB cable.
2. Launch CI-900_Package_Setup32.exe (or CI-900_Package_Setup64.exe, under Windows 64 bit).
3. Set up device as prompted message below



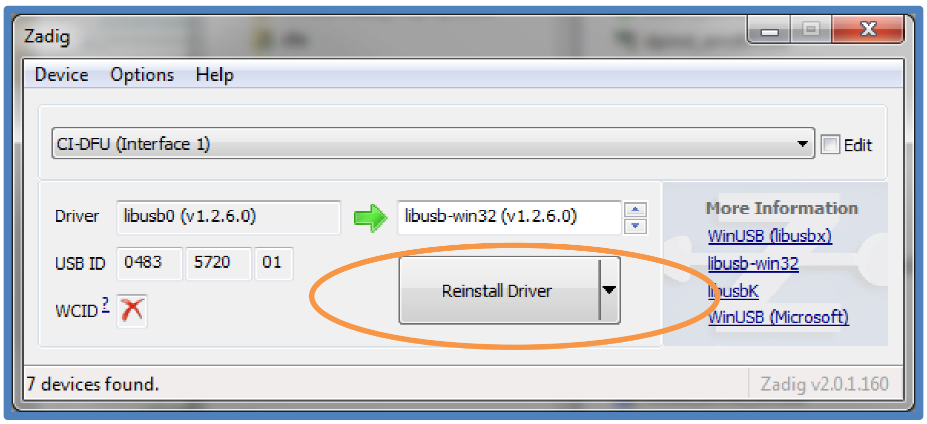
4. The CI-900 requires an libusb driver. In Zadig window, select Options/List All Devices.



5. In the dropdown list, select CI-DFU (Interface 1) device.

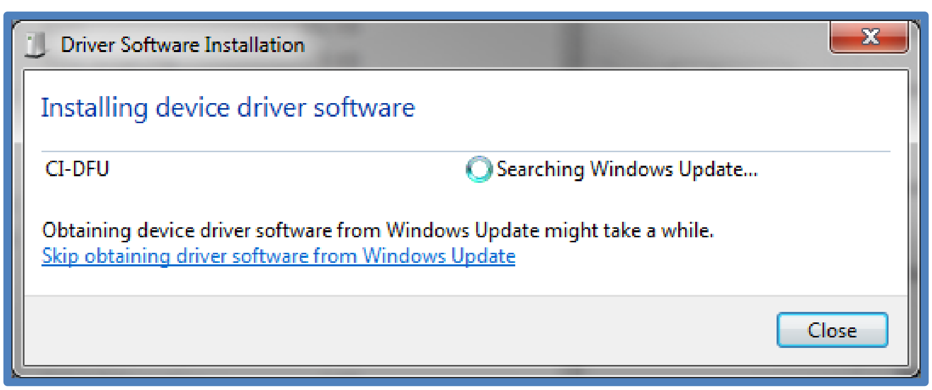


6. At the spinner list (green arrow), select libusb-win32.

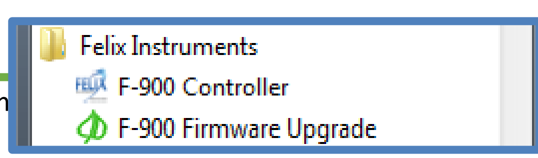


7. Click *Install Driver* to proceed installing libusb driver. This could take up to 1 minute to complete.

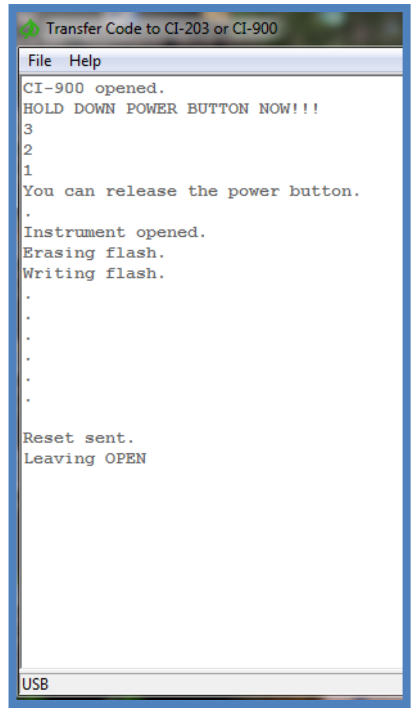
Note: Wait for Windows "obtaining driver" process to complete before clicking *Install driver*.



8. Device drivers and Software package installation is done. Under Windows Start menu, you should be able to find shortcuts for Device's Controller and Firmware Upgrade Program.



CI-900 Firmware Update Procedure



1. After installing the driver, open the **CI-900 Firmware Upgrade** application: “Transfer Code to CI-203 or CI-900.”

2. If device is on, press power button to power off the device. **Hold the down arrow button, then press power button.** The device's internal green LED near USB port/SD card should start flashing quickly. The device must be unplugged for this to work.

3. Select File and Open.

4. Navigate to the **CI-900-ver-x.xx.bin.** This is the code for the instrument.

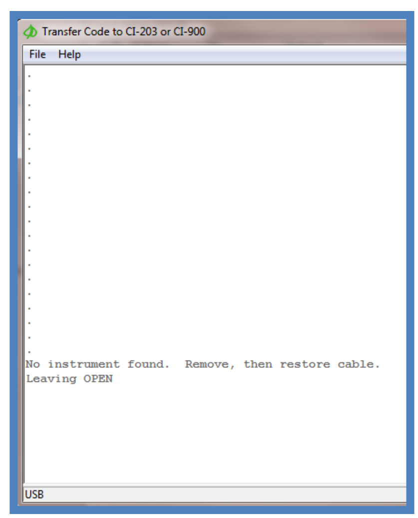
5. Follow the instructions in the software to hold down the power button.

6. Release the power button when instructed.

7. Wait for the flash to be erased and then written. When the firmware transfer is complete, the software will indicate reset sent, followed by “leaving open”. The CI-900 will power off.

8. Power on the CI-900 and check the firmware version at the top of the display. The Transfer Code software application will indicate that no instrument is found, if the CI-900:

   - is not connected to the computer
   - is not powered on
   - driver is not properly installed



If this message is seen, make sure:

- the CI-900 is connected via mini-USB

- the driver is installed
- the CI-900 is powered on

If the CI-900 becomes unresponsive or frozen during the firmware update, especially when using Windows 8, please try the following:

1. Hold the power button for 10 seconds and let go.
2. Hold the down arrow button then press power button, device's internal green LED near USB port/SD card should start flashing quickly
3. Connect the device to computer via USB and repeat the download firmware procedure.

After the firmware update is successful, it is recommended to let the CI-900 measure with the Closed Loop ON overnight (for 12 hours) before using again.

Cleaning and Maintenance

The CI-900 housing can be wiped down with a damp cloth if the unit becomes dirty or dusty. Please make sure to always keep the IN and OUT ports on the front panel clear from any obstructions.

The water in the electrochemical cell of the unit needs to be replenished periodically using distilled water. The exact hours of use before this will depend on the humidity and temperature of the environment the CI-900 is typically used in. Warm or low humidity/dry environments will required more frequent refills. Please contact support@cid-inc.com for more information or to schedule instrument servicing.

Maintaining the Electrochemical Sensor

The liquid reservoir must contain a sufficient amount of electrolyte at all times. The electrocatalytic sensor operates utilizing water and therefore requires replenishment of the electrolyte solution (1 ml/day while operating using continuous mode). Depending on the mode of operation and the environment in which it is used, the sensor cell may need to be replenished with distilled water every 2-3 weeks if Chamber In is not set to ON and filled with distilled water. The electrolyte level should be monitored on regular basis and prior to operation for an extended period of time. The analyzer will arrive filled with the proper electrolyte. The refill or replenishment of the sensor is almost fully automated and uses PolarCept.

Only replenish with distilled water. Refilling is needed on a regular basis if the unit is being run with dry gas and Chamber In is not on and filled with water. If Chamber In is run continuously with distilled water, the level of water in the sensor should not change very much and the levels need only be checked every 6 months.

Check the sensor every 2-3 weeks if run continuously in very dry environments (<20% RH). It is recommended to refill the sensor before the liquid level drops 20 ml. How often the reservoir needs to be refilled will depend on the conditions the instrument is used in (temperature, relative humidity).

Note: A dry gas being fed into the CI-900 at 25 ^{0}C will cause an expected water loss of 0.1 ml/hr; at 30 ^{0} C a dry gas will cause a loss of 0.3 ml/hr. Expected water loss can be up to 3 ml/day when feeding dry gas through the CI-900.

Use Conditioning Chamber In to Replenish the Sensor (RECOMMENDED):

Conditioning Chamber In in special mode with distilled water, can be used to help keep the electrochemical cell hydrated and avoid having to refill the sensor manually with a syringe.

1. Fill Chamber In to the fill-line located on the back of unit using fresh, clean distilled water.
2. Fill Chamber Out with potassium permanganate.
3. Turn on Chamber In and Chamber Out.
4. Enable Closed loop.
5. Allow the unit to run the closed loop with water in Chamber In for several hours or until the unit has returned to the overall sensor full weight
6. Details about the electrochemical cell status can be found in the Setup>Sensor>Cell Hydration menu.

Note: The refill dead time is proportional to the R.H. of the measured gas and the duration of measurement. For example: dry gas at <10% R.H. will have ~1:1 measurement to dead time. Room air at 25-30% R.H. will have ~1:2 ratio. Any unit that measures ~40% R.H. should, in theory, never dry out.

Note: Weighing the entire CI-900 unit on an analytical balance when the sensor is full will allow you to monitor the water level of the sensor, by keeping track of the weight loss of the whole CI-900 unit. Remember to always weigh the CI-900 with the same setup and to follow the instructions above to remove and refill the sensor, when it has lost 20-25 grams of water. The weight of the instrument completely assembled with a full sensor is found in the Production Test Check Sheet.

Warnings

- Read this manual carefully before using: this manual should be read by anyone who will be operating the CI-900.
- By following the guidelines, the CI-900 will function according to the specifications in this instruction manual.
- All repairs should be performed by a CID Bio-Science technician.
- The analyzer must be used to measure the rate of ethylene in the presence of nitrogen, oxygen and carbon dioxide. All other gases in high concentration could lead to erroneous measurements, or the destruction of the sensor. Do not use the instrument in the presence high concentrations of aromatic solvents, hydrocarbons or other volatile organic compounds, such as in unventilated painting rooms or chemical storage rooms.
- Damage to the analyzer can occur if the fluid reservoir level is too low or if the inlet and outlet gas connections are blocked while the pump operates. This can cause false readings or irreparable damage to the sensor.
- If smoke comes out of the analyzer, turn off the power immediately and contact CID Bio-Science.
- Keep the analyzer in a clean and ventilated room at ambient temperature.
- Do not allow fluid to aspirate in the analyzer, which can destroy the sensors.
- **Do not use the CI-900 in a high RF (radio frequency) environment.** High RF will disrupt the CI-900.
- ESD (electrostatic discharge) can also interfere with CI-900.
- **Do not tilt the CI-900 when Chamber In contains water!**

The analyzer has a reservoir containing 1 mol of sulfuric acid (2N H_2SO_4). Avoid contact with skin and eyes. If contact occurs, rinse thoroughly with water or use an eyewash or safety shower. Do not drink the contents of the fluid reservoirs as it could cause chemical burns. See Appendix I for the safety data sheet and further information on sulfuric acid.

Technical Support

If you have a question about the CI-900, first look in the CI-900 Operation Manual. There is also online support available for the CI-900 at http://www.cid-inc.com/support/ci-900-support If you cannot find the answer, you can contact a Technical Support Representative located in your country. CID Bio-Science, Inc. is committed to providing customers with high quality, timely technical support. Technical support representatives are there to answer your technical questions by phone or by e-mail at support@cid-inc.com.

CID Bio-Science, Inc. contact information:

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1554 NE 3rd Ave
Camas, WA 98607 USA

Phone: 800-767-0119 (U.S. and Canada)
360-833-8835
Fax: 360-833-1914

Internet: http://www.cid-inc.com
E-mail: support@cid-inc.com

Customer Service

Customer Service Representatives answer questions about specifications and pricing, and sell all of the CID Bio-Science, Inc. products. Customers sometimes find that they need CID Bio-Science, Inc. to upgrade, recalibrate or repair their system. In order for CID Bio-Science, Inc. to offer these services, the customer must first contact us and obtain a Return Merchandise Authorization (RMA) number. Please contact a customer service representative for specific instructions when returning a product.

Frequently Asked Questions

If there are any questions about the CI-900, please check the Frequently Asked Questions below, as well as the CID Bio-Science support webpage at http://www.cid-inc.com/support

1. What type of fruit produces ethylene?

    a. Climacteric fruits refer to fruits that have high respiration rate during the fruit's ripening. During the ripening process of climacteric fruits, the production of a phytohormone, ethylene, dramatically increases up to 1000-fold of the basal ethylene level. Climacteric fruits are ones that are able to ripen after being picked. An example of climacteric fruit is bananas; they are picked and shipped green and then ripen at a later time (often in the store or home). Climacteric fruits include, but are not limited to, apples, apricots, avocados, bananas, cantaloupes, figs, guavas, kiwis, mangoes, nectarines, peaches, pears, persimmons, plums, and tomatoes. [Source: Wikipedia.com]

2. What should I do if I see moisture develop in the tubing when monitoring a fruit in the chamber?

    a. There is a protective hydrophobic filter inside the IN port on the front of the CI-900. This will prevent moisture from fully entering the instrument. Silica gel in a conditioning chamber can be used to dry out the gas stream, either before or after the gas passes the electrochemical sensor. Refer to the flow path diagram in the Setup>Chamber section of the User Manual for more information.

3. Can the data output be directly linked to the computer, and by what type of connection can be used? And is it MAC and/or PC compatible?

    a. The unit has an SD card and the format can be read on any Mac or PC. Data can also be downloaded via USB. See the Setup>Connection section on page 50 for more information on linking the CI-900 to a computer.

4. How do I change how the data appears in the .csv file?

    a. If data isn't displaying properly, try saving the file as a .csv file type and re-opening it. If saving as a .csv does not fix how the data is displayed, you may need to change the separator value on your computer.

    To change the separator in all .csv text files:

        1. In Microsoft Windows, click the Start button, and then click Control Panel.

        2. Open the Region and Language Options dialog box.

        3. Do one of the following:

a. In Windows Vista and 7, click the Formats tab, and then click Customize this format. In Windows 7 click the "additional settings" button to get to the option to change the separator.

b. In Windows XP, click the Regional Options tab, and then click Customize.

4. Type a new separator in the List separator box. For example, type ","

5. Click OK twice.

NOTE: After you change the list separator character for your computer, all programs use the new character as a list separator. You can change the character back to the default character by following the same procedure.

5. How do I create and open a file to start using the CI-900?

   a. To start using the CI-900, create a file to save data into. Go to File>Create. Change the file00 to the desired file-name and press save. Next, open the file to save measurements. Go to File>Open and use the arrows to highlight the newly created file. If the value next to the file-name is a negative number, this indicates an error. You should delete the file and create it again. Then, open it and check that the value is zero. Now, you can save data into this file.

6. What consumables come with the CI-900?

   a. The CI-900 and CI-900RK ship with potassium permanganate ($KMnO_4$), an ethylene scrubber (Purafil Fresh Air Sachets). $KMnO_4$ is sold at many Home and Garden stores and online. The pellet (vs. crystal or powder) form of $KMnO_4$ is recommended.

      i. http://www.producefreshies.com/

      ii. http://www.water-softeners-filters.com/potassium-permanganate-free-flowing-2-lbs.php?gclid=CjwKEAjwqamhBRDeyKKuuYztxwQSJAA1luvG99Od7hn1UO9syxQjxnCTkdfFe22M_bttL-t8qgs7QhoC2Kfw_wcB

   b. The CI-900RK also ships with a humidity scrubber (silica gel). If the CI-900 includes an optional CO_2 sensor, soda lime is provided as a CO_2 scrubber. Carolina Biological (www.carolina.com) is an online source for soda lime and silica gel.

7. What are some possible applications for the CI-900?

    a. The CI-900 could be used to help optimize Controlled Atmosphere Storage Rooms and prevent losses. Ethylene is an important and sensitive marker for ripening of fruits. Other postharvest research applications are possible.

    b. In addition to plants, some microorganisms, including fungi and bacteria, synthesize ethylene. Microorganisms can cause great losses in the postharvest industry through disease and mold, so research into ethylene and the pathogen-host interaction is important. A common plant pathogen that produces ethylene is *Botrytis cinerea*.

    c. Measuring ethylene concentration in the air of rooms where young apple trees in pots are stored adjacent to refrigerated apple storage rooms, in order to assess the safety to young apple trees. During the winter months, the safe level for storage of first year apple trees is below 50ppm.

    d. Commercial apple growers could monitor the ethylene levels of empty refrigerated rooms before storing bare-root nursery trees. Rooms should be empty of ethylene before storing nursery trees and often growers have no way to monitor this.

    e. Monitoring ethylene emission from industrial sources. Ethylene is of interest because it plays a role in atmospheric ozone chemistry. This will be dependent on interfering gas and the source of industrial emissions.

8. How long does it take to recharge the battery?

    a. About four hours. The unit may be operated while the battery is charging.

9. What happens if the cell runs out of water?

    a. If the cell runs out of water, the lead electrode could undergo sulfation. This would affect the sensitivity by reducing the active area on the lead electrodes. It is more likely that a lack of water in the cell decreases the activity of the electrolyte and increases the resistivity of the Nafion membrane. Both will affect the background current and response time of the cell.

10. What are the advantages of the CI-900RK over the standard CI-900?

    a. Both are portable, but the research kit includes the other components as listed in the “Unpacking the CI-900” section of the User Manual, such as the fruit chamber and wand and hard-sided, wheeled carrying case. The Research Kit is designed to make measurement of fruits non-destructively or in a closed chamber. Fans are built into the fruit chamber to mix the air.

11. What are the most commons uses for Chamber In and Chamber Out?

    a. Both chambers are optional, but it is recommended to use Chamber In as PolarCept for most measurements. The most common use for Chamber In is to separate light hydrocarbons, such as alcohol, from the gas stream which may interfere with the measurement. The most common use for Chamber Out is to be filled with potassium permanganate, so that it cleans all ethylene and other hydrocarbons from the gas stream, so that any ethylene that is measured must have come from the sample. Chamber OUT is also commonly used with $KMnO_4$ to calibrate the zero of the ethylene sensors.

12. During a monitoring experiment, will the sealed fruit chamber influence the result as time goes on?

    a. The air should be scrubbed by enabling conditioning Chamber Out (filled with potassium permanganate). Attach the tubing from the wand that returns to the fruit chamber to the Out port on the front of the CI-900.

13. How is Chamber In used to rehydrate the electrochemical cell?

    a. The electrochemical sensor can be rehydrated by putting distilled water in Chamber In. If water is being used in Chamber In for separating out alcohols, then refilling of the sensor will never be necessary. Similarly, if the sensor is used in a humid environment, the sensor will not dry out.

14. Where are temperature and humidity measured?

    a. The temperature and relative humidity sensors are located inside the CI-900, before the electrochemical sensor. There is an additional relative humidity sensor after the ethylene sensor to help track water loss.

15. What type of membrane does the electrochemical sensor have?

    a. The electrochemical sensor uses a nafion or nafion-like membrane.

16. What is the emission rate of ethylene from the fruit, taking into account the weight of the fruit (or sample) and the time measured?

    a. Flow rate: 0.2L/min = 12.0L/hr

       Sensitivity of C_2H_4 PPM sensor to C_2H_4: 0.1 µL/L or 100 nL/L

       Therefore, the CI-900 optimally detects around 1200 nL/hr. If the specimen weighs 50 grams, then the emission rate is: 24 nL C_2H_4/gfw/h. The unit is nanoliters of ethylene per gram fresh weight per hour.

17. What types of tubing materials have been found to outgas?

    a. Several types of material have been found to outgas interfering gases of the ethylene sensor, such as Tygon. **Viton** and **Teflon** have successfully been found to not outgas.

Supporting Sciences References

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CID BIO-SCIENCE, INC. HARDWARE WARRANTY

Important: Please Read!

Seller's Warranty and Liability: Seller warrants new equipment of its own manufacturing against defective workmanship and materials for a period of one year, of a single shift operation, from date of receipt of equipment - ***the results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause is not to be considered a defect.*** Any defect must be called to the attention of CID Bio-Science, Inc., Camas, Washington, USA, in writing, within 90 days after receipt of the unit.

Seller's liability for defective parts is limited to the repair or replacement of any part of the instrument without charge, if CID Bio-Science, Inc.'s examination discloses that part to have been defective in material or workmanship, and in no event shall exceed the furnishing of replacement parts F.O.B. the factory where originally manufactured. No equipment may be repaired or altered by anyone not authorized by CID Bio-Science, Inc.

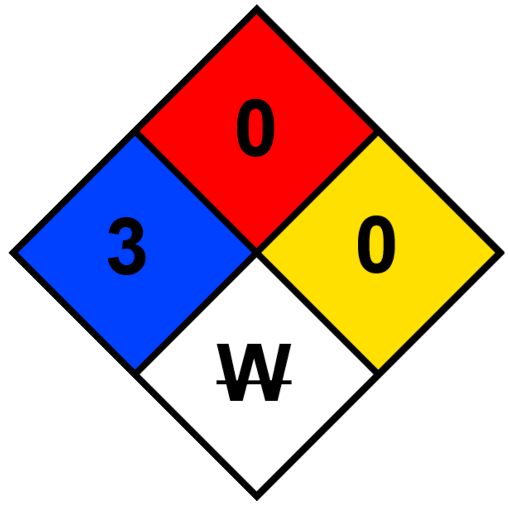
Material and equipment covered hereby, which is not manufactured by Seller, is to be covered only by the warranty of its manufacturer. Seller shall not be liable to the Buyer for loss, damage, or injury to persons (including death), or to property or things, whatsoever, including, but without limitation, products processed by the use of the equipment; or for damages of any kind or nature (including, but without limitation, loss of anticipated profits), occasioned by or arising out of installation, operation, use, misuse, nonuse, repair, or replacement of said material and equipment, or out of the use of any method or process for which the same may be employed. The purchaser is to pack, ship, or deliver the instrument to CID Bio-Science, Inc., in Camas, Washington, USA, within 30 days after CID Bio-Science, Inc. has received written notice of the defect at the customer's expense. No other arrangements may be made unless otherwise approved in writing by CID Bio-Science, Inc.

The use of this equipment constitutes Buyer's acceptance of the terms set forth in this warranty. There are no understandings, representations, or warranties of any kind, express, implied, statutory, or otherwise ***(including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose)***, not expressly set forth herein.

APPENDIX I: Material Safety Data Sheet for 2N Sulfuric Acid Solution

SECTION 1: CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Sulfuric Acid, 2N
Catalog Codes:
CAS#: Mixture.
RTECS: Not applicable.
TSCA: TSCA 8(b) inventory: Sulfuric acid; Water
CI#: Not applicable.
Synonym:
Chemical Name: Not applicable.
Chemical Formula: Not applicable.



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CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300
International CHEMTREC, call: 1-703-527-3887
For non-emergency assistance, call: 1-281-441-4400

SECTION 2: COMPOSTION AND INFORMATION ON INGREDIENTS

Composition:

Name	CAS #	% by Weight
Sulfuric acid	7664-93-9	9.8
Water	7732-18-5	90.2

Toxicological Data on Ingredients: Sulfuric acid: ORAL (LD50): Acute: 2140 mg/kg [Rat.]. VAPOR (LC50): Acute: 255 ppm 4 hour(s) [Rat.].

SECTION 3: HAZARDS IDENTIFICATION

Potential Acute Health Effects:
Extremely hazardous in case of skin contact (corrosive, irritant), of eye contact (irritant), of ingestion, of inhalation. Liquid or spray mist may produce tissue damage particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Inflammation of the eye is characterized by redness, watering, and itching. Skin inflammation is characterized by itching, scaling, reddening, or, occasionally, blistering.

Potential Chronic Health Effects:
Extremely hazardous in case of skin contact (corrosive, irritant), of eye contact (irritant), of ingestion, of inhalation. Nonsensitizer for skin. Non-permeator by skin. CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated or prolonged inhalation of vapors may lead to chronic respiratory irritation.

SECTION 4: FIRST AID MEASURES

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
If the chemical got onto the clothed portion of the body, remove the contaminated clothes as quickly as possible, protecting your own hands and body. Place the victim under a deluge shower. If the chemical got on the victim's exposed skin, such as the hands: Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.
Inhalation:
Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation:
Evacuate the victim to a safe area as soon as possible. Loosen tight clothing such as a collar, tie, belt or waistband. If breathing is difficult, administer oxygen. If the victim is not breathing, perform mouth-to-mouth resuscitation. WARNING: It may be hazardous to the person providing aid to give mouth-to-mouth resuscitation when the inhaled material is toxic, infectious or corrosive. Seek immediate medical attention.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.
Serious Ingestion: Not available.

SECTION 5: FIRE AND EXPLOSION DATA

Flammability of the Product: Non-flammable.
Auto-Ignition Temperature: Not applicable.
Flash Points: Not applicable.
Flammable Limits: Not applicable.
Products of Combustion: Not available.
Fire Hazards in Presence of Various Substances: Not applicable.
Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available.
Risks of explosion of the product in presence of static discharge: Not available.
Fire Fighting Media and Instructions: Not applicable.
Special Remarks on Fire Hazards: Not available.
Special Remarks on Explosion Hazards: Not available.

SECTION 6: ACCIDENTAL RELEASE MEASURES

Small Spill:

Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. If necessary: Neutralize the residue with a dilute solution of sodium carbonate.

Large Spill:
Corrosive liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

SECTION 7: HANDLING AND STORAGE

Precautions:
Keep container dry. Do not breathe gas/fumes/ vapor/spray. Never add water to this product In case of insufficient ventilation, wear suitable respiratory equipment If ingested, seek medical advice immediately and show the container or the label. Avoid contact with skin and eyes Keep away from incompatibles such as alkalis. May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.

Storage:
May corrode metallic surfaces. Store in a metallic or coated fiberboard drum using a strong polyethylene inner package. Corrosive materials should be stored in a separate safety storage cabinet or room.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls:
Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.

Personal Protection:
Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Vapor respirator. Boots. Gloves. A self-contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
Sulfuric acid TWA: 1 STEL: 3 (mg/m3) from ACGIH Consult local authorities for acceptable exposure limits.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

Physical state and appearance: Liquid.
Odor: Odorless.
Taste: Not available.
Molecular Weight: Not applicable.
Color: Clear Colorless.
pH (1% soln/water): 2 [Acidic.]
Boiling Point: The lowest known value is 100°C (212°F) (Water).
Melting Point: Not available.
Critical Temperature: Not available.
Specific Gravity: The only known value is 1 (Water = 1) (Water).
Vapor Pressure: The highest known value is 17.535 mm of Hg (@ 20°C) (Water).
Vapor Density: The highest known value is 0.62 (Air = 1) (Water).
Volatility: Not available.
Odor Threshold: Not available.
Water/Oil Dist. Coefficient.: The product is much more soluble in water.
Ionicity (in Water): Not available.
Dispersion Properties: See solubility in water.
Solubility: Easily soluble in cold water, hot water. Insoluble in methanol, diethyl ether, n-octanol.

SECTION 10: STABILITY AND REACTIVITY DATA

Stability: The product is stable.
Instability Temperature: Not available.
Conditions of Instability: Not available.

Incompatibility with various substances:
Extremely reactive or incompatible with alkalis. Slightly reactive to reactive with metals.

Corrosivity:
Extremely corrosive in presence of aluminum, of zinc. Highly corrosive in presence of steel, of copper. Slightly corrosive to corrosive in presence of stainless steel(304), of stainless steel(316). Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts violently with water especially when water is added to the product. (Sulfuric acid)

Special Remarks on Corrosivity: Not available.
Polymerization: No.

SECTION 11: TOXICOLOGICAL INFORMATION

Routes of Entry: Eye contact. Inhalation. Ingestion.
Toxicity to Animals: LD50: Not available. LC50: Not available.

Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.
Other Toxic Effects on Humans: Extremely hazardous in case of skin contact (corrosive, irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.
Special Remarks on Chronic Effects on Humans: Not available.
Special Remarks on other Toxic Effects on Humans: Not available.

SECTION 12: ECOLOGICAL INFORMATION

Ecotoxicity: Not available.
BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.
Special Remarks on the Products of Biodegradation: Not available.

SECTION 13: DISPOSAL CONSIDERATIONS

Waste Disposal:

SECTION 14: TRANSPORT INFORMATION

DOT Classification: CLASS 8: Corrosive liquid.
Identification: Sulfuric acid, solution: UN2796 PG: II
Special Provisions for Transport: Not available.

SECTION 15: OTHER REGULATORY INFORMATION

Federal and State Regulations: TSCA 8(b) inventory: Sulfuric acid; Water

Other Regulations:
OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:
WHMIS (Canada):
CLASS D-2A: Material causing other toxic effects (VERY TOXIC). CLASS E: Corrosive liquid.
DSCL (EEC): R35- Causes severe burns.
HMIS (U.S.A.):
Health Hazard: 1
Fire Hazard: 0
Reactivity: 0
Personal Protection:
National Fire Protection Association (U.S.A.):
Health: 1
Flammability: 0
Reactivity: 0
Specific hazard:
Protective Equipment: Gloves. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Face shield.

SECTION 16: OTHER INFORMATION

References: Not available.
Other Special Considerations: Not available.
Created: 12/21/2010
Last Updated: 4/23/2012

APPENDIX II: Procedure for CI-900 Validation Using Fruit

The following methods should be run consecutively on a given replicate and repeated for each new replicate (new specimen). At least 5 replicates for pre-climacteric (un-gassed or still green) apples, bananas, or avocados should be run. The data from method 1 and 2 can be combined into a table. The results from method 3 can be graphed, as a figure, to show the trend over time.

Method 1: Sampling with No Filtration/Trapping

The purpose of this method is to determine what response the sensor has without trapping of interfering gases. This can be thought of as the baseline response

Procedure:

1. Turn on the CI-900, verify chambers are set to off and flow is set to 200 ml/min.
2. Connect experimental setup as shown in Figure 14.
3. Load the sample specimen into the fruit chamber.
4. Start measuring the fruit headspace with the CI-900.
5. After sampling the headspace for 5 minutes, or a set period of time of your choosing, take a syringe sample and run it in the GC (gas chromatograph). Record result in spreadsheet program, such as Microsoft Excel.
6. Vent the fruit chamber, record the result in Excel and start method 2. The fruit chamber should be well vented to flush out any plant gases between measurements.

Method 2: Sampling with Filtration/Trapping

The purpose of this method is to determine what response the sensor has with trapping of interfering gases by H_2O. This can be thought of as the effect to the instantaneous measurement.

Procedure:

1. Fill conditioning Chamber In with distilled water and clean the water using potassium permanganate in an in-line column connected to the intake port of the CI-900, until the background signal is below 20ppb.
2. Load the sample specimen into the fruit chamber.
3. Start measuring the fruit headspace with the CI-900.
4. After sampling the headspace for exactly 5 minutes, take a syringe sample and run it in the GC (gas chromatograph). Record result in spreadsheet program, such as Microsoft Excel.
5. Vent the fruit chamber, record the result in Excel and start method 3.

Method 3: Long-Term Monitoring with Filtration

The purpose of this method is to determine the effectiveness of the PolarCept filter for long term measurements. This will require the trap to self-regenerate between consecutive measurements. The regeneration time is defaulted to 6 minutes; however for some species a greater time may be needed. By keeping the default value for avocados, we can better compare results and will demonstrate the weakness of the method and how to realize if the "cleaning" time should be extended.

Procedure:

1. Fill conditioning Chamber In with distilled water and clean the water using potassium permanganate in an in-line column connected to the intake port of the CI-900, until the background signal is below 20ppb.
2. Verify that Chamber In is set to "special" with a sufficient cleaning period for the produce being monitored.
3. Load the sample specimen into the fruit chamber.
4. Start measuring the fruit headspace with the CI-900.
5. Allow the system to run for 5 measurement and cleaning cycles.
6. Vent the chamber and load the data file to a computer.
7. Switch to the next replicate and begin at method 1 again.

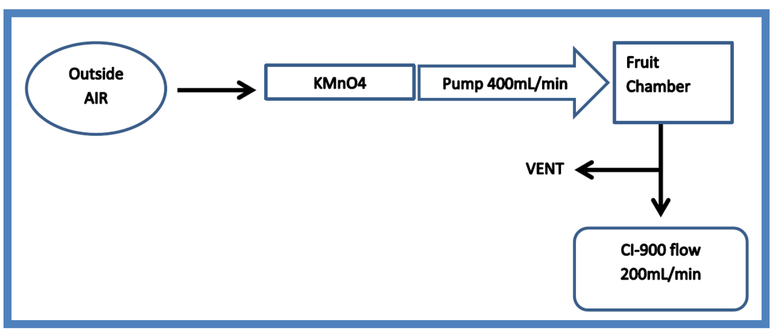


Figure 14: Set-up for fruit chamber using ($KMnO_4$) to scrub ethylene from the outside air.

APPENDIX III: Guidelines for Measuring Sample Bags

The following guidelines are for collecting air samples in standard samples bags. In order to collect an air sample, you must pump air into the bag (pump not included). These bags are often used to collect ambient air samples to analyze later in a laboratory, using a gas chromatograph, or can be connected to the CI-900 using the accessory parts.

- Ensure that the bag material and fittings are appropriate for the compounds to be sampled.
- Use only Teflon or Viton tubing to connect the sample bag to the pump to prevent sample loss by adsorption on tubing walls.
- Before using, flush the bag thoroughly with purified air or nitrogen.
- Analyze the sample within 24 to 48 hours. Long-term storage of air-contaminant mixtures in bags is not recommended.
- Do not ship sample bags by air unless the cargo cabin is pressurized.
- Do not overfill sample bags.
- Secure polypropylene value when opening/closing by holding side stem while turning entire upper portion of fitting one revolution.
- Store bags flat. Do not roll or crease bags during storage.
- Do not use bags at temperatures above 140 ^{0}F (60 ^{0}C).
- Bags are designed for single use only.

To Collect a Sample Using a Sample Bag

1. Flush the bag at least 3 times with purified air or nitrogen before use.
2. To fill a bag, connect tubing from the exhaust port of an air sample pump to the hose connection on the bag (stem protruding from the side of the fittings).
3. To open the shut-off valve, hold the side stem and turn the entire upper portion of the fitting (including the brown syringe port and the white section to which it is attached) counterclockwise one revolution. Turn on the pump and sample.
4. Avoid filling any bag more than 80% of its maximum volume.
5. When sampling is complete, turn off the pump. To close the shut-off valve, hold the side stem and turn the entire upper portion of the fitting clockwise until it is snug.
6. To withdraw samples using a needle and syringe, carefully insert the needle into the septum port in the center of the brown cap and pierce the septum. Do not allow the needle to puncture the bag material when piercing the septum.

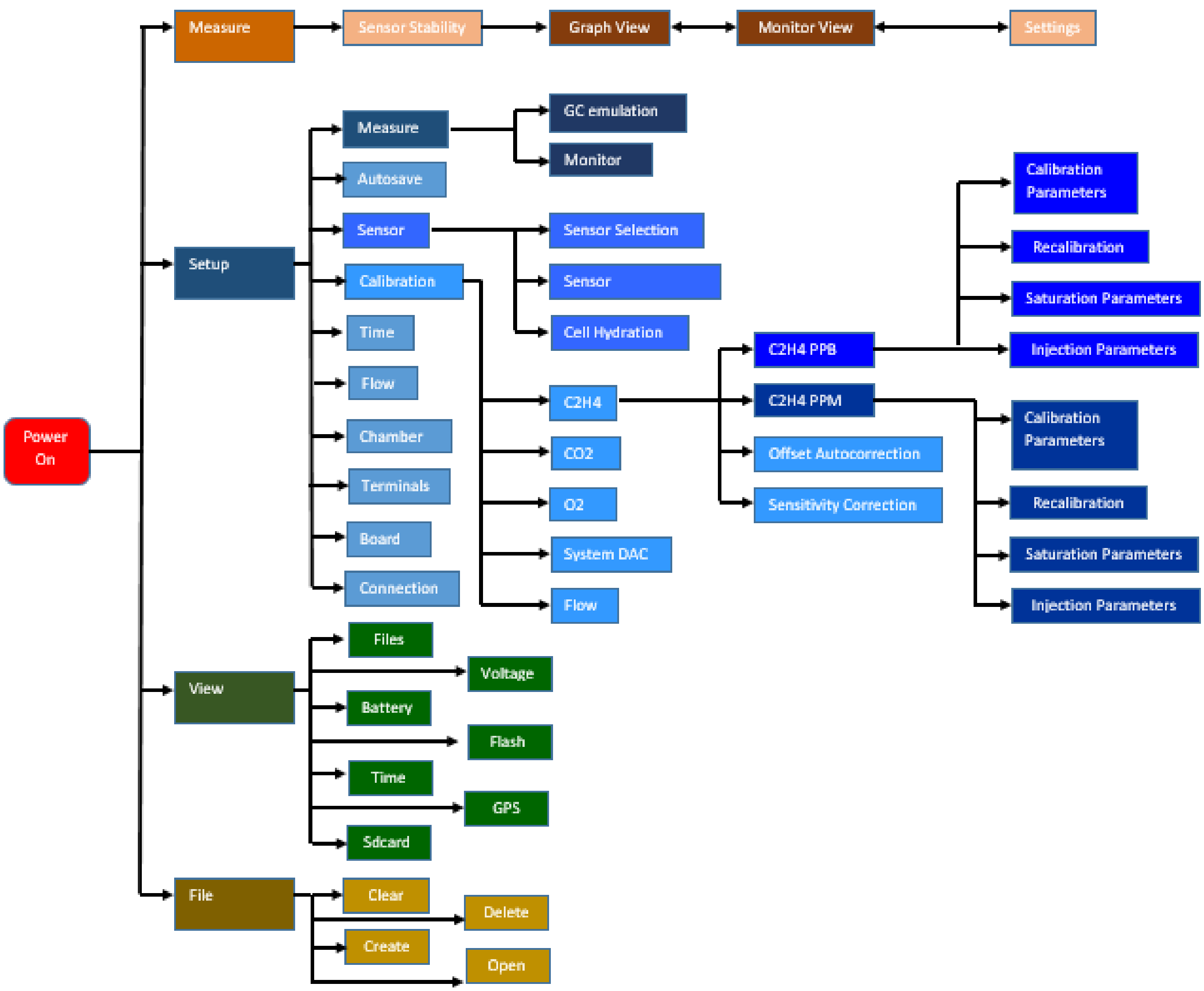
7. Do not use the fitting valve as a handle or hanging device. Although it is durable, it is not intended for these uses.

Analyzing a Sample Bag with the CI-900

- Connect the sample bag to the IN port of the CI-900.
- Open the sample bag to allow gas to start flowing to the CI-900.
- It takes about 3-5 minutes to measure a sample bag if the concentration of ethylene before measuring the sample bag is low.

APPENDIX IV: CI-900 Menu System Diagram

Below is a map of the CI-900 ethylene analyzer menu system. Press the **right** arrow to enter a menu and the left arrow or stop to exit.



1554 NE 3rd Ave, Camas, WA 98607, USA
Phone: (360) 833-8835
sales@cid-inc.com
www.cid-inc.com

CI-900 Production Test Check Sheet

SERIAL NUMBER:	
Firmware Version:	

SENSOR:	Weight (grams):
C2H4 PPB:	
CI-900 fully assembled:	

Optional Sensors	Included (Yes/No)
C02 PPM	
CO2 PCT	
O2 PCT	

CALIBRATION PARAMETERS	C2H4 PPB	C2H4 PPM
Internal offset		
Internal gain		
Calibration RH		
Calibration T		
RH slope		
RH offset		a coef:
T slope		
T offset		

Optional Sensors

CALIBRATION PARAMETERS	CO2 PPM	CO2 PCT
Zero		
Span		
Calibration T		

CALIBRATION PARAMETERS	O2
Internal offset	
Internal gain	
Calibration RH	
Calibration T	

Internal Volume (with optional sensors)	

NOTES: ______________________________

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Warranty Registration Card

1554 NE 3rd Ave, Camas, WA 98607, USA
Phone: (360) 833-8835 Fax: (360) 833-1914 e-mail: sales@cid-inc.com Web: www.cid-inc.com

PRODUCT REGISTRATION CARD

Please complete and return this form to CID, Inc. within 30 days to validate your Warranty on Parts and Labor.

Registration Information:

Your Name:______________________________ Title:_______________

Company/University:____

Address:____

City:_______________________ State:________ Zip:_______________

Country:_____________________Email__________________________

Phone:_________________________ Fax:_______________________

CID Serial Number(s):____

Purchase Date:_________________ Purchase Price:_________________

FOLD ON DOTTED LINE

Your opinions will help improve our service. Please answer the following questions.

1. What was the basis of your product selection?

□ Representative Recommendation
□ Price
□ Product Features
□ Product Design
□ Technical Specifications
□ Brand Name
□ Warranty
□ Service
□ Other __________________________________

2. What other competing brands did you consider? ______________________

3. Where did you first learn of this product?

□ Advertisement in ___________________________
□ Representative
□ Friend/Colleague
□ Exhibit
□ Other __________________________________

4. Who selected this product?

□ I did
□ Research Group
□ University Department
□ Purchasing
□ Other __________________________________

5. Comments/Suggestions:

____

____