DOCUMENT OVERVIEW

This instruction manual is written for firmware version 4.7.X.X

Introduction

Congratulations on the purchase of your new F-900 Portable Ethylene Gas Analyzer. The F-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 0.025 ppm (25 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 F-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 F-900 employs electrochemical 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 F-900 Portable Ethylene Gas Analyzer.

Figure 1: The F-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 (2.96 kg)
- Real time continuous monitoring
- Internal data logging and storage
- Automatic data logging with adjustable interval
- User adjustable flow rate
- Transflective display enables easy viewing in direct sunlight
- Rechargeable Li-Ion battery provides 5 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 ranging 0.8 – 20 ppm C_2H_4 (optional)

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

Specifications

F-900 Specifications	
Display	Sunlight visible transflective graphic LCD
Operating environment	0°C - 45°C (0-90% humidity non-condensing)
Battery Capacity	5-8 hours - Rechargeable Li-Ion (5000 mAh)
Dimensions	183.5mm x 111 mm x 120 mm
Weight	2.96 kg
Enclosure	Anodized aluminum
Typical air Sampling Rate	80 mL/min
Measuring Rate	1 second intervals, open or closed loop
Warm-up time	1 minute
C_2H_4 PPB Sensor	Electrochemical
Nominal Range	0- 10 ppm
Resolution	0.001 ppm
Lower Detection Limit	0.025 ppm (25 ppb)
Accuracy	5% ± 25 ppb
Offset Recalibration	Weekly
Span Recalibration	*3 months (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 % ±0.5 ppm
Offset Recalibration	weekly
Span Recalibration	*3 months (calibration gas required)

*typically < 5% drift/month

GC Emulation Mode Specifications	
C_2H_4 Range	0.8-20 ppm
Accuracy	±10 %
Minimum Sample Volume	5 mL

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)
Resolution	0.1 ppm
Repeatability	±0.1 ppm (short term)
Accuracy	5%
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	Weekly
Span Recalibration	6 months (calibration gas required)
CO_2 Percent Sensor	Infrared Sensor, Pyroelectric detector
Nominal Range	0 – 20%
Resolution	0.01%
Accuracy	5%
Offset recalibration	6 months
Span recalibration	6 months (calibration gas required)
Lifetime	>5 years
Warm-up time	<3 minutes
Weight	7 g
O_2 Percent Sensor	Electrochemical
Nominal Range	0-100%
Resolution	0.1%
Offset recalibration	6 months
Span recalibration	6 months (calibration gas required)
Operating environment	0°C - 55°C (5-95% humidity non-condensing)
Weight	7 g

Warnings

- Read this manual carefully before using: this manual should be read by anyone who will be operating the F-900. By following the guidelines, the F-900 will function according to the specifications in this instruction manual.
- All repairs should be performed by a Felix Instruments 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.
- Use a T-valve when connecting the F-900 to a standard gas tank
- If smoke comes out of the analyzer, turn off the power immediately and contact Felix Instruments-Applied Food 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 F-900 in a high RF (radio frequency) environment. High RF will disrupt the F-900.
- ESD (electrostatic discharge) interferes with the F-900 measurement data.
- **Do not tilt the F-900 when Chamber IN contains water**
- **Do not fill Chamber IN beyond max fill line**
- **WARNING: Do not store the F-900 without charged batteries! The internal batteries must have charge to maintain the accuracy of the sensors, even when the unit is powered off. It is recommended to keep the instrument connected to the power supply for long term storage.**

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.

Theory of Operation

The ethylene sensors in the F-900 are electrochemical. With this type of sensor, the gas sample 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 converted to parts per million (ppm) of ethylene.

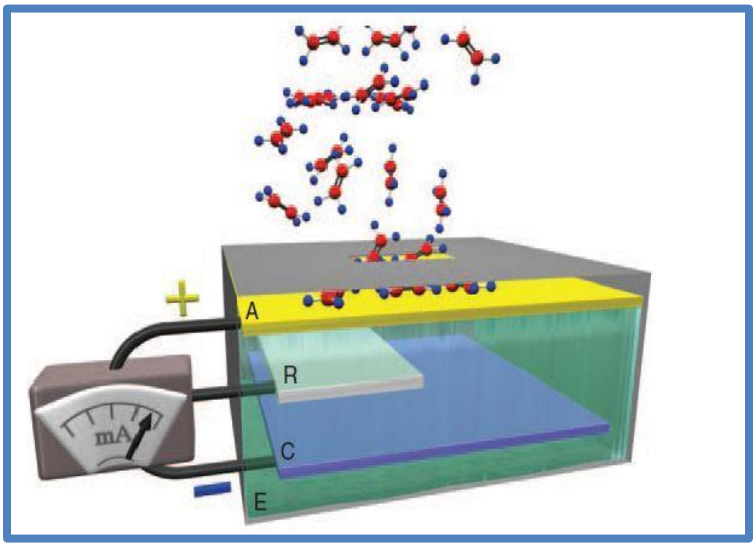


Figure 3: Diagram of an electrochemical sensor. (A) working electrode (R) reference electrode (C) counter electrode (E) electrolyte. Image credit: doi:10.1093/aob/mcs259.

The F-900 flow rate is regulated by a pump and a flow meter. Additional optional sensors are enabled/disabled in the Setup Menu (see page 40), as well as "conditioning chambers" on the back of the instrument (see page 45).

The temperature and relative humidity sensors are located inside the instrument. Therefore, the temperature sensor is subject to heating by the F-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 8), will also affect relative humidity readings.

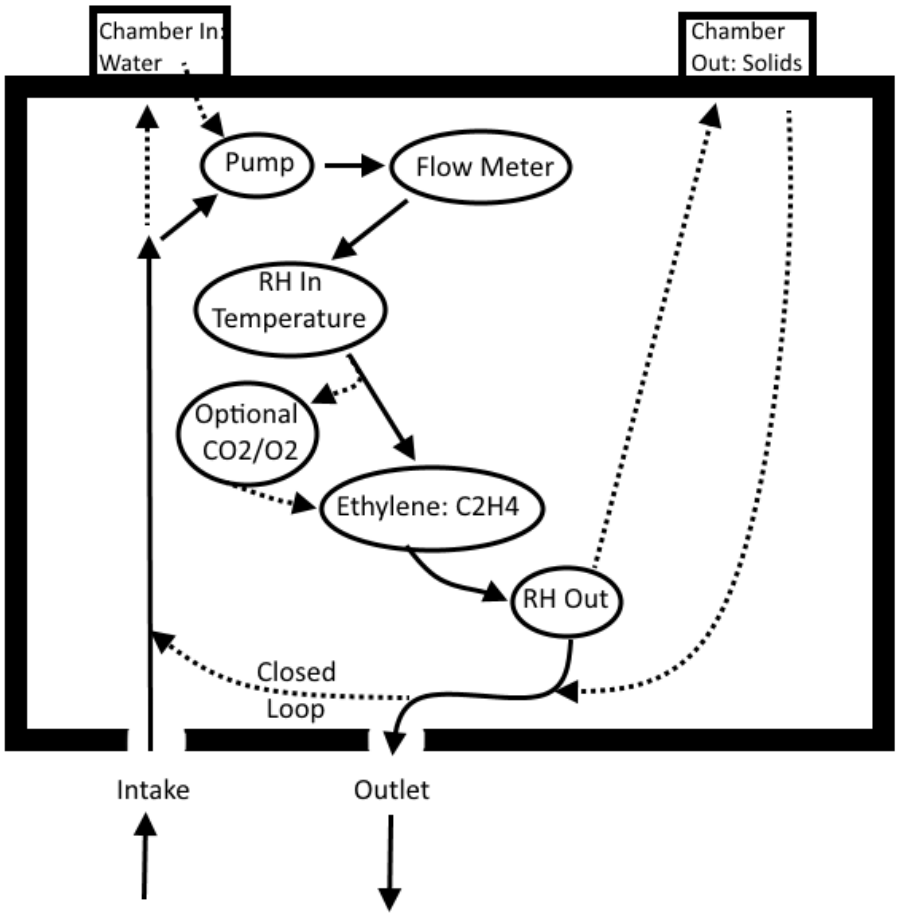


Figure 4: Flow path diagram of the F-900 ethylene analyzer. Dashed line indicates optional flow path capabilities.

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.

Ripening fruit emits 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. Felix Instruments 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.

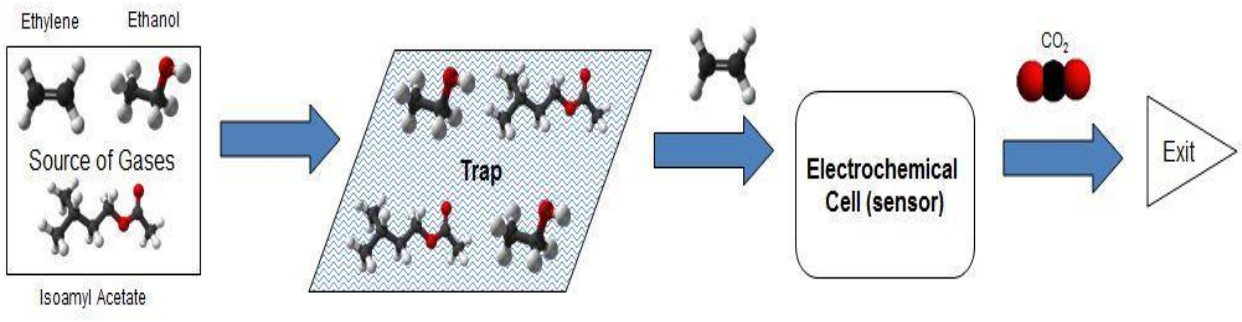
PolarCept

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.

Alcohols can induce a baseline shift and/or change the sensitivity of the ethylene sensor. To recover the sensor after exposing it to alcohols, run it with clean air for a few days.

PolarCept: Measure



PolarCept: Clean

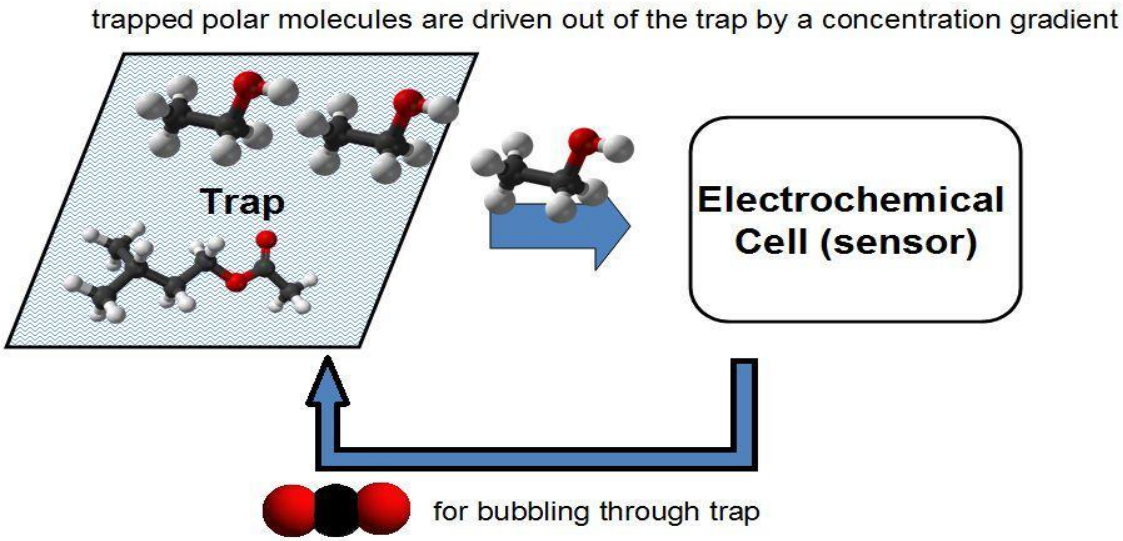


Figure 5: Top: diagram of measure period during use of PolarCept. Bottom: diagram of cleaning period of PolarCept.

Unpacking the F-900

The F-900 base unit arrives with the F-900 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 an F-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 F-900.

Figure 6: Accessories and parts that arrive with the F-900, clockwise from top center: F-900 ethylene analyzer, power supply and heavy duty USB cable, Viton tubing, Teflon tubing with quick connects, assorted quick connects.

The F-900 includes the consumable potassium permanganate ($KMnO_4$), 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.

F-900 Research Kit Accessories

The F-900 Research Kit (F-900RK) includes parts to non-destructively sample fruit in the field or laboratory. The F-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 F-900RK includes all the parts and accessories that arrive with the F-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.

For information on the 8L fruit chamber, please see appendix IV.

Figure 7: The F-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 F-900 and the current firmware version the unit is running. For information on the latest firmware version, please visit the F-900 software webpage (http://felixinstruments.com/support/f-900-support). Below this, a menu will appear on the display with the following options: Measure, Setup, View and File. This is the F-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 F-900 does not power on, eject the SD card or disconnect the mini-USB cable from the front of the instrument. Then, power the F-900 on. Re-insert the SD card or reconnect the charger.

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

Use the up and down arrows to switch between menu options and the right arrow to select. Press the green power button to power off the F-900.

Note: To force a power off and reset of the F-900 at any point, **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 F-900 arrives with a wall charger that can be used to recharge the F-900 battery, as well as for continually powering the unit during long-term monitoring. To charge the F-900:

- Connect the mini-USB cable to the front panel of the F-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 F-900.

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

To use the F-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.

WARNING: Do not store the F-900 without charged batteries! The internal batteries must have charge to maintain the accuracy of the sensors, even when the unit is powered off. Keep the instrument connected to the power supply for long term storage.

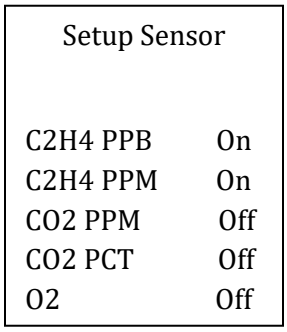
F-900 CO_2 PPM Sensor and Battery Power

The CO_2 PPM sensor will draw power when turned on, even if the F-900 is not actively measuring. If trying to conserve battery life, the sensor should be turned off when not being used.

- 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.



Measure Menu: Taking a Measurement

To begin taking measurements, select the Measure menu option by **pressing the right arrow** 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 F-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 F-900 will begin to warm-up. The F-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 F-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 auto-correction** 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 auto-correction 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 auto-correction, see page 35.

Note: The F-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). Then, allow the instrument to measure for 24 hours while connected to a power supply.

Graph Mode

Graph Mode will be entered automatically once the unit has stabilized in Sensor Stability mode. 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.**

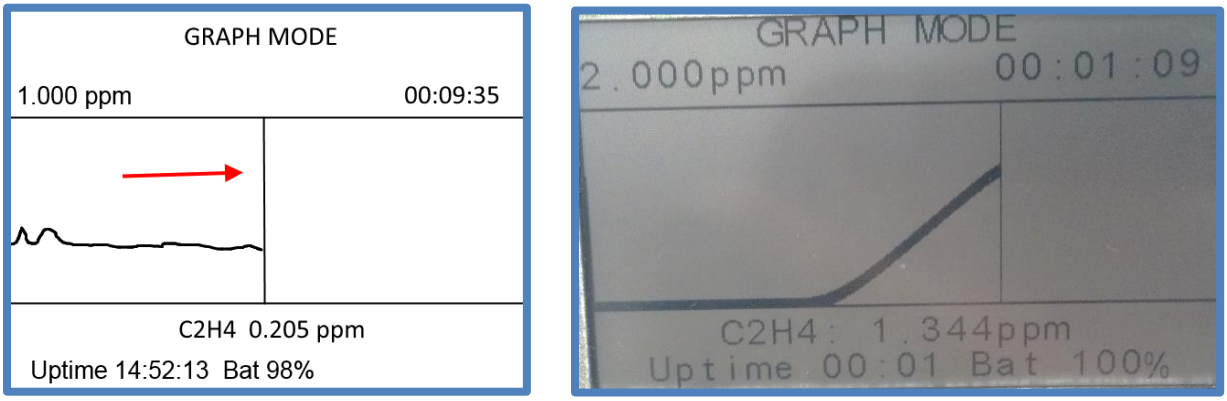


Figure 10: Graph Mode with red arrow indicating direction of movement.

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.

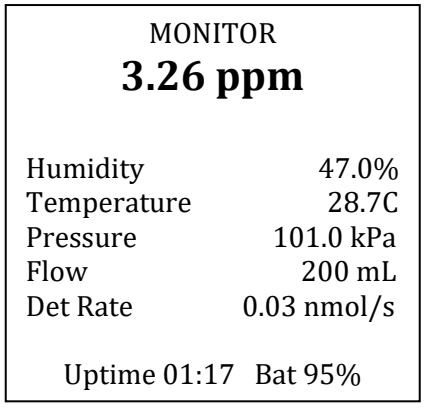
The scale of the graph can be increased or decreased by using the up and down arrows. Pressing the up arrow will zoom in on the data, minimizing the visible range. Using the down key will increase the scale, up to 200 ppm. Note that the minimum range of data visible (down to 0.150 ppm) depends on the 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 F-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 relative **humidity** in percent, of the gas stream in the instrument is displayed followed by the **temperature** in degrees Celsius. The atmospheric **pressure**, is displayed. Press the down arrow to view the **flow** rate in milliliters per minute. The default flow rate is 80 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 (%).



- If Autosave is enabled, "saved" will flash at the top of the display each time the data is automatically saved to the file.
    - Pressing 'save' during measurement when autosave is enabled will toggle the autosave feature **off**.
- 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 F-900 internal electronics. **The temperature reading is often 4-5ºC above ambient and in turn, relative humidity readings are affected. The use of water in Chamber In** (PolarCept, see page 8), **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 = 12.0L/hr
- Sensitivity to C_2H_4: 0.1 µL/L or 100 nL/L

Therefore, the F-900 optimally detects around 1200 nL/hr. 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. Changes cannot be made to the settings menu if the F-900 is "correcting offset". If the measurement is setup for PolarCept (Setup > Chamber > Chamber In = Special) then Chamber In cannot be turned on/off from the Measure > Settings menu. The measurement must be stopped and default Setup Menu parameters changed.

The Set Zero procedure begins by automatically closing the IN and OUT port 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 length of time for the offset can be changed by navigating to Setup > Calibration > C2H4 > Offset Correction. It is recommended to keep at 10 minutes. See page 34 for more details on ethylene offset performed from the settings screen.

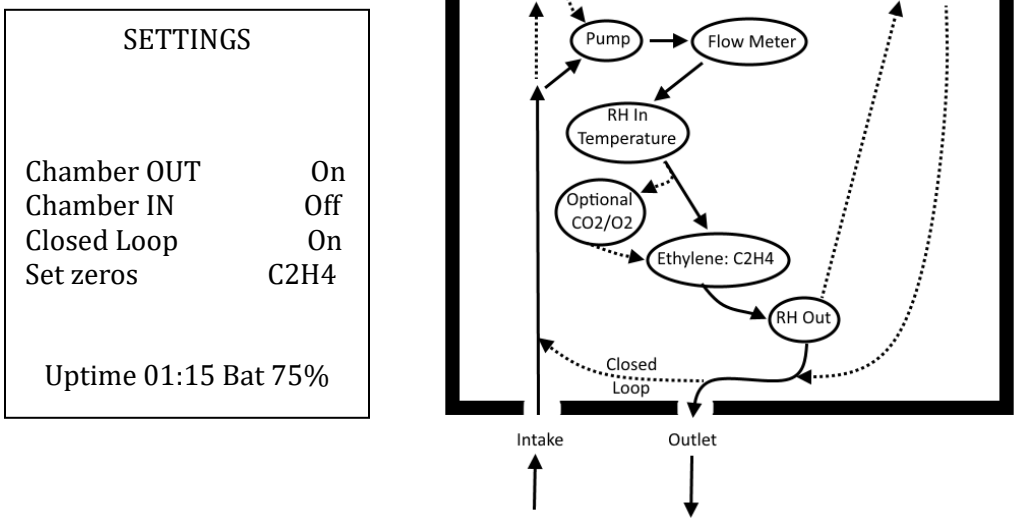


Figure 11: Measurement > Settings Menu display (left); flow path of internal gas stream (right).

Notes About Measurements with the F-900

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.

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 F-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 F-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 F-900, ensure that the intake on the front of the F-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 F-900 and ensure no water has entered the F-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 F-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.

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

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 F-900 tries to autosave, the unit will flash "write error" instead of "saved" at the top of the display.

F-900RK: Using the Research Kit Fruit Chamber

To use the F-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 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 F-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 F-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 F-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 F-900 Monitor Mode.

GC Emulation Mode

To use the F-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.

Calibration standard gas is not required for using GC Emulation Mode. Simultaneous results can be collected for all enabled sensors.

There are several improvements compared to a Gas Chromatograph (GC):

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

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

How GC Emulation Mode Works

The GC Emulation Mode employs a patent pending Flow Inject Analysis to determine ethylene concentrations with typical sample volume of 10ml (larger sample volumes will provide greater accuracy). The resulting value is the comparison between before and after-injection measured values. 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: $$0.025\ ppmv \leq \frac{Injection\ Volume * Expected\ Ethylene\ Concentration}{30mL} \leq 20\ ppmv$$

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.**

Each injection should be done by the same technician, as human technique will alter the result.

GC Emulation Mode Tips

- In general, higher injection volume will also increase signal detection. Recommended minimum injection volume is **5 ml**.
- The F-900 requires about 5-10 minutes of warm-up time when using GC Emulation Mode.

When using GC Emulation Mode, the protocol is to perform 1 injection per sample, which takes approximately 5 minutes:

1. Stabilization time
2. Sample injection (at least 10 mL)
3. Processing time

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

GC Emulation Mode Operation Procedure

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

Mode	GC Emulation

2. Enter the main Measure menu, Setup injection port then press Enter

Setup injection port then press enter

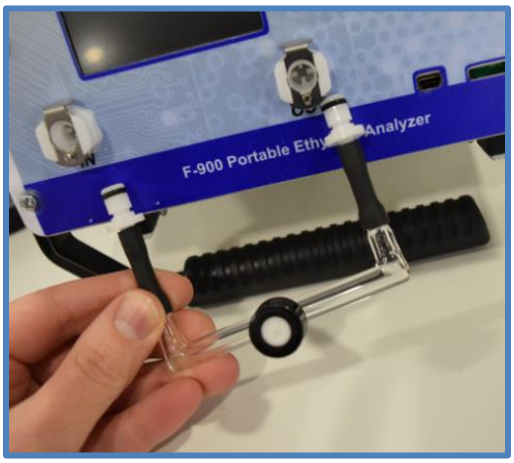


Figure 14: Injection port setup.

3. Wait for the instrument to stabilize.

Stabilizing environment Enter: Skip	
C2H4	x.xxxppm
Humidity	
Temperature	
Flow	
XX%	
Uptime 00:11 Bat 98%	

4. Set parameter then press Enter.

Set parameter then press Enter Sample volume(ml)

5. Inject the gas sample, then press Enter.

Set parameter then press Enter Sample volume(ml)

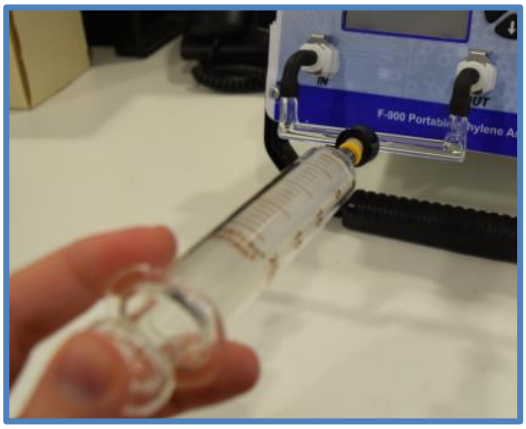


Figure 15: Injection of gas sample.

6. Wait while the sample is processing (~140 seconds).

7. View the results, Enter to repeat for another sample or Stop to exit.

Results Enter: Repeat, Stop: Exit Injection Volume C2H4 …

Figure 16: Proper technique for filling glass syringe from sample bag for GC Emulation Mode.

F-900 Calibration

The F-900 can be calibrated without any additional software. To access the calibration options, navigate to Setup > Calibration. The C_2H_4 ppb and ppm sensor, CO_2 ppm and PCT sensor, and O_2 sensor are all accessible for on-device set zero and span calibrations. Refer to the specifications on pages 3-4 for the calibration schedule on each sensor.

Note: "Set zero" and "offset" are interchangeable terms in the following procedures as well as "span" and "gain".

Pre-requisites

The calibration process consists of three basic steps. The first step is obtaining an offset point (the zero point) and second step is obtaining a span point. Lastly, it is good practice to verify the calibration using another standard gas. See Table 1 for a summary for the standards recommended for each gas sensor. The blue columns are your offset points (step 1). The white columns are you span points (step 2). The green columns are your verification points (step 3). Note that CO2 ppm sensor has two options for obtaining the offset point.

*Table 1: Recommended Standards for Gas Sensors **can use ambient air to verify the O2 sensor*

	20 ppm (C_2H_4) gas	10 ppm (C_2H_4) gas	5 ppm (C_2H_4) gas	2 ppm (C_2H_4) gas	16% (CO_2) gas	5% (CO_2) gas	2,000 ppm (CO_2) gas	1,000 ppm (CO_2) gas	50% (O_2) gas	20.9% (O_2) gas	100% (N_2) gas	Potassium Permanganate ($KMnO_4$)	Soda Lime (NaOH-KOH…)
C_2H_4 ppm sensor	✓	✓										✓	
C_2H_4 ppb sensor			✓	✓								✓	
CO_2 PCT sensor					✓	✓					✓		
CO_2 ppm sensor							✓	✓			✓		✓
O_2 sensor									✓	✓	✓		

All calibrations require the following:

- Flow meter capable of measuring 200 mL/min and lower with accompanying T-junction (refer to Figure 18) OR an on-demand regulator (refer to Figure 17)

- Tubing with low outgassing properties (such as Viton)

Below are some instructions on how to connect your standard gas to calibrate the gas sensors on your F-900.

a. If using an On Demand Flow Regulator, directly connect the regulator to the IN port on the F-900. When using an On Demand-Flow Regulator, the gas is drawn out of the regulator/cylinder by the pump of the F-900. When the regulator is fully twisted onto the cylinder, the PSI on the gauge will move. Rotate the regulator until it is tightly onto the cylinder of gas (clockwise).
    i. The regulator can be removed from the cylinder (a small puff of gas will escape) to be used with other gas cylinders or for storage. To remove the regulator, twist counter-clockwise.

Figure 17: Ethylene calibration gas cylinder with On Demand Flow Regulator connected to F-900 IN port.

b. **If not using an On-Demand Flow Regulator, a T-valve must be used to release extra pressure to avoid damaging the F-900.** Always open the regulator very slowly and allow only 1-2 PSI (6-13 kPa) until the ethylene value starts to increase on the F-900, reference Figure 18.
c. A flow meter can be used in conjunction with the T-valve to be sure that the flow going into the F-900 is at appropriate levels and gas is not being wasted. Connect your standard gas to the input of the flow meter and adjust your regulator to the proper flow rate. Then connect from the output of the flow meter to the 'in' port of the unit.

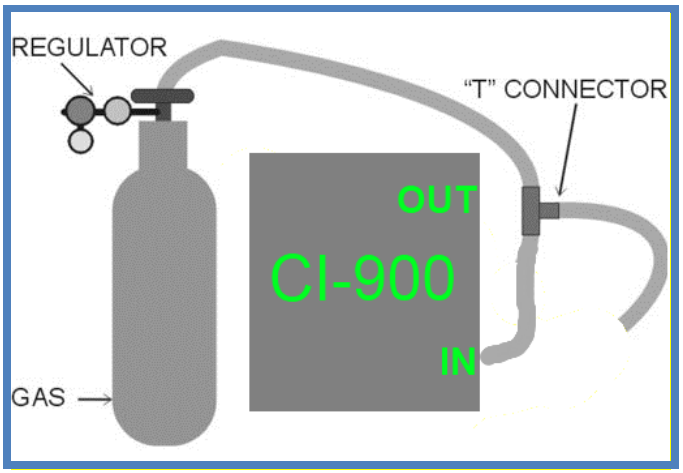


Figure 18: T-valve in tubing.

Standard Operating Procedure

A similar menu flow is set up for each sensor on the F-900. Deviations from these standard operations will be further addressed under the specific sensor below. The F-900 will automatically close and open the needed valves for offset and span calibrations without manual change being required by the user.

1. Under the Setup>Calibration menu choose the sensor you wish to calibrate by pressing the right arrow when desired sensor is highlighted.
2. Options for calibration parameters and recalibration can be seen. Select Re-Calibration.
   Note: Changes to any of the calibration parameters should be performed under the supervision of a Felix Instruments technician only
3. The display will prompt you to attach the appropriate standard gas for setting your internal offset.
4. Connect your standard gas for the offset to the 'in' port on the front of the unit and press 'enter'.
5. The instrument will automatically begin to set the offset and will give a countdown to completion.
6. Once the offset is set the display will automatically change to 'set parameter'.
7. The 'set parameter' display will prompt you to enter the exact concentration of your standard gas. This can be found on the spec sheet delivered with your standard gas tank.
   a. Note: Be sure to note the units required. If the units required are ppm and your standard gas is 2000ppm, this would be entered as 02000.
8. Connect your standard gas for span calibration. Hit 'save'.
9. The instrument will automatically begin to calculate the span calibration and give a countdown to completion.
10. The final screen will display the calibration results.

Ethylene Sensors

Ethylene PPB Sensor

Setting the offset for the ethylene ppb sensor deviates from the SOP given above and the procedure is described below.

1. Select the re-calibration function for the ppb C2H4 sensor.
2. The display will ask you if you want to use the KMnO4 chamber as zero source, press 'enter' for yes.

   Note: It is advisable to use this option. If zeroing the PPB C2H4 sensor with a standard gas rather than using the KMnO4, an additional step of setting up zero gas is required (with the exact amount of C2H4 in gas source). Contact Felix Instrument Support if you need further instructions for this routine.
3. After pressing 'enter' the display will immediately prompt you to 'connect calibration gas', this is referring to your standard gas for setting span.
4. The next screen will ask you to 'set parameter' where you enter the exact concentration of your standard gas. Press 'save'.

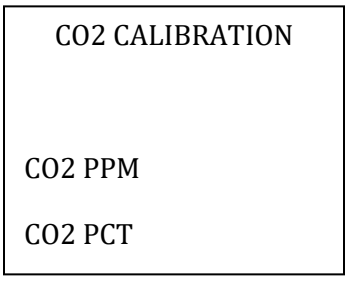
   Note: The entered concentration should be in ppb. If your standard gas spec sheet reports the value in ppm, convert to ppb.
5. The F-900 will automatically start setting offset using the KMnO4 in Chamber out and will give a countdown to completion. Zero calibration takes the instrument around 15-20 minutes to complete.
6. Once offset has been set, the F-900 will immediately start setting span with your calibration gas.
7. The final display will show 'calibration results' and prompt the user to accept by pressing 'enter' or pressing 'stop' to cancel the calibration.

Ethylene PPM Sensor

Calibration of the ethylene ppm sensor follows the standard operating procedure. Please see page 29.

CO2 Sensors

The CO_2 sensor needs to be enabled in the Setup>Sensor>Sensor Selection menu to access the Setup>Calibration>CO_2 menu.



As given in the specifications on page 3, CO_2 ppm zero calibration is recommended weekly. 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.

CO2 PPM

Calibration of the CO2 ppm sensor follows the standard operating procedure when using a standard gas to set zero. Please see page 29. An alternate method exits for setting zero with the use of Soda Lime and is described below.

Note: This is only an option if the research kit has been purchased with the unit.

1. Select the re-calibration function for the CO2 ppm sensor.
2. The display will read 'internal offset' and prompt the user to setup N2. At this point the user can alternatively connect Soda Lime.
3. The Soda Lime needs to be connected to the inlet and outlet port to create a closed loop system.

Figure 19: Soda lime closed loop system.

CO2 Span Buffer Tank System Instructions

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 F-900 CO_2 Sensor with a buffer system:

- The operator should stand away from the F-900.
- Use extra tubing to get the intake source away from human breath.

- Use a buffer tank system to stabilize the intake source.

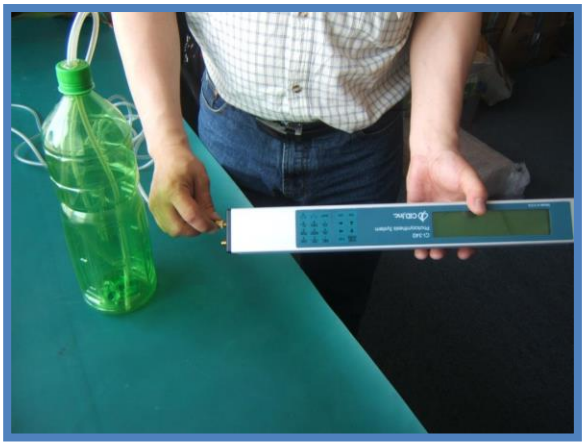
1. Find and clean an empty bottle with cap, which is at least 3L in volume.
2. Drill two small holes in the cap of the buffer bottle: 1 hole is for the intake tube and 1 hole is for the out tubing.

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). CO2 PPM

CO2 PCT

Please follow the Standard Operating Procedure on page 29 and refer to Table 1 on page 27 to calibrate this sensor.

The firmware supports a 3 point calibration for this particular sensor for added accuracy between the 0-20% range. The sensor leaves our facility with the following 3 point span calibration:

- 0.1% CO2
- 5% CO2
- 16%

If you run a span calibration for this sensor, it will replace the closest point from the 3 points listed above.

O_2

Please follow the Standard Operating Procedure on page 29 and refer to Table 1 on page 27 to calibrate this sensor.

Ethylene Sensor Zero Calibration

The instructions above are for two point calibrations of the F-900. Solely setting zero for the ethylene sensor can be accomplished through the Settings screen. 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 Set Zero procedure can be done manually or the F-900 can be programmed to perform the process 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. **(To set zero for the PPM sensor only, navigate to Setup > Sensor > Sensor Selection > C2H4 PPB > OFF before proceeding with the following steps).*

Manually Set Zero

This procedure falls under the Measurement>Settings menu option:

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:
        i. Chamber Out = On
        ii. Chamber In = Off
        iii. Closed Loop = On
12. The instrument will run for the amount of time set in the following menu: Setup > Calibration > C2H4 > Offset Correction. It is recommended to keep this setting at 10 minutes.
13. The instrument will make a "beep" sound twice to indicate that the offset correction is complete.
    a. The instrument will return to Monitor/Graph Mode and "correcting offset" will no longer appear on the display when the zero calibration is complete.
14. The measurement will continue with the original settings for the conditioning chambers and Closed Loop on/off.

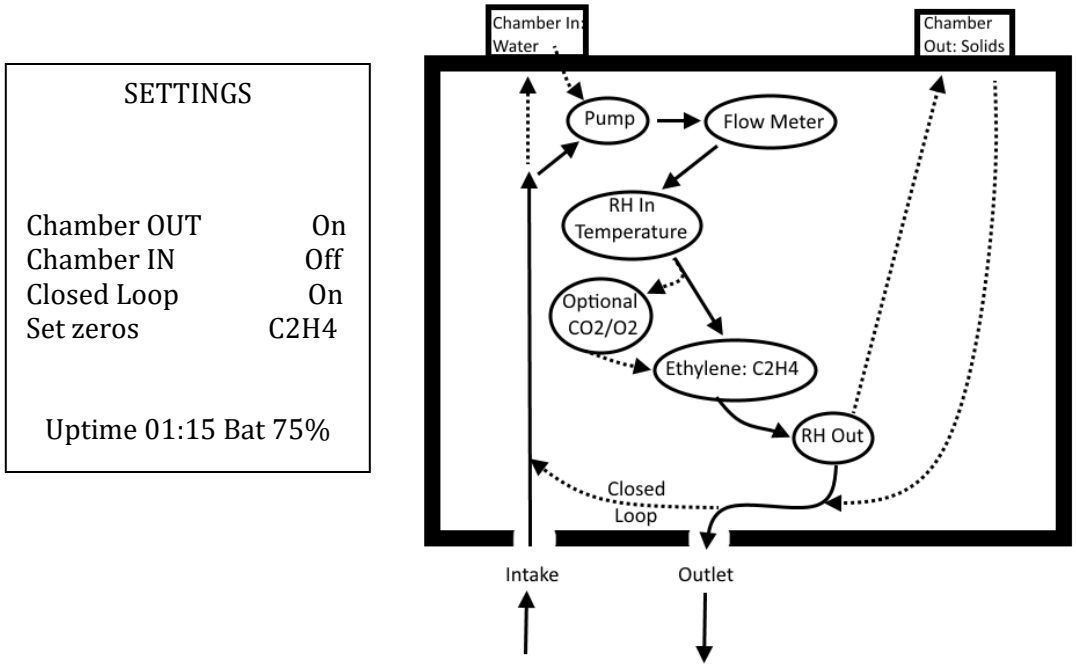


Figure 20: Measurement > Settings Menu display (left); flow path of internal gas stream (right).

Automatically Set Zero: Offset Correction

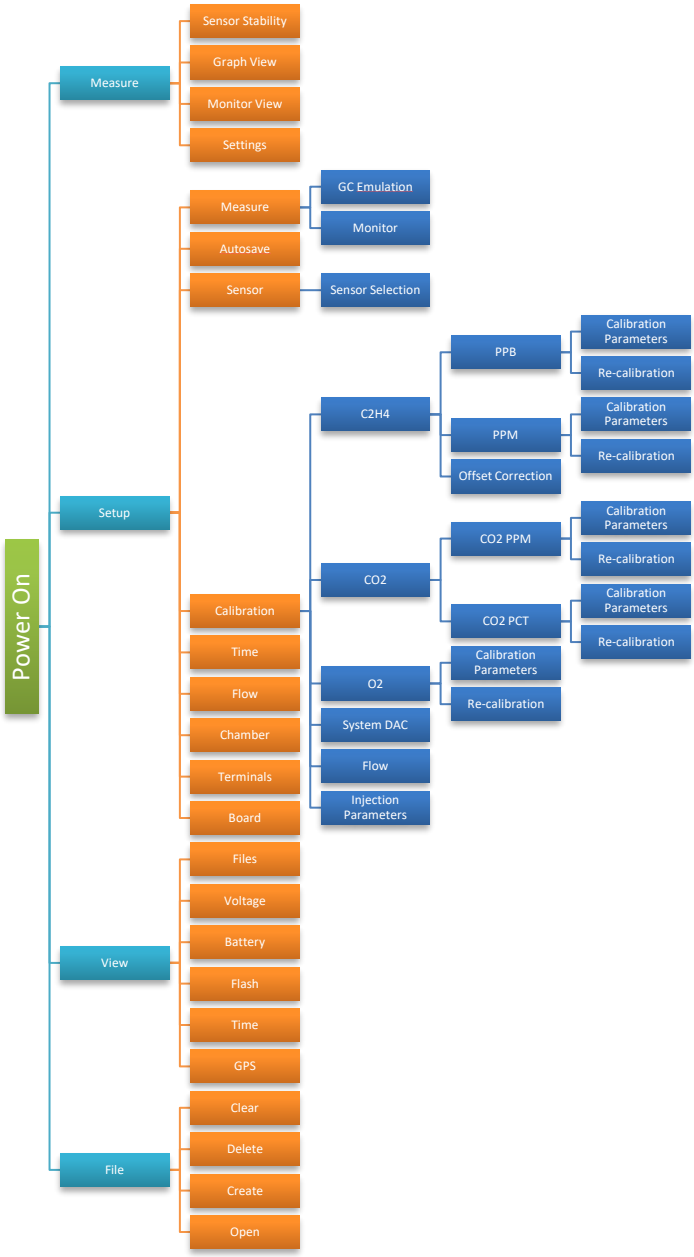
Please see Setup>Calibration>C2H4>Offset Correction on page 442 for additional information or to enable/disable the automatic set zero feature. The automatic offset will stop a measurement to set

the zero, and then re-start the measurement automatically. **This should be used during continuous monitoring or experiments longer than 24 hours.**

The offset correction duration is adjustable (default: 30 minutes) and happens during "Sensor Stability", the first screen when measurement mode is initiated. The default interval between offset corrections 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 correction will be initiated the next time the user enters "Sensor Stability", even if less than 24 hours have passed.

F-900 Menu System Diagram

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



Setup Menu

The F-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, and Board. Use the up or down arrow 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	

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 started on page 15. GC Emulation Mode is available with the F-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 F-900 are saved in .csv (comma separated value) format, to be opened with Microsoft Excel or other spreadsheet program.

Autosave	Menu
Autosave	Yes
Interval	010

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.

- 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.
- If Autosave is enabled, pressing ‘save’ during measurement will toggle Autosave to **off**.
- To avoid changing any configuration, press the Stop key to exit back to the Setup Menu.

Setup Sensor

The Setup>Sensor Menu has **Sensor Selection.** Sensor Selection allows the user to turn on/off the different sensors of the F-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 F-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 0-4 ppm. The C_2H_4 PPM measures from 4-200 ppm, with a lower detection limit of 0.5 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.

Setup Calibration

Please see the F-900 main calibration section, starting on page 27, for calibration procedures. Calibration Parameters and re-calibration steps for C_2H_4, CO_2, and O_2 sensors can be accessed via 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 flow and injection parameters.

C_2H_4 Calibration

****Re-calibration or changes to any of the Calibration Parameters for C_2H_4 should be performed under the supervision of a Felix Instruments 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 Felix Instruments 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. the temperature and RH parameters are automatically populated during ppb sensor span.

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

Offset Correction

Offset Correction 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 default interval between offset corrections 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 correction will be initiated the next time the user enters “Sensor Stability”, even if less than 24 hours have passed. **The offset correction relies on there being $KMnO_4$ in Chamber Out.**

Offset correction	
Automatic	Yes
Interval (hour)	024
Duration (min)	30

Automatic: 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 "Automatic" line to "Yes".

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

Duration: The amount of time the offset correction lasts. It is recommended to have it between 15-30 minutes.

Flow Rate Calibration

To calibrate the flow rate on the F-900, a separate flow meter is required. Please contact Felix Instruments Support for detail instructions.

Setup Time and Date

To change the time and date on the F-900, press the right arrow 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 F-900 is an important factor for taking good measurements. The default flow rate is 80 ml/min. Flow rate is adjustable from 80-200 ml/min.

A flow value below 80 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 (~200 ml/min) is acceptable. **The default flow rate is 80 ml/min**.

Setup	Flow
Set Flow	80
Actual Flow	80

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. If the measurement is started with PolarCept enabled, the measurement must be stopped to make changes to Chamber In at the Setup > Chamber 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 F-900, even when empty, to protect the brass intakes. Always ensure the conditioning chamber is seated properly when screwing it on the F-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 21: 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 zero calibration of ethylene sensors. Chamber Out must be filled with $KMnO_4$ while Chamber In is set to special mode.**

Alternatively, Chamber Out could be used with 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 for zero calibration of the ethylene sensor. $KMnO_4$ beads (not dust) should be sourced locally by the user.

$KMnO_4$ has an added color indicator that turns from purple to brown when it expires and needs replacement. The silica gel 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 F-900.

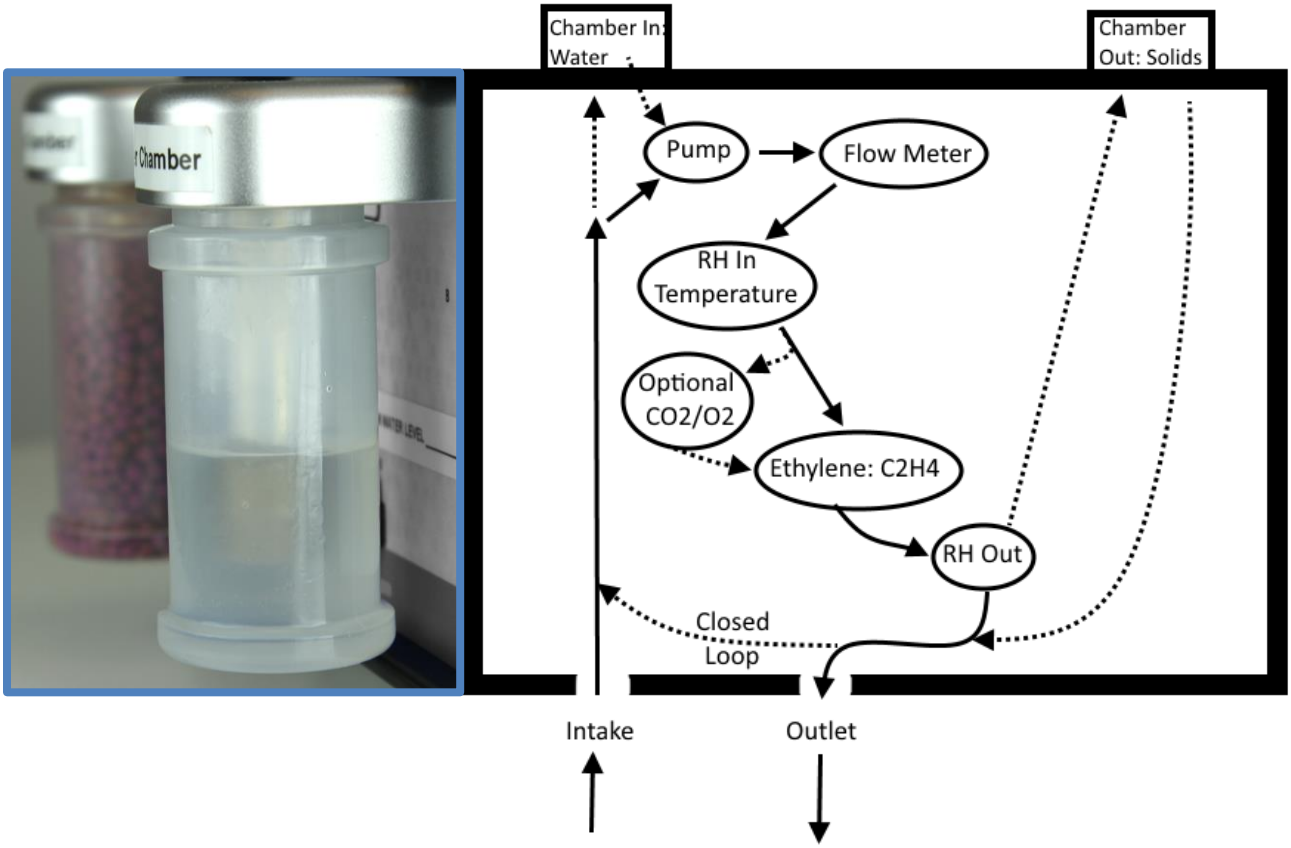


Figure 22: The back of the F-900 with removable and refillable containers for distilled water and $KMnO_4$ (left) and a diagram showing the flow path of the gas stream (right).

Chamber In is on the right side of the back panel. This chamber can be enabled in two different modes. For **PolarCept**, 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 F-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.
    a. To use soda lime or silica gel to condition the gas stream before it is measured, turn Chamber In to On and place the consumable in the conditioning chamber.
3. Chamber In set to **Special**.

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. When Chamber In is set to Special, you will see Measure and Cleaning Period appear below.

Chamber	Menu
CHAMBER_A OUT	Off
CHAMBER_B IN	SPECIAL
MEASURE PERIOD	6 MIN
CLEANING PERIOD	17 MIN

- Fill Chamber In with distilled water to max fill line (located on back of F-900)
- This mode may not be applicable at high ethylene concentrations.
- When the F-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 with approximately 35mL of DI water. Do not fill beyond the max fill line on the back of the instrument. Next, set the length of the measuring period in minutes. This is the time the F-900 will take to do a measurement. When using the water trap, a stabilizing time of at least 3 minutes is required before being able to record a measurement. However, a longer period of measurement (6-7 minutes) is required for accurate readings beyond the stabilization period. Actual times will depend on individual 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 **6 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 0.5 ppm). If not, lengthen the cleaning time and repeat the test. During the cleaning period Chamber Out filled with $KMnO_4$ is utilized to clean the DI water of the interfering gases. Therefore, Chamber Out must be filled with KMnO4 when Chamber In is set to special mode.

When the F-900 has PolarCept turned on, the Monitor Mode display top line will indicate B_SPEC, meaning that Chamber In is enabled in Special mode. Next, the current state (measure or cleaning) will be shown. If the F-900 is in a state of Measure, the data will reflect the current measurement. If the F-900 is in a state of Cleaning, "Clean" is shown in the upper right corner of the display.

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

The F-900 has two hydrophobic filters in-line with the internal tubing. This is to protect the F-900 in case any water is sucked into the instrument when using PolarCept. **To avoid drawing water into the internal tubing of the F-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 F-900 facing up and **do not tilt the instrument** when there is water in the conditioning chamber. When water in Chamber In, do not operate the instrument with the display panel facing upwards.
3. **Do not transport or tip the F-900 if water or moisture is in Chamber In**. Before transport or moving the F-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 or a "flow blocked" error appears on the display, 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.

Setup Terminals

The Setup>Terminals Menu is where the F-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 F-900. The F-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 F-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 VALUE	Terminals 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 F-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 F-900, first pull off the removable portion of the terminal block (pull straight out). The piece in the figure below will separate from the F-900. Slide the wire from what is going to be controlled through the opening for the appropriate pin. 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, gas or external control so, if the F-900 needs to be moved, the terminal block can be disconnected easily. The total power draw of the F-900 is .5-1.5 AMP, the max of 1.5 is assuming all sensors are installed and running.

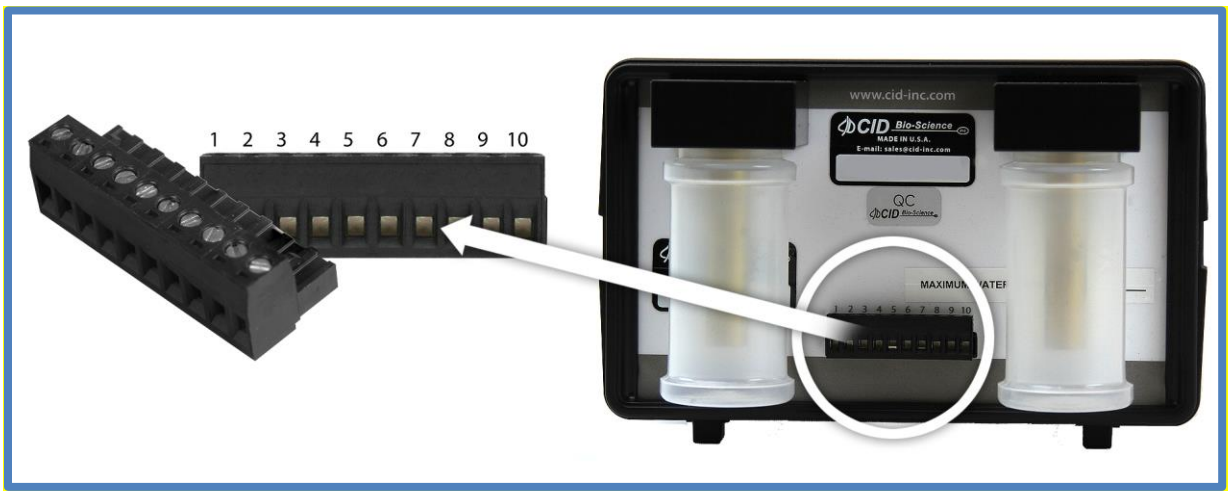


Figure 23: The removable piece of the F-900 terminal block.

Table 3: Designations of the 10 pins of the terminal block (On = 5V; Off = OV):

PIN	Function
1	Ground
2	Current Loop (reserved)
3	Plus 5 volts (limited through 4.7 ohm resistor)
4	Gas valve control (C_2H_4): when CONTL_OUT is ENABLE, OFF if C_2H_4 > GAS_HI, ON if C_2H_4 < GAS_LO
5	Ready signal (5V): ON if during measurement (except correcting offset), OFF otherwise
6	Alarm or error indicator: ON if one of the following happen: battery low/flow blocked/signal out of range/sensor error, OFF otherwise
7	CO_2 analog output: 4-20mA for 0 - max CO_2 range (2000ppm or 100%)
8	C_2H_4 analog output: 4-20mA for 0 - max C_2H_4 range (20ppm or 200ppm)
9	Analog Input (reserved)
10	Analog control input for cleaning: use with CONTL_IN enabled

The digital outputs (4, 5, and 6) can sink up to 45mA to drive an optocoupler. They can only source 0.1mA. Connect the optocoupler photoemitter anode to pin 3 (+5V) and the cathode to the digital output.

Setup Board

The Setup Board Menu should only be changed by a Felix Instruments 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.

The time interval between cpu/microprocessor calculations reaching the digital to analog converter (DAC) output to pins 7 and 8 on the terminal block is every 200 milliseconds. The internal sensor communicates analog signal to the analog to digital converter (ADC), which then supplies digital output to the microprocessor. The microprocessor then provides digital values for calculated concentrations displayed on the F-900. Those concentrations are then updated (every 200 milliseconds) to a DAC output on the terminal block (for CO2 and Ethylene).
There is no output for the O2, but there is for the CO2 and C2H4 sensors.

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 F-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 F-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 Menu shows the current voltage of the instrument. Press the right arrow when Voltage is highlighted to check the unit's voltage. Press the left arrow or Stop to exit back to the View Menu.

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

Voltage is set for each individual unit before leaving the Felix Instruments 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 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

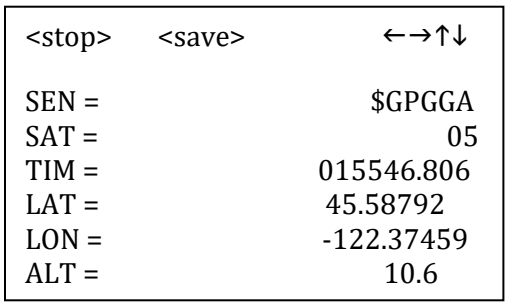
The View>Flash option is only accessible by Felix Instruments technicians.

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.

GPS System Features

The F-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.



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 F-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 F-900, with options to clear, delete, create and open files.

The F-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 F-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 File > Delete Menu. This mode will erase a file (and filename) completely from the 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 File > Create Menu. 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 F-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 F-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 File > Open Menu. 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 F-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, sm_measure or sm_clean 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 24: Example data spreadsheet for a F-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 period in Setup > Chamber > Chamber In = Special and test again.

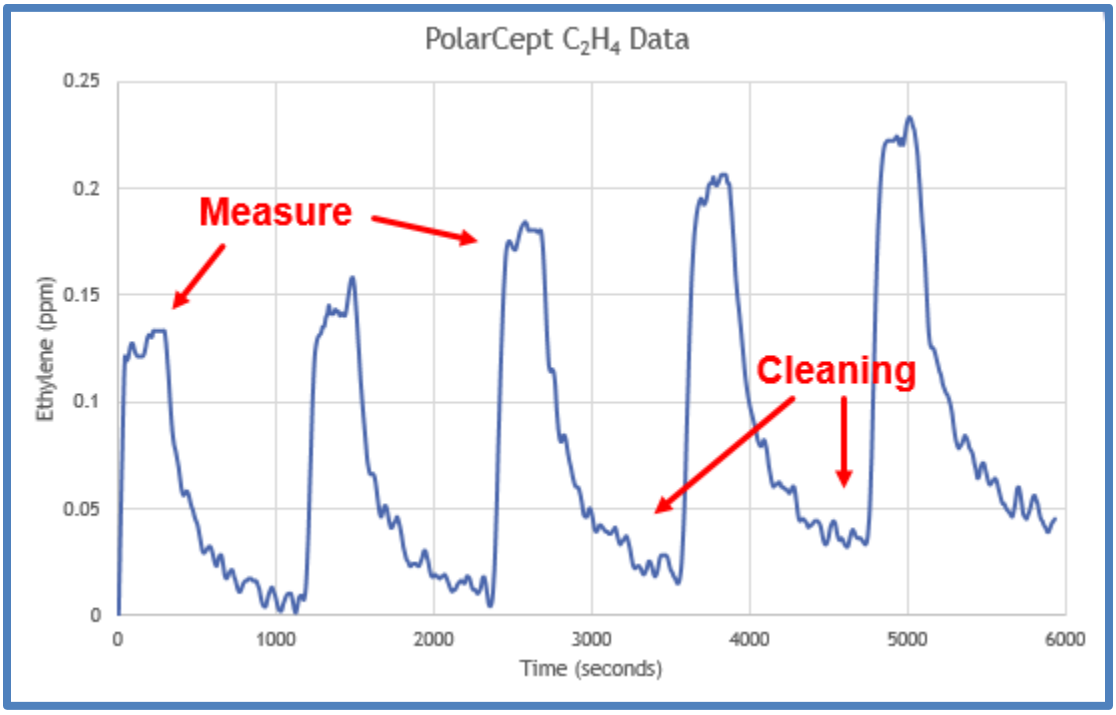


Figure 25: Example of ethylene data graphed showing peaks/valleys for measure and cleaning periods.

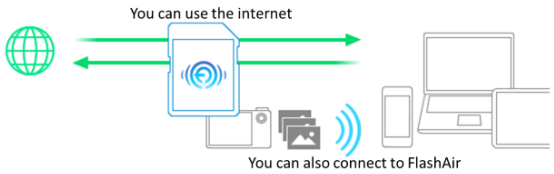
Wireless SD Memory Card Operation

These instructions are meant to accompany the instructions supplied by the vendor for Toshiba FlashAir™ W-03 to use specifically with the F-920 Check It! Gas Analyzer, which can be similarly applied to other Felix Instruments products.

1. Install FlashAir™ Wi-Fi card software appropriate to the SD card.
    a. Visit https://www.toshiba.co.jp/p-media/english/download/wl/software02.htm to download the software for configuring the Wi-Fi card and obtain vendor operation instructions.
2. Insert the Wi-Fi card onto a personal computer (PC).
3. Open the "FlashAirTool" on your PC to configure the SD card.
4. Follow the configuration instructions prompted by the "FlashAirTool".
5. For additional guidelines, access the "Help" menu inside the "FlashAirTool" software.

6. The Wi-Fi card can be enabled in “internet pass thru mode”, outlined in the following documentation provided within the FlashAirTool software:
    - Go to Network Settings on the main menu
      Check Internet pass thru mode
      This function is available for FlashAir™ W-03 and FlashAir™ W-02 (Ver. F19BAW3AW2.00.02 or later) cards.

      When this function is enabled, the FlashAir™ card can be used like a router, by allowing another access point to be connected via the card.
      When an internet access point is connected, images stored on the FlashAir™ card can be viewed, and the internet can also be accessed.
      This is convenient when, for example, uploading image files downloaded form a FlashAir™ card onto social networking services, as there is no need to change the Wi-fi device network settings on your smartphone.



* CAUTION: If you want to connect to the internet without using the internet pass thru mode, the wireless LAN setting connection on

your smartphone or other device must be changed from the FlashAir™ card to the internet access point.

Check the “Enable internet pass thru mode” checkbox to enable “internet pass thru mode”.

- Access Point SSID
  Sets the SSID of the internet access point.
  Enter the SSID for the access point that you will use. An SSID of up to 32 alphanumeric characters can be entered.

- Access Point Password
  Set the internet access point password.
  Enter the password for the access point that you will use.
- In your browser, enter http://flashair to view or stream your files

For more information on the Toshiba FlashAir™ W-03 Wireless SD Memory Card, contact the application vendor at https://www.toshiba.co.jp/p-media/wwsite/contact.htm.

Firmware Update

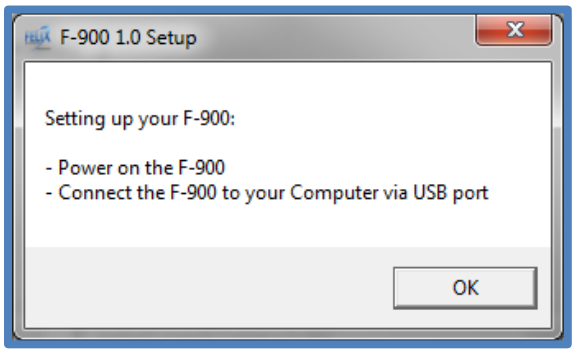
Transfer all data files from the SD card and DELETE all data files on SD card before doing the firmware update! Leaving data files from older firmware versions may corrupt the SD card.

Several files should be accessed from the software CD or downloaded from the F-900 support webpage (https://felixinstruments.com/support/F-900/) under software. Always double-check the webpage for the latest compatible firmware version depending on the serial number of the F-900. Please contact Felix Instruments technical support with questions about firmware updates.

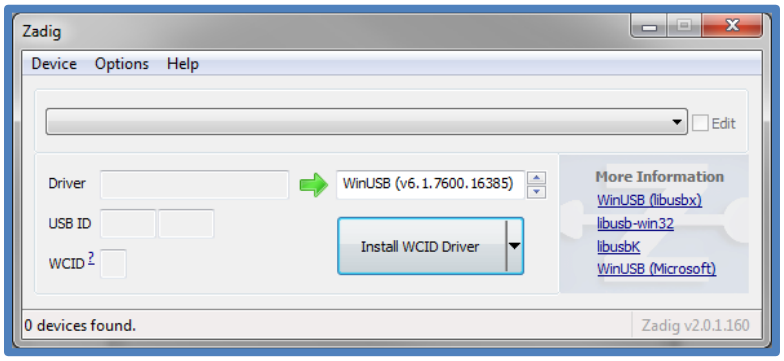
- Setup application: F-900_Package_Setup_v1.0.exe
- Firmware code file: F-900-ver-x.xx.bin (Example: F-900-ver-4.6.1.bin)

F-900 Driver Installation Procedure

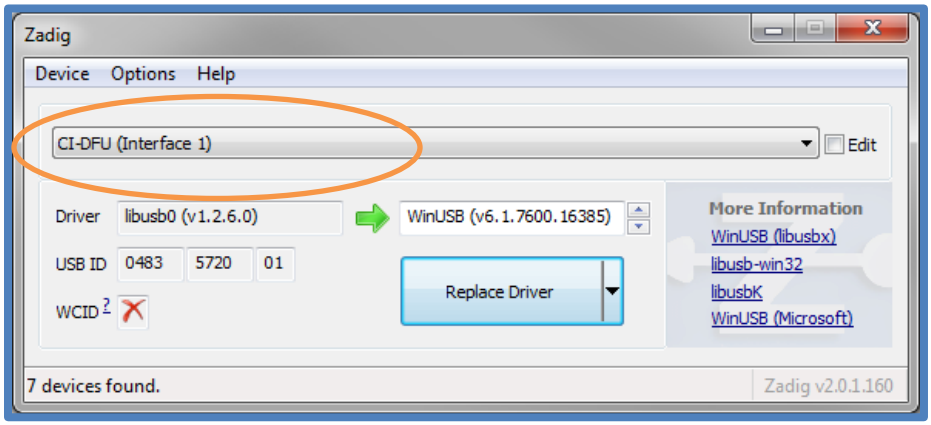
1. Connect the F-900 to the computer using the mini-USB to USB cable.
2. Launch F-900_Package_Setup_v1.0.exe
3. Set up device as prompted message below



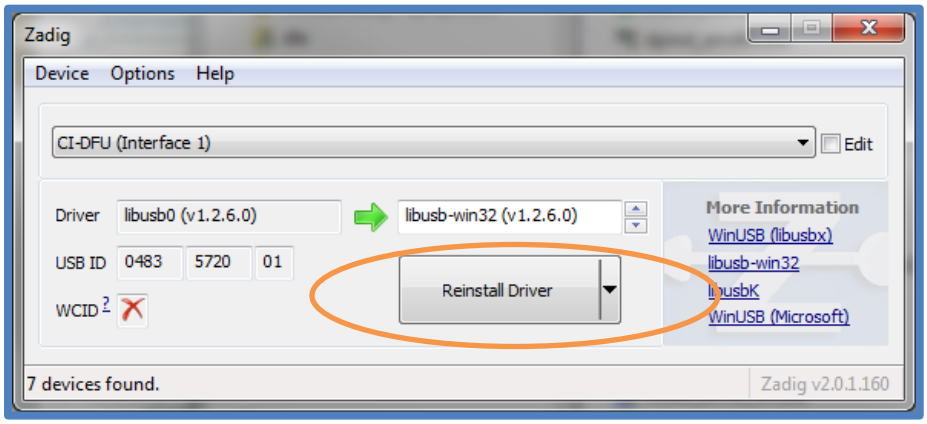
4. The F-900 requires an libusb driver. In the Zadig window, select Options > List All Devices.



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

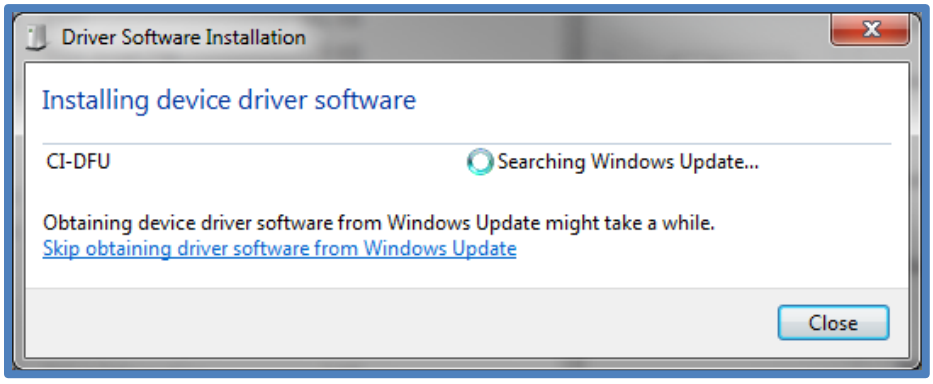


6. At the spinner list (green arrow), select libusb-win32.

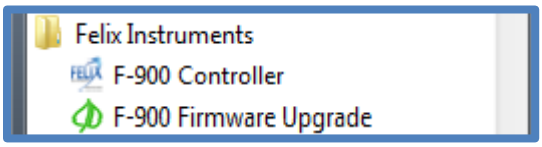


7. Click *Install Driver* to proceed installing libusb driver. This could take up to 1 minute to complete.

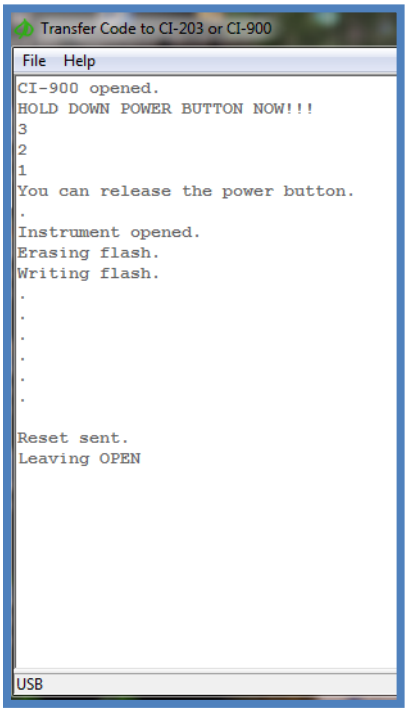
Note: Wait for Windows "obtaining driver" process to complete before clicking *Install driver*.



8. When the device drivers and software package installation is done, check for Java updates. In the Windows Start menu, there will be shortcuts for F-900 Controller and F-900 Firmware Upgrade.



F-900 Firmware Update Procedure



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

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

3. After the green LED is flashing quickly, connect the device to the PC with USB cable.

4. Select File and Open in the F-900 Firmware Upgrade program.

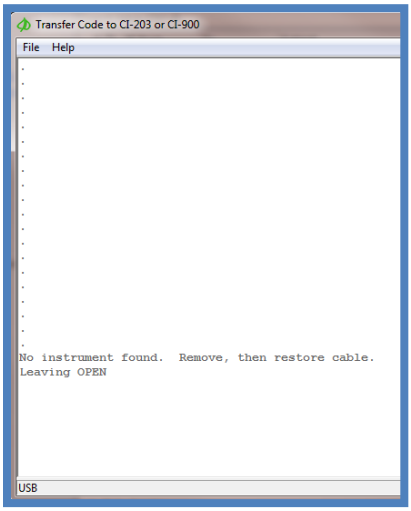
5. Navigate to where the **F-900-ver-x.xx.bin** is saved on the PC hard drive**.** This is the code for the instrument.

6. Follow the instructions in the software to hold down the Power button.

7. Release the Power button when instructed.

8. 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 F-900 will power off.

9. Power on the F-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 F-900:



   A. is not connected to the computer
      - verify USB connection and LED is flashing
   B. is not powered on
      - verify on device display
   C. driver is not properly installed
      - install or re-install F-900 driver

If the F-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 F-900 measure with the **Closed Loop On (Measure > Settings)** for 12 hours.

Technical Support

If you have a question about the F-900, first look in the F-900 Operation Manual. There is also online support available for the F-900 at http://felixinstruments.com/support/f-900-support. If you cannot find the answer, you can contact a Technical Support Representative located in your country. Felix Instruments 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@felixinstruments.com, please use your instrument's serial number as the subject line when sending a support request by email.

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Frequently Asked Questions

If there are any questions about the F-900, please check the Frequently Asked Questions below, as well as the Felix Instruments support webpage at http://felixinstruments.com/support/f-900-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 F-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. The F-900 Controller software is used when connecting to a PC to view real-time data (see page 28 for more details.)

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 F-900?

   a. To start using the F-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 F-900?

   a. The F-900 and F-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**. http://www.producefreshies.com/ is an online source.

   b. The F-900RK also ships with a humidity scrubber (silica gel). If the F-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 F-900?

   a. The F-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 F-900RK over the standard F-900?

    a. Both are portable, but the research kit includes the other components as listed in the "Unpacking the F-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 F-900.

13. Where are temperature and humidity measured?

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

14. 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 F-900 optimally detects around 1200 nL/hr. The unit is nanoliters of ethylene per gram fresh weight per hour.

15. 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.

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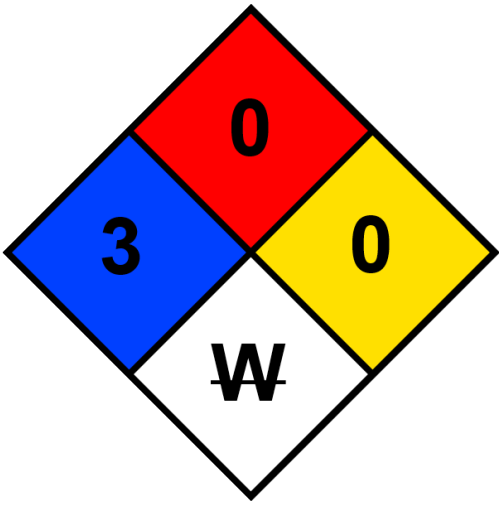
APPENDIX I: Material Safety Data Sheet for 2N Sulfuric Acid Solution

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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(U.S. and Canada): 1-360-833-8835

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 F-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 F-900, verify chambers are set to off and flow is set to 200 ml/min.
2. Connect experimental setup as shown in Figure 25.
3. Load the sample specimen into the fruit chamber.
4. Start measuring the fruit headspace with the F-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 Microsoft 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 F-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 F-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 Microsoft 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" period 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 F-900, until the background signal is below 40ppb.
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 F-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.

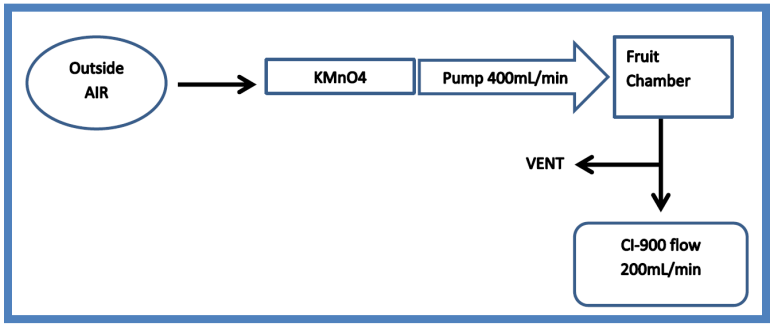


Figure 25: Set-up for fruit chamber using ($KMnO_4$) to scrub ethylene from the outside air.

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 F-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

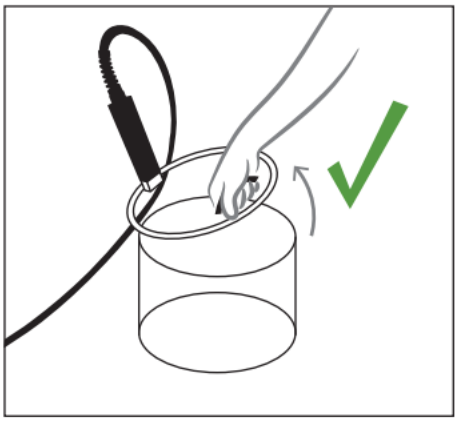
1. Flush the bag at least 3 times with purified air or nitrogen before use.
2. To fill a bag, connect tubing from the exhaust port of an air sample pump to the hose connection on the bag (stem protruding from the side of the fittings).
3. To open the shut-off valve, hold the side stem and turn the entire 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 F-900

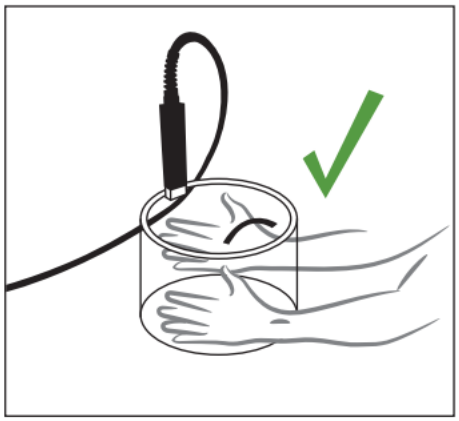
- Connect the sample bag to the IN port of the F-900.
- Open the sample bag to allow gas to start flowing to the F-900.
- It takes about 3-5 minutes to measure a sample bag if the concentration of ethylene before measuring the sample bag is low.

APPENDIX IV: 8L Chamber Accessory

These visuals supply the user with the basic Do's and Don'ts of working with the 8L Chamber accessory. Designed for measuring samples in a closed system, the 8L chamber can easily attach to the inlet and outlet on the F-900 to monitor ethylene, carbon dioxide and oxygen accumulation.



DO: Lift lid by holding base and pulling up on handle



DO: Carry chamber by base

DO NOT: Carry chamber or remove lid using the wand

DO NOT: Carry chamber by lid handle

APPENDIX V: F-900 Controller Software for Calibration

The F-900 Controller software is designed to make calibration quick and easy, with many automated features. (Requires latest version of Java). A major advantage of using the F-900 Controller software to calibrate the sensors is that all calibration parameters are updated and saved in the F-900, including calibrated RH, calibrated T, and internal gain. Additionally, compensation for temperature and relative humidity are automatically applied, based on the internal sensors of the F-900. The F-900 Controller software is primarily used for the **C2H4 PPB sensor span calibration**, which is recommended **weekly**.

Other sensors on the F-900 can be calibrated using the F-900 Controller software. The calibration of the RH sensor requires an external relatively humidity sensor. **Each sensor must have the zero calibration set before carrying out the span calibration.** This can be carried out with KMnO4 and the "set zeros" calibration for ethylene, or for "set zero" of CO2 and O2 sensors by using N_2 gas and the F-900 Controller software (step #1 in the F-900 Controller software "Calibration" tab).

The CO2 PCT is calibrated at 3 known points and 0 ppm to provide the greatest accuracy for the 0-20% range. When recalibrating the CO2 PCT sensor, choose the expected or desired range and calibrate with the recommended concentration. If using the 0-100% CO_2 range, **values above 20% are extrapolated** and not measured due to the limitation of the sensor range. Verify with CO_2 gas within expected range. The following table indicates what concentration of calibration gas is used at Felix Instruments for each sensor. Please refer to calibration prerequisites on pg. ef472597714 28.

Ethylene Sensor Span Calibration

Refer to the Specification on page Specifications3 for the calibration schedule as well as Table 1 on page 28.

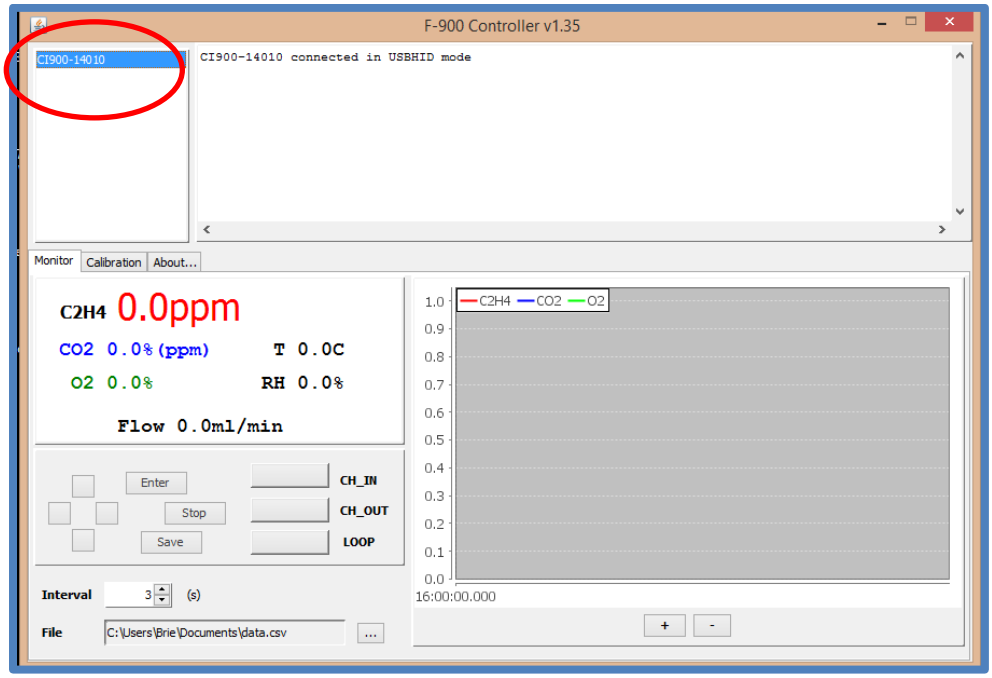
Before performing a span calibration:
1. First perform a zero calibration

2. The F-900 driver must be downloaded and installed using the **F-900 Package Setup v1.X.exe** found on the webpage (http://felixinstruments.com/support/f-900-support/software), as well as detailed instructions. The F-900 Package Setup includes the F-900 Controller software necessary for the calibration.

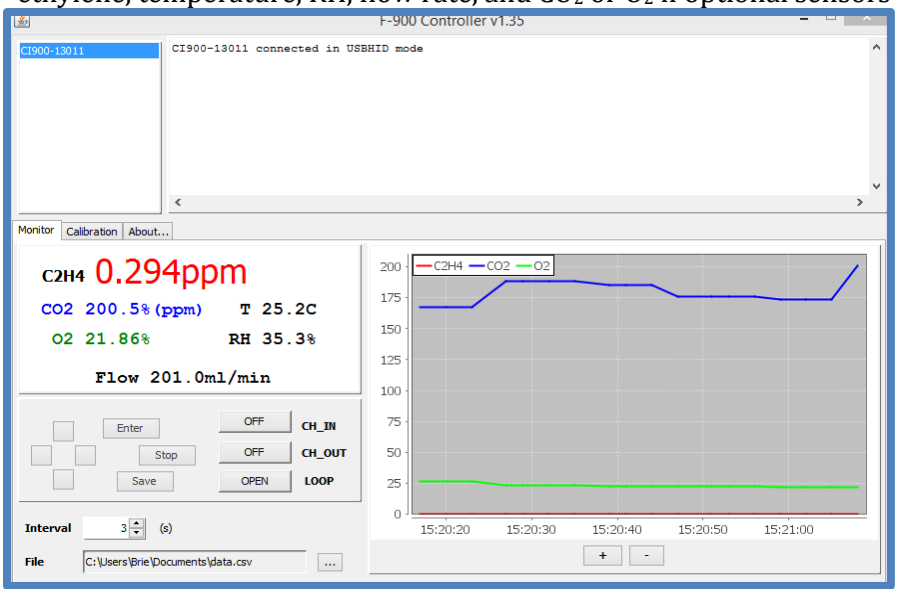
Set C_2H_4 PPB Span

1. Connect the F-900 to the PC using the USB cable. Power on the F-900 and open the F-900 Controller software (Latest version of Java required. Check http://www.java.com/)
    a. If the F-900 display becomes frozen consistently when connecting to the PC, it is possible the SD card is corrupted. To repair, insert the SD card in the computer. If the PC reports disk error, choose "scan and fix". If not right click on the SD card drive > Properties > Tools > Scan. Press and hold the power button for 10 seconds to force a shut-off if the F-900 freezes.

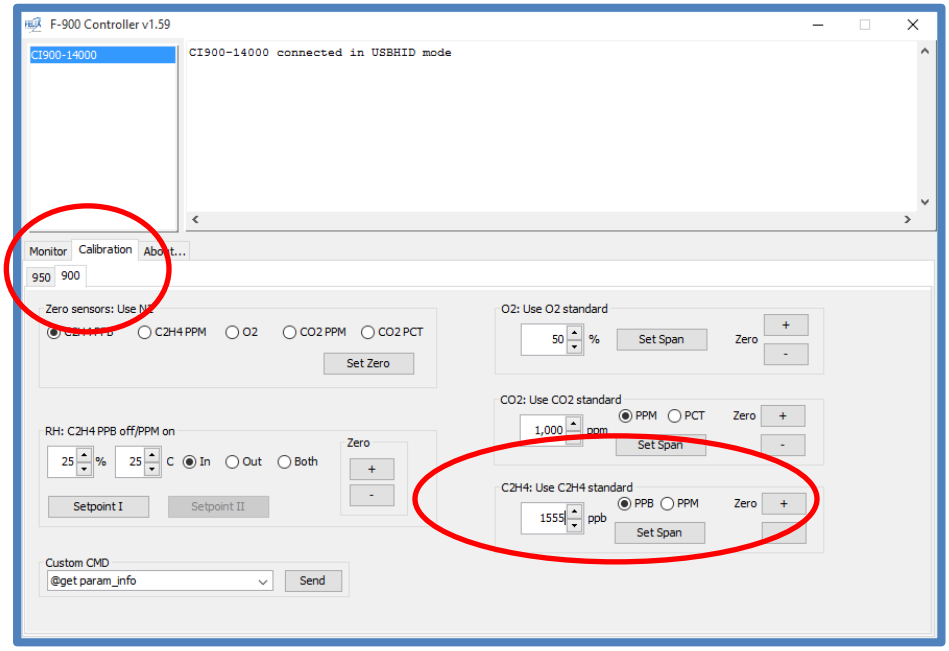
2. The device serial number should appear in the upper left corner of the F-900 Controller software and a message should appear indicating that the device is connected in USBHID mode. Click on the device serial number to connect to that specific instrument. The F-900 Controller software can have more than 1 device connected at a time.



3. On the F-900, navigate to **Measure** and press the **right arrow** to begin a measurement. Press the right arrow again to skip the sensor stabilization.
    a. There is a short lag in the F-900 Controller software as it pulls data from the F-900 instrument. This lag interval is adjustable in 1 second intervals. The monitor view data should begin to appear and update in the F-900 Controller software, including ethylene, temperature, RH, flow rate, and CO_2 or O_2 if optional sensors are enabled.

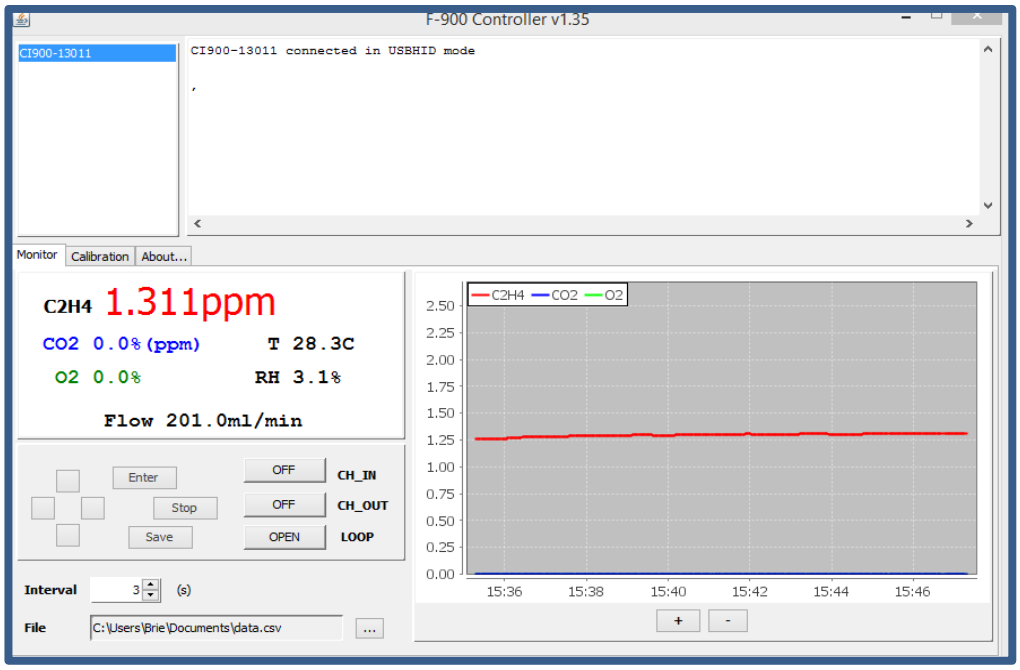


4. Select the "Calibration" tab in the F-900 Controller software. Select the tab for "F-900" to see the various calibrations possible (Zero individual sensors with N_2, Relative Humidity (RH), O_2 Span, CO_2 Span, C_2H_4 Span.)
5. See the last calibration listed: **C_2H_4: Use C_2H_4 standard**.
    a. Select **C_2H_4 PPB** to calibrate the ppb sensor.

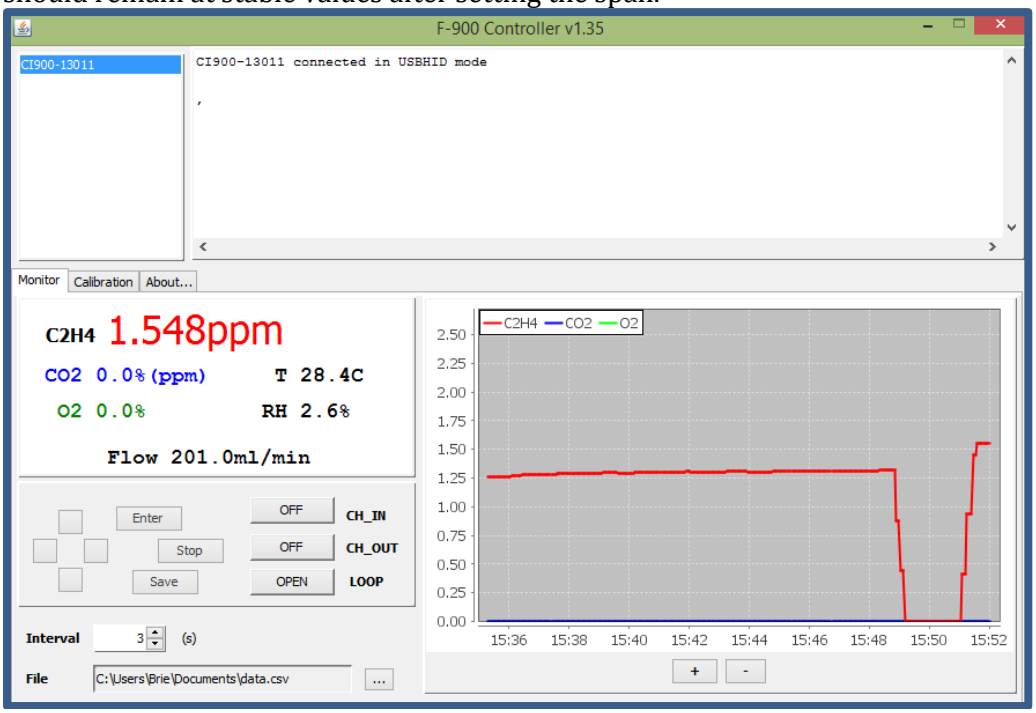


6. Enter the exact ethylene concentration from the calibration standard gas in ppb (ex: 1555 ppb) in the F-900 Controller software.
7. Connect the standard gas to the F-900 intake. Verify that the F-900 measurement settings have Chamber In, Chamber Out and Closed Loop turned off.
8. Watch the ethylene data on the F-900 Controller software now that the standard gas is connected. The data should be trending towards the expected concentration and begin to stabilize.

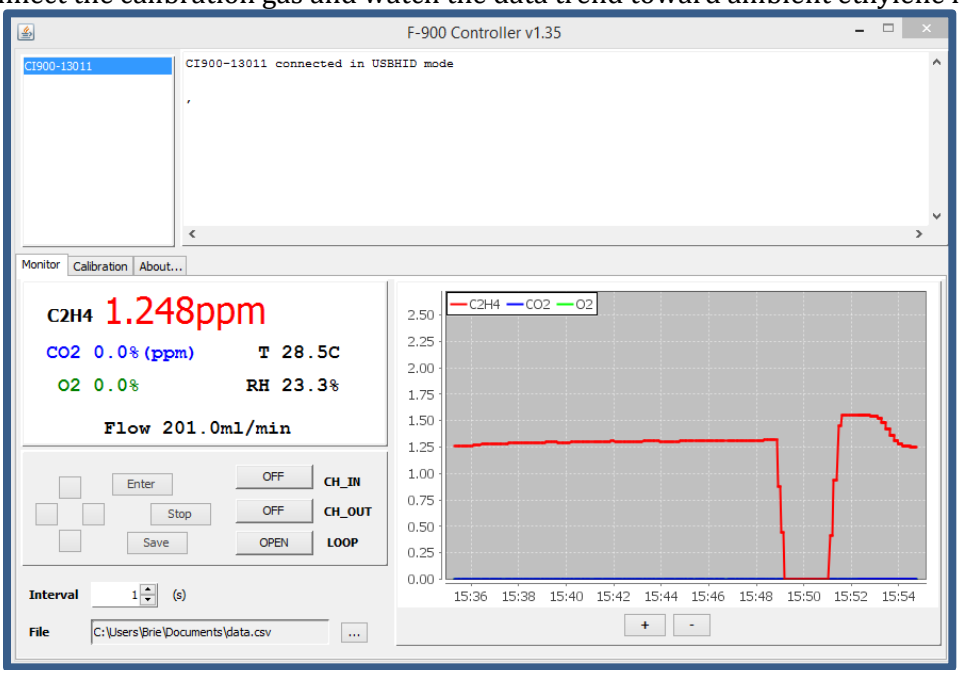
9. **Wait at least 7 minutes once the signal has stabilized** (and does not change more than 40 ppb) before setting the span calibration. To set the span calibration, verify the correct concentration is entered in ppb in the F-900 Controller software and click the "set span" button. Note the value below has stabilized at 1.311 ppm.



10. Once the set span button is pressed, the span concentration (ex: 1.555 ppm) should appear on the F-900 display as well as in the F-900 Controller software. The concentration level should remain at stable values after setting the span.



11. Disconnect the calibration gas and watch the data trend toward ambient ethylene levels.



Guide for Purchasing Standardized Gases for Calibration

When deciding which standard gases to purchase for calibration, there are some important considerations that will help guide your purchase:

1) Determination of concentration of the gas to be purchased. The concentration of the standard gas is the first consideration. It needs to be at a concentration level that is appropriate for calibration of the instrument.

2) Determination of proper regulator for the standard gas tank. A regulator is needed to provide a consistent flow of gas to the instrument at a certain rate. At our facility, we use on-demand regulators that require the pumps within our instruments to pull the gas from the standardized tank. If this is not an option, other regulators are acceptable, just use a T-junction when connecting to the instrument to protect the instrument from damage.

3) Determination of the size of tank to order. Consider how many calibrations can be performed with the volume of gas purchased. Each calibration for the F-920, 940, and 960 will take around 0.3 liters of standard gas.

Below is an example of a standard order our company would make to Air Liquide for a 1.5ppm ethylene standardized gas tank for calibration of the F-940.

Air Liquide is a multi-national company that can deliver products to most business locations worldwide. You may look at www.airliquide.com for your local office.

Air Liquide America Specialty Gasses LLC

Telephone 425-931-8303 or 800-814-4642

A sample order for 34 Liter canister of appropriate calibration gas for an F-940 or F-950 would include the following (*Note, these are Air Liquide's unique product numbers)*:

Part Number: A0909352 Scotty 34

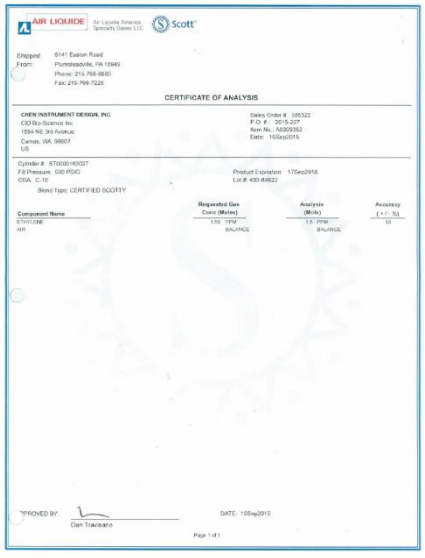
Description: 2 Component Mix, Balance Air, Gas 34, NR

AIR BAL

ETHYLENE 1.5 PPM

Phase: Cylinder Gas **Measurement**: Mole **Class**: N/A

Size: 34


AIR LIQUIDE Scott

CERTIFICATE OF ANALYSIS

Your gas vendor will do their best to meet your specified concentration and will provide a certificate of analysis with your

gas showing what they have delivered. Be certain to use the actual value on the certificate of analysis as it may differ from what you have ordered.

If you don't already own a regulator, you must buy one. The following is the ordering information for the on-demand style regulator that we typically use. (*Note, these are Air Liquide's unique product numbers)*

Part Number: A0315576

Description: Q114DRFRC10 – M14 Demand Regulator

0 – 3 LPM @ 3'

F-900 Production Test Check Sheet

SERIAL NUMBER:
Firmware Version:

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		
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: _____

_____

Warranty Information

Seller's Warranty and Liability:

Felix Instruments- Applied Food Science warrants new equipment of its own manufacturing against defective workmanship and materials for a period of one year from date of sale. 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.
Felix Instruments' liability for repairing or replacing defective parts during the warranty period is contingent on examination by a Felix Instruments authorized representative. Felix Instruments liability will not extend beyond repairing or replacing parts from the factory where they were originally manufactured. Repair or alteration by an unauthorized technician voids warranty.
Material and equipment which is not manufactured by Felix Instruments is to be covered only by the warranty of its manufacturer. Felix Instruments will not be liable to the Buyer for loss, damage, or injury to persons or to property by the use of equipment manufactured by other companies.

Buyer accepts the terms of warranty through use of this instrument and any accessory equipment. 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.

All instrument repairs or replacement covered under warranty require a Returned Material Authorization (RMA) number. Please contact Felix Instruments technical support department at support@felixinstruments.com to obtain an RMA number before shipping instrument to CID Bio-Science, Inc.

Buyer is responsible for shipping charges to Felix Instruments headquarters:

1554 NE 3rd Ave.
Camas, WA 98607
USA

Felix Instruments is responsible for return shipping charges on repairs and/or replacement covered by warranty.