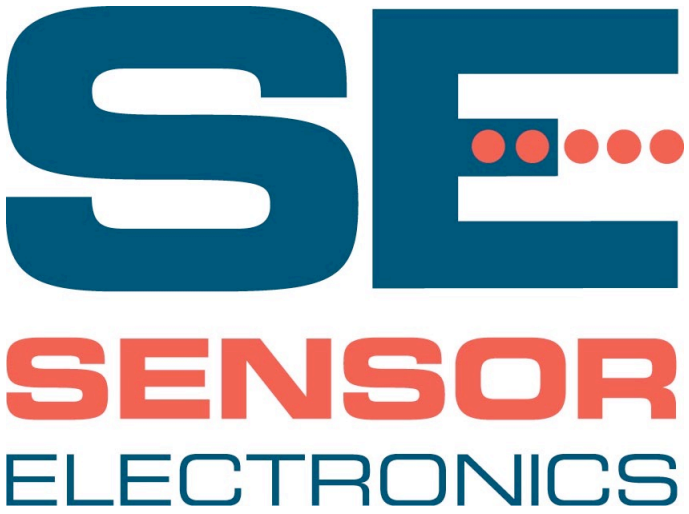


Sensor Electronics Corporation
12730 Creek View Avenue
Savage, Minnesota 55378

Sterilization Training
Training Manual

August 2017

SENSOR ELECTRONICS

SEC *Signature*

Process Gas Analyzer

Features

- *Capable of continuous monitoring for gas vapors*
- *Low cost*
- *Infrared sensing technology*
- *Designed for nonextractive sampling installation*
- *Virtually maintenance free*
- *Explosion proof*
- *Immune to poisoning and etching*
- *Designed for harsh environments*
- *Compact and lightweight*
- *Fast response time*
- *Simple calibration*
- *Self-compensating optical bench (patented)*
- *Linear output*
- *Unaffected by humidity and pressure*
- *Heated optical chamber*
- *Low power consumption*
- *Operates in anaerobic atmospheres*
- *Continual self diagnostics*
- *4 to 20 mA output*

Operation / Description

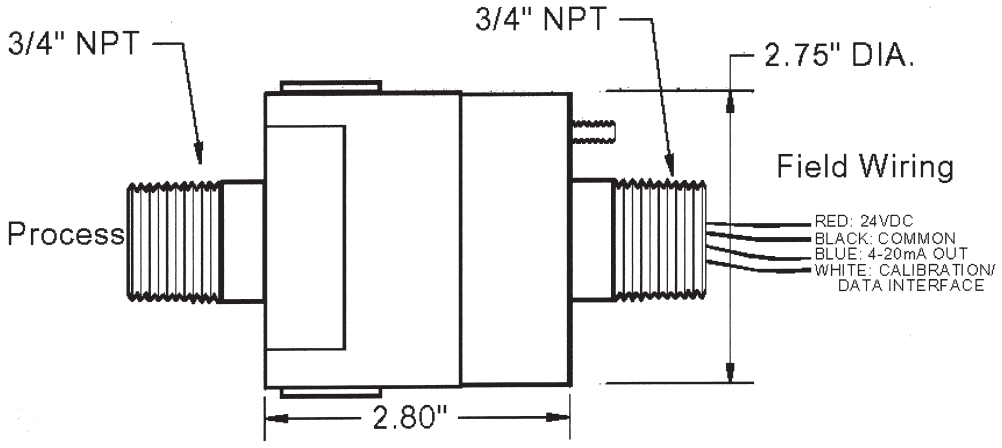
The SEC *Signature* is a self-contained optical gas analyzer designed for non-intrusive continuous monitoring of process gases. The infrared optical system is self-compensating for most aging, environmental, and contamination effects resulting in excellent measurement integrity. An industry standard analog output provides complete remote alarm, fault and calibration signals. The analog output from the device can be connected to chart recorders, data acquisition systems or a process control system.

The SEC *Signature* measures infrared light absorption due to molecular resonances. The monitor is tuned to the infrared signature of the target gas or vapor, measuring light at wavelengths absorbed by the target gas and at wavelengths not absorbed by the target gas. The gas concentration is determined by calculating the ratios of the analytical and reference levels. Embedded linearization algorithms keep the output accurate over the entire measuring range and embedded compensation algorithms maintain measuring accuracy over changing environmental conditions.

The SEC *Signature* employs a reliable, directly opposed optical system. No mirrors or reflecting surfaces are used in this device. The anodized aluminum surfaces of the optical chamber are heated to discourage condensation. Sapphire windows protect the optics eliminating the corrosive effects found in many process monitoring applications.

Once the unit is spanned to a specific mid range gas concentration (a one time operation), routine calibration consists of only rezeroing the device periodically.

Dimensions



Specifications

Range (adjustable): EtO 0-2000mg/liter; Hydrocarbon 0-100% VOL; CO2 0-20% VOL

Model: EtO P/N 142-0597; Hydrocarbon P/N 142-1014; CO2 P/N 142-0848

Construction: Anodized aluminum and sapphire

Mechanical Connection: 3/4" NPT

Weight: 18 ounces

Accuracy: ± 5% of reading or ± 3% full scale (Whichever is greater)

Repeatability: ± 2%

Operating Voltage: 18 - 32 VDC ⎓

Max. Power Consumption: 6 watts

Current Draw (@24 VDC): 250 mA (average) 450 mA (peak)

Analog Output: 0-20 mA (sourced)

Digital Output: Interactive P.C. link

Wire Connections: Red wire (+ 24 VDC) ⎓
Black wire (D.C. common)
Blue wire (4-20 mA output signal)
White wire (Calibration / digital interface)

Approvals: CSA, CE

Rating: Class 1, Div 1, Groups B,C,D (-40C to 50C)

Humidity: 0-99% (Non-condensing)

Operating Temperature: 0-65° C

Operating Pressure: 1 PSIA - 55 PSIA

Installation Category: Cat. 1, Pollution Degree 2

Current Output		Status
4-20	mA	Normal measuring mode
0.0	mA	Unit Fault
0.2	mA	Reference channel fault
0.4	mA	Analytical channel fault
0.8	mA	Unit warm up
1.0	mA	Optics fault
1.2	mA	Zero drift fault
1.6	mA	Calibration fault
2.0	mA	Unit spanning
2.2	mA	Unit zeroing
4.0	mA	Zero gas level
5.6	mA	10% Full Scale
8.0	mA	25% Full Scale
12	mA	50% Full Scale
16	mA	75% Full Scale
20	mA	Full Scale
>20	mA	Over-range

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A Canon Communications LLC Publication

February 2001

MEDICAL DEVICE & DIAGNOSTIC INDUSTRY

THE MAGAZINE OF MEDICAL PRODUCT DESIGN, MANUFACTURING, AND MARKETING

http://www.devicelink.com/mddi

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MEDICAL ELECTRONICS

Current Design Trends

NEW: WEB SITE DIRECTORY, P. 102

Continuous Monitoring of EtO Concentrations during Sterilization

The ability to accurately monitor EtO levels throughout the sterilization process is expected to facilitate validation and result in more cost-efficient operation.

Patrick G. Smith

WIDELY USED FOR sterilizing medical equipment, as well as cosmetics, pharmaceuticals, and food products, ethylene oxide (EtO) has proved to be economical, available, and efficacious for eliminating bacterial and viral microbes. Pumped into a closed container, EtO can effectively eliminate microorganisms within an acceptable time frame.

Despite its effectiveness as a sterilant, however, EtO has a number of significant drawbacks. It is highly toxic—even a sniff can be fatal. EtO can also be dangerously explosive in concentrations as low as 3% by volume, or 30,000 ppm—a spark in the presence of just a trace of the gas can pose a serious hazard. And because EtO carries its own oxygen supply, it is also flammable at 100% concentrations. Put simply, it can explode even in anaerobic atmospheres.

PROCESS ELEMENTS THAT AFFECT STERILIZATION EFFECTIVENESS

The effectiveness of EtO sterilization systems is largely dependent on several factors, including gas concentration, diffusion rate, temperature, and humidity. Each of these process elements can either directly or indirectly influence the system's level of microbial lethality. Each factor must also be balanced against any limitations that may become apparent with the use of specific packaging or products that are to be sterilized with the system.

Gas Concentration. Generally, as EtO levels increase, the sterilization process becomes more effective and requires less dwell time. Concentrations in the chamber are limited by Ideal Gas Law parameters owing to potential condensation.

Diffusion. Another way to reduce dwell time is to increase the diffusion rate of EtO from the chamber to product in the load. This can be accomplished by creating a vacuum in the chamber before it is charged with EtO. As the EtO is injected into the chamber, pressure difference effectively "pulls" the EtO into the product. Another benefit of reduced pressure is increasing the concentration at which condensation occurs. This allows higher EtO concentrations during the cycle.

Because creating and maintaining a high vacuum can be difficult, time-consuming, and expensive, some chambers have been designed to operate with a partial vacuum or at normal air pressures. Using any vacuum, however, can result in certain product-related problems. Some products, for example, may be sensitive to any negative air pressure in the chamber.

Temperature. Because EtO liquefies at 51°F at STP (standard temperature and pressure), the temperature levels inside the sterilization chamber must be high enough to ensure that the EtO is a gas. Thus, product tolerance for high temperatures is another militating factor because chamber temperatures can range from 100° to 150°F, depending on the product to be sterilized. This will also affect sterilization times and efficiencies.

Humidity. The presence of humidity is believed to increase EtO penetration. Thus, maintaining a wet atmosphere in the sterilization chamber can increase the effectiveness of EtO sterilization. A relative humidity (RH) of 35–90% has been demonstrated to be beneficial for

CONTINUOUS EtO MONITORING OFFERS BENEFITS TO MEDICAL DEVICE STERILIZERS

The vital nature of accurate EtO monitoring is underscored by the many hazards associated with its handling. In a single four-year period, EtO was found to be involved in 10 explosions that occurred at sterilization facilities and EtO repackaging plants. All of the explosions caused building damage. In one instance a worker was killed and 59 injured as a result of the explosion. New sensing technologies are being developed to ensure the safe use of EtO.

Manufactured by Sensor Electronics Corp. (SEC; Minneapolis), the SEC EtO Signature infrared EtO monitor incorporates a sophisticated design for EtO measurement applications. According to SEC, the device seems fain to overcome the problems associated with conventional EtO monitoring systems. In extensive real-time real-world tests, the sensor has yielded excellent results, despite wildly varying applications, EtO levels, product parameters and chamber configurations, the company indicates.

The sensor is designed to be mounted non-intrusively through a .75-in. port in the wall of a chamber and/or circulation pipe to accurately measure the concentration of ethylene oxide during a sterilization cycle. The 18-oz sensor's innovative design has been shown to eliminate the effects of humidity and pressure. The device uses a directly opposed optical system, and requires no mirrors or reflecting surfaces. The optical chamber's surfaces are anodized aluminum, and are heated to counter the formation of condensation.

The SEC EtO Signature has been designed to measure the infrared light absorption of the EtO molecule. The IR light is measured at wavelengths absorbed by EtO, and compared to IR wavelengths not absorbed by EtO. The concentration of EtO is determined by calculating wavelength ratios and using embedded linearization/compensation algorithms to develop an accurate output signal, the company explains.

The sensor monitors actual EtO levels inside the chamber, giving a second-by-second assessment of the sterilization process. Because the EtO sensor is not affected by the presence of condensation, readings better than 95% accuracy can be achieved throughout the entire cycle, including charging, sterilization, and evacuation.

Compared with conventional systems, the sensor's proprietary infrared sensing technology has been found to offer a number of benefits."Traditional methods of monitoring EtO include scale weight of the EtO gas tanks used in the process and pressure displacement," says Art Harris, general manager of Chicago Sterilization Services Inc. (CSS; Chicago), which uses the new sensor technology in its sterilization process.

Harris adds, "With this sensor, we have identified visual data that allows us to monitor the rate at which EtO is accepted into the product. A second advantage of having this sensor allows real-time monitoring of the EtO concentration through the entire cycle, allowing us to verify that our cycles provide for a sufficient number of dilute washes after EtO exposure to avoid an EtO rich environment prior to back vent operation." Harris is a member of the Association for the Advancement of Medical Instrumentation (AAMI), a committee member of AAMI's industrial EtO sterilization working group, and a principal contributor to NIOSH *Alerts* on EtO safety.

According to Adam Graham, CSS assistant general manager, "From a quality viewpoint, the reliability and consistency of the sensor and its data has made us more confident about validating our customer's products for parametric release (releasing sterilized product solely on the process parameters rather than biological indicators)."

Graham explains that the availability of a sensor capable of continuously monitoring EtO levels offers certain benefits to device sterilizers. "This sensor has allowed us to effectively monitor our EtO input into each sterilization cycle and we can determine the actual percentage of gas concentration used in each run. An advantage to utilizing this sensor is having concrete evidence of gas usage to incorporate in sterilization process improvement activities."

According to Harris, "I am especially pleased with the consistency of the data and the performance of the sensor. As we ran each test cycle, the output of the sensor data has assured us that it will provide us with accurate repeatability." He adds that, "It is foreseeable that the savings gained from the sensor as we pursue parametric releasing will pay for itself in no time."

effective EtO sterilization. Water vapor, usually steam, is injected before EtO to shorten the time required to complete the sterilization process. The presence of increased humidity, however, can cause the formation of condensation on the product, the chamber walls, and optical EtO sensors.

All these variables—as well as such other factors as product shape and absorption—have made monitoring and controlling the sterilization process imprecise at best. As a result, it has become common for EtO users to add extra time, extra heat, and extra EtO to the process cycle to ensure that satisfactory results are achieved.

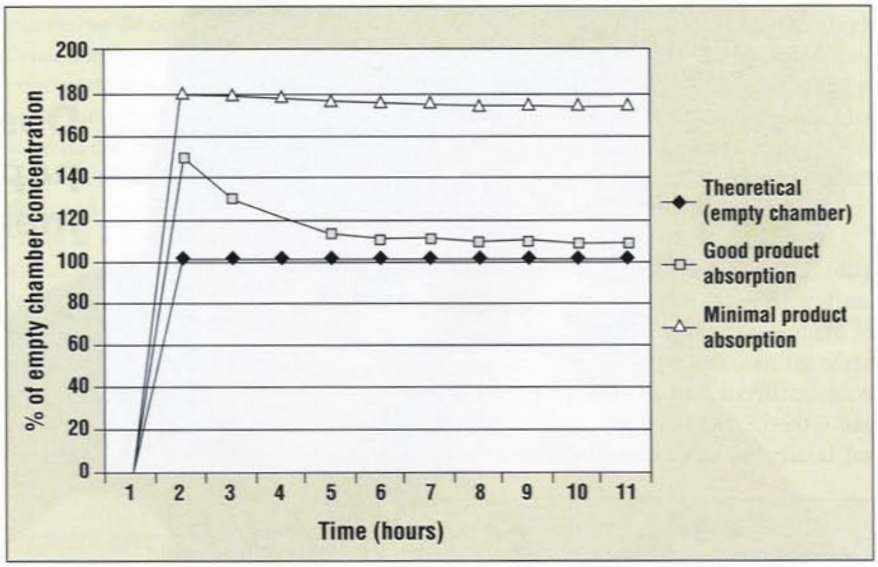

Figure 1. In-chamber EtO concentration as a function of product absorption qualities.

LIMITATIONS TO CONVENTIONAL ETHYLENE OXIDE MONITORING

Because there has been no precise method of measuring the actual proportion of EtO in the chamber, control of the sterilization process often has been more a function of experience than of instrumentation. Although systems capable of generating fairly accurate EtO measurements have been developed, a number of shortcomings have been associated with the use of these EtO sensors. Currently available EtO-sensing systems include:

Near Infrared (IR) Optical Devices. Although EtO absorbs very well in the near IR, so does water, which in vapor form or condensed, typically causes inaccuracies and sometimes erratic signal variations in these systems.

Electrochemical/Solid-State Sensing Cells. Such systems are effective and accurate in an ambient sensing environment; however, they exhibit water response, pressure response, and high drift and short life owing to the in-chamber environment.

Sample-Draw IR Devices. These systems provide accurate results because they measure samples in a controlled external environment. In addition to being costly and complex, they pull toxic and explosive EtO-drenched atmospheres out of the chamber. Leaks into the room are potentially disastrous.

The challenge has been to develop a system that can measure an elusive and ever-changing EtO ratio yet is impervious to the deleterious effects of steam, condensation, varying vacuum or pressure levels, and highly corrosive atmospheres. Ideally, the sensor would be capable of quantifying actual EtO levels throughout the entire sterilization cycle. the device should also be able to monitor and verify gas concentrations, show absorption profiles for the specific product being sterilized, and ensure that all toxic gases have been evacuated before the chamber doors are opened.

CONTINUOUS MONITORING OF ETO CONCENTRATIONS

The proportion of EtO at work in a sterilization chamber varies with time and the specific material to be sterilized. Theoretical chamber concentrations are calculated using gas weights, the assumption of an empty chamber, and the application of the Ideal Gas Law. The concentration of EtO that actually reaches the product in the load is generally a function of the load's absorptive properties and the packaging used. If the material does not absorb EtO—as in the case of metallic medical instruments—the initial inrush of EtO causes an immediate peak and the concentration remains high for the duration of the process.

Figure 1 demonstrates the changes that occur in EtO concentration levels as a function of product absorption. If the material is absorbent—as in the case of cloth garments or bandages—the EtO percentage peaks, then drops back as the gas is absorbed. The level finally equilibrates at a concentration that is usually

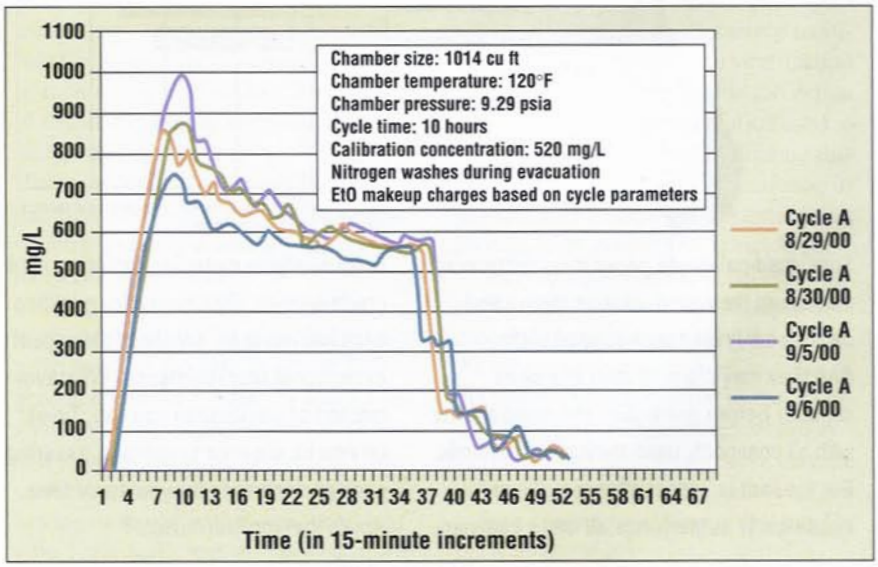

Figure 2. Actual EtO concentration versus time for same-cycle and different loads.

multiwavelength IR light–based sensor is designed to continuously measure the hydrogen-carbon bond IR light absorption of EtO molecules during the sterilization process.

"SEEING" INFRARED ABSORPTION

Like certain conventional sensors, the new design uses IR absorption technology to precisely define and measure EtO levels throughout the sterilization operating cycle. The sensor, however, has been designed to remain unaffected by saturated RH levels and resulting condensation on the sensor viewing lens. Figures 2 and 3 illustrate in-chamber EtO concentration as measured by the sensor. Figure 2 shows the results of monitoring for loads composed of different materials; Figure 3 indicates the device's sensing accuracy by comparing three empty chamber runs in order to verify the calibration point.

The sensor has been designed to remain unaffected by saturated RH levels.

The detector uses IR levels to quantify the actual EtO concentration in the sterilizer chamber. The proprietary method uses principles founded in molecular physics. IR radiation at specific wavelengths excites certain molecular resonances. In the process, some IR energy (considered as light) is absorbed, with the amount of absorption being a function of the concentration, as illustrated in the equation:

$$I = I_0 e^{-acl}$$

where:

- I = amount of light after absorption.
- I_0 = amount of light before absorption.
- a = coefficient of EtO absorption.
- c = gas concentration.
- l = length of light path.

The gas concentration can thus be solved with the equation:

$$c = -1n(I/I_0)/al$$

Because spectral absorption is a function of a gas's molecular structure, it follows that every gas has its own spectral signature. When the sensor has been fine tuned to "see" the wavelengths absorbed by EtO and compare them with wavelengths that are not absorbed by EtO, it has been found capable of measuring actual EtO concentrations in sterilization chambers with virtually complete fidelity.

VAPORIZING CONDENSATION PROBLEMS

Although the new EtO sensor design was based on a technology that offers specific advantages in terms of precision, certain practical problems remained to be overcome—for example, response to water vapor and condensation on the sensor's optical surfaces. RH levels can vary significantly, from near 0 to 100%, during a sterilization cycle depending on product absorption characteristics among other factors.

Ensuring a negligible sensor response to water vapor is critical to maintaining accurate control throughout the cycle, as well as from cycle to cycle. One method for handling the moisture problem is with the use of an RH sensor along with the EtO sensor. The EtO reading can then be adjusted based on the RH intercept. Such an approach is generally cumbersome and can increase the possibility of intrinsic error by a factor of two at the minimum—and often more—because each reading of EtO and RH is subject to drift. Adding a second sensor also multiplies complexity and cost.

By monitoring frequencies that are not affected by the presence of water vapor, the sensor achieves greater immunity to the presence of vapor within the chamber. This is akin to camera haze filters that enable photographic film to "see" through mist and rain, even though the viewer's own vision is obscured.

In addition, if liquid is present on the optical surfaces, it can absorb and distort light, which can cause sensing inaccuracies. For additional EtO fidelity, the optical surfaces of the sensor are heated to eliminate condensation regardless of chamber dew point temperatures.

Aside from water condensation, ethylene glycol condensation can pose another problem in sterilization chambers.

During operating cycles, EtO and H_2O combine to form ethylene glycol, which condenses on every surface within the chamber, including those of the sensor's optical components. Heating those surfaces, however, can literally vaporize the problem. Because the sensor is not affected by condensation, readings have been found to exceed 95% accuracy throughout the process cycle, including during charging, and evacuation.

Ensuring a negligible sensor response to water vapor is critical to maintaining accurate control.

CONCLUSION

A new device has been designed specifically for accurate nonintrusive continuous in-chamber EtO monitoring. The design is intended to address specific pitfalls that have been associated with conventional EtO sensing technology. In addition to its negligible response to water, nitrogen, pressure changes, and temperature changes, the device offers such features as a miniature probe–style package that requires only a tapered threaded hole for mounting, a lack of moving parts or consumable parts that require replacement, and a heater that minimizes the presence of condensation and ethylene glycol.

Long-term testing in many different types of sterilization chambers employing a variety of cycle characteristics has proved the accuracy and reliability of the new approach.

Patrick G. Smith is vice president of engineering and director of research and development at Sensor Electronics Corp. (Minneapolis). ■

A hypertext version of this article will be available on Medical Device Link, http://www.devicelink.com/mddi, by March 1.

Subject: SEC Signature ETO Monitor Product Qualification

General Background
Sensor Electronics Corporation (SEC) has been manufacturing the SEC Signature ETO Monitor since the year 2000. SEC received a U.S. Patent on the sensing technology used in the SEC Signature. The SEC Signature has been installed on various types of ethylene oxide sterilizers. The SEC Signature has been tested and installed on 100% ETO chambers, ETO/Freon blends and ETO/CO2 blended sterilant gases. The SEC Signature is tuned to measure the ethylene oxide hydrocarbon molecule; therefore blended mixtures of ethylene oxide do not cause incorrect readings of ethylene oxide concentrations. The SEC Signature has been installed on sterilization chambers ranging in size from 3M 7XL up to 28 pallets.

Test Data
SEC with the cooperation of end users have verified the SEC Signature's response specifically to ethylene oxide as compared to Ideal Gas Law and Gas Weight calculations under actual chamber operating conditions. Empirical data and reports support the SEC Signature ETO Monitor's specification for accuracy, linearity and repeatability to ethylene oxide in actual chamber conditions.

Manufacturing
Calibration records are issued to the customer and a copy is filed at Sensor Electronics for each device. The SEC Signature is manufactured to production procedures that can be reviewed with our customers at our facility. Each device is temperature cycled numerous times and calibrated with NIST certified calibration gas prior shipment. Our manufacturing facility is audited quarterly by Underwriters Laboratory Canada (ULC) and Canadian Standards Association (CSA). Sensor Electronics is open to customer inspections of our facility.

Signed,

Alan Petersen Jr.
VP Sensor Electronics Corporation
Date: September 5, 2002

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Application Note: 110404 Rev.1

SEC Signature Cleaning and Filter Maintenance in EtO Sterilizer Applications

Optical surface contamination can occur over time because of the accumulation of dust, oil…etc carried by the load. The SEC Signature is designed to compensate for optical contamination, however regular calibrations and cleanings are recommended to ensure accurate and reliable sensing.

Contamination Effects on Unit Performance

Slight:	Negligible effect
Moderate:	Can cause calibration point shift. Recalibrating the device will restore accuracy.
Heavy:	If buildup becomes significant, the output signal can become "jumpy". The Signature will activate "Optics Fault" if optical obscuration becomes a problem.

Recommended Maintenance

Maintenance intervals are highly a function of cycle/load characteristics. Dusty oily dirty loads and very wet cycles may cause the SEC Signature to require more frequent cleaning.
Any time a large volume of oil or other contaminant has entered the chamber during a cycle, the SEC Signature should be removed, filters changed, and optics cleaned. (Any time the SEC Signature is removed and re-mounted a Zero Calibration should be performed)

Filter(s) replacement: Every six months (two stage filtering system)
Optics Cleaning: Every Year
Return unit to factory for cleaning, calibrating and O ring replacement: Every two years.

Replacement Part Numbers:
SEC Signature EtO Monitor 1420597
Hydrophobic Fiberglass Cloth Filter (beige color) 1420852
Teflon Filter (white) 1420701

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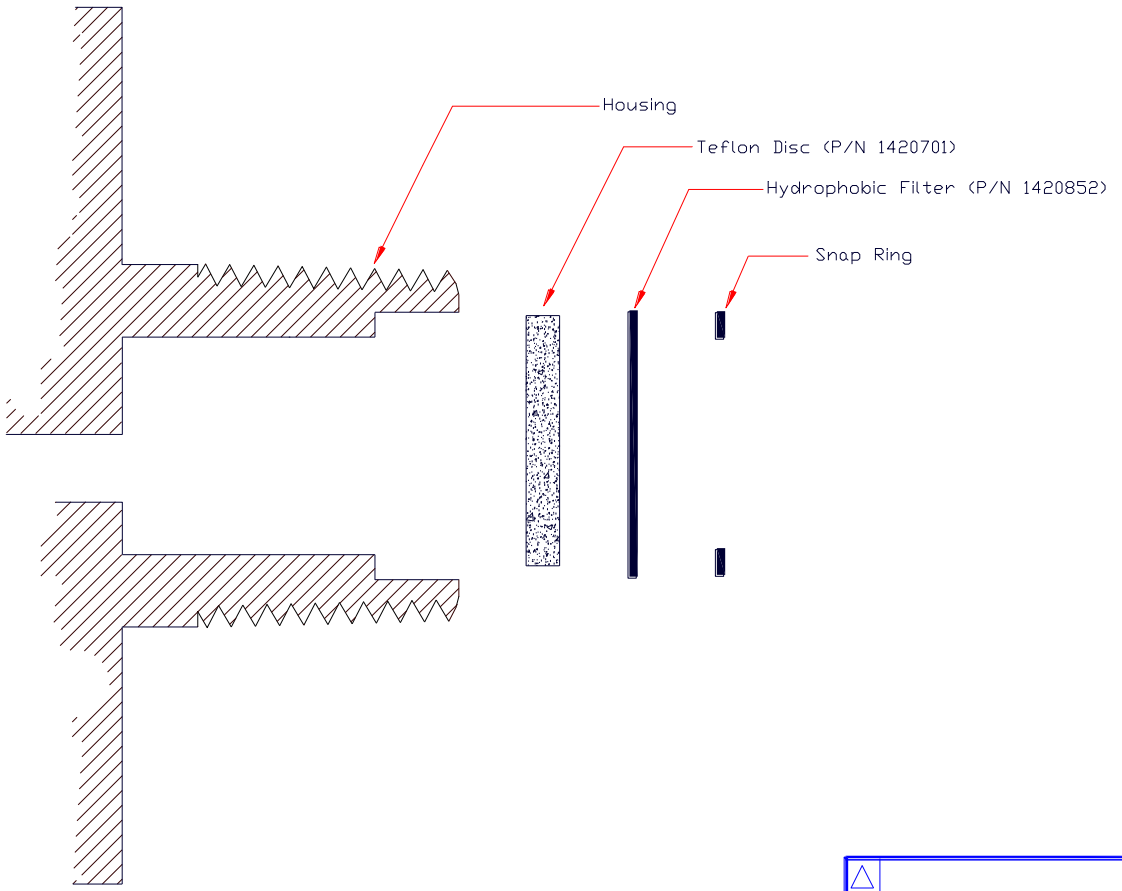

1) DROP TEFLON DISC ONTO LEDGE IN HOUSING
2) PUT EXISTING FILTER ON TOP OF DISC
3) INSTALL SNAP RING INTO BORE
4) PUSH SNAP RING IN, AGAINST FILTER/DISC.

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SENSOR ELECTRONICS CORPORATION

SENSOR ELECTRONICS CORP.
5500 LINCOLN DRIVE
MINNEAPOLIS, MINNESOTA
55436

SCALE: 2:1	DESIGN BY: PGS	REVISED BY:
DATE: 10/23/00	DRAWN BY: PGS	APPROVED BY:

INSTRUCTIONS, INSTALLATION, HYDROPHOBIC SYSTEM

SIZE:	DRAWING NO.	REVISION:
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SEC Signature EtO Linearization Data

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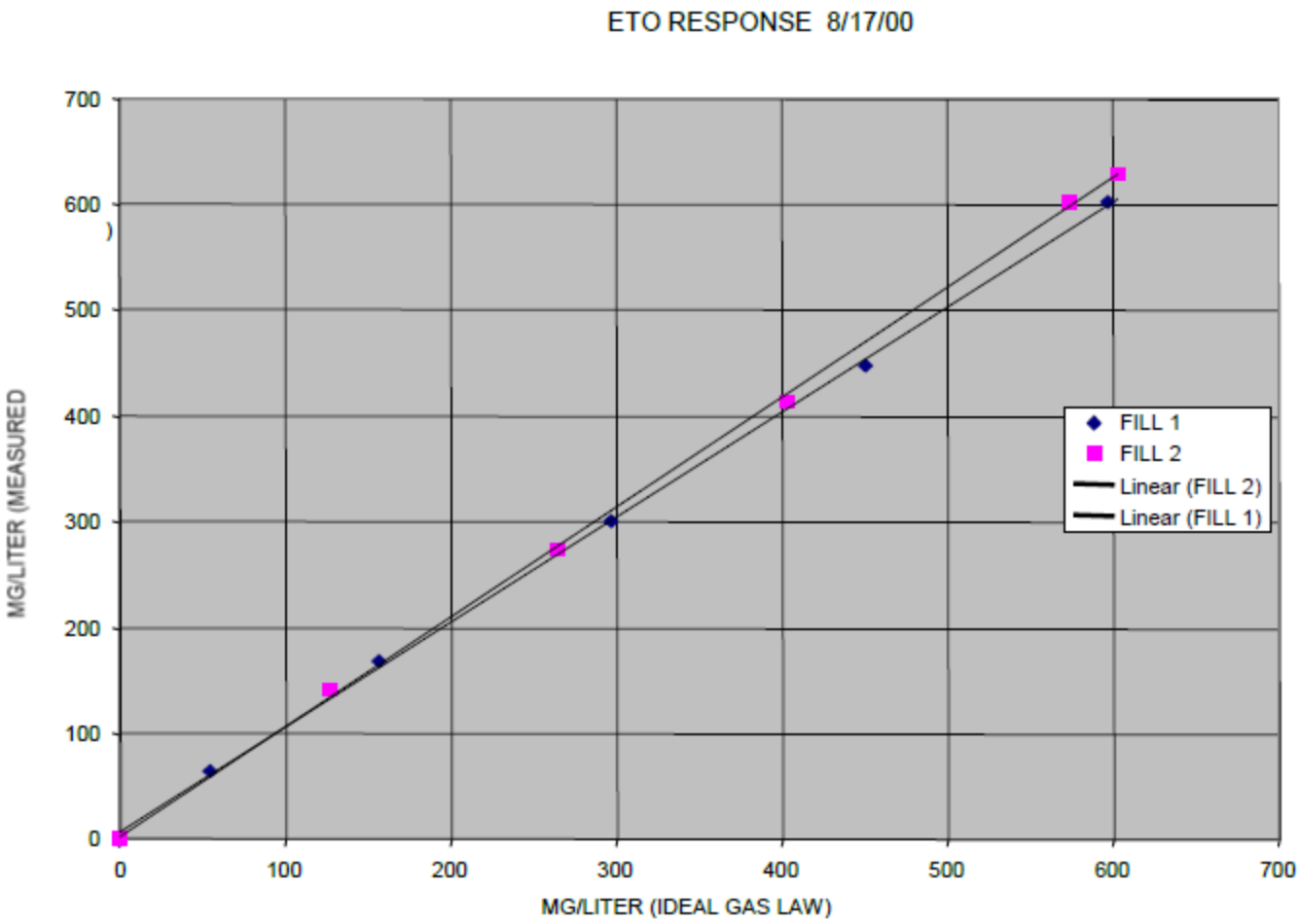
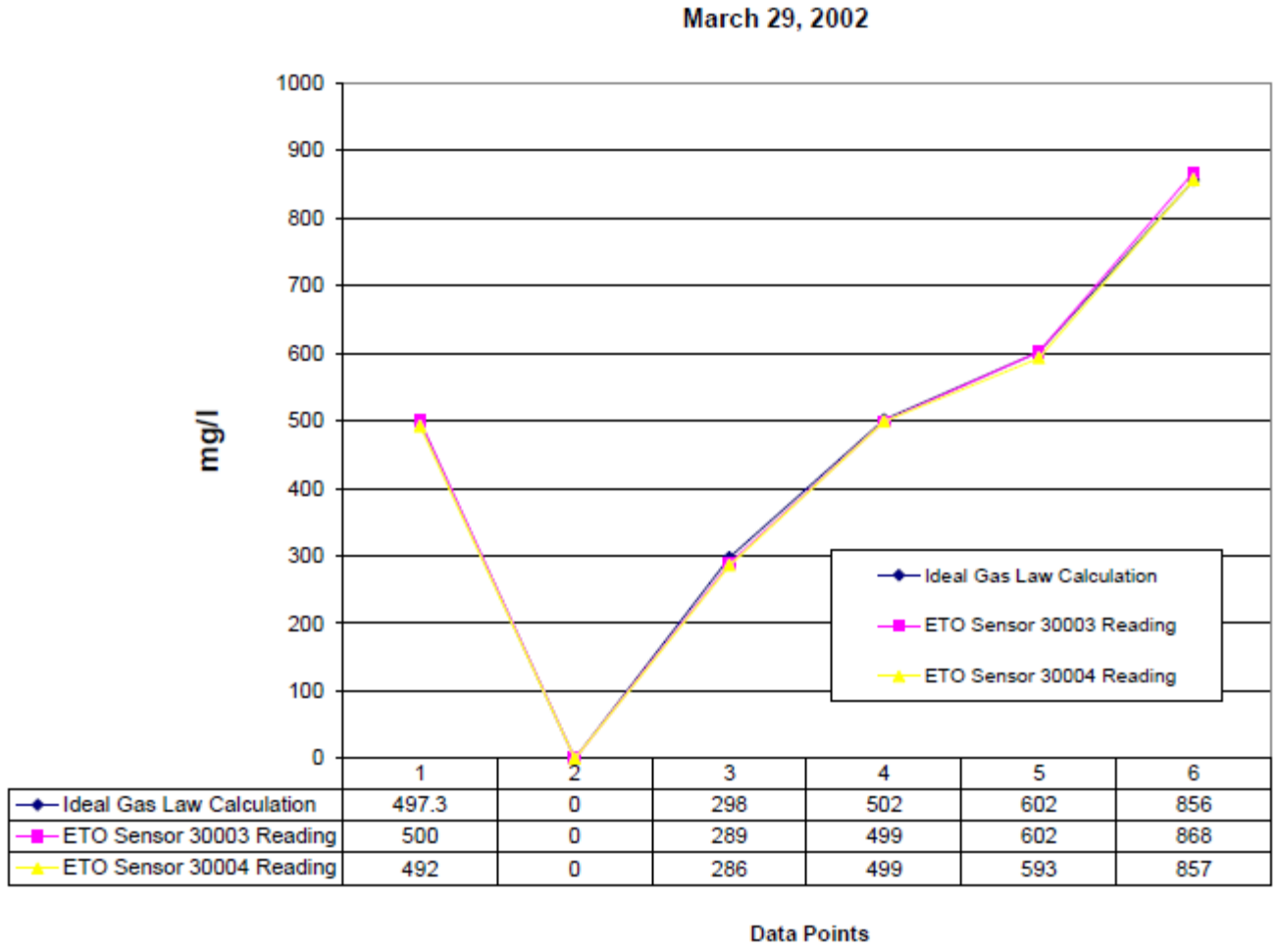
Minneapolis, Minnesota 55436

One Sensor On Two Separate Empty Chamber Runs



Two Sensors On The Same Chamber



	1	2	3	4	5	6
Ideal Gas Law Calculation	497.3	0	298	502	602	856
ETO Sensor 30003 Reading	500	0	289	499	602	868
ETO Sensor 30004 Reading	492	0	286	499	593	857

In Chamber H2O Condensation Considerations

Steam enters the chamber at a temperature higher than the chamber temperature. As the steam temperature cools to the chamber temperature, the steam will condense to liquid water until saturation density is reached for that temperature. The condensation usually occurs on chamber surfaces since they are cooler than the steam/gas mix in the chamber. Condensation on the optical surfaces of the sensor distorts the light and usually causes an erratic output. The signals can be positive, negative or cycle positive and negative. This is why the sensor must be operated at a temperature elevated above chamber temperature.

There are two types of condensation:
1) Flash…This is where a large volume of steam is introduced very rapidly. A film of liquid water is deposited on virtually every surface in the chamber. The water evaporates off warmer surfaces, such as the optical surfaces, fairly quickly.
2) Hard…This is where the surface is running cooler than the chamber temp. These cool surfaces attract liquid water and tend to hold it for an extended time.

Factors:
Injecting steam upstream from the sensor will cause more condensation in the sensor. Steam will tend to condense on the first cool surfaces it encounters. Injecting steam downstream from the sensor gives the steam mores surfaces and more opportunity to condense before encountering the sensor.

If the recirculation line is cooler than the chamber two things can happen.
Water density is lowered in the recirculation line as water condenses on the cooler surfaces. This lowers the H2O readings on the SEC Signature DIR and generates liquid water in the line which can enter the sensor's optical chamber and cause erratic outputs. The sensor employs hydrophobic filters but liquid water and significant pressure change can over whelm the filters.

A cool recirculation pipe can conduct heat away from the sensor making it more difficult to maintain a temperature rise in the sensor.

Over the years we have seem may issues with water condensing on the optical surfaces of the SEC Signature. To reduce or eliminate the water issue the user must verify that the SEC Signature's temperature is 5 degrees C warmer than every step in every cycle. In some cases an external heat source is necessary to achieve the necessary heat rise.

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April 23, 2013

SEC Signature Accuracy – 100% Ethylene Oxide or Ethylene Oxide Blended Gas

The SEC Signature and SEC Signature DIR gas analyzers are designed to monitor hydrocarbon (and water vapor in the DIR) gas molecules utilizing Mid IR Optical Sensing[1]

During the initial design, research and development of these products, Sensor Electronics worked with many sterilization companies testing and developing response, accuracy, repeatability and linearization specifically to ethylene oxide. The sensor are currently installed on sterilization chambers with 100% EtO sterilant gas, EtO/CO2 blended and Oxifume EtO sterilizing gas.

The SEC Signature EtO channel only responds to ethylene oxide gas vapor therefore the stated accuracy on our data sheets can be applied to any type of ethylene oxide sterilizing gas, 100% or blended.

The SEC Signature ethylene oxide sensor uses Mid Infrared optical absorption to detect and quantify methane density. The absorption is based on quantum molecular resonances. Each type of molecule will absorb light at particular wavelengths based on its construction. A C-H bond will absorb light differently than a C-O bond.
We measure ethylene oxide at 3-4um…CO2 absorbs at 4.2um…H2O has minimal absorption in the 3-4um area. Most of the water response is cancelled by our reference filter. The result is a methane sensor with very minimal affects from CO2 and H2O.

Alan H. Petersen, Jr.
President
Sensor Electronics Corporation

[1]Mid IR Optical Sensing
Some gas molecules with a dipole moment can be excited to higher energy states by Mid Infrared photons. (Wavelength=3-8um). These are fundamental inter-molecular motions. Atoms in the molecule move with respect to each other. These are quantum energy levels and the energy contained in the photon must match the energy required to excite that particular motion in that molecule. As the molecule is excited the photon is gone. Longer and shorter wavelength photons pass right through without effect. The molecule will stay excited until it loses the energy by emitting a photon or transferring the energy to another molecule.
An optical system can be constructed where a broadband infrared optical source is illuminating photo detectors sensitive to certain wavelength bands. If the target gas (analyte) is present between the source and detector, light will be absorbed in certain bands and not others. By measuring relative absorption, we can identify and quantify the analyte gas.

The optical absorption is approximated by the following expression:

$I = I_o e^{-(acl)}$

Where I = amount of light after absorption
I_o = amount of light before absorption
a = coefficient of absorption
c = gas concentration
l = length of light path

Solving for gas concentration

$c = -(\ln(I/I_o))/al$

Since the amount of absorption is a function of the number of analyte molecules in the optical path, the concentration is expressed as density (typically mg/l).

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SEC *Signature*
Process Gas Analyzer

Instruction and Operation Manual

Sensor Electronics Corporation
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Savage, Minnesota 55378 USA
(952) 938-9486 Fax (952) 938-9617
email sales@sensorelectronics.com or www.sensorelectronics.com

Part Number 71-3000 Rev 4

Sensor Electronics Corporation

Sensor Electronics Corporation (SEC) is an innovative manufacturer of fixed system gas detection equipment, for combustible gases, oxygen and toxic gases.

Commitment

Our quality and service are uncompromising. We back each of our products with a two-year warranty on all materials and workmanship. We offer technical support, user training and on-site service and maintenance of equipment to meet the needs of our customers.

Gas Detection Service

Individually designed maintenance packages are available for specific customer needs. Service begins with verification of the system installation that includes an initial system check and calibration. We then offer customer training programs (on-site and at factory) to insure that technical personnel fully understand operation and maintenance procedures. When on-the-spot assistance is required, service representatives are available to handle any questions or problems immediately.

Warranty

Sensor Electronics Corporation (SEC) warrants products manufactured by SEC to be free from defects in workmanship and materials for a period of two (2) years from date of shipment from the factory. Any parts returned freight pre-paid to the factory and found defective within the warranty would be repaired or replaced, at SEC's option. SEC will return repaired or replaced equipment pre-paid lowest cost freight. This warranty does not apply to items, which by their nature are subject to deterioration or consumption in normal service. Such items may include:
Fuses and Batteries.
Warranty is voided by abuse including rough handling, mechanical damage, alteration or repair. This warranty covers the full extent of SEC liability and SEC is not responsible for removal, replacement costs, local repair costs, transportation costs or contingent expenses incurred without prior written approval. Sensor Electronics Corporation's obligation under this warranty shall be limited to repair or replacement of any product that has been returned to Sensor Electronics Corporation for warranty consideration. This warranty is expressly in lieu of any and all other warranties expressed or implied, and all other obligations or liabilities on the part of Sensor Electronics Corporation including but not limited to, the fitness for a particular purpose. In no event shall Sensor Electronics Corporation be liable for direct, incidental, or consequential loss or damage of any kind connected with the use of it's products or failure to function or operate properly.

Year 2000 Compliance

All Sensor Electronics products have been tested and are certified by Sensor Electronics to accurately process date/time and date/time related data from, into and between the 20^{th} and 21^{st} centuries. Sensor Electronics products neither contain nor create any logical or mathematical inconsistency, will not malfunction, and will not cease to function when processing date/time data.
Please contact Sensor Electronics for further information.

Table of Contents

I. SPECIFICATIONS

Model: SEC Signature Process Gas Analyzer
CO2 P/N 142-0848
Hydrocarbon P/N 142-1014
Ethylene Oxide P/N 142-0597

Range (adjustable)
CO2 0-100%Vol Max.
Hydrocarbon 0-100%Vol Max.
Ethylene Oxide 0-2000mg/liter Max.

Detection Method: Infrared Optical**/** Diffusion

Construction: Housing is anodized aluminum with sapphire windows.

Rating: Class 1, Division 1, Groups B, C and D,
CSA (Canadian Standards Association)

RFI/EMI Protection: EN-50081-1
EN-50082-1

Accuracy: +/- 5% measured value or +/- 3% full scale (whichever greater)

Repeatability: +/- 3%

Operating Temperature Rating:
-40° to +70°C at 0 to 99% RH (non-condensing)

Operating Pressure: 1PSIA – 55PSIA

Altitude: 0 - 2000 Meters

Operating Voltage: 24 VDC ⎓ Operating range 18 to 32 VDC measured at the detector head.

Output (analog): 4-20 mA (Non-isolated, sourcing), 1000 Ohm load (Max.) at 24 VDC supply voltage.

Output (digital): Interactive PC Link

Average Power Consumption at 24 VDC: 6 watts

Current Draw at 24 VDC: 250 mA (average)
450 mA (peak)

Mechanical connection: ¾" NPT male

Electrical connection: ¾" NPT male

Weight: 18 ounces

Wire Connections: Red wire (+ 24 VDC) ⎓
Black wire (D.C. common)
Blue wire (4-20 mA output signal)
White wire (Calibration / digital interface)

Installation Category: Cat. I, Pollution Degree 2

Approvals: CSA/NRTL Class 1, Div 1, Groups B,C,&D (-40C to 50C)

Declaration of Conformity

Sensor Electronics Corporation
5500 Lincoln Drive
Minneapolis, Minnesota 55436 USA
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Fax: 952.938.9617
Email: sensor@minn.net

Type of Equipment: SEC Signature Process Analyzer
SEC IR PC Link

Model Number: SEC Signature Process Analyzer - Part Number 142-0597
SEC IR PC Link - Part Number 142-0636

I hereby declare that the equipment specified above conforms to the protection requirements of the **EC DIRECTIVE 89/336/EEC** on Electromagnetic Compatibility (EMC), in accordance with the provisions of the Electromagnetic Compatibility Regulations 1992.

The following standards have been applied:

EN 50081 –1
Emissions Standard (Residential Commercial and Light Industry)

EN 50082 –1
Immunity Standard (Residential Commercial and Light Industry)

Signature _____

Patrick G. Smith
Director of Engineering

Date: August 6, 2001

II. GENERAL DESCRIPTION

CONVENTIONS

The following conventions are used in this manual.

⚠ Warning Statement

⎓ VDC (DC Voltage)

The SEC Signature Process Analyzer is a microprocessor based intelligent device that continuously measures levels of gas in process applications.

The SEC Signature Process Analyzer is a stand-alone device providing a 4 to 20 mA signal corresponding to actual concentrations of the process gas being measured.

Features

- Requires minimal routine calibration to ensure proper operation.
- Continuous self-test automatically indicates a fault, with fail to safe operation.
- A multi-layered filtering system protects optics from dirt and water ingress.
- Straight optical path eliminates the need for mirrors, reflective surfaces or beam splitters thereby increasing the stability and reducing the maintenance of the device.
- Discourages condensation interference by internally heating optical chamber.
- Standard 4 to 20 mA output (current sourcing).
- Explosion proof housing designed for duty in harsh environments.
- Smart Calibration AutoAC™ circuit.
- No routine maintenance required

Theory of Operation

The SEC Signature Process Analyzer uses infrared absorption technology to identify and measure gas concentrations. Gases absorb infrared light at certain wavelengths due to molecular resonance. Since each gas has a unique molecular structure, each causes a unique light absorption signature. The Signature Process Analyzer measures light absorption at critical wavelengths and uses embedded algorithms to quantify the concentration. The SEC Signature Process Analyzer uses an infrared light source at one end of the optical path and an infrared light sensor at the opposite end. The reliable optical system and lack of delicate components such as beam splitters and mirrors make the Signature Process Analyzer very stable and robust in harsh process environments.

The SEC Signature Process Analyzer utilizes a unique Automatic Analog Control circuit, the AutoAC™ circuit (Patented). The AutoAC™ continuously makes adjustments to null out effects from temperature, component drift, dirty optics, interferents and aging. These adjustments are made according to algorithms derived from infrared gas absorption theory. The AutoAC™ circuit is continuously checking all unit operating parameters. If any parameter goes out of tolerance, the AutoAC™ circuit sets a fault code appropriate to the problem. The AutoAC™ circuit ensures that once the unit is spanned, it will remain accurate as long as the zero is accurate. Simply calibrate (span one time) the unit with a specific amount of gas and the device will accurately track
in-process gas concentrations. The only ongoing calibration that is necessary is an occasional zero.

III. INSTALLATION

Mechanical

The SEC Signature Process Analyzer has a ¾" male NPT threaded connector for installing the device on a process line. Ideally the device can be installed on the recirculation line of a chamber (see Figure 4). The device is vacuum tested at the factory to 1 inches of mercury absolute and pressure tested to 40 psi.

Electrical

The SEC Signature Process Analyzer has a ¾" male NPT threaded connector (with 4 wires) for mounting the detector to a junction box. SEC can provide a junction box for this purpose with terminals (see Figure 5).

A user-supplied junction box can also be used, providing it has the appropriate sized NPT conduit entries. This junction box must be suitable for use in the application and location in which it is being installed.

Wiring connections

Red wire:	18 to 32 VDC ⎓
Black wire:	DC negative (common)
Blue wire:	4 to 20 mA output
White wire:	Smart Calibration Wire (data wire)

Refer to Figures 2 and 3 for general wiring details.

Insulator

The SEC Signature Process Gas Analyzer's internal temperature should be at least 10º F warmer than the process temperature to discourage condensation on the optical surfaces. The Signature Process Gas Analyzer is internally heated but mounting the device to a cold surface can draw significant heat from the Signature Process Gas Analyzer.

The internal temperature of the Signature Process Gas Analyzer can be monitored using the SEC IR PC LINK software package.

Before insulator is installed

If the internal temperature is not 10º F above the process temperature, a simple insulator (SEC supplied) can be installed around the Signature Process Gas Analyzer to help retain heat.

Insulator installed

IV. CALIBRATION / OPERATION

Warning: The user shall be made aware that if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Zeroing

Zeroing the SEC Signature Process Analyzer is the only regular calibration (maintenance) operation normally required.

SEC Signature Process Analyzer zero calibration is initiated by connecting the calibration lead (white wire) to the negative lead (DC common) of the power supply for ten (10) seconds and releasing. Although this can be accomplished manually, installation of a switch is recommended. It is recommended that this switch be a momentary type switch to prevent it from inadvertently being left in the calibrate position. The zero calibration operation is initiated at the rising edge (releasing). The zero initiation can be verified at on the 4 to 20 mA output (2.2 mA)

Note: For best accuracy, the unit should be powered up for at least 30 minutes before any calibration operation.

Current Output and Corresponding Status Table

Current Output	Status.
0-20 mA	Normal measuring mode
0.0 mA	Unit Fault
0.2 mA	Reference channel fault
0.4 mA	Analytical channel fault
0.8 mA	Unit warm up
1.0 mA	Optics fault
1.2 mA	Zero drift fault
1.6 mA	Calibration fault
2.0 mA	Unit spanning
2.2 mA	Unit zeroing
4.0 mA	Zero gas level (0%LEL)
5.6 mA	(10%LEL)
8.0 mA	(25%LEL)
12 mA	(50%LEL)
16 mA	(75%LEL)
20 mA	Full scale (100% LEL)
20.1- 23 mA	Over-range (> 100% LEL)

The 4 to 20 mA output is a non-isolated current source.

Warm-up

When power is applied to the detector, it enters a one (1) minute warm-up mode in which time it performs diagnostic checks and allows the sensor to stabilize before beginning normal operation. The current output during this period is 0.8 milliamperes. At the end of the warm-up period with no faults present, the detector automatically enters the normal operating mode. If a fault is present after warm-up, the detector current output will indicate the fault (see chart above).

Normal

In the normal operating mode, the 4 to 20 mA signal levels correspond to the detected gas concentration. The device continuously performs self-diagnostics, checks for calibration requests and outputs operating status (see table).

Spanning

Spanning is only required to establish measurement range. The span point becomes the mid range point of the SEC Signature Process Analyzer. Each Signature Process Analyzer is factory spanned but a re-span can be done under actual process conditions if required.

Spanning the SEC Signature Process Analyzer in field by connecting the SEC Signature Process Analyzer to the SEC IR PC Link (P/N 142-0636) and a computer (provided by others) running the software (provided by SEC). The software is compatible with most versions of Microsoft® Windows® 95/98/2000. During the spanning routine, the current output of the SEC Signature Process Analyzer will go to 2.0 mA.

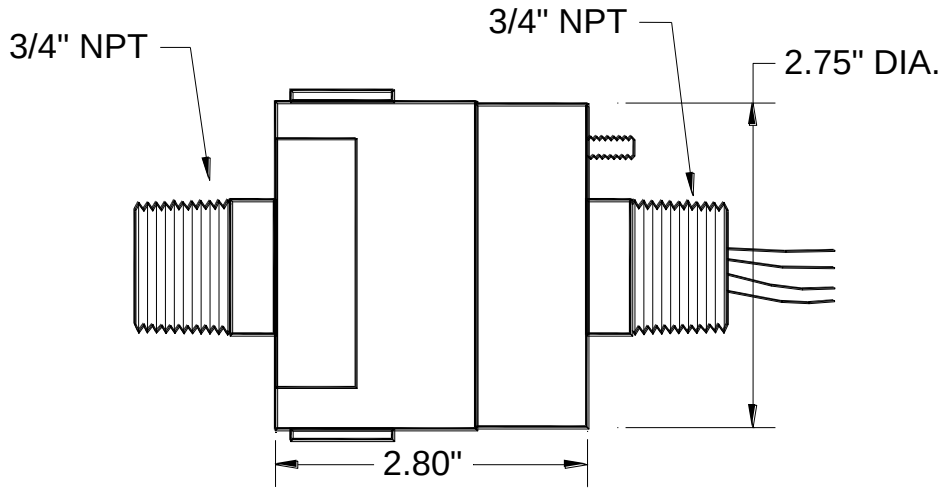
Note: For best accuracy, the unit should be powered up for at least 30 minutes before any calibration operation.

V. PARTS LIST

Part Number	Description
142-0636	SEC IR PC Link Kit
142-1022	Replacement Filter Kit
142-0876	Insulator
190-1000	SEC 2001 Explosion proof junction box

VI. DRAWING SECTION

Figure #	Title
Figure 1	Overall Layout
Figure 2	Wiring Diagram
Figure 3	Block Wiring Diagram
Figure 4	Mechanical Diagram
Figure 5	Sensor Separation Kit



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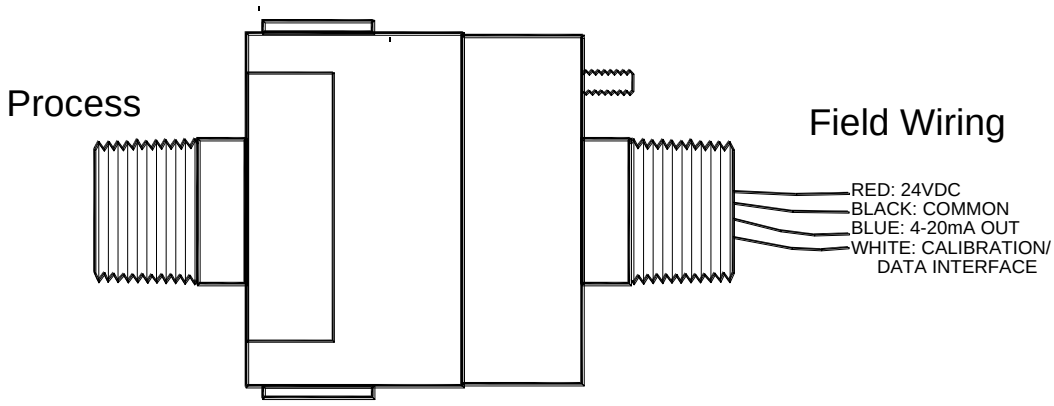
OVERALL LAYOUT
SEC Signature Process Analyzer

FIGURE 1



Field Wiring Connections:
Red wire (+ 24 VDC)
Black wire (D.C. common)
Blue wire (4-20 mA output signal)
White wire (Calibration / digital interface)

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WIRING DIAGRAM

SEC Signature Process Analyzer

FIGURE 2

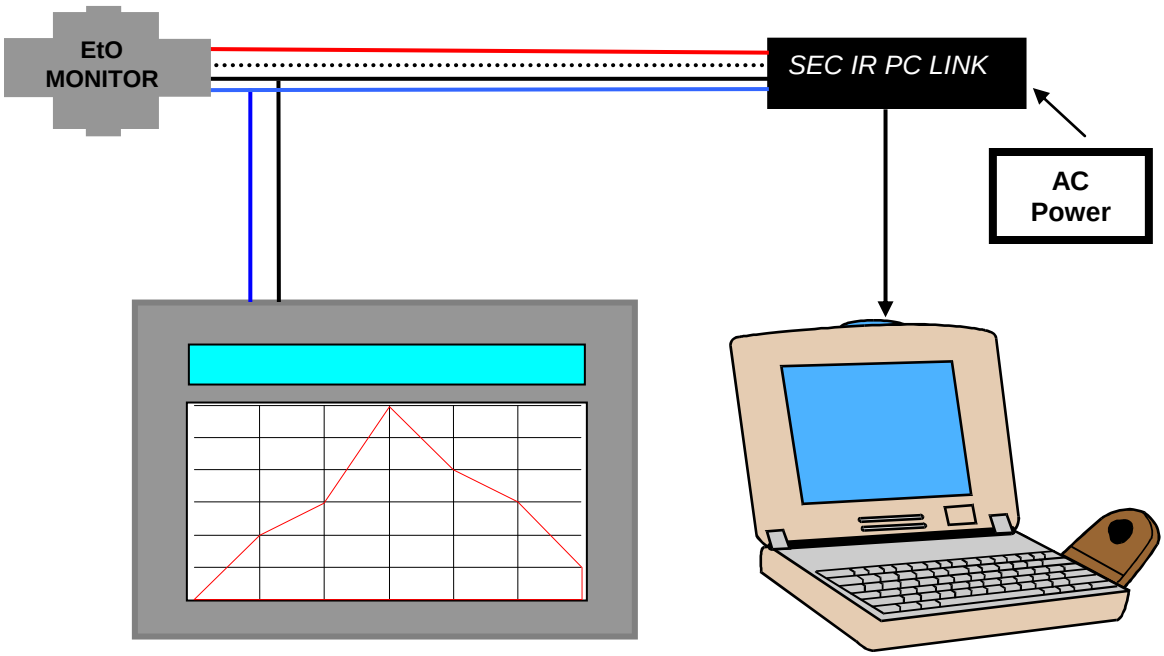

Chart Recorder
PLC, DAS, DCS, DVM
(Any control or monitoring system that accepts a 4-20 mA or 0-5 VDC signal)

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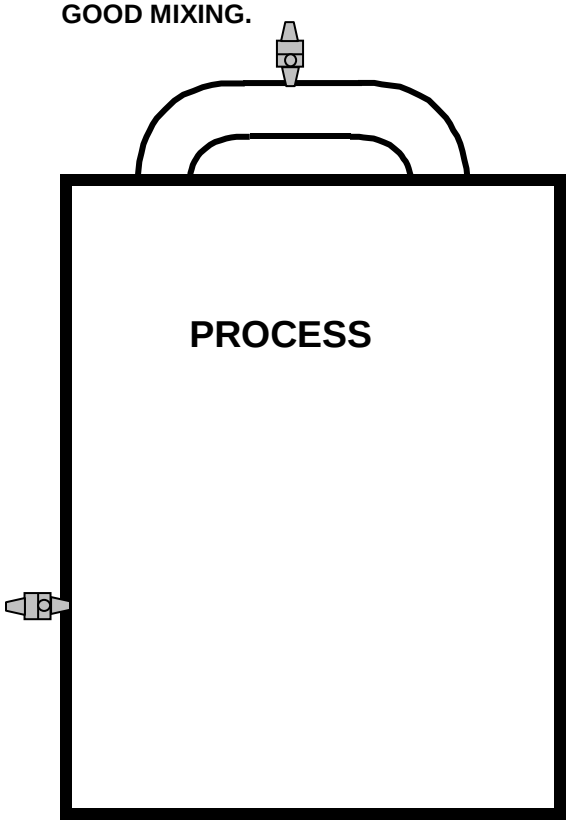
BLOCK WIRING DIAGRAM
SEC Signature Process Analyzer

FIGURE 3

RECIRCULATION SYSTEM OPTIMAL MOUNTING LOCATION. GAS FLOW ENSURES FAST RESPONSE AND GOOD MIXING.



VESSEL WALL GOOD LOCATION UNLESS IN STAGNANT AREA

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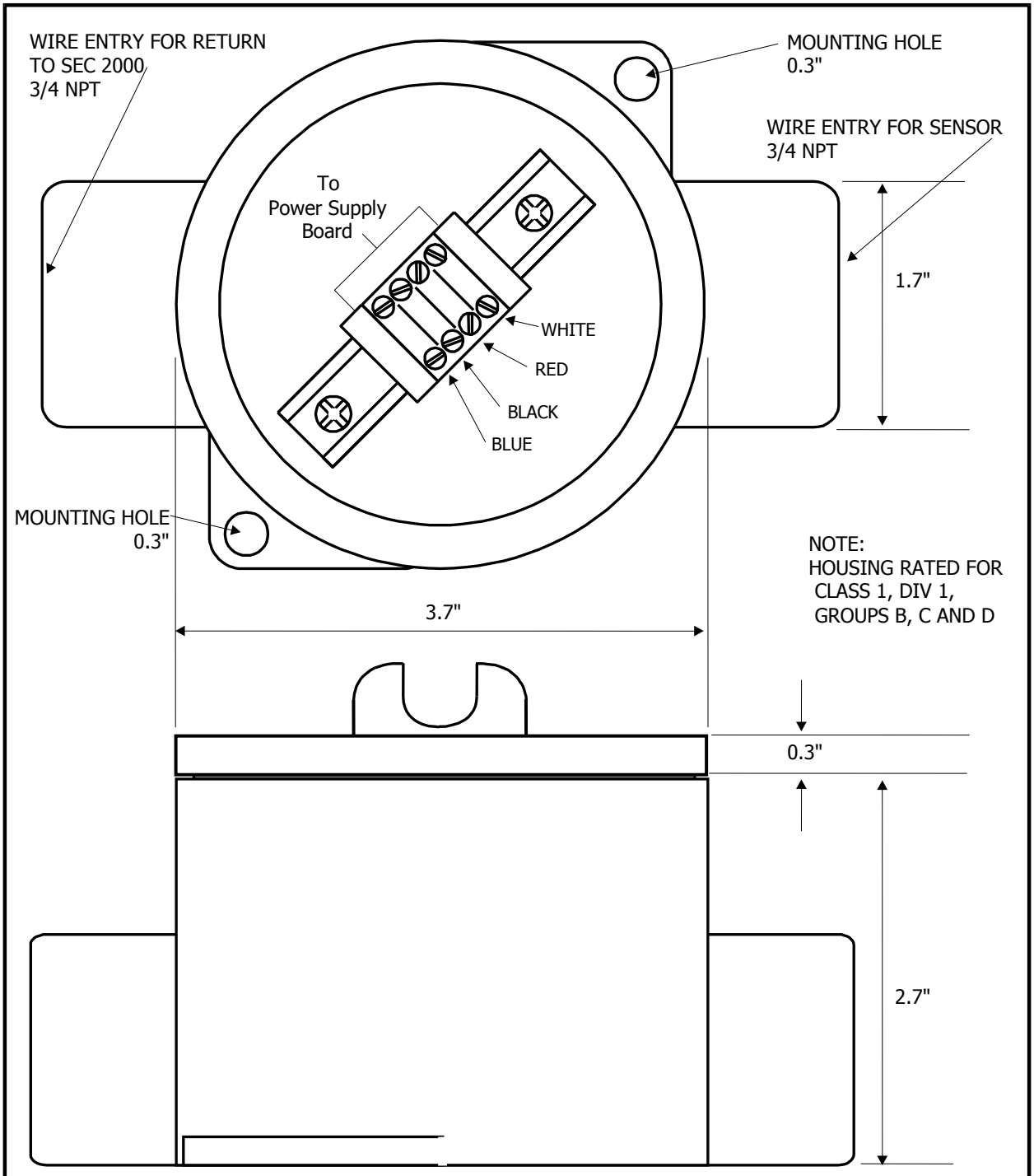
MECHANICAL DIAGRAM

FIGURE 4



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SEC SENSOR
SEPARATION KIT

FIGURE 5

SEC *Signature* EtO Monitor

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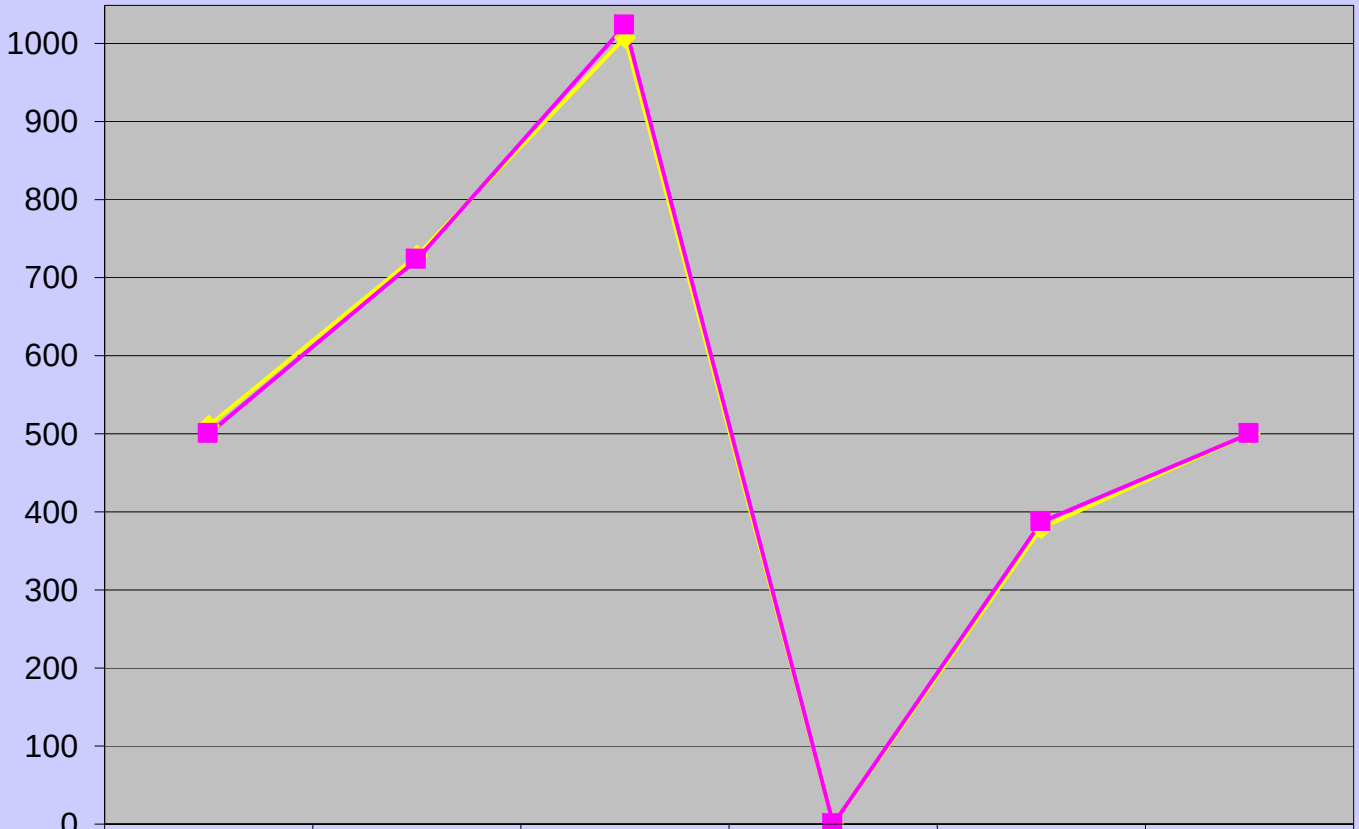
Accuracy

Graph - Span Cycle Empty Chamber

Graph - Ethylene Oxide Theoretical Values and Measured Values for a Soft Cycle

Span Cycle Empty Chamber

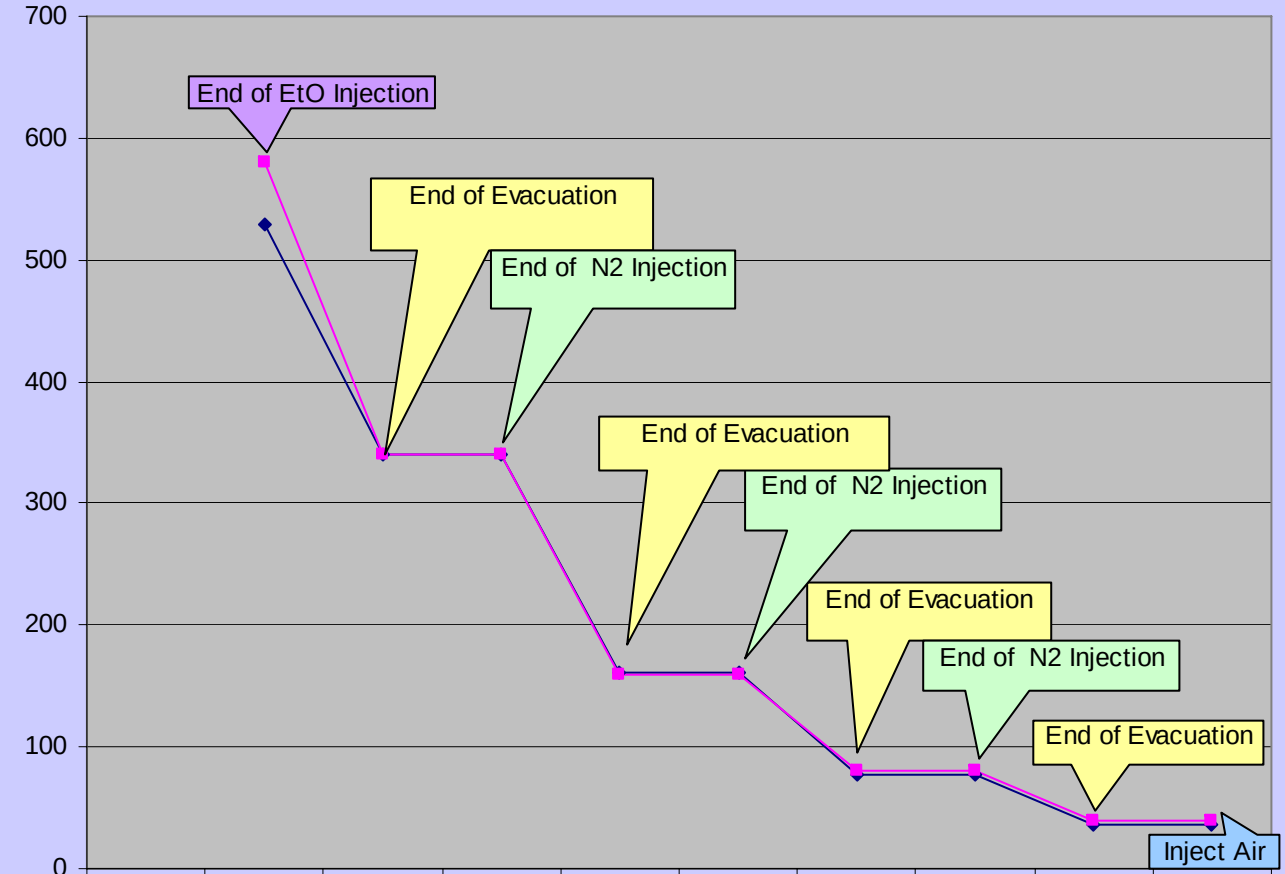


	1	2	3	4	5	6
Measured (mg/l)	510	730	1010	0	380	500
Theoretical (mg/l)	500	724	1024	0	386.9	500

- **Chamber Size: 1535 cubic feet**
- **Chamber Temperature: 120º F**
- **Chamber Pressure: 6.83 PSIA**

Ethylene Oxide Theoretical Values and Measured Values for a Soft Cycle

- **Chamber Size: 1014 cubic feet**
- **Chamber Temperature: 120º F**
- **Chamber Pressure: 9.29 PSIA**



	1	2	3	4	5	6	7	8	9	10
Theoretical Values Cycle A		529.2	340.4	340.2	161.3	161.3	76.5	76.5	36.2	36.2
Measured Values of a Production Cycle A		580	340	340	160	160	80	80	40	40

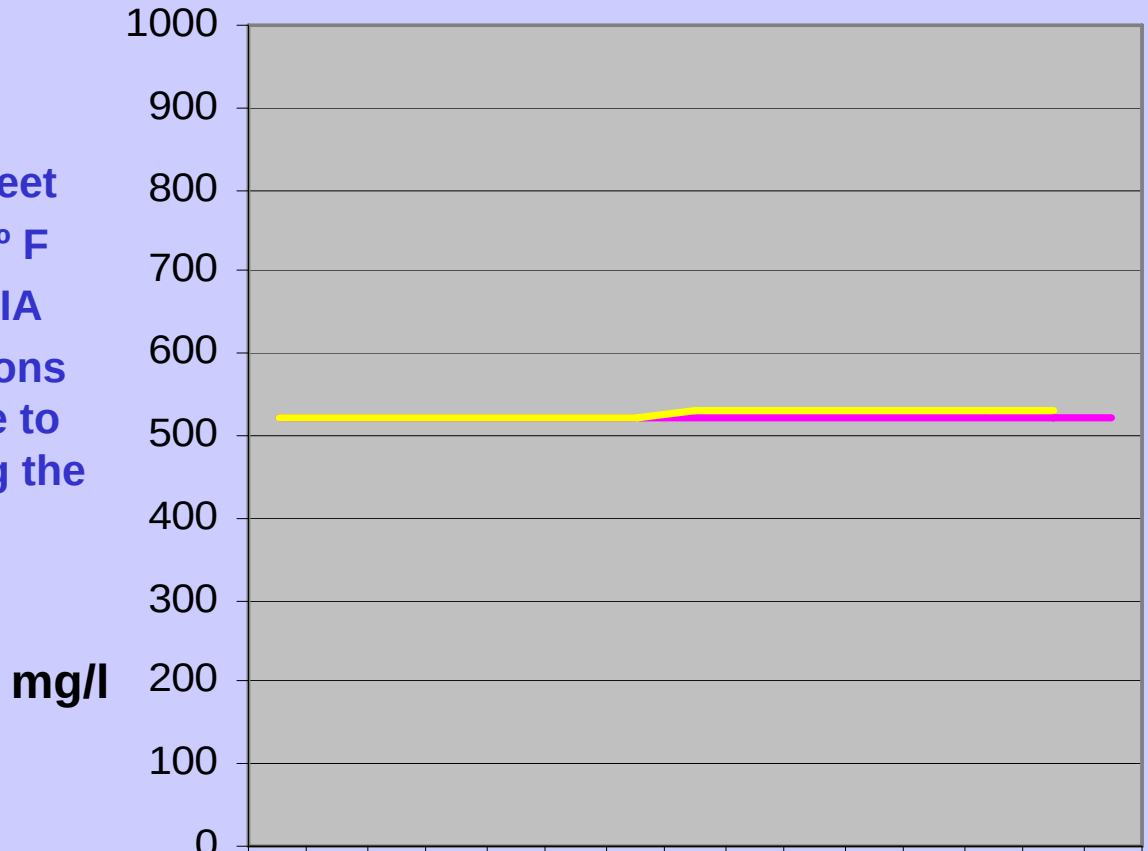
Repeatability

Graph - Soft Cycle Empty Chamber Runs

Graph - Deep Cycle Empty Chamber Runs

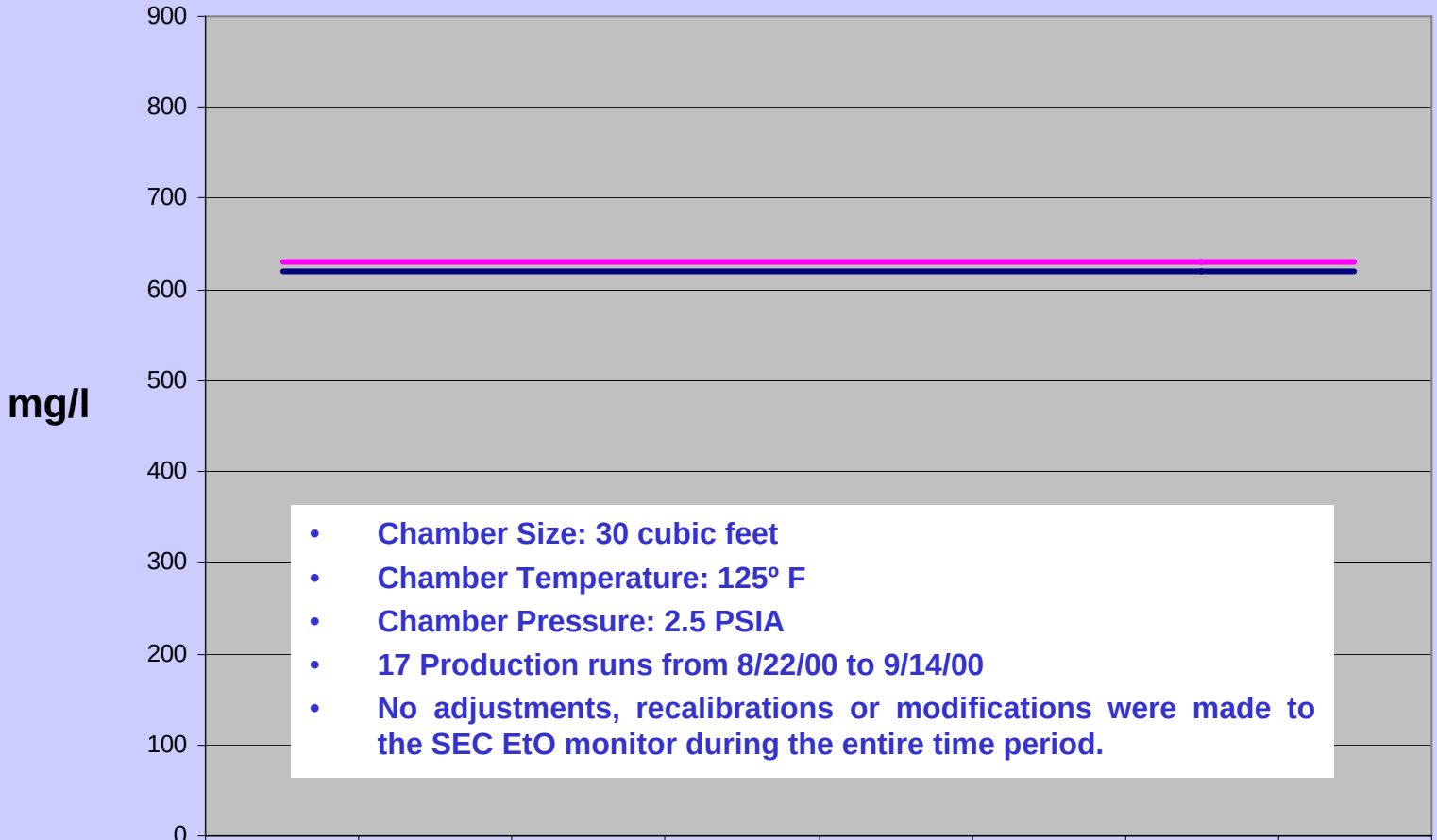
Soft Cycle Empty Chamber Runs

- **Chamber Size: 1014 cubic feet**
- **Chamber Temperature: 120º F**
- **Chamber Pressure: 9.29 PSIA**
- **No adjustments, recalibrations or modifications were made to the SEC EtO monitor during the entire time period.**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cycle A Empty Chamber 9/18/00	520	520	520	520	520	520	520	520	520	520	520	520			
Cycle A Empty Chamber 10/10/00 After 28 Production Runs	520	520	520	520	520	520	520	520	520	520	520	520	520	520	520
Cycle A Empty Chamber 11/6/00 After 59 Production Runs	520	520	520	520	520	520	520	530	530	530	530	530	530	530	

Deep Cycle Empty Chamber Runs

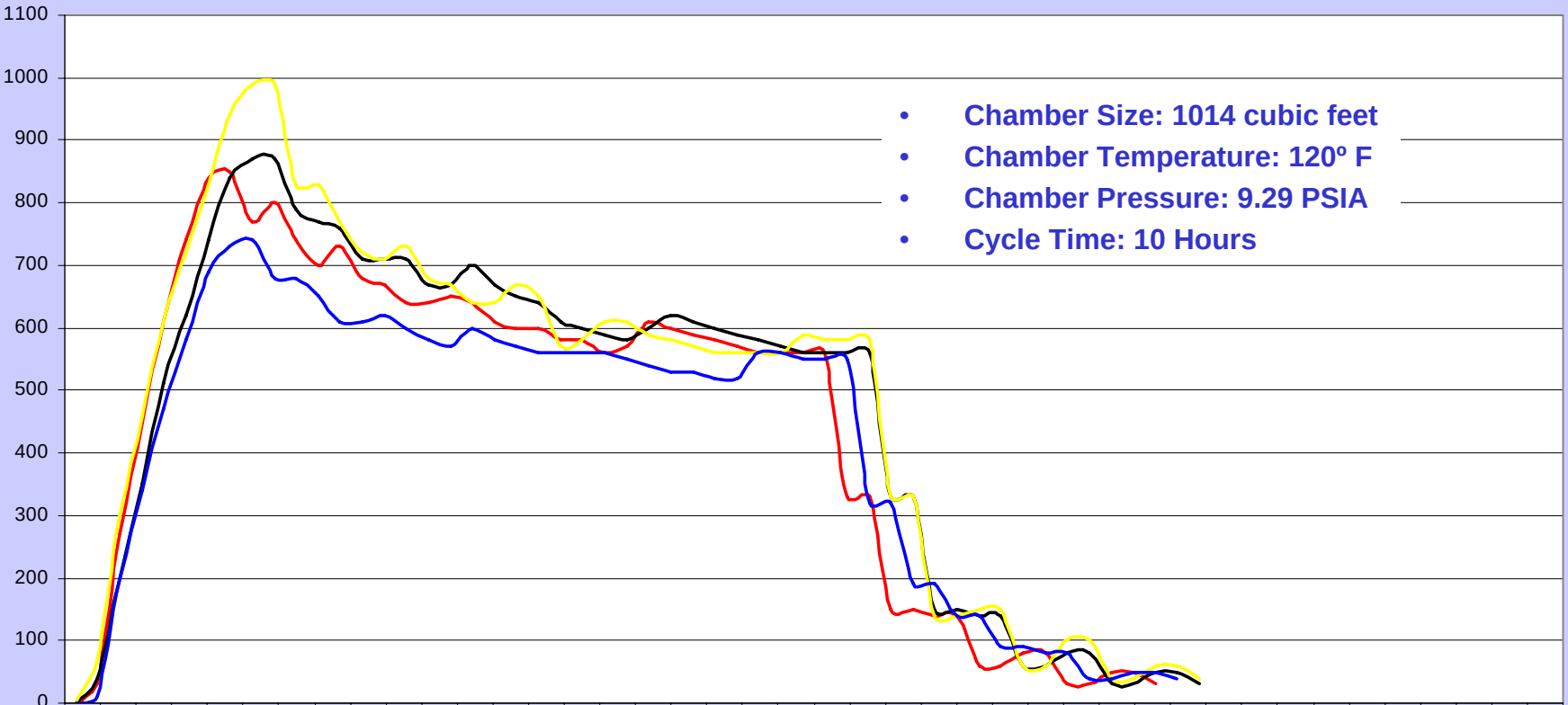


	1	2	3	4	5	6	7	8
Empty Chamber 8/22/00	620	620	620	620	620	620	620	620
Empty Chamber 9/14/00	630	630	630	630	630	630	630	630

Sterilization Load Profiling

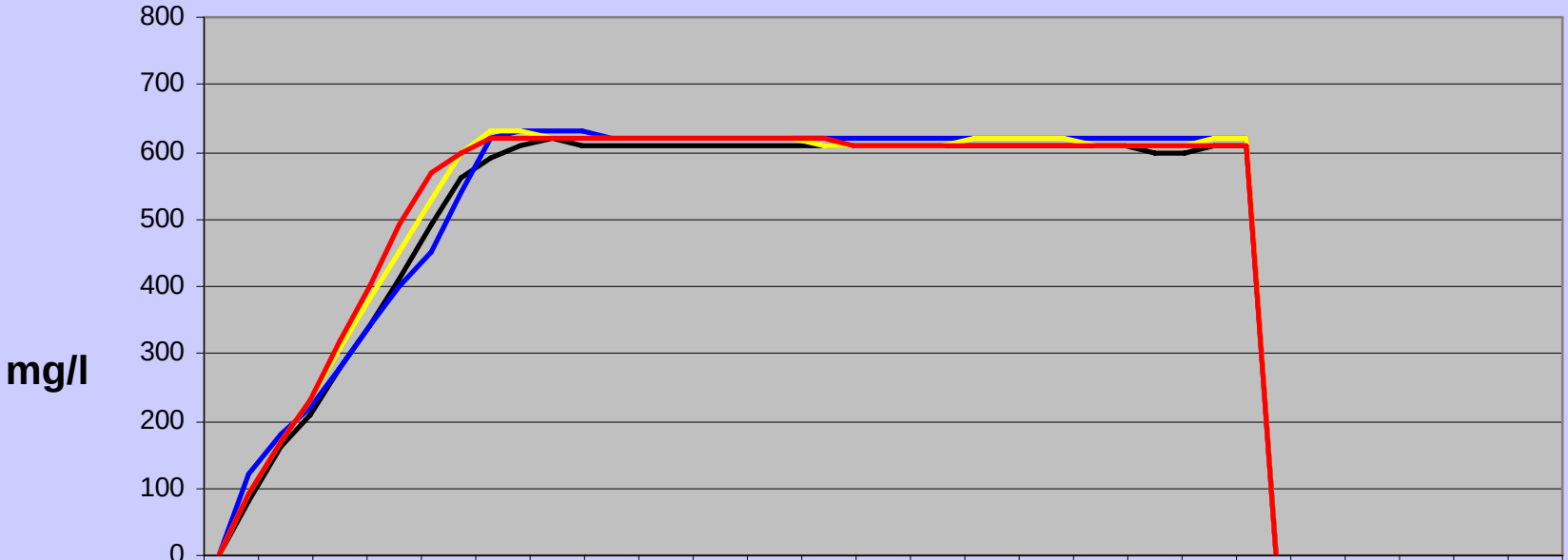
Graph - Same Cycle Different Loads

Same Cycle Different Loads



	1	3	4	6	7	9	11	12	14	16	17	19	20	22	24	25	27	29	30	32	33	35	37	38	40	41	43	45	46	48	50	51	53	54	56	58	59	61	63	64	66	67
Cycle A 8/29/00	0	270	450	740	840	770	740	700	680	640	640	640	610	600	580	560	610	590	580	560	560	560	330	150	140	140	60	80	30	50	30											
Cycle A 8/30/00	0	200	350	620	740	870	790	770	710	710	670	700	670	640	600	590	600	610	600	580	570	560	560	330	150	150	140	60	80	30	50	50										
Cycle A 9/5/00	2	300	460	720	830	990	830	830	720	730	680	640	640	650	580	610	590	570	560	560	560	580	580	330	140	140	150	60	100	40	60	60										
Cycle A 9/6/00	0	200	340	580	690	740	680	650	610	600	580	600	580	560	560	560	540	530	520	560	560	550	320	320	190	140	90	80	80	40	50	40										

Deep Cycle Production Runs
Various Loads



	1	3	5	6	8	10	12	14	15	17	19	21	23	24	26	28	30	32	33	35	37	39	41	42	44
Deep Cycle 10/11/00	0	160	280	340	490	590	620	610	610	610	610	610	610	610	610	610	610	600	600	610					
Deep Cycle 9/27/00	0	180	280	340	450	620	630	620	620	620	620	620	620	620	620	620	620	620	620	620					
Deep Cycle 9/21/00	0	170	310	380	530	630	620	620	620	620	620	610	610	610	620	620	610	610	610	620					
Deep Cycle 9/20/00	0	170	320	400	570	620	620	620	620	620	620	620	610	610	610	610	610	610	610	610					

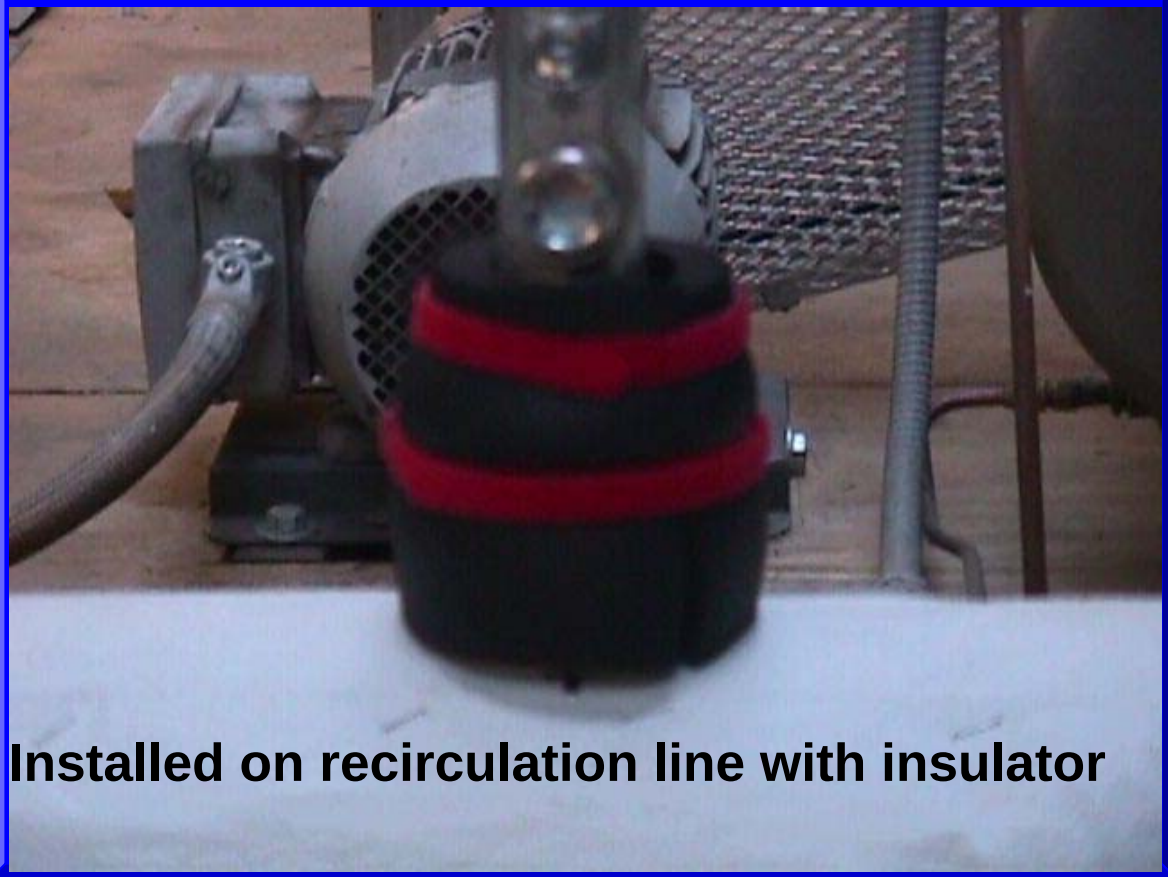
- **Chamber Size: 30 cubic feet**
- **Chamber Temperature: 125º F**
- **Chamber Pressure: 2.5 PSIA**
- **Cycle Time: 3.5 Hours**

Typical Installation

SEC *Signature* EtO Monitor

Installed on recirculation line

SEC *Signature* EtO Monitor



Installed on recirculation line with insulator

INTERNATIONAL
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The Technology and Application of Industrial, Specialty and Medical Gases™

Ethylene Oxide (EtO) Sterilization and Measurement Techniques

By Patrick Smith

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Ethylene Oxide (EtO) Sterilization and Measurement Techniques

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While EtO is a superb sterilization agent, its toxic and explosive properties demand careful monitoring

Widely used for sterilizing medical equipment, (as well as cosmetics, pharmaceuticals, food products, plastics), ethylene oxide (EtO) is economical, available and efficacious in effectively eliminating bacterial and viral microbes. Unfortunately, ethylene oxide has significant drawbacks as well.It is highly toxic and dangerously explosive.Explosive concentrations of EtO range from 3 to 100 % by volume. And because EtO carries its own oxygen supply, it can explode even in anaerobic (oxygen-free) atmospheres.

Despite all this, EtO is a superb sterilant. Pumped into a closed container, it effectively kills off all microorganisms within an acceptable time frame.

Depending on operating requirements, EtO sterilization chambers range from small cabinets enclosing a few cubic feet to giant containers the size of railroad boxcars. EtO effectiveness is a function of, product/packaging characteristics, cycle time, temperature, humidity, and EtO concentration. See Figure 1 for a general overview of a sterilizer.

One way to accelerate EtO diffusion into the product is to hold a vacuum in the chamber before EtO is introduced. Product under vacuum tends to "pull" the EtO in as the EtO is introduced into the chamber. Depending on product construction, most cycles use a hard vacuum or partial vacuum.

Pumped into a closed container, it effectively kills all microorganisms

Some cycles add inert gas (such as nitrogen) following EtO injection to increase chamber pressure and "push" the EtO into the product.

Along with affecting sterilization times and efficiencies, chamber temperatures must be high enough to ensure that EtO is a gas.(At sea level pressure, EtO boils at 51°F.)Product tolerance for high temperatures can be a mitigating factor, however; generally chamber temperatures range from 110°F to 130°F.

Humidity is also a factor because "wet" atmospheres improve EtO's effectiveness. So water vapor (generally steam) is often injected before the EtO is introduced to make the product slightly wet. EtO is soluble in water, therefore the water acts as a conduit to help the EtO diffuse through the

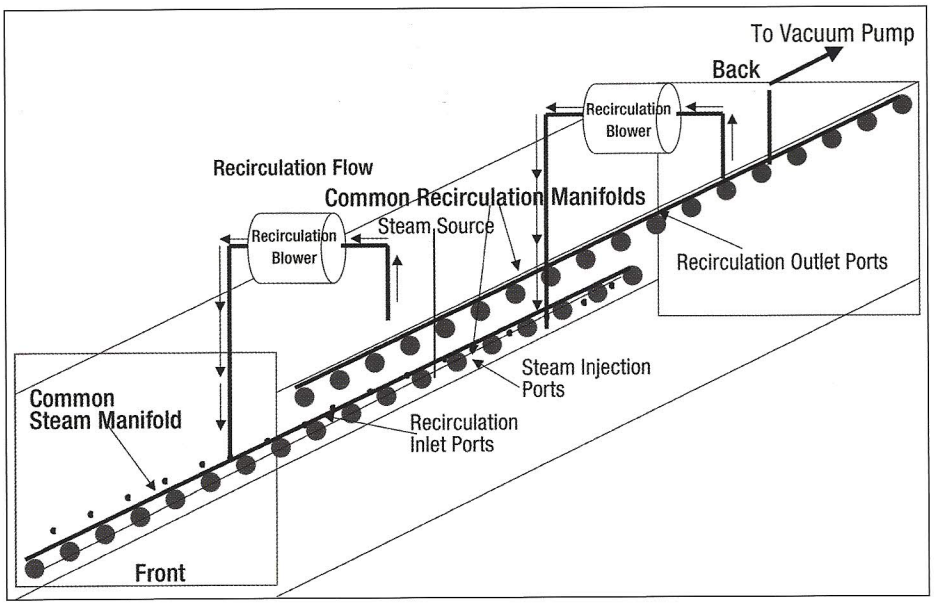


Figure 1. Sterilizer general overview (not to scale)

packaging and into the product. This often shortens the required sterilization time.

A typical sterilization cycle begins with initial chamber evacuation. Vacuum pumps evacuate some or most of the air from the chamber. After a leak check, steam is injected into the chamber and allowed to equilibrate. Then the EtO charge is injected and allowed to permeate into the product. EtO "dwell time" is usually measured in hours during which EtO make-up injections may be required. Following EtO dwell, the chamber is evacuated and nitrogen washed. A nitrogen wash involves injecting and evacuating N_2 several times. This helps remove any remaining EtO from the chamber and load. The load is then removed from the chamber and aerated. Aeration allows the remaining traces of EtO and H_2O to vaporize from the product. The product is then ready for shipment (See Figure 2).

Quantifying EtO and H_2O concentrations is problematic

Historically, biological indicators (BI) were used to verify the "kill". Biological indicators are packets of bacterial spores. The packets are embedded in the product load and subjected to the sterilization cycle. The packets are then "developed". This involves allowing the spores to grow under controlled conditions. If no spores grow, the load is deemed sterile and shipped to users. The BI developing process usually takes several days, presenting a significant cost to the manufacturer.

Enter Parametric Release

Parametric release involves running a "validated cycle", verifying cycle parameters, and releasing product without the use of biological indicators (BI). Validating a cycle requires multiple cycle runs with actual product containing biological indicators. Chamber parameters such as temperature, pressure, EtO concentrations, and water vapor concentrations are recorded. If the BI verifies the kill for every run, that cycle is considered validated for that load.

Once the cycle is validated, product can be released after sterilization (without BI verification) so long as the parameters recorded during the validation process are reproduced during the cycle. But this means that we need to be able to accurately measure chamber parameters.

Several good temperature and pressure transducers on the market perform reliably in an EtO sterilization chamber. Unfortunately quantifying EtO and H_2O concentrations in a sterilization chamber is problematic at best. Pressure extremes, condensing humidity, and the reactive nature of EtO destroy or render inaccurate, most polymer, electrochemical, solid state and optical sensors. Extracting samples for conditioning and measurement brings this very dangerous gas out of the chamber where one leaking fitting could prove disastrous. The most accurate and reliable EtO and H_2O sensors use mid-infrared optical sensing techniques.

Mid-IR Optical Sensing

Some gas molecules with a dipole moment can be excited to higher energy states by mid-infrared photons (whose wavelength = 3-8μm). These are fundamental inter-molecular motions. Atoms in the molecule move with respect to each other. These are quantum energy levels and the energy contained in the photon must match the energy required to excite that particular motion in that molecule. The molecule will stay excited until it loses the energy by emitting a photon or transferring the energy to another molecule. Longer and shorter wavelength photons pass right through without effect. Since both EtO and H_2O have optically active modes in the mid-infrared region, both can be measured. EtO is measured in a band where H_2O has minimal absorption and vice-versa.

An optical system can be constructed where a broadband infrared optical source is illuminating photo detectors sensitive to certain wavelength bands. If the target gas (analyte) is present between the source and detector, light will be absorbed in certain bands and not others. By measuring relative absorption, we

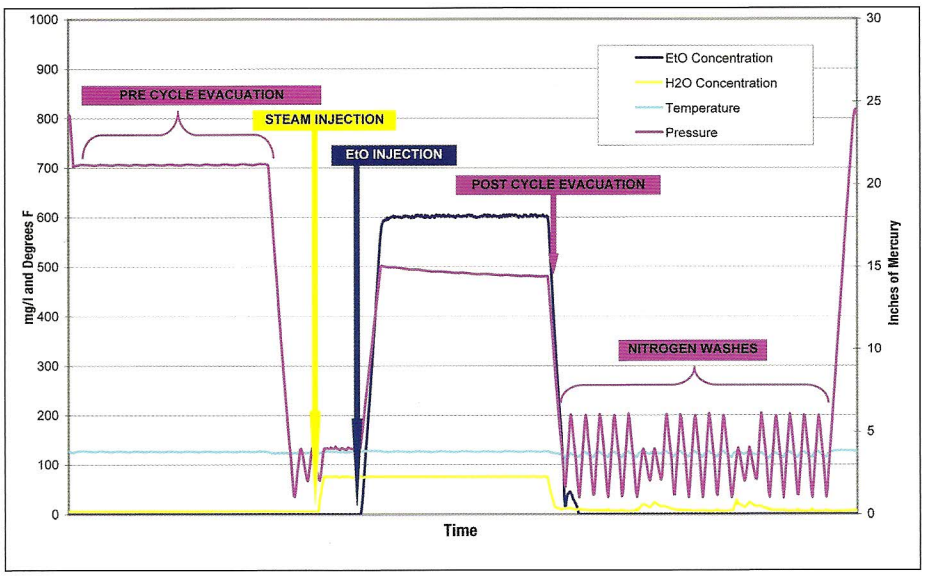


Figure 2. Typical sterilization cycle

can identify and quantify the analyte gas.

The optical absorption is approximated by the following expression:

$$I = I_o e^{-(acl)}$$

Where

I = amount of light after absorption

I_o = amount of light before absorption

a = coefficient of EtO absorption

c = gas concentration

l = length of light path

Solving for gas concentration

$$c = -(\ln(I/I_o))/al$$

Since the amount of absorption is a function of the number of analyte molecules in the optical path, the concentration is expressed as density (typically mg/l). This approach has long been used to develop rugged reliable ambient gas detectors.

Engaging the Sensor With the Sterilizer Chamber

The sensor housing mounts directly to the chamber using a ported ¾" NPT fitting. Small and in close proximity to the gas flow, the optical chamber samples chamber gas through filtered passive diffusion. Pressure differential drives gas in and out of the chamber. Because aluminum oxides are resistant to EtO, surfaces exposed to EtO are anodized aluminum and aluminum oxide.

Condensation on the sensor's optical surfaces can significantly degrade an optical detector's output.H_2O condensation is especially critical as liquid water absorbs and scatters light, making the output erratic. Also, during the sterilization cycle, ethylene oxide and water combine to form ethylene glycol that could also potentially condense on the optics. To counteract this problem, the optical surfaces are heated to discourage condensation. This results in a compact, nonintrusive, reliable, and repeatable sensor.

Safety

A sterilization environment is considered a Class 1 explosive area. This means that explosive gas mixtures are present. Equipment operating in this type of environment needs to be either intrinsically safe or explosion proof.

An intrinsically safe device is designed so it cannot deliver enough energy to ignite an explosive mixture. An explosion proof device is designed so that when an explosive mixture is ignited in the interior of the unit, the housing stays intact and the internal explosion doesn't ignite an explosive mixture outside the unit.

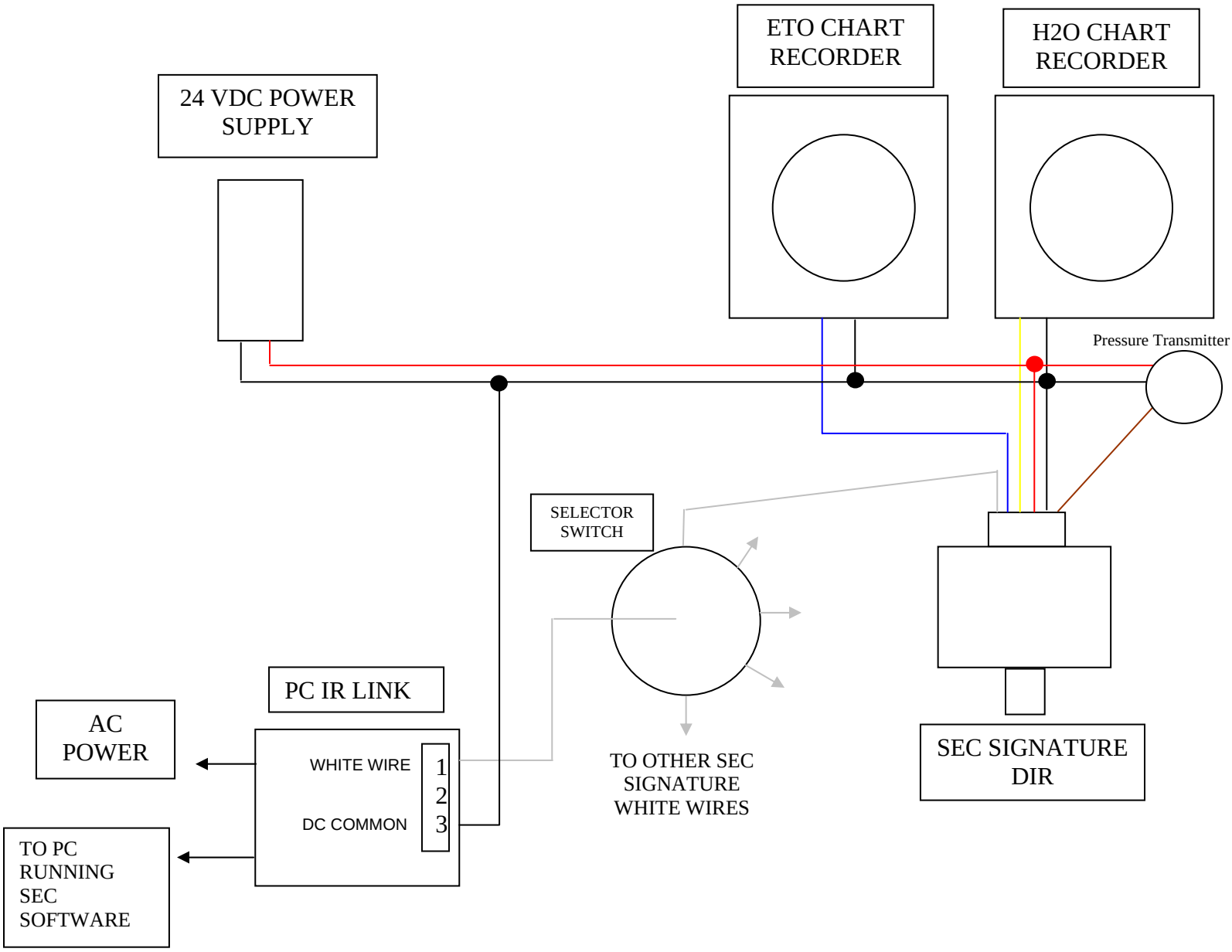
Due to the optical source power levels and temperature, the IR sensor is designed as an explosion proof device. The unit's explosion proof performance is tested and verified by independent approval agencies who assign a rating to the unit such as: Class 1, Division 1, Groups B,C, and D. Such a rating is acceptable for an EtO sterilizer since EtO is considered a group B explosive.

Conclusion

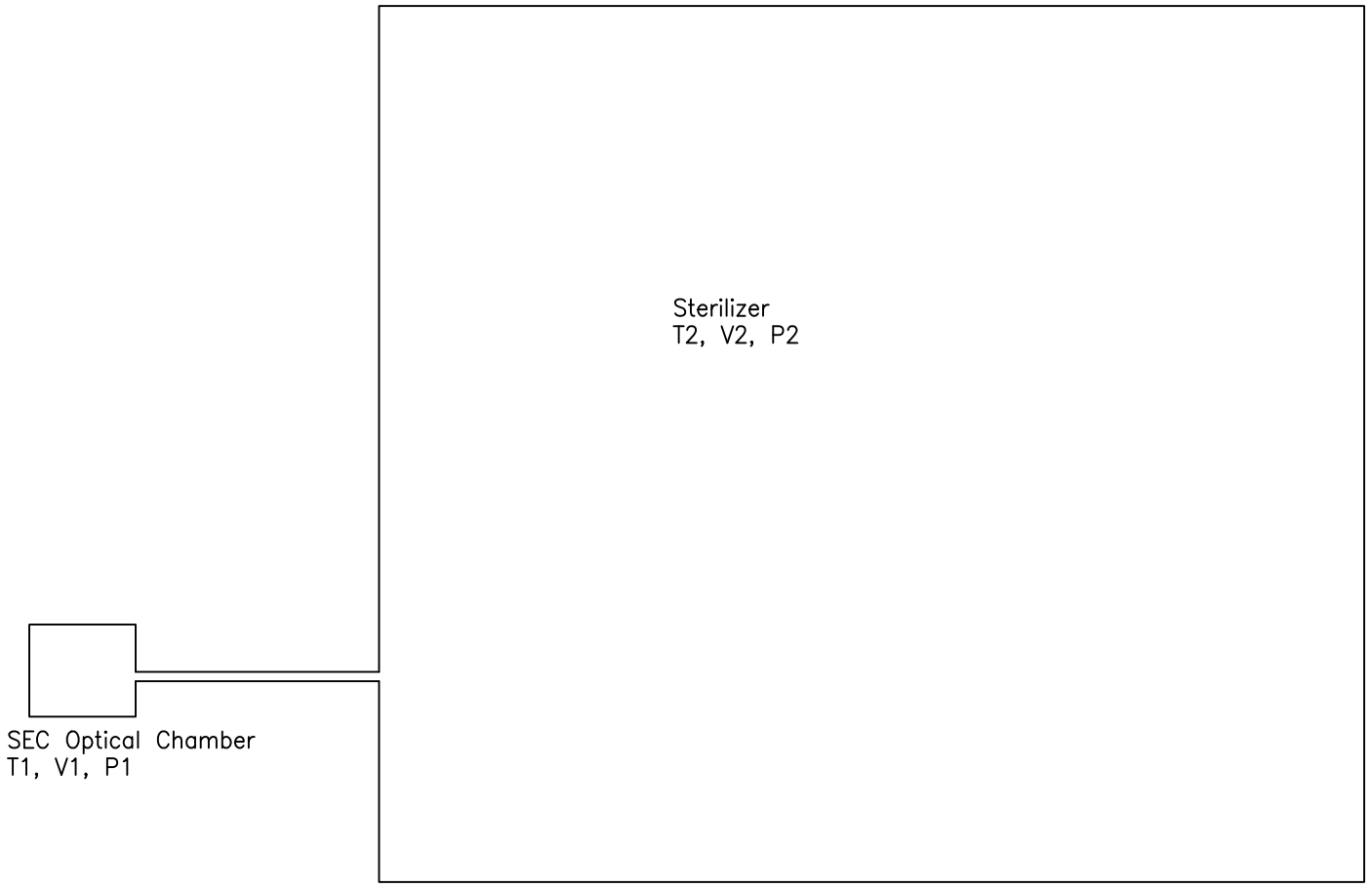
In conclusion, reliable mid infrared EtO and H_2O sensors have enabled manufacturers to employ parametric product release. This has significantly improved the sterilization process by:

- Shortening the sterilization process
- Providing accurate concentration profiles leading to better process control
- Making more efficient and cost effective sterilization cycles. G&I

PATRICK G. SMITH *IS VICE PRESIDENT AND DIRECTOR OF RESEARCH AND DEVELOPMENT FOR SENSOR ELECTRONICS, A MINNEAPOLIS-BASED MANUFACTURER OF ADVANCED DETECTORS AND ANALYZERS OF EXPLOSIVE AND TOXIC GASES. AFTER GRADUATING FROM THE UNIVERSITY OF MINNESOTA WITH A DEGREE IN ELECTRICAL ENGINEERING, MR. SMITH DID EXTENSIVE COURSEWORK IN CHEMISTRY, AND THEN GRADUATE WORK IN COMPUTER SCIENCE AND ELECTRICAL ENGINEERING. IN HIS PROFESSIONAL CAREER MR. SMITH HAS WORKED IN OPTICAL RESEARCH, WITH SPECIAL FOCUS ON ULTRAVIOLET AND INFRARED RADIATION AS WELL AS THE VISIBLE LIGHT SPECTRA. HE HAS DEVELOPED GAS-DETECTION SYSTEMS FOR APPLICATIONS IN THE SEMICONDUCTOR, MEDICAL, PETROCHEMICAL, COMPUTER AND ENVIRONMENTAL-PROTECTION AREAS. HE HOLDS SEVERAL PATENTS FOR ADVANCED OPTICAL/ELECTRONIC SENSORS. HE CAN BE REACHED AT 952-938-9486 OR SMITH@SENSORELECTRONICS.COM.*


ETO CHART RECORDER
H2O CHART RECORDER
24 VDC POWER SUPPLY
Pressure Transmitter
SELECTOR SWITCH
PC IR LINK
AC POWER
WHITE WIRE
DC COMMON
1
2
3
TO PC RUNNING SEC SOFTWARE
TO OTHER SEC SIGNATURE WHITE WIRES
SEC SIGNATURE DIR

Application Note: Density/Temperature Relationship Sterilization Sensing



Ideal Gas Law (PV=nRT) applies to gas in optical chamber and sterilizer chamber.
Since the two chambers are connected, pressure will be the same. This causes a Density relationship between the two chambers based on temperature.

Density=D=n/V=P/RT
D1=SEC Density = P1/RT1 D2=Sterilizer Density = P2/RT2
P1=P2=D1RT1=D2RT2 therefore D1/D2 = RT2/RT1 = T2/T1
The Density ratio is equal to the inverse Temperature ratio (Kelvin)

Using the *relative heater mode (DIR) and/or a fixed external heat source, causes a constant sensor temperature rise over chamber temperature.
As the chamber temperature varies, the sensor temperature varies also.
This causes the Density ratio to remain relatively constant over cycle temperature variations.
Calibrations should be performed using the same temperature rise.

*DIR can be operated in "Relative Mode" or "Fixed Mode". Signature is inherently "Relative Mode".

Application Note: 110404 Rev.1

SEC Signature Cleaning and Filter Maintenance in EtO Sterilizer Applications

Optical surface contamination can occur over time because of the accumulation of dust, oil…etc carried by the load. The SEC Signature is designed to compensate for optical contamination, however regular calibrations and cleanings are recommended to ensure accurate and reliable sensing.

Contamination Effects on Unit Performance

Slight:	Negligible effect
Moderate:	Can cause calibration point shift. Recalibrating the device will restore accuracy.
Heavy:	If buildup becomes significant, the output signal can become "jumpy". The Signature will activate "Optics Fault" if optical obscuration becomes a problem.

Recommended Maintenance

Maintenance intervals are highly a function of cycle/load characteristics. Dusty oily dirty loads and very wet cycles may cause the SEC Signature to require more frequent cleaning.
Any time a large volume of oil or other contaminant has entered the chamber during a cycle, the SEC Signature should be removed, filters changed, and optics cleaned. (Any time the SEC Signature is removed and re-mounted a Zero Calibration should be performed)

Filter(s) replacement: Every six months (two stage filtering system)
Optics Cleaning: Every Year
Return unit to factory for cleaning, calibrating and O ring replacement: Every two years.

Replacement Part Numbers:
SEC Signature EtO Monitor 1420597
Hydrophobic Fiberglass Cloth Filter (beige color) 1420852
Teflon Filter (white) 1420701

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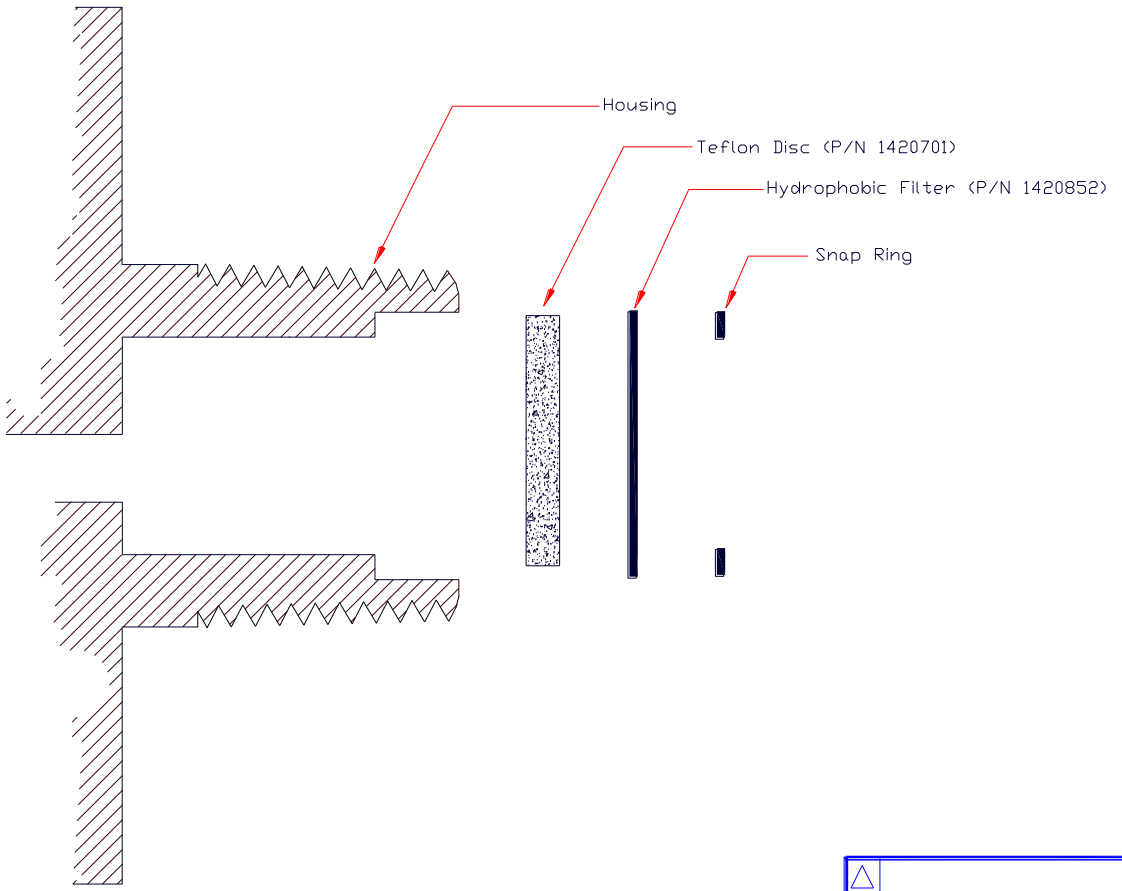

1) DROP TEFLON DISC ONTO LEDGE IN HOUSING
2) PUT EXISTING FILTER ON TOP OF DISC
3) INSTALL SNAP RING INTO BORE
4) PUSH SNAP RING IN, AGAINST FILTER/DISC.

NO.		BY CHKD.
△		
△		

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5500 LINCOLN DRIVE
MINNEAPOLIS, MINNESOTA
55436

SCALE: 2:1	DESIGN BY: PGS	REVISED BY:
DATE: 10/23/00	DRAWN BY: PGS	APPROVED BY:

INSTRUCTIONS, INSTALLATION, HYDROPHOBIC SYSTEM

SIZE:	DRAWING NO.	REVISION:
B		

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June 26, 2013

Subject: Two Point Calibration – Linearity H2O Channel

Product: SEC Signature DIR

The response curve for water vapor (H2O) is inherently non-linear. The sensor uses a linearization algorithm to produce an output linear to concentration. The Zero operation (with N2) teaches the sensor what no gas looks like, the Span operation teaches the sensor what 1/4 scale (75 mg/l) looks like. The sensor then uses these two points to align the analog signal to the digital linearization curve. This ensures linearity over the full, fixed sensing range, 0-300 mg/l. Accurate Zero and Span points are critical to producing an accurate linear output.

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Date: September 02, 2015

Application Note: 090215
SEC Signature DIR Software Version Log

The SEC Signature software changes are included in the program code for the SEC Signature DIR. The code notes are attached describe the software changes. Below is a summary of the revisions dates.

6/5/2006	Rev 6
2/17/2007	Rev 7
4/29/2007	Rev 8
9/11/2009	Rev 9
10/26/2009	Rev 10
10/27/2009	Rev 11/12
12/20/2011	Rev 13
8/7/2013	Rev 14

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```
//=====================================================================
//      Filename: MAIN.C
// Function Name: main()
//        Author: PGS
//
//   Description: Main loop of IR-Sensor Firmware.
//    Parameters:
//                 Input: None.
//                Output: None.
// This version uses eight sample averaging to develop the output (Main.c)
// Reference and Analytical factors changed from 128 to 205 to increase
// resolution of Index Factor resulting from calculation (Main.c)
// Ideal Gas Law correction table changed to flat (no correction)
// in Globals.h
// There are two ways to compile:
// 1)STANDARD, Ideal gas law compensation enabled (uses table)
//             Standard source adjustment used <tbls_std.h>
//             Temperature value adjusted down 3 steps due to increased
//             internal heating with the CSA housing.
// 2)ETO, Ideal gas law compensation not enabled (doesn't use table)
//             short path length source adjustment used <tbls_eto.h>
//             compile choice is made in <var_defs.h> using "unit_type"
// Rev 6
//  Add "zero" exclusion for float conversion function.
// Rev 7
//  Remove CH1 pressure correction during "COMP_ZERO".
// Rev 8
//  Linearization Polynomial can produce negative result for small R-A values. Test for negative
//  result and use zero for any negative. ("main.c")
// Rev 9
//  Increase time for AGC to 185mS
//  Add Pressure Comp Upper Limit. This value is loaded with table (float)
// Rev 10
//  Add 1/8 scale (37.5 mg/l) to CH 1 span routine
//  Reconstructed 10/27/09...original source code and backup lost or shredded by Vista
// Rev 11/12
//  Adjust CH1 Span Target for 1/4 & 1/8 scale span for linearization non-linearities.
//  Add functions to store factory settings (Span Pot,Zero Pot,Span Tweak, 4-20):
//  RS232_RXTX.c, main.c, globals.c, write_cals.c, rd_cals.c
//  and to re-install stored factory settings: RS232_RXTX,main.c
//  Replace if(!variable) with if(varaible==0)
//  and replace if(variable) with if(varaible!=0) for variables larger than 1 bit
//  New CCS compiler only looks at first bit...doesn't always work right for larger variables
//  Install cal wire zeroing routine. Grounding Cal Wire triggers sequential CH0 and CH1 zeros: Main.c
//  New CCS compiler (4.125) doesn't initialize variables at declaration. Add variable initialization statements.
// Rev 13
//  Fix bug where Ch1 Factory Cal Values are read for CH0 & CH1. RS232_RXTX.c change "if" to "else if"

// Rev 14
//  Make calsw function configurable. either zero CH0&CH1 or zero CH0 only. CH0 bits_byte.6 (globals.h)
//
```

April 11, 2014

Cross Calibrating Signature DIR Gas Analyzers

The SEC Signature DIR gas analyzers are designed to independently monitor hydrocarbon and water vapor gas molecules utilizing Mid IR Optical Sensing[1]

Designing the linearization curve for the water channel, Sensor Electronics generated water vapor concentrations at various pressure concentrations.

Problem: Finding an NIST calibration gas for the SEC Signature DIR water channel.

Objective: Find a one point calibration concentration at room conditions for the SEC Signature DIR water channel.

Carbon dioxide was chosen because of its optical similarity to water vapor's spectral absorbance response characteristics, low toxic, and availability as high concentration gas.
A Signature was calibrated using 75mg/l water vapor.
The same unit was exposed to different levels of carbon dioxide gas, balance nitrogen at 26C and 745mmHg.
20.5% Volume Carbon Dioxide balance N2 was found to generate the equivalent of 75 mg/l water vapor at these conditions. Since an optical sensor measures gas density directly, the temperature and pressure of the gas are important. The density of the gas mix is a function of temperature and pressure (Ideal gas Law) so when CO2 is used to calibrate the water channel, Optical and Pressure Compensation must be disabled until calibration is complete.

During the initial design, research and development of these products, Sensor Electronics worked with many sterilization companies testing and developing response, accuracy, repeatability and linearization specifically to ethylene oxide.

Problem: Dealing with high level EtO in a manufacturing environment is very problematic due to toxicity and explosion risk.

Objective: Find a one point cross to 500mg/l EtO that can be developed in room conditions using a less toxic surrogate gas. The factory calibration gas must be traceable to NIST standards.

Ethylene was chosen because of its optical similarity to EtO, low toxic, and availability as high concentration gas.
A Signature was calibrated using 500mg/l EtO (100% EtO).
The same unit was exposed to different levels of ethylene gas at 26C and 745mmHg.
70% Volume Ethylene / 30% N2 was found to generate the equivalent of 500mg/l Eto at these conditions.
Since an optical sensor measures gas density directly, the temperature and pressure of the gas are important. The density of the gas mix is a function of temperature and pressure (Ideal gas Law).
If Ethylene is used for field calibration and atmospheric conditions are different from our test conditions, the calibration can vary somewhat from the 500mg/l equivalent.
Calibrating in-chamber with EtO is our recommended field calibration procedure.

If ethylene is used for the bench calibration and an in chamber span with EtO is not going to be performed as a minimum SEC recommend after the Signature is reinstalled on the chamber, the sensor should be zero calibrated with humidity in the chamber.

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Alan H. Petersen Jr.
Sensor Electronics Corporation

[1]Mid IR Optical Sensing

Some gas molecules with a dipole moment can be excited to higher energy states by Mid Infrared photons. (Wavelength=3-8um). These are fundamental inter-molecular motions. Atoms in the molecule move with respect to each other. These are quantum energy levels and the energy contained in the photon must match the energy required to excite that particular motion in that molecule. As the molecule is excited the photon is gone. Longer and shorter wavelength photons pass right through without effect. The molecule will stay excited until it loses the energy by emitting a photon or transferring the energy to another molecule.

An optical system can be constructed where a broadband infrared optical source is illuminating photo detectors sensitive to certain wavelength bands. If the target gas (analyte) is present between the source and detector, light will be absorbed in certain bands and not others. By measuring relative absorption, we can identify and quantify the analyte gas.

The optical absorption is approximated by the following expression:

$I = I_o e^{-(acl)}$

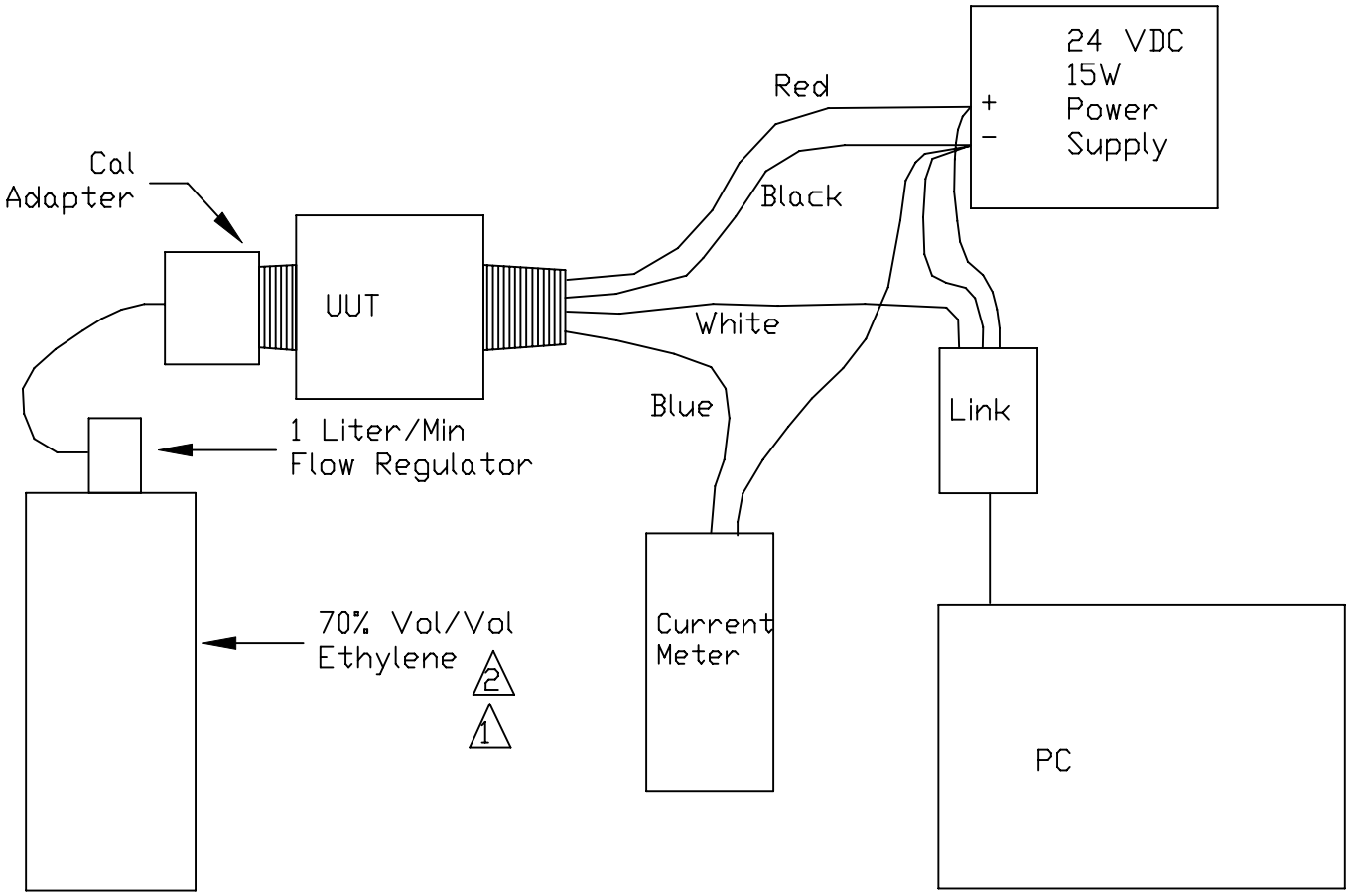
Where I = amount of light after absorption
I_o = amount of light before absorption
a = coefficient of absorption
c = gas concentration
l = length of light path

Solving for gas concentration

$c = -(\ln(I/I_o))/al$

Since the amount of absorption is a function of the number of analyte molecules in the optical path, the concentration is expressed as density (typically mg/l).

1. Apply +24VDC +/-2VDC Power to UUT
2. Allow UUT to warm up 30 Min. minimum. Unit Temp 42 degrees +/- 4 degrees.
3. Read checksum to verify correct linerization table 42, Firmware 8
4. Connect to Meter, Link and PC (Figure)
5. Install ETO Cal Adapter
6. Initiate Zero operation from PC
   Verify "Zeroed" returned from UUT
   Verify 4mA +/- .05mA output
7. Apply 70% Vol/Vol Ethylene △2
   at a 1 Liter/Min flow rate for 2 Min.
8. Initiate Span command from PC
   Verify "Spanned" returned from UUT
   Verify 12mA +/- .05mA output
   Verify a stable output for 30 Sec.
   Disconnect Cal gas/Cal adapter, verify output returns to 4 mA
9. Log data.



NOTES
△1. Calibration gas equivalent to approx. 500mg/l ETO
△2 Cal Gas +/-2% , NIST Traceable, Balance N2

NO.	REVISION	BY / CHKD.	DATE
△D	MODIFY TO DIR CALIBRATION	TP / PGS	12/26 07
△C	CHANGE CAL GAS TO 70% V/V	TP / PGS	9/20 01
△B	CLARIFY NOTE 2 (NIST)	TP / PGS	5/9 01
△A	RELEASED	TP / PGS	2/11 01

SENSOR ELECTRONICS CORPORATION

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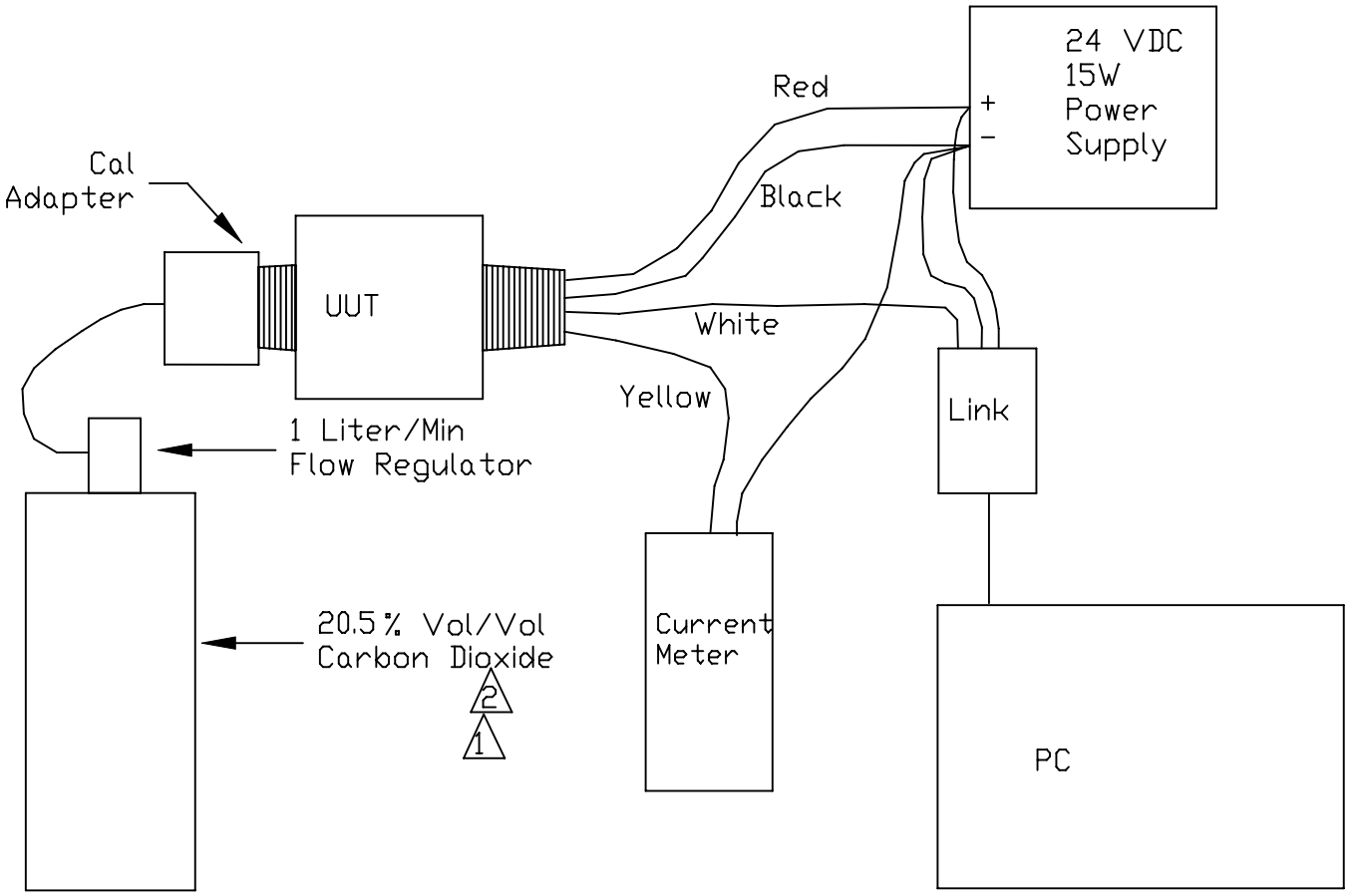
5500 LINCOLN DRIVE
MINNEAPOLIS, MINNESOTA
55436

SCALE: N/A	DESIGN BY: PGS	REVISED BY:
DATE: 6/2/00	DRAWN BY:	APPROVED BY:

PROCEDURE, CALIBRATION, ETO SEC SIGNATURE DIR

SIZE: A	DRAWING NO. 7204	REVISION: D

1. Apply +24VDC +/-2VDC Power to UUT
2. Allow UUT to warm up 30 Min. minimum. Unit Temp 42 degrees +/- 4 degrees.
3. Read checksum to verify correct linerization table 5E, Firmware 8
4. Pressure Compensation: OFF
5. Connect to Meter, Link and PC (Figure)
6. Install ETO Cal Adapter, apply 99.999% Vol/Vol Nitrogen @ 1 lpm for 2 min.
7. Initiate Zero operation from PC
   Verify "Zeroed" returned from UUT
   Verify 4mA +/- .05mA output
8. Apply 20.5% Vol/Vol Carbon Dioxide (2)
   at a 1 Liter/Min flow rate for 2 Min.
9. Initiate Span command from PC
   Verify "Spanned" returned from UUT
   Verify 8mA +/- .05mA output
   Verify a stable output for 30 Sec.
   Disconnect Cal gas/Cal adapter, verify output returns to 4 mA
10. Log data.



NOTES
(1) Calibration gas equivalent to approx. 75mg/l Water Vapor
(2) Cal Gas +/-2% , NIST Traceable, Balance N2.

NO.	REVISION	BY / CHKD.	DATE
D	MODIFY TO DIR CALIBRATION	TP / PGS	12/26 / 07
C	CHANGE CAL GAS TO 70% V/V	TP / PGS	9/20 / 01
B	CLARIFY NOTE 2 (NIST)	TP / PGS	5/9 / 01
A	RELEASED	TP / PGS	2/11 / 01

SENSOR ELECTRONICS CORPORATION

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5500 LINCOLN DRIVE
MINNEAPOLIS, MINNESOTA
55436

SCALE: N/A	DESIGN BY: PGS	REVISED BY:
DATE: 6/2/00	DRAWN BY:	APPROVED BY:

PROCEDURE, CALIBRATION, H2O SEC SIGNATURE DIR

SIZE:	DRAWING NO.	REVISION:
A	7204 H2O	D

May 31, 2017

Subject: H2OWin Software / SEC PC IR Link

Product: SEC Signature DIR

The H2OWin software, developed by Sensor Electronics Corporation (SEC) is designed to be used with the SEC PC IR Link and a customer supplied personal computer (PC). The software sends and receives information from the computer to SEC Signature DIR EtO/H2O Monitor. The primary use for the H2OWin software is for troubleshooting and calibration of the SEC Signature DIR Monitor. The H2OWin software is not used with the SEC Signature DIR monitor continuously. The software has no real-time data gathering or information storage features.

The SEC PC IR Link is used as a bidirectional communication interface between the SEC Signature DIR and personal computer. There are no calibration requirements for the SEC PC IR Link. If the SEC PC Link is used to power the SEC Signature DIR, the 24 VDC power supply output should be measured annually. The voltage can be measured on Terminals 2 (+) and 3 (-).

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September 30, 2015

Application Note: 093015
SEC Signature DIR Accuracy

The SEC Signature DIR EtO channel is specified as follows:

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale
@ 500mg/l EtO…500 +/- (25 + 10 + 3) = 500 +/- 38mg/l

Assuming pure water vapor with optical compensation and pressure compensation disabled.
The SEC Signature DIR H2O channel is specified as follows:

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale
@ 75mg/l H2O…75 +/- (3.75 + 1.5 + 0.9) = 75 +/- 7 mg/l

This assumes water vapor mixed with EtO, N2, O2 with optical compensation and pressure compensation enabled. The presence of other gases can cause significant errors in the H2O reading unless optical and pressure compensation are used.

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale
Optical compensation error = 2% of value
Pressure compensation error = 2% of value
@ 75mg/l H2O…75 +/- (3.75 + 1.5 + 0.9 + 1.5 + 1.5) = 75 +/- 10 mg/l

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July 31, 2015

Subject: Sensor Calibration Temperature

Product: SEC Signature DIR EtO/H2O Gas Analyzer

Sensor Electronics recommended the following calibration procedures to be used by customers to calibrate the SEC Signature DIR in the field:

Procedure Calibration SEC Signature DIR ETO 7204

Procedure Calibration SEC Signature DIR H2O 7204 H2O

Both of these calibration procedures include a step to heat the sensor to 42 degree C (+/- 4 degree C) prior to applying any calibration gas. This temperature is recommended for the normal operating temperature to be ambient.

Sensor Electronics recommended to calibrate the sensor about 10 degree C (+/- 5 degree C) higher than the normal operating temperature, to ensure that there is no moisture build up on the sensor.

For a normal operating temperature of 54 degree C, the calibration temperature would be about 60 to 70 degree C.

For both calibration procedures, Sensor Electronics recommended to apply 99.9 % Nitrogen gas prior to initiating zero operation.

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Converting mg/l to RH

$$RH\% = \left[\frac{(273.2 + t)\, D}{1323^{\exp(17.3 * t) / (t + 238)}} \right] * 100$$

D = Measured density mg/l
t = Temperature C°

SENSOR ELECTRONICS

SEC Signature DIR

Dual Infrared Process Gas Analyzer

Features

- *Capable of non-intrusive continuous monitoring for 2 different gas vapors*
- *Infrared sensing technology*
- *Designed for nonextractive sampling installation*
- *Virtually maintenance free*
- *Explosion proof*
- *Immune to poisoning and etching*
- *Designed for harsh environments*
- *Compact and lightweight*
- *Fast response time*
- *Simple calibration*
- *Self-compensating optical system (patented)*
- *Linear outputs*
- *Programmable heated optical chamber*
- *Independent pressure compensation input*
- *Operates in anaerobic atmospheres*
- *Continual self diagnostics*
- *Dedicated 4 to 20 mA output for each channel*

Operation / Description

The SEC Signature DIR is a self-contained dual chamber optical gas analyzer designed for non-intrusive continuous monitoring of process gases. The infrared optical system is self-compensating for most aging, environmental, and contamination effects resulting in excellent measurement integrity. An industry standard analog output provides complete remote alarm, fault and calibration signals. The analog output from the device can be connected to chart recorders, data acquisition systems or a process control system.

The SEC Signature DIR measures infrared light absorption due to molecular resonances. The monitor is tuned to the infrared signature of the target gas or vapor, measuring light at wavelengths absorbed by the target gas and at wavelengths not absorbed by the target gas. The gas concentration is determined by calculating the ratios of the analytical and reference levels. Embedded linearization algorithms keep the output accurate over the entire measuring range and embedded compensation algorithms maintain measuring accuracy over changing environmental conditions.

The SEC Signature DIR employs a reliable, directly opposed optical system. No mirrors or reflecting surfaces are used in this device. All optical surfaces are heated to discourage measurement error due to condensation. Rugged sapphire windows protect the optics eliminating the corrosive effects found in many process monitoring applications.

Once the unit is spanned to a specific mid range gas concentration (a one time operation), routine calibration consists of only rezeroing the device periodically.

SEC Signature DIR Dual Infrared Process Gas Analyzer

SPECIFICATIONS

Range (adjustable): EtO 0-2000mg/liter
Hydrocarbon 0-100% VOL

CO2 0-100% VOL
H2O 0-100 mg/liter
H2O 0-300 mg/liter

Models: EtO/H2O
Hydrocarbon/H2O
CO2/ Hydrocarbon

Rating: Class 1, Div 1, Groups B,C,D (-40 to + 75° C)

Humidity: 0-99% (Non-condensing)

Operating Temperature: 0-75° C

Operating Pressure: 1 - 55 PSIA

Installation Category: Cat. 1, Pollution Degree 2

Construction: Anodized aluminum and sapphire

Dimensions: 5.5" (H) x 4.25" (W) (inches)

Mechanical Connection: 3/4" NPT

Approvals: CSA

Weight: 2.65 lbs

Accuracy: ± (5% of reading + .3% of full scale)
With optical comp enabled add 2% of reading
With pressure comp enabled add 2% of reading

Repeatability: ± 2%

Operating Voltage: 18 – 32 VDC ⎓

Max. Power Consumption: 35 watts

Current Draw (@ 24 VDC): 1.0 A (average)

Analog Outputs: Ch 0: 0-20mA (sourced)
Ch 1: 0-20mA (sourced)

Digital Output: Interactive P.C. link (White Wire)

Input Compensation Channel: 4-20mA (400Ω)

Current Output	Status
4-20 mA	Normal measuring mode
0.0 mA	Unit Fault
0.2 mA	Reference channel fault
0.4 mA	Analytical channel fault
0.8 mA	Unit warm up
1.0 mA	Optics fault
1.2 mA	Zero drift fault
1.6 mA	Calibration fault
2.0 mA	Unit spanning
2.2 mA	Unit zeroing
4.0 mA	Zero gas level
5.6 mA	10% Full Scale
8.0 mA	25% Full Scale
12 mA	50% Full Scale
16 mA	75% Full Scale
20 mA	Full scale
>20 mA	Over-range

Wire Connections: **Red wire (+ 24 VDC) ⎓**
Black wire (D.C. common)
Blue wire (4-20 mA output signal Ch 0)
Yellow wire (4-20 mA output signal Ch 1)
White wire (Digital interface)
Brown wire (Compensation input)

Sensor Electronics Corporation

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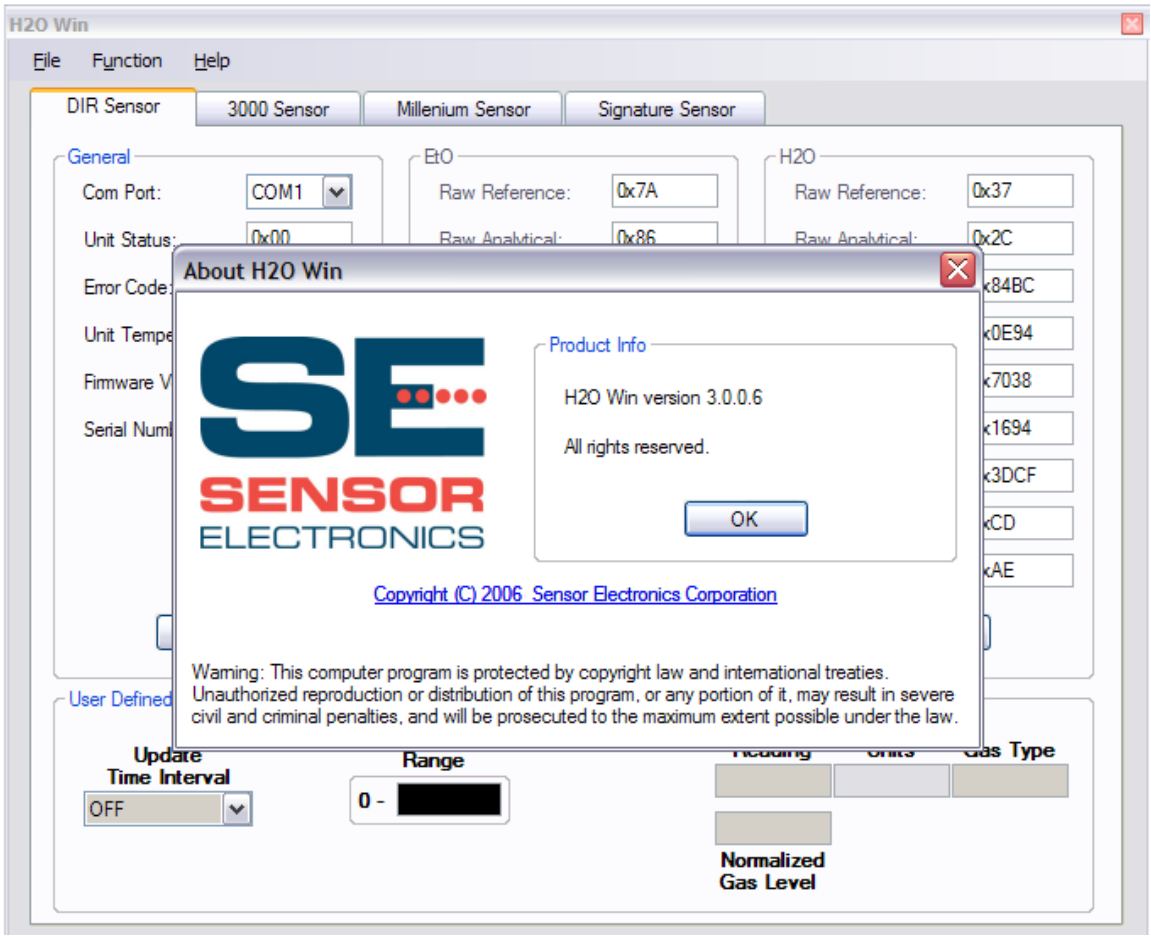
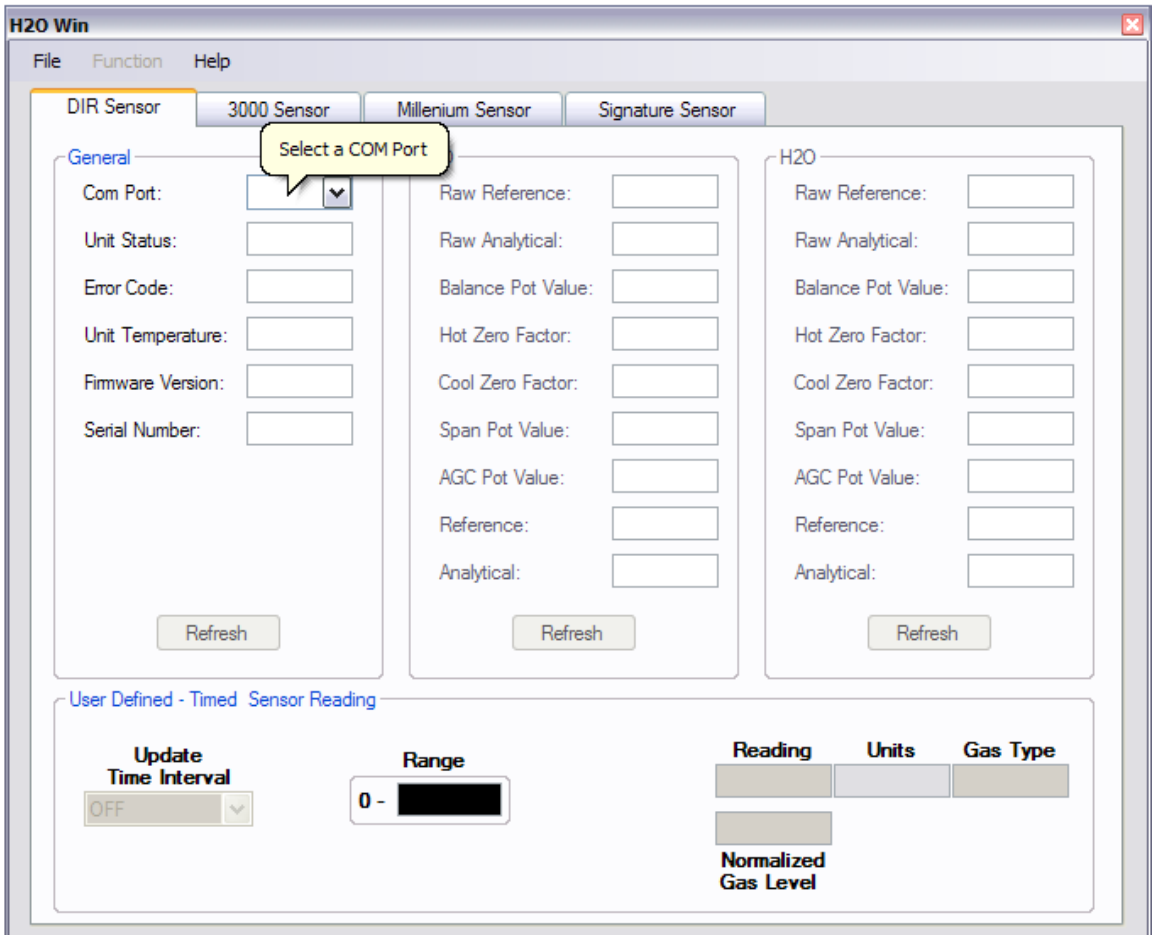
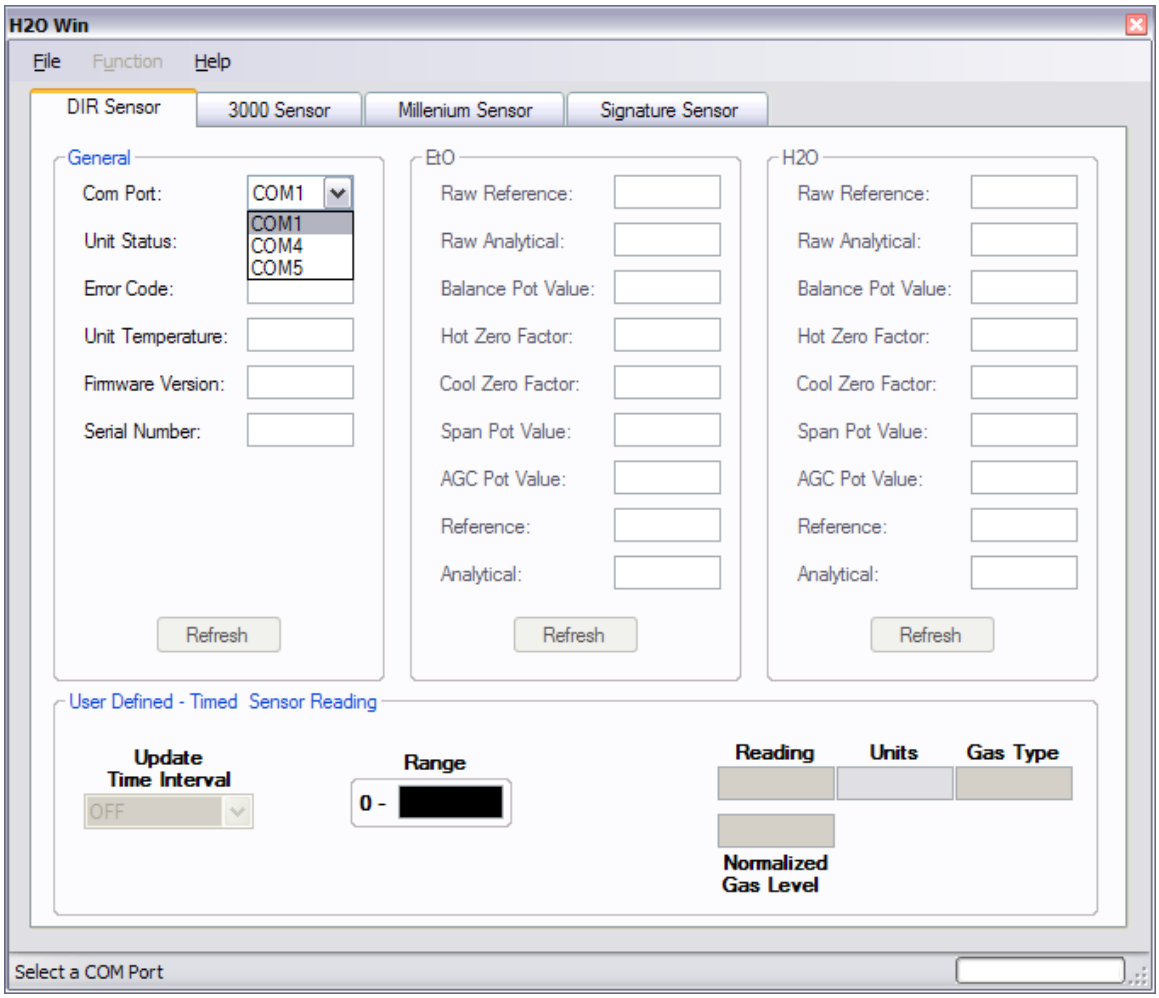


Current version of SEC software used with SEC Signature DIR. This software can be downloaded from the Sensor Electronics website. www.sensorelectronics.com
Note: The SEC H2O Win software requires Microsoft.Net to run. The download process will prompt the operator to download this software. Download the x86 version.

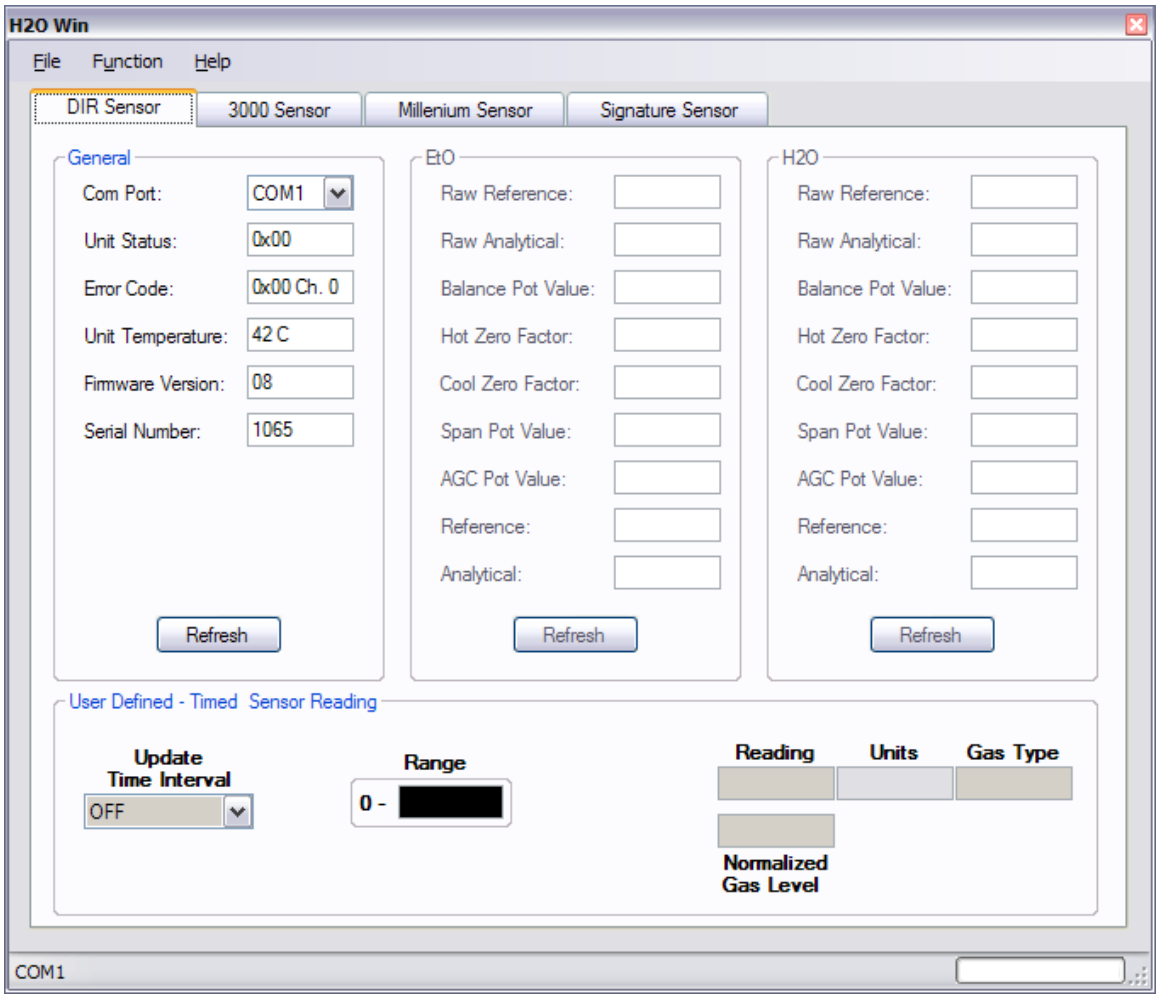
The software is used on a PC connected to an SEC PC IR Link Kit (PN 1420636) via a 9 pin serial (straight through) cable. The SEC Signature is wired to the SEC PC IR Link, if the SEC Signature DIR is powered from a different 24 VDC power supply (external to the PC IR Link) only the white (communication wire) and black (DC Common) wire need to be connected to the PC IR Link to communicate.



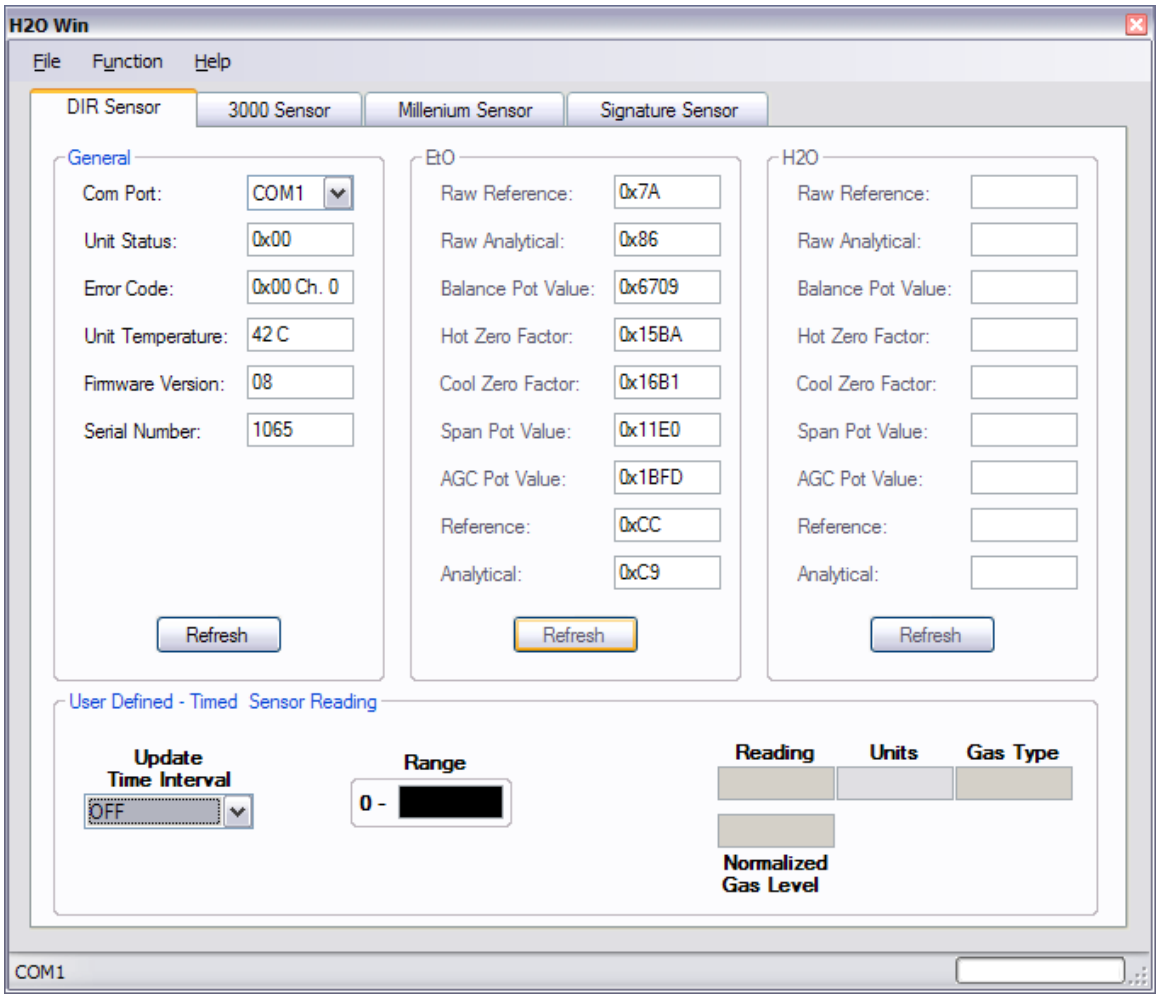
Select the communication port used on the PC. If the computer does not have a 9 pin serial port a USB to 9 pin serial adaptor can be used.



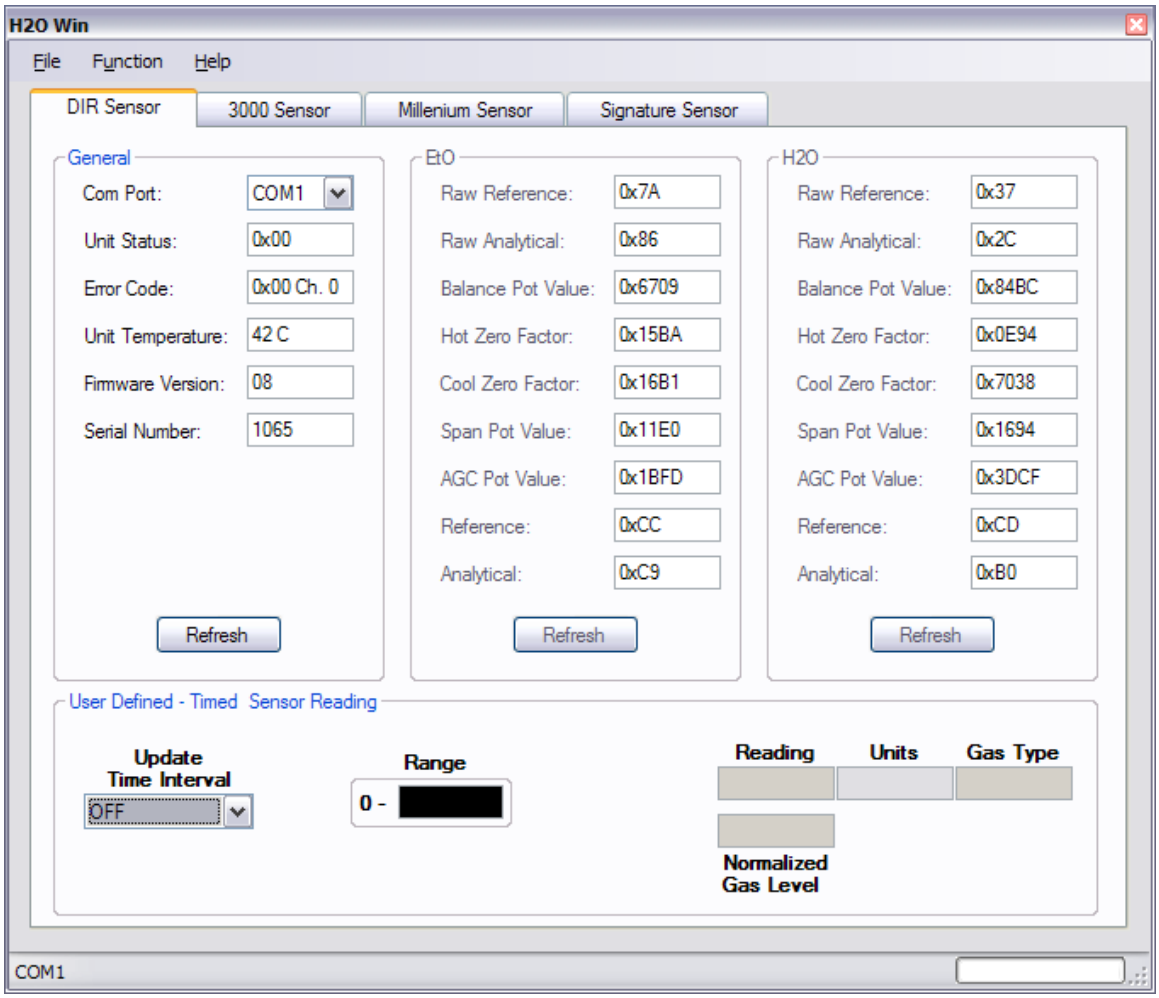
The software recognizes the available ports on the PC. Select the one to be used.



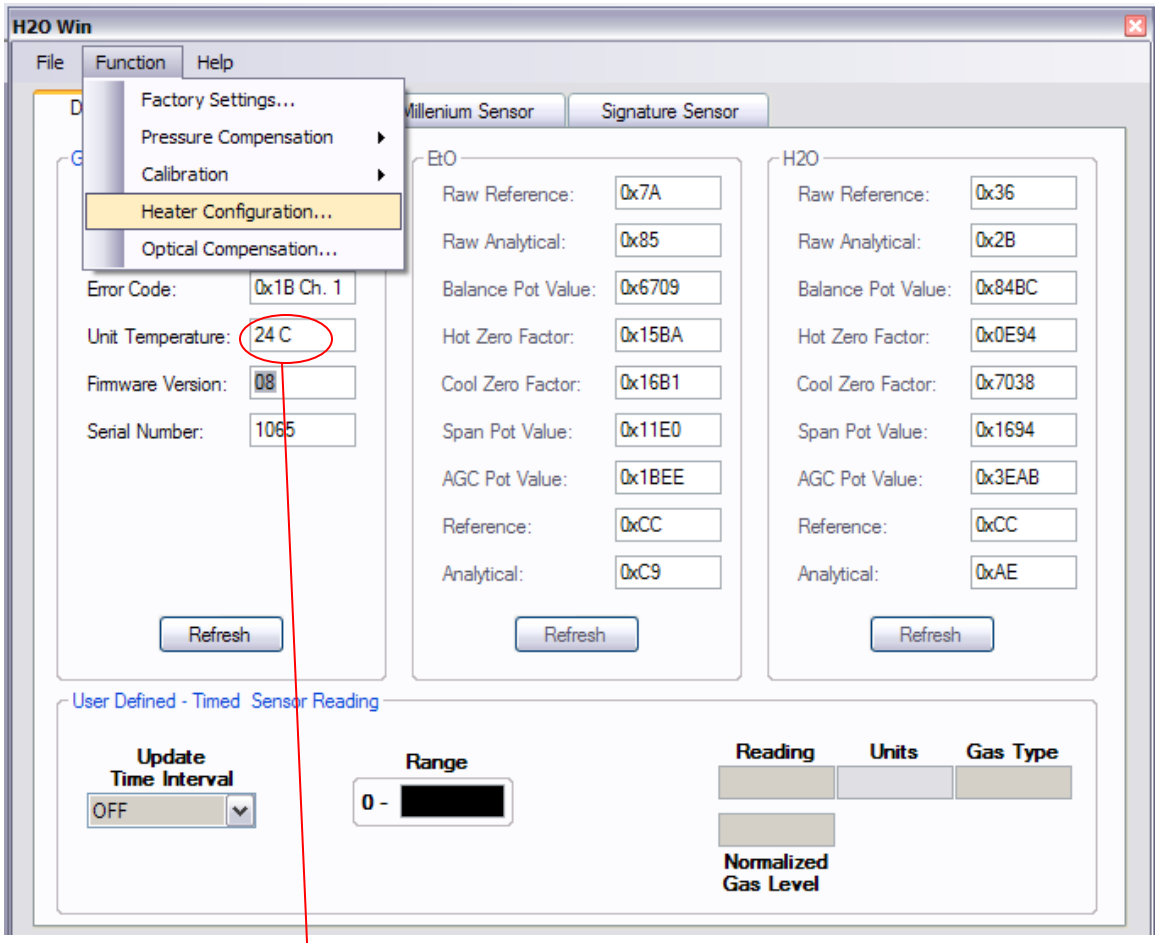
Once communication is established the “General” area is automatically updated. The General, EtO and H2O areas are all manually updated using the individual “Refresh” buttons.



Example of selecting Refresh EtO channel.



Example of selecting Refresh H2O channel.

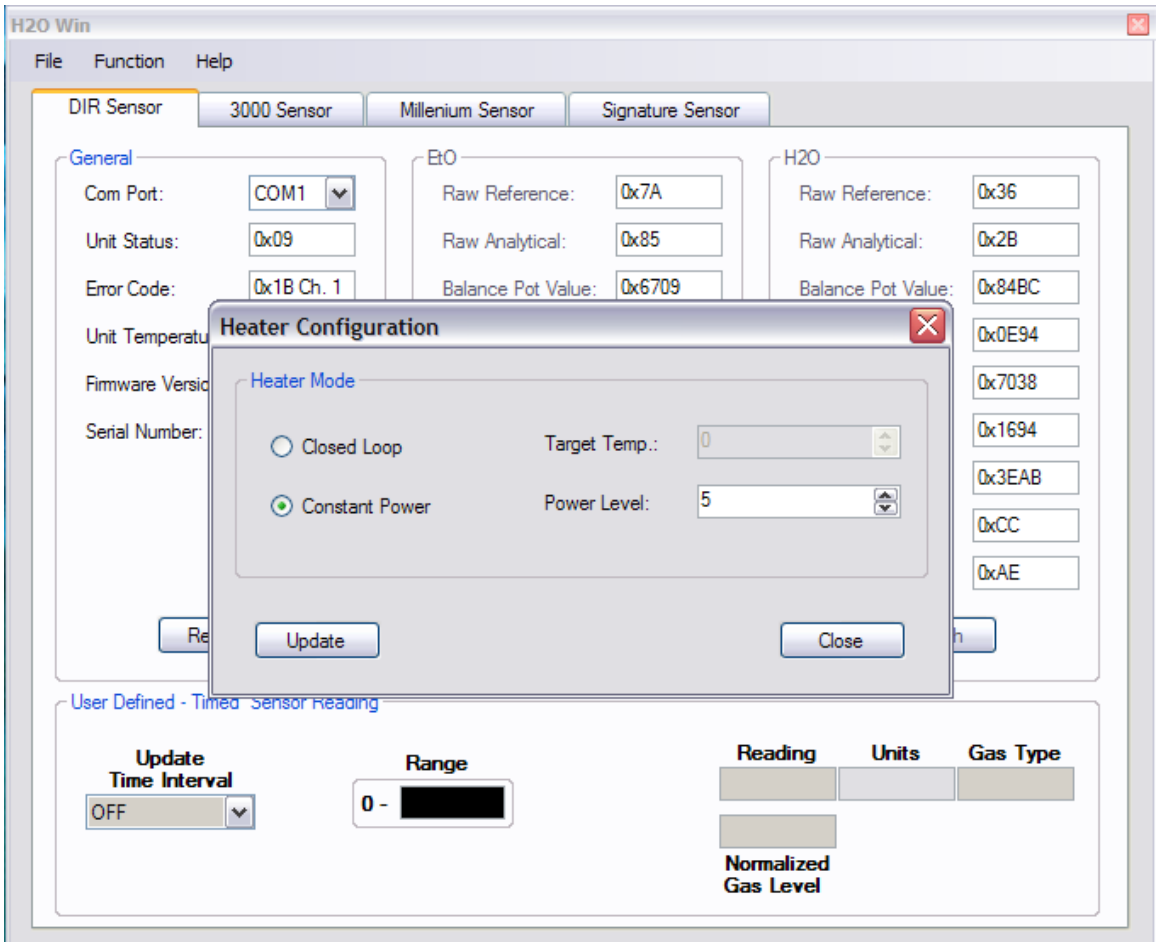


The Function tab will allow the operator to configure the SEC Signature DIR. When prompted for a password the password is:

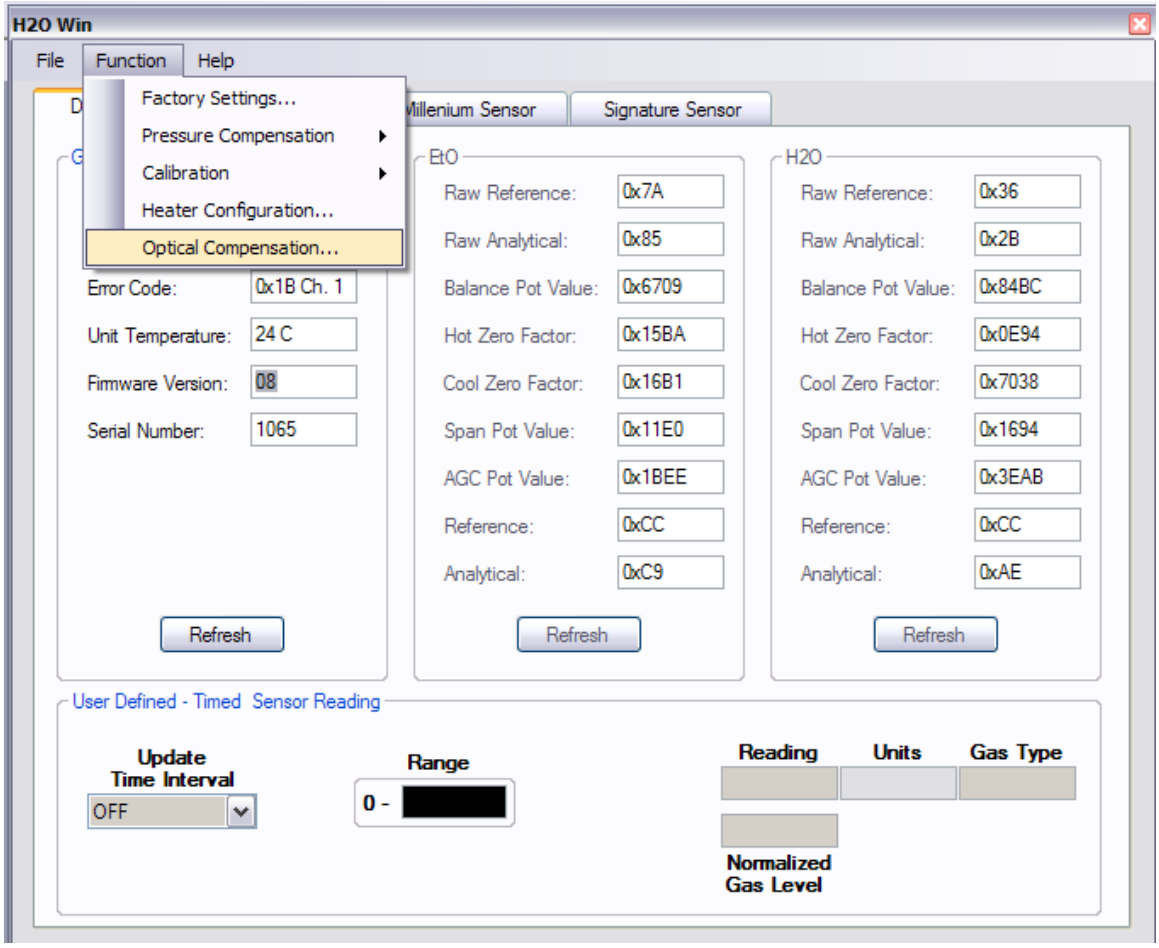
sec

First step is to configure the heater. The heater is configured by monitoring the SEC Signature DIR's temperature. The temperature should be a minimum of 5 degrees C above process temperature throughout the entire process cycle.

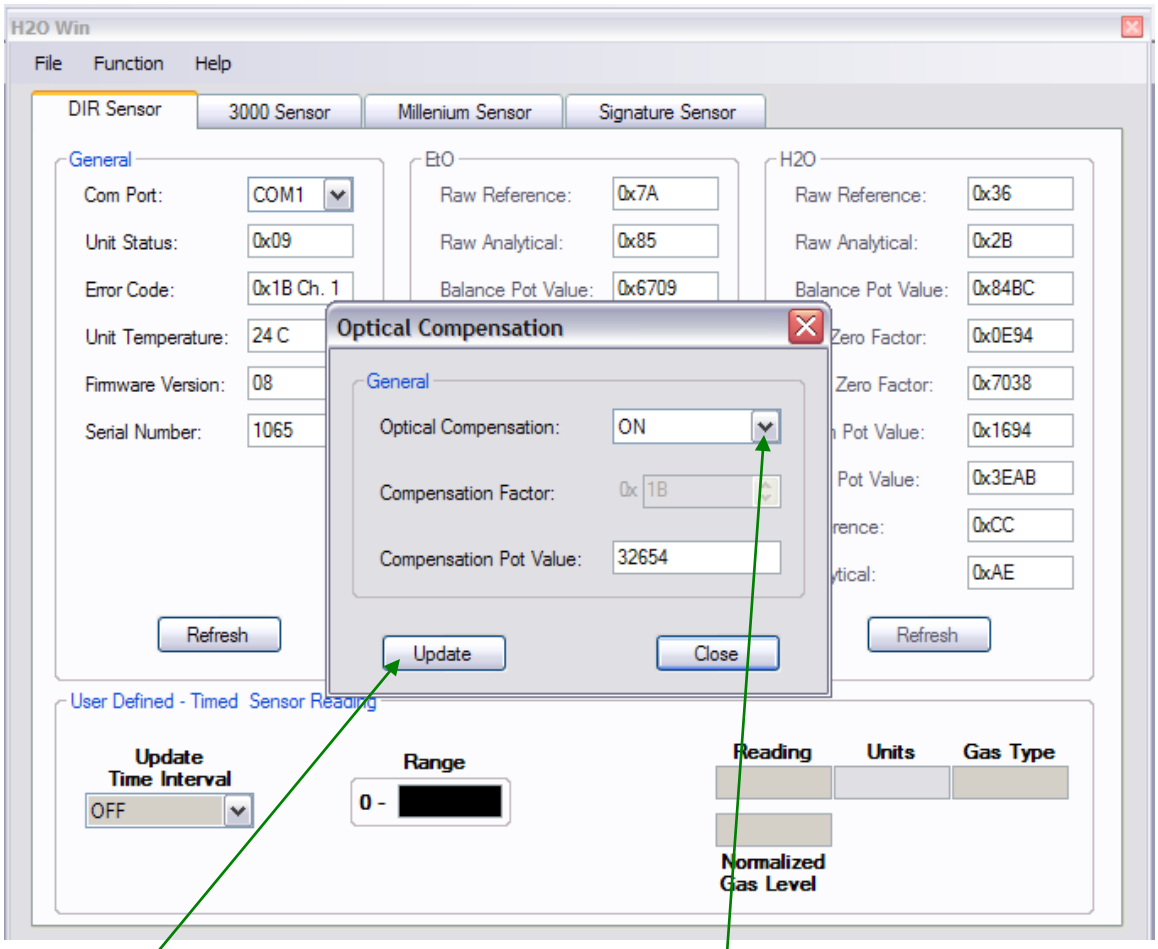
Insulating the SEC Signature DIR is recommended.



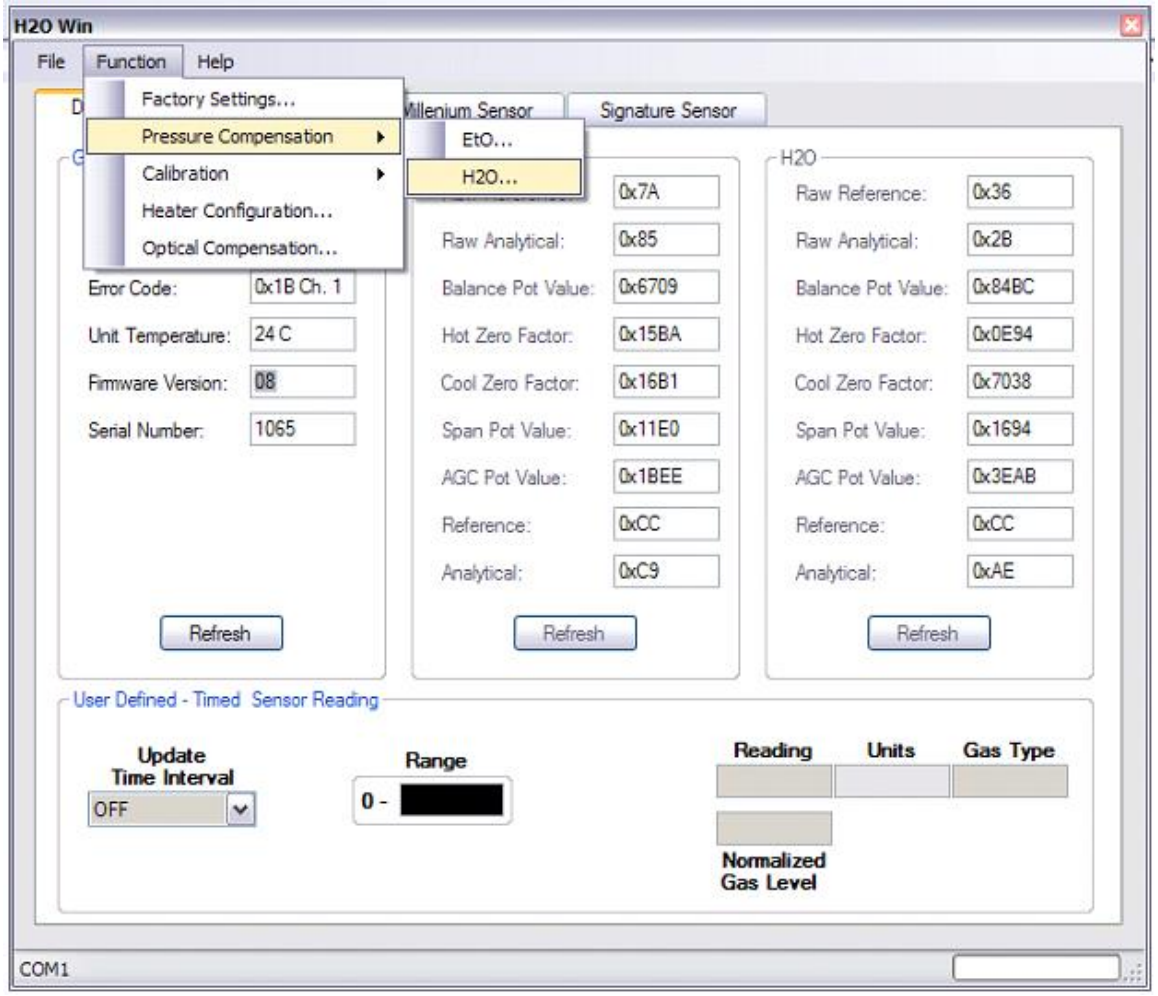
SEC recommends the SEC Signature be operated in the constant power mode. The SEC Signature DIR heat can be raised by increasing the Power Level number and lowered by decreasing the Power Level number. The Power Level number scale is 0-10. Once the number is changed, select Update to load the new number into the SEC Signature DIR.



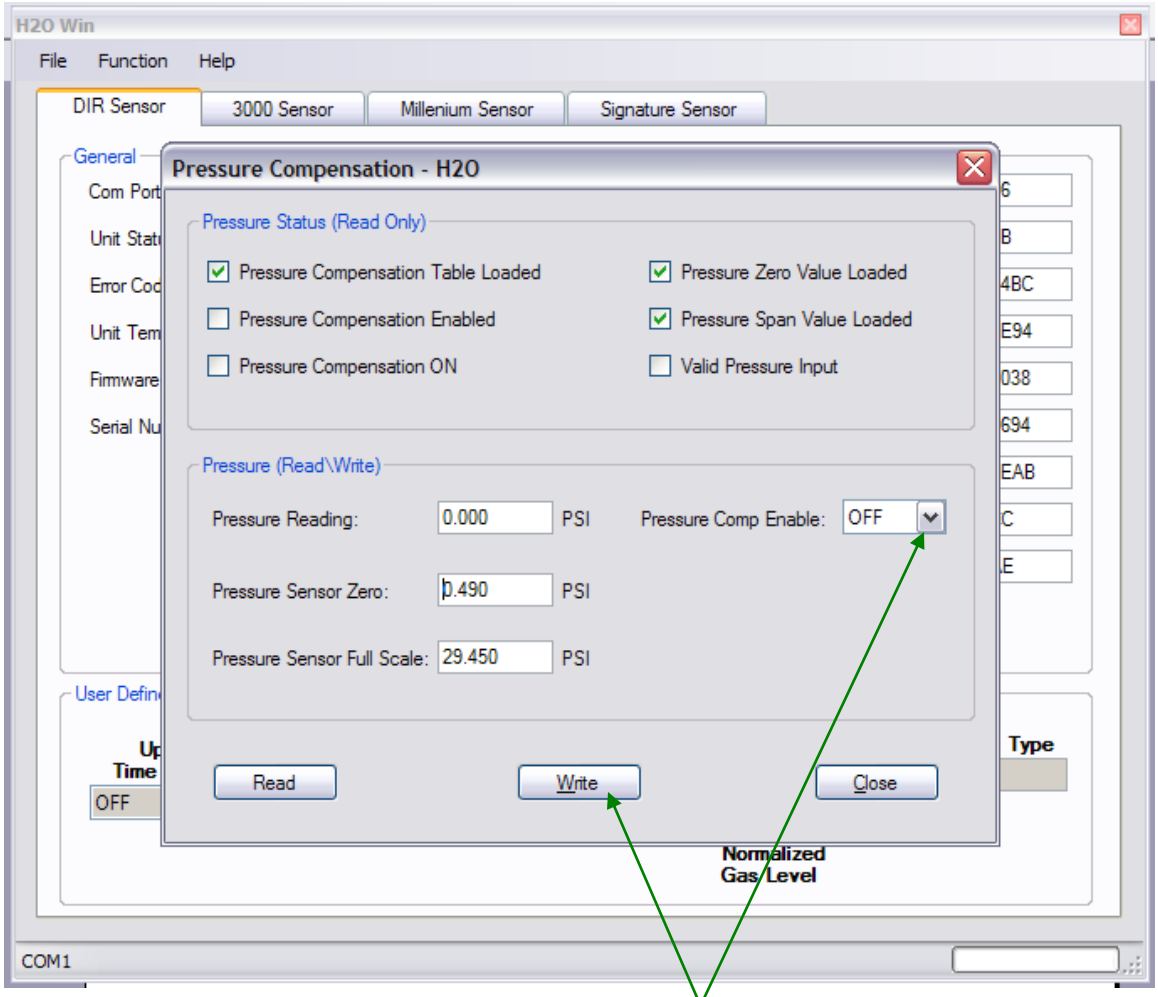
Optical Compensation is used to cancel any EtO response on the H2O channel.



The operator can turn the Optical Compensation ON or OFF. If a change is made, select Update to send the information to the SEC Signature DIR.

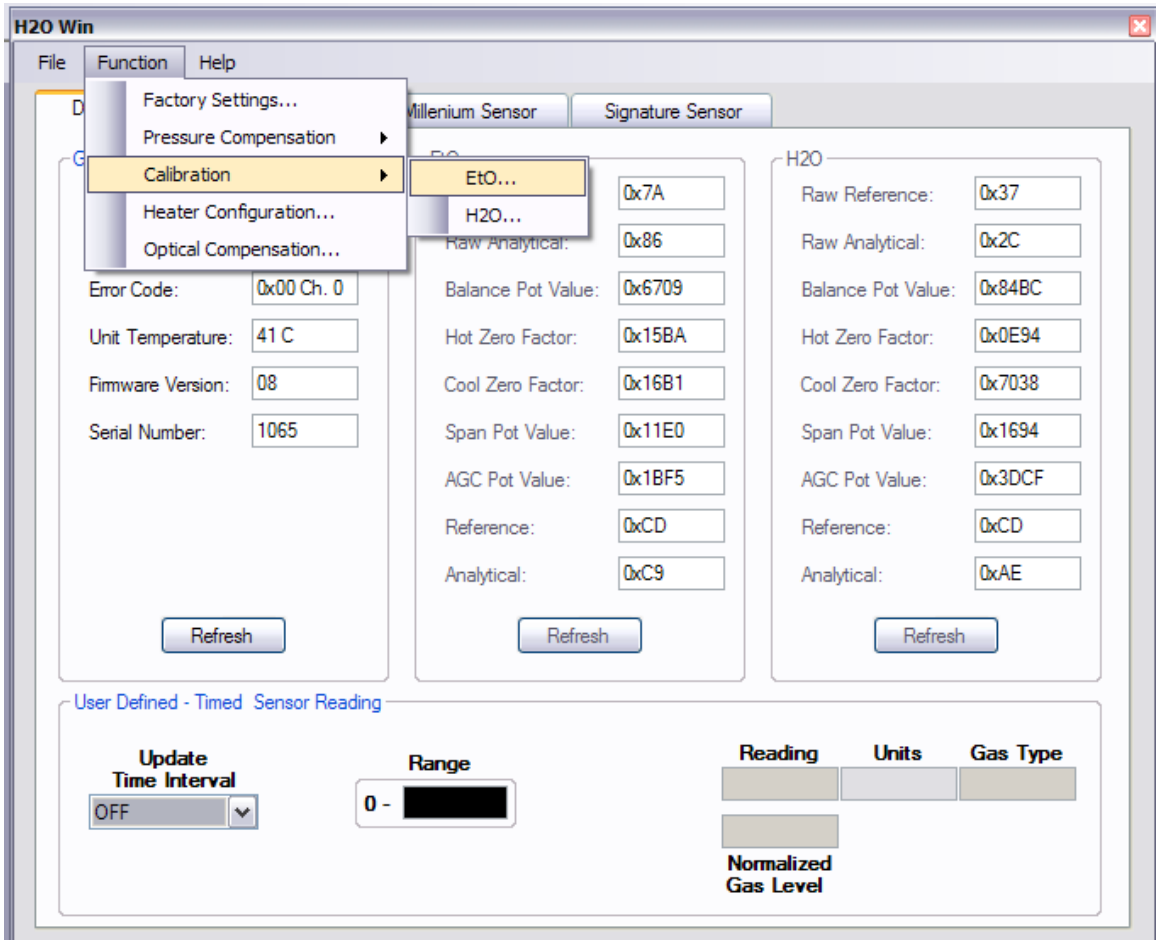


Pressure Compensation is used to cancel pressure effects on the H2O channel. If Pressure Compensation is disabled the SEC Signature DIR assumes all pressure rise in the chamber is due to water vapor. When other vapors such as nitrogen or EtO are injected into the chamber, there will be an effect on the H2O molecule absorption characteristics. If accurate H2O readings are recorded / required throughout the entire cycle, SEC recommends adding an absolute pressure transmitter to the SEC Signature DIR circuit and enabling the pressure compensation feature. Details can be found in the SEC Signature DIR Instruction Manual.



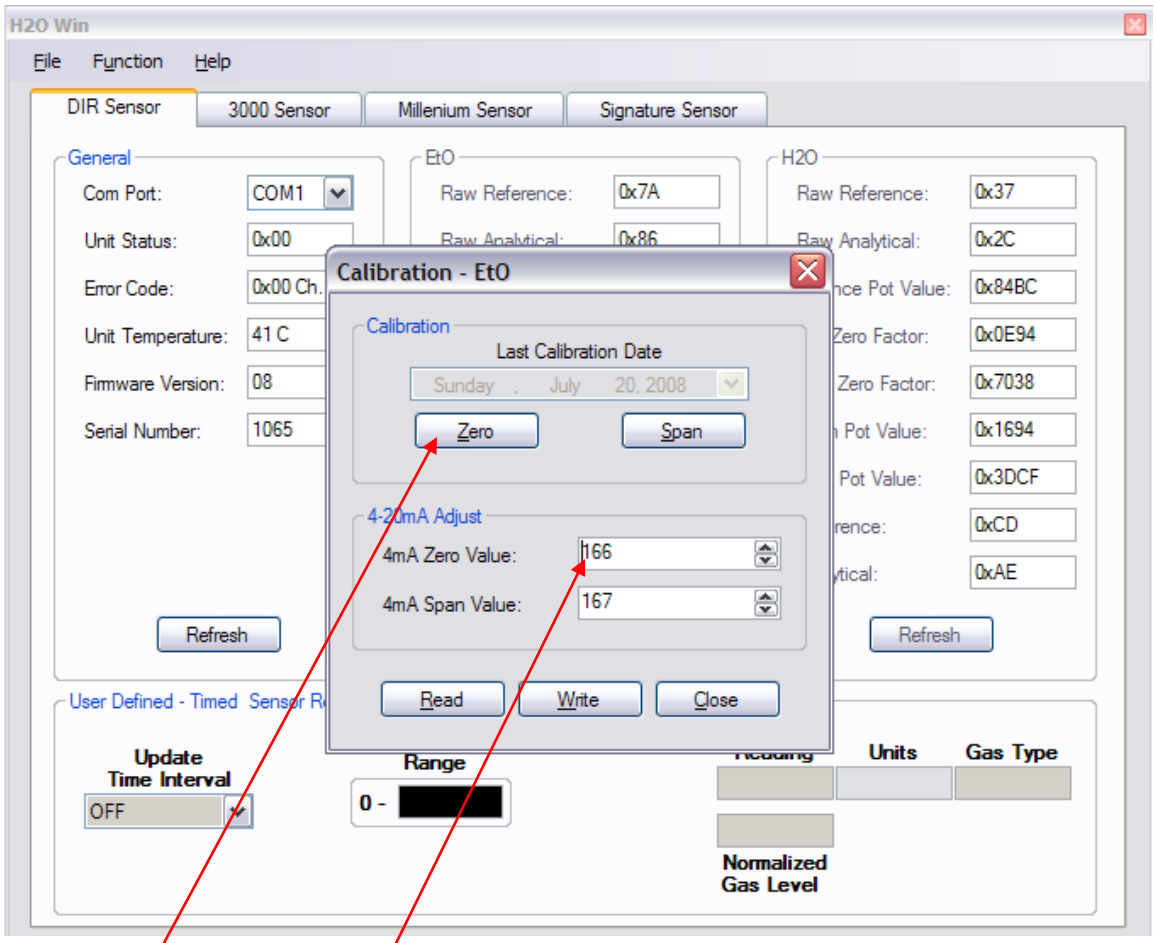
The page allows the operator to configure the pressure compensation features. The SEC Signature DIR only knows PSIA. If an absolute pressure transmitter with another measurement scale is used (inHg, bar, etc), the units must be converted to PSIA and input into the SEC Signature DIR as PSIA.

To turn the Pressure Compensation ON click the box and Write it to the SEC Signature DIR.



EtO channel Calibration

Note: If calibrating H2O channel with CO2 (20.5% volume), DISABLE both the Optical and Pressure Compensation before entering the calibration procedure. If calibrating the H2O channel with water vapor ENABLE both the Optical and Pressure Compensation if being used.



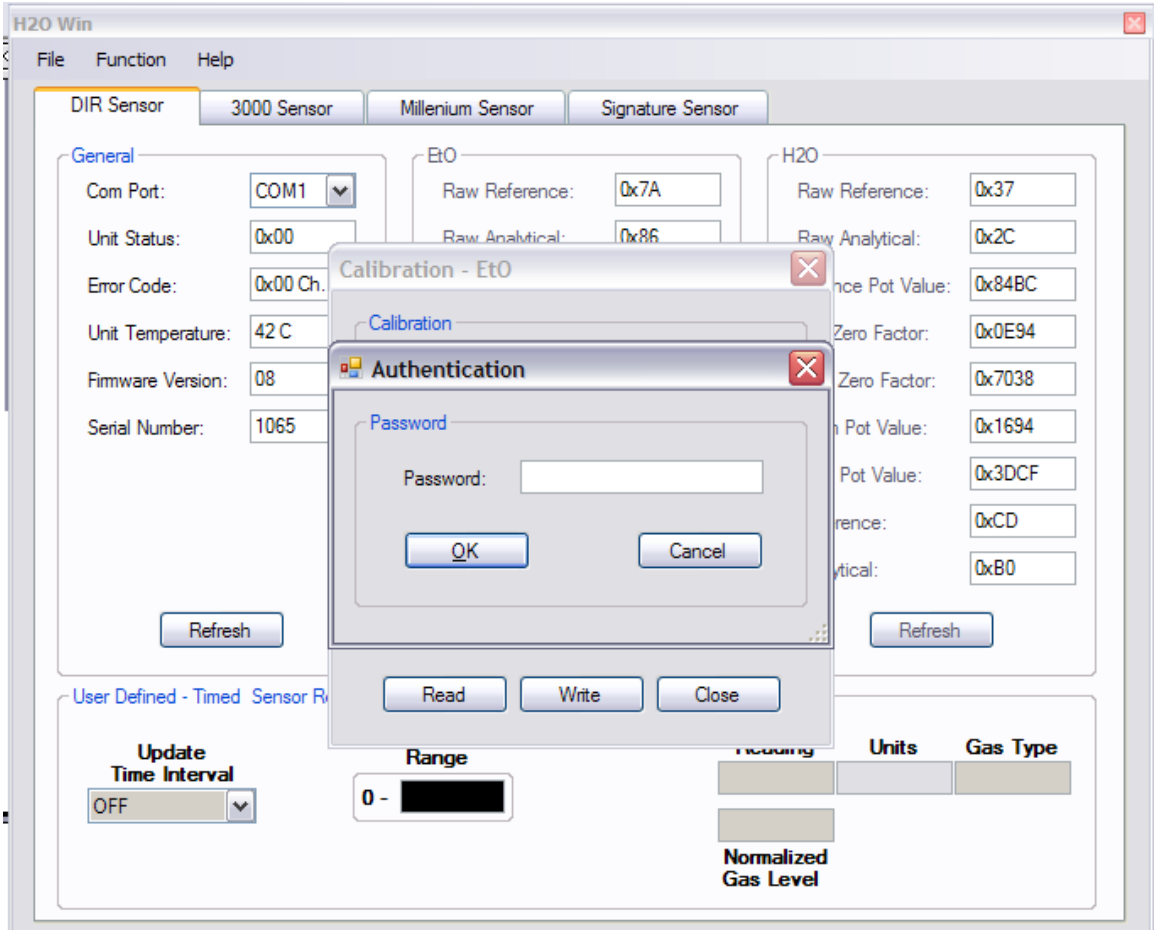
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 12mA) span current output value.

Zero

Apply 99.9% volume nitrogen to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Select Zero button and the Authentication box (example on next page) will appear requiring the operator to enter the password. Enter password select OK and the EtO channel is zeroed. The H2O channel can be zeroed at this time also. The operator will have to close out of the Calibration EtO box and enter the Calibration H2O menu.

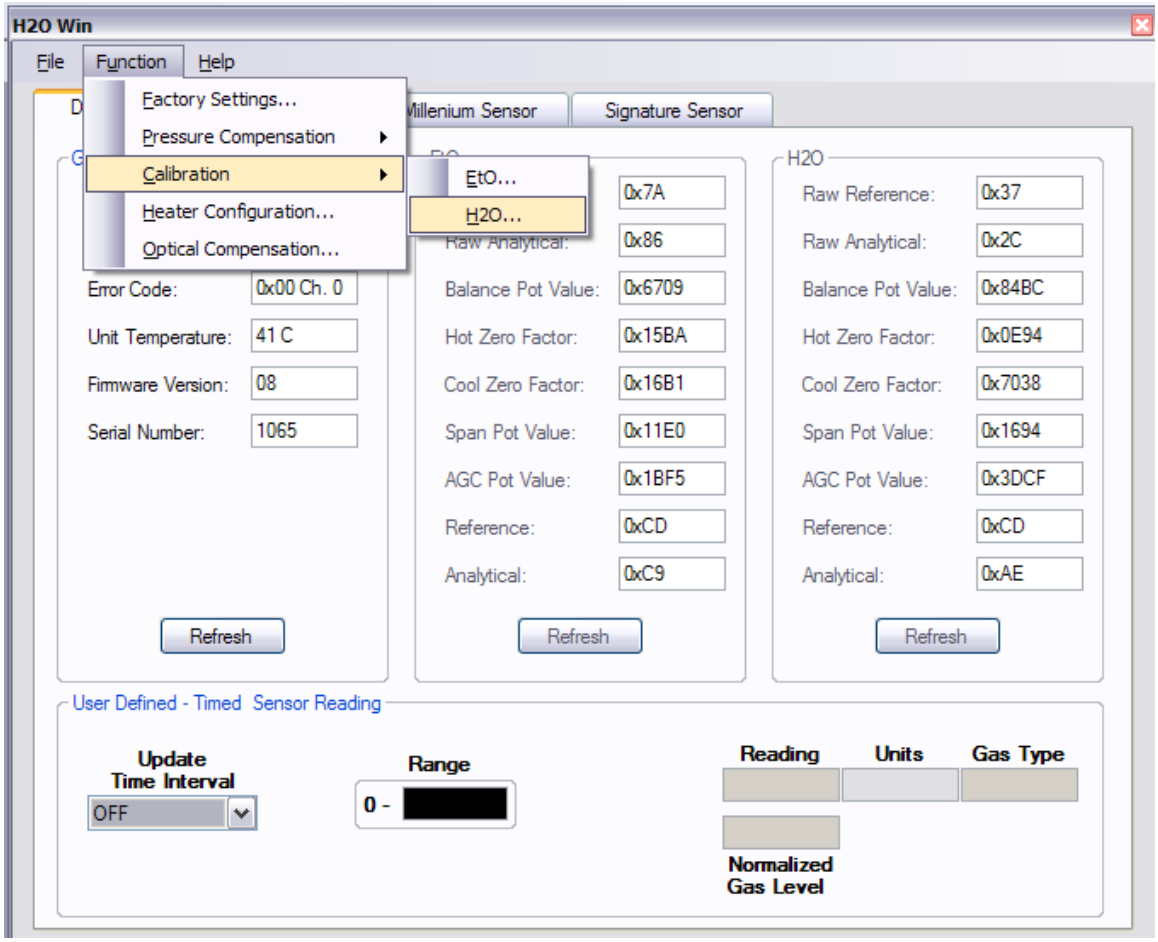
4mA Zero Value

Once the SEC Signature is zeroed, the operator can tweak the current output to read 4 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



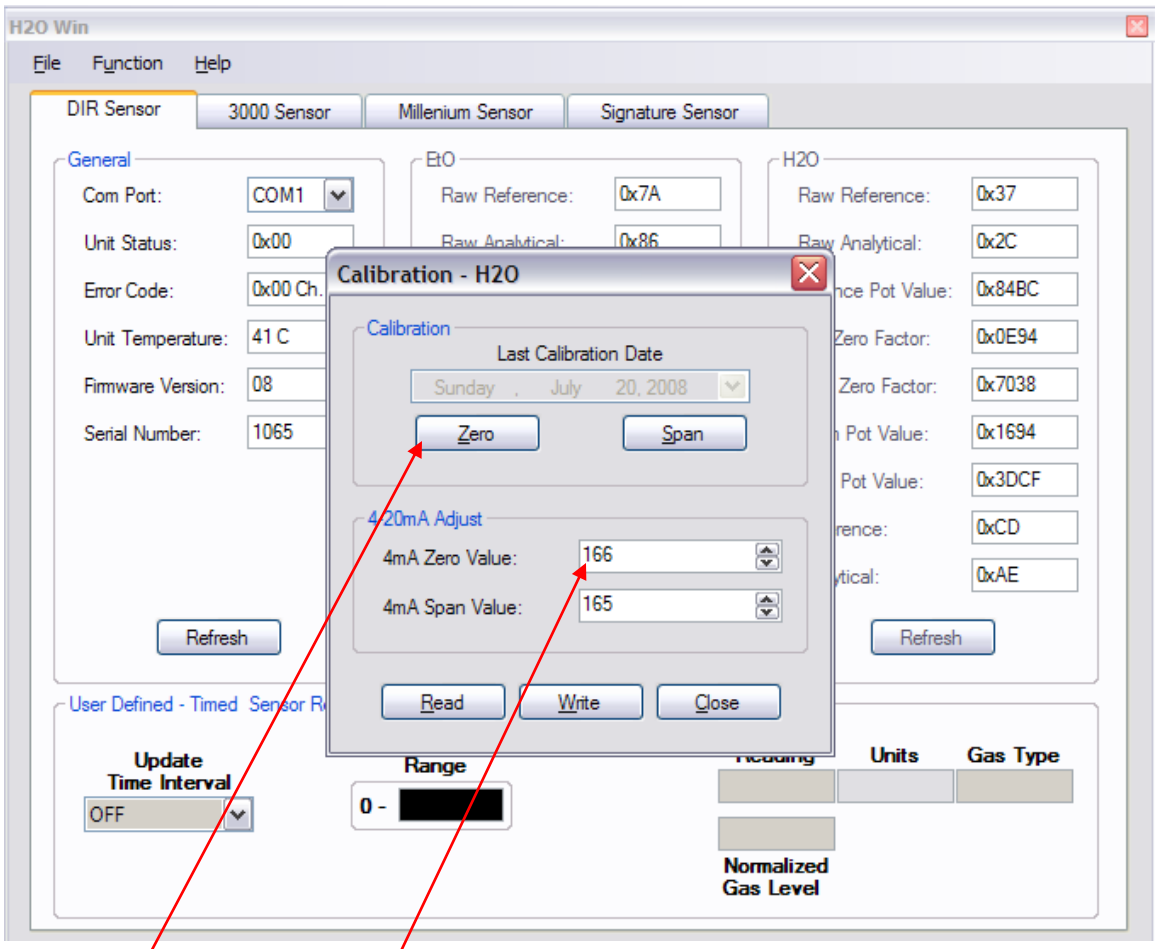
Password:

sec



H2O channel Calibration

Note: If calibrating H2O channel with CO2 (20.5% volume), DISABLE both the Optical and Pressure Compensation before entering the calibration procedure. If calibrating the H2O channel with water vapor ENABLE both the Optical and Pressure Compensation if being used.



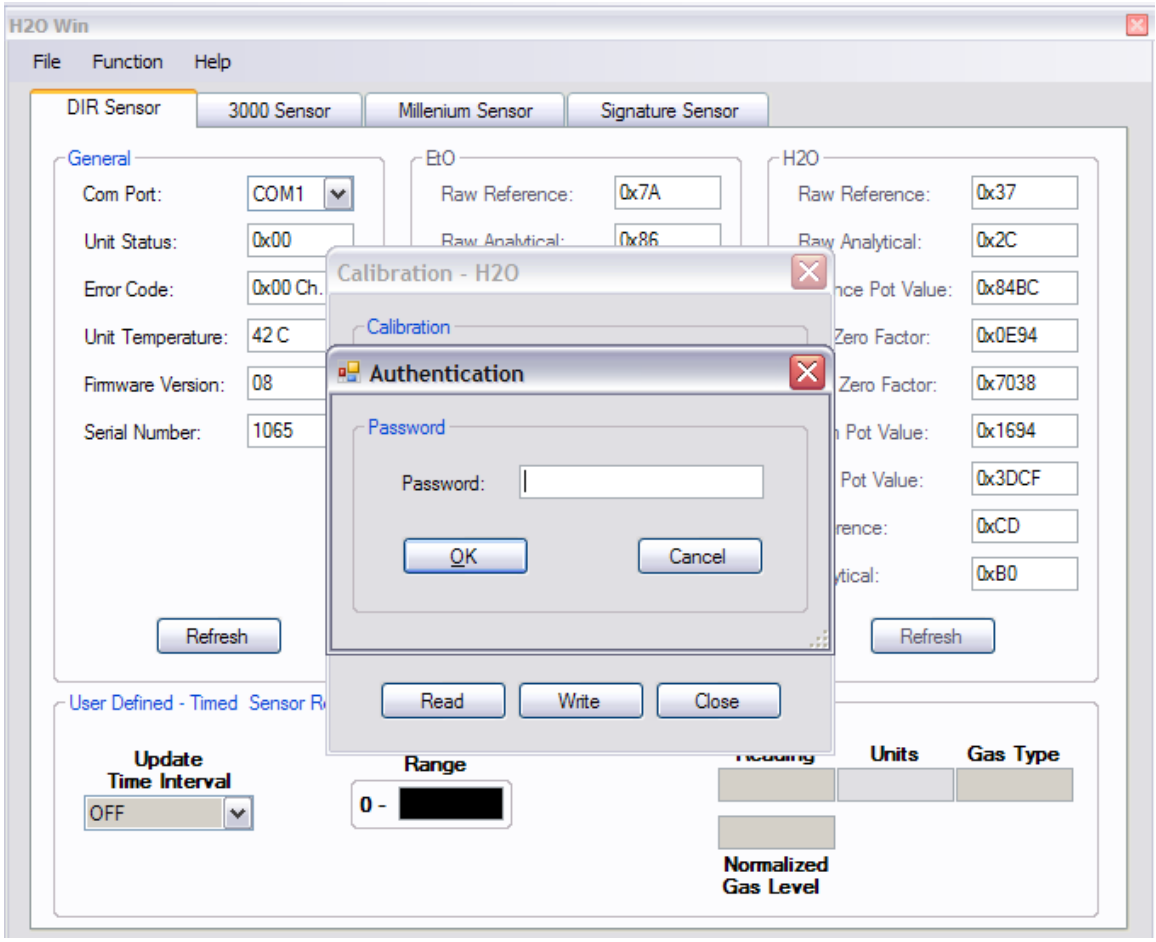
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 8mA) span current output value.

Zero

Apply 99.9% volume nitrogen to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Select Zero button and the Authentication box (example on next page) will appear requiring the operator to enter the password. Enter password select OK and the H2O channel is zeroed. The EtO channel can be zeroed at this time if it has not been done. The operator will have to close out of the Calibration H2O box and enter the Calibration EtO menu.

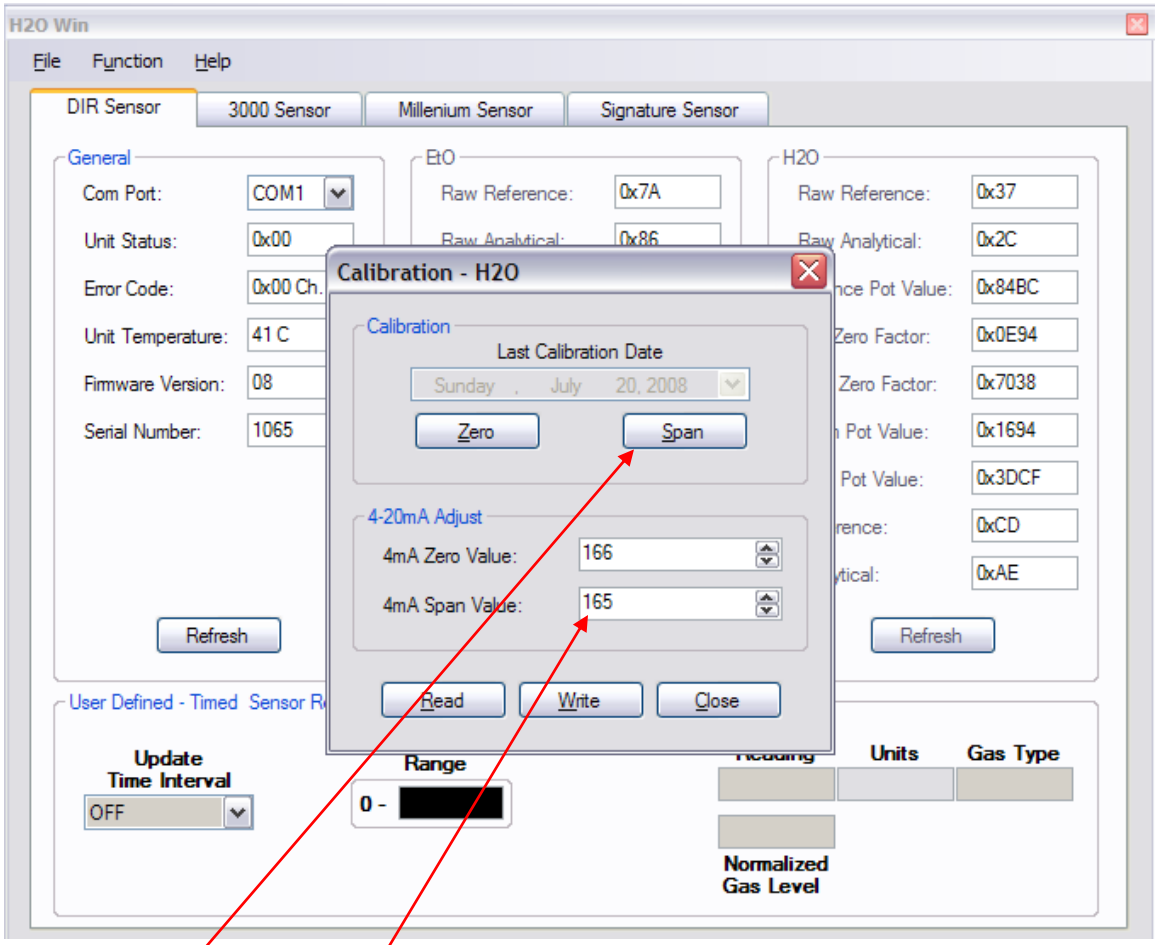
4mA Zero Value

Once the SEC Signature is zeroed, the operator can tweak the current output to read 4 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



Password:

sec



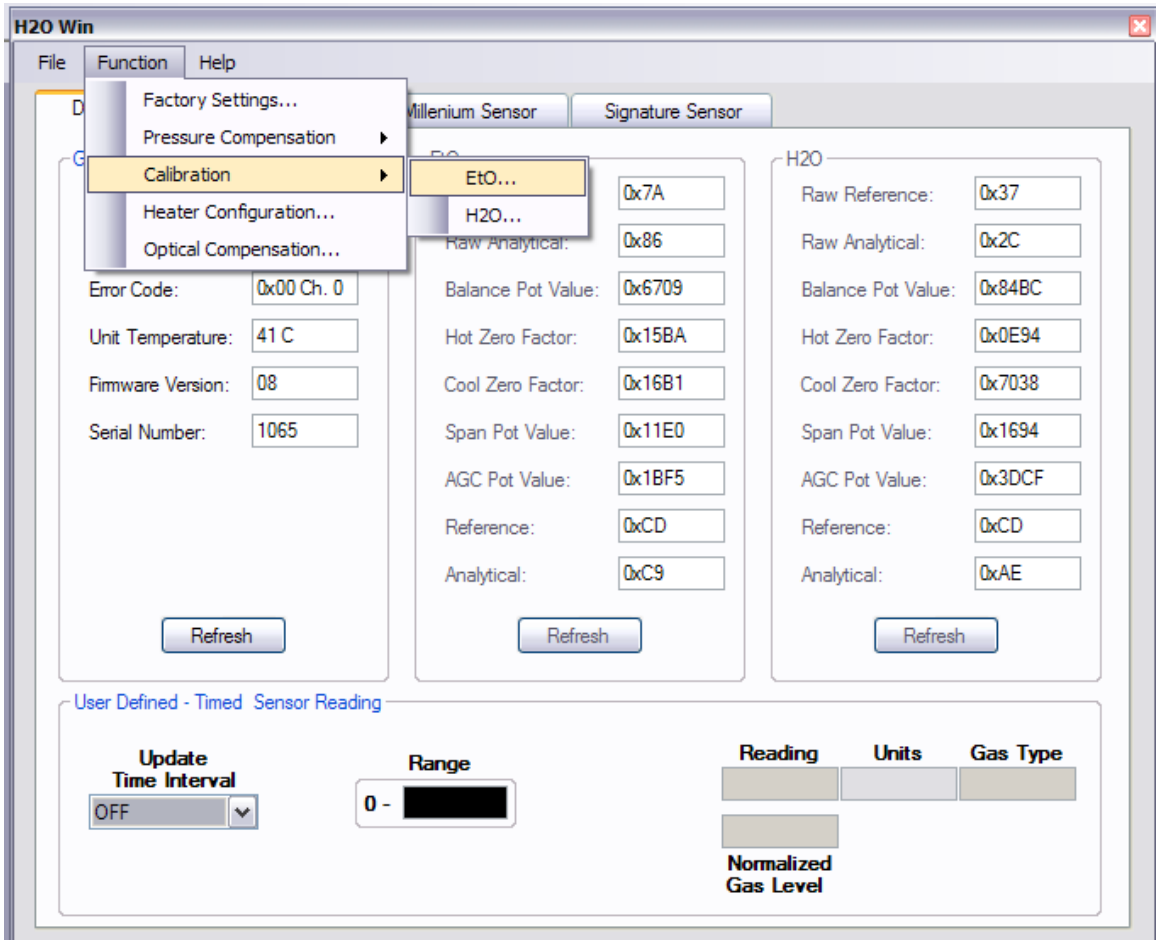
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 8mA) span current output value.

Span

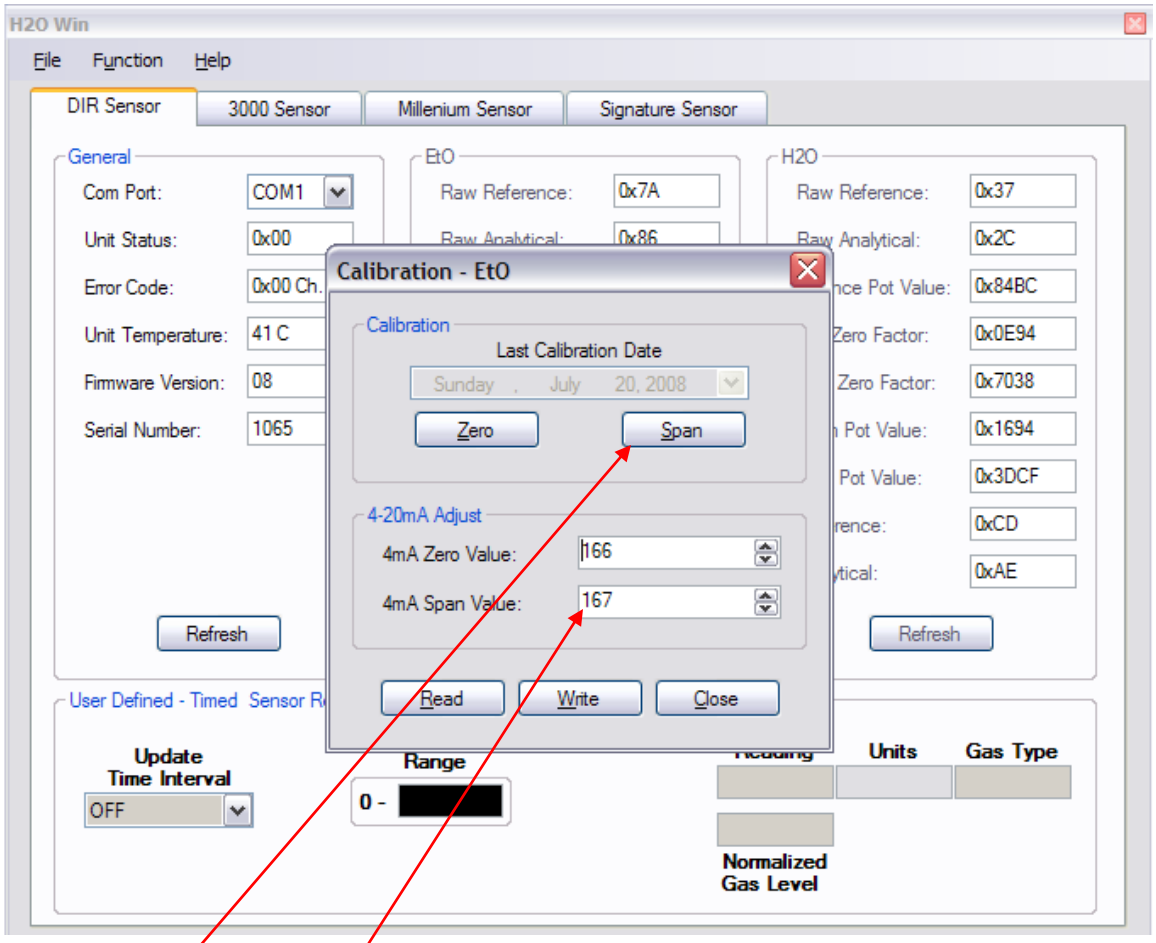
Apply 20.5% volume CO2 to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Allow the SEC Signature DIR to stabilize. Select Span button and the Authentication box will appear requiring the operator to enter the password. Enter password select OK and the H2O channel is spanned.

4mA Span Value

Once the SEC Signature is spanned, the operator can tweak the current output to read 8 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



The final step is to span the EtO channel.



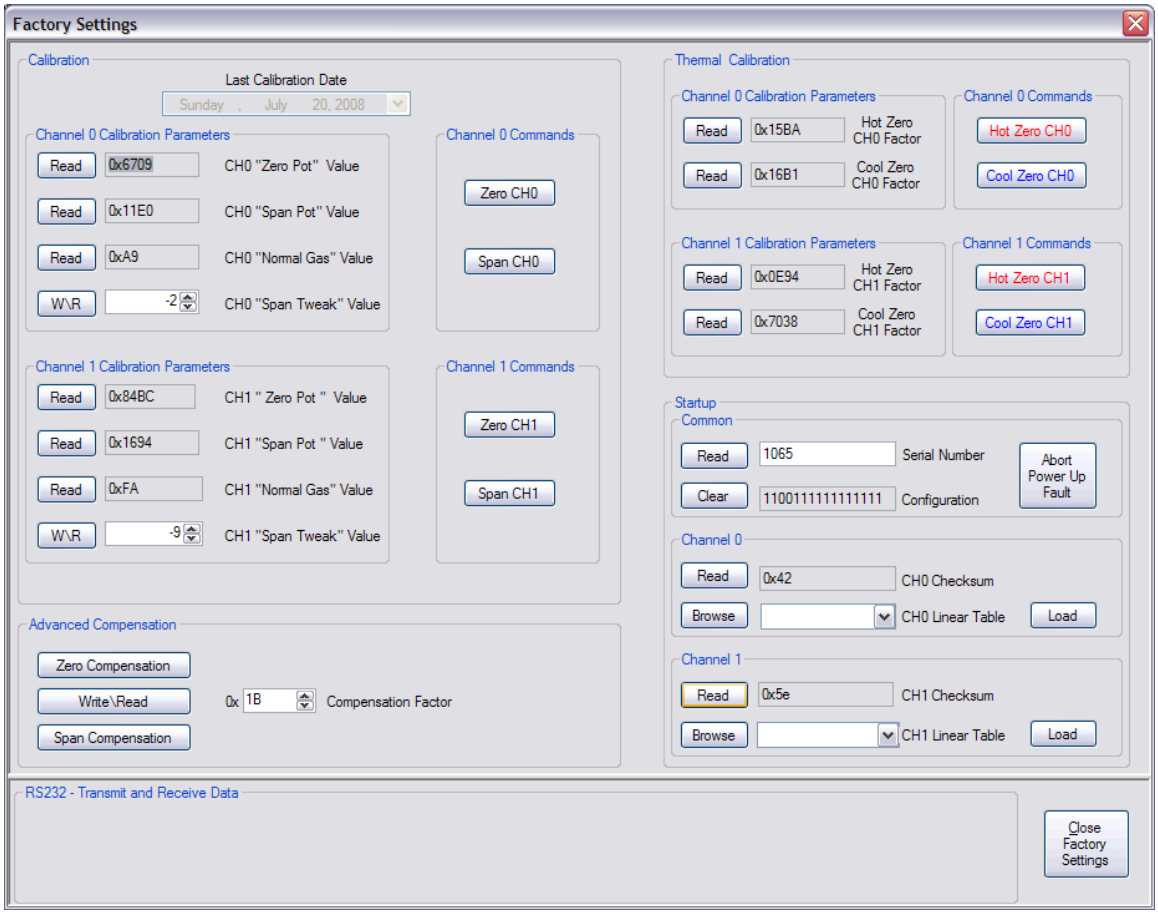
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 12mA) span current output value.

Span

Charge the chamber with EtO to 50% full scale. Allow the SEC Signature DIR to stabilize (approximately 15 minutes into EtO dwell. Select Span button and the Authentication box will appear requiring the operator to enter the password. Enter password select OK and the EtO channel is spanned.

4mA Span Value

Once the SEC Signature is spanned, the operator can tweak the current output to read 12 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



This page can only be reached with a special password. Only factory trained operators have access to this page.

SEC *Signature DIR* Process Monitor

Instruction and Operation Manual

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Part Number 71-3001 Version 011008

Sensor Electronics Corporation

Sensor Electronics Corporation (SEC) is an innovative manufacturer of fixed system gas detection equipment, for combustible gases, oxygen and toxic gases.

Commitment

Our quality and service are uncompromising. We back each of our products with a two-year warranty on all materials and workmanship. We offer technical support, user training and on-site service and maintenance of equipment to meet the needs of our customers.

Gas Detection Service

Individually designed maintenance packages are available for specific customer needs. Service begins with verification of the system installation that includes an initial system check and calibration. We then offer customer training programs (on-site and at factory) to insure that technical personnel fully understand operation and maintenance procedures. When on-the-spot assistance is required, service representatives are available to handle any questions or problems immediately.

Warranty

Sensor Electronics Corporation (SEC) warrants products manufactured by SEC to be free from defects in workmanship and materials for a period of two (2) years from date of shipment from the factory. Any parts returned freight pre-paid to the factory and found defective within the warranty will be repaired or replaced, at SEC's option. SEC will return repaired or replaced equipment pre-paid lowest cost freight. This warranty does not apply to items which by their nature are subject to deterioration or consumption in normal service. Such items may include:
Fuses and Batteries.
Warranty is voided by abuse including rough handling, mechanical damage, alteration or repair. This warranty covers the full extent of SEC liability and SEC is not responsible for removal, replacement costs, local repair costs, transportation costs or contingent expenses incurred without prior written approval. Sensor Electronics Corporation's obligation under this warranty shall be limited to repair or replacement of any product that has been returned to Sensor Electronics Corporation for warranty consideration. This warranty is expressly in lieu of any and all other warranties expressed or implied, and all other obligations or liabilities on the part of Sensor Electronics Corporation including but not limited to, the fitness for a particular purpose. In no event shall Sensor Electronics Corporation be liable for direct, incidental, or consequential loss or damage of any kind connected with the use of it's products or failure to function or operate properly.

Year 2000 Compliance

All Sensor Electronics products have been tested and are certified by Sensor Electronics to accurately process date/time and date/time related data from, into and between the 20^{th} and 21^{st} centuries. Sensor Electronics products neither contain nor create any logical or mathematical inconsistency, will not malfunction, and will not cease to function when processing date/time data.
Please contact Sensor Electronics for further information.

Table of Contents

I. SPECIFICATIONS

Model: SEC Signature DIR **Part Number:** DIR011021000000

Measuring Range: EtO Channel**:** 0-2000 milligrams/liter (maximum)
Factory calibrated to 0-1000 mg/l EtO
H2O Channel: 0-500 milligrams/liter (maximum)
Factory calibrated to 0-300mg/l H2O

Detection Method: Diffusion

Construction: Housing is anodized aluminum with sapphire optical windows.

Rating: CSA: Class 1, Division 1, Groups BCD

Accuracy: +/- 5% measured value or +/- 3% full scale (whichever greater)

Repeatability: +/- 3%

Operating Temperature Rating: +0°C to +75°C (maximum)
+32°F to +167°F (maximum)

Operating Voltage: 24 VDC. Operating range 18 to 32 VDC measured at the detector head.

Outputs (analog): 4-20 mA (Source type), max. 1000 Ohm load at 24 VDC supply voltage.

Output (digital): Interactive PC Link

Power Consumption at 24 VDC: 35 watts (Max)

Current Draw at 24 VDC: 1A (average)

Mechanical connection to sterilizer: ¾" NPT male

Electrical connection: ¾" NPT male

Weight: 30 ounces

Wire Connections:
Red wire (+ 24 VDC)
Black wire (D.C. common)
Blue wire (4-20 output EtO)
Yellow Wire (4-20mA output H2O)
White wire (Calibration / digital interface)
Brown wire (Pressure Input 4-20mA)

II. GENERAL DESCRIPTION

The SEC Signature DIR Process monitor is a microprocessor based intelligent device that continuously and simultaneously monitors levels of EtO and H2O in sterilization chambers.

The SEC Signature DIR Process monitor is a stand-alone device providing a dedicated 4-20 mA signal corresponding to actual concentrations of ethylene oxide and a dedicated 4-20mA signal corresponding to the actual concentration of H2O.

Features

- Programmable Heater operates in Relative or Closed Loop Mode.
- Continuous self-test automatically indicates a fault, with fail to safe operation.
- A multi-layered filtering system protects optics from dirt and water ingress.
- Straight optical path eliminates the need for mirrors, reflective surfaces or beam splitters thereby increasing the stability and reducing the maintenance of the device.
- Discourages condensation interference by internally heating optical chamber.
- Standard 4 to 20 mA outputs (current sources).
- Explosion proof housing designed for duty in harsh environments.
- Smart Calibration AutoAC™ circuit.

Theory of Operation

The SEC Signature DIR Process monitor uses infrared absorption technology for detecting target gas concentrations. Gases absorb infrared light only at certain wavelengths. The concentration of a gas can be measured by the difference of two channels (wavelengths), a reference and a measurement channel. The SEC Signature DIR Process monitor uses an infrared light source at one end and a dual channel receiver at the opposite end. The dual channel receiver measures the intensity of two specific wavelengths, one at an absorption wavelength and another outside of the absorption wavelength. The gas concentration is determined by a comparison of these two values.

The multi channel receivers incorporate single wafer double filter technology with internal optical barriers. The elements are perfectly matched resulting in overall stability and superior performance throughout the entire temperature range. By using this multi channel receiver there is no need to use any special lenses or beam splitters to achieve the dual measurement bands.

The SEC Signature DIR Process monitor utilizes a unique Automatic Analog Control circuit, the AutoAC™ circuit (Patent Pending). The AutoAC™ continuously makes adjustments to null out effects from temperature, component drift, dirty optics, interferents and aging. These adjustments are made according to algorithms derived from infrared gas absorption theory. The AutoAC™ circuit is continuously checking all unit operating parameters. If any parameter goes out of tolerance, the AutoAC™ circuit sets a fault code appropriate to the problem. The AutoAC™ circuit ensures that once the unit is spanned, it will remain accurate as long as the zero is accurate. Simply calibrate (span one time) the unit with a specific amount of gas and the device will repeatable track the gas concentrations in the chamber throughout the entire load cycle. The only ongoing calibration that is necessary is an occasional zero.

The optical absorption efficiency of water vapor is a function of the chamber pressure. Higher chamber pressures cause more absorption resulting in higher signal levels.
The H2O channel is designed to be accurate with pressure rise due to the vapor pressure of the H2O in the chamber.
Pressure rise due to N2 EtO injections will cause higher H2O readings. Therefore, the H2O signal will be accurate as long as the chamber contains only water vapor.

If accurate readings are required throughout the entire cycle, pressure compensation will be necessary. Pressure compensation is achieved by adding the pressure compensation option and using a dedicated absolute pressure sensor mounted close to the sensor. The 4-20mA output from the pressure sensor is connected to the sensor's pressure input wire.

III. INSTALLATION

Mechanical

The SEC Signature DIR Process monitor has a ¾" male NPT threaded connector for installing the device on the sterilizer. Ideally the device can be installed on the recirculation line (see Figure 4). The device is vacuum tested at the factory to 1 inches of mercury absolute and pressure tested to 40 psi.

Electrical

The SEC Signature DIR Process monitor has a ¾" male NPT threaded connector (with 4 wires) for mounting the detector to a junction box. SEC can provide a junction box for this purpose with terminals (see Figure 5).

A user-supplied junction box can also be used, providing it has the appropriate sized NPT conduit entries. This junction box must be suitable for use in the application and location in which it is being installed.

Wiring connections

Red wire:	18 to 32 VDC
Black wire:	DC negative (common)
Blue wire:	4 to 20 mA output EtO
Yellow wire:	4 to 20 mA output H2O
White wire:	Smart Calibration Wire (data wire)
Brown wire:	Pressure Input (4-20mA)

Refer to Figures 2 and 3 for general wiring details.

Insulator

The SEC DIR Signature internal temperature should be at least 6º C warmer than the process temperature. Temperature rise can be adjusted by adjusting heater level. *The internal temperature of the Signature DIR can be adjusted and monitored using the SEC IR PC LINK software package.* If more temperature rise is needed with heater at full power, it may be necessary to insulate sensor.

IV. OPERATION

Warm-up

When power is applied to the detector, it enters a one (1) minute warm-up mode in which time it performs diagnostic checks and allows the sensor to stabilize before beginning normal operation. The current output during this period is 0.8 milliamperes. At the end of the warm-up period with no faults present, the detector automatically enters the normal operating mode. If a fault is present after warm-up, the detector current output will indicate the fault (see chart above).

Normal

In the normal operating mode, the 4 to 20 mA signal levels correspond to the detected gas concentrations. The device continuously performs self diagnostics, checks for calibration requests and displays operating status (see table).

Calibration

Calibration operations and Parameter download are accomplished via the Sensor's white wire.
White wire is connected to Data Translator (SEC IR PC Link P/N 1420636)
Data Translator is connected to PC via serial port. Operating from USB port requires a USB to serial converter.
Commands are issued from PC (Software Package Supplied by SEC)
The software is compatible with most versions of Microsoft® Windows®
Note: For best accuracy, the unit should be powered up for at least 1 hour before any calibration operation.

Zeroing

EtO (Channel 0)

Zeroing should be performed:

When unit is installed on chamber
If Sensor doesn't return to zero between cycles
If Sensor shows abnormally high or low concentration readings during EtO exposure.
Annually (more often if the load material is dusty or oily)

Procedure:

After chamber evacuation, water injection and dwell:
Move cursor to "Zero EtO Channel" using "Up/Down" arrows
<enter>
Zero Channel 0 ? (Y/N)
<Y><enter> will initiate Zero Operation
The EtO output goes to 2.2mA while Zeroing.
A successful Zero will result in 4.0mA
An unsuccessful Zero will result in a 4-20mA fault level. (<4mA) See Status table.

H2O (Channel 1)

Zeroing should be performed:

When unit is installed on chamber.
If sensor shows abnormally high or low concentration readings during H2O exposure.
Annually (more often if the load material is dusty or oily)

Procedure:

It is very difficult to remove water from the chamber. Even after several N2 washes and evacuations, enough water can remain in the chamber to skew the zero. The best way to ensure an accurate zero is to apply dry N2 directly to the sensor either in the chamber or removed from the chamber.

Procedure:

Move cursor to "Zero H2O Channel" using "Up/Down" arrows
<enter>
Zero Channel 1? (Y/N)
<Y><enter> will initiate Zero Operation
The H2O output goes to 2.2mA while Zeroing.
A successful Zero will result in 4.0mA
An unsuccessful Zero will result in a 4-20mA fault level. (<4mA) See Status table.

Note: For best accuracy, the unit should be powered up for at least 1 hour before any calibration operation.

Note: When calibrating with the sensor removed from chamber, best accuracy is obtained by calibrating with the sensor in the same physical orientation as when installed on chamber.

Current Output and Corresponding Status Table

Current Output	Status
4-20 mA	Normal measuring mode
0.0 mA	Unit Fault
0.2 mA	Reference channel fault
0.4 mA	Analytical channel fault
0.8 mA	Unit warm up
1.0 mA	Optics fault
1.2 mA	Zero drift fault
1.6 mA	Calibration fault
2.0 mA	Unit spanning
2.2 mA	Unit zeroing
4.0 mA	Zero gas level
20 mA	Full scale

The 4 to 20 mA outputs are non-isolated current sources.

Spanning

Spanning is only required to establish measurement range. Spanning teaches the unit what 50% of full scale looks like (25% for H2O).

The unit is designed to be spanned at the typical empty chamber operating concentration. The fact that the span value becomes 50%(25%) of full scale gives the unit over-range capability. This is important since certain loads will cause the EtO concentration (in the headspace) to spike much higher than the theoretical concentration right after injection. Over-range capability allows the unit to track concentrations through the spikes.

The span will only be as accurate as the Zero point. **Spanning should always be proceeded with Zeroing**.

(Example) When the EtO channel is spanned at 520 mg/l, full scale range is 0 to 1040 mg/l.
When the H2O channel is spanned at 75 mg/l, full scale range is 0 to 300 mg/l.

EtO(Channel 0**)**

The EtO channel is factory coarse spanned with ethylene span gas to a range of 0-1000 mg/l EtO.

Spanning should be performed:

If abnormally high or low EtO readings are observed during EtO exposure and re-zeroing didn't resolve the problem.

If the unit needs to be ranged for a different full scale concentration.

Procedure:
Perform Zero Operation.
Introduce desired EtO concentration into chamber and let equilibrate.
Move cursor to "Span EtO Channel" using "Up/Down" arrows
<enter>
Span Channel 0 ? (Y/N)
<Y><enter> will initiate Span Operation
The EtO output goes to 2.0mA while Spanning.
A successful Span will result in 12mA
An unsuccessful Span will result in a 4-20mA fault level. (<4mA) See Status table.

H2O(Channel 1**)**

The H2O channel is factory spanned with 20.5 % volume CO2 (balance N2) span gas to a range of 0-300 mg/l H2O.

Spanning should be performed:

If abnormally high or low H2O readings are observed during H2O exposure and re-zeroing didn't resolve the problem. (Be aware of pressure response that could be skewing your readings)

If the unit needs to be ranged for a different full scale concentration.
Procedure:
Perform Zero Operation.
Introduce desired H2O concentration into chamber and let equilibrate.
Move cursor to "Span H2O Channel" using "Up/Down" arrows
<enter>
Span Channel 0 ? (Y/N)
<Y><enter> will initiate Span Operation
The H2O output goes to 2.0mA while Spanning.
A successful Span will result in 8 mA
An unsuccessful Span will result in a 4-20mA fault level. (<4mA) See Status table.

Note: For best accuracy, the unit should be powered up for at least 1 hour before any calibration operation.

Heater Adjustment

Relative Mode (Recommended)

In the Relative Mode, a constant power level is applied to the heaters. This will give the best accuracy over process temperature variations. There are 10 fixed power levels; 0=heaters off, 10=Full Power.

The sensor temperature is a function of process temperature, mounting surface temperature, and ambient temperature. Therefore, an empirical method is the best way to set the heater level.

Procedure:

To adjust heater, select “Heater Level”
The heater mode will be displayed (Relative)
Followed by the current Heater Level
Followed by “Change Power Level? (Y/N)”
<Y><enter>
“New Heater Level: “
Enter Heater Level and <return>

Closed Loop Mode

In the Closed Loop Mode, a target temperature set by user and the heater level is automatically adjusted to keep the sensor temperature at the target temperature.

Procedure:

To adjust target temperature, select “Heater Level”
The heater mode will be displayed (Closed Loop)
Followed by the current Target Temp
Followed by “Change Target Temp? (Y/N)”
<Y><enter>
“New Target Temp: “
Enter Target Temp and <return>

Calibration Certification

Document: 7305 Rev. 1.001

Customer:

Sales Order:
Ship Date:

SEC Signature DIR Serial #	Channel	Cal Date	Cal Gas Value	Span Hex Value	Check Sum (Linearization)	Firmware Rev
	Channel 0 EtO		**70% Volume Ethylene +/-2% NIST Traceable**			
	Channel 1 H2O		**20.5% Volume CO2 +/-2% NIST Traceable**			

Calibration Procedure: 7304
Test Procedure: 7302

TEST PERSON SIGNATURE PRINT NAME DATE

_____ _____ _____

70%V/V Ethylene generates a unit response approximately equivalent to 500 mg/l ethylene oxide. This results in a range of 0-1000mg/l.
20.5%V/V CO2 generates a unit response approximately equivalent to 75 mg/l water vapor. This results in a range of 0-300mg/l.
Best accuracy requires the unit to be zeroed and spanned in-chamber at operating temperature and humidity, using typical concentrations of EtO and H2O for spanning.

Example of Calibration Certification

Each SEC Signature is shipped with a completed Calibration Certification.

V. PARTS LIST

Part Number	Description
DIR011021000000	SEC Signature DIR Process monitor
142-1750	SEC DIR PC Link Kit
190-10001	SEC 2001 Explosion proof junction box
142-0852	Replacement Screen
142-0701	Replacement Filter

VI. DRAWING SECTION

Figure #	Title
Figure 1	Dimensions/Wiring
Figure 2	Mounting
Figure 3	PC Link Wiring
Figure 4	Sensor Separation Kit

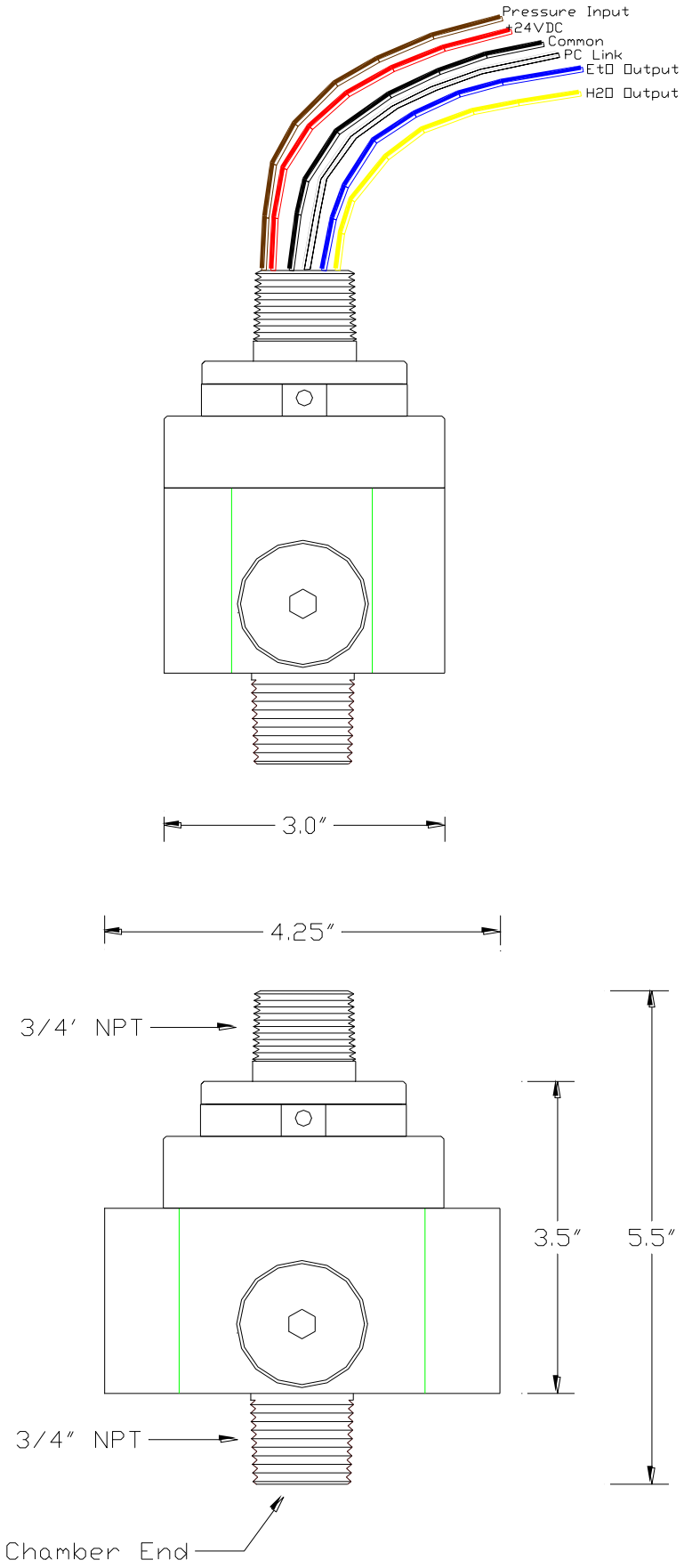

Pressure Input
+24VDC
Common
PC Link
Et Output
H2 Output
3.0″
4.25″
3/4′ NPT
3.5″
5.5″
3/4″ NPT
Chamber End

Figure 1

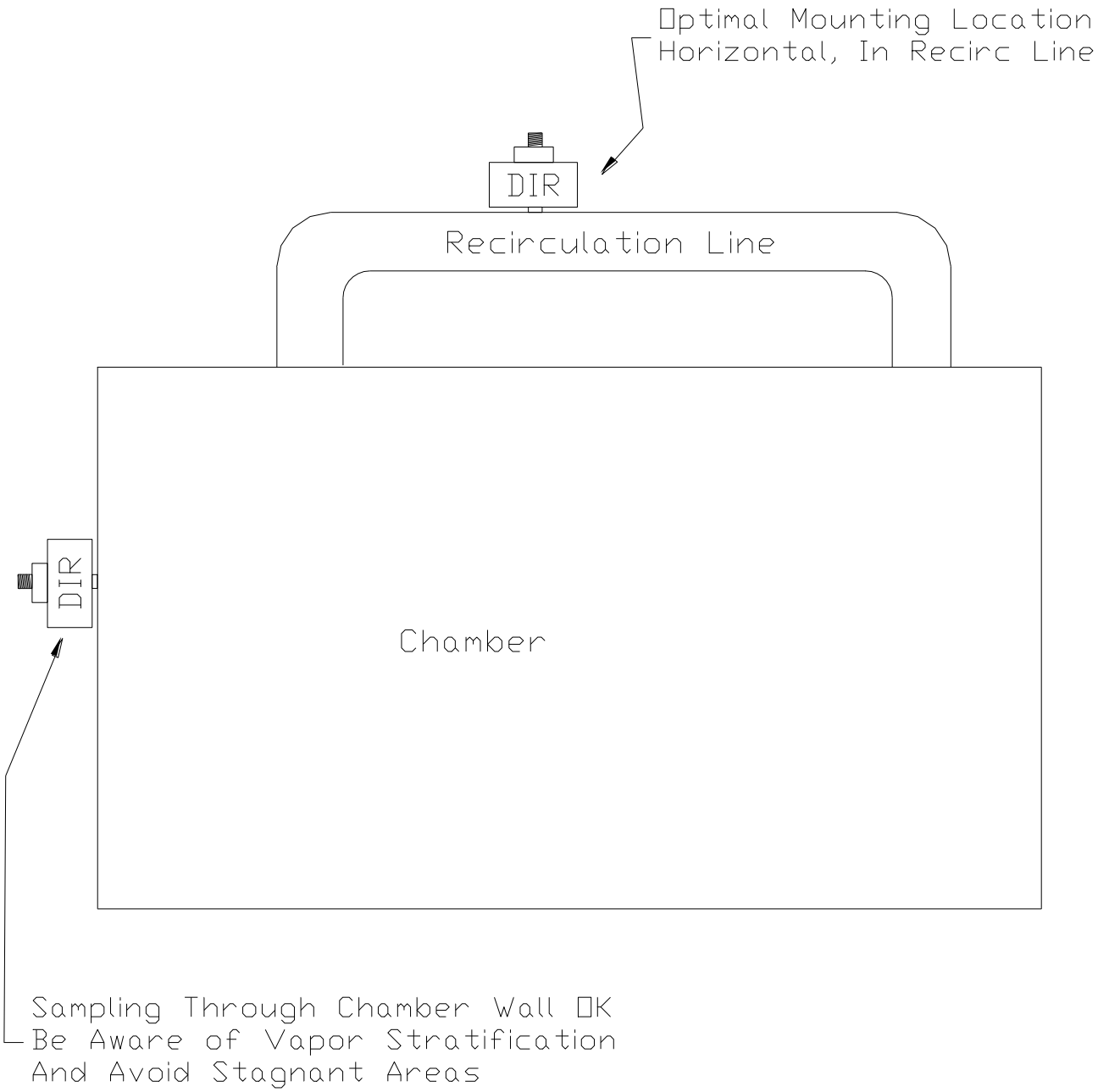

Optimal Mounting Location
Horizontal, In Recirc Line
DIR
Recirculation Line
DIR
Chamber
Sampling Through Chamber Wall OK
Be Aware of Vapor Stratification
And Avoid Stagnant Areas

Figure 2

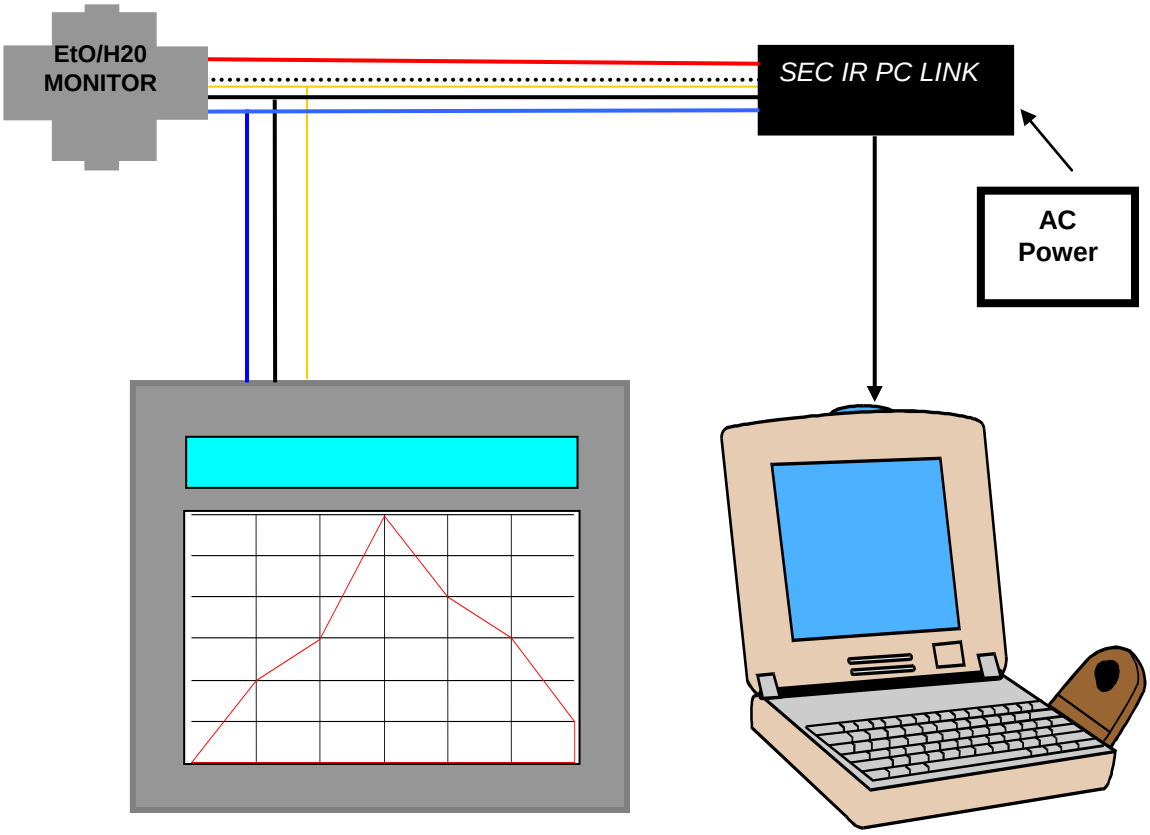
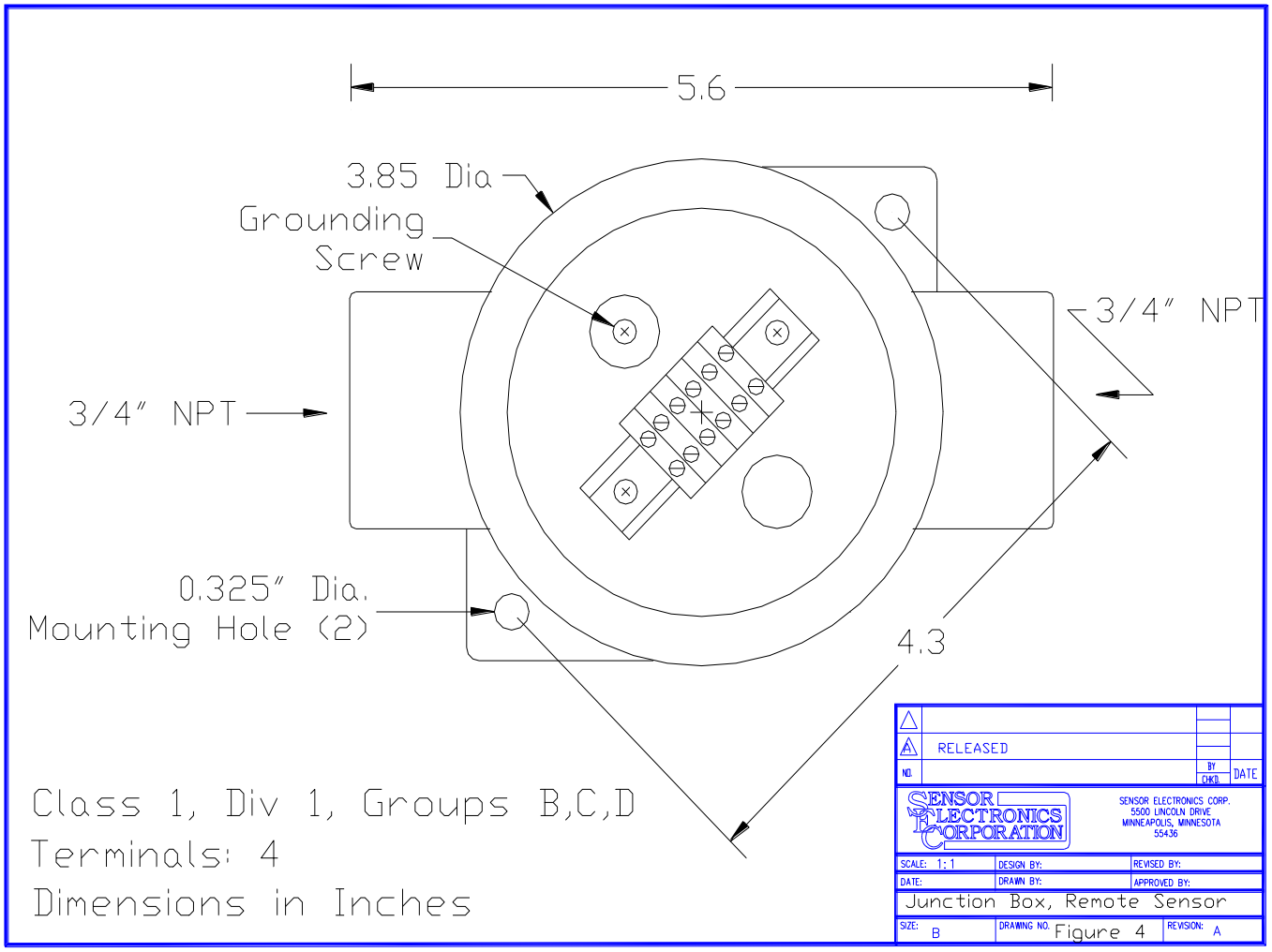


Chart Recorder
PLC, DAS, DCS, DVM
(Any control or monitoring system that accepts a 4-20 mA or 0-5 VDC signal)

Figure **3**

Figure **4**


5.6
3.85 Dia
Grounding
Screw
3/4" NPT
3/4" NPT
0.325" Dia.
Mounting Hole (2)
4.3
Class 1, Div 1, Groups B,C,D
Terminals: 4
Dimensions in Inches
RELEASED
NO.
BY
CHKD
DATE
SENSOR ELECTRONICS CORPORATION
SENSOR ELECTRONICS, CORP.
5500 LINCOLN DRIVE
MINNEAPOLIS, MINNESOTA
55436
SCALE: 1:1
DESIGN BY:
REVISED BY:
DATE:
DRAWN BY:
APPROVED BY:
Junction Box, Remote Sensor
SIZE: B
DRAWING NO. Figure 4
REVISION: A

SENSOR ELECTRONICS CORPORATION

MONITORING ETO & WATER VAPOR IN ETHYLENE OXIDE STERILIZATION CHAMBERS

EOSA MEETING MAY 2010

SENSOR ELECTRONICS CORPORATION

In 2001 Sensor Electronics Corporation (SEC) introduced the single channel SEC Signature EtO Monitor in to the ethylene oxide sterilization industry.

FEED BACK FROM THE INDUSTRY

The SEC Signature was accepted by the EtO sterilization industry, providing a low cost instrument, producing repeatable readings and very low maintenance costs.

As the installation base expanded SEC learned how a next generation device could be improved to meet the industry needs.

HEAT ISSUES

In high humidity cycles or dynamic conditioning cycles the internal heater of the SEC Signature did not produce enough heat to eliminate water from condensing on the optical surfaces even when the device was insulated.

In some cases the end user had to provide an external heat source to the SEC Signature.

ANALOG OUTPUT RESOLUTION

The SEC Signature uses an 8 bit A/D converter.

For example a unit ranged 0-1000 mg/l has output steps of 8 mg/l.

The device can measure less than 8 mg/l but the analog output cannot resolve between the 8 mg/l step. The device will toggle between these two points often perceived by the customer as “noise”.

ANALOG OUTPUT ADJUSTMENT

To SEC a zero reading is 4.00 milliamps +/- 0.05 milliamps (mA).

To SEC a span reading is 12.00 milliamps +/- 0.05 milliamps (mA).

Some customers have very sophisticated high resolution sterilizer control systems. In order to compensate for the control system readings or wiring loss the SEC device should be able to be “tweaked” to closely match the control system readings.

SEC SIGNATURE DIR ETO & H2O MONITOR

In 2005 SEC started testing the SEC Signature DIR on EtO Sterilization Chambers

- The DIR analyzer quantifies EtO and water vapor densities by measuring infrared light absorption at certain wavelengths.
- The DIR passively samples chamber gas. A recirculation line is an optimal mounting location since the recirculation system generally contains a representative sample of the gas mix in the chamber and the turbulence in the gas stream helps maximize the refresh rate of the gas sample in the DIR's measuring chamber.
- To maintain accurate H2O readings in the presence of other gases (N2,02,EO) pressure compensation and optical compensation must be enabled for the H2O channel.

COMPARED TO THE SINGLE CHANNEL DEVICE THE SIGNATURE DIR HAS THESE IMPROVEMENTS

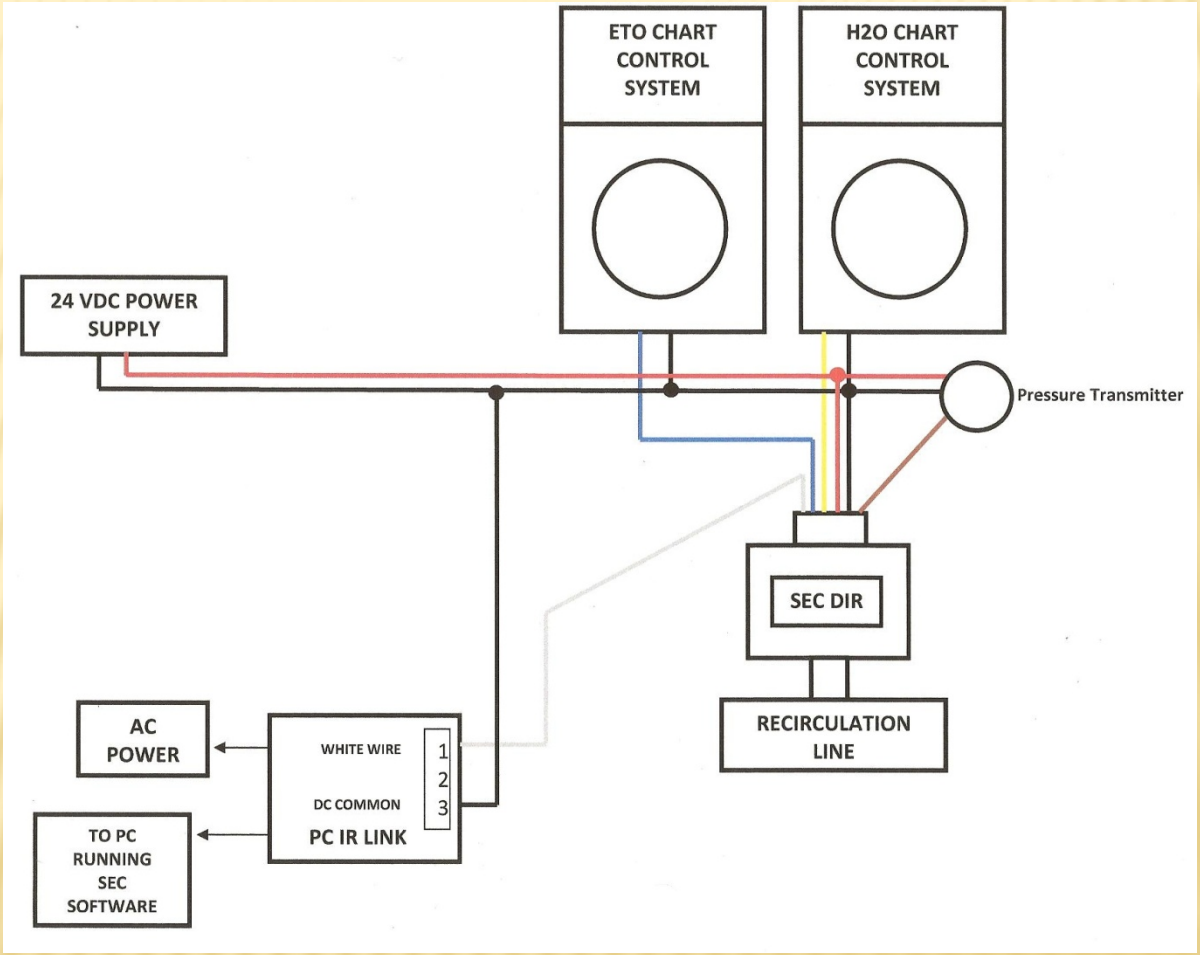
10 times the internal heater capacity.

The ability for the end user to adjust “tweak” the EtO and H2O analog outputs to match the control system input.

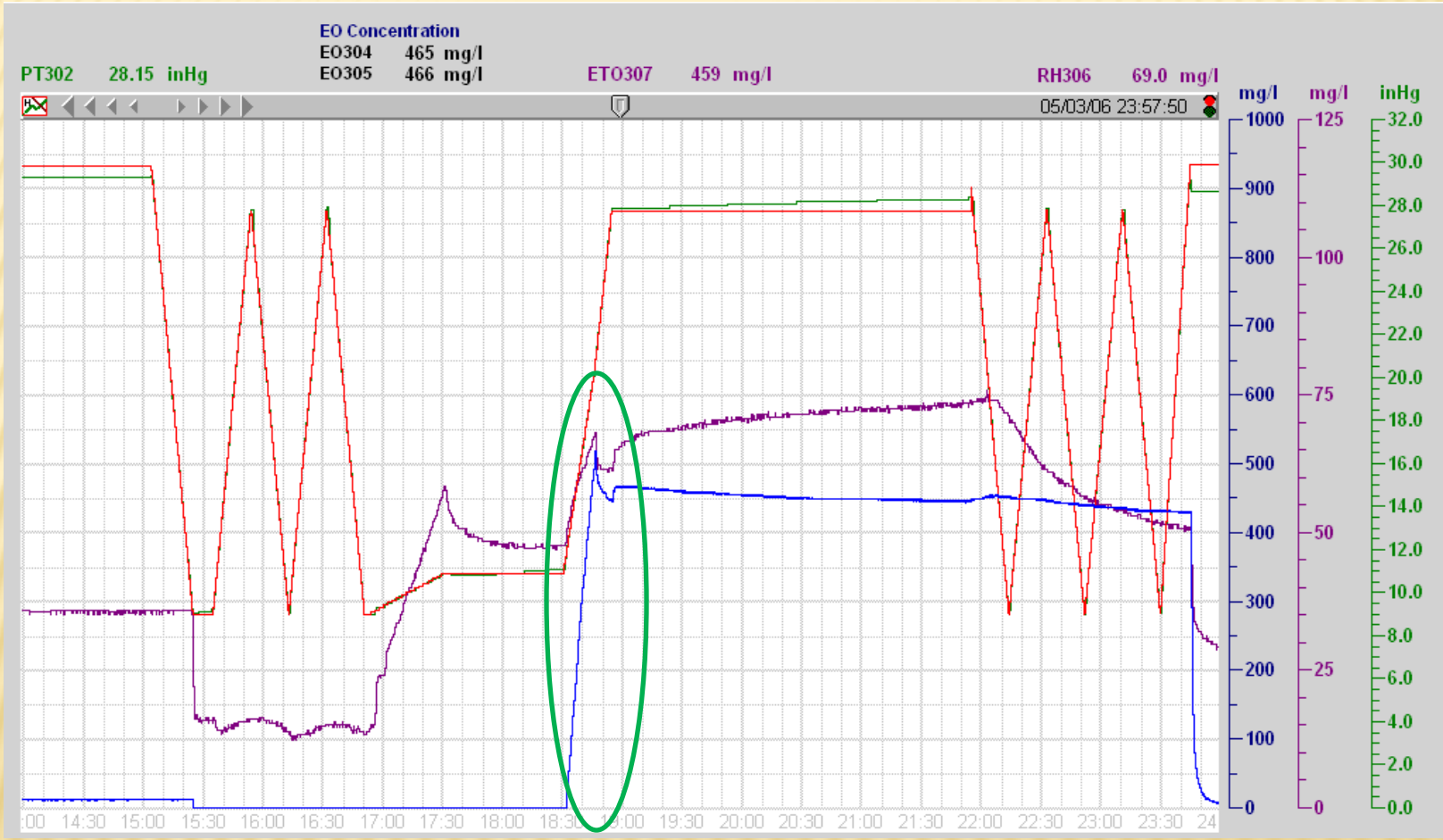
4 times the output signal resolution (10 bit).

RESOLUTION BETWEEN SINGLE AND DUAL

PRESSURE COMPENSATION DIAGRAM



WATER VAPOR PRESSURE EFFECT WITHOUT COMPENSATION



Pressure influences the water molecule requiring pressure compensation to be an added feature in the SEC Signature DIR

DIR INSTALLATION TIPS

- **Unit Temperature**

  Unit should operate at around **5ºC warmer** than the highest cycle temperature. If the unit is operated too cool, condensation can form on the optical surfaces causing erratic readings.

- **Load Effects**

  The DIR measures gas concentration in the chamber headspace. The load in the chamber can alter headspace densities by reducing effective chamber volume, absorbing EO, H2O, or both. **Any calibration runs should be performed in an empty chamber.**

- **Leaking Fitting**

  A leaking fitting near the DIR can **dilute the gas in the measuring chamber** with room air causing low readings. The amount of dilution will be a function of the leak location, leak size, and chamber pressure.

DIR INSTALLATION TIPS

- **Stagnant Sensing Location**

  A mounting location in an **area of the chamber with little or no gas movement may read inaccurately** relative to representative chamber densities. With little mixing, gas mixes in the chamber can begin to stratify according to weight. EtO is heavy and will tend to collect near the bottom of the chamber, H2O is relatively light and will tend to migrate to the higher areas of the chamber.

- **Pressure Packing**

  The recirculation blower will have a pressure differential from input to output. The pressure differential is a function of the blower parameters and the amount of gas in the chamber. Sensing after **(exhaust) the blower can result in higher readings** than sensing before the blower.

DIR INSTALLATION TIPS

- **Gas Injection Location**

  Injecting **gas upstream from the DIR can cause response peaks** as the DIR is flooded with the gas. The reading will normalize as the mixture equilibrates in the chamber.

- **Cool Surfaces and Condensation**

  Any cool surfaces between the gas stream and the DIR may cause erratic and erroneous reading. This could be fittings, cal adapter, flanges, pipes… Ensure that **all components of the mounting are above the condensation temperature of all gas mix components**.

DIR INSTALLATION TIPS

- **Chamber Leaks**

  Room air leaking (tiny leaks) into the chamber will make a pressure rise calculated density appear higher than it actually is. **The DIR will appear to be reading low since there is little or no response to room air.**

- **H2O Channel Zero**

  Water is typically difficult to remove from the chamber. If there is pressure in the chamber following an evacuation, much of the remaining pressure can be due to water still present in the chamber. This would not be a good time to zero the H2O channel. **Exposing the DIR to dry N2 directly or running several N2 chamber washes is usually required to dry the DIR enough for a good H2O zero.**

DIR INSTALLATION TIPS

- **Wiring**

  Using light gauge wire can cause erratic operation. When supplying a single unit at 50 feet or less, use at least 16AWG wire for +24V and Common wires. For long runs or multiple units, contact factory for proper wire gauge.

- **Intrinsic (IS) Barrier**

  Supplying power to the unit through an intrinsic barrier will render the unit inoperable. **An intrinsic barrier can't supply the power required to run the unit.** The DIR is designed as explosion proof and requires wiring to be run in explosion proof conduit to a safe area.

OUTPUT SPECIFICATIONS

The SEC Signature DIR EtO channel is specified as follows:

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale

@ 500mg/l EtO…500 +/- (25 + 10 + 3) = 500 +/- 38mg/l

Assuming pure water vapor with optical compensation and pressure compensation disabled.
The SEC Signature DIR H2O channel is specified as follows:

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale

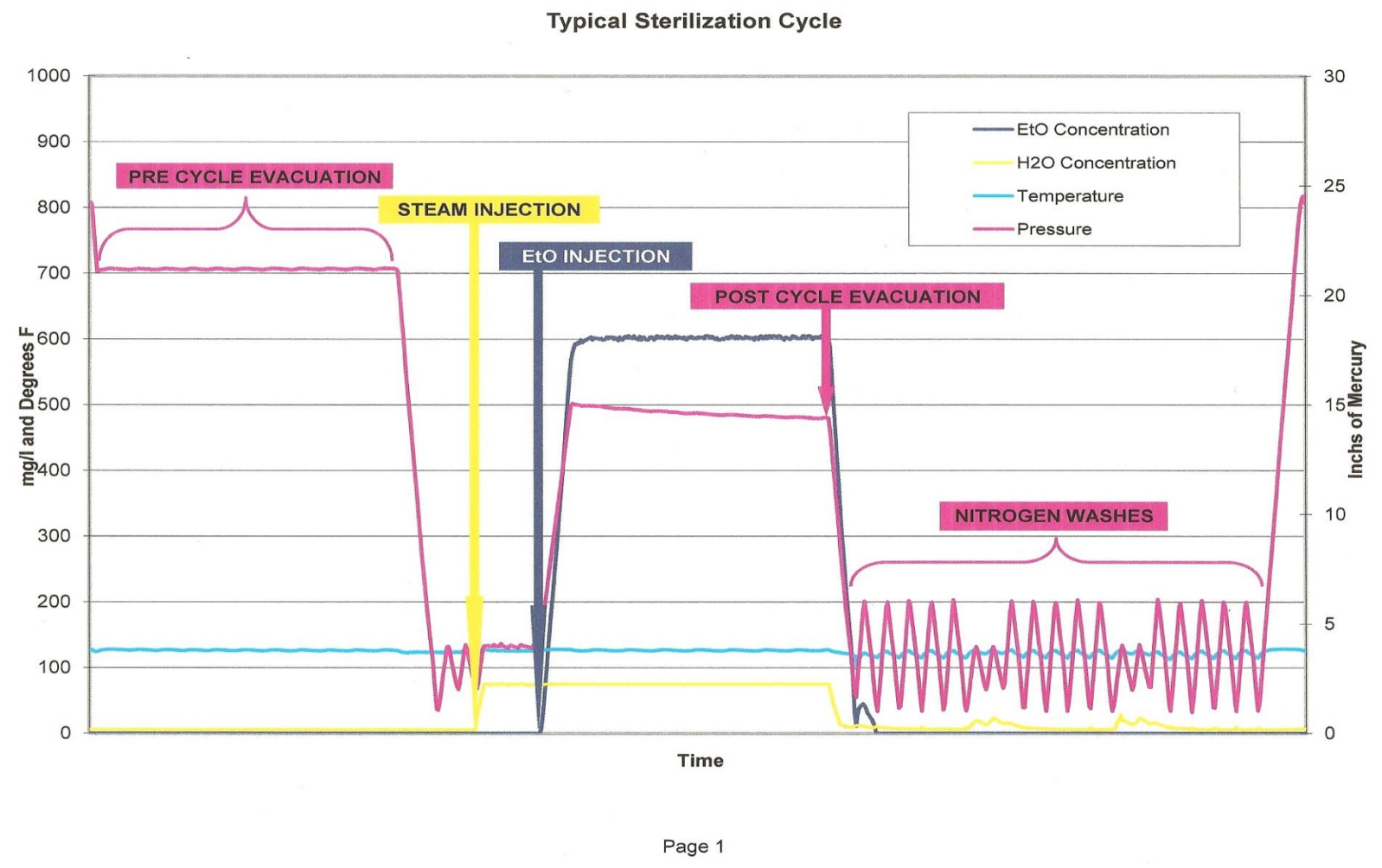
@ 75mg/l H2O…75 +/- (3.75 + 1.5 + 0.9) = 75 +/- 7 mg/l

This assumes water vapor mixed with EtO, N2, O2 with optical compensation and pressure compensation enabled.
The presence of other gases can cause significant errors in the H2O reading unless optical and pressure compensation are used.

Accuracy = 5% of value
Repeatability = 2% of value
Output resolution = 0.3% of full scale
Optical compensation error = 2% of value
Pressure compensation error = 2% of value

@ 75mg/l H2O…75 +/- (3.75 + 1.5 + 0.9 + 1.5 + 1.5) = 75 +/- 10 mg/l

GRAPH


Typical Sterilization Cycle
PRE CYCLE EVACUATION
STEAM INJECTION
EtO INJECTION
POST CYCLE EVACUATION
NITROGEN WASHES
EtO Concentration
H2O Concentration
Temperature
Pressure
mg/l and Degrees F
Inchs of Mercury
Time
1000
900
800
700
600
500
400
300
200
100
0
30
25
20
15
10
5
0
Page 1

SEC IR PC LINK

Instruction and Operation Manual

Sensor Electronics Corporation
5500 Lincoln Drive
Minneapolis, Minnesota 55436 USA
(952) 938-9486 Fax (952) 938-9617
email sensor@minn.net **or www.sensorelectronics.com**

Part Number 71-4000 Version 031902

Sensor Electronics Corporation

Sensor Electronics Corporation (SEC) is an innovative manufacturer of fixed system gas detection equipment, for combustible gases, oxygen and toxic gases.

Commitment

Our quality and service are uncompromising. We back each of our products with a two-year warranty on all materials and workmanship. We offer technical support, user training and on-site service and maintenance of equipment to meet the needs of our customers.

Gas Detection Service

Individually designed maintenance packages are available for specific customer needs. Service begins with verification of the system installation that includes an initial system check and calibration. We then offer customer training programs (on-site and at factory) to insure that technical personnel fully understand operation and maintenance procedures. When on-the-spot assistance is required, service representatives are available to handle any questions or problems immediately.

Warranty

Sensor Electronics Corporation (SEC) warrants products manufactured by SEC to be free from defects in workmanship and materials for a period of two (2) years from date of shipment from the factory. Any parts returned freight pre-paid to the factory and found defective within the warranty will be repaired or replaced, at SEC's option. SEC will return repaired or replaced equipment pre-paid lowest cost freight. This warranty does not apply to items which by their nature are subject to deterioration or consumption in normal service. Such items may include:
Fuses and Batteries.
Warranty is voided by abuse including rough handling, mechanical damage, alteration or repair. This warranty covers the full extent of SEC liability and SEC is not responsible for removal, replacement costs, local repair costs, transportation costs or contingent expenses incurred without prior written approval. Sensor Electronics Corporation's obligation under this warranty shall be limited to repair or replacement of any product that has been returned to Sensor Electronics Corporation for warranty consideration. This warranty is expressly in lieu of any and all other warranties expressed or implied, and all other obligations or liabilities on the part of Sensor Electronics Corporation including but not limited to, the fitness for a particular purpose. In no event shall Sensor Electronics Corporation be liable for direct, incidental, or consequential loss or damage of any kind connected with the use of it's products or failure to function or operate properly.

Year 2000 Compliance

All Sensor Electronics products have been tested and are certified by Sensor Electronics to accurately process date/time and date/time related data from, into and between the 20^{th} and 21^{st} centuries. Sensor Electronics products neither contain nor create any logical or mathematical inconsistency, will not malfunction, and will not cease to function when processing date/time data.
Please contact Sensor Electronics for further information.

Table of Contents

Declaration of Conformity

Sensor Electronics Corporation
5500 Lincoln Drive
Minneapolis, Minnesota 55436 USA
Telephone: 952.938.9486
Fax: 952.938.9617
Email: sensor@minn.net

Type of Equipment: SEC Signature EtO Monitor
SEC IR PC Link

Model Number: SEC Signature EtO Monitor - Part Number 142-0597
SEC IR PC Link - Part Number 142-0636

I hereby declare that the equipment specified above conforms to the protection requirements of the **EC DIRECTIVE 89/336/EEC** on Electromagnetic Compatibility (EMC), in accordance with the provisions of the Electromagnetic Compatibility Regulations 1992.

The following standards have been applied;

EN 50081 –1
Emissions Standard (Residential Commercial and Light Industry)

EN 50082 –1
Immunity Standard (Residential Commercial and Light Industry)

Signature _____

Patrick G. Smith
Director of Engineering

Date: August 6, 2001

I. GENERAL DESCRIPTION

The SEC IR PC LINK is designed to provide power and status indication to the family of SEC infrared gas monitors. The SEC IR PC LINK can also be used with a PC to communicate to the infrared gas monitoring device.

The SEC IR PC LINK has a selectable analog output signal that can be connected to a chart recorder, DCS, PLC, DVM or virtually any type of control system.

The SEC Signature infrared gas monitoring devices require a one time span after installation. After the spanning the SEC Signature, an annual zero calibration procedure is recommended. The SEC IR PC LINK has a Unit Zero pushbutton that can be used to perform routine zero calibration of the devices. The span and zero procedures are described later in this manual.

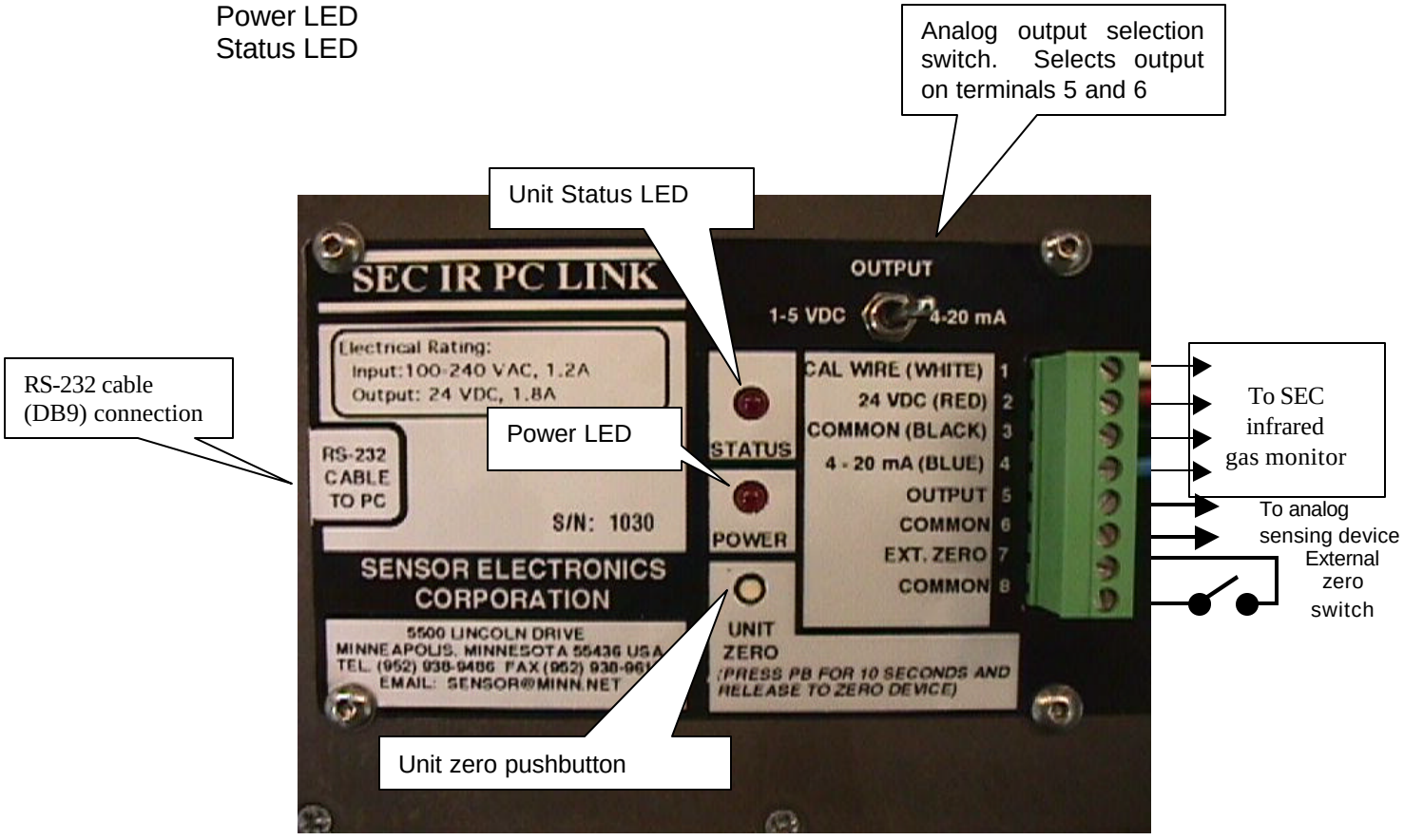
The SEC IR PC LINK package consists of the following items

(1) SEC IR PC LINK box
(1) PC Interface Cable
(1) WinPCLink Software Diskette*

**The software requires Microsoft® Windows® 95 or higher.*

Specifications

Input Power:	110 to 220 VAC.
Output Voltage:	24 VDC
Analog Output:	0 – 5 VDC or 4 – 20 mA
Digital Output:	RS-232
Indicators:	
Power LED	
Status LED	



II. OPERATION / CALIBRATION

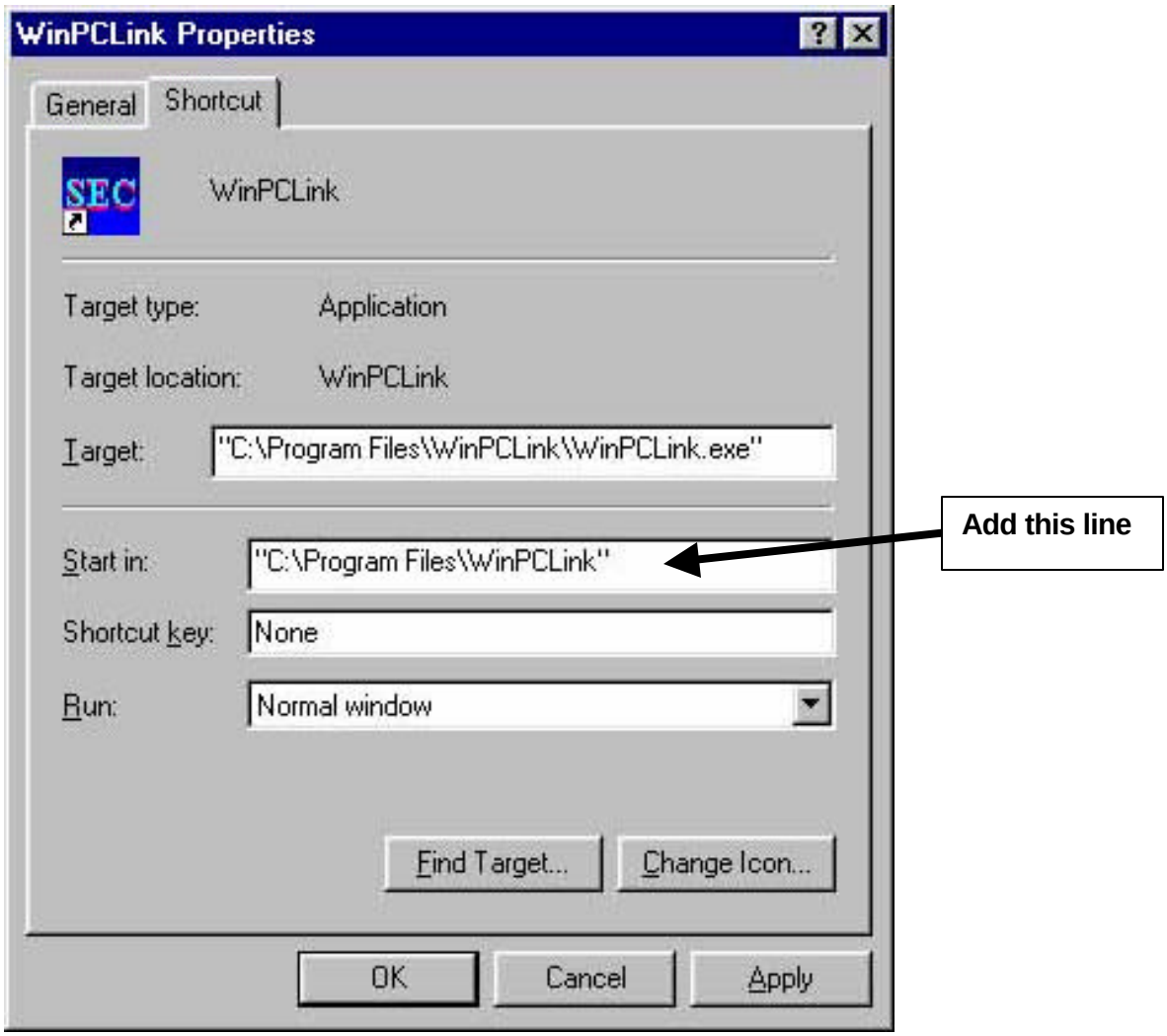
Installing WinPCLink Software

Run the Setup from the diskette or CD.

Optional Desktop Icon Setting

If you created the WinPCLink desktop icon with the setup program:

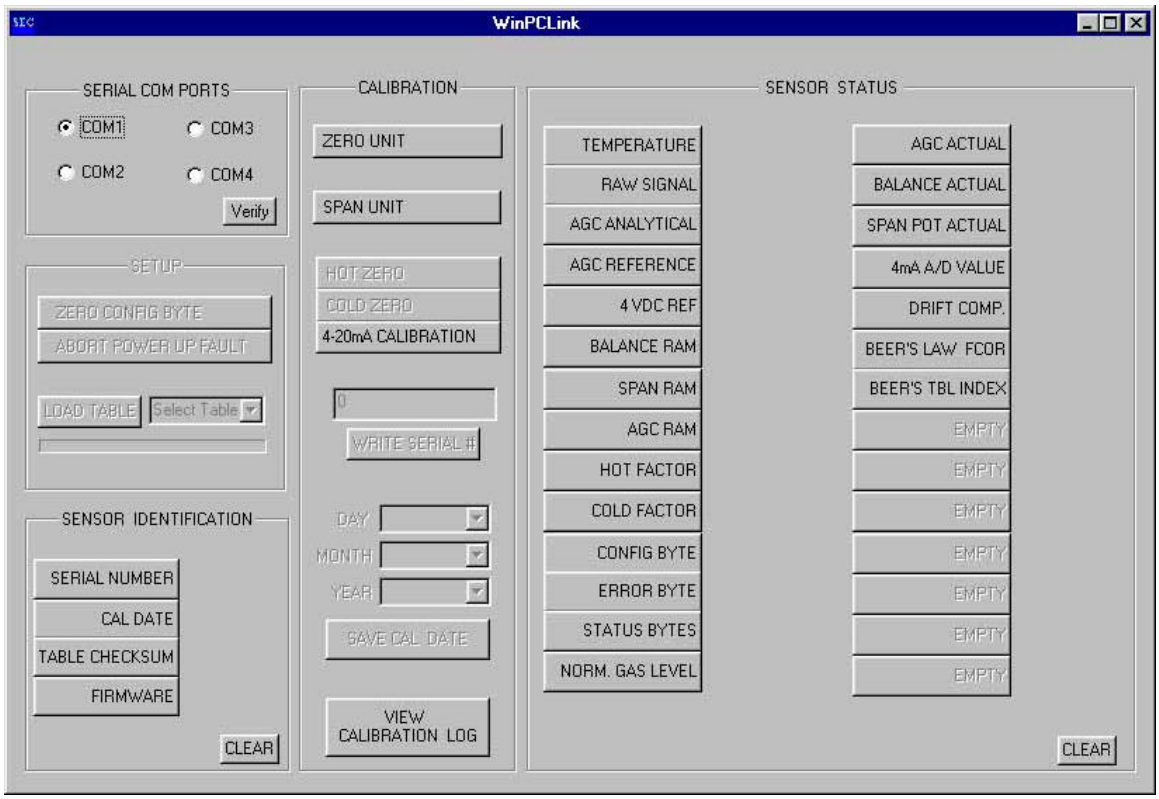
- Right-click on the icon and select **Properties**.
- Select **Shortcut** tab.
- In **Start in** field copy this line: "C:\Program Files\WinPCLink" Click on Apply button.



This will put the sensor and calibration data file in the root directory instead of on the desktop. Do the same for the shortcut in Start Menu *C:\WINDOWS\Start Menu\Programs\WinPCLink*

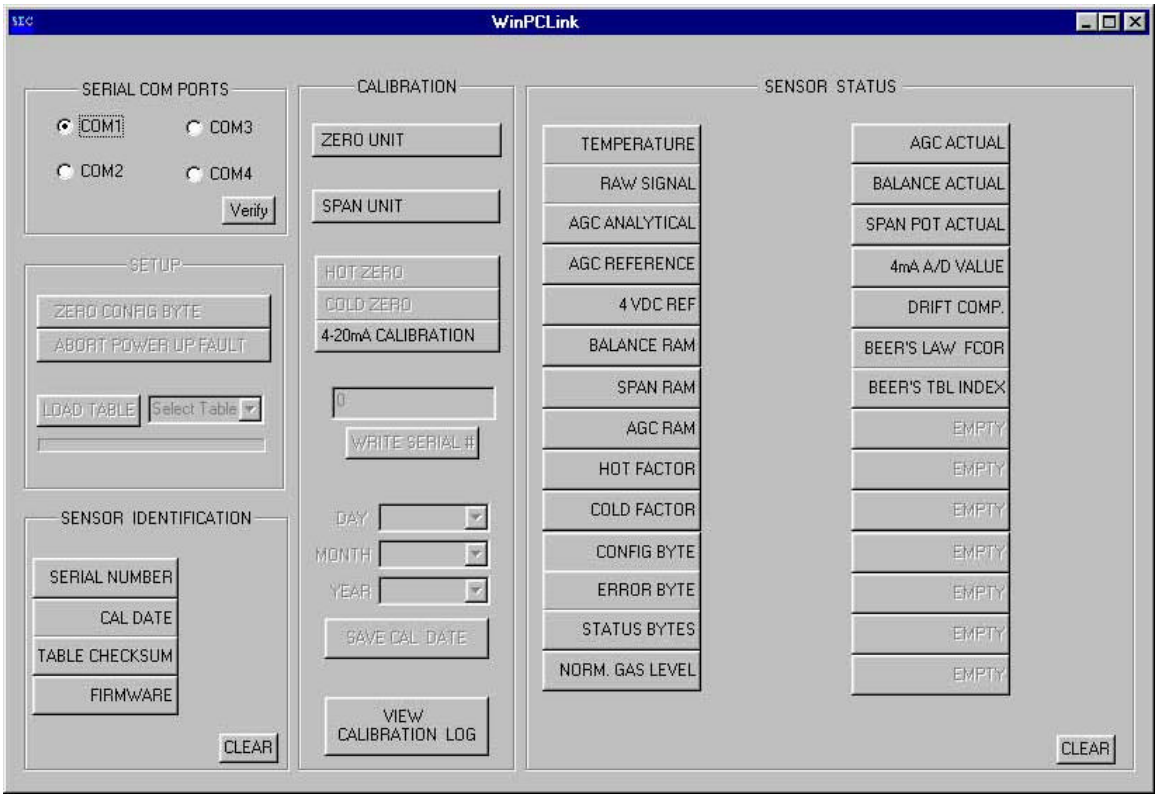
PC Communication Port Setting

The SEC WinPCLink software default communication port is COM port 1. If the SEC PC IR LINK is connected to a COM port other then COM 1, use the PC mouse pointer and click on the serial port that the PC IR LINK is connected. Click on the “Verify” button to check communication with selected port. A message box will appear confirming the port is connected. Once the port is connected the WinPCLink software is ready to run.



Read Serial Number of Device

The serial number is stamped on the housing and programmed in to the device at the factory. To electronically read the device's serial number use the PC mouse and click on the "SERIAL NUMBER" button.



The serial number of the device will appear at the right hand side of the "SERIAL NUMBER" button.

Other data from the sensor can be displayed in the SENSOR IDENTIFICATION window such as CAL DATE. Once the data is retrieved for the sensor, use the mouse pointer and click on the "CLEAR" button in the SENSOR IDENTIFICATION window to remove the data.

SEC Signature Temperature

The temperature of the SEC Signature should be at least 10º F (5.6º C) higher than the process / sterilizer temperature. To read the internal temperature of the SEC Signature use the mouse pointer and click on the "TEMPERATURE" button in the SENSOR STATUS window.

Other data can be viewed in decimal numbers (and hex) in the SENSOR STATUS window using the pointer and clicking on the button. *Most of this data is only used at the factory or for troubleshooting by factory personnel.* Once the data has been observed, click on the CLEAR button in the SENSOR STATUS window to remove the data.

SEC Signature Calibration

Zero Unit

The SEC Signature should be "zeroed" at the end of the humidity dwell cycle prior to injecting gas. To zero the device use the PC mouse pointer and click on the "ZERO UNIT" button in the CALIBRATION window. During the zeroing procedure the Status LED on the SEC IR LINK will momentary flash twice.

Once the Zero command has been initiated the following PC screen will display "Recording Data" once the zero procedure is completed a message box will appear "Sensor Zeroed and Data Recorded". Click on the OK box. The data can be viewed by clicking on the "VIEW CALIBRATION LOG" box in the CALIBRATION window. The PC automatically updates the Signature's calibration date and time.

Span Unit

The SEC Signature should be "spanned" (one time) after the gas injection is complete and the conditions in the sterilizer are stable. To span the device use the PC mouse pointer and click on the "SPAN UNIT" button in the CALIBRATION window. A message box will ask you to confirm you wish to span unit. Click the Yes button if you wish to span the unit or the No button if the SPAN UNIT was accidentally selected. During the spanning procedure the PC screen will display "Recording Data" and the Status LED on the SEC IR LINK will momentary flash three times. Once the span procedure is completed a message box will appear "Sensor Spanned and Data Recorded". Click on the OK box. The device is spanned (calibrated) to a mid range (50%) value of the full-scale value. Example: *If the unit is spanned at a concentration of 520 mg/l the full-scale range of the device is 0 to 1040 mg/l.*

The data can be viewed by clicking on the "VIEW CALIBRATION LOG" box in the CALIBRATION window. The PC automatically updates the Signature's calibration date and time.

Unit Status Byte

The SEC Signature can be queried for status information. To retrieve current status of the SEC Signature use the mouse pointer and click on the "STATUS BYTE" button in the SENSOR STATUS window. Unit status can also be identified according to the flash rate of the Status LED on the SEC IR PC LINK. See chart for LED flash rate status indication.
During the units warm up period (Flash Rate 5) the SEC Signature will not communicate to the WinPCLink software.

UNIT STATUS FLASH CODES

-LED will flash at the designated rate based on the current Unit Status.

Decimal Flash Rate	**Status Byte (hex) Value**	**Corresponding Unit Status**	**Description**
1	0	Unit Running	Unit is measuring gas and adjusting 4-20ma output accordingly.
2	2	Unit Zero Calibrating	Unit goes through its *zero calibration* procedure.
3	3	Unit Spanning	Unit goes through its *spanning* procedure.
4	4	Unit 4-20ma Calibrating	Unit goes through its *4-20ma-calibration* procedure.
5	5	Unit Warm-up	Unit is waiting for source device to reach its operating temperature.
6	6	Power-up Fault	Unit has determined a *Power-Up* fault condition.
7	7	Calibration Fault	Unit has determined an error during *calibration* procedure.
8	8	Span Fault	Unit has determined an error during *spanning* procedure.
9	9	Unit Fault	Unit has determined a *Unit_Fault* condition.
10	A	Optics Fault	Unit has determined an *Optics_Fault* condition.
11	B	Zero Drift Fault	Unit has determined a *Zero_Drift_Fault* condition.
12	C	Configuration Fault	Unit has never been *Zeroed, Spanned, Source* calibrated, or E^2 has a Header byte error.
13	D	Hot Zero	
14	E	Cool Zero	
15	F	Down Loading Table	
16	10	Reference Ch Fault	AGC Pot out of range
17	11	Analytical Ch Fault	Balance Pot out of range

Production Certificate

Each IR PC Link is supplied with a completed Production Certificate. The following is an example of the document.

PRODUCT CERTIFICATION

Document Number 7201
Revision 1.003

DEVICE TYPE: SEC PC IR LINK
PART NUMBER: 142-0636
SERIAL NUMBER:

CHECK SUM:
MANUFACTURE DATE:
INITIAL TEST DATE:
START BURN IN DATE:
END BURN IN DATE:

FUNCTIONAL TESTING

24 VDC		RS-232 COMM PORT		1-5 VDC		4-20 mA		ZERO PUSH BUTTON		EXTERNAL ZERO INPUT	
MEASURED VALUE	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	PASS	FAIL	

TEST PERSON SIGNATURE **DATE**

_____ _____

SENSOR ELECTRONICS CORPORATION
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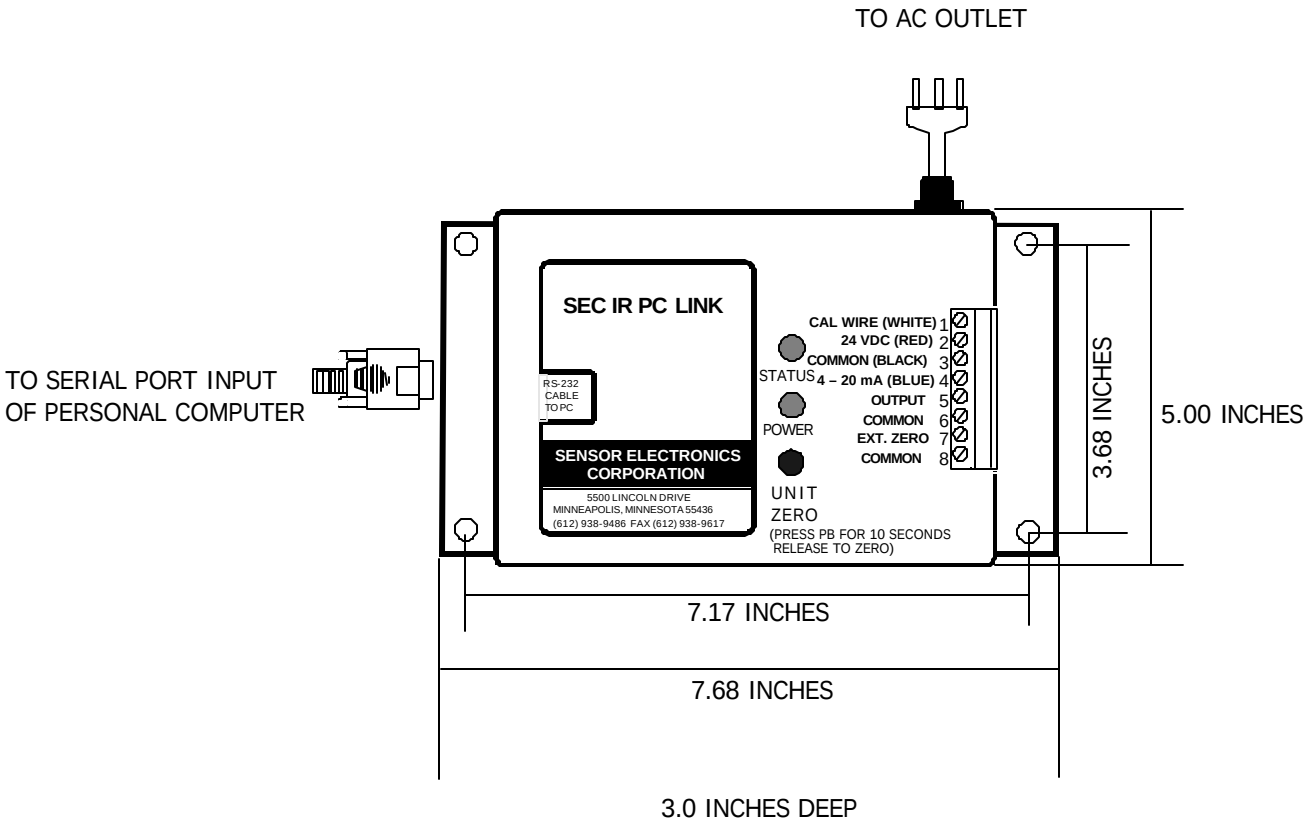
III. PARTS LIST

Description	Part Number
SEC IR PC LINK	142-0634
9 Pin Interface Cable	147-1001
SEC IR PC LINK Kit	142-0636



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SEC IR PC LINK
WIRING & DIMENSIONAL
DIAGRAM

FIGURE 1

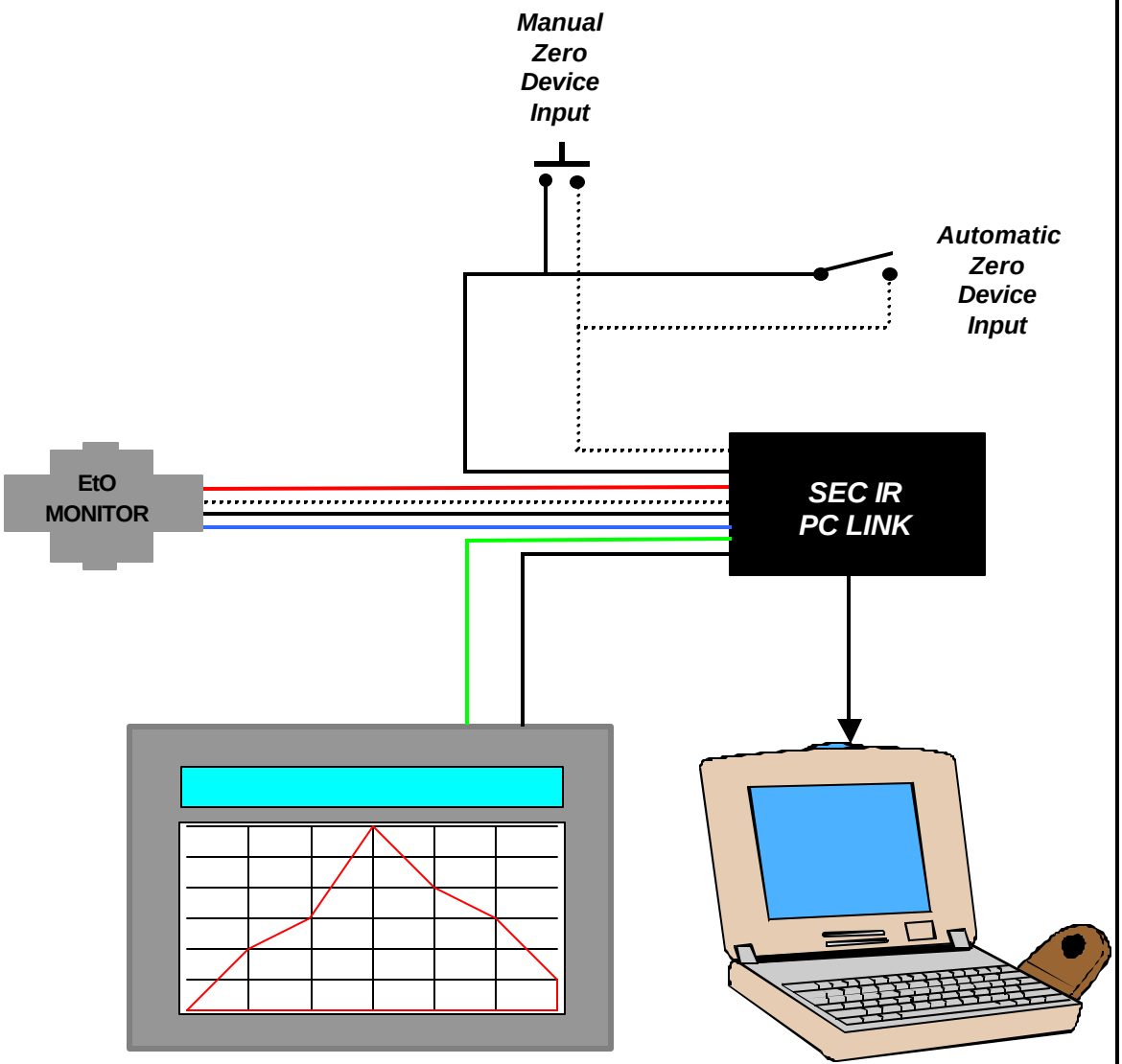

Chart Recorder
PLC, DAS, DCS, DVM
(Any control or monitoring system that accepts a 4-20 mA or 0-5 VDC signal)

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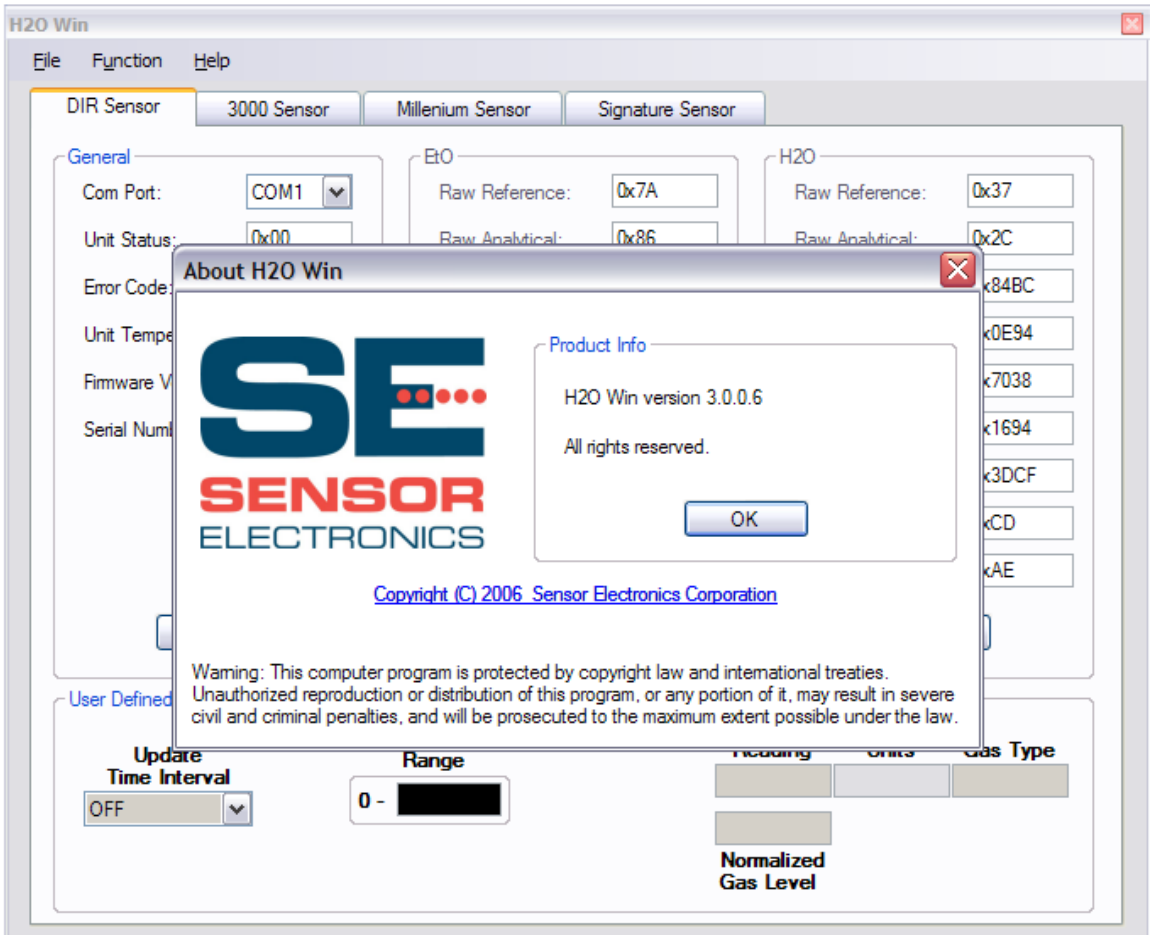
BLOCK WIRING DIAGRAM

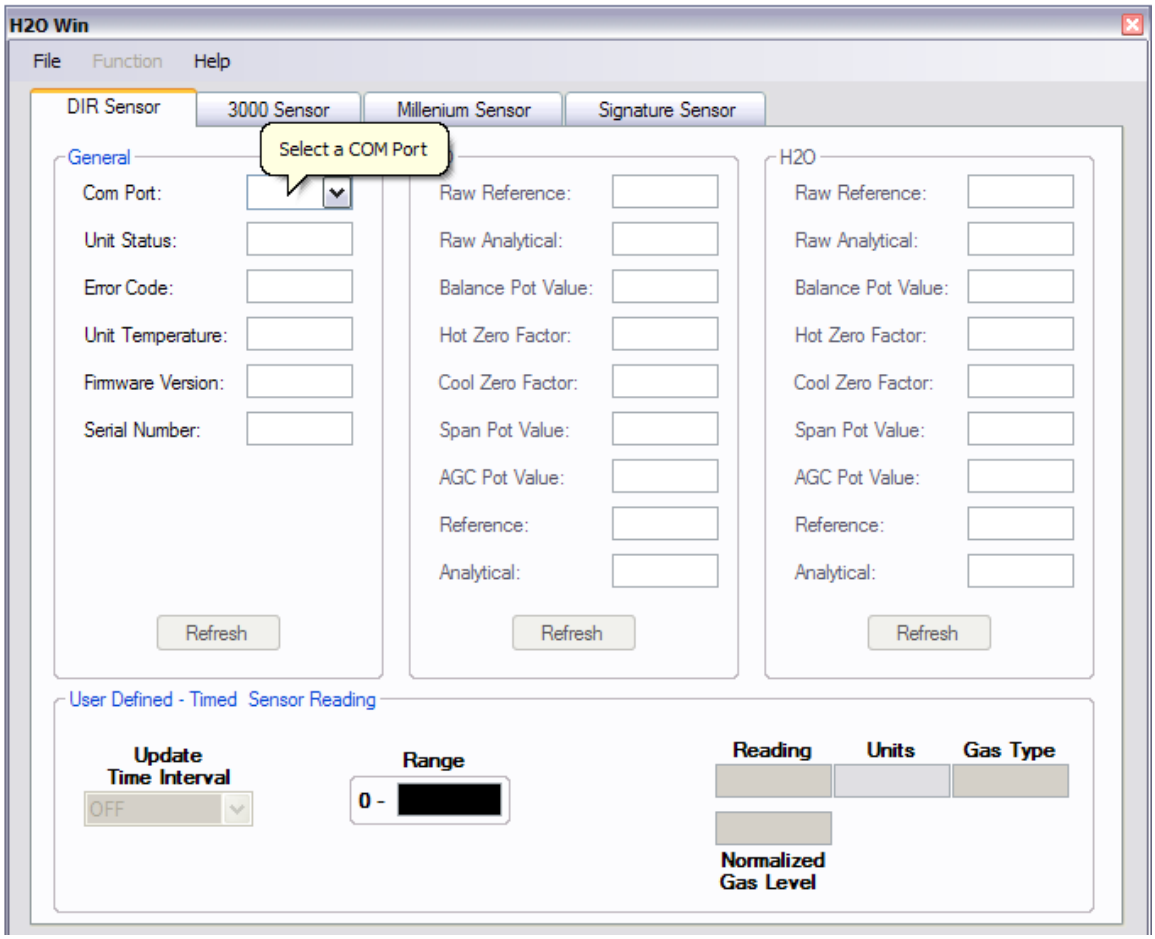
SEC IR PC LINK

FIGURE 2

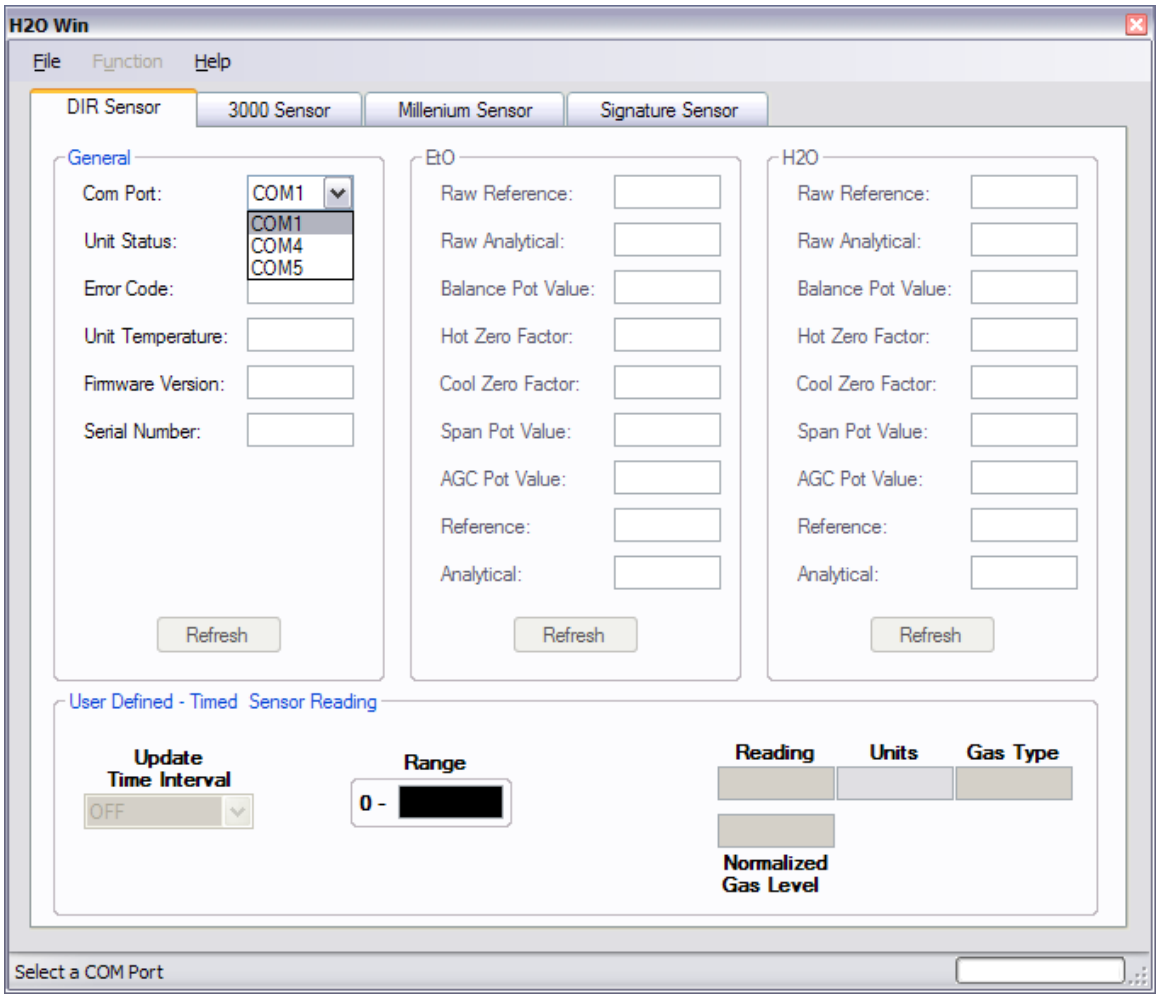


Current version of SEC software used with SEC Signature DIR. This software can be downloaded from the Sensor Electronics website. www.sensorelectronics.com
Note: The SEC H2O Win software requires Microsoft.Net to run. The download process will prompt the operator to download this software. Download the x86 version.

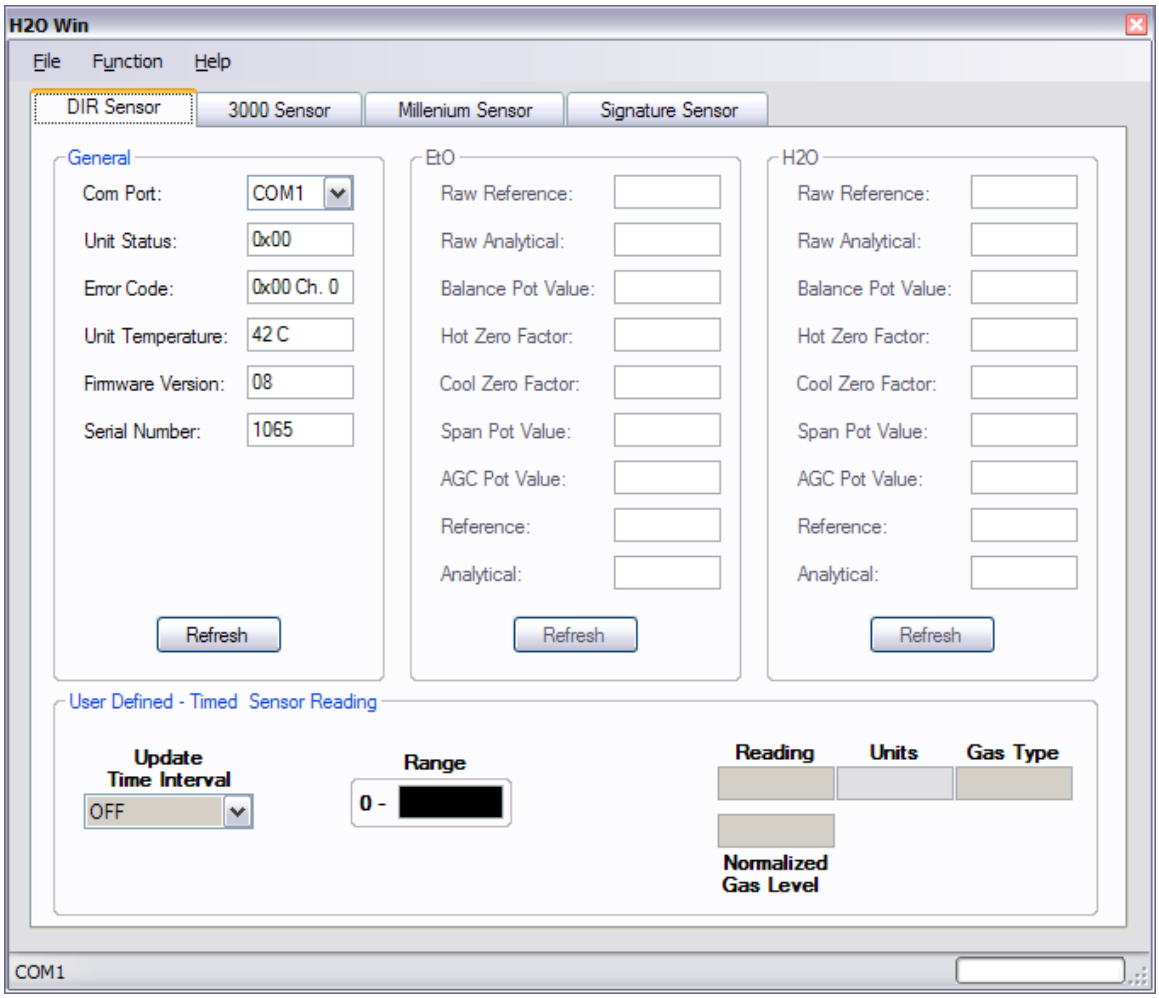
The software is used on a PC connected to an SEC PC IR Link Kit (PN 1420636) via a 9 pin serial (straight through) cable. The SEC Signature is wired to the SEC PC IR Link, if the SEC Signature DIR is powered from a different 24 VDC power supply (external to the PC IR Link) only the white (communication wire) and black (DC Common) wire need to be connected to the PC IR Link to communicate.



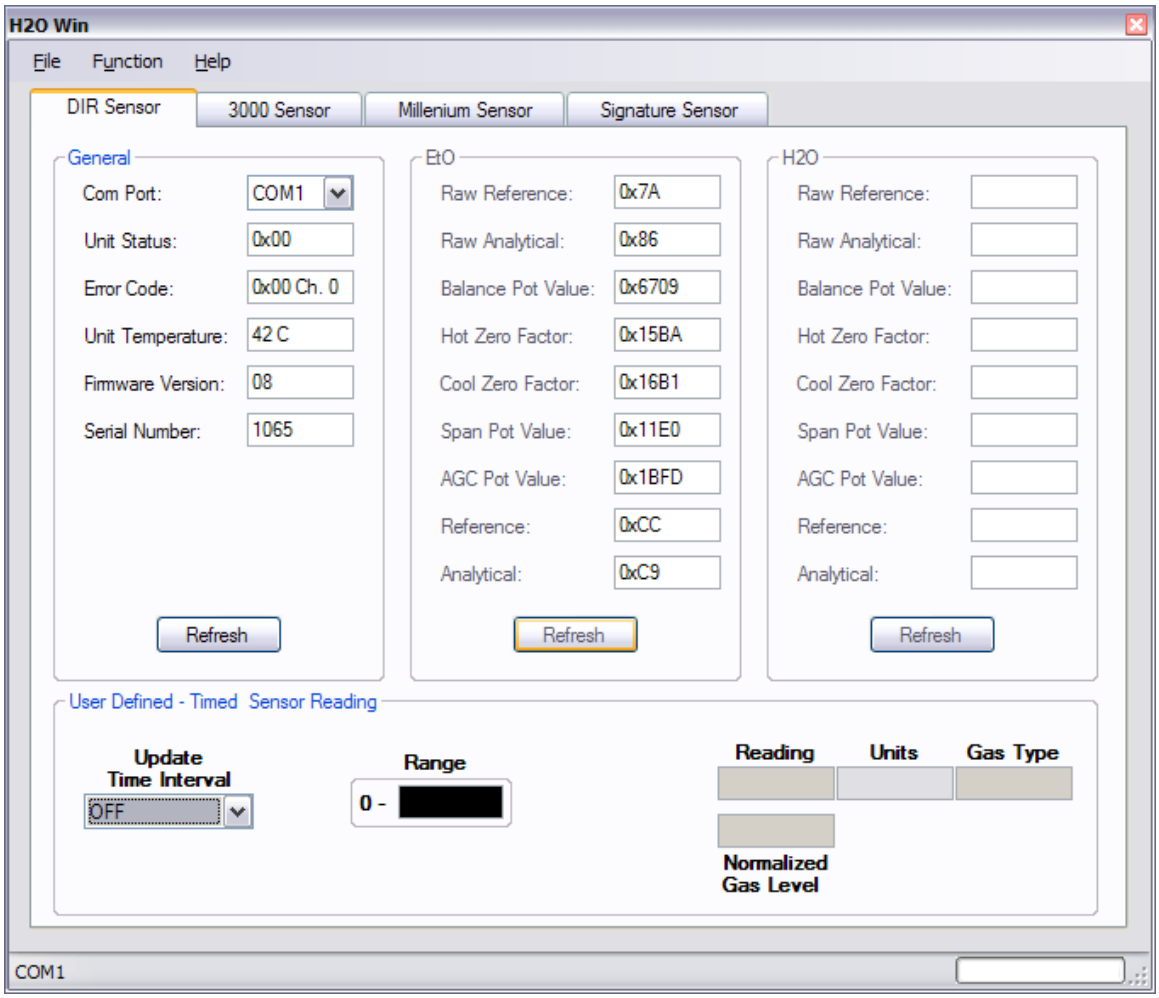
Select the communication port used on the PC. If the computer does not have a 9 pin serial port a USB to 9 pin serial adaptor can be used.



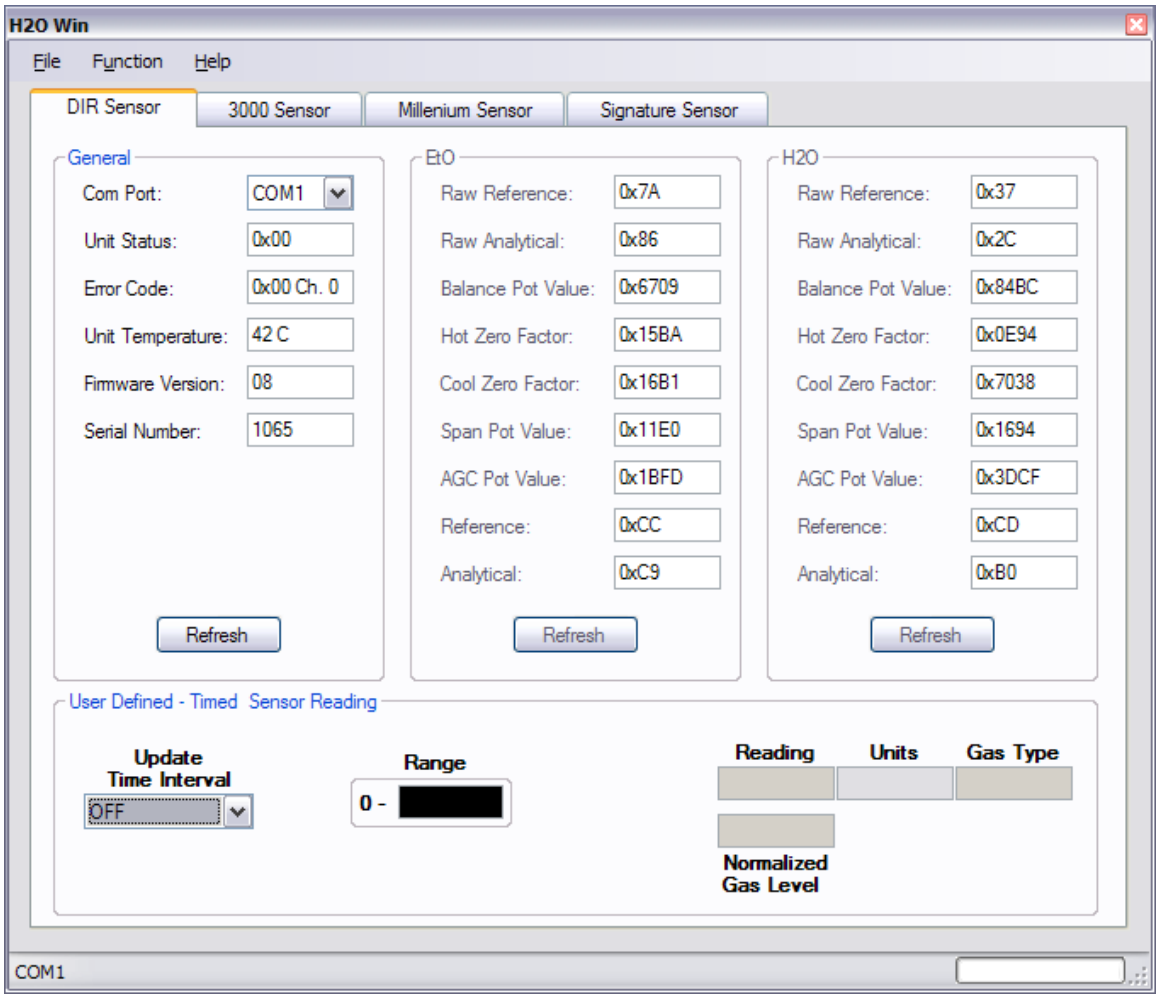
The software recognizes the available ports on the PC. Select the one to be used.



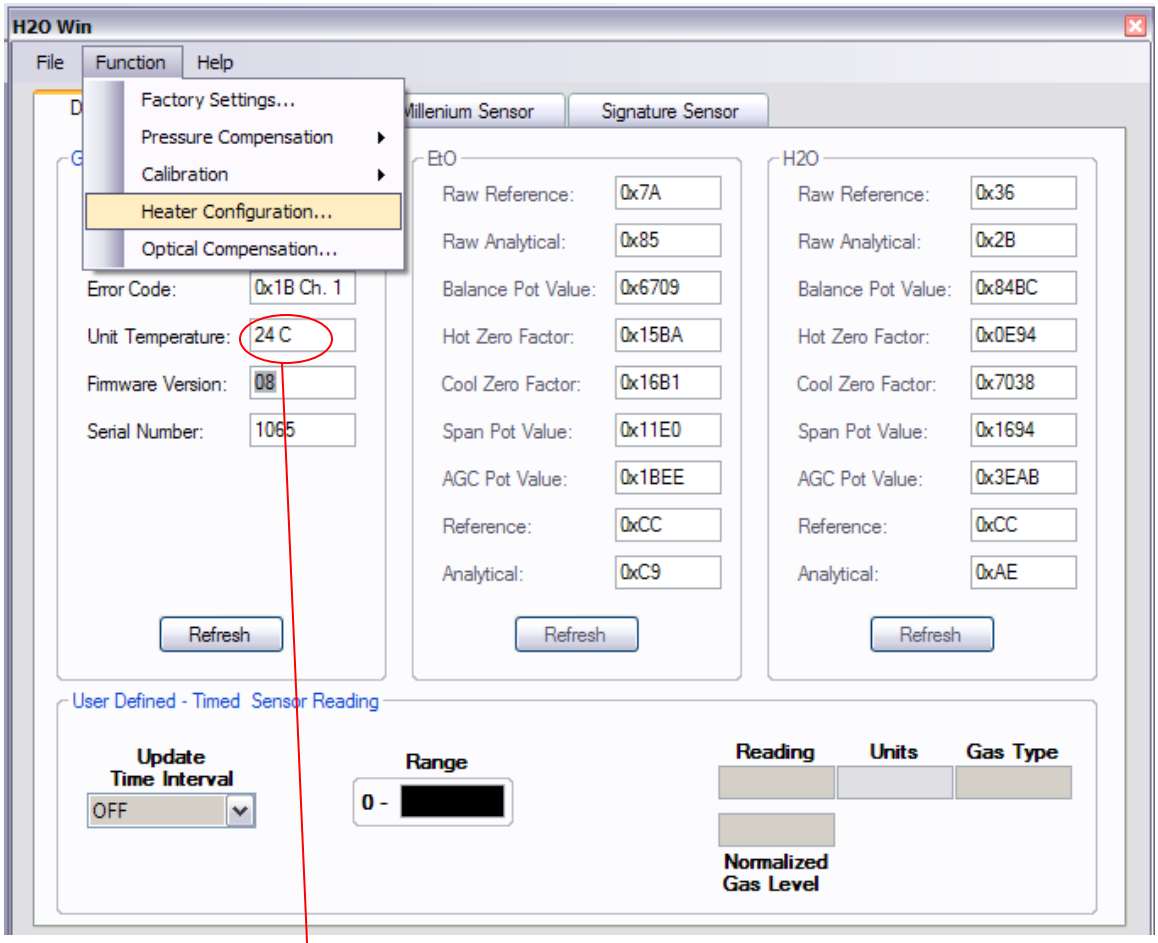
Once communication is established the “General” area is automatically updated. The General, EtO and H2O areas are all manually updated using the individual “Refresh” buttons.



Example of selecting Refresh EtO channel.



Example of selecting Refresh H2O channel.

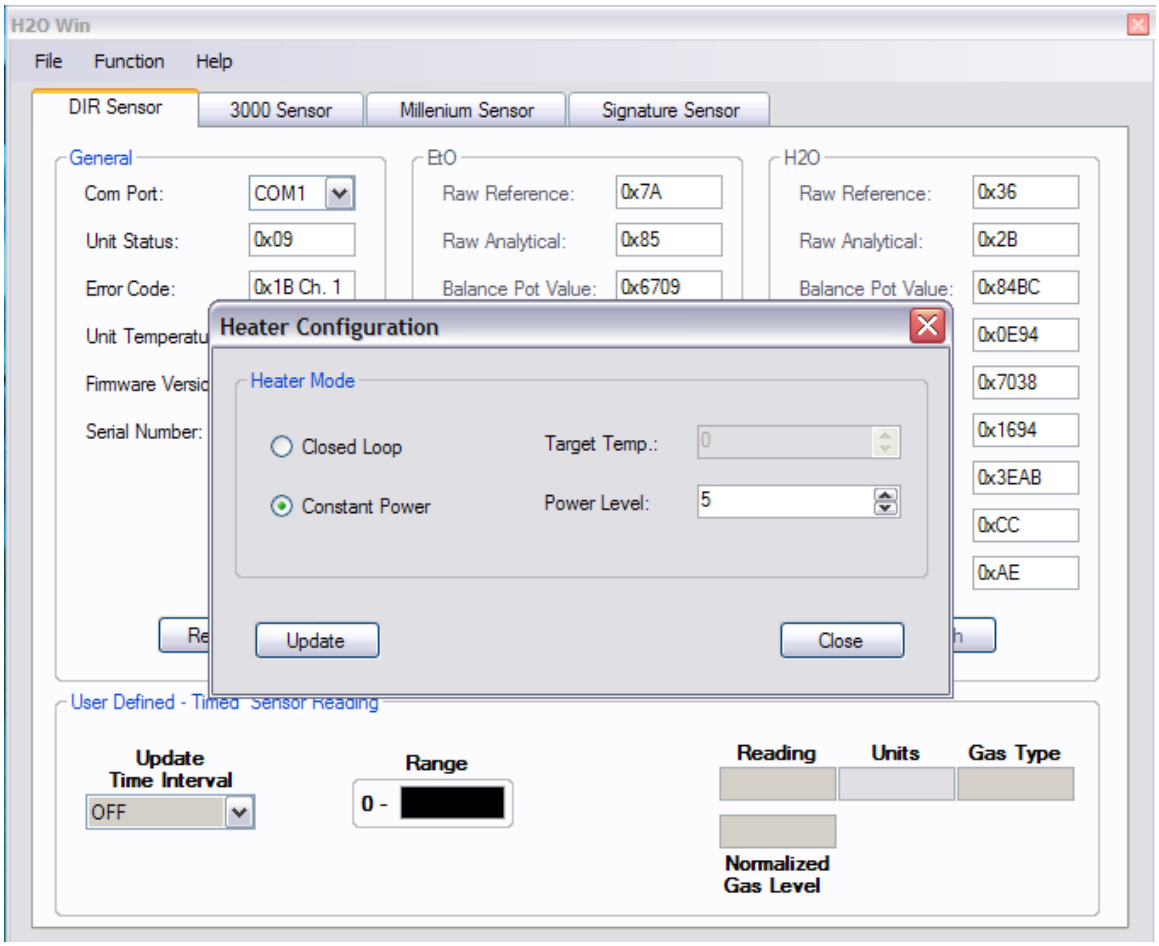


The Function tab will allow the operator to configure the SEC Signature DIR. When prompted for a password the password is:

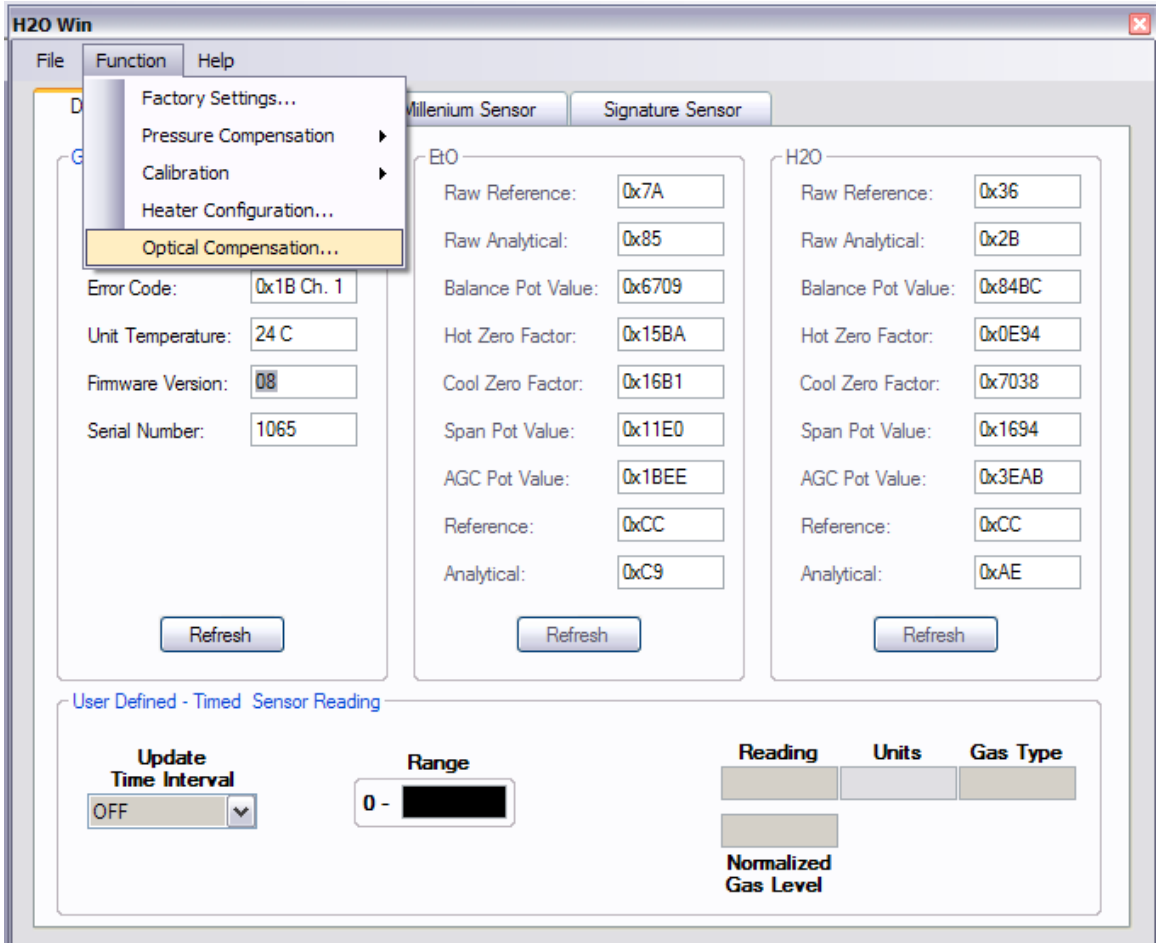
sec

First step is to configure the heater. The heater is configured by monitoring the SEC Signature DIR's temperature. The temperature should be a minimum of 5 degrees C above process temperature throughout the entire process cycle.

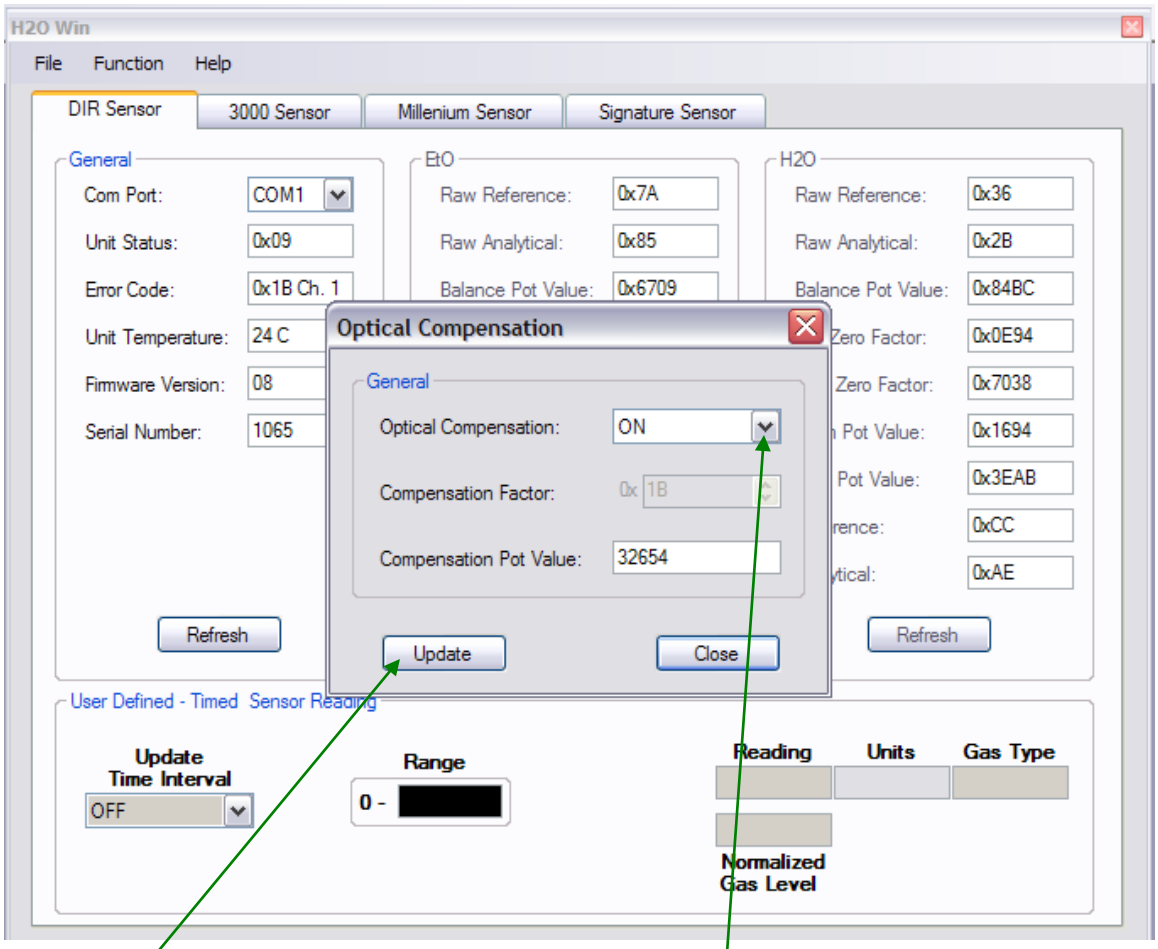
Insulating the SEC Signature DIR is recommended.



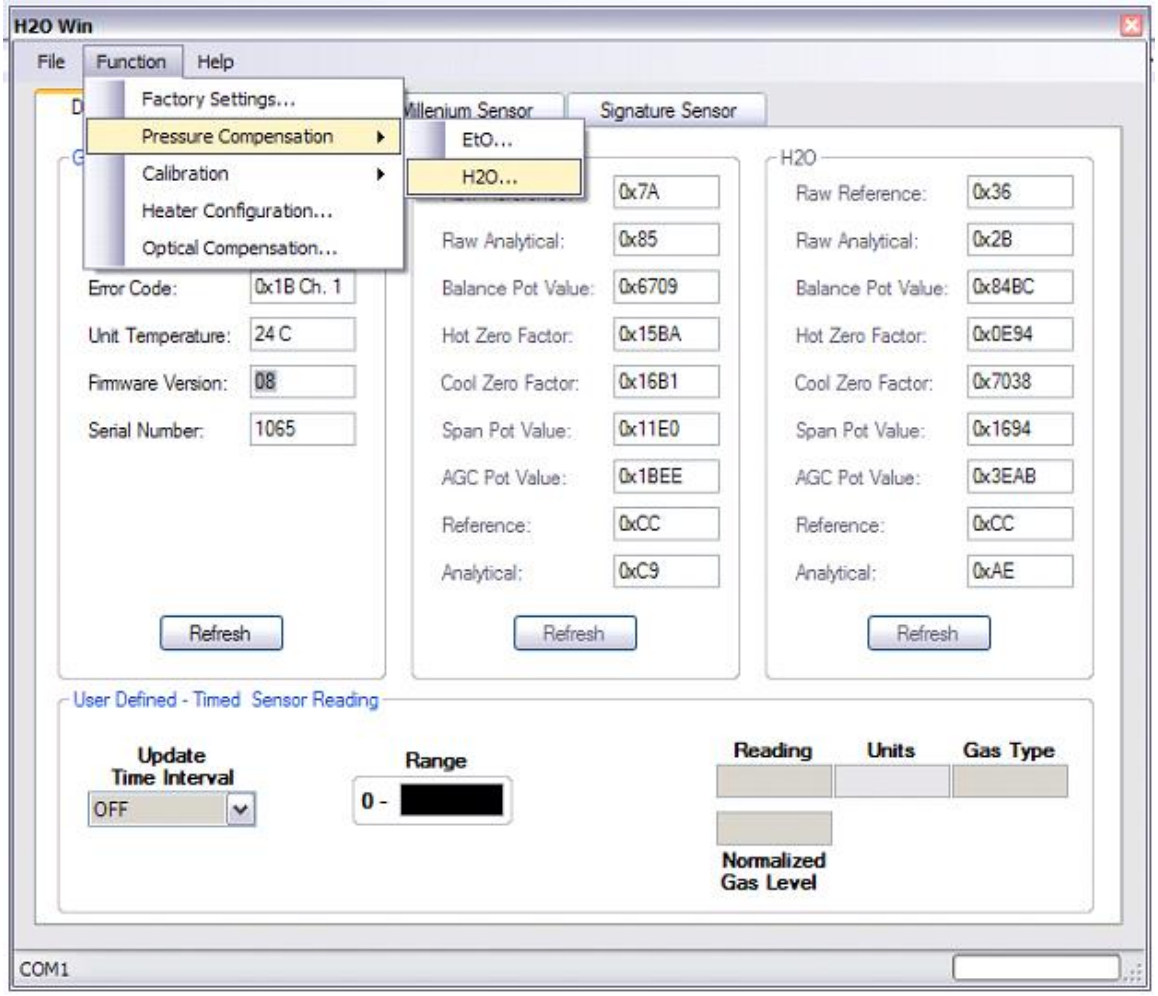
SEC recommends the SEC Signature be operated in the constant power mode. The SEC Signature DIR heat can be raised by increasing the Power Level number and lowered by decreasing the Power Level number. The Power Level number scale is 0-10. Once the number is changed, select Update to load the new number into the SEC Signature DIR.



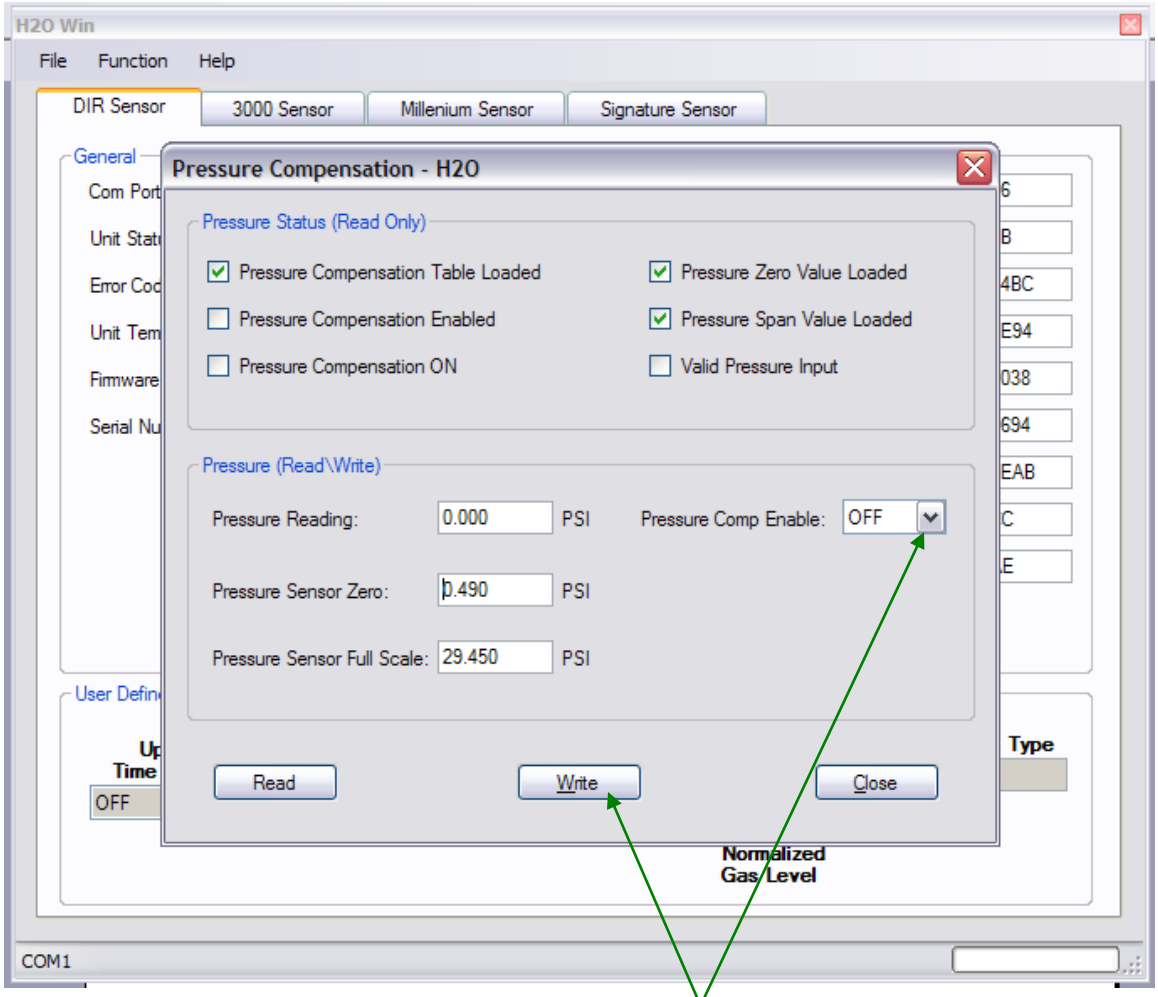
Optical Compensation is used to cancel any EtO response on the H2O channel.



The operator can turn the Optical Compensation ON or OFF. If a change is made, select Update to send the information to the SEC Signature DIR.

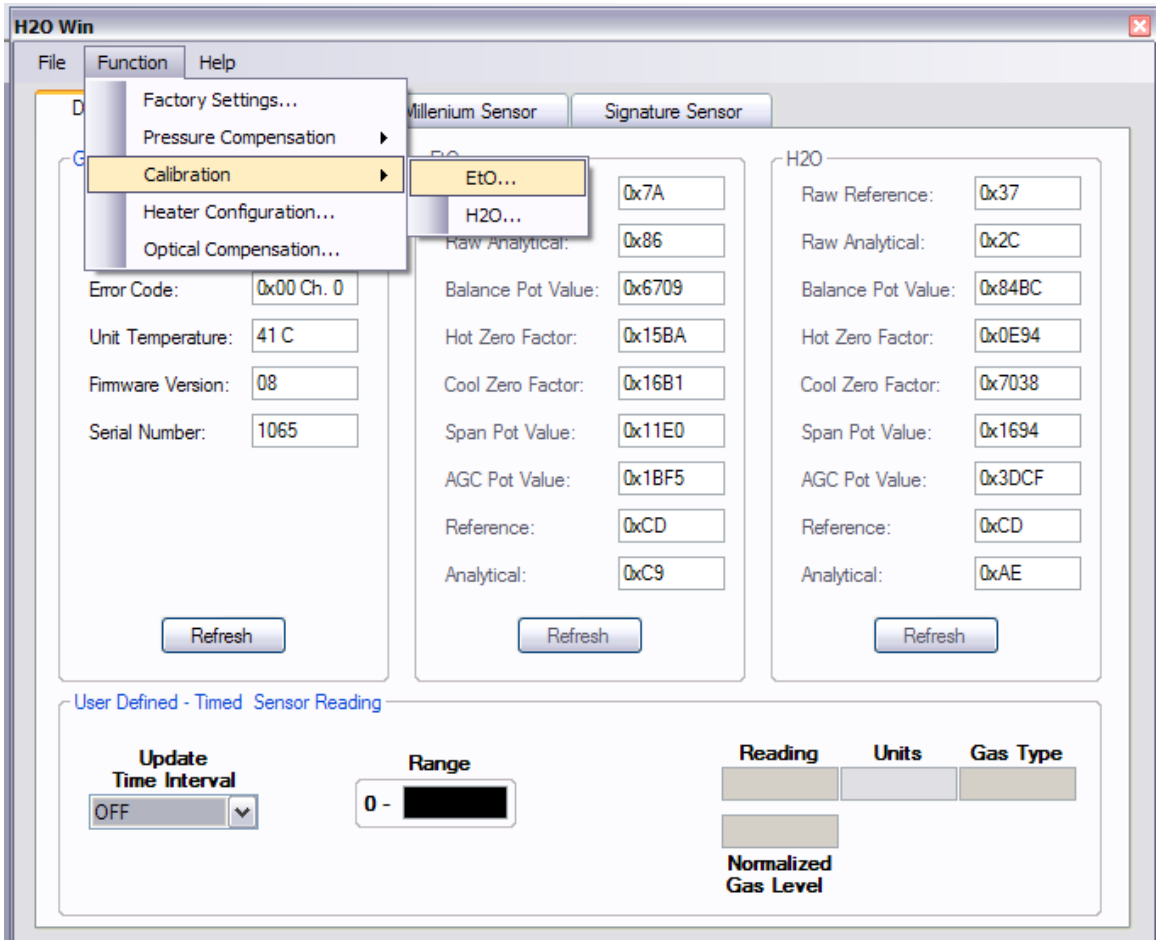


Pressure Compensation is used to cancel pressure effects on the H2O channel. If Pressure Compensation is disabled the SEC Signature DIR assumes all pressure rise in the chamber is due to water vapor. When other vapors such as nitrogen or EtO are injected into the chamber, there will be an effect on the H2O molecule absorption characteristics. If accurate H2O readings are recorded / required throughout the entire cycle, SEC recommends adding an absolute pressure transmitter to the SEC Signature DIR circuit and enabling the pressure compensation feature. Details can be found in the SEC Signature DIR Instruction Manual.



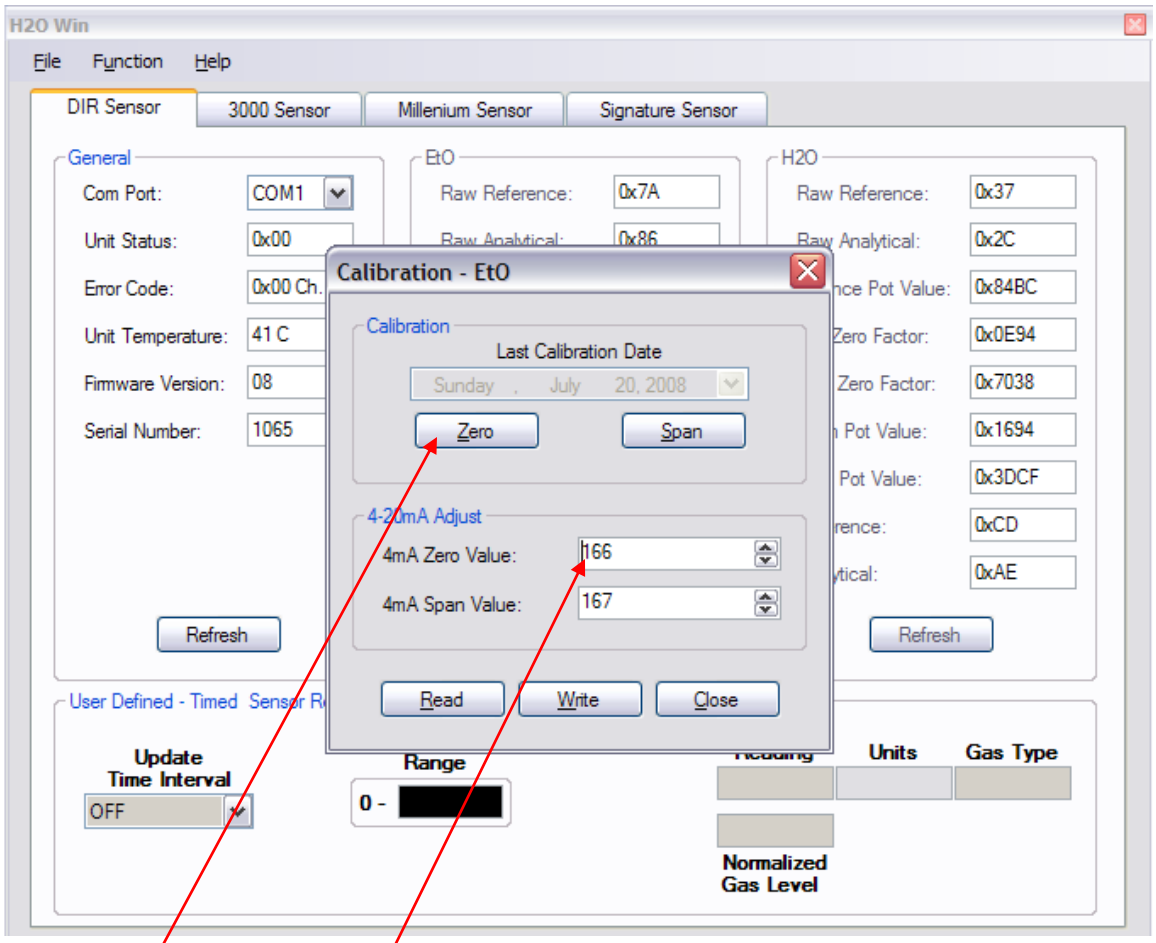
The page allows the operator to configure the pressure compensation features. The SEC Signature DIR only knows PSIA. If an absolute pressure transmitter with another measurement scale is used (inHg, bar, etc), the units must be converted to PSIA and input into the SEC Signature DIR as PSIA.

To turn the Pressure Compensation ON click the box and Write it to the SEC Signature DIR.



EtO channel Calibration

Note: If calibrating H2O channel with CO2 (20.5% volume), DISABLE both the Optical and Pressure Compensation before entering the calibration procedure. If calibrating the H2O channel with water vapor ENABLE both the Optical and Pressure Compensation if being used.



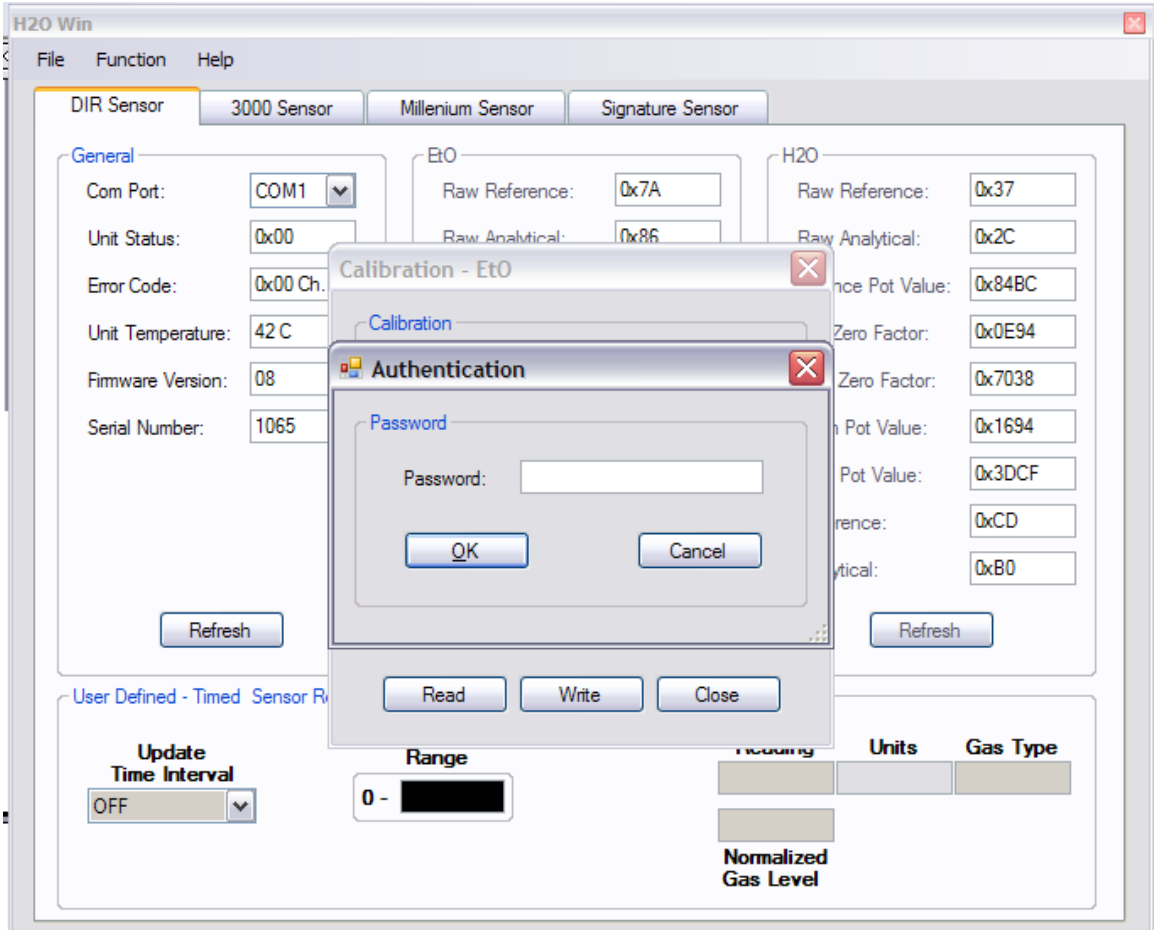
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 12mA) span current output value.

Zero

Apply 99.9% volume nitrogen to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Select Zero button and the Authentication box (example on next page) will appear requiring the operator to enter the password. Enter password select OK and the EtO channel is zeroed. The H2O channel can be zeroed at this time also. The operator will have to close out of the Calibration EtO box and enter the Calibration H2O menu.

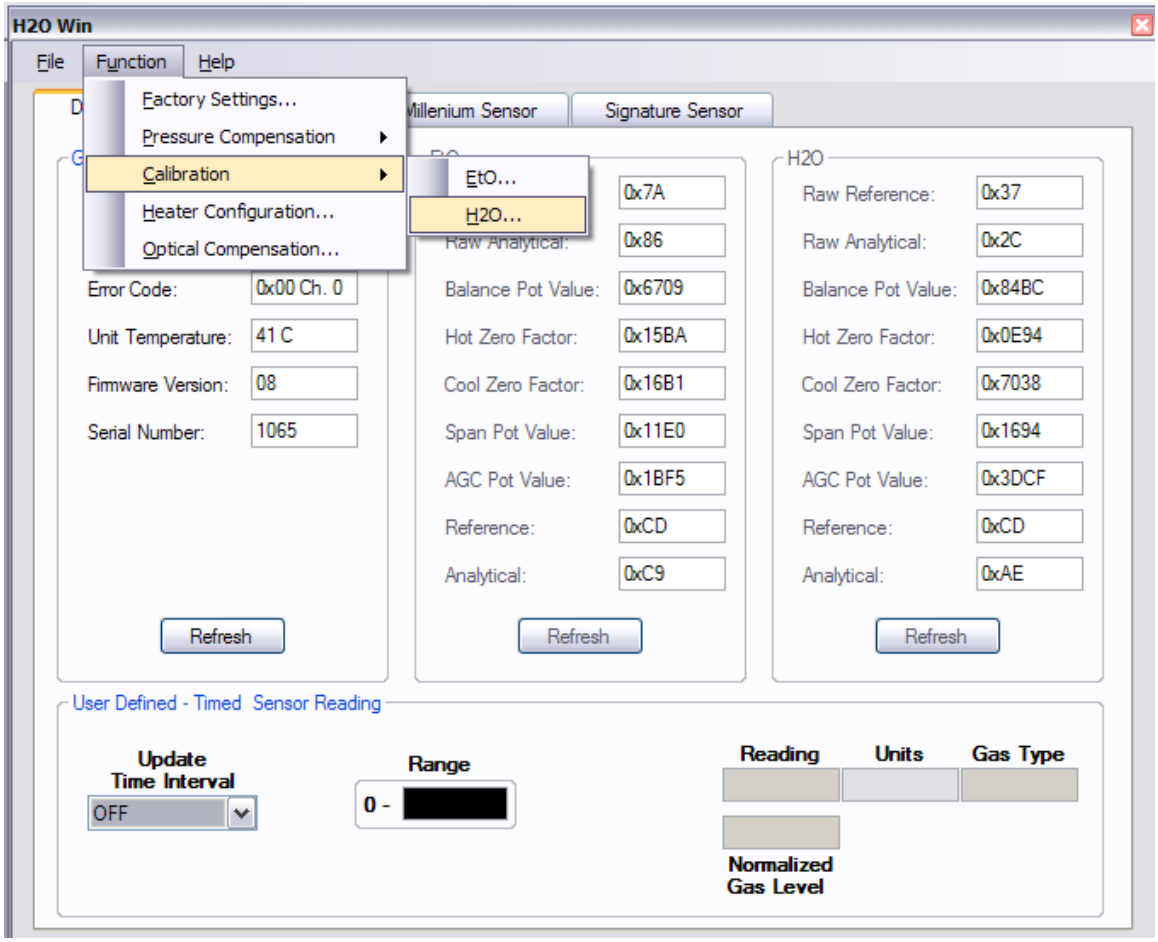
4mA Zero Value

Once the SEC Signature is zeroed, the operator can tweak the current output to read 4 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



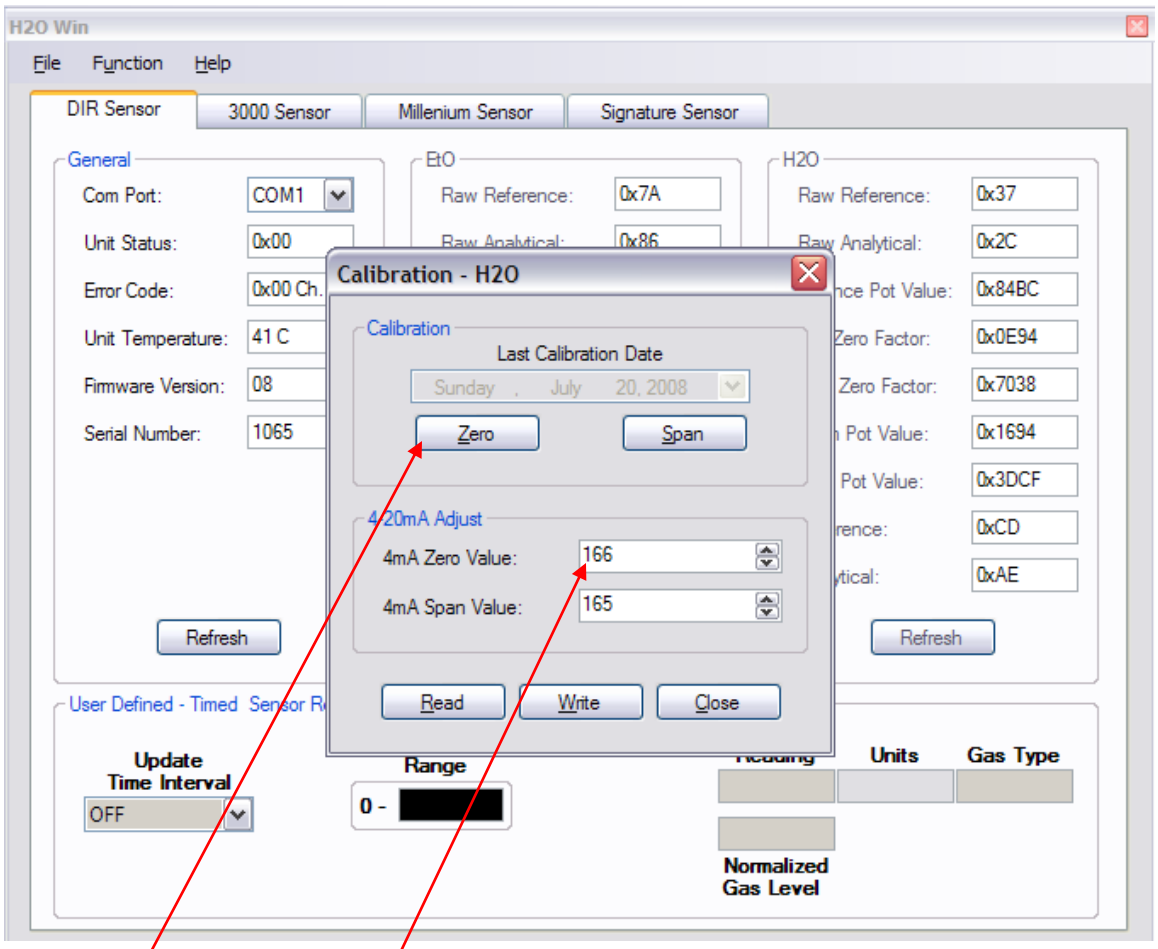
Password:

sec



H2O channel Calibration

Note: If calibrating H2O channel with CO2 (20.5% volume), DISABLE both the Optical and Pressure Compensation before entering the calibration procedure. If calibrating the H2O channel with water vapor ENABLE both the Optical and Pressure Compensation if being used.



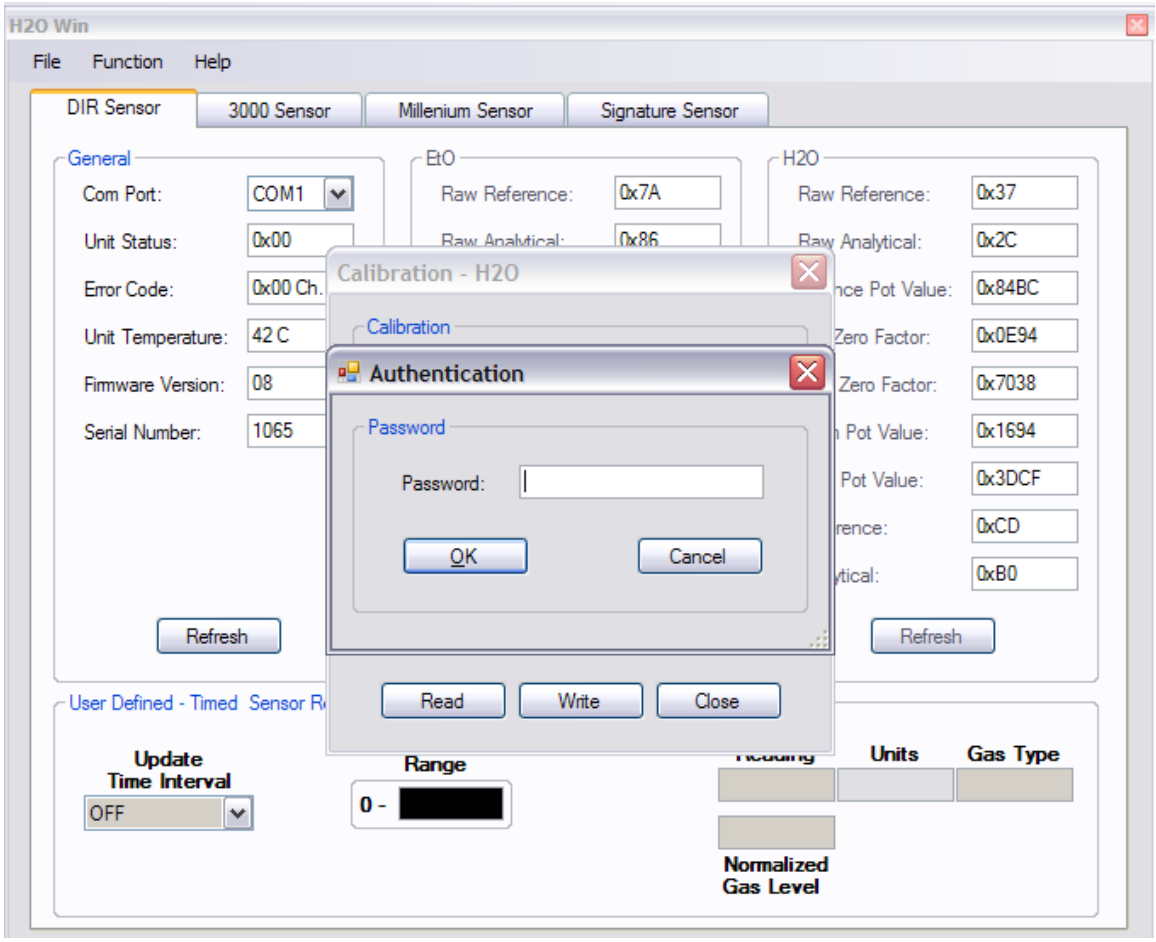
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 8mA) span current output value.

Zero

Apply 99.9% volume nitrogen to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Select Zero button and the Authentication box (example on next page) will appear requiring the operator to enter the password. Enter password select OK and the H2O channel is zeroed. The EtO channel can be zeroed at this time if it has not been done. The operator will have to close out of the Calibration H2O box and enter the Calibration EtO menu.

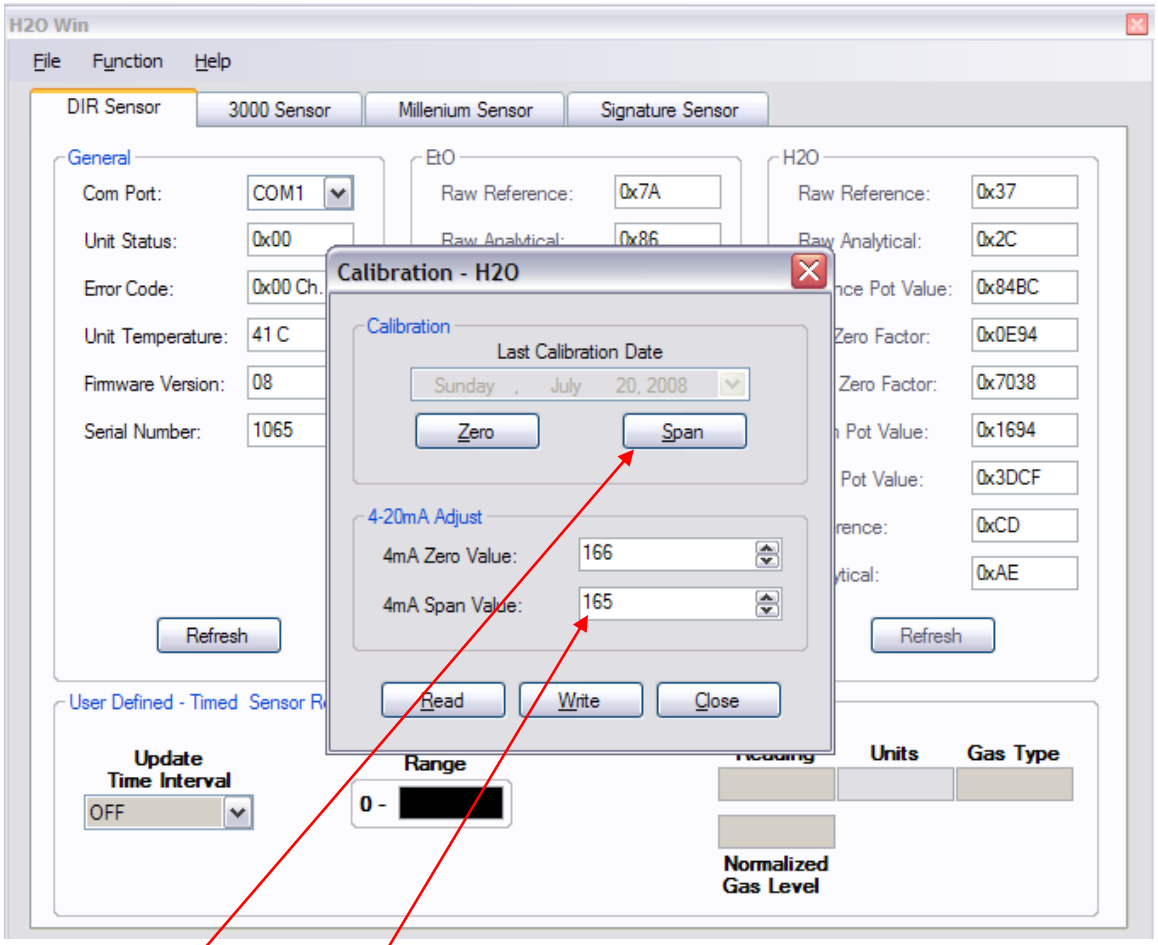
4mA Zero Value

Once the SEC Signature is zeroed, the operator can tweak the current output to read 4 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



Password:

sec



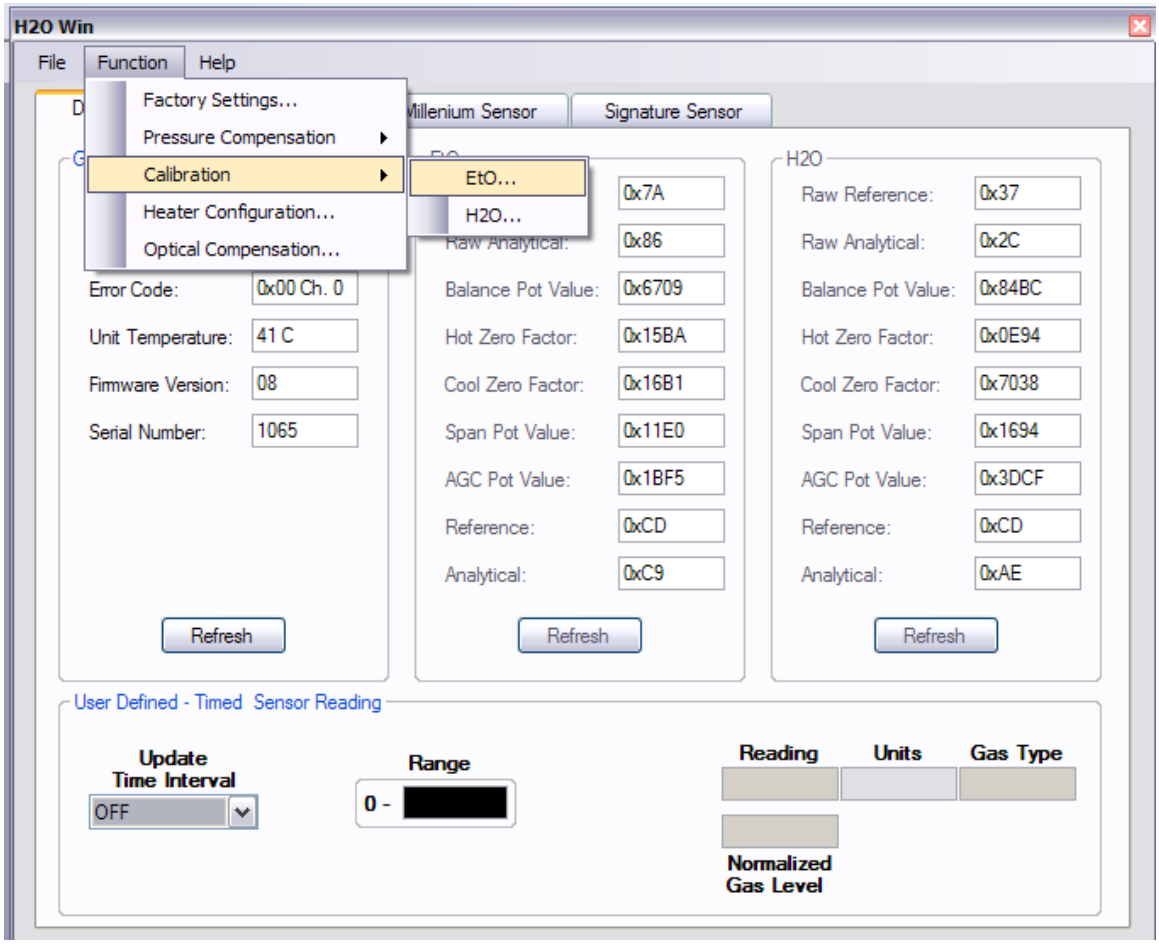
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 8mA) span current output value.

Span

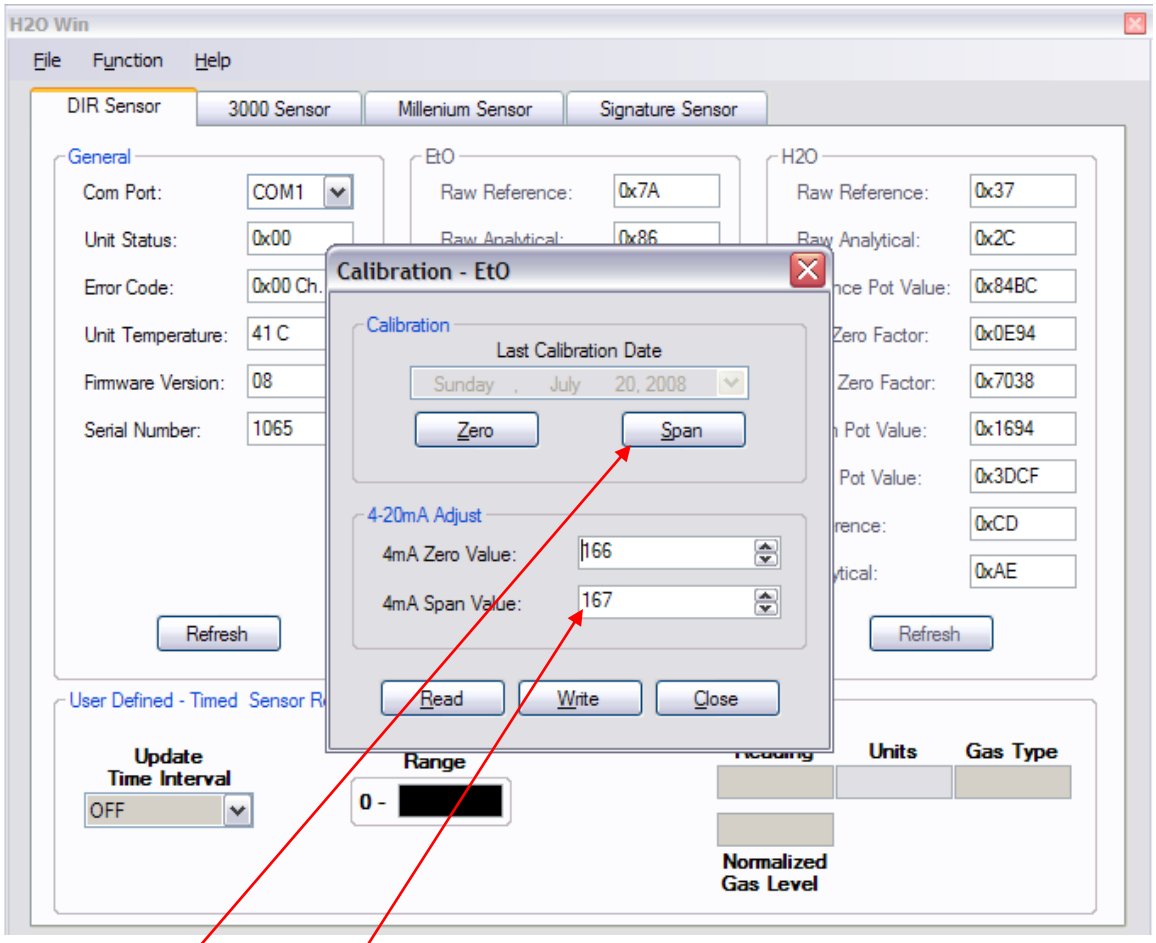
Apply 20.5% volume CO2 to the SEC Signature DIR for approximately 5 minutes at 2 liter per minute flow rate. Allow the SEC Signature DIR to stabilize. Select Span button and the Authentication box will appear requiring the operator to enter the password. Enter password select OK and the H2O channel is spanned.

4mA Span Value

Once the SEC Signature is spanned, the operator can tweak the current output to read 8 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



The final step is to span the EtO channel.



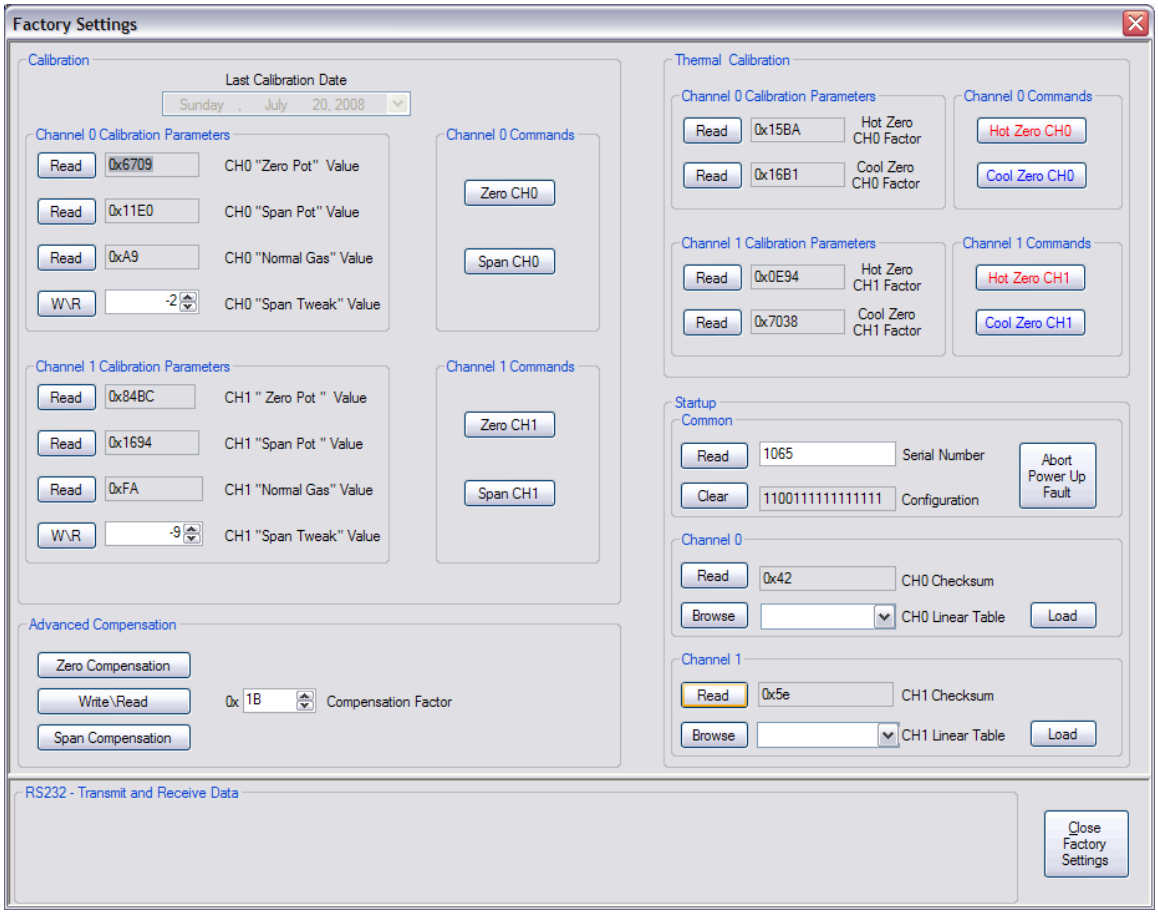
This box allows the operator to zero, span, adjust the 4mA zero current output value and adjust the 4mA (actually 12mA) span current output value.

Span

Charge the chamber with EtO to 50% full scale. Allow the SEC Signature DIR to stabilize (approximately 15 minutes into EtO dwell. Select Span button and the Authentication box will appear requiring the operator to enter the password. Enter password select OK and the EtO channel is spanned.

4mA Span Value

Once the SEC Signature is spanned, the operator can tweak the current output to read 12 mA ± 0.03 mA by changing the number up or down. Increasing the number raises the current output lowering the number decreases the output current. One step change is approximately 0.03 mA. After the number is changed, the operator must select the Write button to load the new value into the SEC Signature DIR.



This page can only be reached with a special password. Only factory trained operators have access to this page.