ABB C1D2
LGR-ICOS™ Gas Analyzer
Service Manual

HAZLOC X-Purge C1D1 &2
& HAZLOC Z-Purge C1D2

P/N: 950-0000-0001-VLR5

Rev. AA, April 2016

Table of Contents

Warning!	Service to the *LGR-ICOS* Gas Analyzer is to be performed only by certified service personnel trained on this instrument. User/operator adjustments inside the instrument are neither necessary nor recommended by the manufacturer.

Patent

The *LGR-ICOS*™ Gas Analyzer technology is protected by patents:

- 7,468,797
- 6,839,140
- 6,795,190
- 6,694,067

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NOTE: Please be prepared to provide the serial numbers of all units.

1 Introduction

This manual is intended for personnel in charge of maintaining and servicing the *LGR-ICOS* Gas Analyzer. It includes safety information, measurement theory, wiring diagrams, diagnostic and troubleshooting procedures, component repair and replacement procedures, parts list, and MSDS of solvents used for cleaning the instrument's mirrors.

2 Safety

The following pages provide important safety precautions.

Class of Laser Equipment

The *LGR-ICOS* Gas Analyzer is a Class 1 laser instrument when the front panel is secured into position.

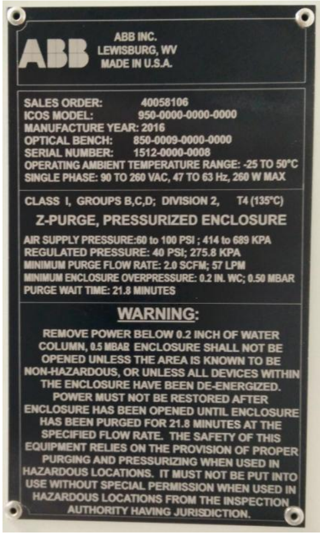
Certification

The *LGR-ICOS* Gas Analyzer received the following safety certifications:

Table 1 *LGR-ICOS* Gas Analyzer Safety Certifications

Certification	X-Purge Standards Tested & Met	Z-Purge Standards Tested & Met
North American Certifications	Class I Division 1 (or 2) Group B, C, D, and Zone 1 (or2) Group IIB+H2 Temperature Code T4	Class I Division 2 Group B, C, D, and Zone 2 Group IIB+H2 Temperature Code T4
CSA C US	NEC and CEC, 61010-1, NFPA 496, NEMA 250, UL 1203 C22.2 No. 30 UL 913, C22.2 No. 157 UL 60079-0 UL 60079-1 UL 60079-2 UL 60079-11	NEC and CEC, 61010-1 NFPA 496 NEMA 250 ISA 12.12.01 UL 60079-0 UL 60079-2 UL 60079-15
Ex	II 2G Ex db ib pxb IIB+H2 T4 Gb -20 C < Ta < +50C – IP54 ATEX Zone 1 or 2 2014/34/EU ATEX Directive: EN 60079-0, EN 60079-2, EN 60079-15 EN 61010, EN 61010-2-101 Laser Safety, EN 60825-1 2004/108/EC EMC Directive, EN 61326-1.	II 3G Ex nA pzc IIB+H2 T4 Gc -20 C < Ta < +50C – IP54 ATEX Zone 2 2014/34/EU ATEX Directive: EN 60079-0, EN 60079-2, EN 60079-15 EN 61010, EN 61010-2-101 Laser Safety, EN 60825-1 2004/108/EC EMC Directive, EN 61326-1.
IECEx	Zone 1 or 2 Ex db ib pxb IIB+H2 T4 Gb	Zone 2 Ex nA pzc IIB+H2 T4 Gc
CE	2014/34/EU (ATEX), EN60079-0 2004/108/EU (EMC), EN61326-1	2014/34/EU (ATEX), EN60079-0 2004/108/EU (EMC), EN61326-1
FDA	Title 21 Code of Federal Regulations, chapter 1, sub-chapter J	Title 21 Code of Federal Regulations, chapter 1, sub-chapter J.

Fig. 1 *LGR-ICOS* Gas Analyzer Certification Labels



WEEE Directive

The *LGR-ICOS* Gas Analyzer product is not subject to Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC or relevant national laws (e.g. ElektroG in Germany).

The product must be disposed of at a specialized recycling facility. Do not use municipal garbage collection points. According to WEEE Directive 2002/96/EC, only products used in private applications may be disposed of at municipal garbage facilities. Proper disposal prevents negative effects on people and the environment, and supports the reuse of valuable raw materials.

Symbols

The following symbols may be used in the documentation or on the instrument:

Table 2 Documentation Symbols

Symbols	Meaning
	Important information
	Danger: Failure to comply may result in death. Warning: Failure to comply may result in serious injury. Caution: Failure instructions carefully to avoid equipment damage or personal injury.
	Hot surface
	High voltage

Labels

The following labels are affixed at specific locations on or in the *LGR-ICOS* Gas Analyzer. They identify hazardous areas.

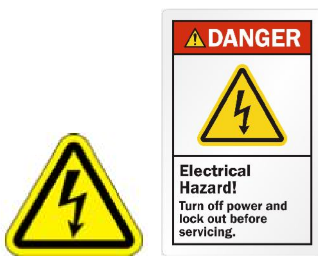
Fig. 2 Heavy Object Label

This label is affixed to the outer covers of the *LGR-ICOS* Gas Analyzer. The instrument weights ~ 248 pounds.

Fig. 3 Pinch Point Label

This label is located on the ICOS cell enclosure held in place with latch snaps, and also on the front panel when at the close position.

Fig. 4 High Voltage Label



This label is located on the interior side of the right-hand side panel, next to the AC power terminal block, the filter AC line powering the instrument, and on the purge controller.

Fig. 5 Laser Radiation Label

These labels are located on the ICOS cell enclosure. The fiber laser is visible only when the insulated enclosure is removed from the ICOS cell.

Fig. 6 Burn Hazard Label

This label is located on the ICOS cell enclosure. A few heater units used to control gas temperature can be set to very high temperatures. Contact with these heaters is only possible if the safety insulated enclosure is removed.

Fig. 7 Fire Hazard Label

During scheduled preventive maintenance (PM), chemicals used to clean the ICOS cell mirror are flammable.

Operator Safety

When its front panel is closed and locked into position, the *LGR-ICOS* Gas Analyzer runs safely, without risk to the operator. Operating the instrument in any other condition can damage the equipment or injure personnel. Follow these general safety guidelines at all times.

NOTE: The LGR-ICOS Gas Analyzer is a Category II (overvoltage category) installation.

Do not operate the Gas Analyzer when the front panel is open:

- The front panel protects against electrical shocks and explosions due to gas leakage in the surrounding area.
- Should a spark occur, the Gas Analyzer is designed to 1) maintain a specific internal pressure, 2) dilute and purge the instrument of possible internal gas leaks, and 3) contain explosions.
- Only the X-Purge Gas Analyzer has an internal pressure bypass switch. Do not use the bypass switch when the instrument inlet gas line is connected to a flowing customer gas line.

Danger! 	Bypassing the internal pressure interlock switch to open the front panel during instrument operations can cause serious bodily injury or death due to possible explosion and/or direct exposure to customer gas from possible internal leaks.

Heavy Objects

The Gas Analyzer, which weighs approximately 248 lbs., qualifies as a heavy object.

Caution!	The *LGR-ICOS* Gas Analyzer should not be hand-carried. It is recommended that the unit be rolled to its final mounting site with a floor fork lift or a wheeled table. Lifting the instrument to the final mounting location should be accomplished, with guidance, with a hoist or fork lift.

Do the following when relocating the *LGR-ICOS* Gas Analyzer:

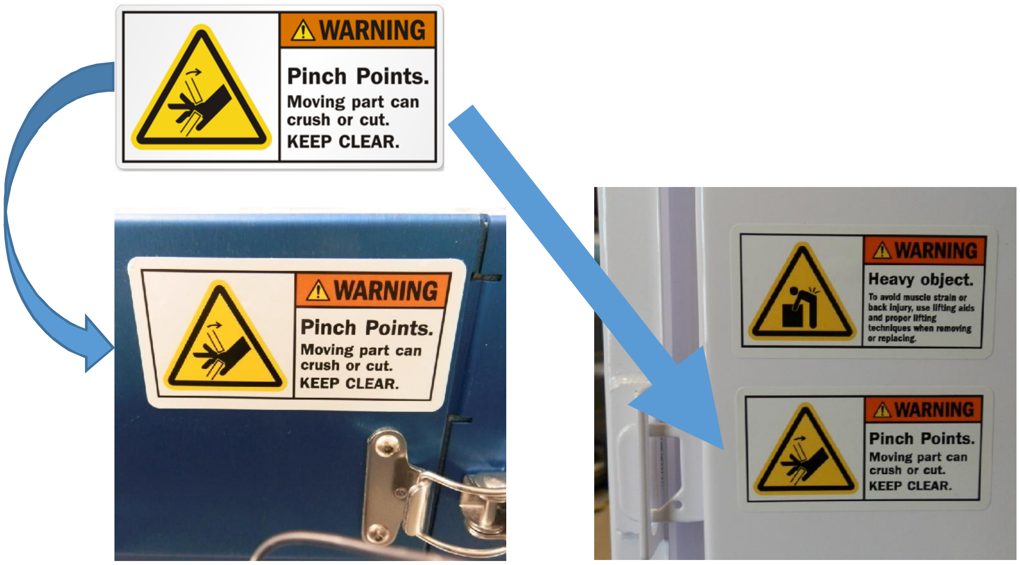
- Use a mechanical hoist, if available.
- Use a minimum of three people for lifting, moving and mounting the Gas Analyzer.
- Use proper lifting techniques:
    - Do not lift with your legs straight or from a forward bent position.
    - Bend your knees and lower your hips, using your leg muscles to lift.
    - Make sure that you stay as close to the load as possible.
- Test the load to make sure that you are able to lift it safely. If so, lift the load while keeping it as close to your body as possible.
- Avoid sudden movements and NEVER twist your body. A bending and twisting motion could cause the discs in your spine to rupture. If you have to turn the instrument, make sure that your hips and shoulders are always aligned; move your feet first so that you face the area where you can safely put down the load.
- If the load is not safe to lift by yourself, make sure that you get help. When two persons (or more) are performing the lift, make sure that your actions are synchronized. You must communicate with each other to avoid injury, and it is best for one person to make the calls so that you can lift together.
- Avoid lifting heavy objects with one hand. Always try to balance the load in both hands, or get a cart.

Fig. 8 Heavy Object Label and Location

Pinch Point Hazards

There are several pinch point hazards to personnel on or inside the Gas Analyzer. Pinch point hazard locations are marked with a pinch point label. One is next to the clamp that locks the blue heat shield in place, and the other is located on the instrument side panel.

Fig. 9 Pinch Point Label and Location



Hazardous Voltages

There are two voltage potentials operating above 30 volts RMS on the *LGR-ICOS* Gas Analyzer. They provide 117V AC and are located at the power entry module that feeds the AC/DC voltage converter. Components at these two locations are marked with the electrical hazard label.

Fig. 10 Electrical Hazard Label and Locations

Safety Provisions

The insulation and enclosure protect instrument operators from contact with hazardous voltages during normal system operation. If a short circuit or other over-current condition occurs, the internal fuse protects individual power supplies and disconnects the power line from the incoming power supply.

Location of Hazardous Voltages

Electrical hazard warning labels are applied wherever the removal of a panel can create an opportunity for contact with hazardous voltages.

Electrical Safety Task Types

When a procedure contains a task that takes place where direct exposure to electricity may happen, the task type is identified according to the SEMI S2-93A standard.

Should a technician or engineer perform additional communication connections on the *LGR-ICOS* Gas Analyzer, be aware of the electrical task type encountered while performing these connections. Table 3 provides a list of SEMI S2-93A task types and their definitions.

Table 3 Electrical Safety Task Types

Type	Definition
Type 1	• Equipment is fully de-energized (electrically "cold")
Type 2	• Equipment is energized • Live circuits are covered or insulated • Work is performed at a remote location to prevent accidental shocks
Type 3	• Equipment is energized • Live circuits are exposed and accidental contact is possible • Potential exposures are less than 30 volts RMS, 42.2 volts peak, 240 volt-amps, and 20 joules
Type 4	• Equipment is energized • Live circuits are exposed and accidental contact is possible • Potential exposures are greater than 30 volts RMS, 42.2 volts peak, 240 volt-amps, 20 joules, or radio frequency (RF) is present
Type 5	• Equipment is energized • Measurements and adjustments require physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes

Electrical Hazards During Normal Operation

Normally, when the Gas Analyzer front panel is closed, the instrument is a Type 2 electrical safety task.

The insulation and front panel protect operators from electrical hazards. The front panel must remain in place during normal operation. The safety interlock, the instrument's internal pressure interlock switch, protects operators from accidental exposure to Type 3 electrical hazards.

Electrical Hazards During Service Operation

Service to the *LGR-ICOS* Gas Analyzer should only be performed by personnel that has completed service training for the instrument.

Personnel are not exposed to live circuits unless the front panel is opened and the pressure switch interlock is defeated or bypassed. Most service procedures require opening the front panel. During these tasks, service personnel is potentially exposed to Type 3 electrical hazards. A Type 4 electrical hazard is encountered when validating AC power coming from the facility while the outer case cover plate is removed from the AC inlet and purge.

There are no Type 5 tasks required for the Gas Analyzer.

Laser Hazards

There are up to two lasers operating inside the *LGR-ICOS* Gas Analyzer. The laser wavelength is determined by the type of gas to measure. Under normal operation, with the instrument front panel closed, the Gas Analyzer spectroscopy instrument is a *Class 1 Laser Product* in accordance with *Title 21 Code of Federal Regulations, chapter 1, sub-chapter J*.

Class 1 Laser Product

Lasers used in the *LGR-ICOS* Gas Analyzer are rated Class 3B, >5 mW. Lasers are enclosed and not accessible unless the enclosure is removed for servicing. A laser warning label is affixed to the enclosure covering the lasers.

Fig. 11 Laser Radiation Labels

Lasers in the Gas Analyzer are not field serviceable. Should a laser failed in the field, the whole ICOS module will be replaced containing a complete aligned measurement optics. There is only one type of user-serviceable parts in the Gas Analyzer ICOS module: the ICOS mirrors that can be clean during preventive maintenance (PM) of the instrument.

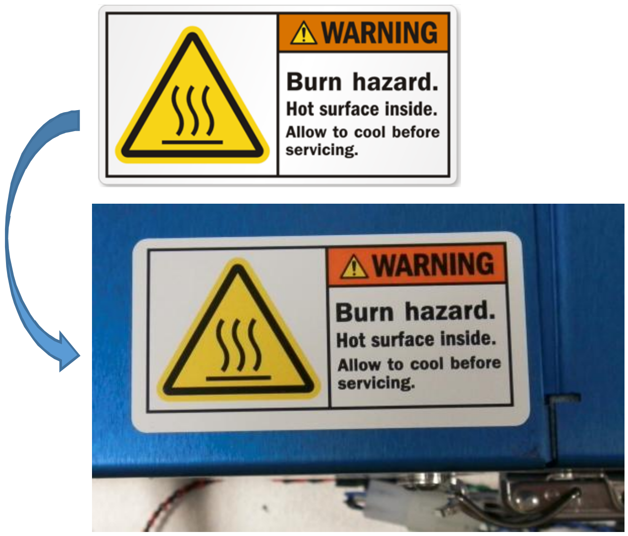
A laser Interlock Switch is attached to the left side blue thermal shield such that when the shield is removed for access to the ICOS Assembly, the Interlock Key will be separated from the lock thus removing power to the laser through the Laser Controller PCB.

NOTE: Laser replacement requires the removal of the ICOS module from the main enclosure. The laser is contained within the ICOS module. The removed ICOS module can be ship back to ABB for repair.

Burn Hazards

Burn hazards are defined as components that can cause physical burns upon contact. The *LGR-ICOS* Gas Analyzer is designed to measure high-temperature gases at up to 105°C through the inlet gas line and inside the ICOS module. The ICOS module is heated, and its temperature can be set up to maintain a 175°C operating temperature. The temperature set point of the ICOS module depends on the gas to be analyzed. Burn hazard labels are placed in the area of the instrument's inlet gas line and the ICOS insulated enclosure to help identify burn hazards inside the assembly.

Fig. 12 Burn Hazard Label and Location



Burn hazards may be encountered during replacement or check of the ICOS heater, filter, thermocouple, and/or valve. Allow the system to cool off after it has been powered down for maintenance.

Fire Hazards

Small amounts of methanol and acetone are used to clean surfaces on the *LGR-ICOS* Gas Analyzer. A typical service procedure requires the use of less than 25 milliliters of such chemicals. These chemicals present a fire hazard. Use these chemicals only in accordance with local regulations and standards. Do not use these chemicals near open flames, sparks, or heat. Wipes soaked in such chemicals must be disposed of in accordance with requirements of 40 CFR, local fire department and environmental jurisdictions.

Fig. 13 Fire Hazard Label

Safety Provisions

Follow these precautions when dealing with all chemicals:

- Keep all chemical containers away from heat, sparks, and open flames.
- Use only on grounded equipment and with non-sparking tools.
- Store in a cool, dry, and well-ventilated place, away from incompatible materials.

In case of a spill:

- Make sure all handling equipment is electrically grounded.
- Mop or wipe up, and then place all chemical-soaked items in containers approved by the US Department of Transportation (DOT) or the appropriate local regulatory agency.

Internal Pressure Interlock Switch

The *LGR-ICOS* Gas Analyzer is equipped with an internal pressure switch. The pressure switch's main purpose on the X-Purge configured instrument is to cut off the AC power to the Gas Analyzer and prevent operators or service personnel from operating the instrument when the front panel is opened in a gaseous environment. This prevents possible explosions from sparks generated when connecting component(s) or probing electronics in the Gas Analyzer when it is energized. This same switch on the Z-Purge configured instruments will only notify the customer, if connected to the customer equipment monitoring center, that the front panel is open but will not shut down the AC power to the instrument.

Purging Air from The Enclosure After Service

To prevent possible explosions upon power up, air inside the Gas Analyzer enclosure needs to be purged whenever the front panel was opened. To achieve this, the internal pressure interlock switch, part of the X-Purge controller, will not transfer power to the Gas Analyzer through its relay switch until the purge process is completed and the front panel is closed and sealed. Air within the Gas Analyzer enclosure will be diluted and replaced with either CDA or N_2 from the customer facility to prevent any possibility of ignition. This process is automatically set on the X-Purge by the purge controller and takes about 22 minutes with the following condition: The source CDA pressure provided by the customer facility is ≥ 50 psi with the flow rate ≥ 57 LPM (2 SCFM).

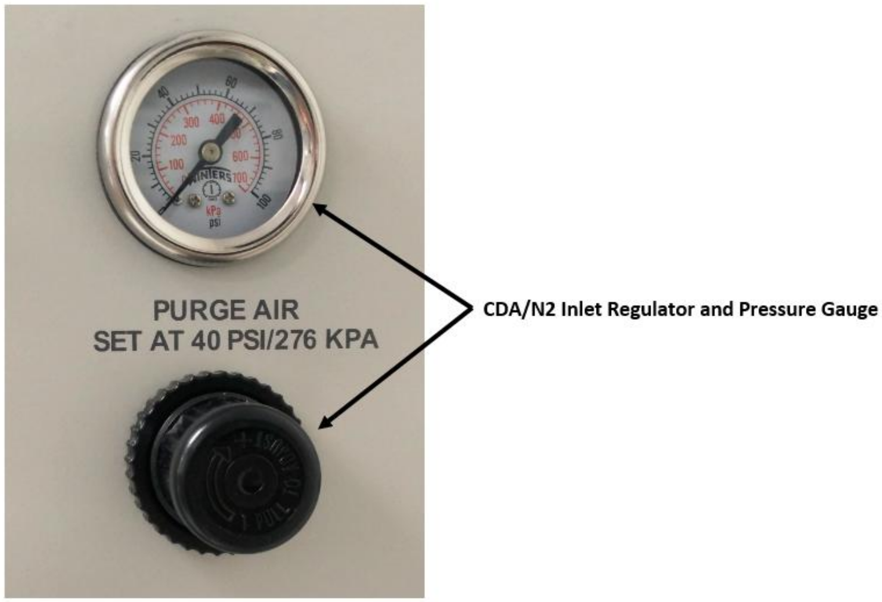
To purge air from a X-Purge configured enclosure:

STEP 1 Remove the internal pressure interlock switch bypass key from the bypass switch.

STEP 2 Close the front panel and secure it into place with all locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch in the X-Purge unit will not trip to allow power to the Gas Analyzer.

STEP 3 Verify there a pressure of at least 40 psi registers on the CDA inlet regulator.

Fig. 14 Purge Gas CDA Regulator And Pressure Gauge



STEP 4 Wait for the purge controller to finish purging air from within the Gas Analyzer enclosure, after about 22 minutes, the Gas Analyzer will restart for X-Purge configured instruments.

To purge air from a Z-Purge configured enclosure:

STEP 1 Close the front panel and secure it into place with all the locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will trigger with an alarm, but will not stop the instrument from powering up.

STEP 2 Verify there a pressure of at least 40 psi registers on the CDA inlet regulator. If it does not register 40 psi, resolve the air leak and test again.

STEP 3 Wait for the purge controller to finish purging air from within the Gas Analyzer enclosure, after about 22 minutes, turn on the power from the GUA junction box to power on the Gas Analyzer.

Danger!	Failure to properly purge air from the instrument prior to its restart may cause serious injury or death from unexpected explosion.

3 Features and Measurement Theory

The *LGR-ICOS* Gas Analyzer is a cavity-based spectroscopy instrument. The cavity design of the Gas Analyzer enhances the amount of spectral energy produced by a laser, covering a small wavelength band targeted at measuring specific “gas” molecules through absorption at the gas molecule’s resonance frequency. The enhancement improves the signal-to-noise ratio, thus delivering a higher sampling ratio, from parts per million (ppm) to parts for billion (ppb). The type of gas that the Gas Analyzer can measure is based on the laser wavelength and the gas that has molecules resonating in the laser’s frequency bandwidth. There are various Gas Analyzer models, each targeting gases that various industries are interested in monitoring. All measurements are taken in real time.

Main Features

The Gas Analyzer main features are:

- Measurement and processing time down to 10 seconds for certain gases
- Reduced data cross interference
- Sensitivity up to ppb

The external interface supports:

- Modbus/TCP (RJ–45): Customer-configured analog gas concentration output data
- Ethernet (RJ–45): Communication link with the Gas Analyzer computer
- USB (live disconnect module): Data transfer between a USB memory stick and the Gas Analyzer computer
- 5.08 mm terminal block: gas concentration and alarms, and 4–20 mA analog output

Purging

The Gas Analyzer is operating in an active internal purge enclosure where regulated CDA (clean air) is pumped in the enclosure to evacuate any gas build-up. This is designed in compliance with Class 1 Division 2 Groups B, C, and D; Temperature Code T3, and ATEX Zone 2 requirements.

The CDA air is not used to maintain electronics at operating temperature within the Gas Analyzer. The supporting electronics selected within the Gas Analyzer are military-grade and can withstand a higher operating temperature without significant impact on operational life. The expected internal operating temperature should be between +10°C and +15°C above the temperature outside the instrument.

Theory of Operation

For gas measurements based on conventional laser-absorption spectroscopy, a laser beam is directed through a sample and the mixing ratio (or mole fraction) of gas is determined from the measured absorption using Beer's Law, which may be expressed with equation 1.

Equation 1 $$\frac{I_v}{I_o} = e^{-SL_x P\phi_v}$$

where:

- I_v = the transmitted intensity through the sample at frequency *v*
- I_o = the (reference) laser intensity prior to entering the cell
- *S* = the absorption line strength of the probed transition
- *L* = the optical path length of the laser beam through the sample
- *X* = the mole fraction
- *P* = the gas pressure
- Φ_v = the line-shape function of the transition at frequency *v*

In this case:

Equation 2 $$\int \phi(v)dv = 1$$

If the laser line width is much narrower than the width of the absorption feature, high-resolution absorption spectrum may be recorded by tuning the laser wavelength over the probed feature.

Integration of the measured spectrum with the measured values of:

- Gas temperature
- Gas pressure
- Path length
- Line strength of the probed transition

allows one to determine the mole fraction directly from the relation:

Equation 3 $$x = \frac{-1}{SLP}\int_v \ ln\left(\frac{I_v}{I_o}\right)dv$$

This equation is used to determine gas concentrations, even in hostile environments, without using calibration gases or reference standards, meaning that measurements are "*absolute*".

The values measured are:

- Mixtures containing several species
- Flows at elevated temperatures and pressures

Calibrated gases would normally be used to verify measurement accuracy, as a monitor to a fix process and for troubleshooting.

LGR Off-Axis ICOS

Off-axis integrated-cavity output spectroscopy (ICOS) uses a high-finesse optical cavity as an absorption cell. Unlike multi-pass detectors, which are typically limited to path lengths of less than two hundred meters, an off-axis ICOS absorption cell effectively traps the laser photon so that, on average, it makes thousands of passes before leaving the cell. As a result, the effective optical path length may be several thousands meters using high-reflectivity mirrors and thus the measured absorption of light after it passes through the optical cavity is significantly enhanced. For example, for a cell composed of two 99.99% reflectivity mirrors 25 cm apart, the effective optical path length is 2500 meters.

Because the path length depends only on optical losses in the cavity and not on a unique beam trajectory (like conventional multi-pass cells or cavity-ring-down systems), the optical alignment is very robust, allowing for reliable operation in the field. The effective optical path length is determined routinely by simply switching the laser off and measuring the necessary time for light to leave the cavity (typically tenths of microseconds).

As with conventional tunable-laser absorption-spectroscopy methods:

- Laser wavelength selection is based upon the selected absorption feature of the target gas to be measured.
- The measured absorption spectrum is recorded and used to determine a quantitative measurement of the mixing ratio with and without external calibration, when combined with the recorded:
    - Measured gas temperature and pressure in the cell
    - Effective path length
    - Known line strength

Measurement Stability

Measurement stability is achieved partly through a temperature- and pressure-controlled environment. For the same measured gas, changes in either temperature or pressure will generate a change in measurement results. This is not to say that laser stability (and not noise), along with supporting electronics, do not have an impact. Operating temperature and pressure are determined through testing and are gas-dependent. Table 4 is a sample list of factory settings for specific gases, and their corresponding operating temperature and pressure.

Table 4 Factory Temperature & Pressure Of Gas Type

Gas Type	Operating Temperature	Operating Pressure
O_2	23.59°C	140.18 Torr
H_2S	44.29°C	100.20 Torr
CO_2	44.29°C	100.20 Torr

Temperature and Pressure Control

Several factors control measurement stability. One factor is temperature. The incoming gas sample requires temperature control to keep the electrons in the gas atom at a fixed energy level. By injecting a specific wavelength of light into the gas environment, the gas electrons would absorbed the photon's energy and moves the electron from one energy state to another energy state. When heat is applied or removed from the gas, the kinetic energy of the electrons in the gas molecules changes shifting the spectra/absorption lines. The spectra/absorption lines define the wavelengths of light that the gas electrons can absorb to move it from one energy state to another. This is the reason for establishing and maintaining a consistent measurement environment is to improve measurement repeatability because the laser is set to operate at a specific frequency band. There are other reasons why the gas sample is heated, but they will not be discussed in this manual as they are proprietary to ABB.

Because of that, the temperature of the gas going through the ICOS system is controlled. To control the temperature of the gas sample going into the ICOS system, the path is heated. To maintain the heat level, a closed loop feedback is achieved by thermocouples attached to the tubes and ICOS cavity, parts through which gas samples pass to be analyzed. Operating temperatures measured by the thermocouples are fed back to several PID temperature controllers. To drive heaters, temperature controllers turn on or off a relay switch that feeds DC power directly to the heaters.

The kinetic energy of the gas molecule also changes with pressure. If there is an increase in gas pressure in a fixed volume measurement chamber, the gas molecules will be moving faster and are bounces more often against other molecules in a denser environment. These electrons in the gas molecule will be at a higher energy state and requires less photon energy from absorption to move it from state to another thus shifting the spectra/absorption line. If both pressure and temperature of the measurement gas is maintained throughout the measurement, a more stable repeatable measurement will result.

This is the reason why the ICOS pressure is constantly measured. In a leak-free ICOS system, the pressure is maintained by a fixed orifice. Pressure drops are normally the result of a leak in the connection points, at the link between the inlet sample gas line and the 10µ filter, from gas expansion, at the 2µ filter, at the pressure valve connected to the ICOS cell, or at the pressure gauge connected to the ICOS cell.

Lasers and Astigmatic Mirrors

The final factors that impact measurement stability and accuracy are laser signal strength, operating frequencies, and the astigmatic mirrors within the ICOS Gas Analyzer. Mirrors have an impact on the “length” and lasers have an impact on “transmission intensity” through the sample solution. This is as defined in equations 1 to 3 of the Theory of Operation chapter on page 21 of this manual.

Also, astigmatic mirror reflectivity efficiency drops over time due to surface contamination from the gas. When this happens, measurement results can be seen with a shorter “ring-down” time. Long ring-down times mean that the laser beam is reflecting back and forth within the ICOS cell; this lowers the intensity which results in lower overall absorption.

Laser intensity is controlled through the laser control PCA to provide a constant output signal strength. Feedback intensity level is provided through the near infra-red (NIR) detector and is ported to the computer stack. On the “intensity profile”, the maximum intensity level will vary depending on the lasers selected for the particular gas type. When lasers decay, intensity profiles move downward to a lower level. The maximum decay limit is 10% off the original recorded measurement when the product was first installed on site. A sample gas measurement spectrum profile, listing all available information for that profile, is shown in Fig. 15. Table 5 is a summary of the components impacting gas measurement results.

Fig. 15 Transmitted Intensity & Absorption Profile Data

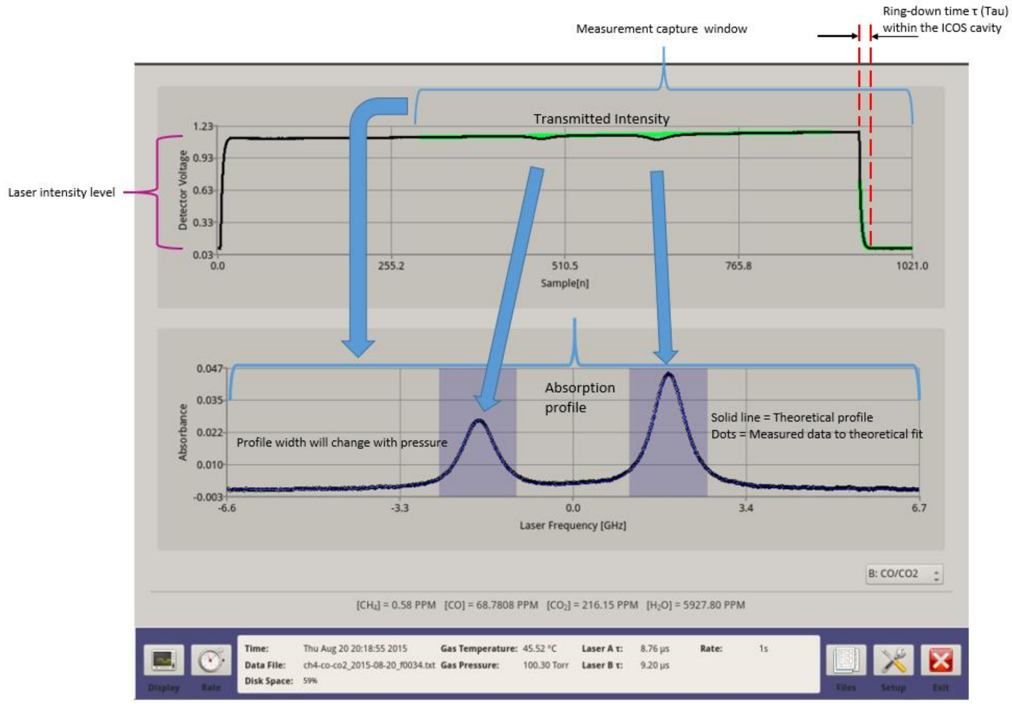


Table 5 *LGR-ICOS* Measurement Components Function & Impact

Components	Function	Impact
PC104 stack	System communications	System operations
Heaters/Relays/Thermocouple/ Temperature Controller	Temperature control of gas sample measured	Measurement shift
Pressure valve, fixed orifice	ICOS pressure control	Absorption level
Laser	Gas probing light source	Transmitted intensity
Astigmatic Mirrors	Cavity length	Ring-down time

Measurement Sensitivity

Measurement sensitivity is a function of the total length that the laser travels within the ICOS cell. The main components impacting sensitivity are:

- Laser intensity
- PZT
- Astigmatic mirrors

If laser intensity drops, the total length (L) that the laser travels within the cavity decreases, resulting in a decrease in absorption by the available laser beam reflections. Laser intensity level will vary and is gas-dependent.

If the 2 PZTs are not functioning, the area covered by the laser within the cavity will be reduced, thus decreasing absorption.

Astigmatic mirror contamination reduces the reflectivity level, thus impacting the intensity of the reflective laser and reducing the overall length that the laser beam travels within the cavity.

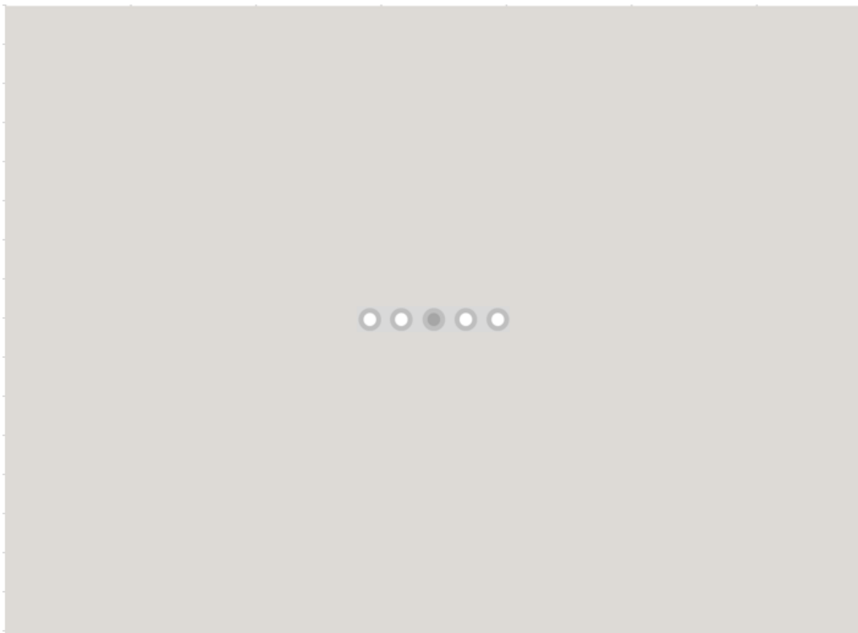
Self Correction

Small drifts in laser wavelength are compensated in software by adjusting the laser temperature, thus providing a dynamic response when matching the measured data to the theoretical answer.

4 User Interface Operation

Upon powering up the system, the first display that appears is the program loading screen, as shown in Fig. 16.

Fig. 16 Program Loading Screen



After the programs are loaded, the Gas Analyzer displays the Numerical screen showing gas concentration(s) (see Fig. 18) measured within the ICOS cell. If the Gas Analyzer has been deactivated for more than 10 minutes, the gas lines leading to ICOS cell need to be brought up to measurement temperature. Initially they will be below their targeted measurement temperature, thus generating a warning error, and possibly an alarm. Allow instrument heaters time to bring the system up to the correct operating temperature before accepting any data generated from the instrument. The time necessary for instrument heaters to reach, overshoot and come back down to control the gas line and ICOS cell temperature will vary depending on the environment in which the instrument is located. At a normal ambient temperature of 20°C, the instrument temperature should stabilize within 20 minutes.

Control Bar

The Control Bar (see Fig. 17) allows operators to control various operational aspects of the Gas Analyzer.

Fig. 17 Control Bar

Operators select an option by tapping the required button on the touchscreen or by using a keyboard/mouse and moving the pointer to click a button.

Display Button

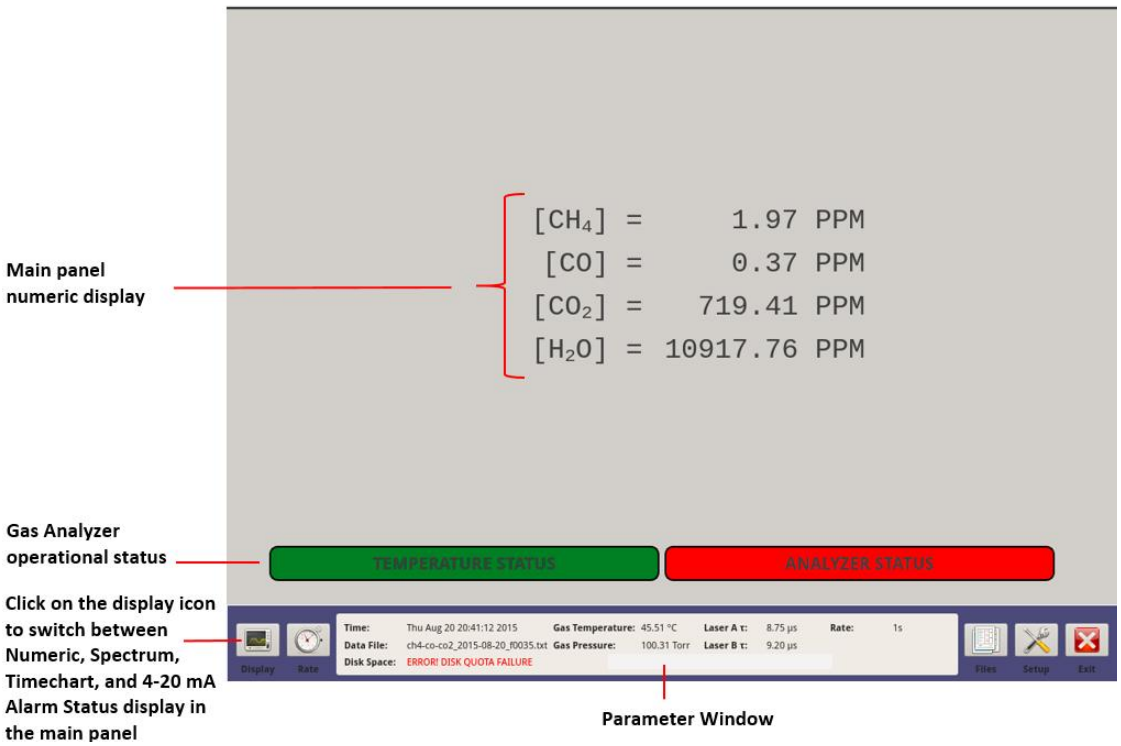
In the Control Bar, the Display button (see Fig. 17) allows operators to select the type of display:

- Numerical (Fig. 18)
- Spectrum (Fig. 19)
- Timechart (Fig. 20)
- Alarms Status (Fig. 21)

Numerical Display

The Numerical display is one of the simplest screen for go-no go decisions based strictly on gas concentration measurements. Sample gases are measured in ppm, and possibly even in ppb. Fig. 18 is an example of a Numerical display when measuring four different gas samples.

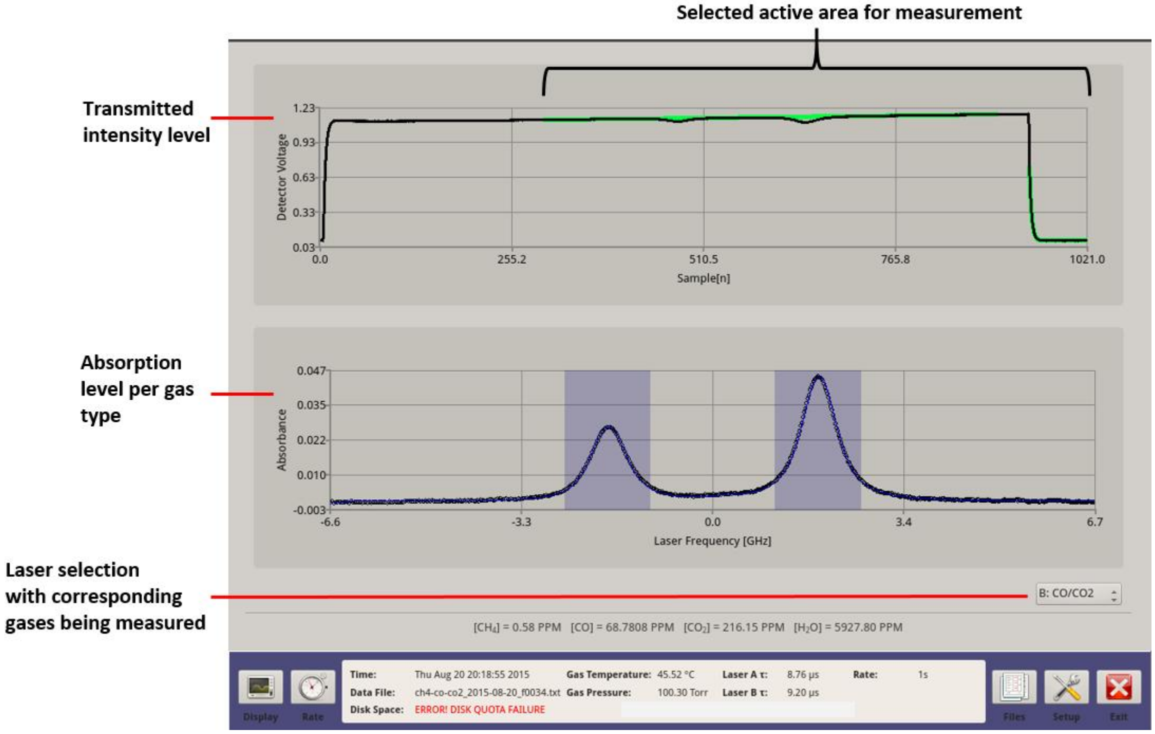
Fig. 18 Numerical Display Screen



Spectrum Display

The spectrum display screen (see Fig. 19) provides additional information about the gas measured: the Gas Analyzer sensitivity level (seen in the Transmitted Intensity diagram), the absorption level, the targeted gas theoretic fit, and the ring-down time (indicating the need to clean the astigmatic mirrors).

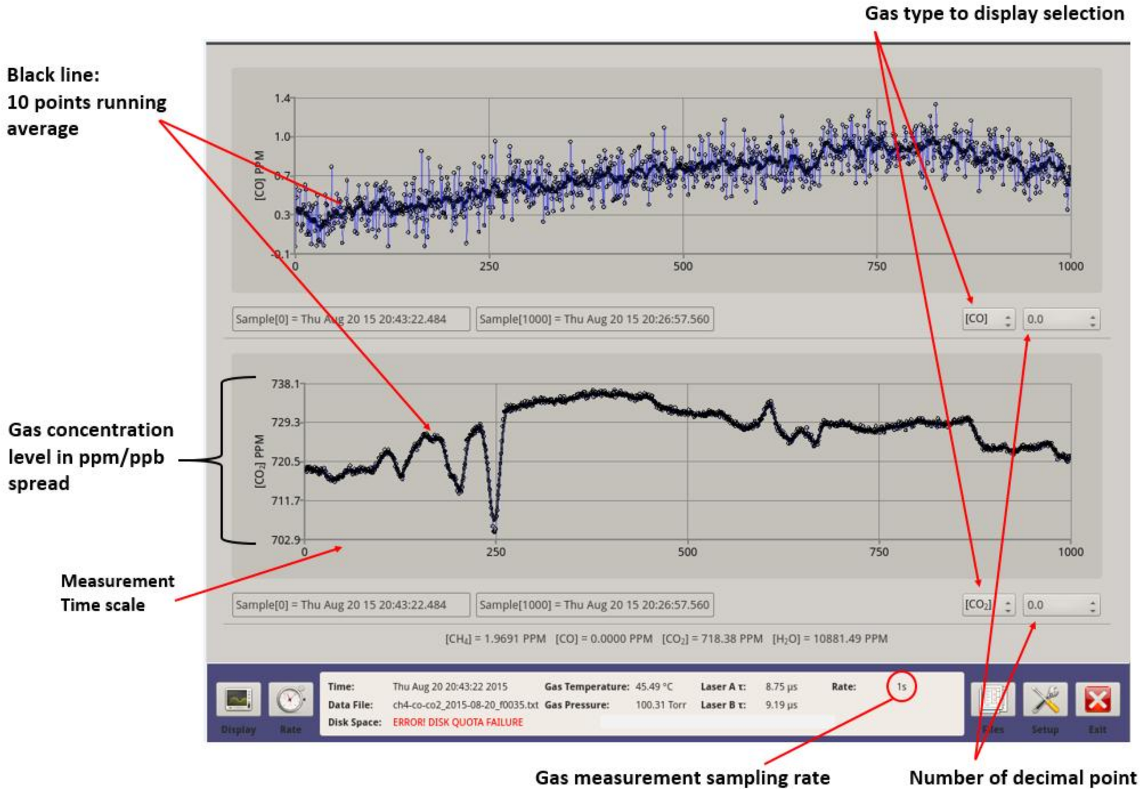
Fig. 19 Spectrum Display Screen



Timechart Display

The Timechart display in Fig. 20 provides the gas sample measured absorption (in ppm or ppb). Each dot represents a measured level at a customizable interval “rate”. The solid black line is a running average of last 10 data points. This allows operators to view the spread in determining the measured gas concentration level.

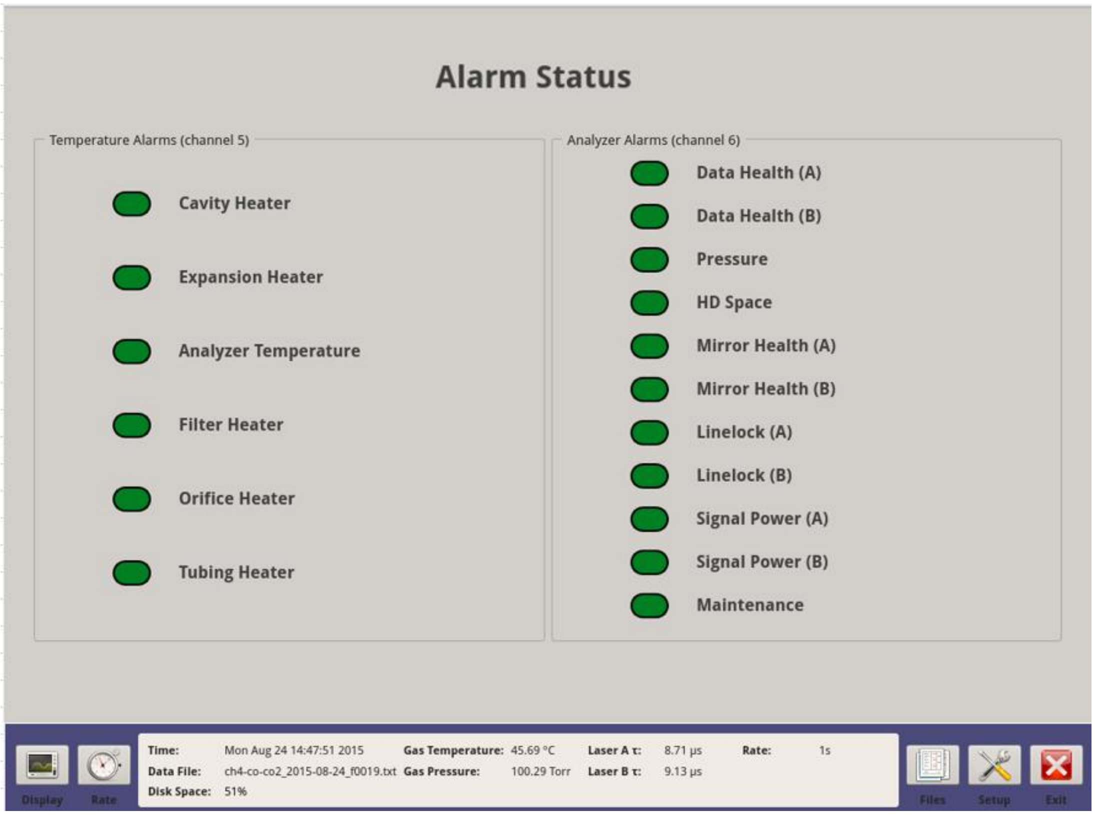
Fig. 20 Timechart Display



Alarm Status Display

The Alarm Status display (see Fig. 21) provides operators with the Gas Analyzer operational status. The Alarm Status display uses a traffic light metaphor. Green means no problem. Yellow means it is out of spec and the data may not be reliable or maintenance is required soon. Red means the Gas Analyzer requires maintenance to correct an identified fault and resume operation at a performance level meeting instrument specifications. A description of the cause of the alarm is displayed by selecting the relevant alarm button.

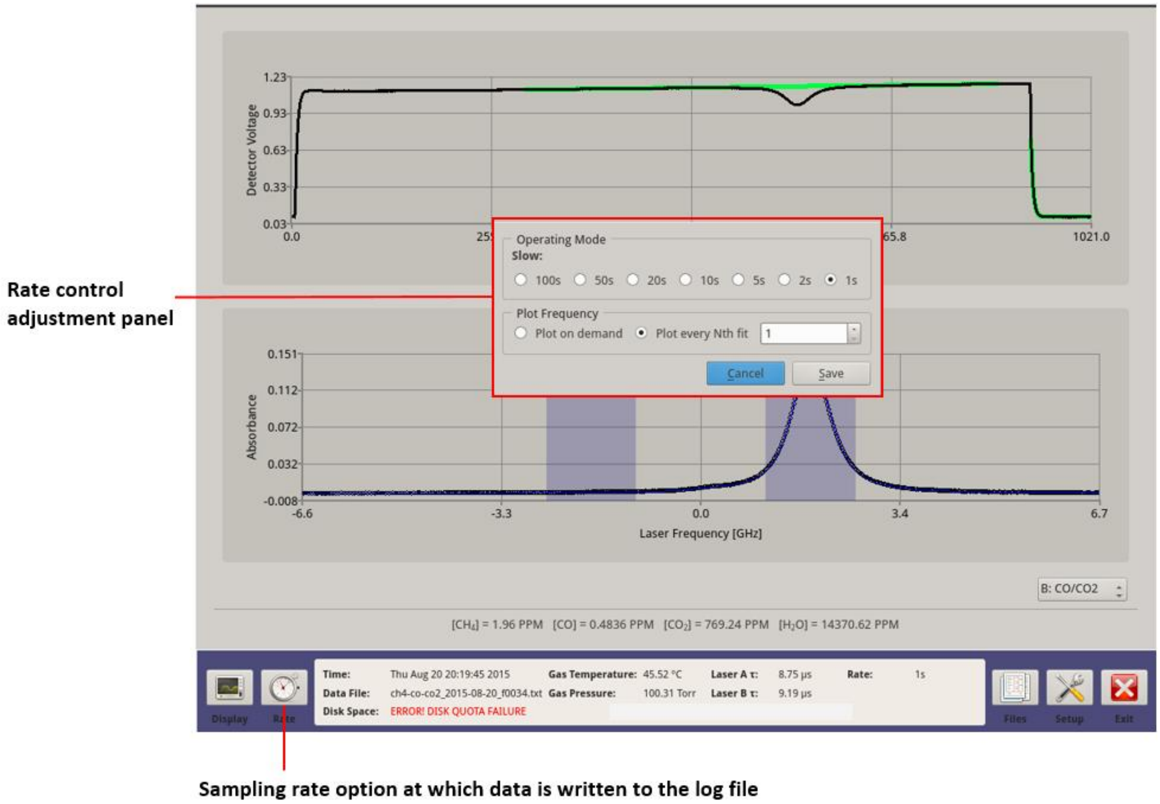
Fig. 21 Alarm Status Display Screen



Rate Button

By clicking Rate in the Control Bar, operators can change the rate at which data is written to the log file. Fig. 22 displays the Rate screen along with the rate control adjustment window.

Fig. 22 Rate Control Display



Data is acquired at a rate of 1 Hz and averaged for a selected interval (1 to 100 seconds) before being written into the data file and plotted on the time chart. Longer averaging periods (or equivalently, slower data acquisition rates) yield better measurement precision.

File Button

By clicking File in the Control Bar, operators access the Data Files window for transferring measurement data saved by the Gas Analyzer. The top left field is the path to the data folder:

/home/lgr/data

Within the *data* folder is an active daily file being saved, and the archive of past files. Operators will see:

yyyy-mm-dd (active data measurement file)

archive (folder of past measurement data points)

Whenever the Gas Analyzer application software is launched, the Gas Analyzer automatically creates a file when measured data is saved. New files are automatically generated every 24 hours. The file name is set in the following order:

- The first 6 characters represent the Gas Analyzer model.
- The next 10 characters represent the date (yyyy-mm-dd).
- The last set of characters is the serial number that defines the sequence of data taken.

To access the *archive* files, click on the *archive* folder. If you need to go back to the previous screen, click the up arrow to the right of the file path line */home/lgr/data/archive*. Data files are written in text format (ASCII) and contain labeled columns that show:

- Data column with time
- Gas concentration
- Cell pressure
- Cell temperature
- Ambient temperature
- Ring-down time

The data format can be changed by clicking *Setup* in the Control Bar (see page 34).

File Transfer

For C1D2-certified instruments, file transfer with a USB memory stick requires a connection through a cable gland on the left side of the Gas Analyzer enclosure.

Fig. 23 USB Cable Gland Dongle

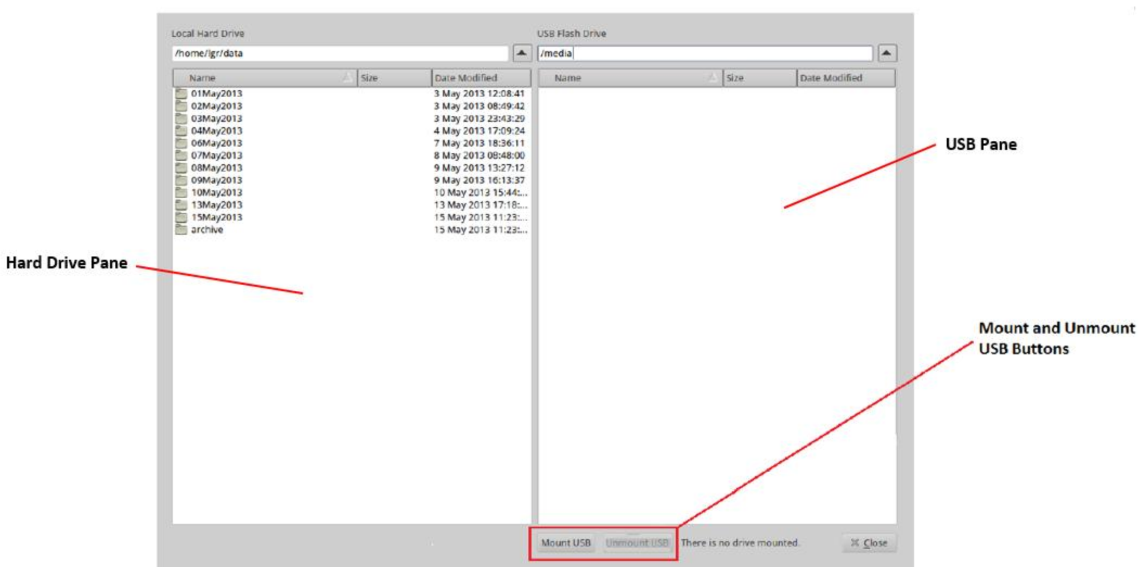
The USB memory stick needs to be in a Fat32 format before any file can be transferred to it. Once the USB memory stick is properly formatted to receive data files from the Gas Analyzer hard drive:

STEP 1 Install the USB memory stick into the cable gland dongle (see Fig. 23).

STEP 2 Insert the cable gland dongle, with USB memory stick enclosed, in the cable gland USB port on the left side of the Gas Analyzer enclosure.

STEP 3 Click Mount USB (see Fig. 24).

Fig. 24 User Interface for Mounting the USB Memory Stick



STEP 4 Transfer files by dragging them from the Local Hard Drive pane and dropping them to the USB Flash Drive pane.

STEP 5 Click Unmount USB to stop communication with the USB memory stick before removing the USB memory stick.

STEP 6 Click Close to exit the Data Files screen.

File Cleanup

When the hard drive is showing > 75% full, it is time to perform data clean up.

To do so:

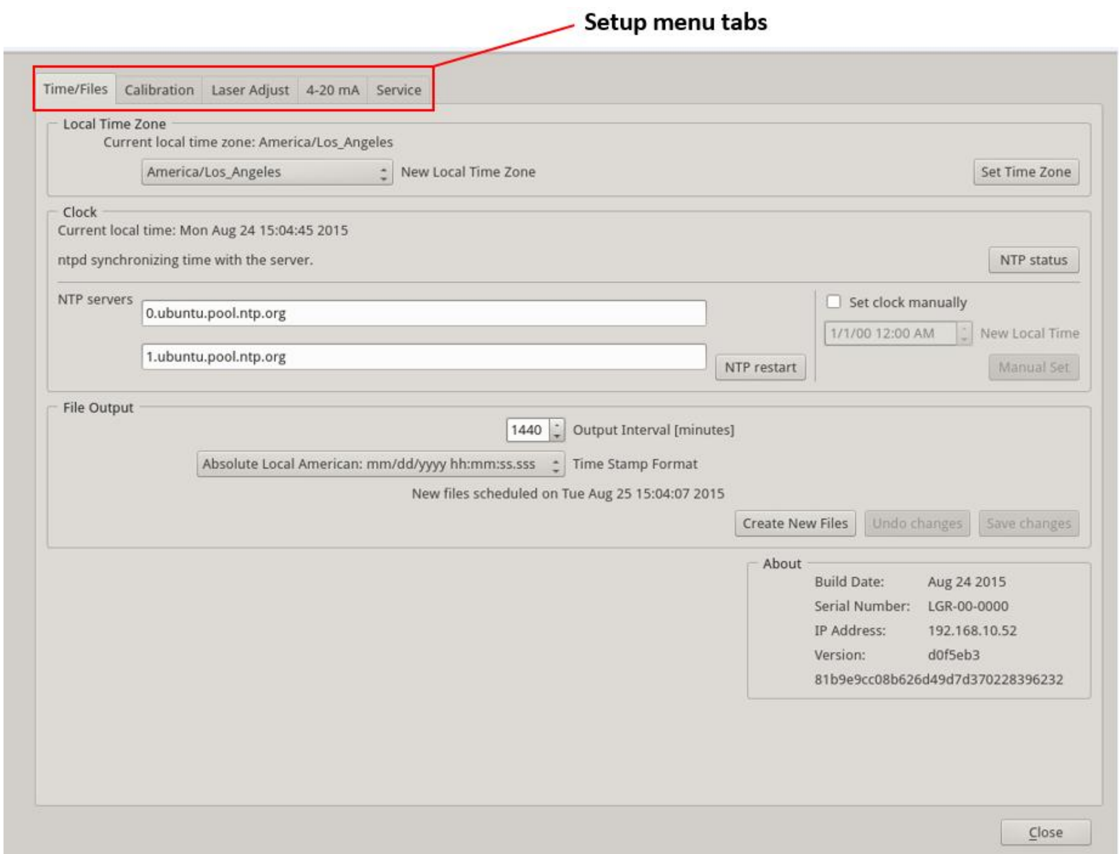
STEP 1 Using the touchscreen and highlight the file to be deleted.

STEP 2 Select Delete on the display screen.

Setup Button

When clicking Setup, the Setup screen appears, giving operators access to additional configuration and service menus. When entering the Setup screen, the Time/Files tab is displayed by default (see Fig. 25).

Fig. 25 Setup Screen



Options in the Setup screen are:

- Time/Files (for setting time and file format)
- Calibration (single point calibration using a known reference standard)
- Laser Adjust (for fine tuning laser wavelength for GOF)
- 4–20 mA (for setting the scale for concentration-to-mA conversion)
- Service (only accessible by ABB service personnel)

Time/Files Tab

The Time/Files tab allows operators to configure the LAN server to which it is connected (NTP Server box). Also, the About box provides LAN connection information between the Gas Analyzer and the customer network to which it is connected.

The Set Clock section lets operators adjust the Gas Analyzer current time and date (see Fig. 26). The time zone and daylight savings enable/disable feature are also set there. The available time stamp formats are listed in Table 6.

Fig. 26 Adjustable Parameters in Time/Files Tab

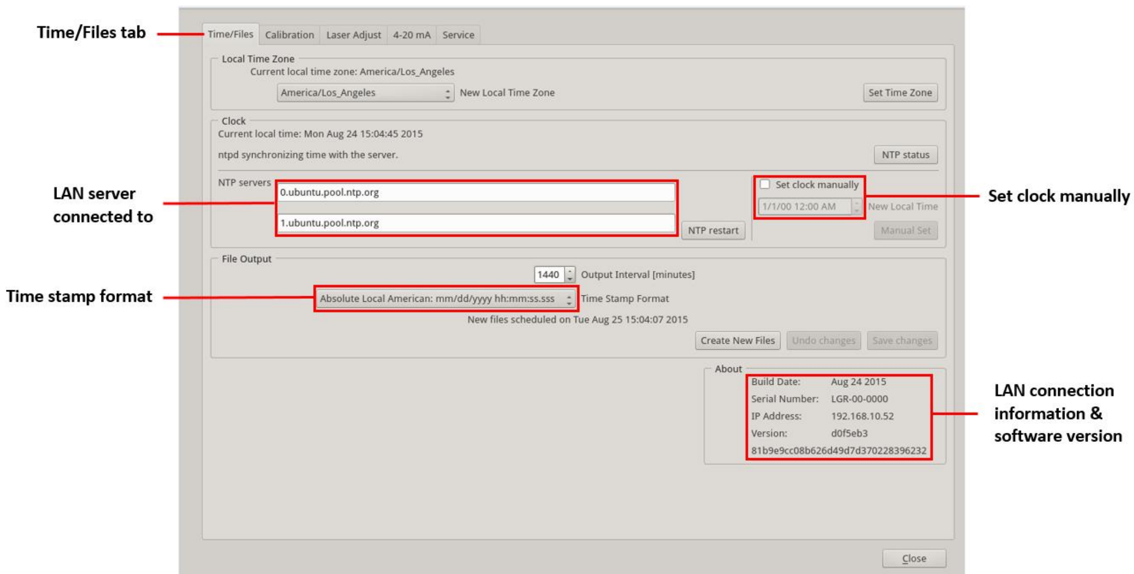


Table 6 Time Stamp Formats

Time Stamp Name	Format
Absolute Local American	mm/dd/yyyy, hh:mm:ss.sss
Absolute Local European	dd/mm/yyyy, hh:mm:ss.sss
Absolute GMT American	mm/dd/yyyy, hh:mm:ss.sss
Absolute GMT European	dd/mm/yyyy, hh:mm:ss.sss
Relative Seconds After Power On	ssssss.sss
Relative Seconds in Hours, Minutes, Seconds	hh:mm:ss.sss

Calibration Tab

The Calibration tab provides operators with the tools to calibrate the Gas Analyzer without having to send the instrument back to the factory. Calibration is only required after a fiber laser and/or NIR detector is replaced. Before performing calibration on the Gas Analyzer, operators need to have the following information:

- Traceable regulated gas type
- Traceable regulated gas type concentration

To perform a gas calibration, connect the traceable regulated bottled gas to the Gas Analyzer gas inlet line (see Fig. 27 for the parameter fields identified in the procedure):

STEP 1 In the Control Bar, click Setup. The Setup screen appears.

STEP 2 Click the Calibration tab.

STEP 3 In the Calibration tab, check the Calibrate box in the Reference Gas Settings pane.

STEP 4 In the traceable regulated bottled gas, enter the gas concentration for the gas type displayed on the left of the gas concentration entry box.

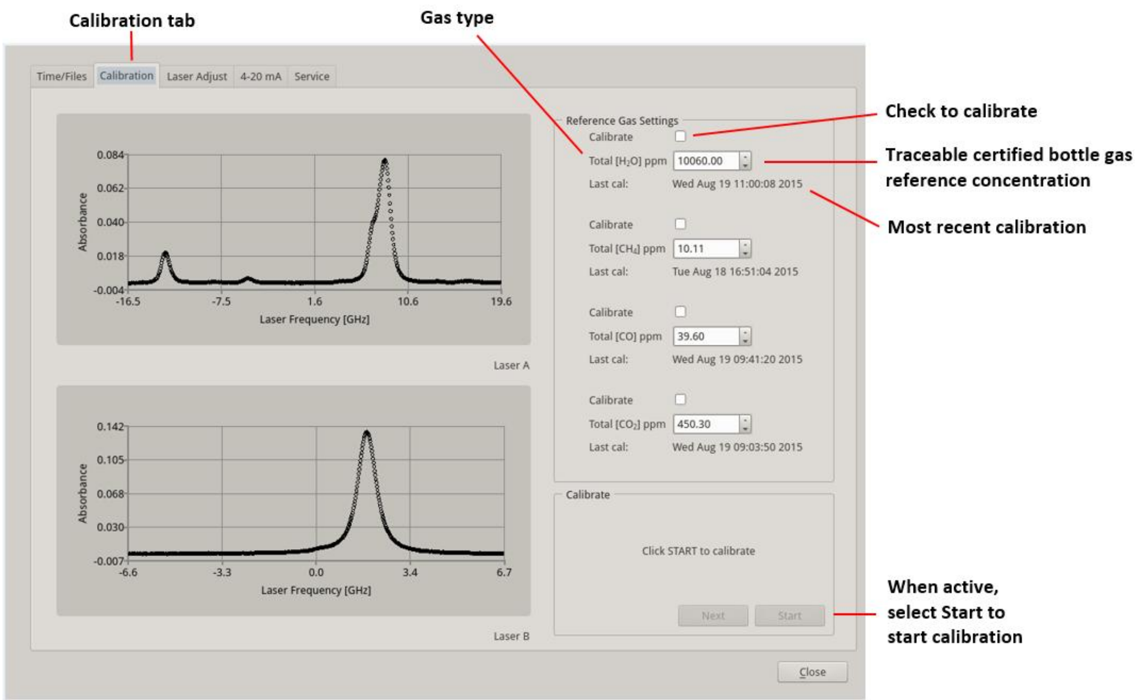
STEP 5 In the Calibrate pane, click Start to start the calibration.

STEP 6 Repeat these steps for all gases measured by the Gas Analyzer.

STEP 7 After calibration is complete, click OK. The Gas Analyzer will then resume its normal measurement mode.

STEP 8 Click Close to exit the calibration screen.

Fig. 27 Calibration Tab



Laser Adjust Tab

The Laser Adjust tab allows operators to tune the laser wavelength. Laser adjustment may be needed for the following reasons:

- The laser's wavelength has drifted beyond the target range of the analyzer.
- The analyzer is operated outside the recommended temperature range.

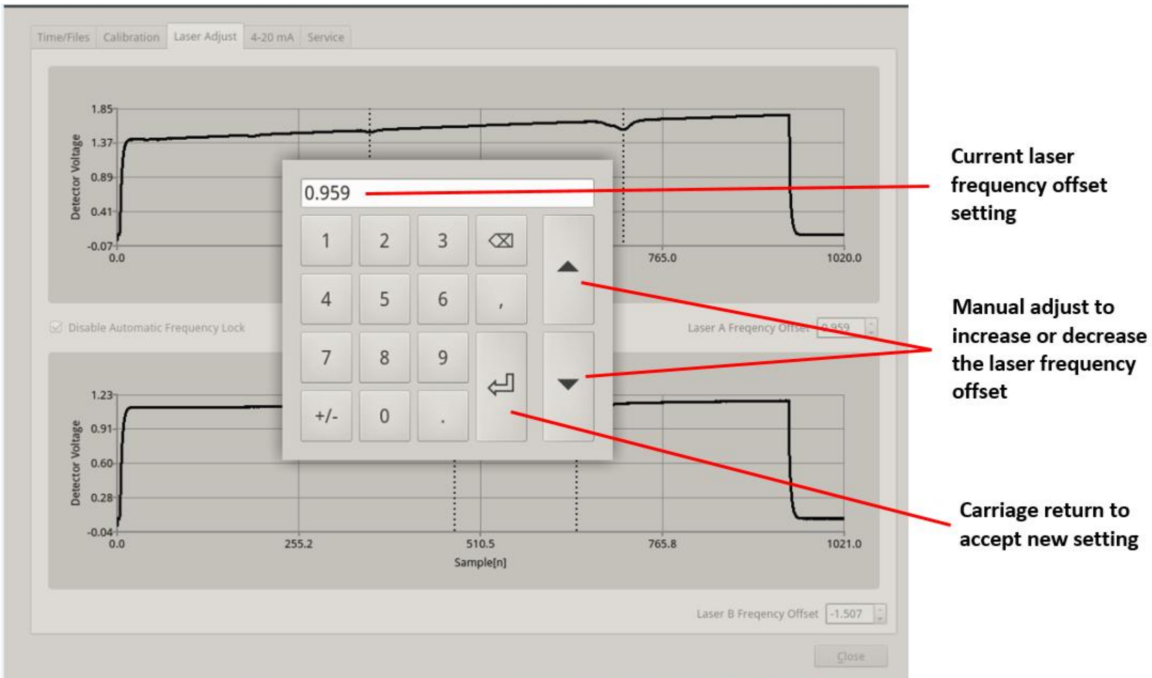
Check the parameter field *Disable Automatic Frequency Lock* for manual adjust of the laser wavelength. Unchecked this same parameter field *Disable Automatic Frequency lock* to have the Gas Analyzer to auto-adjust the laser wavelength during normal operation to compensate for any laser wavelength drift over time to align with the measured absorption peak(s).

In Fig. 28, the Laser Adjust tab displays the current gas sample measurement intensity profile and the corresponding absorption frequency by dips in the profile. The vertical dotted lines in the same profile screen are the expected target absorption line. To compensate for this difference, the laser wavelength is modified to have the bottom of the profile dip to center around the dotted line, the theoretical target. To achieve this, the voltage driving the fiber laser is modified to move the laser operating wavelength. If the Gas Analyzer has two lasers, each laser can be fine-tuned to have the measured absorption in line with the theoretical target.

Fig. 28 Laser Adjust for Optimizing Measurement Calibration

When selecting the laser frequency offset (for laser A or B), the frequency offset adjust box (see Fig. 29) appears and the operator can change the laser operating frequency.

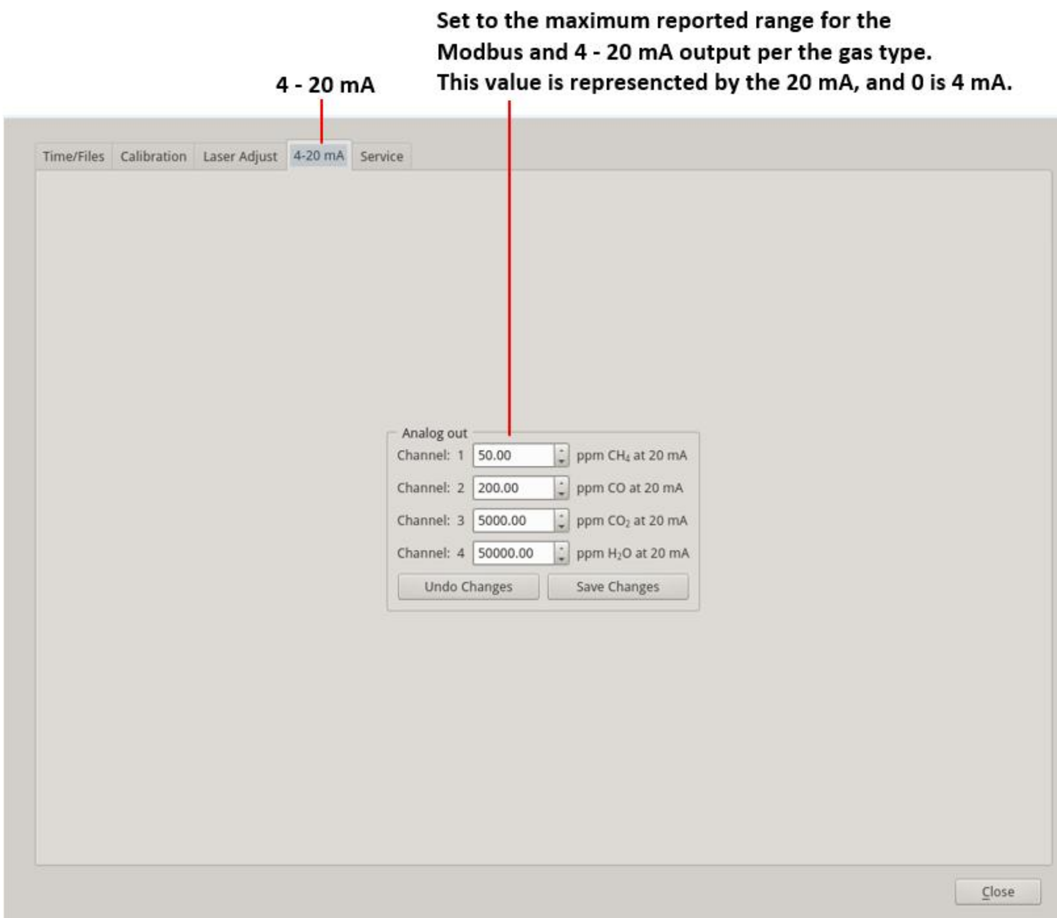
Fig. 29 Laser Frequency Offset Adjust Screen



4–20 mA Tab

The 4–20 mA tab allows operators to set the 4–20 mA output corresponding to each gas type measured concentration. The number of available 4–20 mA output adjustable channels is dependent on the Gas Analyzer model.

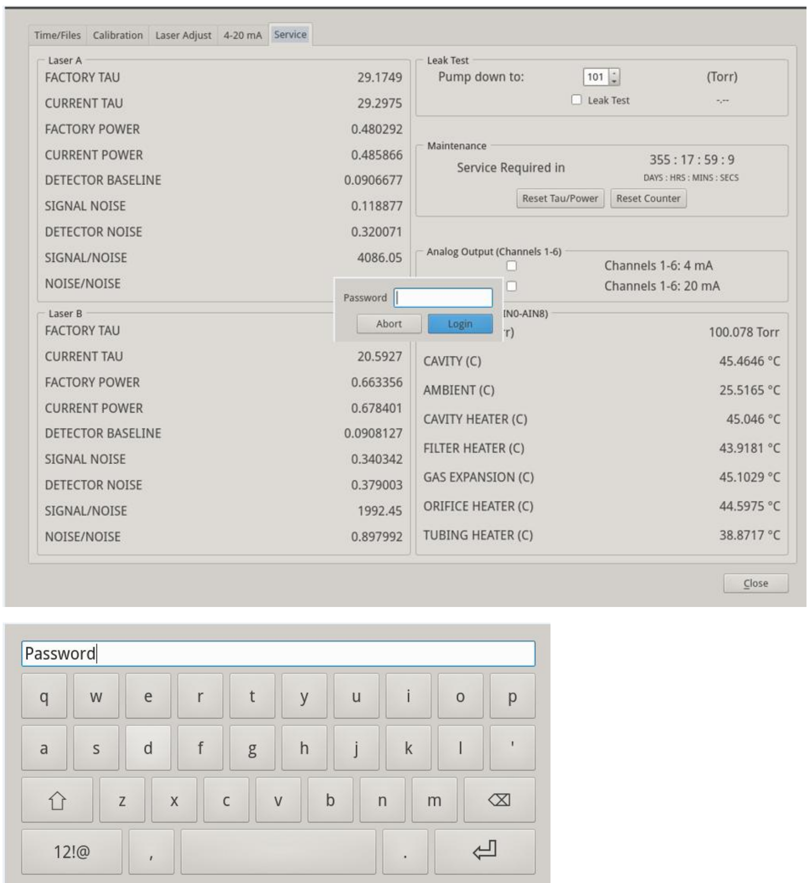
Fig. 30 4–20 mA Analog Out Adjustment



Service Tab

The Service tab allows service engineers to manipulate inputs on individual bus lines to generate a specific output response for performance validation. A password is required when selecting the Service tab. When the cursor is placed in the password box, a virtual keyboard appears where the operator can enter the password (see Fig. 31). The current password for access is ICOService.

Fig. 31 Service Tab and Login Keyboard



In the Laser boxes:

FACTORY TAU represents the reflectivity level of the ICOS astigmatic mirrors. In the Alarm Status display, Mirror Health represents the CURRENT TAU reading in reference to the factory reading. At 10% degradation, the mirror health alarm will turn yellow. At 20% degradation, the mirror health alarm will turn red, meaning that the ICOS astigmatic mirrors need to be cleaned.

FACTORY POWER and CURRENT POWER represent the “Signal Power” on the Alarm Status display. Signal power is the laser signal level as seen by the Near Infra-Red (NIR) detector. The laser signal level depends on the type of gas measured by a specific Gas Analyzer model. FACTORY POWER represents the reference for the laser decay rate. Should the CURRENT POWER show a 10% loss in reference to the FACTORY POWER, a yellow alarm will be issued on the Alarm Status display. If the CURRENT POWER shows a 20% loss in reference to the FACTORY POWER, a red alarm will be issued on the Alarm Status display.

NOTE: TAU and POWER errors can be the result of mirrors being contaminated or lasers decayed to a level triggering an error. The only way to determine which component caused the alarm would be to measure the laser output power using a light power meter and compare the measured results with the reference results obtained with the same light power meter during instrument installation.

The remaining five signals: DETECTOR BASELINE, SIGNAL NOISE, DETECTOR NOISE, SIGNAL/NOISE, and NOISE/NOISE are monitored and reported only during manufacturing, for optically aligning lasers and detectors to achieve optimal measurement performances.

In the Leak Test pane, a leak test can be performed to determine if there is a pressure leak within the ICOS assembly.

To setup the leak test:

STEP 1 Set the Pump down to box to 101.

STEP 2 Check the Leak Test box.

The leak test starts. The inlet gas valve closes and the exhaust pump runs until the pressure reaches 101 Torr. This should take 2 minutes. If this is not achieved in 2 minutes, there is a pressure leak between the inlet gas valve and the exhaust pump. Should the pressure within the ICOS reach 101 Torr in 2 minutes, the proportional valve closes, thus sealing both the input and output of the ICOS cell.

STEP 3 In the next 5 minutes, the instrument calculates the pressure bleed rate and displays a value under the (Torr) field.

The leak rate specification is < 0.1 Torr/minute. If the specification is not obtained, follow procedures to locate the leak and fix it.

The Analog Inputs (AIN0 – AIN8) pane provides the actual heater measured temperatures as transferred from the thermocouples to the temperature controllers to the S310 DSP PCA. These temperatures should match the temperatures registered on the temperature controller (left red display readings). If the temperature controller does not register the same temperature value, it must be reprogrammed so that the reference voltage set for both high and low temperatures is locked in.

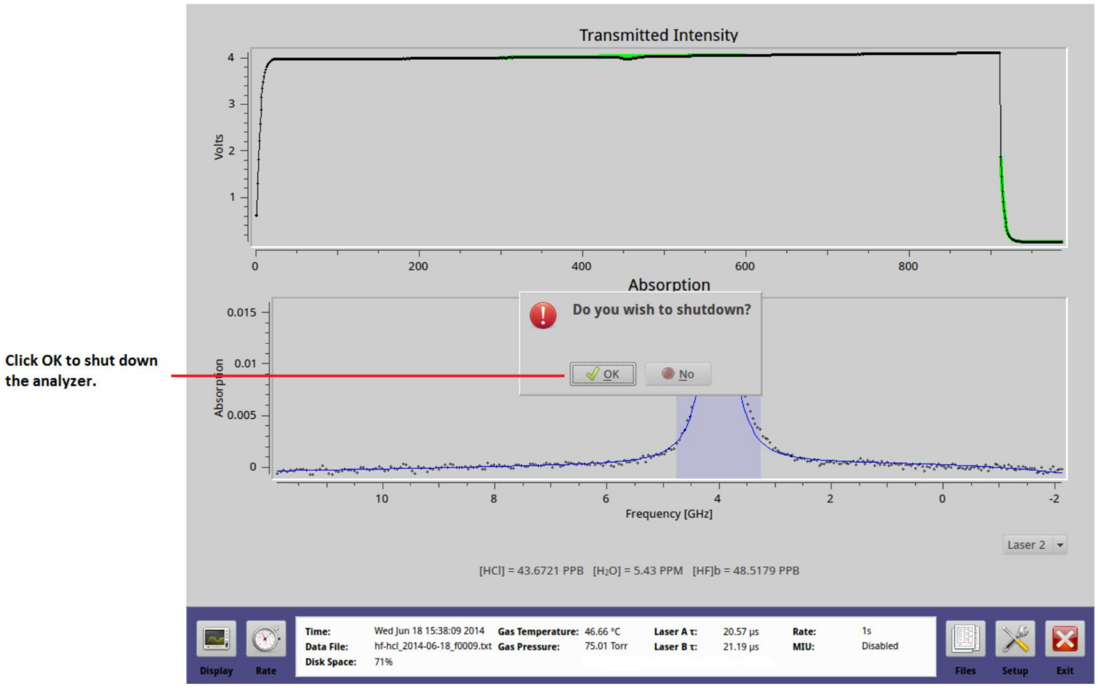
The Analog Output (Channels 1-6) pane allows operators to set a fixed output voltage level reading that determines if the device's, Modbus and signal isolators are generating the correct converted signal levels. By checking the Channel 1-6: 4 mA box, the output to the gas concentration (Channels 1-4) and Warning/Alarm (Channels 5-6) outputs should register 4 mA. In the Modbus for the gas concentrations, they should register 0 ppm. The output voltage from the S310 DSP board will be 0V DC.

By checking the Channels 1-6: 20 mA box in the Analog Output (Channels 1-6) pane, the S310 will output 5V DC to both the signal isolator and Modbus input lines. The output from the signal isolator should register 20 mA (gas concentration 1-4). The Modbus output should register 20 mA for Channel 5-6, but for the gas concentration, if they were set to convert to ppm/ppb, they will produce an upper range limit. If the Modbus was configured to also read 4–20 mA output for the gas concentration, the output should register 20 mA.

Gas Analyzer Shutdown

To properly shutdown the Gas Analyzer, always perform a soft shutdown by first clicking Exit in the Control Bar. When the dialog box appears with the question Do you wish to shutdown? (see Fig. 32), click OK.

Fig. 32 Shutdown Screen



4–20 mA

The Gas Analyzer is equipped with a 4–20 mA output for gas measurement data, and for system alarm status, should one use it for remote data monitoring. The interface for the 4–20 mA is through a cable gland that is located and marked on the left side of the Gas Analyzer enclosure (see Fig. 34).

Modbus TCP/IP

The Modbus TCP/IP is user-configurable, but it is configured from the factory where the measured gas concentration goes to the processing electronics in the form of an analog signal in the 0 to 5V DC range. This analog signal is then scaled to parts per million (ppm) to match an output value in terms of gas concentration to that of the traceable bottled gas used to calibrate the instrument. 0 volts would represent 0 ppm and 5 volts would represent some established value based on the measurement of the traceable bottled gas as reference point. This 5 volts value should match the number set in the Setup → 4-20 mA menu screen as seen in Figure 30.

The Modbus TCP/IP also provides operators with real-time instrument alarm status. For alarms, a voltage-to-mA conversion of 0 volt is equal to 4 mA, and 5 volts is equal to 20 mA. The interface to the Modbus is through a cable gland that is located and marked on the left side of the Gas Analyzer enclosure (see Fig. 34).

Purge Controller

The C1D2 *LGR-ICOS* Gas Analyzer is equipped with a purge controller to ensure operational safety. The Gas Analyzer is purged continuously with either CDA or nitrogen. An internal pressure interlock switch within the Gas Analyzer X-Purge only enclosure is used to automatically kill the AC power to the instrument should there be a loss in internal pressure (for example, when the front panel is opened). This feature prevents possible sparks from igniting the surrounding environment if someone is performing maintenance on the instrument or is trying to bypass the safety protocol by inserting electronic devices in the interface panel that could cause a spark in a gaseous environment, thus creating an explosion. On the Z-Purge enclosure equipped instruments, the pressure interlock switch only provides the user a warning but will not kill power to the instrument.

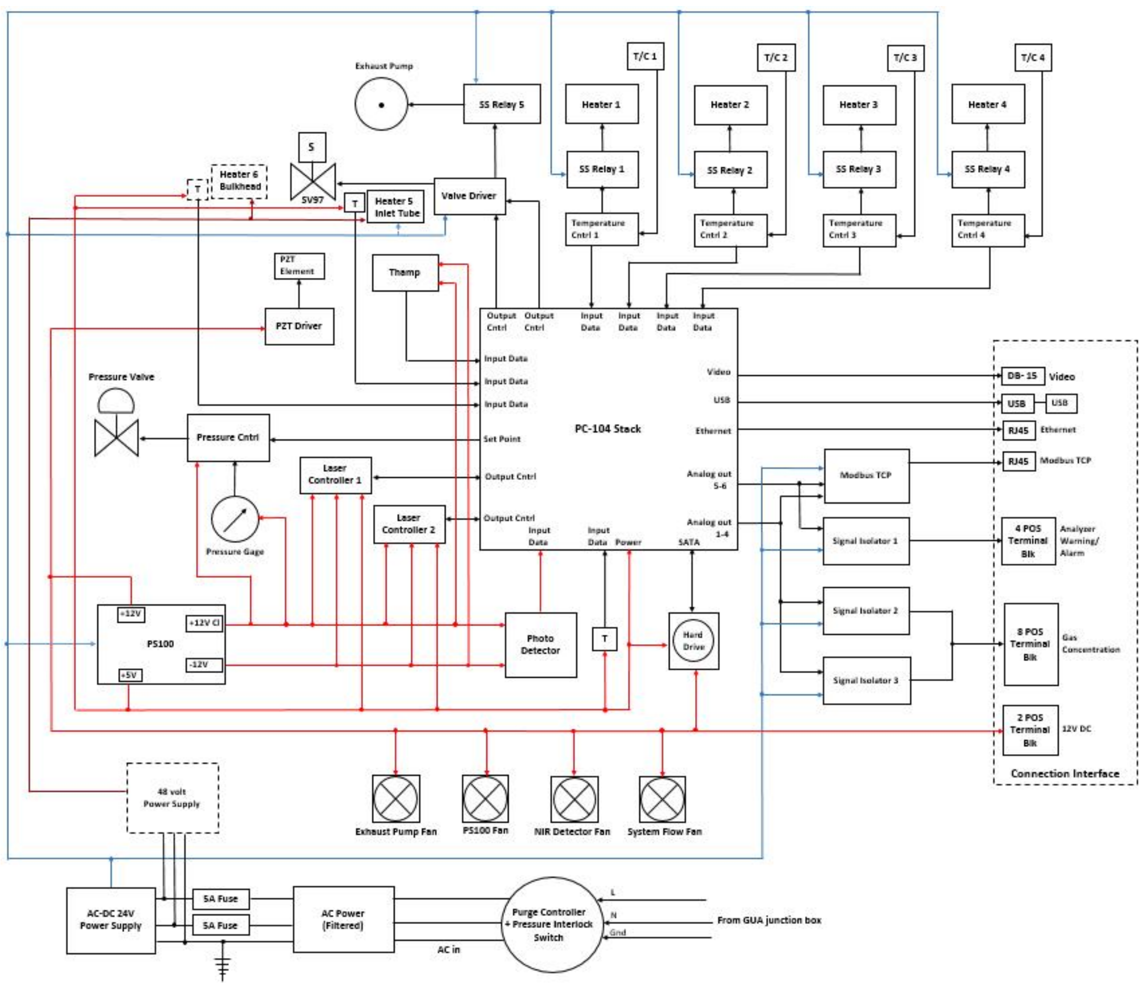
There is one signal line pair (see Table 7) provided for notification of the purge controller status. This is located on the top panel of the Gas Analyzer enclosure (see Figure 35).

5 ICOS Gas Analyzer System

System Block Diagram

The system block diagram on Fig. 33 illustrates a standard ICOS Gas Analyzer. Inlet gas port heating is available as an option. This option will be required for gases having a high moisture content and/or if the gas is sticky, impacting measurement stability by contaminating the mirrors. The change is an additional heater on the gas inlet port line located before entering the SV97 inlet solenoid gas valve.

Fig. 33 Standard ICOS Gas Analyzer

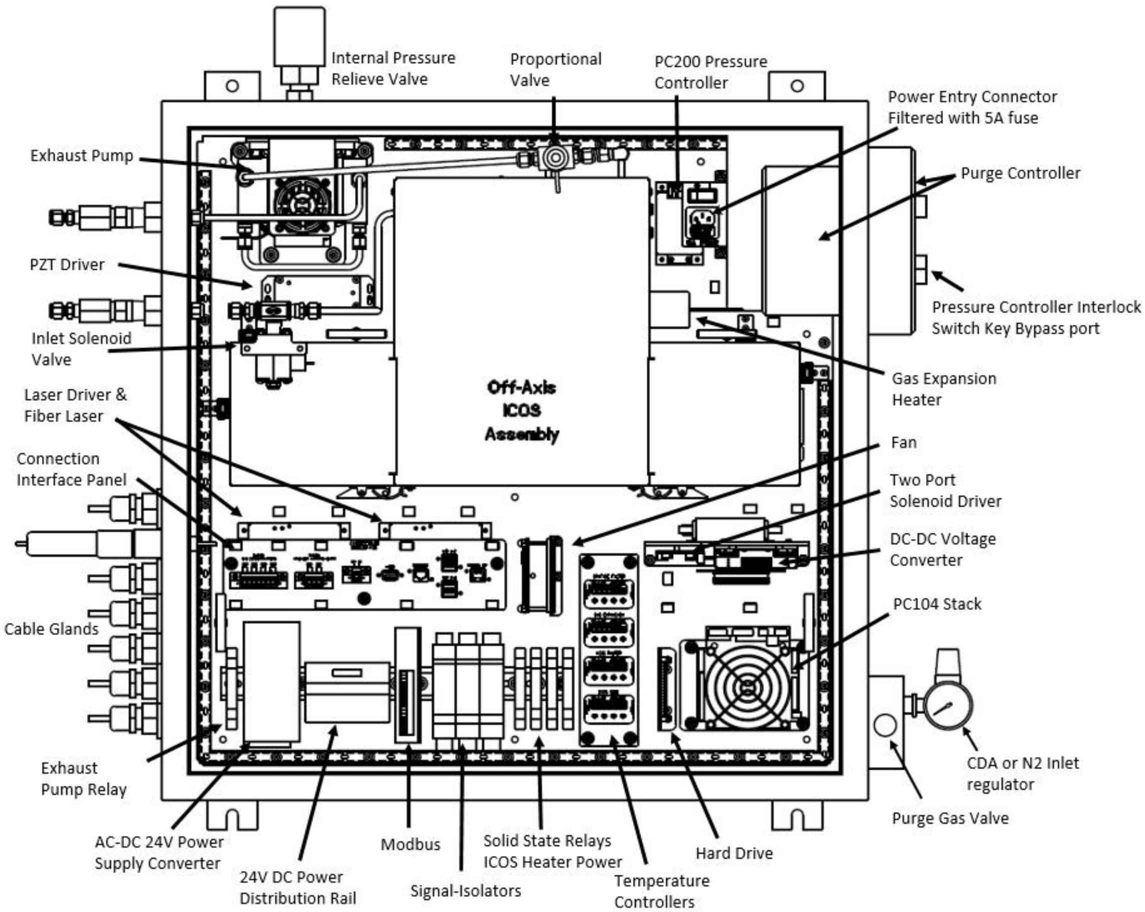


Warning!

Only authorized personnel may open the *LGR-ICOS* Gas Analyzer to perform internal maintenance. Follow the “Lockout/Tag out” procedure for the AC/DC supply power when servicing the Gas Analyzer. It is recommended that ABB field service engineers perform all repairs and PM services to the Gas Analyzer.

A layout of the internal parts illustrated on the system block diagram is shown in Fig. 34.

Fig. 34 ICOS Gas Analyzer Components & Their Location

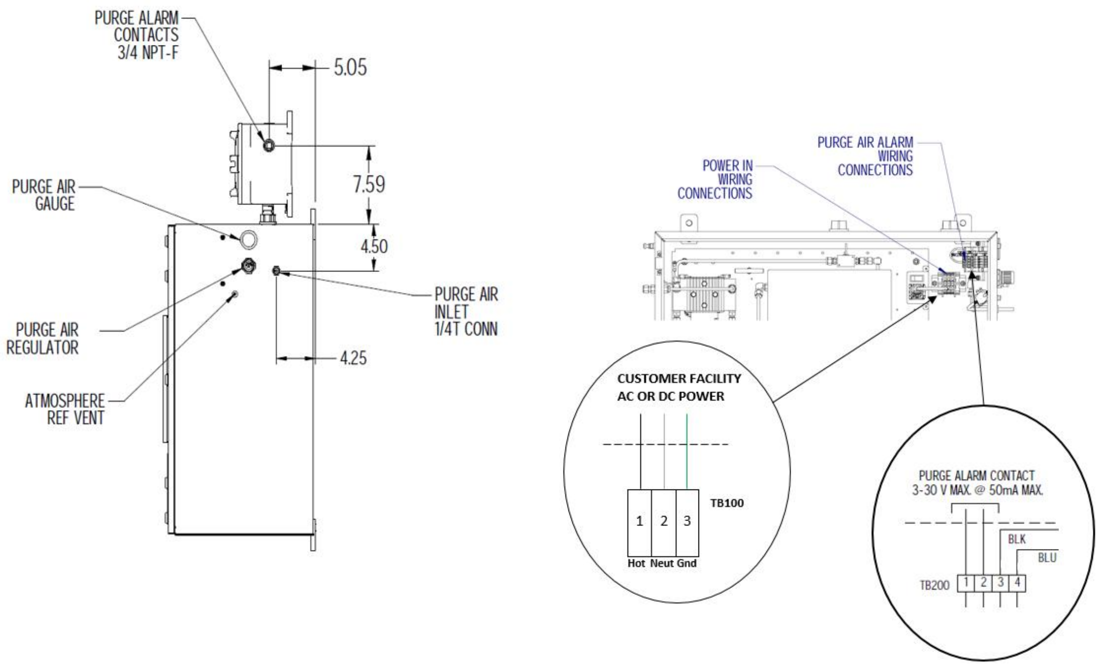


Danger!	When replacing components and verifying performance, the Gas Analyzer will need to be powered up with the front panel opened and closed. In a hazardous environment, this may not be allowed, to prevent possible injury or death of people in the surrounding work area. Ask the customer if this is allowable in their environment. Obtain a work permit from the customer before working on the instrument. If the instrument can only be powered up at the end of the repair cycle, once the instrument is closed for verification, we are working right now on the best method of determining the failed component(s). The procedures in this manual describes work performed while the Gas Analyzer is powered up.

Internal Pressure Interlock Switch

The internal pressure interlock switch in the Gas Analyzer is designed to limit the amount of sample gas entering the instrument at all times. When the purge alarm is in a "close" state, it means there is no air purge or flow alarm and all is well. In this state, there should be around +20V at 100mA across TB70 pin 1and pin 2 (Figure 36). If TB70 pin 1 and pin 2 registered ~ 0V, there is a fault with the instrument purge system. The internal pressure interlock switch is located next to the Gas Analyzer On/Off switch (see Fig. 35).

Fig. 35 X-Purge Internal Pressure Interlock Switch & Switch Bypass



The AC power lines coming from the facility are routed and connected to the purge controller terminal block. The purge controller terminal block is connected to the internal pressure interlock switch that monitors the Gas Analyzer operating internal pressure. This internal pressure interlock switch on the X-Purge can be bypassed when testing the Gas Analyzer. To setup the purge controller alarm that should be monitored by the customer, see Table 7.

Table 7 Purge Controller Alarms

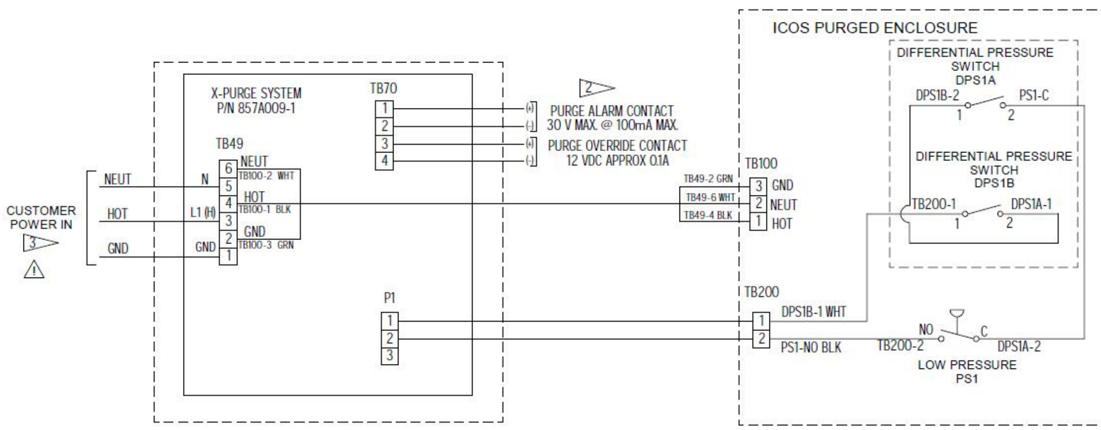
TB70 Contact No.	Purge Alarm Signal Description	Wire End Labeled
1	Loss of purge pressure/flow alarm	X2-1
2	Loss of purge pressure/flow alarm-return	X2-2

In this manual, as part of the problem identification process, the Gas Analyzer needs to be in operation to view the status of various components controlling heaters, exhaust pumps, and system communications. To maintain power while the front panel is opened, the internal pressure interlock switch bypass must be used on the X-Purge equipped instrument. A work permit from the customer is required to maintain operating power to the Gas Analyzer and have the front panel opened when working on the instrument.

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

When the internal pressure interlock switch bypass key is removed from the bypass setting, power to the Gas Analyzer is not instantly restored. The purge controller will be in the process of reading the internal pressure and exhaust flow of the Gas Analyzer to determine if the set internal pressure level meets a safe operating level, and performing several purging cycles before supplying power to the Gas Analyzer.

Fig. 36 Purge Controller Circuit

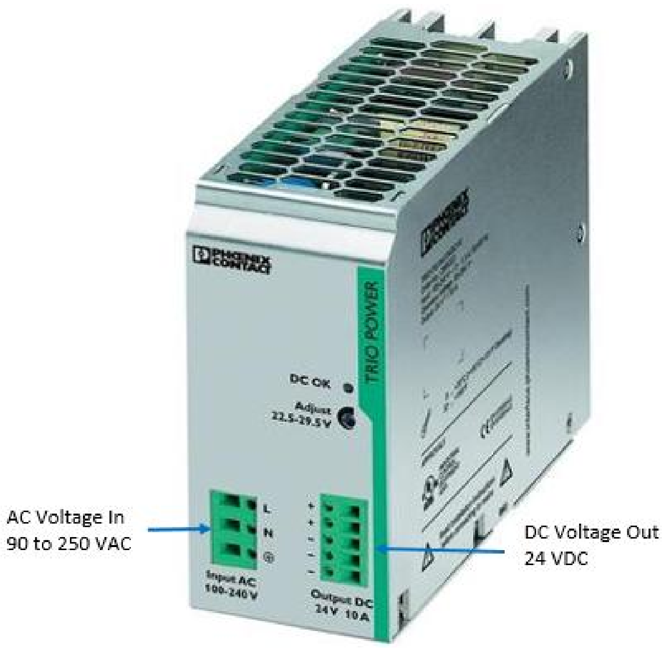


Danger!	On Gas Analyzers equipped with a Z-Purge, the internal pressure interlock switch will not remove AC power from the instrument. The internal pressure interlock switch, if connected by the customer, will only provide a signal to the facility that the internal pressure switch of the Gas Analyzer has been tripped or not.

AC/DC 24V Power Supply Converter

The AC/DC 24V power supply converter (see Fig. 37) provides DC power to the instrument. The AC power feeding this AC/DC power supply comes directly from an inlet filter with a 5A fuse (power entry connector) connected to the purge controller panel main AC terminal block source. With a volt meter, measuring between "L" and "N" should provide an AC voltage reading between 90V AC and 250V AC, depending on the customer facility. The DC output should read 24V between the "+" and "–" terminals. That output can be fine-tuned. When the instrument is operating correctly, the "DC OK" LED should be lit up.

Fig. 37 AC/DC Power Supply Converter



Troubleshooting

NOTE: This procedure is a Type 4 electrical safety task.

Required items and tools:

- Philips screwdriver
- Digital volt meter (DVM)
- Grounding wrist strap
- Blade screwdriver

Danger!	Testing or checking the AC/DC 24V power supply converter requires that the Gas Analyzer's power supply be energized. In this energized state, the person servicing the instrument will be exposed to high AC power, where an accidental contact could cause injury or death to personnel testing or checking the converter. This task qualifies as a Type 4 electrical safety task. Use proper precautions when probing the power supply with test meters.

Danger! ⚠	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To troubleshoot the AC/DC 24V power supply converter:

STEP 1 Shut off the customer sample gas line that is connected to the Gas Analyzer inlet gas line.

STEP 2 Open the customer filtered air check valve that is shared with the sample gas line connected to the Gas Analyzer.

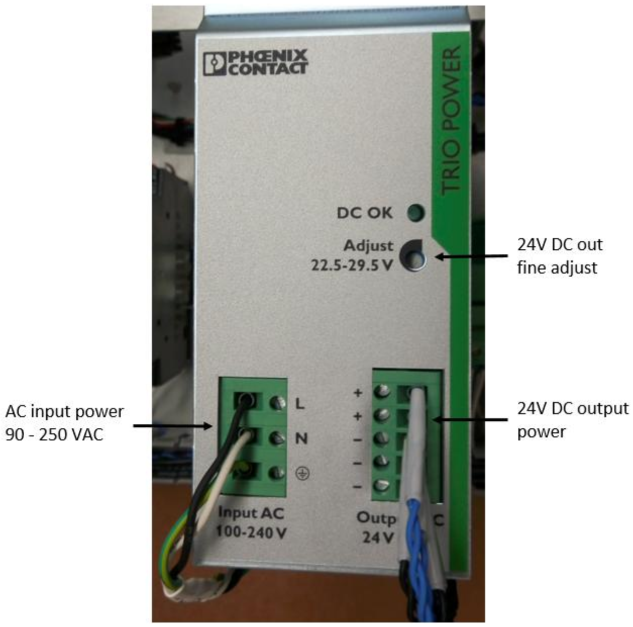
STEP 3 Use the internal pressure bypass key to disable the internal pressure kill switch.

STEP 4 Use a Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

STEP 5 Open the Gas Analyzer front panel and connect your grounding wrist strap to any bare metal on the Gas Analyzer chassis.

STEP 6 With a DVM set to measure AC voltage, determine if there is AC power on the “L” and “N” terminals. The result should read somewhere between 90V AC and 250V AC. See Fig. 38 to locate the terminals.

Fig. 38 AC/DC Power Supply Converter Connection Points



STEP 7 If the AC input voltage is correct, check the output side of the 24V DC by inserting the DVM test probe on the + and – terminals. If there is no 24V DC power, replace the unit.

Replacement

NOTE: This procedure is a Type 4 electrical safety task.

Required items and tools:

- Philips screwdriver
- Thin blade screwdriver
- Digital volt meter (DVM)
- Wire cutter
- Grounding wrist strap
- Tie wraps

Danger! 	When defeating the internal pressure switch to access any component inside the ICOS Gas Analyzer, the instrument is still energized and can cause injury or death to personnel servicing/probing it. All work performed on the instrument is considered a Type 3 electrical safety task, save for when working on the AC power, such as when probing the inlet AC power on the AC/DC power supply converter or at the power entry connector, where it becomes a Type 4 electrical safety task. It is required to power down the instrument prior to removing and replacing parts.

To replace the AC/DC 24V power supply converter:

STEP 1 Shut off the customer sample gas line connected to the Gas Analyzer inlet gas line.

STEP 2 Open the customer filtered air check valve that is shared with the sample gas line connected to the Gas Analyzer.

STEP 3 Shut off the AC power feeding the Gas Analyzer at the customer remote GUA junction box.

STEP 4 Perform the “lockout/tag out procedure” on the GUA junction box.

STEP 5 Determine the presence of AC power:

a. Use the Philip screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel and connect your grounding wrist strap to any bare metal on the Gas Analyzer chassis.

c. With the DVM set to measure AC voltage, determine if there is AC power between “L” and “N” terminals of the AC/DC 24V power supply converter. It should read 0V AC. If it does not, locate and turn off the power source.

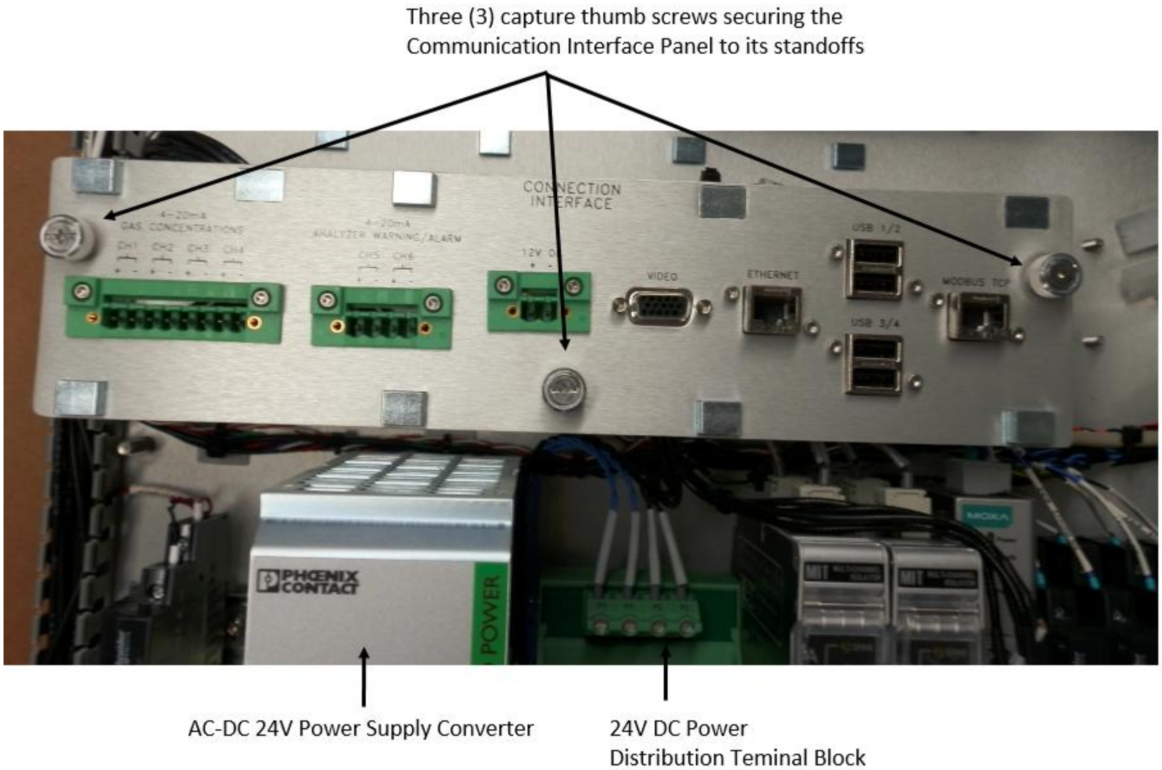
STEP 6 Remove the AC/DC 24V power supply converter:

a. With a thin blade screwdriver, unscrew the clamp screw enough to remove the wires from the “L” (black wire), “N” (white wire), and “Gnd” (yellow/green striped wire) terminals, then do the same for the “+” (blue wires) and – (black wires) terminals.

b. With a wire cutter, cut off the tie wrap holding the AC power and 24V DC wires to the AC/DC power supply converter.

c. Detach the communication interface panel (see Fig. 39) from its standoff by unscrewing the three capture thumb screws. With the communication interface panel leaning against the ICOS assembly, the AC/DC power supply converter will detach itself from the DIN rail.

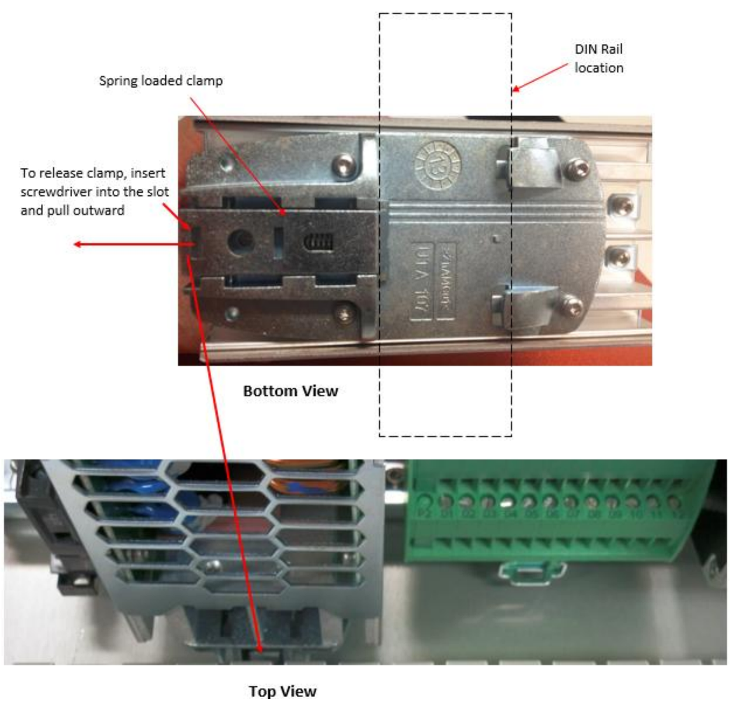
Fig. 39 Three Capture Thumb Screws on the Communication Interface Panel



d. With the blade screwdriver, move the spring-loaded clamp outward to unlatch the AC/DC power converter from the DIN rail (see Fig. 40).

e. Tilt the top towards the communication interface panel to unhook it from the DIN rail.

Fig. 40 AC/DC 24V Power Converter Bottom DIN Clamp



STEP 7 Reinstall the AC/DC 24V power supply converter:

a. Pull the spring-loaded clamp outward while tilted toward the communication interface panel.

b. Slide the base of the power supply against the DIN rail and tilt the bottom rear, thus releasing the spring-loaded slot so that the unit latches to the rail.

c. Reconnect both the AC line-in wires to the respective “L”, “N”, and “Gnd” terminals, and the 24V DC wires to the “+” and “–“ terminals. Verify that the wires are in the proper terminals.

d. Neatly tie-wrap the power cables to the AC/DC 24V power supply converter.

e. Cut off and discard the excess tie wrap.

f. Remove the “lockout-tag out” tag from the customer GUA junction box that provides AC power to the Gas Analyzer. Switch on the power and secure the GUA junction box according to customer requirements.

STEP 8 Verify power:

a. Take readings at the “L” and “N” terminals to make sure that there is no AC power feeding the AC/DC 24V power supply converter. If there is power, make sure that the pressure interlock switch is not bypassed.

b. After making sure that there is no power at the power supply converter input terminal, enable the bypass switch with the internal pressure interlock switch bypass key. This should allow AC power between the customer source and the AC/DC 24V power supply converter.

c. With a DVM, measure the AC power at terminals “L” and “N”. It should read somewhere between 90V AC and 250V AC. If it reads 0V AC, make sure that the fuse at the inlet filter is not blown and that there is AC power going into the purge controller at the terminals.

d. Once AC power has been verified, measure the 24 VDC at the output on the “+” and “–“ terminals. Adjust the *22.5 to 29.5* port of the power supply converter to have the output read between 24.0V DC to 24.2V DC.

e. Verify that all electronic components are running and functioning before closing the front panel.

STEP 9 Restart the system:

a. Perform a soft shutdown of the operating software using the touchscreen monitor.

b. Remove the bypass key from the internal pressure interlock switch.

c. Close the front panel and secure it into place with all locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through the Gas Analyzer.

d. Verify that the CDA/N2 inlet pressure gauge registers at least 4 psi.

e. With a blade screwdriver, rotate the purge gas valve on the CDA/N2 purge inlet to the “On” position.

f. After a minimum of 12 minutes, the Gas Analyzer restarts, once the purge controller completes its purge of the air within the Gas Analyzer enclosure. Once power is restored to the Gas Analyzer, turn the purge gas valve to the “Off” position (90° to the right of the “On” position) on instruments using N_2 as its purging gas. For instrument using CDA as its purging gas, leave the purge gas valve in the “On” position.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

STEP 10 Once the Gas Analyzer has completed its initialization, verify that temperature and pressure are moving toward their original settings and stabilize there.

STEP 11 Close the customer's filtered air line check valve.

STEP 12 Open the customer's sample gas line feeding into the Gas Analyzer inlet gas line.

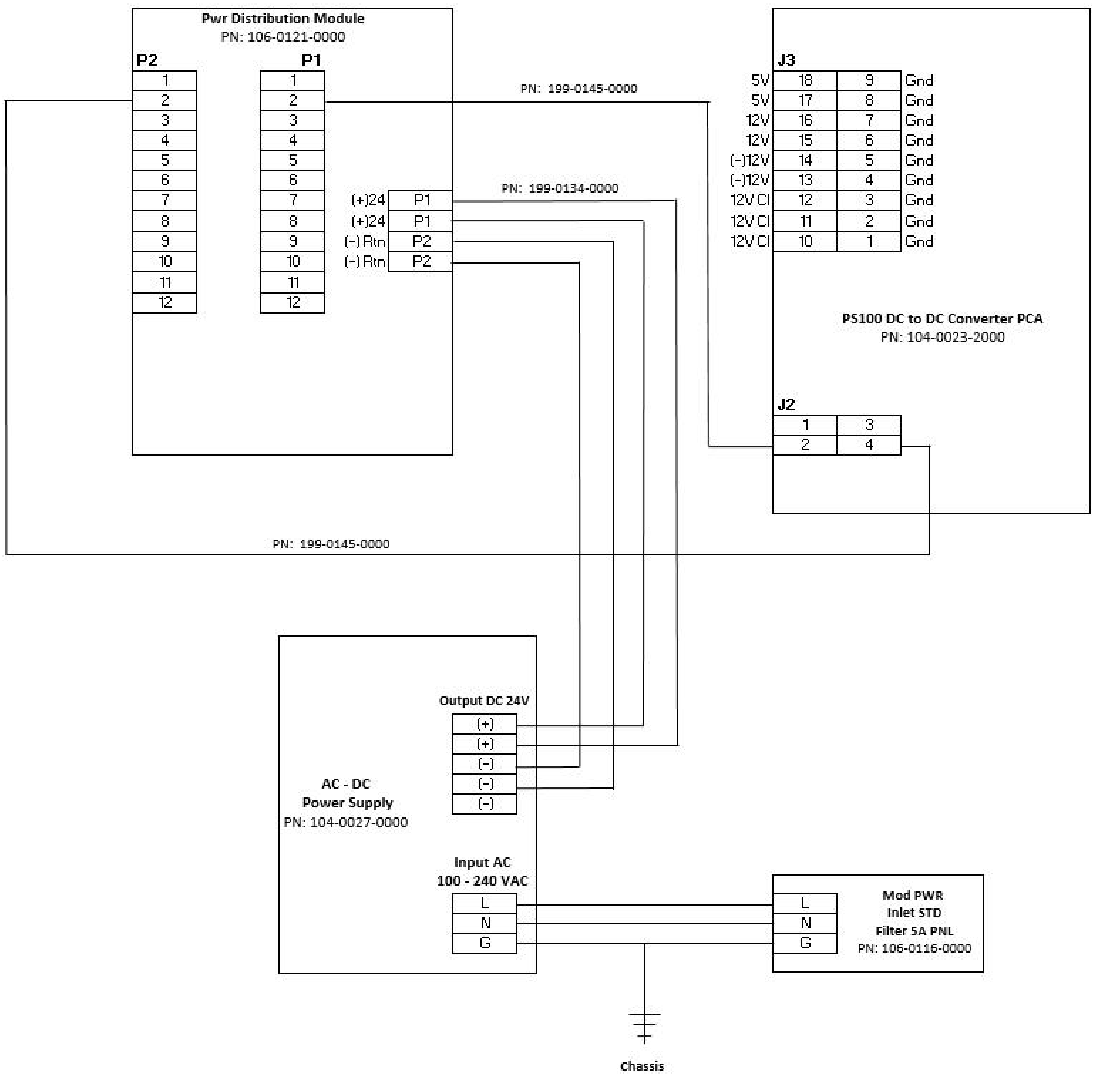
STEP 13 Allow the Gas Analyzer to stabilize for 20 minutes and make sure that the current performance data matches data saved in the past archive.

STEP 14 Release the Gas Analyzer back to the customer.

DC/DC Voltage Converter

The DC/DC voltage converter takes the 24V DC supply from the AC/DC power supply and provides the output DC voltages that support all system electronics, save for the heaters and exhaust pump. Fig. 41 is the power connection diagram between the AC/DC 24V power supply converter to the DC/DC voltage converter.

Fig. 41 AC/DC to DC/DC Power Connections



DC voltages coming from the DC/DC voltage converter are color-coded. The wire-color-to-voltage-level association is listed in Table 8.

Table 8 Wire-Color-to-DC-Voltage Association

Wire Color	DC Voltage
Black	Common
Red	+5 volts
Green	+12 volts
Purple	+12 volts
Blue	+15 volts or +24 volts
White	–12 volts
Orange	–15 volts or –24 volts

Troubleshooting

NOTE: This is a Type 3 electrical safety task.

Required items and tools:

- Philips screwdriver
- DVM
- Blade screwdriver
- Grounding wrist strap

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To troubleshoot the DC/DC voltage converter:

STEP 1 Shut off the customer sample gas line connected to the Gas Analyzer inlet gas line.

STEP 2 Open the customer filtered air check valve sharing the same sample gas line that is connected to the Gas Analyzer.

STEP 3 Use the internal pressure bypass key to disable the internal pressure kill switch.

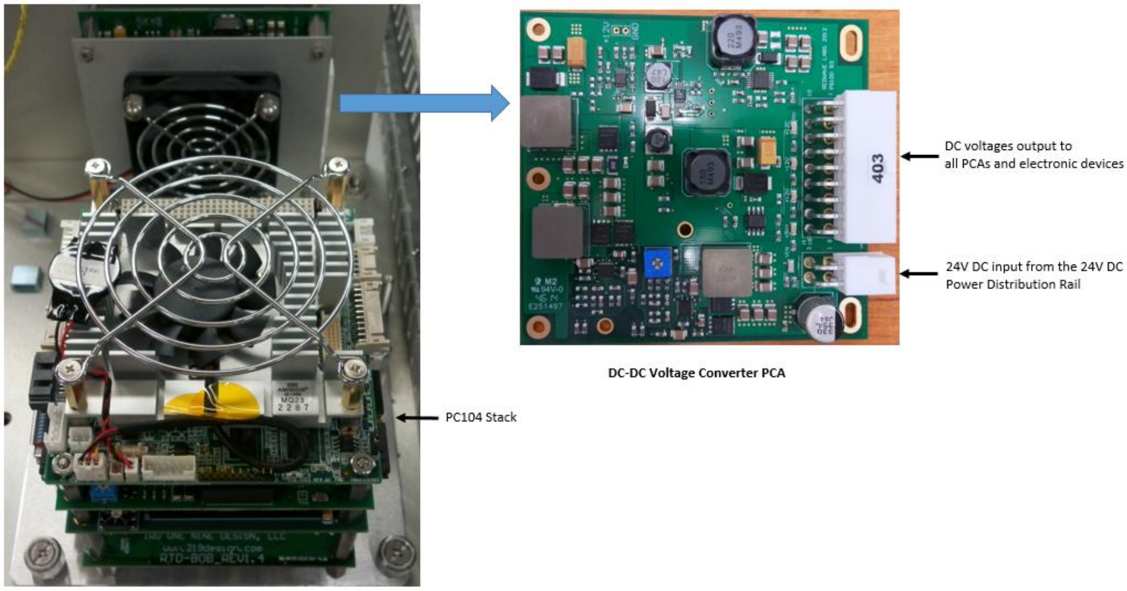
STEP 4 Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

STEP 5 Open the Gas Analyzer front panel and secure your grounding wrist strap to any bare metal on the Gas Analyzer chassis.

STEP 6 With a DVM, measure the terminal block output at the lower rail, verifying the presence of a 24V DC voltage. If there is 24V DC voltage, continue with the next step. Otherwise, the problem is with the AC/DC power supply converter.

STEP 7 Disconnect the 24V DC power cable going into the DC/DC voltage converter. To locate the 24V DC power cable, see Fig. 42.

Fig. 42 DC/DC Voltage Converter PCA



STEP 8 Measure power on that cable end to make sure that the problem is not with the input power cable. The “blue” wire is the +24V and the “black” wire is the return.

STEP 9 If the input power reading is correct, power down the Gas Analyzer through the operating software:

a. Click Exit from the Control Bar.

b. Click OK when prompt in the Shutdown message box.

c. Turn off the power switch.

STEP 10 Re-connect the 24V DC power supply cable onto the DC/DC voltage converter.

STEP 11 Turn on the Gas Analyzer.

STEP 12 With a DVM, measure output voltages coming out of the DC/DC voltage converter cable at the connector. Refer to Table 8 on page 54 for expected DC voltage levels. If any of the voltages are incorrect, disconnect the load from the problem voltage line to determine if the load is causing a drain on that line, or if it is on the DC/DC voltage converter.

STEP 13 Replace the faulty component.

Replacement

NOTE: This is a Type 3 electrical safety task.

Required items and tools:

- Grounding wrist strap
- Philips screwdriver
- Standard Allen wrench set
- Blade screwdriver
- DVM

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the DC/DC voltage converter:

STEP 1 Remove the faulty converter:

a. On the instrument touchscreen, click Exit follow by OK to perform a soft shutdown on the Shutdown screen prompt, if possible.

b. Shut off the customer sample gas line connected to the Gas Analyzer inlet gas line.

c. Open the customer filtered air check valve that shares the same sample gas line connected to the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

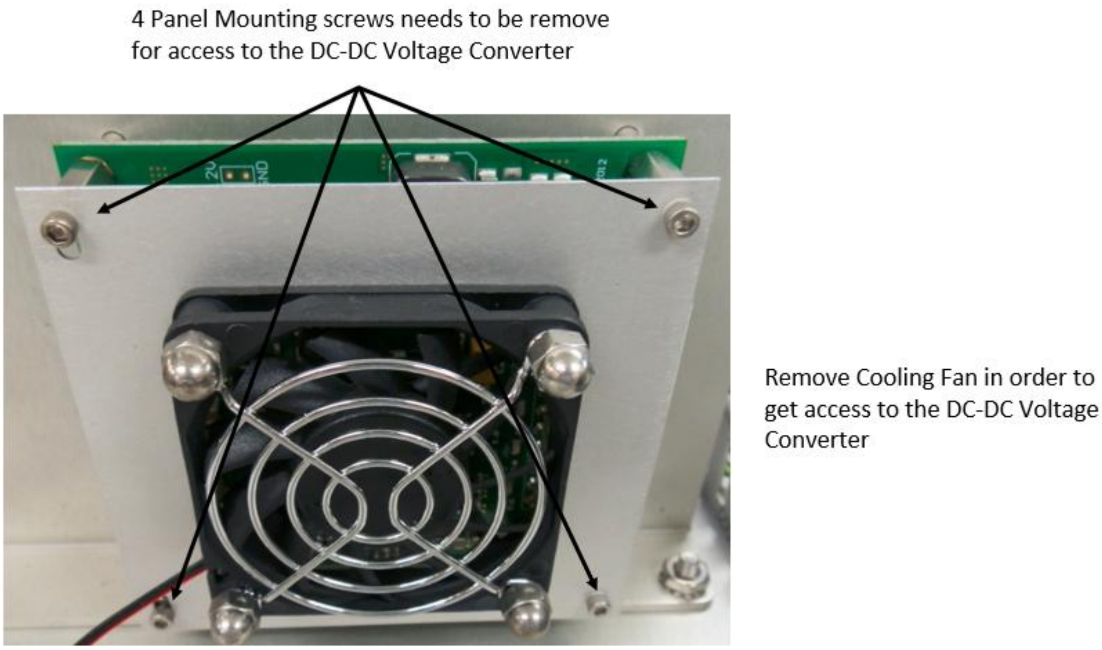
b. Open the Gas Analyzer front panel and secure your grounding wrist strap to any bare metal on the Gas Analyzer chassis.

STEP 3 Turn off the Gas Analyzer. The On/Off switch is located inside the enclosure, in the upper right corner.

STEP 4 Disconnect the two power cables at the DC/DC voltage converter.

STEP 5 Remove the four screws holding the cooling fan panel mount on top of the DC/DC voltage converter. See Fig. 43 to locate the four panel mounting screws.

Fig. 43 DC/DC Voltage Converter Cooling Fan



STEP 6 Remove the four standoffs locking the DC/DC voltage converter into place and remove the faulty DC/DC voltage converter.

STEP 7 Install the new DC/DC voltage converter:

a. Reverse steps 5 through 3.

b. Bypass the pressure interlock by using internal pressure interlock switch bypass key.

STEP 8 Turn on the Gas Analyzer. AC power should be fed to the 24V AC/DC power supply converter.

STEP 9 Measure DC power at the DC/DC voltage converter to make sure that voltages are correct.

STEP 10 Make sure that all electronic components are running and functioning properly before closing up the front panel.

STEP 11 Using the instrument touchscreen, perform a soft shutdown.

STEP 12 Remove the pressure interlock switch bypass key from the purge controller switch.

STEP 13 Close the front panel and secure it into place with all locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through to the Gas Analyzer.

STEP 14 Finish the procedure:

a. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

b. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

c. Initialize the Gas Analyzer when prompted.

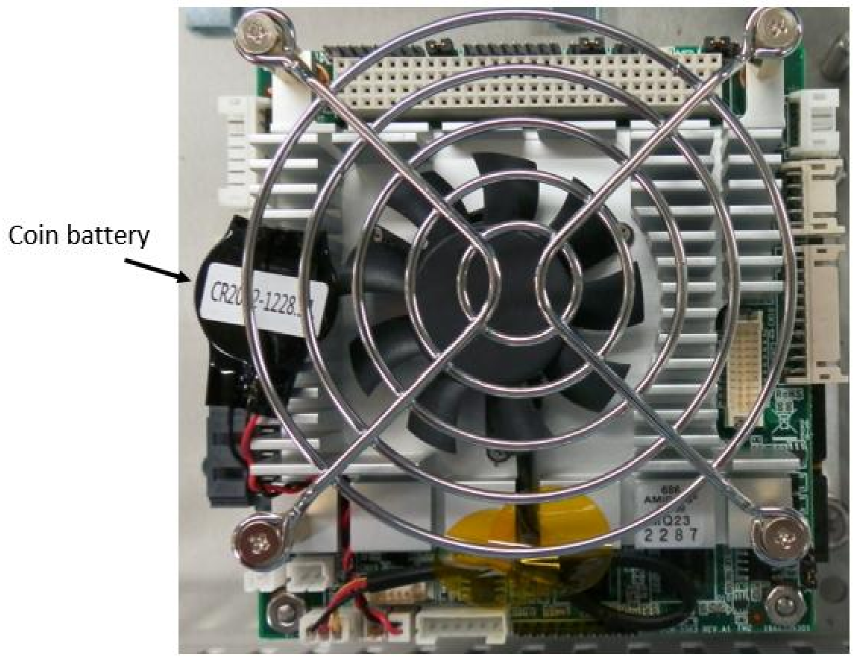
d. Once the Gas Analyzer has completed its initialization, verify that temperature and pressure are moving toward their original settings and stabilize there.
e. Close the customer's filtered air line check valve.
f. Open the customer’s sample gas line feeding into the Gas Analyzer inlet gas line.
g. Allow the Gas Analyzer to stabilize for 20 minutes and make sure that the current performance data matches data saved in the past archive.
h. Release the Gas Analyzer back to the customer.

PC104 Stack

The *LGR-ICOS* Gas Analyzer operates with a single board computer (PC104 stack) equipped with an Intel Atom microprocessor. This single board computer is integrated with a digital signal processor (DSP) board along with a multiple I/O (MIO) board that collects signals from the ICOS detector for both processing light signals and controlling the light source intensity to maintain the ICOS module sensitivity level. All input/output communications such as USB, Ethernet, VGA, and RS232 originate from the single board computer. The design is focused on:

- Low noise communications between the computer and the ICOS assembly (data acquisition and processing)
- Monitoring of various control signals
- Providing an interface to operators

Fig. 44 PC104 Stack Top View



There is practically no maintenance required on the PC104 stack. The computer stack CMOS BIOS is not configurable. The only replaceable item on this stack is the CR2032 +3V DC coin battery.

Fig. 45 details the PC104 stack communication lines to the rest of the system.

S310 DSP PCA

The S310 DSP (Digital Signal Processor) PCA main function is to take the incoming data, measurements and status signals, and process them to a known output format for external reading.

S310 PCA summary functions:

- Laser output intensity and operating frequency
- Measurement data processing from the NIR detector after A/D conversion
- Temperature monitoring at the plumbing line leading into the ICOS and out
- ICOS cavity internal pressure monitoring
- Providing data in a 0-to-5V DC format for the external communication

Input data ports are J5 and J7. The output port is J4. Signals on these three ports are listed in Table 9 to Table 11.

Table 9 S310 DSP J4 Output Port Signals

Pin #	Signal Description	Output
1	Laser 1 Temp Control	Intensity and frequency control. Pulse signal.
2	Laser 1 Return Gnd	
3	Laser 2 Temp Control	Intensity and frequency control. Pulse signal.
4	Laser 2 Return Gnd	
5	Temp Warning/Alarm	0-to-5V DC to Signal Isolator 3.
6	Temp Warning /Alarm Gnd	
7	Analyzer Warning/Alarm	0-to-5V DC to Signal Isolator 3.
8	Analyzer Warning/Alarm Gnd	
9	Gas Concentration 1 Analog out	0-to-5V DC to Signal Isolator 1.
10	Gas Concentration 1 Return Gnd	
11	Gas Concentration 2 Analog out	0-to-5V DC to Signal Isolator 1.
12	Gas Concentration 2 Return Gnd	
13	Gas Concentration 3 Analog out	0-to-5V DC to Signal Isolator 2.
14	Gas Concentration 3 Return Gnd	
15	Gas Concentration 4 Analog out	0-to-5V DC to Signal Isolator 2.
16	Gas Concentration 4 Return Gnd	

Table 10 S310 DSP J5 Input Signals

Pin #	Signal Description	Input
1	ICOS filter heater temperature	0-to-5V DC from temperature controller
2		
3	ICOS filter heater temperature Gnd	
4		
5	Gas expansion heater temperature	0-to-5V DC from temperature controller

Pin #	Signal Description	Input
6		
7	Gas expansion heater temperature Gnd	
8		
9	Orifice heater temperature	0-to-5V DC from temperature controller
10		
11	Orifice heater temperature Gnd	
12		
13	Inlet tube temperature	0-to-5V DC from inlet tube thermistor
14		
15	Inlet tube temperature Gnd	
16		

Table 11 S310 DSP J7 Signals Input

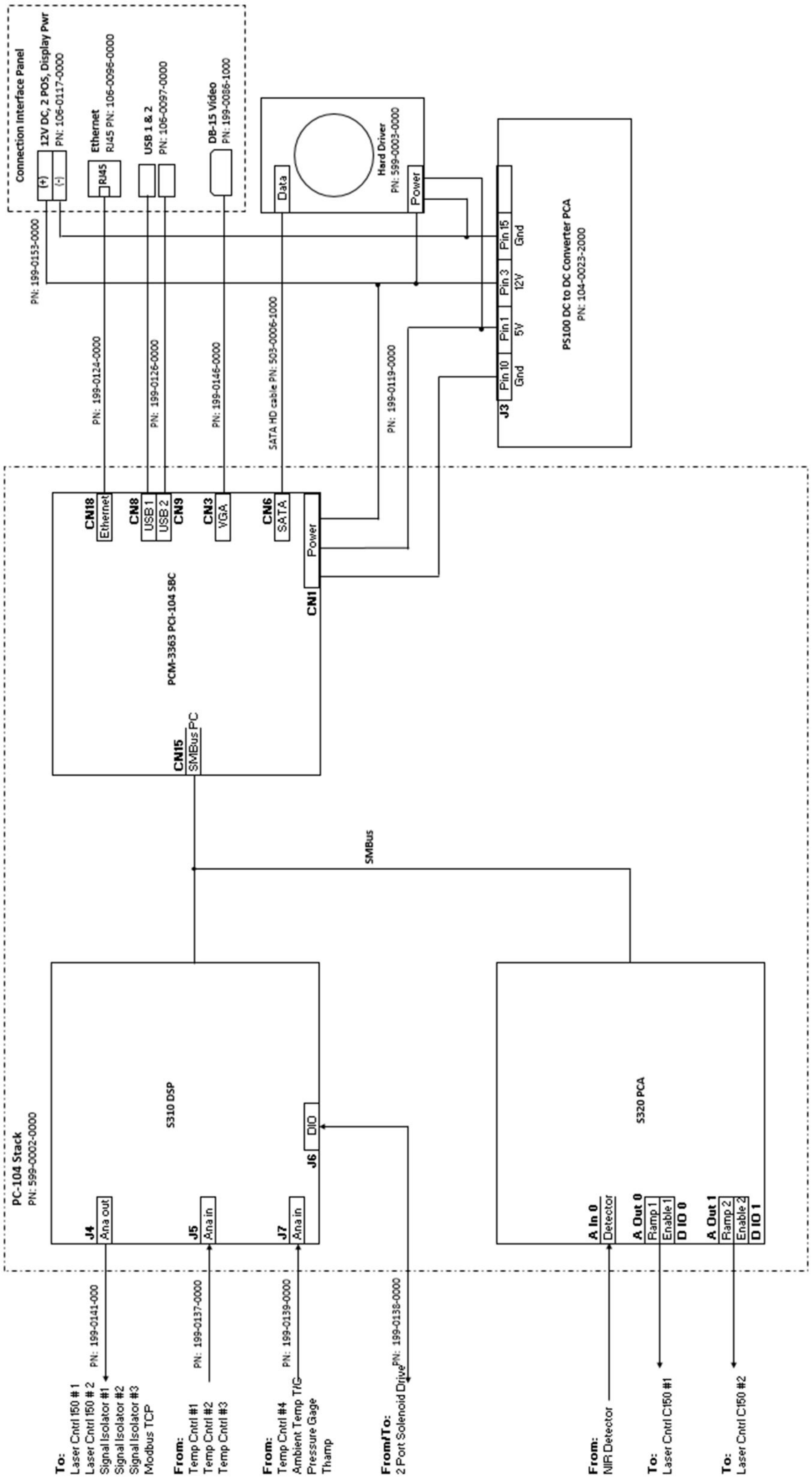
Pin #	Signal Description	Input
1	Cavity pressure	0-to-5V DC from pressure gauge
2	Bulkhead temperature	0-to-5V DC from bulkhead thermistor
3	Cavity pressure Gnd	
4	Bulkhead temperature Gnd	
5	Cavity temperature	0-to-5V DC from temperature controller
6		
7	Cavity temperature Gnd	
8		
9	Ambient case temperature	0-to-5V DC from thermistor on computer stack
10		
11	Ambient case temperature Gnd	
12		
13	Cavity heater temperature	0-to-5V DC from temperature controller
14		
15	Cavity heater temperature Gnd	
16		

The S310 DSP PCA controls the laser intensity and operating frequency by changing the fiber laser operating temperature.

Fig. 46 details the connections between the PC150 laser controller and S310 and S320 Multi I/O PCA.

The S310 DSP PCA also processes the NIR detector measured data routed to the S320 Multi I/O PCA through a coax cable. The analog signal is converted to digital before being sent to the S310 DSP PCA for processing.

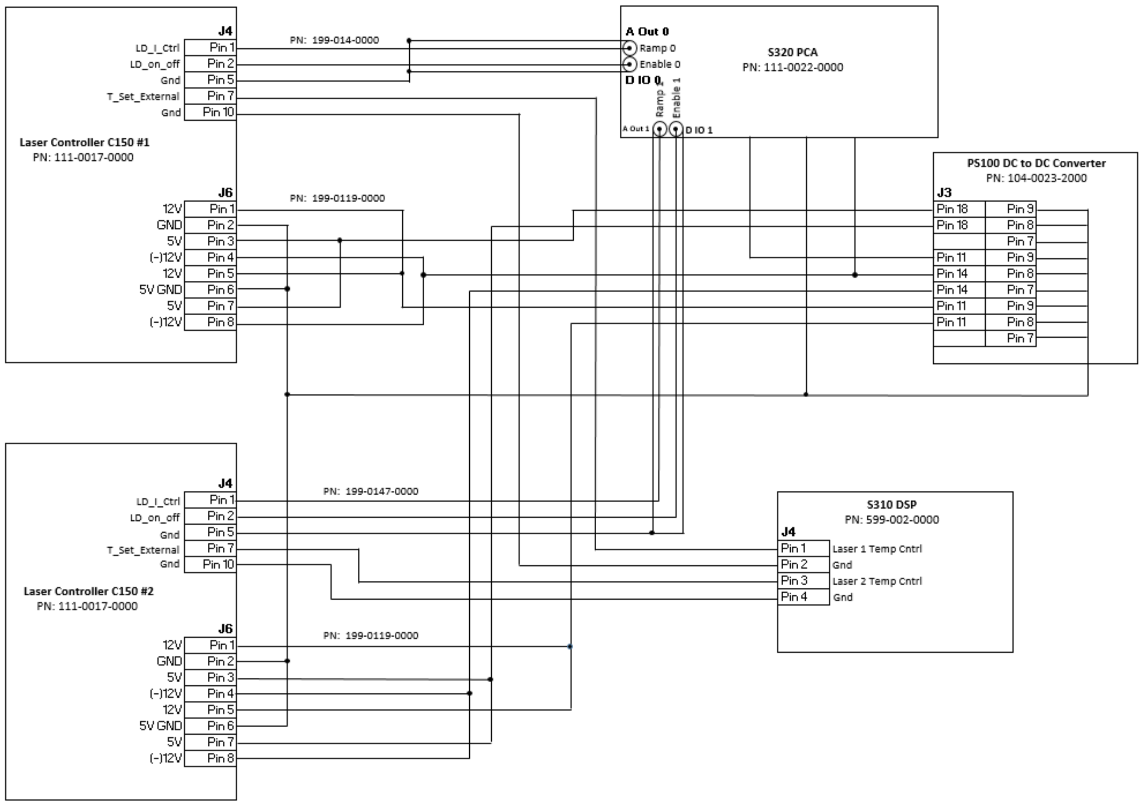
Fig. 45 PC104 Stack Wiring Diagram



S320 Multi I/O PCA

The S320 Multi I/O PCA serves for both laser control and data collection. From the S320 Multi I/O PCA, the *Enable* line turns the laser current on and off on the C150 laser controller PCA driving the fiber laser. The *Enable* line is a TTL signal where logic 1 is "enable" and a logic 0 is "disable". The *Ramp* line controls the laser current on the same C150 laser controller PCA. The amount of current is set during the system tuning step of the manufacturing calibration process. The current cannot be adjusted in the field. The laser drive signal travels from the S310 DSP board to the S320 Multi I/O PCA.

Fig. 46 S320 & S310 DSP PCA Laser Control Diagram



Troubleshooting

To troubleshoot the Gas Analyzer motherboard, you need:

- Laptop running the Windows operating system
- Ethernet patch cable
- Wireless mouse with USB RF chip

The following problems can be encountered on a faulty motherboard:

Table 12 PC104 Stack Motherboard Issues and Checks

Problem	Checks	
No VGA output	STEP 1	Disconnect the touchscreen VGA cable from the communication interface panel and connect it to your laptop.
	STEP 2	Go to the control panel to see if you can display your computer image on the Gas Analyzer touchscreen. If you can not, the problem lies with the monitor. If you can, the problem lies with the motherboard.
No Ethernet output	STEP 1	Plug in an Ethernet patch cable between your laptop and the Ethernet port on the customer router where the Gas Analyzer Ethernet cable is also connected.
	STEP 2	In the Windows operating system, from the Start menu, select All programs → Accessories → Command. In the Command Prompt window, type: ipconfig /all and press Return.
	STEP 3	Look for the laptop and Gas Analyzer IP addresses from the addresses displayed from the “ipconfig /all” command. You may want to ask the customer if a static IP address was assigned to the instrument.
	STEP 4	In the Windows operating system, from the Start menu, select All programs → Accessories → Run.
	STEP 5	Enter the computer default name: \\LGR-XXXX-XXXXX and press Enter. XXXX-XXXXX is the instrument serial number. If all this fails, replace the computer stack.
No USB access	STEP 1	Insert a wireless mouse RF dongle in the USB cable gland dongle that is connected to the communication interface panel.
	STEP 2	Check if the Gas Analyzer computer recognizes the mouse by looking for a cursor on the display screen.
	Warning! Do not attempt to connect the USB device directly in the communication interface panel for it could cause a spark and an explosion.	

Replacement

The PC104 stack is a single assembly and is replaced as one unit.

NOTE: *This procedure is a Type 3 electrical safety task.*

Required items and tools:

- Philip screwdriver
- Grounding wrist strap
- Blade screwdriver

Warning!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To replace the PC104 stack motherboard:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

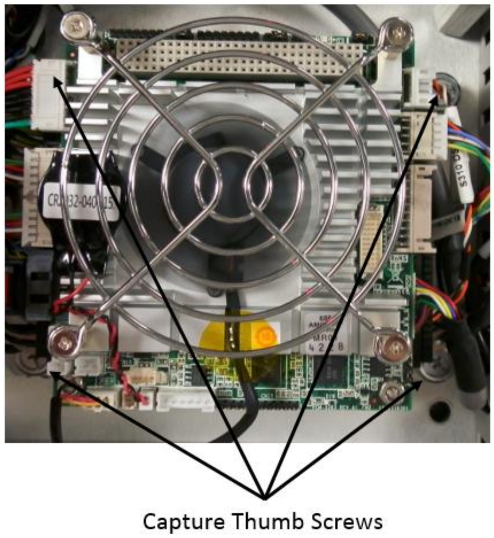
c. Secure your grounding wrist strap to the any bare metal surface on the Gas Analyzer chassis.

STEP 3 Switch the Gas Analyzer On/Off switch (inside the enclosure, in the upper right corner) to the Off position.

STEP 4 Remove the faulty PC104 stack:

a. With the Philips screwdriver, remove the four captive thumb screws (see Fig. 47 for location) that secure the PC104 stack to the chassis base plate.

Fig. 47 PC104 Stack Captive Thumb Screw Locations



b. Carefully lift the faulty PC104 stack from the base plate.

c. Disconnect all cables and SMC connectors from the PC104 stack.

d. Transfer the S320 Multi I/O PCA from the old PC104 stack to the new one. This is needed to avoid gain differences between the S320 Multi I/O PCAs, which would cause a measurement shifts.

STEP 5 Replace the PC104 stack

a. Re-connect all cables removed on step 4c to the new PC104 stack. See Fig. 48 and Fig. 49 for cable locations.

Fig. 48 PC104 Stack Motherboard Connections

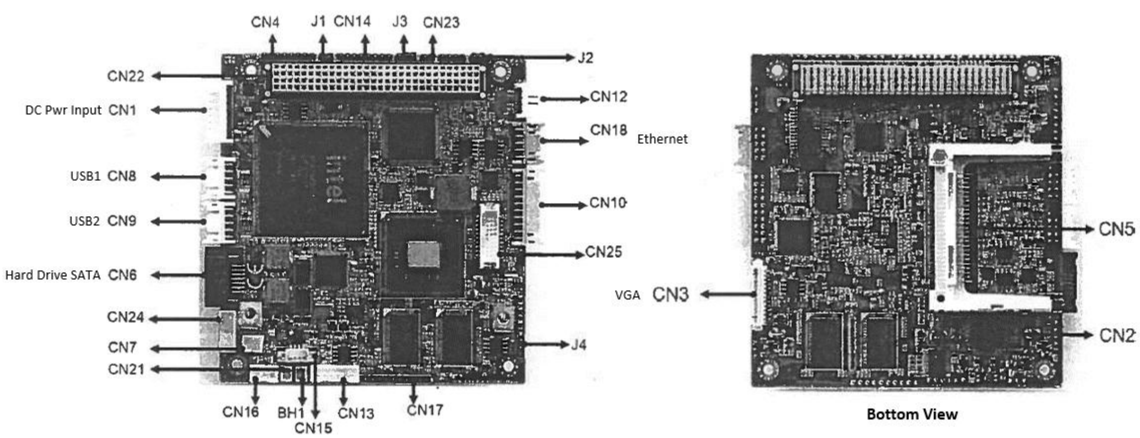
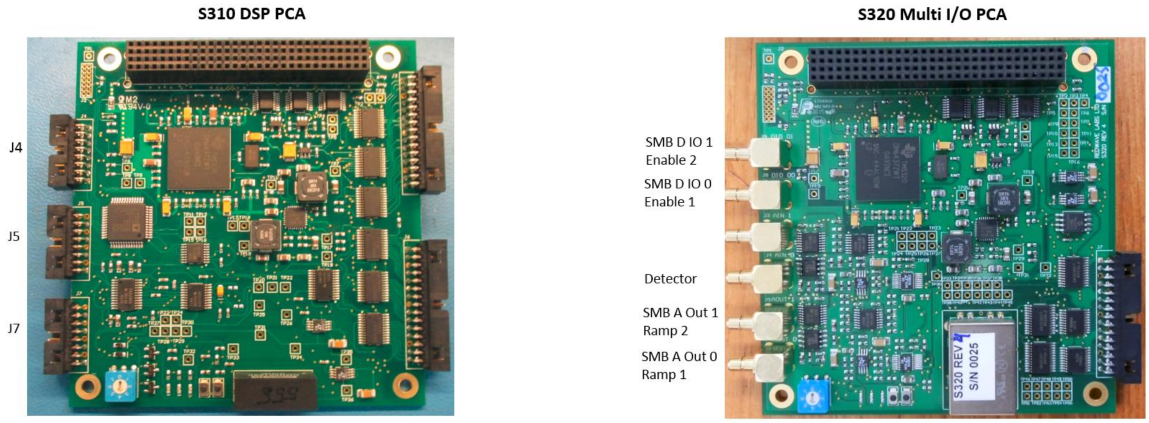


Fig. 49 S310 DSP PCA & S320 PCA Connections



b. Insert the new PC104 stack in the spot previously occupied by the faulty PC104 stack.

c. Lock it into place with the four captive screws.

STEP 6 Disconnect your grounding wrist strap from the instrument chassis.

STEP 7 Boot up the instrument:

a. With the bypass key, bypass the internal pressure interlock. This should boot up the instrument.

b. Look at the instrument touchscreen to make sure that the system is booting up properly.

c. Verify that all functions, temperature controllers, solid state relays, and Modbus are working properly.

STEP 8 Perform a soft shutdown of the instrument:

a. From the Control Bar on the touchscreen, click Exit.

b. In the following window that appears, confirm the shutdown by clicking OK.

c. Remove the pressure interlock switch bypass key from the switch.

STEP 9 Close the Gas Analyzer and finish the procedure:

a. Close the front panel and secure it into place with all locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through to the Gas Analyzer.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Initialize the Gas Analyzer when prompted.

e. Once the Gas Analyzer has completed its initialization, verify that temperature and pressure are moving toward their original settings and stabilize there.

f. Close the customer's filtered air line going into the Gas Analyzer inlet gas line.

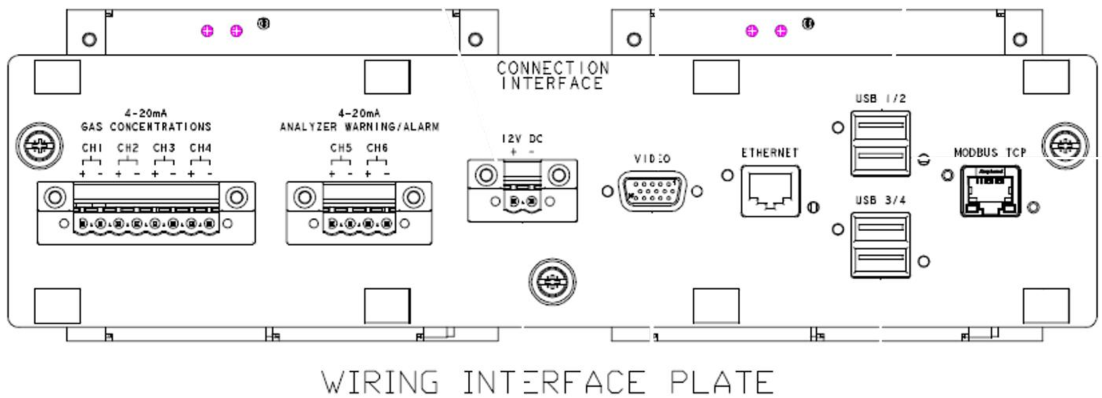
g. Open the customer's sample gas line feeding into the Gas Analyzer inlet gas line.

I/O Interfaces

The ICOS Gas Analyzer provides the following I/O interfaces on the internal connection interface panel (see Fig. 50):

- Ethernet (RJ–45)
- Modbus/TCP (RJ–45)
- USB (live disconnect module)
- 4–20 mA analog out (5.08 mm terminal block)

Fig. 50 Connection Interface Panel



The length of Ethernet and Modbus cables is limited by the type of cable used. For example, 100BaseTX is limited to 100 meters using RJ–45 connections (see Table 13).

Table 13 RJ–45 Cable Guide

Parameter	RJ–45
Cable specification	Category 5[1] UTP[2], 22 to 24 AWG
Maximum segment length	100 m (328 ft.) for 100BaseTX
Maximum network length	200 m (656 ft.) with one repeater

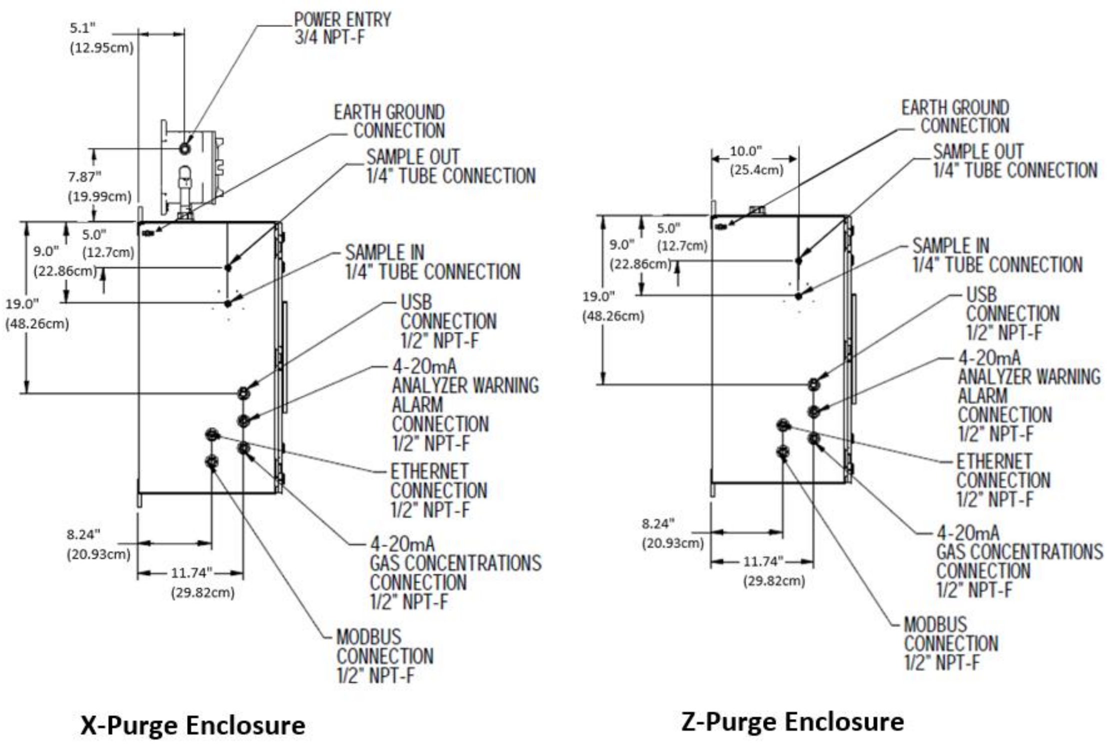
These interfaces allow operators to save measured data logged in the ICOS Gas Analyzer hard drive and transfer them to another storage location.

All cables going into these communication ports need to be routed in their designated sockets through a "*cable gland dongle*" located on the left side panel (see Fig. 51). The Gas Analyzer comes with cable glands preinstalled. Cable glands are designed to comply with CID2 regulation regarding containment of explosions and trapping of gases within the Gas Analyzer.

[1] EIA/TIA-568 TSB or EIA-TIA-568 compliant
[2] Category 5 UTP RJ–45 or 150 Ohm STP MII cable

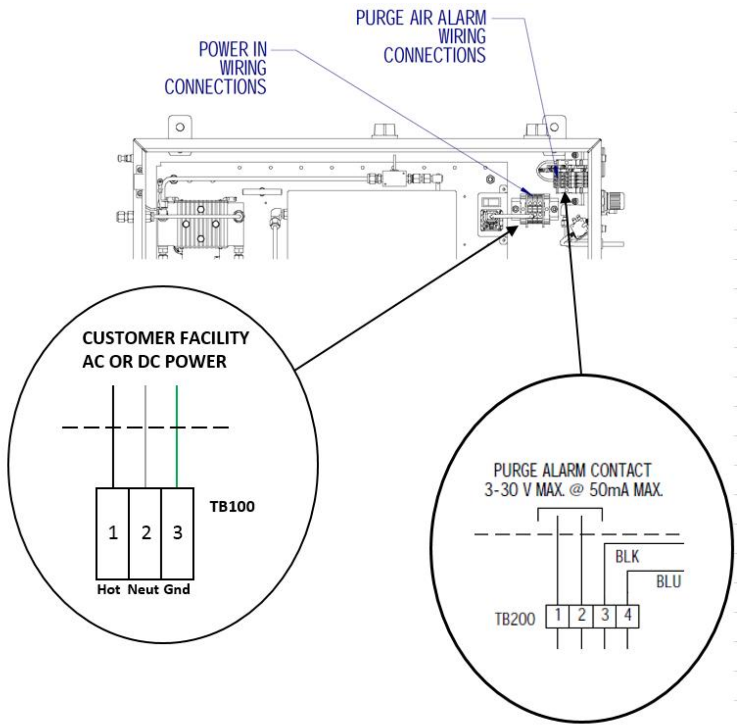
Danger!	Do not plug any cable or device directly into the communication interface panel or into any port within the Gas Analyzer after the instrument has been installed and the gas lines connected. Any spark resulting from a direct connection could possibly ignite any residual gas present in the Gas Analyzer and its surrounding area. This could lead to serious injury or death. *Cut AC power* to the Gas Analyzer before inserting any device into any port on the instrument.

Fig. 51 ICOS Gas Analyzer Left Side View



There is purge controller terminal block (see Fig. 52) is located at the upper right corner of the enclosure. This controller contains alarm terminal contacts related to the instrument purge.

Fig. 52 Purge Controller Terminal Block



Each terminal contact represents a specific failure as defined in Fig. 52. Connection to these dry contacts would be through a cable gland hole labelled "*Purge Alarm Normal Dry Contacts*", just beneath the AC power inlet on the left side panel, as pictured in Fig. 51.

Remote I/O Data Access: Ethernet

The ICOS Gas Analyzer runs the Unix operating system. Data files stored on the Gas Analyzer internal hard drive can be accessed as a Windows Share Drive over a local area network (LAN) Ethernet connection.

For this feature to work, the Gas Analyzer must:

- Be connected to a local area network (LAN) via the RJ–45 Ethernet connection through the cable gland located on the left side of the Gas Analyzer enclosure.
- Receive a response to a Dynamic Host Configuration Protocol (DHCP) request when the Gas Analyzer is initialized. If the Gas Analyzer does not receive a reply, the Gas Analyzer will:
  - Disable the Ethernet port
  - Not attempt another DHCP request until the Gas Analyzer is restarted

When both conditions are met, the data directory can be accessed using a Windows computer on the same LAN. To access the shared drive from Windows:

STEP 1 Select Start → Run.

STEP 2 Enter: \\LGR-XXXX-XXXXX and press Enter.

After the communication link has been established, a Windows Share Drive directory window displays a *lgrdata* subdirectory.

STEP 3 Double-click the *lgrdata* directory to display a listing of data files stored on the internal hard disk. Open or transfer any of the data files as you would with any Windows Share Drive.

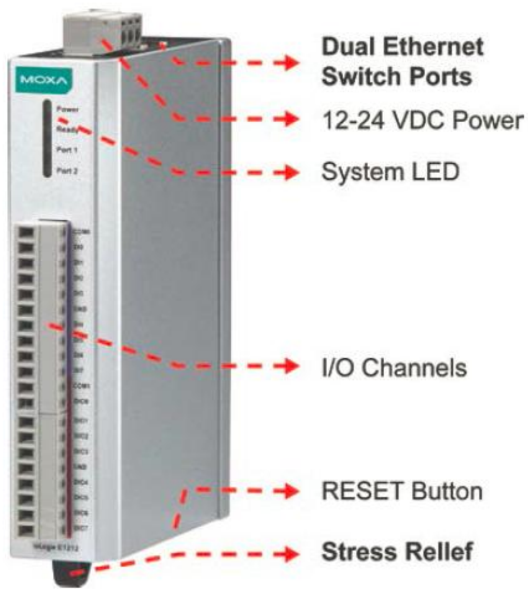
Remote I/O Data Access: Modbus

With each ICOS Gas Analyzer, a Moxa application CD and instructions (P/N: 1112012001031) are shipped in support of the ioLogik E1240 Modbus. This application allows for linking and configuring the Modbus to a required format. Modbus outputs are the measured gases and the warning/fault signals. The Modbus gas concentration measurement results are configured to the input lines in Table 14.

Table 14 Modbus Gas Concentration Line Setting

Input Line	Gas
A10+	Warning
A10–	
A11+	Alarm
A11–	
A12+	Gas #1 Concentration
A12–	
A13+	Gas #2 Concentration
A13–	
A14+	Gas #3 Concentration
A14–	
A15+	Gas #4 Concentration
A15–	

Fig. 53 Modbus LED Location



Modbus LED indicators define the instrument operational status. Table 15 describes the status of each LED.

Table 15 Modbus LED Description

Type	Color	Description
Power	Amber	System is powered on
	Off	System is powered off
Ready	Green	System is ready
	Flashing	Every 1 second when the “Locate” function is triggered
	Flashing	Every 2 seconds when the firmware is being upgraded
	Flashing	Every 0.5 second to indicate “Safe Mode”
	Off	System is not ready
Port 1	Green	Ethernet connection established
	Flashing	Transmitting or receiving data
Port 2	Green	Ethernet connection established
	Flashing	Transmitting or receiving data

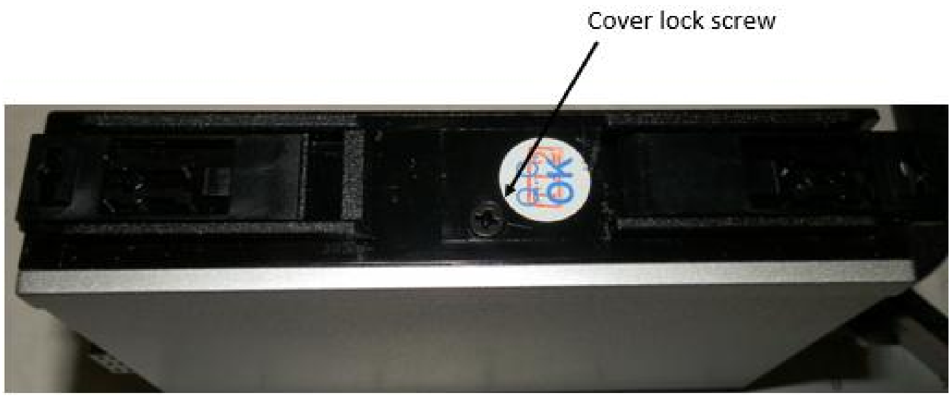
Modbus Configuration: Analog Input (AI)

If the Modbus requires replacing, configure the unit to accept analog input in voltage (default settings).

To perform/verify this configuration, open up the unit:

STEP 1 Remove the cover lock screw. See Fig. 54.

Fig. 54 Modbus Rear View, Internal Access

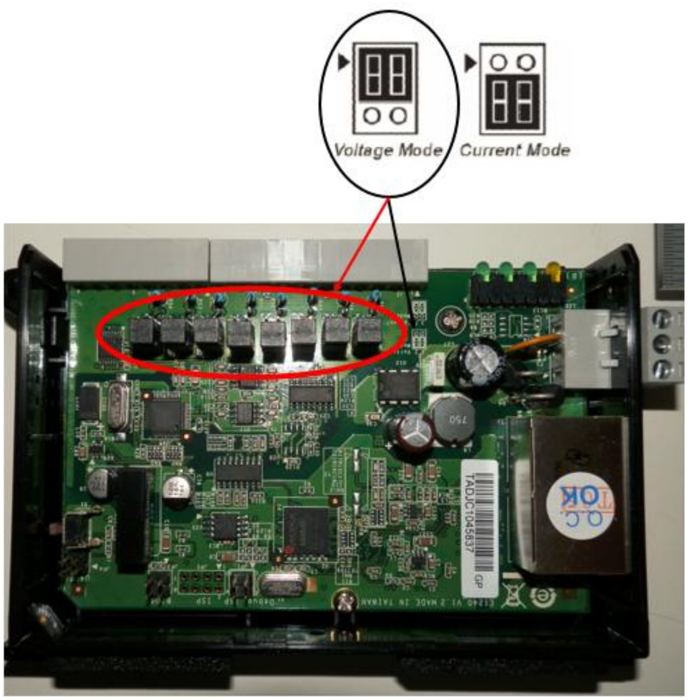


STEP 2 Pull out the two I/O Channel connectors at the front of the unit.

STEP 3 Lift up the cover from the rear.

STEP 4 Make sure that jumper settings are correct.

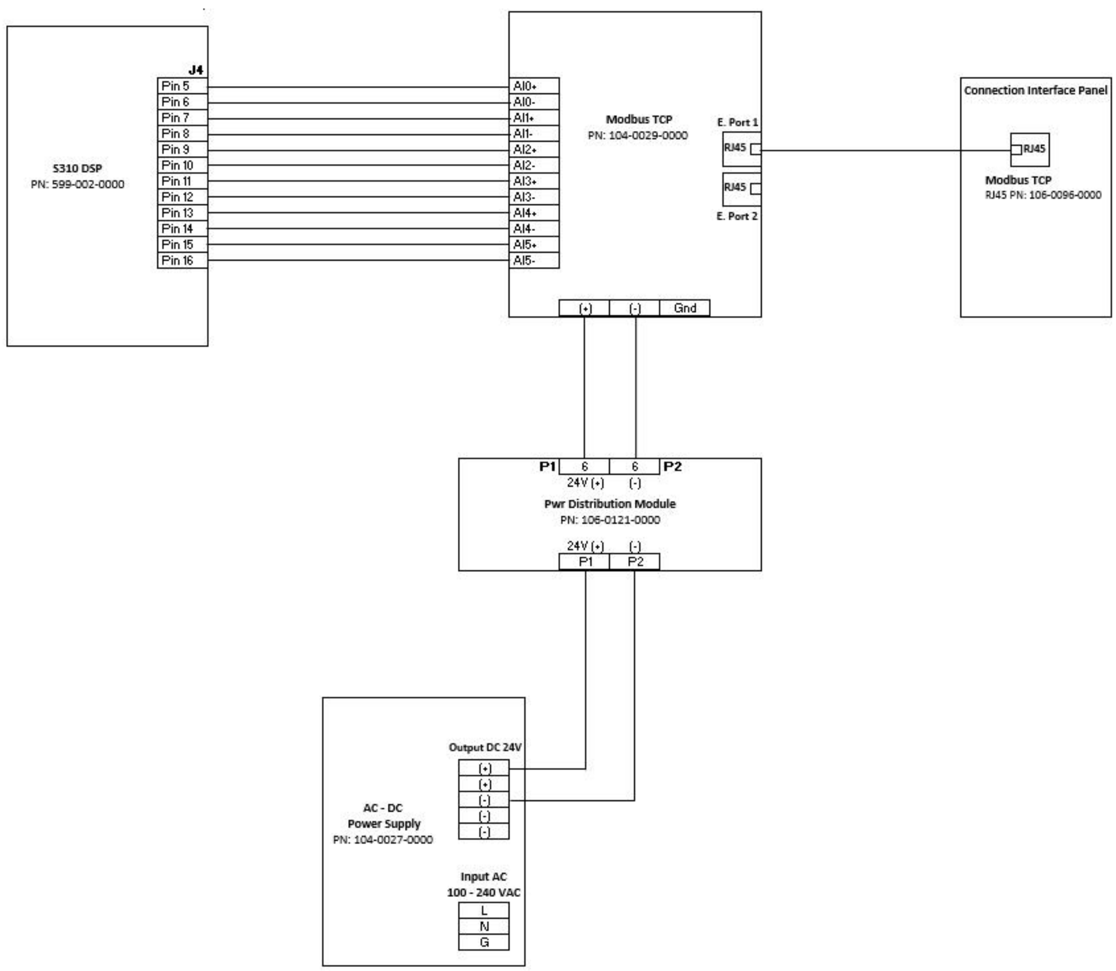
Fig. 55 Jumper Settings



Modbus Communication

The Modbus provides an alternate source for gathering measured data using a network or a direct computer interface. Measurement data transferred to the Modbus come from the S310 DSP board on the PC104 stack. The data signal to the Modbus is also split to go to the signal isolators and provide a 4–20 mA signal output. The Modbus output data for Gas Analyzer warnings and alarms are in a 4–20 mA configuration, and the gas concentration data is in parts per million (ppm). Fig. 56 details the ioLogik Modbus communication lines with the S310 DSP and the connection interface panel for network communications.

Fig. 56 Gas Analyzer Modbus Communication Interface



Modbus network communication is performed using the Web Console application software from ioLogik. To use Web Console, the Modbus IP address is required. The Modbus factory default IP address is 192.168.127.254 and the subnet mask is 255.255.255.0

The customer will most likely change this default address. To determine what is the new Modbus IP address, download and run the ioSearch software from the Moxa website, or locate the disk provided to the customer when the Gas Analyzer was installed.

NOTE: For the Modbus to be accessible over the Internet, port forwarding is required. The recommended port forwarding number is 502.

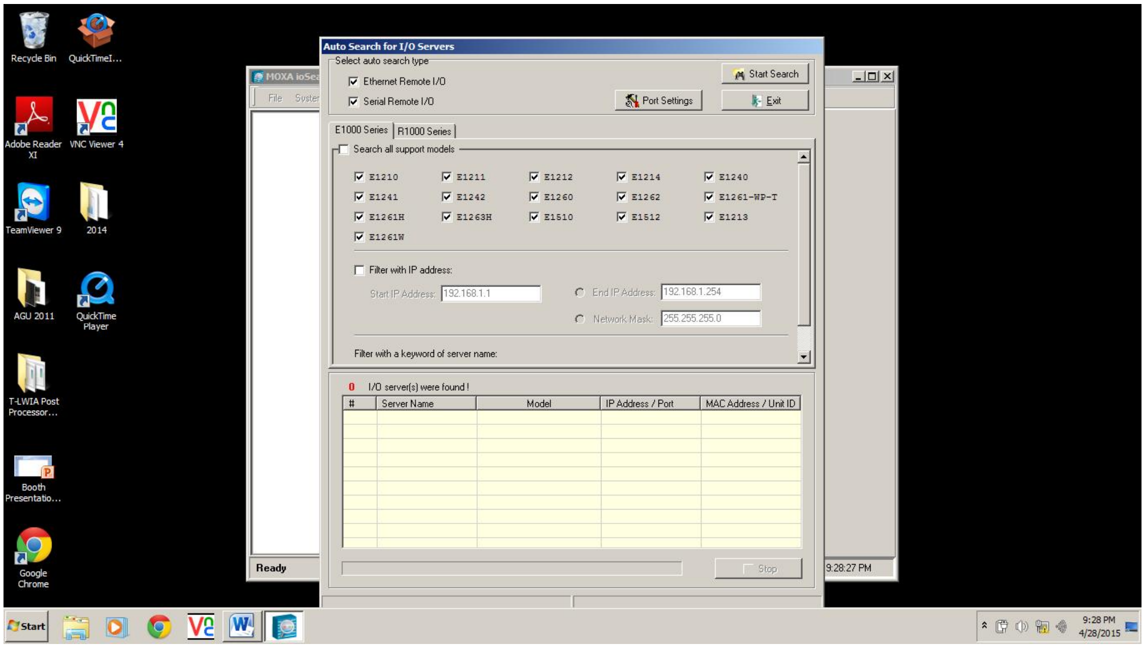
To search for the Modbus IP address using ioSearch:

STEP 1 Connect to the customer's Ethernet network to which the Modbus is connected.

STEP 2 From the Windows Start menu, select Program Files → MOXA → Utility → ioSearch.

STEP 3 From the ioSearch menu bar, select Auto Scan Active Ethernet I/O Server. The *Auto Search for I/O Servers* window will appear (see Fig. 57).

Fig. 57 Auto Search for I/O Servers Dialog Box

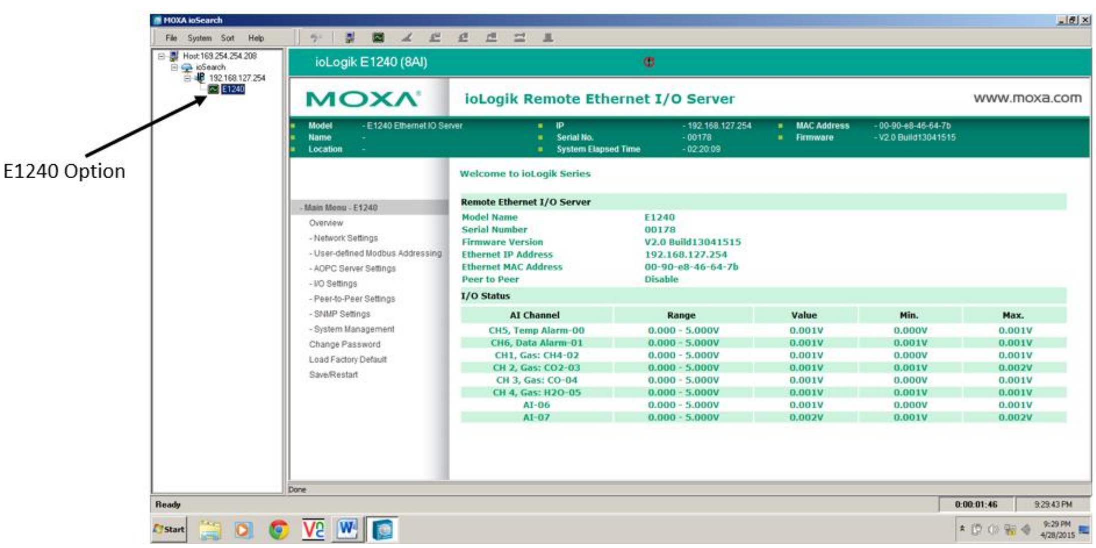


STEP 4 In the *Select auto search type* box, click Start Search.

STEP 5 Once the IP address is found, there are two methods to access the Modbus: method 1 would be to continue using the ioSearch application; method 2 would be to use a browser and enter the IP address into the URL.

- With method 1, in the Web Console screen, select E1240 in the leftmost tree (see Fig. 58). The current ioLogik Modbus configuration is displayed. The default IP address of the ioLogik Modbus is 192.168.127.254. This may no longer be true. After the Gas Analyzer was installed, the customer might have given it a different IP address when interfacing this instrument with other equipment found at the facility.

Fig. 58 ioLogik Modbus Web Console Screen Access



- With method 2, to access the Modbus server (ioLogik device), open a web browser on a computer connected to the same network as the Modbus and use the IP address found on step 4. The URL to input in the web browser would be: http//(IP address)/

STEP 6 Upon gaining access to the ioLogik device through the device IP address, the device's Web Console screen will be displayed. At this point you are now in direct communication with the device. Should you run into an issue concerning connection or communication, you can contact the Moxa tech support line at 1-888-669-2872.

STEP 7 If somehow the ioLogik Modbus got corrupted, one can load the default factory settings back onto the ioLogik Modbus:

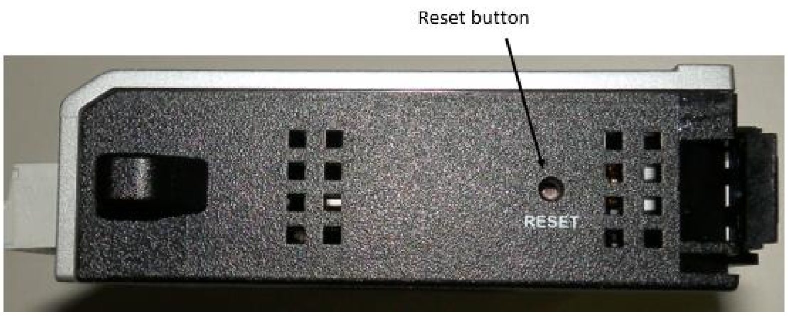
a. Make sure that the power is on.

b. Hold down the RESET button for five seconds (see Fig. 59).

c. In the ioSearch utility, right-click on the specific ioLogik device and select Reset to Default.

d. Select Load Factory Default from the Web Console screen.

Fig. 59 ioLogik Modbus Reset Button, Bottom View



Modbus IP Address Change

Customers have the option of changing the ioLogik Modbus IP address, should more than one Modbus be installed at their facility, or should the specific IP address be already assigned to another device in their network.

To change the Modbus IP Address:

STEP 1 Connect into the customer Ethernet network into which the Modbus is connected.

STEP 2 From the Start menu, select Program Files → MOXA → Utility → ioSearch.

STEP 3 From the ioSearch window, select Auto Scan Active Ethernet I/O Server. The Auto Search for I/O Servers window appears.

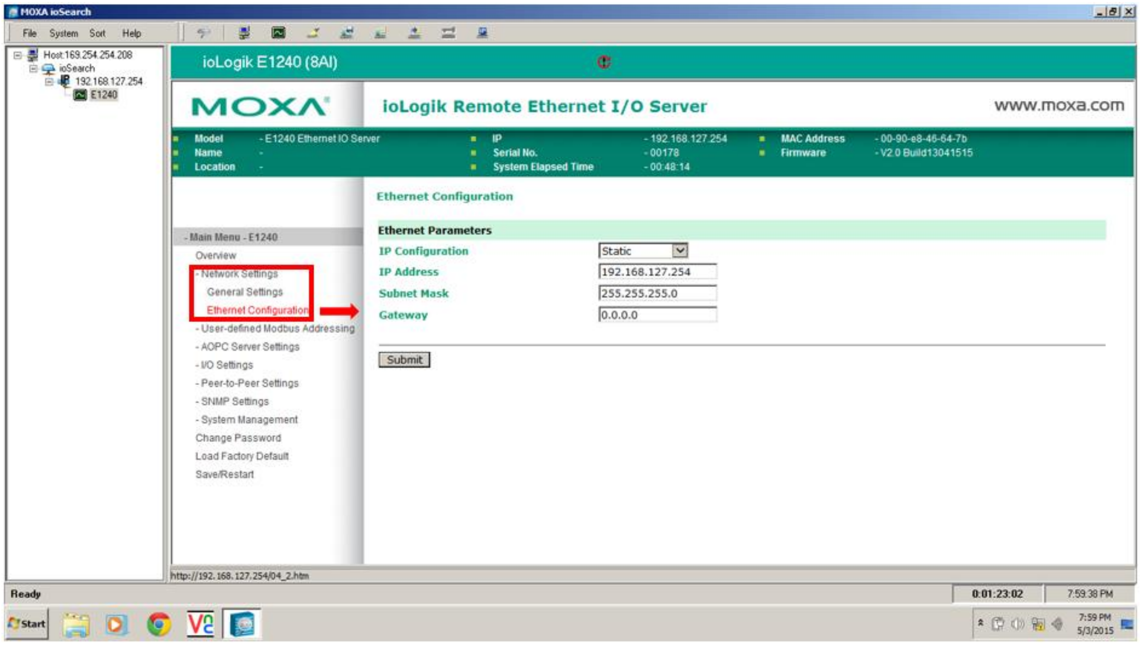
STEP 4 Click Start Search.

STEP 5 Locate the IP address of the Modbus whose address one wants to change and select the E1240 device under that IP address. This will display the main screen for the E1240 device.

STEP 6 In the ioLogik E1240 menu, under Overview, select Network Settings → Ethernet Configuration. In the screen that appears (see Fig. 60), one can change the Modbus IP address.

STEP 7 Change the IP address as required and click Submit to save the change. If you do not click Submit after you made the change, the device will not update the information once you exit the screen.

Fig. 60 ioLogik Modbus Ethernet Configuration Screen



Modbus Output Data Channels Configuration

The Modbus output data can be configured. There are up to six output channels. Channels 1 through 4 are reserved for up to four different gas type outputs. Channels 5 and 6 are used for instrument warnings and alarms. Each of the six AI used can be renamed to help identify the measurement taken. Also, in analog input (AI) channel settings, one can scale the input 0–5V DC to any configured output signal whether that be voltage, current, or ppm in a spectroscopy instrument.

To edit the IO Channel name and set the gas measurement parameter scaling:

STEP 1 Connect to the customer Ethernet network where the Modbus is connected.

STEP 2 From the Windows Start menu, select Program Files → MOXA → Utility → ioSearch.

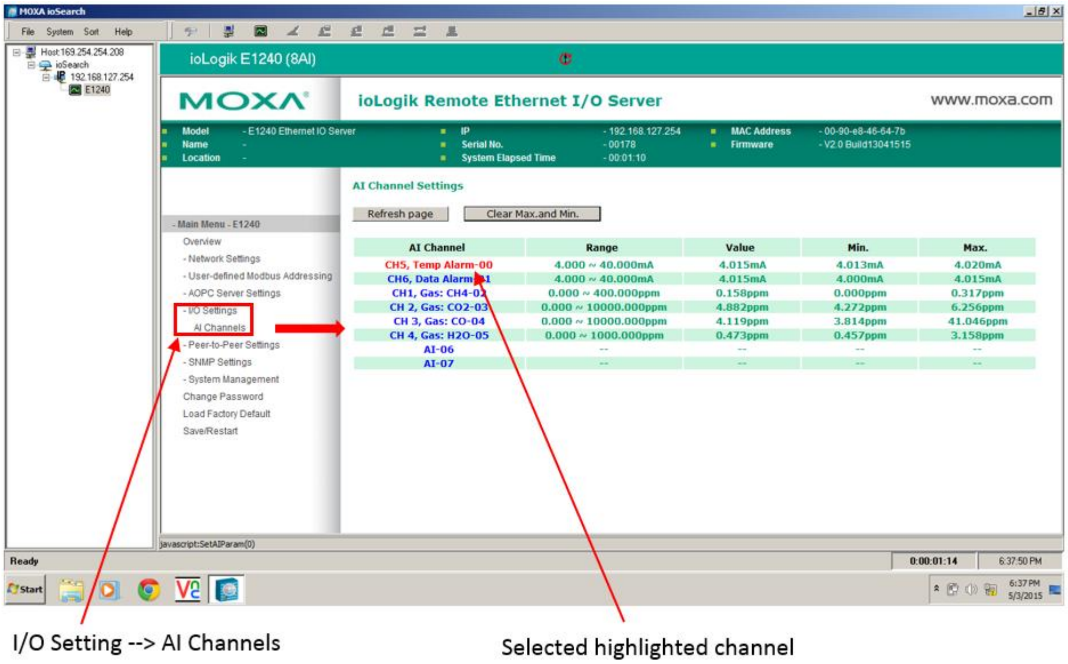
STEP 3 From the ioSearch window, select Auto Scan Active Ethernet I/O Server. The Auto Search for I/O Servers window appears.

STEP 4 Click Start Search.

STEP 5 Locate the Modbus IP address that needs to be changed and select the E1240 device under that IP address. This will display the main screen for the E1240 device.

STEP 6 From the main screen, select I/O Settings → AI Channels. In the AI Channel Settings screen, one can change the analog input name. To perform this task, click on the name to be changed (see Fig. 61).

Fig. 61 ioLogik Analog Input (AI) Channels Settings Screen



STEP 7 In the AI Channel "*n*" Settings screen, make the appropriate changes:

a. Set the Modbus AI Input Range.

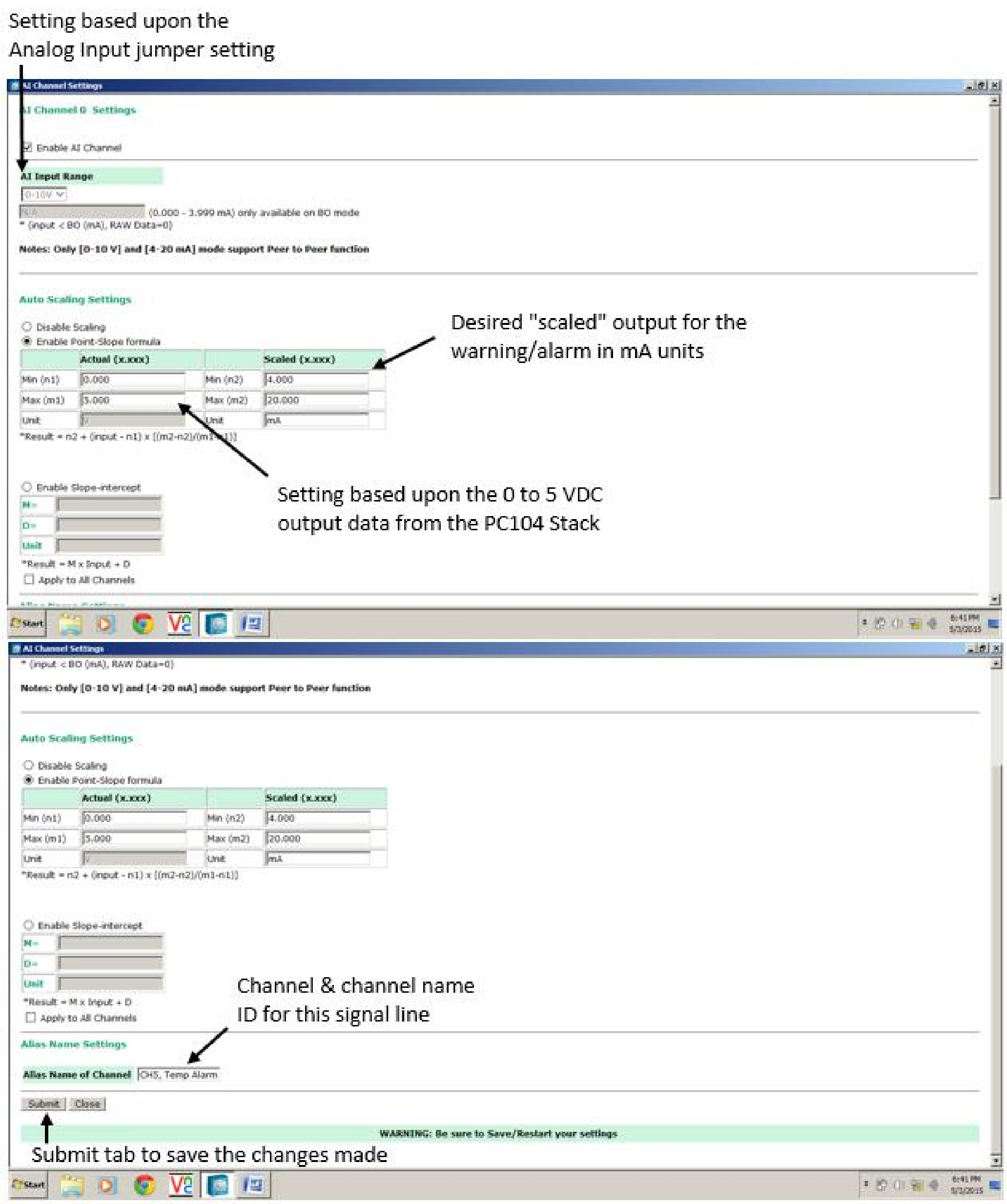
b. Set the corresponding Output range & unit type.

c. Select Enable Point-Slope formula.

d. Edit the channel name.

e. Click Submit to save the changes. See Fig. 62 to locate the items described above. This figure is just for the "warning" signal set on Channel 5.

Fig. 62 Analog Input Editing Screen



STEP 8 For gas concentration only, validate the scaling by matching the AI Channel Settings data to the data on the Numerical display screen:

a. Click Refresh page.

b. Look at the Value column for the specific channel being monitored.

c. If the numbers do not match, repeat step 7 by changing the Scaling parameters and repeat until the two numbers match.

Modbus Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- Philip screwdriver
- Blade screwdriver
- Grounding wrist strap

Danger! ⚠	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To replace the Modbus:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to the any bare metal surface on the Gas Analyzer chassis.

STEP 3 Disconnect and remove the faulty Modbus:

a. Insert a blade screw driver in the gap between the case and the AI Channel contact strip

b. Pry upward to disconnect the contract strip from the Modbus. See Fig. 63 to locate the AI Channel contact strip.

Fig. 63 Modbus Power & AI Connection Points

c. Insert the blade screw driver at the bottom of the Modbus clamping slot and pull outward to unlatch the Modbus from the DIN rail.

d. Disconnect the power contact jack from the Modbus.

STEP 4 Install the new Modbus:

a. Insert the power contact jack in the new Modbus.

b. With the Modbus bottom mounting clamp in the out position, mount the Modbus on the DIN rail.

c. Clamp it into place by sliding the clamp inward on the DIN rail.

STEP 5 Bypass the internal pressure interlock switch by using the bypass key. There should be power to the *LGR-ICOS* Gas Analyzer computer.

STEP 6 Setup the ioLogik Modbus analog input (AI) parameters for Warnings and Alarms on Channels 5 and 6 and, if all input channels are used, gas concentration on channels 1 through 4 using the customer LAN and not the Gas Analyzer.

STEP 7 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 8 Close the front panel and secure it into place with all the locking clamps.

If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through to the Gas Analyzer.

STEP 9 Remove the pressure interlock switch bypass key from the switch.

STEP 10 Finish the procedure:

a. Verify that the CDA/N_2 inlet pressure gauge registers at least 4 psi.

b. With a blade screwdriver, rotate the purge gas valve on the CDA/N_2 purge inlet to the “On” position.

c. After a minimum of 12 minutes, the Gas Analyzer restarts, once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

d. Once power is restored to the Gas Analyzer, turn the purge gas valve to the “Off” position (90° to the right of the “On” position) for instruments using N_2 as its purging gas. For instruments using CDA as its purging gas, leave the purge gas valve in the “On” position.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

e. Initialize the Gas Analyzer when prompted.

f. Once the Gas Analyzer has completed its initialization, verify that temperature and pressure are moving toward their original settings and stabilize there.

g. Close the customer's filtered air line going into the Gas Analyzer inlet gas line.

h. Open the customer’s sample gas line feeding into the Gas Analyzer inlet gas line.

Local: USB Data Access

The ICOS Gas Analyzer only supports USB up to version 2.0. To transfer files using a USB memory stick, the USB device, within a dongle (see Fig. 64), needs to be connected in the cable gland on the outside of the Gas Analyzer. The reason for using this type of interface is to eliminate the risks of generating sparks when inserting a USB device into the Gas Analyzer USB port, as this could cause an explosion if gas concentrations within the instrument are high enough.

Fig. 64 USB Cable Gland Dongle

The USB memory stick needs to be in a Fat32 format before any file is transferred to it:

STEP 1 From the Windows Start menu, select Computer.

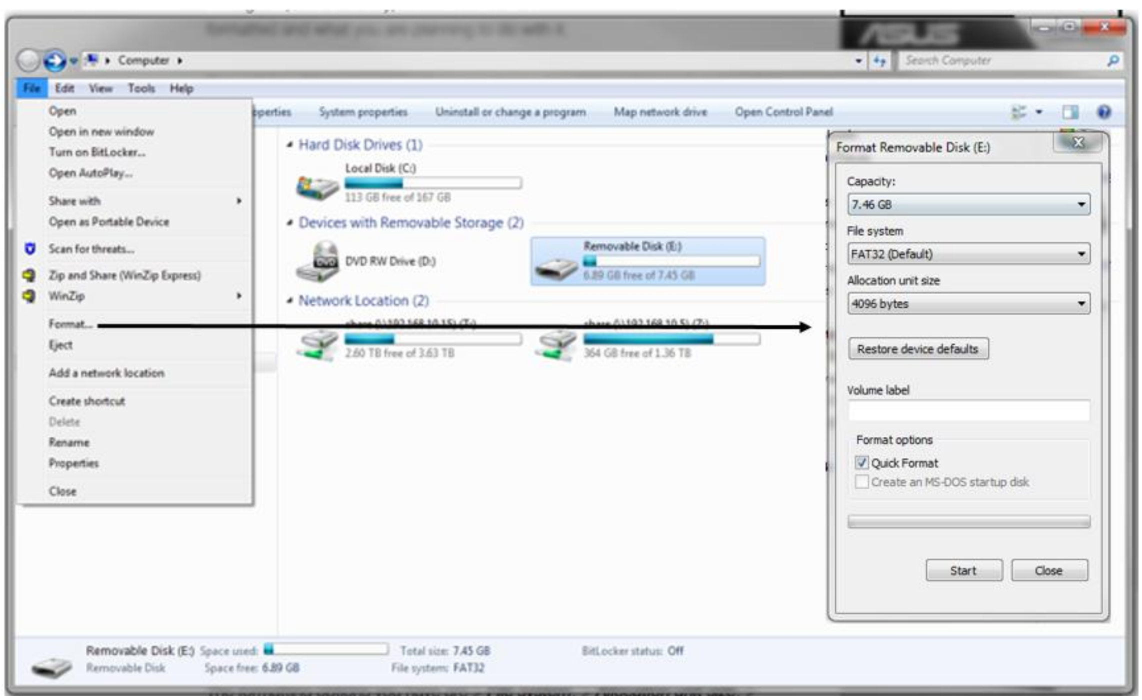
STEP 2 Select the memory stick to format in the Computer screen.

STEP 3 In the File menu, select Format…

STEP 4 In for Format screen, select FAT32 in the File system drop-down menu; leave all other parameters to their default settings (see Fig. 65).

STEP 5 Click Start.

Fig. 65 Formatting USB Memory Stick



Troubleshooting USB Connections

Once the USB memory stick is properly formatted to receive data files from the Gas Analyzer hard drive:

STEP 1 Insert it into the cable gland marked for USB.

STEP 2 From the initialization screen, select Service → Files → Mount USB.

If the USB memory stick is recognized, everything is working properly. If it is not recognized, perform a soft shutdown and power down the Gas Analyzer.

STEP 3 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 4 Power down the Gas Analyzer:

a. Access the GUA junction box that supplies AC power to the Gas Analyzer.

b. Switch off the AC power feeding the Gas Analyzer.

c. Perform the "lockout/tag out" procedure on that GUA junction box.

Danger!	Do not plug any cable or device directly into the communication interface panel or into any port within the Gas Analyzer after the instrument has been installed and the gas lines connected. Any spark resulting from a direct connection could possibly ignite any residual gas present in the Gas Analyzer and its surrounding area. This could lead to serious injury or death. *Cut AC power* to the Gas Analyzer before inserting any device into any port on the instrument.

STEP 5 Open the Gas Analyzer:

a. Loosen the clamps around the Gas Analyzer front panel and open the panel.

b. Visually check if USB cable 1 or 2 is damaged.

c. If everything appears good, swap USB cable 1 and USB cable 2 at CN8 and CN9 on the PC104 stack. See Fig. 48 to locate both USB ports on the PC104 stack.

STEP 6 Close the front panel and secure it into place with all the locking clamps.

If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through to the Gas Analyzer.

STEP 7 Finish the procedure:

a. Verify that the CDA/N_2 inlet pressure gauge registers at least 4 psi.

b. With a blade screwdriver, rotate the purge gas valve on the CDA/N_2 purge inlet to the "On" position.

c. Access the GUA junction box and remove the "lockout/ tag out" lock.

d. Switch on the AC power to the Gas Analyzer. After a minimum of 12 minutes, the Gas Analyzer restarts, once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

e. Once power is restored to the Gas Analyzer, turn the purge gas valve to the "Off" position (90° to the right of the "On" position) on instruments using N_2 as its purging gas. For the instruments using CDA as its purging gas, leave the purge gas valve in the "On" position.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

STEP 8 After the Gas Analyzer completed its boot up, repeat Step 2 to determine if the problem is resolved. If the answer is no, replace the PC104 stack.

4–20mA Analog Output Signal Isolators

There are up to three signal isolators used to convert the 0–5V DC voltage signal level of the processed analog data from the S310 DSP PCA to a 4–20 mA signal. Each signal isolator (see Fig. 66) can only provide two independent data channels, thus two different gas concentration data in the form of 4–20mA. The signal isolator's main function is to clean out the noise from the input signal and provide a clean output signal using optical transistors, also often referred to as optical isolators (opto-isolators).

Gas analyzers that measure one or two gas types use one signal isolator. Gas analyzers that measure three or four gas types use two signal isolators. There is always one signal isolator for Gas Analyzer "warnings" and "alarms" to assist in identifying instrument issues. Fig. 67 shows how signal isolators are wired to the PC104 stack through the S310 DSP PCA and the latter's 4–20 mA output on the communication interface panel.

To determine if there is an issue with the signal isolator, use a DVM to probe the input analog signal going to the Modbus. If there is a DC voltage displayed on the DVM, then the problem is with the signal isolator for that particular signal. Signal isolators are aligned from left to right. The left-most represents Channel 1 (Ch1) and Channel 2 (Ch2) of the 4–20 mA connection interface panel. The next signal isolator to the right provides the output of Channel 3 (Ch3) and Channel 4 (Ch4). The signal isolator on the very right will always be set for instrument alarms. Gas concentration data sent out to both the signal isolator and the Modbus are from the same output port on the PC104 stack. The signal isolator converts this voltage signal to a current signal, whereas the Modbus keeps the signal in volts. Analog gas concentration signals received by the Modbus for Channel 1 through 4 are defined in Table 16.

Table 16 Modbus Input Gas Concentration Analog Signals

Gas Concentration Channel	Modbus Input Port
Channel 5 Signal	AI0+
Channel 5 Return	AI0–
Channel 6 Signal	AI1+
Channel 6 Return	AI1–
Channel 1 Signal	AI2+
Channel 1 Return	AI2–
Channel 2 Signal	AI3+
Channel 2 Return	AI3–
Channel 3 Signal	AI4+
Channel 3 Return	AI4–
Channel 4 Signal	AI5+
Channel 4 Return	AI5–

Fig. 66 2-Channel Signal Isolator

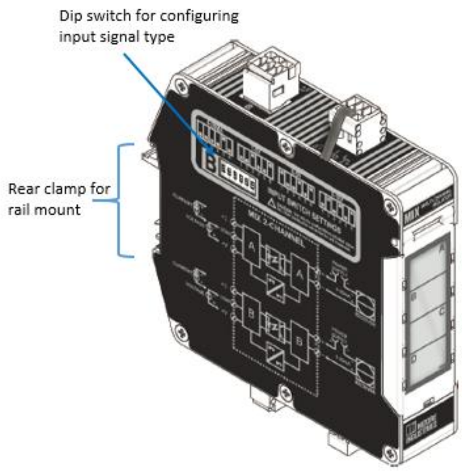
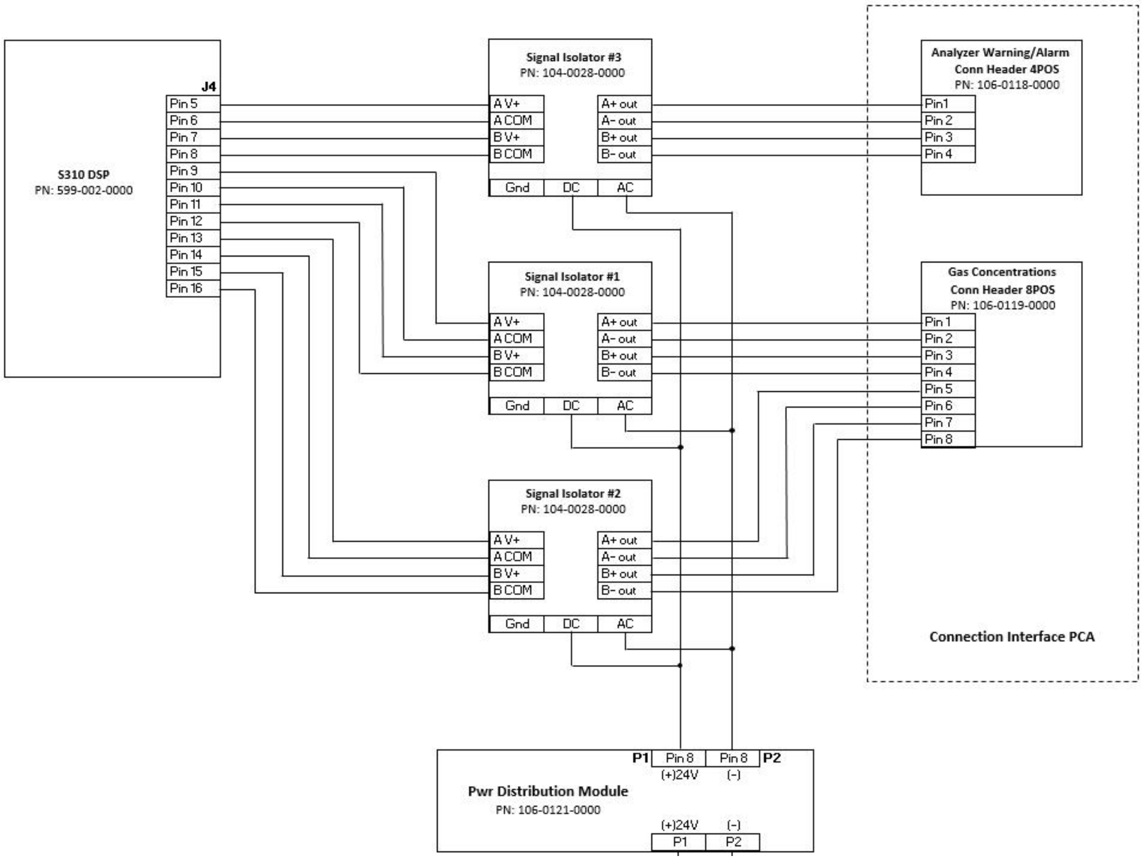


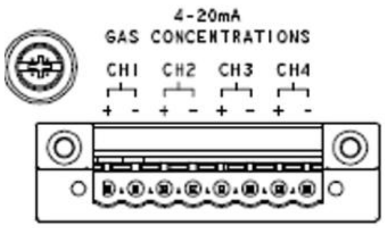
Fig. 67 Signal Isolators Input/Output Connections



Gas Concentration 4–20 mA Analog Outputs

Values for 4–20 mA gas concentrations are provided/ported out through the 5.08 mm terminal block. Depending on the Gas Analyzer model purchased, up to four individual gases can be analyzed, and output results translated into 4–20 mA values. The four individual gases are output through CH1, CH2, CH3, and CH4 on the connection interface panel shown in Fig. 68. Fig. 68 displays the connection points used to sample gas concentrations. The information output is in real time.

Fig. 68 Gas Concentration Phoenix Connection Points



Warning/Alarm 4–20mA Signal Outputs

Instrument warning/alarm data is provided/ported out through the terminal block in a 4–20 mA signal format. There are two independent instrument fault channels, CH5 and CH6, provided on the connection interface panel as shown in Fig. 69.

Fig. 69 Gas Analyzer Warning/Alarm Phoenix Connection Points

Table 17 and

Table 18 provide the current outputs in milliamps (mA) and their corresponding warning/alarm description within the ICOS Gas Analyzer.

Table 17 Channel 5 Analyzer Warnings/Alarms

Warning / Alarm	Current (mA)	UI Display 4–20 mA Alarm Status	Detected Problem
Alarm	4 ± 0.1	Cavity temperature	Cavity temperature is too high or too low
Alarm	5 ± 0.1	Expansion temperature	Expansion chamber temperature is too high or too low
Alarm	6 ± 0.1	Bulkhead temperature (Only with Bulkhead option)	Bulkhead temperature is too high or too low
Alarm	7 ± 0.1	Filter temperature	Filter temperature is too high or too low
Alarm	8 ± 0.1	Orifice temperature	Orifice temperature is too high or too low
Alarm	9 ± 0.1	Inlet tubing temperature	Inlet tubing temperature is too high or too low
Alarm	10 ± 0.1	Analyzer temperature	Ambient temperature is outside of alarm set point range

Warning / Alarm	Current (mA)	UI Display 4–20 mA Alarm Status	Detected Problem
Warning	12 ± 0.1	Cavity temperature	Cavity temperature is above or below normal
Warning	13 ± 0.1	Expansion temperature	Expansion chamber temperature is above or below normal
Warning	14 ± 0.1	Bulkhead temperature (Only with Bulkhead option)	Bulkhead temperature is above or below normal
Warning	15 ± 0.1	Filter temperature	Filter temperature is above or below normal
Warning	16 ± 0.1	Orifice temperature	Orifice temperature is above or below normal
Warning	17 ± 0.1	NaN reading	NaN (Not a Number). Faulty random number/character result being displayed
Warning	18 ± 0.1	Tubing temperature	Tubing temperature is above or below normal
No issue	20 ± 0.1		No warning/alarm

Table 18 Channel 6 Analyzer Warnings/Alarms

Warning / Alarm	Current (mA)	UI Display 4-20 mA Alarm Status	CH6 Detected Problem
Alarm	4 ± 0.1	Data health (A) ± (B)	Laser A and/or B goodness of fit is poor
Alarm	5 ± 0.1	Pressure	Pressure is not in operating range
Alarm	6 ± 0.1	HD space	HD space is low. Delete oldest files
Alarm	7 ± 0.1	Mirror health (A) ± (B)	Mirror health has degraded. Clean mirrors
Alarm	8 ± 0.1	Linelock (A) ± (B)	Laser A and/or B peak position is outside of control range. Contact customer support
Alarm	9 ± 0.1	Signal power (A) ± (B)	Laser A and/or B power has degraded. Contact customer support
Alarm	10 ± 0.1	Maintenance	Maintenance is needed on system now
Warning	12 ± 0.1	Data health (A) ± (B)	Laser A and/or B goodness of fit is not optimal
Warning	13 ± 0.1	Pressure	Pressure is noisy
Warning	14 ± 0.1	HD space	HD space is low
Warning	15 ± 0.1	Mirror health (A) ± (B)	Mirror health is degrading. Clean mirrors soon
Warning	16 ± 0.1	Linelock (A) ± (B)	Laser A and/or B peak position is moving very fast
Warning	17 ± 0.1	Signal power (A) ± (B)	Laser A and/or B power is degrading. Contact customer support soon
Warning	18 ± 0.1	Maintenance	Maintenance is needed on system soon
No issue	20 ± 0.1		No warning/alarm

Signal Isolator Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- Philips screwdriver
- Grounding wrist strap
- Thin blade screwdriver
- Digital volt meter (DVM)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace a signal isolator:

STEP 1 Perform a soft shutdown

a. From the Control Bar on the touchscreen, click Exit follow by Ok upon prompt in the Shutdown window.

b. Shut off the customer gas sample line connected to the Gas Analyzer inlet gas line.

c. Open the customer filtered air line check valve to allow filtered air to go through the Gas Analyzer inlet gas line.

STEP 2 Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

STEP 3 Open the Gas Analyzer front panel and secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

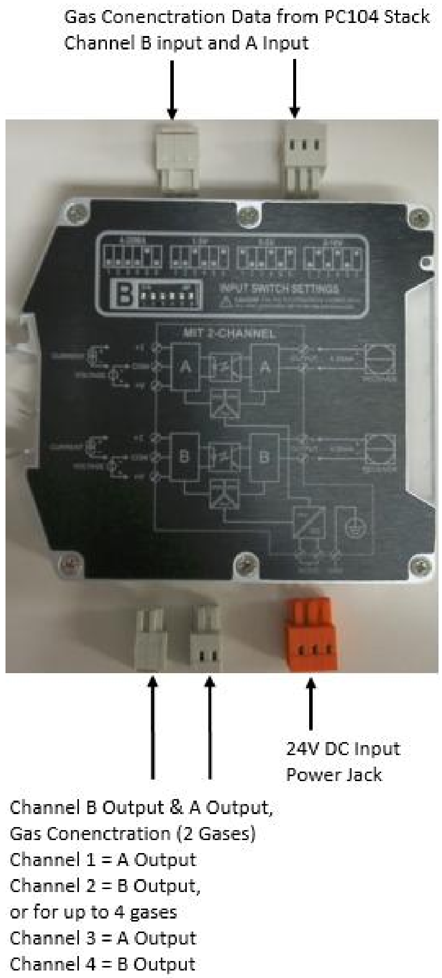
There should be no power to the Gas Analyzer electronics since the internal pressure interlock switch bypass key is not inserted in the bypass switch.

STEP 4 Remove the signal isolator

a. Gently tilt the top of the signal isolator toward the Communication Interface panel to unlatch its spring clamps from the DIN rail.

b. Disconnect the communication line jacks from the faulty signal isolator (not individual wires connected to the jacks). See Fig. 70 to locate the input/output line jacks.

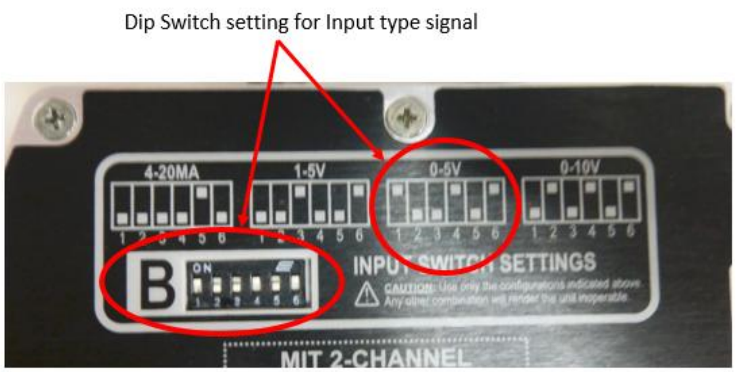
Fig. 70 Signal Isolator Input and Output Data Connection Points



STEP 5 Install the new signal isolator:

a. Make sure that the replacement signal isolator is configured for reading input voltages between 0V DC and 5V DC for both channel A and B. See Fig. 71 for the proper dip switch settings for a 0–5V DC analog input from the PC104 stack.

Fig. 71 Signal Isolator Input Signal Type Setting



b. Transfer the communication line jacks to the new signal isolator. Jacks play a key role in preventing incorrect connections.

c. Gently latch the back of the signal isolator to the DIN rail and press down the front of the unit to clamp it to the DIN rail.

STEP 6 Close the Gas Analyzer and finish the procedure:

a. Close the front panel and secure it into place with all locking clamps. If there is an air leak at the front panel while the instrument is pressurizing, the internal pressure interlock switch will not trip to allow power to pass through to the Gas Analyzer.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 4 psi.

c. With a blade screwdriver, rotate the purge gas valve on the CDA/N_2 purge inlet to the “On” position.

d. After a minimum of 12 minutes, the Gas Analyzer restarts, once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

e. Once power is restored to the Gas Analyzer, turn the purge gas valve to the “Off” position (90° to the right of the “On” position) on instruments using N_2 as its purging gas. On instruments using CDA as its purging gas, leave the purge gas valve in the “On” position.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

f. Initialize the Gas Analyzer when prompted.

g. Once the Gas Analyzer has completed its initialization, make sure that temperature and pressure values are moving toward their original settings and remain stable.

h. Close the customer's filtered air line going into the Gas Analyzer inlet gas line.

i. Open the customer’s sample gas line feeding into the Gas Analyzer inlet gas line.

STEP 7 To determine if the output data is correct, look at the customer center where the 4–20 mA values are collected.

Temperature Controller

The number of temperature controllers depends on the instrument model. Currently there are four temperature controllers and the heaters that they control are located at the orifice, the gas expander, the ICOS filter, and the ICOS cell.

Temperature controllers are used to ensure stable measurements by controlling targeted regions of the ICOS Gas Analyzer and best maintaining a constant gas temperature from the gas entry to its exhaust. The temperature controller (see Fig. 72) requires an input from a thermocouple to determine if heaters need be turned on or off to achieve and maintain the programmed temperature. If the thermocouple connected to the temperature controller fails, an error message is displayed in red (see Fig. 73) on the temperature controller readout.

When the temperature controller is operating correctly, number "2" above the green display will perform as such:

- It will stay lit while the temperature controller feeds >+5V DC to the solid state relay, thus enabling the 24V DC voltage to be fed to the heaters it controls.
- It will blink when the thermocouple registers a temperature reading (red number to the left of the temperature controller) indicating that the unit it is monitoring has reached the target temperature (green number on the right). At this time, the temperature controller will turn the solid state relay on or off to maintain the target temperature.
- If the target temperature is exceeded, the temperature controller will turn off the relay. At this point, the number "2" (see Fig. 72) will be off.

NOTE: Even though the temperature reading may exceed the target temperature, it will take some time for the temperature to drop back down. This is normal.

Fig. 72 Temperature Controller

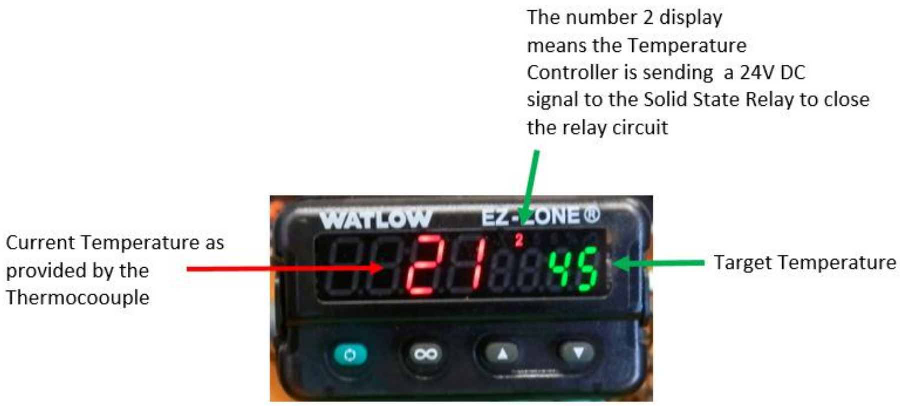


Fig. 73 Temperature Controller Error: Missing Thermocouple Signal

Other possible failure modes are:

- Incorrect reading of the thermocouple, where the temperature reading does not move.
- Heater temperature is not in a controlled state.
- Output status provided to the PC104 stack is incorrect.

Temperature controllers can be swapped between units to assist in troubleshooting the origin of the problem encountered with the controller or with the PC104 stack that converts the signal. If the problem follows the swapped temperature controller during the swap, the problem lies with the temperature controller. To determine if the issue lies with the PC104 stack, use a DVM set to measure DC voltage, and measure the translated temperature at the temperature controller between *G1(+)* and *F1(–)*.

The temperature controller is programed to have 0 volts equal to –25°C and 5 volts equal to 175°C. Use Table 19 to match specific voltages, read at G1 and F1, to their respective temperature. If the measured voltage and corresponding temperature do not match that displayed on the temperature controller, the problem could be that the temperature controller lost its programmed settings for the voltage-to-temperature conversion, or that the internal electronics are defective and need to be replaced.

Table 19 Temperature Controller Voltage-to-Temperature Conversion

Voltage	Temperature	Voltage	Temperature	Voltage	Temperature
1	15°C	2.4	71°C	3.8	127°C
1.1	19°C	2.5	75°C	3.9	131°C
1.2	23°C	2.6	79°C	4.0	135°C
1.3	27°C	2.7	83°C	4.1	139°C
1.4	31°C	2.8	87°C	4.2	143°C
1.5	35°C	2.9	91°C	4.3	147°C
1.6	39°C	3	95°C	4.4	151°C
1.7	43°C	3.1	99°C	4.5	155°C
1.8	47°C	3.2	103°C	4.6	159°C
1.9	51°C	3.3	107°C	4.7	163°C
2	55°C	3.4	111°C	4.8	167°C
2.1	59°C	3.5	115°C	4.9	171°C
2.2	63°C	3.6	119°C	5.0	175°C
2.3	67°C	3.7	123°C		

NOTE: The output temperature reading on the instrument touchscreen represents only the ICOS cell temperature.

Temperature Controller Testing & Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- Thin blade screwdriver
- Two flat pieces of metal shims ~ 1″ × 5″ × 1/16″
- Grounding wrist strap
- Philips screwdriver

Danger!	Probing electronics on an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To test and replace a temperature controller:

STEP 1 Power down the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer’s gas line valve going into the Gas Analyzer inlet gas line.

d. Open the customer’s filtered air line check valve to allow filtered air to go through the Gas Analyzer inlet gas line.

e. Disable the internal pressure interlock switch with the bypass key.

STEP 2 Identify the faulty temperature controller and test it:

a. Open the Gas Analyzer front panel. The Gas Analyzer is still in operation.

b. Connect the grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

c. Look at the target temperature setting (the green number on the right). Is the red number on the left (the current temperature) moving toward this target value? If the red number is lower, the number “2” on the controller display should be lit solid, indicating that a 24V DC is sent to the corresponding solid state relay.

d. Measure the output at G1 and F1 to determine if the DC out voltage corresponds to the temperature stated by the PC104 stack.

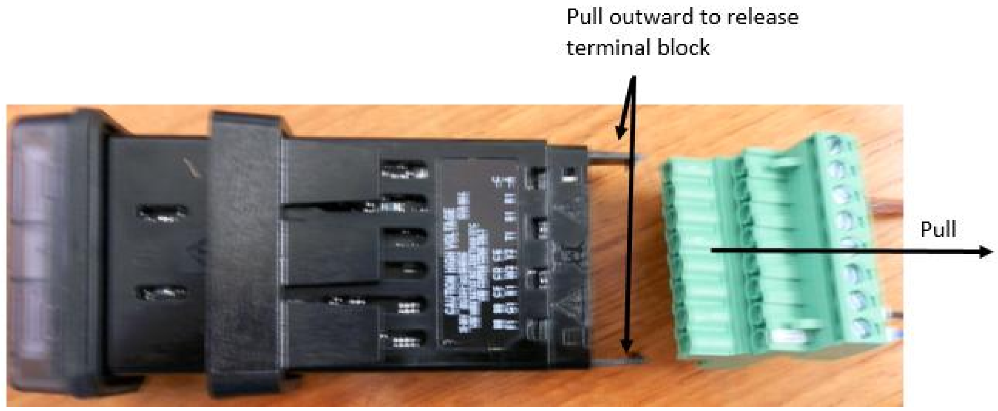
STEP 3 Put the Gas Analyzer On/Off switch (inside the enclosure, in the upper right corner) at the “Off” position.

STEP 4 Remove the faulty temperature controller:

a. Remove the four thumb screws securing the temperature controller mount to its standoff.

b. Disconnect the two terminal block connectors, containing the power, thermocouple, and I/O, from the bottom of the temperature controller that needs to be replaced. See Fig. 74 for the disassembly.

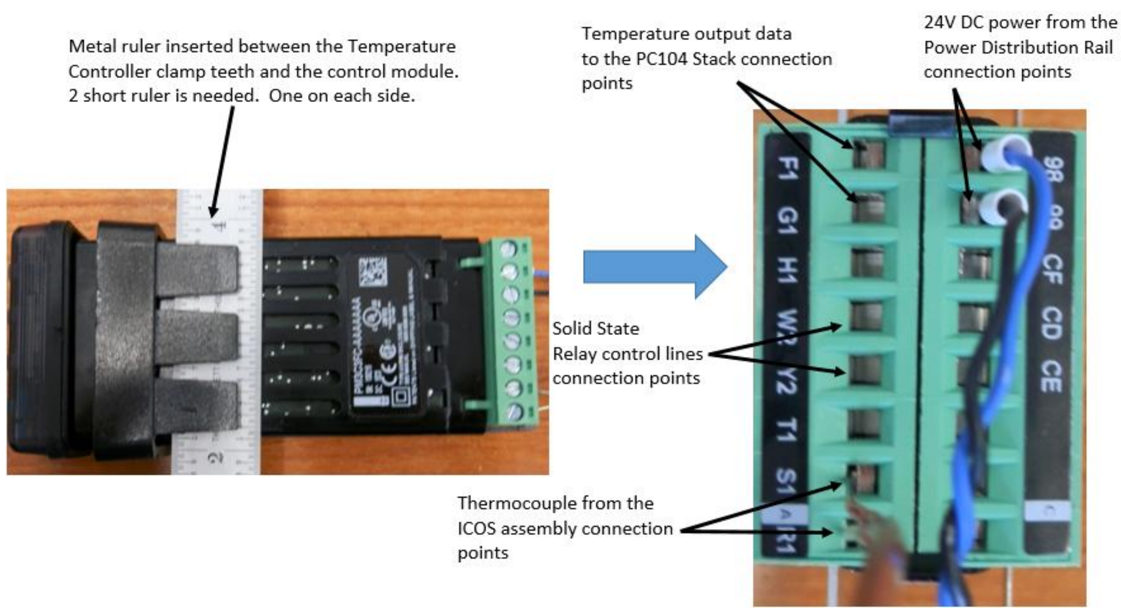
Fig. 74 Temperature Controller Disassembly



c. On each side of the temperature controller, insert a thin flat piece of metal between the temperature controller and its clamping clip.

d. Slide out the faulty temperature controller. See Fig. 75 for releasing the clamping clips.

Fig. 75 Temperature Controller Removal From Locking Clamp



STEP 5 Install the new temperature controller:

a. Insert the new temperature controller into the mount.

b. Slide the clamping clip to hold it in place within the mount.

c. Insert the communication and signal connectors back into the temperature controller. The connectors are keyed in such a way that it is impossible to insert them incorrectly.

d. Install the temperature controller mount back on its standoff.

e. Lock it in place with four thumbscrews.

STEP 6 Put the Gas Analyzer On/Off switch (inside the enclosure, in the upper right corner) to the “On” position.

STEP 7 Make sure that the temperature controller is sending the drive signal that enables the heater solid state relay and the correct temperature reading to the PC104 stack.

STEP 8 Disconnect your grounding wrist strap from the instrument chassis.

STEP 9 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the following window that appears, confirm the shutdown by clicking OK.

c. Remove the bypass key from the purge controller internal pressure interlock switch.

STEP 10 Close the Gas Analyzer and verify results.

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 11 Verify results:

a. Verify that temperature and pressure are moving toward their original settings and are stable.

b. Close the filtered air check valve line feeding the Gas Analyzer.

c. Open the customer’s sample gas line to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

Programming the Temperature Controller

Should the temperature controller lose its settings, symptoms like thermocouple current reading by the temperature controller not matching that of the voltage level being sent to the PC104 stack can occur. Another issue that can occur is that channel 2 (the number 2 at the top center of the temperature controller) is not lit to close the solid state relay and enable power to the heater. If this is a settings issue, reprogramming of the temperature controller is recommended.

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- Philips screwdriver
- Digital volt meter (DVM)
- Blade screwdriver

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To program the temperature controller:

STEP 1 Open the Gas Analyzer:

a. Close the customer gas line valve going into the Gas Analyzer inlet gas line.

b. Open the customer's filtered air line check valve to allow filtered air to go to the Gas Analyzer inlet gas line.

c. Bypass the internal pressure interlock switch with the bypass key.

d. With the Philips screwdriver, loosen the front panel clamps.

e. Open the front panel.

STEP 2 Select the K-Type thermocouple used:

a. Hold both the ^ and v arrow keys until "Ai set" appears.

b. Press the green key. "tC Sen" should appear. If "tC Sen" does not appear, press the ^ or v arrow key until it does.

c. Press the green key. An "H" should appear, representing the *K-type thermocouple* used on the instrument. If the letter "H" does not appear, press the ^ or v arrow key until it does.

d. Press the green key.

e. Press the Infinity key ∞ once to get back to "Ai set".

STEP 3 Select the temperature unit:

a. Use the ^ arrow key to display "gLBL Set".

b. Press the green key once to display "F C_F".

c. To display "C C-F" (Celsius instead of Fahrenheit), use the ^ arrow key to change F to C.

d. Press the Infinity key ∞ to go back to "gLBL Set".

STEP 4 Enter the voltage and range setting mode:

a. Press the v arrow key until "otPt Set" appears.

b. Press the green key to display "1otPt".

c. Press the green key to display "voLt o.ty".

d. Press the green key to display “hEAt Fn”.

e. Press the **^** arrow key until “rMt Fn” appears.

NOTE: You may not see this line and/or the next one depending upon what was previously programed by the manufacturer.

f. Press the green key to display “Ai r.Sr”.

g. Press the green key to display “1 Fi”.

STEP 5 Program the controller low and high voltage settings:

a. Press the green key to display “0.00 S.Lo” (low voltage setting for the controller). If not at 0.00, use the **^** or **v** arrow keys to make it display “0.00 S.lo”.

This is the scale low setting. It represents *–25°C* and defines the low range sent to the S310 board for reading current thermocouple data from the various devices monitored on the instrument.

b. Press the green key to display “0.00 S.Hi” (high voltage setting for the controller). If not at 5.00, use the **^** or **v** arrow keys to make it display “5.00 S.hi”. This is the upper voltage limit sent to the S310 board.

STEP 6 Program the controller low and high range settings:

a. Press the green key to display “# r.Lo”. “#” is currently the temperature controller low range setting.

b. Use the **^** or **v** arrow keys to get the “#” value to read “–25 r.Lo”. This is the lower temperature limit that the instrument heaters should be able to reach.

c. Press the green key to display the “# r.Hi”. “#” is currently the temperature controller high range setting.

d. Use the **^** or **v** arrow keys to get the “#” value to read “175 r.Hi”. This will be the upper temperature limit that the instrument heaters should be able to reach.

STEP 7 Exit the voltage and range setting mode:

a. Press the infinity key ∞ once to get back to “1 otPt”.

b. Press the **^** arrow once to get to “2 otPt”.

c. Press the green key. “ALM Fn” appears. If this is not the case, press the **^** or **v** arrow key until it does.

d. Press the green key to display “1 Fi”. If this is not the case, use the **^** or **v** arrow keys until it does.

e. Press the green key. “ALM Fn” appears.

f. Use the **^** or **v** arrow keys to change this to “hEAt Fn”.

STEP 8 Press and hold down the infinity **∞** key for 3 seconds to exit the screen. At this point, the current temperature should be displayed.

STEP 9 Use the **^** or **v** arrow keys to set the temperature (green number on the display) for the device it is controlling.

STEP 10 Check the results. For the temperature controller to be properly programmed, the following must be true:

- The number “2” will be lit solid until the target temperature is reached and provides 24V to the solid state relay switch, keeping the heater powered.
- When the target temperature is reached, the number “2” number will blink, indicating that the the solid state relay turns on and off to maintain the component temperature.
- The current temperature reading (the red number on the display) should correspond to the output voltage on G1 and F1 going to the PC104 stack. See Table 19 for the conversion values.

STEP 11 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Remove the bypass key from the purge controller internal pressure interlock switch.

STEP 12 Close the Gas Analyzer and verify results.

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 13 Verify results:

a. Verify that temperature and pressure are moving toward their original settings and are stable.

b. Close the filtered air check valve line feeding the Gas Analyzer.

c. Open the customer’s sample gas line to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

Fig. 76 provides a partial schematic of the temperature controller connections to the S310 DSP. The information provided by the temperature controller is the temperature reading of the thermocouples used to identity if there is a temperature issue at specific locations in the Gas Analyzer. All four controlled heaters and thermocouples that monitor Gas Analyzer heaters have an identical wiring to their specific temperature controller.

Fig. 76 Partial Temperature Controller to S310 DSP Connections

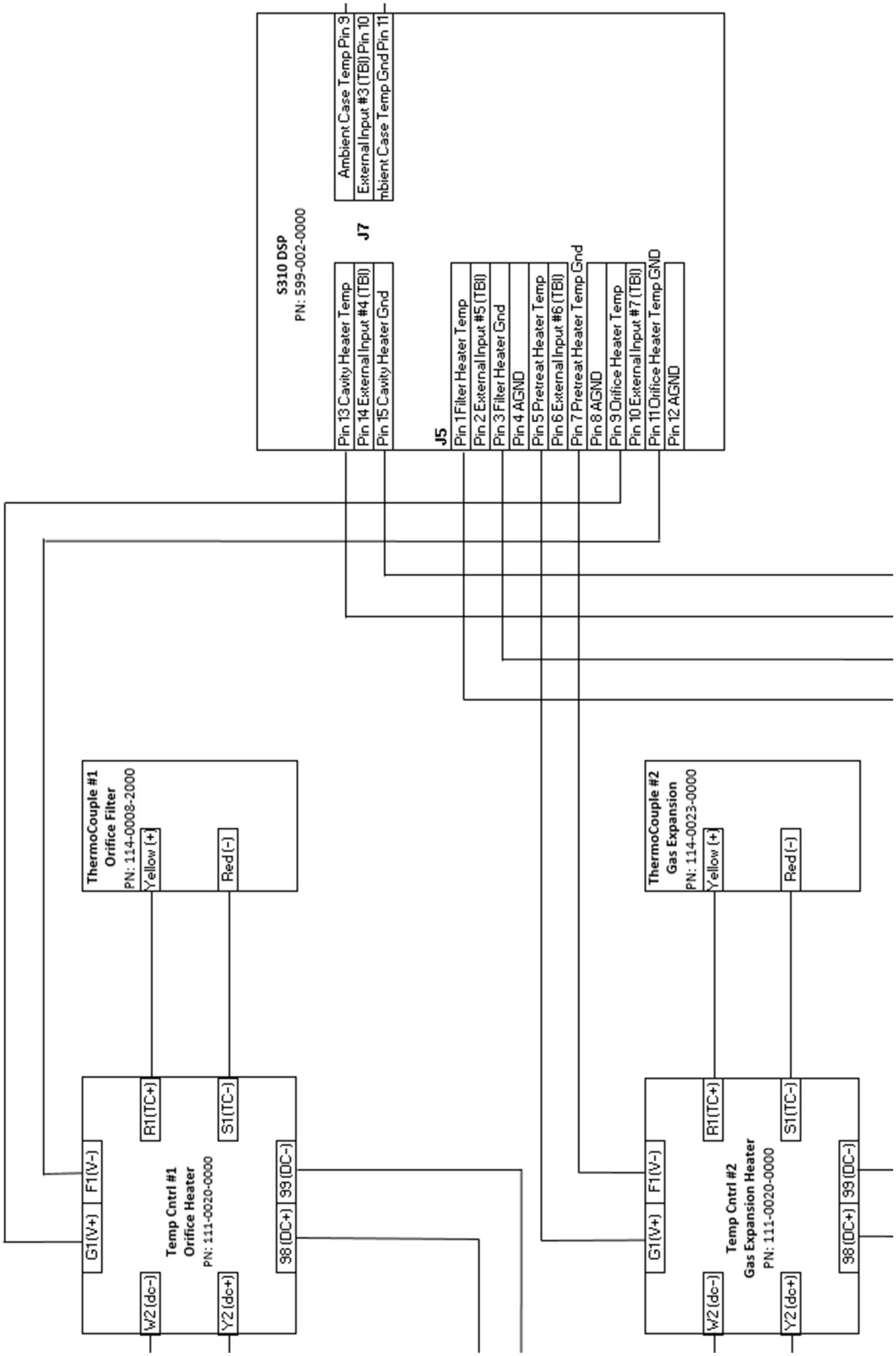
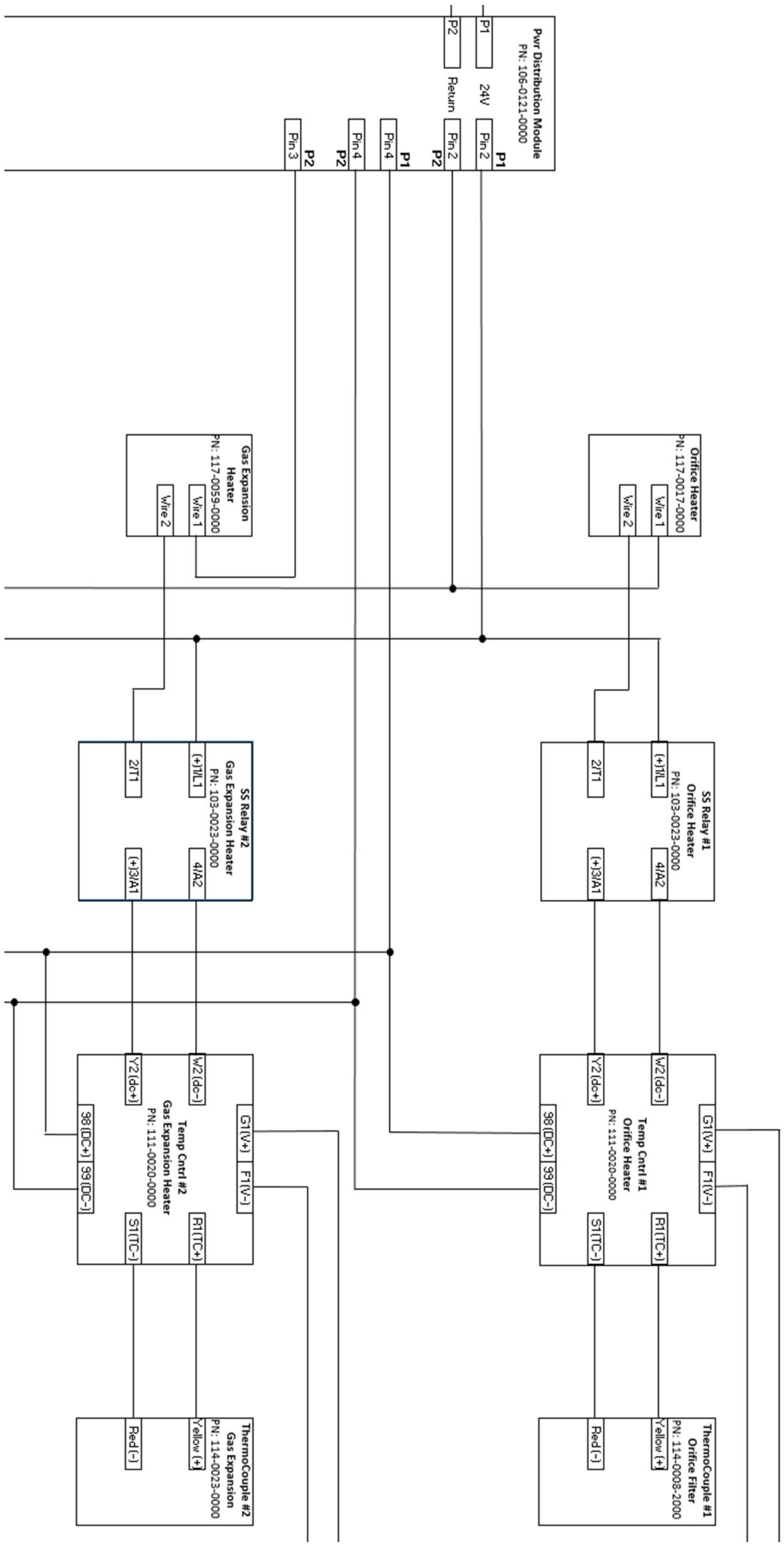


Fig. 77 details how the temperature controller is wired to establish a close loop feedback control between it, the heaters, and the thermocouples.

Fig. 77 Temperature Control Loop



Solid State Relays

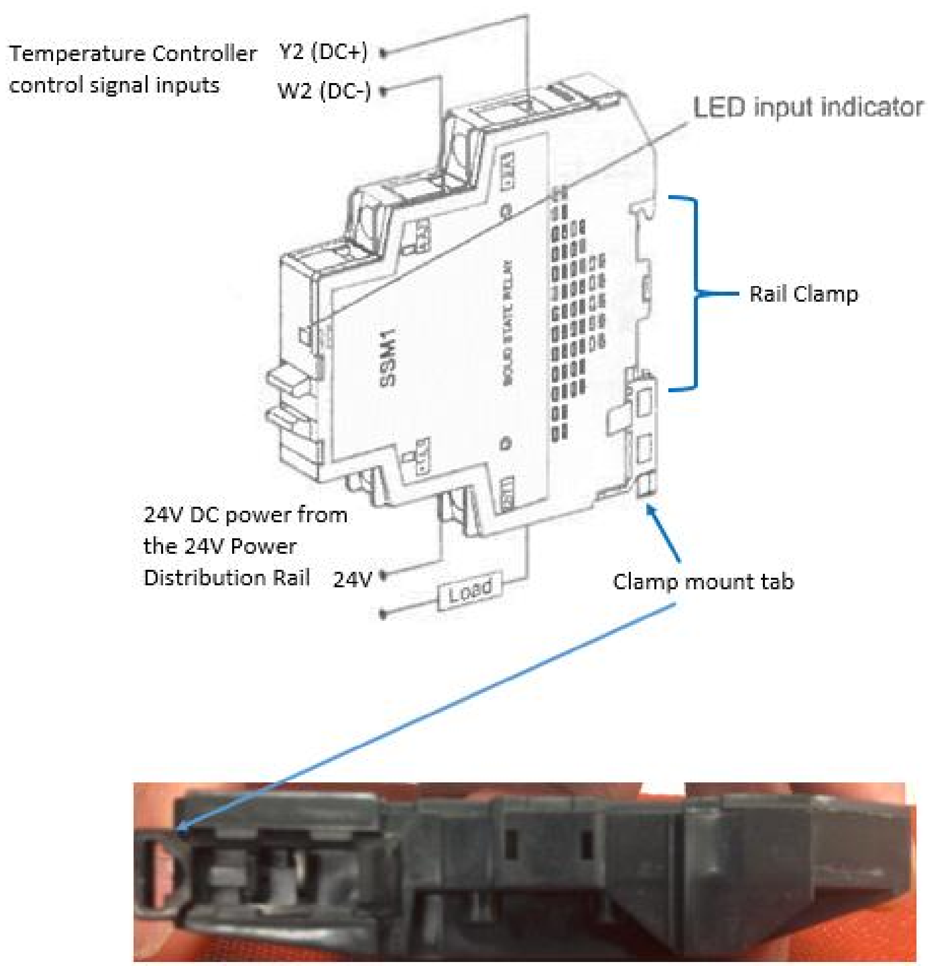
Solid state relays (see Fig. 78) are used to control ICOS assembly heaters and also provide continuous power to the exhaust pump. Solid state relays for the heaters receive their “enable/disable” commands from the temperature controller. The temperature controller would provide the >5V DC to close the relay and allow 24V DC from the 24V power distribution rail to energize the heater and heat the ICOS assembly. Solid state relay inputs are designed with a TTL input requiring >4V DC to close the switch.

The solid state relay that allows 24V DC power to flow through its contacts to the exhaust pump is controlled by the 2-port solenoid driver. The exhaust pump should always be on to draw exhaust gas from the ICOS assembly.

When the solid state relay is enabled (energized), the top green LED will be lit.

Solid state relays can be swapped between units to assist in troubleshooting. They can help confirm whether or not the problem encountered follows the solid state relay.

Fig. 78 Solid State Relay



Solid State Relay Bottom View

Troubleshooting

Solid state relay outputs only have two logic states: open and close (see Table 20).

NOTE: This procedure is a Type 3 electrical safety task.

Table 20 Solid State Relay Input & Corresponding Output Result

Contact Voltage Between 4/A2 & +3/A1	Output State Between +1/L1 & 2/T1
> 5V	Shorted
0V	Open

Required items and tools:

- Philips screwdriver
- Digital volt meter (DVM)
- Thin blade screwdriver
- Grounding wrist strap

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To troubleshoot solid state relays:

STEP 1 Close the customer’s gas line valve going into the Gas Analyzer inlet gas line.

STEP 2 Open the customer’s filtered air line check valve to allow filtered air to go through the Gas Analyzer inlet gas line.

STEP 3 Bypass the internal pressure interlock switch with the bypass key.

STEP 4 With the Philips screwdriver, loosen the front panel clamps.

STEP 5 For ICOS heater issues, look at the temperature controller to determine which solid state relay is not functioning properly, assuming that the thermocouple, temperature controller, and heaters are all functioning properly. For exhaust pump issues, go to the next step.

a. Look for the unit where the heater target temperature is not reached and is not moving, over a short period of time, while the number “2” indicator on the temperature controller is lit solid. See Fig. 79 for relay display numbers identification.

b. Identify the solid state relay that corresponds to the temperature controller that is not increasing heater temperature or is unable to shut down when it reaches several degrees above the target temperature.

c. Set the DVM to read volts in DC and place the DVM test probe on solid state relay input terminals 4/A2 and +3/A1 (see Fig. 79 for location). See Table 21 for the expected output signal for the given input signal.

STEP 6 If the exhaust pump is not running, slide switch 2 on the left of the 2-port solenoid valve driver. This switch overrides computer commands and directly supplies the exhaust pump solid state relay contacts 4/A2 and +3/A1 with >5V DC to close the relay.

Fig. 79 Temperature Controller Sending Drive Signals to the Relays

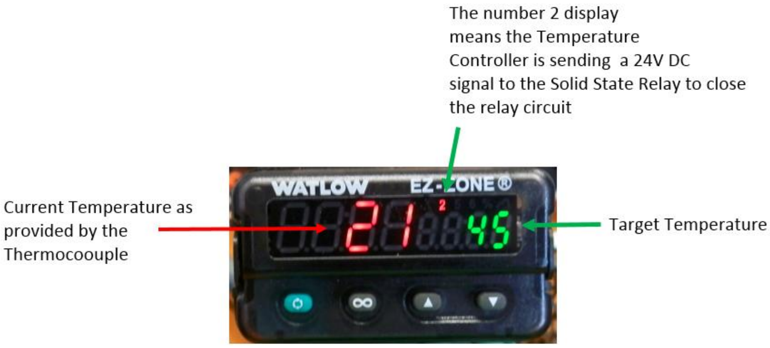


Fig. 80 Solid State Relay Input & Output Terminals

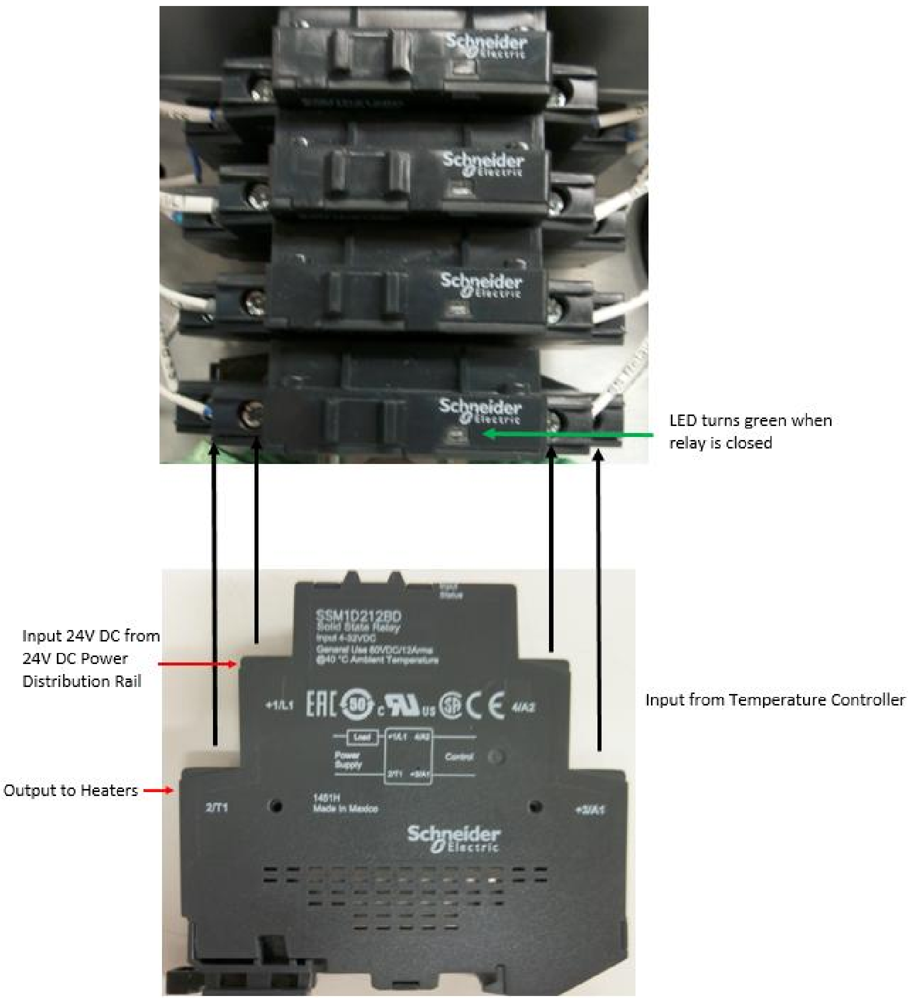


Table 21 Relay Table Inputs & Corresponding Outputs

Input Voltage Between 4/A2 and +3/A1	Output Voltage Between +1/L1 and 2/T1	Heater Status
< 4 volts	24V DC	Off
> 4 volts	~ 0.6V DC	Heating

Replacement

To replace solid state relays:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Set the Gas Analyzer On/Off switch to the “Off” position.

d. Close the customer’s gas line valve going into the Gas Analyzer inlet gas line.

e. Open the customer’s filtered air line check valve to allow filtered air to go through the Gas Analyzer inlet gas line.

f. Bypass the internal pressure interlock switch with the bypass key.

g. With the Philips screwdriver, loosen the front panel clamps.

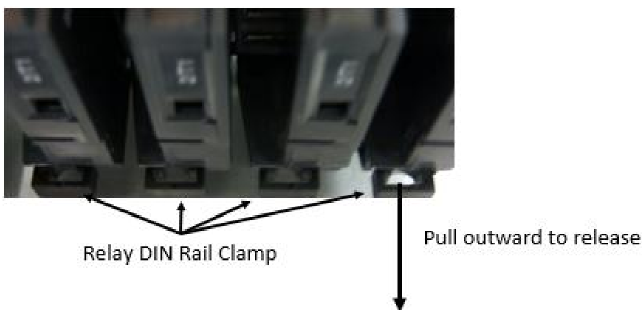
h. Open the front panel.

STEP 2 Remove the faulty solid state relay:

a. Insert the tip of the the blade screwdriver into the solid state relay DIN rail clamp at the bottom of the unit.

b. Pull downward. This will release the relay. See Fig. 81to locate of the DIN rail clamp.

Fig. 81 Solid State Relay DIN Rail Release Clamp



c. Loosen the four relay contact clamp screws and remove the wires.

STEP 3 Install the new solid state relay:

a. Re-install the wires in the new relay. The wires are labeled for each contact.

b. Insert the new relay on the DIN rail and lock it into place by pushing in the slot on the bottom of the relay to clamp it back on the rail.

STEP 4 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 5 With the Gas Analyzer electronics powered up and the temperature controller initialization complete, the red and green temperature numbers appear.

If the exhaust pump relay was replaced, the exhaust pump should start running upon power up.

STEP 6 Verify again that the drive signal to the relay is there, and it is providing the correct output response based upon the input voltage level.

STEP 7 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Remove the bypass key from the purge controller internal pressure interlock switch.

STEP 8 Close the Gas Analyzer and verify results.

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger! 	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 9 Verify results:

a. Verify that temperature and pressure are moving toward their original settings and are stable.

b. Close the filtered air check valve line feeding the Gas Analyzer.

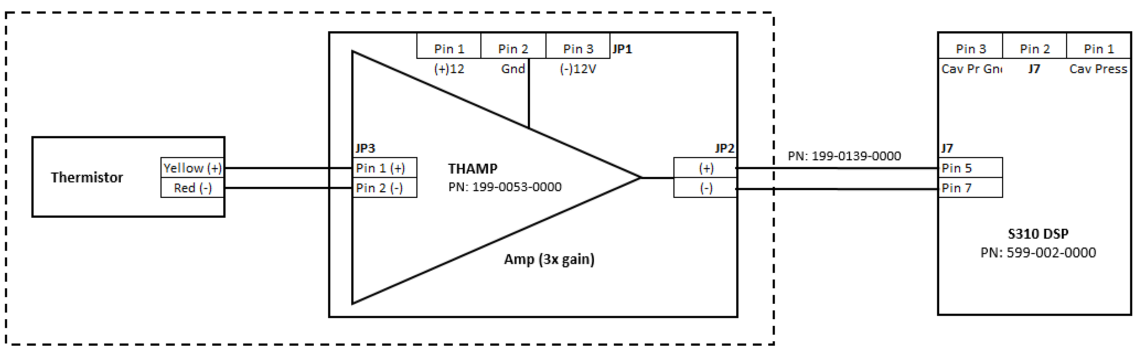
c. Open the customer's sample gas line to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

Thermistor Amplifier (ThAmp)

The ThAmp is a thermistor amplifier assembly mounted inside the ICOS cell to measure gas temperature within the cell. The reading is the same as the one displayed under Gas Temperature in the Control Bar. This temperature is monitored by the PC104 stack through the S310 DSP board. Fig. 82 shows the communication link between the components.

Fig. 82 ThAmp Wiring Diagram



Troubleshooting

Before performing any troubleshooting on thermistors, make sure that the instrument is powered down. Thermistor failure is commonly the result of an open circuit providing no signal back for signal processing. To determine if the thermistor is open, disconnect J7 from the S310 DSP PCA and, with a DVM, check for some resistance values between pin 7 and pin 5.

Replacement

Required items and tools:

- Philips screwdriver
- 9/16″ open end wrench (2)
- Swagelok gap inspection gauge
- Blade screwdriver

NOTE: *This procedure is a Type 1 electrical safety task.*

Danger!	Before any work is performed in the Gas Analyzer, even with the power removed, approval and written consent from the customer is required, and "Red Tags" provided, for off line operation. Failure to acquire such permit may endanger you and people around you when servicing the Gas Analyzer in an environment that requires specific safety protocols to be followed, thus avoiding possible accidents that could result in injury or possibly death.

To replace the ThAmp:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.
b. In the window that appears, confirm the shutdown by clicking OK.
c. Set the Gas Analyzer On/Off switch to the "Off" position.
d. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.
e. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.
f. Shut off the facility AC power at the GUA junction box powering the Gas Analyzer.
g. Perform the "lockout tag out" procedure on the GUA junction box.
h. Close the shutoff valve on the customer side of the exhaust gas line (if present).

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.
b. Open the Gas Analyzer front panel.
c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

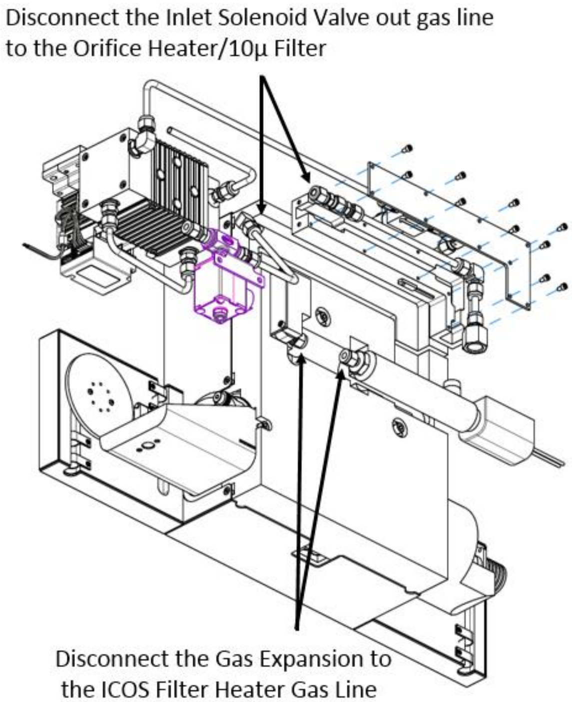
STEP 3 Put the Gas Analyzer On/Off switch (inside the enclosure, in the upper right corner) to the "Off" position.

STEP 4 Open the ICOS assembly:

a. Release the two latches holding the sides of each blue cover.
b. Remove the left and right heat shield covers from the ICOS assembly.
c. Gently slide the cover away from the "tongue" that is inserted into the top cover
d. Lifting out the cover.
e. Remove the six screws (two on the left side, two on the right side, and two on top) that secure the top cover to the base of the blue enclosure.
f. Remove the top insulation foam from the ICOS assembly.
g. Disconnect the gas expansion heater from the ICOS filter heater inlet at the Swagelok location that is accessible when the top foam is removed. See Fig. 83 to locate the disconnect points.

h. Disconnect the inlet solenoid valve from the orifice heater/10µ filter assembly. See Fig. 83 to locate the disconnect point.

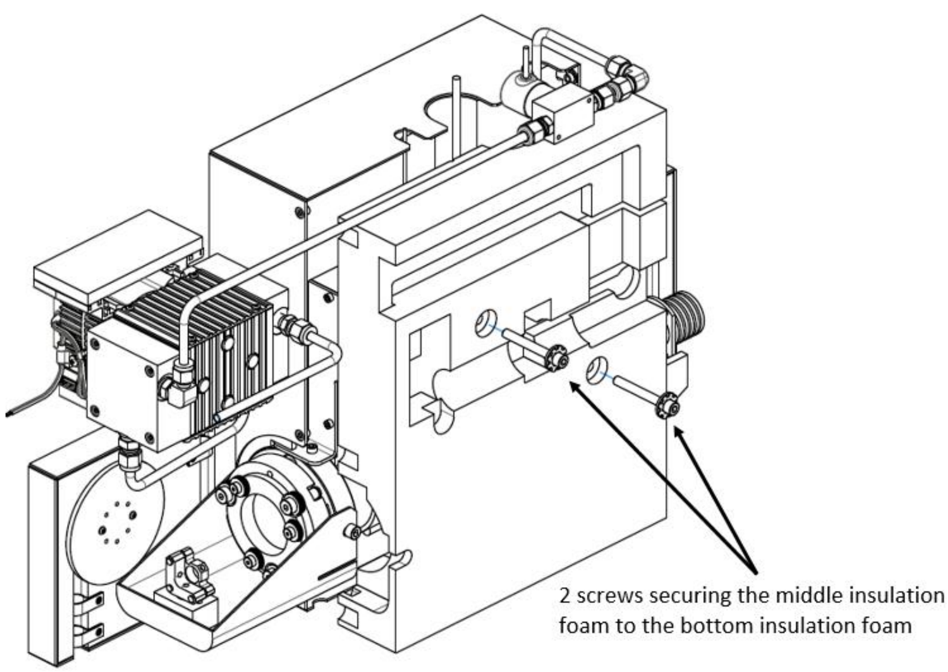
Fig. 83 Orifice Heater/Filter & Gas Expansion Heater Connections



i. Remove both the orifice heater/filter and gas expansion heaters from the ICOS assembly.

j. Remove the two screws that secure the middle insulation foam to the bottom insulation foam. See Fig. 84 for location.

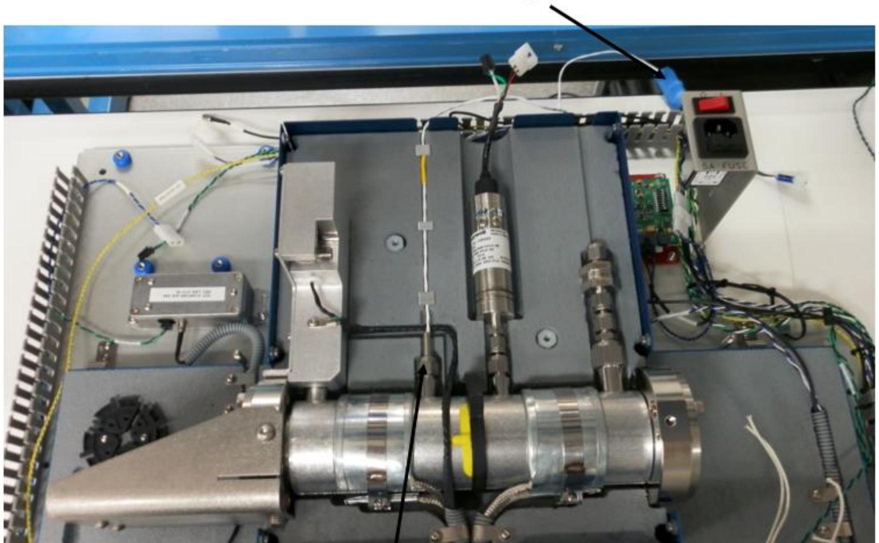
Fig. 84 Middle Insulating Foam Securing Screws



STEP 5 Remove the ThAmp:

a. Disconnect the ThAmp power and communication cable from the source. To locate the ThAmp power and communication cable, see Fig. 85.

Fig. 85 ICOS Assembly ThAmp



b. Unscrew the Swagelok and remove the faulty ThAmp from the ICOS cell.

STEP 6 Install the new ThAmp:

a. Insert the new ThAmp and use the Swagelok to lock it into place in the ICOS cell. Only tighten the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes.

NOTE: Over tightening the Swagelok could damage pipe ends and threads.

b. Neatly place the ThAmp cable in the cutout at the top of the instrument.

c. Connect the power and communication cable of the ThAmp.

STEP 7 Close the ICOS assembly:

a. Install the middle insulation foam and secure it into place with the two screws that were removed previously.

b. Reconnect the gas expansion to the ICOS filter/heater assembly. Only tighten the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes.

c. Reconnect the orifice filter/heater to the inlet solenoid valve exhaust gas line. Only tighten the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes.

d. Place the top heat insulator foam covering the ICOS heaters.

e. Put back the top heat shield covering the top insulation foam.

f. Secure the top cover with the six screws removed earlier to access the ThAmp.

g. Put back the left and right side heat shield covers, connecting them to the top heat shield cover by carefully sliding the tongue into the gap of the top cover and locking them into position with the latches.

STEP 8 Go to the GUA junction box and turn on AC power to the Gas Analyzer.

STEP 9 Bypass the internal pressure interlock switch by inserting the bypass key in the purge controller bypass port (not require for Z-Purge enclosure).

STEP 10 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 11 After the Gas Analyzer software completes it initialization process, wait a few minutes for the instrument to stabilize.

STEP 12 On the Control Bar, verify that the ICOS cell pressure does not go outside the ± 1% range of the instrument original settings.

If there are no pressure leaks and the ThAmp is running properly when looking at the Control Bar, the Gas Temperature provides a number greater than 0.

If there are leaks, verify three locations: between the inlet solenoid valve and the orifice filter/heater, between the gas expansion and the ICOS filter/heater, and at the ThAmp connection to the ICOS cell. Refer to section Pressure Control on page 144 to perform such checks and repairs.

STEP 13 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 14 Close the Gas Analyzer and verify results.

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!

Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 15 Verify results:

a. Verify that temperature and pressure are moving toward their original settings and are stable.

b. Close the filtered air check valve line feeding the Gas Analyzer.

c. Open the customer’s sample gas line to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

Fiber Lasers

The ICOS measurement module is comprised of:

- One laser (or two operating at different wavelengths)
- Astigmatic mirrors
- PZT + driver
- NIR detector

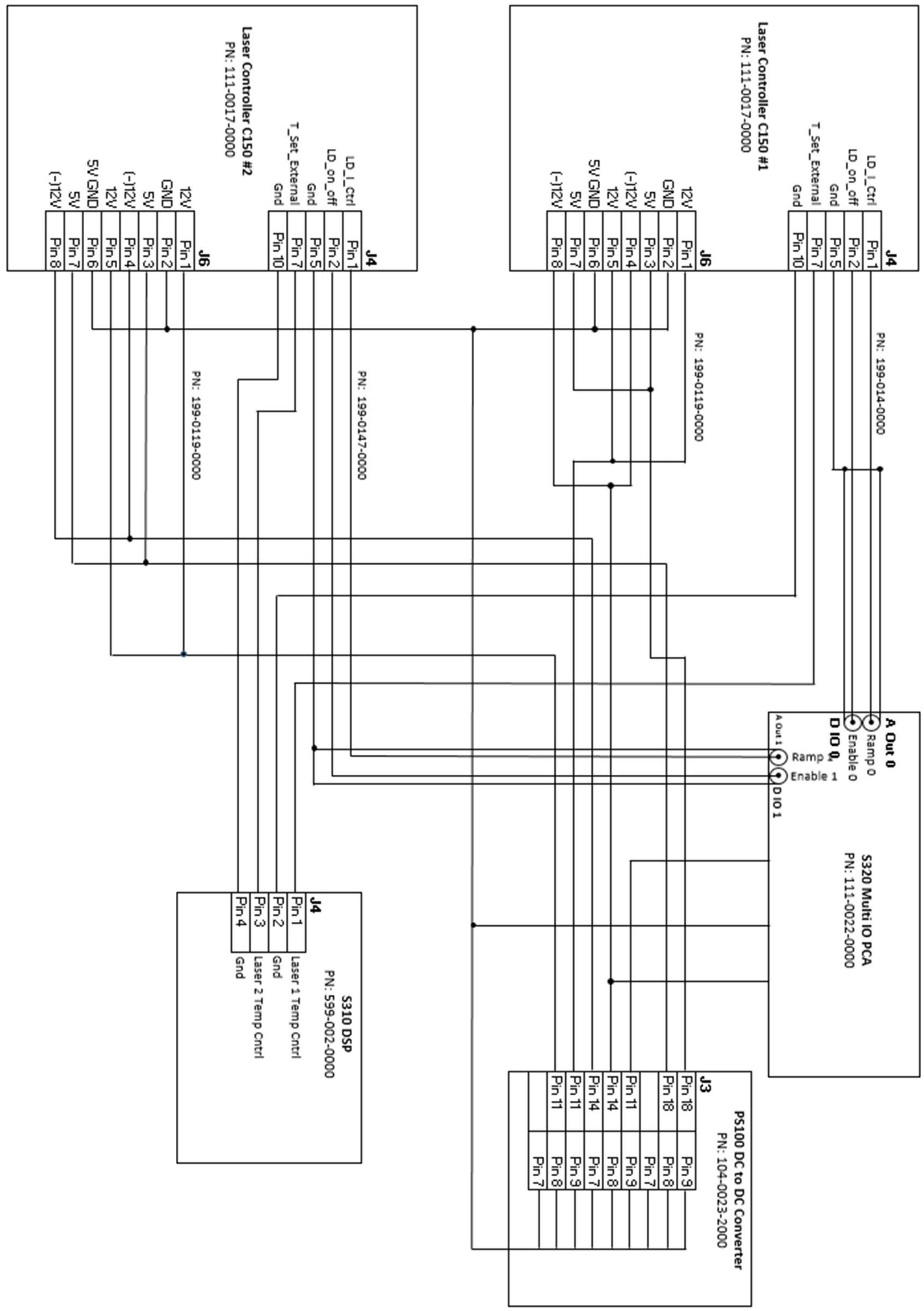
Fiber lasers are configured to operate over a narrow operating bandwidth tuned to the resonance frequency of the gas to be measured. When mounted on the board, the driver/fiber laser combo is part of the C150 laser controller. On the PC104 stack, the S310 DSP and S320 Multi I/O PCA control the C150 laser controller.

The fiber laser is not field-replaceable when optical alignment needs to performed. Should a fiber laser need to be field-replaced, the whole unit (fiber laser, laser mount, C150 laser controller, ICOS cell with 2 µm filter, pressure gauge with ThAmp still connected to it) will be ordered and factory pre-aligned to quickly bring up the Gas Analyzer. To achieve this, the field service engineer must provide the Gas Analyzer serial number upon ordering for this assembly to be factory-built. The instrument serial number will provide the fiber laser operating frequency with respect to the original Gas Analyzer ordered by the customer.

There are up to two fiber lasers per Gas Analyzer, depending on the model.

Fig. 86 is the wiring diagram of the C150 laser controller and its communication with the PC104 stack.

Fig. 86 Gas Analyzer Laser Controller Wiring Diagram



Troubleshooting

There are three possible laser failure scenarios:

- The laser produces no output, or the laser beam intensity dropped below the usage range required to make stable measurements.
- Laser noise level increases to the point where the measured concentration becomes very unstable.
- Laser mode hopping, where a laser wavelength would suddenly switch back and forth and would be analyzed as a shift in the absorption wavelength.

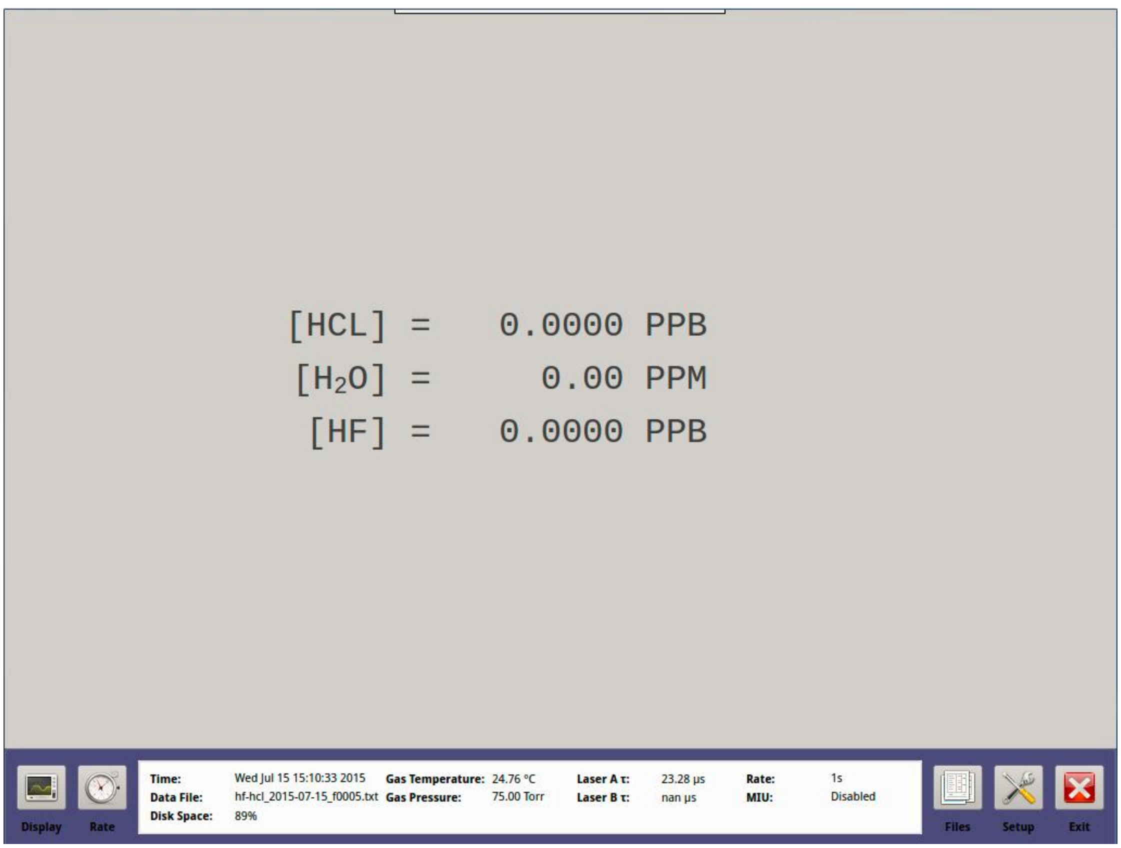
The “No output/laser intensity drop” and “laser noise” scenarios are more likely to happen then the laser “mode hopping” scenario.

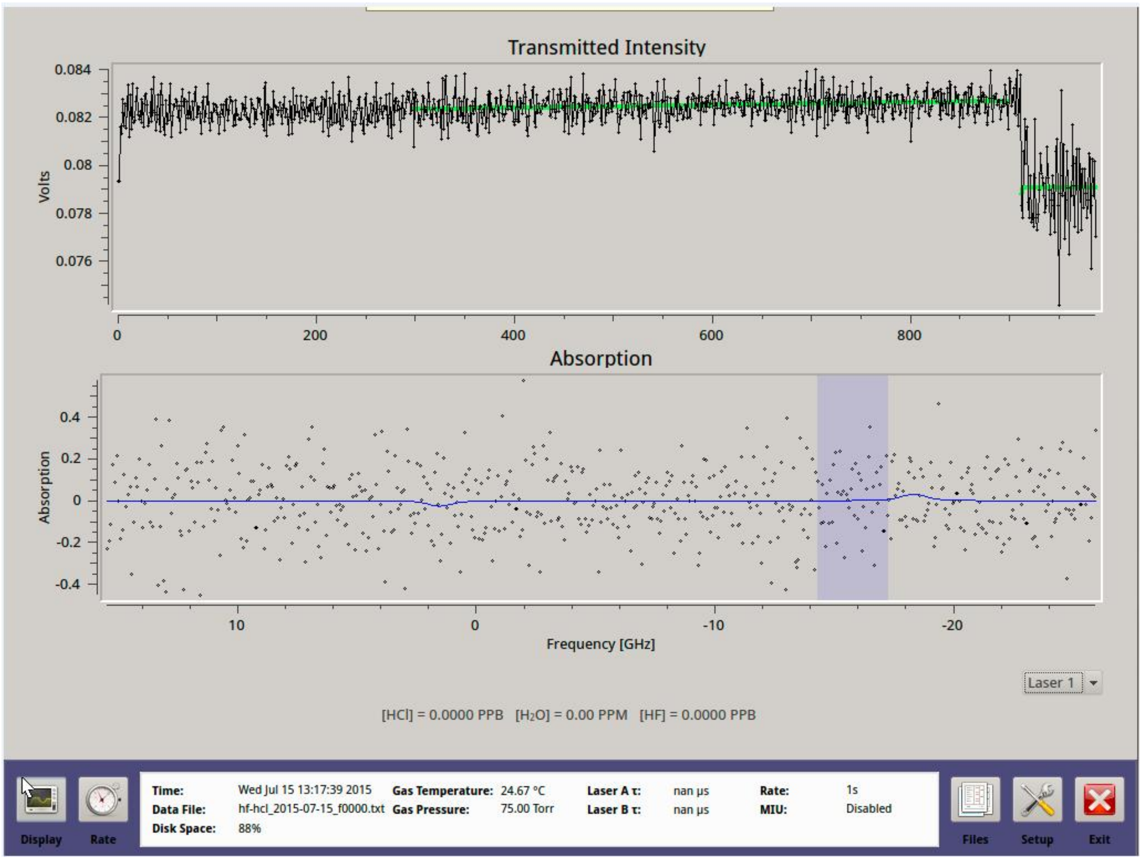
In the “No output/laser intensity drop” scenario, the Numerical display will put out some arbitrary numbers as it will only be measuring NIR detector background noise in ppm for a specific gas sample at a specific wavelength (see Fig. 87). The Spectral display should show >0.01 volt, but less than 0.1 volt with the displayed signal coming only from detector noise.

However, you may also have similar results should the NIR detector fail. If this is the case, the Spectral display will go down to 0.00 volts and not 0.01 volts. If the Gas Analyzer is equipped with two lasers measuring two, three to four different gases, determine if the Numerical and Spectral displays show no signal outside of the background noise level signal.

The fiber lasers used in the Gas Analyzer are pulsed, meaning that they turn on and off. In a two-laser Gas Analyzer system, lasers alternate their on/off state. When one is on, the other is off, and vice-versa. Thus, the laser that is off will have no impact on the measurement taken by the laser that is currently on.

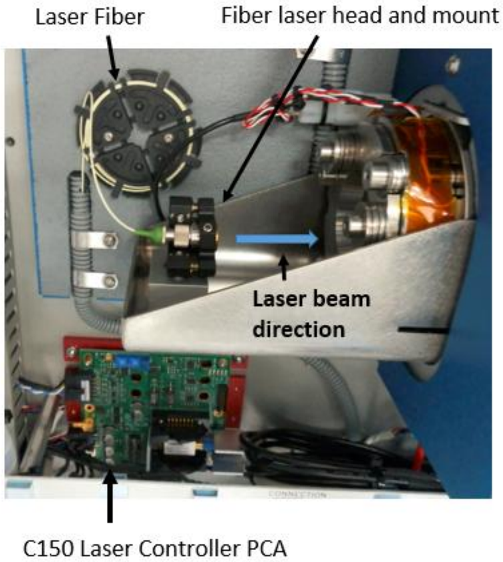
Fig. 87 Numerical & Spectral Displays On No Laser Output





To determine if the laser is emitting a light beam, place a fluorescence infrared detector card in the path of the laser beam (see Fig. 88 for laser beam path) and look for a laser spot on it. This card does not work with Gas Analyzers lasers that operate at wavelengths above 1600 nm. Thus, all HCL gas type Gas Analyzers do not work with this particular fluorescence infrared detector card since it has a visible range between 760 nm and 1600 nm.

Fig. 88 Fiber Laser Found Under The Blue Heat Shield Cover



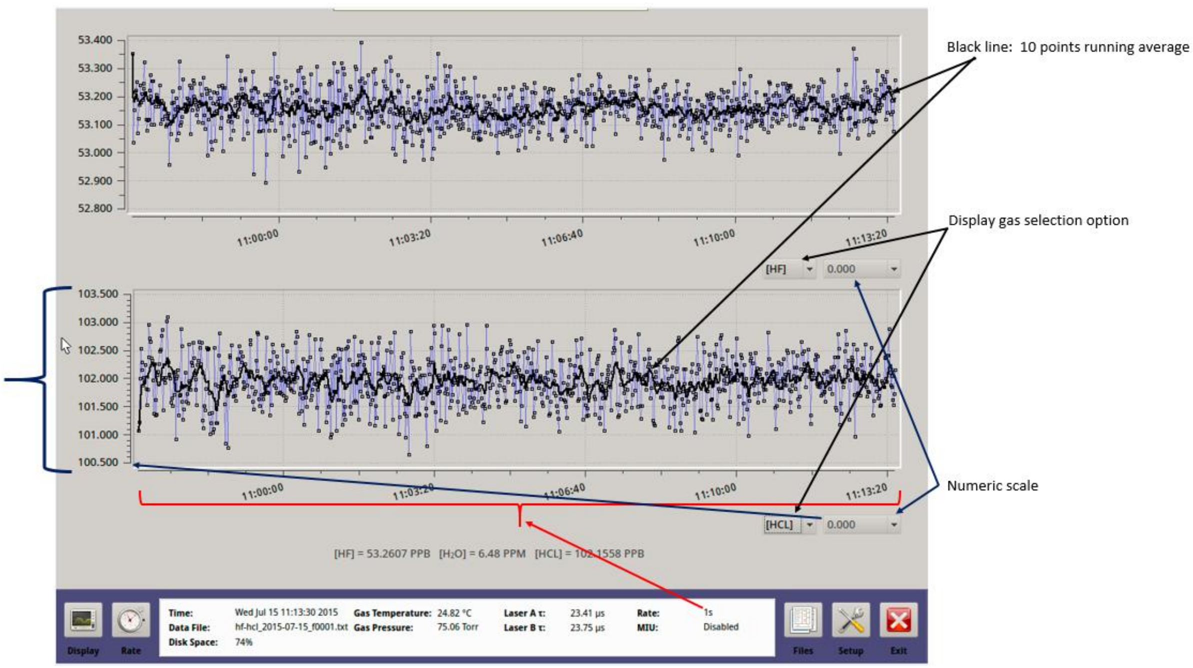
Warning!	Use proper laser safety glasses with OD covering the range between 700 nm and 1800 nm with a working laser. Avoid placing reflective material in front of the laser beam path as it could reflect beyond the safe enclosure provided by the instrument. Secondary reflective beams can permanently damage eyes looking directly into the laser beam path.

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

In the noisy laser scenario, the Numerical display values for the gas’ specific laser wavelength will be a higher ppm value variation.

The Timechart measurements will show higher point-to-point fluctuations and exceed the 1-sigma (1 standard deviation) precision. Fig. 89 is a representative of a normal Timechart point-to-point measurement.

Fig. 89 Timechart Point-to-Point Measurement



*NOTE: The performance specification of 1**σ** at 1 second measurement applies only to traceable regulated certified bottled gas. Customer gas samples are too contaminated.*

Replacement

Fiber lasers cannot be replaced in the field. Should there be a fiber laser issue, the entire measurement module must be removed from the outer enclosure and shipped back to LGR for repair or if the customer purchased a spare ICOS module consisting of a ICOS cell, laser and driver with a matched S320 Multi IO PCA, 2 um filters already fitted into the inlet and outlet of the ICOS, with a Thamp and Pressure Gauge already mounted on the ICOS cell, just that section can be changed out in the field. A box needs to be ordered for shipping back the whole measurement module unit, or just the ICOS system module being replaced for repair.

NOTE: Two people must participate during measurement module removal.

Required items and tools:

- 9/16″ open end wrench (2)
- 7/16″ socket and ratchet
- Two unions and four end caps to close the four outlet and inlet gas lines
- Thin blade screwdriver
- Computer power cord
- Wheeled table or cart
- Shipping box

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

Removing the measurement module

To remove the measurement module:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer. Allow the Gas Analyzer to run for 5 minutes to purge the gas contained in the ICOS system.

e. Shut off the facility AC power at the GUA junction box.

f. Perform the “lockout tag out” procedure on the GUA junction box.

g. Close the shutoff valve on the customer side of the exhaust gas line (if present).

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Attach your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Power down the Gas Analyzer:

a. Put the Gas Analyzer On/Off switch (inside the enclosure, in the upper right corner) to the “Off” position.

b. Disconnect the On/Off switch coming from the purge controller.

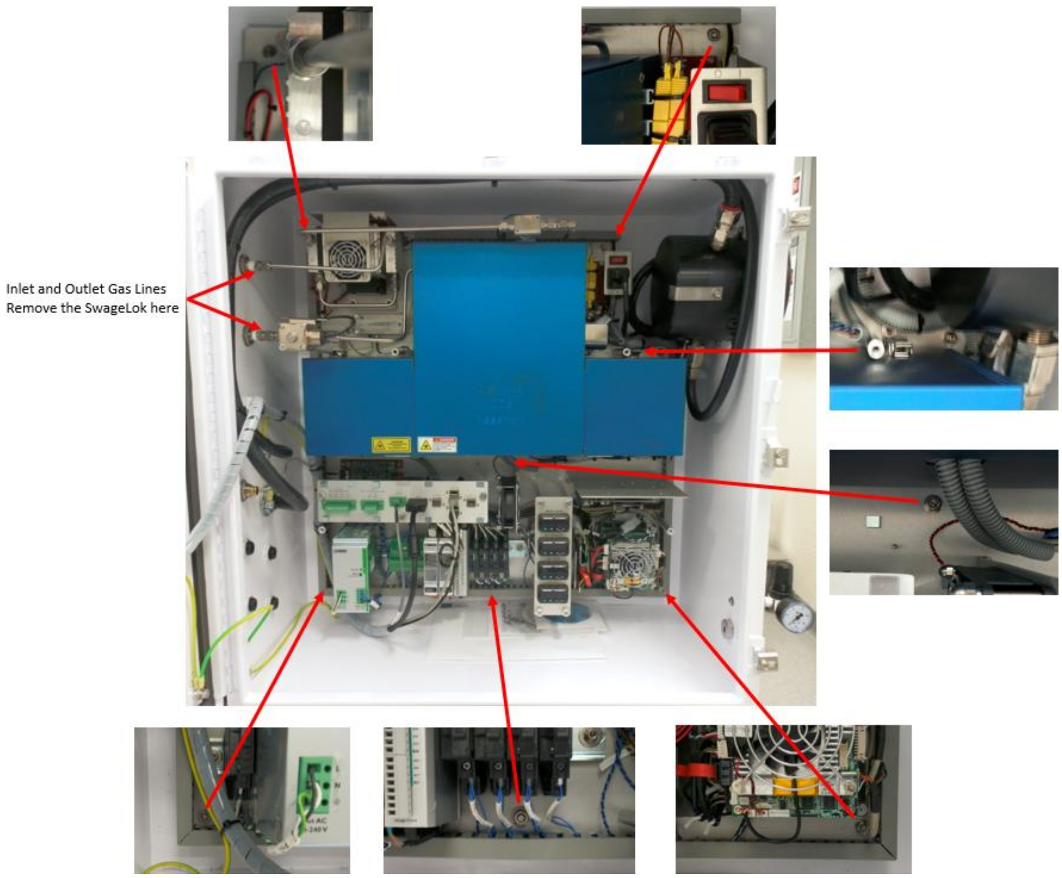
c. Disconnect the inlet and outlet gas lines at the connector inside the enclosure.

d. Disconnect all external connectors from the communication interface panel.

STEP 4 Remove the ICOS measurement module:

a. Remove the seven nuts/standoff securing the ICOS measurement module to the enclosure. See Fig. 90 for the location of these seven nut/standoffs. Leave the 7 nuts/standoffs inside the enclosure so that they are available when putting the repaired Gas Analyzer back into the enclosure.

Fig. 90 7 Nuts/Standoff Securing the ICOS Measurement Module



b. Slide the table or cart next to the edge of the Gas Analyzer.

c. Lock the wheels in place.

d. With the help of another person, hold on the T-handles.

e. Pull the measurement module off the seven bolts holding it to the enclosure.

f. Once the measurement module is off the bolts, lift and tilt it to the left, to allow sufficient room on the right.

g. Slide the measurement module off the enclosure.

h. Lay it onto the table or cart.

i. Cap the ends of the inlet and outlet gas lines coming in from the customer side.

j. Fit a union on the Gas Analyzer inlet and outlet gas lines followed by the end caps.

STEP 5 For sending the Gas Analyzer back to ABB/LGR for repair.

k. Order a shipping container for the Gas Analyzer if it is to be shipped back to ABB/LGR for repair.

l. If the unit is to be repair on site, continue to Step 6. If the unit is to be shipped to ABB/LGR, proceed to section: "Install the New Measurement Module".

Removing the ICOS module for module replacement only

To remove the ICOS module:

STEP 6 Removing the ICOS module with attached lasers.

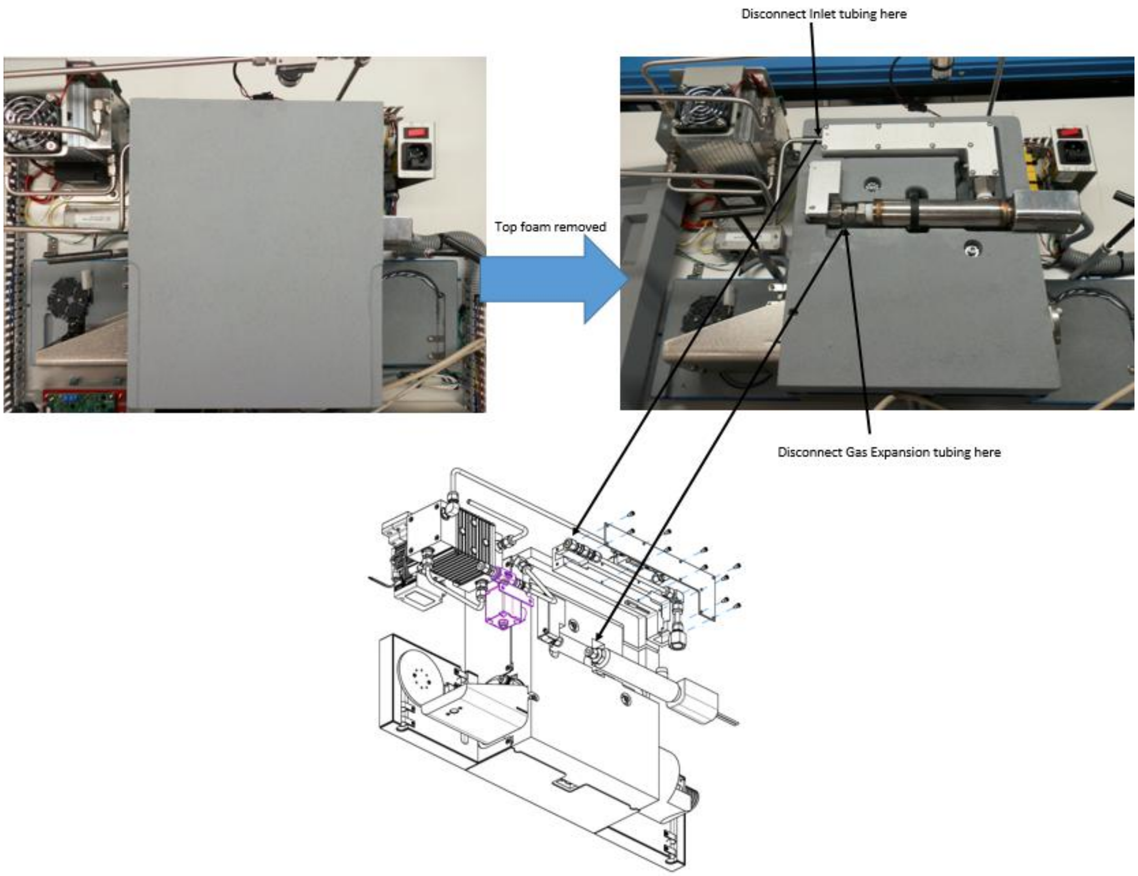
m. Remove the blue shield covering the ICOS module.

n. Remove the top center foam from the ICOS assembly.

o. Disconnect the inlet tubing from the Orifice/heater with 10µm filter assembly (see Fig. 91).

p. Disconnect the Gas Expansion assembly from the 2µm filter/heater assembly (see Fig. 91).

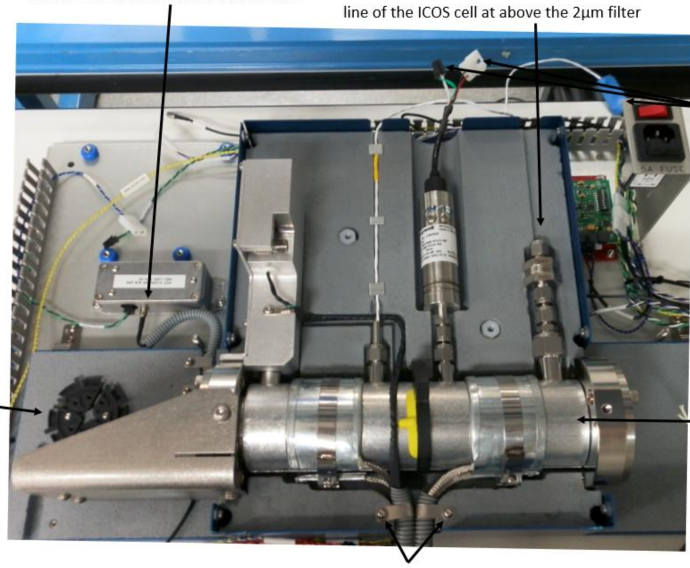
Fig. 91 ICOS Inlet heater/orifice and expansion heater removal



q. Remove the two screws holding down the center foam follow by removing the center foam.

r. Disconnect the Proportion Valve from the ICOS cell exhaust side of the 2µm filter (see Fig. 92).

Fig. 92 Proportion Valve separation from the 2µm exhaust side filter



s. Unscrew the 2 screws holding down the ICOS cell band heaters cables to the foam.

t. Disconnect the ICOS cell band heater power cable connector at its source supply connector.

u. Disconnect the thermocouple wires from both the ICOS Cell and ICOS Filter Temperature Controllers.

v. Disconnect the PZT elements drive cable from the PZT driver.

w. Unscrew the 2 screws holding down the PZT element drive cable to the foam.

x. Unscrew the 2 screws holding the coiled fiber laser fiber onto the foam.

y. Unmount the Communication Interface board and set it on aside from the C150 Laser Controller/Driver PCA(s).

z. Disconnect both the communication and power cables from the C150 Laser Controller/Driver PCA(s).

aa. Remove the 4 screws that secures the C150 Laser Controller/Driver PCA(s) to the instrument chassis.

bb. Detach the PC104 computer stack from the chassis.

cc. Remove the Ramp(s), Enable(s), and detector SMB cables from the S320 Multi IO PCA card.

dd. Remove the S320 Multi IO PCA card from the PC104 computer stack.

ee. Make sure all cables are that connected to the ICOS Cell module are free and lift the ICOS Cell module from the instrument. Be careful of not kinking the laser fiber.

Installing the ICOS module

To remove the measurement module:

STEP 7 Reverse the steps taken in Step 6 except now you will be install a new matched S320 Multi IO PCA on the PC104 computer stack.

ff. After installing the new ICOS Cell module to the instrument, insert the Computer power cord to power the Gas Analyzer on and proceed to perform a leak test to verify there is no pressure leak at both the inlet heater connection made at the 10µm Filter/Heater and at the connection between the Gas Expansion to the 2µm Filter/Heater.

gg. In the service menu screen, set the pressure valve to the value that the instrument was set to for sampling the gas.

hh. Execute the pressure leak test from the service menu screen. Resolve any failure(s) encountered.

ii. Continue to "Install the New Measurement Module" in completing the replacement procedure.

Installing the New Measurement Module

To install the new measurement module:

STEP 1 Position the new measurement module:

a. With the help of another person, remove the new measurement module from the box and set it on a wheeled table or a cart.

b. Move the measurement module near the empty enclosure.

c. Loosen the clamps around the Gas Analyzer enclosure front panel.

d. Open the front panel.

e. Inside the Gas Analyzer enclosure, remove the end caps from the customer inlet and outlet gas lines.

f. Remove the end caps and unions from the measurement module inlet and outlet gas lines.

g. Move the wheeled table or cart next to the empty enclosure.

h. Perform a visual inspection of the measurement module individual components and gently tug on these components to make sure that nothing is loose.

i. With the help of another person, lift the measurement module and slide it on the enclosure's seven protruding mounting bolts.

NOTE: You will need to tilt up the measurement module's left side so that the upper right side will slide by the Gas Analyzer purge controller module.

j. Screw in the seven nuts/standoff into the appropriate mounting bolts that hold the Gas Analyzer into place.

STEP 2 Connect the Gas Analyzer AC power and gas lines:

a. Connect the inlet and outlet gas lines between the customer source and the Gas Analyzer.

b. Open the customer inlet filtered air line check valve to allow only filtered atmospheric air to be drawn in. Keep the customer sample gas line shut off.

c. Open the customer exhaust line valve to allow draw from the Gas Analyzer.

d. Plug in the AC power cord from the purge controller to the Gas Analyzer On/Off switch.

e. Go to the GUA junction box and switch on the AC power.

STEP 3 Use the bypass key to bypass the internal pressure interlock switch and allow power to the Gas Analyzer.

STEP 4 Put the On/Off switch to the "On" position.

STEP 5 Make sure that all system electronics boot up and run properly:

a. Look for changing numbers on the temperature controller display, and look at the instrument touchscreen to make sure that the Gas Analyzer application software boots up properly as well.

b. Make sure that temperature controllers are operational by looking at the set and current temperature readings, by making sure that the relays are enabled, that green LEDs are lit solid when supplying 24V to the heaters, and blink upon reaching the target temperature (the green LED should be off when the current temperature exceeds the target temperature).

STEP 6 Once the Gas Analyzer has completed its initialization and displays gas concentrations on the Numerical display, look at the Control Bar to read the current ICOS cell pressure.

The value read should be the same as the one indicated in the document shipped from the factory where a value was measured after the Gas Analyzer was repaired. If the internal pressure matches that from the factory, proceed to step 7. If that is not the case:

a. On the solenoid valve driver PCA, move switch 1 to the center position to close the inlet gas valve.

b. Move switch 2 to the left so that the exhaust pump runs continuously without requiring commands from the computer.

   Fig. shows the solenoid valve switch settings when in normal operation. Switches 1 and 2 can be repositioned to check for pressure leaks. Table 22 indicates the position of solenoid valve driver PCA switches 1 and 2 and the corresponding responses from the control component.

c. With the inlet solenoid valve closed, look at the pressure level again. It should bring the pressure down to 25 Torr within three minutes.

   If is does not, troubleshoot the vacuum leak. Refer to section Troubleshooting Pneumatics Leaks on page 145.

   If the leak is at the connection on the inlet side, inspect the Swagelok for damage.

   If nothing is found, proceed to lock the two pipes together and use the Swagelok gap inspection gauge for ¼″ tubes to ensure proper tightness between the Swagelok and the pipe.

d. Move the solenoid valve driver PCA switch position back to the left position for normal operation.

Fig. 93 Solenoid Valve Driver PCA, Normal Operation Switch Settings

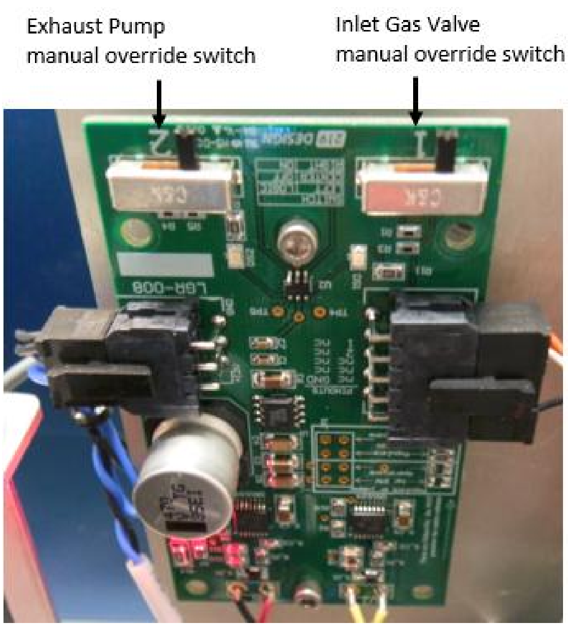


Table 22 Solenoid Valve Driver PCA Switch Position & Response

Switch Position	Sw2: Exhaust Pump	Sw1: Inlet Gas Valve
Left (Normal Operation)	Controlled by computer	Controlled by computer
Center	Power off	Valve close (power off)
Right	Continuous run	Valve open

STEP 7 Look for, and remove, any loose debris within the instrument.

STEP 8 Close the front panel and lock it into position with the clamps on all sides.

STEP 9 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 10 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 11 Put back the bypass key port bolt cover.

STEP 12 Verify results:

a. Verify that the CDA/N_2 inlet pressure gauge registers at least 4 psi.

b. With a blade screwdriver, rotate the purge gas valve on the CDA/N_2 purge inlet to the "On" position.

c. After a minimum of 12 minutes, the Gas Analyzer restarts, once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

d. Once power is restored to the Gas Analyzer, turn the purge gas valve to the "Off" position (90° to the right of the "On" position) on instruments using N_2 as the purging gas. For instruments using CDA as the purging gas, leave the purge gas valve in the "On" position.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

e. Initialize the Gas Analyzer upon prompt.

STEP 13 Verify that temperature and pressure are moving toward their original settings and remain stable.

STEP 14 Take a sample of the air that is currently going into the Gas Analyzer.

STEP 15 Make sure that profile signatures are the same between the current gas spectrum displayed and the one measured at the factory prior to the Gas Analyzer being returned. The two spectrum profile signatures should overlap each other (save for the signal amplitude, since the two air samples are from different parts of the country).

STEP 16 If a traceable, regulated, and certified bottled gas was used in the customer sample gas line during the Gas Analyzer installation, close the check valve on the filtered atmospheric air line.

STEP 17 Opening the check valve to the traceable bottled gas.

STEP 18 Allow a few minutes for the traceable bottled gas to purge the content in the ICOS cell.

STEP 19 Look at the measured traceable bottled gas and verify the output data with regards to measurement accuracy, stability, and repeatability. In the Timebase display, results for the measured gas should be stable to within 1 sigma (1 standard deviation) at 1 second of measurement.

STEP 20 In the Control Bar, click Display to access the Spectrum display. The sample test and regulated gas should line up in the "optical absorption" graph (blue line [sample data] overlaying the black line [theoretical model]). This is often referred to as the Goodness of Fit (GOF).

NOTE: Gas Analyzer calibration should not be necessary. After repair, the Gas Analyzer is recalibrated to the specifications defined for the gas type being measured at the customer site at the time of its original installation.

STEP 21 Save the measured data on the Gas Analyzer for future service references.

STEP 22 Shut off the valve to the traceable bottled gas.

STEP 23 Open the customer sample gas line and allow a few minutes for the current gas to purge the ICOS cell before reviewing the measurement data.

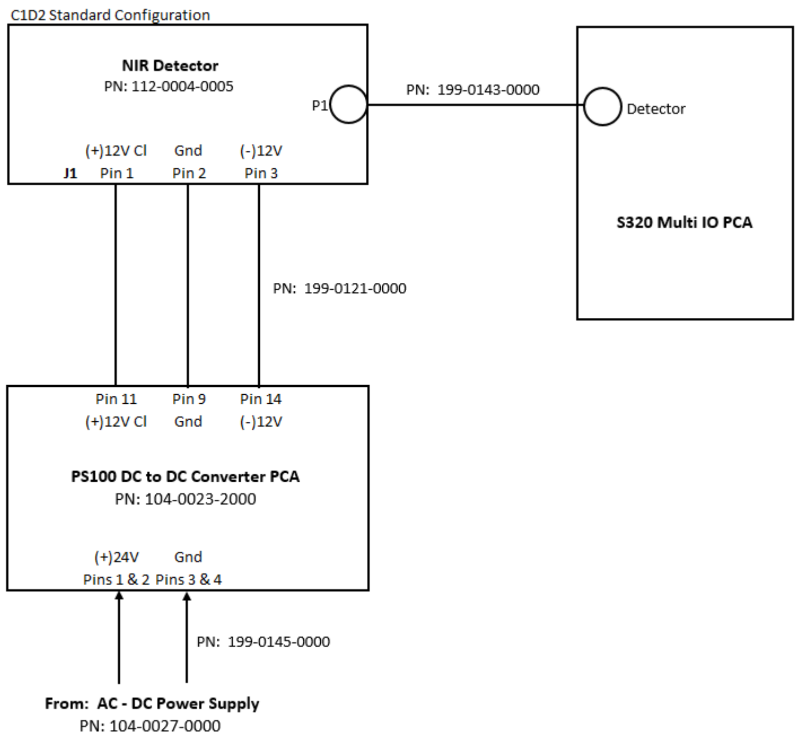
STEP 24 Make sure that customer sample gases fall back within their daily baseline.

NIR Detector

The near infra-red (NIR) detector functions as a low noise photocell detector that captures the resulting laser intensity for a specific gas as this gas passes through the ICOS cell and the astigmatic mirrors. For specific gas types, the NIR output signal is collected at the S320 Multi I/O PCA and is sent for signal processing to the S310 DSP of the PC104 stack. Communication signals between the NIR detector and the S320 Multi I/O PCA are shown in Fig. 91.

If the NIR detector is replaced, a calibration of the Gas Analyzer will be required with a traceable bottled tested and regulated gas that was selected based on the customer sample gas type being measured.

Fig. 91 NIR Detector & S320 Multi I/O Communication Connections



Troubleshooting

The NIR detector has two failure modes. The first is a noisy output and the second is no output at all. To evaluate the output noise from the NIR detector, one needs to see the past time-based plotted point-to-point data that was reported good and use that data as a baseline.

NOTE: The high point-to-point data, >1σ (68% of the data points), is the precision spec for this instrument, but noise can be also come from a defective PZT.

If the NIR detector truly failed, with no output signal, the signal intensity profile would go down to 0.00V. A dead laser will produce not light for the detector, but the detector background noise should still register in the 0.01V measurement range. If the instrument has two laser systems, check both laser signal intensity profiles. If they still register 0.00V, the NIR detector has failed.

For single laser systems, if an “IR laser detection card” is available, insert the card in front of the laser close to the PZT elements and see if there is a laser spot. This operation is performed while the Gas Analyzer is powered on and the left ICOS cover is off.

NOTE: The IR laser detection card will not work on HCL products because the laser used in HCL products is beyond the card sensitivity range.

Replacement

NOTE: This procedure is a Type 1 electrical safety task.

Required items and tools:

- Philips screwdriver
- Digital volt meter (DVM)
- Thin blade screwdriver
- Grounding wrist strap
- Blade screwdriver

Danger! ⚠	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the NIR detector:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

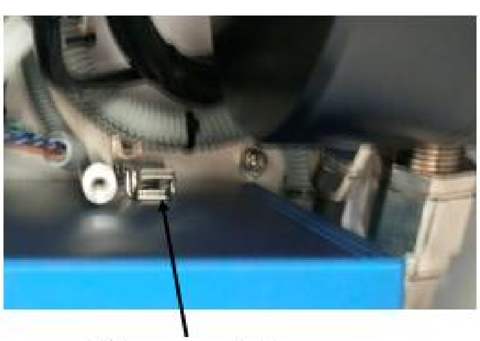
c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis. At this time, the Gas Analyzer should have no power.

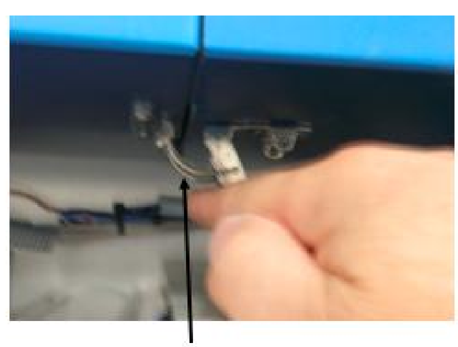
STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the ICOS cell cover:

a. Open the latches at the top and bottom of the blue cover located on the right side of the ICOS cell. To locate the latches, see Fig. 92.

Fig. 92 ICOS Right Cover Latches





b. Remove the blue cover.

c. Before pulling the cover from the enclosure, slide its right side to the right so that the “tongue”, that goes into the top cover, is out of the way.

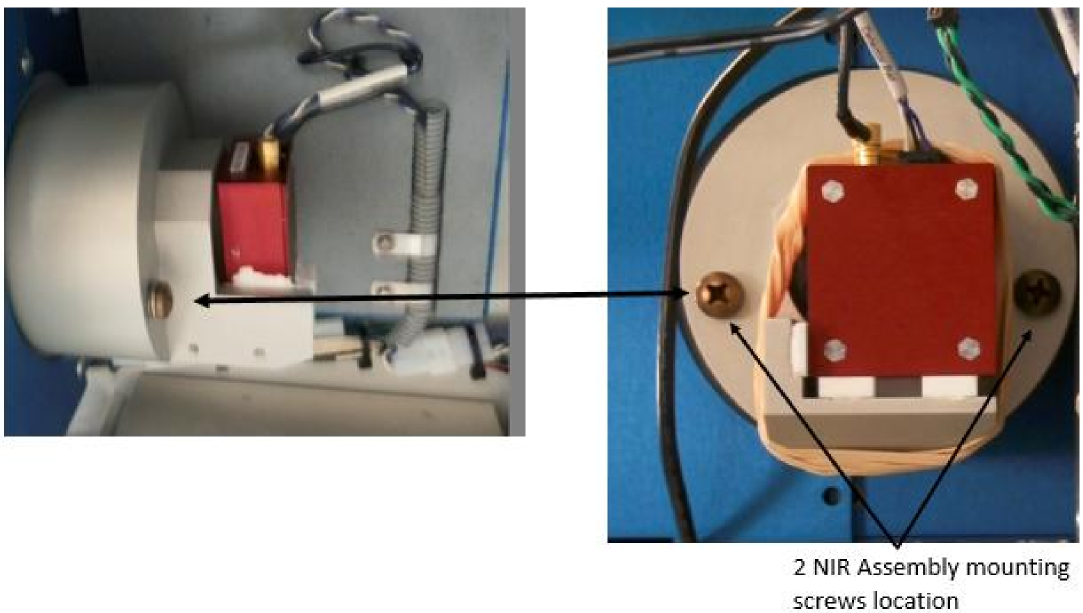
NOTE: Do not bend the cover “tongue” in the removal process.

d. Disconnect the detector fan cable so that the cover can be laid down without putting stress on the cable.

STEP 5 Disconnect the communication cable from the NIR detector.

STEP 6 Remove the two mounting screws that hold the NIR detector to the ICOS cell. The NIR detector assembly should be easily removed. To locate the two screws to remove, see Fig. 93.

Fig. 93 Location of the NIR Assembly Mounting Screws



STEP 7 Install the new NIR detector in the ICOS cell:

a. Align the screw holes and secure them into place with the two screws that were removed when taking the detector out.

b. Re-attached the detector fan power cable on the right side cover.

STEP 8 Reinstall the right side cover and secure it into place with the top and bottom latches.

STEP 9 Put the Gas Analyzer On/Off switch to the “On” position. The Gas Analyzer will remain off because the internal pressure interlock switch is still tripped while the front panel is open.

STEP 10 Close the Gas Analyzer:

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 11 Verify that temperature and pressure are moving toward their original settings and remain stable.

STEP 12 Allow 20+ minutes for the Gas Analyzer to reach proper internal pressure and a stable internal operating temperature.

STEP 13 Close the filtered air line check valve feeding the Gas Analyzer.

ICOS System Calibration with New NIR detector

Once the new NIR detector is installed, the ICOS system needs calibration.

To do so:

STEP 1 To perform measurements with the Gas Analyzer, open the customer traceable, regulated and certified bottled gas line that is inline with the sample gas line.

STEP 2 Allow the Gas Analyzer to purge the ICOS system with the traceable, regulated, and certified bottled gas for a few minutes.

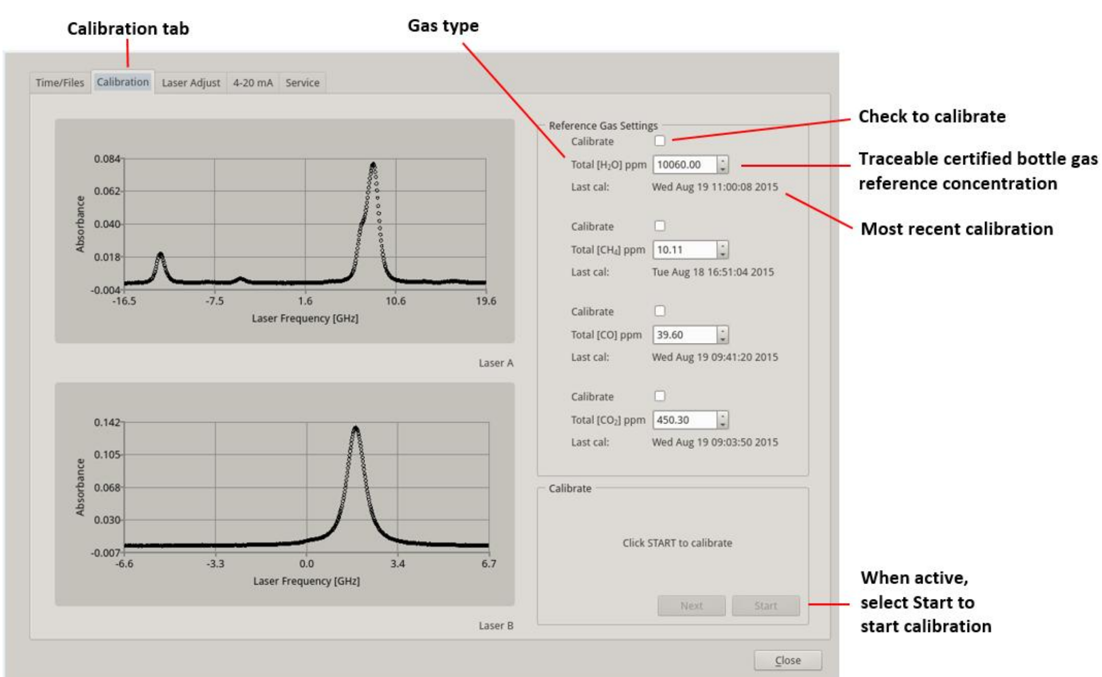
STEP 3 Click Setup in the Control Bar.

STEP 4 In the Setup screen, click the Calibration tab.

STEP 5 In the Reference Gas Settings, check the box next to the gas that you wish to calibrate. This would be the traceable bottled gas.

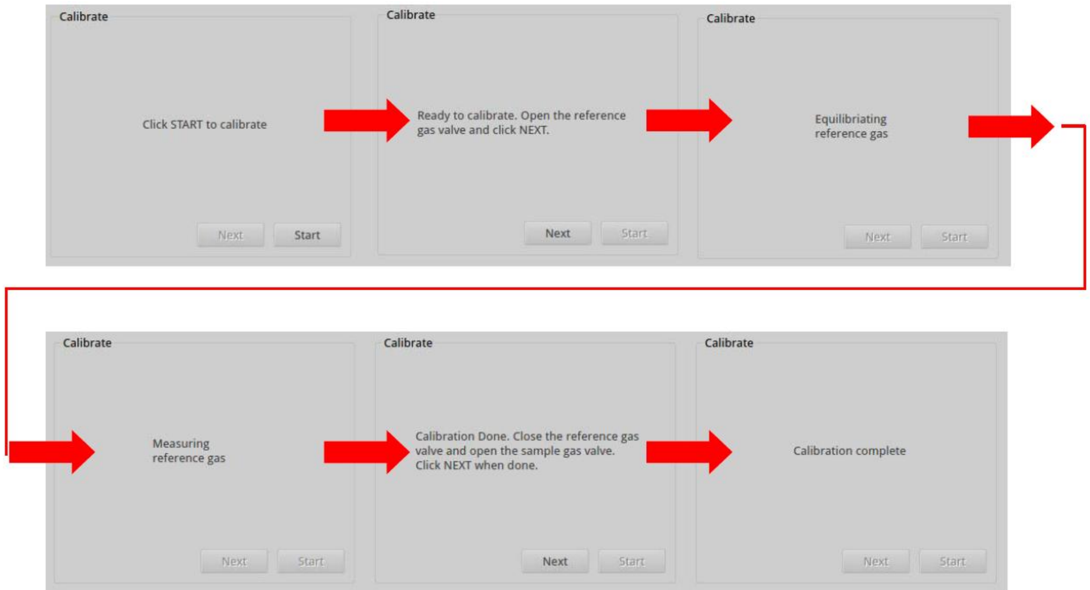
STEP 6 Enter the known concentration for the traceable bottled gas. See Fig. 94 for the calibration parameter fields that require user input.

Fig. 94 Gas Calibration Screen



STEP 7 Click Start to start the calibration process. The screen shots in Fig. 95 will appear and the user will need to select Start or Next to progress to the next phase until the calibration sequence is completed.

Fig. 95 Gas Calibration Flow Chart



STEP 8 If the customer has multiple traceable bottled gases available to cover the gases being measured by the Gas Analyzer at the customer site, repeat steps 1 and 2 for all the traceable bottled gases.

STEP 9 Close the traceable bottled gas line check valve.

STEP 10 Open the customer sample gas line valve that is connected to the Gas Analyzer inlet gas line.

STEP 11 Click Close to exit the Calibration screen.

STEP 12 In the Control Bar, click Display.

STEP 13 Select the Profile screen.

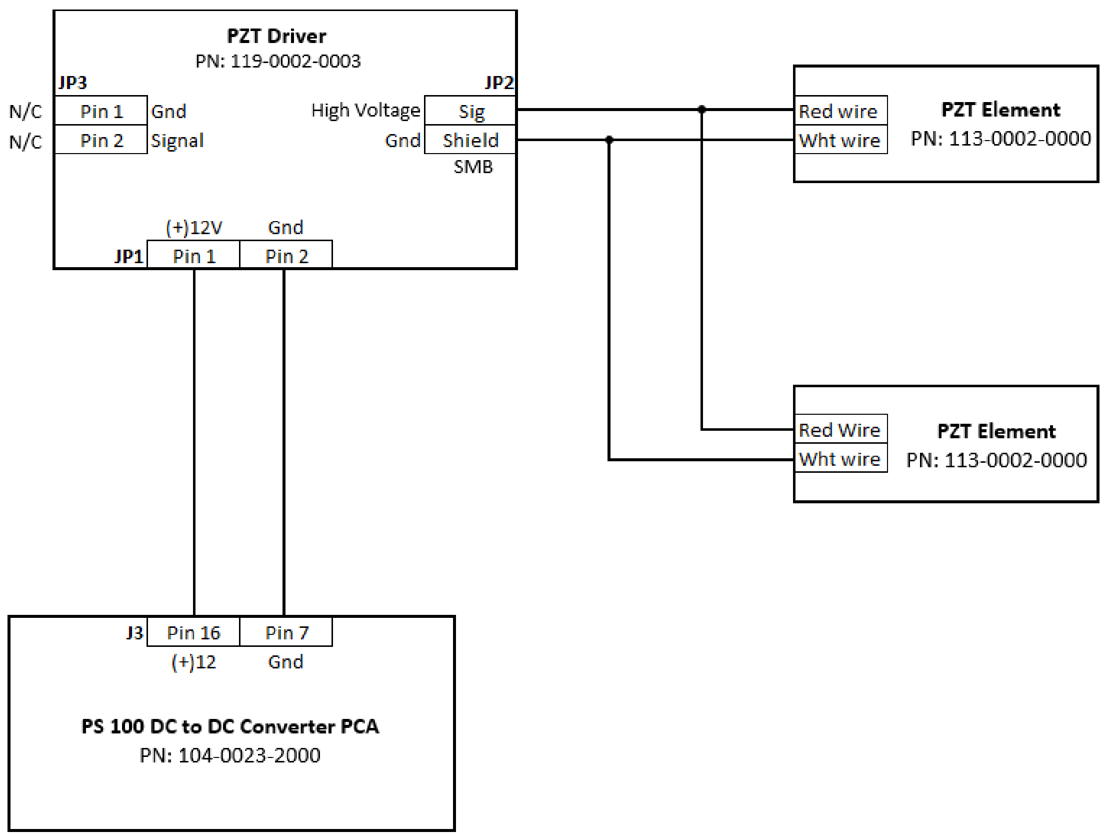
STEP 14 Compare the current profile data with any previous profile data that the customer may have saved to verify that the readings are back within the “control band” that the customer had obtained before.

PZT Elements & Driver

The purpose of PZT elements is to make one astigmatic mirror oscillate, thus increasing the length of the path taken by the laser beam in the ICOS cell. Another benefit of making a mirror oscillate is avoiding light wave constructive interference and reducing light source noise. The impact of this feature (obtaining cleaner measurements) is more visible in a low sensitivity isotope gas. In this sense, it could be difficult to troubleshoot the PZT elements just by looking at the spectrum profile. PZT elements will either work or not. The maximum travel range of PZT elements is approximately 3µ. There are two PZT elements per ICOS cell. They are always mounted on the mirror that is on the side where the laser head is mounted.

A wiring diagram illustrating the interconnections between the PZT driver and the PZT is shown in Fig. 96.

Fig. 96 PZT Driver & Connections



Troubleshooting

For PZT elements to oscillate, the drive voltage measured at the PZT power connector is a saw tooth waveform at 200V DC. If this were measured with an oscilloscope, you would see a 0V DC to 200V DC saw tooth type waveform with a short pause between waveforms. If measuring this same signal with a DVM set to AC voltage, it would read a V_{RMS} ~141V AC.

With the drive cable disconnected from the PZT elements, the parallel PZT measured across the leads, with the DVM set to measure capacitance, should read between 506 nF and 374 nF (440 nF ±15%). You should not get an infinity "∞" measurement in capacitance.

Replacement

PZT elements and their mount/flange are replaced as a unit. PZT elements are glued with a preload onto the mount to establish a fixed amount of movement against the ICOS cell. With one of the astigmatic mirrors clamped down on the PZT mount, the mirror is oscillating with the mount.

NOTE: This procedure is a Type 1 electrical safety task.

Required items and tools:

- 5/32″ Allen wrench
- 3/32″ Allen wrench
- Philips screwdriver
- Digital volt meter
- Blade screwdriver
- Lens tissue
- Flat table surface
- Mirror cleaning block from the mirror cleaning kit
- Teflon tube from the mirror cleaning kit

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the PZT:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner of the enclosure.

STEP 4 Remove the ICOS cell heat shield cover:

a. Open the latches at the top and bottom of the blue cover.

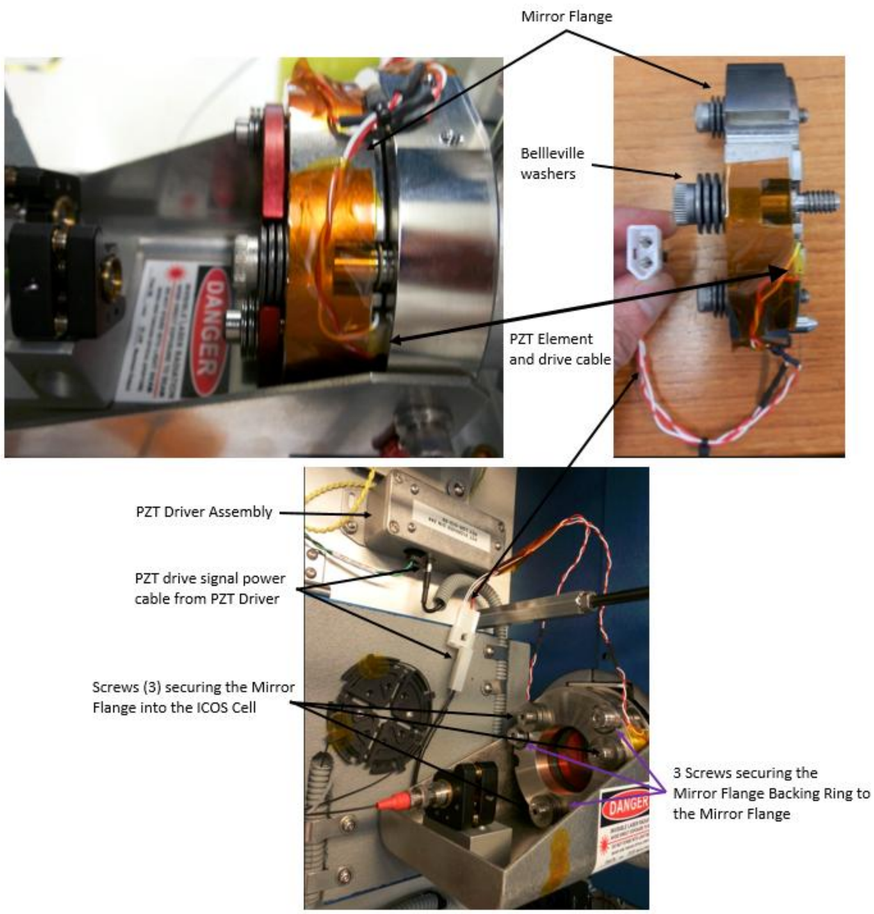
b. Before pulling the cover from the enclosure, slide its right side to the right so that the “tongue”, that goes into the top cover, is out of the way.

NOTE: Do not bend the cover “tongue” in the removal process.

c. Remove the blue cover.

STEP 5 Disconnect the PZT drive signal power cable connecting the PZT driver to the PZT elements. See Fig. to locate the components described.

Fig. 100 PZT Driver and Element

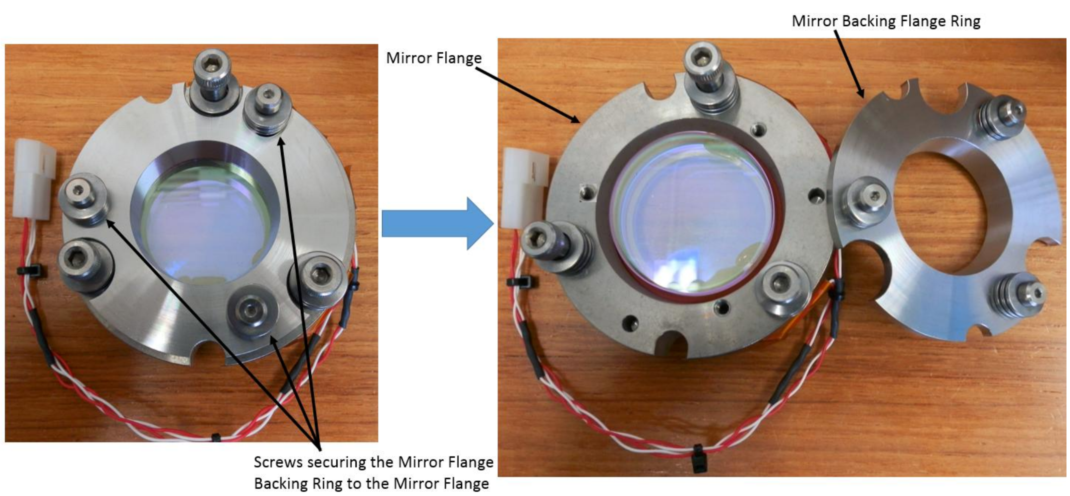


STEP 6 Remove the astigmatic mirror:

a. With a 5/32″ Allen wrench, loosen the three clamp capture screws that secures the mirror flange to the mirror flange backing ring (see Fig.).

NOTE: Do not to touch the mirror when removing the mirror flange from the ICOS cell, and do not bump the fiber laser head on its mount.

Fig. 101 Mirror Flange Backing Ring Separated From Mirror Flange



b. With a lens tissue placed on the clean, dust free, flat table surface, lay down the mirror flange (flange screws up).

c. With the 3/32″ Allen wrench, remove the three screws holding the mirror flange backing ring that holds the astigmatic mirror to the mirror flange.

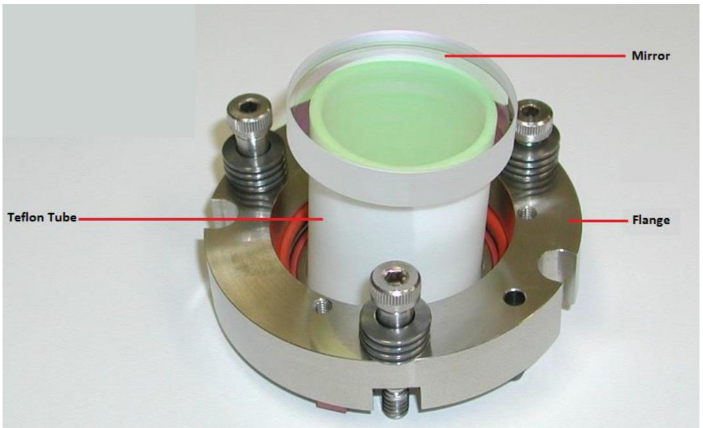
d. Place the mirror flange backing ring on top of another sheet of lens tissue.

e. Place the mirror flange on top of the short Teflon tube, and push the flange down slowly until the mirror pops out of the flange O-ring (see Fig. 97).

f. Place the mirror on the mirror cleaning block with the arrow on the side edge of the mirror pointing up.

NOTE: Hold the astigmatic mirror by its edges only. If, at any point during the removal and separation of the mirror from the PZT flange, you touch the mirror and leave a mark, follow the mirror cleaning procedure given in section Astigmatic Mirrors on page 133.

Fig. 97 Astigmatic Mirror Removal

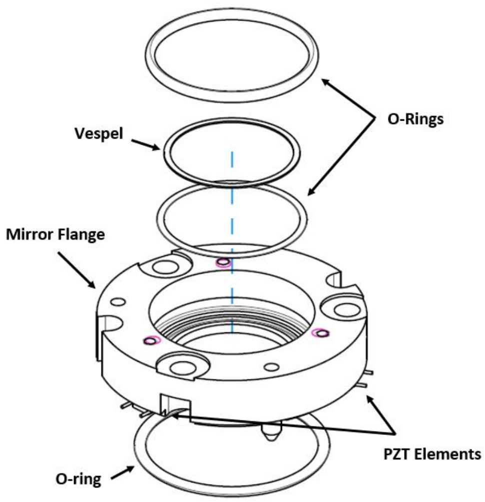


STEP 7 Replace the mirror flange and PZT element:

a. Place the new mirror flange and PZT element on top of a lens tissue, with the PZT element at the bottom.

b. Center the top side O-rings and Vespel (see Fig. 98) to their respective cutout grooves on the mirror flange.

Fig. 98 Mirror Flange O-Ring & Vespel Alignment



c. Holding the edges of the astigmatic mirror, transfer and center the mirror into the mirror flange (the down-pointing arrow identifies the coated surface).

d. Insert the mirror flange backing ring into the mirror flange.

e. Put the three screws back in on the mirror flange backing ring.

f. Tighten the three screws evenly, first by hand, then a bit more by moving from one screw to the next, keeping an even pressure on all sides of the flange when pressing up against the ICOS cell. The shoulder screws will control the depth of travel of the screws into the ICOS cell.

g. Verify that the bottom O-ring and the PZT element side of the mirror flange are in place within the slot.

h. Align and secure the mirror flange into the ICOS cell. The mirror flange is keyed so that it will only go in one way into the ICOS cell.

STEP 8 Reconnect the PZT drive signal from the PZT driver to the PZT elements.

STEP 9 Put back the left side of the ICOS blue heat shield cover back on the ICOS cell:

a. Slide the tab in from the left side to mate with the top blue shield cover.

b. Use the upper and lower latch clamps to secure the left blue heat shield in place.

STEP 10 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 11 Close the Gas Analyzer:

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 12 Finish the procedure and verify results:

a. Verify that temperature and pressure are moving toward their original settings and remain stable.

b. Close the filtered air line check valve feeding the Gas Analyzer.

c. Open the customer sample gas line valve to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

e. Close the Gas Analyzer front panel. The Gas Analyzer takes about 20 minutes to reboot. This is the time it takes for the pressure interlock switch to complete its test cycle.

f. Verify that the Gas Analyzer is providing accurate measurements.

Astigmatic Mirrors

The purpose of the two astigmatic mirrors (one mounted at each end of the ICOS cell) is to reflect the laser as many times as possible across the cavity and through the sample gas for absorption at the gas' specific wavelength. Mirrors will get contaminated by the sample gas being measured within the ICOS system and lose their effectiveness. The level of contamination can be measured by the "ring-down time" when the laser is off in pulse mode. The detector then measures the exponentially decaying light intensity as the laser beam bounces between the two mirrors. The ring-down time is mirror-coating dependent. The targeted ring-down time for new C1D2 Gas Analyzers is >30 ms for all gases except HF and HCL gases. The ring-down time for HF and HCL Gas Analyzers is 20 ms. When mirror reflectivity drops by more than 10% compared to its original level, a ring-down (Tau) alarm is triggered. At this point, mirrors need to be cleaned. If any mirror is scratched or damaged by the measured gases, it will need to be replaced or cleaned.

Astigmatic Mirror Cleaning or Replacement

NOTE: This procedure is a Type 1 electrical safety task.

Required items and tools:

- Philips screwdriver
- 5/32" Allen wrench
- 3/32" Allen wrench
- Lens tissue
- [3]Methanol (Sigma-Aldrich Product #: 414719)
- [3]Acetone (Sigma-Aldrich Product #: 154598)
- Clean table for optical parts
- Mirror cleaning block
- Teflon tube
- Dropper bottles (2)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To clean and/or replace astigmatic mirrors:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

[3] Specific product from Sigma-Aldrich. The only one that does not leave residue films or particles on the surface wiped with a lens tissue.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the ICOS cell left heat shield cover:

a. Open the latches at the top and bottom of the blue cover.

b. Slide the cover to the left so that the cover “tongue” is out.

c. Before pulling the cover from the enclosure, slide it to the left so that the “tongue”, that goes into the top cover, is out of the way.

NOTE: Do not bend the cover “tongue” in the removal process.

STEP 5 Disconnect the PZT drive signal power cable linking the PZT driver to the PZT. See Fig. for location of the components described.

STEP 6 Remove the astigmatic mirror:

a. With a 5/32″ Allen wrench, loosen the three captive screws that secure the mirror flange and astigmatic mirror mount to the ICOS cell.

NOTE: Do not touch the mirror when removing the flange from the ICOS cell.

NOTE: If the Gas Analyzer is in a cleanroom in a semiconductor fab, get a cleanroom cloth, wrap the mirror flange (with mirror assembly) and take it out of the cleanroom for cleaning. No type of paper is allowed in a semiconductor fab. All materials going in such a fab need to be wiped down according to the customer protocol. Do not wipe the mirror. Just wipe the flange.

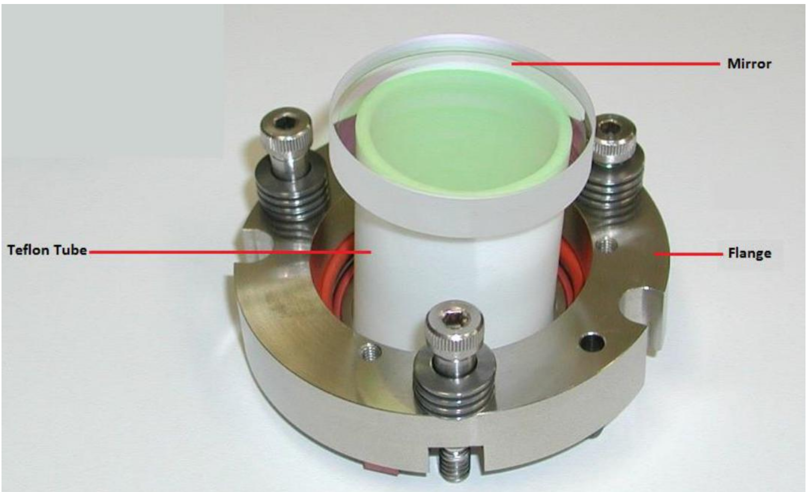
b. With a lens tissue placed on the clean, dust free, flat table surface, lay the mirror flange down (flange screws up).

c. With a 3/32″ Allen wrench, remove the three screws from the mirror flange backing ring that holds the astigmatic mirror to the mirror flange.

d. Place the mirror flange backing ring on top of another sheet of lens tissue.

e. Place the mirror flange on top of the short Teflon tube and push the flange downward slowly until the mirror pops out of the flange O-ring (see Fig. 99).

Fig. 99 Astigmatic Mirror Removal



f. Place the mirror on the mirror cleaning block, with the arrow on the mirror edge pointing down (anti-reflection side up) as shown in Fig. 100.

STEP 7 Prepare the acetone cleaning:

a. Transfer a very small amount of fresh acetone from the capped acetone bottle to the acetone dropper bottle. Use just enough to rinse the dropper bottle.

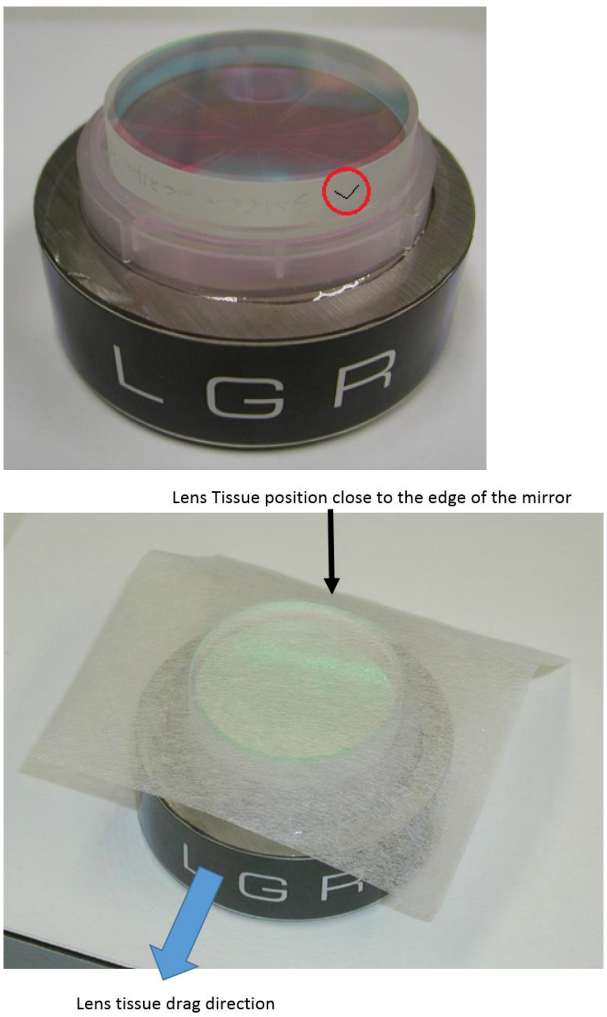
b. With the dropper top closed, shake the dropper bottle to rinse the interior of the bottle and discard the rinse acetone.

c. Fill the acetone dropper bottle 1/4 to 1/3 full with fresh acetone.

d. Remove a single sheet of lens tissue from the pack.

e. Place the sheet on the mirror with the mirror at the edge of the sheet. Leave enough tissue free on the near side of the optic to hold when you drag it. See Fig. 100 on the positioning of the lens tissue.

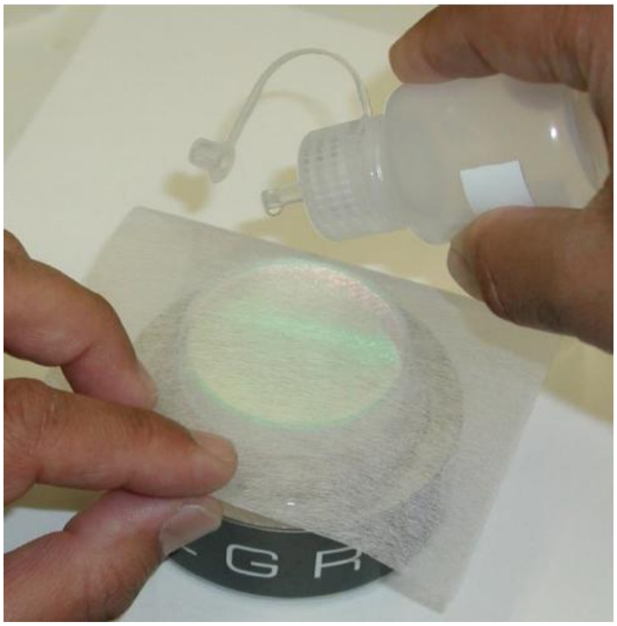
Fig. 100 Lens Tissue Positioning For Mirror Cleaning



STEP 8 Clean the mirror:

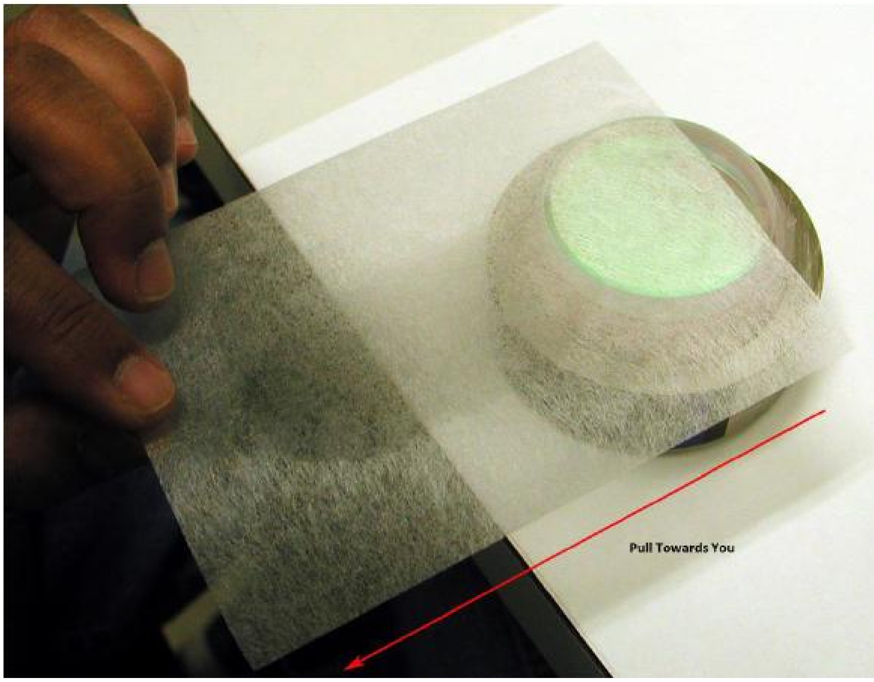
a. Using the acetone dropper bottle, place four drops of acetone on the tissue, above the center of the mirror. The solvent should completely wick up to the mirror edge (see Fig. 101).

Fig. 101 Where to Apply Cleaning Solution on Lens Tissue



b. Pull the lens tissue toward you with a consistent but light pressure over the full length of the mirror (see Fig. 102) at a speed which matches the evaporation rate of the solvent from the surface. This is called drag wiping. If you see liquid on the mirror after you wiped it over, you were wiping too fast.

Fig. 102 Lens Tissue Drag Direction When Cleaning Mirror



c. Discard the used lens tissue after a single pass.

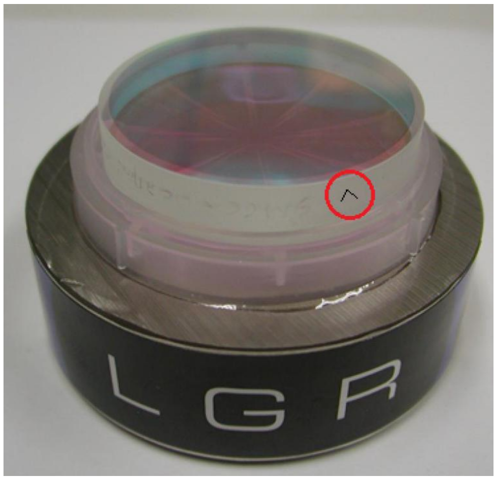
d. Repeat steps 7e through 8c for at least two cycles, starting with acetone, then methanol, then acetone again, and methanol.

e. If chemical residues that were on the mirror are still there after the wipe, repeat steps 7e through 8d until residues are removed.

f. If there is no progress shown in removing chemical residues from the mirror after each wipe sequence, one with acetone and one with methanol, order a replacement mirror. If cleaning was successful, proceed to step 9.

g. Invert the mirror in the mirror cleaning block so that the high reflectivity (HR) surface is on top and the arrow is facing up, as shown in Fig. 103.

Fig. 103 Mirror HR Surface

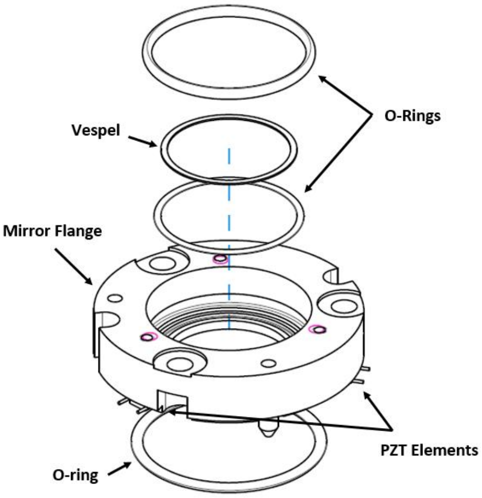


STEP 9 Replace the mirror flange and PZT element:

a. Place the new mirror flange and PZT element on top of a lens tissue, with the PZT element at the bottom.

b. Center the top side O-rings and Vespel (see Fig. 104) to their respective cutout grooves on the mirror flange.

Fig. 104 Mirror Flange O-Ring & Vespel Alignment



c. Holding the edges of the astigmatic mirror, transfer and center the mirror into the mirror flange (the down-pointing arrow identifies the coated surface).

d. Insert the mirror flange backing ring on the mirror flange.

e. Put the three screws back in on the mirror flange backing ring.

f. Tighten the three screws evenly, first by hand, then a bit more by moving from one screw to the next to keep an even pressure on all sides of the flange when pressing up against the ICOS cell. The shoulder screws will control the depth of travel of the screws into the ICOS cell.

g. Verify that the bottom O-ring and the PZT element side of the mirror flange are in place within the slot.

h. Align and secure the mirror flange into the ICOS cell. The mirror flange is keyed so that it will only go in one way into the ICOS cell.

STEP 10 Reconnect the PZT drive signal from the PZT driver to the PZT elements.

STEP 11 Put back the left side of the ICOS blue heat shield cover on the ICOS cell:

a. Slide the tab in from the left side to mate with the blue shield top cover.

b. Use the upper and lower latch clamps to secure the left blue heat shield in place.

STEP 12 Remove the ICOS cell detector cover:

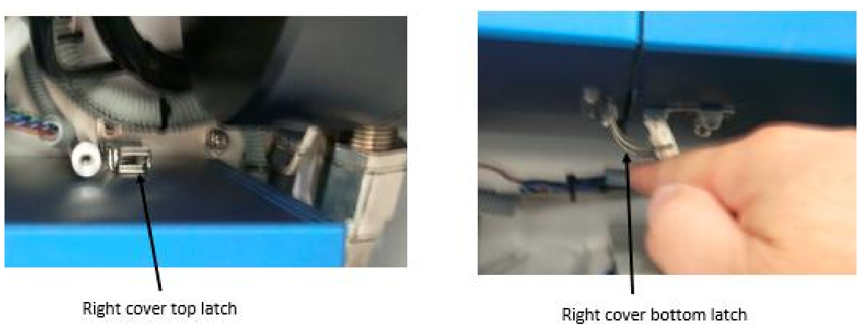
a. Open the latches at the top and bottom of the blue cover. To locate the latches, see Fig. 105.

b. Before pulling the cover from the enclosure, slide its right side to the right so that the “tongue”, that goes into the top cover, is out of the way.

NOTE: Do not bend the cover “tongue” in the removal process.

c. Remove the cover.

Fig. 105 ICOS Right Cover Latches



STEP 13 Disconnect the detector fan cable so that the cover can be laid down without putting stress on the cable.

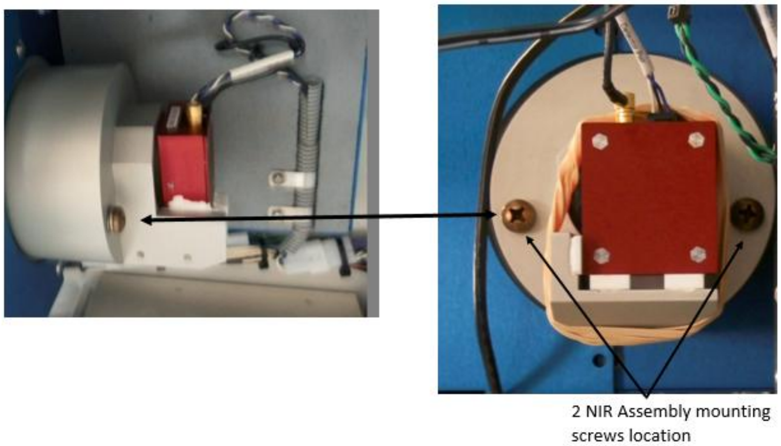
STEP 14 Remove the NIR detector:

a. Disconnect the communication cable from the NIR detector.

b. Remove the two mounting screws that hold the NIR detector to the ICOS cell.

c. Gently pull to the right the round mount containing a focusing lens and NIR detector assembly. The assembly should slide out easily once the the screws are removed. See Fig. 106 to locate the two screws to be removed first before pulling out the focusing lens and NIR detector assembly mount.

Fig. 106 NIR Assembly Mounting Screws Locations



With the NIR detector assembly and mount removed, the mirror flange is exposed on the detector side of the ICOS assembly. This mirror flange is exactly the same as the mirror flange on the laser side of the ICOS assembly, except that there is no PZT element on it.

STEP 15 Clean, reinstall and lock the astigmatic mirror:

a. Use the 5/32″ Allen key to loosen the three captive screws that hold the mirror flange to the ICOS assembly.

b. Repeat steps 6b through 9 to clean, reinstall and lock the astigmatic mirror back in the receiving end of the ICOS assembly.

c. Place the outer blue shield cover back, enclosing the NIR detector.

d. Reconnect the NIR detector fan power connector to the fan. Be careful not to bend the tongue on the blue shield top cover that is to be inserted in the top cover groove.

STEP 16 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 17 Close the Gas Analyzer:

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause serious injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 18 Finish the procedure and verify results:

a. Verify that temperature and pressure are moving toward their original settings and remain stable.

b. Close the filtered air line check valve feeding the Gas Analyzer.

c. Open the customer sample gas line valve to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

e. Close the Gas Analyzer front panel. The Gas Analyzer takes about 20 minutes to reboot. This is the time it takes for the pressure interlock switch to complete its test cycle.

f. Verify that the Gas Analyzer is providing accurate measurements.

STEP 19 In the Control Bar, look at "Laser A τ" and "Laser B τ" values (see Fig. 107; laser B τ only appears when Gas Analyzers are configured with two lasers). Ring down time is represented by the Greek letter τ. If the ring down time still exceeds 10% degradation from the reference factory setting (as shown in the Service tab, Fig. 31), replace the astigmatic mirrors.

Fig. 107 Control Bar – Ring-Down Time **τ**

NOTE: Ring-down time will vary depending on the Gas Analyzer model and the type of gas to be analyzed.

NOTE: Astigmatic mirrors are model-dependent. Make sure to order the correct astigmatic mirrors when replacement is required.

Calibration

The Gas Analyzer needs to be calibrated whenever the fiber laser or NIR detector is replaced. Calibration involves applying the correct extinction coefficient for the:

- Wavelength of the measured gas environment
- Selected laser wavelength
- Specific wavelength reflectivity level, providing the travel distance within the ICOS cell
- Concentration of the particular gas being measured in the customer's application.

The calibration end result should be a good fit between the measured data and the theoretical model.

Fine adjustment to the laser wavelength improves goodness of fit (GOF) between the theoretical model and the measured results. Over time, as the laser ages, its operating wavelength will gradually change. This change is automatically corrected by the Gas Analyzer application software (unless this feature is disabled). The laser operating wavelength can be entered manually to re-establish the proper GOF.

Required items and tools:

- Traceable regulated bottled gases

To calibrate the laser wavelength:

STEP 1 Close the customer sample gas line going to the Gas Analyzer inlet gas line.

STEP 2 Open the customer traceable, regulated, and certified bottled gas line check valve that is in line with the sample gas line.

STEP 3 Allow a few minutes for the Gas Analyzer to purge the ICOS system with the traceable, regulated, and certified bottled gas.

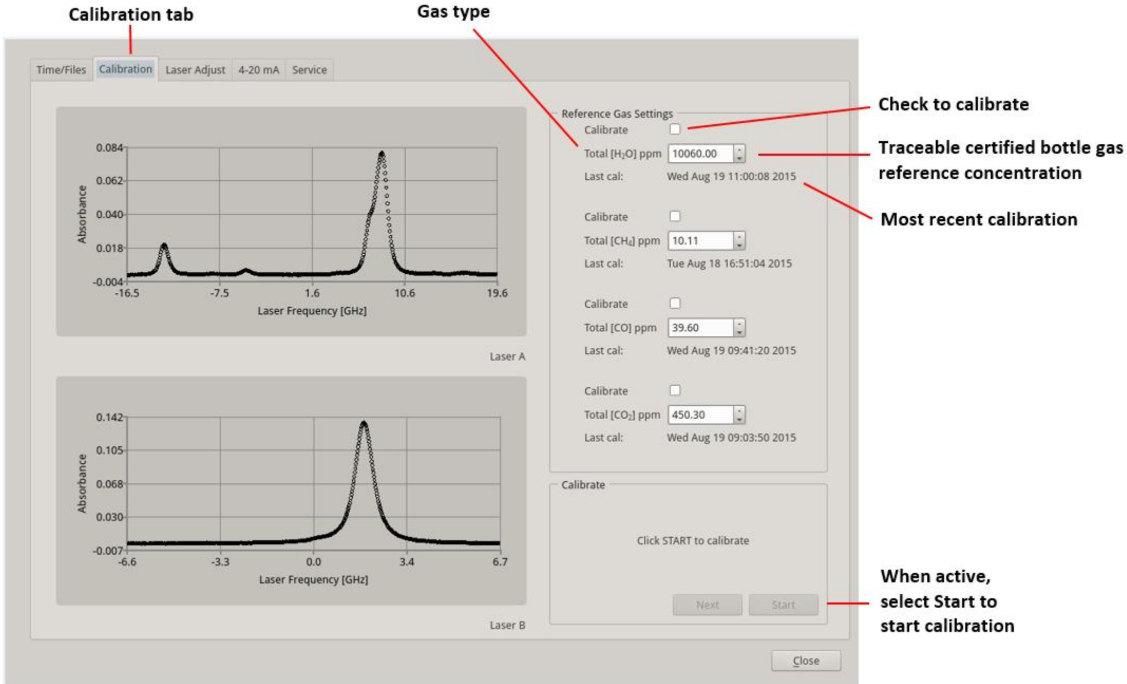
STEP 4 After the Gas Analyzer application software is launched, click Setup in the Control Bar.

STEP 5 In the Setup display, click the Calibration tab.

STEP 6 In the Reference Gas Settings, check the box next to the gas that you wish to calibrate. This would be the traceable bottled gas.

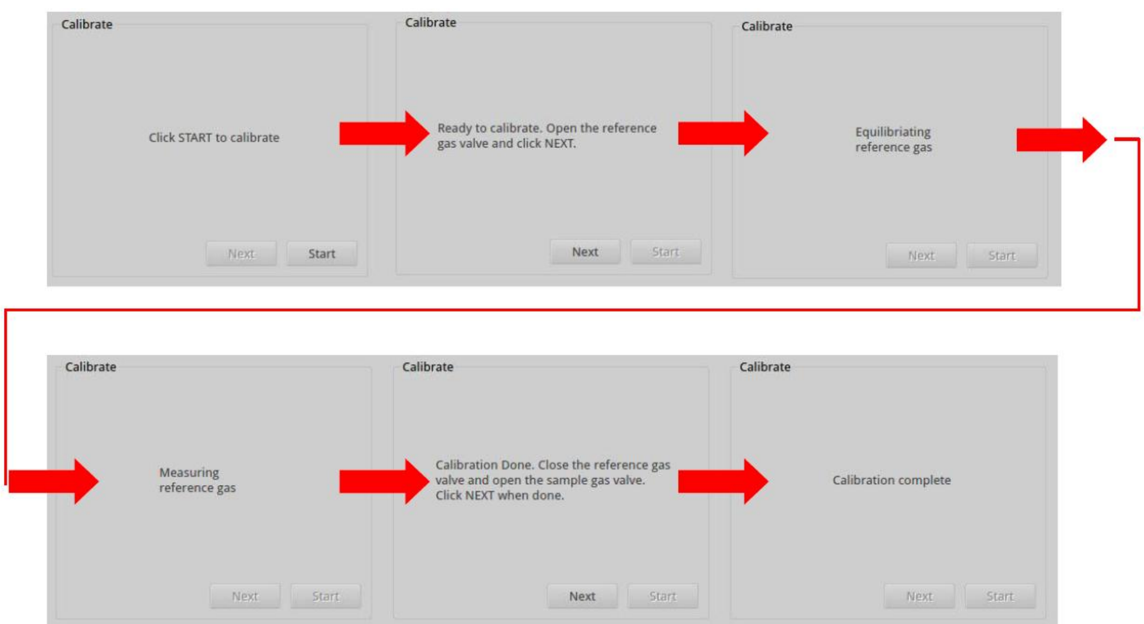
STEP 7 Enter the traceable bottled gas known concentration. See Fig. 108 for the parameter fields that require user input.

Fig. 108 Gas Calibration Display



STEP 8 Click Start. The screen shots in Fig. 109 will appear in sequence. The operator will need to click Start or Next to progress to the next phase of the calibration until the sequence is completed.

Fig. 109 Gas Calibration Flowchart



STEP 9 If the customer has multiple traceable regulated bottled gases available to cover the gases being measured by the Gas Analyzer at the customer site, repeat steps 5 through 7 with all traceable bottled gases.

STEP 10 Close the traceable bottled gas line valve.

STEP 11 Open the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

STEP 12 Click Close to exit from the Calibration screen.

STEP 13 Click Display in Control Bar.

STEP 14 In the screen that appears, select the Profile screen.

Laser Wavelength Fine Tuning

To fine tune the laser wavelength:

STEP 1 In the Setup screen, click the Laser Adjust tab.

STEP 2 In Fig. 110, the Laser Adjust tab displays the current gas sample measurement intensity profile and the corresponding absorption (dips in the profile). The vertical dotted lines in the same profile screen are the location of the expected absorption peaks. To correct for this difference, the laser wavelength is adjusted so that the bottom of the absorption peaks center around the dotted lines. To achieve this, the voltage setting the laser temperature is adjusted to move the laser operating wavelength. If the Gas Analyzer comes with two lasers, each laser can be fine-tuned so that the measured absorption peaks are in line with the theoretical targets.

Fig. 110 Laser Adjust Tab

STEP 3 Adjust the laser wavelength by selecting the UP or DOWN arrow on the Laser A frequency offset. If the Gas Analyzer contains two lasers, the Laser B voltage field would also be displayed as seen in Fig. 110. All adjustments are in real time, meaning that the measured profile should shift as the laser drive voltage changes. Once the peaks are centered on the dotted lines, the required adjustments are completed.

STEP 4 Click Close to exit the Setup display.

STEP 5 Turn off the traceable regulated bottled gas check valve.

STEP 6 Open the customer sample gas line so that the Gas Analyzer can take measurements.

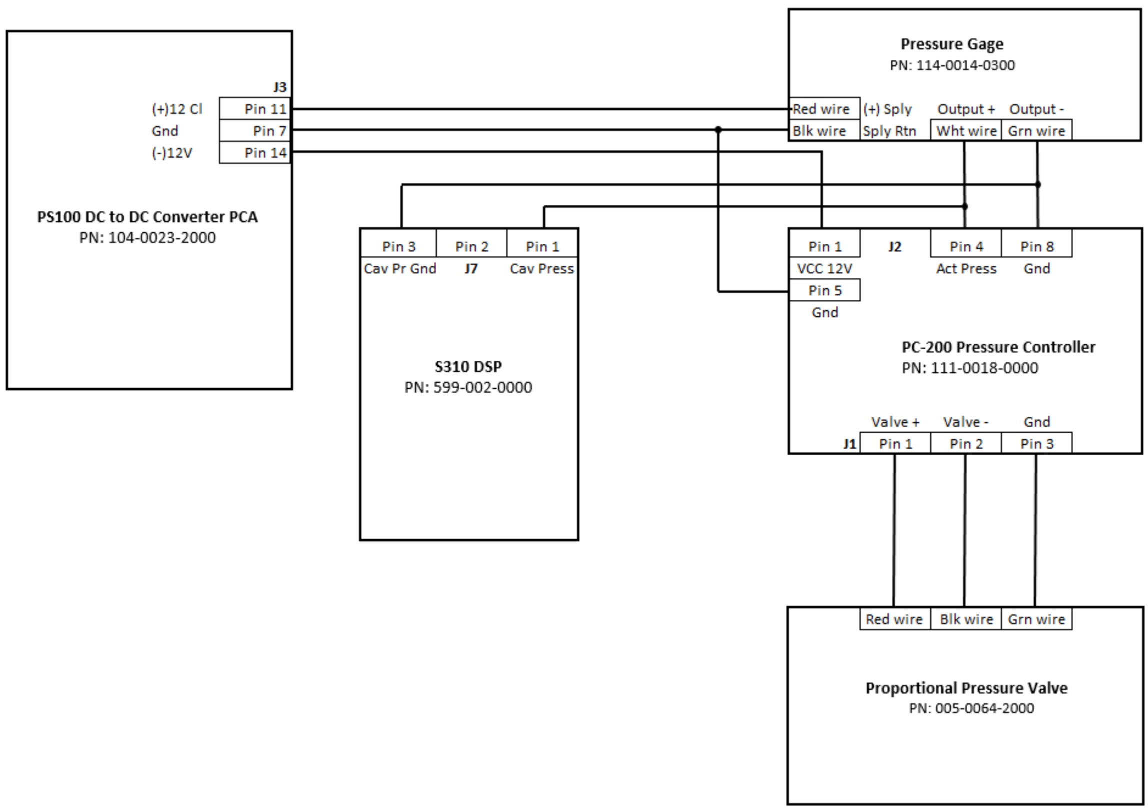
STEP 7 In the Spectrum display, verify that the customer's gas sample measured goodness of fit (GOF) overlaps the theoretical values.

Pressure Control

Tight pressure control (within < 0.3 Torr) along with tight temperature control (< ±2°C variation within the ICOS cell) of the sample gas being measured establishes a very repeatable use case for measurement repeatability. As stated in the measurement theory, a change in temperature and pressure will change the kinetic energy of gas molecules resulting in a shifts the gas's absorption line.

The ICOS Gas Analyzer uses backend pressure control to control the amount of pressure within the ICOS cell. Pressure within the ICOS is created by the instrument exhaust pump pulling gas through the ICOS. The amount of pressure within the ICOS is controlled by the proportional valve at the exhaust end of the ICOS cell. With the inlet gas valve open, and the gas flow rate supplied by the customer inlet gas line, the amount of pressure within the ICOS cell is monitored by a pressure gauge that sends its measured readings to the PC200 pressure controller PCA. Based on the pressure set for the Gas Analyzer, the PC200 pressure controller provides the drive voltage that opens and closes the proportional valve, thus maintaining a fixed pressure level within the ICOS cell. Fig. 111 is the wiring diagram of the ICOS Cell back end pressure control system.

Fig. 111 Pressure Control Wiring Diagram



Problems that the pneumatic system can encounter:

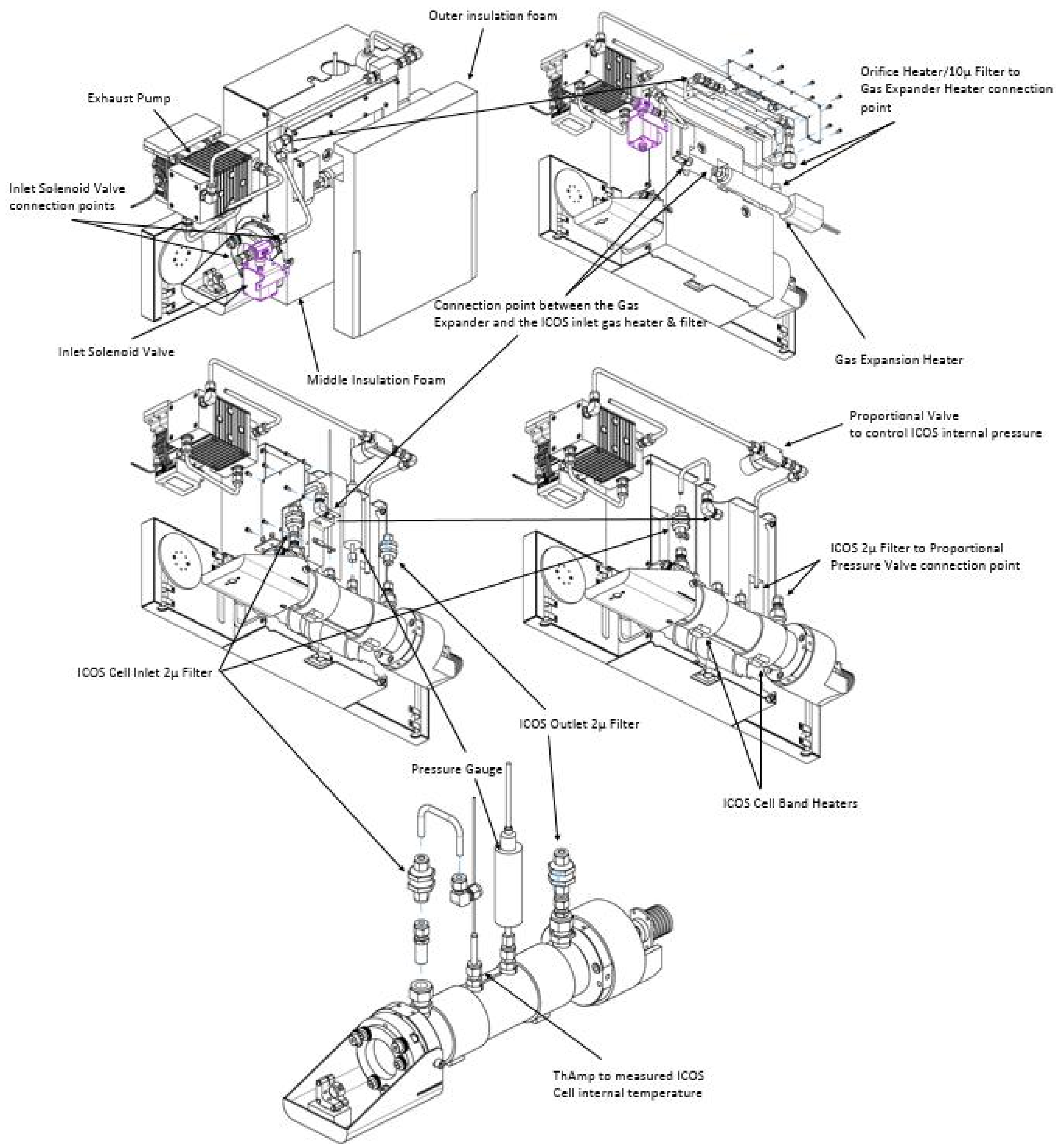
- Leaks
- Inlet or outlet valve failure
- Clogged filter(s)
- Valve control failure
- Exhaust pump failure

Troubleshooting Pneumatics Leaks

NOTE: This procedure is a Type 3 electrical safety task.

The ICOS cell pressure variation specification is < 1%. A change in pressure in the ICOS cell is normally the result of a leak at the connection points in the gas line of the ICOS assembly. The other possibility would be that the filters in the same gas lines are plugged from filtering the incoming sample gas for measurement. Fig. 112 illustrates an exploded view of the ICOS system, showing the various pneumatics line connection points, their components and their names.

Fig. 112 ICOS Assembly Exploded View



For pressure leak tests, an end cap will be used for the pneumatics gas tubes at the starting point on the inlet gas solenoid or where the last repair was made on the ICOS instrument. If testing these two locations proves inconclusive, move forward to determine at which end of the ICOS cell the leak is occurring by taking a leak test measurement at a location in the middle.

NOTE: *If any reverse unscrewing has occurred on standard pipe threads that require Teflon tape, these joints are the most likely points of failure.*

The location of these joints are 1) the connection point between the orifice heater output (with 10µ filter) and the gas expander and 2) on either side of the inlet solenoid valve. Overtightening the Swagelok will normally cause damage, flaring out the pipe at the contact point. Overtightening can be checked with a Swagelok gap inspection gauge.

Caution!	When performing leak tests, always bleed from the inlet solenoid valve side, to prevent the ICOS cell from getting dirty.

NOTE: *When reconnecting a piece of tube to another with a Swagelok, use a Swagelok gap inspection gauge to control how far in to turn the nut that seals the Swagelok to the tube. Using the Swagelok gap inspection gauge will prevent damage to the Swagelok. Stainless steel tubes on the Gas Analyzer have a ¼*″ *outer diameter.*

NOTE: *Certain materials like stainless steel will automatically cold weld to each other when interlocked using a Swagelok, thus requiring force to break them apart.*

Required items and tools:

- 4 end caps
- Swagelok union
- 9/16″ open end wrench
- ½″ open end wrench
- Philips screwdriver
- Swagelok gap inspection gauge for ¼″ tube (*no-go* gauge)
- Taega Seal PTFE tape ½″ wide (mil spec Teflon tape)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To test for pressure leaks:

STEP 1 From past Gas Analyzer logged data, look for recorded pressure readings. If that source is not available, look for the Gas Analyzer data sheet that was shipped with the instrument. If that is not available, contact LGR with the instrument serial number to obtain the instrument’s logged baseline measurements performed prior to the instrument being shipped to the customer. This will be the target results to obtain.

STEP 2 Shut off the customer sample gas line connected to the Gas Analyzer inlet gas line.

STEP 3 Open the filtered air line check valve on the same line.

STEP 4 Insert the bypass key in the internal pressure interlock switch to bypass the interlock and keep the instrument powered on once the Gas Analyzer front panel is opened.

STEP 5 Open the Gas Analyzer

a. Use the Philip screwdriver to loosen all clamps securing the Gas Analyzer front panel.

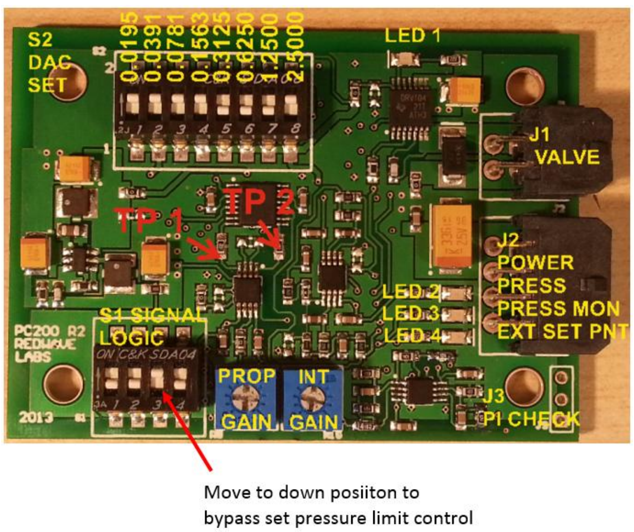
b. Open the Gas Analyzer front panel.

c. Secure the grounding wrist strap to the Gas Analyzer chassis.

STEP 6 Slide Sw1 on the solenoid valve driver to the center position to close the inlet solenoid valve.

STEP 7 On the PC200 pressure controller, set switch S1 dip switch 3 to the same (down) position as the other three dip switches so that the system pumps down, setting the proportional valve wide open, bypassing the pressure set by the eight S2 dip switches. Fig. 113 shows the location of the S1 switch on the PC200 pressure controller PCA.

Fig. 113 PC200 Pressure Controller PCA



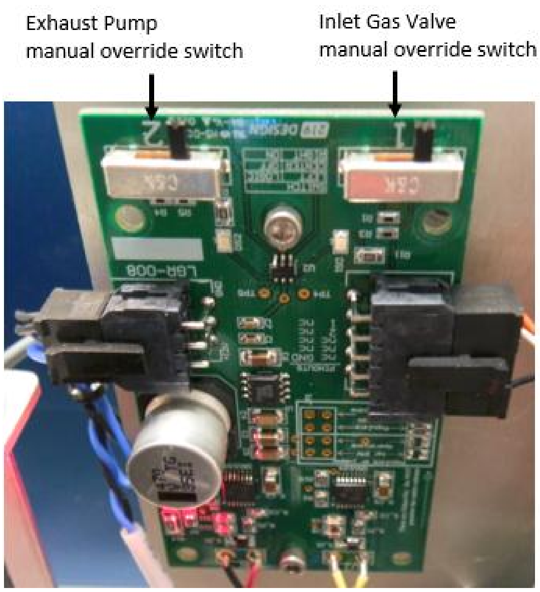
STEP 8 Look at the cell pressure reading on the Control Bar. The cell pressure should drop to ≤25 Torr within three minutes. If that is the case, the leak was between the inlet gas line coming into the Gas Analyzer enclosure and the inlet solenoid valve. That problem is now solved. Otherwise, proceed to test the remaining parts of the ICOS assembly and continue to the next step.

STEP 9 Disconnect the proportional valve power cable connector. This will close the valve inside the proportional valve. See Fig. 114 to locate the proportional valve power connector.

Fig. 114 Proportional Valve Power Connector

STEP 10 On the solenoid valve driver PCA, slide Sw2 to the center position to stop the exhaust pump. See Fig. 115 to locate Sw2.

Fig. 115 Solenoid Valve Driver PCA, Normal Operation Switch Setting



STEP 11 On the solenoid valve driver, slide Sw1 to the right position to open the inlet solenoid valve. This will release/bleed out the vacuum air within the ICOS cell for easier removal of the interconnecting tubes.

STEP 12 Open the latches holding the blue cover heat shield on both left and right sides of the ICOS assembly

STEP 13 Slide out the shields, keeping the tongue straight.

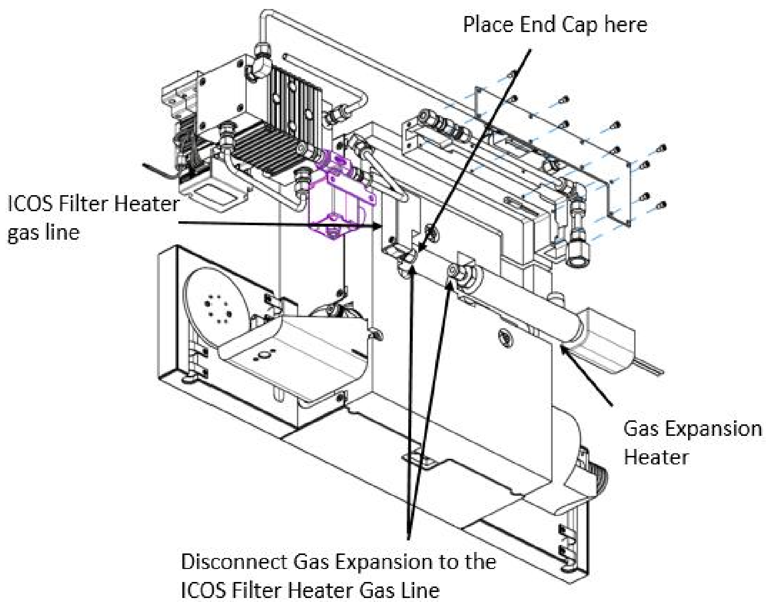
STEP 14 Before lifting out the three sides of the heat shield, remove the two screws that hold these sides in place.

STEP 15 Remove the ICOS assembly top heat shield cover.

STEP 16 Remove the outer center foam exposing the orifice filter heater and gas expander assemblies.

STEP 17 Disconnect the union between the gas expander and the ICOS filter heater (see Fig. 116).

Fig. 116 Gas Expander Heater – ICOS Filter Heater Connection Point



STEP 18 Install an end cap on the ICOS filter heater open gas line that was connected to the gas expander (see Fig. 116).

STEP 19 Slide Sw2 on the solenoid valve driver PCA to the left to turn on the exhaust pump.

STEP 20 Reconnect the power line to the proportional valve.

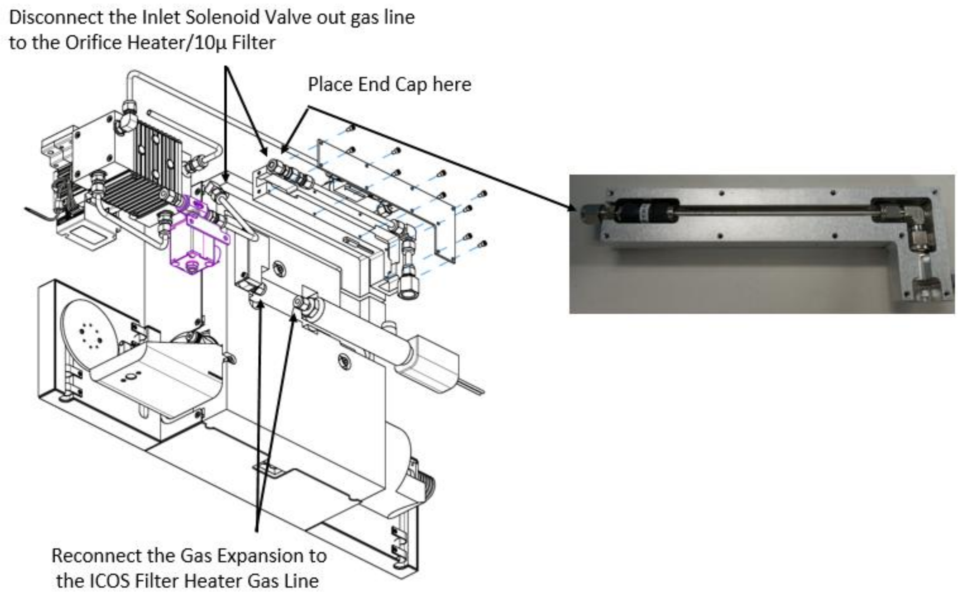
STEP 21 On the PC200 pressure controller, set switch S1 dip switch 3 to the same (down) position as the other three dip switches so that the system pumps down, setting the proportional valve wide open, bypassing the pressure set by the eight S2 dip switches. Fig. 113 shows the location of switch S1 on the PC200 pressure controller PCA.

STEP 22 Look at the cell pressure reading on the Control Bar. The cell pressure should drop to ≤25 Torr within three minutes. If that is the case, the leak is between the end cap and the proportional valve. Otherwise, the leak is in the line between the gas expander and the inlet solenoid valve.

STEP 23 For leaks between the gas expander and the inlet solenoid valve:

a. Use the Swagelok gap inspection gauge for ¼″ tubes and check the gaps between the Swagelok locking nut and the nut on the mating surface.
b. Disconnect the power line to the proportional valve. The valve closes.
c. On the solenoid driver board, slide Sw2 to the center position to stop the exhaust pump.
d. Disconnect the gas line linking the inlet solenoid valve to the orifice heater/10µ filter assembly.
e. Install an end cap on the orifice heater/10µ filter side of the pipe (see Fig. 117).

Fig. 117 Inlet Solenoid Valve - Orifice Heater /10µ Filter Connection



f. Remove the end cap from the ICOS filter heater assembly.

g. Reconnect the ICOS filter heater assembly to the gas expansion heater assembly.

h. Use the Swagelok gap inspection gauge for ¼″ tubes to properly tighten the Swagelok into position. The gap between the Swagelok nut and mating side should be barely smaller that the gap inspection gauge for pipes of that diameter.

i. On the solenoid valve driver board, slide Sw2 to the left to turn on the exhaust pump.

j. Reconnect power to the proportional valve to open it.

k. Again, verify if the ICOS cell pressure drops to ≤25 Torr within 3 minutes. If it passes the test with the end cap at this position, the leak is at the inlet solenoid valve, most likely at the joint with the Teflon tape.

l. Replace the Teflon tape on the reducer fitting connected to either side of the inlet solenoid valve. Do not pull the fitting from the inlet solenoid valve once it is in. Pulling it out will cause the Teflon tape to tear even more within the pipe, creating a bigger leak.

m. Repeat the steps to turn off the exhaust pump.

n. Close the proportional valve before removing the end cap and transferring it to another location.

o. Once the leak is found and fixed, test with all the gas lines reconnected. Retest again to verify that it is truly fixed and skip the remaining part of the instructions for repair at a different location.

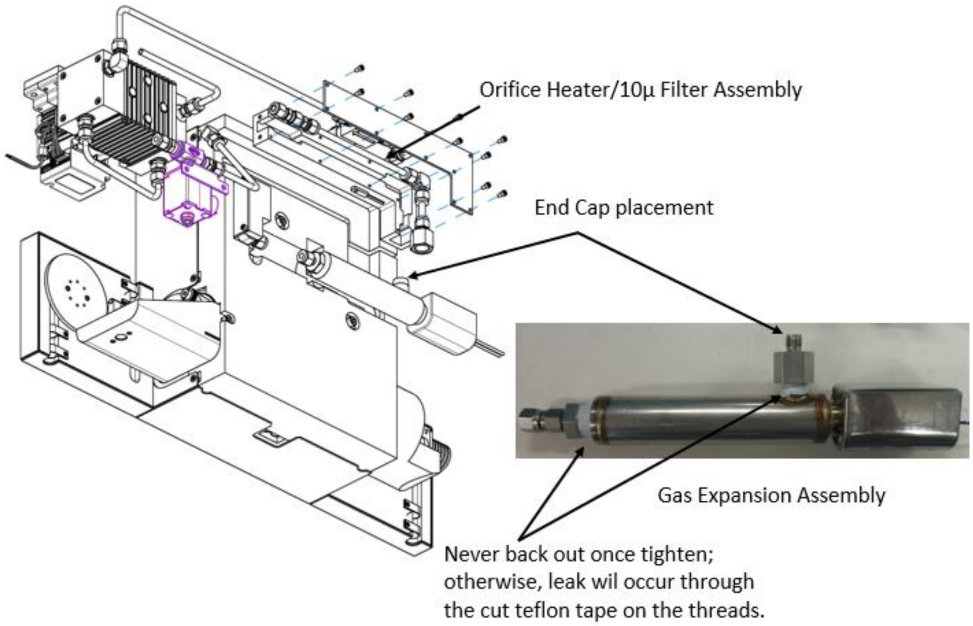
If it failed at this position, the problem is now narrowed to the union between the orifice heater/10µ assembly and the gas expansion assembly. The leak is most likely at the Teflon tape on the joints' input and output.

STEP 24 For verification, remove power from the proportional valve.

STEP 25 Turn off the exhaust pump.

STEP 26 Transfer the end cap to the gas expansion entry point (see Fig. 118).

Fig. 118 Orifice Heater/10µ Filter – Gas Expansion Connections



STEP 27 Turn on the exhaust pump using the switch at the solenoid valve driver PCA.

STEP 28 Reconnect power to the proportional valve and note the time it takes for the ICOS cell to reach ≤25 Torr.

STEP 29 If it is still leaking, the problem is with the connection using the Teflon tape on the gas expansion:

a. Replace the Teflon tape. Do not pull out the reducer with the Teflon tape. That will cause a tear in the Teflon tape and create a bigger leak.

b. After repairs are made, re-test the fix.

For leaks between the ICOS cell and the exhaust pump, the air bleed out time is 0.1 Torr per minute with the exhaust pump is turned off and the end cap is still on the ICOS filter heater from step 18. The only connection points that can be tested would be the line between the ICOS cell exhaust port and the proportion valve. If the vacuum loss is greater than 0.1 Torr per minute, the problem is with the tube between these two parts. The tube needs to be replaced.

However, if the bleed time is met, the problem would be with the line between the proportional valve and the exhaust pump.

STEP 30 Reassemble the ICOS system:

a. Close the Gas Analyzer front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 31 Finish the procedure and verify results:

a. Verify that temperature and pressure are moving toward their original settings and remain stable.

b. Close the filtered air line check valve feeding the Gas Analyzer.

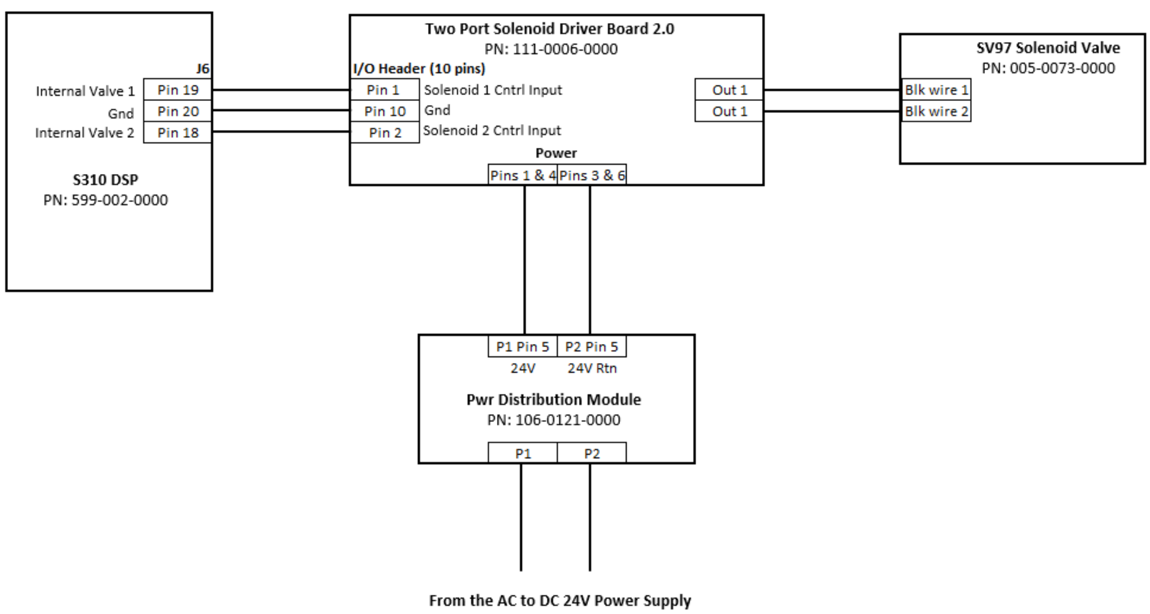
c. Open the customer sample gas line valve to the Gas Analyzer inlet gas line.

d. After 20 minutes, verify that gas measurements are stable and accurate.

Inlet Solenoid Valve

The inlet solenoid valve allows the incoming flow of customer gas sample to the Gas Analyzer ICOS system. There are only two operating states for this valve: open or close. The inlet solenoid valve is in the “normally closed” state when there is no power. The inlet solenoid valve is controlled by the computer on the PC104 stack through the S310 DSP PCA. This S310 DSP PCA sends on/off signals to the 2-port solenoid driver board to provide or cut power to the solenoid valve. While in operation, the valve is always open. The drive voltage to open the valve is 6V DC (the starting voltage will be ~24V DC and will transition down to 6V DC). This voltage can be measured at the “Out 1” terminal on the 2-port solenoid driver board. Fig. 119 illustrates the inlet solenoid valve wiring diagram.

Fig. 119 Inlet Solenoid Valve Wiring Diagram



Troubleshooting

To make sure that the inlet solenoid valve is operating properly, one has to look at both the ICOS cell pressure reading and the measured gas spectrum display. With the inlet valve closed and the exhaust pump working properly, the ICOS cell pressure reading (in Torr) will drop from the normal baseline if the Gas Analyzer is operating properly. Also, when the inlet solenoid valve is closed, all readings for the customer's incoming gas (not including noise readings coming from the NIR detector) will be around 0 ppm. Gas spectrums will not display absorption profiles. However, plugged filters on the inlet side of the ICOS cell can produce similar results.

To determine if the valve switches from one position to the other, listen for a "clunk" sound during the valve transition. With the 2-port solenoid driver board providing a 6V DC drive voltage, slide Sw1 from the center position to the left position to open the valve. Slide it from left to center to close the valve.

Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- 4 end caps
- Swagelok union
- 9/16″ open end wrench
- ½″ open end wrench
- Philips screwdriver
- Blade screwdriver
- Swagelok gap inspection gauge for ¼″ tubes (*no-go* gauge)
- Taega Seal PTFE tape ½″ wide (mil spec Teflon tape)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To replace the inlet solenoid valve:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the "Off" position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the inlet solenoid valve:

a. Uncouple the inlet solenoid valve right Swagelok and separate it from the gas line going into the orifice filter/heater assembly.

b. Disconnect the inlet solenoid valve power cable.

c. Uncouple the inlet solenoid valve from the left Swagelok

d. Remove the inlet solenoid valve from the assembly.

STEP 5 Connect the new inlet solenoid valve power cable.

STEP 6 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 7 On the 2-port solenoid driver board, move Sw1 from center to left to open the valve. Listen for the transition.

STEP 8 Slide Sw1 from left to center to close the valve.

STEP 9 After making sure that the new inlet solenoid valve is working properly, reconnect the two ends back to the inlet gas line and the outlet line leading to the orifice filter/heater assembly.

STEP 10 Slide Sw1 to the right.

STEP 11 When locking in the gas lines leading to and away from the inlet solenoid valve, tighten the Swagelok only slightly beyond the Swagelok gap inspection gauge for ¼″ tubes.

NOTE: Over tightening the Swagelok can damage pipe ends and threads. Make sure that the “arrow” on the inlet solenoid valve points to the right, in the direction of the gas flow. Do not pull on the reducer that has been locked in the inlet solenoid valve. That would cause a leak at the threads.

STEP 12 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 13 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 14 Close the Gas Analyzer:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 15 Finish the procedure and verify results:

a. After the Gas Analyzer completes its initialization process, verify that temperature and pressure are moving toward their original settings and remain stable.

b. Close the filtered air line check valve on the customer sample gas line.

c. Open the customer sample gas line and give the Gas Analyzer a few minute to fill the ICOS cell with the gas sample.

d. Make sure that customer gas measurements are back within their control limits.

e. Wait a few minutes to allow the exhaust pump to pull in the filtered air from the gas line and look at the Control Bar to see if the ICOS cell pressure goes back to the original baseline level for this Gas Analyzer model.

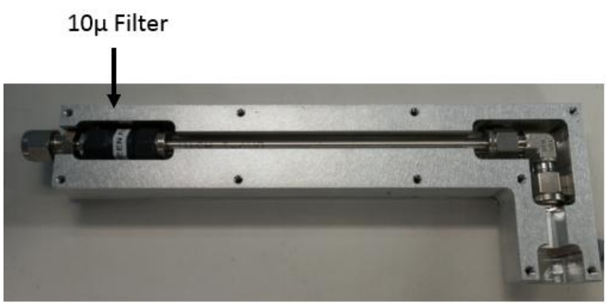
Filters

There are four filters currently in use in the ICOS assembly. Three of them are on the input side to prevent wet substances from getting into the ICOS cell. The fourth is just after the ICOS cell, to prevent contaminants from going into the ICOS cell should back pressure occur in the pneumatic system when the ICOS assembly is opened for maintenance.

There is one 10µm filter placed at the inlet solenoid valve to trap substances mixed in with the gas. This filter needs to be replaced every year as part of the preventive maintenance (PM).

The second 10µm filter is placed in the orifice heater filter to further filter out contaminants from the gas. This filter is replaced every five years with the orifice. The 10µm filter and orifice are shown in Fig. 120. The whole plumbing, filters and pipes are replaced as part of the five-year PM.

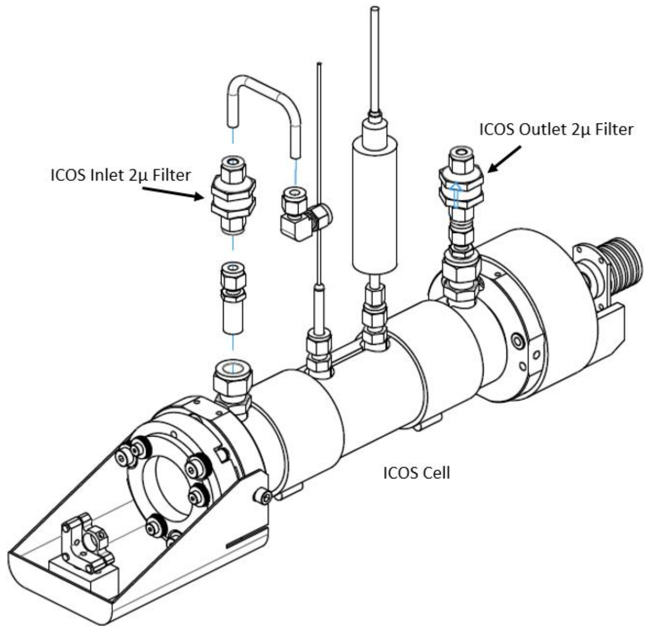
Fig. 120 10µ Filter Location



There are two 2µm filters in the ICOS assembly. One is located right before the sample gas inlet into the ICOS cell. The second 2µm filter is located at the ICOS cell gas output. The 2µm filter in front of the ICOS cell captures fine contaminants before they reach the ICOS cell. On the output side of the ICOS cell, the 2µm filter prevents contaminants from going back into the ICOS cell if the wrong end were to be opened and cause air back pressure into the ICOS cell. These filters are replaced every 10 years in PM. Fig. 121 shows the locations of the 2µm filters. The filters are simply screens and there is no orientation requirement to define flow direction.

NOTE: Filters used in HCL and ammonia Gas Analyzers require a special coating to allow the measured gas to go through the filters without getting trapped in it. Be sure to order the appropriate filter type when performing a replacement. Filters are identified by gas type.

Fig. 121 2µ Filter Locations

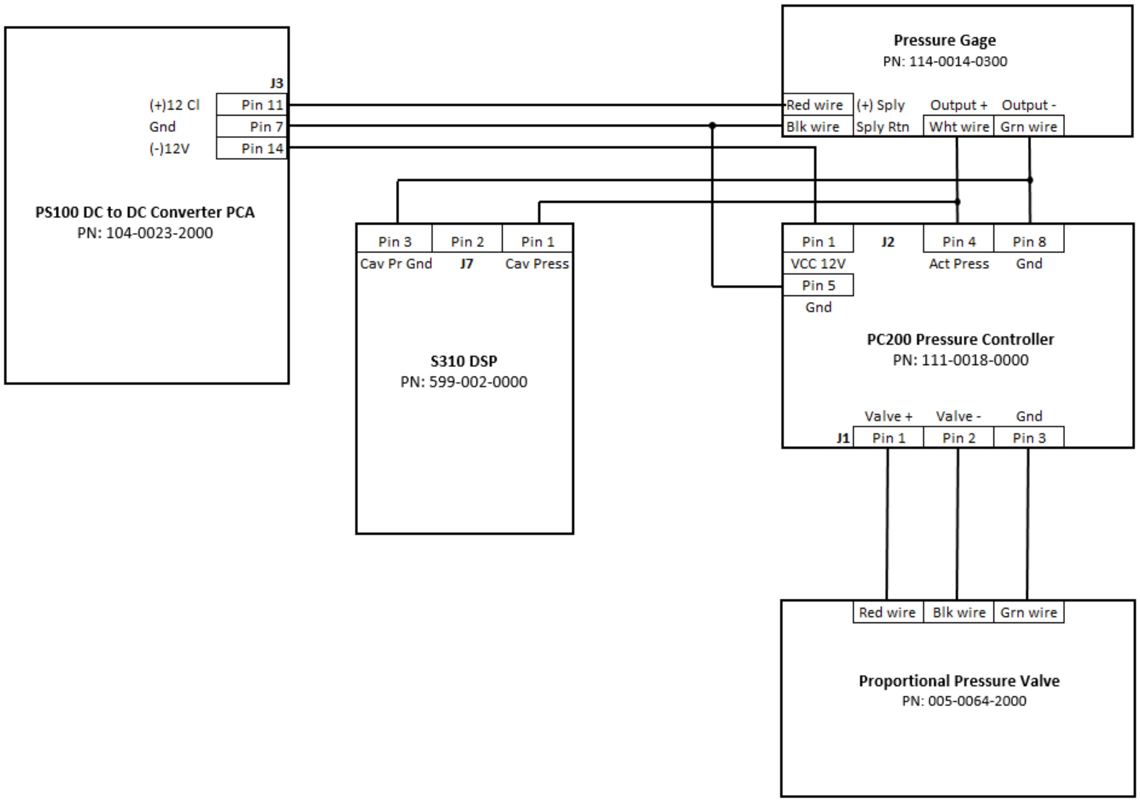


If the customer gas is really dirty and causes filters to clog more quickly than expected, the result of a clogged filter will be an increase in the ICOS cell pressure as read in the Control Bar. In this situation, filters must be replaced before reaching the targeted PM time frame. Filter replacement instructions will be in the PM procedure.

Pressure Control System

The pressure control system is comprised of the PC200 pressure controller, the proportional valve and a pressure gauge. These components control the ICOS cell internal pressure. Measurements taken by the ICOS cell pressure gauge are sent to the PC200 pressure controller through connector J2 pin 4 (actual pressure) and pin 8 (ground, a DC voltage level). This signal is compared with the voltage set on the S2 dip switches. The S2 dip switches are set to achieve a specific pressure level within the ICOS cell by opening the proportional valve to a certain degree. The amount of vacuum drawn by the exhaust pump is fixed since it only runs at one speed, so the pressure inside the ICOS cell is controlled by changing the size of the proportional valve opening. Fig. 122 illustrates the pressure control wiring diagram.

Fig. 122 Pressure Control Loop Wiring Diagram



Troubleshooting

To troubleshoot the pressure control system when the pressure inside the ICOS cell exceeds the factory set limits, one needs to initiate a pressure change and measure what changes and what does not, to determine the faulty component.

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- Thin blade screwdriver
- Philips screwdriver
- Grounding wrist strap
- Digital volt meter (DVM)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To troubleshoot the pressure control system:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the customer sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

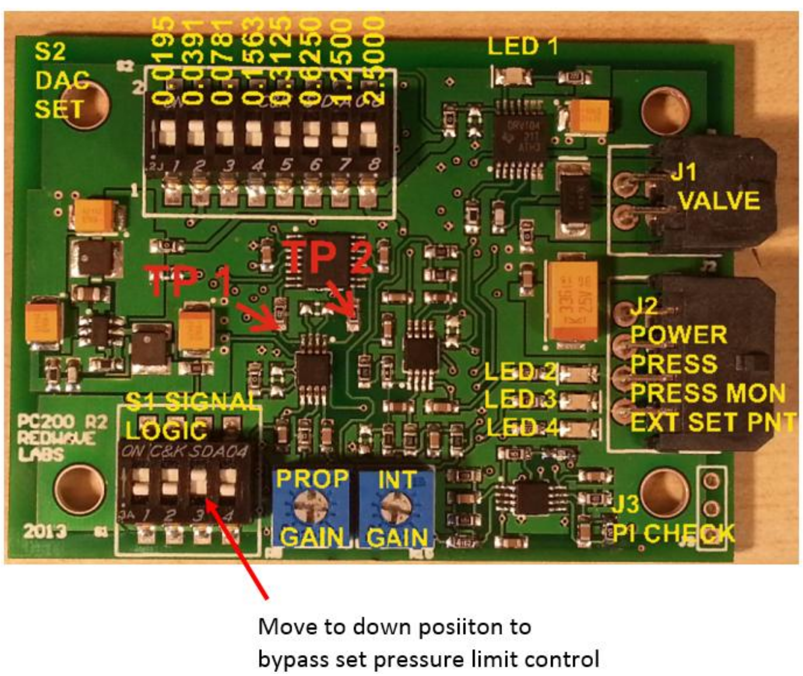
STEP 3 Insert the DVM test probe into connector J2 pin 4 (+ terminal) and pin 8 (ground) of the PC200 pressure controller board.

STEP 4 Set the DVM to read DC voltage (see Fig. 123 for J2 connector pinout location). Remember the current DC voltage reading at pins 4 and 8 of the PC200 pressure controller board.

Fig. 123 J2 Connector Pinout

STEP 5 Move the S1 dip switch 3 to the *down* position on the PC200 pressure controller board (see Fig. 124 for the S1 dip switch location).

Fig. 124 PC200 Pressure Controller PCA



STEP 6 DC voltage from pins 4 and 8 should move upward so that the proportional valve opens even more. If voltage moves upward, the pressure gauge attached to the ICOS cell is working properly.

If they do not, check if there is DC power feeding the pressure gauge at the power connector. It should register +12V (purple wire) and –12V (white wire) relative to the ground (black wire). If DC voltages are present, the problem lies with the pressure gauge. Go to the procedure to replace the pressure gauge.

STEP 7 If the pressure gauge is working, insert the DVM test probe in the PC200 pressure controller proportional valve red (+V) and white (–V) wire power connectors. Remember the voltage readings registered on the DVM.

STEP 8 On the PC200 pressure controller board, move the S1 dip switch 3 back to its original *up* position, opposite the other three dip switch positions.

STEP 9 Allow a few minutes for the air pressure within the ICOS cell to bleed out to a level where the ICOS cell pressure starts going back up. This pressure going up is caused by the proportional valve closing slightly to correspond to the voltage drop and bringing the ICOS cell internal pressure to the pressure set by the S2 dip switches.

STEP 10 If the voltage changes, the PC200 pressure controller board is working properly. If the voltage changes but the pressure does not go outside the ICOS bleed rate, the problem is a stuck proportional valve.

NOTE: If power to the proportional valve is cut, the valve should close. Replace the faulty component.

Proportional Valve Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- 4 end caps
- Swagelok union
- 9/16″ open end wrench (2)
- ½″ open end wrench
- Philips screwdriver
- Blade screwdriver
- Swagelok gap inspection gauge for ¼″ tubes (*no-go* gauge)
- Taega Seal PTFE tape ½″ wide (mil spec Teflon tape)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the proportional valve:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the proportional valve:

a. Disconnect the power cable connected to the proportional valve.

b. Uncouple the proportional valve right Swagelok below the elbow.

c. Separate it from the gas line coming from the ICOS cell assembly.

d. Uncouple the proportional valve left Swagelok.

e. Separate it from the exhaust line going to the exhaust pump.

STEP 5 Install the new proportional valve:

a. Insert the gas line leading from the ICOS cell to the proportional valve inlet at the elbow. The arrow on the proportional valve should point toward the exhaust valve.

b. Secure the gas line into place by tightening the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes. Do not overtighten the Swagelok as this could damage the pipe and its thread.

c. Insert the gas line linking the exhaust pump to the proportional valve.

d. Secure the gas line into place by tightening the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes. Do not overtighten the Swagelok as this could damage the pipe and its thread.

STEP 6 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 7 After the Gas Analyzer completes its initialization process, make sure that temperature and pressure move toward their original settings and remain stable.

STEP 8 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 9 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 10 Close the Gas Analyzer:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Initialize the Gas Analyzer upon prompt.

STEP 11 Finish the procedure and verify results:

a. Once the Gas Analyzer completed its initialization, verify that temperature and pressure are moving toward their original settings and remain stable.

b. Wait a few minutes to allow the exhaust pump to pull in the filtered air from the gas line and look at the Control Bar to see if the ICOS cell pressure goes back to the original baseline level for this Gas Analyzer model.

STEP 12 Close the filtered air line check valve on the customer sample gas line.

STEP 13 Open the customer sample gas line and give the Gas Analyzer a few minute to fill the ICOS cell with the gas sample.

STEP 14 Make sure that customer gas measurements are back within their control limits.

PC200 Pressure Controller Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required tools and items:

- Philips screwdriver
- Grounding wrist strap
- Standard set of Allen wrenches
- Thin blade screwdriver

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the PC200 pressure controller:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Replace the PC200 pressure controller board:

a. Disconnect the power and communication cables from the PC200 pressure controller board.

b. Remove the board from the Gas Analyzer chassis.

c. Make sure that S1 and S2 dip switch settings on the new PC200 pressure controller board match the settings on the board that was just removed.

d. Secure the new PC200 pressure controller board to the Gas Analyzer chassis.

e. Connect the power and communication cables to the new PC200 pressure controller board.

STEP 5 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 6 Once the Gas Analyzer completed its initialization, wait a few minutes and look at the Control Bar to see if the ICOS cell pressure goes back to the original baseline level for this Gas Analyzer model.

STEP 7 Disconnect the grounding wrist strap from the Gas Analyzer chassis.

STEP 8 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 9 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 10 Close the Gas Analyzer and verify results:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Close the filtered air line check valve on the customer sample gas line feeding the Gas Analyzer.

e. Open the customer sample gas line valve and let the gas sample go into the Gas Analyzer for measurement.

f. Wait 20 minutes for the system to stabilize by looking at the Gas Analyzer gas operating temperature and pressure readings to see if they reached the values set before to the instrument’s failure.

g. Make sure that customer gas measurements are back within the control limits that existed prior to instrument failure.

Exhaust Pump

The exhaust pump sole function is to expel the gas sample that has passed through the ICOS system. It should be running continuously. If the exhaust pump fails, the ICOS internal pressure will increase dramatically as if the exhaust was plugged. A 2-port solenoid driver controls the exhaust pump. The control line is ported to the exhaust pump relay. There should be a 12V DC going between the signal line and the return line, when measured at the relay. When the relay is closed, a 24V DC will be supplied to the exhaust pump.

NOTE: A failed proportional valve will give the same symptoms as a failed exhaust pump if only looking at the ICOS cell pressure.

The exhaust pump diaphragm is replaced once a year during the yearly preventive maintenance (PM). The exhaust pump will be replaced every five years during PM.

Troubleshooting

There is only one failure mode on the exhaust pump, but there are two possible causes:

- Motor failure, i.e.: bearings, windings, electronics, etc.
- Tear in the diaphragm

Motor failure is easily identified when verifying if the exhaust pump is running on 24V DC. When running, the pump should vibrate.

To troubleshoot a diaphragm failure, the line between the exhaust pump and the proportional valve needs to be separated from the proportional valve itself. Then, run the exhaust pump and check if there is a vacuum draw from the open pipe end, and air pressure pushing out on the exhaust side. If one or the other does not happen, the diaphragm is damaged. If the exhaust pump works properly, the problem lies with the proportional valve.

For instructions on how to replace the diaphragm on the exhaust pump, see the appropriate PM procedure.

Replacement

NOTE: This procedure is a Type 3 electrical safety task.

Required items and tools:

- 1/8″ T-style Allen wrench
- 9/16″ open end wrench (2)
- Philips screwdriver
- Blade screwdriver
- Swagelok gap inspection gauge for ¼″ tubes (*no-go* gauge)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To replace the exhaust pump:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the customer sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

f. Turn the key to put it into bypass mode.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

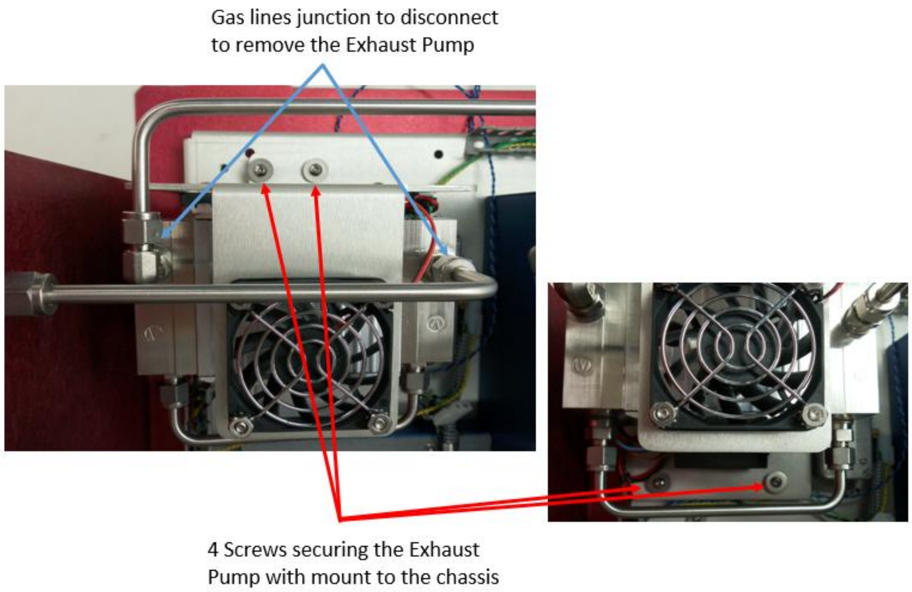
STEP 3 Disconnect the exhaust pump 24V DC power at the power connector.

STEP 4 Remove the exhaust pump:

a. Disconnect the Swagelok fittings on the left outlet to the customer exhaust line and the right inlet between the ICOS cell and the exhaust pump.

b. Separate the pipes from the Swagelok. To locate the Swagelok fitting disconnect points, see Fig. 125.

Fig. 125 Exhaust Pump



c. Remove the four screws that secure the exhaust pump and mount to the chassis. Remove the top screws last. To locate the four exhaust pump mount screws, see Fig. 125.

STEP 5 Install the new exhaust pump:

a. Transfer the new exhaust pump on the mount.

b. Reinstall the assembly (mount and exhaust pump) onto the Gas Analyzer chassis. Mount the two top screws first to provide support when putting back in the two bottom screws.

c. Reconnect the exhaust gas line between the exhaust pump and the proportional valve.

d. Tighten the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes to secure the gas line into place. Overtightening could damage the Swagelok and, in turn, damage the pipe and pipe threads.

e. Reconnect the exhaust gas line between the exhaust pump and the exhaust line leading out of the Gas Analyzer enclosure.

f. Tighten the Swagelok slightly beyond the Swagelok gap inspection gauge for ¼″ tubes to secure the gas line into place. Overtightening could damage the Swagelok and, in turn, damage the pipe and pipe threads.

STEP 6 Reconnect the exhaust pump power cable to the DC power supply connector at the solid state relay.

STEP 7 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 8 Once the Gas Analyzer completes it initialization, select the Numerical display on the Control Bar and verify that the ICOS cell pressure is back to normal levels. If the ICOS cell pressure is low, check again for leaks at the Swagelok fitting. Resolve all leaks before closing up the instrument.

STEP 9 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 10 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 11 Close the Gas Analyzer and verify results:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Close the filtered air line check valve on the customer sample gas line feeding the Gas Analyzer.

e. Open the customer sample gas line valve and let the gas sample go into the Gas Analyzer for measurement.

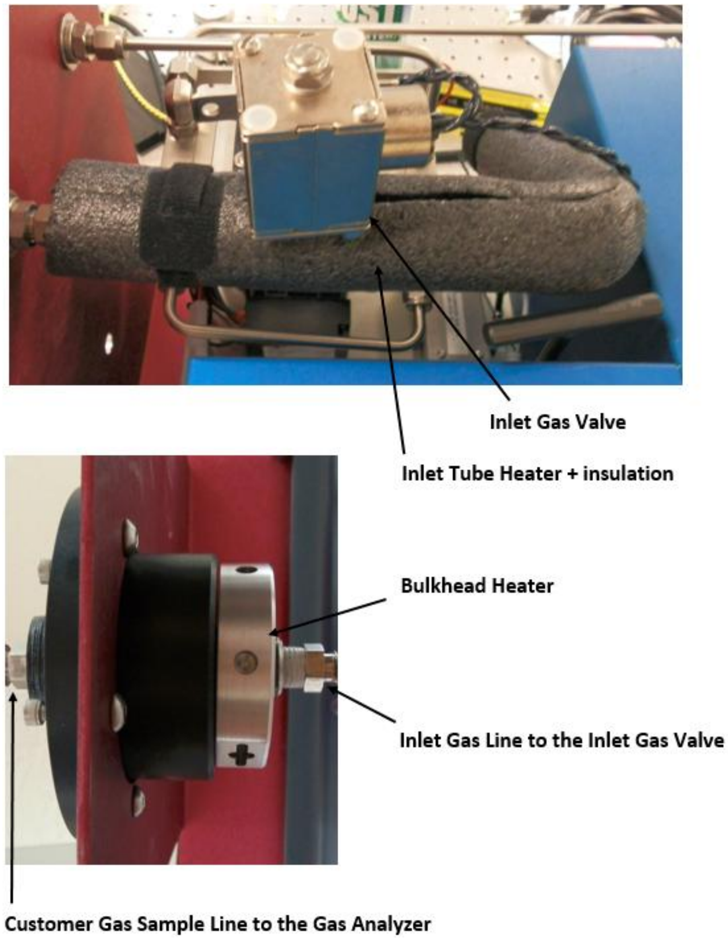
f. Wait 20 minutes for the system to stabilize by looking at the Gas Analyzer gas operating temperature and pressure readings to see if they reached the values set before to the instrument’s failure.

g. Make sure that customer gas measurements are back within the control limits that existed prior to instrument failure.

Inlet Tube Heater & Bulkhead Heater

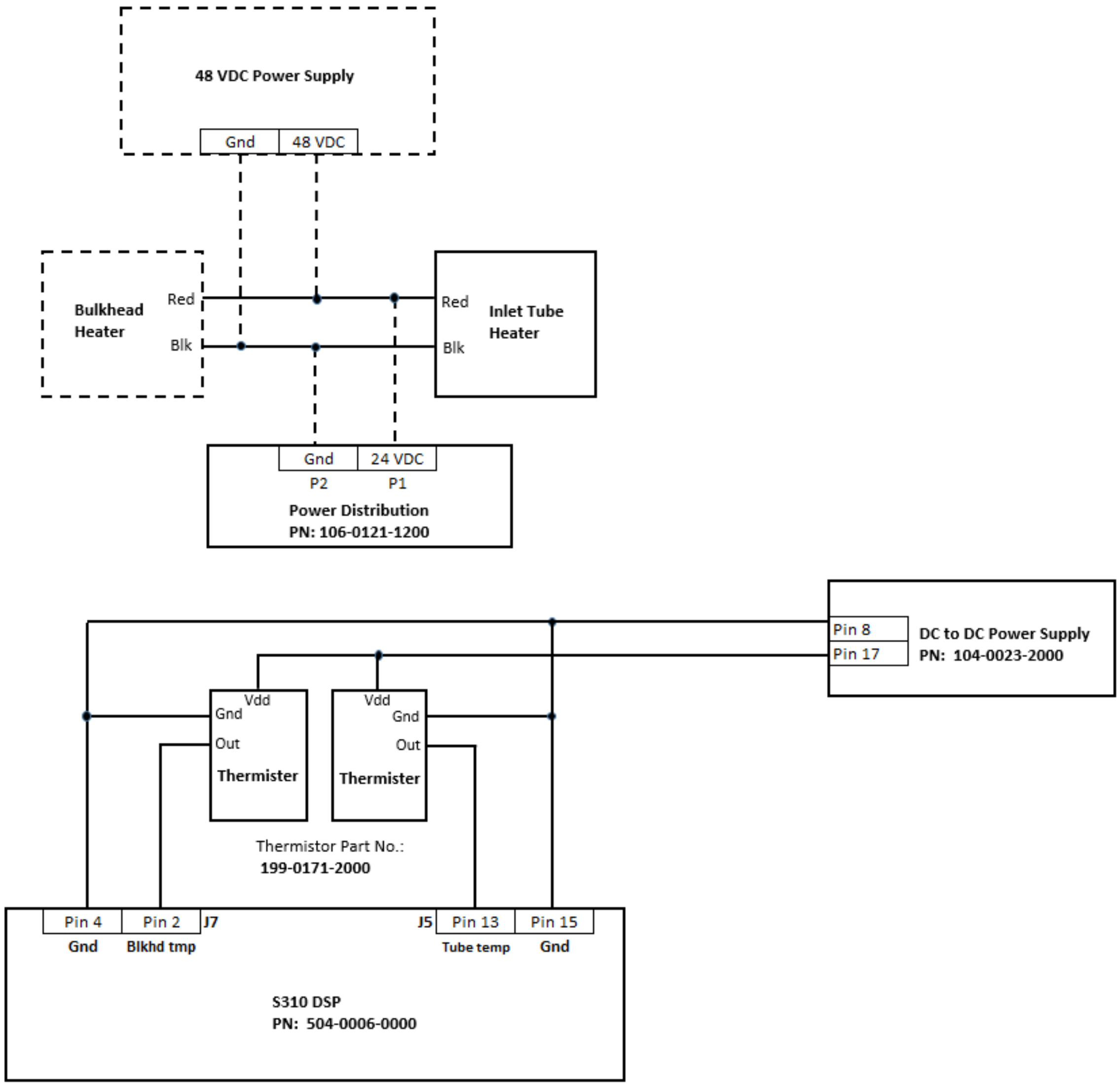
The inlet tube heater and bulkhead heater (optional) prevent condensation buildup at the inlet gas line within the Gas Analyzer. These two heaters are not feedback control heaters. Thermistors are attached to the inlet and bulkhead heaters and provide working state feedback information. The expected temperature provided by both heaters will be greater than 30°C but never exceed 50°C.

Fig. 126 Bulkhead & Inlet Tube Heaters



Unless the Gas Analyzer is configured with the inlet tube heater option, the inlet tube heater assembly is powered by the 24V DC line coming from the power distribution module. If the Gas Analyzer is configured with the bulkhead heater, both heaters are then powered by a 48V DC power supply. See Fig. 127 for the wiring diagram of the two heater assemblies and their monitoring thermistors.

Fig. 127 Bulkhead & Inlet Tube Heater Assembly Wiring Diagram



Troubleshooting

There are only two possible operating conditions for the bulkhead and inlet tube heaters: on or off. Each heater has a thermistor linking it to the component it has to heat. For troubleshooting purposes, the two thermistors are considered identical and interchangeable. Only the inlet tube heater is monitored on the Alarm Status display. The displayed reading is registered in the Service tab of the Setup display. To verify if the thermistor is working properly, connect a DVM and ohm-meter between the two leads. An open circuit is problematic. For heaters using the inlet tube heater thermistor power and data line, switch the connector to the bulkhead heater thermistor and look for temperatures registering on the Service tab Tubing temperature field.

Replacement

NOTE: This procedure is a Type 3 electrical safety task.

The inlet tube heater is a strip heater bended to the curvature of the inlet gas tube line. This strip heater is held in place by Velcro tie-wraps. An insulating foam (also tied into place with a Velcro tie-wrap) covers the strip heater.

Required items and tools:

- Philips screwdriver
- Blade screwdriver
- Grounding wrist strap

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and "red tags" for offline operation, before any work is performed.

To replace the bulkhead and inlet tube heaters:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.
b. In the window that appears, confirm the shutdown by clicking OK.
c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.
d. Open the customer filtered air line valve that is in line with the customer sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.
b. Open the Gas Analyzer front panel.
c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Remove the faulty strip heater:

a. Remove the Velcro tie-wraps from the outer foam insulating the inlet tube heater.
b. Peel off the sticky insulating foam from the inlet tube gas line.
c. Disconnect the inlet tube heater power source connector.
d. Remove the Velcro tie-wraps securing the strip heater to the inlet gas tube line.
e. Take out the faulty strip heater.

STEP 4 Install the new strip heater:

a. Bend the new strip heater to the curvature of the inlet gas tube line.
b. Tie the heater into place with the Velcro tie-wraps. If the inlet tube thermistor was removed when taking out the strip heater, tape it on the inlet gas tube now.
c. Install the insulating foam around the strip heater. The inside of the insulation is sticky so it will hold onto the surface with which it has made contact.
d. Use the Velcro tie-wraps to hold the insulating foam in place around the strip heater.
e. Connect the strip heater power connector to its power source.

STEP 5 Close the Gas Analyzer and verify results:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

   For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. After the Gas Analyzer completes its initialization process, go the Service tab in the Setup screen and verify that the inlet tube heater measured temperature is going beyond 30°C.

e. Close the filtered air line check valve on the customer sample gas line feeding the Gas Analyzer.

f. Open the customer sample gas line valve and let the gas sample go into the Gas Analyzer for measurement.

g. Once the Gas Analyzer has stabilized, make sure that the customer gas measurements fall back into the previous control range.

6 Data Analysis Tips

Summary

Gas Analyzer failures can be categorized by function, based on what support the instrument uses to create and maintain measurement results to specifications. In Table 23, the Gas Analyzer main components are identified with defined function and their expected impact on measurements.

Table 23 *LGR-ICOS* Measurement Components, Function & Impact

Components	Function	Impact
PC104 stack	System communications	• System operations • I/O
Heaters/Relays/Thermocouple/ Temperature Controller	Temperature control of measured gas sample	• Measurement shift • Measurement stability
Pressure valve, fixed orifice	ICOS pressure control	• Absorption level • Measurement stability
Laser	Gas probing light source	• Transmitted intensity • GOF due to wavelength shift
Astigmatic Mirrors	Cavity length	• Ring-down time • Absorption level

Data Analysis

The ICOS Gas Analyzer runs the Linux operating system. All menu screens are created and all data is processed and saved using the Linux programming language. Collected measured data is written in text (ASCII) format with labeled columns. This allows for data plotting in Microsoft® Excel® for review and analysis over time. From plotting out data over time, anomalies should be questioned as to whether there is a problem with the gas sample or with the instrument.

To determine which of the two possibilities is the problem, plot out the gases measured, the “cell pressure” (in Torr units) and the “cell temperature.” Lay down one plot over the other. Does the measured gas data trend/shift follow each other, including cell pressure and temperature over the same period of time? See Table 24 for gas or instrument issues based on the collected measurement data.

Table 24 Gas/Instrument Issue Table

Case	Gas Sample 1	Gas Sample 2	Gas Sample 3	Gas Sample 4	Cell Pressure	Cell Temp	Issue Possibility: Gas/Instrument
1	Yes	No	No	No	No	No	Gas
2	Yes	Yes	Yes	Yes	No	Yes	Instrument
3	Yes	Yes	Yes	Yes	Yes	No	Instrument
4	Yes	Yes	Yes	Yes	No	No	Gas/Instrument

In “Case 1”, where there is a notable trend or shift in 1 or 2 gas sample measurements, but the remaining gases are stable, and there is no change in both the instrument measured pressure or temperature, the problem will most likely be that the gas composition has changed. To validate this conclusion, use a “traceable, tested, and regulated” bottled gas of the gas type that shows a trending/shift issue, to determine whether the resulting answer measured by the instrument is correct or not.

In “Case 2” and “Case 3”, where all gases measured are trending/shifted and the cell temperature or pressure is moving, the problem is with the instrument. See Table 17 and

Table 18 to determine the cause of the issue. It is recommended at this point to call ABB regarding the problem encountered.

In “Case 4”, where all gases are trending/shifting but there are no changes in cell temperature or pressure, there could still be issues with the instrument laser, detector, or mirrors within the ICOS cell.

With the laser and detector, the possibilities could be:

- Output power is lower, as seen by the detector
- Laser is drifting
- Detector is noisy
- PZT failure (there is very little impact on high absorption gases, but for low absorption gases, the signal-to-noise ratio will be impacted, in turn impacting the quality of measurements)
- Dirty mirrors

On the gas sample side, the problem could be contamination on the lines feeding the instrument. The best way to check this out is to take multiple measurements using a “traceable, tested, and regulated” bottled gas for repeatability and stability at the targeted wavelength.

NOTE: The output temperature reading in the Control Bar displays only the ICOS cell temperature that is read by the ThAmp. It does not provide information on the gas inlet temperature, the gas passing through the orifice and the gas expansion heaters.

4–20 mA Output Conversion Table

The 4–20 mA output conversion table (see Table 25) provides service engineers with a method to troubleshoot output data from both the signal isolators and the Modbus to see if they correlate to the input signal provided through the S310 DSP board of the PC104 stack. The S310 DSP board output signal (0-to-5 volts) is sent to both the signal isolators and Modbus through a daisy chain.

Table 25 Signal Isolator Voltage-to-4–20 mA Current Conversion

Voltage	Current (mA)	Voltage	Current (mA)	Voltage	Current (mA)
0	4	1.7	9.44	3.4	14.88
0.1	4.32	1.8	9.76	3.5	15.2
0.2	4.64	1.9	10.08	3.6	15.52
0.3	4.96	2	10.4	3.7	15.84
0.4	5.28	2.1	10.72	3.8	16.16
0.5	5.6	2.2	11.04	3.9	16.48
0.6	5.92	2.3	11.36	4	16.8
0.7	6.24	2.4	11.68	4.1	17.12
0.8	6.56	2.5	12	4.2	17.44
0.9	6.88	2.6	12.32	4.3	17.76
1	7.2	2.7	12.64	4.4	18.08
1.1	7.52	2.8	12.96	4.5	18.4
1.2	7.84	2.9	13.28	4.6	18.72
1.3	8.16	3	13.6	4.7	19.04
1.4	8.48	3.1	13.92	4.8	19.36
1.5	8.8	3.2	14.24	4.9	19.68
1.6	9.12	3.3	14.56	5	20

Using The Swagelok Gap Inspection Gauge

When reconnecting or replacing gas lines inside the Gas Analyzer, it is critical to achieve a proper seal and prevent leaks. The gas flow rate through the ICOS cell needs to be stable to achieve repeatable measurements. If a connection is too loose between two pipes, a leak might occur. If a connection is too tight, it will damage the pipe and/or threads, making the components more difficult to remove. There are two different sets of instructions of sealing/joining pipes with a Swagelok. The first instruction set is for the pre-Swagelok pipes, and the second is for current Swagelok pipes.

To tighten pre-Swagelok pipes and lock two pipes together:

STEP 1 Finger tighten the locking nut.

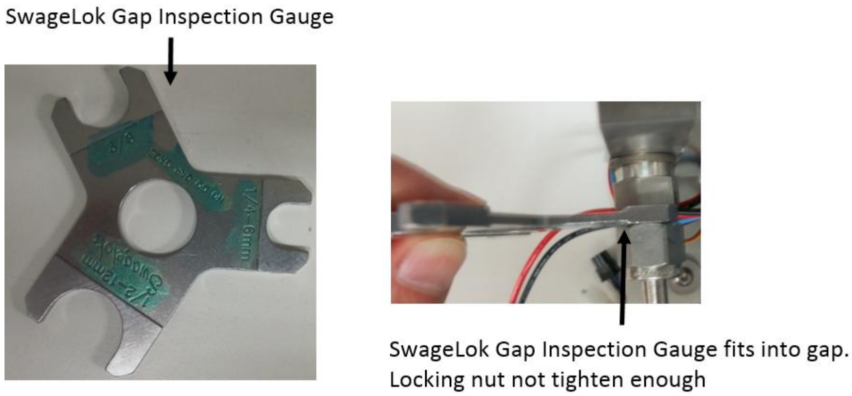
STEP 2 With a wrench, turn the locking nut 1 ¼ turn beyond the finger-tight position.

To tighten current Swagelok pipes:

STEP 1 Finger tighten the locking nut.

STEP 2 With a wrench, turn the locking nut ¼ turn beyond the finger-tight position, but to do it properly, use the Swagelok gap inspection gauge. This gauge is a *no-go* gauge: if it can fit into the gap between the locking nut and its associated nut fitting, it is not tight enough and needs to be turned a bit more so that the Swagelok gap inspection gauge does not fit in, but barely.

Fig. 128 Swagelok Gap Inspection Gauge



Traceable Regulated Certified Bottled Gas

Always use traceable regulated certified bottled gas for verify measurement performances and accuracy. They are the baseline to which the Gas Analyzer is calibrated. If traceable regulated certified bottled gas measurements taken by the Gas Analyzer match what is written on the bottle, and the customer sample gas measurements are unstable, the problem lies with the customer gas.

7 Preventive Maintenance

Summary

The ICOS Gas Analyzer requires yearly Preventive Maintenance (PM) to maintain its measurement performances. There are four category of PM parts:

- Parts that need to be replaced every year
  - o 10µm screen filter at the inlet solenoid valve on the gas inlet side
  - o Exhaust pump diaphragm
- Parts that need maintenance (but not replacement) *every* year
  - o System hard drive
  - o Astigmatic mirrors
- Parts that need to be replaced every *five* years
  - o Exhaust pump
  - o 10µm filter/orifice at the orifice filter/heater assembly
- Parts that need to be replaced *every* ten years
  - o 2µm ICOS filter/heater
  - o 2µm ICOS exhaust filter

Hard drive maintenance requires that some of the older data stored in the archive folder be removed from the instrument and stored in another location. The customer should be notified of this action and it should provide off-location storage. Not all measurement data should be deleted from the instrument. Older data provides users and service engineers with the instrument recorded performance baseline when the instrument was working well. This baseline is needed for future instrument servicing purposes as repair references.

Cleaning of the ICOS astigmatic mirrors is required after processed gas contaminated the mirrors, reducing their effectiveness and resulting in noisier measurements.

Data Review

Required items and tools:

- Laptop running Microsoft® Excel®
- USB memory stick
- Cable gland dongle

To review data:

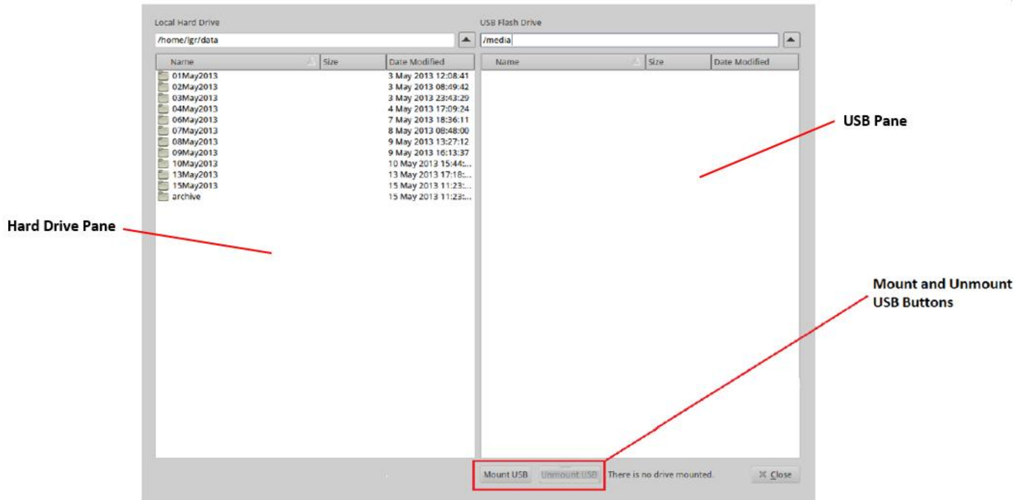
STEP 1 Install the USB memory stick in the cable gland dongle.

STEP 2 Insert the cable gland dongle with enclosed USB memory stick, in the USB port on the left side of the Gas Analyzer enclosure.

STEP 3 In the Control Bar, click Files.

STEP 4 On the screen that appears, click Mount USB (see Fig. 129).

Fig. 129 Mounting the USB Memory Stick



STEP 5 Click on the Local Hard Drive pane to access the archive folder.

STEP 6 For each month of data stored, drag from the Local Hard Drive pane a week's worth of files and drop them on the USB Flash Drive pane.

STEP 7 Click Unmount to stop communications with the USB memory stick.

STEP 8 Wait for the Safe to Remove USB Memory Device message before removing the USB memory stick.

STEP 9 Click Close to close the Files screen.

STEP 10 In Microsoft Excel, plot the data taken from the instrument. Look for possible trends, signal losses, and data instabilities for each gas type, and compare this data by overlaying one graph on top of the other. This data should indicate the instrument's measurement sensitivity to temperature and pressure changes.

Hard Disk Maintenance

STEP 1 Ask the customer what part of the stored measurement data needs to be kept.

STEP 2 With the Gas Analyzer still powered up and ready to take gas measurements, click Files in the Control Bar.

STEP 3 In the archive folder, save the first month of gas measurements taken by the instrument. This data will serve for future reference when repairing the instrument.

Also, for future analysis, keep a week's worth for every month of logged data. Over time, if the instrument encounters measurement data issues, i.e., stability, trends, shifts, etc., one can determine the possible cause of the problem by looking at past and current data and at what has changed in the logged parameters.

STEP 4 Delete everything else:

a. With the mouse, highlight the files to delete.

b. Right-click and select Delete from the contextual menu that appears.

STEP 5 After the files are deleted, note how much hard disk space is available.

STEP 6 Based on the rate of data collection, determine when the hard disk will exceed 75% of the total storage capacity. If the calculated time is less than a year away, delete more of the data files that the customer stated need not be kept.

STEP 7 Close the Files screen and go back to the Numerical display.

Every Year PM

System Check

NOTE: *This procedure is a Type 3 electrical safety task.*

Required items and tools:

- Philips screwdriver
- Digital volt meter (DVM)
- Grounding wrist strap

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To check the system:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the check valve to the filtered air line that is in line with the customer sample gas line going into the Gas Analyzer.

e. Bypass the interlock by inserting the bypass key in the internal pressure interlock switch port.

f. Turn the key to put it into bypass mode.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 With the DVM, measure the output of the AC/DC 24V power supply on the rail terminal block at P1 and P2. Make sure it is within ± 0.2V of 24V DC.

STEP 4 Inspect cables connectors for any discoloration or damage caused by the environment. Order and replace any cable and/or connector that appears to be failing.

STEP 5 Check the DC voltages from the DC/DC voltage converter for outputs +5, +12 dirty, –12, +12 clean, and +24V DC. The +15V DC is not used.

NOTE: *Voltage levels should fall within ± 0.2V DC. Only the +5V DC can be adjusted on the board’s single variable resistor. Use wire color codes to determine the expected voltage level for each colored wire. See Table 8.*

STEP 6 Continue with the 10µm Inlet Gas Filter Replacement (see page 177).

10µ Inlet Gas Filter Replacement

Required tools and items:

- 10µ filter inlet assembly
- Inlet solenoid valve

NOTE: *There are three different 10µm filter assemblies. All three filters will fit into the gas lines as designed, but their effectiveness is gas-dependent. The wrong filter type may plug up the gas line or filter out the gas that the customer wants to measure. Make sure to order the correct filter based on the Gas Analyzer model number.*

STEP 1 With the Gas Analyzer still powered on, stop the exhaust pump by switching S2 to the center position on the 2-port solenoid driver board.

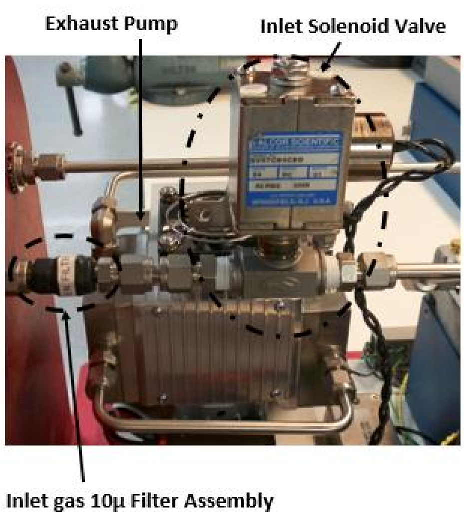
STEP 2 Remove the Velcro around the inlet tube.

STEP 3 Peel back the insulating foam covering the inlet tube.

STEP 4 Disconnect the Swagelok fitting between the inlet gas line and the enclosure wall to the inlet solenoid valve.

STEP 5 Remove the 10µm filter assembly from the inlet gas line going into the inlet solenoid valve. To locate the filter, see Fig. 130.

Fig. 130 10µm Filter Assembly



STEP 6 Install a new 10µm filter assembly onto the inlet gas line going into the inlet solenoid valve. Use Swagelok nuts to keep it into positon.

STEP 7 Connect the inlet gas line from the enclosure wall to the 10µm filter screen. Use Swagelok nuts to keep it into positon.

Use the Swagelok gap inspection gauge as a *no-go* gauge when tightening the Swagelok nuts for proper tightness. The final nut position should be only barely over the gauge gap where the gauge can no longer fit into the gap between the two nuts.

STEP 8 Move switch S2 on the 2-port solenoid driver board to the left position. The exhaust pump should be running.

STEP 9 Make sure that the ICOS cell pressure on the Control Bar reads the same pressure level as before the replacement. If it does not, and the pressure reading drops, check for leaks.

STEP 10 Move switch S2 on the 2-port solenoid driver board back to the right, to computer control.

Astigmatic Mirror Cleaning/Replacement

NOTE: This procedure is a Type 1 electrical safety task.

Required items and tools:

- Philips screwdriver
- 5/32″ Allen wrench
- 3/32″ Allen wrench
- Lens tissue
- [4]Methanol (Sigma-Aldrich Product #: 414719)
- [4]Acetone (Sigma-Aldrich Product #: 154598)
- Clean table for optical parts
- Mirror cleaning block
- Hollow Teflon tube
- Dropper bottles (2)
- Traceable regulated certified bottle gas(es) (from customer on their gas lines)

Danger!	Probing electronics in an operating Gas Analyzer can accidentally create sparks if the internal pressure interlock switch is in bypass mode. This situation can result in serious injury or death due to the possible explosion of gas build-ups in the surrounding work area. All work to be performed in these conditions requires approval and written consent from the customer, and “red tags” for offline operation, before any work is performed.

To clean astigmatic mirrors:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the ICOS cell left heat shield cover:

a. Open the latches at the top and bottom of the blue cover.

b. Slide the cover to the left so that the cover “tongue” is out.

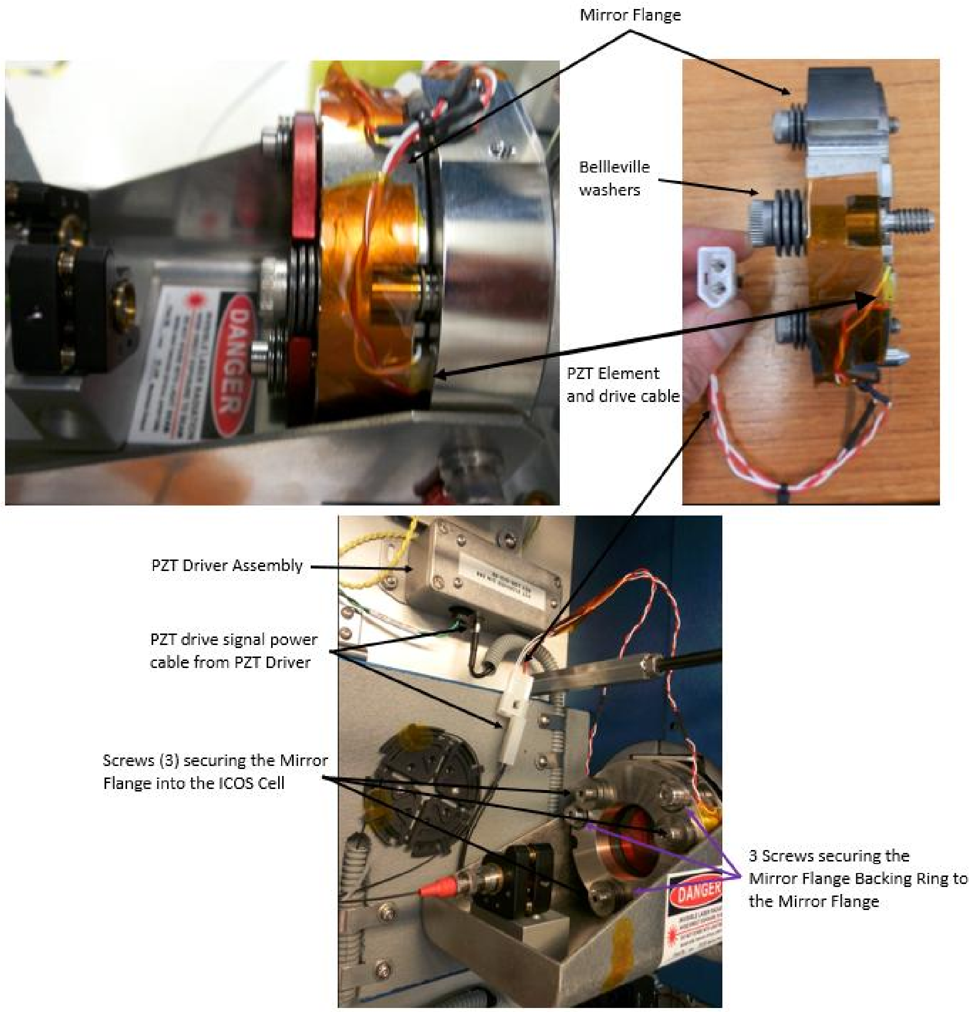
c. Before pulling the cover from the enclosure, slide it to the left so that the “tongue”, that goes into the top cover, is out of the way.

NOTE: Do not bend the cover “tongue” in the removal process.

STEP 5 Disconnect the PZT drive signal power cable linking the PZT driver to the PZT. See Fig. 131 for location of the components described.

[4] Specific product from Sigma-Aldrich. The only one that does not leave residue films or particles on the surface wiped with a lens tissue.

Fig. 131 PZT Driver & Element



STEP 6 Remove the astigmatic mirror:

a. With a 5/32″ Allen wrench, loosen the three captive screws that secure the mirror flange and astigmatic mirror mount to the ICOS cell.

NOTE: Do not touch the mirror when removing the flange from the ICOS cell.

NOTE: If the Gas Analyzer is in a cleanroom in a semiconductor fab, get a cleanroom cloth, wrap the mirror flange (with mirror assembly) and take it out of the cleanroom for cleaning. No type of paper is allowed in a semiconductor fab. All materials going in such a fab need to be wiped down according to the customer protocol. Do not wipe the mirror. Just wipe the flange.

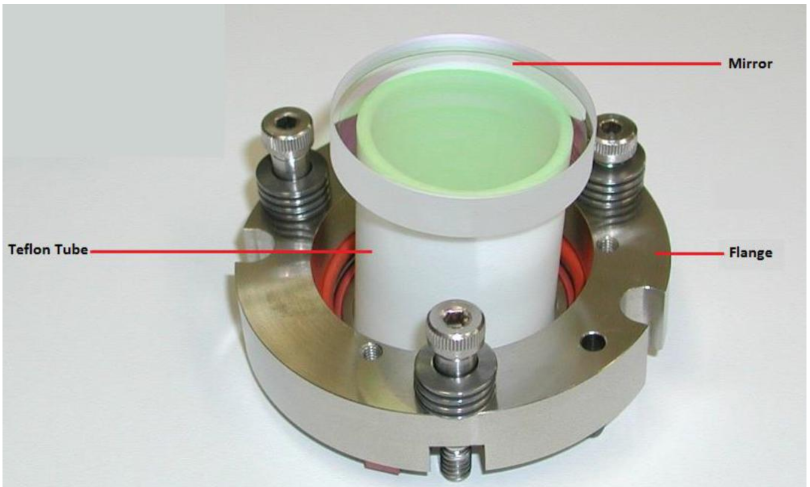
b. With a lens tissue placed on the clean, dust free, flat table surface, lay the mirror flange down (flange screws up).

c. With a 3/32″ Allen wrench, remove the three screws from the mirror flange backing ring that holds the astigmatic mirror to the mirror flange.

d. Place the mirror flange backing ring on top of another sheet of lens tissue.

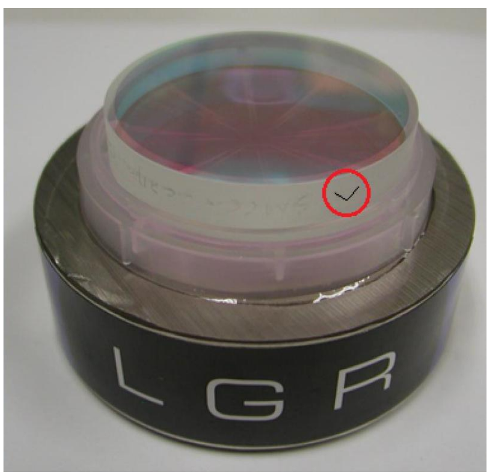
e. Place the mirror flange on top of the short Teflon tube and push the flange downward slowly until the mirror pops out of the flange O-ring (see Fig. 132).

Fig. 132 Astigmatic Mirror Removal



f. Place the mirror on the mirror cleaning block, with the arrow on the mirror edge pointing down (anti-reflection side up) as shown in Fig. 133.

Fig. 133 Astigmatic Mirror On Cleaning Block



STEP 7 Prepare the acetone and methanol cleaning:

a. Transfer a very small amount of fresh acetone from the capped acetone bottle to the acetone dropper bottle. Use just enough to rinse the dropper bottle.

b. With the dropper top closed, shake the dropper bottle to rinse the interior of the bottle and discard the rinse acetone.

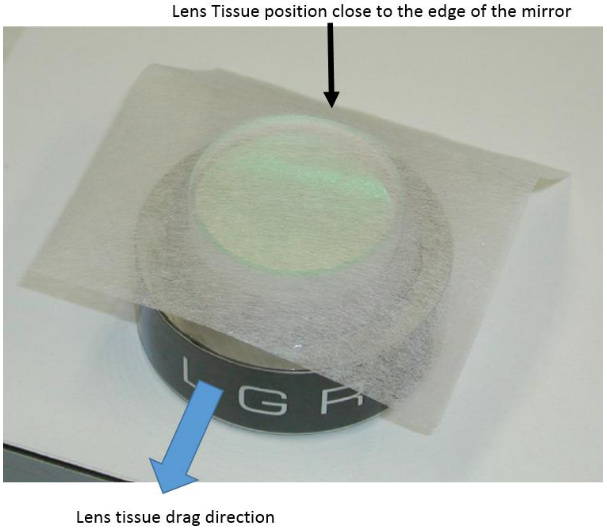
c. Fill the acetone dropper bottle with 1/4 to 1/3 full with fresh acetone.

d. In a different bottle, perform steps 7a through 7c for the methanol solution.

e. Remove a single sheet of lens tissue from the pack.

f. Place the sheet on the mirror with the mirror at the edge of the sheet. Leave enough tissue free on the near side of the optic to hold when you drag it. See Fig. 134 on the positioning of the lens tissue.

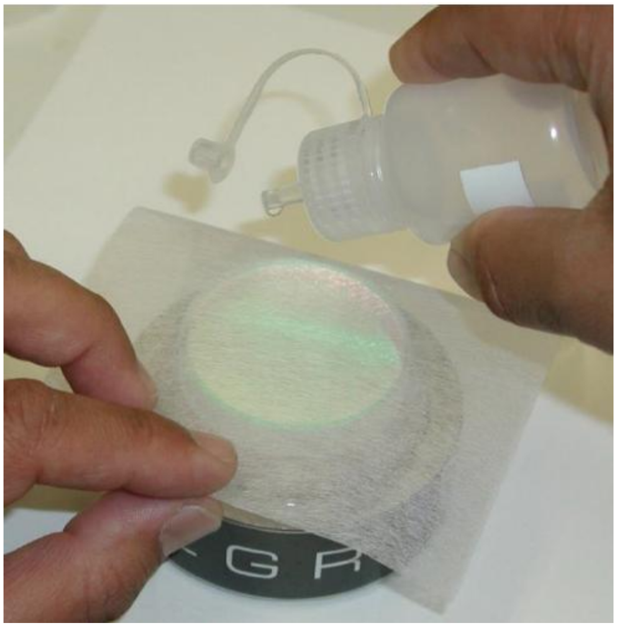
Fig. 134 Lens Tissue Positioning For Mirror Cleaning



STEP 8 Clean the mirror:

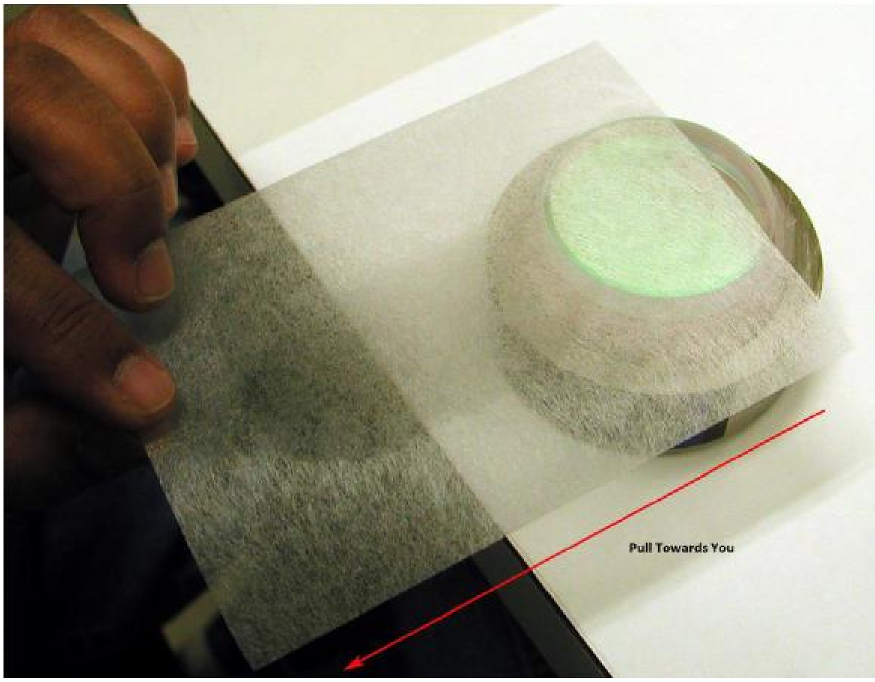
a. Using the acetone dropper bottle, place four drops of acetone on the tissue, above the center of the mirror. The solvent should completely wick up to the mirror edge (see Fig. 135).

Fig. 135 Where to Apply Cleaning Solution on Lens Tissue



b. Pull the lens tissue toward you with a consistent but light pressure over the full length of the mirror (see Fig. 136) at a speed which matches the evaporation rate of the solvent from the surface. This is called drag wiping. If you see liquid on the mirror after you wiped it over, you were wiping too fast.

Fig. 136 Lens Tissue Drag Direction When Cleaning Mirror



c. Discard the used lens tissue after a single pass.

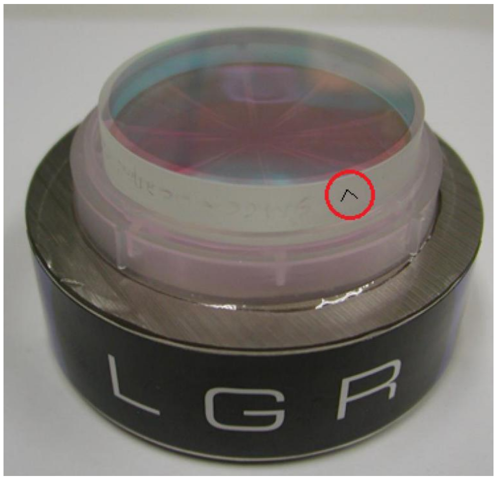
d. Repeat steps 8a through 8c for methanol. Repeat this for at least two cycles, starting with acetone, then methanol, then acetone again, and methanol.

e. If chemical residues that were on the mirror are still there after the wipe, repeat steps 8a through 8d until residues are removed.

f. If there is no progress shown in removing chemical residues from the mirror after each wipe sequence, one with acetone and one with methanol, order a replacement mirror.

g. Invert the mirror in the mirror cleaning block so that the high reflectivity (HR) surface is on top and the arrow is facing up, as shown in Fig. 137.

Fig. 137 Mirror HR Surface

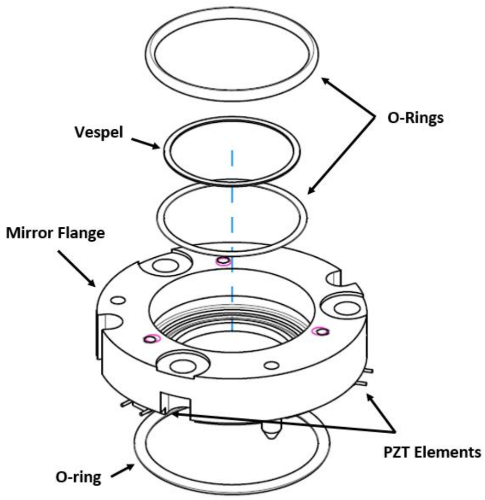


STEP 9 Replace the mirror flange and PZT element:

a. Place the new mirror flange and PZT element on top of a lens tissue, with the PZT element at the bottom.

b. Center the top side O-rings and Vespel (see Fig. 138) to their respective cutout grooves on the mirror flange.

Fig. 138 Mirror Flange O-Ring & Vespel Alignment



c. Holding the edges of the astigmatic mirror, transfer and center the mirror into the mirror flange (the down-pointing arrow identifies the coated surface).

d. Insert the mirror flange backing ring into the mirror flange.

e. Put the three screws back in on the mirror flange backing ring.

f. Tighten the three screws evenly, first by hand, then a bit more by moving from one screw to the next to keep an even pressure on all sides of the flange pressing up against the ICOS cell. The shoulder screws will control the depth of travel of the screws into the ICOS cell.

g. Verify that the bottom O-ring and the PZT element side of the mirror flange are in place within the slot.

h. Align and secure the mirror flange into the ICOS cell. The mirror flange is keyed so that it will only go in one way into the ICOS cell. When tightening the 3 outer shoulder captive screws, finger tighten all three screws to the same tightness to start; then proceed to tighten a bit more rotating from one screw to the next to get an even pressure from all sides of the flange when pressed up against the ICOS cell. The shoulder screws will control the depth of travel of the screws into the ICOS cell.

STEP 10 Reconnect the PZT drive signal from the PZT driver to the PZT elements.

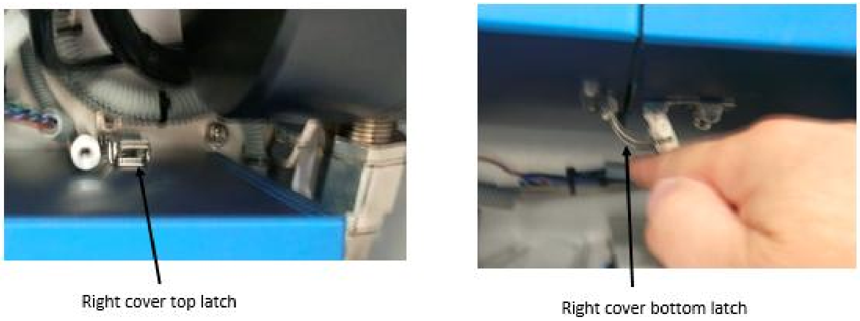
STEP 11 Put back the left side of the ICOS blue heat shield cover back on the ICOS cell:

a. Slide the tab in from the left side to mate with the top blue shield cover.

b. Use the upper and lower latch clamps to secure the left blue heat shield in place.

STEP 12 Open the latches at the top and bottom right of the blue cover. To locate the latches, see Fig. 139.

Fig. 139 ICOS Right Cover Latches



STEP 13 Disconnect the NIR detector fan cable so that the cover can be laid down without putting stress on the cable.

Before pulling the cover from the enclosure, slide its right side to the right so that the “tongue”, that goes into the top cover, is out of the way.

NOTE: Do not bend the cover “tongue” in the removal process.

STEP 14 Remove the cover.

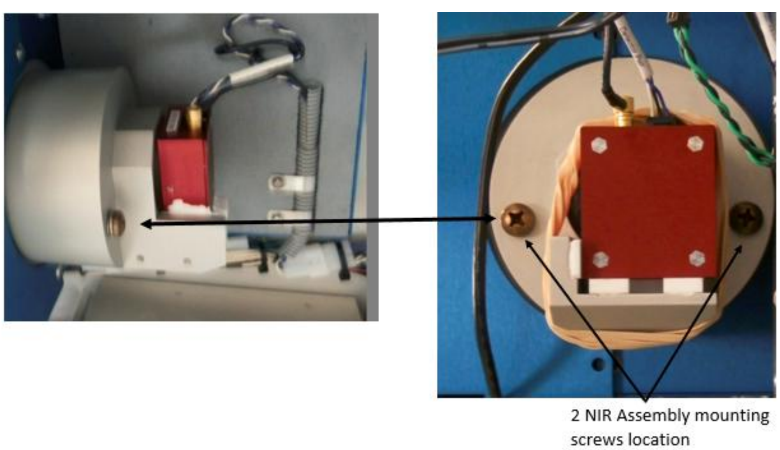
STEP 15 Remove the NIR detector:

a. Disconnect the communication cable from the NIR detector.

b. Remove the two mounting screws that hold the NIR detector to the ICOS cell.

c. Gently pull to the right the round mount containing a focusing lens and NIR detector assembly. The assembly should slide out easily once the the screws are removed. See Fig. 140 to locate the two screws to be removed first before pulling out the focusing lens and NIR detector assembly mount.

Fig. 140 NIR Assembly Mounting Screws Locations



With the NIR detector assembly and mount removed, the mirror flange is exposed on the detector side of the ICOS assembly. This mirror flange is exactly the same as the mirror flange on the laser side of the ICOS assembly, except that there is no PZT element on it.

STEP 16 Clean, reinstall and lock the astigmatic mirror:

a. Use the 5/32″ Allen key to loosen the three captive screws that hold the mirror flange to the ICOS assembly.

b. Repeat steps 6 through 9 to clean, reinstall and lock the astigmatic mirror back in the receiving end of the ICOS assembly. Ignore any references to the PZT because the receiving end does not have a PZT element.

c. Place the outer blue shield cover back, enclosing the NIR detector.

d. Reconnect the NIR detector fan power connector to the fan. Be careful not to bend the tongue on the blue shield cover that is to be inserted to the top blue cover groove.

STEP 17 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 18 Make sure that the Gas Analyzer boots up:

a. Make sure that the temperature controllers light up and start controlling the heater relays.

b. On the monitor, make sure that the Gas Analyzer operating software initializes successfully.

STEP 19 In the Control Bar, look at “Laser A τ” and “Laser B τ” values (see Fig. 141; laser B τ only appears when Gas Analyzers are configured with two lasers). Ring-down time is represented by the Greek letter τ. If the ring down time still exceeds 10% degradation from the reference factory setting (as shown in the Service tab, Fig. 31), replace the astigmatic mirrors.

Fig. 141 Control Bar - Ring Down Time **τ**

NOTE: Ring-down time will vary depending on the Gas Analyzer model and the type of gas to be analyzed.

NOTE: Astigmatic mirrors are model-dependent. Make sure to order the correct astigmatic mirrors when replacement is required.

Every Year PM Components Replacement

Exhaust Pump Diaphragm Replacement

Required items and tools:

- Philips screwdriver
- 9/16″ open end wrench (2)
- Exhaust pump diaphragm kit
- 10µm filter assembly
- Clean table for parts disassembly and re-assembly
- T-handle standard Allen wrench set
- Standard Allen wrench set
- Swagelok gap inspection gauge
- End cap

To replace the exhaust pump diaphragm:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

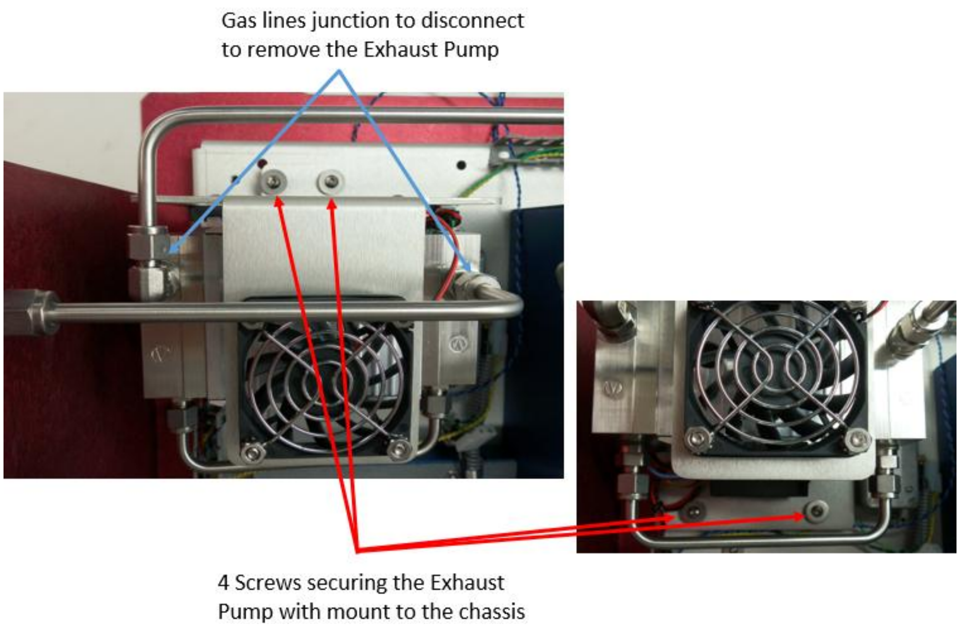
STEP 4 Remove the exhaust pump assembly:

a. Disconnect the exhaust pump 24V DC power connector.

b. Disconnect the Swagelok fittings on both the left outlet to the customer exhaust line and the right inlet side from the ICOS cell exhaust pump.

c. Disconnect the pipes from the Swagelok (to locate the Swagelok fitting disconnect points, see Fig. 142).

Fig. 142 Exhaust Pump



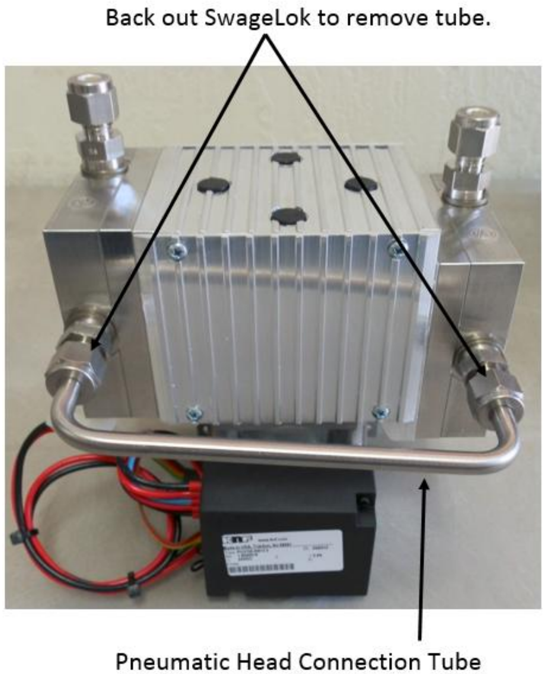
d. Remove the four screws that secure the exhaust pump and support bracket to the instrument chassis. Remove the top screws last. To locate the four exhaust pump mounting screws, see Fig. 143.

e. Place the exhaust pump assembly on the table.

NOTE: If the Gas Analyzer has reached the end of its 5th year of operation, skip the steps below and move directly to the exhaust pump replacement procedure on page 191.

STEP 5 Remove the pneumatic head connection tube and set it aside.

Fig. 143 Exhaust Pump Pneumatic Head Connection Tube

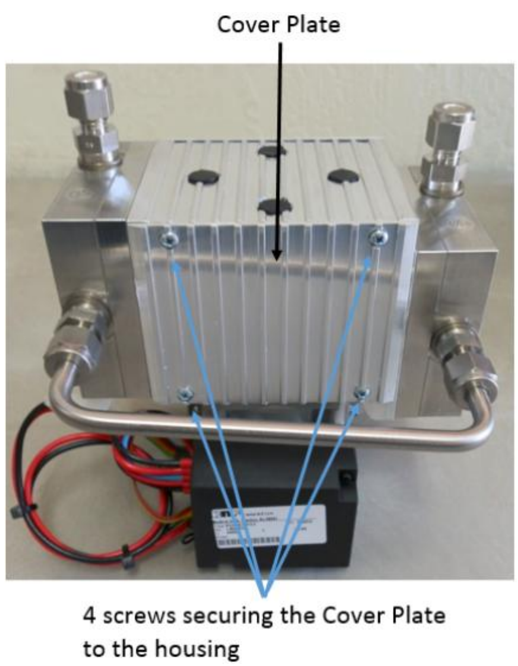


STEP 6 Dismantle the exhaust pump:

a. Unscrew the four screws holding the housing cover plate (see Fig. 144).

b. Remove the housing cover plate.

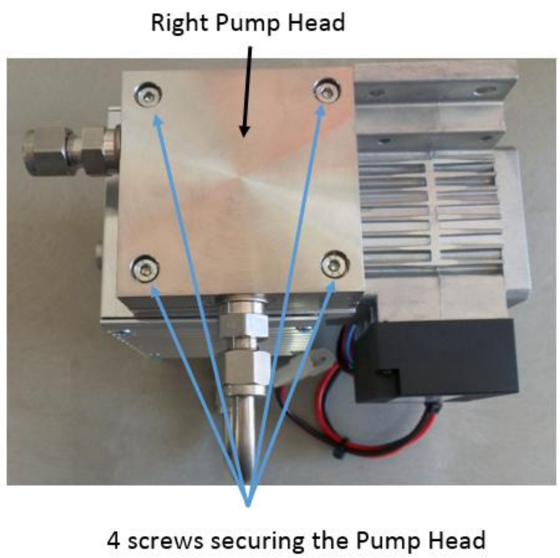
Fig. 144 Housing Cover Plate



c. Rotate the pump so that the pump head is facing up.

d. Remove the four screws (see Fig. 145) securing the pump head. As one wants to replace only one diaphragm and two valves at a time, leave the other pump head in the instrument at this time.

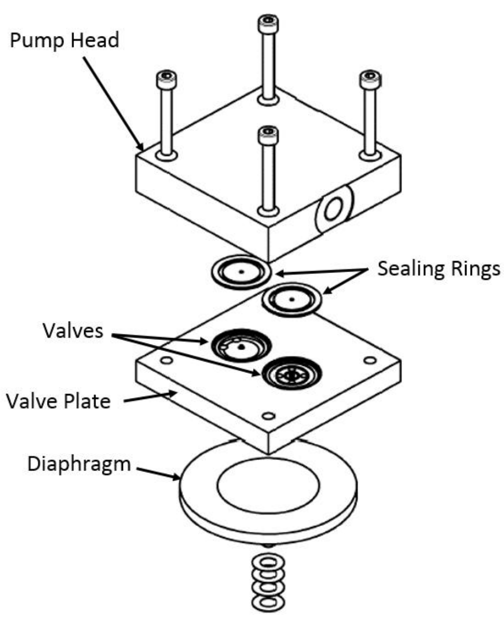
Fig. 145 Pump Head



e. Remove the valve plate containing the valves and the sealing ring (see Fig. 146) from the pump housing.

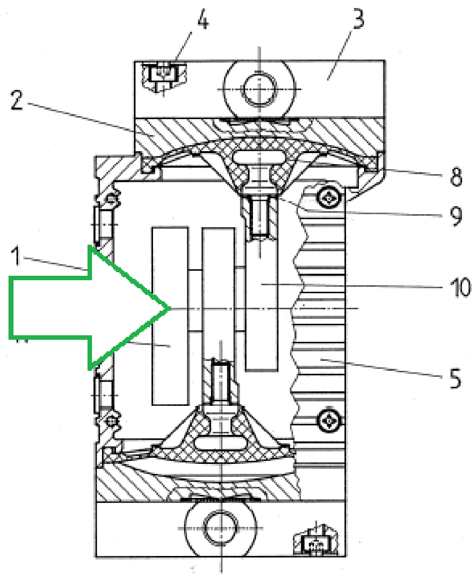
NOTE: Pay attention to the orientation of the valves on the valve plate.

Fig. 146 Exhaust Pump Diagram



f. From the cover plate side, rotate the counterweight (indicated with a green arrow in Fig. 147) inside the pump so that the diaphragm is in the middle of its travel.

Fig. 147 Exhaust Motor Piston Counterweight



g. Remove and replace the diaphragm in the pump housing.

h. Change the two valves and the sealing rings.

STEP 7 Put the pump head back on the exhaust pump.

STEP 8 Secure it in place with the four screws used during removal.

STEP 9 Repeat steps 6c through 6h for the left side head.

STEP 10 Reinstall the exhaust pump:

a. Put the cover plate back on the exhaust pump.

b. Secure it into place with the four screws used during removal.

c. Connect the pneumatic head tube back on the head that was removed when dismantling the exhaust pump.

d. Mount the exhaust pump on its mounting plate.

e. Mount the exhaust pump and mounting plate back on the Gas Analyzer. Put the two top screws in first, to support the pump when putting in the two bottom screws.

f. Connect the exhaust pump power cable to the DC connector.

STEP 11 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 12 On the 2-port solenoid driver board, switch S2 to the left position to run the exhaust pump.

STEP 13 Make sure that there is airflow inside the exhaust pump:

a. On the inlet side, place a strip of lens tissue one inch away from the exhaust pump opening and verify that there is suction.

b. On the outlet side, place a strip of lens tissue in front of the exhaust pump to verify that air is pushed out.

STEP 14 On the 2-port solenoid driver board, switch S2 to the center position to stop the exhaust pump.

STEP 15 Reconnect the exhaust pump:

a. Connect the exhaust line between the enclosure and the exhaust pump.

b. Finger tighten the Swagelok nut, but do not tighten it completely into place.

c. Connect the exhaust line between the proportional valve and the exhaust pump.

d. Tighten the Swagelok nuts at the exhaust pump assembly inlet and outlet.

Use the Swagelok gap inspection gauge as a *no-go* gauge when tightening the Swagelok nuts for proper tightness. The final nut position should be only barely over the gauge gap where the gauge can no longer fit into the gap between the two nuts.

STEP 16 On the 2-port solenoid driver board, switch S2 to the left to run the exhaust pump.

STEP 17 In the Control Bar, read the ICOS cell pressure. If it matches within ±1% of the readings obtained prior to the exhaust pump replacement, the replacement procedure is complete.

If it is beyond the ±1%, determine the problem and its location. If the pressure reading is lower, the gas line is clogged. If the pressure is higher, the gas line is leaking. In this last scenario, the problem needs to be fixed, to avoid future pressure control issue(s).

STEP 18 On the 2-port solenoid driver board, switch S2 to the right position to return control of the exhaust pump back to the computer.

STEP 19 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

STEP 20 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 21 Close the Gas Analyzer:

a. Close the front panel and secure it into position with all door clamps.

b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Close the filtered air line check valve on the customer sample gas line feeding the instrument.

STEP 22 Verify the replacement:

a. Open the traceable regulated certified bottled gas line valve and let the gas sample go into the Gas Analyzer for measurement.

b. Make sure that gas concentration measurements match the numbers written for the gas bottle. If they do not, calibrate the Gas Analyzer to the traceable regulated certified bottled gas(es) that the Gas Analyzer is designed to measure. Make sure that the bottled gas is not running low as this may produce incorrect concentration levels.

c. Close the check valve to the traceable regulated certified gas bottle.

d. Open the Gas Analyzer valve to the customer sample gas line.

e. Review the customer gas sample measured data. Make sure that the customer gas sample measurements are back within their control limits for that specific gas type. If they are not, the problem is with the customer gas.

You have completed the yearly preventive maintenance.

5-Year Preventive Maintenance

Exhaust Pump Replacement

To replace the exhaust pump:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Replace the exhaust pump:

a. Remove the screws securing the exhaust pump to its mount.

b. Remove the pump from its mount.

c. Install the new exhaust pump assembly on the mount.

d. Install the exhaust pump and mount assembly back in the Gas Analyzer. Put in the top two screws first.

e. Connect the exhaust line linking the enclosure and the exhaust pump. Finger tighten the Swagelok nuts, *but do not tighten it completely into place yet.*

f. Connect the exhaust line linking the proportional valve and the exhaust pump.

g. Tighten the Swagelok nuts at the exhaust pump assembly inlet and outlet. Use the Swagelok gap inspection gauge as a *no-go* gauge when tightening the Swagelok nuts for proper tightness. The final nut position should be only barely over the gauge gap where the gauge can no longer fit into the gap between the two nuts.

STEP 5 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 6 After the Gas Analyzer completes its initialization, read the ICOS cell pressure on the Control Bar. If it matches within ±1% of the readings obtained prior to the exhaust pump replacement, the replacement procedure is complete. Continue onto the 10µ filter and orifice replacement procedure on page 192.

If it is beyond the ±1%, determine the problem and its location. If the pressure reading is lower, the gas line is clogged. If the pressure is higher, the gas line is leaking. In this last scenario, the problem needs to be fixed to avoid future pressure control issue(s).

10µ Filter and Orifice Replacement

Required items and tools:

- 10µm filter assembly
- Orifice assembly

To replace the 10µm filter and orifice:

STEP 1 On the 2-port solenoid valve driver board, slide switch S2 to the center position. The exhaust pump should stop.

STEP 2 Remove the ICOS assembly blue heat shield:

NOTE: The screws securing the three covers must be removed before the shield can be lifted out.

a. Unlock the blue cover latches.

b. On the right shield cover, disconnect the power to the NIR detector fan.

c. Slide the left and right shields out while keeping the “tongue” straight.

d. Remove the heat shield top cover.

e. Remove the top insulation foam from the ICOS assembly.

STEP 3 Disconnect the 10µm filter and orifice:

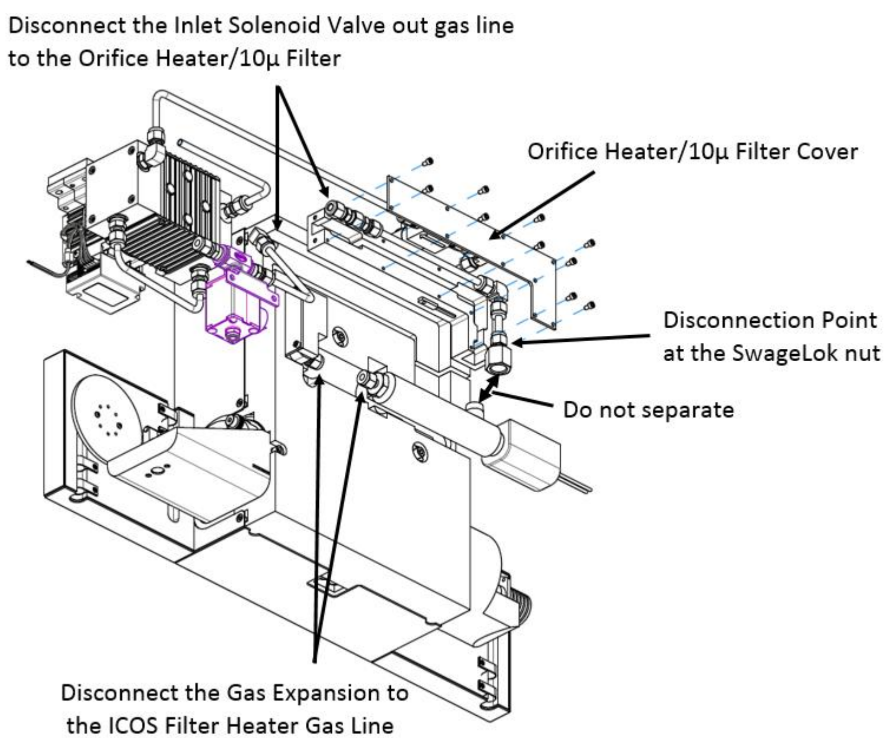
a. Disconnect the inlet gas line linking the inlet solenoid valve and the end of the orifice filter/heater assembly.

b. Disconnect the gas expansion from the inlet ICOS cell filter/heater. To locate the disconnection points, see Fig. 148.

c. Remove the orifice filter/heater assembly cover plate.

d. Disconnect the gas expansion from the orifice assembly at the Swagelok location and NOT at the reducer with Teflon tape that is connected into the gas expansion. See Fig. 148.

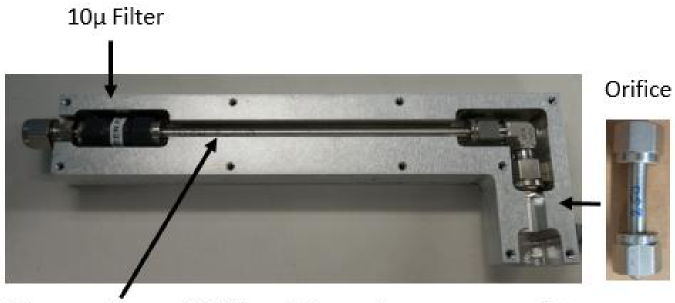
Fig. 148 Disconnection Point For Orifice Filter & Orifice Replacement



STEP 4 Replace the 10µm filter assembly

a. Remove the 10µm filter assembly (gas line, elbow and orifice) (see Fig. 149).

Fig. 149 10µm Filter, Gas Line, Elbow and Orifice



b. With Swagelok nuts, connect the new 10µm filter assembly with gas line, elbow and orifice to the gas expansion.
c. Align and slide the gas expansion tube into the ICOS inlet 2µm filter/heater assembly.
d. With Swagelok nuts, connect the gas expansion back to the ICOS cell 2µm filter/heater assembly.
e. With Swagelok nuts, connect the gas line from the inlet solenoid valve to the orifice filter/heater assembly.

STEP 5 Put the cover back over the orifice filter/heater assembly.

STEP 6 Test connections for leaks:

a. Slide switch S2 to the left position on the 2-port solenoid driver board so that the exhaust pump starts.
b. Read the ICOS cell pressure on the Control Bar. If it is not within ±1 Torr of the original reading prior to this replacement, check for leaks and resolve them.

STEP 7 Slide switch S2 to the right position on the 2-port solenoid driver board so that the computer starts running the exhaust pump.

STEP 8 Reinstall the blue heat shield

a. Put back the top insulation foam that covers the gas expansion and orifice filter/heater assemblies.
b. Install the top heat shield cover on the top insulation foam.
c. Secure it into place by the six screws removed to get access to the 10µ filter assembly with gas line, elbow and orifice to the gas expansion.
d. Slide in the left and right shield cover tongues in the gap on the top blue shield cover.
e. Latch the left and right shields into place.

STEP 9 Reconnect the NIR detector fan power cable.

STEP 10 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.
b. In the window that appears, confirm the shutdown by clicking OK.

STEP 11 Remove the internal pressure interlock switch bypass key from the purge controller.

STEP 12 Close the Gas Analyzer:

a. Close the front panel and secure it into position with all door clamps.
b. Verify that the CDA/N_2 inlet pressure gauge registers at least 40 psi.

c. For X-Purge enclosure instruments, after a minimum of 22 minutes, the Gas Analyzer restarts once the purge controller completes its purge of the air within the Gas Analyzer enclosure.

For Z-Purge enclosure instrument, you will need to time the 22 minutes before powering on the instrument since there is no automatic restart circuit built into the Z-Purge system design.

Danger!	Failure to properly perform the instrument air purging steps prior to its restart may cause injury or death from unexpected explosions.

d. Close the filtered air line check valve on the customer sample gas line feeding the instrument.

STEP 13 Verify the replacement:

a. Open the traceable regulated certified bottled gas line valve and let the gas sample go into the Gas Analyzer for measurement.

b. Allow 20 minutes for the Gas Analyzer to stabilize and verify the measurement of the traceable regulated certified bottled gas concentration matches the numbers written for the gas bottle.

If they do not, calibrate the Gas Analyzer to the traceable regulated certified bottled gas(es) that the Gas Analyzer is designed to measure. Make sure that the bottled gas is not running low as that may produce incorrect concentration levels.

c. Close the check valve to the traceable regulated certified gas bottle.

d. Open the Gas Analyzer valve to the customer sample gas line.

e. Review the customer gas sample measured data. Make sure that the customer gas sample measurements are back within their control limits for that specific gas type.

The 5-year preventive maintenance is now complete.

10-Year Preventive Maintenance

10µ Filter and Orifice Replacement

Required items and tools:

- 10µm filter assembly
- Orifice assembly

To replace the 10µm filter assembly:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.
b. In the window that appears, confirm the shutdown by clicking OK.
c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.
d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.
b. Open the Gas Analyzer front panel.
c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Turn off the AC power to the Gas Analyzer at the GUA junction box.

STEP 5 Perform a “lockout/tag out” procedure at the GUA junction box.

STEP 6 Disconnect the Gas Analyzer:

a. Disconnect the purge controller power cable connected to the Gas Analyzer AC power On/Off switch.
b. Disconnect the exhaust pump exhaust line going to the customer exhaust at the enclosure.
c. Disconnect the inlet solenoid valve gas line at the 10µm filter, between the valve and the enclosure.
d. Remove the seven screws that secure the Gas Analyzer to the enclosure. Remove the two top screws last.

STEP 7 Place a table next to the edge of the Gas Analyzer.

STEP 8 With another person’s help, lift and remove the Gas Analyzer module from the enclosure and place it on a table. Take the Gas Analyzer to a clean location where it can be worked on.

STEP 9 Remove the ICOS assembly blue heat shield:

NOTE: The screws securing the left, right, and top covers must be removed before the shield can be lifted out.

a. Unlock the blue cover latches.
b. On the right shield cover, disconnect the power to the NIR detector fan.
c. Slide the left and right shields out while keeping the “tongue” straight.
d. Remove the heat shield top cover.
e. Remove the top insulation foam from the ICOS assembly.

STEP 10 Disconnect the 10µm filter and orifice:

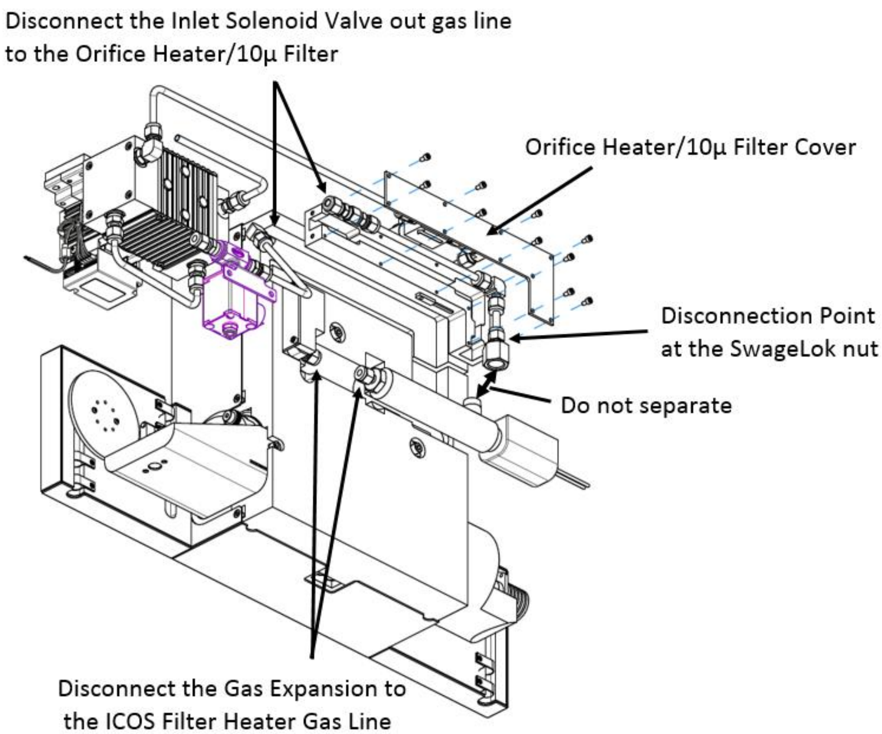
a. Disconnect the inlet gas line linking the inlet solenoid valve and the end of the orifice filter/heater assembly.

b. Disconnect the gas expansion from the inlet ICOS cell filter/heater. To locate the disconnection points, see Fig. 150.

c. Remove the orifice filter/heater assembly cover plate.

d. Disconnect the gas expansion from the orifice assembly at the Swagelok location and NOT at the reducer with Teflon tape that is connected into the gas expansion. See Fig. 150.

Fig. 150 Disconnection Point For Orifice Filter & Orifice Replacement



STEP 11 Remove the 10µm filter assembly (gas line, elbow and orifice) (see Fig. 151).

Fig. 151 10µm Filter, Gas Line, Elbow and Orifice

STEP 12 Put the new 10µm filter with orifice and gas expansion on the table and go to the 2µm filter replacement procedure.

2µm Filter Replacement

Required items and tools:

- 2µm filter
- Clean table with wheels

NOTE: There are multiple 2µm filter assemblies. All these filter assemblies will fit into the gas lines as designed, but their effectiveness is gas-dependent. The wrong filter type may plug up the gas line or filter out the gas that the customer wants to measure. Make sure to order the correct filter based on the Gas Analyzer model number.

To replace the 2µm filter:

STEP 1 Perform a soft shutdown on the Gas Analyzer:

a. From the Control Bar on the touchscreen, click Exit.

b. In the window that appears, confirm the shutdown by clicking OK.

c. Close the customer sample gas line valve connected to the Gas Analyzer inlet gas line.

d. Open the customer filtered air line valve that is in line with the sample gas line going into the Gas Analyzer.

STEP 2 Open the Gas Analyzer enclosure:

a. Use the Philips screwdriver to loosen all clamps securing the Gas Analyzer front panel.

b. Open the Gas Analyzer front panel.

c. Secure your grounding wrist strap to any bare metal surface on the Gas Analyzer chassis.

STEP 3 Put the Gas Analyzer On/Off switch to the “Off” position. This switch is located in the upper right corner, next to the purge controller.

STEP 4 Remove the two screws holding the ICOS assembly top heat shield.

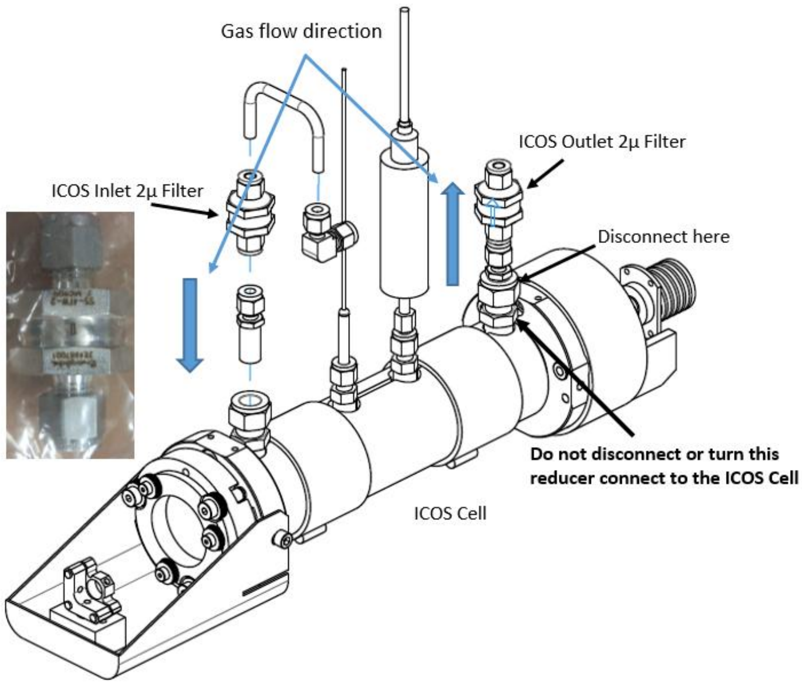
STEP 5 Unscrew the Swagelok nut on the gas line between the exhaust side of the ICOS outlet 2µ filter and the proportional valve.

STEP 6 Separate the two assemblies.

STEP 7 Replace the exhaust line 2µm filter assembly:

a. Remove the 2µm filter assembly from the exhaust line. To locate the 2µm filters, see Fig. 152.

Fig. 152 2µm Filter Assembly Locations



b. Install a new 2µm filter assembly on the exhaust line going to the proportional valve. Make sure that you have the flow arrow pointing in the appropriate direction before locking in the Swagelok fittings.

c. Re-connect the Swagelok nut with the new 2µm filter assembly on the exhaust side of the ICOS cell assembly.

STEP 8 Unscrew the Swagelok nut on the gas line between the ICOS cell and the ICOS inlet 2µm filter/heater assembly.

STEP 9 Separate the two assemblies.

STEP 10 Replace the exhaust line 2µm filter assembly:

a. Remove the 2µm filter assembly from the ICOS cell filter/heater assembly.

b. Install the new 2µm filter assembly in the ICOS cell filter/heater assembly. Make sure you have the flow *arrow* pointing in the appropriate direction before locking in the Swagelok fittings.

c. Re-connect the Swagelok nut with the new 2µm filter assembly on the inlet side of the ICOS cell assembly.

STEP 11 Tighten the Swagelok nuts at the ICOS cell assembly inlet and outlet. Use the Swagelok gap inspection gauge as a *no-go* gauge when tightening the Swagelok nuts for proper tightness. The final nut position should be only barely over the gauge gap where the gauge can no longer fit into the gap between the two nuts.

STEP 12 Reconnect the Gas Analyzer:

a. Place the middle insulation foam on top of the ICOS cell assembly and secure it into place using the two screws taken out earlier, during removal.

b. Use Swagelok nuts to connect the gas expansion to the inlet ICOS cell filter/heater assembly.

c. Use Swagelok nuts to connect the gas line from the inlet solenoid valve to the orifice filter/heater assembly.

d. Put the cover back over the orifice filter/heater assembly.

e. Install the Gas Analyzer back within the enclosure. Use the seven screws removed earlier to secure it into place.

f. Reconnect the purge controller AC power cord to the Gas Analyzer AC power switch.

g. Go to the GUA junction box and turn on the switch to make AC power available to the Gas Analyzer.

STEP 13 Put the Gas Analyzer On/Off switch to the “On” position.

STEP 14 Test connections for leaks:

a. Slide switch S2 to the left position on the 2-port solenoid driver board so that the exhaust pump starts.

b. Read the ICOS cell pressure on the Control Bar. If it is not within ±1 Torr of the original reading prior to this replacement, check for leaks and resolve them.

STEP 15 Slide switch S2 to the right position on the 2-port solenoid driver board so that the computer starts running the exhaust pump.

STEP 16 Reinstall the blue heat shield

a. Put back the top insulation foam that covers the gas expansion and orifice filter/heater assemblies.

b. Install the top heat shield cover on the top insulation foam.

c. Secure it into place by the six screws removed to get access to the 10µm filter assembly with gas line, elbow and orifice to the gas expansion.

d. Slide in the left and right shield cover tongues in the gap on the top blue shield cover.

e. Latch the left and right shields into place.

STEP 17 Reconnect the NIR detector fan power cable.

STEP 18 Close the Gas Analyzer:

a. Close the front panel and secure it into position with all door clamps.

b. Close the filtered air line check valve on the customer sample gas line feeding the instrument.

STEP 19 Verify the replacement:

a. Open the traceable regulated certified bottled gas line valve and let the gas sample go into the Gas Analyzer for measurement.

b. Allow 20 minutes for the Gas Analyzer to stabilize and verify the measurement of the traceable regulated certified bottled gas concentration matches the numbers written for the gas bottle.

If they do not, calibrate the Gas Analyzer to the traceable regulated certified bottled gas(es) that the Gas Analyzer is designed to measure. Make sure that the bottled gas is not running low as that may produce incorrect concentration levels.

c. Close the check valve to the traceable regulated certified gas bottle.

d. Open the Gas Analyzer valve to the customer sample gas line.

e. Review the customer gas sample measured data. Make sure that the customer gas sample measurements are back within their control limits for that specific gas type.

The 10-year preventive maintenance is now complete.

Appendix A Gas Analyzer Parts List

CAT #	Description
950-0000-9000-0000	KIT, YEARLY MAINTENANCE, C1D2 Inlet Filter Assembly, 10µ screen PUMP REBUILD KIT, (×2) PU3752 Mirror Cleaning Kit
950-0000-9001-0000	KIT, 5-YEAR PREVENTIVE MAINTENANCE, C1D2 Inlet Filter Assembly, 10µ screen ASSY, PUMP, Dual Head, C1D2 Mirror Cleaning Kit ASSY, FILTER, 10µ, C1D2 ASSY, ORIFICE, 200µ
950-0000-9002-0000	KIT, 10-YEAR PREVENTIVE MAINTENANCE, C1D2 Inlet Filter Assembly, 10µ screen ASSY, PUMP, Dual Head, C1D2 Mirror Cleaning Kit ASSY, FILTER, 10µ, C1D2 ASSY, ORIFICE, 200µ ¼″ tube in-line filter, 2µ ASSY, Gas Expansion Heater Solenoid Inlet Valve
950-0000-9003-0000	FUSE, 5A (PACK OF 5)
950-0000-9004-0000	SWITCH, POWER
950-0000-9005-0000	POWER SUPPLY, 24V
950-0000-9006-0000	PS100, DC/DC CONVERTER
950-0000-9007-0000	FAN, 80MM
950-0000-9008-0000	FAN, 60MM
950-0000-9009-0000	ASSY, PZT DRIVER
950-0000-9010-0000	PC200, PRESSURE CONTROLLER
950-0000-9011-0000	PRESSURE GAUGE, 3PSIA
950-0000-9012-0000	PUMP, DUAL HEAD WITH FITTINGS
950-0000-9013-0000	PROPORTIONAL VALVE
950-0000-9014-0000	THERMOCOUPLE, ORIFICE
950-0000-9015-0000	THERMOCOUPLE, ICOS FILTER
950-0000-9016-0000	THERMOCOUPLE, ICOS CELL
950-0000-9017-0000	MODULE, MODBUS
950-0000-9018-0000	MODULE, SOLID-STATE RELAY

CAT #	Description
950-0000-9019-0000	MODULE, TEMPERATURE CONTROLLER
950-0000-9020-0000	MODULE, SIGNAL ISOLATOR, 4–20mA
950-0000-9021-0000	THAMP, ICOS
950-0000-9022-0000	INLET SOLENOID VALVE
950-0000-9023-0000	PCB, 2CH VALVE DRIVER
950-0000-9024-0000	HEATER BAND (QTY 2), ICOS
950-0000-9025-0000	HEATER ASSY, ORIFICE
950-0000-9026-0000	HEATER ASSY, ICOS FILTER
950-0000-9027-0000	HEATER ASSY, GAS EXPANSION w/TC
950-0000-9028-0000	ICOS FLANGE, DYNAMIC w/PZT
950-0000-9029-0000	THERMISTOR ASSY, BULKHEAD HEAT SENSOR
950-0000-9030-0000	THERMISTOR ASSY, HEAT SENSOR GP
950-0000-9031-0000	PC104 STACK w/FASTCARD, ICOS
950-0000-9032-0000	HARD DRIVE, 320GB SATA II/300

Appendix B Gas Transmitted Intensity & Absorption Profiles

Fig. 153 O_2 Typical Profile

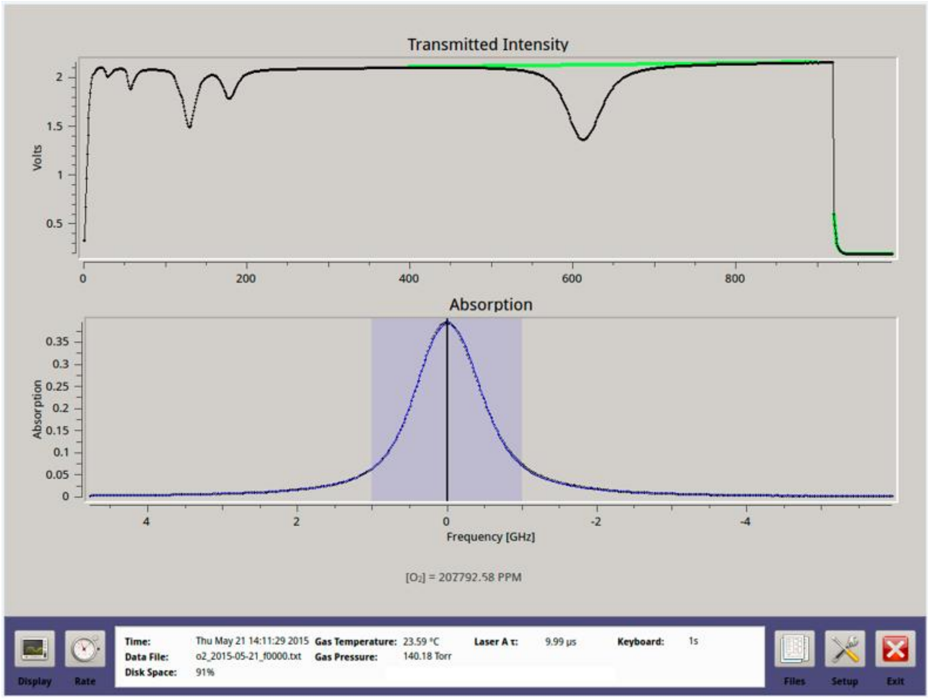


Fig. 154 O_2 Incorrect Profile

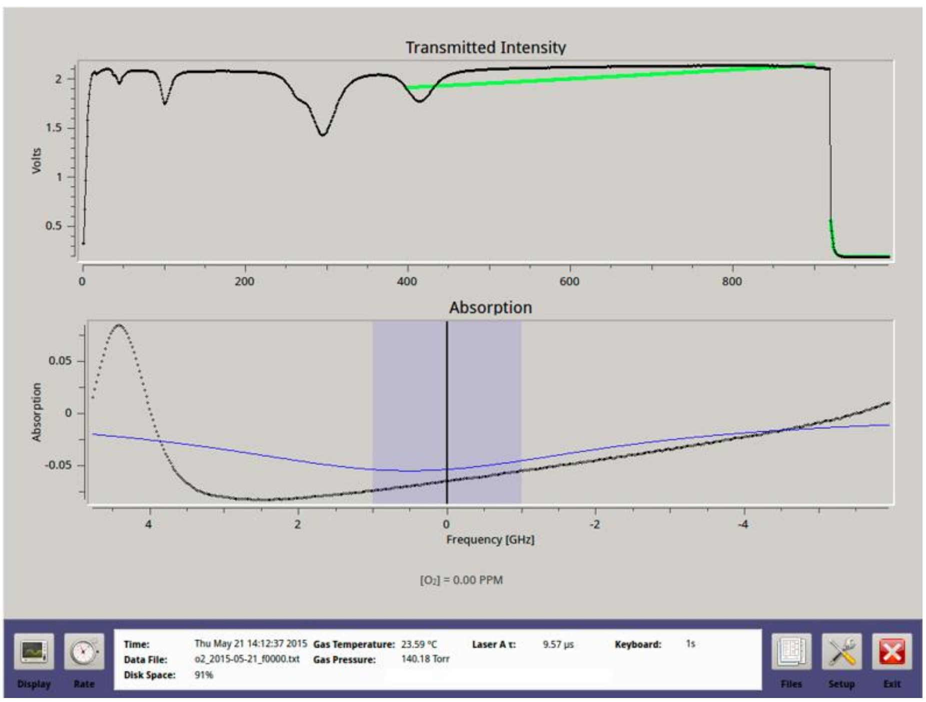


Fig. 155 H_2S Typical Profile

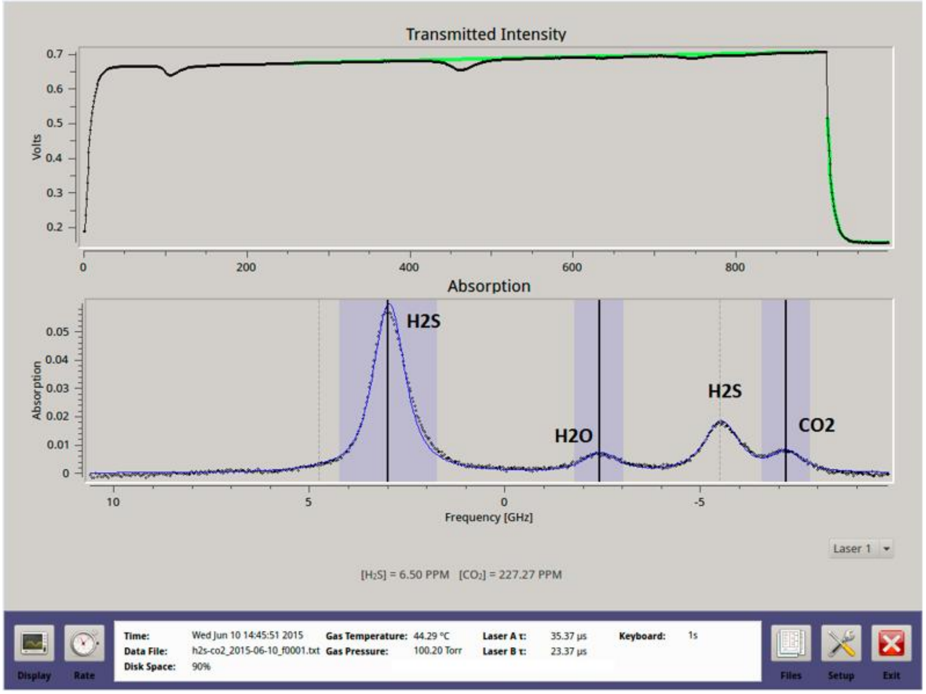


Fig. 156 CO_2 Typical Profile

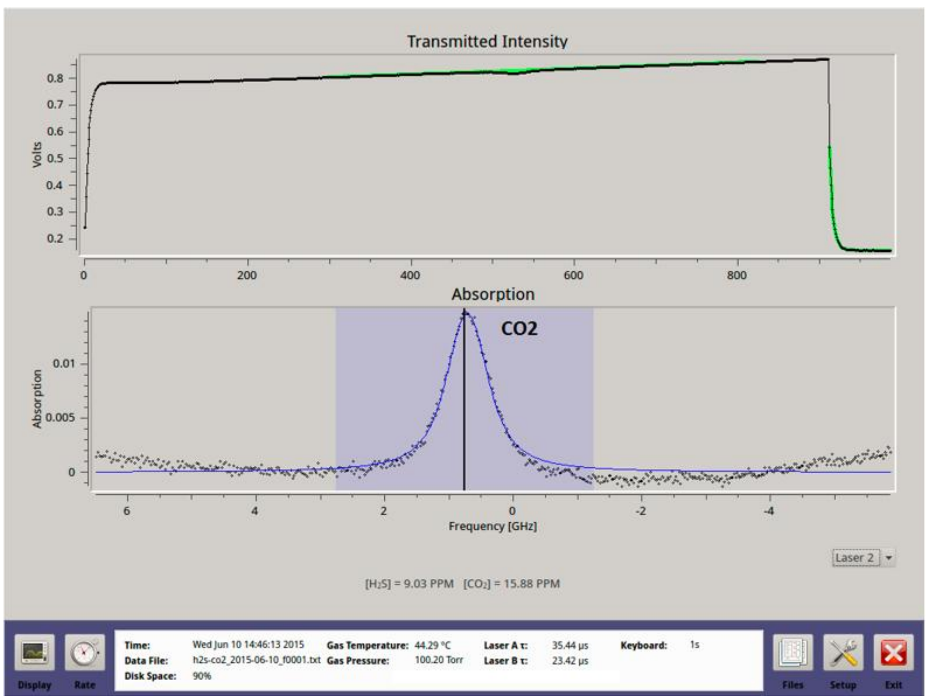


Fig. 157 CH_4/H_2O Typical Profile

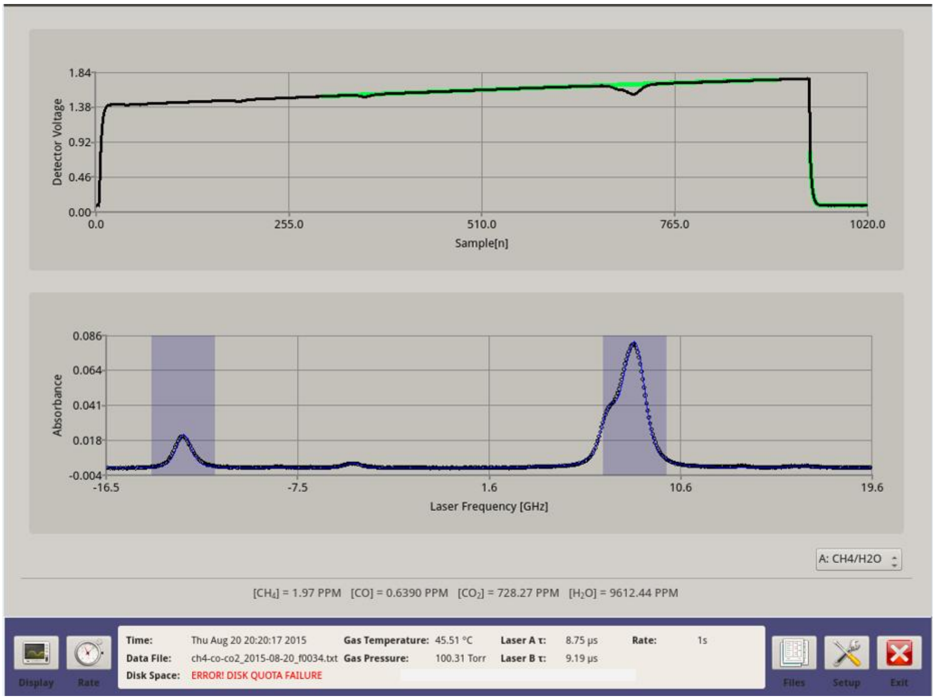
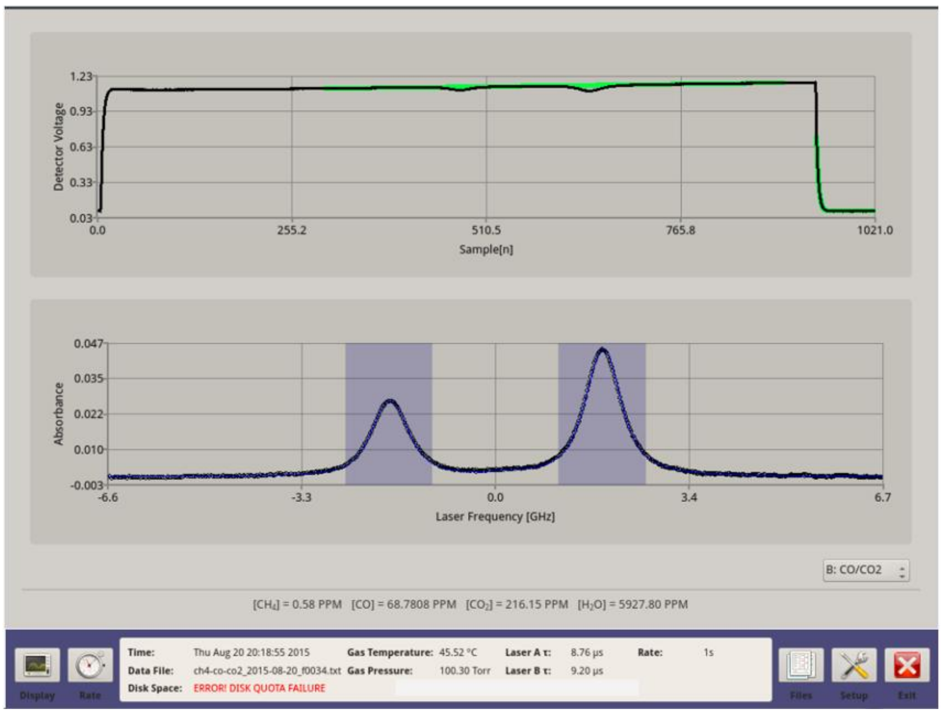


Fig. 158 CO/CO_2 Typical Profile



Appendix C Material Safety Data Sheets

This chapter provides material safety data sheets for the chemicals typically used in *LGR-ICOS* Gas Analyzer instruments. Each chemical has an MSDS, which lists the product name, supplier contacts (including emergency numbers), chemical and safety information, and other information as determined by the chemical manufacturer.

NOTE: The MSDS in this chapter is for reference only. MSDS documents come from different manufacturers, and are subject to change. Refer to the site-specific MSDS at your location for additional material safety information.

Methanol MSDS

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name:	Methanol
Product number:	414719
Brand:	Fluka
Index-No.:	603-001-00-X
CAS-No.:	67-56-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses:	Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone:	+1 800-325-5832
Fax:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Flammable liquids (Category 2), H225
Acute toxicity, Oral (Category 3), H301
Acute toxicity, Inhalation (Category 3), H331
Acute toxicity, Dermal (Category 3), H311
Specific target organ toxicity - single exposure (Category 1), H370
For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram	
Signal word	Danger
Hazard statement(s)	
H225	Highly flammable liquid and vapor.
H301 + H311 + H331	Toxic if swallowed, in contact with skin or if inhaled
H370	Causes damage to organs.
Precautionary statement(s)	
P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P260	Do not breathe dust/ fume/ gas/ mist/ vapors/ spray.
P264	Wash skin thoroughly after handling.
P270	Do not eat, drink or smoke when using this product.
P271	Use only outdoors or in a well-ventilated area.
P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P310	IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.
P303 + P361 + P353	IF ON SKIN (or hair): Remove/ Take off immediately all contaminated clothing. Rinse skin with water/ shower.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P307 + P311	IF exposed: Call a POISON CENTER or doctor/ physician.
P322	Specific measures (see supplemental first aid instructions on this label).
P330	Rinse mouth.
P361	Remove/Take off immediately all contaminated clothing.
P363	Wash contaminated clothing before reuse.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam for extinction.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P403 + P235	Store in a well-ventilated place. Keep cool.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS – none

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Synonyms:	Methyl alcohol
Formula:	CH_4O
Molecular weight:	32.04 g/mol
CAS-No.:	67-56-1
EC-No.:	200-659-6
Index-No.:	603-001-00-X
Registration number:	01-2119433307-44-XXXX

Hazardous components

Component	Classification	Concentration
Methanol		
	Flam. Liq. 2; Acute Tox. 3; STOT SE 1; H225, H301 + H311 + H331, H370	<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed

The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed

No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Wear respiratory protection. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapors accumulating to form explosive concentrations.
Vapors can accumulate in low areas.
For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapor or mist.
Use explosion-proof equipment. Keep away from sources of ignition - No smoking. Take measures to prevent the buildup of electrostatic charge.
For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

7.3 Specific end use(s)
Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Methanol	67-56-1	TWA	200.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Headache Nausea Dizziness Eye damage Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Danger of cutaneous absorption		
		STEL	250.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Headache Nausea Dizziness Eye damage Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Danger of cutaneous absorption		
		TWA	200.000000 ppm 260.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Potential for dermal absorption		
		ST	250.000000 ppm 325.000000 mg/m3	USA. NIOSH Recommended Exposure Limits
		Potential for dermal absorption		
		TWA	200.000000 ppm	USA. Occupational Exposure Limit
			260.000000 mg/m3	(OSHA) - Table Z-1 Limits for Air Contaminants
		The value in mg/m3 is approximate.		

Biological occupational exposure limits

Component	CAS-No.	Parameters	Value	Biological specimen	Basis
Methanol	67-56-1	Methanol	15.0000 mg/l	Urine	ACGIH – Biological Exposure Indices (BEI)
	Remarks	End of shift (As soon as possible after exposure ceases)			

Derived No Effect Level (DNEL)

Application Area	Exposure Routes	Health effect	Value
Workers	Skin contact	Long-term systemic effects	40mg/kg BW/d
Consumers	Skin contact	Long-term systemic effects	8mg/kg BW/d
Consumers	Ingestion	Long-term systemic effects	8mg/kg BW/d
Workers	Skin contact	Acute systemic effects	40mg/kg BW/d
Consumers	Skin contact	Acute systemic effects	8mg/kg BW/d

Consumers	Ingestion	Acute systemic effects	8mg/kg BW/d
Workers	Inhalation	Acute systemic effects	260 mg/m3
Workers	Inhalation	Acute local effects	260 mg/m3
Workers	Inhalation	Long-term systemic effects	260 mg/m3
Workers	Inhalation	Long-term local effects	260 mg/m3
Consumers	Inhalation	Acute systemic effects	50 mg/m3
Consumers	Inhalation	Acute local effects	50 mg/m3
Consumers	Inhalation	Long-term systemic effects	50 mg/m3
Consumers	Inhalation	Long-term local effects	50 mg/m3

Predicted No Effect Concentration (PNEC)

Compartment	Value
Soil	23.5 mg/kg
Marine water	15.4 mg/l
Fresh water	154 mg/l
Fresh water sediment	570.4 mg/kg
Onsite sewage treatment plant	100 mg/kg

8.2 Exposure controls

Appropriate engineering controls
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

Personal protective equipment

Eye/face protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: butyl-rubber
Minimum layer thickness: 0.3 mm
Break through time: 480 min
Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.4 mm
Break through time: 31 min
Material tested: Camatril® (KCL 730 / Aldrich Z677442, Size M)
data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection
Complete suit protecting against chemicals, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN(EU).

Control of environmental exposure
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a) Appearance Form:	liquid
Color:	colorless
b) Odor	pungent
c) Odor	Threshold No data available
d) pH	No data available
e) Melting point/freezing point	
Melting point/range:	-98°C (-144°F) - lit.
f) Initial boiling point and boiling range	64.7°C (148.5°F)
g) Flash point	9.7°C (49.5°F) - closed cup
h) Evaporation rate	No data available
i) Flammability (solid, gas)	No data available
j) Upper/lower flammability or explosive limits	
Upper explosion limit:	36%(V)
Lower explosion limit:	6%(V)
k) Vapor pressure	130.3 hPa (97.7 mmHg) at 20.0°C (68.0°F) 546.6 hPa (410.0 mmHg) at 50.0°C (122.0°F) 169.27 hPa (126.96 mmHg) at 25.0°C (77.0°F)
l) Vapor density	1.11
m) Relative density	0.791 g/cm^3 at 25°C (77°F)

n) Water solubility completely miscible

o) Partition coefficient: noctanol/water	log Pow: -0.77
p) Auto-ignition temperature	455.0°C (851.0°F) at 1,013 hPa (760 mmHg)
q) Decomposition temperature	No data available
r) Viscosity	No data available
s) Explosive properties	Not explosive
t) Oxidizing properties	The substance or mixture is not classified as oxidizing.

9.2 Other safety information

Minimum ignition energy	0.14 mJ
Conductivity	< 1 μS/cm
Relative vapor density	1.11

10. STABILITY AND REACTIVITY

10.1 Reactivity

No data available

10.2 Chemical stability

Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

Vapors may form explosive mixture with air.

10.4 Conditions to avoid

Heat, flames and sparks. Extremes of temperature and direct sunlight.

10.5 Incompatible materials

Acid chlorides, Acid anhydrides, Oxidizing agents, Alkali metals, Reducing agents, Acids

10.6 Hazardous decomposition products

Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LDLO Oral - Human - 143 mg/kg
Remarks: Lungs, Thorax, or Respiration: Dyspnea. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

LD50 Oral - Rat - 1,187 - 2,769 mg/kg

LC50 Inhalation - Rat - 4 h - 128.2 mg/l

LC50 Inhalation - Rat - 6 h - 87.6 mg/l

LD50 Dermal - Rabbit - 17,100 mg/kg

No data available

Skin corrosion/irritation
Skin - Rabbit
Result: No skin irritation

Serious eye damage/eye irritation
Eyes - Rabbit
Result: No eye irritation

Respiratory or skin sensitization
Maximization Test (GPMT) - Guinea pig
Does not cause skin sensitization.
(OECD Test Guideline 406)

Germ cell mutagenicity
Ames test
S. typhimurium
Result: negative in vitro assay fibroblast
Result: negative
Mutation in mammalian somatic cells.
Mutagenicity (in vivo mammalian bone-marrow cytogenetic test, chromosomal analysis)
Mouse - male and female
Result: negative

Carcinogenicity
IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
Damage to fetus not classifiable
Fertility classification not possible from current data.

Specific target organ toxicity - single exposure
Causes damage to organs.

Specific target organ toxicity - repeated exposure
The substance or mixture is not classified as specific target organ toxicant, repeated exposure.

Aspiration hazard
No aspiration toxicity classification

Additional Information
RTECS: PC1400000
Methyl alcohol may be fatal or cause blindness if swallowed.
Effects due to ingestion may include:, Headache, Dizziness, Drowsiness, metabolic acidosis, Coma, Seizures.
Symptoms may be delayed., Damage of the:, Liver, Kidney
Central nervous system - Breathing difficulties - Based on Human Evidence
Stomach - Irregularities - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish mortality	LC50 - Lepomis macrochirus (Bluegill) - 15,400.0 mg/l - 96 h NOEC - Oryzias latipes - 7,900 mg/l - 200 h
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - > 10,000.00 mg/l - 48 h
Toxicity to algae	Growth inhibition EC50 - Scenedesmus capricornutum (fresh water algae) - 22,000.0 mg/l - 96 h

12.2 Persistence and degradability

Biodegradability	aerobic - Exposure time 5 d
Result:	72 % - rapidly biodegradable
Biochemical Oxygen Demand (BOD)	600 - 1,120 mg/g
Chemical Oxygen Demand (COD)	1,420 mg/g
Theoretical oxygen demand	1,500 mg/g

12.3 Bioaccumulative potential

Bioaccumulation	Cyprinus carpio (Carp) - 72 d at 20 °C - 5 mg/l

Bioconcentration factor (BCF): 1.0

12.4 Mobility in soil
Will not adsorb on soil.

12.5 Results of PBT and vPvB assessment
PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

Additional ecological Information	Avoid release to the environment.
Stability in water	at 19 °C83 - 91 % - 72 h
Remarks:	Hydrolyses on contact with water. Hydrolyses readily.

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product

Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging

Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)

UN number: 1230	Class: 3	Packing group: II
Proper shipping name:	Methanol	
Reportable Quantity (RQ):	5000 lbs	
Poison Inhalation Hazard:	No	

IMDG

UN number: 1230	Class: 3 (6.1)	Packing group: II EMS-No: F-E, S-D
Proper shipping name:	METHANOL	

IATA

UN number: 1230	Class: 3 (6.1)	Packing group: II
Proper shipping name:	Methanol	

15. REGULATORY INFORMATION

SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Methanol	67-56-1	2007-07-01

SARA 311/312 Hazards

Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Methanol	67-56-1	2007-07-01

Pennsylvania Right To Know Components

Methanol	CAS-No. 67-56-1	Revision Date 2007-07-01

New Jersey Right To Know Components

Methanol	CAS-No. 67-56-1	Revision Date 2007-07-01

California Prop. 65 Components

WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm. Methanol	CAS-No. 67-56-1	Revision Date 2012-03-16

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Acute Tox.	Acute toxicity
Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapor.
H301	Toxic if swallowed.
H301 + H311 + H331	Toxic if swallowed, in contact with skin or if inhaled
H311	Toxic in contact with skin.
H331	Toxic if inhaled.
H370	Causes damage to organs.

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0

Further information

 The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Acetone MSDS

1. PRODUCT AND COMPANY IDENTIFICATION

1.1 Product identifiers

Product name:	Acetone
Product Number:	154598
Brand:	Sigma-Aldrich
Index-No.:	606-001-00-8
CAS-No.:	67-64-1

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified uses:	Laboratory chemicals, Manufacture of substances

1.3 Details of the supplier of the safety data sheet

Company:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone:	+1 800-325-5832
Fax:	+1 800-325-5052

1.4 Emergency telephone number

Emergency Phone #:	(314) 776-6555

2. HAZARDS IDENTIFICATION

2.1 Classification of the substance or mixture

GHS Classification in accordance with 29 CFR 1910 (OSHA HCS)

Flammable liquids (Category 2), H225
Eye irritation (Category 2A), H319
Specific target organ toxicity - single exposure (Category 3), Central nervous system, H336
For the full text of the H-Statements mentioned in this Section, see Section 16.

2.2 GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H225	Highly flammable liquid and vapor.
H319	Causes serious eye irritation.
H336	May cause drowsiness or dizziness.

Precautionary statement(s)

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P233	Keep container tightly closed.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ ventilating/ lighting/ equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P261	Avoid breathing dust/ fume/ gas/ mist/ vapors/ spray.

P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P280	Wear protective gloves/ eye protection/ face protection.
P303 + P361 + P353	IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304 + P340 + P312	IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER or doctor/ physician if you feel unwell.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P337 + P313	If eye irritation persists: Get medical advice/ attention.
P370 + P378	In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P403 + P235	Store in a well-ventilated place. Keep cool.
P405	Store locked up.
P501	Dispose of contents/ container to an approved waste disposal plant.

2.3 Hazards not otherwise classified (HNOC) or not covered by GHS

Repeated exposure may cause skin dryness or cracking.

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Substances

Formula	: C_3H_6O
Molecular weight	: 58.08 g/mol
CAS-No.	: 67-64-1
EC-No.	: 200-662-2
Index-No.	: 606-001-00-8
Registration number	: 01-2119471330-49-XXXX

Component Classification Concentration

Acetone

Flam. Liq. 2; Eye Irrit. 2A; STOT SE 3; H225, H319, H336

<= 100 %

For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1 Description of first aid measures

General advice

Consult a physician. Show this safety data sheet to the doctor in attendance. Move out of dangerous area.

If inhaled

If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact

Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

4.2 Most important symptoms and effects, both acute and delayed
The most important known symptoms and effects are described in the labelling (see section 2.2) and/or in section 11

4.3 Indication of any immediate medical attention and special treatment needed
No data available

5. FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

5.2 Special hazards arising from the substance or mixture
Carbon oxides

5.3 Advice for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

5.4 Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures
Use personal protective equipment. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapors accumulating to form explosive concentrations. Vapors can accumulate in low areas. For personal protection see section 8.

6.2 Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

6.3 Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

6.4 Reference to other sections
For disposal see section 13.

7. HANDLING AND STORAGE

7.1 Precautions for safe handling

Avoid contact with skin and eyes. Avoid inhalation of vapor or mist. Use explosion-proof equipment. Keep away from sources of ignition - No smoking. Take measures to prevent the buildup of electrostatic charge. For precautions see section 2.2.

7.2 Conditions for safe storage, including any incompatibilities

Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage. Storage class (TRGS 510): Flammable liquids

7.3 Specific end use(s)

Apart from the uses mentioned in section 1.2 no other specific uses are stipulated

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Components with workplace control parameters

Component	CAS-No.	Value	Control parameters	Basis
Acetone	67-64-1	TWA	500.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Remarks	Central Nervous System impairment Hematologic effects Upper Respiratory Tract irritation Eye irritation Adopted values or notations enclosed are those for which changes are proposed in the NIC See Notice of Intended Changes (NIC) Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Not classifiable as a human carcinogen		
		TWA	500 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Central Nervous System impairment Hematologic effects Upper Respiratory Tract irritation Eye irritation Adopted values or notations enclosed are those for which changes are proposed in the NIC See Notice of Intended Changes (NIC) Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Not classifiable as a human carcinogen		
		STEL	750.000000 ppm	USA. ACGIH Threshold Limit Values (TLV)
		Central Nervous System impairment Hematologic effects Upper Respiratory Tract irritation Eye irritation Adopted values or notations enclosed are those for which changes are proposed in the NIC See Notice of Intended Changes (NIC) Substances for which there is a Biological Exposure Index or Indices		

(see BEI® section)
Not classifiable as a human carcinogen

STEL	750 ppm	USA. ACGIH Threshold Limit Values (TLV)

Central Nervous System impairment
Hematologic effects
Upper Respiratory Tract irritation
Eye irritation
Adopted values or notations enclosed are those for which changes are proposed in the NIC
See Notice of Intended Changes (NIC)
Substances for which there is a Biological Exposure Index or Indices (see BEI® section)
Not classifiable as a human carcinogen

TWA	1,000.0 ppm 2,400.0 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants

The value in mg/m3 is approximate.

TWA	250.000000 Ppm 590.000000 mg/m3	USA. NIOSH Recommended Exposure Limits

Biological occupational exposure limits

Component	CAS-No.	Parameters	Value	Biological specimen	Basis
Acetone	67-64-1	Acetone	50.0000 mg/l	Urine	ACGIH - Biological Exposure Indices (BEI)
	Remarks	End of shift (As soon as possible after exposure ceases)			

Derived No Effect Level (DNEL)

Application Area	Exposure routes	Health effect	Value
Workers	Skin contact	Long-term systemic effects	186mg/kg BW/d
Consumers	Ingestion	Long-term systemic effects	62mg/kg BW/d
Consumers	Skin contact	Long-term systemic effects	62mg/kg BW/d
Workers	Inhalation	Acute systemic effects	2420 mg/m3
Workers	Inhalation	Long-term systemic effects	1210 mg/m3
Consumers	Inhalation	Long-term systemic effects	200 mg/m3

Predicted No Effect Concentration (PNEC)

Compartment	Value
Soil	33.3 mg/kg
Marine water	1.06 mg/l
Fresh water	10.6 mg/l
Marine sediment	3.04 mg/kg
Fresh water sediment	30.4 mg/kg
Onsite sewage treatment plant	100 mg/l

8.2 Exposure controls

Appropriate engineering controls

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Personal protective equipment

Eye/face protection

Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin protection

Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without
touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: butyl-rubber
Minimum layer thickness: 0.3 mm
Break through time: 480 min
Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)

Splash contact
Material: butyl-rubber
Minimum layer thickness: 0.3 mm
Break through time: 480 min
Material tested: Butoject® (KCL 897 / Aldrich Z677647, Size M)
data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Body Protection

impervious clothing, Flame retardant antistatic protective clothing., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Respiratory protection

Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multipurpose combination (US) or type AXBEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN(EU).

Control of environmental exposure

Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a) Appearance Form:	liquid, clear
Color:	colorless
b) Odor	No data available
c) Odor	Threshold No data available
d) pH	No data available
e) Melting point/freezing point	
Melting point/range:	-94 °C (-137 °F) - lit.
f) Initial boiling point and boiling range:	56 °C (133 °F) at 1,013 hPa (760 mmHg) - lit.
g) Flash point	-16.99 °C (1.42 °F) - closed cup
h) Evaporation rate	No data available
i) Flammability (solid, gas)	No data available
j) Upper/lower flammability or explosive limits	
Upper explosion limit:	13 %(V)
Lower explosion limit:	2 %(V)
k) Vapor pressure	533.3 hPa (400.0 mmHg) at 39.5 °C (103.1 °F) 245.3 hPa (184.0 mmHg) at 20.0 °C (68.0 °F)
l) Vapor density	No data available
m) Relative density	0.791 g/cm3 at 25 °C (77 °F)
n) Water solubility	completely miscible
o) Partition coefficient: noctanol/water log Pow	: -0.24
p) Auto-ignition temperature	465.0 °C (869.0 °F)
q) Decomposition temperature	No data available
r) Viscosity	No data available
s) Explosive properties	No data available
t) Oxidizing properties	No data available

9.2 Other safety information

Surface tension	23.2 mN/m at 20.0 °C (68.0 °F)

10. STABILITY AND REACTIVITY

10.1 Reactivity
No data available

10.2 Chemical stability
Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions
Vapors may form explosive mixture with air.

10.4 Conditions to avoid
Heat, flames and sparks.

10.5 Incompatible materials
Bases, Oxidizing agents, Reducing agents, Acetone reacts violently with phosphorous ox-chloride.

10.6 Hazardous decomposition products
Other decomposition products - No data available
In the event of fire: see section 5

11. TOXICOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 Oral - Rat - 5,800 mg/kg
Remarks: Behavioral: Altered sleep time (including change in righting reflex). Behavioral: Tremor. Behavioral: Headache. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

LC50 Inhalation - Rat - 8 h - 50,100 mg/m3
Remarks: Drowsiness Dizziness Unconsciousness

LD50 Dermal - Guinea pig - 7,426 mg/kg
No data available

Skin corrosion/irritation
Skin - Rabbit
Result: Mild skin irritation - 24 h

Serious eye damage/eye irritation
Eyes - Rabbit
Result: Eye irritation - 24 h

Respiratory or skin sensitization
- Guinea pig
Result: Does not cause skin sensitization.

Germ cell mutagenicity
No data available

Carcinogenicity
This product is or contains a component that is not classifiable as to its carcinogenicity based on its IARC, ACGIH, NTP, or EPA classification.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity
No data available

Specific target organ toxicity - single exposure
May cause drowsiness or dizziness.

Specific target organ toxicity - repeated exposure
No data available

Aspiration hazard
No data available
Additional Information
RTECS: AL3150000

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Kidney - Irregularities - Based on Human Evidence
Skin - Dermatitis - Based on Human Evidence

12. ECOLOGICAL INFORMATION

12.1 Toxicity

Toxicity to fish	LC50 - Oncorhynchus my kiss (rainbow trout) - 5,540 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	LC50 - Daphnia magna (Water flea) - 8,800 mg/l - 48 h
Toxicity to algae Remarks:	No data available

12.2 Persistence and degradability

Biodegradability	Result: 91 % - Readily biodegradable (OECD Test Guideline 301B)

12.3 Bio-accumulative potential

Does not bio-accumulate.

12.4 Mobility in soil

No data available

12.5 Results of PBT and vPvB assessment

PBT/vPvB assessment not available as chemical safety assessment not required/not conducted

12.6 Other adverse effects

No data available

13. DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Product

Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging

Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)

UN number: 1090	Class: 3	Packing group: II
Proper shipping name:	Acetone	
Reportable Quantity (RQ):	5000 lbs	

Poison Inhalation Hazard: No

IMDG

UN number: 1090	Class: 3	Packing group: II EMS-No: F-E, S-D
Proper shipping name:	ACETONE	

IATA

UN number: 1090	Class: 3	Packing group: II
Proper shipping name:	Acetone	

15. REGULATORY INFORMATION

SARA 302 Components

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De-Minimis) reporting levels established by SARA Title III, Section 313.

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Acetone	67-64-1	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Acetone	67-64-1	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Acetone	67-64-1	2007-03-01

California Prop. 65 Components

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Full text of H-Statements referred to under sections 2 and 3.

Eye Irrit.	Eye irritation
Flam. Liq.	Flammable liquids
H225	Highly flammable liquid and vapour.
H319	Causes serious eye irritation.
H336	May cause drowsiness or dizziness.
STOT SE	Specific target organ toxicity - single exposure

HMIS Rating

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical Hazard	0

NFPA Rating

Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0
Health hazard:	2
Fire Hazard:	3
Reactivity Hazard:	0

Further information

 The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Preparation Information

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