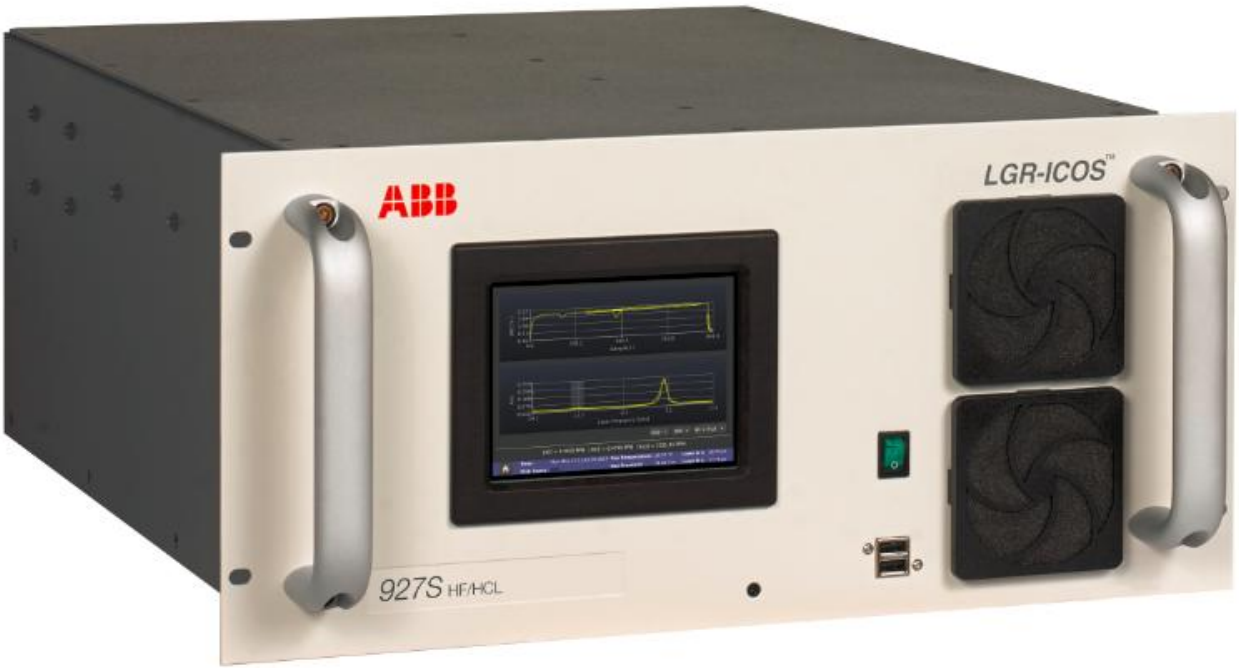
ABB
927 Series Gas Analyzer
Service Manual



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Warning!	Service to the ABB 927 Gas Analyzer is to be performed only by Certified Service Personnel trained on servicing this instrument. User/operator adjustments inside the instrument neither necessary nor recommended by the manufacturer.

Patent

The 927 Gas Analyzer™ technology is protected by patents:

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

Copyright

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Customer Support

ABB provides product support services worldwide. To receive product support, either in or out of warranty, contact the ABB office that serves your geographical area, or the office indicated below:

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

1. Introduction

This manual contains basic information on using the ABB 927 Gas Analyzer, as well as instrument installation, operational safety, maintenance, and troubleshooting information.

This manual describes the various menu and data screens and what information they provide. It also provides instructions to allow the user to calibrate the instrument to its traceable certified bottle gases, adjust data sampling rates, and transfer data through various means, when equipped with specific options.

Even though this user manual provides additional information on the instrument hardware components and their particular functions, it is recommended to have an ABB Service Personnel address any issues encountered with the ABB 927 Gas Analyzer.

2. Safety

The following pages provide important safety precautions.

Class of Laser Equipment

The ABB 927 Gas Analyzer is a Class 1 laser instrument when the front panel is secured into position.

Certification

The ABB 927 Gas Analyzer received the following safety certifications:

Table 1 ABB 927 Gas Analyzer Safety Certifications

Symbols	Standards Tested & Met
CE	EN61326-1:2013
FDA	Title 21 Code of Federal Regulations, chapter 1, sub-chapter J

Figure 1 ABB 927 Gas Analyzer Certification Labels

WEEE Directive

The ABB 927 Gas Analyzer product is not subject to WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment) 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 the 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
	Note: Important information
	Danger: Failure to comply may result in death. Warning: Failure to comply may result in serious injury. Caution: Follow instructions carefully to avoid equipment damage or personal injury.
	High voltage

Labels

The following labels are affixed at specific locations on or in the ABB 927 Gas Analyzer. They identify hazardous areas.

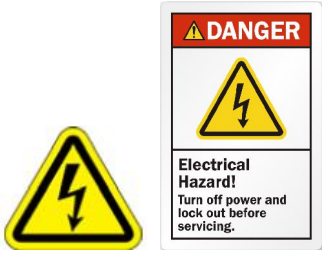
Figure 2 Heavy Object Label

This label is affixed to the outer covers of the ABB 927 Gas Analyzer. The instrument weights ~ 68 pounds.

Figure 3 Pinch Point Label

This label is located on the outer cover enclosure covering the instrument internal components and are held in place with screws.

Figure 4 High Voltage Label



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

Figure 5 Laser Radiation Label

These labels are located on the top cover of the instrument. The fiber laser is visible only when the top instrument cover is removed.

Figure 6 Fire Hazard Label

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

Operator Safety

When the top panel is closed and locked into position, the ABB 927 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 ABB 927 Gas Analyzer is a Category II (overvoltage category) installation.

Do not operate the Gas Analyzer when the top enclosure panel is removed.

- The top enclosure panel protects against electrical shock.
- The Gas Analyzer has a laser interlock switch attached to the top enclosure panels. Do not disable the laser interlock switch when the instrument is powered on. The laser interlock switch is to protect the user of a class IIIb laser used in the Gas Analyzer.

Warning!	Bypassing the laser interlock switch to check on the operation of the laser is not recommended. With the top enclosure cover open, one has direct access to the laser(s) where a primary or secondary reflections of a class IIIb laser can damage the eye.

Heavy Objects

The Gas Analyzer, which weighs approximately 68 lbs. (29 kg), qualifies as a heavy object.

Caution!	The ABB 927 Gas Analyzer should not be hand-carried. It is recommended that the unit be rolled to its final mounting site on a wheeled table. Lifting the instrument to the final mounting location should be accomplished with two people.

When lifting heavy objects:

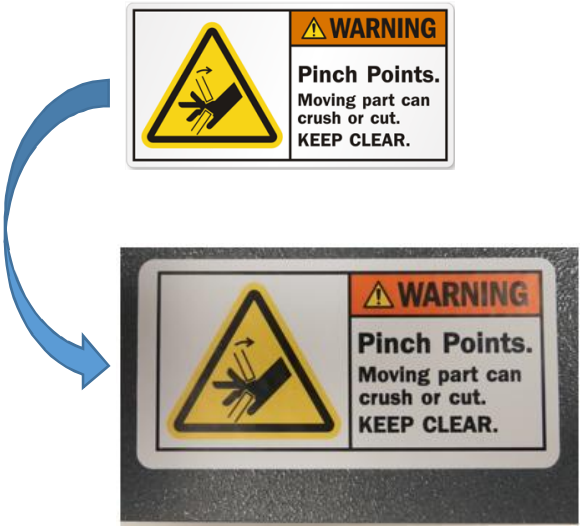
- Use a mechanical hoist, if available.
- Use a minimum of two people for lifting, moving and mounting the Gas Analyzer.
- Use proper lifting techniques:
  - Do not lift with your legs straight or from a forward bent position.
  - Bend your knees and lower your hips, using your leg muscles to lift.
  - 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.

Figure 7 Heavy Object Label and Location

Pinch Point Hazards

There are several pinch point hazards to personnel on the Gas Analyzer. Pinch point hazard locations are marked with a pinch point label. All pinch point locations are on the Gas Analyzer top cover. When lowering the top cover of the Gas Analyzer panel back into place after removal, remove your fingers from the edges where the top cover mates with the side panels of the Gas Analyzer.

Figure 8 Pinch Point Label and Location



Hazardous Voltages

There are three voltage potentials operating above 30 volts RMS on the ABB 927 Gas Analyzer. They provide 115V AC or 220V AC and are located at the power entry module that feeds the two (2) DC Power Supplies, and one (1) Solid State Relay. Components at these three locations/area are marked with the electrical hazard label.

Figure 9 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 the 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 ABB 927 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 preclude accidental shock
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 • Voltage potential 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 top enclosure panel is closed, the instrument is a Type 2 electrical safety task.

The insulation and panels protect operators from electrical hazards. The top panel must remain in place during normal operation. There is only a laser interlock within the instrument to remove power to the laser should the top cover be remove for servicing. This is to protect operators from accidental exposure to indirect laser beam. Should the top cover be remove with the instrument still powered on, the operator will be expose to Type 4 electrical hazards.

Electrical Hazards During Service Operation

Service to the ABB 927 Gas Analyzer should only be perform by a person that has completed the service training for the instrument.

Personnel are expose to live circuit whenever the top panel is opened with the instrument still powered on. Most service tasks require opening the top panel. During these tasks, service personnel are potentially expose to Type 3 electrical hazards. A Type 4 electrical hazard will be encountered when validating AC power from the facility at the power entry module of the instrument to the AC/DC power supply converter.

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

Laser Hazards

There are up to two (2) lasers used in the ABB 927 Gas Analyzer. The laser wavelength is determined by the type of gas to be measure. Under normal operation, with the Gas Analyzer enclosure top 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

Laser(s) used in the ABB 927 Gas Analyzer are rated Class 3B, > 5 mW. Lasers are enclosed and not accessible unless the enclosure is removed for servicing. Laser warning labels are affixed to the enclosure covering the laser(s).

Figure 10 Laser Radiation Labels

Laser(s) 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 component of user-serviceable parts in the Gas Analyzer ICOS module: the ICOS mirrors that can be clean during preventive maintenance (PM) of the instrument.

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.

Internal Laser Interlock Switch

The ABB 927 Gas Analyzer is equipped with an internal laser interlock switch. The interlock switch's main purpose is to disable the laser by removing its power. This prevents exposure and damaging eye accident cause by a class IIIb laser through primary and secondary reflections in the ICOS module. The laser interlock is located on the left side panel toward the front top corner of the instrument. It is keyed where the physical key is mounted on the top panel when lowered into the switch key slot, it will enable a signal to the Laser Controller/Driver board that the interlock is closed to allow power to reach the laser(s).

Fire Hazards

Small amounts of methanol and acetone are used to clean surfaces on the 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.

Figure 11 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.

3. Installation

Visually inspect the ABB 927 Gas Analyzer shipping box for any damages from shipping. If the Gas Analyzer shipped box is located outside, move it inside where the temperature in the enclosed area is similar to that of the instrument's final place for operation. When it is time to unbox the instrument, if there is a large temperature difference between the outside location (where the box was left) and the inside temperature, allow time for the instrument's internal temperature to match the temperature inside the enclosed area, thus preventing condensation from forming up on the instrument's surface when removing the protective bags.

Shipping Package Removal

Table 4 Tools Required for Package Removal

Required tools
Box cutter
Wheeled table or cart capable of carrying no less than 100 lbs.
ESD wrist grounding strap
Ethernet cable
ioSearch application software for ioLogik E1240 (Modbus)

1. [ ] Cut the shipping tape from the top of the box carton.
2. [ ] Remove the top shipping foam from inside the box.
3. [ ] Position the wheeled table or cart next the opened box.
4. [ ] Carefully lift the Gas Analyzer from its shipping box to the wheeled table.
5. [ ] Remove the plastic covering from the Gas Analyzer.
6. [ ] Move the Gas Analyzer to the location where the instrument is to be installed.

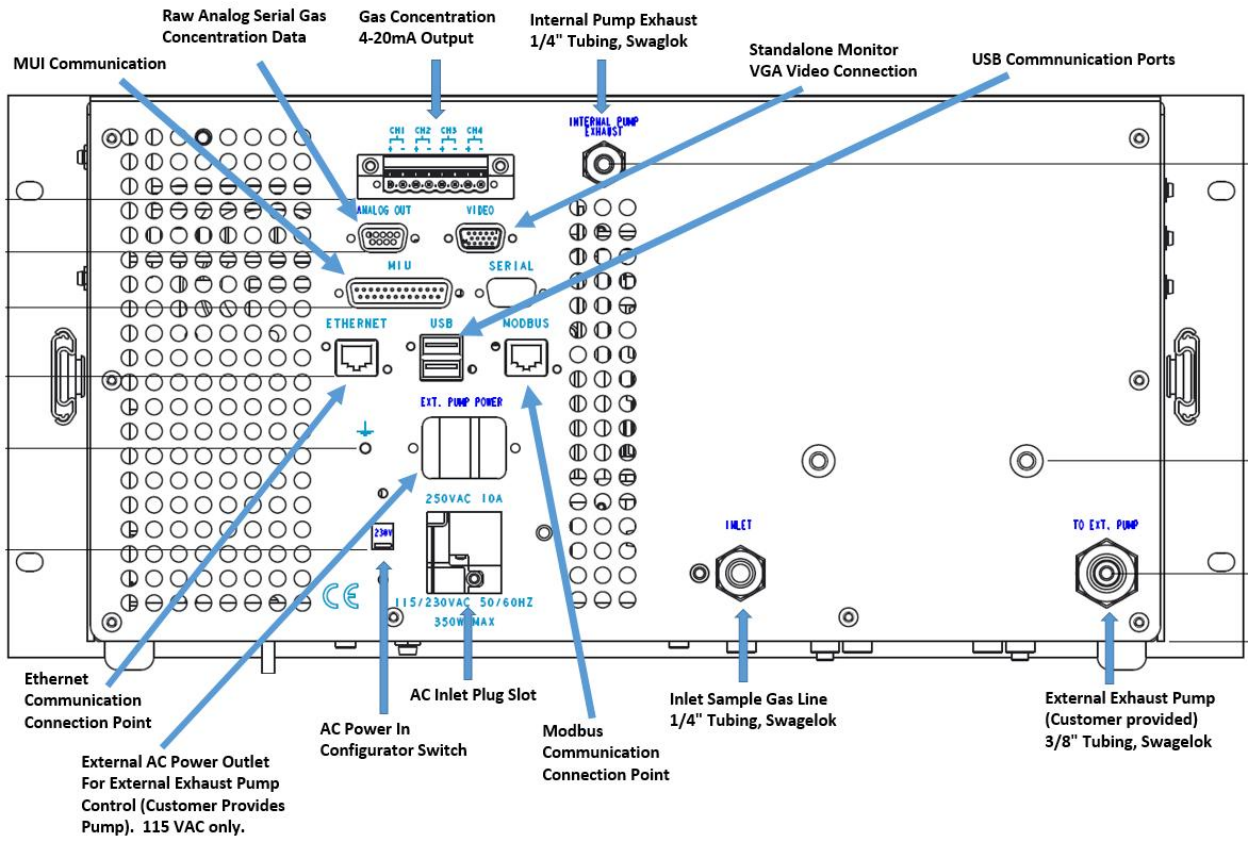
Gas Analyzer Mounting & Facilitation

1. [ ] With the help of another person people, lift the Gas Analyzer and mount it to its final location.
2. [ ] Connect the facility communication lines to the rear of the instrument per the labels ID. Reference Figure 12 for location of all communication ports and fittings to properly plumb the Gas Analyzer.

Note!	There is no rear USB communication port. All USB communication port are on the front panel of the Gas Analyzer.

Note!	All cables connected to the IO ports at the rear panel of the instrument should be shielded. For both the Ethernet and Modbus cables, it is recommended to use double shielded Category 6 S/FTP or SF/UTP type cable. Shielding of communication cable is required to suppress possible radiated and conductive interference affecting the instrument electronics function.

Figure 12 927 Gas Analyzer Communication, Gas Lines, & Power Ports



System Power Up & Communication Checks

3. [ ] With the sample gas line plumb into the Gas Analyzer, and the exhaust line connected to facility exhaust, power on the instrument using the On/Off switch located on the instrument front panel.

4. [ ] Connect the facility communication lines to the rear of the instrument per the labels ID. Reference Figure 12 for location of all communication ports. Do not connect the sample gas line to the gas inlet port at this time.

5. [ ] For 927T model gas analyzer:

   Remove by unscrewing the plugs on the sample gas Inlet port and the Internal Pump Exhaust port from the rear of the instrument. Store the plugs for future use should the Gas Analyzer be moved to a new location.

   Connect the internal exhaust pump, 0.25” tube SwageLok, to the facility gas exhaust line.

   For 927S model gas analyzer:

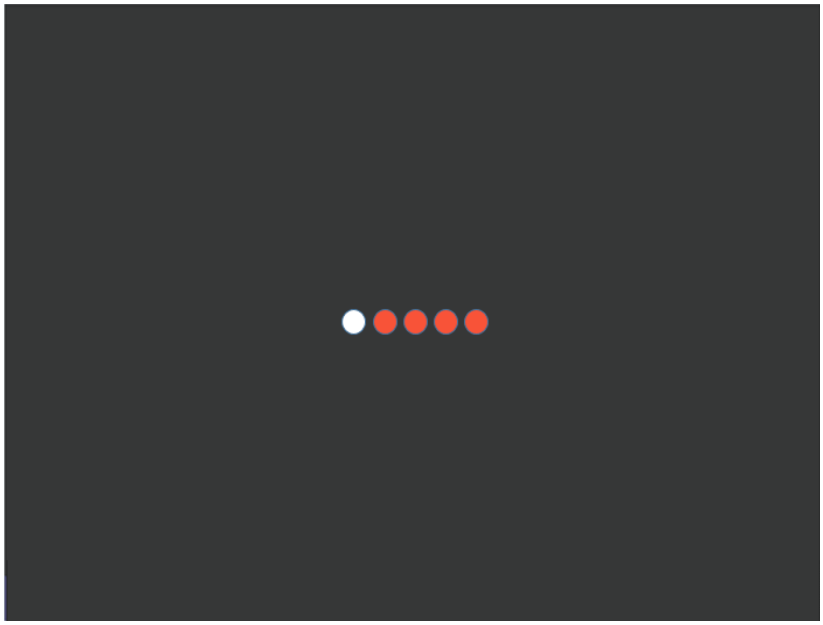
   a. Attached the supplied external exhaust pump inlet through a vacuum line to the rear panel to the port marked “TO EXT. PMP”. The line size is 0.375” (9.525 mm) tube Swagelok. The inlet is marked by the arrow symbol on top of the pump pointing in the direction of the air flow it will be drawing in and exhausting out.

   b. Attached the exhaust pump exhaust line to the facility exhaust port.

6. [ ] If a monitor and keyboard is available, connect the keyboard and mouse in the USB port in the front of the instrument, and the monitor VGA cable to the rear in the Video port.

7. [ ] Power on the instrument using the front On/Off switch.
8. [ ] On both the monitor display, the one is connected to video port in the rear, and the smaller front display, the system software should boot up after processing the system bios. The first screen to be display would be a blank screen with five (5) dots and with one highlight dot scrolling through the five dots as seen in Figure 13, the Program Loading Screen.

Figure 13 Program Loading Screen



After the instrument software completes it booting sequence, the “Main Display” screen will appear.

9. [ ] In the Main Display icon menu screen, tap on the Numeric Display icon. Once in the Numeric Display screen, the gas concentration currently being measured is coming in from the rear through the sample gas inlet port. Unless the air in the room is what the instrument is set to measure, the Numeric display should display “0” for each gas concentration.
10. [ ] Obtain from the shipped documents that came with the Gas Analyzer, get the instrument pre-ship measured data. Look at the instrument HMI Dashboard, Figure 14 (example only). Compare the “*Gas Pressure*” to that currently displayed in the Numeric display screen. If they are the same, the Gas Analyzer is working properly.

Figure 14 HMI Dashboard

11. [ ] Tap the home icon on the HMI dashboard to get back to the Main Display screen.
12. [ ] Select the Alarm Status icon. The Alarm Status screen displaying all the monitored tool parameters should be all green identifying there is no operational issue with the Gas Analyzer. Select the Home icon to get back to the Main Display screen.
13. [ ] If there is a regulated traceable bottle gas available that matches to the sample gas type the instrument configured to measure, connect its gas line to the Inlet gas port of the Gas Analyzer. Make sure the valve in the bottle gas is closed.

14. [ ] Connect the facility exhaust gas line to the External and/or Internal Exhaust Pump port (Internal Exhaust Pump may not be in the purchased model). Make sure the exhaust line is drawing 0.6 LPM minimum.

15. [ ] Open the regulated traceable bottle gas valve. After 5 minutes to allow the bottle gas to go through the Gas Analyzer, verify the measured value on the Numeric display screen is within the concentration range recorded on the regulated traceable bottle gas. If the measurement is outside the concentration range of the regulated traceable bottle gas, calibration is require. To recalibrate the Gas Analyzer for that specific gas concentration, follow the procedure called "*Calibration*" under section *6 User Interface Operations* of this manual.

16. [ ] Close the regulated traceable bottle gas valve. Remove the regulated traceable bottle gas line from the Gas Analyzer sample gas inlet port.

17. [ ] Connect the sample gas line to be measured by the Gas Analyzer to the sample gas Inlet port.

18. [ ] Open the valve to the sample gas line. The Gas Analyzer should be displaying the measured concentration of the sample gas passing through its measurement chamber.

19. [ ] If the monitor, keyboard and mouse is not going to remain connected on the Gas Analyzer, then:

    a. Exit out from the Gas Analyzer operating software by selecting [Exit] icon on the main display. Select [Yes] to the follow up question: *Do you wish to Shutdown*?.

    b. Once the software have completed its exit and display the message: *You may turn off the Analyzer now*, toggle the On/Off switch at the front of the instrument to the Off position.

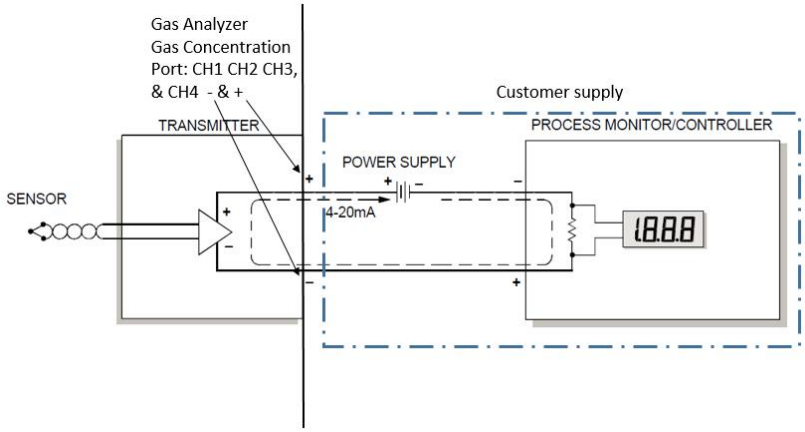
    c. Disconnect the VGA cable from the monitor that is attached to the Video port at the rear of the instrument.

    d. Disconnect the keyboard and mouse from the front USB port.

Note!	
	Failure to follow the sequence in first selecting "exit" follow by "shutdown" prior to disconnecting the keyboard and mount from the USB port can lockup the instrument.

20. [ ] Connect the remaining communication cable(s) 4-20mA gas concentration, Modbus, and/or Ethernet line to I/O ports at the rear instrument panel. Note that the 4-20mA setup is a passive circuit requiring the customer to supply +12 to +24 vdc to the gas concentration contacts at the rear of the Gas Analyzer.

Figure 6 4-20mA Passive Circuit Connection Diagram



21. [ ] Reboot the Gas Analyzer. The instrument is now ready to take gas measurements.

4. Measurement Theory

The ABB 927 Gas Analyzer is a cavity-based Spectroscopy instrument. The cavity design of the ABB 927 Gas Analyzer enhances the absorption of laser light by the target gas molecule. The enhancement improves the signal to noise ratio over conventional laser sensors enabling trace gas measurement and sensitive monitoring. The type of gas that the ABB 927 Gas Analyzer can measure is based upon the laser wavelength used. There are various ABB 927 Gas Analyzer models, each targeting gases that various industries are interested in monitoring. All measurements are taken in real time.

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 $$\frac{I_v}{I_o} = e^{-SL_xP\phi_v}$$

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 spectra may be recorded by tuning the laser wavelength over the probed feature.

Integration of the measured spectra 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.

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 tens of microseconds).

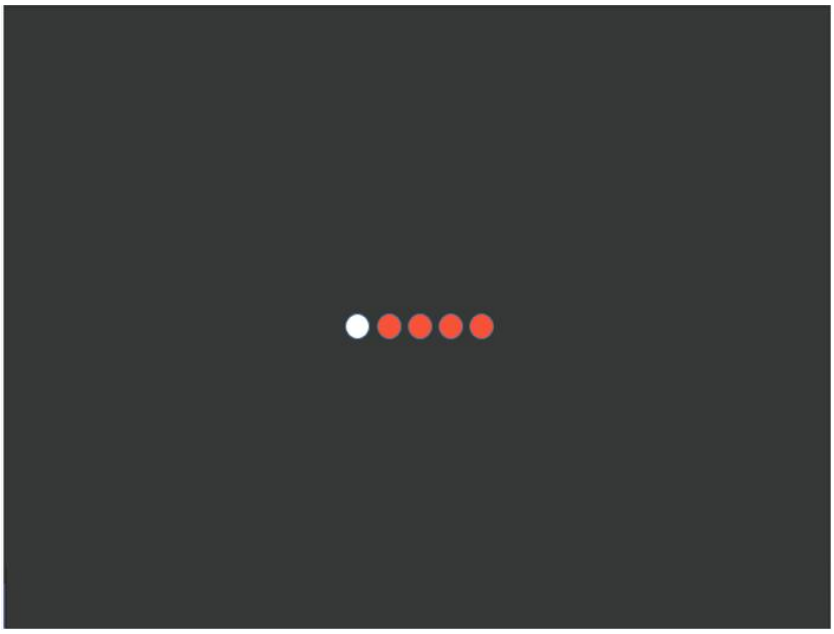
As with conventional tunable-laser absorption-spectroscopy methods:

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

5. User Interface Operation

Power up the system using the front On/Off switch. The front User Interface screen is for reading gas concentration and to shut down the software for system power down. A second VGA port is provided in the back panel of the instrument. With the VGA monitor connected to the VGA port, the user will be able to fully utilize the all the available menus for displays, data sampling rate, data transfer, and system calibration. If the user were to use the second monitor and connected it to the rear VGA port, upon booting the system up, the first screen displayed is the program loading screen, as shown in Figure 16.

Figure 7 Program Loading Screen



After the programs are loaded, the Gas Analyzer launches into the Main Display screen displaying the gas concentration(s) (see Figure 10) measured within the *LGR-ICOS* cell. If the Gas Analyzer has been deactivated for more than 10 minutes, the gas lines leading to *LGR-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 the *LGR-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.

HMI Dashboard

In the HMI Dashboard (Figure 17), operators can see the current measured key operating parameters of the instrument.

Figure 8 HMI Dashboard

This HMI Dashboard is display in every screen. Tapping on the home icon on the left side of the HMI Dashboard will bring the software application back to the Main Display screen.

Main Display

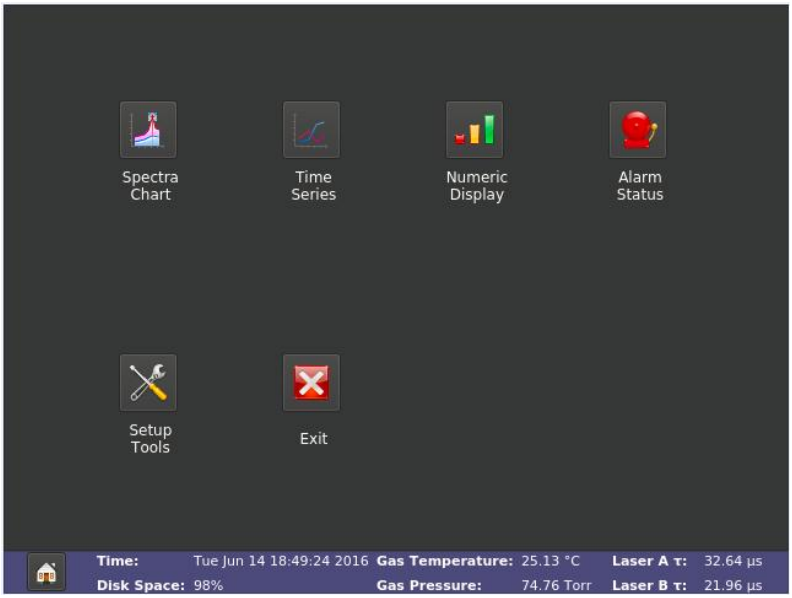
In the Main Display screen (Figure 18), there are feature icons allowing the operators to select the type of measured data or setup feature menu to display. The Main Display screen feature icons are:

- Numeric Display (Figure 10)
- Spectra Chart (Figure 11)
- Time Series (Figure 12)
- Alarms Status (Figure 13)
- Setup Tools (Figure 23)
- Exit

Main Display Screen

The Main Display screen will be the first screen to be display after the Program Loading screen upon powering up the instrument. The Main Display screen offers the options to look at the measured data in several different formats, system Alarms, and the ability to configure the instrument for external communication interface.

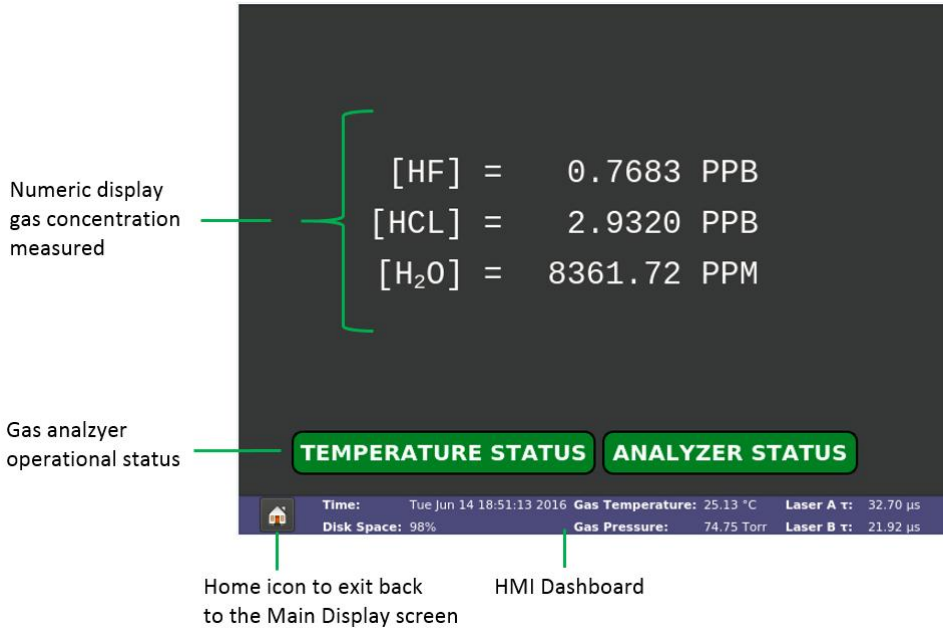
Figure 9 Main Display Screen



Numeric Display

The Numeric Display is one of the simplest screen for go/no go decisions based strictly on gas concentration measurements. The sample gas(es) measured are in ppm, and possibly in ppb. Figure 19 is an example of a Numerical data display for measurement of four different gas samples.

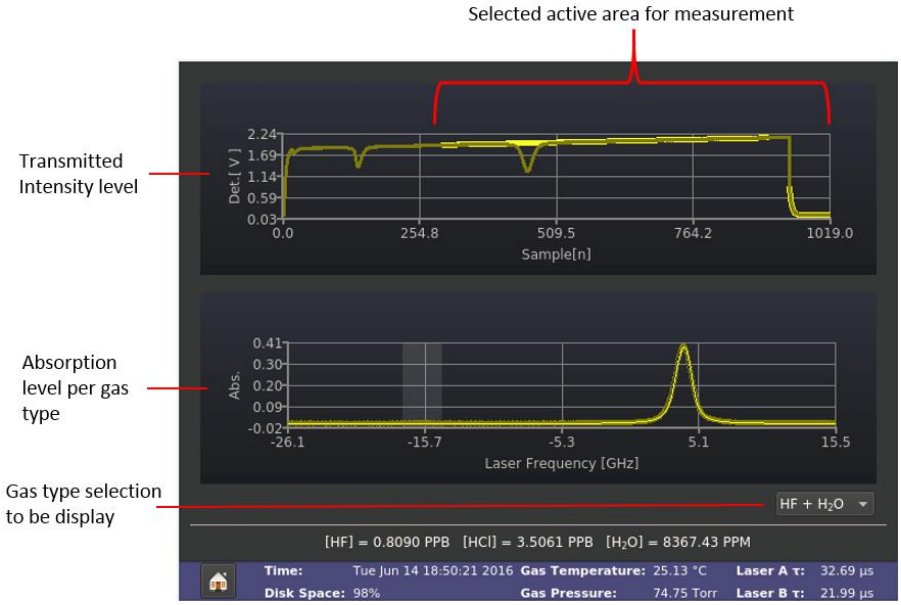
Figure 10 Numerical Display Screen



Spectra Chart Display

The sample Spectra Chart display in Figure 20 provides additional information concerning the measured gas: the Gas Analyzer sensitivity level seen in the Transmitted Intensity diagram, the absorption level, the theoretic fit of the targeted gas, and the ring-down time indicating the need to clean the astigmatic mirrors.

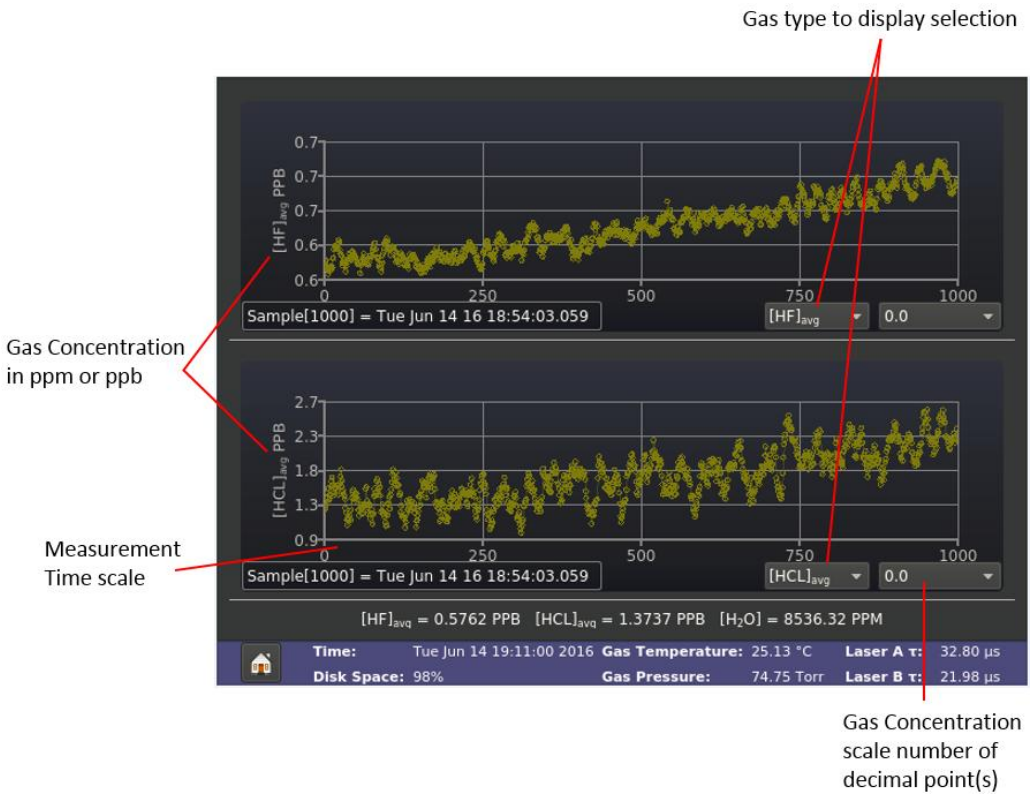
Figure 11 Spectra Chart Display Screen



Time Series Display

The Time Series display in Figure 21 provides the absorption (in ppm or ppb) of the sample gas measured. Each dot represents a measured level at a customizable interval “rate”.

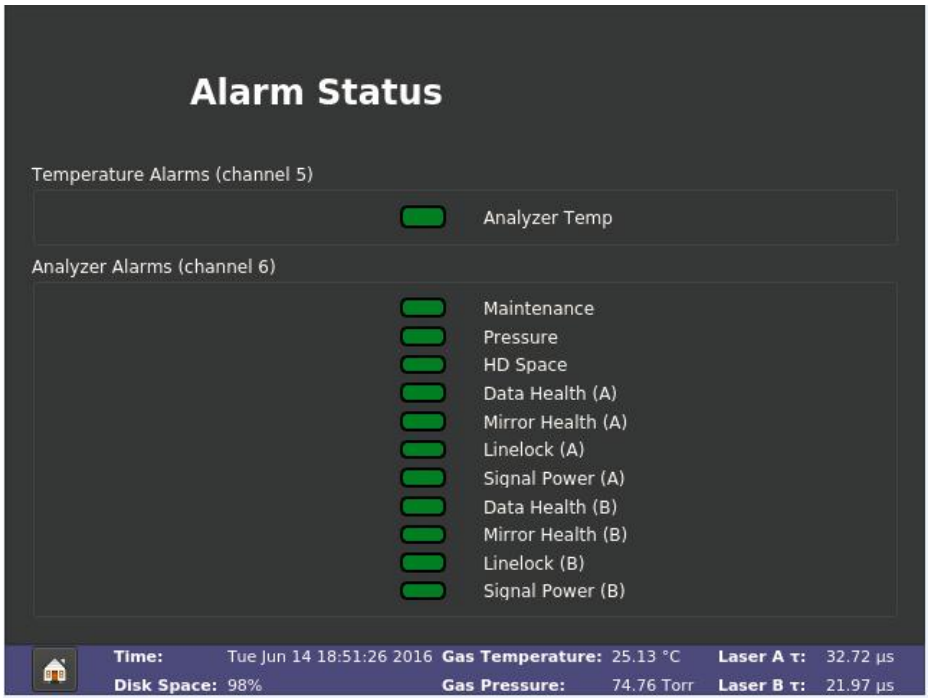
Figure 12 Time Series Display



Alarm Status Display

The Alarm Status display (Figure 22) 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.

Figure 13 Alarm Status Display

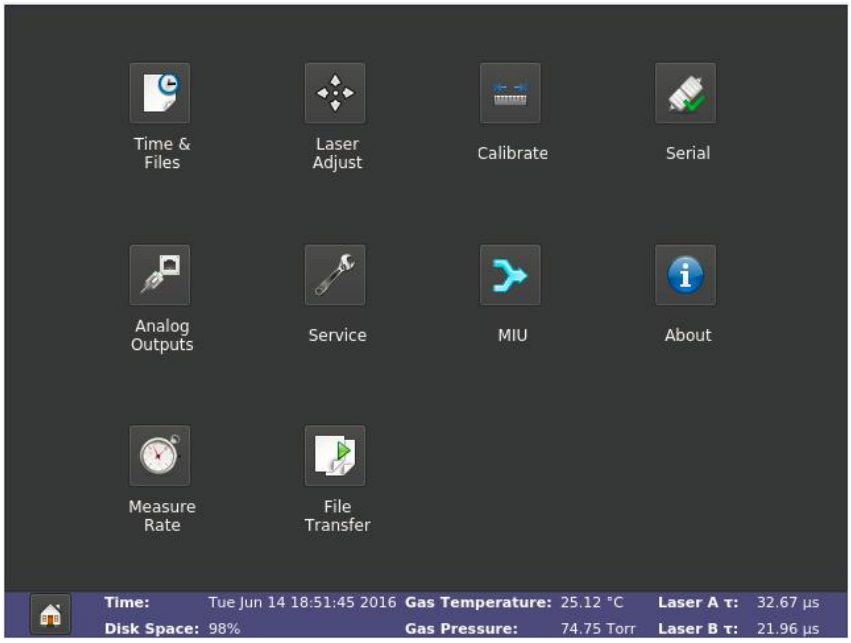


Setup Tools Display

The Setup Tools screen (Figure 23) provides the user to configure the instrument for measurement settings, calibration, and external communication. The Setup Tools display provides the following options:

- Time & Files
- Laser Adjust
- Calibrate
- Serial
- Analog Outputs
- Service
- MIU
- Measure Rate
- File Transfer
- About

Figure 14 Setup Tools Screen

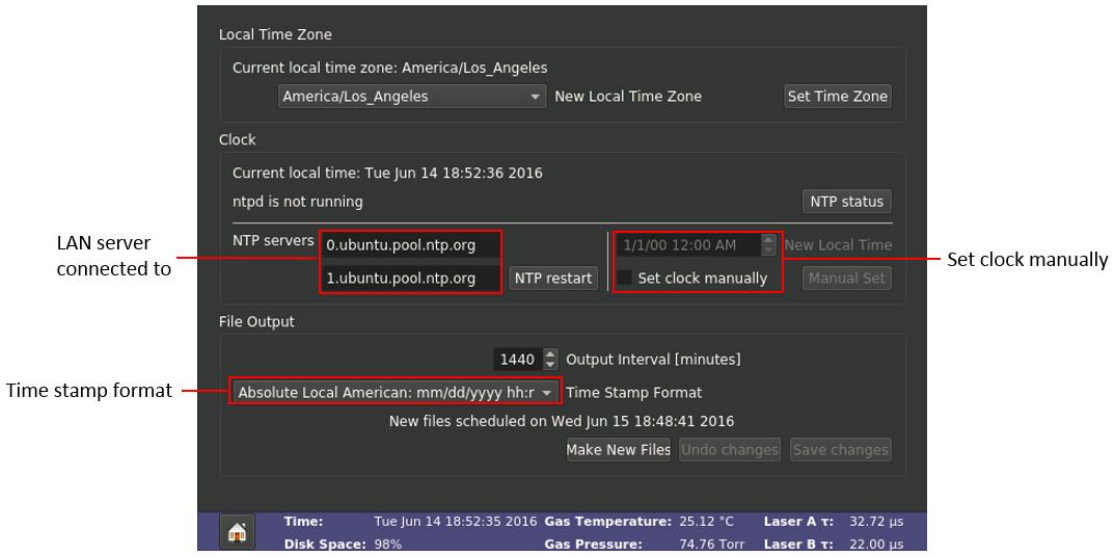


Time & Files

The Time & Files screen 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 current time and date for the Gas Analyzer (Figure 24). The time zone and daylight savings enable/disable feature are also set there.

Figure 15 Time/Files Screen



On this tab, operators can also set the current time and date. The available time stamp formats are listed in Table .

Table 5 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

Laser Adjust

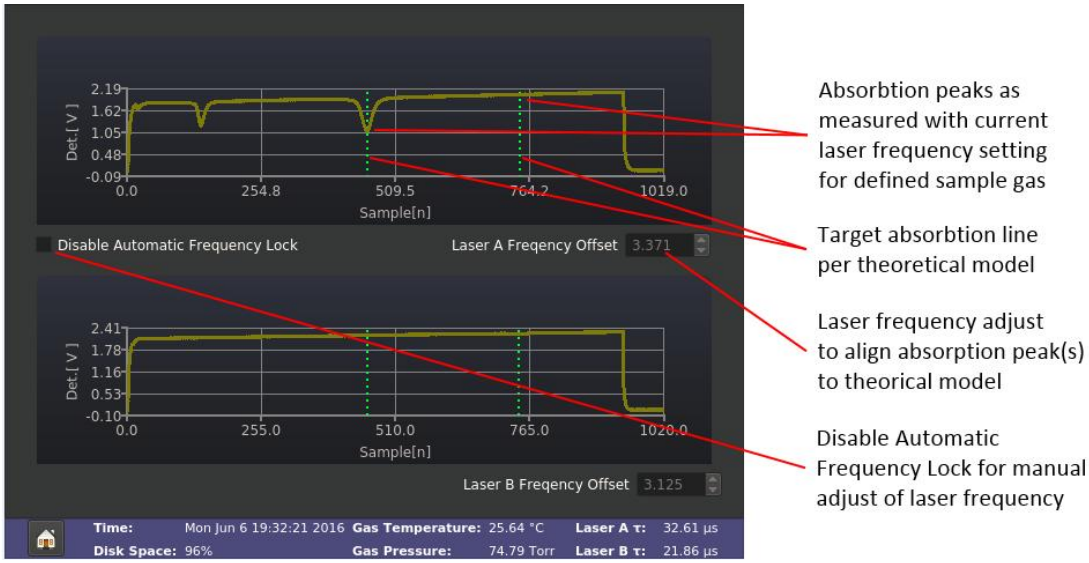
The Laser Adjust tab allows operators to tune the laser wavelength. Laser adjustment may be needed for the following reasons:

- 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).

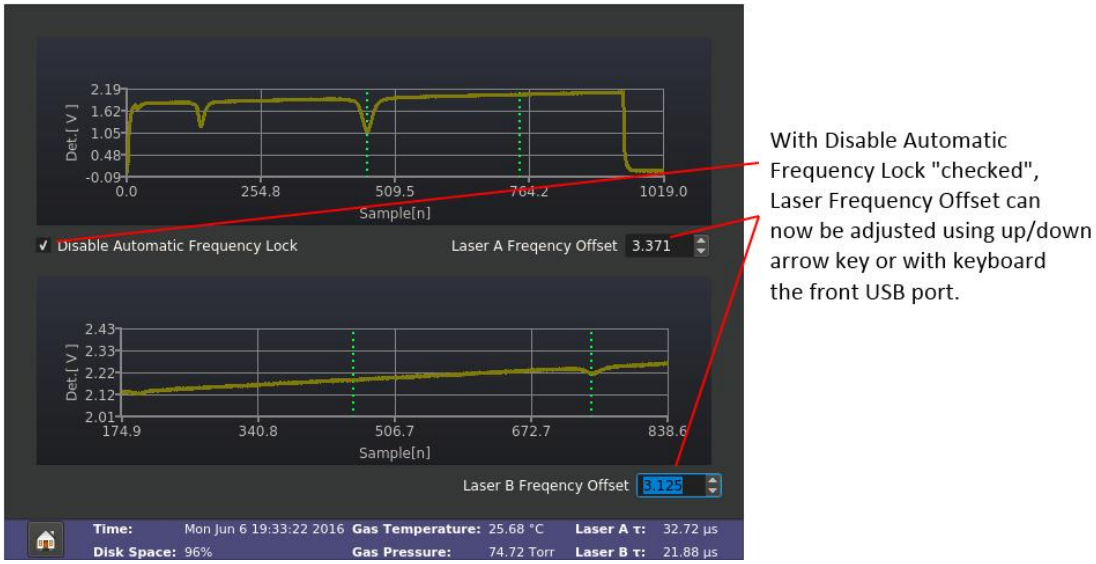
In Figure 16, the Laser Adjust tab displays the current gas sample measurement intensity profile and the corresponding absorption frequency by dips in the profile. The vertical dotted lines in the same profile screen are the expected target absorption line (When the absorption line is locked into the dip, it is referred to as "Linelock".). If the line and the dip are not aligned, compensation 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.

Figure 16 Laser Adjust for Optimizing Measurement Calibration



To change the laser frequency offset (for laser A or B), the Disable Automatic Frequency Lock box (Figure 26) needs to be checked thus allowing the operator to change the laser operating frequency using the up/down arrow key in parameter control window or through a USB keyboard if attached to the instrument front USB port.

Figure 17 Laser Frequency Offset Adjust



Calibration

The Calibrate tab provides operators with the tools to calibrate the Gas Analyzer without having to send the instrument back to the factory. Before performing calibration on the Gas Analyzer, the operator needs to have the following information available:

- Traceable regulated gas type
- Traceable regulated gas type concentration

To perform a gas calibration, connect the traceable regulated bottle gas to the Gas Analyzer gas inlet line (reference Figure 27 for the parameter fields identified in the procedure):

STEP 1 Select the Calibrate icon, check the Calibrate box in the Reference Gas Settings pane.

STEP 2 In the traceable regulated bottled gas, enter the gas concentration for the gas type listed to the left of the gas concentration entry box.

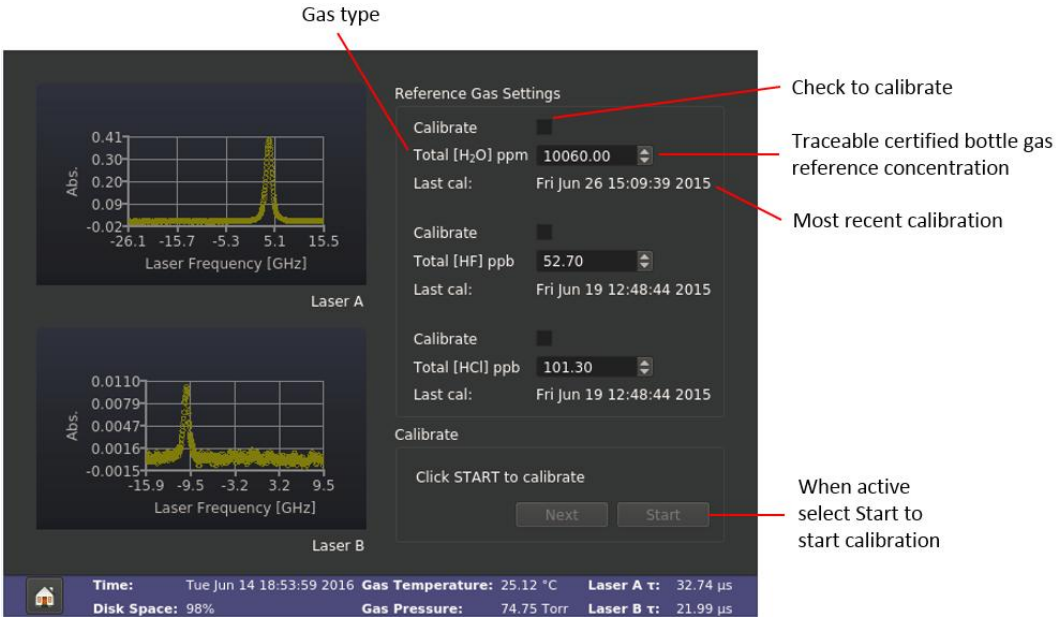
STEP 3 Click Start to start the calibration.

STEP 4 Repeat these steps for all gases measured by the Gas Analyzer.

STEP 5 After calibration is complete, click OK. The Gas Analyzer will then resume its normal measurement mode.

STEP 6 Select the Home icon to exit the calibration screen.

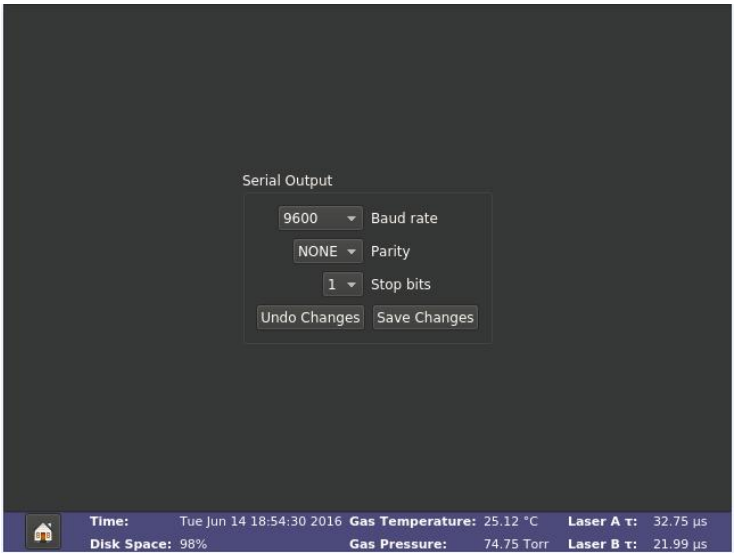
Figure 18 Calibration Screen



Serial Communication

When selecting the Serial icon, the Serial screen appears giving operators access to configure the serial communication port at the rear of the instrument. The Serial option box display shown in Figure 28 are the options available for serial output of the measured data.

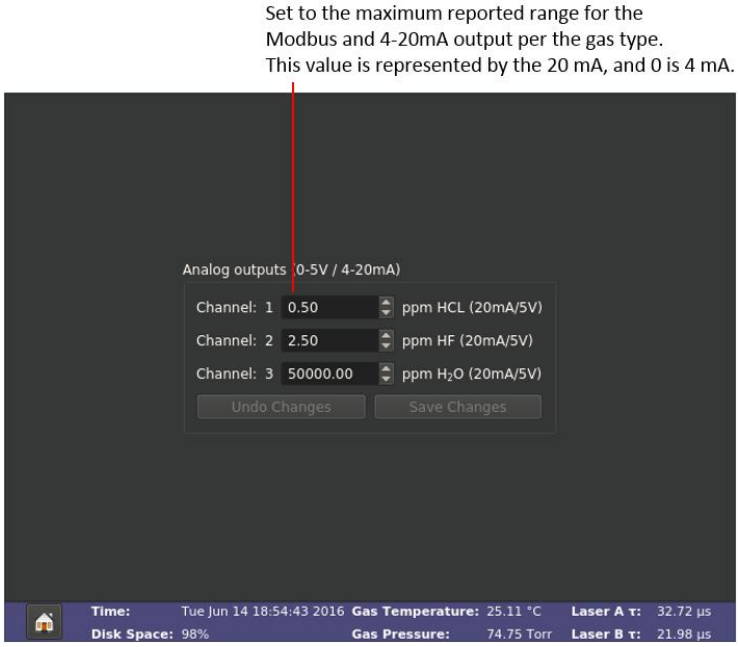
Figure 19 Serial Screen



Analog Outputs

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

Figure 20 Analog Output Adjustment (Example)



This same conversion table is applied to the Gas Concentration output in a 4-20 mA format at the Gas Analyzer rear IO panel. The Analog Out, a 9 pin D connector will provide the same information for each gas measured except it will be providing 0-5 volts voltage level prior to signal conversion to the 4-20 mA format. The 9 pin D Analog Out configuration is listed in Table 6.

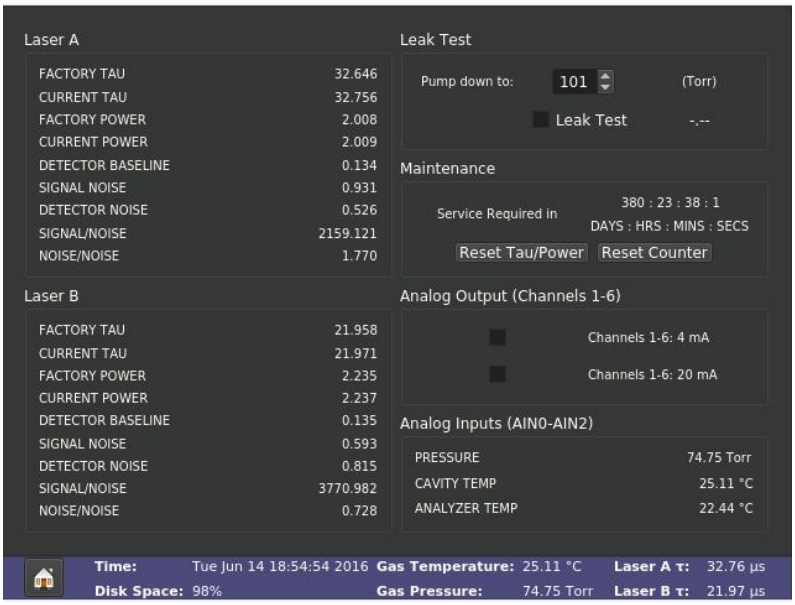
Table 6 Analog Out Pin Configuration

Pin Assignment	Analog Out Signal
Pin 1	Gas Concentration #1 +V
Pin 6	Gas Concentration #1 RETURN
Pin 2	Gas Concentration #2 +V
Pin 7	Gas Concentration #2 RETURN
Pin 3	Gas Concentration #3 +V
Pin 8	Gas Concentration #3 RETURN
Pin 4	Gas Concentration #4 +V
Pin 9	Gas Concentration #4 RETURN

Service

The Service menu is only accessible by ABB-trained field service engineers for updating the last changes made to the instrument. These settings are reference by the instrument to determine the level of change that could affect the instrument measurement performance. The instrument alarms threshold level are set based upon the last fixed setting. The access to the Service screen is password protected.

Figure 21 Service Menu Screen (Example)

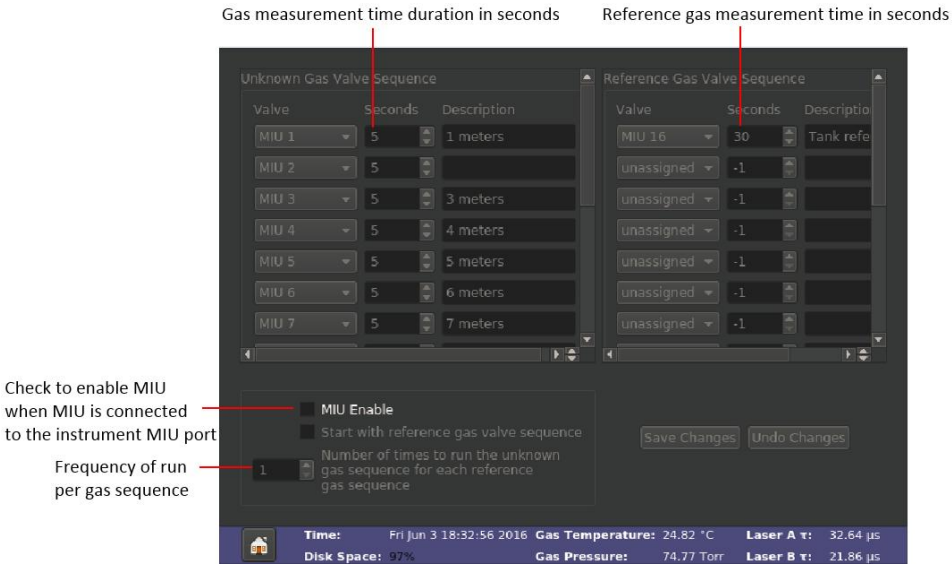


MIU Application (MIU Unit Required)

The MIU (Multi-port Inlet Unit) application is a switch for multiple sampling of inlet gases and corresponding reference gases from various sources going through a MIU unit (separately sold item) to one instrument.

To set up the MIU, tap the entry field to set the duration of each test measurement and gas description.

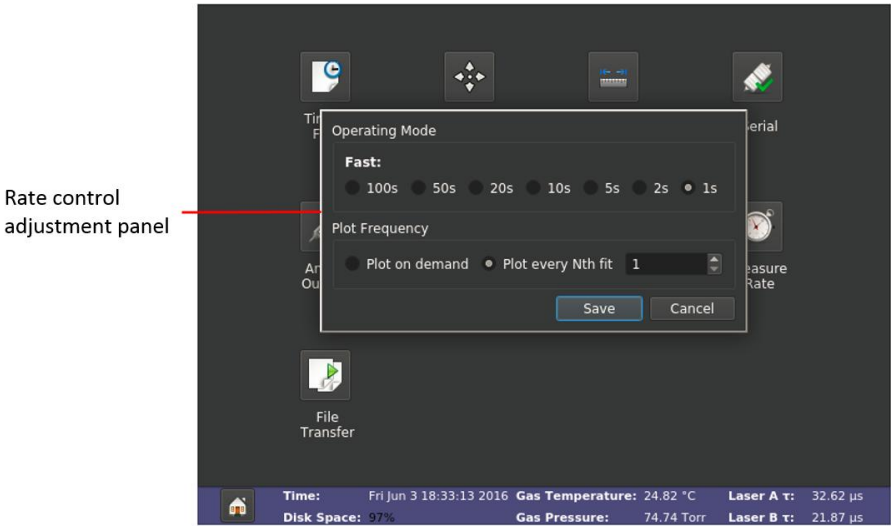
Figure 22 MIU Setup Screen



Measure Rate

By clicking Measure Rate icon in the Setup display screen, operators can change the rate at which data is written to the log file. Figure 32 displays the Rate Control Adjustment panel.

Figure 23 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 than shorter averaging periods.

File Transfer

By clicking File Transfer icon in Setup Tools, operators access the File Transfer menu for transferring measurement data saved by the Gas Analyzer. The first screen displayed will be 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 will automatically create a file name to save the measured data. New file names 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 are for the file number in defining the sequence of the data taken.

To access the *archive* files, click on the *archive* folder. If you need to go back to the previous screen, click the arrow that is pointing up 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

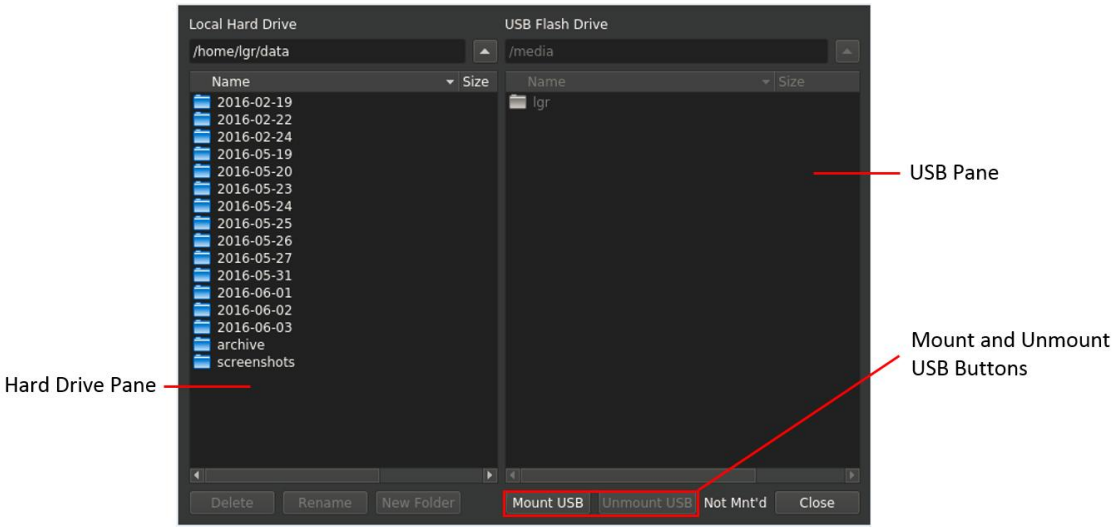
Transferring Files

File transfer is perform with a USB memory stick inserted into the front panel USB port. The USB memory stick needs to be in a Fat32 format before any file is transfer 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 into the instrument front USB port.

STEP 2 Click on Mount USB (see Figure 33).

Figure 24 User Interface for Mounting the USB Memory Stick



STEP 3 Transfer file(s) by dragging them from the Local Hard Drive pane and dropping them to the USB Flash Drive pane.

STEP 4 Click Unmount to stop communication with the USB memory stick before removing the USB memory stick.

STEP 5 Click Close to exit the Data Files screen.

STEP 6 When the hard drive is showing > 75% full, it is time to perform data clean up.

To do so:

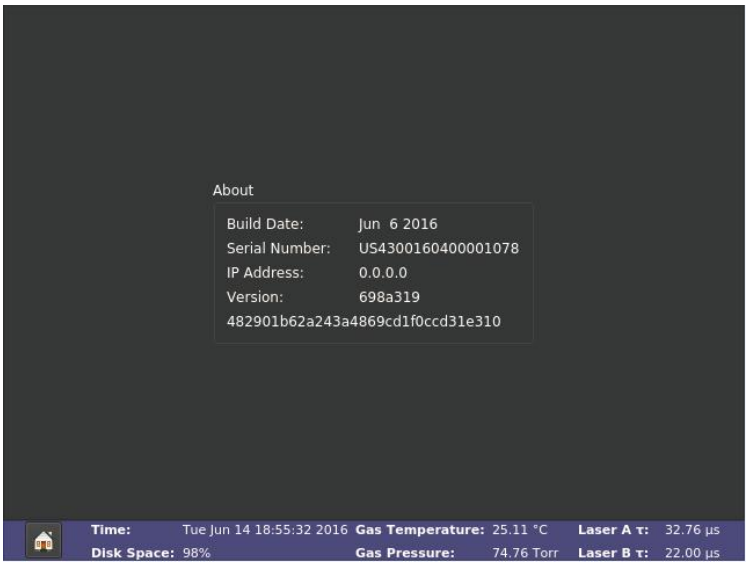
STEP 1 Using the touchscreen and highlight the file to be deleted.

STEP 2 Select Delete on the display screen.

About

By selecting the About icon, the operator can identify the current configuration/setting of the Gas Analyzer.

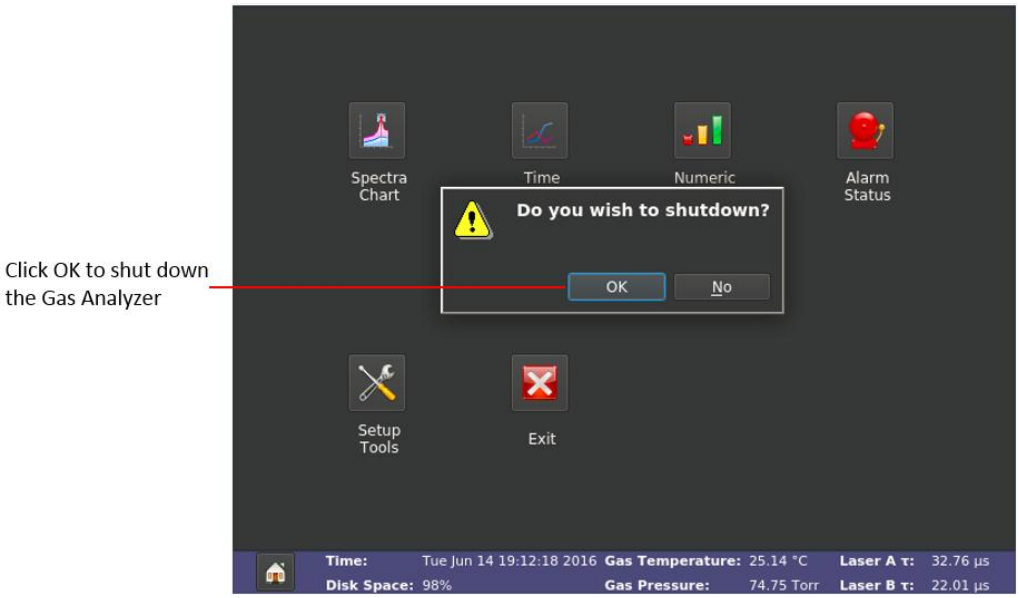
Figure 25 About Screen



Gas Analyzer Shutdown

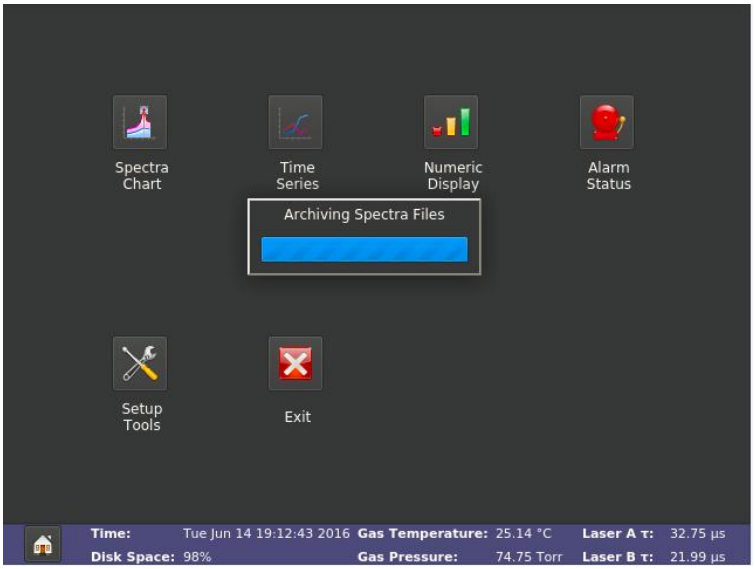
To properly shutdown the Gas Analyzer, always perform a soft shutdown by first selecting *Exit*. When the dialog box appears with the question "*Do you wish to shutdown?*" (Figure 35), click OK.

Figure 26 Shutdown Screen



Once OK is selected, the instrument will perform an archiving process with the *Archiving Spectra Files* screen being display (Figure 36).

Figure 27 Shutdown Screen



After the archiving process is completed, you can now power the instrument off. Powering downing the instrument without going through this process can corrupt the operating software.

6. Communications – Data and Alarms

I/O Interfaces

The input/output interfaces provided by the ABB 927 Gas Analyzer on the Gas Analyzer rear panel (see Figure 12) are:

- Ethernet (RJ-45)
- Modbus/TCP (RJ-45) (Option. Not active unless option is purchased)
- USB (only the top port of the two rear panel USB port is active at this time)
- 4–20 mA analog out (5.08mm terminal block)
- RS232 serial data in ASCI format
- 9 Pin D Analog Data out
- MIU

Remote I/O Data Access

Ethernet

The ABB 927 Gas Analyzer is designed to run the Unix operating system. Data files stored on the internal hard drive of the ABB 927 Gas Analyzer can be accessed via 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 DHCP (Dynamic Host Configuration Protocol) request when the Gas Analyzer is initialized. If the Gas Analyzer does not receive a reply, it 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 Windows Share Drive:

STEP 1 Select Start → Run and enter: \\LGR-XXXX-XXXXX

STEP 2 Press [Enter].

After the communication link is established, a Windows Share Drive directory window will appear as subdirectory *lgrdata*.

STEP 3 Double-click the *lgrdata* directory to display the data files stored on the internal hard drive.

STEP 4 Open or transfer any of the data files as you would with any other Windows Share Drive.

Note: At the time of the writing of this manual, and the application software that was installed on the Gas Analyzer instrument, Ethernet connection protocol between the instrument and Windows may have changed. If problem arise in trying to establish communication between the Gas Analyzer using the Ethernet, contact ABB Technical Support for assistance to rectify the problem encountered.

To access the analyzer data directory as a Windows Share using an Ethernet connection on a local area network (LAN).

The data files stored on the internal hard disk drive of the analyzer can be accessed as a Windows Share over a Local Area Network (LAN) Ethernet connection. For this function to operate the analyzer must:

- Be connected to a Local Area Network (LAN) via the RJ-45 Ethernet connection on the rear panel.
- Receive a response to a DHCP (Dynamic Host Configuration Protocol) request when the analyzer is initialized. If the analyzer does not receive a reply, the analyzer:
- Disables the Ethernet port.
- Does not attempt another DHCP request until the analyzer is restarted.

When both conditions are met, the data directory can be accessed using a Windows computer on the same LAN:

Click Start > Run, and enter:
\\LGR-XX-XXXX
(where XX-XXXX is the serial number of the analyzer.)
Click OK.
In a short time (usually between 10 and 60 seconds for the first access), a Windows Share directory window displays a subdirectory lgrdata.
Double-click on the lgrdata directory, to see a listing of the data files stored on the internal hard disk drive of the analyzer.
Open or transfer any of the data files as you would with any Windows share drive.

Additional Notes:

The analyzer shared data directory may not be visible by browsing for it in Windows Network Neighborhood. If it is, it is in the LGR workgroup. The computer name will be LGR-XX-XXXX, where XX-XXXX is the analyzer serial number.

You can open the data file that is currently being written into by the analyzer without interrupting the analyzer operation (a snapshot of the file as it was displayed when you opened it). Notice that the current data file is only updated occasionally (every four KB of data), so a new data file will appear empty until enough data is collected and written to the disk.

If a LAN is not available, plug the analyzer into a simple standalone broadband router (such as, Netgear Model RP614) to enable the analyzer to obtain a DHCP address from the router when the analyzer is started. You can then plug any Windows computer into the same broadband router and access the data directory.

A crossover Ethernet cable will NOT allow an external computer to access the shared data directory, as the analyzer will not obtain a DHCP address on initialization and will shut down its Ethernet interface.

You might be able to access the shared analyzer data directory from computers running operating systems other than Windows. The analyzer uses a Samba server to share the data directory, which might be accessed by any appropriate Samba client application.

Modbus

A Moxa application CD (P/N: 1112012001031) and associated instructions are shipped with each ABB 927 Gas Analyzer in support of the ioLogik E1240 Modbus. This allows the user to link and configure the Modbus to their desired format. Modbus outputs are the gas concentration measured signals in ppm or ppb. The Modbus measured gas concentration results are connected to input lines shown in Table 7. A brief instruction outline is provided in this manual on how to communicate with the Modbus using ioSearch.

Table 7 Modbus Gas Concentration Line Setting

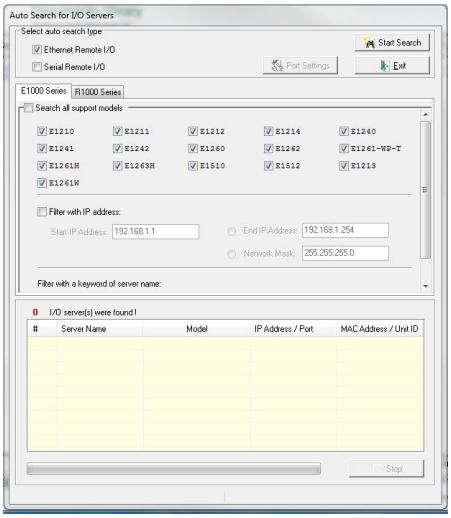
Input Lines	Gas
AI0+	Gas #1 Concentration
AI0–	
AI1+	Gas #2 Concentration
AI1–	
AI2+	Gas #3 Concentration
AI2–	
AI3+	Gas #4 Concentration
AI3–	

Modbus Configuration

To communicate with the Moxa Modbus using a computer, the connecting computer will need to have;

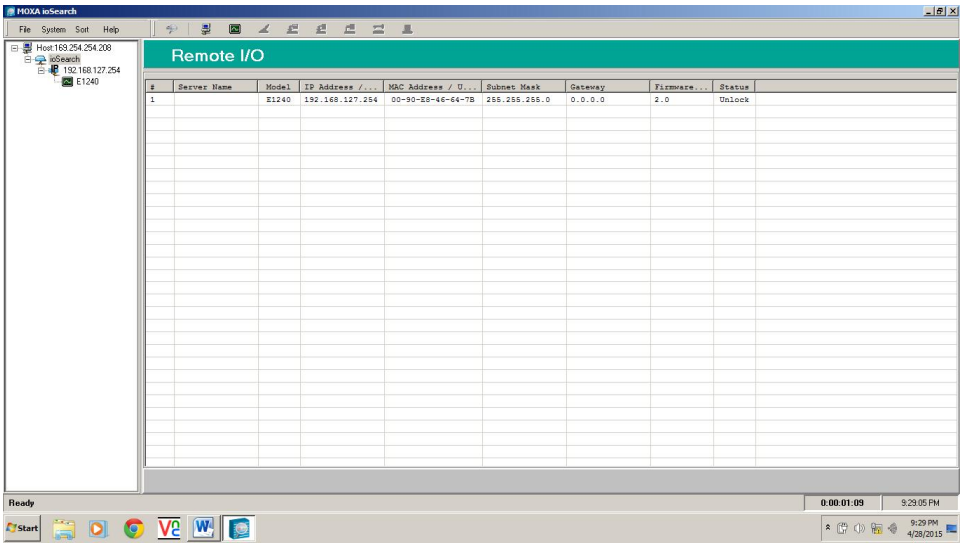
1. Install the Moxa application software ioSearch.
2. The connecting computer needs to have its firewall disabled in order to install ioSearch.
3. Using either a straight-through or cross-over Ethernet cable to link the connecting computer and the Modbus using the Ethernet port located at the rear panel of the Gas Analyzer.
4. Execute the Moxa application file *ioSearch*.
5. Upon executing ioSearch, the Auto Search for I/O Servers menu will be displayed (Figure 37). Select the *Start Search* tab to locate the Modbus.

Figure 28 Auto Search for I/O Servers Menu Screen



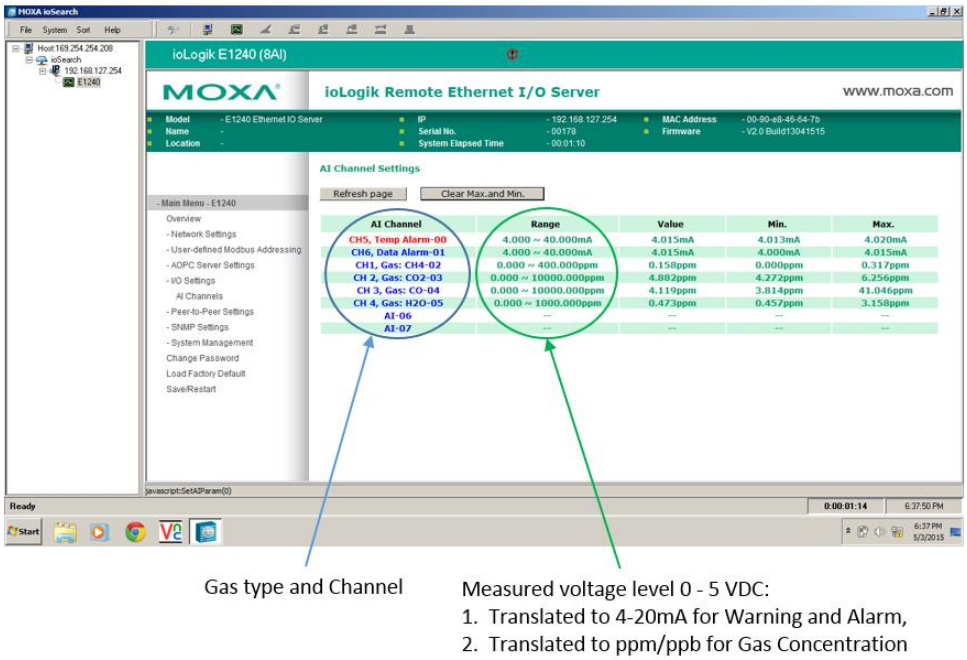
6. Once the ioLogik Modbus device is located, the following Remote I/O menu screen (Figure 38) will appear, listing the ioLogik devices found.

Figure 29 Remote I/O Menu Screen



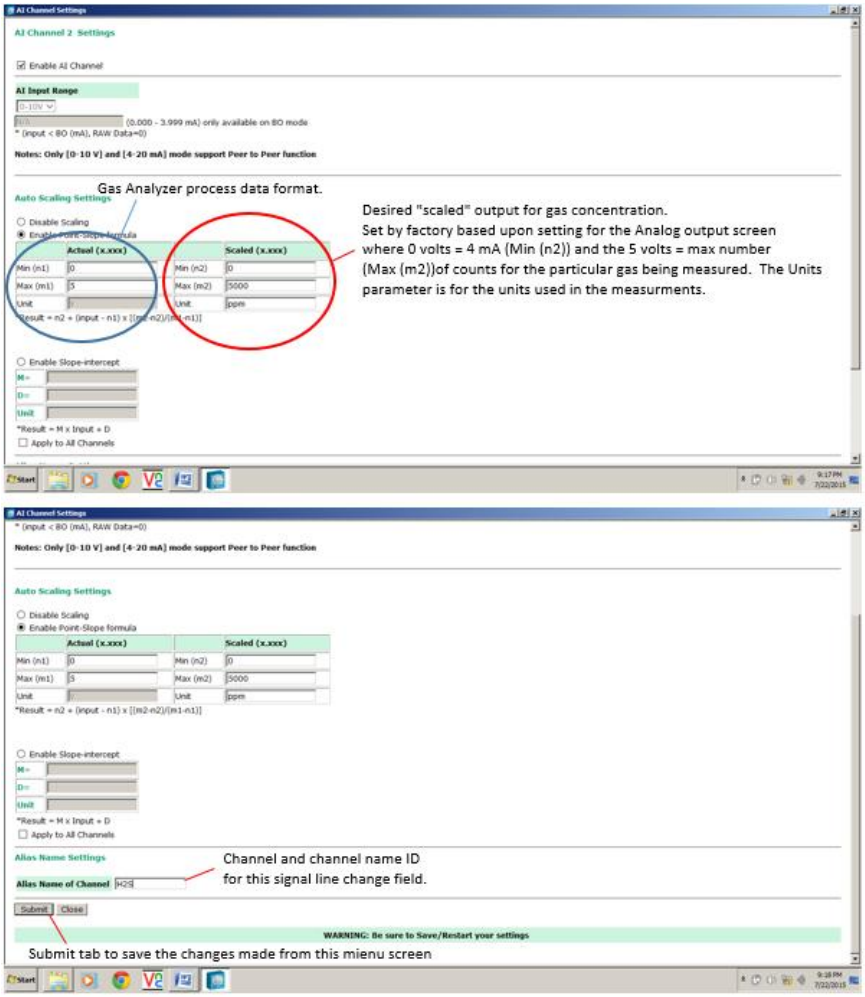
7. Select “E1240” on the left side tree. The “web console” appears, with the preset parameters currently loaded into the ioLogik Modbus device as shown in Figure 39.

Figure 30 Analog Input Configuration Screen



8. In the I/O Setting → AI Channel menu screen (Figure 30), select the first item under the AI Channel (in the example from Figure 34, it would be CH5, Temp Alarms-00). In the AI menu screen (Figure 40), it allows the user to change the scale output of the Modbus data in reference to the 0 to 5 volts. This change would result in a different output result by the Modbus. When making any changes on the AI Channel Setting menu screen, the user must select *Submit* at the bottom of the menus screen in order to lock the changes made when exiting out from the menu screen.

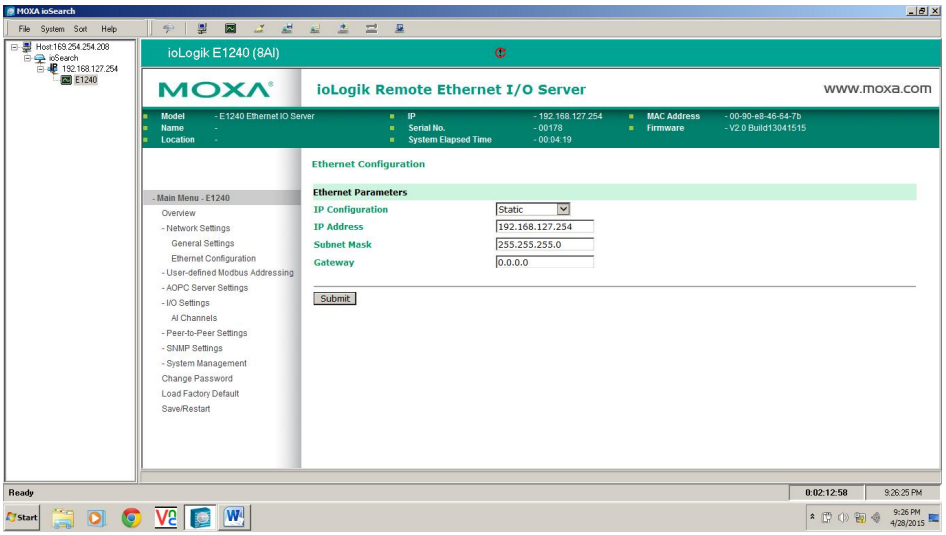
Figure 31 AI Channel Settings



Changing the Modbus IP Address

1. If the user wants to change the Modbus IP address, select Network → Ethernet Configuration and the following menu screen will appear (Figure 41).

Figure 32 ioLogik Ethernet Configuration Menu Screen



If the user does make a change to the IP address of the ioLogik Modbus, the user needs to select the *Submit* tab to save changes before exiting the menu screen; otherwise, the new IP address will not be saved.

2. Quit the ioLogik application.
3. Disconnect the Ethernet cable linking the connected from the Gas Analyzer Modbus port at the rear panel.

Additional Modbus Configuration Information

Connect to Device

- Use Modbus TCP protocol
- Default IP Address: 192.168.127.254
- Default Modbus port: 502
- Default device ID: 1
- Starting register: 1
- Number of registers: 24

Read Only Registers

- Each channel is output on 2 registers with different formats
- Registers 1-8 are integers where 32768 is the full scale
- Registers 9-24 are floating point with the least significant bit first
- Output on the Warning/Alarm channels are given by integer values between 4 – 20. The 4 – 20 integer values are converted to a color code as shown in Table 6 Analyzer Warnings/Alarms defining the level of urgency per alarm type. These are the same alarms can be viewed in the Alarm Status screen (Figure 22).
    - 4 – 10 indicates various alarms conditions (Red)
    - 12 – 18 indicates various warning conditions (Yellow)
    - 20 indicates status is good (Green)
- Output on the gas concentration channels are in units of ppm where the full scale is defined in the software and in the configuration of the Moxa
    - Full scale is configured in the software in the setup menu under the 4-20 mA tab where the full scale in ppm is defined for 20 mA output (or full scale of Moxa)
    - For registers 9-24 to report the correct gas concentration the Moxa must be configured to have the same full scale as in the software (The factory default has consistent full scales. If the software full scale is changed then the Moxa full scale must be set to the same value using Moxa ioSearch software included.)

Local Data Access

USB

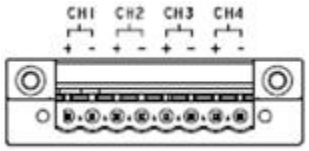
The ABB 927 Gas Analyzer only supports up to USB 2.0. Refer to the File Transfer section on page 33 for instructions on transferring data from the Gas Analyzer to a USB 2.0 memory stick.

Gas Concentrations

4–20 mA Analog Outputs

4 to 20 mA gas concentration values are provided and 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 rear instrument panel shown in Figure 12. Figure 42 displays the connection points provided allows the user measure the sample gas concentrations as a current (*i*) level. The information output is in real time.

Figure 33 Gas Concentration 5.08mm Terminal Block Connection Point



Alarms

Table 8 Analyzer Warning/Alarm provides the meaning behind each alarm color level of key parameters that are monitored in real time by the Gas Analyzer and displayed whenever the Alarm Status icon is selected by the user.

Table 8 Analyzer Warnings/Alarms

Warning / Alarm	UI Display	Detected Problem
Alarm	Maintenance	Maintenance is needed on system now
Alarm	Pressure	Pressure is not in operating range
Alarm	HD Space	HD Space is near full, deleting oldest files
Alarm	Data Health (A)/(B)	Laser A and/or B goodness of fit is poor
Alarm	Mirror Health (A)/(B)	Mirror health has degraded, clean mirrors
Alarm	Linelock (A)/(B)	Laser A and/or B peak position is outside of control range
Alarm	Signal Power (A)/(B)	Laser A and/or B power has degraded > 20%, contact customer support
Alarm	Analyzer Temp	Ambient temperature is outside of alarm set point range
No issue	Maintenance	No alarm
Warning	Pressure	Pressure range is noisy, pressure reading is not stable
Warning	HD Space	HD Space is low, <20% available
Warning	Data Health (A)/(B)	Laser A and/or B goodness of fit is not optimal
Warning	Mirror Health (A)/(B)	Mirror health is degrading, clean mirrors soon
Warning	Linelock (A)/(B)	Laser A and/or B peak position profile is moving away from theoretical target.
Warning	Signal Power (A)/(B)	Laser A and/or B power is degrading, contact customer support soon

7. Maintenance

Block Diagram

The block diagram in Figure 43 is a simplified layout of the *LGR-ICOS* Gas Analyzer, excluding the internal pressure interlock switch and the VGA monitor. Figure 44 is a simplified pneumatic flow diagram.

Figure 34 ABB 927 Gas Analyzer Block Diagram

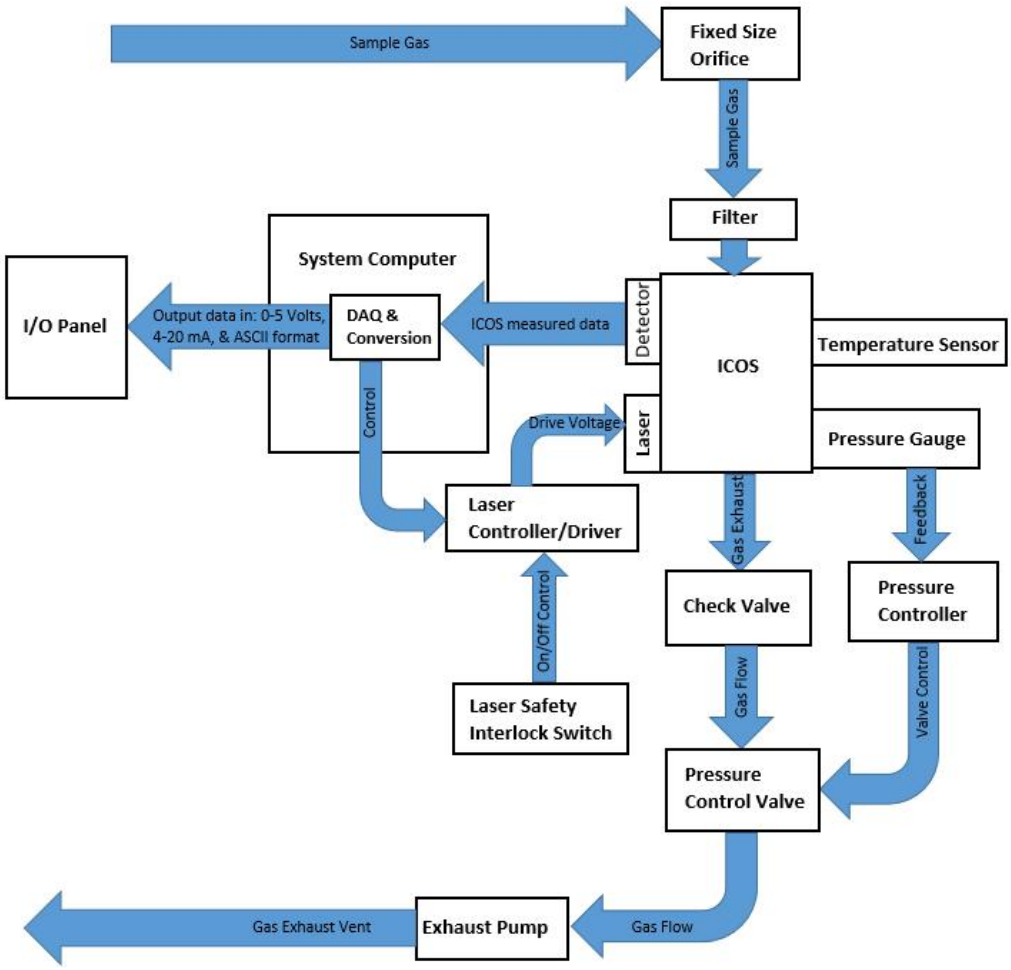
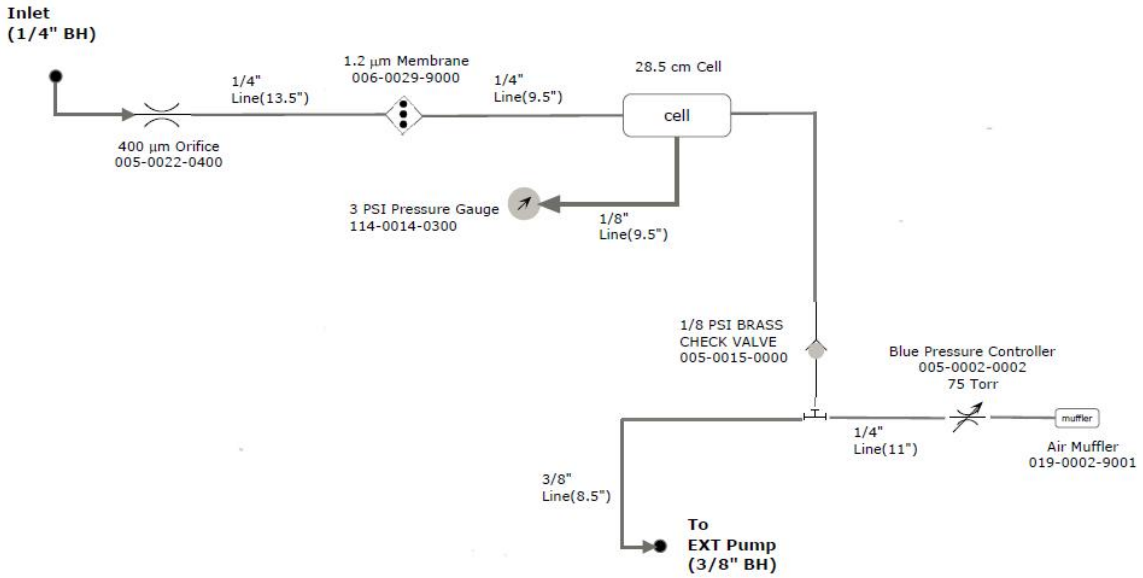


Figure 35 ABB 927 Gas Analyzer Pneumatics Flow Diagram



PC104 Stack

The ABB 927 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 the light signal and controlling the light source intensity to maintain the level of sensitivity of the ICOS module. 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

Pressure Control

Several factors control measurement stability. One factor is temperature. The incoming gas sample needs to maintain at a specific temperature range 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.

The temperature of the sample gas is measured by a thermocouple within the ICOS cell. This information collected can provide the user information on possibly why the measured gas concentration results over a period of time is drifting.

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 monitored. In a leak-free ICOS system, the pressure within the ICOS cell is maintained by the Pressure Control Valve changing or maintaining its opening size as gas is pulled through it by the Exhaust Pump. A pressure gauge connected into the ICOS cell constantly monitors the pressure within the ICOS cell where the pressure measurement is taken and fed back to the Pressure Controller PCB controlling the Pressure Control Valve providing a complete feedback loop.

Laser(s) 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 “effective path length” and the 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 19 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. In the short term this will lead to reduced measurement sensitivity and, in the long term, inaccurate measurements.

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.

Table 9 ABB 927 Measurement Components Function & Impact

Components	Function	Impact
PC104 Stack	System communications	System operations
Pressure Valve, Fixed Orifice	ICOS pressure control	Absorption level
Laser	Gas probing light source	Transmitted intensity
Astigmatic Mirrors	Cavity length	Ring-down time

Self Correction

Small drifts in laser wavelength are compensated by adjusting the laser temperature, thus providing a dynamic response. To deactivate this feature, uncheck the box *Disable Laser Frequency Lock* in the *Laser Adjust* screen on page 27. Deactivate this feature only if the peaks are visible but outside target window and the user changes the laser adjust to get the peak on target.

Output Data

The measured output data collected and processed by the PC104 computer stack provides a DC signal level representing the ppm in the Numerical display of the measured gas sample. A signal isolator converts this DC voltage signal, ranging from 0 to 5 volts, to a 4–20 mA signal. This DC voltage signal is also ported to both an external 9 pin D connector, and the Modbus. The 9 pin D connector is configured to provide the user with the raw signal translated 0 to 5 volt data where Gas Concentration signal pair are assigned to each pins in the 9 pin D connector (Table 10).

Table 10 ABB 927 9 Pin D Raw Signal Output

Gas Concentration	9 Pin D Assigned Pins
Gas Concentration #1 analog +	Pin 1 (+)
Gas Concentration #1 analog -	Pin 6 (-)
Gas Concentration #2 analog +	Pin 2 (+)
Gas Concentration #2 analog -	Pin 7 (-)
Gas Concentration #3 analog +	Pin 3 (+)
Gas Concentration #3 analog -	Pin 8 (-)
Gas Concentration #4 analog +	Pin 4 (+)
Gas Concentration #4 analog -	Pin 9 (-)

The output signal from the Modbus is user-configurable to the desired output unit: mA, Volts, ppm, or ppb. In the 927 Gas Analyzer, the output units are either in ppm (parts per million) or ppb (parts per billion). The output channels of the Modbus are configured as follow in Table 11.

Table 11 ABB 927 9 Pin D Raw Signal Output

Gas Concentration	Modbus Channel Assignment
Gas Concentration #1 analog +	Analog In 0+
Gas Concentration #1 analog -	Analog In 0-
Gas Concentration #2 analog +	Analog In 1+
Gas Concentration #2 analog -	Analog In 1-
Gas Concentration #3 analog +	Analog In 2+
Gas Concentration #3 analog -	Analog In 2-
Gas Concentration #4 analog +	Analog In 3+
Gas Concentration #4 analog -	Analog In 3-

Data Analysis

The ABB 927 Gas Analyzer runs on the Linux operating system. All menu screens created and all data processed and saved uses the Linux programing 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 “gas temperature” inside of the ICOS cell. 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?

Laser decay and/or mirror contamination over time, or PZT failure will increase the measurement noise providing a higher point to point variation of the measured data.

8. Troubleshooting, Remove & Replace

When approaching a problem reported on the Gas Analyzer, always determine what information is available from the instrument to determine the course of action in solving it. From the Gas Analyzer Alarm Status Display, review the alarms. In the Alarm section of this manual, Table 6 provides a brief description of the problem encountered by the instrument. The result of the alarm(s) can be broken down to two (2) categories. One category would be measurement issue, and the second would be some kind of communication issue.

The break down of the two possible issues in what will be seen from the instrument by the user are:

- Measurement data issues
  - Instability
  - Long term drift
  - Data shift
- Communication issues
  - Data Transfer
  - Slowness in command execution
  - System initialization

Measurement Issue

The performance specification for the 927 Gas Analyzer are gas dependent as defined in Table 12. To check on instrument performance, use a NIST traceable bottle gas as the test sample and not the customer gas that is to be evaluated. If the instrument meets the performance spec using the traceable bottle gas at various time periods validating long term measurement stability, the problem is not in the instrument but lies elsewhere like the customer gas being processed is contaminated.

Table 12 927 Gas Analyzer Performance Specification

Parameters		H_2O	NH_3		HCl	HF	H_2O
Precision (Repeatability)		<50 ppm (1 sec) <20 ppm (10 sec)	<1.5 ppb (1 sec) <0.6 ppb (10 sec)		<0.4 ppb (1 sec) <0.2 ppb (10 sec)	<0.1 ppb (1 sec) <0.05 ppb (10 sec)	<50 ppm (1 sec) <20 ppm (10 sec)
Accuracy (Traceable to NIST)							
Tool to tool matching		< 1000 ppm, +/- 10 %	> 10 ppb: +/- 1% < 10 pbb: +/- 10%		> 10 ppb: +/- 1% < 10 ppb: +/- 10%		< 1000 ppm, +/- 10%

Measurement Instability

The following components/element have a factor in measurement stability. These components/elements are:

- Gas temperature
- Gas pressure
- Low laser light level
- Contaminated mirrors
- Gas sample contamination
- Filter clogged
- Failing exhaust pump
- Pressure control valve
- Pressure Controller PCB

In order to determine the cause, a reference point needs to be acquired from the instrument when it was working in accordance to the customer. The data can be obtained from the instrument. For the gas temperature and pressure, the instant data point can be obtain from the HMI Dashboard (Figure 45).

Figure 36 HMI Dashboard

From the HMI Dashboard, look at the current gas temperature and gas pressure and compare it to the data of when the instrument was installed. It should not have change. Also, pull the measurement log files from the instrument and plot the gas temperature and pressure to see if the measured data fluxuates with either the temperature or pressure.

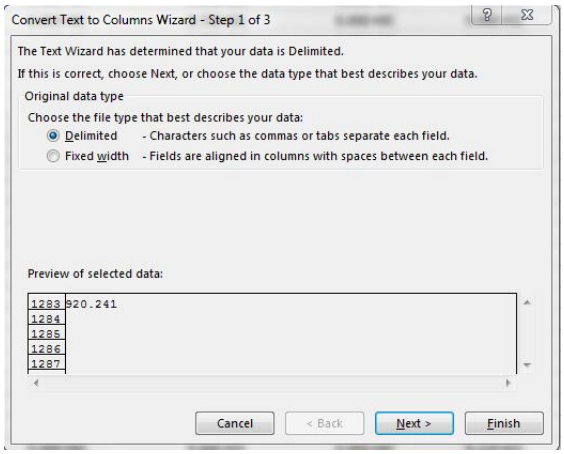
To access the data:

STEP 1 Follow the instructions in the "File Transfer" section of this manual to get the data onto a memory stick from the instrument. If this is not allowed in certain Semiconductor fabs, as the customer to obtain the data from the date before, when the instrument was measuring correctly, and the current data when it is measuring bad.

STEP 2 Inside of each folder will be a zip file with a time stamp. Inside of the zip file is a text file with a .txt extension. To plot the data out in Excel:

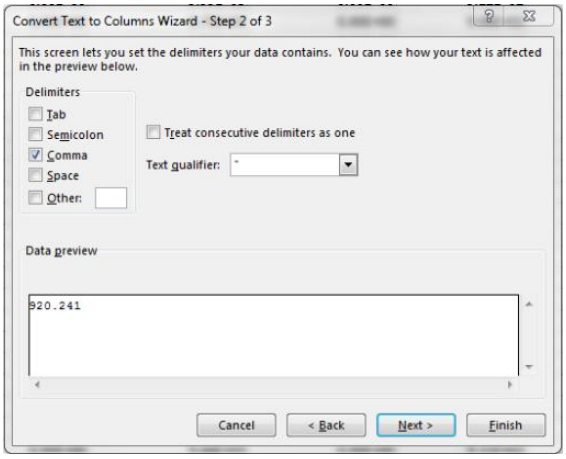
a. Open the .txt file in Notepad,
b. Copy the data within by highlighting all the data within then right click on the mouse and select the highlighted area of the data and click on Copy.
c. Open Excel and paste the data to the blank spreadsheet to the first cell A1.
d. In the Excel toolbar, click on Data.
e. In the Data toolbar options, click on *Text to Column*. The "Convert Text to Columns Wizard – Step 1 of 3" box will appear as shown in Figure 46.

Figure 37 Convert Test to Columns Wizard – Step 1 of 3



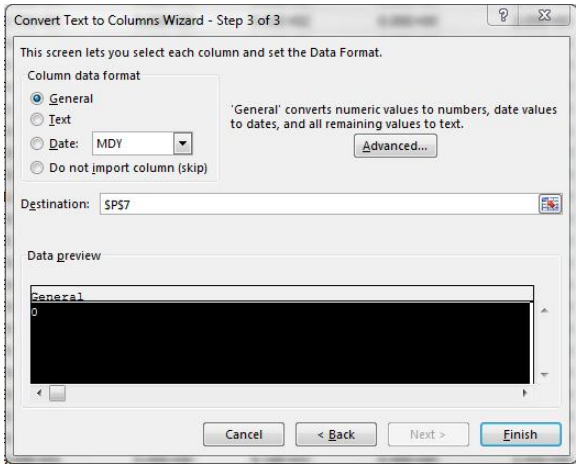
f. Select the "Delimited – Characters such as commas or tabs separate each field" option, then click on *Next*.
g. In "Convert Text to Columns Wizard – Step 2 of 3", click on the "*Comma*" box in the Delimiters options for separating the data (Figure 47). Click *Next* to proceed to the next step.

Figure 38 Convert Text to Columns Wizard – Step 2 of 3



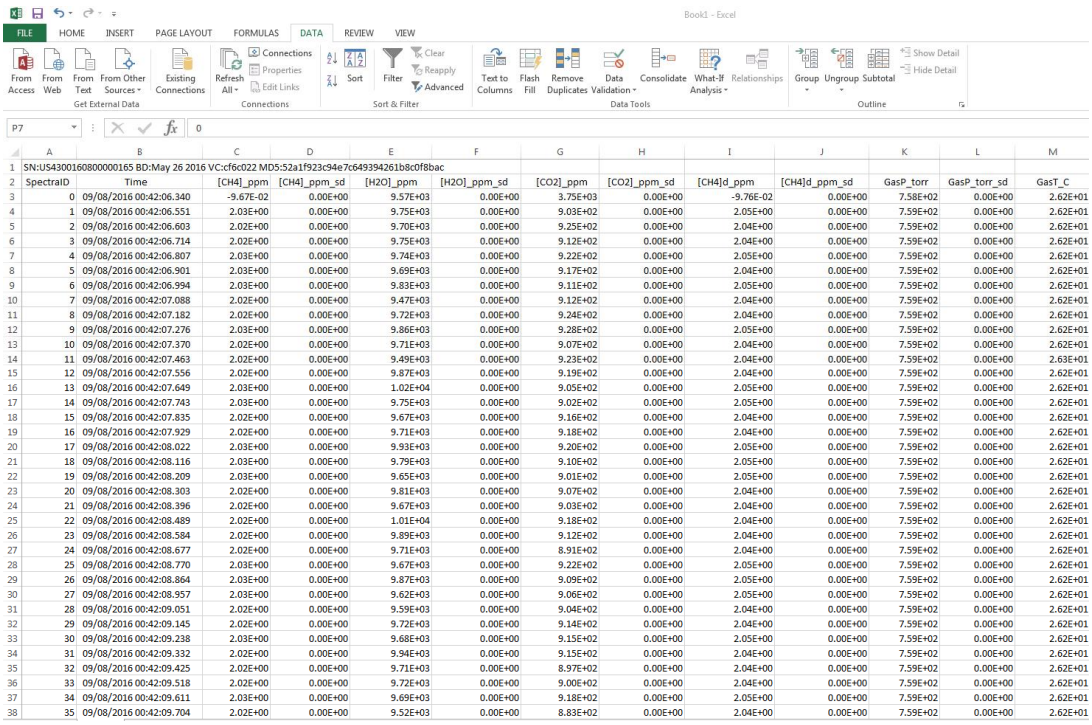
h. In "Convert Text to Columns Wizard – Step 3 of 3", click on the "*General*" box in the Delimiters options for separating the data as shown in Figure 48. Click *Finish* to finish the process of separating the data in their appropriate columns for plotting.

Figure 39 Convert Test to Columns Wizard – Step 3 of 3



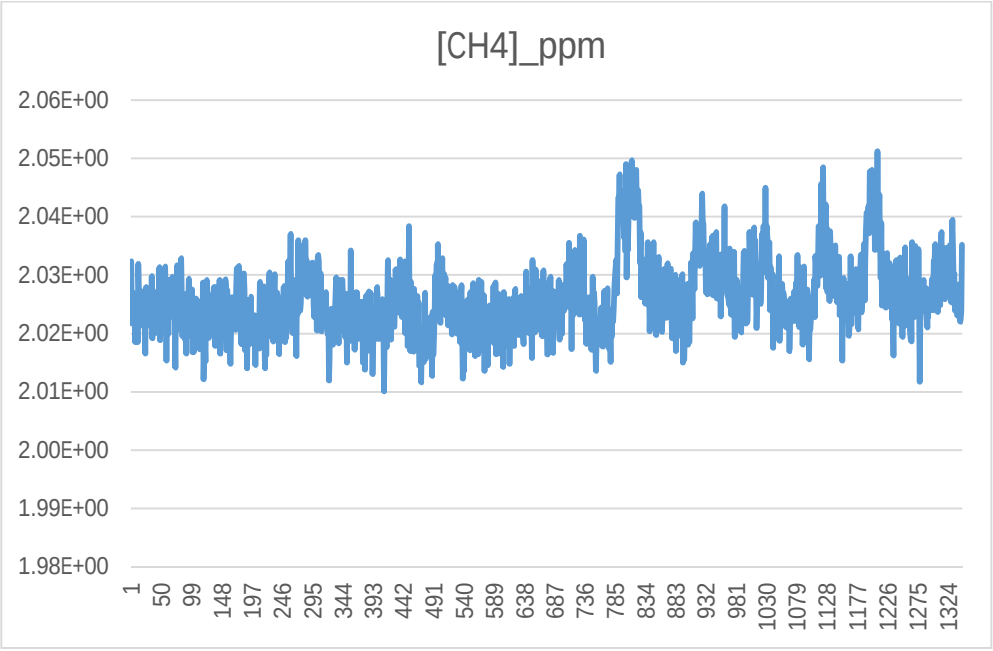
The resulting Excel spreadsheet will look like Figure 49 with all the measured and recorded data in the file is sorted per parameter heading.

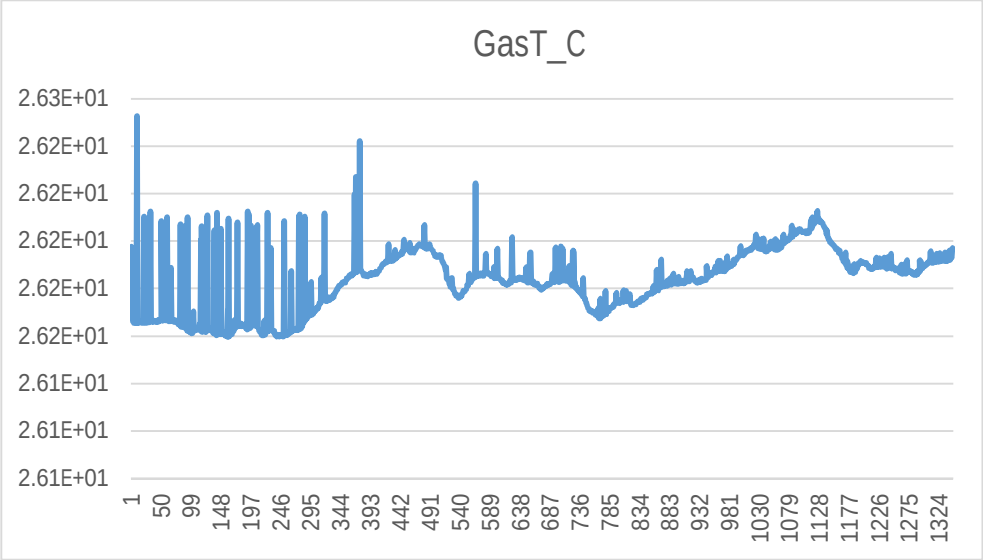
Figure 40 Convert Text Into An Excel Spreadsheet With Alignment

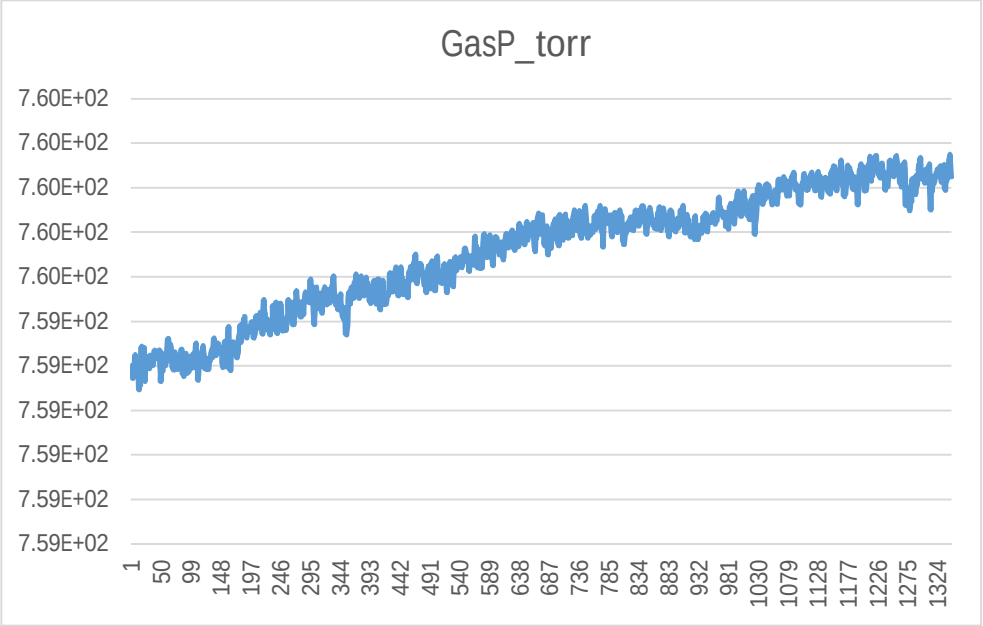


	A	B	C	D	E	F	G	H	I	J	K	L	M
1	SN:US43001608000001 65 BD:May 26 2016 VC:cf6c022 MD5:52a1f923c94e7c649394261b8c0f8bac												
2	SpectralD	Time	[CH4]_ppm	[CH4]_ppm_sd	[H2O]_ppm	[H2O]_ppm_sd	[CO2]_ppm	[CO2]_ppm_sd	[CH4]d_ppm	[CH4]d_ppm_sd	GasP_torr	GasP_torr_sd	GasT_C
3	0	09/08/2016 00:42:06.340	-9.67E-02	0.00E+00	9.57E+03	0.00E+00	3.75E+03	0.00E+00	-9.76E-02	0.00E+00	7.58E+02	0.00E+00	2.62E+01
4	1	09/08/2016 00:42:06.551	2.03E+00	0.00E+00	9.75E+03	0.00E+00	9.03E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
5	2	09/08/2016 00:42:06.603	2.02E+00	0.00E+00	9.70E+03	0.00E+00	9.25E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
6	3	09/08/2016 00:42:06.714	2.02E+00	0.00E+00	9.75E+03	0.00E+00	9.12E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
7	4	09/08/2016 00:42:06.807	2.03E+00	0.00E+00	9.74E+03	0.00E+00	9.22E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
8	5	09/08/2016 00:42:06.901	2.03E+00	0.00E+00	9.69E+03	0.00E+00	9.17E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
9	6	09/08/2016 00:42:06.994	2.03E+00	0.00E+00	9.83E+03	0.00E+00	9.11E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
10	7	09/08/2016 00:42:07.088	2.02E+00	0.00E+00	9.47E+03	0.00E+00	9.12E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
11	8	09/08/2016 00:42:07.182	2.02E+00	0.00E+00	9.72E+03	0.00E+00	9.24E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
12	9	09/08/2016 00:42:07.276	2.03E+00	0.00E+00	9.86E+03	0.00E+00	9.28E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
13	10	09/08/2016 00:42:07.370	2.02E+00	0.00E+00	9.71E+03	0.00E+00	9.07E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
14	11	09/08/2016 00:42:07.463	2.02E+00	0.00E+00	9.49E+03	0.00E+00	9.23E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.63E+01
15	12	09/08/2016 00:42:07.556	2.02E+00	0.00E+00	9.87E+03	0.00E+00	9.19E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
16	13	09/08/2016 00:42:07.649	2.03E+00	0.00E+00	1.02E+04	0.00E+00	9.05E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
17	14	09/08/2016 00:42:07.743	2.03E+00	0.00E+00	9.75E+03	0.00E+00	9.02E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
18	15	09/08/2016 00:42:07.835	2.02E+00	0.00E+00	9.67E+03	0.00E+00	9.16E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
19	16	09/08/2016 00:42:07.929	2.02E+00	0.00E+00	9.71E+03	0.00E+00	9.18E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
20	17	09/08/2016 00:42:08.022	2.03E+00	0.00E+00	9.93E+03	0.00E+00	9.20E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
21	18	09/08/2016 00:42:08.116	2.03E+00	0.00E+00	9.79E+03	0.00E+00	9.10E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
22	19	09/08/2016 00:42:08.209	2.03E+00	0.00E+00	9.65E+03	0.00E+00	9.01E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
23	20	09/08/2016 00:42:08.303	2.02E+00	0.00E+00	9.81E+03	0.00E+00	9.07E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
24	21	09/08/2016 00:42:08.396	2.02E+00	0.00E+00	9.67E+03	0.00E+00	9.03E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
25	22	09/08/2016 00:42:08.489	2.02E+00	0.00E+00	1.01E+04	0.00E+00	9.18E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
26	23	09/08/2016 00:42:08.584	2.02E+00	0.00E+00	9.89E+03	0.00E+00	9.12E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
27	24	09/08/2016 00:42:08.677	2.02E+00	0.00E+00	9.71E+03	0.00E+00	8.91E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
28	25	09/08/2016 00:42:08.770	2.03E+00	0.00E+00	9.67E+03	0.00E+00	9.22E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
29	26	09/08/2016 00:42:08.864	2.03E+00	0.00E+00	9.87E+03	0.00E+00	9.09E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
30	27	09/08/2016 00:42:08.957	2.03E+00	0.00E+00	9.62E+03	0.00E+00	9.06E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
31	28	09/08/2016 00:42:09.051	2.02E+00	0.00E+00	9.59E+03	0.00E+00	9.04E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
32	29	09/08/2016 00:42:09.145	2.02E+00	0.00E+00	9.72E+03	0.00E+00	9.14E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
33	30	09/08/2016 00:42:09.238	2.03E+00	0.00E+00	9.68E+03	0.00E+00	9.15E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
34	31	09/08/2016 00:42:09.332	2.02E+00	0.00E+00	9.94E+03	0.00E+00	9.15E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
35	32	09/08/2016 00:42:09.425	2.02E+00	0.00E+00	9.71E+03	0.00E+00	8.97E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
36	33	09/08/2016 00:42:09.518	2.02E+00	0.00E+00	9.72E+03	0.00E+00	9.00E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
37	34	09/08/2016 00:42:09.611	2.03E+00	0.00E+00	9.69E+03	0.00E+00	9.18E+02	0.00E+00	2.05E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01
38	35	09/08/2016 00:42:09.704	2.02E+00	0.00E+00	9.52E+03	0.00E+00	8.83E+02	0.00E+00	2.04E+00	0.00E+00	7.59E+02	0.00E+00	2.62E+01

STEP 3 Plot out in Excel the GasP_torr (gas pressure), GasT_C (gas temperature), and the gas name in ppm from the column. For this example, the gas type is (CH4)_ppm. The individual plots should look like:







Looking at the plots, is there a correlation between the measured gas results (CH4)_ppm, the peaks and valleys of the profile to that of either the GasT_C or GasP_torr? If the peaks and valleys do not match, the problem is not cause by the gas temperature or pressure change as seen in the ICOS cell. The impact of the gas temperature and pressure sensitivity to gas concentration can be seen from these plots. The main measurement change that cell temperature and pressure have would be in either a jump in the gas concentration cause by a large jump in temperature or pressure reading or an upward or downward trend if the temperature or pressure shows a gradual change.

Measurement data instability, higher point to point fluctuation, comes from less gas absorption level within the ICOS Cell. The cause of less absorption within the cell could be either a decaying laser or ICOS mirrors getting more contaminated. The other possibility is detector noise has increased. It can be a combination of all three. When laser intensity is lower, and/or the mirror reflectivity decreases, signal noise becomes more of an issue concerning measurement stability.

Note: Laser(s) used on the Gas Analyzer have a normal 15 years life. The laser decay rate is very very slow.

As a guide line, the laser intensity for the Gas Analyzer measuring NH_3 gas should read > 0.5 volts in the Spectra Chart display. The laser intensity for the Gas Analyzer measuring HCl and HF gases should read > 1.0 volts in the Spectra Chart display.

The last component that can cause measurement instability is a noisy power supply. So even though the laser intensity has not decay to the point where the measurement should be impacted and/or the ICOS mirrors are not that contaminated, the noise from the power source would make the signal to noise ratio from the detector worse thus resulting in a higher point to point instability.

If the ICOS mirrors are an issue, the instrument should push out an error, Mirror Health (A)/(B), in the Alarm display screen. What this means is that the reflectivity levels has decay reducing the amount of times the laser light would be reflected off the mirrors thus producing a lower light level for absorption by the gas molecules. This can be seen as a result of a longer ring down time (the down slope tail) in the measured spectra display for the gas being measured.

It is not possible to measure detector noise with the system current operating software. If one can rule out all other possibility causes of noise contributor, then move forward to replace the detector.

Noisy DC power supply can cause increase noise in the measurement through the detector. However, most reported failure type experienced on the power supply is that it fails completely providing no output voltage. The *maximum AC ripple noise on the DC output lines is 5 mV* on the clean DC Power Supply.

Pressure Issues

The following items can impact the measurement pressure within the ICOS measurement module.

- Exhaust pump(s) (External Exhaust Pump supplied by the customer, and/or Internal Exhaust Pump within the Gas Analyzer)
- 1.2µ Teflon Filter
- Check Valve
- Pressure Control Valve
- Pressure Controller PCB
- Pressure Gauge
- 400µ Orifice

The test method employed is to test each component one at a time to look for a pressure change in the ICOS cell module as registered by the Pressure Gauge. All testing to be completed must have the customer gas line to the Gas Analyzer inlet line shut off before the start of any testing. *A leak in the pneumatics system will show a lower pressure reading. A restriction (partial or full plug) in the pneumatic system will show a higher pressure reading*.

Warning!	Prior to the start of servicing the Gas Analyzer, shut off the customer sample gas line feeding the instrument follow by opening the customer atmospheric air line feeding to the instrument. Failure to perform this step will expose personnel in around the area to hazardous gas when opening lines within the Gas Analyzer during troubleshooting and cause bodily injury.

Pressure Test

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

Required items and tools:

- Standard Allen wrench set
- Philips screw driver
- Laser safety goggle for IR wavelength
- Laser interlock key
- Open end wrenches, 3/8 and 1/4 inch
- NIST traceable bottle gas
- DVM (Digital Volt Meter)
- End cap

To perform the pressure test/diagnostic:

STEP 1 Record the current gas pressure registered on the HMI Dashboard. If the gas pressure reading is close to the original gas pressure, the Exhaust Pump(s) are working fine along with the AC and DC relays.

STEP 2 Shut off the customer sample gas line valve feeding the Gas Analyzer inlet line.

STEP 3 Open the customer air line to the Gas Analyzer inlet line.

STEP 4 Perform a software shutdown of the Gas Analyzer by selecting the *Exit* icon follow by selecting *Ok* in the *Shutdown* window screen when prompted.

STEP 5 Power off the On/Off switch on the Gas Analyzer.

STEP 6 Remove the top cover of the Gas Analyzer.

STEP 7 Insert your laser interlock key to the Laser Interlock Switch on the Gas Analyzer. If you did not bring a laser interlock key with you, remove the one that is mounted on the Gas Analyzer top panel and use it to close the interlock switch.

STEP 8 Power on the Gas Analyzer using the On/Off switch in the front panel.

STEP 9 When the Gas Analyzer completes it boot process and goes into Main Display screen, wait a few minutes to allow the instrument to stabilize. Once stabilized, record the current pressure reading displayed in the HMI dashboard. During the stabilization period, the pressure reading should already be close to the previous reading, since there is nowhere the gas within the system can bleed out to in a closed vacuum system.

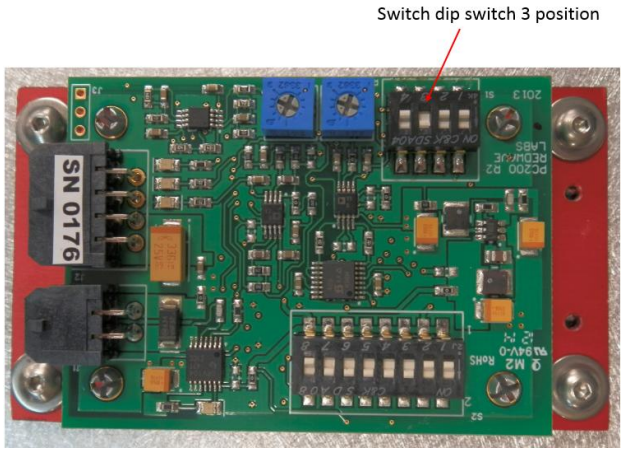
STEP 10 Disconnect the customer gas inlet line to the instrument in the back panel and screw in the end cap to the gas inlet of the Gas Analyzer.

STEP 11 Disconnect the left side panel from the Gas Analyzer by first removing the three (3) screws connecting the back panel to the left side panel. Remove the four (4) screws from the bottom panel to the left side panel. Remove the two (2) left front handle screws separating the left side panel from the front panel.

STEP 12 Remove the three (3) screws holding the top cover from the Pressure Controller PCB (PC200).

STEP 13 On the Pressure Controller PCB, at S1 switch dip switch 3 position (see Figure 50).

Figure 41 927 Gas Analyzer Pressure Controller (PC200) PCB



This should pull the internal pressure within the ICOS module down to 0 torrs within 20 seconds. If it does not, this instrument either have:

1. a bad leak;
2. a stuck Check Valve
3. a Stuck Pressure Controller Valve

If there is a plug, and the pressure remain high, the problem lies before the Check Valve because the Pressure Gauge that is being read is before the Check Valve located on the output side of the ICOS Cell.

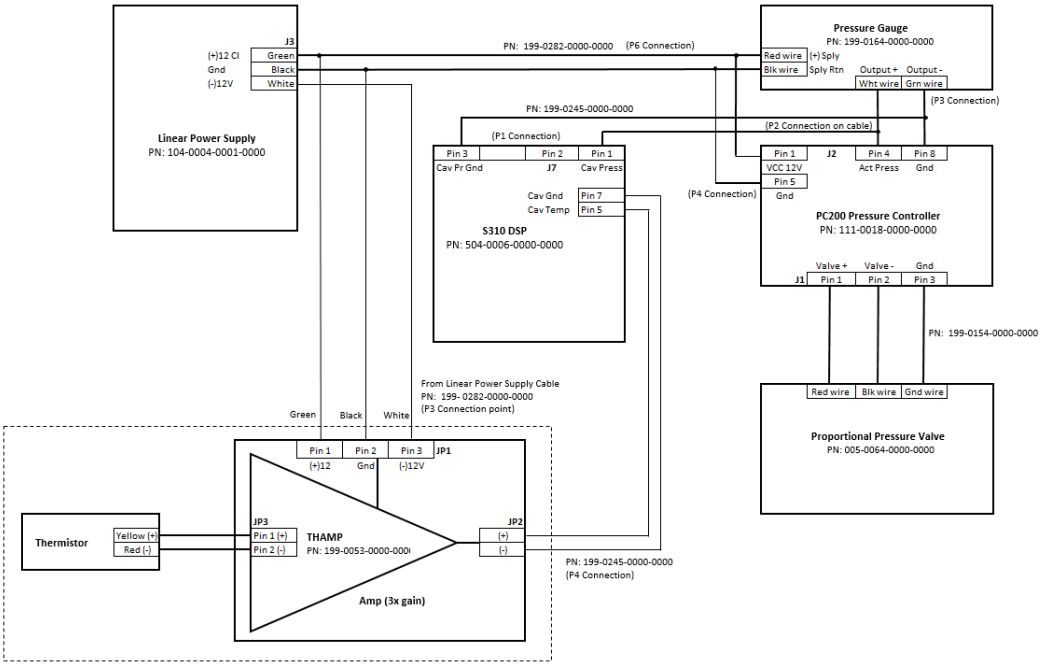
Note: The maximum pressure within the ICOS Cell is 760 torrs.

STEP 14 Verify the Pressure Controller (PC200) is working

a. Insert the test leads of the DVM to Microfit connector with the positive lead to Pin 1 (red wire), and negative lead to Pin 2 (black wire) (reference Figure 51 on how the Pressure Control system is wired). Note the third black line is the shielding ground from the cable and is inserted into Pin 3 and is tied to the green wire from the Pressure Controller PCB. Set the DVM to measure DC voltage and set to measure less than 5 volts DC.

b. On the Pressure Controller, switch dip switch 3 to the opposite side. On the DVM should respond with a change in the DC voltage level upon the dip switch change. If there is a voltage change registered on the DVM, that is an indication that the Pressure Controller PCB is working. On the Pressure Control valve, the valve should close a bit when the DC voltage goes down, and opens when the DC voltage goes up.

Figure 42 927 Gas Analyzer Pressure Control



STEP 15 Verify the Pressure Controller Valve and Check Valve is working.

a. With the dip switch 3 still in the opposite side to increase the opening of the Pressure Controller Valve, disconnect the vacuum line between the Check Valve and the Pressure Controller Valve on the Pressure Controller Valve side. Does the ICOS Cell pressure go down. If yes, replace the Pressure Controller Valve. If no, replace the Check Valve.

To check for acceptable leak rate level, return the dip switch 3 position back to its original position and allow the pressure within the ICOS Cell to go back to its original pressure reading.

STEP 16 Disconnect the vacuum line from the External Exhaust Pump and insert an end cap to the exit port to hold the gas pressure within the ICOS Cell.

Note: Without the External Exhaust Pump running, the Check Valve should be closed since there is no draw to pull down the Check Valve internal valve spring to open it.

STEP 17 Disconnect the inlet gas vacuum line at the Gas Analyzer and quickly insert the end cap to hold the internal pressure of the ICOS system in place. Determine the bleed rate. The bleed rate should be < 0.1 torr per minute. If the bleed rate is > 0.1 torr per minute, then proceed to step a.

a. If the ICOS Cell pressure bleed rate is still > 0.1 torr per minute, disconnect the vacuum line between the 400µ Orifice and the 1.2µ Teflon Filter at the 1.2µ Teflon Filter and insert the end cap at this location.

b. Measure the ICOS Cell bleed rate. If the bleed rate is < 0.1 torr per minute, the leak is in the connection at the inlet of the 1.2µ Teflon Filter or at the connection points on the 400µ Orifice. Retighten the connection point and retest again. If the pressure reading is still > 0.1 torr per minute, proceed to step c.

c. The leak is at the connection point between the 1.2µ Teflon Filter and the inlet port of the ICOS Cell. You can try tighten up Swagelok fittings at the output side of the 1.2µ Teflon Filter and the inlet port of the ICOS Cell and then recheck if this would reduce the bleed rate to < 0.1 torr per minute.

   If this is the case, remove the end cap from the 1.2µ Teflon Filter and allow the system to bleed out to atmospheric pressure. Only after the ICOS Cell bleeds out you can replace the 1.2µ Teflon Filter. Do not damage the seal between the filter and the Swagelok that is attached to it with applied RTV.

STEP 18 Re-verify the system does not have a leak or a plug after any changes has been made to the pneumatic path.

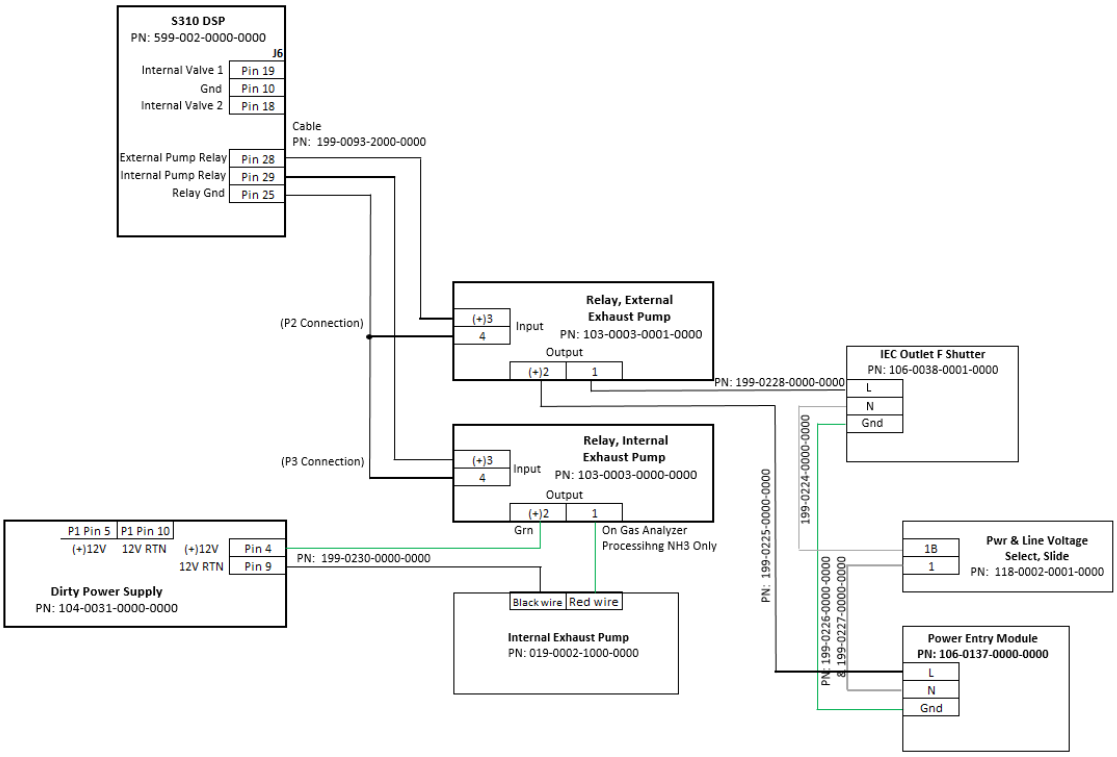
Exhaust Pump

The Gas Analyzer can use up to two (2) Exhaust Pumps to pull the gas through the ICOS module. One pump would be external to the Gas Analyzer and possibly one mounted internally (on Gas Analyzer measuring NH_3 gas concentration) within the instrument. If either exhaust pump fails, there will be no sample gas pulled through the ICOS module for measurement. There are no adjustment(s) for the exhaust pump. They are either on or off. The External Exhaust Pump receives it AC power through the rear panel IEC Outlet. The on/off control from the Gas Analyzer is from the instrument AC Relay that gets its control through the S310 PCB on the PC104 Computer Stack. The Internal Exhaust Pump receives its DC power through the DC Relay within the instrument. Its' on/off control is also from the S310 PCB on the PC104 Computer Stack. Reference Figure 52 on how both the Internal and External Exhaust Pump is wired in the Gas Analyzer.

Warning!	Probing the lines on the AC Relay is a type 4 electrical safety task. Accidental touching of the AC line can cause bodily injury.

Note: Not all NH_3 Gas Analyzers will have an Internal Exhaust Pump. This option is customer dependent.

Figure 43 927 Gas Analyzer Internal And External Exhaust Pump Wiring Diagram



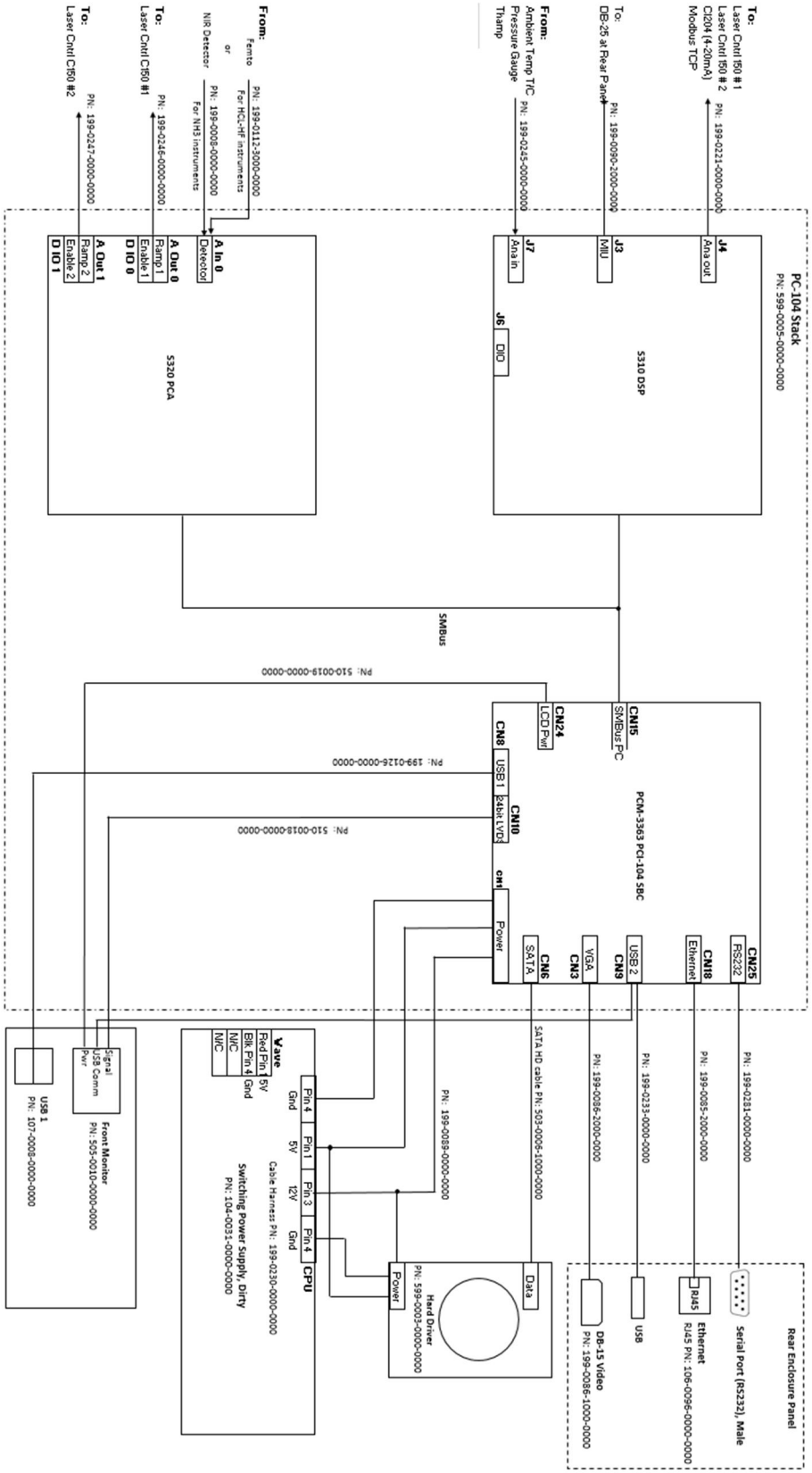
Communication Issues

There are three (3) causes of communications issues. The first would be general hardware (PC104 Computer Stack) failure. The second would be general software failure. The third would be incorrect system configuration.

Signal Output

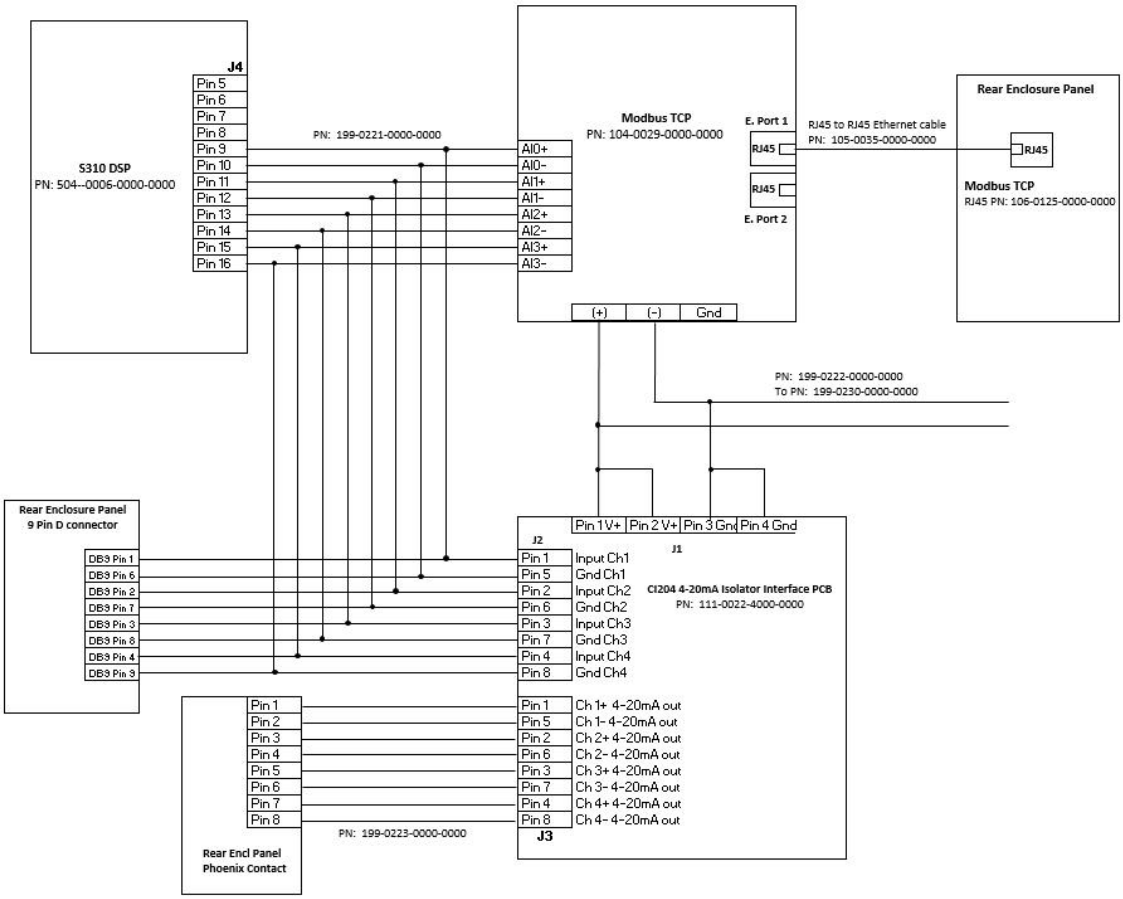
The PC104 Computer Stack provides all communication IO between the Gas Analyzer and the outside world. Gas Analyzer detector output signals are captured through the S320 Fast Card. Laser intensity (current level) and pulse (on/off) controls are also provided on this PCB for the Diode Laser. The detector signal get routed to the S310 PCB where its processes the data and puts out an analog signal in a 0 to 5 volts format to both the Modbus, and to the CI204 voltage to current converter PCB to supply the gas concentration data in a 4 – 20 mA format for the customer to measure. Figure 53 shows how the PC104 Computer Stack is connected to the various other components that are on the Gas Analyzer.

Figure 44 927 Gas Analyzer PC104 Computer Stack Wiring Diagram



Since the 927 Gas Analyzer offers the Modbus interface as an option, it may not be in the instrument for troubleshooting the 4-20 mA output signal. To verify if there is a gas concentration voltage signal coming out from the S310 PCB, make sure the line is supposed to provide a signal by looking at the display monitor of the instrument to determine if a gas concentration reading reads above 0 in the Numeric display screen. Note that to increase the gas concentration level being displayed on the screen, go to the Analog Output menu screen and adjust the proportion of the 0 to 5 volts analog output signal for the 4 to 20 mA output for each gas concentration channels. Use a digital volt meter to measure a voltage reading on the Analog out DB 9 connector located at the rear panel. If there is a voltage signal output from the S310 PCB and no 4-20 mA current level from the Phoenix Contact at the rear panel, the problem will be either the cable/connector issue, or the CI204 PCB failure. If you do not get a voltage output at the Analog out 9 pin D connector, but there is a gas concentration level displayed on the screen, the problem lies in the PC104 Computer Stack. Reference Figure 54, the 927 Gas Concentration Analog Voltage Signal Path And Conversions, to track the gas concentration voltage output signal to the various IOs.

Figure 45 927 Gas Concentration Analog Voltage Signal Path And Conversions

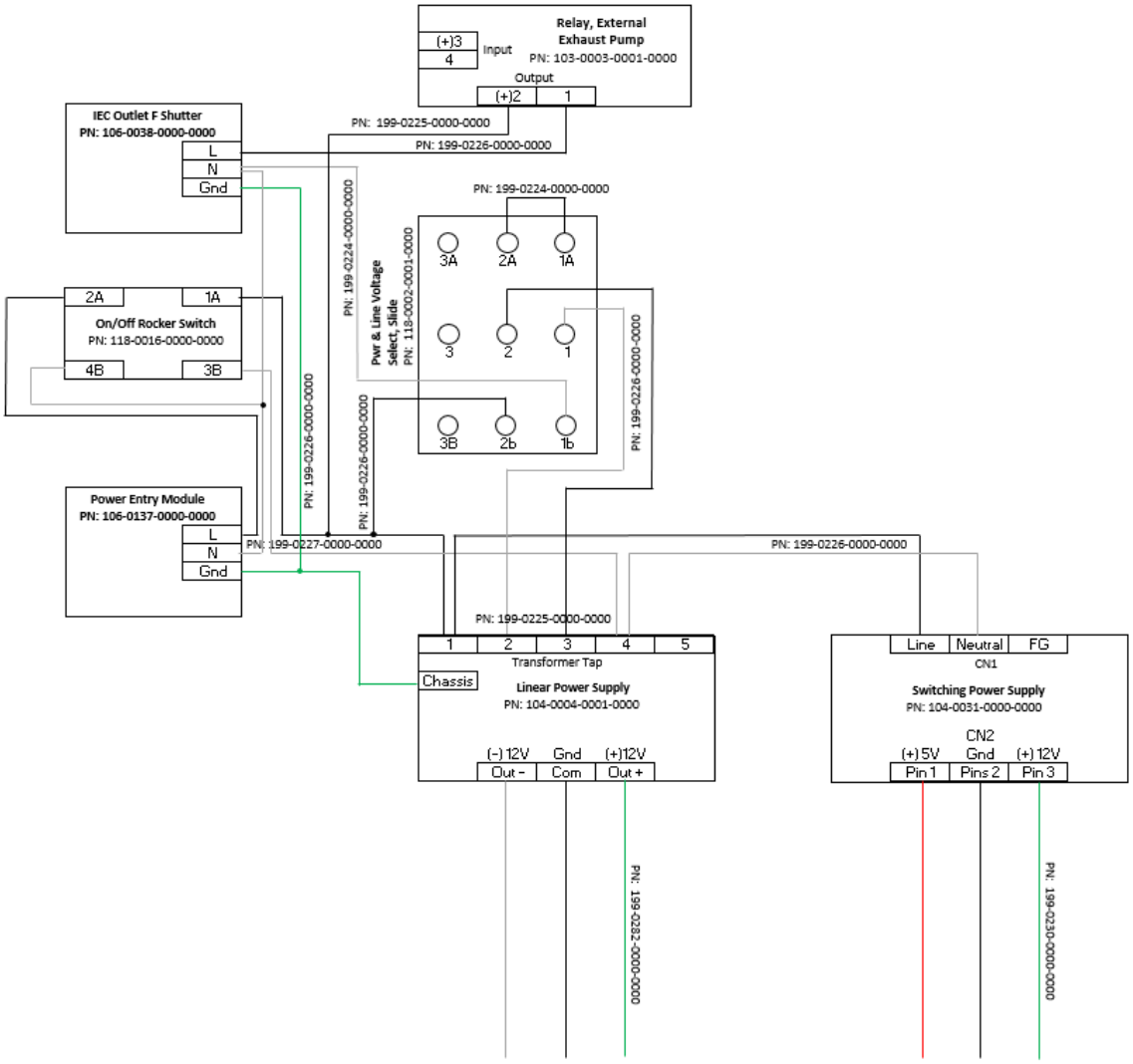


System Boot

If at any time the Gas Analyzer does not boot up to the Gas Analyzer user interface software upon power up, you either have a problem at the DC Power Supply, or a faulty PC104 Computer Stack, or a Hard Drive failure. To troubleshoot the Power Supplies, reference Figure 55, the 927 Power Supply Wiring Diagram for expected voltage levels per tap.

If the power supply tested to be fine and the computer boots up and displays the BIOS setting it processed and then stops and goes no further, that is a symptom of a problem with the hard drive operating software (corruption) or the hard drive itself.

Figure 46 927 Power Supply Wiring Diagram

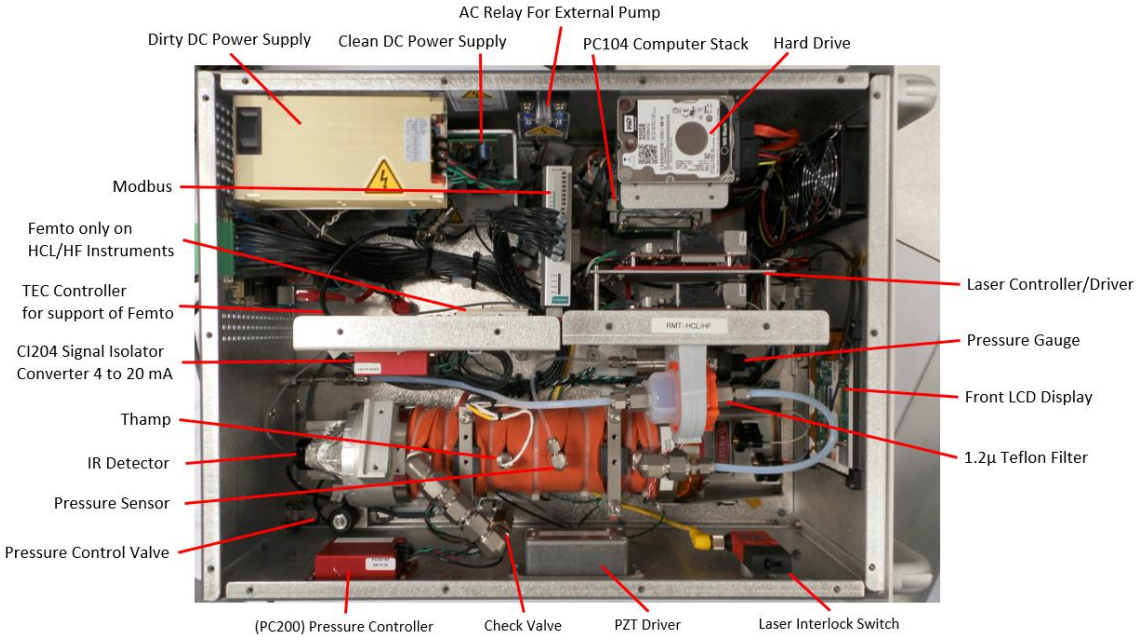


Remove And Replace

All hardware components, excluding the ICOS Module containing the Laser(s), can be replaced in the field. Prior to any removal of component(s), always wear an ESD wrist strap tied to ground before touching the components. All replacement perform on the Gas Analyzer must be first power down removing all electricity from the instrument. The 927 Gas Analyzer components layout is shown in Figure 56.

When replacing the PC104 Computer Stack, transfer the S320 PCB from the current stack to the new stack. This is required to avoid having to recalibrate the Gas Analyzer due to slight gain changes between two boards. Also, when replacing the ICOS module with the Laser, transfer the S320 PCB that came with the module to the exist PC104 Computer Stack. Once the new ICOS module is installed on the unit with along with the S320 PCB, recalibration of the instrument is required with a NIST traceable bottle gas.

Figure 47 927 Gas Analyzer Components Layout



9. Preventative Maintenance

The ABB 927 Gas Analyzer requires every six months to yearly preventative maintenance (PM) to maintain its measurement performance. There are four categories of PM parts:

- Parts that may need to be replaced every six months
- Parts that need maintenance, but may not need replacement, every year
- Parts that need to be replaced every two years
- Parts that need to be replaced every five years
- Parts that need to be replaced every ten years

Parts requiring maintenance every year are:

- System hard drive
- Astigmatic mirrors

Parts to check and possibly replace every six months are:

- Internal pump diaphragm (927T instruments only)
- Exhaust pump diaphragm (927S instruments only)
- Membrane filter

Parts to replace every two years are:

- Exhaust pump diaphragm (927S instruments only)
- Internal pump diaphragm (927T instruments only)

Parts to replace every five years are:

- Exhaust pump (927T instruments only)
- ICOS O-Rings

Parts to replace every ten years are:

- Proportional Pressure Valve
- System hard drive
- Pressure Controller

Hard drive maintenance requires that some of the older data stored in the archive folder be removed from the instrument and put into another storage location. The tool owner should be notified of this action and provide the alternate storage location. It is not advisable to delete all measured and stored data from the instrument. Older data provides operators/service engineers a recorded performance baseline of the instrument when it was working properly. This data will serve as a reference of working performance data when servicing or repairing the instrument in the future.

Cleaning the two ICOS astigmatic mirrors is required when processed gases contaminate and coat the mirrors, reducing its effectiveness and resulting in reduced measurement precision and/or inaccurate data.

Preventive maintenance should be performed by trained personnel that have successfully completed the maintenance course on the ABB 927 Series Gas Analyzer.

Mirror Cleaning Procedure

The ICOS Astigmatic Mirror requires cleaning when the Gas Analyzer issues a Mirror Health error in the Alarm screen. Cleaning of the mirrors should be performed in a class 10,000 or better environment.

NOTE: This is a Type 1 electrical safety task.

Required items and tools:

- ABB/LGR Mirror Cleaning kit
  - 1-30ml LDPE screw-top bottle filled with Acetone (HPLC Plus, ≥99.9%)
  - 1-30ml LDPE screw-top bottle filled with Methanol (HPLC Plus, ≥99.9%)
  - 1-30ml LDPE Dropper Bottle labeled Acetone
  - 1-30ml LDPE Dropper Bottle labeled Methanol
  - 1-Compressed air duster canister
  - 1-Chapman screwdriver kit
  - 1-Stainless steel mirror cleaning block
  - 1-Delrin mirror pushing tube

Figure 48 Mirror Cleaning Kit

Note: Compressed Air Canister and paper are not allow in Fab Cleanroom. Lens tissue are allowed in a Fab Cleanroom. Always ask the customer their cleanroom policy concerning what can be taken into their cleanroom.

STEP 1 Close the valve to the customer inlet sample gas line going into the Gas Analyzer.

STEP 2 Open the valve on the customer inlet air line going into the Gas Analyzer to purge the Gas Analyzer that would have the sample customer gas in the ICOS module.

STEP 3 Power down the Gas Analyzer by first selecting the *Exit* icon followed by *Ok* when prompt to shut down the instrument.

STEP 4 Close the valve on the customer inlet air line going into the Gas Analyzer.

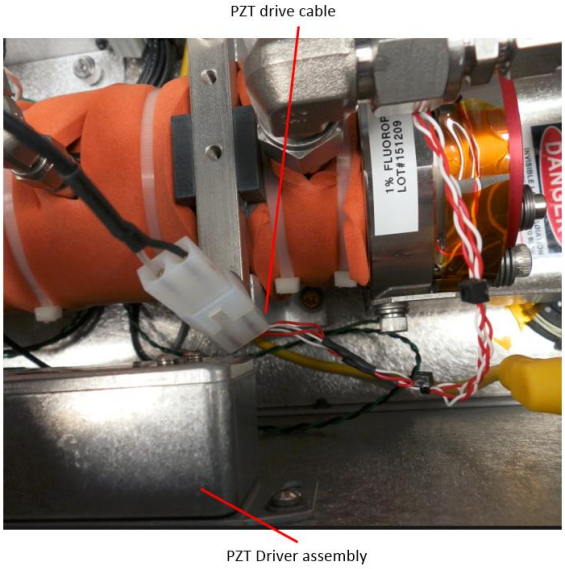
STEP 5 If possible, disconnect the inlet sample gas line from the Gas Analyzer. Perform this same task for the outlet exhaust gas line.

STEP 6 Move the Gas Analyzer to a table where it can be worked on.

STEP 7 Remove the top enclosure cover from the Gas Analyzer to exposing its internal components.

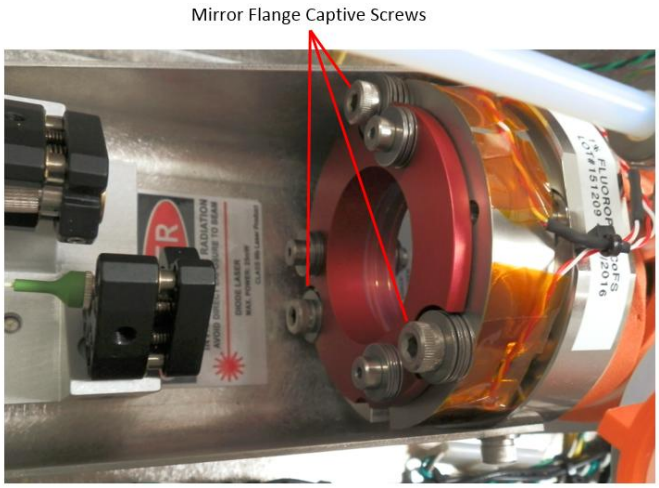
STEP 8 Disconnect the PZT drive cable on the ICOS module from the PZT Driver assembly. Reference Figure 58 for identifying the PZT drive cable on the ICOS module.

Figure 49 PZT Drive Cable



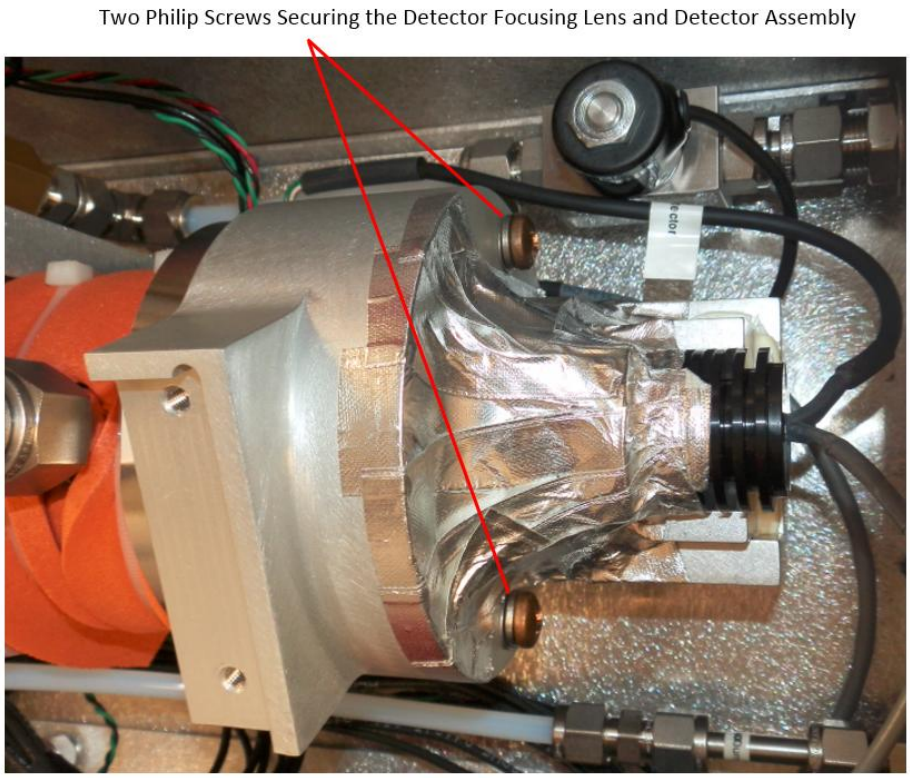
STEP 9 Remove the Mirror Flanges from the ICOS module on the laser side by loosening the three outer flange captive screws. Reference Figure 59 for the location of the Mirror Flange Captive Screws. Set the Mirror Flange with Mirror assembly off to the side for now. Do not touch the reflective surface side of the mirror.

Figure 50 Mirror Flange Captive Screws



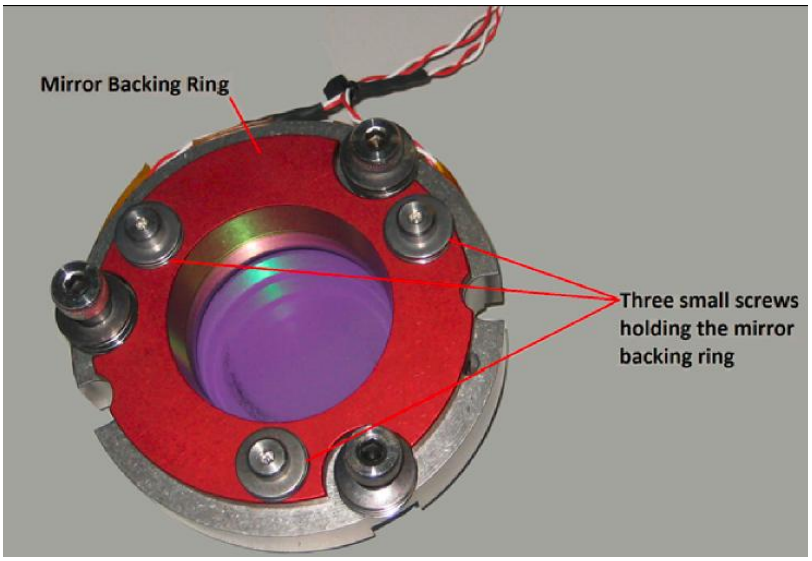
STEP 10 Remove the two (2) Philip screws securing the Detector Focusing Lens and Detector assembly from the ICOS module. Slide out the Detector Focusing Lens and Detector assembly from the ICOS module allowing access to the second mirror on the ICOS module assembly. Reference Figure 60 for the location of the Philip screws to be removed.

Figure 51 Detector Focusing Lens & Detector End Cap Assembly



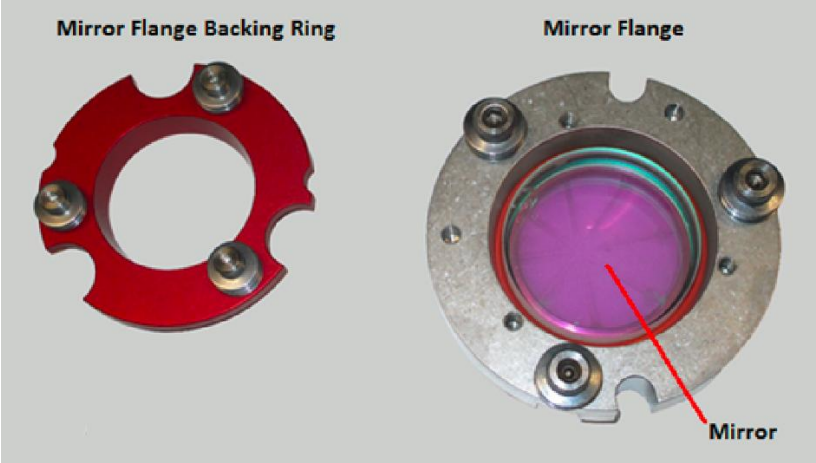
STEP 11 Place the flange on a clean surface as shown in Figure 61. The mirror reflective side in this position will be facing down.

Figure 52 Detector Focusing Lens & Detector End Cap Assembly



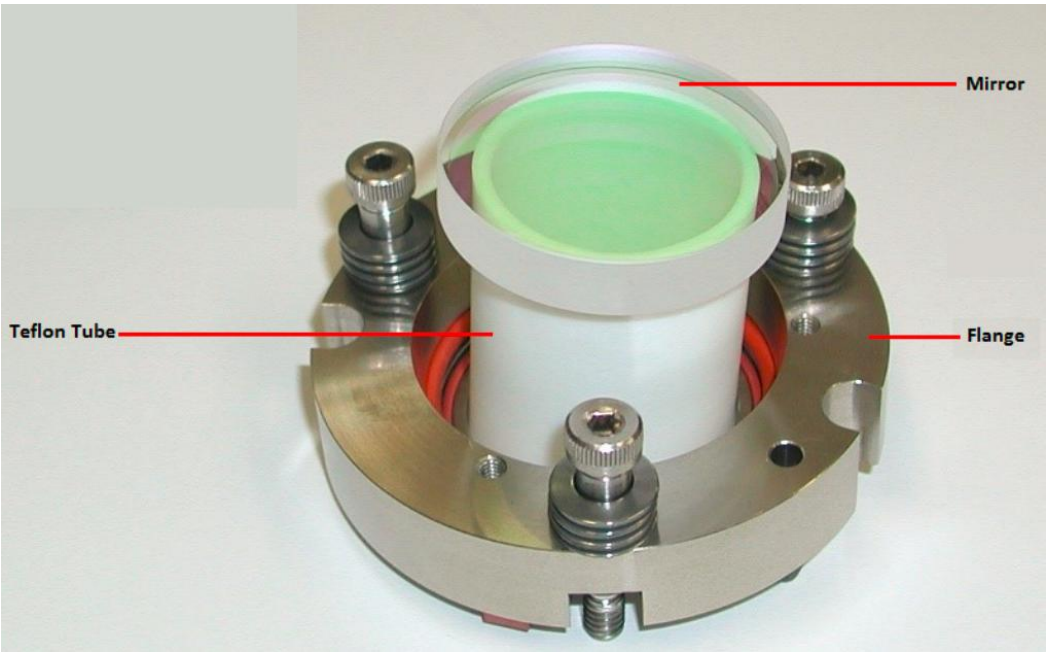
STEP 12 Detach the backing ring by loosening and removing the three small hex head screws. If the small diameter face seal O-ring sticks to the mirror, gently remove it and place the O-ring back into the groove at the bottom of the flange. Reference Figure 62 upon separating the Mirror Flange Backing Ring from the Mirror Flange.

Figure 53 Detach Backing Ring From The Mirror Flange



STEP 13 Place the mirror flange on top of the Teflon tube (provided) and carefully push the flange downwards until the mirror pops out of the flange O-ring as shown in Figure 63.

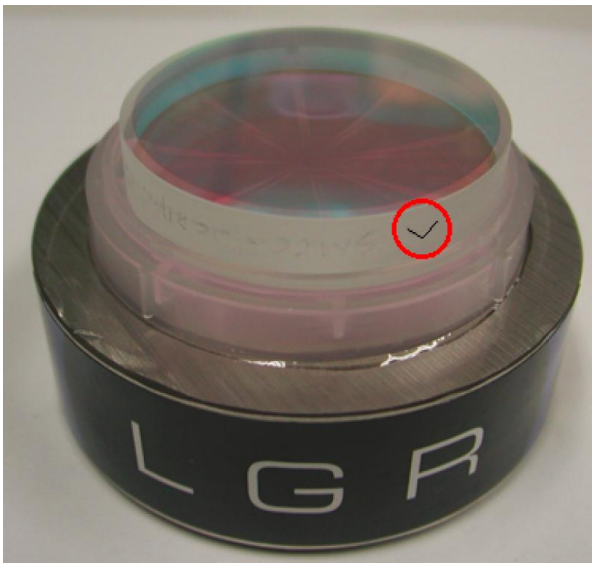
Figure 54 Releasing The Mirror



STEP 14 Place the mirror on the mirror cleaning block with the arrow on the mirror edge pointing down (anti-reflection side up) as shown in Figure 64.

Note: When handling the mirror, always grab the mirror from the side edges and not on the flat surfaces.

Figure 55 Mirror In Cleaning Block With High-Reflectivity Side Down



STEP 15 Transfer a very small amount of fresh acetone from the Acetone Screw-Cap Bottle to the Acetone Dropper Bottle. Use just enough to rinse the dropper bottle.

STEP 16 With the dropper top closed, shake the dropper bottle to rinse the interior of the bottle and discard the rinse acetone. In a cleanroom environment for discarding the rinse acetone, pour it to a clean room cloth to absorb its content. Discard the cleanroom cloth per the customer cleanroom disposal process.

STEP 17 Fill the Acetone Dropper Bottle approximately ¼ full with fresh acetone as seen in Figure 65.

STEP 18 Repeat STEPs 15 through 17 for Methanol.

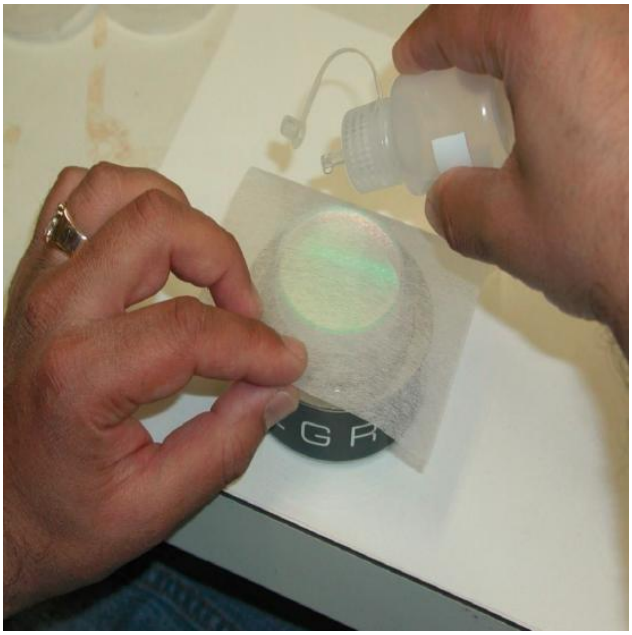
Figure 56 Acetone And Methanol Dropper Bottles

STEP 19 Separate a single sheet of lens tissue from the pack. 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 mirror to hold when you drag it as shown in Figure 66.

Figure 57 Lens Tissue Placement On the Mirror

STEP 20 Using the acetone dropper bottle, place 4 drops of Acetone onto the tissue at the center of the mirror as shown in Figure 67. The solvent will wick to the edge of the mirror.

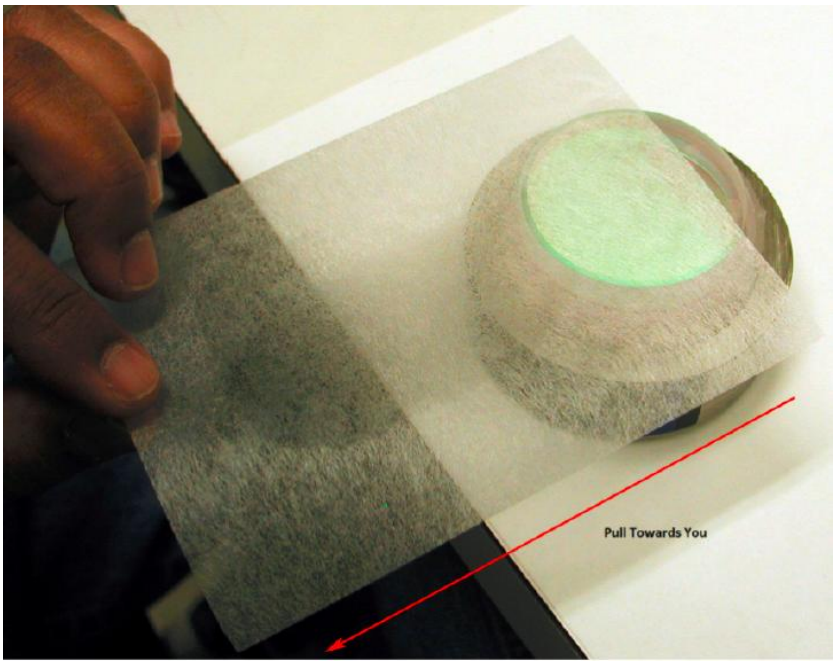
Figure 58 Drag Wipe Step 1



STEP 21 Pull the tissue toward you with a consistent but light pressure over the full length of the mirror at a speed which matches the evaporation rate of the solvent from the surface as shown in Figure 68. This is called drag wiping.

Note: If you see liquid on the mirror after you pass the wire over it, then you are wiping too fast.

Figure 59 Drag Wipe Step 1



STEP 22 Discard the used tissue.

STEP 23 Lay a clean tissue on top of the mirror.

STEP 24 Place 4 drops of Methanol on a clean tissue and repeat the drag wipe process.

STEP 25 Discard the tissue after each drag wipe.

STEP 26 Invert the mirror in the mirror cleaning block so that the high reflectivity surface is on top and the arrow is facing up as shown in Figure 69.

Figure 60 Cleaning The High Reflective Surface

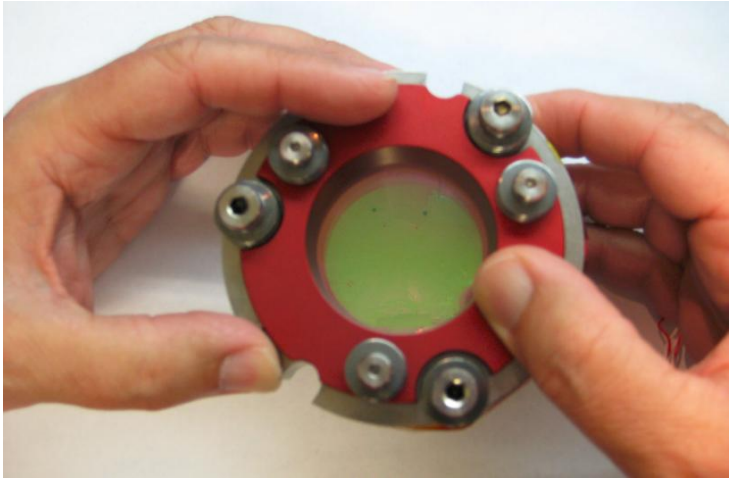
STEP 27 Perform the drag wipe process in this order on the high reflectivity side:

a. Acetone (4 drops)
b. Methanol (4 drops)
c. Acetone (4 drops)
d. Methanol (4 drops)

STEP 28 Reassemble the ICOS module by first reassembling the mirrors back onto the flanges. Make sure the high reflective side will be facing toward the measurement cell. When placed into the flange, the mirror sits on the outer O-ring.

STEP 29 Place the backing ring gently onto the mirror, positioned so that the notches on the backing ring match with the notches on the flange. Use the ring to press the mirror into place as shown in Figure 70.

Figure 61 Press The Backing Onto The Mirror



STEP 30 Tighten each screw a few turns at a time while creating equal pressure on the mirror. Repeat this until all screws are tight. Be careful not to over tighten the screws as this may strip the threads.

STEP 31 Place the flange onto the cavity and tighten the large bolts until they are tight for both flanges with mirror. Be careful not to over tighten the screws as this may strip the threads.

STEP 32 Reconnect the PZT Drive cable between the PZT Driver and the PZT on the Mirror Flange.

STEP 33 Reattach the Detector Focusing Lens and Detector assembly back onto the ICOS module.

STEP 34 Reattach the top panel back onto the Gas Analyzer.

STEP 35 Put the Gas Analyzer back into the location where it was originally.

STEP 36 Reattach the customer sample gas line and exhaust line on to the Gas Analyzer.

STEP 37 Power on the instrument and verify that ring down time (Tau) is close to back where it was originally.

STEP 38 Verify the customer sample gas measurement is back to their control limits. If they are not, take a measurement of a NIST traceable bottle gas and verify if the current calibration is correct. If not, perform calibration on the Gas Analyzer using the NIST traceable bottle gas.

Appendix A: Safety Data Sheets

This chapter provides material safety data sheets for the chemicals typically used in ABB 927 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 260.000000 mg/m3	USA. Occupational Exposure Limit (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

	CAS-No.	Revision Date
Methanol	67-56-1	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Methanol	67-56-1	2007-07-01

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING: This product contains a chemical known to the State of California to cause birth defects or other reproductive harm. Methanol	67-56-1	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

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Preparation Information

Sigma-Aldrich Corporation
Product Safety – Americas Region
1-800-521-8956

Acetone SDS

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 routes	Exposure	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

Acetone	CAS-No.	Revision Date
	67-64-1	2007-03-01

Pennsylvania Right To Know Components

Acetone	CAS-No.	Revision Date
	67-64-1	2007-03-01

New Jersey Right To Know Components

Acetone	CAS-No.	Revision Date
	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

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