PICARRO

G2114 Analyzer for H_2O_2 (Hydrogen Peroxide) User Manual

Picarro Analyzer User Manual

Thank you for purchasing a Picarro product. Your Picarro system is a quality product that has been designed and manufactured to provide reliable performance.

This User Manual (UM) is an important part of your purchase as it will help familiarize you with the system and explain the numerous features that have been designed into it. Please read this manual thoroughly before using your Picarro system.

Please contact Picarro or your authorized Picarro distributor should you have questions regarding specific applications or if you require additional information.

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1. INTRODUCTION TO TECHNOLOGY

Picarro analyzers use time-based, optical absorption spectroscopy of the target gases to determine concentration. They are based on wavelength-scanned cavity ring-down spectroscopy (WS-CRDS), a technology in which light re-circulates many times through the sample, creating a very long effective path length for the light to interact with the sample, thus, enabling excellent detection sensitivity in a compact and rugged instrument.

The Picarro analyzer is comprised of two modules:

The **Analyzer** contains the spectrometer, sample chamber, and a computer with a hard drive to store and analyze data. The single analyzer module controls the operation of the system and converts spectroscopic measurements into gas concentration data.

The **External Vacuum Pump** draws the sample gas through the instrument.

1.1 Cavity Ring-Down Spectroscopy (CRDS)

Nearly every small gas-phase molecule (e.g., CO_2, H_2O, H_2S, NH_3) and isotopologue (e.g., $H_2^{18}O$, $^{13}CO_2$, $^{15}N^{14}N^{16}O$) uniquely absorb specific wavelengths of near-infrared light. The strength of the light absorption is related to the concentration of a molecule in a sample and the distance that light travels through the sample, called the path length.

Conventional infrared spectrometers are typically only sensitive enough to detect trace gases at levels in the part-per-million. Cavity Ring-Down Spectroscopy (CRDS), on the other hand, is one thousand to one million more times sensitive.

In Picarro analyzers, light from a single-frequency laser enters a cavity where three mirrors reflect the laser light as seen in Figure 1. The light enters through the mirror closest to the laser, bounces off the angled mirror in the lower right corner of the cavity, travels to the hemispherical mirror at the top of the cavity, bounces toward the mirror in the lower left corner of the cavity, and then returns to the first mirror. This motion becomes a continuous traveling light wave, which is represented by the dark orange path in Figure 1.

Figure 1:
Schematic of the Picarro CRDS analyzer cavity
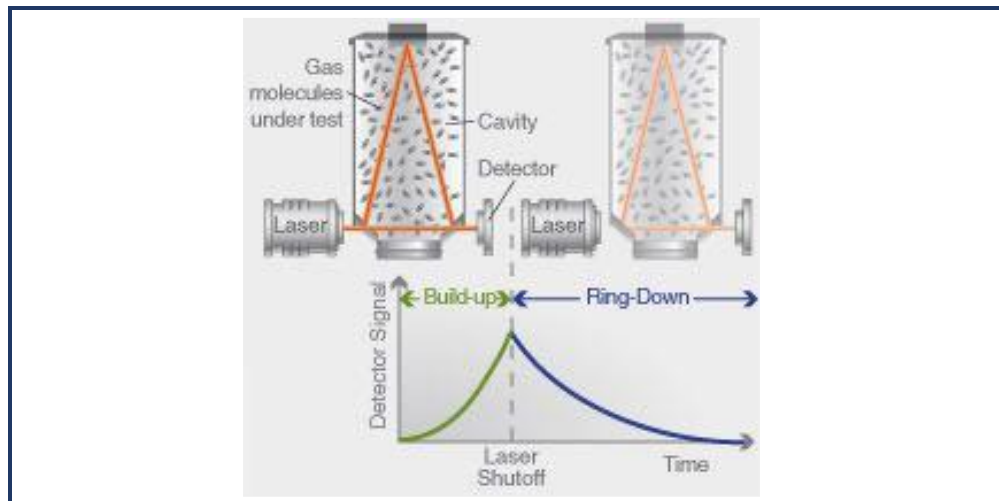
When the laser is on, the cavity quickly fills with laser light. A small amount of the laser light is transmitted through the mirror closest to the photodetector, which turns the incident light into a signal that is directly proportional to the light intensity in the cavity.

When the photodetector signal reaches a threshold level (in a few tens of microseconds), the laser is turned off. The light contained within the cavity continues to bounce between the mirrors (about 40,000 times). Since the mirrors have slightly less than 100% reflectivity (99.999%), the light inside the cavity steadily leaks out of the cavity. The intensity of the light reaching the detector decreases, falling exponentially until it reaches zero. This decay, or "ring-down," is measured in real time by the photodetector.

1.2 Relating Ring-Down Time to Absorption Intensity

The time it takes to ring-down is inversely related to the total optical loss in the cavity, including the strength of molecular absorption at a given wavelength of light. For an empty cavity, the time it takes for the intensity to decrease by a given percent is determined solely by the reflectivity of the mirrors. A cavity containing gas that absorbs light will have a shorter ring-down time than an empty cavity. As the light circulates in a cavity with a gas sample, the molecular absorption by the gas results in a decrease of the light intensity.

Determining absorption intensity at a specific wavelength requires comparing the ring-down time of an empty cavity to the ring-down time of a cavity that contains gas. Picarro instruments gather measurements from an "empty" cavity by switching the light to wavelengths that are not absorbed by the target molecules. The analyzer subsequently measures ring-down times at wavelengths that are absorbed by the target gas. The analyzer automatically and continuously compares these two types of ring-down times, and the software uses those comparisons to calculate absorption intensities.

Figure 2: Light intensity as a function of time in a CRDS system
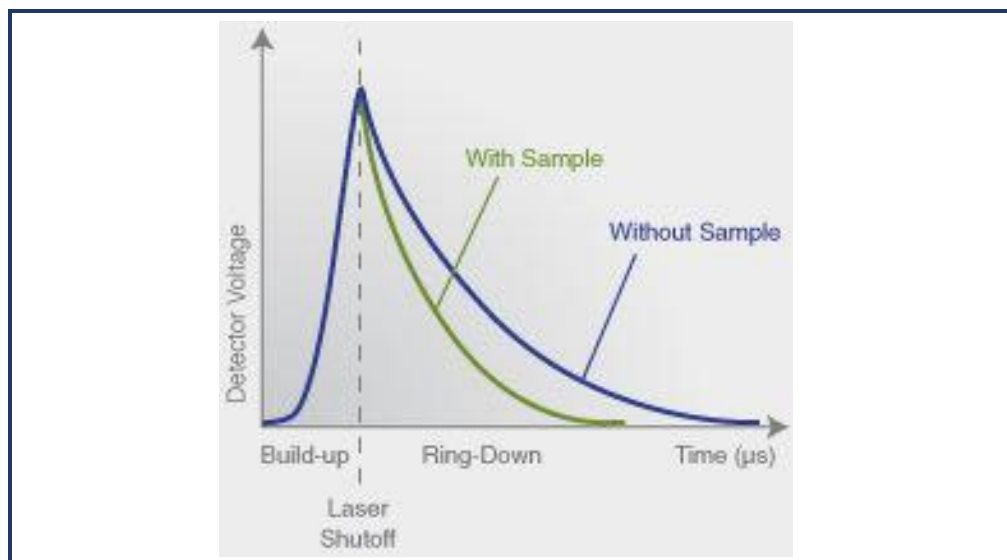
1.3 Converting Absorption Intensity to Concentration

Plotting the absorbance at each measured wavelength generates an optical spectrum. This spectrum contains absorbance peaks that are unique to each molecule in the sample. The height of a particular absorption peak is proportional to the concentration of a molecule that generated the signal.

The height of the peak is calculated by subtracting the maximal absorbance from the baseline absorbance. Figure 3 shows a plot of ideal optical spectra with a clean, uniform baseline on either side of the absorption peak.

Figure 3: Absorption Spectral Curve
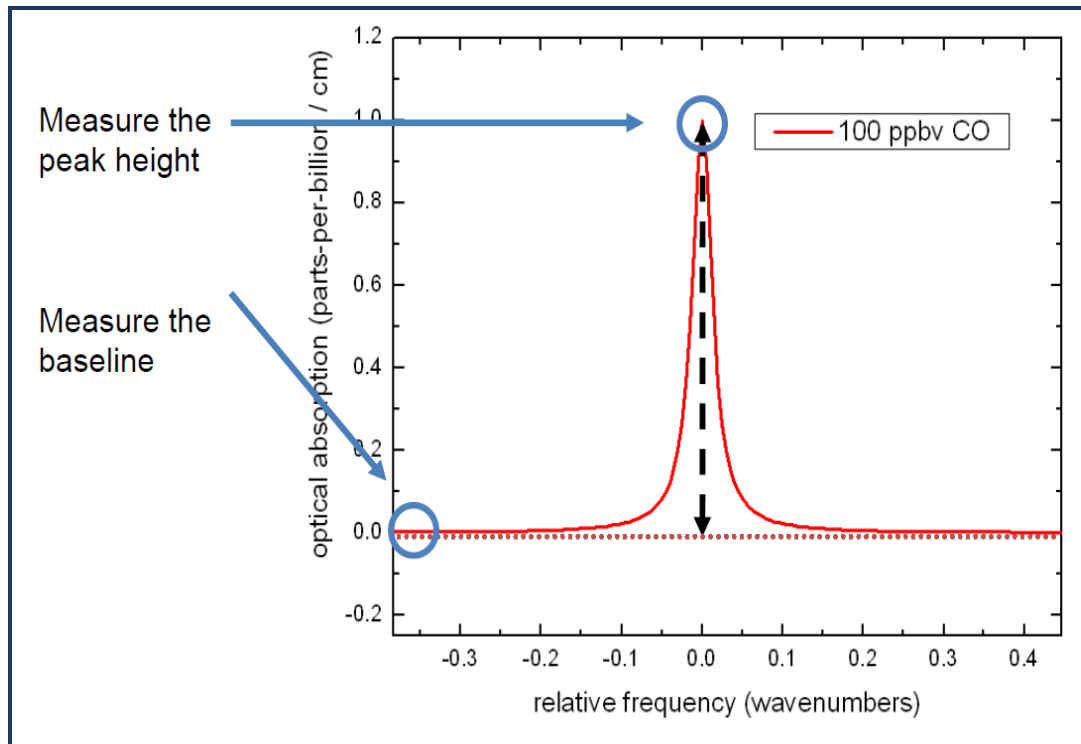
Optical spectra often contain several absorption lines, nested closely together. A particular absorption peak may be visible between lines, but the absorption may not return to the baseline before it rises in response to another molecule. Picarro analyzers calculate the baseline underneath a poorly resolved peak by modeling the absorption peaks from other surrounding molecules and subtracting contributions from neighboring peaks to the absorption intensity.

1.4 Spectral Precision and High Sensitivity Measurements

Picarro analyzers contain two features that provide high spectral precision:

- Proprietary **wavelength monitor (WLM)** that measures the absolute laser wavelength to a precision that is a few orders of magnitude narrower than the spectral linewidth: Picarro's patented WLM measures absolute laser wavelength to a precision more than 1,000 times narrower than the observed Doppler-broadened linewidth for small gas-phase molecules. The instruments lock the laser to the WLM, and then the monitor tunes to wavelengths known to be maximally and minimally absorbed by the target molecule. The result is closely clustered absorption intensities at and around the wavelength of peak absorption.

- Precise temperature and pressure control in the sample cavity: Accurate absorption measurements at precisely known wavelengths account for little unless the temperature and pressure of the CRDS measurement cavity are known. The observed line intensity and shape depend on the temperature and pressure inside the sample cavity. To completely minimize instrument measurement drift, temperature and pressure must be actively stabilized to constant values.

For precise temperature control, the sample cavity is surrounded by layers of thermally insulating material to provide a high degree of passive thermal stability. The cavity is further actively stabilized by means of a solid-state heating system locked to the output of a thermal sensor. This enables the temperature of the cavity to be within 20 mK of the set temperature.

For precise pressure control, the cavity pressure is monitored using a high-linearity pressure transducer. The system computer uses this pressure data in a feedback loop to control proportional valves that adjust the inlet and outlet gas flow of the cavity.

2. CONVENTIONS

The following icons are used throughout this manual to emphasize important information in the text. These icons indicate dangers to either the operator or to the analyzer, and other important information.

⚠️	Consult the user's manual for important information (When you see this symbol placed at hazard points on equipment, consult the user manual).
📝	**NOTE** is important information that you should be aware of before proceeding.
⚠️ **WARNING**	**WARNING** indicates an imminent danger to the user.
☢️ **WARNING**	**LASER WARNING** alerts you of a laser danger.
⚠️ **CAUTION**	**CAUTION** alerts you of a potential danger to equipment or to the user.
💡 **REMINDER**	**REMINDER** is a helpful hint to procedures listed in the text.

3. ACRONYMS

This manual includes various acronyms. For definitions, see below:

Acronym	Definition
CRDS	Cavity Ring-Down Spectroscopy
GUI	Graphical User Interface
cm	centimeters
mm	millimeters
” (as in 1/4”)	Inches
H_2O_2	Hydrogen Peroxide
H_2O	Water
NH_3	Ammonia
CO_2	Carbon Dioxide
HB	Hotbox
WB	Warm box
ppm	Parts Per Million
ppb	Parts Per Billion
‰	per mil
°C	degrees Celsius

4. SAFETY

4.1 General Safety

CDRH Certification

This Picarro Analyzer complies with 21 CFR Chapter 1, sub-chapter J, and is classified as a Class 1 laser system when all panels and covers are on.

CE Certification

This Picarro Analyzer complies with the European standards and the instrument is affixed with a CE label. This CE label is located on the rear of the instrument.

WARNING

Using this analyzer in a manner not specified by Picarro may result in damage to the analyzer and render it unsafe to operate.

WARNING

This analyzer is for indoor use only and has an ingress protection rating of IPx-0. Analyzer is NOT protected against exposure to water including dripping, spraying, splashing or immersion.

WARNING

Do not operate in an explosive atmosphere! Do not operate in the presence of flammable gases or fumes.

CAUTION

The analyzer contains no user serviceable components except the particulate filter. Do not attempt repairs; instead, report all problems to Picarro Customer Service or your local distributor. Please contact Picarro if you have any questions regarding the safe operation of this equipment.

WARNING

The inlet gas connector on the back panel of the Analyzer, and its immediate vicinity, runs hot during operation of the analyzer. Take care when connecting gas lines or working at the rear of the instrument to wear protective gloves or avoid contact with these surfaces.

WARNING

This analyzer weighs 46 lbs. (20.9 kg). Use the technique described below when lifting the analyzer.

a. Before lifting, inspect the unit for slippery substances or sharp edges.

b. Lift with two people, one on each side of the analyzer.

c. Crouch down and stay close to the unit. Always keep your back as straight as possible.

d. Position your feet for sturdy balance. Lift with your legs, not your back.

e. Do not twist the back while carrying the unit. Rotate direction with hip joints.

f. Lower the unit by bending at the knees.

4.2 Laser Safety

WARNING

This equipment is classified as a Class 1 laser product with an embedded 3B laser in accordance with EN 60825-1:2014. Do not to open the enclosure where this label is placed; there are no user serviceable parts inside.

The following Laser Safety Label is affixed to the outer cover of the analyzer.

WARNING

The laser is a Class3B when exposed.
Only operate or service this device in accordance with the instructions in this guide, and only open the device in an approved laser safe service area using appropriate laser-safety glasses.

The following **Laser Safety Label** is affixed to the inside of the analyzer:

Figure 4:
Laser Safety
Label

CAUTION

**CLASS 3B INVISIBLE LASER
RADIATION WHEN OPEN
AVOID EXPOSURE TO THE BEAM**

WARNING

Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

5. UNPACKING THE ANALYZER

5.1 Inspect the Shipping Boxes

Picarro products are inspected and tested before leaving the factory. Their packing containers have been designed to keep the equipment safe from damage during transit.

Inspect the condition of the boxes upon arrival. The larger box includes the analyzer and most of the accessories. Even if the outer box shows damage, the inner box holding the analyzer is cushioned enough that it will protect the instrument under most circumstances.

If the equipment does appear to be damaged, photograph the damages and contact Picarro (email pictures if possible) as soon as possible.

5.2 Unpack the Shipping Boxes

This section describes the contents of the shipping boxes:

Inspect each item to ensure it is not damaged.

If items are missing, contact Picarro.

Keep the shipping packages to reuse when transporting the analyzer.

Contact Picarro for options on transporting systems to remote labs.

WARNING

This analyzer weighs 46 lbs. (20.9 kg). Use the technique outlined in the General Safety section on page 15 when lifting or moving the analyzer.

Figure 4:
Box Contents
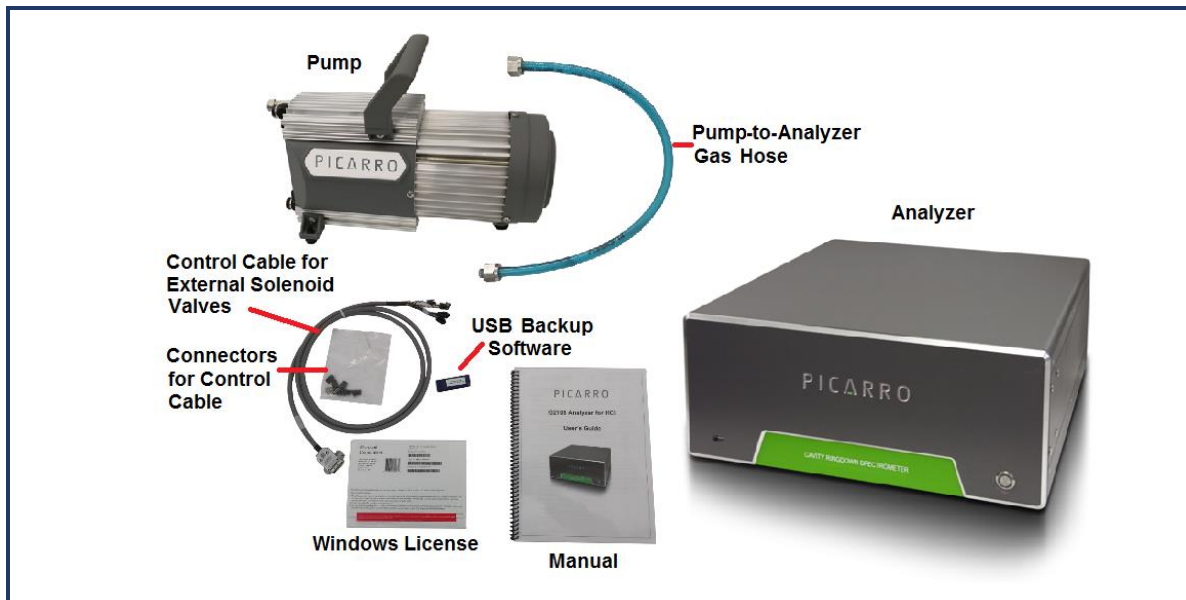
Box One: Analyzer and Accessories

Item (qty)	Description
Analyzer (1)	Includes all the data acquisition, control, and communications hardware and firmware to perform all gas handling, spectral collection and analysis.
A/C Power Cables (1)	A power cable with connectors appropriate to your country is provided. The analyzer automatically adjusts to local voltage.
Keyboard (1)	USB keyboard
Mouse (1)	USB mouse
Control Cable (1)	For External Solenoid Valves
Nut (1) and Ferrules (2)	For connecting input line to analyzer INPUT
Document Packet (1)	Includes this manual, certificate of compliance, and Windows License.
USB Flash Drive	Contains backup software.

Box Two: Vacuum Pump and Accessories

Item (qty)	Description
Pump (1)	Provides vacuum required for sample gas sequencing into and out of the analyzer.
A/C Power Cable (1)	A power cable with connectors appropriate to your country is provided.
Vacuum Hose (1)	Hose to connect the pump to the analyzer.
Pump Manual (1)	Detailed instructions for pump.

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6. ANALYZER OVERVIEW

6.1 Intended Use

The G2114 Analyzer measures concentrations of H_2O_2 precisely using Picarro's patented Cavity Ring-Down Spectroscopy (CRDS) technology. The analyzer can be deployed in a lab or in the field, allowing in-situ analysis for both trace and ambient amounts of H_2O_2 monitoring applications.

6.2 External Vacuum Pump

The external vacuum pump is used to maintain cavity pressure inside the analyzer. The pump should be connected and running whenever the analyzer is in use.

Figure 5: External vacuum pump

Vacuum Inlet

Power Switch

Exhaust Port   Power Connector
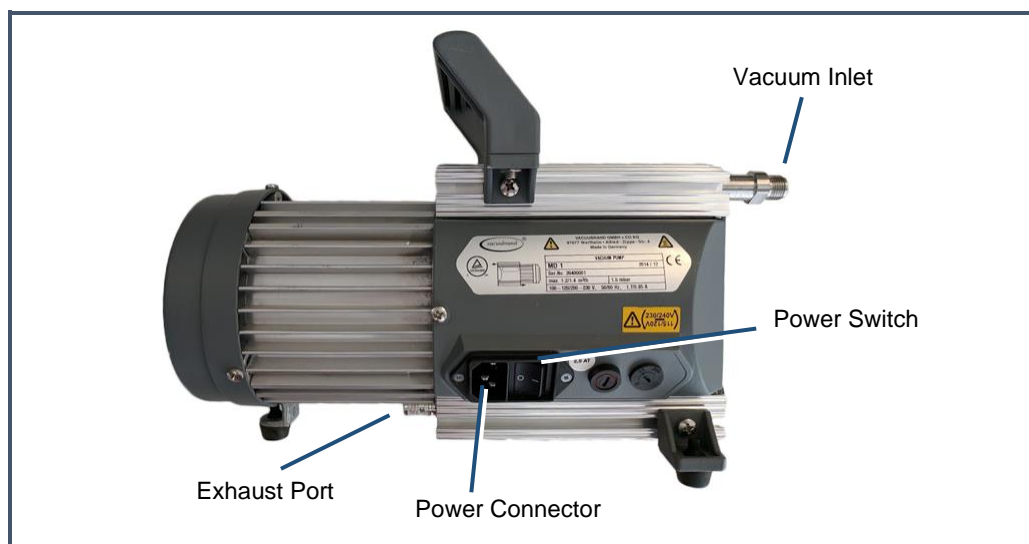
6.3 Analyzer Specifications

Weight (Total) **Analyzer** **Pump**	60.4 lbs. (27.4 kg), Including external pump 46 lbs. (20.9 kg) 14.4 lbs. (6.5 kg)
Analyzer Dimensions	Length: 17.55" (43.2 cm) Width: 17" (44.6 cm) Height: 7" (17.8 cm)
Temperature Range	Storage: 0 °C to 70 °C; Operation: 10 °C to 35 °C
Sample Flowrate	<1 slm at 760 torr (101 kPa)
Ambient Humidity Range	<85% R.H. non-condensing
Maximum Altitude	10,000 ft. (operation)
Clearance	Front: 6" (15.3 cm); Rear: 6" (15.3 cm)
Power Requirements **Startup Power** **Steady-state Power** **Mains Supply Voltage Fluctuation**	100 to 240 VAC; 47 to 63 Hz (auto-sensing) <375 W at start-up (Analyzer and Pump) 120 W (Analyzer), 150 W (Pump) Steady-state operation ±10% of the nominal voltage
Minimum Rated Circuit Amperage	10 A @115 VAC 5 A @230 VAC
Liquid Ingress Protection	None

7. INSTALLATION

This section describes the setup and installation of the Picarro Analyzer. Please read and understand this section thoroughly before proceeding with the installation.

WARNING	**Using this analyzer in a manner not specified by Picarro may result in damage to the analyzer and render it unsafe to operate.**

WARNING	**Do not attach electrical power to, or start the analyzer until *after* attaching and turning on the External Vacuum Pump. Do not disconnect the vacuum line while the analyzer is running. Failure to do so could result in damage to the optics.**

WARNING	**Picarro sells USB enabled devices, such as GPS, which is approved for use. Please do not connect USB hubs or unapproved USB devices, other than flash drives to the computer because they can interfere with the operation of the analyzer.**

WARNING	**If rack mounted, the Analyzer cannot support itself using a front rack mount kit alone. The instrument *must* be supported by a shelf or additional rails attached to the rack.**

CAUTION	**If the analyzer has been stored at less than 10 °C, allow the components to equalize to room temperature before starting the installation process.**

CAUTION	**Analyzer is for indoor use only and has an ingress protection rating of IPx-0. Analyzer is NOT protected against exposure to water including dripping, spraying, splashing or immersion.**

CAUTION

When the analyzer is being integrated to an external system, the safety of that system is the responsibility of the assembler of that system.

CAUTION

During installation and operation, do not position the analyzer so that it is difficult to operate the disconnecting device.

NOTE

Take care to ensure that warm air is exhausted from an enclosure in which the analyzer is mounted.

CAUTION

It is imperative that the analyzer have adequate ventilation and/or cooling to maintain the ambient temperature below 35 °C when operating. Failure to provide adequate airflow, especially clearance at the front and rear panels, to ensure proper airflow and/or cooling to the analyzer will result in overheating of the analyzer causing a shutdown and potential damage. There should be 4" (10cm) of clearance in the front and back of the analyzer.

Thermal Specifications	Min	Max	Description
Ambient Operating Temperature	10 °C	35 °C	Worst-case environmental limits (unless otherwise specified)

7.1 Analyzer and Vacuum Setup

WARNING

This analyzer weighs 46 lbs. (20.9 kg). Use the technique outlined in the General Safety section on page 15 when lifting or moving the analyzer.

1. Remove the Analyzer and the External Vacuum Pump from their respective shipping containers.

2. Place the Analyzer on a bench top or flat surface. Place the External Vacuum Pump near-by or on the floor. Don't push the analyzer into position yet, there are cables to be installed on the back panel.

3. Unpack the analyzer accessories. The Certificate of Compliance and USB drive should be stored in a safe place and may be required if you contact Picarro with questions about your analyzer.

4. Remove the caps from the analyzer's INLET and VACUUM connection ports. Save the caps; you should reinstall them when the analyzer is stored, moved or shipped.

5. Remove the cap from vacuum pump's inlet. Save the cap for later use. Reinstall the caps when the pump is stored, moved or shipped.

6. Connect one end of the vacuum hose to the pump: hand tighten the nut and then use an 11/16" wrench (not included) to make an additional turn of one flat (about 60 degrees).

7. Connect the analyzer to a power source using the supplied AC power cable.

CAUTION

Use the AC power cables supplied with the analyzer or a similarly rated cable. Check with Picarro technical support if you have questions about power cable replacement. An inadequately rated power cable can result in equipment damage.

CAUTION

Cords shall be RATED for the maximum current for the equipment and the cable used shall meet the requirements of IEC 60227 or IEC 60245. Cords certified or approved by a recognized testing authority are regarded as meeting this requirement. The connector type used should be: IEC320 C13.

8. If desired, attach a tube to the External Vacuum Pump exhaust port and direct to a safe place for venting the mixture of sample gases.

9. Select the appropriate voltage, 110V or 220V, for the External Vacuum Pump using the Power Switch located on the pump.

10. Connect the External Vacuum Pump to a power source using the other AC power cable.

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NOTE
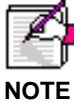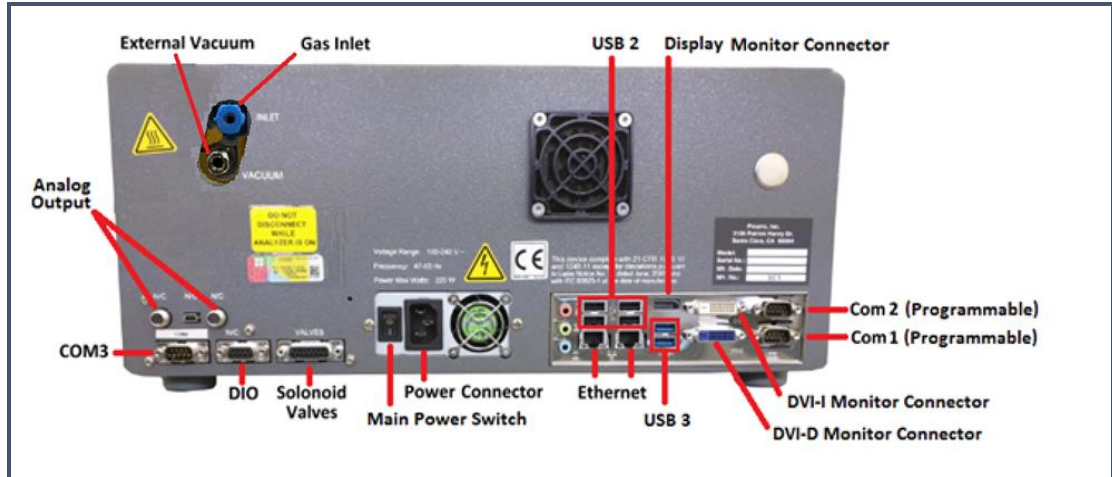
The software to operate the instrument will start automatically after the operating system has loaded. The user interface will appear a few seconds after the instrument software starts. See Section.

7.2 Connecting to the Analyzer Inlet

Connect to the inlet of the analyzer using ¼" OD PTFE or PFA tubing using the supplied plastic ¼" PFA inlet nut and ferrules.

WARNING

When using compressed gases, follow all appropriate safety conventions, including use of eye protection, physical restraint of cylinders, etc.

Making a New Connection:

When using new tubing, follow these steps.

1. Place the two ferrules inside the nut as shown.

Figure 7: Orientation of ferrules and nut

2. Loosely connect the nut to the **INLET** on the back panel of the analyzer about a full turn, being careful not to let the ferrules fall out.

3. Insert the tubing into the back of the nut, feeding it in as far as possible without deforming the tubing.

4. Hand tighten the nut.

5. Using a 5/8" wrench (not included), tighten the nut approximately seven flats (420 degrees).

Replacing a connection

1. When reattaching tubing that already has a nut connected:

2. Inspect ferrules. If you see any damage, replace the ferrules and follow the directions above for making a new connection.

3. If there is no damage, hand tighten the connector to the analyzer's INLET.

4. Using a 5/8" wrench (not included), tighten the nut approximately one flat (60 degrees).

7.3 Setting Up a Monitor, Keyboard, and Mouse

A video monitor (not included), keyboard, and mouse are required for monitoring device operations, viewing or changing settings (including setting user permissions), or validating device performance.

NOTE | **This device will operate under its default settings without any direct control of the internal software.**

1. Connect a keyboard to one of the available USB ports.

2. Connect a mouse to one of the available USB ports.

3. Connect a monitor to one of the DVI monitor ports. The analyzer will detect the connection and adjust the resolution to match the monitor.

4. Connect the monitor to a power source.

5. Turn on power to the monitor.

8. BASIC OPERATION

8.1 Picarro Analyzer System

The schematic below is an overview of the Picarro hardware, software, and data file generation.

Figure 8: Picarro Analyzer Functional Schematic
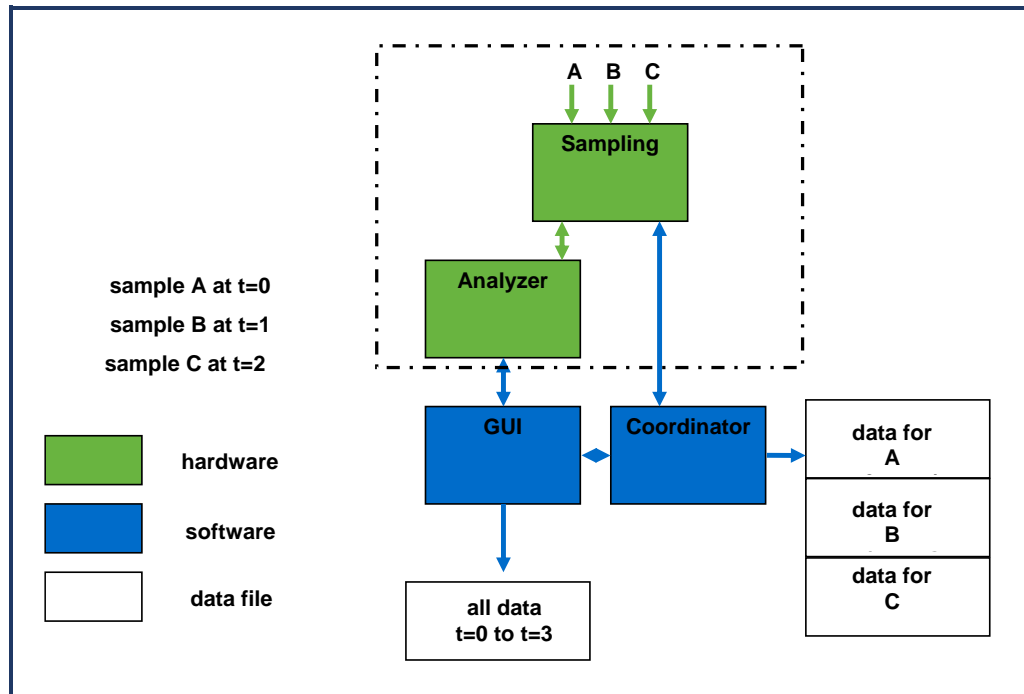
The samples A, B, and C (if applicable) are introduced into the analyzer sequentially by a sampling module, if present. The sampling module could be a set of customer-supplied valves, a valve manifold, a discrete sampling module, or other device. The timing of sample introduction is controlled by the coordinator or valve sequencer software. The analyzer measures continuously and reports the data to the Graphical User Interface (GUI) which saves a single file where all data is reported as a function of time. The coordinator gets data from the GUI and creates a single file, and the data is reported as a function of sample.

8.2 Startup

When the main power is turned on the analyzer will automatically start, including the GUI as depicted below (heading of the window may be different depending on the type of analyzer).

Figure 9: Analayzer GUI
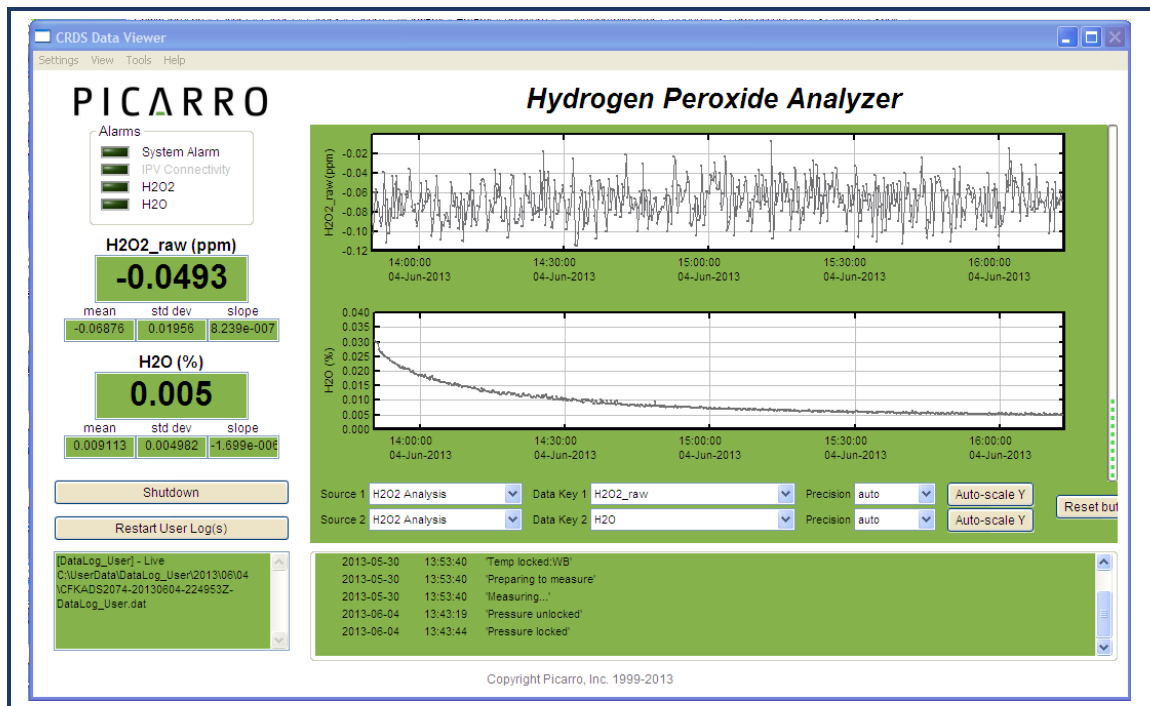
The analyzer will not begin producing data until all the measurement parameters have reached their operational set points. A message will be display in the status log window (lower right box) when each set point is reached. A full explanation of the GUI functions and status log messages can be referenced under the "**GUI Functions**" chapter in the Table of Contents.

There are various icons and folders in the desktop which allow you to: switch between different measuring modes, start the instrument, see graphical representation of your data, and more. For more information, please refer to "**Desktop and Icon Folders**" chapter in the Table of Contents.

Data will be saved automatically once the analyzer starts to produce data. The data in the GUI is the continuous real time read out from the analyzer. A user relevant subset of this data is stored in:

C:\Userdata\DataLog_User\YYYY\MM\DD

where Y=year, M=month, and D=day. Further details can be referenced in the Table of Contents under "**Data**."

The Setup Tool allows you to change data file saving details, in addition to allowing you configure which data element files are written to data files, digital data output (via serial port or TCP/IP), remote data delivery (via email), GUI properties and more (see "**Setup Tool**" chapter in the Table of Contents).

To shut down your analyzer and/or the software correctly, please refer to "**Shutdown Procedure**" chapter in the Table of Contents**.**

In order to measure discrete samples (such as individual gas bags) or from multiple locations, a separate software window (coordinator) is used to control the sample source and match the corresponding real time read out with the sample source. Depending on system configuration, coordinator programs may not be included. When switching valves to draw in ambient air from different heights, refer to the "**External Valve Sequencer**" chapter in the Table of Contents.

8.3 Shutdown Procedure

To shut down the analyzer using the GUI:

1. Click on the "Shutdown" button located on the left side of the Data Viewer window.

2. A window will pop-up prompting the user to confirm the shutdown. Once confirmed, the analyzer software and hardware will turn off.

3. Manually turn off the pump(s) and dry gas (only if your system requires it).

⚠️
CAUTION

A flow of clean, relatively dry gas should always be directed to the instrument for several minutes prior to shutting down. Trapping a high-moisture content gas sample in the cavity can cause condensation damage to the mirrors as the instrument cools from its operating temperature.

⚠️
CAUTION

Do not turn off the pump or disconnect the vacuum line while the instrument is operating.

CAUTION

FOR G2xxxx ANALYZERS: If you have trouble turning off the analyzer software, do not kill the process(es) in the task manager; rather, double-click on the "Stop Instrument" icon in the Diagnostics folder on your desktop.

Figure 10:

Shutdown Window
The heading shown may vary depending on the analyzer type
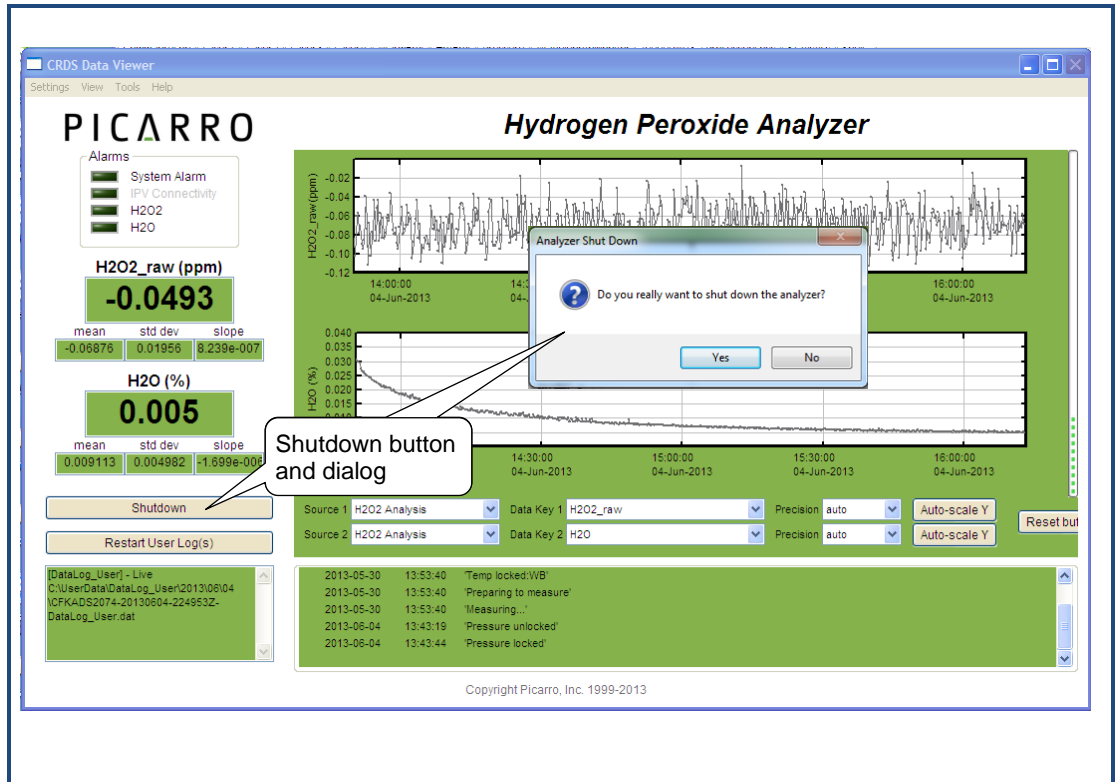
8.4 In case of an Electrical Power Outage

If the power to the analyzer is cut-off for any reason, the analyzer will cease operation. However, when the power is reapplied, the analyzer will restart automatically. The Picarro software tools will also properly close out previous files and open new files for data collection so that previously collected data, instrument diagnostics, and other parameters recorded up to the time of power outage are retained.

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9. DESKTOP ICONS AND FOLDERS

On the Windows desktop, there may be the following icons and folders. The choices may vary depending on the configuration of your analyzer.

1. **Start Instrument**: When clicked, the analyzer will start measuring in the configuration that it was in when the software/analyzer was shut down.

2. **Picarro Mode Switcher** (may not be included depending on the system configuration): leads to a window which will allow you to switch between various measurement modes.

3. **Picarro Controller**: opens a useful diagnostic panel allowing the user to see the analyzer's internal temperatures, pressure, and spectroscopy in real time. This program has user-accessible functions, but cannot change anything related to analyzer functionality and is intended for diagnostics purposes only.

4. **Picarro Utilities Folder**:

   - **Data File Viewer**: converts between *.dat* and *.h5* data files and allows graphical data viewing.

   - **Data Recal**: allows data recalibration based on known and certified data.

   - **Setup Tools**: allows editing of various settings for the analyzer (see "**Setup Tools**" chapter of this manual).

5. **Diagnostic Folder**:

   - **Stop Instrument**: allows you to turn off the analyzer in an emergency event through a popup window. Please see "**Shutdown Procedure**" section of this manual to shut down the analyzer under normal circumstances.

Figure 11: Stop CRDS Dialog

CAUTION

EXCEEDING GAS INLET PRESSURE OR TEMPERATURE SPECIFICATIONS COULD RESULT IN DAMAGE TO THE INSTRUMENT. In the case of higher input pressure or flow, configuring a sampling bypass manifold system is recommended. Use a 'tee' at the gas inlet and either return the remainder to the main gas stream or exhaust appropriately.

CAUTION

DO NOT DISCONNECT the AC power to the analyzer, vacuum line or the AC power to the external vacuum pump while analyzer is operating. Damage may be caused by current surges if power is applied while attaching or removing cables.

CAUTION

Analyzers which include the external valve control option are provided with a cable consisting of five electrical connections intended for controlling solenoid valves (typically 12VDC <1A max). It is important to electrically isolate the solenoid valves from the analyzer's ground to avoid electrical interference which could compromise the analyzer's accuracy.

10. GUI FUNCTIONS

The Picarro analyzer Graphical User Interface (GUI) has useful features. Types of data shown in the main GUI will differ between different analyzer configurations. Below is a layout of the Picarro G2000 series analyzer GUI.

Figure 12: GUI Functions
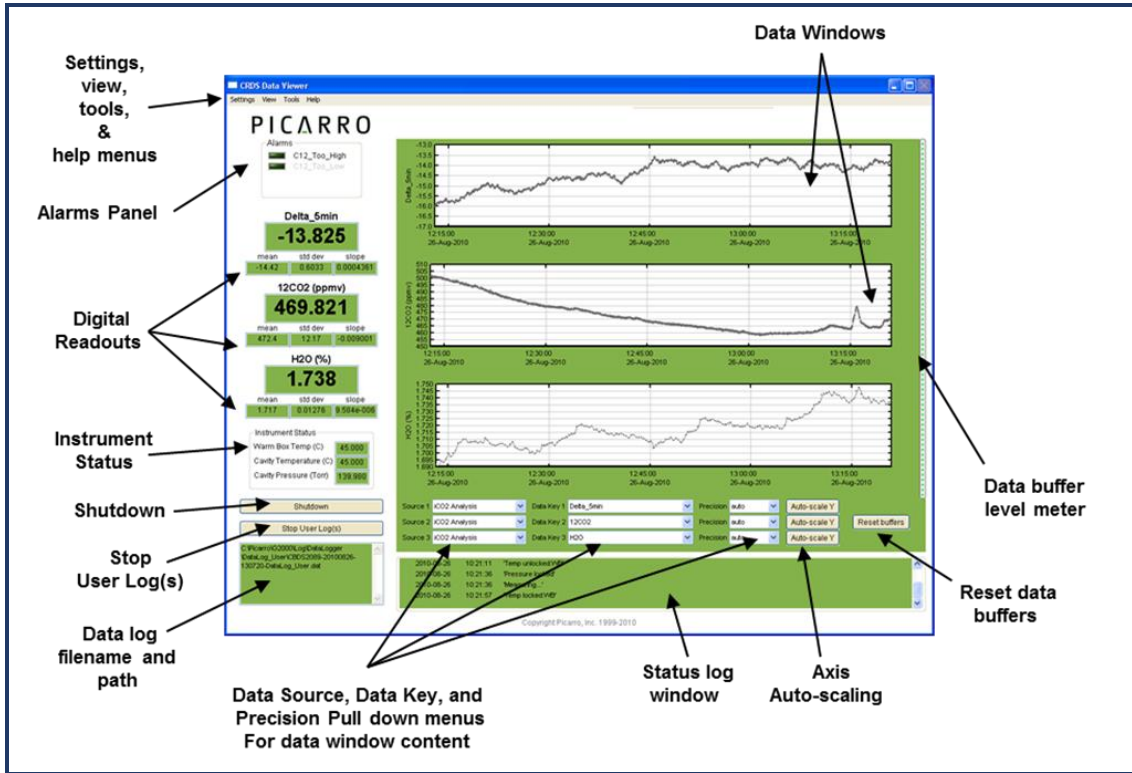
10.1 SETTINGS, VIEW, TOOLS, AND HELP MENUS

Settings Menu:

Change GUI Mode from Standard to Service: This is the access point to a password-protected service mode where additional operational and measurement parameters are displayed. Selecting and clicking on this entry opens the Cavity Ring-Down Spectrometer Controller. This is reserved for Picarro service operators only.

View Menu:

- Lock/Unlock time axis when zoomed: When locked, forces the multiple graphs to display on the same time scale during zoom.

- Show/hide statistics: Toggles the measurement statistics display (see "**Digital Readout**" later in this chapter).

- Show/hide instrument status: Toggles the instruments status display (see "**Instrument Status**" later in this chapter).

Tools Menu:

- User Calibration: Opens the user calibration window (default password is "picarro"). The calibration slope and intercept can be entered to immediately see the effects in the data (refer to "**Calibration**" section in the Table of Contents).

- Sequencer GUI: Toggles the display of the external valve sequencer window.

Help Menu:

- About: Displays the version number of the instrument.

10.2 Alarm Panel

The panel in the upper left-hand corner of the GUI is used to monitor the status of the internal instrument alarms. These indicators are gas concentration alarms (i.e., "CO_2 Too High/Low"). The gas concentration alarm LEDs are off (grayed out) when the respective concentrations are below a certain value, and they are illuminated when the respective concentrations are above/below a certain value.

To view the alarm set point, click on the LED and a dialog box will appear, indicating the alarm setting. The user can either enable the alarm or change the set point.

Figure 13:
Setting Alarm
Dialog
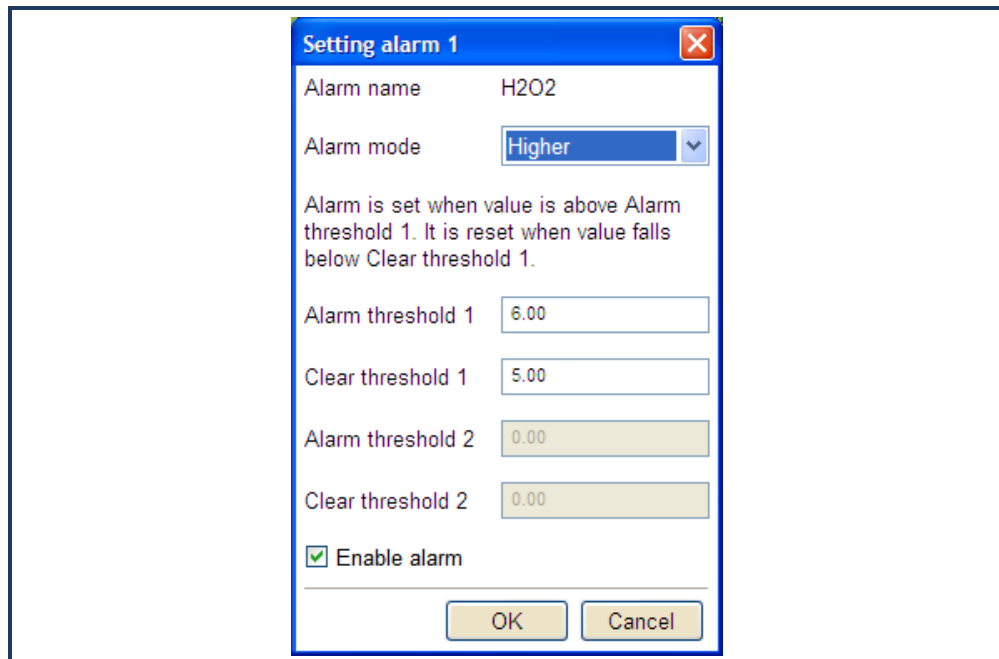
To change the set point, type the value you wish to set the alarm to and press the "ok" button to confirm. If you do not wish to change the alarm value anymore, press "cancel." If you do nothing, the dialog box will eventually disappear and the alarm value will remain unchanged.

10.3 Digital Readouts

Displays the latest value recorded for the selected Data Key for each Data Window. Changing the Data Key changes the Digital Readout as well as changes the Data Window view.

If the "Show Statistics" entry is enabled in the "View" menu, the mean, standard deviation and slope of the data in the graph are dynamically calculated and indicated below the digital concentration readout. These numbers change to reflect statistics of visible data in the data window.

10.4 Start/Stop Data Log Button

The analyzer automatically records and saves all data collected into *.dat* files.

Press the button to actively record on a separate data log file. A dialog box will appear prompting you for a filename and location. Press this button again to stop recording the data file.

10.5 Data Log Filename and Path

The filename and path of the active data log is displayed in this pane. The indicator is grayed-out if there is no active data log (i.e., if a new data log has not been started using the "Start/Stop New Data Log" button). A new file will be generated at midnight, which will be saved to the same location as the original log file.

10.6 Data Window

The data window displays a graph of any stream of data vs. system time, with a format of *hh:mm:ss.* The user can select which data stream are displayed using combinations from the "Data Source and Data Key" pull down menus. The precision displayed can be adjusted using the "Precision" menu and auto-scaling of the 'Y' axis is also available.

10.7 Instrument Status

If these parameters are enabled through the "Show Instrument Status" entry in the "View" Menu on the main toolbar digital readouts for Warm Box Temperature, Cavity Temperature and Cavity Pressure are displayed to the left of the main trend graphs.

10.8 Data Source and Data Key Pull Down Menus

These two menus enable selection of the data stream that is viewed in the *data window.* Data streams available on the GUI are gas concentrations, if "instrument Analysis" (where *instrument* represents the system installed) is selected, or if "sensors" is selected, the analyzer's optical cavity pressure or temperature can be viewed as well as the nominal ambient temperature of the analyzer ("DAS temp") and the temperature of the analyzer's electronics chamber, indicated as "warm chamber temp."

10.9 Precision Pulldown Menu

Click on this icon to select the precision displayed on the y-axis, between 0 and 4 digits of precision or "auto." The currently selected precision is displayed during operation. This does not affect the precision of the saved data in the data log files or results files.

10.10 Status Log Window

This window displays instrument status messages, in the following form: *YYYY-MM-DD hh:mm:ss <message>*. See the "**Status Log Messages**" chapter in the Table of Contents.

10.11 Reset Buffer Button

Press this button to clear all data in the Data Window (also clearing the internal data buffer of the GUI). Pressing this button has no effect on the data log files stored by the instrument.

10.12 Data Buffer Level Meter

The meter to the right of the Data Window indicates how much of the internal memory of the GUI is used to retain historical data, which also corresponds to what is shown in the Data Window. There is an internal limit of a finite number of points and once that limit is reached, old data is removed from the buffer as new data is collected.

This buffer affects *only* the data displayed in the Data Window, not the data stored in any files. This buffer is empty upon instrument start up, and can also be emptied by pressing the "Reset Buffer" button in the lower right-hand corner of the GUI.

10.13 Graph Zooming

To zoom into the graph, hold and drag the magnifying glass over the section to be zoomed. To do this, click on one corner of the area you want to zoom. Hold the left mouse button and move the mouse to create a box that covers the region of interest. When the box is properly drawn, release the left button and boxed area will automatically scale to fill the Data Window.

To zoom back out or to redraw the zoom box, double click the left button anywhere in the Data Window.

To autoscale the y-axis of either graph, use the autoscale buttons below the graph. To lock or unlock the time axes of each graph during zooming, select that menu item in the "View" menu.

11. COMMON STATUS LOG MESSAGES

Temperature Locked: WB/HB (normal startup)

The system waits for the warm box ("WB" – the temperature-controlled electronics and wavelength monitor chamber) to reach operating temperature. Similarly, the temperature of the hot box ("HB" – the temperature-controlled chamber containing the analyzer's optical cavity and gas handling system) is stabilized. This is typically the longest step in the startup sequence. The duration of this step can range from 5 to 60 minutes, depending on the ambient temperature and how much time has elapsed since the last startup.

Entering Measurement (normal startup)

Spectral scanning has started. Concentration measurements will be available in approximately 30 seconds. The instrument will continue to scan and report concentration measurements until the instrument is shutdown using the procedure below.

Pressure Stabilizing/Locked (normal startup)

The valve control system begins to allow flow through the analyzer and stabilizes the pressure inside the cavity.
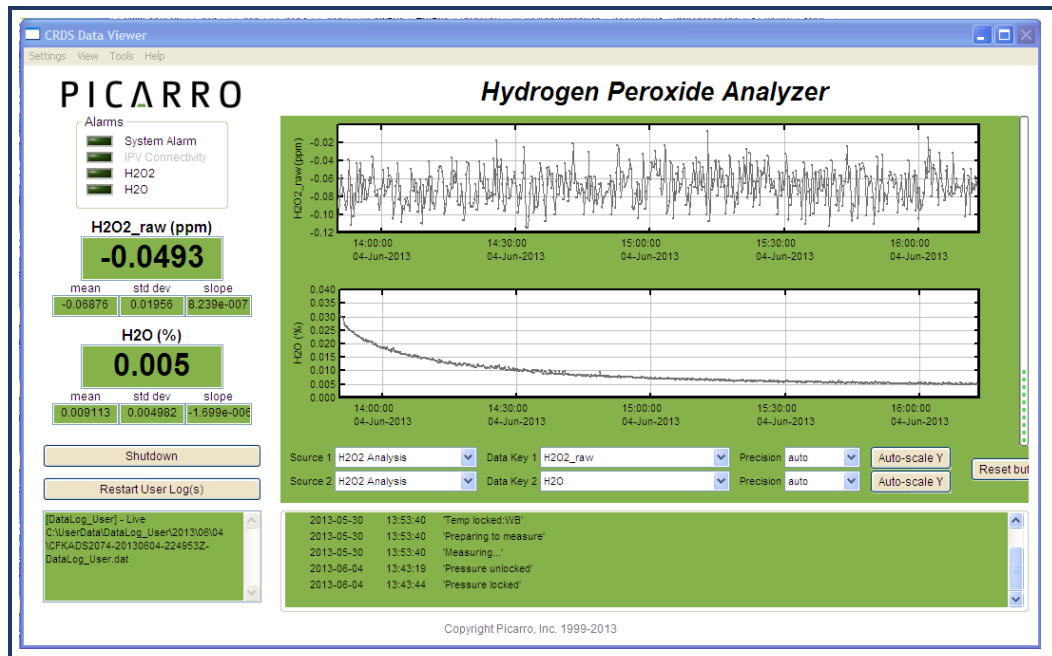
Measuring (normal startup)

This is the normal mode of operation after startup has completed.

Pressure High – check vacuum pump (error)

There is unusually high pressure. The pump is either weak or dying or the vacuum hose has a leak.

12. DATA

During operation, the analyzer generates ASCII format text output file that is updated after each batch of concentration measurement is complete. The analyzer also creates directories to store the data based on the date the data was acquired. After each data file has been closed, it is moved to an archive directory, and a new file is started in the original location. To keep the data files easy to manage and to limit the size of individual files and directories, please see "**Setup Tools**" in the "**Utilities**" folder on your desktop to modify various aspects of data storage.

There are two data directories: "**UserData**" and "**Archived Data**."

12.1 UserData

This directory contains current and recent data.

DataLog_User: stores data as measurements are made.

o Location: *C:\UserData\DataLog_User\Year\Month\Day*

o Naming Convention:

- Example: *CFHADS2007-20111222-000131-DataLog_User.dat*

- CFHADS: Instrument Serial Number

- 20111222: Year, month, and day of when file was started

- 000131: Hour, minute, and second of when file was started (using a 24 hour clock).

o **DataLog_User_Sync**: same data as DataLog_User, except that the data are evenly spaced in time (0.1 s interval). *This type data is only available when measured in flux mode, and is useful only for Flux G2311-f analyzers.*

- Location: *C:\UserData\DataLog_User_Sync\Year\Month\Day*

- Naming Convention:

  - Example: *CFHADS2007-20111222-000131-DataLog_User_Sync.dat*

  - Explanations are as same as for DataLog_User.

12.2 Archived_Data

This directory contains past data.

- **DataLog_User_Backup**: archived, older data that is stored in compressed .zip format.

  - Location: *C:\Picarro\G2000\Log\Archive\DataLog_User_Backup\Year\Month\ Day*

  - Naming Convention:

    - Example: *DataLog_User_Backup_20111107_005427.zip*

    - 20111107: Year, month, and day of when the file was started.

    - 005427: Hour, minute, and second of when file was started (using a 24 hour clock).

- **DataLog_Private**: complete data file which includes additional parameters beyond the concentration data such as instrument temperatures and pressure, set points, and spectroscopic information. This information is generally not useful to the user, but it can be useful for diagnostic purposes. For more information, please contact Picarro.

  o Location: *C:\Picarro\G2000\Log\Archive\DataLog_Private\Year\Month\Day*

13. SETUP TOOL

In the desktop folder called "Picarro Utilities," the "Setup Tool" can be launched by double clicking on its icon. The tool allows the user to configure data file saving details, including which data elements are written to data files, digital data output (via serial port or TCP/IP), remote data delivery (via email), and general GUI properties.

Seven tabs of the Setup Tool window are explained in the next pages. If you have any questions about the Setup Tool, please contact Picarro or refer to Picarro Community for further details: http://www.picarro.com/community/

13.1 Data Logger Tab

This tab allows the user to configure various data file saving details, including which data elements are written to which data files.


- **Data Columns**: Controls which data elements are written to data files.

- **Hours of Each Log File:** Controls the size of each data document.

- **Enable Mailbox Archiving:** Enables archiving of data in the mailbox folder: *C:\Picarro\G2000\Log\Archive\DataLog_Mailbox*

- **Archived Directory Structure:** Specifies part of naming convention for data documents.

- **Total User Log Storage Size (GB):** Specifies the size of storage allowed for UserData (recent data – see "**Data**" chapter).

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

13.2 Port Manager Tab

This tab prepares the **COMMAND INTERFACE** tab by managing the digital data output/input ports via serial port or TCP/IP.
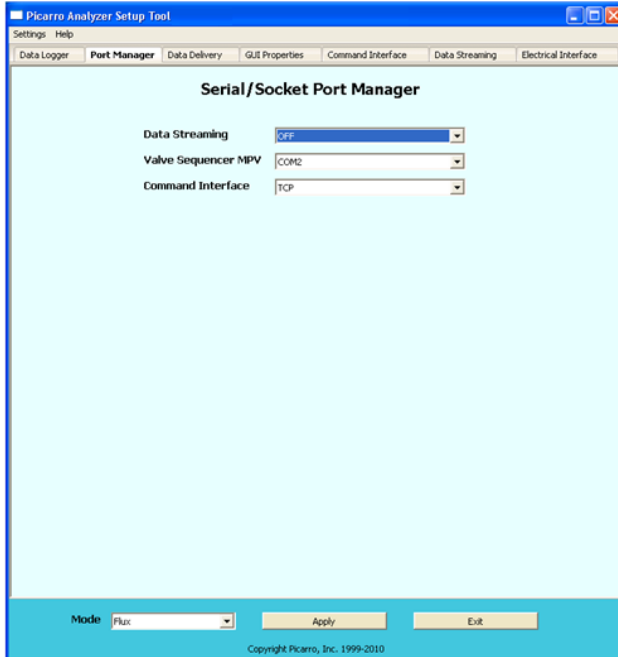
On this window, specify:

- **Data Streaming** port: COM1, COM2, or Off

- **Valve Sequencer** port: COM1, COM2, or Off

- **Command Interface** port: COM1, COM2, TCP, or Off

Make sure there are no COM port conflicts before clicking "Apply"; otherwise the system will not work.

See "**External Valve Sequencer**" chapter of this manual to learn more about valve sequencer.

After making the appropriate edits, click "Apply" to put changes into effect and then "Exit" to close the window.

Serial Communication: the analyzer supports an RS-232 physical command interface, which can be used to control the instrument and to retrieve concentration data. Not all features of the instrument are available on the serial interface. For details on how to use the serial command interface, please see the "**Programming Guide**" (in *.pdf* format on the installation CD). This command set may also be used across a TCP/IP interface through an Ethernet connection.

13.3 Data Delivery Tab

This tab allows the user to schedule remote data delivery by email.

- **Delivery Start Time:** Time of the day when data will be sent.

- **SSL:** Depending on the sender's email server, the sender can activate the Secure Sockets Layer (SSL).

- **Use Authentication:** Turning this on will require the receiver to provide a **username** and a **password** on this window in order to access data.

- **From:** Sender's email.

- **To:** Receiver's email.

- **Subject:** Subject line of the email.

- **Data Directory:** Location of the data you want to email.

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

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13.4 GUI Properties Tab

This tab allows you to set the number of line graphs visible on the main GUI. It also enables the control of the valve sequencer from the main GUI.
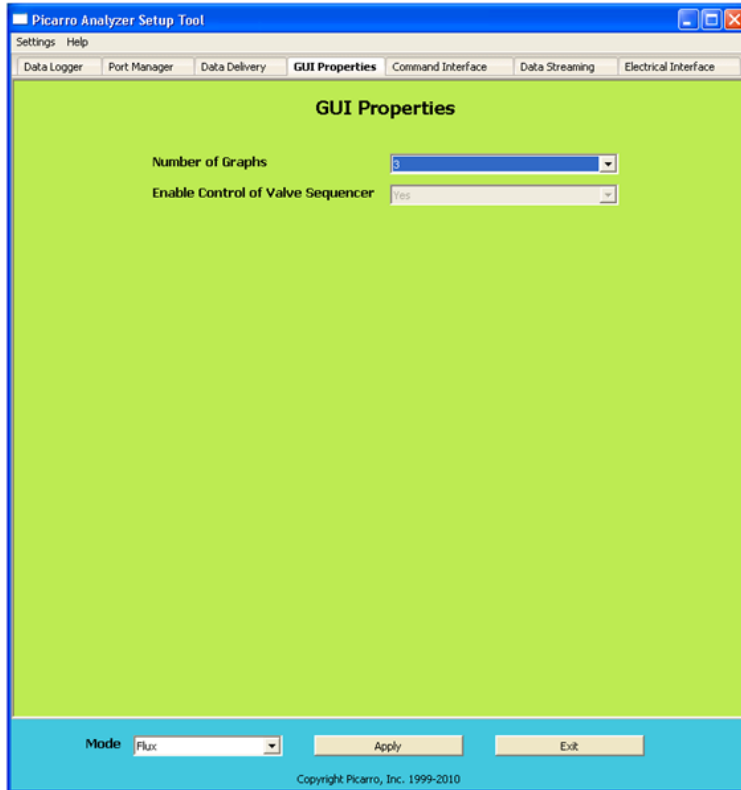
To make the "Valve Sequencer" menu item visible under the "Tools" menu of the main GUI:

1 Click on "Settings" of the "Setup Tool" window, and then "Switch to Service" mode.

2 Choose "Yes" next to "Enable Control Valve Sequencer" drop down menu on the "GUI Properties" tab.

3 Click "Apply" to put changes into effect, and then "Exit" to close the window.

You should now be able to access the "Show/Hide Valve Sequencer GUI" menu from the main GUI under "Tools"

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

13.5 Command Interface Tab

This tab specifies the digital data output that are sent via ports COM or TCP (specified from the **PORT MANAGER** tab).

To pull data, you will need to send commands to the **COMMAND INTERFACE** (see the "**Programming Guide**" in *.pdf* format on the installation CD for commands). This is different from **DATA STREAMING** (see next section of this chapter).
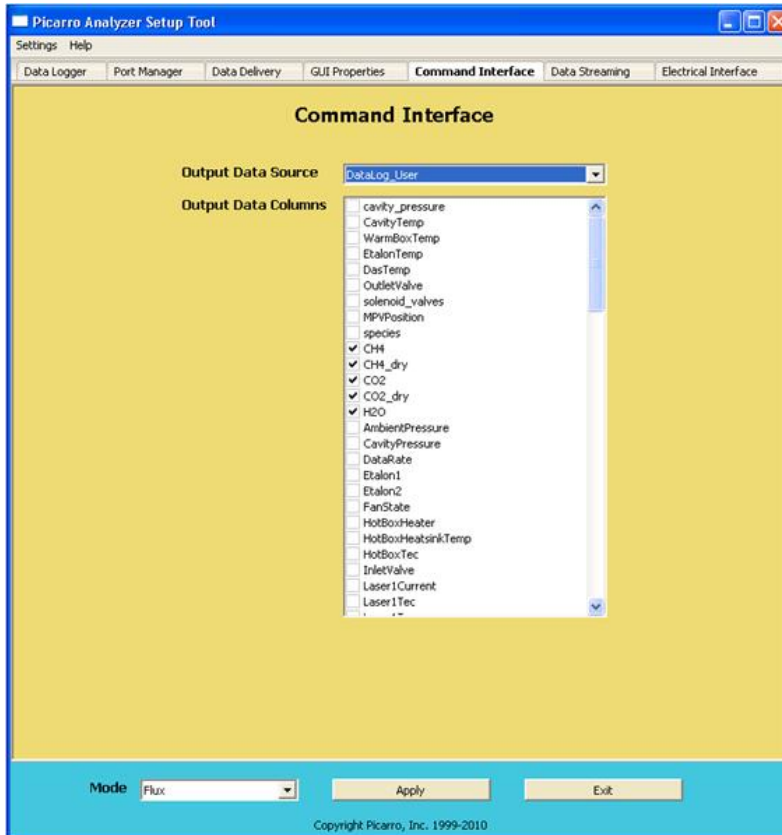
Output Data Source: Two types of recent output data can be specified:

- Datalog_User
- DataLog_User_Sync (relevant only for Flux G2311-f analyzers).

See "**Data**" chapter of this manual for more information.

Output Data Columns: Select the type of data available for the **COMMAND INTERFACE** to access.
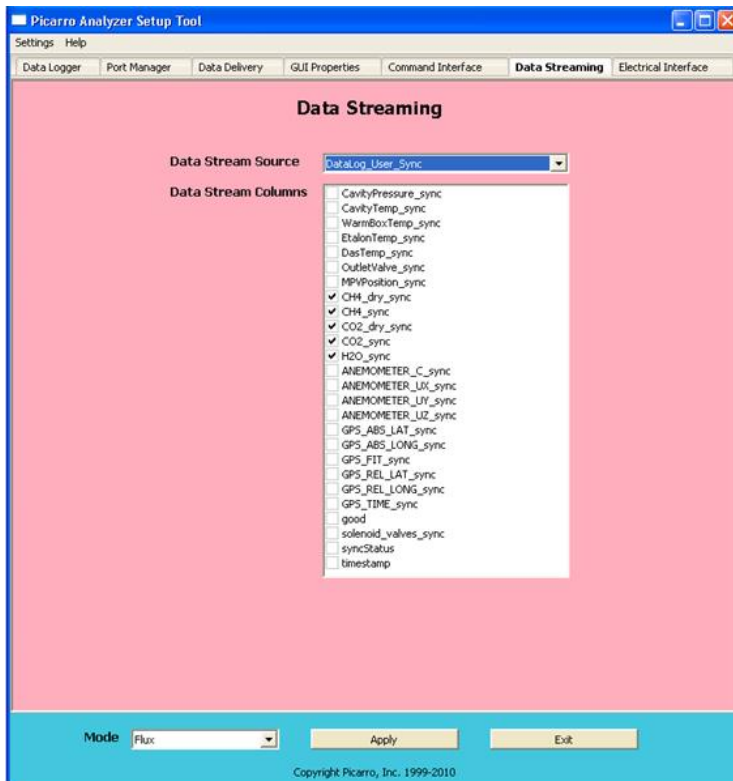
This is setup and initialization only. If a data type is not checked, it cannot be outputted by the **COMMAND INTERFACE** – you will need to return to this tab and mark the desired data type.

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

13.6 Data Streaming Tab

This tab specifies the digital data output to send via COM port (specified from the **PORT MANAGER** tab).

DATA STREAMING outputs data continuously, whereas the **COMMAND INTERFACE** needs commands to output data (see previous section of this chapter).

Output Data Source: Two types of recent output data can be specified:

- Datalog_User
- DataLog_User_Sync (relevant only for Flux G2311-f analyzers).

See "**Data**" chapter of this manual for more information.

Output Data Columns: Select the type of data available for **DATA STREAMING** to access.

This is setup and initialization only. If a data type is not checked, it cannot be outputted by **DATA STREAMING** – you will need to return to this tab and mark the desired data type.

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

13.7 Electrical Interface Tab (optional)

This tab is enabled if your analyzer is optionally configured with an Electrical Interface Card (EIC).
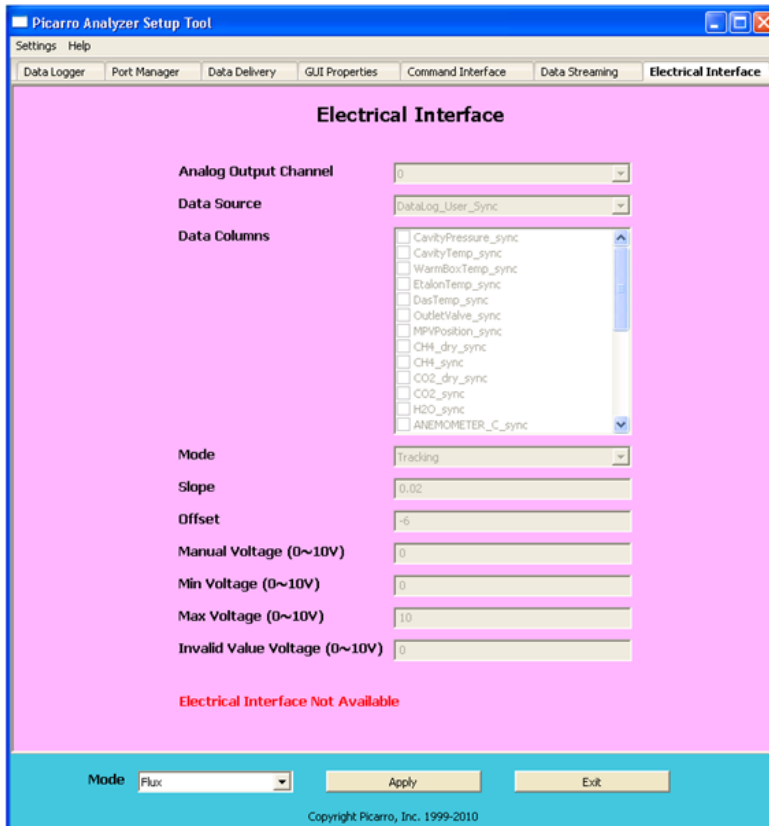
The **ELECTRICAL INTERFACE** tab allows customization of each analog output channel.

The EIC provides up to 8 analog signals available to the user for monitoring various measurements results and analyzer parameters.

Note that this tab will be disabled if your analyzer was not configured to work with an analog peripheral.

After making the appropriate edits, click "Apply" to put changes into effect, and then "Exit" to close the window.

14. REMOTE DATA ACCESS

14.1 Serial Communication

The analyzer supports an RS-232 physical command interface, which can be used to control the instrument and to retrieve concentration data. Not all features of the instrument are available on the serial interface. For details on how to use the serial command interface, please see "**Programming Guide**" (included in *.pdf* format on the installation CD) and "**Troubleshooting**" chapter of this manual. This command set may also be used across a TCP/IP interface through an Ethernet connection. Please contact Picarro or visit our Community website for further details.

14.2 Remote Data Access

Using the *RemoteAccess.ini* file, the analyzer can be configured to automatically:

- Send data from the instrument to a list of e-mail accounts.
- Measure the offset of the host computer system clock from a set of internet timeservers and (optionally) to resynchronize the clock on the basis of this information.

The internet connection need not be permanent; it can be a dial-up connection accessible via a user-supplied USB modem. If a dial-up connection to the internet is employed, it is used only on demand in order to minimize the connection time.

The task of sending data and/or synchronizing the clock on the analyzer is performed using the *C:\Picarro\G2000\HostExe\RemoteAccess.exe* program. This program can be set up to run periodically using the Windows Task Scheduler at a user-configurable frequency.

Each time that the *RemoteAccess.exe* program runs, it appends information to a log file, which keeps a record of the results of the time synchronization and of the files sent by e-mail. The *RemoteAccess.exe* program is configurable by means of an initialization file, which includes information such as the login credentials for the dial-up connection, the e-mail account, and the list of timeservers.

The initialization file is found at:

C:\Picarro\G2000\AppConfig\Config\RemoteAccess\RemoteAccess.ini

It should be placed in the same directory as the executable *RemoteAccess.exe*. The file has one required section named **LOGGING** and three optional sections named **NTP**, **DIALUP**, and **EMAIL**.

LOGGING

The **LOGGING** section has a single key "Logfile" whose value is the path to the log file. Once this log file exceeds 64 kilobytes in length, it is backed up appending a numeric extension to the file name and a new file is open. A total of ten backup log files are kept.

NTP

The **NTP** section controls querying the internet time servers using the SNTP protocol (RFC4330) and the resetting of the clock on the host computer. If the section is not present, time synchronization is not carried out. The keys "Server1," "Server2," etc., are used to specify the URLs of the timeservers. As many of these timeservers are interrogated as possible, and the clock offset is computed on using the median of the results obtained from the available servers. If the "UpdateClock" key is set to true ("1"), the offset is applied to the host clock. Otherwise, the offset is recorded, but the host clock is not changed.

EMAIL

The **EMAIL** section controls the sending of the data files as email attachments. If the section is not present, email messages are not sent. The key "Directory" specifies the directory that contains the data files. When the program is run, files in this directory are sent to the specified recipients and the files are deleted. In order to avoid problems with incomplete files, programs that place files into this directory should do so using an atomic operation, such as a rename. The "Server" key is set to the name of an RFC2821-compliant SMTP server that actually sends the email messages.

The "From" key is the email address from which the messages are sent. Note that some SMTP servers check that the source is permitted to send mail while others allow any name in this field. The collection of email addresses to which copies of the email is sent is specified by the keys "To1," "To2," etc. The "Subject" key is used to fill the subject field in the email header, and may be set to any string.

Depending on the SMTP server, it may be necessary to use authentication before emails can be sent, as described in RFC2554. If such authentication is not needed, the key "UseAuthentication" is set to false ("0"). If this key is set to true ("1"), two additional keys "Username" and "Password" must also be specified for the email account.

DIALUP

The **DIALUP** section is used if a dial-up connection to the Internet needs to be established when the program runs. If the section does not exist, a permanent connection is assumed to be available for carrying out the other tasks specified in the initialization file. The "ConnectionName" key specifies the name of the dial-up connection to use, as listed under "Network Connections" in the Control Panel. The values of the keys "Username," "Password," and "Number" are used to make the connection.

Example of "*RemoteAccess.ini*" file

```
[LOGGING]
Logfile=c:/temp/RemoteAccessLog

[NTP]
Server1=time-a.nist.gov
Server2=time-b.nist.gov
Server3=time-a.timefreq.bldrdoc.gov
Server4=time-b.timefreq.bldrdoc.gov
Server5=time-c.timefreq.bldrdoc.gov
Server6=time.nist.gov
Server7=time-nw.nist.gov
UpdateClock=1

[DIALUP]
ConnectionName=Picarro Dialup Access
Username=user
Password=password
Number=14085551212

[EMAIL]
Server=smtp.servername.org
Directory=c:/picarro/mailbox
From=instrument@picarro.com
To1=recipient1@site1.com
To2=recipient2@site2.com
Subject=CRDS data from Silverstone instrument
UseAuthentication=0
```

15. DATA FILE VIEWER

Picarro 2000 series analyzers allow users to archive data using a highly-compressed, binary *.hdf5* or *.h5* format.

Screenshots below show the Data File Viewer program, which can be found in the "Picarro Utilities" folder on the analyzer's desktop. This programs allows you to open *.h5* files, convert *.h5* files to **.dat* files (also convert **.dat* to *.h5*), as well as to do batch conversions. Through this program, multiple *.h5* files can be joined, and then viewed as graphs. In the graph window, you can select any of the data columns in the file, autoscale, zoom, hide/show points, and calculate statistics of data within the graph window.

If you have any questions, please contact Picarro or refer to Picarro Community for more information. http://www.picarro.com/community/
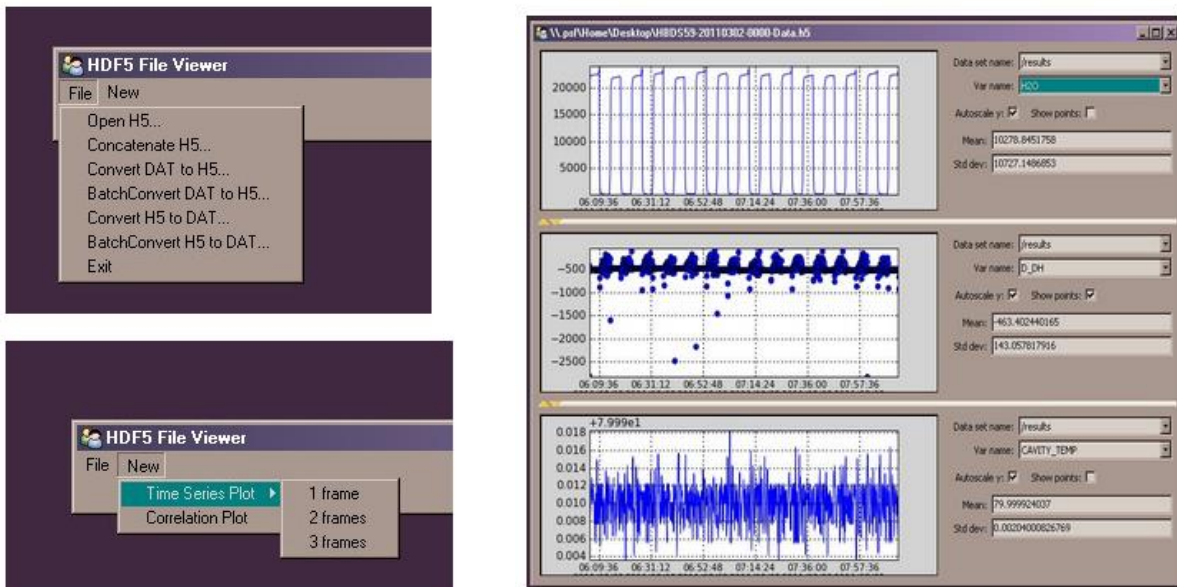
16. EXTERNAL VALVE SEQUENCER

The Picarro valve sequencer window appears as below:
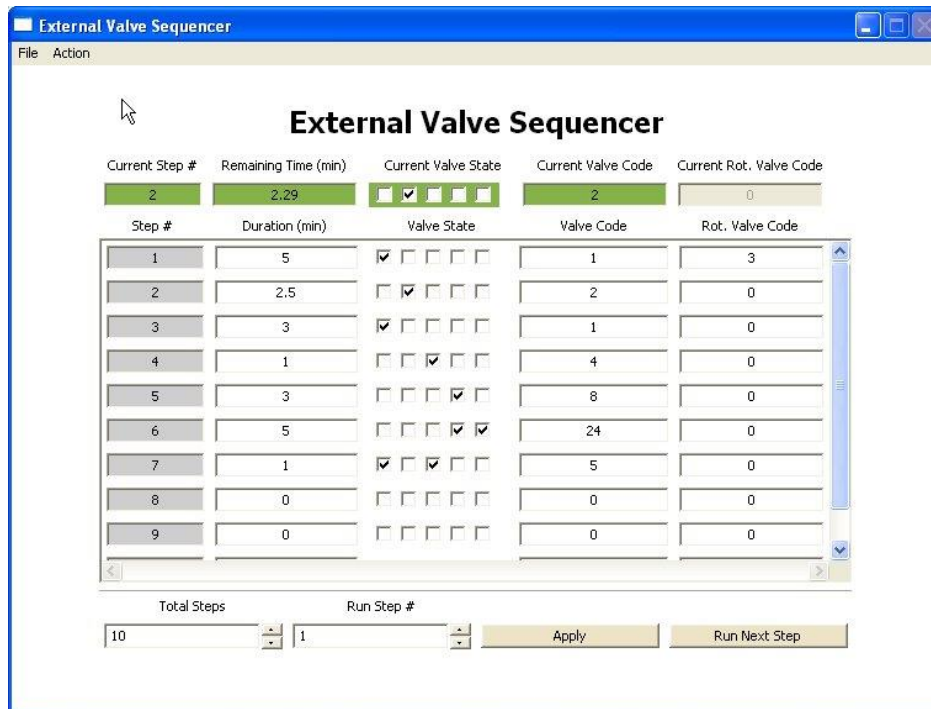
Introduction

The Picarro analyzer can control two types of valves:

1. Solenoid valve(s): DC voltage powered valve with normally open (NO) and normally closed (NC) positions. These can be either 2-way or 3-way valves.

2. Rotary Selector valve: digitally controlled valve used to send selected flow from one of many inputs (up to 32) into the analyzer

Both types of valves can be simultaneously controlled through a common software interface called the "External Valve Sequencer," which is available from the Tools menu in the GUI.

Default Configuration

For all models of Picarro analyzers, the rotary valve control is disabled in the factory default setting. The solenoid valve control, however, is ready to use by default for all solenoid valve connectors.

Setting up Solenoid Valves

Up to six solenoid valves can be controlled by the Valve Sequencer software. Each valve should operate using 12 VDC with a maximum current requirement of 1.5 ampere. This analyzer comes with a cable which can be connected to the solenoid valves.

The valve connector cable should be connected to the 15-pin connector at the lower left corner of the analyzer. There are six pairs of wires with connectors labeled V1, V2 … V6 with 2-pin female Molex connectors (Molex#43020-0200) for connection to the solenoid valves. Connect V1 to solenoid valve 1, V2 to solenoid valve 2, etc. for valves wired with matching Molex connectors. Do not connect the solenoid valve to the analyzer ground -- use only the provided electrical connectors.

Setting Up Rotary Selector Valve

A multi-position rotary selector valve can be controlled by the Valve Sequencer software. It is controlled by standard serial commands in the Valco (VICI) protocol. Valco rotary valve models SD, SC, SF, ST, and STF are all supported, but not all configurations will be appropriate due to tube diameter, pressure or materials of construction. This setup will also require a Valco microelectric high torque actuator. A single combination package such as EMT2ST16MWE includes a 16 position, low-pressure ST valve in stainless steel, 1/8" tubing, 2" standoff, and microelectric high torque actuator. Please refer to http://www.vici.com/vval/st_8-1.php#16pos for further options, and consult with Valco directly for more details.

The Valco controller should be installed per manufacturer's instructions. The 9-pin female connector cable should mate with its corresponding male port (labeled "MPV") on the analyzer. Please note the 9-pin connector cable is not supplied with the instrument.

The setup will be similar to that in the pictures below:
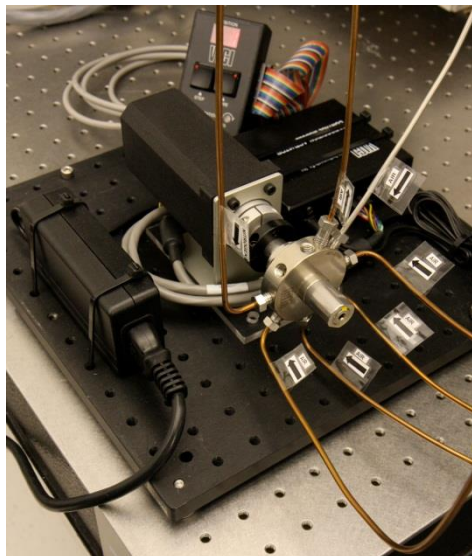
Valve Sequencer Software

The Valve Sequencer software allows the user to set steps in which solenoid valves are turned on/off and the rotary selector valve is set to a single position. The current step, elapsed duration, and valve states are shown in the top most row of the valve sequencer command window. The duration of each step is set in minutes; for example, 1 minute and 30 seconds corresponds to 1.5 minutes.

Please note the number of steps correlates with the total steps in the sequence. But the count of the steps starts at "0." So, according to the image, the first step of the sequence is designated Current Step "0" and the second step in the sequence is designated Current Step "1." The "Go to First Step" menu item under "Action" restarts the sequence from step 1.

Different sequences can be created and saved in the software. Use the "Sequence File #" field to select which file the sequence will be saved to (0 to 10 are the available choices). Click the up/down arrows to select the desired number.

Configuring a Valve Sequence

Each "step" sets the rotary valve to a single position and activates the indicated solenoid valve(s) for a set period of time. Multiple steps can be carried out in sequential order to switch between different gas sources, flush out a manifold, or other gas handling operation. Create the number of desired steps in the sequence by clicking the up/down arrow for "steps."

For each step select the box for each solenoid valve to be opened. The check mark in the "current valve state" window indicates a solenoid valve is open. Note: In this example, we assume normally closed (NC) valves are used. A check indicates current is flowing to the valve thus powering it open. The positions from left to right correspond to solenoid valves V1…V6.

The rotary selector valve position can be set in the column labeled "Rot. Valve Code." Enter the number that corresponds to the desired valve position. A value of 1 in this field corresponds to position 2 on the Valco valve. Only one rotary position can be selected per step.

Step duration is determined by the value entered in the "duration (min)" field, where the duration of the step is in minutes. If duration values are set to less than 0.1 minutes they may not be carried out correctly.

The "valve code" field is a configuration- dependent, read-only display field that shows the total state of that particular step in a numerical code. Should the most upper right grey box display a value of 512, 256 or be greyed-out, that indicates no rotary selector valve is connected to the instrument, or it is not functioning. For each individual measurement the analyzer makes, the valve codes and rotary valve positions corresponding to the valve state(s) at that point in time are saved alongside the concentration data.

Once the valve sequence has been programmed, it can be saved using the button "save valve sequence file" — it will be saved under the sequence file number selected.

Loading and Running a Saved Sequence

To load a valve sequence file, select the desired "sequence file number" and press "load valve sequence file." If the user has been running a different sequence from the one that was loaded, the user needs to press "Next Step" to initialize the newly selected sequence.

To run a sequence file press "Enable Sequencer." This button will turn to "Disable Sequencer" once the sequence starts. (The sequencer should be activated if it was disabled but not necessary to change from one sequence to another). The sequence will repeat itself indefinitely until disabled or the software exited. If enabled, the sequence will continue to run after the "close sequencer window" button is pressed.

If desired, the valve sequence can be forwarded to the next step of the sequence by pressing the "run next step" button. To stop the sequencer file, use the "Start/Stop Sequencer" menu item under the "Action" menu. This will leave all valves in their current state. In some situations, it is convenient to program the last step in the sequence to be a safe or default

valve state. The sequencer can be advanced to the last step should the user need to put the solenoid or rotary vales into a safe/default state. The "Reset All Valves" de-activates all valves. Using the "Hide Sequencer Interface" closes the window, but if the sequencer is enabled, it will continue to run in the background. To jump to a particular step, increment the "run step 3" and click "Apply."

Both solenoid and rotary valve codes are recorded in columns in the output data files indicating the active valve configuration respective to when data is taken. These codes can be used as event timing flags. For example, if no solenoid valves are present, the codes will be recorded regardless of whether a valve is connected or not.

17. CALIBRATION

You can use either of the methods below to calibrate your analyzer. Method 1 requires you to make a graph (known standards versus measured standards) to calibrate the analyzer. Method 2 does not require you to make any graph; however, the effect of its calibration is harder to reverse in comparison to Method 1.

17.1 Method 1: Using the Main Graphics User Interface (GUI) To Calibrate the Analyzer

Since the Picarro analyzer is extremely linear, it is only necessary to use three calibration standards to calibrate each gas or isotopic species (two points define the calibration line and a third intermediate point is used for verification). The exact value of each calibration standard is not of particular importance as long as they span a representative range of values over which the analyzer will typically be operated. It is reasonable to use a concentration of zero for the low calibration value, for example. Although it is not necessary to use more than three standards, additional standards can be used to further constrain the linear calibration coefficients.

To perform a calibration or verification of calibration:

3. Introduce the first calibration standard into the analyzer for an interval long enough for the analyzer to yield a stable measurement of that sample. The stated concentration of the calibration sample (a calibrated gas bottle, for example) and the value the analyzer reads for that sample are recorded for each calibration standard used.

4. Plot the values to determine the linear relationship between the known calibration values and the analyzer's reported values. It is important to plot the analyzer's reported concentration on the horizontal axis and the gas standards' stated concentrations on the vertical axis.

5. Calculate a linear best-fit equation from the data. The slope and intercept of the best-fit line through these points are the two values that are used to calibrate the analyzer. Determining the linear relationship between the known calibration values and the analyzer's reported concentration enables the calculation of a calibration offset (slope and intercept). This adds a correction term to the analyzer's factory or previous calibration.

Changing the analyzer's calibration is intended to be done infrequently. Instead of recalibrating frequently to increase the accuracy of the data, users often just verify the calibration by measuring three or more gas standards and use the same regression procedure described here to calculate an offset by which to correct their data offline.

In the calibration example data below, fitting the three standards yields the linear equation y = 0.9866x + 5.2658 where the slope m=0.9866 and the intercept b=5.2658. This equation would be used with x=raw data measured by the analyzer (labelled "CRDS Reported") to give y=corrected data (labelled "Certified" value).

	CRDS Reported Value	Certified Value
Calibration Point #1	200.1	202.7
Calibration Point #2	600.3	597.6
Calibration Point #3	400.0	400.0
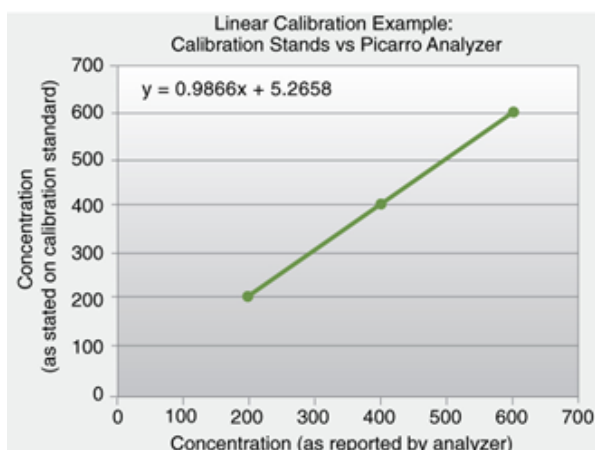
These calibration values are inputted into the software by selecting the "User Calibration" from the Tools menu and entering the slope and intercept for each species (see below). This is a password-protected function, with the default password "picarro."

After the calibration is entered, it will take effect immediately after clicking "ok."

To return to the factory calibration, simply set the slope to "1" and the intercept to "0" for each species.

17.2 Method 2: Using the "Picarro Data Recalibration Tool" to Calibrate the Analyzer

This tool can be used after you have performed the calibration measurements of standards with your Picarro analyzer.
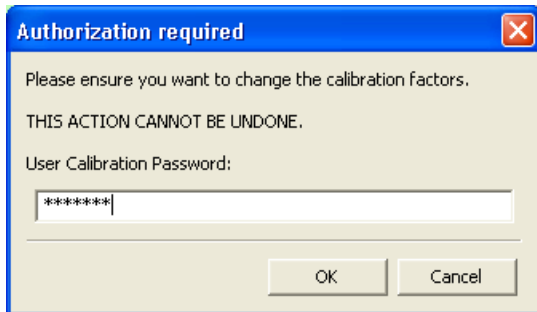
The Picarro Data Recalibration ("Data Recal" icon) software can be found in the "Picarro Utilities" folder in the desktop, and it can be used to recalibrate the data analyzed by Picarro analyzers.

1. Double-click the "Data Recal" icon to pull up the window to the left.

2. Click on "Clear Entries" to reset the values in the "Picarro Data Recalibration" window.

3. Enter data values into the "Certified" (expected ppm values).

4. Enter data values into the "CRDS Reported" (ppm reported by Picarro analyzer) columns.

5. Check the boxes in the "Used for Recal" column that you want the software to base the calibration on.

6. Click the "Compute" button. The recalibrated values will appear in the rightmost column called "Recalibrated".

7. Click "Apply New Cal" if you want to apply the calibration to your future measurements.

8. The default User Calibration Password is "picarro." Click "OK" to continue. **NOTE: This action cannot be undone from the "Picarro Data Recalibration Window," but it CAN be undone in METHOD 1 in the "User Calibration" window.**
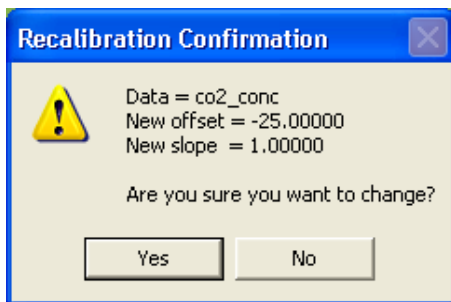
**9.** Review the values in the window, and click "YES" to confirm.

10. Click "OK" to continue.
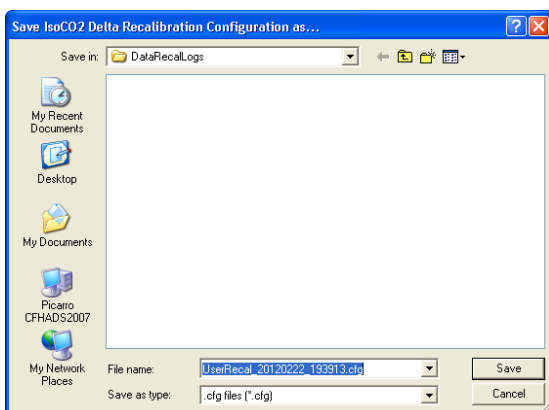
11. You now have the option to save your calibration settings. Click "Cancel" if you don't want to save your new calibration setting.

12. You have now calibrated your analyzer. The next time you do any sample measurements, the measurements will be based on the new calibration setting.

18. CAVITY RING-DOWN SPECTROMETER CONTROLLER

On your desktop, there is an icon labelled "Picarro Controller." Clicking on this icon will open up a useful diagnostics panel (see image below), allowing the user to see the analyzer's internal temperatures, pressure, and spectroscopy in real time. This program has user-accessible functions, but cannot change anything related to analyzer functionality and is intended for diagnostics purposes only.
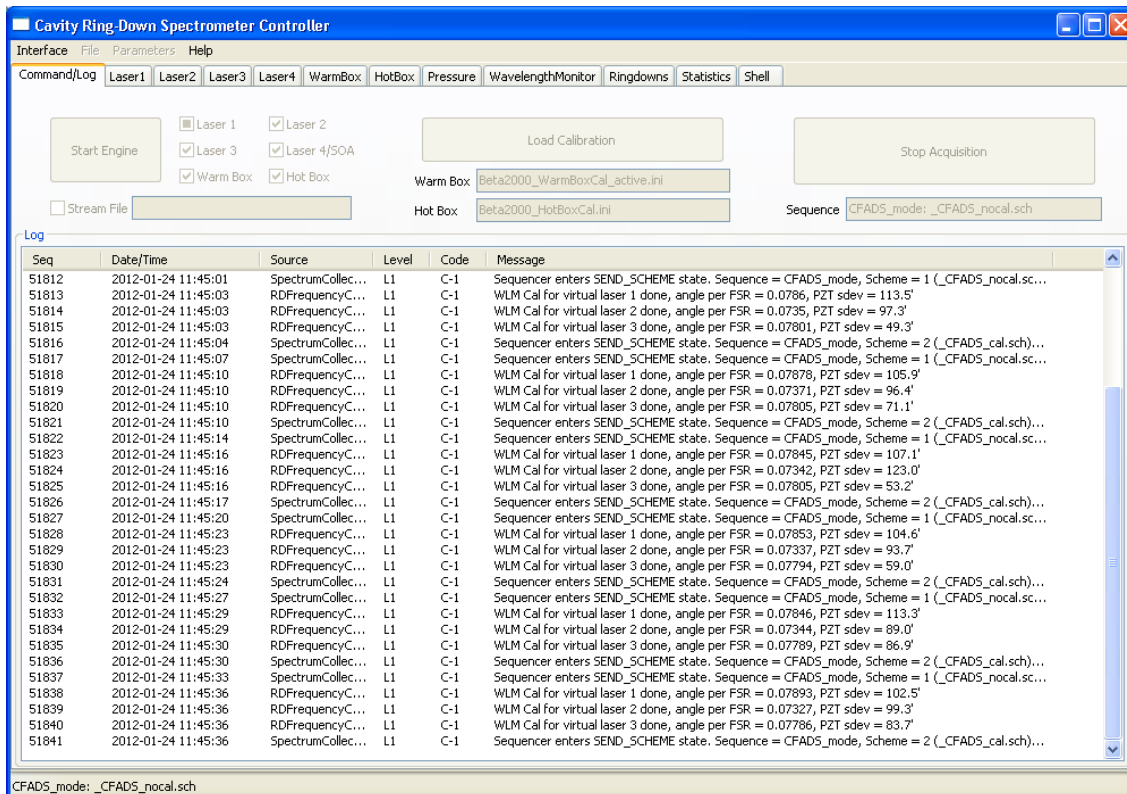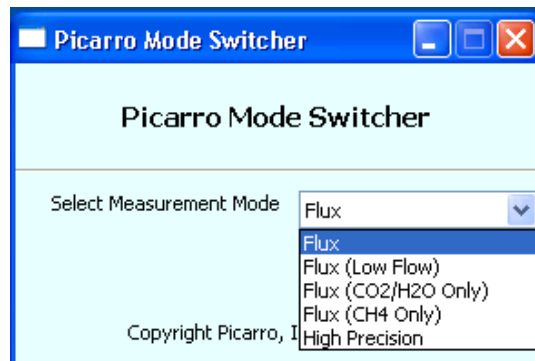
19. MEASUREMENT MODES

The "Picarro Mode Switcher" allows users to operate the analyzer in various modes. Switching between measurement modes is accomplished with a few easy steps:

1. Activate the user interface by double-clicking the "Picarro Mode Switcher" icon on the analyzer's desktop.

2. The following user interface will appear on the desktop. (Note that the choices in the dropdown menu will vary between different analyzers.)

3. To switch modes, click on the dropdown box menu and select the desired measurement mode. Then click the launch button. (The image below shows choices for a flux analyzer.)

4. Confirm your selection when prompted by the confirmation dialog box.
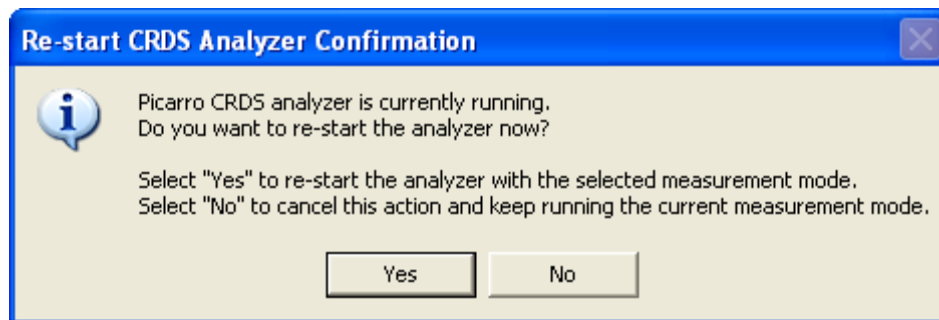
5. The analyzer software will then re-start in the new measurement mode. There is no need to turn the vacuum pump off during this process.

20. SERVICE AND MAINTENANCE

The advanced, rugged design of Picarro analyzers provides stable, long-term operation with minimal service or maintenance. With the exception of the particulate filter, the analyzer is not user serviceable. Should it appear to malfunction, please refer to the "**Troubleshooting**" chapter of this manual or contact Picarro.

20.1 Particulate Filter

Filters can become clogged after years of use in dirty environments. The symptoms of a clogged filter include the analyzer reporting "pressure low" or there being no flow into the instrument, causing unusual measurements.

If liquid water is accidentally sucked into the inlet line, it will clog the filter and impede the flow (usually for a few days) until the water evaporates. If this occurs, it is important to NOT turn off the analyzer or replace the filter until the filter is dry. The reason for this is that the increased humidity due to liquid water in the filter can cause condensation on the optics if the analyzer is allowed to cool from its operating temperature. Often, after the filter dries, the analyzer will begin functioning normally, and a filter replacement is not necessary.

There are two in-line, sub-micron particulate filters before the measurement cavity:

6. The first filter is user-replaceable and is found immediately following the inlet at the back of the analyzer. Replacement filters can be purchased from Picarro to be installed by the user.

7. The second filter, which is directly attached to the cavity, is NOT user-replaceable. NEVER remove this filter, as it is directly attached to the cavity.

20.2 Tools Required

- 2 mm hex driver
- 9/16" open end wrench
- 5/8" open end wrench
- 11/16" open end wrench

20.3 **Removing** the **Old Particulate Filter**

The following procedure is **ONLY** for the **user-serviceable particulate filter** (first filter).
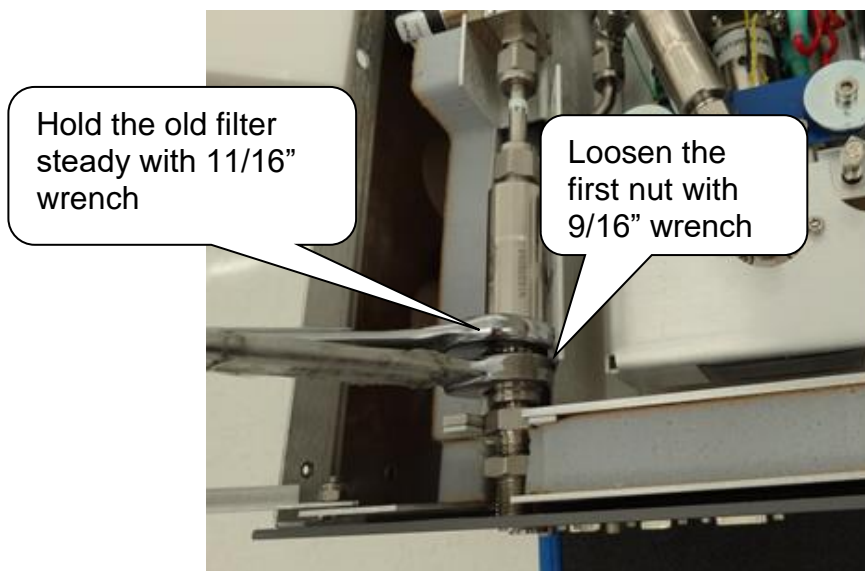
1. Move the analyzer to a clean work environment.

2. Using a 2 mm hex driver, remove the top lid of the analyzer by removing six M3x6mm socket flathead screws.

3. Loosen and remove the two screws on the inner long side of the bigger box. Open the lid.
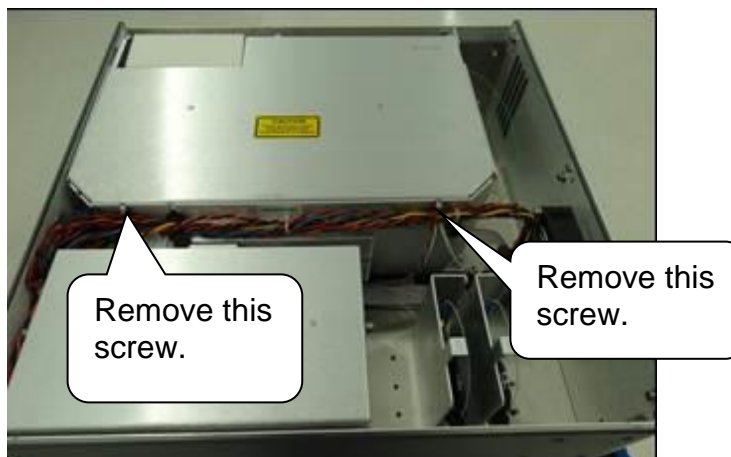
4. Using a 5/8" wrench, loosen the retaining nut on the input bulkhead (about 1 full turn should be enough).

5. Slide the foam towards left side of the analyzer (from the back of the analyzer) to remove it.
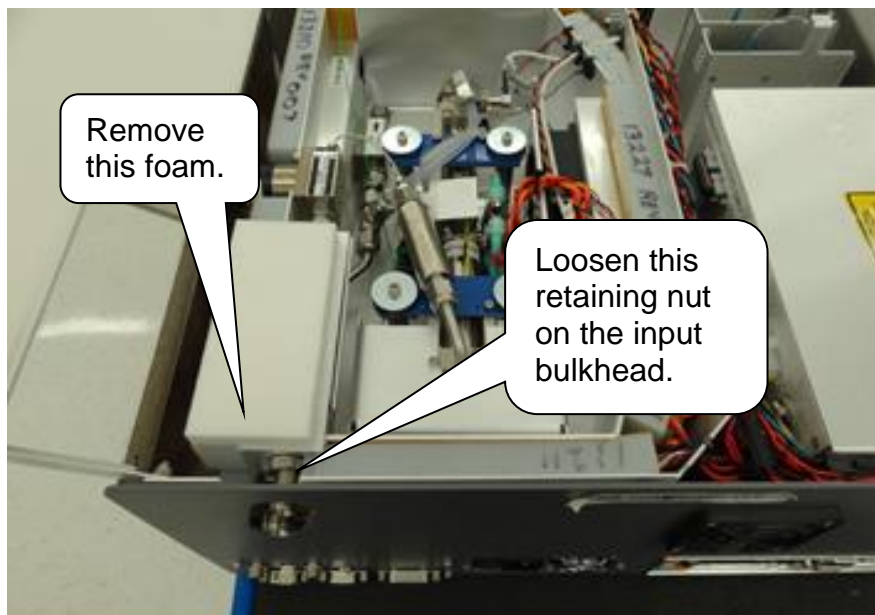
6. Using the 9/16" and 11/16" wrenches, loosen the two nuts that are securing the filter to the analyzer.

Loosen this first nut

Loosen this second nut

Hold the old filter steady with 11/16" wrench

Loosen the first nut with 9/16" wrench

Hold the old filter steady with 11/16" wrench

Loosen the second nut with 9/16" wrench
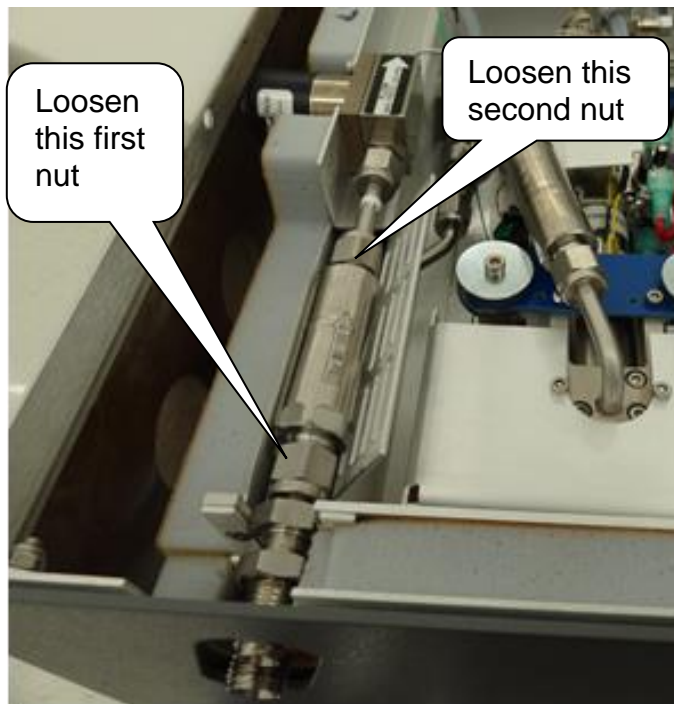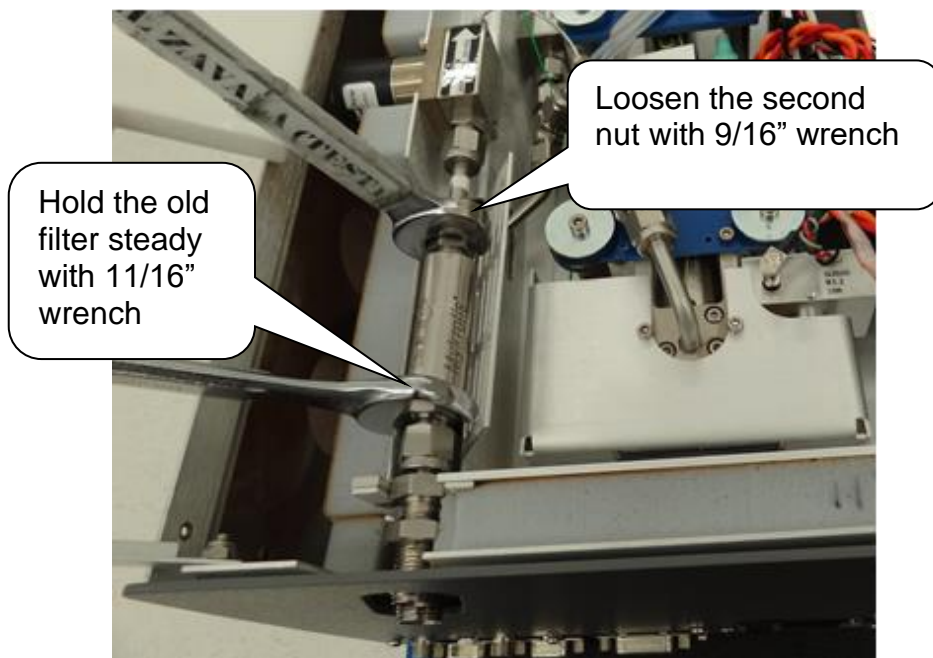
7. Slide the filter slightly towards the back of the analyzer and lift it out.
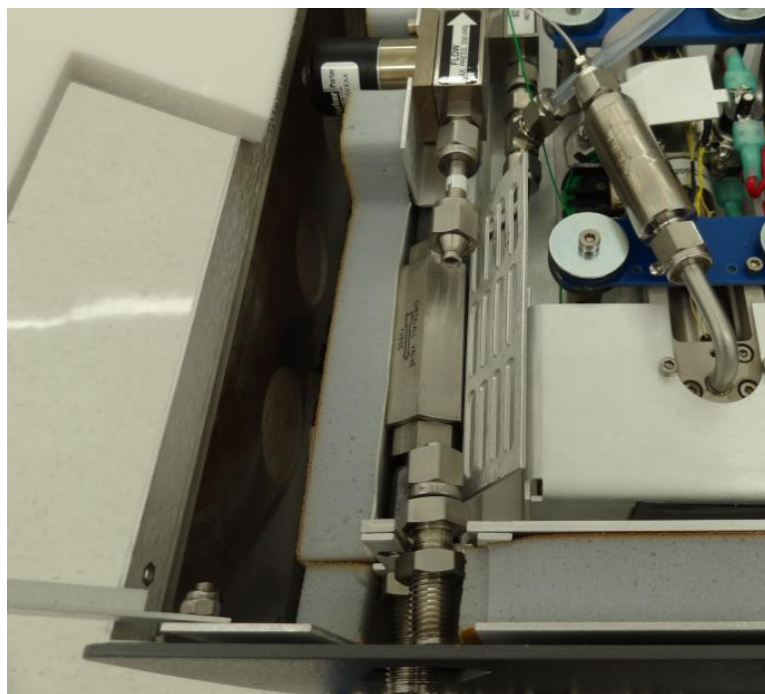
Installing the New Filter
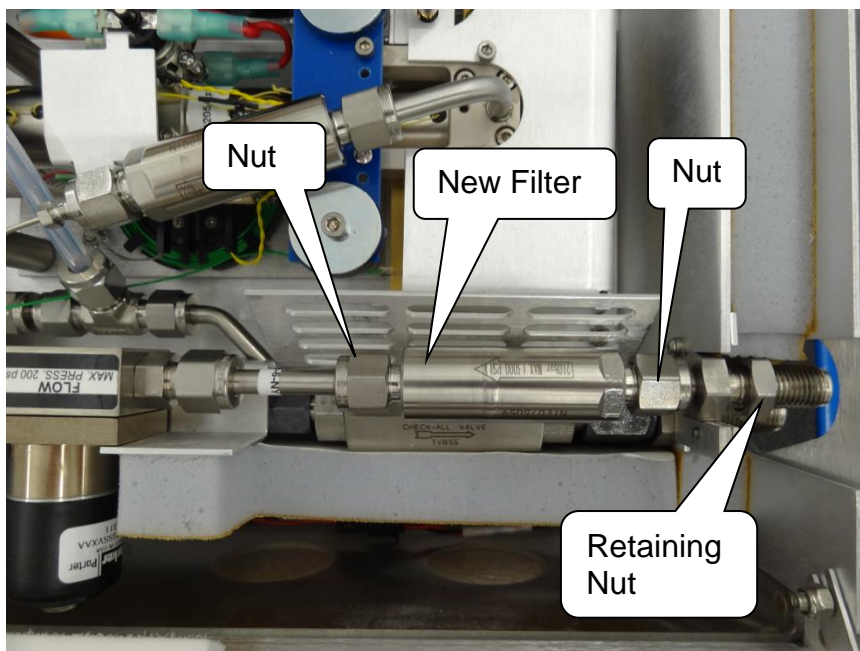
	Note: When re-attaching 1/4" Swagelok fittings, the nut should be hand-tightened and then turned an additional 1/8 of a turn using a wrench.

1. Remove the filter from its packaging.
2. Using the 9/16" and 11/16" wrenches, attach it to the two nuts. The arrow on the filter needs to point away from the back of the analyzer.

3. Using a 5/8" wrench, reposition the filter foam cover and tighten the retaining nut on the bulkhead fitting. The metal edge of the filter cover should be under the foam.
4. With a 2mm hex driver, reattach the analyzer's top with six screws.

20.4 Cleaning

Clean the outside of the analyzer with a clean dry cloth. Only certified service technicians should access or clean the inside of the analyzer.

21. TROUBLESHOOTING

The following section lists problems that may be encountered during installation and operation of the analyzer. The corresponding step-by-step procedures provide resolution in most cases. If, after attempting these procedures, the problem remains unresolved, please contact Picarro Technical Support. More troubleshooting information is available on the Community section of our website.

21.1 Power LED on analyzer does not illuminate

Context: Turning on the analyzer by momentarily depressing its front panel power switch should apply power. The green power LED is illuminated when it detects the correct power levels.

1. Check that the AC power cord is attached and plugged into a working outlet.
2. Check that the rear on-off switch near the AC power cord is in the on position.
3. Press and hold the front panel power switch for at least 5 seconds as the analyzer may take several seconds to respond.

21.2 User interface program does not start

Context: The computer is typically configured to automatically start the instrument and its associated user interface program after booting up. If it does not start automatically, the program may be launched by double-clicking the "Start Instrument" icon on the desktop. Communication problems with the analyzer may occur if the analyzer fails to initialize correctly on power up.

Shut down the computer using the following procedure only:

1. Click on the computer's "Start" menu in the lower left hand corner.
2. Select the red "Shut Down" button.
3. Select "Shut down" in the drop-down box.
4. Wait for the computer and analyzer to turn off completely and the shutdown to complete normally.
5. After a few seconds, restart the computer by momentarily depressing the power button.
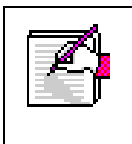
	NOTE: Do not simply restart Windows by selecting "Restart" in the drop-down box on Step 3, since this does not cycle the power to the analyzer.

21.3 Sample pressure cannot be controlled to the appropriate value for concentration measurements

Context: Under normal operation, the cavity pressure is automatically locked to the correct value by means of electronically controlled inlet and outlet valves. The message "Pressure Locked" on the front panel display and the user interface indicates that the cavity pressure is at the appropriate value. Should either of the messages "Pressure high" or "Pressure low" be displayed, the cavity pressure is out of its correct operating range.

1. The "Pressure low" message indicates that there is insufficient gas available at the inlet of the analyzer. Check the inlet plumbing to the analyzer and ensure that the pressure at the inlet is within the specifications.

2. The "Pressure high" message indicates that gas cannot be removed from the analyzer at a sufficient rate. Check the vacuum line between the analyzer and the power vacuum unit for leaks. Failure of the vacuum pump, injecting dilution gas at excessive pressure, or excessive pressure at the inlet can also cause this problem.

21.4 User interface program "freezes" and does not update graphs as data are collected

Context: The computer may become unresponsive, causing the programs that control the analyzer to stop functioning. The computer and analyzer should be shut down and restarted.

If the computer responds to the mouse, a normal Windows shutdown may be carried out:

1. Click on the computer's "Start" menu in the lower left hand corner.

2. Select the red "Shut Down" button.

3. Select "Shut down" in the drop-down box.

4. Wait for the computer and analyzer to turn off completely and the shutdown to complete normally.

5. After a few seconds, restart the computer by momentarily depressing the power button.

If the computer does not respond to the mouse:

1. Hold down the power switch on the front panel for a few seconds until the computer and the instrument power off.

2. After another few seconds, restart the analyzer by momentarily depressing the power button.

22. TRANSPORTATION AND STORAGE

In the event that the instrument will be transported or stored, the following procedure can be used to prepare the instrument and repack it into the original carton. All original packing materials the analyzer was shipped with should have been retained.

1. Ensure clean dry gas is still attached to the instrument prior to shutting down. This prevents condensation inside the system during storage or shipment.

2. Click the "Shutdown" button on the GUI.

3. Select the "Turn off Analyzer and Prepare for Shipping" option (see "Shutdown Procedure" chapter of this manual for details).

4. Disconnect the all tubing and electrical connections from the analyzer.

5. To prevent contamination and possible damage to the connector threads, place caps on all gas connections.

6. Place the analyzer in a plastic bag with a packet of desiccant. Seal the bags with tape.

7. Pack the analyzer in the original shipping container ensuring that all of the foam pieces are in place to protect the analyzer during shipping.

CAUTION

WHEN SHIPPING OR RELOCATING THE ANALYZER, IT IS IMPORTANT TO PROTECT IT FROM MECHANICAL SHOCKS. FAILURE TO DO SO CAN COMPROMIZE ITS PERFORMANCE. WHEN SHIPPING THE ANALYZER, USE ITS ORIGINAL PACKAGING ONLY.

23. LIMITED WARRANTY

Picarro, Inc. warrants its Products to be free from defects in material and workmanship and to perform in the manner and under the conditions specified in the Product specifications for twelve (12) months from shipment.

This warranty is the only warranty made by Picarro with respect to its Products and no person is authorized to bind Picarro for any obligations or liabilities beyond this warranty in connection with its Products. This warranty is made to the original Purchaser only, is non-transferable and may only be modified or amended by a written instrument signed by a duly authorized officer of Picarro. Sub-systems manufactured by other firms, but integrated into Picarro Products, are covered by the original manufacturer's warranty and Picarro makes no warranty, express or implied, regarding such sub-systems. Products or parts thereof which are replaced or repaired under this warranty are warranted only for the remaining, un-expired portion of the original warranty period applicable to the specific Product replaced or repaired. Products or parts thereof which are replaced or repaired outside of this warranty are warranted only for ninety days.

	NOTE: DISCLAIMER
	THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES WHETHER WRITTEN, ORAL OR IMPLIED, AND SHALL BE THE PURCHASER'S SOLE REMEDY AND PICARRO'S SOLE LIABILITY IN CONTRACT OR OTHERWISE FOR THE PRODUCT. PICARRO EXPRESSLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

The Purchaser's exclusive remedy with respect to any defective Product shall be to have Picarro repair or replace such defective Product or credit the Purchaser's account, whichever Picarro may elect in its sole discretion. If it is found that any Product has been returned which is not defective, the Purchaser will be notified and such Product returned at the Purchaser's expense. In addition, a charge for testing and examination may, at Picarro's sole discretion, be made on any Product so returned.

These remedies are available only if: i) Picarro is notified in writing by the Purchaser promptly upon discovery of a Product defect, and in any event within the warranty period; ii) Picarro's examination of such Product discloses to Picarro's satisfaction that such defects actually exist and the Product has not been repaired, worked on, altered by persons not authorized by Picarro, subject to misuse, negligence or accident, or connected, installed, used or adjusted otherwise than in accordance with the instructions furnished by Picarro.

The following warranty conditions shall apply to all Picarro, Inc. products unless amended by a written instrument signed by a duly authorized officer of Picarro:

ADJUSTMENT – No electrical, mechanical or optical adjustments to the product(s) are permitted.

PARTS AND LABOR - New or factory-built replacements for defective parts will be supplied for twelve (12) months from date of shipment of the product. Replacement parts are warranted for the remaining portion of the original warranty period. There will be no charge for repair of products under warranty where the repair work is done by Picarro, Inc.

NOT COVERED BY THE WARRANTY – Damage to any optical surface from improper handling or cleaning procedures. This applies specifically to those items subjected to excess laser radiation, contaminated environments, extreme temperature or abrasive cleaning. Damage due to ESD, abuse, misuse, improper installation or application, alteration, accident, negligence in use, improper storage, transportation or handling. No warranty shall apply where the original equipment identifications have been removed, defaced, altered or where there is any evidence of alterations, adjustments, removal of protective outer enclosure, any attempt to repair the product by unauthorized personnel or with parts other than those provided by Picarro, Inc.

DAMAGE IN SHIPMENT - Your analyzer should be inspected and tested as soon as it is received. The product is packaged for safe delivery. If the product is damaged in any way, you should immediately file a claim with the carrier or, if insured separately, with the insurance company. Picarro, Inc. will not be responsible for damage sustained in shipment. All Picarro products are F.O.B. origin, shipped from the Picarro factory or Picarro distributor. The price of all Products, unless otherwise specifically stated, is Ex- Works, Santa Clara, CA, as defined by Incoterms, 2010. The cost of normal packaging for shipment is included in the invoiced price. Where Buyer specifies special packaging, a charge will be made to cover any extra expense.

CLAIMS ASSISTANCE - Call Picarro, Inc. Customer Service or your local distributor for assistance. Give our representative the full details of the problem. Helpful information or shipping instructions will be provided. If requested, estimates of the charges for non-warranty or other service work will be supplied before work begins.

RETURN PROCEDURE - Customers must obtain a Return Merchandise Authorization Number from Picarro, Inc. prior to returning units. Products being returned for repair must be shipped in their original shipping cartons to avoid damage.

TO ACTIVATE THE LOGMEIN SOFTWARE

1. Click on the "LogMeIn" icon in the Windows task bar at the lower right hand corner. The "LogMeIn Free" window will pop up.

2. Click the "Turn on now" button.
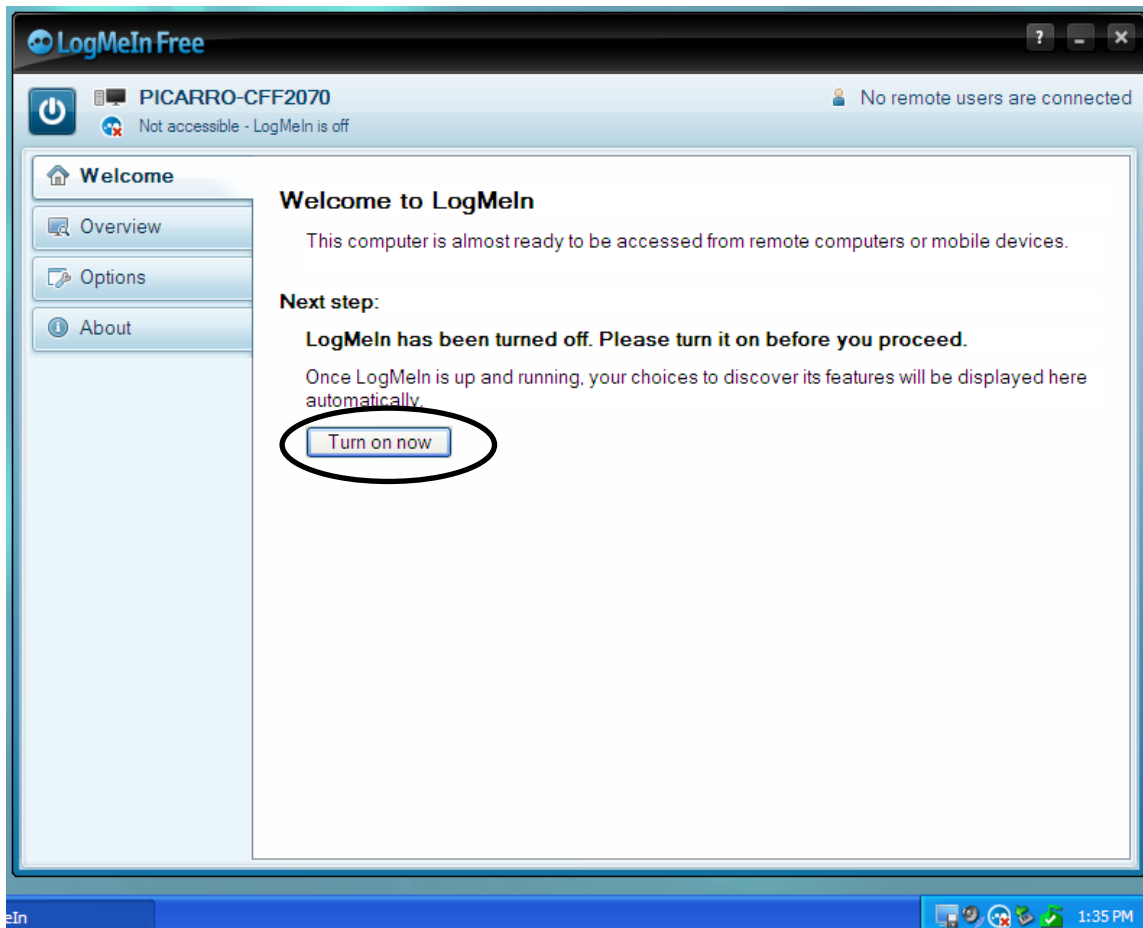
3. Send both the "Description" and "LogMeIn account holder's email" entries to Picarro, including a description of your problem. The "LogMeIn account holder's email" shows the account that the instrument is currently on (default is an @picarro.com email).
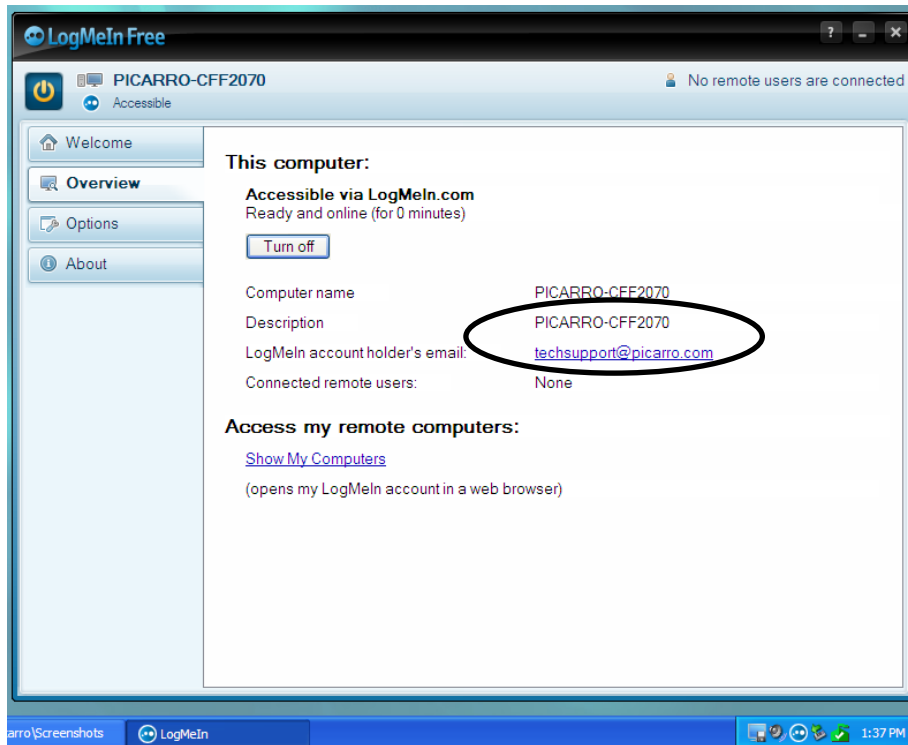
4. After your problem has been solved, you can turn off Picarro's access to your desktop by clicking on the "Turn off" button (see screenshot above).