PICARRO

G2108 Analyzer for HCl
User Manual

Picarro, Inc.
3105 Patrick Henry Drive
Santa Clara, CA 95054, USA
Tel: +1 408 962 3900
www.picarro.com
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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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Contact Information

General Technical Support:

Email: support@picarro.com

Phone: +1 408 962 3991

European Technical Center:

Email: support@picarro.com

Phone: +31 85 888 1650

Customer Service:

Email: orders@picarro.com

Phone: +1 408 962 3992

3105 Patrick Henry Drive
Santa Clara, California, 95054USA
Phone +1 408 962 3900 • Fax +1 408 962 3200
www.picarro.com

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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.

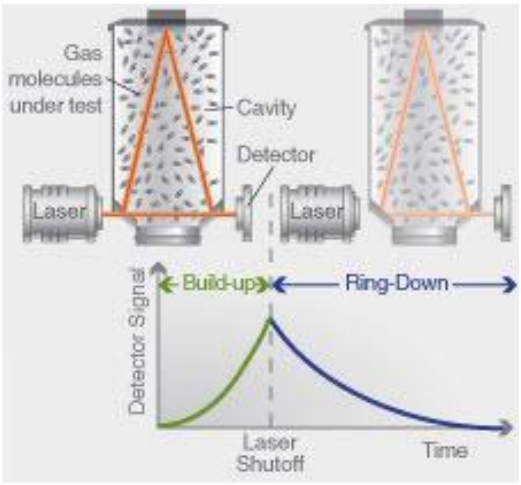
1.1 Cavity Ring-Down Spectroscopy (CRDS)

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.

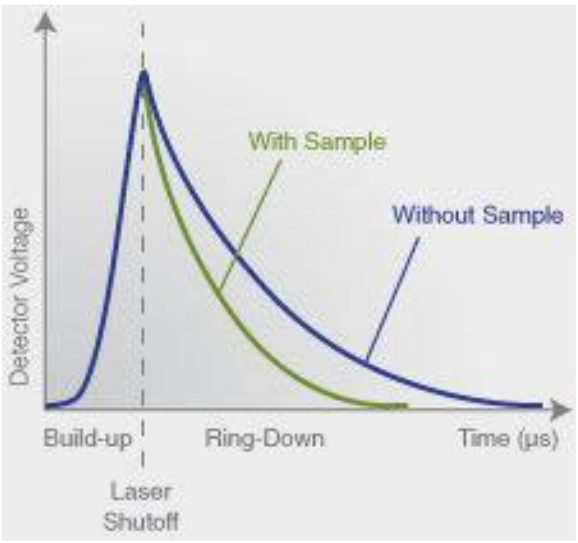


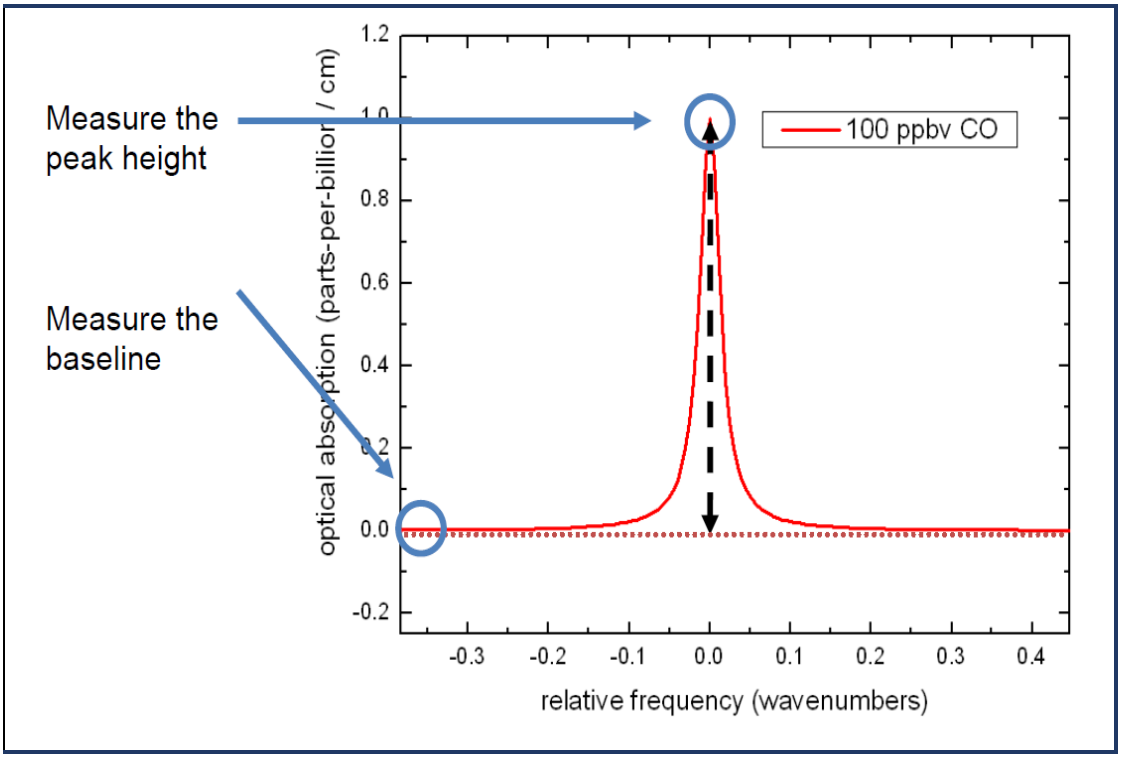
Figure 2: Light intensity as a function of time in a CRDS system

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
HCl	Hydrogen Chloride
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 58.6 lbs. (26.6 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

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.

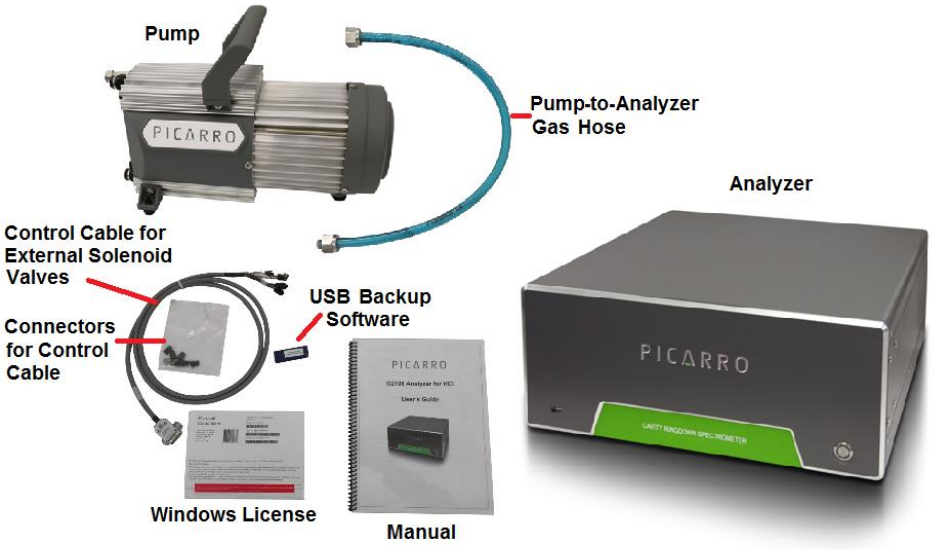
Keep the shipping packages to reuse when transporting the analyzer.

Contact Picarro for options on transporting systems to remote labs.

WARNING

This analyzer weighs 58.6 lbs. (26.6 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.

6. ANALYZER OVERVIEW

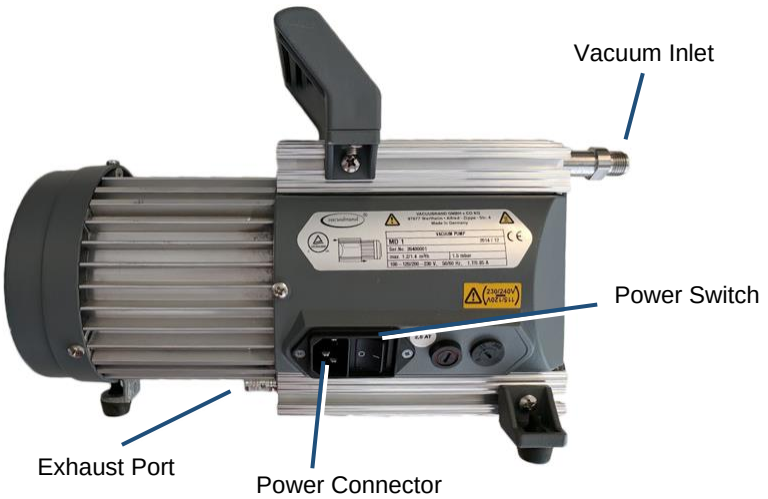
6.1 Intended Use

The G2108 Analyzer measures concentrations of HCl 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 HCl 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



6.3 Analyzer Specifications

Weight (Total) **Analyzer** **Pump**	73 lbs. (33.1 kg), Including external pump 58.6 lbs. (26.6 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	<1.8 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	10A @115VAC, 5A @230VAC
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

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

WARNING

This analyzer weighs 58.6 lbs. (26.6 kg). Use the technique outlined in the General Safety section on page 15 when lifting or moving the analyzer.

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

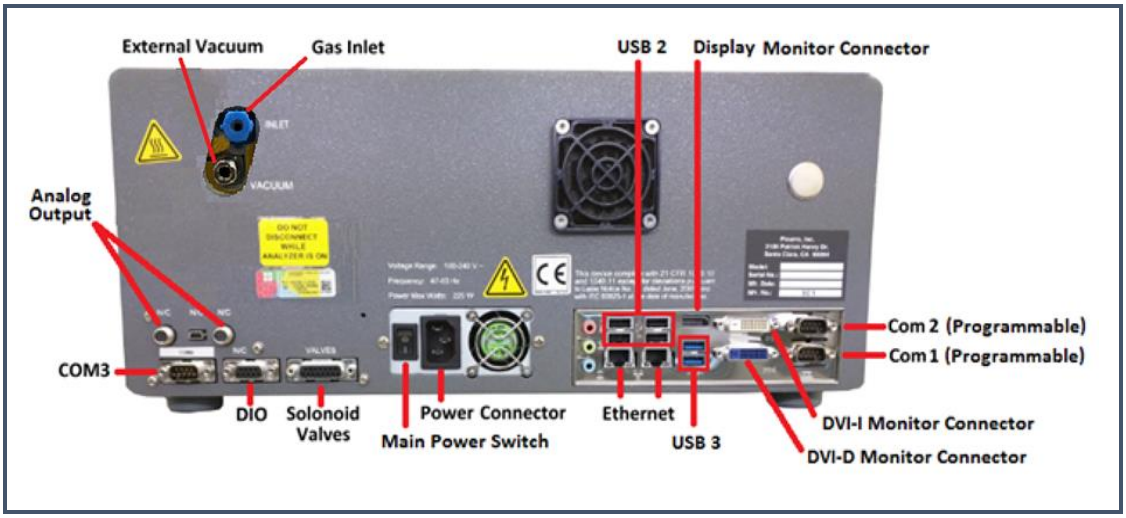
Use the AC power cables supplied with the analyzer or a similarly rated cable. Check with Picarro technical support if you have questions about power cable replacement. An inadequately rated power cable can result in equipment damage.

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.

Figure 6: Analyzer Back Panel



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 8.1.

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

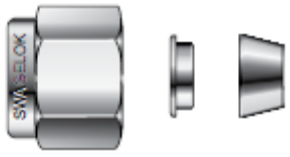
When using compressed gases, follow all appropriate safety conventions, including use of eye protection, physical restraint of cylinders, etc.

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.

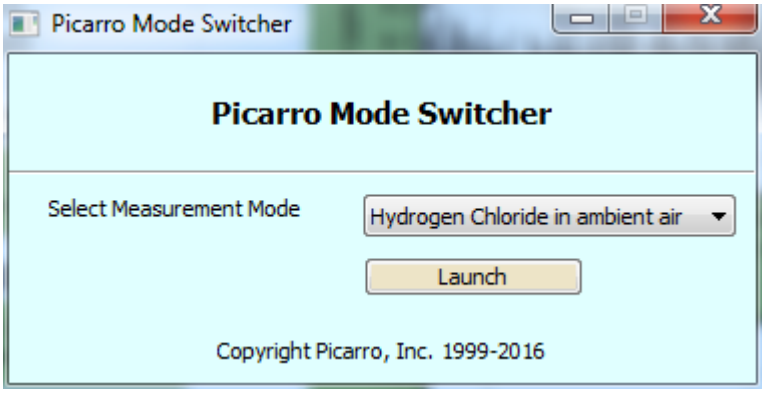
1. Connect a keyboard to one of the available USB ports.
2. Connect a mouse to one of the available USB ports.
3. Connect a monitor to one of the DVI monitor ports. The analyzer will detect the connection and adjust the resolution to match the monitor.
4. Connect the monitor to a power source.
5. Turn on power to the monitor.

8. BASIC OPERATION

8.1 Startup

When the main power is turned on the analyzer will automatically start, including the Graphical User Interface (GUI). The screen will look like that in Figure 10. A full explanation of the GUI functions can be found in Appendix B

Figure 8: Mode Switcher

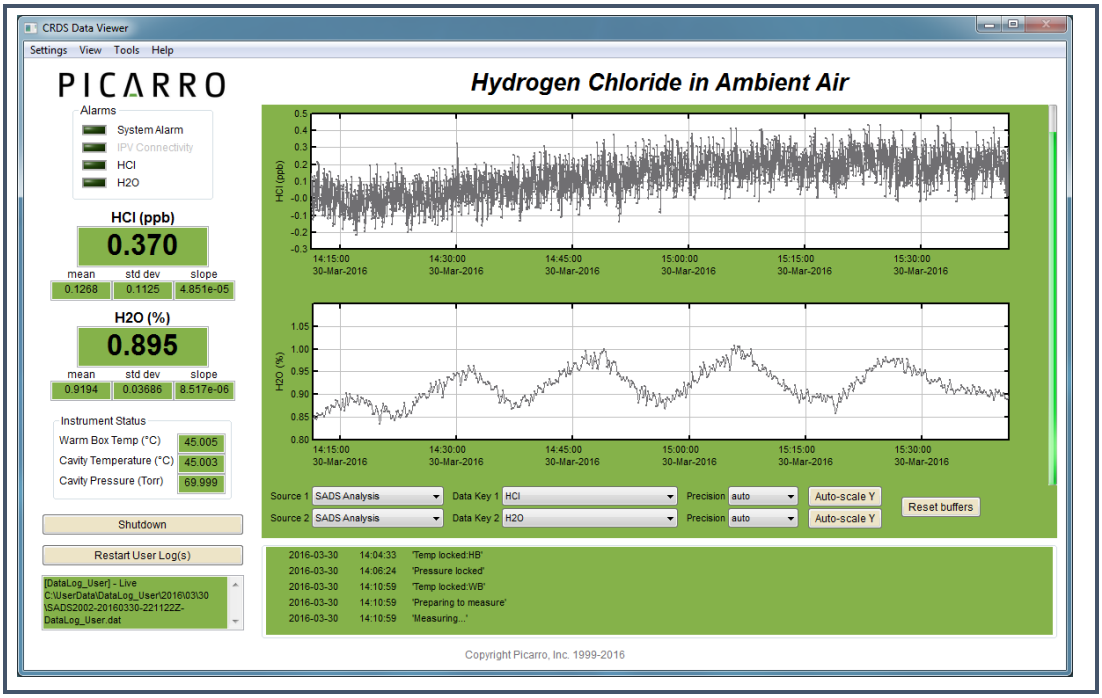


Desktop Icons:

- **Controller:** Instrument diagnostics and service information
- **Picarro Mode Switcher:** Restarts analyzer in different measurement mode. Most analyzer models are configured for one mode and may not include the Mode Switcher. (Figure 9). If the analyzer has multiple modes, this allows the user to switch between them easily.
- **Start Instrument-** Restarts the software if the software has been shut down (optional on some systems)
- **Stop Picarro:** Shuts down software (but not computer).
- **Coordinator Launcher:** Starts the coordinator software which controls sample introduction to the analyzer. (Some analyzers may not have this due to their configuration).

  The analyzer will not begin producing data until all the measurement parameters have reached their operational set points. A message will be displayed in the Status log window (see Figure 10, bottom panel) when each set point is reached. A full explanation of each status log message can be found in Appendix A.

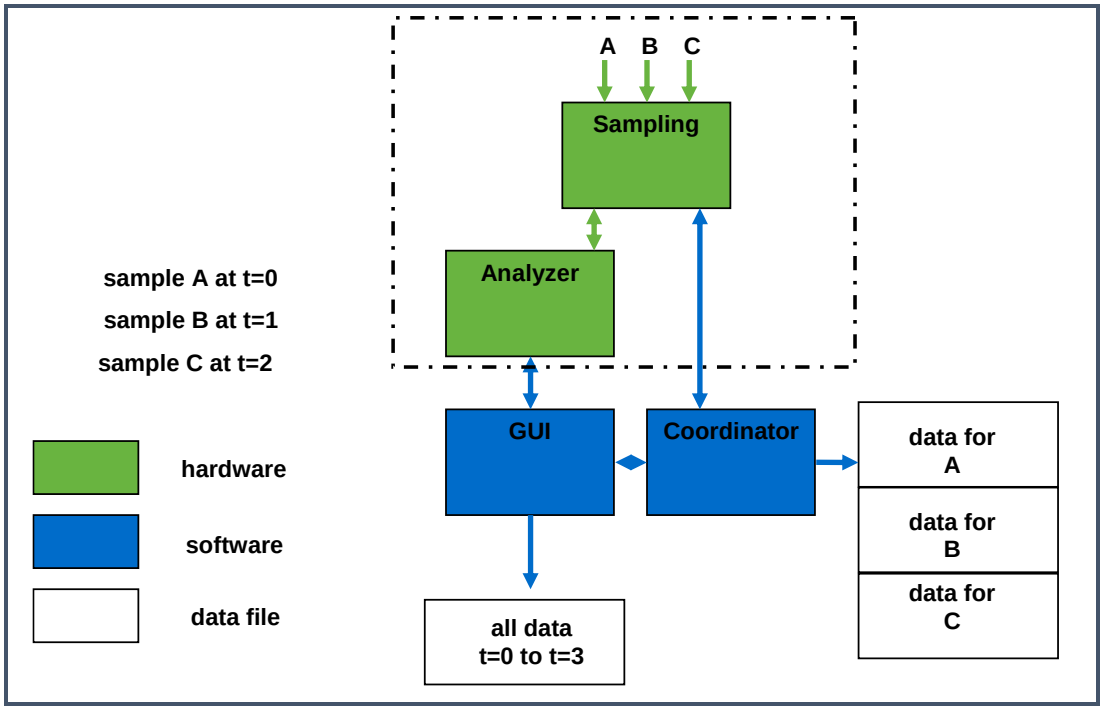
Figure 9: Picarro Analyzer GUI



Data is 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, D=day. Further details are found under the file management section in Appendix B.

In order to measure discrete samples (such as individual gas bags) or from multiple locations (when switching valves draw in ambient air from different heights) 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.

Figure 10: Picarro Analyzer System Schematic



The samples A, B, and C 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 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, the data is reported as a function of sample.

8.2 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.

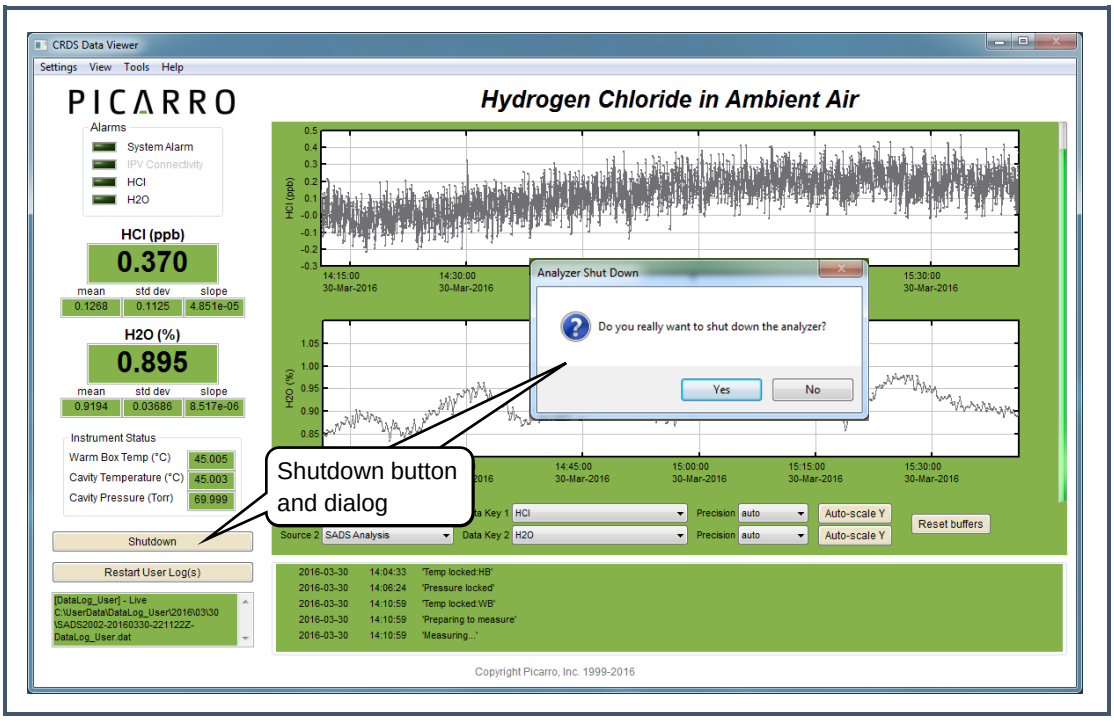
CAUTION

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 11:

Shutdown Window

The heading shown may vary depending on the analyzer type



8.3 In case of an Electrical Power Outage

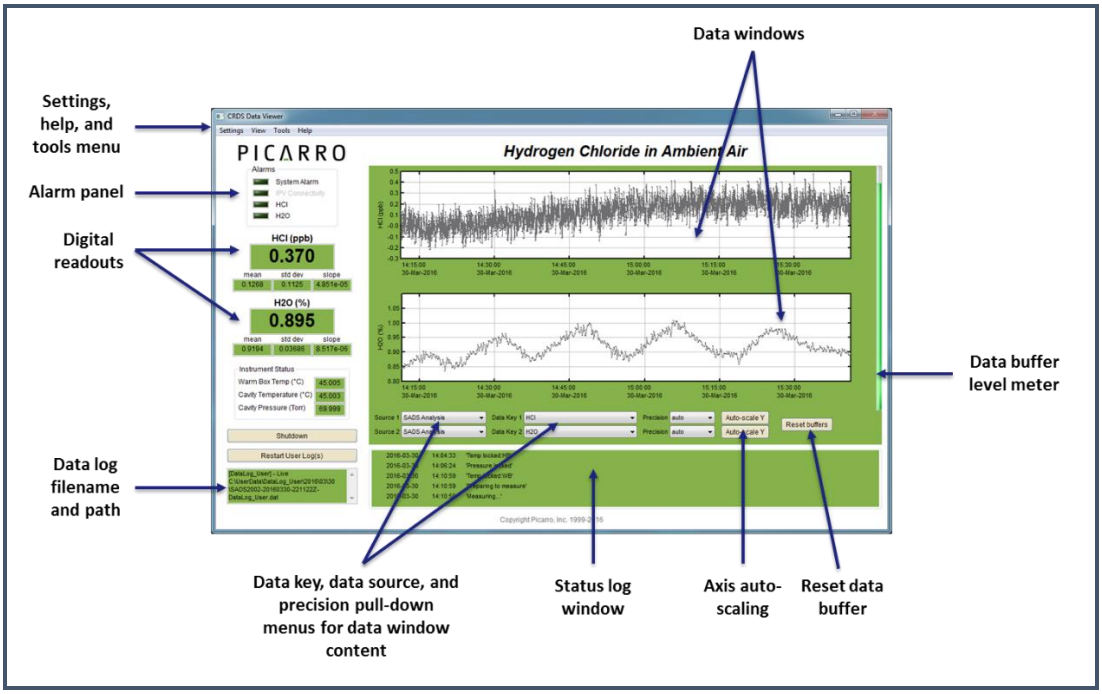
If the power to the analyzer is cut-off for any reason, the analyzer will cease operation. However, when the power is reapplied, the analyzer will restart automatically. The Picarro software tools will also properly close out previous files and open new files for data collection so that previously collected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

9. LIST OF GUI FUNCTIONS

9.1 Additional Tools and Information

The Picarro analyzer GUI has several other buttons and features as labelled in Figure 13.

Figure 12: GUI Functions



9.2 Settings, Tools and Help Menus:

Settings Menu

Left clicking on the Settings menu pulls down a menu that has one entry ‘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

This menu item has three entries:

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

2. Show/hide statistics: Toggles the measurement statistics display, see 'Digital Readout' below.
3. Show/hide instrument status: Toggles the instruments status display. See 'Instrument Status', below.

Tools Menu

This menu item has three entries:

1. User Calibration: Opens the user calibration window (default password is "picarro"). The password can be reset in the QuickGui.ini file in the instrument directory: "C:\Picarro\G2000\AppConfig \Config\QuickGUI\" under the section:
2. [Authorization] UserCalPassword = Picarro Show/Hide Valve
3. Sequencer GUI: Toggles the display of the external valve sequencer window.

The calibration slope and intercept can be entered and their effects immediately seen in the data. Please refer to the section at the end of this manual concerning calibration.

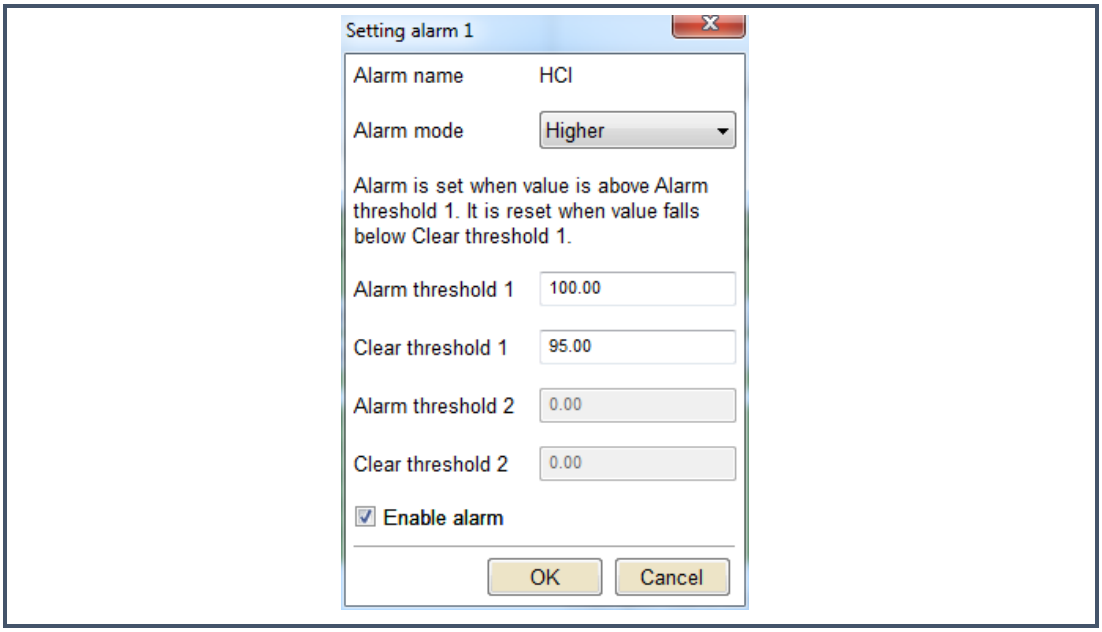
Help Menu

About Displays the version number of the instrument.

9.3 Alarm Panel

This panel is used to monitor the status of the internal instrument alarms. These indicators are gas concentration alarms, such as "HCL Too High/Low" depending on instrument configuration. The gas concentration alarm LEDs are off (grayed) 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 and allow the user to enable it or change the setpoint:

Figure 13: GUI Functions



Type the value you wish to set the alarm to and press the “OK” button, or press “Cancel” if you do not wish to change the alarm value. If you do nothing, the dialog box will disappear and the alarm value will remain unchanged. The units are those that appear in the GUI graph.

9.4 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 is dynamically calculated and indicated below the digital concentration readout. These numbers change to reflect statistics of whatever data is in the data window.

9.5 Start / Stop Data Log Button

The Analyzer automatically records all data collected on the instrument and saves it for later analysis. These files are called Data.dat files, which are described below in the section called “File Management”. In addition, the user can record a separate data log file. Press this button if you would like the instrument to start recording a separate data file. A dialog box will appear prompting you for a filename and location. Press this button again to stop recording the data file.

9.6 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.

9.7 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.

9.8 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.

9.9 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.”

9.10 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.

9.11 Status Log Window

This window displays instrument status messages, in the following form: “MM/DD/YYYY hh:mm:ss generic message text.” These messages include all messages sent to the DAS.

9.12 Reset Data Buffer Button

Press this button to clear the internal data buffer of the GUI (this clears the current data traces from the graphs). This has the effect of clearing all data in the data window. Pressing this button has no effect on any of the data log files stored by the instrument.

9.13 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 collected with the instrument. There is an internal limit of a finite number of points. Once that number of data points is collected, the buffer is full, and 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 startup, and can also be emptied by pressing the *reset data buffer button* in the lower-right-hand corner of the GUI.

9.14 Graph Zooming

To zoom the graph, simply drag the magnifying glass over the section to be zoomed and click and hold the left mouse button. While holding down the left button, 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, double click on the left button. 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.

10. FILE MANAGEMENT

10.1 Overview

During operation, the Analyzer generates various ASCII-format text output files that are updated after each batch of concentration measurements is complete. For example, one of the user output files is named SADS2###-yyyymmdd-hhmm-DataLog_User_Raw.dat where “SADS2###” or similar is the instrument serial number. The data files are created every 15 minutes.

The file name is generated from the instrument serial number, the date, and the time when the instrument was started. For example:

SADS2001-20160127-1029-DataLog_User_Raw.dat

SADS2001 is the instrument serial number

20160127 is the date, 1/27/2016, in format yyyymmdd (to allow chronological sorting of data files).

1029 is the time the file was started, 10:29 am, formatted as hhmm using a 24 hour clock.

The raw user data is contained in folders in the directory: C:\UserData \DataLog_User\[year]\[month]\[day]\hour. This is data that has not been re-sampled to exact 0.1s time intervals. There is a similar directory C:\UserData\DataLog_Sync\... which includes data that is evenly spaced in time at the data rate of the analyzer.

Data files are created every 60 minutes and stored for 90 days before they are automatically deleted. The file deletion frequency and details can be modified in the file: C:\Picarro\G2000\AppConfig\Config\Archiver\Archiver.ini. This is explained below.

During data acquisition, the analyzer creates directories to store the data, based on the date the data were acquired. After each datafile has been closed (every 15 mintes) it is moved to an archive directory, and a new file is started in the original location. The archive directory is C:\Picarro\G2000\Log\Archive\ and has subdirectories DataLog_Mailbox, DataLog_Private and DataLog_EventLogs with files arranged by year\month\day\hour.

There are more complete data files which include additional information beyond the concentration data including parameters such as instrument temperatures and pressure, setpoints and

spectroscopic information. This information is generally not useful to the user, but can be useful for diagnostic purposes and is store in the directory C:\Picarro\G2000\Log\Archive\DataLog_Private \[year]\[month]\[day]\[hour].

For more information about how to include various columns of data from the DataLog_Private in the C:\UserData DataLog files, please contact Picarro.

The current data file can be found in C:\Picarro\G2000\Log\DataLogger\. Within this directory, there are subdirectories for DataLog_Private, DataLog_User_Raw and DataLog_User_Sync. Similarly, the archive directory has subdirectories arranged by file type. The subdirectories are further organized by \[year]\[month]\[day]\[hour].

To keep the data files easy to manage and to limit the size of individual files and directories, the software automatically generates new files each time the instrument is powered up and also at midnight each night. When new files are created at midnight, their file name will contain the new date and a time of 00:00. For example, if the system was started at 10:29 am on 2/5/2016 it would create a file named 20160205\SADS2001-20160205-1029-UserLog.dat. Then at midnight a new file will be created SADS2001-20160206-0000-UserLog.dat.

10.2 File Archival and Automatic Deletion of Old Files

The analyzer can automatically compress (zip) and archive old files as mentioned above. This operation is controlled by the ini file: C:\Picarro\G2000\ AppConfig\Config\Archiver\Archiver.ini. For each file type, there are various items along with some recommended default settings which may vary by file type:

Directory = C:/UserData/DataLog_Sync

Optionally specifies which directory to find files to archive.

MaxCount = -1

Specifies how many files to keep. A setting of -1 indicates that there is no maximum number of files. Generally -1 is used in conjunction with a maximum size limit, below.

MaxSize_MB = 1500

Specifies that a maximum of 1.5 GB of data is to be kept before the system begins to delete old data.

Compress = True/False

Specifies if archived files are to be zipped – recommended setting is true to save hard drive space. True means files are zipped, false means files are not zipped.

AggregationCount = 0

If compression is set to TRUE, specifies how many files to be included in each zip archive.

StorageMode = FIFO

First in first out. Specifies that old data is deleted first.

Quantum = 4

Generally should not be changed. Specifies the files be sorted by year\month\day\hour in the archived directory structure.

In addition to the automatic file and directory management described above, the analyzer also automatically deletes various files specified in C:\Picarro\ G2000\AppConfig\Config\FileEraser\FileEraser.ini. There are various settings, as described below:

runtime_interval_hrs = 0.5

Specifies how often (in hours) to run the file eraser.

path = ../../../Log/Archive/DataLog_Private

Specifies which directory to look in for files to delete.

extension = dat

Specifies which files having what extension are to be deleted. If empty, it deletes all files.

delete_time_hrs = 48

Specifies how long to keep files prior to deletion.

10.3 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.

11. CALIBRATION

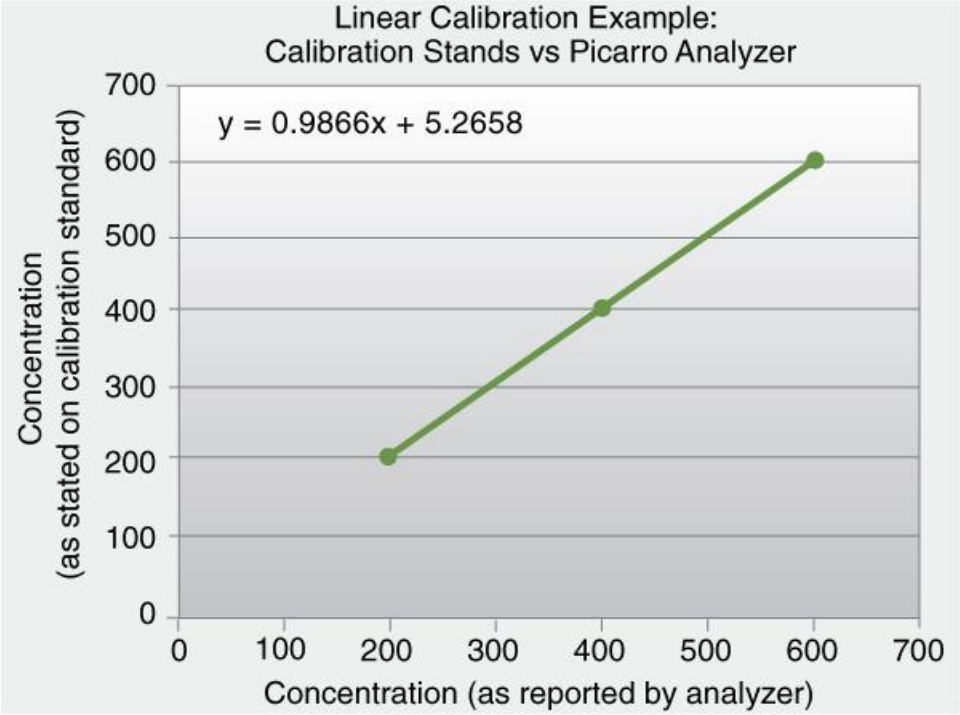
Since the Picarro Analyzer is extremely linear, it is only necessary to use three calibration standards to calibrate each gas species (two points define the calibration line and a third intermediate point is used for verification). The exact value of each calibration standard is not of particular importance 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, the user simply introduces 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. These values can then be plotted, as shown below, in a spreadsheet, for example, to determine the linear relationship between the known calibration values and the analyzer's reported values. A linear best-fit equation can be calculated from the data. It is important to plot the analyzer's reported concentration on the horizontal axis and the gas standards' stated concentrations on the vertical axis. The slope and intercept of the best-fit line through these points are the two values that are used to calibrate the analyzer. By determining what the linear relationship is between the known calibration values and the analyzer's reported concentration values in this way, a calibration offset (slope and intercept) can be calculated so as to add 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. Using the equation in the graph below, this would be accomplished point-by-point by calculating the corrected data "y" by using the analyzer's data "x" so that: Datacorrected = 0.9866•Dataraw+5.268.

	Value Given by Analyzer	Value of Calibration Standard
Calibration point #1	200.1	202.7
Calibration point #2	600.3	597.6
Calibration point #3	400.0	400.0

Figure 14: Linear Calibration Example



Calibration values are input into the software by selecting the “User Calibration” from the Tools menu and entering the slope and intercept for each species. This is a password-protected function, with the default password “picarro” and can be changed by modifying an *.ini file as previously described. 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.

12. 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 Customer Service at (408) 962-3900 or techsupport@picarro.com.

12.1 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.

a) Check that the AC power cord is attached and plugged into a working outlet.

b) Check that the rear on-off switch near the AC power cord is in the on position.

c) Press and hold the front panel power switch for at least 5 seconds as the analyzer may take several seconds to respond.

12.2 User Interface Program Does Not Start

Context: The computer may be configured to start the instrument and the associated user interface program automatically after it completes its boot-up sequence, or the program may be launched using the “Start instrument” icon on the desktop.

a) Communications problems with the analyzer may occur if the analyzer fails to initialize correctly on power up. Should the analyzer initialization process not complete correctly, shut down the instrument by shutting down the Windows operating system on the control computer: use the Start menu, select the red Shut down button and select “Shut down” in the drop-down box under “What do you want the computer to do?”. Wait for the shutdown to complete normally and for the computer and analyzer to turn off completely. After a few seconds, restart the computer by momentarily depressing the power button.

Note: Do not simply restart Windows, since this does not cycle the power to the analyzer.

12.3 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.

a) 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.

b) 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.

12.4 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.

a) Re-setting the computer and the instrument requires that the computer be shut down and restarted. If the computer responds to the mouse, a normal Windows shutdown may be carried out: use the Start menu, select the red Shut down button and select “Shut down” in the drop-down box under “What do you want the computer to do?” Wait for the shutdown to complete normally and for the computer and analyzer to turn off completely. After a few seconds, restart the computer by momentarily depressing the power button.

b) If the computer does not respond to the mouse, hold down the power switch on the front panel for a few seconds until the computer and the instrument turn off. After another few seconds, restart the analyzer by momentarily depressing the power button.

13. SERVICE AND MAINTENANCE

The advanced, rugged design of the 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 Guide or contact Picarro.

13.1 Particulate Filter Replacement

There are two in-line, sub-micron particulate filters before the measurement cavity. The first is user-replaceable and replacement filters can be purchased from Picarro and installed by the user.

CAUTION

It is important to NEVER remove the filter that is directly attached to the cavity. Only change the filter immediately following the inlet at the back of the analyzer. Refer to the filter replacement procedure in this document for further details.

The symptoms of a clogged filer can be analyzer reporting “pressure low” or there being no flow into the instrument, causing unusual measurements. Filters can become clogged after years of use in dirty environments. 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 it evaporates.

If this occurs, it is important to NOT turn off the analyzer or replace the filter until it 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.

Tools Required:

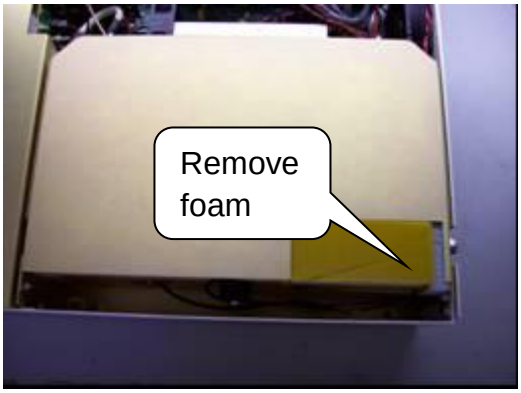
- 1.5mm hex driver
- 9/16” open-end wrench
- 5/8” open-end wrench
- 11/16” open-end wrench

Removing the Old Particulate Filter

Move the analyzer to a clean work environment

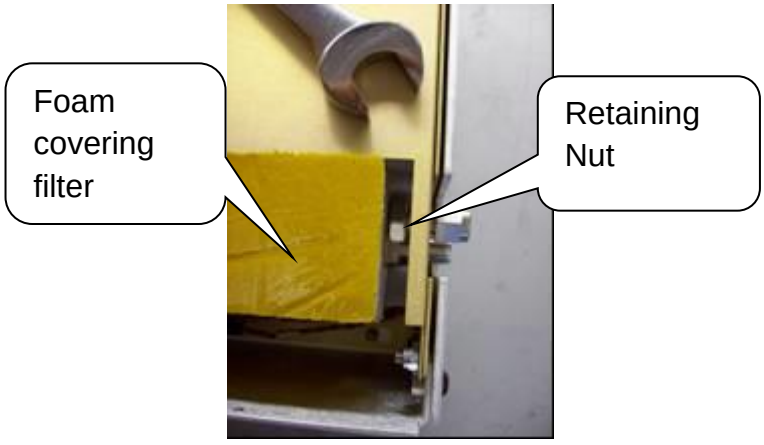
1. Using the 1.5mm hex driver, remove analyzer top lid by removing six (3 per side) M3 x 6mm socket flathead screws.
2. Remove the piece of foam from around the input bulkhead by sliding it towards the back of the analyzer.

Figure 15: View of right side of DAS



3. Using the 5/8” wrench, loosen the retaining nut on the input bulkhead (about 1 full turn should be enough).

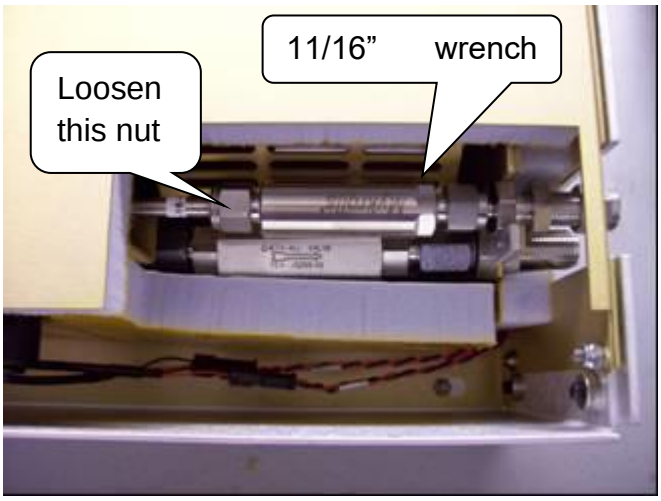
Figure 16: Bulkhead Retaining Nut loosened



4. Slide the filter cover (with foam on top and side) towards the right side of the analyzer to remove it.

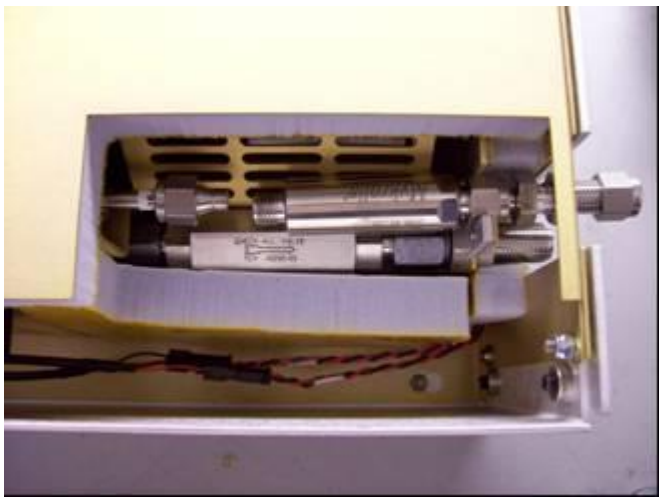
5. Using the 9/16” and 11/16” wrenches, disconnect the filter from the tube section near the front of the analzyer.

Figure 17: Filter Cover Removed



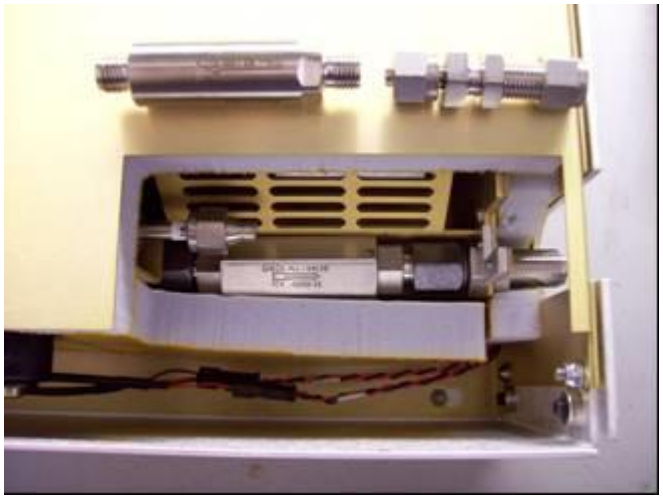
6. Slide the filter and bulkhead slightly towards the back of the analyzer and lift out.

Figure 18: Filter and Bulkhead Slid Slightly Towards Back of DAS



7. Using the 9/16” and 11/16” wrenches, disconnect the filter from bulkhead fitting.

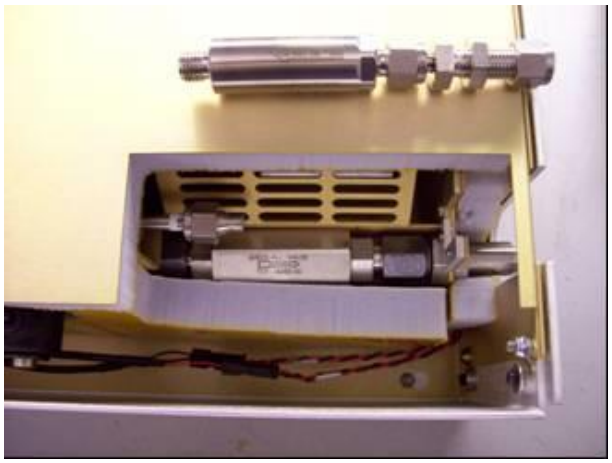
Figure 19: Filter Removed and Separated From Bulkhead Fitting



Installing the new filter:

8. 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.
9. Using the 9/16” and 11/16” wrenches, remove the filter from its packaging and attach it to the bulkhead fitting. The arrow on the filter needs to point away from the bulkhead fitting.
10. Using the 9/16” and 11/16” wrenches, reposition the filter and bulkhead fitting, and reattach to the tube section.

Figure 20: New Filter Attached to Bulkhead Fitting



11. Using the 5/8” wrench, reposition the filter cover and tighten the retaining nut on the bulkhead fitting. The metal edge of the filter cover should be under the foam of the top of the enclosure.
12. Reposition the piece of foam around the input bulkhead fitting.
13. With the 1.5mm hex driver, reattach the analyzer top with 3 screws on each side.

13.2 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.

14. 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.

14.1 Packing the Analyzer

1. Shutdown the instrument using the shutdown button, using the “prepare for shipment” option. Clean dry gas should be attached to the instrument prior to shutting down. This prevents condensation inside the system during storage or shipment.
2. Disconnect the all tubing and electrical connections from the analyzer.
3. To prevent contamination and possible damage to the connector threads, place caps on all gas connections.
4. Place the analyzer in a plastic bag with a package of desiccant. Seal the bags with tape.
5. 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 compromise its performance. When shipping the analyzer, use its original packaging only.

15. 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 nontransferable 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

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.

16. APPENDIX A – REMOTE DATA ACCESS

16.1 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 the Programming Guide (included in pdf format on the installation CD). This command set may also be used across a TCP/IP interface through an Ethernet connection. Please contact Picarro for further details.

16.2 Remote Data Access

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

1. Send data from the instrument to a list of e-mail accounts.
2. 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, and may be a dial-up connection accessible via a user-supplied USB modem. 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 setup to run periodically using the Windows task scheduler at a user-configurable frequency. If a dial-up connection to the Internet is employed, it is used only on demand in order to minimize the connection time.

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:

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. The logging section has a single key Logfile whose value is the path to the log file. Once this log file exceeds 64 kbytes 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.

16.3 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, the offset is applied to the host clock. Otherwise, the offset is recorded, but the host clock is not changed.

16.4 Email

The EMAIL section controls the sending of the data files as e-mail attachments. If the section is not present, e-mail 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 e-mail messages.

The From key is the e-mail 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 e-mail addresses to which copies of the e-mail is sent is specified by the keys To1, To2, etc. The Subject key is used to fill the subject field in the e-mail header, and may be set to any string. Depending on the SMTP server, it may be necessary to use authentication before e-mails can be sent, as described in RFC2554. If such authentication is not needed, the key UseAuthentication is set

to false. If this key is set to true, two additional keys Username and Password must also be specified for the e-mail account.

16.5 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

17. APPENDIX B - STATUS LOG MESSAGES

Normal Start Up Messages

Temperature Locked: WB (HB)

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

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

The valve control system begins to allow flow through the analyzer and stabilizes the pressure inside the cavity.

Measuring

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

18. APPENDIX C – USER DATA FILES

Column headers	Description	Units (if applicable)
DATE	Date of measurement (GMT)	Year-Month-Day
TIME	Time of measurement (instrument time, GMT)	Hour:Minute:Second.ms
FRAC_DAYS_SINCE_JAN1	Fraction of days since Jan 1 (max = 365)	
FRAC_HRS_SINCE_JAN1	Fraction of hours since Jan 1 (max = 8760)	
JULIAN_DAYS	Julian days in since Jan 1 00:00 GMT	
EPOCH_TIME	Number of seconds that have elapsed since Jan 1, 1970 GMT	
ALARM_STATUS	Binary system alarm (0 = no alarm; 1 = alarm)	
INST_STATUS	Hardware status code; should always equal 963 in proper operation	
CavityPressure	Cavity Pressure	Torr
CavityTemp	Cavity Temperature	deg C
DasTemp	Temperature measured on the data acquisition system board	deg C
EtalonTemp	Temperature measured at the wavelength monitor (WLM)	deg C
WarmBoxTemp	Temperature of the stabilized enclosure containing the WLM	deg C
species	Code for molecule measured (=64 for HCl , 63 for HCl and water)	
MPVPosition	Integer code for the valve position	
OutletValve	Integer controlling the flow through the proportional valve	
solenoid_valves	Integer code for solenoid valve controller	
HCl	Mole fraction of HCl, not corrected for effect of water vapor	ppb
HCl_30sec	30 second window average of HCl	ppb
HCl_2min	2 minute window average of HCl	ppb
HCl_5min	5 minute window average of HCl	ppb
H2O	Mole fraction of water vapor	percent

DataLog_User.dat column descriptions

19. APPENDIX D – PRIVATE DATA FILES

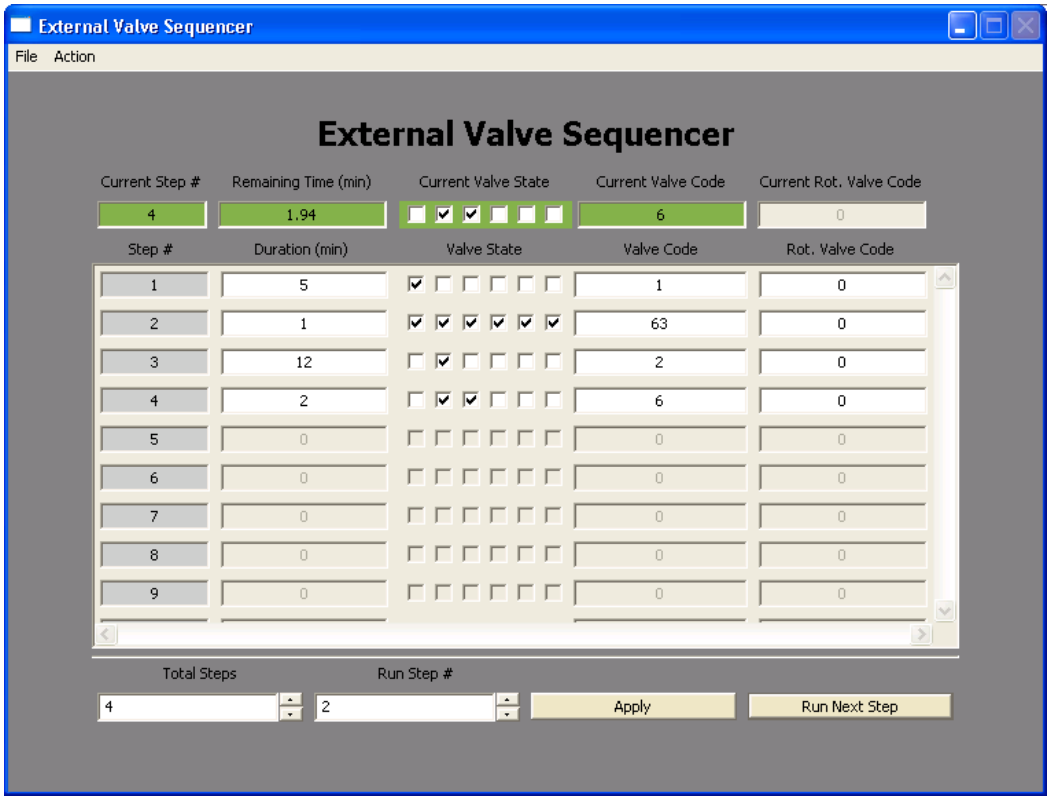
EtalonTemp	Temperature measured at the WLM	deg C
FRAC_DAYS_SINCE_JAN1	Fractional number of days since Jan 1 (max = 365)	
FRAC_HRS_SINCE_JAN1	Fractional number of hours since Jan 1 (max = 8760)	
FanState	Binary output fan off/on	
Flow1	Flow meter output (not used on this analyzer)	
H2O	Mole fraction of water vapor	percent
HCl	Mole fraction of HCl after calibration	ppb
HotBoxHeater	DAC output to hot box heater controller	DN
HotBoxHeatsinkTemp	Temperature measured at the hot box heatsink	deg C
HotBoxTec	DAC output to hot box thermoelectric cooler	DN
INST_STATUS	Hardware status code; should always equal 963 if the analyzer is operating properly	
InletValve	DAC output to proportional valve at cavity inlet	DN

Private Data Log column headers	Description	Units (if applicable)
SchemeVersion	Version number for scheme used to control data acquisition	
SpectrumID	Integer code identifying the spectrum used to generate this line of data (=64 for HCl only, 63 for HCl and water)	
ValveMask	Integer code describing the state of the valve sequencer	
WarmBoxHeatsinkTemp	Temperature measured at the warm box heatsink	deg C
WarmBoxTec	DAC output to warm box thermoelectric cooler	DN
WarmBoxTemp	Temperature measured at the warm box	deg C
base_70a	Absorption baseline at the frequency of the HCl line	ppb/cm
baseline_level	Constant term in the polynomial (in frequency) representation of baseline absorption	ppb/cm
baseline_slope	Linear term in the polynomial representation of baseline absorption	ppb/cm per wavenumber
cal_enabled	Binary flag set to 1 if WLM calibration is enabled	
cavity_pressure	Cavity Pressure	Torr
cavity_temperature	Cavity Temperature	deg C
dm_latency	"Data manager latency": time between mean time of ring-downs and invokation of the	seconds
fittime	Time spent in the fit script for this spectrum	seconds
h2o_conc_raw	Uncalibrated water concentration from fit to strong water line	percent
hcl_adjust	Frequency adjustment to be applied to WLM	wavenumbers
hcl_conc	HCl concentration from hcl_conc_raw adjusted for cross-talk for water and methane, b	ppb
hcl_conc_raw	Uncalibrated HCl concentration = coefficient times peak absorption of HCl uncorrected	ppb
hcl_shift	Frequency shift between the best-fit to thewide HCl+H2O spectrum and the frequency a	wavenumbers
hcl_shifta	Frequency shift between the best-fit to the narrow HCl only spectrum and the frequenc	wavenumbers
interval	Difference between successive time stamps of the spectra ssent to the fitter	seconds
max_fitter_latency	Time interval between mean time of ring-downs and reporting from the slowest fitter (	seconds
ngroups	Number of different optical frequencies comprising the spectrum	Integer
numRDs	Number of ring-down measurements comprising the spectrum	Integer
peak_62	Peak absorption of the water line from Levenberg-Marquardt fit	ppb/cm
peak_70	Peak absorption of the HCl line adjacent from the fit to the wide spectrum with HCl and	ppb/cm
peak_70a	Peak absorption of the HCl line adjacent from the fit to the narrow spectrum with HCl o	ppb/cm
pzt_mean	Mean value of the ADC output to the high voltage source for the piezoelectric translato	DN
pzt_stdev	Standard deviation of the ADC output to the high voltage source for the piezoelectric tr	DN
res	RMS average residual of the Levenberg-Marquardt fit	ppb/cm
solenoid_valves	Integer code for solenoid valve controller	
species	Integer code designating the molecule being measured (=64 for HCl only, 63 for HCl and water)	
spect_duration	Time spent acquiring the spectral data (time between first and last ring-down in spectr	seconds
spect_latency	Time interval between mean time of ring-downs and reporting from the spectrum colle	seconds
str60	Coefficient multiplying normalized Galatry function for the water line, from Levenberg-	ppb/cm
str70	Coefficient multiplying normalized Galatry function for the HCl line, from fit to the wide	ppb/cm
str70a	Coefficient multiplying normalized Galatry function for theHCl line from the narrow spe	ppb/cm
time	Number of milliseconds since midnight Jan. 1, 1970 (also called EPOCH_TIME)	milliseconds
timestamp	Unix time stamp for this spectrum	milliseconds
wlm1_offset	Current frequency offset of the wavelength monitor	wavenumbers
y_62	Collisional broadening parameter for the water line	dimensionless number
y_70	Collisional broadening parameter for the HCl line	dimensionless number

20. APPENDIX E – EXTERNAL VALVE SEQUENCER

The Picarro valve sequencer window appears as in Figure 15 below:

Figure 21: Valve Sequencer Layout



20.1 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.

20.2 Default Configuration

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

20.3 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 current requirement of <1.5 Ampere maximum. 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.

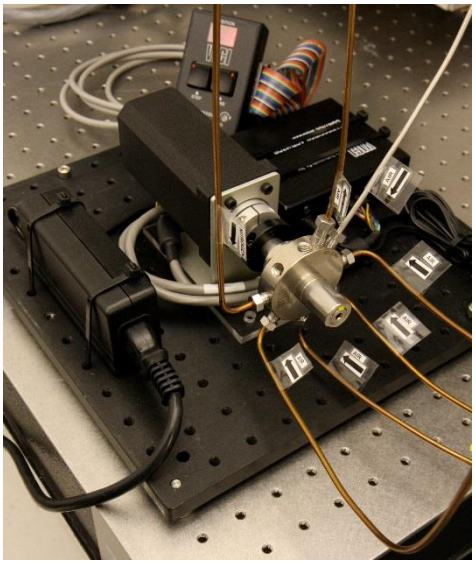
20.4 Setting Up Rotary Selector Valve

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 (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 (female) should mate with its corresponding, male port of the analyzer and labeled “MPV”. Please note the 9 pin connector cable is not supplied with the instrument.

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

Figure 22: Rotary Selector Valve Setup



20.5 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.

20.6 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 <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.

20.7 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.