Using the LI-830 and LI-850 Gas Analyzers

LI-COR®

Using the LI-830 and LI-850

Gas Analyzers

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Notes on Safety

This LI-COR product has been designed to be safe when operated in the manner described in this manual. The safety of this product cannot be assured if the product is used in any other way than is specified in this manual. The product is intended to be used by qualified personnel. Read this entire manual before using the product.

Equipment markings:	
	The product is marked with this symbol when it is necessary for you to refer to the manual or accompanying documents in order to protect against injury or damage to the product.
	The product is marked with this symbol when a hazardous voltage may be present.
	The product is marked with this symbol if a Chassis Ground connection is required.
	The product is marked with this symbol to indicate that a direct current (DC) power supply is required.
WARNING	Warnings must be followed carefully to avoid bodily injury.
CAUTION	Cautions must be observed to avoid damage to your equipment.
Manual markings:	
Warning	Warnings must be followed carefully to avoid bodily injury.
Caution	Cautions must be observed to avoid damage to your equipment.
Note	Notes contain important information and useful tips on the operation of your equipment.

CE Marking:

This product is a CE-marked product. For conformity information, contact LI-COR Support at envsupport@licor.com. Outside of the U.S., contact your local sales office or distributor.

California Proposition 65 Warning

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Federal Communications Commission Radio Interference Statement

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed in accordance with the instruction manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC rules, which are designed to provide a reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user, at his own expense, will be required to take whatever measures may be required to correct the interference.

Waste Electronic and Electrical Equipment (WEEE) Notice

This symbol indicates that the product is to be collected separately from unsorted municipal waste. The following applies to users in European countries: This product is designated for separate collection at an appropriate collection point. Do not dispose of as household waste. For more information, contact your local distributor or the local authorities in charge of waste management.

LI-830 CO2 气体分析仪 and LI-850 CO2 / H2O 气体分析仪 LI-830 CO_2 Gas Analyzer and LI-850 CO_2/H_2O Gas Analyzer						
零件名称 Part Name	有毒有害物质或元素 Toxic and Hazardous Substances or Elements					
	铅 (PB)	汞 (Hg)	镉 (Cd)	六价铬 (Cr(VI))	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
印刷电路板 (PCBs)	X	O	O	O	O	O
机电零件 (Electromechanical Parts)	X	O	O	O	O	O
光学平台 (Optical Bench)	X	O	O	O	O	O
泵套件 (Pump Kit)	X	O	O	O	O	O
金属零件 (Metal Parts)	X	O	O	O	O	O
外壳 (Enclosure)	X	O	O	O	O	O
显示 (Display)	O	O	O	O	O	O

该表是根据SJ / T 11364的规定编制的。

O = 表示零件所有均质材料中有毒有害物质的含量低于GB / T 26572中所述的浓度极限要求

indicates that the content of the toxic and hazardous substance in all the Homogeneous Materials of the part is below the concentration limit requirement as described in GB/T 26572

X = 表示零件的至少一种均质材料中有毒有害物质的含量超过了GB / T 26572中所述的浓度极限要求

indicates that the content of the toxic and hazardous substance in at least one Homogeneous Material of the part exceeds the concentration limit requirement as described in GB/T 26572

Doc. #53-19136
January 10, 2020

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Section 1.
Introduction to the instruments

The LI-830 and LI-850 gas analyzers both measure CO_2 in air at concentrations from 0 to 20,000 ppm. The instruments differ in that the LI-850 measures water vapor in air, but the LI-830 does not. As a consequence of the water vapor measurement, the LI-850 is able to measure CO_2 concentrations with greater accuracy than the LI-830. Regardless of this difference, operating both instruments is essentially the same. This document provides basic operating instructions for the analyzers.

Online resources

In addition to the contents of your box, you may be interested in the following resources. All are available from www.licor.com/env/support. Select the **LI-830 and LI-850 Analyzer**.

Application software

The software used to interact with the instrument is available for both Windows® and macOS® operating systems. It is used to configure the instrument, read measurements, and configure data logging to a computer. For Windows 7 and 8, the device drivers must be installed manually before you can connect with the instrument. Software is available from licor.com/830-850-support.

Integrator's guide

The Integrator's Guide describes how to control the instrument using a terminal program and read data in a command-line interface.

Instruction manual

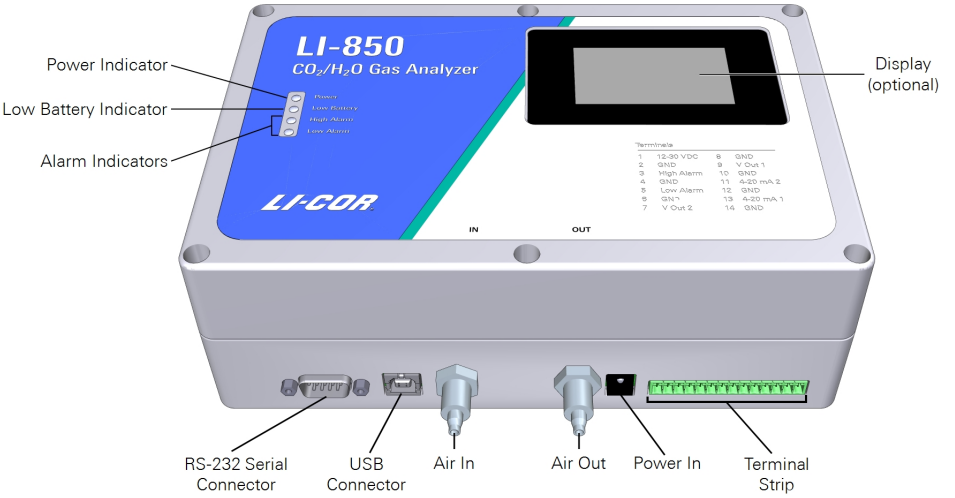
A .pdf version of this document can be downloaded to your computer.

What's what

The LI-830 and LI-850 include a core set of components and each may include optional components. These are described below.

Gas analyzer

This is the gas analyzer in an enclosure. It may include an optional built-in pump and display.



- **Power** indicator: Illuminates when the instrument is powered on.
- **Low Battery** indicator: Illuminates if the power supply voltage drops below 10.5 volts. The instrument will continue to operate with a low battery, but expect a corresponding decline in performance.
- **Alarm** indicators illuminate if an alarm threshold has been crossed. See *Using alarms* on page 3-9.
- **RS-232 Serial** and **USB** connectors to connect with a computer or serial device.
- **Air Inlet** and **Air Out**lets are shipped with covers in place. Keep the covers so you can put them back over the ports when the analyzer is not in use.
- **Power In:** Compatible with 12 to 30 VDC power supplies.
- The **Terminal Strip** has another power connector and outputs for alarms and digital-to-analog converters (DAC).

Accessories kit

Part Number
9980-065

The instrument includes a standard accessories kit, which has accessories and some replacement parts for your gas analyzer. The accessories kit includes the following components:

Description	Quantity	Part Number
Universal power supply; Input: 100 to 240 VAC, 50 to 60 Hz; Output: 12 VDC, 2.5 amps	1	591-19495
Outlet adapter kit for universal power supply	1	591-13033
USB cable; Standard 1.8 m USB-A to USB-B[a]	1	392-06652
RS-232 null modem, cross-over cable kit[a]	1	9975-016
14-pin terminal block; Includes label sticker (250-05340)	1	331-05273
Tube fitting nuts for air inlet and outlet	2	9861-036
Bev-a-line IV plastic tubing; 3.6 meter roll	1	222-01824
Air filters	2	9967-008
Quick-connect straight unions	2	300-03123
Cleaning kit	1	9980-066
3" Source and detector cleaning swabs	5	610-05314
5" Optical path cleaning swabs	5	610-05315
O-Rings (AS-018 Nitrile 70)	4	192-00226
Black polyurethane feet	4	234-02268

Air pump (optional)

An optional air pump is available for the gas analyzer. The pump (if applicable) is installed in the gas analyzer case. If you want to add a pump, you can order one later.

Display (optional)

An optional display is available. The display shows CO_2 concentration, H_2O concentration (LI-850 only), bench temperature, and pressure.

[a]The use of cables other than those provided may result in improper electrical performance.

Section 2.
Connecting with the analyzer

The following tutorial describes the basic steps you'll follow when you turn on the LI-830 or LI-850 for the first time.

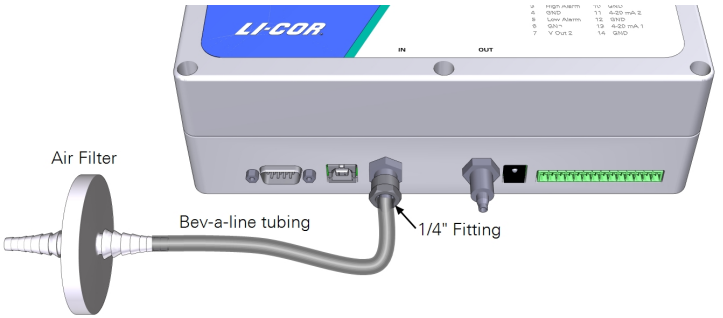
1 Install the software on your computer

The software is used to configure data communication, analog and digital outputs, alarms, data logging, and to verify the calibration. Software is available from licor.com/env/support/LI-850/software.html.

2 Install an air filter on the air-in port

> **Caution:** Always install an air filter on the input air before operating the LI-830 or LI-850. Failure to use a filter will cause contamination of the optical bench. As an extra precaution, you can blow compressed air through the filter in the normal flow direction to remove any contaminants.

Retrieve an air filter and tubing from the accessories kit. Cut a 5 to 10 cm piece of tubing. Attach the filter and tubing to the air-in port. Observe the arrow on the filter and be sure that the air flow is in the proper direction.



3 Install the USB cable

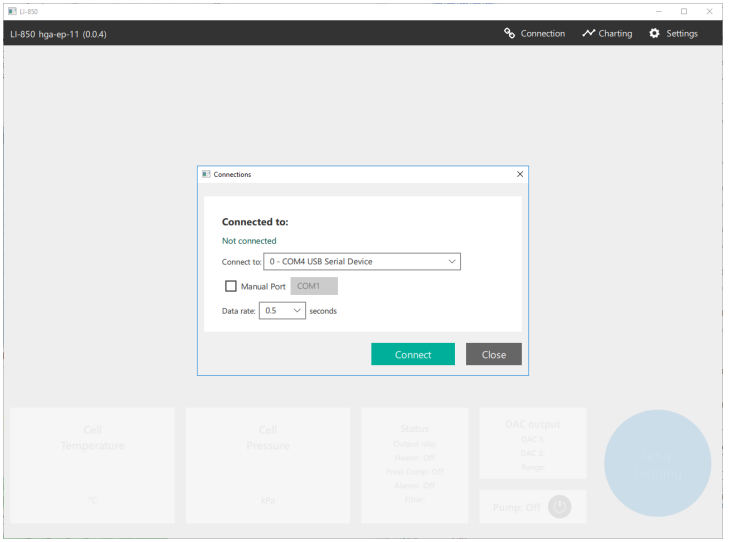
The USB connection is the simplest way to connect the analyzer with a computer. If you want to use the RS-232 serial connection instead, connect the cable to the serial port, and install a serial-to-USB adapter on the serial cable, if needed.

4 Power on the gas analyzer

The LI-830 and LI-850 will turn on when power is supplied, so plug in the power cable to turn it on. If you use an alternative power supply, it must be able to source a minimum of 1.2 A at 12 VDC while the instrument warms up. After the warmup, the instrument will draw about 0.3 A at 12 VDC.

5 Connect with the gas analyzer

Start the software.

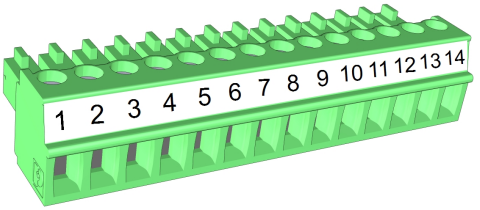


Click the **Connection** button in the upper right of the display. Select your instrument from the list, set the data rate, then click **Connect**. Data will populate the window after connecting. You can enter the COM port manually by checking Manual Port and setting the port number (COM#).

If you are using Windows® 7 or 8, install the drivers before you connect, as described in *Installing device drivers* on page 2-5.

The terminal strip

The terminal strip connects to the front panel of the instrument. The pin assignments are given on the top of the instrument, and there is a sticker in the accessories kit that you can use to help identify which terminal is which.



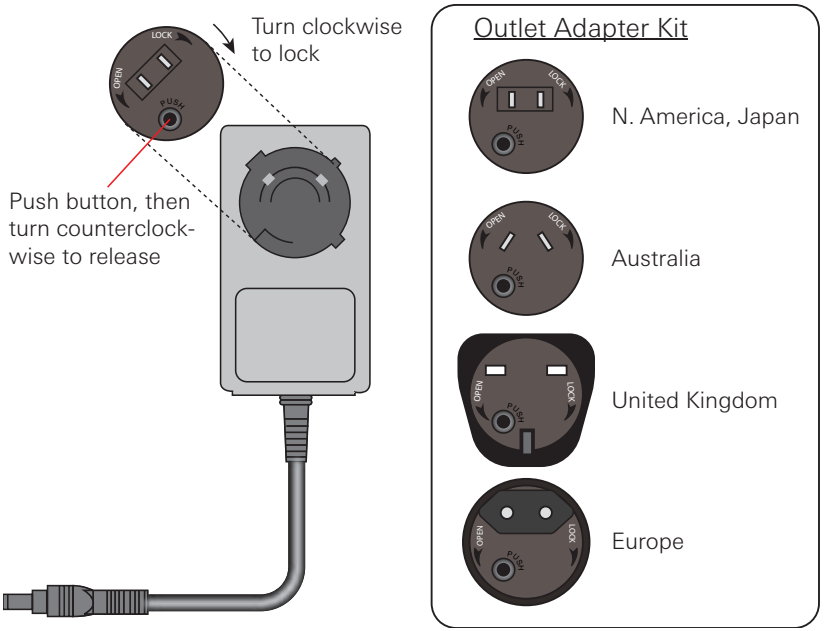
Terminal	Label	Description
1	12-30 VDC	Voltage In, 12-30 VDC
2	GND	Ground
3	High Alarm	High Alarm
4	GND	Ground
5	Low Alarm	Low Alarm
6	GND	Ground
7	V OUT 2	Voltage output channel 2
8	GND	Ground
9	V OUT 1	Voltage output channel 1
10	GND	Ground
11	4-20 mA 2	Current output channel 2
12	GND	Ground
13	4-20 mA 1	Current output channel 1
14	GND	Ground

Powering the LI-830 and LI-850

A power supply—either a battery or the universal power adapter—can be connected to the LI-830 and LI-850 power jack or to pins 1 and 2 on the terminal strip. The instruments require 12 to 30 VDC. The power supply must be able to provide 14 watts (1.2 A at 12 V) during warmup and about 3.6 watts (0.3 A at 12 V) during normal operation.

Using the universal power adapter

The included power supply is compatible with mains power in most localities globally (input 100 to 240 VAC, 50 to 60 Hz; output 12 VDC, 2.5 amps). You may need to install different blades from the outlet adapter kit to fit your wall outlets.



Using the terminal strip power connectors

The terminal strip has connectors for any power supply that has bare leads. Pin 1 is the positive (+) terminal, and pin 2 is the negative (-) terminal.

Installing device drivers

If you are using Windows 7 and 8, you'll need to install device drivers. After connecting the LI-830 and LI-850 to your computer with the USB cable, follow these steps:

1. Download the drivers and unzip the file.

   Drivers are available at licor.com/env/support/LI-850/software.html or directly at licor.com/documents/pamrygkdwsl8c61wj6y815gnf4tukh3t

2. Press the Windows key (), type **Device Manager**, and press **Enter** to open your device manager.
3. Under **Other Devices**, select the LI-830/LI-850.
4. Right-click LI-830/LI-850 and select **Update Driver Software**.
5. Browse and select the folder with the driver files.
6. Click **Next** to finish installing the drivers.

   When they are installed, you should see **LI-COR 8x0** under **Ports (COM & LPT)**.

Storing the gas analyzer

When you are done using the gas analyzer, follow these practices to be sure that it is ready to use the next time you need it. The instrument can be stored in non-condensing conditions. If the instrument is stored in high humidity or moderate humidity for a long time while powered off, some optical components may temporarily become saturated with humidity. If this occurs, the instrument may need to run for several days before readings return to normal. When storing the instrument.

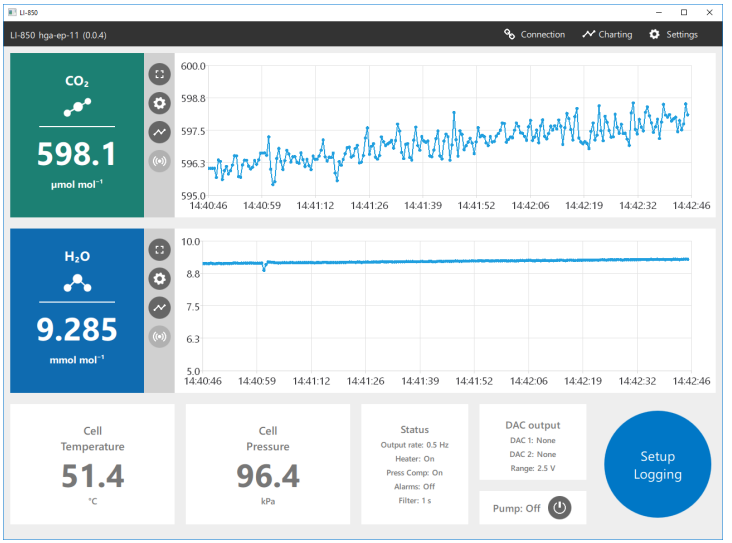
- Install the covers over the air inlet and outlet. This will keep dust, bugs, and other contaminants out of the optical cell.
- Disconnect the power supply and power wires.
- If possible, store the instrument in an air conditioned environment.

Section 3.
Configuring the gas analyzer

This section describes the basic operating procedures for the LI-830 and LI-850 gas analyzers. This section depends upon the instrument software, which can be downloaded from the LI-COR technical support web site: www.licor.com/env/support.

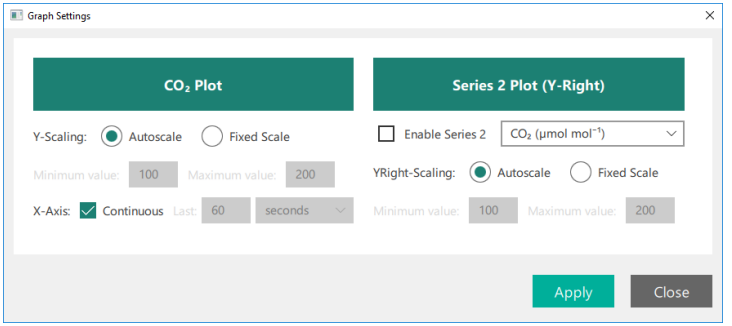
Overview of the software

After connecting, the software presents you with live data and graphs. With the LI-830, you'll have CO_2; with the LI-850, you'll have both CO_2 and H_2O.



Configuring graphs

The software will always display a graph on the main page (two with the LI-850), and you can configure the graphs by clicking the **Charting** button or any of the **Chart Settings** buttons beside a particular chart. The options available are the same, regardless of how you get to them.



The graphs display a fixed variable: CO_2 and H_2O with the LI-850. You can configure the settings for each graph and add a second variable. The options are:

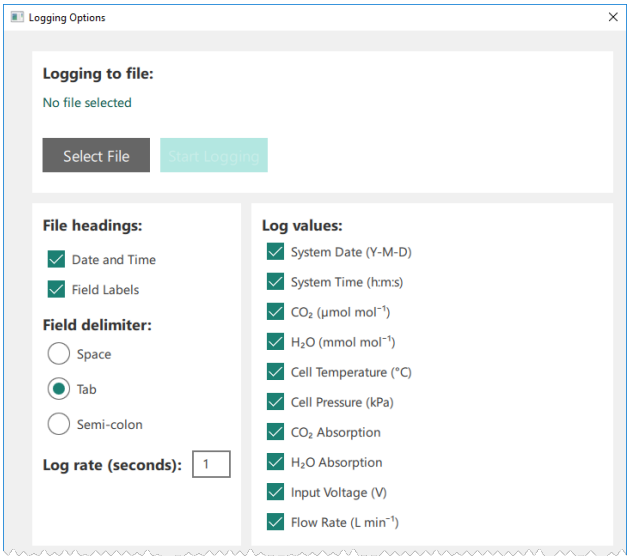
Y-Scaling: Choose **Autoscale** or **Fixed Scale**. With **Fixed Scale**, you can set the minimum and maximum value for each variable displayed.

X-Axis: With **Continuous** checked, the graph will display all of the data from the time you connect to the instrument, rescaling the x-axis when needed. With **Continuous** cleared, the graph can be configured to display the most recent data for a time period.

Series 2 is an option to plot a second variable on the graph with scaling on the right axis. When checked, you can choose from CO_2 concentration, cell temperature, cell pressure, CO_2 absorption, or input voltage. With the LI-850, the H_2O concentration, H_2O dewpoint, and H_2O absorption will also be available.

Logging data to a PC

The instrument can log data as a text file, which will be stored to the connected computer. Configure the log file under **Settings > Logging Options**. To log data:



1 Create a file.

Click **Select File**, then choose the directory where you want to store the file, and name the file.

2 Configure the log parameters.

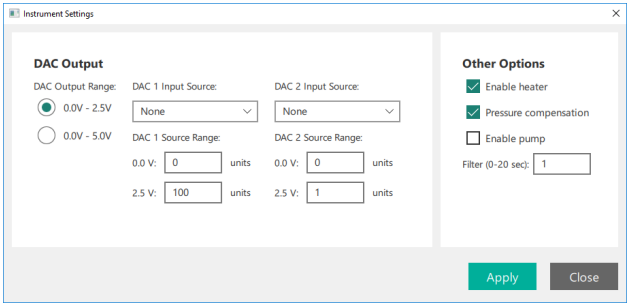
- **File headings**: When checked, the **Date and Time** and **Field Labels** for data columns will be included in the data file header.
- **Field delimiter**: Choose between a space, tab, or semi-colon delimited text file.
- **Log rate (seconds)**: How often a value is recorded. This can be one measurement per 0.5, 1, 2, 3, 4, 5, 10, or 20 seconds. It is independent of the **Filter** setting (described in *Other options* on page 3-8).
- **Log values**: Select the values you want in the log file.

3 Click **Start logging**.

The instrument will create a text file according to the parameters you set. You can open the logged data in a text editor or most spreadsheet programs.

Instrument settings

Under **Instrument > Settings**, you'll find the **DAC** (digital-to-analog) **Outputs** (0 to 2.5 V, which also enables the 4 to 20 mA output, and 0 to 5 V, which disables the 4 to 20 mA output), and **Other Options**, including the heater controls, pressure compensation control, pump control, and the digital signal filter. The 4 to 20 mA output is enabled only when the 0 to 2.5 V range is selected.



Configuring the DAC outputs

This section describes how to configure the voltage and current outputs. Both voltage and current outputs are configured at the same time, in the same place:

- **DAC 1** configures **V Out 1** (pin 9) and **4-20 mA 1** (pin 13; only when the 0 to 2.5 V range is selected) on the terminal strip
- **DAC 2** configures **V Out 2** (pin 7) and **4-20 mA 2** (pin 11; only when the 0 to 2.5 V range is selected) on the terminal strip

Optimizing the DAC resolution

When configuring the analog outputs, keep in mind that the selected ppm range will affect the resolution of data that is sent over the analog outputs.

Think of it like this: The 16-bit DACs can output a fixed number of values (65,536 to be exact). If a DAC is configured to output 0 to 5000 mV, you will have resolution of 0.076 mV per count.

$$\frac{5000\ mV}{65536\ counts} = 0.076\ mV/count \qquad 3\text{-}1$$

With the 0 to 5 volt output range corresponding with a 0 to 20,000 ppm CO_2 concentration range, the finest change in concentration that can be resolved is equal to 0.31 ppm.

$$\frac{20000\ ppm\ range}{65536\ counts} = 0.31\ ppm/count \qquad 3\text{-}2$$

If you are measuring concentrations between 0 and 10,000 ppm, the range is 10,000 ppm. By configuring the DAC range for 0 V = 0 ppm CO_2 and 5 V = 10,000 ppm, the DAC output will have twice the resolution as it would in the previous configuration.

$$\frac{10000\ ppm\ range}{65536\ counts} = 0.15\ ppm/count \qquad 3\text{-}3$$

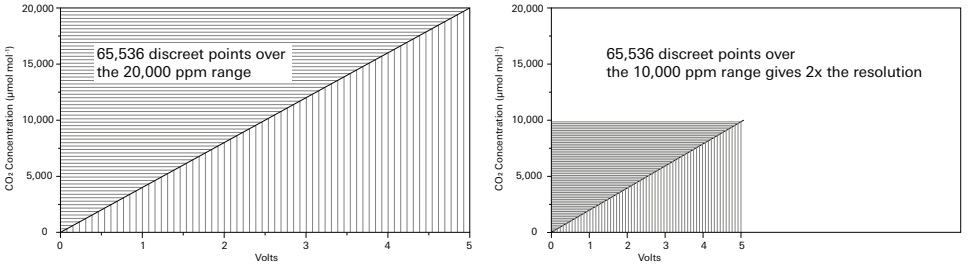


Figure 3-1. The resolution of the analog outputs depends upon the range. If the DACs are configured to output data over the full 0 to 20,000 ppm range, the data output over the DACs will have lower resolution (left). If the DACs are configured to output data over a narrower range (for example, 0 to 10,000 ppm as shown on the right), the data output over the DACs will have higher resolution.

Also keep in mind that the instrument will not output meaningful information over the DACs if the measured value is outside of the configured output range.

Computing readings from the DAC output

Here we give some example computations.

Example 1: Computing CO_2 from a voltage output; 0 to 500 ppm range

The CO_2 concentration is calculated from the DAC output. In this example, let's configure the output range for 0 V = 0 ppm and 5 V = 500 ppm. The concentration is computed from:

$$CO_2 = V_{output}\left(\frac{CO2_{range}}{V_{range}}\right) \quad 3\text{-}4$$

If the output voltage is 2.9 V, then

$$CO_2 = 2.9\ V\left(\frac{500\ ppm}{5\ V}\right) = 290\ ppm \quad 3\text{-}5$$

Example 2: Computing CO_2 from a voltage output; 300 to 500 ppm range

In this example, let's configure the output range for 0 V = 300 ppm and 5 V = 500 ppm, so the full range is 200 ppm, and notably, 0 V is no longer 0 ppm.

$$CO_2 = V_{output}\left(\frac{CO2_{max} - CO2_{min}}{V_{range}}\right) + CO2_{min} \quad 3\text{-}6$$

$CO2_{max}$ is the reading that corresponds with the high voltage output (500 ppm in this case), and $CO2_{min}$ is the reading that corresponds with the low voltage output (300 ppm in this case). With an output voltage of 2.9, the concentration is:

$$CO_2 = 2.9\ V\left(\frac{200\ ppm}{5V}\right) + 300\ ppm = 416\ ppm \quad 3\text{-}7$$

Example 3: Computing CO_2 from a current output; 0 to 500 ppm range

Unlike the voltage outputs, which are 0 to 2.5 or 0 to 5 V, the current outputs are from 4 to 20 mA (the 4 to 20 mA output is only available when the 0 to 2.5 V range is selected). Therefore, the range is always 16 (20 - 4), and the offset is always 4. Electrical current is indicated with *I*. In this example, let's configure the output range for 4 mA = 0 ppm and 20 mA = 500 ppm. The concentration is computed from:

$$CO_2 = (I_{output} - 4) \times \left(\frac{CO2_{range}}{I_{range}}\right) \quad 3\text{-}8$$

If the current is 16.25 mA, then

$$CO_2 = (16.25\ mA - 4) \times \left(\frac{500\ ppm}{16\ mA}\right) = 382.8\ ppm \quad 3\text{-}9$$

Example 4: Computing CO_2 from a current output; 300 to 500 ppm range

In this example, let's configure the output range so that 4 mA = 300 ppm and 20 mA = 500 ppm (the 4 to 20 mA output is only available when the 0 to 2.5 V range is

selected). Now, we need an offset that corresponds with the minimum CO_2 reading (300 ppm).

$$CO_2 = (I_{output} - 4) \times \left(\frac{CO2_{max} - CO2_{min}}{16\ mA}\right) + CO2_{min} \quad \text{3-10}$$

If the current is 16.25 mA, then

$$CO_2 = (16.25\ mA - 4) \times \left(\frac{200\ ppm}{16\ mA}\right) + 300\ ppm = 453\ ppm \quad \text{3-11}$$

Example 5: Computing cell temperature from a voltage output

Cell temperature (T in °C) is calculated from the DAC output with the following:

$$T = (X_F - X_Z)\frac{V}{V_{max}} + X_Z \quad \text{3-12}$$

where X_F is the full scale temperature value that corresponds to the high voltage, X_Z is the temperature value that corresponds to the low voltage, V is the voltage reading, and V_{max} is the output range (either 2.5 V or 5 V).

Example 6: Computing cell pressure from a voltage output

Cell pressure (kPa) can be computed from a voltage output with the following:

$$Pressure = (X_F - X_Z)\frac{V}{V_{max}} + X_Z \quad \text{3-13}$$

where X_F is the full scale pressure value that corresponds to the high voltage, X_Z is the pressure value that corresponds to the low voltage, V is the voltage reading, and V_{max} is the output range (either 2.5 V or 5 V).

Other options

Enable heater: The heater should be enabled to maintain the optical bench temperature. Normally the optical bench will be about 51.4 °C. If you disable the heater, the instrument will not perform as specified.

Pressure compensation: Pressure compensation should be applied to ensure that the instrument compensates for changes in pressure. Disabling pressure compensation will lead to less accurate measurements.

Enable pump: If your instrument is equipped with a pump, this box will be interactive. Check it to turn the pump on. Clear it to turn the pump off.

Filter: The digital filter instructs the instrument to average the readings. A value of 0 means no averaging, whereas a value of 20 instructs the instrument to average the previous 20 seconds of measurements. Increasing the averaging time will decrease the variation in each reported value, but will also reduce the instrument response time.

Using the pump

For instruments that are equipped with the LI-COR-installed pump, the pump is activated through the interface.

> **Note:** The pump will not run until the optical cell has reached the operating temperature of about 50 °C, regardless of the setting. If the cell temperature drops below 50 °C, the instrument will disable the pump temporarily until the cell warms back up.

To turn on the pump from the main window, click the pump button so it reads Pump: On. Or, click Settings > Instrument and check Enable pump.

Using alarms

The alarms can be set for CO_2 or H_2O (in the LI-850). Each alarm features an activation level and a deadband. The high alarm is activated if the measured concentration exceeds a high threshold. The high deadband is the range below the threshold that the alarm remains activated. The low alarm is activated if the measured concentration drops below a low threshold. The low deadband is the range above the low threshold that the alarm remains activated.

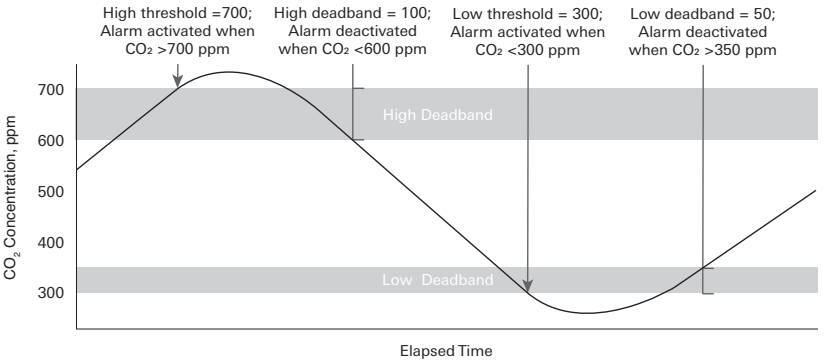


Figure 3-2. An alarm is triggered when a concentration is outside of a threshold. For example, the high alarm is activated if the CO_2 concentration exceeds 700 ppm. The alarm is deactivated when the concentration drops below 600 ppm (high deadband = 100). The low alarm is activated if the concentration drops below 300 ppm and is deactivated when the concentration rises above 350 ppm (low deadband = 50).

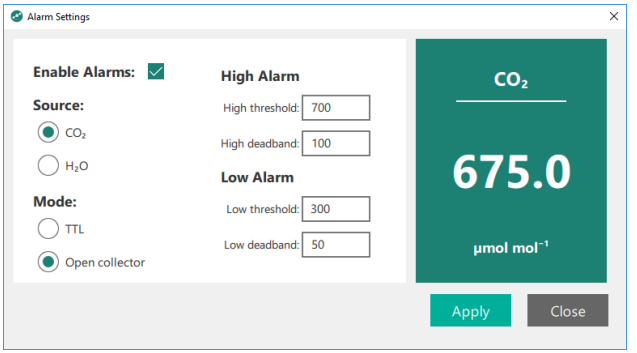


Figure 3-3. The **Alarm Settings** *window is where you configure alarms. The settings shown here will give the behavior shown in Figure 3-2 above.*

In **TTL mode** (transistor-to-transistor logic), the instrument sends a +5 V signal when the alarm is off and a 0 V signal when it is on. The alarm can be used to activate a relay switch or send a digital signal, for example. In **Open collector mode**, the alarm works like a switch. There is infinite resistance when the alarm is off and low resistance when the alarm is on, allowing current to flow between the pins.

Alarms are configured under **Settings > Alarm Thresholds**. To configure the alarms:

1. Check **Enable Alarms**.

   Select whether the alarm should be for CO_2 or H_2O (with the LI-850). Alarms can be set for one or the other, not both.

2. Configure the **High Alarms**.
   - The **High threshold** is the high level at which the alarm is activated.
   - The **High deadband** is the range below the high threshold that the alarm remains activated.

3. Configure the **Low Alarms**.
   - The **Low threshold** is the low level at which the alarm is activated.
   - The **Low deadband** the range above the low threshold that the alarm remains activated.

4. Click **Apply** when you are done.

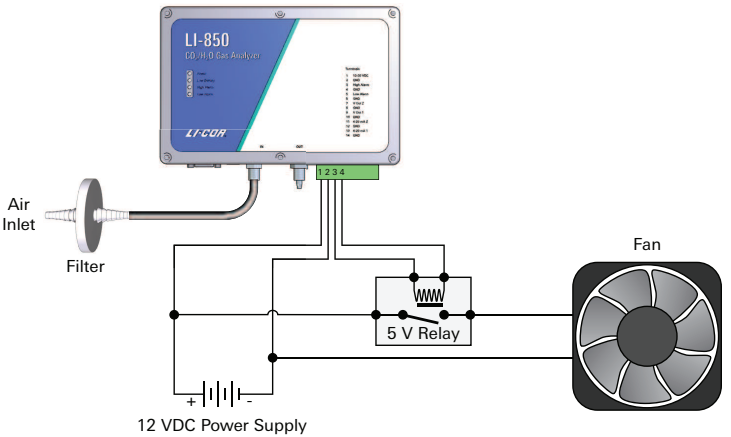


Figure 3-4. In this example, the high alarm is used to activate a relay, which turns on a fan.

Section 4.
Troubleshooting

In this section, we describe how to identify some potential problems. If you can't find a solution here, contact your local distributor or LI-COR technical support for more help.

Instrument will not power on

Power supply adequate? The power supply should source at least 1.2 amps at 12 VDC (minimum of 14 watts during warmup).

Blown fuse? The instrument can be powered from the power jack or pins one and two on the terminal strip. Each connection has its own fuse.

- If you are unable to power on the instrument using the jack, but can power it on using the terminal strip, you probably have a blown power jack fuse.
- If the opposite is true, you probably have a blown terminal strip fuse.
- If you can't power it using either connection, you may have blown both fuses.

Check the resistance across the fuse contacts using an ohm meter. A reading of 0 means that the fuse is good; a reading of 1 indicates that the fuse is blown.

See *Replacing a fuse* on page 5-6 for complete instructions.

Unable to span or zero the instrument

Dirt in the optics? If the optical cell becomes contaminated, the instrument will drift in either the zero or span.

See *Cleaning the optical bench* on page 5-4 for complete instructions.

Instrument reports -50 ppm CO_2 or measurements jump around

If the instrument measures -50 ppm or the measurements are going between negative and positive values, or just simply not making any sense, the optical source may have failed or be in the midst of failure. Contact technical support for additional troubleshooting help.

Section 5.
Maintenance

The LI-830 and LI-850 will require little maintenance. Typical maintenance procedures are described in this section.

User calibration

If the instrument is not measuring as expected, or if you have disassembled the optical bench for any reason, you should check the zero and span settings and set them if necessary. The zero and span are an offset and slope. The zero value ensures that the instrument shows zero when the gas has a zero concentration. A change in the zero will affect every measurement. The span setting ensures a correct measurement at a known non-zero concentration. A change in the span affects higher concentration measurements more than lower ones.

Setting the CO_2 zero

Always perform the zero first. To set the zero, you'll need either a tank of dry air that is free of CO_2 or a CO_2 scrubbing chemical such as wet soda lime and a desiccant such as Drierite.

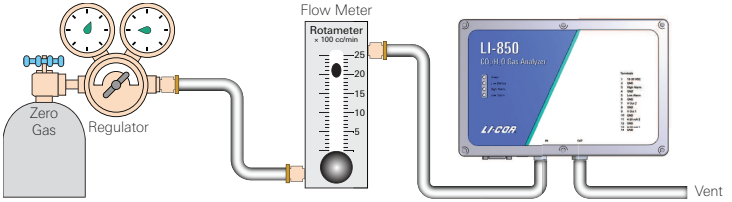
1 Plumb the zero-gas tank or scrubber to the air inlet.

Be sure to use an air filter to prevent contaminants from entering the optical path.

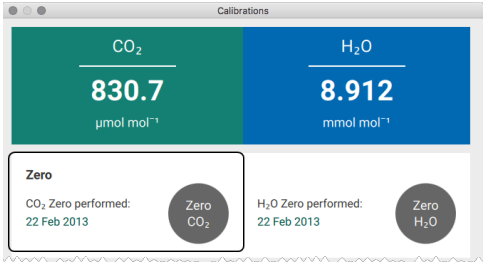
- If using tank air, the pressure of the tank is sufficient to flow the gas through the analyzer. Allow at least 0.75 liters per minute to flow through the cell (no more than 1.0 lpm).
  Caution: Disable the pump to allow tank pressure to drive the flow of calibration gases.
- If using a scrubbing chemical, use the internal pump or a user-supplied pump to draw air through the analyzer.

2 Install a 10 to 20 cm length of tubing to the air outlet.

This vent prevents ambient air from diffusing upstream into the optical cell.



3 When the CO_2 concentration has stabilized, click the **Zero CO_2** button.

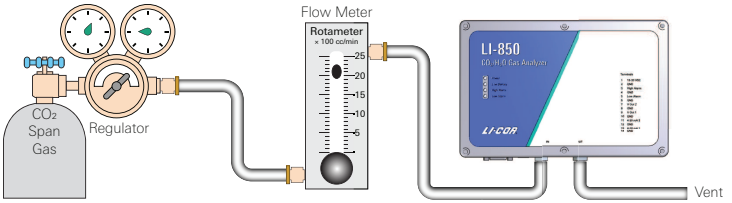


Setting the primary CO_2 span

When choosing a span gas, we recommend a gas concentration that is close to the upper limit of what you expect to measure. For example, if you are measuring near-ambient levels, choose a span gas that is near 400 ppm CO_2 (as opposed to 18,000 ppm). Similarly, if you are measuring concentrations near 15,000 ppm CO_2, a span gas with 100 ppm would not be ideal.

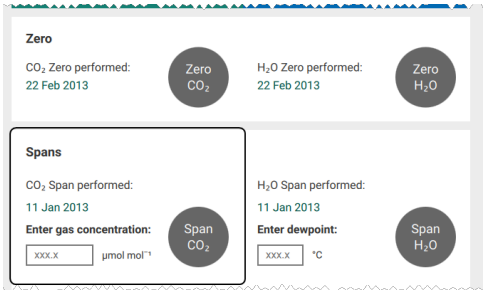
4 After zeroing, flow a gas with a known CO_2 concentration through the analyzer at a rate of 0.5 liters per minute.

Caution: Disable the pump to allow tank pressure to drive the flow of calibration gases.



5 Enter the CO_2 concentration of the span gas into the software

6 When the CO_2 reading has stabilized, click **Span CO_2**.



Setting the secondary CO_2 span

You can set a second span (using a gas that has a CO_2 concentration that is higher or lower than the primary span gas) to improve the precision of the analyzer. The process is exactly the same as setting the primary span, only you'll enter a different concentration and click **Span2 CO_2**.

Setting the H_2O zero and spans (LI-850 only)

The water vapor span can be set with a dew point generator such as the LI-610. The procedure is the same as setting the CO_2 zero and spans, only this uses known concentrations of water vapor rather than CO_2.

Caution: Setting the zero and span incorrectly for either CO_2 or H_2O will adversely impact the performance of your instrument. If you do not have the proper equipment to span the analyzer, it is best to leave it alone.

Recovering from a bad zero or span

If your attempt to zero or span does not go as planned, you can restore the factory default zero and span settings. The information you need is provided on the calibration sheet (included with the instrument or available for download from www.licor.com/env/support/). Under **Settings > Calibrations > Advanced**, enter the factory zero and span values for your instrument.

Cleaning the optical bench

The optical bench can be removed and cleaned if necessary. If, for example, you are unable to set the span, the optics may be contaminated. Generally speaking, don't undertake this procedure unless you've ruled out other potential problems. You'll have to set the instrument zero and span after reassembling the optical bench.

1. Turn off the instrument.

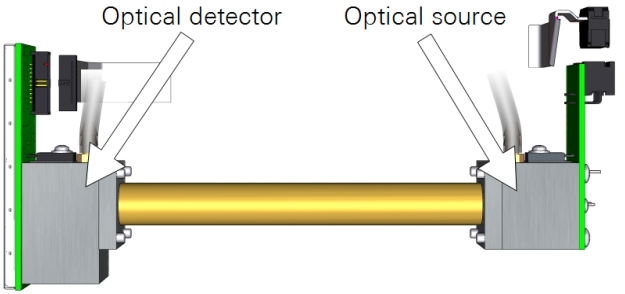
   Unplug the power cable.

2. Remove the top cover.

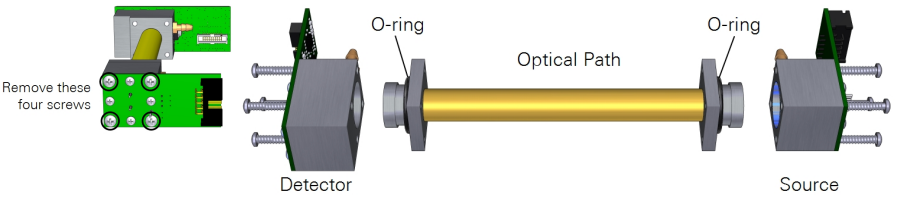
   It is attached with 6 captive screws. Loosen each of the screws until the top cover is free of the bottom. If your instrument has a display, carefully rotate the top cover out of the way without straining the cable, and then unplug the display cable. Set the cover aside, being careful not to strain the ribbon cable.

3. Remove the cables from the source and detector.

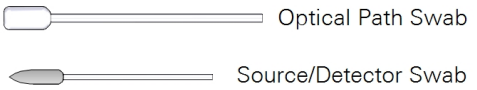
   Gently grasp the plug and pull it free of the assembly. Leave the tubes in place.



4. Carefully lift the optical bench out of the foam.
5. Remove the screws that secure the source and detector (4 each), then separate the source and detector housings (with circuit boards attached) from the optical path.



6 Clean the parts.



Retrieve an optical path swab from the accessories kit. Dip one end into a 50:50 ethanol-water mixture (mild dish washing soap and water will work too) and carefully swab both ends of the optical path. Dip a Source/Detector swab into the solution and then swab around the source and detector to remove any residue.

Caution: Do not use abrasive cleansers. Abrasive cleaners can irreparably damage the gold plating on the optical path, source, or detector.

7 Inspect the hose barbs and tubing.

If the tubes are dirty or damaged, replace them with new tubes (available from LI-COR, part number 6580-041). Carefully remove them from the hose barbs. If the tubes are in good condition and clean, you may be able to reuse them. If the hose barbs are dirty, remove them and clean them with rubbing alcohol or soapy water. Use caution: Do not scratch the hose barbs because scratches may cause leaks.

8 Inspect the O-rings.

If they are smashed flat or damaged in any way, replace them with new O-rings (part number 192-00226) from the accessories kit.

9 Let the optical bench components dry.

10 Reassemble the optical bench.

Attach the source and detector. The orientation of the optical path cylinder is unimportant — either end can be inserted into the source and detector housing. Tighten each of the screws snugly.

11 Place the optical bench in the foam, plug in the source and detector connectors, and re-assemble the case.

Be sure the foam insulation on the top cover is positioned over the optical bench. It is required for thermal stability.

12 Perform a zero and span calibration. See *User calibration* on page 5-1.

Replacing a fuse

The power supply and terminal strip are both protected by fuses. The instrument has one extra fuse (Littelfuse 476 Series Nano$^{2®}$ 3 amp 125 V fuse) that can be used in the event that one of the fuses blows. If you are able to power on the instrument using one of these two ways—but not the other—a fuse may be blown. If you can't power the instrument using either way, both fuses may be blown (or you may have a power supply issue).

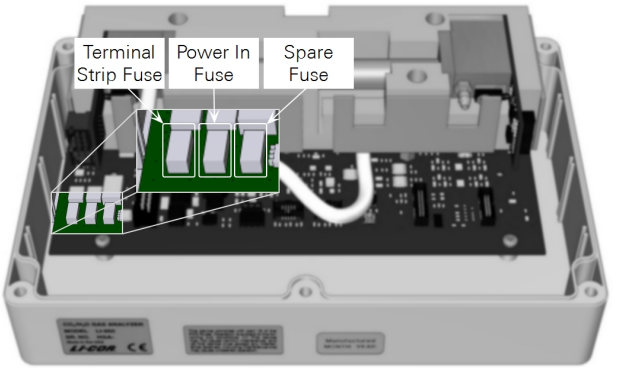
Before simply replacing a fuse, be sure to identify the problem that caused the fuse to blow in the first place. Otherwise, you'll just blow the spare fuse, in which case, you'll still have the problem and you'll be out of spare fuses. After identifying and solving the problem that caused the fuse to blow, replace the fuse:

1. Open the case.

   Loosen each of the six top cover screws until the top cover is free of the bottom. If your instrument has a display, carefully rotate the top cover out of the way without straining the cable, and then unplug the display cable. Set the cover aside.

2. Locate the fuses.

   With the air-in and -out ports facing away from you, the fuses are mounted to the lower left corner of the lowest circuit board. In the image, ribbon cables and tubes have been removed for clarity.



3. Using a needle-nose pliers, grasp the blown fuse and remove it from the holder.
4. Replace it with a spare fuse.
5. Power on the instrument to verify that the issue is resolved.

Appendix A.
Equation Summary

The LI-830 and LI-850 compute CO_2 concentrations using an equation of the form

$$c = f(\alpha'')(T + 273.15) \quad \text{A-1}$$

where c is concentration, $f()$ is the calibration function, a" is the absorptance, $g(a,P)$ is the pressure correction, $S(a)$ is the span, and T is the temperature (°C) of the gas in the cell, typically 51.5 °C. Absorptance is computed from

$$\alpha'' = \alpha' g(\alpha, P) \quad \text{A-2}$$

a' is a span corrected absorptance, and $g(a,P)$ is the pressure correction.

$$\alpha' = \alpha S(\alpha) \quad \text{A-3}$$

$S(a)$ is the span function, and raw absorptance a is computed from

$$\alpha = \left(1 - \frac{V}{V_o} Z\right) \quad \text{A-4}$$

where V and V_o are the raw detector sample and reference readings, and Z is the zeroing parameter.

Span is a linear function of absorptance.

$$S(\alpha) = S_o + S_1 \alpha \quad \text{A-5}$$

H_2O Equations (LI-850 only)

Absorptance a_w for water vapor is computed from

$$\alpha_w = \left(1 - \frac{V_w}{V_{wo}} Z_w\right) \quad \text{A-6}$$

$$\alpha'_w = \alpha_w S_w (\alpha_w)$$

$$\alpha''_w = \alpha' g_w (\alpha_w, P)$$

where V_W and V_{WO} are the sample and reference raw detector readings, and Z_W is the zero parameter. The pressure correction for water vapor is an empirical function $g_W()$ of absorptance and pressure P:

$$g_w(\alpha_w, P) = \frac{P_o}{P\left(1+0.8\alpha_w\left(\frac{P_o}{P}-1\right)\right)} \quad \text{A-7}$$

The value of P_o is 99 kPa. When the pressure correction is not enabled, $g_W()$ is simply 1.0. Water vapor concentration W (mmol mol^{-1}) is computed from

$$W = f_w (\alpha''_w)(T + 273.15) \quad \text{A-8}$$

where $f_W(x)$ is a third order polynomial whose coefficients are given on the calibration sheet.

$$f_w (x) = a_{w1} x + a_{w2} x^2 + a_{w3} x^3 \quad \text{A-9}$$

CO_2 Equations

The measurement of CO_2 is a bit more complicated than for H_2O because of the influence of water vapor. There is a slight direct cross sensitivity in the CO_2 signal to H_2O. This is measured at the factory and accounted for in the computation of absorptance (equation A-10). There is also a band broadening effect that is accounted for in the computation of concentration (equation A-14).

CO_2 absorptance αc is computed from

$$\alpha_c = \left(1 - \left(\frac{V_c}{V_{co}} + X_{wc}\left(1 - \frac{V_w}{V_{wo}} Z_w\right)\right) Z_c\right) \quad \text{A-10}$$

$$\alpha'_c = \alpha_c S_c(\alpha_c)$$

$$\alpha''_c = \alpha'_c g_c(\alpha_c, P)$$

where V_c and V_{co} are the raw detector signals for sample and reference, Z_c is the CO_2 zero parameter, and X_{wc} is a cross sensitivity parameter for the effect of water vapor on CO_2. Its value is reported on the calibration sheet as **XS=**.

The empirical pressure correction function $g_c()$ depends on CO_2 absorptance and pressure:

When $P = P_o$, $g_c() = 1$.

When $P < P_o$

$$g_c(\alpha_c, P) = X$$

$$X = \frac{1}{A + B\left(\frac{1}{z-\alpha_c} - \frac{1}{z}\right)} + 1$$

$$A = \frac{1}{a(p-1)} \qquad \text{A-11}$$

$$B = \frac{1}{\frac{1}{b+cp} + d}$$

$$p = \frac{P_0}{P}$$

where a = 1.10158, b = -6.1217E-3, c = -0.266278, d = 3.69895, and z is the asymptotic value of absorptance, obtained from the calibration coefficients (equation A-15).

$$z = a_{c1} + a_{c3} \qquad \text{A-12}$$

When $P > P_o$

$$g_c(\alpha_c, P) = \frac{1}{X}$$

$$P = \frac{P}{P_0} \qquad \text{A-13}$$

where X, A, and B are computed as in equation A-11. CO_2 concentration C (µmol mol^{-1}) is computed from

$$C = f_c\left(\frac{\alpha''_c}{\psi(W)}\right)\psi(W)\,(T + 273.15) \quad \text{A-14}$$

where $f_c(x)$ is a function whose inverse is a double rectangular hyperbola, and whose coefficients (*a1*…*a4*) are given on the calibration sheet.

$$f_c^{-1}(C) = \frac{a_{c1}C}{a_{c2}+C} + \frac{a_{c3}C}{a_{c4}+C} \quad \text{A-15}$$

Solving equation A-15 for C yields the calibration function

$$f_c\left(x\right) = \frac{\left(a_2a_3+a_1a_4\right)-\left(a_2+a_4\right)x-\sqrt{(a_2-a_4)^2x^2+Dx+(a_2a_3+a_1a_4)^2}}{2(x-a_1-a_3)} \quad \text{A-16}$$

Where

$$D = 2\,(a_2 - a_4)\,(a_1a_4 - a_2a_3) \quad \text{A-17}$$

$\psi(W)$ accounts for band broadening by water vapor.

$$\psi(W) = 1 + (h(\alpha_c) - 1)\,\frac{W}{1000} \quad \text{A-18}$$

The band broadening coefficient $h(a_c)$ has been determined to be 1.45 for the instrument for CO_2 concentrations near ambient. At higher concentrations, the value decreases. We capture this behavior with an empirical relationship (equation A-19).

$$h(\alpha_c) = \frac{1}{(0.64b_w-0.64)e^{-3\left(\frac{z}{\alpha_c}-1\right)}+\frac{1}{b_w}} \quad \text{A-19}$$

Where z is from equation A-12, and b_w is the low concentration band broadening coefficient: 1.45. This is the value shown on the calibration sheet as *BB* = 1.45. The typical relationship between $h(a_c)$ and CO_2 concentration is shown in *Figure A-1* on the facing page. ('Typical' because the exact relationship depends on the relationship between absorptance and CO_2, which is the calibration curve.)

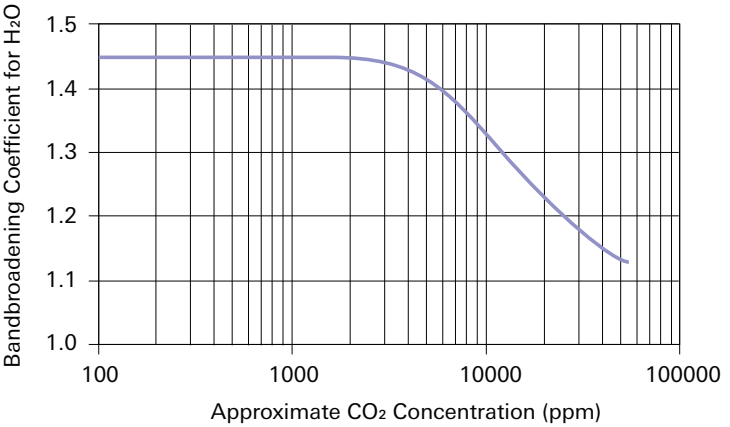


Figure A-1. The typical relationship between h(a_c) *and* CO_2 *concentration.*

Note: We formulated equation A-19 with $0.64b_w - 0.64$ instead of the simple equivalent (0.29) because this allows band broadening corrections to be turned off by setting b_w to 1. When b_w =1, $h(a_c)$ = 1 everywhere. Also, to avoid computational problems (underflows, overflows, and division by zero) we constrain the argument a_c when computing $h(a_c)$ to be $0.1 < a_c \leq z$. a_c - 0.1 is typically equivalent to about 600 ppm.

Calibration Equations

The following equations describe the implementation of zero and span calibrations.

Zeroing H_2O (LI-850 only)

When the command for zeroing water is received, the LI-850 computes the water zero from equation A-20, where $\overline{V}_w$ and $\overline{V}_{wo}$ are averaged for 5 seconds.

$$Z_w = \frac{\overline{V}_{wo}}{\overline{V}_w} \qquad \text{A-20}$$

Zeroing CO_2

When the command for zeroing CO_2 is received, the instrument computes the CO_2 zero term from equation A-21, where $\overline{V}_c$, $\overline{V}_{co}$, $\overline{V}_w$, and $\overline{V}_{wo}$ are averaged for 5 seconds.

$$Z_c = \frac{1}{\left(\frac{\overline{V}_c}{\overline{V}_{co}} + X_{wc}\left(1 - \frac{\overline{V}_w}{\overline{V}_{wo}} Z_w\right)\right)} \quad \text{A-21}$$

Spanning H_2O (LI-850 only)

When the command for setting the span for H_2O is received, along with the target concentration W_T, from the target concentration, the target absoprtance a_T is computed from

$$\alpha_{wT} = f_w^{-1}\left(\frac{W_T}{T + 273.15}\right) \quad \text{A-22}$$

LI-850 computes S_{w0} from equation A-23 , where $\overline{\alpha}_w$ is averaged over five seconds.

$$S_{w0} = \frac{\beta_w}{\overline{\alpha}_w} - S_{w1}\overline{\alpha}_w \quad \text{A-23}$$

where

$$\beta_w = \frac{\alpha_{wT}}{g_w(\alpha_{wT}, P)} \quad \text{A-24}$$

The instrument retains the following values, which are used for subsequent secondary spans:

$$\alpha_{w1} = \overline{\alpha}_w \quad \text{A-25}$$

$$\beta_{w1} = \beta_w$$

Secondary Span H_2O (LI-850 only)

When the secondary span command for H_2O is received, the instrument computes new values for both S_{w0} and S_{w1}. First, it measures a new $\overline{\alpha}_w$ and computes a new β_w from equation A-24. Then, it uses these plus the retained values (α_{w1} and β_{w1} from the previous normal span) to compute

$$S_{w1} = \frac{\frac{\beta_w}{\overline{\alpha}_w} - \frac{\beta_{w1}}{\alpha_{w1}}}{\overline{\alpha}_w - \alpha_{w1}} \quad \text{A-26}$$

Given the new span slope S_{w1}, it updates the span offset S_{w0} by equation A-23.

Spanning CO_2

When the command for setting the CO_2 span is received, along with the target concentration C_T, the instrument computes S_{c0} from equation A-28, where $\overline{\alpha}_c$ and $\overline{W}$ are averaged for 5 seconds.

$$\alpha_{cT} = f_c^{-1}\left(\frac{C_T}{(T+273.15)\psi(\overline{W})}\right) \quad \text{A-27}$$

$$S_{c0} = \frac{\beta_c}{\overline{\alpha}_c} - S_{c1}\overline{\alpha}_c \quad \text{A-28}$$

where

$$\beta_c = \frac{\alpha_{cT}\psi(\overline{W})}{g_c(\alpha_{cT},P)} \quad \text{A-29}$$

Note that

$$\psi(\overline{W}) = 1 + (h(\alpha_{cT}) - 1)\frac{\overline{W}}{1000}$$

$$= \left(1 + \left(\frac{1}{(0.64b_w - 0.64)e^{-3\left(\frac{z}{\alpha_{cT}} - 1\right)} + \frac{1}{b_e}} - 1\right)\frac{\overline{W}}{1000}\right) \quad \text{A-30}$$

We need αcT to compute $\psi(\overline{W})$, but αcT depends on $\psi(\overline{W})$. We resolve this by using an approximation (equation A-31) instead when computing equation A-30

$$\alpha_{cT} \approx f_c^{-1}\left(\frac{C_T}{(T+273.15)}\right) \quad \text{A-31}$$

The instrument retains the following values, which are used for subsequent secondary spans, if necessary:

$$\alpha_{c1} = \overline{\alpha}_c \quad \text{A-32}$$

$$\beta_{c1} = \beta_c \quad \text{A-33}$$

Secondary Span CO_2

When the secondary span command for CO_2 is received, the instrument computes new values for both S_{c0} and S_{c1}. First, it measures a new $\overline{\alpha}_c$ and computes a new β_c

from equation A-29. Then it uses these, plus the retained values (α_{c1} and β_{c1} from the previous normal span) to compute

$$S_{c1} = \frac{\frac{\beta_c}{\bar{\alpha}_c} - \frac{\beta_{c1}}{\alpha_{c1}}}{\bar{\alpha}_c - \alpha_{c1}} \quad \text{A-34}$$

Given the new span slope S_{c1}, it updates the span offset S_{c0} by equation A-28.

Appendix B.
Specifications

CO_2 measurements

Measurement range: 0 to 20,000 ppm

Accuracy

LI-850: Within 1.5% of reading

LI-830: Within 3% of reading

Calibration drift

Zero drift[1]: <0.15 ppm / °C

Span drift[2]: <0.03% / °C

Total drift at 370 ppm[3]: <0.4 ppm / °C

RMS noise at 370 ppm with 1 sec signal filtering: <1 ppm

Sensitivity to water vapor (LI-850 only): <0.1 ppm CO_2 / mmol mol^{-1} H_2O

Lower limit of detection: 1.5 ppm

H_2O measurements (LI-850 only)

Measurement range: 0 to 60 mmol mol^{-1}

Accuracy: Better than 1.5% of reading

Calibration drift

Drift at 0 mmol mol^{-1}: <0.005 mmol mol^{-1} / °C

Span drift at 10 mmol mol^{-1}: <0.006 mmol mol^{-1} / °C

Total drift at 10 mmol mol^{-1}: <0.016 mmol mol^{-1} / °C

RMS noise at 10 mmol mol^{-1} with 1 sec signal filtering: <0.01 mmol mol^{-1}

Sensitivity to CO_2: <0.0001 mmol mol^{-1} H_2O / ppm CO_2

Lower limit of detection: 0.015 mmol mol^{-1}

[1]Zero drift is the change with temperature at 0 concentration.

[2]Span drift is the residual error after re-zeroing following a temperature change.

[3]Total drift is the change with temperature without re-zeroing or re-spanning.

General

Output rate: Up to 2 measurements per second
Response time (**T90**)
CO_2: <3.5 seconds from 0 to 375 ppm
H_2O (**LI-850 only**)**:** <3.5 seconds from 0 to 21 mmol mol^{-1}
Measurement principle: Non-Dispersive Infrared
Traceability
CO_2: Traceable gases to WMO standards from 0 to 3,000 ppm; traceable gases to EPA protocol gases from 3,000 to 20,000 ppm
H_2O (**LI-850 only**)**:** NIST traceable LI-610 Portable Dew Point Generator
Pressure compensation range: 50 to 110 kPa
Maximum gas flow rate: 1 liter min^{-1}
Output signals: Two analog voltage (0 to 2.5 V or 0 to 5 V) and two current (4 to 20 mA)
Digital outputs: TTL (0 to 5 V) or Open Collector
DAC resolution: 16 bits across user-specified range
Power requirements
Input voltage: 12-30 VDC
After warmup (**without pump**)**:** 0.33A @ 12 VDC (4.0 W) average
After warmup (**with pump**)**:** 0.42A @ 12 VDC (5.0 W) average
During warmup: 1.2 A @ 12 VDC (14 W) maximum
Operating temperature range: -20 to 45 °C
Relative humidity range: 0 to 95% RH, Non-condensing
Dimensions: 22.23 cm W × 15.25 cm D × 7.62 cm H
Weight
No pump, no display: 1.0 kg
No pump, with display: 1.02 kg
With pump, no display: 1.3 kg
With pump, with display: 1.32 kg
Internal optical cell volume: 14.5 mL

Pump specifications (optional)

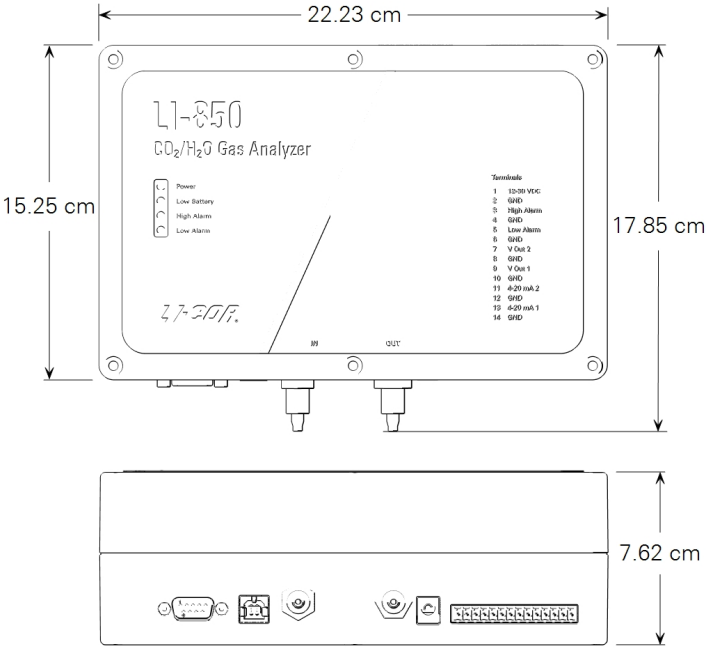
Operating temperature range: 5 to 45 °C
Storage temperature range: -20 to 60 °C
Operating humidity range: 0 to 80% RH
Nominal flow rate: 0.75 liters $minute^{-1}$
Power consumption: 1 W (nominally)
Expected life span: 8,000 hrs in standard conditions with a normal load

Display specifications (optional)

Dimensions: 6.7 cm corner-to-corner
Resolution: 400 × 200 px; monochrome
Power consumption: <200 µW
Displayed variables: CO_2 reading, H_2O reading (LI-850 only), optical bench temperature, and pressure.

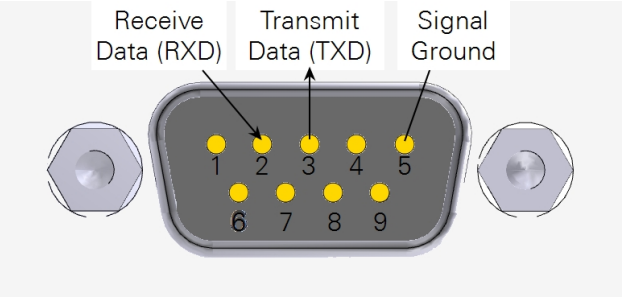
Specifications subject to change without prior notice.

Dimensional drawings



Serial cable pin assignments

The image below shows the pin assignments for the 9-pin RS-232 serial connector.



Serial communication parameters

The LI-830 and LI-850 can communicate through a RS-232 serial port on the front of the instrument. You may need to set the communication parameters on your computer or your terminal emulator program. The RS-232 port is configured as Data Terminal Equipment (DTE) with no hardware handshaking. It is bi-directional, meaning information can be transferred both into and out of the instrument. The port is configured as follows:

- Baud Rate: 9600 bps
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: None

Standard Terms and Conditions

1. General. LI-COR Inc. ("LI-COR") is delivering these goods and products ("Products") subject to these Terms and Conditions of Sale ("Conditions"). Buyer will be deemed to have assented to these Conditions upon Buyer's placement of order. Notwithstanding the above, failure of LI-COR to object to provisions contained in any purchase order or other form or document from Buyer shall not be construed as a waiver of these Conditions nor an acceptance of any such provision.

2. Buyer's Use Only/No Resale. The purchase of Products only conveys to Buyer the non-transferable right for only Buyer to use the quantity of Products and components of Products purchased in compliance with the applicable intended use statement, limited use statement or limited label license, if any, in LI-COR catalogues or on the label or other documentation accompanying the Products (all such statements or licenses being incorporated herein by reference as if set forth herein in their entirety). Buyer has no right to resell the Products, or any portion of them, and any such resale is strictly prohibited unless LI-COR first accepts and approves a purchase order and acknowledges in writing that the Products may be resold by Buyer and the terms of such resales.

3. Prices/Taxes. All prices are quoted for delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA. Accordingly, unless otherwise specified by LI-COR, prices are exclusive of shipping, insurance and installation charges, all of which are Buyer's sole responsibility. All prices are exclusive of all sales, use, excise, value added, withholding and other taxes, and all customs, duties, documentation charges, and freights forwarder charges now or hereafter claimed or imposed by any governmental authority upon the sale of the Products. Any such charges will be added to the product invoice or subsequently invoiced to the Buyer. In the event LI-COR is required to pay any such tax, duty or charge, Buyer will promptly reimburse LI-COR.

4. Payment Terms. All payments shall be made in immediately available U.S. Dollars net thirty (30) days from the date of invoice for qualified accounts, without set-off, deduction or withholding of any kind, unless otherwise stated by LI-COR in writing and may be paid by check (drawn on a U.S. bank), wire transfer or major credit card. All open account invoicing must be pre-approved. Any amounts not paid when due will accrue interest at the rate of 1 1/2% per month, or the maximum amount allowed by law, if lower. In the event that any payment is more than thirty (30) days late, LI-COR shall have the right to suspend doing business with Buyer until all past due balances are made current. Buyer shall pay for all costs (including reasonable fees) incurred by LI-COR in connection with the collection of late payments. Each accepted purchase order is a separate, independent transaction, and Buyer has no right of set-off against other purchase orders or other transactions with LI-COR. Buyer hereby grants LI-COR a security interest in the Products in the amount of the unpaid balance of the purchase price until paid in full. LI-COR may file a financing statement for such security interest and Buyer shall sign any such statements or other documentation necessary to perfect LI-COR security interest.

5. Return Policy. Buyer may return non-consumable Products to LI-COR within forty-five (45) days of invoice date only with prior authorization by LI-COR, the Product(s) being returned in new and unused condition and must be resalable as new. Any returned Product(s) are subject to payment of a fifteen percent (15%) re-stocking fee on all items returned. Buyer shall be responsible to make payment to LI-COR for any and all expenses related to deinstallation of the Product(s), including but not limited to shipping, duties, and taxes. All payments subject to this provision shall be made to LI-COR within thirty (30) days of return, or de-installation, of the Product(s).

6. Delays In Performance. LI-COR shall not be liable for any delay in performance hereunder due to unforeseen circumstances or due to circumstances beyond its control including, but not limited to, acts of nature, acts of government, labor disputes, delays in transportation, delays in customs clearance and delays in delivery or inability to deliver by LI-COR's suppliers.

7. Shipment and Packing. All Product prices exclude costs of shipping and handling and insurance, in accordance with delivery terms designated by LI-COR. Unless otherwise agreed in writing, such costs will be paid by the Buyer and will appear as a separate item on LI-COR invoice. LI-COR shall ship in accordance with LI-COR standard practices. Buyer may specify different shipping instructions, subject to agreement by LI-COR. Unless otherwise agreed to in writing by LI-COR, all products shall be packaged, if appropriate, for shipment and storage in accordance with standard commercial practices. All packing shall conform to carrier requirements.

8. Partial Shipments. Any Products delivered in partial shipments may be invoiced individually. Additional shipping and handling charges may apply.

9. Title/Risk of Loss. All domestic shipments are made FOB per Uniform Commercial Code. All international shipments are made per INCOTERMS 2000 designated by LI-COR. LI-COR title to the Products and the risk of loss of or damage to the Products ordered by the Buyer will pass to Buyer at time of LI-COR delivery of Products to the carrier. The carrier shall be deemed Buyer's agent, and any claims for damages in shipment must be filed with the carrier. LI-COR is authorized to designate a carrier pursuant to LI-COR standard shipping practices unless otherwise specified in writing by Buyer.

10. Intellectual Property Rights. Title to and ownership of the documentation, and any improved, updated, modified or additional parts thereof, and all copyright, patent, trade secret, trademark and other intellectual property rights embodied in the Products, shall at all times remain the property of LI-COR or LI-COR licensors.

11. Acceptance. All sales are final and all Products shall automatically be deemed accepted upon delivery to Buyer when goods are loaded on the carrier at LI-COR premises in Lincoln, Nebraska, USA. Buyer may not return any Products to LI-COR except as provided for by LI-COR warranty or as provided herein.

12. Product Warranties. Unless otherwise specified by LI-COR:

(a) LI-COR warrants that, for a period of twelve (12) months from the date of shipment of the Products from LI-COR (the "Warranty Period"), unless otherwise specified for individual Products or extended by a Support Contract or Extended Warranty Contract, the Products sold hereunder will be free from material defects in materials and workmanship and will conform to LI-COR published specifications in effect as of the date of manufacture. LI-COR SPECIFICALLY DISCLAIMS ANY INDIRECT,SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES (INCLUDING LOSS OF USE OR LOST PROFITS) WHICH MAY RESULT FROM THE USE OF PRODUCTS PURCHASED HEREUNDER, AS FURTHER SET FORTH IN SECTION 13 OF THESE CONDITIONS OF SALE. This limited warranty extends only to Buyer as original purchaser unless otherwise agreed upon in writing by LI-COR.

(b) The foregoing warranty shall not apply if the defective Product (i) has been subjected to abuse, misuse, neglect, negligence, accident, improper testing, improper installation, improper storage, improper handling or use contrary to any instructions issued by LI-COR, (ii) has been repaired or altered by persons other than LI-COR, (iii) has not been installed, operated, repaired and maintained in accordance with the documentation or operated outside of the environmental specifications for the Product; (iv) has failed due an Act of God, including but not limited to fire, flood, tornado, earthquake, hurricane or lightning or (v) has been used with any devices, accessories or products not manufactured by or approved by LI-COR. In addition, the foregoing warranty shall not apply to Products (i) LI-COR Standard Terms and Conditions of Sale – rev. 5/15/2009 marked or identified as "sample," (ii) loaned or provided to Buyer at no cost, or (iii) which are sold "as is."

c) If during the Warranty Period: (i) LI-COR is notified promptly in writing upon discovery of any defect in the Product, including a detailed description of such alleged defect, (ii) such Product is returned, transportation charges prepaid, to LI-COR designated manufacturing facility subject to the prior approval of LI-COR with a valid Return Material Authorization ("RMA") number, and (iii) LI-COR inspections and tests determine that the Product is indeed defective and the Product has not been subjected to any of the conditions set forth above, then, as Buyer's sole remedy and LI-COR sole obligation under the foregoing warranty, LI-COR will, at LI-COR option, repair or replace without charge the defective Product. In no event will the Buyer itself nor will the Buyer allow any party other than LI-COR or a third party authorized in writing by LI-COR to perform any service on the Products.

(d) During the Warranty Period, LI-COR will provide on-site warranty repair for Odyssey® Infrared Imager, Aerius Automated Infrared Imager, Pearl® Imager and/ or 4300 DNA Analyzer Products including travel costs, repair parts, and labor to maintain the hardware in proper operating condition. At LI-COR discretion, the Buyer may be required to run certain diagnostic procedures to help determine the source of the problem before on-site warranty repair is rendered. If an on-site service call is initiated, LI-COR will dispatch a service technician to the Buyer site. On-site service will be provided 8:00 a.m. to 5:00 p.m. (Buyer local time), Monday through Friday, excluding LI-COR holidays. The cost of a repair/service call for an instrument malfunction caused by third party hardware and/or software will be billed to Buyer on a time and material basis.

(e) Any Product that has either been repaired or replaced under this warranty shall have warranty coverage (parts only) for the longer of ninety (90) days or the remaining original warranty period. Replacement parts used in the repair of Products may be new or equivalent to new.

(f) EXCEPT FOR THE WARRANTIES SET FORTH IN THIS SECTION, LI-COR MAKES NO OTHER WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, WITH RESPECT TO ANY PRODUCTS OR OTHER PRODUCTS PROVIDED IN CONNECTION WITH THESE CONDITIONS, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NONINFRINGEMENT, OR ARISING FROM COURSE OF PERFORMANCE, DEALING, USAGE OR TRADE.

(g) Notwithstanding anything herein to the contrary, LI-COR makes no warranty with respect to any third party products provided under these Conditions. Buyer's sole remedy with respect to such third party products shall be pursuant to the original manufacturer's or licensor's warranty, if any, to Buyer, to the extent permitted by the original manufacturer or licensor.

13. Limitation of Liability. IN NO EVENT SHALL LI-COR, ITS LICENSORS OR ITS SUPPLIERS BE LIABLE TO BUYER OR ANY THIRD PARTY FOR COSTS OF PROCUREMENT OF SUBSTITUTE PRODUCTS OR SERVICES, LOST PROFITS, DATA OR BUSINESS, OR FOR ANY INDIRECT, SPECIAL, INCIDENTAL, EXEMPLARY OR CONSEQUENTIAL DAMAGES OF ANY KIND ARISING OUT OF OR IN CONNECTION WITH THE USE OF THE PRODUCTS OR THESE CONDITIONS, HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY (WHETHER IN CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY, PRODUCTS LIABILITY OR OTHERWISE). LI-COR TOTAL AND CUMULATIVE LIABILITY ARISING OUT OF OR IN CONNECTION WITH ANY PRODUCTS PURCHASED BY BUYER HEREUNDER SHALL IN NO EVENT EXCEED THE PURCHASE PRICE PAID BY BUYER FOR SUCH PRODUCTS. THE LIMITATIONS SET FORTH IN THIS SECTION SHALL APPLY EVEN IF LI-COR OR ITS SUPPLIERS HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, AND NOTWITHSTANDING ANY FAILURE OF ESSENTIAL PURPOSE OF ANY LIMITED REMEDY.

14. Authorized Use of Biotechnology Products. Unless otherwise expressly indicated in LI-COR catalogues, LI-COR website or on the label or other documentation accompanying Biotechnology Products, the LI-COR Biotechnology Products are intended for RESEARCH USE ONLY and are not to be used for any other purposes including, but not limited to, unauthorized commercial purposes, in vitro diagnostic purposes, ex vivo or in vivo therapeutic purposes, investigational use, in foods, drugs, devices or cosmetics of any kind, or for consumption by or use in connection with or administration or application to humans or animals. Buyer acknowledges that the Biotechnology Products have not necessarily been tested for safety or efficacy, unless expressly stated in LI-COR catalogs or on the label or other documentation accompanying the Biotechnology Products.

15. Authorized Use of Biotechnology Products. Unless otherwise expressly indicated in LI-COR catalogues, LI-COR website or on the label or other documentation accompanying Biotechnology Products, the LI-COR Biotechnology Products are intended for RESEARCH USE ONLY and are not to be used for any other purposes including, but not limited to, unauthorized commercial purposes, in vitro diagnostic purposes, ex vivo or in vivo therapeutic purposes, investigational use, in foods, drugs, devices or cosmetics of any kind, or for consumption by or use in connection with or administration or application to humans or animals. Buyer acknowledges that the Biotechnology Products have not necessarily been tested for safety or efficacy, unless expressly stated in LI-COR catalogs or on the label or other documentation accompanying the Biotechnology Products.

16. Severability. If any portion of these Conditions is held invalid, the parties agree that such invalidity shall not affect the validity of the remaining portions of these Conditions.

17. Export Control. Buyer acknowledges and agrees that the Products purchased under these Conditions may be subject to restrictions and controls imposed by the United States Government and the regulations thereunder. BUYER WARRANTS THAT IT WILL NOT EXPORT OR RE-EXPORT ANY PRODUCTS PURCHASED WITHOUT PRIOR WRITTEN NOTIFICATION AND APPROVAL OF LI-COR.

18. Assignment. Buyer shall not assign or transfer these Conditions or any rights or obligations under these Conditions, whether voluntary or by operation of law, without the prior written consent of LI-COR. LI-COR may assign or transfer these Conditions to any successor by way of merger, acquisition or sale of all or substantially all of the assets relating to these Conditions. LI-COR or any successor may assign all or part of the right to payments under these Conditions. Any assignment or transfer of these Conditions made in contravention of the terms hereof shall be null and void. Subject to the foregoing, these Conditions shall be binding on and inure to the benefit of the parties' respective successors and permitted assigns.

19. Entire Agreement. These Conditions of Sale take precedence over Buyer's additional or different terms and conditions, to which notice of objection is hereby given. Acceptance by Buyer is limited to LI-COR Conditions of Sale. Neither LI-COR commencement of performance nor delivery shall be deemed or construed as acceptance of Buyer's additional or different terms and conditions. These Conditions supersede all prior communications, transactions, and understandings, whether oral or written, and constitute the sole and entire agreement between the parties

pertaining to the referenced quotation or purchase order, provided that: (1) these Conditions shall not, without LI-COR prior written consent, supersede any conflicting terms of: (a) prior written agreements duly executed by LI-COR, or (b) governmental purchase orders, terms of purchase, requests for quotation or acquisition regulations relative to governmental purchasers; and (2) to the extent not in conflict with any such prior or governmental terms, these Conditions shall supplement them. No modification, addition or deletion, or waiver of any of the terms and conditions of these Conditions shall be binding on either party unless made in a non-preprinted agreement clearly understood by both parties to be a modification or waiver, and signed by a duly authorized representative of each party.

20. Entire Agreement. These Conditions of Sale take precedence over Buyer's additional or different terms and conditions, to which notice of objection is hereby given. Acceptance by Buyer is limited to LI-COR Conditions of Sale. Neither LI-COR commencement of performance nor delivery shall be deemed or construed as acceptance of Buyer's additional or different terms and conditions. These Conditions supersede all prior communications, transactions, and understandings, whether oral or written, and constitute the sole and entire agreement between the parties pertaining to the referenced quotation or purchase order, provided that: (1) these Conditions shall not, without LI-COR prior written consent, supersede any conflicting terms of: (a) prior written agreements duly executed by LI-COR, or (b) governmental purchase orders, terms of purchase, requests for quotation or acquisition regulations relative to governmental purchasers; and (2) to the extent not in conflict with any such prior or governmental terms, these Conditions shall supplement them. No modification, addition or deletion, or waiver of any of the terms and conditions of these Conditions shall be binding on either party unless made in a non-preprinted agreement clearly understood by both parties to be a modification or waiver, and signed by a duly authorized representative of each party.

21. Force Majeure. Shipping dates are approximate and may be delayed absent prompt receipt from Buyer of all necessary information. LI-COR shall not be responsible for any failure to perform or delay attributable in whole or in part to any cause beyond its reasonable control, including but not limited to Acts of God, government actions, war, civil disturbance, insurrection, sabotage, labor shortages or disputes, failure or delay in delivery by LI-COR suppliers or subcontractors, transportation difficulties, customs clearance, shortage of energy, raw materials or equipment, or Buyer's fault or negligence. In the event of any such delay the date of delivery shall, at the request of LI-COR, be deferred for a period equal to the time lost by reason of the delay.

22. Governing Law and Venue. These Conditions and performance by the parties hereunder shall be construed in accordance with the laws of the State of Nebraska, U.S.A., without regard to provisions on the conflicts of laws.

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