

Instruction Manual

GEMINI

End-tidal O₂ & CO₂ Analyzer



Read instructions carefully before operating this device.

- 1 This device is not to be used for Human Life Support applications.***
- 2 To avoid possible electrical shock, do not operate this device if it is wet or has had liquids spilled onto it.***
- 3 Service or calibration procedures should only be performed by qualified personnel familiar with the electrical hazards of line-powered devices.***



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STATEMENT OF WARRANTY

IF THIS INSTRUMENT FAILS WITHIN A PERIOD OF ONE YEAR FROM THE DATE OF DELIVERY OR INSTALLATION, CWE, INC. WILL, AT ITS OPTION, REPAIR OR REPLACE IT FREE OF CHARGE TO THE PURCHASER. THIS WARRANTY EXCLUDES DAMAGE INCURRED THROUGH ABUSE OR ACCIDENT AND CONSUMABLE ITEMS OR COMPONENTS SUCH AS BATTERIES. CWE, INC. DOES NOT ASSUME ANY LIABILITY FOR ANY CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OR MISUSE OF THIS INSTRUMENT. THIS WARRANTY IS APPLICABLE ONLY TO THE ORIGINAL PURCHASER OF THE INSTRUMENT, AND IS NON-TRANSFERRABLE.

IF YOU HAVE A PROBLEM

Please call or write describing your problem. We can often identify what is wrong, and suggest a solution without recourse to returning the device. Defective units under warranty should be returned to the factory along with a note describing the nature of the fault. Every effort will be made to ensure prompt repair or replacement of the device.

FACTORY SERVICE

Out of warranty or damaged instruments may be returned to the factory postage prepaid for service at prevailing rates. Upon request, a written or verbal quotation for such service will be issued after examination of the unit but prior to commencing repairs or service. Address requests for service or technical information to:

CWE, Incorporated
Technical Support Department
TEL (610)642-7719
info@cwe-inc.com

LIFE SUPPORT POLICY

Instruments manufactured by CWE, Incorporated are not authorized for use as critical components in human life support devices or systems. "Life support devices or systems", as used herein, are devices or systems whose failure to perform, whether through misuse, failure, or proper operation, can reasonably be expected to result in significant injury to the operator or subject persons.

This document last updated on July 28, 2023.

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1.0 INTRODUCTION

The GEMINI is a high-performance respiratory gas analyzer for the routine monitoring of expired carbon dioxide and oxygen gas concentrations and respiratory rate. For CO₂, a temperature-controlled, infrared optical bench is used, which features fast response, excellent accuracy, and long-term stability. Oxygen measurement is accomplished using an advanced design, rapid response paramagnetic analyzer. Respiratory rate is computed on a breath-by-breath basis from the CO₂ excursions. The unit is completely self-contained: the sensors, control electronics, displays, and sampling pump are housed in a rack-mountable enclosure.

The digital readout of CO₂ concentration shows either the instantaneous value, or the peak end-tidal value. The O₂ concentration is shown as a continuous reading. Analog outputs provide a linear voltage corresponding to the current gas concentrations and respiratory rate. An RS232 serial output is provided for connection to an external computer, whereby data can be independently collected and analyzed.

The GEMINI has built-in audible and visual alarms for detecting out-of-range end-tidal CO₂ or respiratory rate conditions. These alarms have adjustable high and low limits, which are remembered by the instrument and reinstated when it is next used.

A special feature of the GEMINI is an open module slot that can hold any of the SYSTEM 1000 instrumentation modules. Available modules include a cardiometer, blood pressure monitor, and many other functions. This flexibility allows the GEMINI to serve as a full-featured physiological monitoring system.



GEMINI Respiratory Gas Analyzer front panel

2.0 SPECIFICATIONS

Carbon dioxide analyzer	single beam infrared
Sample cell materials	sapphire and stainless steel
Sample inlet connector	Luer female
Measurement range	0-10% CO ₂
Analog output scaling	1.1V/% (0-10V)
Linearity	0.1% CO ₂
Repeatability	0.1% CO ₂
Response time (T ₁₀ - T ₉₀)	120mS at 100 ml/min sampling
Response time (T ₁₀ - T ₉₀)	150mS at 50 ml/min sampling
Zero stability	0.1% (8 hours), 0.2% (24 hours)
Interference effects: 50% N ₂ O	0.1% at 0% CO ₂ , 0.6% at 5% CO ₂ (uncomp.)
N ₂ O compensation (internal jumper for 25, 50, 75%)	0.1% at 5% CO ₂
Maximum sample cell pressure.....	± 5 psig
Interference effects: vaporized anaesthetic agents	negligible
Operating temperature range	5-40° C
Optical bench temperature	48° C, controlled
Warm-up time	6 min to 0.2%, 10 min to 0.1%
Oxygen analyzer	paramagnetic
Linearity	0.1% O ₂
Repeatability	<0.01% O ₂ /hour
Zero stability	±0.1% O ₂ /day
Response time	<200mS
Operating temperature	0 – 65°C
Maximum pressure	15 psi
Maximum sample flow	250 ml/min
Measurement range	0 – 100% (0 – 95% usable)
Sample flowmeter	20 - 200 ml/min
Calibration controls (O ₂ , CO ₂)	Zero, Span (10-turn dials)
Respiratory rate measurement range	5 – 120 breaths/min
Alarm adjustment range: CO ₂	1.0 – 9.9%
Alarm adjustment range: Respiratory rate	5 – 120 breaths/min
Analog signal outputs (rear panel)	BNC jacks
CO ₂ output scaling	1.0V / %CO ₂
O ₂ output scaling	0.1V / %O ₂
Respiratory rate output scaling	0.05V / bpm
Alarm output	5V if alarm condition, 0V if no alarm
Serial data output format	9600 baud, 8 data, no parity, 1 stop bit
Electrical requirements	120VAC/220VAC switchable, 35VA
Dimensions (main unit)	19W x 5.25H x 16D in., 49W x 13H x 41D cm
Weight	10 lbs. (4.5kg)

3.0 SETTING UP THE GEMINI

- ❶ Place the GEMINI control unit in a stable location close to the subject or animal being monitored. Note that the output signals are on the rear panel. When monitoring small animals, it is desirable to locate the unit as close to the animal as possible, to minimize sample tube volume.
- ❷ Be sure the VOLTAGE SELECTOR switch on the rear panel is set correctly. Plug the included power cord into the receptacle on the rear panel, and the other end into a grounded AC outlet.
- ❸ Attach the sample tubing to the SAMPLE INLET port on the front panel. This should be flexible tubing (Tygon or similar), with an inside diameter of 0.050 - 0.062" (1.25 - 1.60 mm). For long-term monitoring, it is recommended that the included Nafion sample tubing be used. This tubing, recognizable by its braided appearance, passes water vapor through its membrane, thus drying the sample gas. Whatever tubing is used, be sure that the miniature in-line filter is always in place. This filter is the final line of defense that prevents water from entering the sample cells.
- ❹ Switch POWER on. The digital display should come on, showing a "welcome" message, indicating that the unit is receiving power and operating. Adjust the SAMPLE FLOW appropriately. The higher the sample flow, the faster the response of the instrument.
- ❺ The unit requires about ten minutes to warm up and stabilize. After about 5 minutes, the analyzer will be usable, with an accuracy of 0.2%. After 10 minutes, the full rated accuracy of 0.1% will be available. Warm-up time depends on the ambient temperature.
- ❻ See the remainder of this manual for the various operating modes and controls.

4.0 OPERATION

4.1 SAMPLE FLOW

The flowmeter on the front panel is used to regulate the sample flow to the sensing cells. The higher the flow rate, the faster the response of the analyzer. If possible, select a flow rate in the 35 - 100 ml/min range. Smaller flow rates can be used, with a consequent increase in response time.

The GEMINI monitor can be used with a wide range of animals. For use with rodents and similar sized animals, special considerations are necessary because of their very small volumes and fast respiratory rates. In general, the sample flow rate should be kept as high as practicable to ensure fast analyzer response. In addition, the volume of the sample tubing must be as small as possible to prevent sample dilution and minimize the gas transit time from the sample point to the analyzer cell. If the following suggestions are followed, good end-tidal measurements can be achieved with small animals.

4.11 MINIMIZING SAMPLE TUBING VOLUME

Ideally, the **SAMPLE INLET** should be connected directly to the endotracheal tube as close to the animal as possible, ALWAYS using a small hydrophobic in-filter at the GEMINI **SAMPLE INLET** port. Several centimeters of small-bore tubing is acceptable between the sample port and the tracheal connection if the sample rate is kept reasonably high. Avoid large moisture absorbers, which typically have a substantial internal volume. Moisture-reducing sample tubing, such as DuPont Nafion[®], is ideal, and is included in the Accessories Kit (Part No. 11-01101) provided with the instrument. The CO₂ sample cell itself is heated and will not condense water vapor. Be careful to keep the sample tubing free of liquid water, however.

4.12 SAMPLE FLOW RATE

The response time of the analyzer is directly proportional to the sample flow rate. Although the analyzer will work with rates as low as 20cc/min, optimum response time is realized with sampling in the 35 – 100 ml/min range. To avoid depleting the available expired volume with mechanically ventilated small animals, the analyzer sample flow can be returned to the breathing circuit. This will result in a net volume change of zero. The **SAMPLE OUTLET** port on the rear panel is provided for this purpose. Be sure to return the volume to a point distal from the sample point to prevent diluting the end-tidal sample.

4.2 CONDITIONING THE SAMPLE

It is extremely important that no condensed water or other fluids enter the sample cells. Such contamination will shift the zero or make zeroing the instrument impossible. A moisture blocking filter should be used between the sample site and the **SAMPLE INLET**. DuPont Nafion[®] sample lines are also available, which remove water vapor from the gas sample. The sample tubing should be inspected periodically to ensure there is no trapped moisture. If visible water has condensed in this tubing, it should be disconnected and dried using compressed air. Water entering the CO₂ sample cell will cause unstable reading and zero offsets. If water or other contaminants have entered the instrument, see Section 5.0 and Appendix A for cell-cleaning procedures.

4.3 LCD DISPLAY

The front-panel lcd display shows all current measurements, the settings and state of the programmable alarms, and a graphical display of the CO₂ concentration. During normal operation, the display will appear as follows:

```
CO2 5.4%    O2 20.9%  
Resp 15     ALM: OFF  
<3.0/7.5> <010/100>  
|||||||
```

The first line of the display shows the current CO₂ and O₂ concentrations. The second line shows the respiratory rate in breaths/minute, and what (if any) alarms are currently active. The fourth line shows a bar graph of the fast CO₂ measurement. This serves as a quick visual indicator of changing CO₂. The fourth line also serves as a message area for special conditions, such as alarms or errors.

4.4 CALIBRATION

Calibrating the GEMINI is straightforward. Because of the inherent linearity of the analyzers, only a two-point calibration is required. For CO₂ calibration, a 5% CO₂ in air calibration mixture is ideal. For O₂ calibration, 100% nitrogen or other oxygen-free gas is required. Each gas has its own set of **ZERO** and **SPAN** controls for calibration.

CO₂: With the instrument fully warmed-up, and the **SAMPLE INLET** port opened to room air, adjust the **ZERO** knob to achieve a reading of 0.0%. Once a stable zero has been established, a known calibration gas is introduced to the **SAMPLE INLET**. Adjust the **SPAN** knob until the display indicates the concentration of the calibration gas.

O₂: Allow the instrument to sample the 100% N₂ (or other zero-oxygen gas), and adjust the **ZERO** control until the display reads 0.0%. Open the sample line to room air, and adjust the **SPAN** control until the display reads 20.9%

4.5 END-TIDAL OR FAST CO₂ DISPLAY SWITCH

The lcd display on the GEMINI can report CO₂ concentration in either a continuous reading (**FAST**), or as the peak expired value (**END TIDAL**).

Note that the CO₂ output (rear panel) always provides the fast response signal.

4.6 SETTING AND USING THE ALARMS

This GEMINI provides user-selectable alarms for end-tidal CO₂ (ETCO₂) and respiratory rate. Either alarm can be activated independently, and both have adjustable upper and lower alarm limits. When an alarm is activated, the **ALARM** LED will light, and a beep will sound according to the following pattern:

CO₂ out of range: beep every 2 seconds

Resp. rate out of range: beep every 5 seconds

To set either alarm range, move the **CO₂ ALARM** or **RESP RATE ALARM** lever switch to either the **HI** (up) or **LO** (down) position, and hold it there while turning the **SET** knob. The alarm setting selected will change on the display:

<3.5/6.0> <30/60>

The left-hand group is the low and high CO₂ range, respectively; the right-hand group is the respiratory rate range.

The lower two lever switches are used to activate the alarms. The lcd display shows which alarms (if any) are currently active.

4.7 ANALOG OUTPUT SIGNALS (Rear Panel)

Analog outputs are provided for CO₂ concentration, O₂ concentration, respiratory rate, and the alarm status. These signals are scaled as follows:

CO₂ output 1.0V / %CO₂

O₂ output 0.1V / %O₂

Respiratory rate 0.05V / bpm

Alarm status 5V if alarm, 0V if no alarm

4.8 RS232 OUTPUT (Rear Panel)

A serial interface is provided for external data collection and analysis. Two formats are available, which are selected by the **SERIAL FORMAT SWITCH** (rear panel). A sample of each is shown:

format 1 ETCO₂, ETO₂, rate 5.5,16.3,23<cr>

format 2 CO₂(fast), O₂(fast) 4.5,17.0<cr>

FORMAT 1 is sent out once-per-breath; **FORMAT 2** is sent every 50mS (200 samples/sec). These numbers are sent as simple ASCII characters, separated by commas, and each data set ends with a <cr> character (ASCII 13). This format allows for easy importation into spreadsheets or other analysis software.

The protocol used is 9600,N,8,1 which is almost universally available using any terminal program (e.g., Windows HyperTerminal).

5.0 MAINTENANCE

The GEMINI monitor requires no routine maintenance, other than periodically replacing the in-line hydrophobic filter. This filter is inserted in the sample line between the sample tubing and the **SAMPLE INLET** on the front panel of the instrument. These filters (and a variety of sample-conditioning tubing and filters) are included in the Accessories Kit included with the instrument, and are available separately from CWE, Inc. (Part No. 11-01108).

CAUTION! NEVER OPERATE THE INSTRUMENT WITHOUT THIS IN-LINE HYDROPHOBIC FILTER. THIS FILTER PREVENTS LIQUIDS AND OTHER CONTAMINANTS FROM ENTERING THE SAMPLE CELLS.

If, despite the above warning, water or other fluids have entered the instrument, it will be necessary to clean the CO₂ sample cell. The symptoms of a dirty cell are that the user will be unable to zero the CO₂ reading.

With care, the sample cell can be cleaned without removing it from the optical bench. To do this, disconnect the tubing from both the inlet (end) and outlet (top) of the stainless-steel sample cell. The CO₂ sample cell should be cleaned by flushing ethyl alcohol through it, using a syringe and small piece of flexible tubing. After the cell is flushed several times, dry it out by carefully forcing a dry gas (nitrogen or air) through it.

In case of extreme contamination, the sample cell can be replaced by the user (CWE Part No. 11-01109).

6.0 ORDERING INFORMATION

Accessories and replacement parts for the GEMINI are available from CWE, Inc. The following table describes these items and gives the Part Numbers.

PART No.	DESCRIPTION
14-10000	GEMINI CO ₂ Analyzer (complete unit)
11-01101	Accessory kit: 2 moisture traps, 2 sample lines, 1 Nafion [®] line
11-01102	Sample line, 5', with male Luer-loc connectors
11-01103	Sample line, 2' Nafion (evaporates condensed moisture)
11-01104	Sample tubing, .040" ID Tygon, 10' coil
11-01105	Luer-loc connector, .040" - .062" ID tubing - male Luer
11-01106	Luer-loc connector, .125" ID tubing - male Luer
11-01108	In-line miniature hydrophobic filter, 13mm dia, Luer fittings, pk of 5
11-01109	Replacement CO ₂ sample cell assembly

CONNECTION DIAGRAMS

