

# Instruction Manual

# CAPSTAR-100

## End-Tidal CO<sub>2</sub> Analyzer



***Read instructions carefully before operating this device.***

- ❶ This device is not to be used for Human Life Support applications.
- ❷ To avoid possible electrical shock, do not operate this device if it is wet or has had liquids spilled onto it.
- ❸ 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](mailto: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 May 26, 2023

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## 1.0 INTRODUCTION

The CAPSTAR-100 is a high-performance respiratory gas analyzer for the routine monitoring of expired carbon dioxide and respiratory rate. The CO<sub>2</sub> sensor is a temperature-controlled, infrared optical bench, which features fast response, excellent accuracy, and long-term stability. End-tidal CO<sub>2</sub> (ETCO<sub>2</sub>) and respiratory rate (RR) is computed on a breath-by-breath basis from the CO<sub>2</sub> excursions. The unit is completely self-contained: the sensor, control electronics, displays, and sampling pump are housed in a convenient benchtop enclosure, or rack-mountable using optional rack-mount brackets.

The digital readout of CO<sub>2</sub> concentration shows either the instantaneous value, or the peak end-tidal value. An analog output provides a linear voltage corresponding to the current gas concentration. This output is directly compatible with most data acquisition systems or recorders. A standard RS232 serial output is also provided, which sends ETCO<sub>2</sub> and RR information in a variety of user-selectable formats.

The CAPSTAR-100 has built-in audible and visual alarms for detecting out-of-range end-tidal CO<sub>2</sub> 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.



*Capstar-100 front panel*

## 2.0 SPECIFICATIONS

Carbon dioxide sensor	single beam infrared
Sample cell materials	sapphire and stainless steel
Sample inlet connector	Luer female
Measurement range	0-10% CO <sub>2</sub>
Linearity	0.1% CO <sub>2</sub>
Repeatability	0.1% CO <sub>2</sub>
Response time (T <sub>10</sub> - T <sub>90</sub> )	110mS at 60 ml/min sampling
Response time (T <sub>10</sub> - T <sub>90</sub> )	100mS at 100 ml/min sampling
Zero stability	0.1% (8 hours), 0.2% (24 hours)
Interference effects: 50% N <sub>2</sub> O	0.1% at 0% CO <sub>2</sub> , 0.6% at 5% CO <sub>2</sub> (uncomp.)
N <sub>2</sub> O compensation	.1% at 5% CO <sub>2</sub>
Maximum sample cell pressure	± 5 psig
Interference effects: vaporized anesthetic 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%
Sample flow adjustment range	10 - 200 ml/min
Respiratory rate measurement range	5 – 120 breaths/min
Alarm adjustment range: ETCO <sub>2</sub>	1.0 – 9.9%
Alarm adjustment range: Respiratory Rate	5 – 120 breaths/min
Analog signal output	BNC jacks
CO <sub>2</sub> output scaling	0.4V / %CO <sub>2</sub>
Serial data output format	9600 baud, 8 data, no parity, 1 stop bit
Power adapter (supplied)	5VDC@4A
Mains requirements for power adapter	120VAC/220VAC universal
Dimensions	9W x 4H x 9D in. (23 x 10 x 23cm)
Weight	4 lbs. (1.8kg)

### 3.0 SETTING UP THE CAPSTAR-100

- 1 Place the CAPSTAR-100 control unit in a stable location close to the subject or animal being monitored. When monitoring small animals, it is desirable to locate the unit as close to the animal as possible, to minimize sample tube volume.
- 2 Attach the included 5V **POWER ADAPTER** to the rear-panel jack. Plug the included mains power cord into a suitable grounded AC outlet.

**Note:** *The supplied **POWER ADAPTER** is a universal type, and can be used with any 120/230, 50/60Hz mains voltage.*

- 3 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.

**Note:** *Never operate the instrument without the in-line hydrophobic disk filter!*

- 4 Switch **POWER** on. The graphic LCD display will come on, showing a "welcome" message and the firmware version, followed by the main display screen. The **SAMPLE FLOW** can be adjusted at this time.
- 5 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.
- 6 See the remainder of this manual for the various operating modes and controls.

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## 4.0 OPERATION

### 4.1 SAMPLE FLOW

The **SAMPLE FLOW** knob on the front panel is used to regulate the sample flow to the sensing cell. This flow is internally measured by a mass flow sensor and displayed on the display as: S:050cc

The response time of the analyzer is directly proportional to the sample flow rate. Although the analyzer will work with rates as low as 10cc/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.

For use with rodents and similar sized animals, special considerations are necessary because of their very small volumes and fast respiratory rates. 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. Follow the instructions below to achieve optimal end-tidal measurements 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-line filter at the CAPSTAR-100 **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 Nafion<sup>®</sup>, is ideal, and is included in the Accessories Kit provided with the instrument. The CO<sub>2</sub> sample cell itself is heated, and will not condense water vapor. Be careful to keep the sample tubing free of liquid water, however. (see *Connection Diagram*, p. 14)

**Note: Never operate the instrument without the in-line hydrophobic disk filter!**

## 4.12 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 hydrophobic filter should always be used between the sample line and the **SAMPLE INLET**. Nafion<sup>®</sup> sample lines are provided, which reduce water vapor in 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 CO<sub>2</sub> sample cell will cause unstable reading and zero offsets.

## 4.2 LCD DISPLAY

The front-panel graphic LCD screen shows all current measurements, the settings and state of the programmable alarms, and a graphical display of the ETCO<sub>2</sub> concentration. During normal operation, the display will appear as follows:



The first line of the display shows the current CO<sub>2</sub> concentration (either **FAST** or **ET**, **PERCENT** or **mmHg**). At upper right is the current Respiratory Rate (RR) in breaths-per-minute (bpm).

The second line shows the **SAMPLE FLOW RATE** in cc/min, the **NUMBER OF BREATHS TO AVERAGE** in the ETCO<sub>2</sub> display, and whether the **ALARM** is on or off.

The third line shows the alarm low and high settings for ETCO<sub>2</sub> (left) and Respiratory Rate (right).

The box at the bottom of the screen shows a bar graph of the ETCO<sub>2</sub> reading, updated once per second. This serves as a quick visual indicator of changing CO<sub>2</sub> over time.



### 4.3 CALIBRATE FUNCTIONS

Calibrating the CAPSTAR-100 is straightforward. Because of the inherent linearity of the sensor, only a two-point calibration is required. For CO<sub>2</sub> calibration, a 5% CO<sub>2</sub> in air calibration mixture is ideal.

**Zero:** With the instrument fully warmed-up, and the **SAMPLE INLET** port opened to room air, press the **ZERO** button. The instrument will read the zero gas for several seconds and then adjust and store a zero-offset value.

**High:** Let the instrument sample a gas with known CO<sub>2</sub> concentration (optimally between 5.0 and 10.0%) and then press the **HIGH** button. If necessary, rotate the **ADJUST** knob until the correct CO<sub>2</sub> reading is displayed.

**NOTE:** See Section 5.0 for instructions on calibration gas connections.

**CAUTION:** DO NOT apply pressurized gas to the sample in port. This will result in inaccurate calibration and can permanently damage the instrument.

### 4.4 DISPLAY FUNCTIONS

**Mode:** This pushbutton toggles the display between **FAST** (continuous) and **ET** (peak end-tidal). Note that the CO<sub>2</sub> **OUTPUT** always provides the **FAST** response signal.

**Units:** This pushbutton toggles the display between **PERCENT** or **mmHg** units of concentration.

### 4.5 ALARM FUNCTIONS

This CAPSTAR-100 provides user-selectable alarms for ETCO<sub>2</sub> and respiratory rate (RR). Both have adjustable upper and lower alarm limits. When an alarm is activated, the **ALARM LED** will light, and a periodic beep will sound if the **BEEP** function is active. The alarm messages are as follows:

<CO2 OUT OF RANGE>

<RESP RATE ALARM>

**RR Alarm:** Press the **RR** pushbutton and follow the prompts. The current setting to be adjusted will be blinking. Turn the **ADJUST** knob to change the setting as desired. After the **LOW** limit is set, press the **ADJUST** knob to

accept. Then the **HIGH** setting can be adjusted. When done, press the **ADJUST** knob to exit. The format of the **RR** alarm settings is as follows:

<010:120> (low and high **RR** alarm settings)

Note that these functions will time-out and exit automatically after 10 seconds if no adjustments are made.

**ETCO<sub>2</sub> Alarm:** Press the **ETCO<sub>2</sub>** pushbutton and follow the prompts. The current setting to be adjusted will be blinking. Turn the **ADJUST** knob to change the setting as desired. After the **LOW** limit is set, press the **ADJUST** knob to accept. Then the **HIGH** setting can be adjusted. When done, press the **ADJUST** knob to exit. The format of the **ETCO<sub>2</sub>** alarm settings is as follows:

<2.0:7.0> (low and high **ETCO<sub>2</sub>** alarm settings)

## 4.6 MISCELLANEOUS FUNCTIONS

**Beep:** Pressing the **BEEP** pushbutton toggles the alarm beep on or off. The alarm display functions are not affected by the **BEEP** setting.

**AUX:** Pressing the **AUX** pushbutton opens a menu of miscellaneous display and operation settings. Once **AUX** is selected, rotate the **ADJUST** knob to show the desired function, and press the **ADJUST** knob to allow setting. These are described individually below:

**CO<sub>2</sub> Display:** The user can select a display format as follows:  
9.9% or 9.99%

**Breaths to Average:** The user can select the number of breaths to use in the averaging of the **ETCO<sub>2</sub>** and **RR** display. The possible settings are:

2, 4, 6, 8, 10, 12, 14, or 16 breaths

**LCD Brightness:** The user can set the brightness of the backlight on the **ICD** graphic display. The range of setting is:

100 (dim) to 255 (bright)

**Serial format:** The user can select from four RS232 serial output formats. These are as follows:

0 = disabled

1 = every breath

2 = 1 set of data/second

3 = 1 set of data per 10 seconds

The format of each data set is:

"05.33,127<13>" or, ETCO<sub>2</sub> percent, RR, <Carriage Return>

**Restore defaults:** Selecting this function will restore the factory defaults for all settings.

## 4.7 CO<sub>2</sub> OUTPUT SIGNAL

An analog output is provided for the CO<sub>2</sub> concentration. This signal is scaled as follows:

CO<sub>2</sub> output            0.4V / %CO<sub>2</sub>

Note that this output always provides the **FAST** (continuous) CO<sub>2</sub> concentration, regardless of the display setting.

## 4.8 RS232 OUTPUT (Rear Panel)

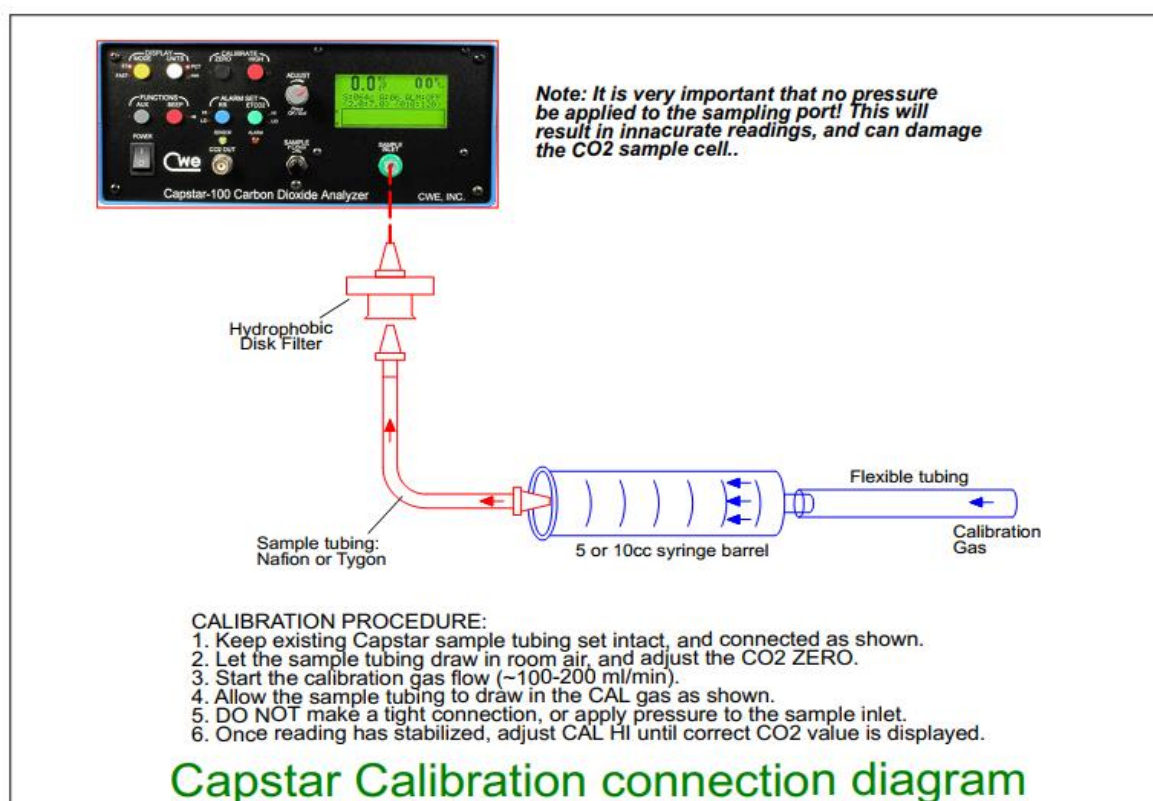
A serial interface is provided for external data collection and analysis. The data is sent according to the timing set in the **Serial Format** setting of the **AUX** functions. The serial protocol is as follows: 9600,N,8,1

If your computer does not have a standard serial port, a USB-Serial Adapter is available that effectively creates a virtual serial COM port (see Ordering Information).

## 5.0 CO2 CALIBRATION PROCEDURE

When calibrating the Capstar-100 it is important to avoid applying pressure to the SAMPLE INLET port. The diagram below illustrates a simple means of coupling a calibration gas source while calibrating. Note that the gas just flows around the distal end of the sample tubing, allowing the instrument to draw in the gas at its own flow rate.

***NOTE! Never apply pressure directly to the SAMPLE INLET. This can permanently damage the CO2 sample cell, and will void the product warranty.***



*Recommended calibration setup diagram*

## 6.0 MAINTENANCE

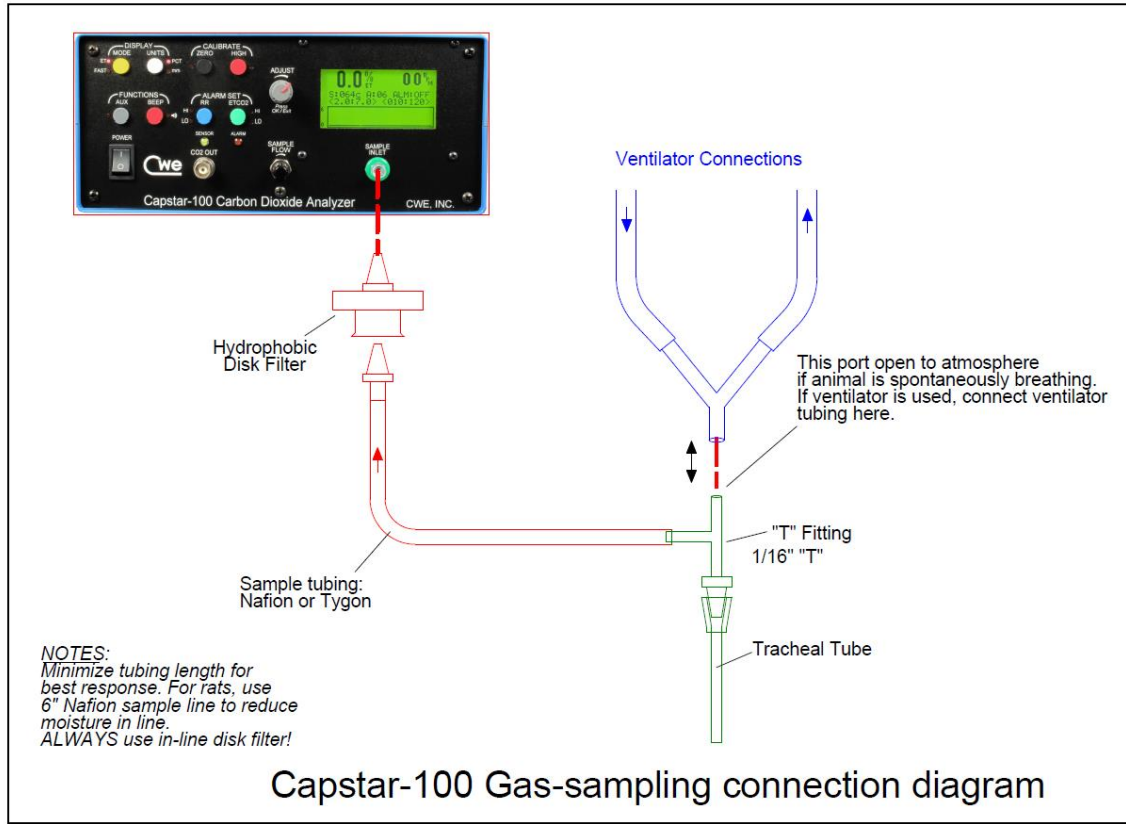
The CAPSTAR-100 monitor requires no routine maintenance, other than periodically replacing the in-line hydrophobic filter. This filter is inserted in the sample line between the sample tubing and the **SAMPLE INLET** on the front panel of the instrument. These filters are included in the Accessories Kit included with the instrument, and are available separately from CWE, Inc.

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

## 7.0 ORDERING INFORMATION

Accessories and replacement parts for the CAPSTAR-100 are available from CWE, Inc.

<b>PART NO.</b>	<b>DESCRIPTION</b>
11-10000	CAPSTAR-100 CO <sub>2</sub> Analyzer (complete unit)
11-01101	Accessory kit: sample lines, 2 Nafion <sup>®</sup> lines, disk filters & fittings
11-01102	Sample line, 4 feet, with male Luer-loc connectors
11-01103	Sample line, 2 feet Nafion (evaporates condensed moisture)
11-01111	Sample line, 6 inches, Nafion (evaporates condensed moisture)
11-01108	In-line miniature hydrophobic filter, 13mm dia, Luer fittings, pk of 5
20-01001	USB-Serial Adapter



*Typical Sample Connection Diagram*