Instruction Manual

MicroCapStar

End-tidal CO_2 Analyzer for mice, rats, & larger animals

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 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.*

---

www.cwe-inc.com

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
info@cwe-inc.com
TEL (610)642-7719

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 was last updated on August 31, 2023.

TABLE OF CONTENTS

1.0 INTRODUCTION

The MicroCapStar is a micro-sampling respiratory gas analyzer for monitoring the expired carbon dioxide gas concentration and respiratory rate of small animals, including mice. CO$_2$ is measured using a temperature-controlled, infrared optical bench, which features fast response, excellent accuracy, and long-term stability. Respiratory rate is computed on a breath-by-breath basis from the CO$_2$ excursions. The unit is completely self-contained: the sensors, control electronics, displays, and sampling pumps are housed in a rack-mountable enclosure.

The low sample flow is made possible through the use of a unique carrier flow sample system. This employs actively controlled positive (carrier) and negative (sample) flows, allowing the gas sample to be rapidly transported to the measurement cell. The flows are automatically and continuously adjusted to compensate for different sample tubing setups and measurement conditions.

The front-panel LCD panel shows CO$_2$ concentration (percent or mmHg) as either the instantaneous value (**FAST** mode), or the end-tidal (**ET** mode) value. ET CO$_2$ and respiratory rate (RR) are updated on each breath, and can be averaged over a user-selectable number of breaths for a more stable reading. Analog outputs provide a linear voltage corresponding to the current gas concentration and respiratory rate. An RS232 serial output is provided for connection to an external computer, whereby data can be independently collected and analyzed.

The MicroCapStar has built-in audible and visual alarms for detecting out-of-range end-tidal CO$_2$ and other alarm conditions. The CO$_2$ alarm range, averaging mode, and calibration settings are stored in non-volatile memory and automatically reinstated when the instrument is next used.

Figure 1: MicroCapStar Front Panel

2.0 SPECIFICATIONS

Carbon dioxide measurement...single beam infrared
    Measurement range..0 – 11.0% (0 – 83mmHg) CO$_2$
    Accuracy 0.15% (1.1mmHg)
    Resolution (internal and analog output) 0.01% (0.1mmHg)
    Resolution (display) 0.01% (1.0mmHg)
    Linearity .... 0.1% CO$_2$
    Repeatability.. 0.1% CO$_2$
    Response time (T$_{10}$ - T$_{90}$) .... 75mS at 70 ml/min through cell
    Sample cell materials.. sapphire and stainless steel
    Analog output scaling of sensor 1.0V/% (0-10V)
    Zero stability .... 0.2% (8 hours), 0.3% (24 hours)
    Interference effects: 50% N$_2$O ....0.1% at 0% CO$_2$, 0.6% at 5% CO$_2$ (uncomp.)
    Maximum sample cell pressure.. $\pm$ 5 psig
    Interference effects: vaporized anaesthetic agents ....negligible
    Operating temperature range...5-40° C
    Optical bench temperature ....48° C, controlled
    Warm-up time ....4 min to 0.2%, 10 min to 0.1%
ETCO$_2$ trend display .... 5 minute graphical scrolling display
Sample flow .... 10ml/min nominal, adjustable 5 – 20 ml/min
Sample tubing connections (carrier flow, sample inlet) .... Luer female
Standard sample tubing set .... 0.030" (0.76mm) ID X 39" (1m) long
Calibration controls .... Zero, Span
ETCO$_2$ alarm adjustment range .... 1.0 – 9.9% (8 – 75mmHg)
ET and RR averaging interval .... 0 (no averaging), 4, 8, 12, or 16 breaths
Respiratory rate measurement range .... 5 – 200 breaths/min
Signal outputs (rear panel) .... BNC jacks
CO$_2$ output scaling .... 0.5V / %CO$_2$ (10% CO$_2$ = 5.0V)
Respiratory rate output scaling .... 0.025V / bpm
Alarm output .... 5V if alarm condition, 0V if no alarm
Serial data output format .... 2400 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 MICROCAPSTAR

❶ Place the MICROCAPSTAR control unit in a stable location close to the subject or animal being monitored. Note that the output signals are on the rear panel.

❷ Attach the sample tubing set to the front panel SAMPLE INLET and CARRIER OUTLET Luer connectors. Be sure the miniature hydrophobic filter is installed at the SAMPLE INLET connection. This filter is the final line of defense that prevents water or particulates from entering the infrared CO2 sample cell.

❸ Switch POWER on. The front-panel display should come on, showing a "welcome" message, indicating that the unit is receiving power and operating. The sensors and flow controls will take about five minutes to warm up and stabilize.

> **NOTE:** *Both tubing connections,* SAMPLE INLET *and* CARRIER OUTLET *MUST be connected for proper operation!*

❹ The distal end of the sample tubing set has a miniature "T" connector. This should be connected as closely as possible to the endotracheal tube connection to insure a good end-tidal sample. Various tubing adapters are provided for making this connection. See *Figure 3* for a connection diagram.

❺ See the remainder of this manual for the various operating modes and controls.

4.0 OPERATION

4.1 CALIBRATION

The CO$_2$ sensor used in the MicroCapStar is highly linear, so a two-point calibration is all that is required.

Zero adjust: With the sample tubing set open to room air, press the **CAL HIGH / CAL LOW** rocker switch to the **CAL LOW** position and hold it there. Rotate the **SET** knob until the reading shows 0.0% or alternates between 0.0 and 0.1%. Note that the display stops at 0.0%, but negative readings are indicated by a flashing "-" sign to the left of the CO$_2$ reading.

Span adjust: With the sample tubing set sampling 5.0% CO$_2$ (or other cal gas in the range 5 – 10% CO$_2$) press the **CAL HIGH / CAL LOW** rocker switch to the **CAL HIGH** position and hold it there. Adjust the **SET** knob until the calibration gas value is displayed ($\pm$0.1%).   Calibration can be performed in either percent or mmHg display mode.

Note: Do not apply any pressure to the sample tubing inlet. Place the sample port loosely into a stream of the calibration gas so that the instrument can freely draw in the sample at its own rate.

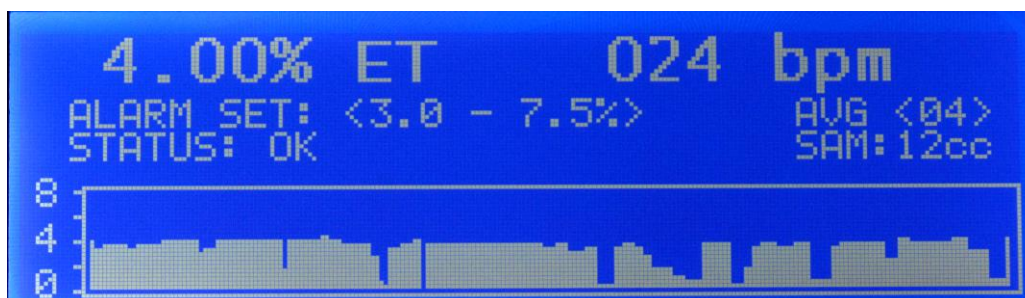## 4.2 MONITOR DISPLAY AND SETTINGS

Figure 2: MicroCapStar LCD display panel

The front-panel LCD panel shows the current measurements, the settings and state of the programmable alarm, operator messages, and a graphical trend display of the ETCO$_2$ concentration. The principal measurements, CO$_2$ and respiratory rate, are displayed at the top of the display, for example:

4.9%   123 bpm, or **37mm   123 bpm**.

The second line shows ETCO$_2$ alarm band settings in either percent or mmHg, depending on the setting of the **MMHG / PERCENT** switch. The number of breaths being averaged is also displayed as: **AVG <4>**.

The third line shows error or alarm messages and/or system status. The current sample flow is displayed as: **SAM: 10cc**.

At the bottom of the display is a scrolling bar graph showing ETCO$_2$. This trend display shows the last five minutes of monitoring, and serves as an indicator of rising or falling CO$_2$ values. The range of this display is 0 – 8.0% (0 – 60 mmHg).

4.3 END-TIDAL OR FAST CO$_2$ DISPLAY SWITCH

The LCD display on the MicroCapStar can report CO$_2$ concentration in either a continuous reading (**FAST**), or as the peak expired value (**END TIDAL**), depending on the setting of this switch. In **FAST** mode, the display is updated at approximately 3 readings/second.

Note that the **CO$_2$ OUTPUT** (rear panel) always provides the fast response signal.

4.4 mmHg / PERCENT SWITCH

This switch selects the display mode as either percent CO$_2$ concentration, or as partial pressure in mmHg.

4.5 CO$_2$ ALARM ON / OFF SWITCH

When switched on, an alarm will sound if the monitored ETCO$_2$ falls outside of the alarm band range. The **ERROR** LED will also flash to indicate this alarm condition.

4.6 INDICATOR LED'S

Sensor Not Ready: This LED will be illuminated while the CO$_2$ sensor is warming up.

Check Sample Flow: This LED will flash if the sample flow is obstructed or otherwise out of range.

Error: This LED will flash if an error or alarm condition is encountered. The LCD panel will provide a description of the condition.

4.7 SETTING AND USING THE ETCO$_2$ ALARM

This MicroCapStar provides a user-selectable alarm for ETCO$_2$. When this alarm is turned on, and an out of range ETCO$_2$ measurement is encountered, an alarm will sound and the **ERROR** LED will flash.

To set the alarm range, move and hold the **CO2 ALARM HIGH / LOW** switch to either the **HIGH** (up) or **LOW** (down) position, and hold it there while turning the **SET** knob. The alarm setting selected will change on the display, e.g.: **<3.5 - 6.0%>, or   <26 – 46 mm>**

4.8 SETTING THE SAMPLE FLOW RATE

This sample flow rate can be adjusted over the range of approximately 5 – 20 ml/min. The factory setting is approximately 7.5 ml/min, which has been found suitable for both mice and rats, but lower settings may be desirable with very small animals.

To adjust the sample flow, hold the **CAL** switch in the **HIGH** position, and momentarily press the **SET** knob. The display will show:

STATUS: Flow 350U 07.4cc

Rotate the **SET** knob until the desired flow rate in cc/min is indicated, and press the set knob to exit.

Note: If the sample flow rate is changed, the instrument must be re-calibrated before accurate readings can be obtained.

4.9 SETTING THE DISPLAY AVERAGING INTERVAL

The ETCO$_2$ and respiratory rate (RR) are computed on each detected breath. These values can be averaged over a user-selectable number of breaths to produce a more stable display.

To adjust the averaging interval, hold the **CAL** switch in the **LOW** position, and momentarily press the **SET** knob. The display will show:

STATUS: Set AVG: Press KNOB   AVG <8>

Rotate the **SET** knob until the desired number of breaths is indicated (0, 4, 8, 12 or 16), and press the **SET** knob to exit.

Note: A setting of <0> indicates no averaging; the value will then be updated on each breath.

4.10 ANALOG OUTPUT SIGNALS (Rear Panel)

Analog outputs are provided for CO$_2$ concentration, respiratory rate, and the alarm status. These signals are scaled as follows:

CO$_2$ output: 0.5V / %CO$_2$

Respiratory rate: 0.025V / bpm

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

4.11 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	ETCO$_2$, rate	once each breath
FORMAT 2	ETCO$_2$, rate	every 10 seconds

These numbers are sent as simple ASCII characters, separated by commas, and each data set ends with a <cr> character (ASCII 13), e.g. **5.41,149<cr>** (ETCO$_2$ = 5.41%, rate = 149 bpm). This format allows for easy importation into spreadsheets or other analysis software.

The protocol used is 2400,N,8,1 which is almost universally available using any terminal program (e.g., Windows HyperTerminal).

5.0 MAINTENANCE

The MicroCapStar monitor requires no routine maintenance, other than periodically replacing the in-line hydrophobic filter. This filter is inserted in the **SAMPLE INLET** port 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 FILTER. THIS FILTER PREVENTS LIQUIDS AND OTHER FOREIGN MATTER FROM ENTERING THE SAMPLE CELL.**

5.1 ERROR MESSAGES

Sensors not ready: This is a normal message during the warm-up period. If this appears after the instrument is fully warmed up, factory servicing is required.

CO2 Alarm!: This indicates the current ETCO$_2$ reading is outside the range of the alarm band.

Check sample flow: This indicates the sample flow rate is not within operating limits. The cause may be a clogged hydrophobic filter or sample tubing. If this message continues to appear after replacement of this filter, the sample tubing set may be blocked or kinked.

OK: This is the normal status display and indicates there are no operational problems with the instrument.

5.2 RESTORE FACTORY DEFAULT SETTINGS

Do the following to return all calibration and alarm settings to their factory state: While holding the **CO2 ALARM** switch in the **HIGH** position (up), press the **ADJUST** knob.

Press the **ADJUST** knob again to perform the restore defaults function, or briefly move the **CAL HIGH** switch to its active position (up). In either case, the instrument will restart.

Note: Be sure to recalibrate the CO$_2$ high and low settings following a change to factory settings.

6.0 ORDERING INFORMATION

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

PART No.	DESCRIPTION
15-10000	MICROCAPSTAR CO$_2$ Analyzer, with sample set & accessories
15-00100	Sample tubing set, 1m
15-00110	Sample tubing set, 2m
15-01101	MICROCAPSTAR accessory kit. Includes 6' of 0.062" ID tubing, 3 inline miniature hydrophobic disk filters, 2 ea "X", "Y", and "T" fittings for 0.062" ID tubing.
11-01108	In-line miniature hydrophobic filter, 13mm dia, Luer fittings, pk of 5
11-02000	Replacement sample air pump
11-01112	6 Meter Tubing Set for MicroCapStar

MicroCapStar Quick Start Guide

Setup:

Connect the MicroCapStar sample tubing set using the attached diagram as a guide. Keep the tubing volumes as small as possible.

Try to make the connection between the distal "T" connector and the other tracheal tube connections easily detachable for calibration purposes.

Startup:

Turn on the MicroCapStar. The display will show some startup messages, and then will indicate that it is waiting for the flow zeros to stabilize.

After this initial period, the sample pumps will come on, and the sample flow system will stabilize. The **SENSOR NOT READY** light will stay on while the infrared CO$_2$ sensor warms up.

It is recommended that the unit be running for at least 1/2 hour before initial measurements, to allow time for the CO$_2$ sensor to fully stabilize.

Calibration:

After the instrument has warmed up, adjust the **ZERO** and **SPAN** calibrations (see *Figure 4*).

ZERO adjustment:

For the **ZERO** calibration, open the distal "T" connector to room air. Hold the **CAL** switch in the **CAL LOW** position and rotate the adjustment knob until the display reads 0.0% (00.0mm). Note that a minus sign (-) will appear if the reading is below zero.

SPAN adjustment:

For the **SPAN** calibration, apply a 5% CO$_2$ calibration gas to the "T" connector. Hold the **CAL** switch in the **CAL HI** position and rotate the adjustment knob until the display reads 5.0% (00.0mm). See *Figure 4*, below.

After this initial calibration, it will be only necessary to check the **ZERO** setting after several hours of use.

Sample connections:

Figure 3, below, shows the recommended sample tubing connections. Other connection schemes are possible but be sure to connect the distal "T" connector of the sample tubing as close as possible to the endotracheal tube to minimize dead volume and insure a good end-tidal sample.
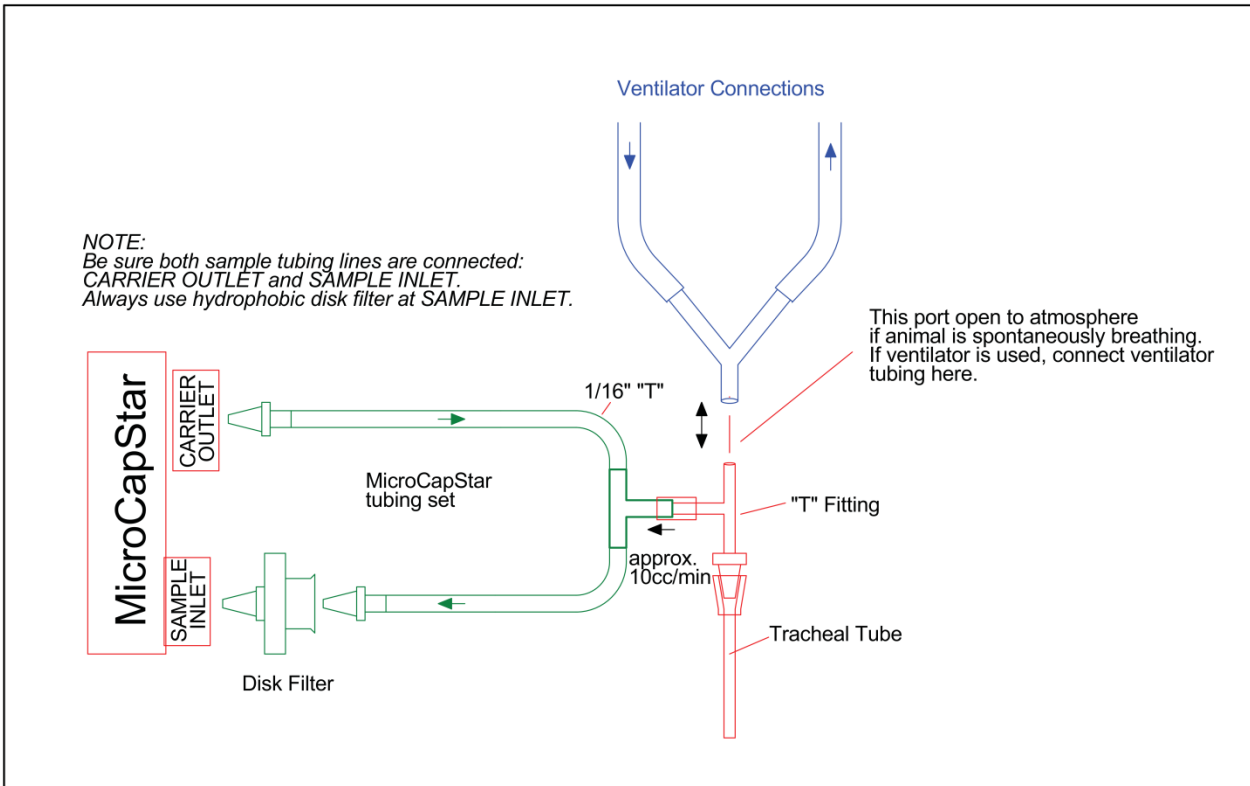
Figure 3: Recommended sampling connections.

IMPORTANT NOTE:
For the instrument to operate properly, both the SAMPLE INLET *tubing and the* CARRIER OUTLET *tubing MUST be connected. Always use the miniature in-line disk filter at the* SAMPLE INLET*.*

CALIBRATION PROCEDURE:
1. Keep existing MicroCapStar sample tubing set intact, and connected as shown.
2. Let the sampling port (distal "T") draw in room air, and adjust the CAL LO control.
3. Start the calibration gas flow (~100-200 ml/min).
4. DO NOT apply any pressure to the sampling port.
5. Once reading has stabilized, adjust CAL HI until correct CO2 value is displayed.

MicroCapStar

CARRIER OUTLET

SAMPLE INLET

MicroCapStar tubing set

Disk Filter

Flexible tubing

5 or 10cc syringe barrel
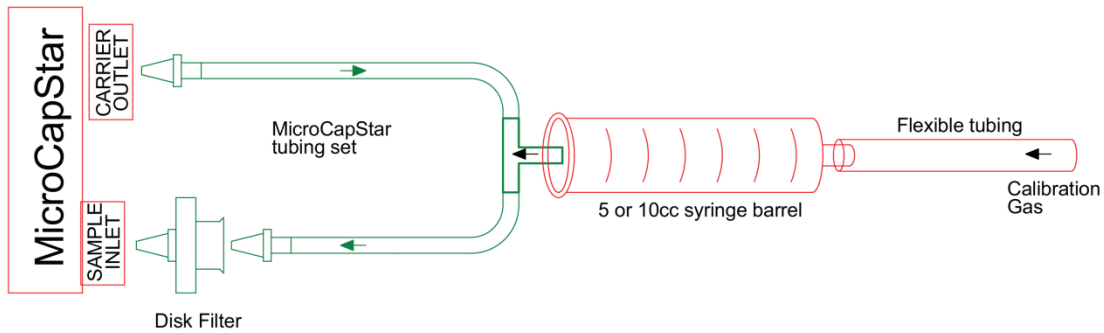
Calibration Gas

Note: It is very important that no pressure be applied to the sampling port! This will skew the calibration and result in innacurate readings when monitoring.

MicroCapStar Calibration connection diagram

Figure 4: Calibration procedure diagram