Operation MANUAL

CARBOMETER - CO2 concentration measurement unit

LAMBDA CO_2-meter: CO_2 concentration measurement unit

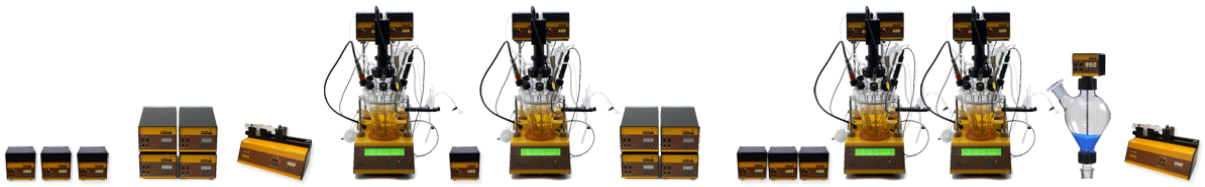
LAMBDA **CARBOMETER (CO_2-METER)** allows the measurement of the **concentration of CO_2 gas (0 – 100%) in the outgas / exit gas** of the MINIFOR fermentor and bioreactor and the digital transfer of the data to the PC achieved through its **RS-485 interface**. The measured data can be visualized and recorded for example by the **industrial fermentation software SIAM**.

It does not require any additional connector, cable or side neck. Connected to the glass outgas condenser (or Peltier outgas condenser) of the MINIFOR laboratory fermentor and bioreactor, the CO_2-METER measures the concentration of the CO_2 gas produced.

With SIAM industrial fermentation software, the **RQ** (respiratory quotient) from the **CPR** and **OUR** (obtained from **LAMBDA O_2-METER**) during the fermentation process can be calculated.

LAMBDA Laboratory Instruments

LAMBDA Laboratory Instruments develops innovative, high quality lab-scale instruments with an excellent price to performance ratio for biotechnology, microbiology, food and agricultural, chemical and pharmaceutical industries, research and development as well as for general laboratory and research applications.



LAMBDA MINIFOR – highly innovative and compact fermenter/bioreactor system for laboratory scale fermentation and cell cultures

LAMBDA OMNICOLL – fraction collector-sampler for unlimited number of fractions

LAMBDA PRECIFLOW, MULTIFLOW, HIFLOW, MAXIFLOW AND MEGAFLOW peristaltic pumps – reliable, precise and extremely compact

LAMBDA SAFETY POWDER DOSER AND HI-DOSER – allows automatic feeding of powders without spoon. Safe operation with hazardous material (GLP)

LAMBDA VIT-FIT (HP) polyvalent syringe pump with extremely robust mechanics – programmable infusion and filling from micro syringes to large volume syringes of 150 ml without adapter

LAMBDA MASSFLOW – precise gas flow measurement and control with data acquisition option

LAMBDA PUMP-FLOW INTEGRATOR – with LAMBDA pumps and doser allows the visualization and recording of the pumped volume

TABLE OF CONTENTS

1 SETTING UP THE CO_2-METER 3
1.1 Overview of CO_2-METER connections 3
1.2 Power supply 4
1.3 Measurement of CO_2 concentration in the outgas / exit gas 4
2 PC CONTROL & SOFTWARE 4
2.1 Setting up the address of CO_2-METER 4
2.2 PC connection 5
2.3 SIAM industrial fermentation software 5
3 CALIBRATION PROCEDURE FOR THE CO_2-METER 5
3.1 Zero setting 5
3.2 Sensitivity setting 5
4 TECHNICAL SPECIFICATIONS 6
4.1 General specification 6
4.2 Remote control (Inputs/outputs) 6
5 ACCESSORIES 7
6 GUARANTEE 7
7 APPENDIX 8
7.1 RS communication protocol of LAMBDA CO_2-METER AND O_2-METER 8
7.2 RS-connection scheme 9

1 SETTING UP THE CO_2-METER

1.1 Overview of CO_2-METER connections

Table 1 Connection overview of CO_2-METER: Stand-alone instrument, with MINIFOR fermentor-bioreactor or PC software

	CO_2-METER (stand-alone)	**CO_2-METER with MINIFOR**	**CO_2-METER with PC software**
Remote control	-	Pump remote control (analog and digital) cable (8 poles)	-
RS-interface	-	RS-485 interface (incorporated with CO_2-METER)	RS-485 interface (incorporated with CO_2-METER)
PC connection	-	Please refer MINIFOR operation manual	USB or serial port
MINIFOR connection	-	**PUMP** - socket at the rear of MINIFOR control unit	-
1. REMOTE (rear of CO_2-METER)	-	o Connect one end of 8-pole remote control cable to the **PUMP** - socket at the rear of the **MINIFOR control unit** o Other end of the 8-pole remote control cable to **REMOTE**-socket at the rear of **CO_2-METER**	o Connect the **RS-485 connection kit** to the **PC** with the help of the **USB** connector. o Plug-in the other end of the connection kit (RS-485 connection cable) to the **REMOTE** socket of **CO_2-METER**
2. POWER (rear of CO_2-METER)	o Plug the connector of power supply cable into the **POWER** - socket (12 V) at the rear of **CO_2-METER** o Universal plug-in power supply (100-240 V AC/50-60 Hz, 12 VDC, 12 W) to mains	-	o Plug the connector of power supply cable into the **POWER** - socket (12 V) at the rear of **CO_2-METER** o Universal plug-in power supply (100-240 V AC/50-60 Hz, 12 VDC, 12 W) to mains
3. IN nozzle (rear of CO_2-METER)	Connect the gas tubing from the **outgas / exit gas condenser** to the **IN nozzle** of CO_2-METER and secure it with clamps		
4. OUT nozzle (rear of CO_2-METER)	Connect tubing to the **OUT nozzle** of CO_2-METER to lead the measured gas to O_2-METER / CH_4-METER / to measure total gas flow or others		

1.2 Power supply

The LAMBDA CO_2-METER is powered by MINIFOR Fermentor-Bioreactor. The CO_2-METER is connected with the corresponding 8-pole remote control cable *(art. no. 4810)* to the **"PUMP"** - socket at the rear of the **MINIFOR** laboratory fermenter-bioreactor.

The other end of the 8-pole remote control cable (art. no. 4810) is plugged into the **"REMOTE"** - socket at the rear of the **CO_2-METER**.

When **used independently** of the MINIFOR laboratory bioreactor-fermentor, a universal **plug-in power supply** (100-240 V AC/50-60 Hz, 12 VDC, 12 W) is used *(art. no. 4820)*.

Connected to the power supply, all LEDs and the display of the CO_2-METER light shortly. This allows a function control of all signal elements.

1.3 Measurement of CO_2 concentration in the outgas / exit gas

The gas tubing from the **outgas / exit gas condenser** (glass or Peltier outgas condenser of MINIFOR fermentor-bioreactor) is connected to the **"IN" nozzle** at the rear of CO_2-METER to measure the concentration of CO_2 (0-100%).

The concentration of CO_2 in the outgas / exit gas can be measured in terms of **0 - 9.99% and 10.0 - 99.9%.**

The gas tubing from the **"OUT" nozzle** of CO_2-METER can be connected to the other outgas concentration measurement instruments like O_2-METER, CH_4-METER (IN nozzle) or measure total gas flow with a MASSFLOW gas flow meter.

2 PC CONTROL & SOFTWARE

The measured CO_2 outgas concentration data can be visualized and recorded, for example by the industrial fermentation software SIAM.

2.1 Setting up the address of CO_2-METER

To look up/modify the instrument address:

- ✓ Disconnect the 8-pole remote control cable from CO_2-METER (when used together with the MINIFOR fermentor-bioreactor) or the power supply (stand-alone or PC)
- ✓ Press the **CO2 [%]** button continuously and at the same time connect the 8-pole remote control cable to CO_2-METER (when used together with the MINIFOR fermentor-bioreactor) or the power supply (stand-alone or PC)
- ✓ The message ***"A"*** and two numbers will appear on the display. This number from 00 to 99 is the current address of the CO_2-METER
- ✓ To change the address, press the buttons **Λ Λ Λ** under the display until the desired number is obtained.
- ✓ To confirm and save the address, press the **OK** button.

2.2 PC connection

CO_2-METER with PC software: CO_2-METER with the RS-485 connection kit (*includes: RS-485 connection cable, RS-232/485 converter, Power supply for RS-232/485 converter and USB to RS-232 converter)* is connected to the USB port of the PC (when used independently of MINIFOR fermentor-bioreactor) for the control by software.

CO_2-METER with MINIFOR: CO_2-METER is connected to the **"PUMP"** – socket at the rear of MINIFOR fermentor-bioreactor. MINIFOR fermentor-bioreactor is connected to the SIAM industrial fermentation software with the help of PC connection kit.

2.3 SIAM industrial fermentation software

SIAM industrial fermentation software is intended for the automation of fermentation and cell culture processes at laboratories.

When used together with MINIFOR fermentor-bioreactor, the SIAM industrial fermentation software allows to calculate the **RQ** (respiratory quotient or respiratory coefficient) from the **CPR** (Carbon dioxide Production Rate) and **OUR** (Oxygen Uptake Rate, obtained from LAMBDA O_2-METER) during the fermentation process.

3 CALIBRATION PROCEDURE FOR THE CO_2-METER

The CO_2 concentration can be calibrated on the LAMBDA CARBOMETER (CO2-Meter). The calibration is a two-point calibration consisting of zero-setting and sensitivity setting:

3.1 Zero setting

On the rear side of the LAMBDA CARBOMETER (CO2-METER), there are two buttons labeled **N_2** and **Air**. These buttons are used for the zero setting of the instrument.

Connect a source of nitrogen (N_2) gas to the CARBOMETER input barb. The gas flow rate should be around 200 ml/min. The display shows a value, which is gradually stabilizing and approaching zero. After the value on the display stabilizes, press the button in the hole on the rear side labeled **N_2**. The display shows ***"0.00"***.

A simpler but less accurate way is to use an air flow for the zero setting (air flow rate should be around 200 ml/min). In this case, after the value on the display stabilizes, press the button in the hole on the rear side labeled **Air**. The display shows ***"0.04"***, which corresponds to the expected concentration of CO_2 in air (400 ppm).

3.2 Sensitivity setting

Connect a source of **known concentration of CO_2** to the CARBOMETER input barb. The gas flow rate should be around 200 ml/min.

The display will stabilize with the actual value of CO_2 concentration. After the actual value of CO_2 concentration has stabilized the correction factor can be calculated as the ratio between the real CO_2 concentration and the actual measured CO_2 concentration.

Unplug the power supply and continuously press the $\wedge$ button located below the highest order digit of the display and reconnect the power supply. The display shows ***"SLP"*** and

then the value of the correction factor. Use the ∧ buttons under the display to set the desired value of the correction factor and press button ↵. The correction factor is saved, the display shows the actual CO_2 concentration and the CARBOMETER is switched to operation mode.

4 TECHNICAL SPECIFICATIONS

4.1 General specification

Type:	LAMBDA CARBOMETER CO_2 concentration measurement (0-100%)
Accuracy:	± 3% reading or 1 digit
Measurement range:	
[CO_2]	0 – 9.99 % and 10.0 – 99.9%
Interface:	RS-485
Power supply:	90–240 V/50–60 Hz AC plug-in power supply with DC 12V/12W output
Dimensions:	10.5 (H) x 8 (W) x 17 (D) cm
Weight:	0.6 kg
Safety:	CE, meets IEC 1010/1 norm for laboratory instruments
Operation temperature:	0-40 °C
Operation humidity:	0-90% RH, not condensing

For safety reasons the voltage of the external signal must **not exceed** 48 V to earth!

4.2 Remote control (Inputs/outputs)

No.	***Colour***	***Description***
1	*yellow*	*(+) input remote speed control 0-10V *)*
2	*grey*	*not used*
3	*green*	*earth, 0 V*
4	*brown*	*+ 12 V*
5	*white*	*(+) input remote ON/OFF; 0V = ON, 3–12 V = OFF* *(this logic can be inversed on demand)*
6	*pink*	*earth, ground (GND)*
7	*red*	*RS 485 B (-)*
8	*blue*	*RS 485 A (+)*

**) (zero line connected to the contact no. 3)*

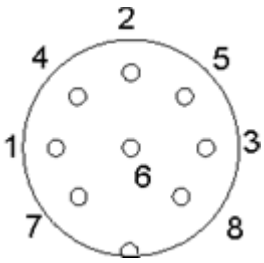


Figure 3.2-1 8 pole connector

5 ACCESSORIES

ART. NO.	ACCESSORIES
	PC connection
4817-kit	*RS-485 connection kit (for connection to a serial port or USB port)*
	Control
4810	*Pump remote control (analog and digital) cable, 8 poles connector*
800202	*Quadruple plug box (power and RS-connection for up to 4 LAMBDA laboratory instruments)*
	Spare parts
4820	*Plug-in power supply (12 V / 12 W) [Plug-type: AU, CH, EU, UK, US]*
4815	*Silicone tubing 3/5 mm (10 m)*
800202	*Quadruple plug box (power and RS-connection for up to 4 LAMBDA laboratory instruments)*
800083	*Electronic Peltier air output condenser (no water connection required)*
	Outgas concentration measurement
8080	*OXYMETER (O_2-METER) O_2 concentration measurement (0-25%)*
8081	*CARBOMETER (CO_2-METER) CO_2 concentration measurement (0-100%)*
8082	*METHAMETER (CH_4-METER) CH_4 concentration measurement (0-100%)*

6 GUARANTEE

LAMBDA provides a two-year guarantee on material and manufacturing defects, if the instrument was used according to the operation manual.

Conditions of guarantee:

- The instrument must be returned with a complete description of the defect or problem. In order to send back the equipment for repair, you will need a returns authorization number from LAMBDA.
- The customer will send the instrument to our service office.
- Damage or loss of items during transport will not be compensated for by LAMBDA.
- Failure to fulfil these requirements will disqualify the customer from compensation.

Serial Number: _____

Guarantee from: _____

7 APPENDIX

7.1 RS communication protocol of LAMBDA CO_2-METER AND O_2-METER

7.1.1 Communication settings:

Speed:	2400 Baud
Data format:	8 bit, odd parity, 1 stop bit
Transmit-Receive switching:	DTR (usually automatic switching)
Transmit-Receive interval:	10 ms

7.1.2 Data format for transmission from the computer (master):

ss mm **z** qs c send data

where:

ss	is the address of the slave receiver
mm	is the address of the transmitter (master)
z	command
qs	Checksum
c	carriage return CR (ASCII 0D)

7.1.3 Commands for CO_2-METER

#ssmm**K**qsc	send concentration of CO2 [%]
#ssmm**H**qsc	send humidity value [%]
#ssmm**T**qsc	send temperature [º C]
#ssmm**G**qsc	send the measure value of the concentration of CO2 [%]
#ssmm**V**qsc	send the measure value of the concentration of CO2 [%]

* Commands **G** and **V** allow MASSFLOW simulation in SIAM

7.1.4 Commands for O_2-METER

#ssmm**K**qsc	to send the value of the concentration of O_2 [%]
#ssmm**O**qsc	to send the value of O_2 partial pressure [mbar]
#ssmm**P**qsc	to send the value of the total pressure [mbar]
#ssmm**T**qsc	to send value of temperature [º C]
#ssmm**G**qsc	to send the measure value of the concentration of O_2 [%]
#ssmm**V**qsc	to send the measure value of the concentration of O_2 [%]

* Commands **G** and **V** allow MASSFLOW simulation in SIAM

7.1.5 Data format for transmission to the computer (master):

< mm ss a xxxx qs c

where:

a	indicator variables (1 character ASCII)
xxxx	data (4 ASCII number 0.....9 - transmission from high to low)
qs	checksum in hexadecimal format (2 ASCII symbols 0.....9 A B C D E F)
c	carriage return CR (ASCII 0D)

<mmss**K**xxxxqsc	value of O_2 or CO_2 concentration (xx.xx) [%]
<mmss**O**xxxxqsc	value of the partial pressure of O_2 (xxx.x) [° C]
<mmss**P**xxxxqsc	value of the total pressure (xxxx) [mbar]
<mmss**T**xxxxqsc	value of temperature (xxx.x) [° C]
<mmss**H**xxxxqsc	value of humidity (xx.xx)

Simulation of MASSFLOW in SIAM (commands G and V):

<mmss**r**xxxqsc	value of the concentration of O_2 or CO_2 (xx.x) [%]

7.2 RS-connection scheme

The 8-pole DIN connector “REMOTE” is used for the remote control and RS-485 connection.

No.	***Colour***	***Description***
1	*yellow*	*(+) input remote speed control 0-10V *)*
2	*grey*	*not used*
3	*green*	*earth, 0 V*
4	*brown*	*+ 12 V*
5	*white*	*(+) input remote ON/OFF; 0V = ON, 3–12 V = OFF* *(this logic can be inversed on demand)*
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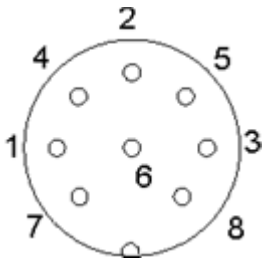

Figure 7.2-1 8 pole connector

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