CD-300

CO_2 ANALYZER

USER'S MANUAL

No 83669

DATEX
INSTRUMENTARIUM OY

P.O. BOX 387 00101 HELSINKI 10 FINLAND
PHONE 90-711211 · TELEX 124667

1. INTRODUCTION

1.A. Applications

The CD-300 CO_2 Analyzer is used for the continuous measurement of $\%CO_2$ in gas mixtures. This is most useful for respiratory monitoring of: a) adequacy of ventilation in anaesthesia, b) changes in circulation, respiration or metabolism, c) pulmonary circulation during cardiac bypass, e) the need for increased sedation, f) the efficacy of blood transfusion, g) weaning after anaesthesia. The CD-300 may also be used in the instrumentation for Pulmonary Physiology and for many research applications.

1.B. Description of Operation

The measurement principle of the CD-300 is based on the absorbtion of Infrared radiation by CO_2. The Sample Gas is drawn into the Measuring Chamber by a small pump. Infrared light is divided into two paths, one passing through the Measuring Chamber and one through a Reference Chamber. The exact wavelength of light is selected by a narrow band interference filter. The light transmitted through the Measuring and Reference Chambers is measured alternately by a Lead Selenide photodetector. The difference in the two measurements gives the absorbtion by the CO_2 in the Measuring Chamber. This system of measurement compensates for possible changes in the light source, filter or photodetector. The absorbtion by the CO_2 is proportional to the CO_2 concentration. After electronic processing, this difference signal is displayed on the Front Panel Meter.

1.C. Special Features

The CD-300 contains a number of special features which contribute to ease of operation and convenience. These features are: a) solid state circuitry for maximum reliability and ruggedness, b) short warm-up time for emergency use, c) small sample size for minimum disturbance of respirator system, d) fast response time for capnogram recording, e) digital display of minimum or maximum $\%CO_2$ per respiratory cycle, f) digital display of respiration rate, g) push button N_2O compensation, h) built-in recorder for immediately available capnograms, i) easy connection to ventilators with a wide variety of adaptors.

1.D. Setting-Up Instructions

The CD-300 is ready to operate when delivered. If no external damage is evident the Analyzer may be plugged in and turned on immediately. The function of the Controls, Inputs and Outputs is explained in §3 of this Manual and the Measurement Procedures are explained in §4.

2. TECHNICAL DATA

2.A. Measurement Specifications

Measurement Range	0 to 10% CO_2 Volume
Measurement Accuracy (Dry sample at 1000 mbar pressure)	+/-2% of full scale (+/-0.2% absolute)
Zero Point Drift	+/-2% of full scale
Rise Time (minimum) (Maximum flow rate with no Sample Tube or Water Trap)	0.05 sec. (10% to 90%)

2.B. Outputs

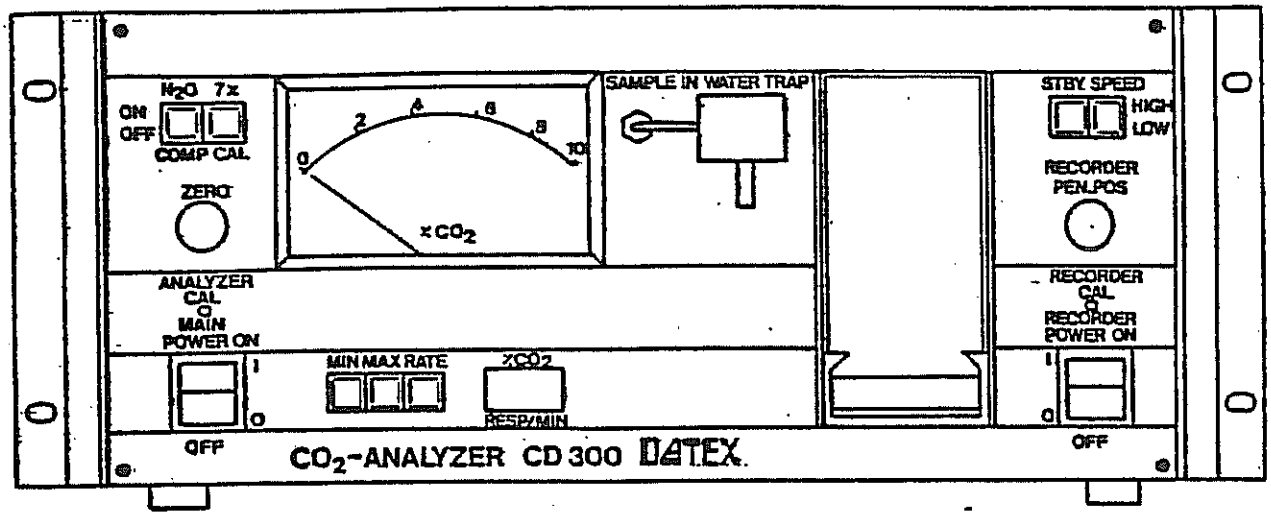
Illuminated Panel Meter	0 to 10% CO_2
Digital Display (pushbutton selectable)	Max. % CO_2/Resp.Cycle Min. % CO_2/Resp.Cycle Respirations/Minute
Strip Chart Recorder (25 and 750 mm/min. chart speed 50 Hz 30 and 900 mm/min. chart speed 60 Hz)	0 to 10% CO_2
Recorder Signal	0 to 1.0 volts

2.C. Power and Environment Requirements

Line Voltage	220 volts A.C. (117 volts option)
Line Frequency	50 or 60 Hz
Power Consumption	100 watts
Temperature	+15 to +35 C^{o}
Operating Position	Within 15 degrees of Horizontal

2.D. Physical Characteristics

Dimensions	
Height	177 mm
Width	435 mm
(with rack amount adapters)	482 mm (19 inches)
Length	304 mm
Weight	13 Kg
Sample Gas Flow Rates (approximately)	1.5 l/min. 0.4 l/min. 0.2 l/min. 0.05 l/min. (optional)



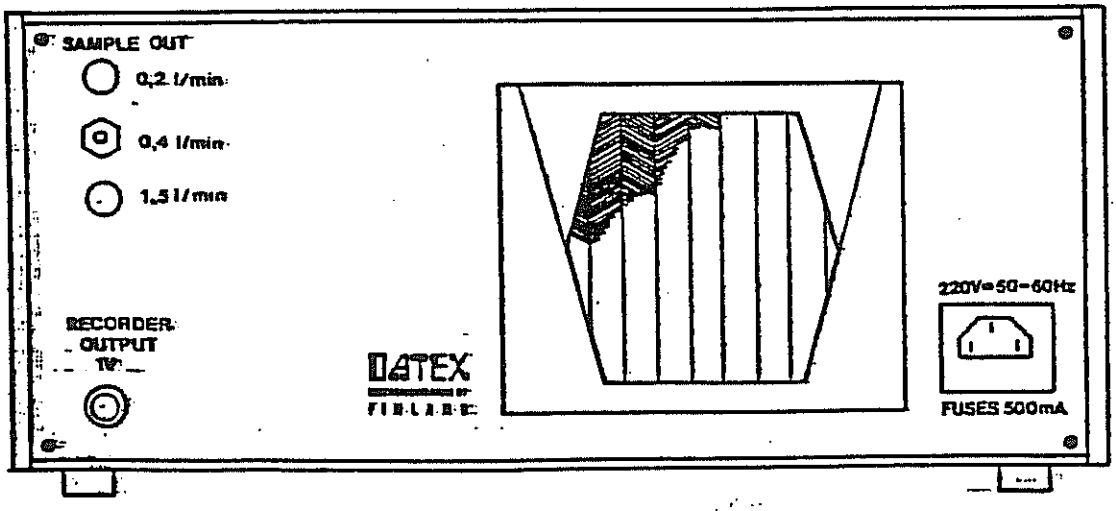


Fig. 3.a. FRONT AND REAR PANEL OF CD-300

3. OPERATING PROCEDURES

3.A. General Principles

The operation of the CD-300 is simplified by push-button controls and built-in calibration and compensation devices. The gas to be measured is connected to the Sample Inlet, either via the Water Trap or directly. The CD-300 is precalibrated and is ready to read VOL %CO_2 immediately. The procedures for measuring and calibrating are described in sections 4. MEASUREMENT PROCEDURE and 5. CALIBRATION PROCEDURE.

3.B. List of Functions and Operation (see Fig.3.a.)

3.B.1. Controls

MAIN POWER ON Switch
This Switch controls the main power to the CD-300. When the power is turned on the Panel Meter light goes on. Warm-up takes about 5 minutes.

ZERO CONTROL
This Control sets the zero of the Analyzer Electronics. The procedure for setting the Zero is described in §4.C.

ANALYZER CAL. Control
This screwdriver adjustable control is used to adjust the gain the analyzer electronics. For the adjustment procedure see §5. CALIBRATION PROCEDURE.

N_2O COMP. Switch (On-Off)
This Switch provides compensation for N_2O in the Sample Gas. When more than 30% of the Sample Gas is N_2O this Button should be pressed ("ON" Position)
7% CAL. Switch (On-Off)
This Switch provides a signal to the Recorder which is equal to a 7% CO_2 concentration.

MIN. Switch

When this Button is pressed the Digital Display shows the minimum $\%CO_2$ per respiration cycle.

MAX. Switch

When this Button is pressed the Digital Display shows the maximum $\%CO_2$ per respiratory cycle.

When MIN. and MAX. Switches are pressed simultaneously the Digital Display shows alternatingly the minimum and the maximum $\%CO_2$ per respiratory cycle.

RATE Switch

When this Button is pressed the Digital Display shows the Respiration Rate sampled over an interval of approximately 10 seconds.

RECORDER POWER ON Switch

This Switch controls the power to the Recorder. When it is turned On ("I" is pressed) the Recorder will be ready to operate.

RECORDER PEN. POS. Control

This Control sets the position of the Recorder Pen. It is primarily used for Zeroing the Recorder.

STBY. Switch

When this Standby Button is pressed the Recorder is ready to operate but the chart paper will not move.

RECORDER CAL. Control

This screwdriver adjustable Control is used to adjust the sensitivity of the recorder amplifier. For the adjustment procedure see 7% CAL. Switch.

SPEED Switch (High-Low)

When this Button is pressed Down the Chart Paper will run at the Low Speed (25 mm/min.). When the Button is Up the Chart Paper runs at the High Speed of 750 mm/min (50 Hz operation). For 60 Hz operation the corresponding speeds are 30 and 900 mm/min.

3.B.2. Inputs

SAMPLE IN

This tube connector leads to the Measuring Chamber. The Sample Gas may be either input directly or through the Water Trap.

WATER TRAP

This Trap serves to remove excess water vapor from the Gas Sample. It is effective at flow rates of 0.2 and 0.4 liters/minute but not at 1.5 liter/minute.

POWER CONNECTOR (Rear Panel)

The Main Power Cord is connected to this socket. The appropriate line voltage and frequency are marked on the rear panel.

3.B.3. Outputs

PANEL METER (%CO_2)

This Meter displays the %CO_2 concentration in the Sample Gas. The range is from 0 to 10 %. The meter illumination lamp serves as a Power On indicator.

DIGITAL DISPLAY (resp/min and %CO_2)

This two digit display shows either maximum or minimum %CO_2 per respiratory cycle or the respiratory rate. The display mode is selected by pressing the appropriate button to the left of the display.

RECORDER

This strip chart Recorder gives an instantaneous record of %CO_2 during the respiratory cycle (Capnogram). The Recorder is operated by the Controls to the right of the paper drive.

SAMPLE OUT Ports (Rear Panel)

These three ports are the outlets of the Sample Gas from the pump. Two ports are always covered and one is open. The one that is open selects the Sample Gas flow rate. No connections should be made to these prots.

If, however a gas scavenging system is used, be certain that the tubing flow resistance or suction pump do not change the pressure at outlet. Such changes cause the flow rates to change.

4. MEASUREMENT PROCEDURE

4.A. Normal Respiration Monitoring

For continuous respiration monitoring, the flow rate can be set at either 0.2 or 0.4 liters/minute. The Water Trap should be used to prevent condensation in the Measuring Chamber. When used this way, the rise time of the measurement is fairly long (see §4.D.). The procedure for Normal Respiration Monitoring is as follows:

1) Connect the Main Power and turn the POWER Switch on.
2) Connect the Sample Tube to the Water Trap. Open the appropriate Sample Out port to select the flow rate.
3) If the Sample Gas has an N_2O content of more than 30%, press the N_2O Compensation Button.
4) Zero the Analyzer after the POWER has been on for at least one minute (see § 4.C.).
5) Connect the Sample Tube to the Breathing Tube as close to the Patient as possible, at the upper end of the endotrachial tube, for example. Be sure that there are no air leaks.
6) Empty the Water Trap at one hour intervals or whenever it is half full, whichever comes first.

4.B. Measurement Requiring a High Resolution Recording

To obtain high resolution, the maximum Sample Gas flow rate should be used. The Water Trap should not be used (it is not effective at high flow rates anyway). The Sample Tube should be as short as possible and should have an inside diameter of 2 mm. Care should be taken to minimize the possibility of condensation, saliva or other contaminants entering the Measuring Chamber.

The procedure for high resolution measurements is as follows:

1) Connect the Main Power and turn the POWER Switch on
2) Connect the Sample Tube directly to Sample In and open the appropriate Sample Out Port to select the Flow rate (1.5 liters/minute in this case).
3) If the Sample Gas has an N_2O content of more than 30%, press the N_2O Compensation Button
4) Zero the Analyzer after the POWER has been on for at least one minute (see § 4.C.)
5) Connect the Sample Tube to the Sample Connector. Be sure that there are no air leaks.

A rough idea of the resolution of a measurement can be obtained from section 4.D. The Table of Rise Times (Table 4.D.1.) gives the time resolution of measurements under various conditions.

4.C. Zeroing the Analyzer

The CD-300 has two ZERO Controls, one for the Analyzer Electronics and one for the Recorder. The procedure for zeroing is the same for both. This procedure is as follows:

1) Turn on the Analyzer and allow to warm up for at least one minute
2) Run the Recorder at Low Speed if it is to be zeroed
3) If an anaesthetic gas or mixture of gases is to be used, this should be used as the zero standard. In other cases, room air with a CO_2 absorber may be used as the zero standard. If a CO_2 absorber is not available the zero point should be set at $\sim$ 0.05 $\%CO_2$ (in this case be careful to keep the Sample Inlet away from expired air).
4) Set the Panel Meter to Zero with the ZERO Control on the left side of the Analyzer

5) Set the Recorder to Zero with the PEN POS. Control (Adhere to this sequence of adjustments as step 4 also changes the Recorder Pen position)

6) Reset the Zero level whenever convenient. (Zero drift is the main source of error in CO_2 measurements.)

4.D. Measurement Time Resolution

A number of factors effect the Time Resolution of the Analyzer. These are 1) length of the Sample Tube, 2) inside diameter of the Sample Tube, 3) if the Water Trap is used or by-passed, 4) the Sample Gas flow rate. All of these factors have an effect on the amount of mixing and dispersion of the Sample Gas. If we assume that a CO_2 Sample is injected at the Sample In Port, the $\%CO_2$ reading should ideally come to a new value instantly. Due to the mixing and dispersion of the Sample Gas, this will actually take some time. This is called the Rise Time. Rise Times are generally given as the time taken for the reading to go from 10% to 90% of the stable measured value. Table 4.d. gives Rise Times for the CD-300 under various conditions.

Table 4.d. Analyzer Rise Times (10% to 90%)

Sample Gas Flow Rate	Length of Sample Tube	Sample Tube Inside Dia.	Water Trap	Rise Time
0.2 l/min	1.5 meter	2.0 mm	YES	0.75 sec.
0.4 l/min	"	"	"	0.5 "
1.5 l/min	"	"	"	0.16 "
0.2 l/min	15 cm	"	"	0.75 "
0.4 l/min	"	"	"	0.5 "
1.5 l/min	"	"	"	0.16 "
0.2 l/min	"	"	NO	0.15 "
0.4 l/min	"	"	"	0.13 "
1.5 l/min	"	"	"	0.07 "

4.E. Atmospheric Pressure Correction

The output signal of the CD-300 is determined by the number of CO_2 molecules in the Measuring Chamber. This is essentially a measure of the Partial Pressure of CO_2 in the Sample Gas. The Analyzer is calibrated to read Volume $\%CO_2$ at standard pressure. Changes in pressure will therefore effect the absolute accuracy of the measurements. For control or monitoring purposes this is generally not important as the monitored parameter is mainly relative changes in the CO_2 level and not the absolute values. For absolute measurements however, the following correction procedure must be used:

1) Measure the atmospheric pressure (or obtain a value from the local weather service).
2) Calculate the $\%CO_2$ correction factor as follows:

$$\text{Corr. Fact.} = 1 + \left(\frac{P_1 - P_2}{P_2} \times 1.5\right)$$

where P_1 = standard pressure (1000 mbar or 760 mm Hg)

P_2 = local pressure

1.5 = sensitivity factor (a 1% change in pressure gives a 1.5 % change in the $\%CO_2$ reading)

3) Multiply the $\%CO_2$ reading by the Correction Factor to get the correct absolute $\%CO_2$.

5. CALIBRATION PROCEDURE

The CD-300 is factory calibrated. If it has not been damaged in shipment, it is ready to use as soon as it is unpacked and set-up. Due to the possibilities of contamination entering the Measuring Chamber of the Analyzer, it is a good idea to check the calibration occasionally.

5.A. Calibration Equipment

The following items are necessary for the Calibration procedure:

1) A bottle of CO_2 gas in air of a known percentage (between 5.0% and 10.0%)
2) A Calibration Chamber made as shown in Fig.5.a.
3) A CO_2 absorber (for zeroing)
4) A Laboratory Quality Barometer (or an up-to-date report from the local weather station of the atmospheric pressure).

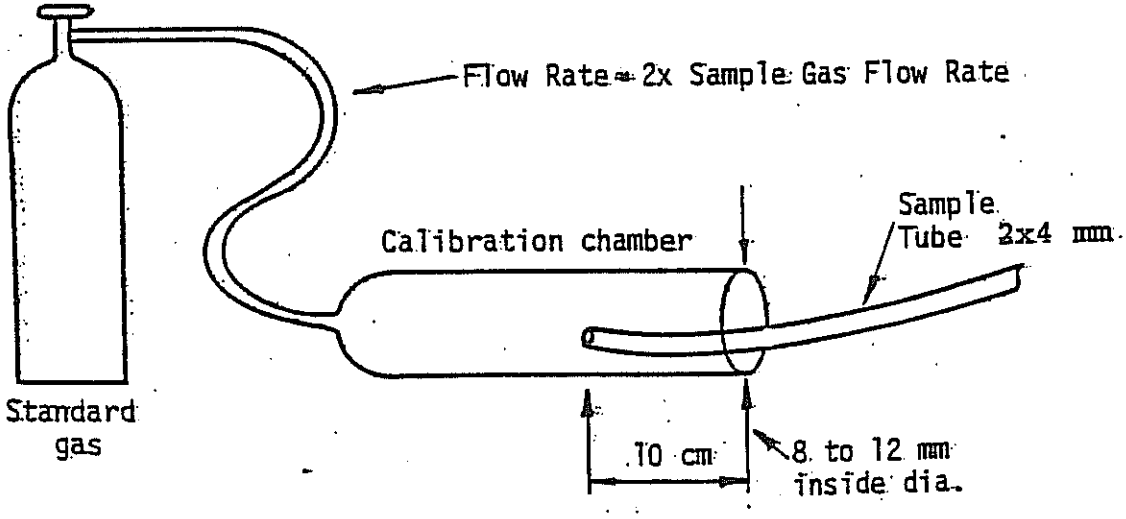


Fig. 5.a. Calibration Chamber and Connections

5.B. Calibration Procedure

The $\%CO_2$ Calibration Procedure is as follows:

1) Allow the Analyzer to warm up for 2 hours
2) Use the same measuring set-up that you normally use (same flow rate, sample tube)
3) Zero the Analyzer using a CO_2 absorber and the mixture of Anaesthetic Gas or air that is normally used
4) Place the Sample Tube in the Calibration Chamber as shown in Fig.5.A.
5) Turn on the Standard Gas and adjust the flow rate so that it is at least twice that of the Analyzer Sample Gas flow rate. (The flow rate should not be so high as to cause increased pressure in the Calibration Chamber).
6) Wait until the Panel Meter reading becomes perfectly stable
7) Adjust the Analyzer Gain Control until the Panel Meter reads exactly the same as the CO_2 concentration of the Standard Gas (including the pressure correction).
8) Recheck the Zero Setting. If it is not exactly Zero, the calibration must be repeated.

6. MAINTENANCE AND TROUBLESHOOTING

6.A. Routine Maintenance

The problems most likely to occur with the CD-300 involve contamination of the Measuring Chamber. In most cases these problems can be solved simply by drying the Chamber. The procedure for this is as follows:

1) Remove the Sample Tube and connect it to the Sample Out Port. Empty the Water Trap.
2) Run the Analyzer until the Zero point remains constant and until the Sample Tube is dry
3) If the Analyzer cannot be zeroed after running for a few hours, the Measuring Chamber will have to be cleaned (see Service Manual §3.B.)

The only other possible source of trouble might be the connections of the internal tubing. These should be inspected whenever the Analyzer is opened. The procedures for replacing tubing are described in the Service Manual (§3.C.).

6.B. Troubleshooting

The following is a Table showing the most likely problems and the best solutions.

PROBLEM	POSSIBLE CAUSE	SOLUTION
The analyzer does not work when the power is turned on.	The power cord is not plugged in. The fuse is blown.	Plug in the power cord. Check the fuse and replace if needed.
The panel meter is at the right side of the scale.	The Measuring Chamber is dirty.	Dry the Measuring Chamber (§6.A.) See Service Manual section 3.B.
The panel meter can be zeroed but it does not measure $\%CO_2$	Sample tube is not connected. Internal Pump Tubes have come off. The Pump is not working. The Chopper Plate is not rotating.	Check Sample Tube connections. Check the Internal Tube connections. Check the Pump. Check the Plate and free if necessary.

6.C. Recorder Maintenance

The only general maintenance procedure required by the Recorder is changing the paper. This procedure is as follows:

1) Turn off the Recorder Power
2) Open the Recorder by pulling out on the small handles at the top (see Fig.6.c.)
3) Tear off any remaining chart paper and lift supply core off paper post
4) Place new paper roll on paper post as shown in Fig.6.c.
5) Pass the paper over the Writing Edge
6) Close the Recorder by pressing handles firmly
7) Turn the Recorder Power on and run the Recorder at LOW SPEED
8) Push the paper behind the Rubber Roller at the bottom. The paper will be pulled through and will come out from behind the roller

6.D. Stylus Temperature Adjustment

If the line on the paper is too dark or too light the stylus temperature must be adjusted. The Stylus Temperature Adjusting Screw is behind the Recorder so the Recorder must be opened (as described above) to adjust the temperature.