BOOK

2

INSTRUCTION MANUAL FOR STEADY STATE DIFFUSION CAPACITY MODULES

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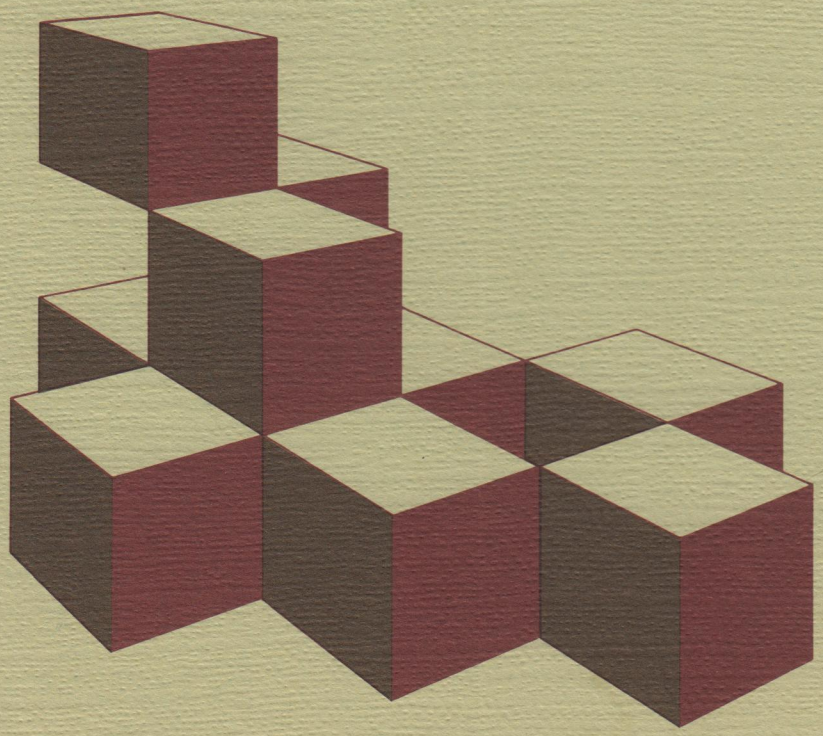

The Collins
Modular Lung
Analyzer System

PRODUCT CERTIFICATION

Warren E. Collins, Inc. certifies that this equipment was thoroughly inspected and tested and met its published specifications when it was shipped from the factory.

GUARANTEE*

All apparatus and accessories, with the exception of rubber and plastic materials, are guaranteed for one year from the date of delivery to be free from original defects in workmanship and materials under normal and proper use. All rubber or plastic materials are guaranteed for 90 days from the date of delivery. This guarantee covers the repair or replacement of the equipment at the option of the manufacturer.

Defective parts or components must be returned to the factory for repair or replacement after verbal or written return authorization is granted. No charge will be made under warranty except transportation to and from the factory. All returns should be prepaid. Upon request, a qualified technician will service the equipment at an hourly charge plus transportation and expenses. No other warranties are expressed or implied and the manufacturer is not liable for any special or consequential damages that may result in the use of this equipment.

*Those items manufactured by other than Warren E. Collins, Inc. are subject to the manufacturer's guarantee only.

MANUAL NO. 22158 SECOND PRINTING: September, 1976
THIRD PRINTING: February, 1979

Additional manuals available at $4.00 each.

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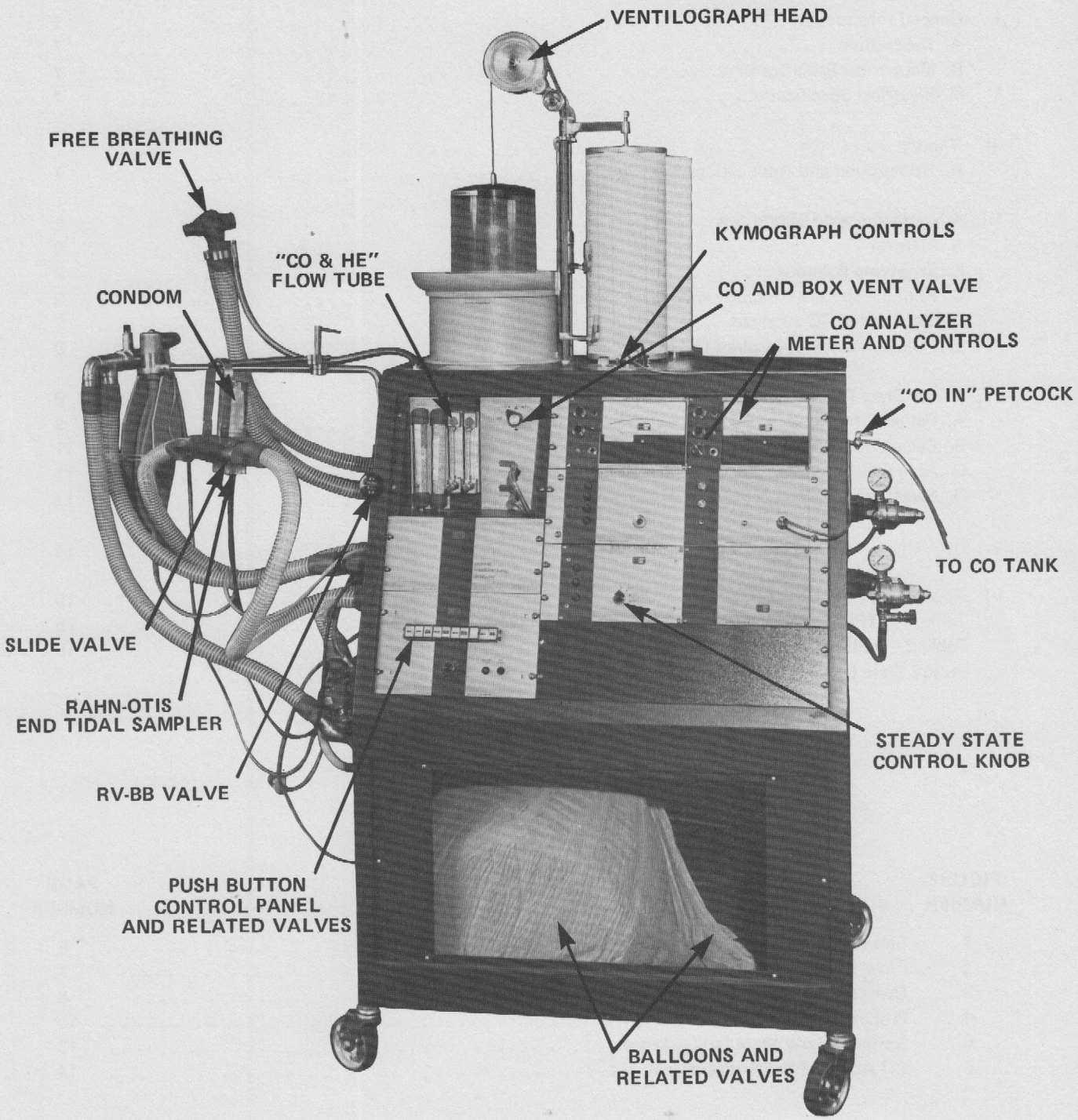


Figure 1 - Steady State CO Diffusion Module Components

INSTRUCTION MANUAL FOR THE COLLINS STEADY STATE D_{LCO} DIFFUSION MODULES

I. GENERAL INFORMATION

I.A. DESCRIPTION

A.1. The Collins Steady State CO Diffusion Modules consist of several major components which are packaged to fit our large console. The illustration in this manual shows analog rather than digital analyzer displays which is the basic difference between any of the CO Diffusion Modules. Figure 1 shows the basic equipment layout with all the major components utilized in this test identified.

A.2. The essential instrumentation required for this test includes:

a. Spirometer with 7 liter bell
b. 120 liter box with two 100 liter balloons and associated valves and blower
c. Rahn-Otis End Tidal Sampler
d. Non-dispersive, infrared CO analyzer
e. Push button control panel with associated valves and circuitry

NOTE: A large cylinder of analyzed 0.1% CO and balance air is required which is available from Matheson Gas Products Division, East Rutherford, New Jersey.

I.B. MECHANICAL SPECIFICATIONS

B.1. Figure 2 shows the flow-resistance curve of the Rahn-Otis End Tidal Sampler.

I.C. ELECTRICAL SPECIFICATIONS

C.1. CO analyzer

Range: Dual Range CO; 0.1% and 0.3%
Response Time: 90% of final readings in 5 seconds
Noise Level: less than 1% of full scale
Zero Drift: less than 1% of full scale in 24 hours
Span Drift: less than 1% of full scale in 24 hours
Repeatability: ±1% of full scale
Temperature Effect: analyzer accuracy maintained from 40° to 120°F Ambient
Vibration Effect: analyzer unaffected by normal environmental vibration
Warm-up Time: 30 minutes

II. THEORY

II.A. BACKGROUND AND APPLICATIONS

A.1. The diffusion capacity test measures the rate at which inspired CO or 0_2 is transferred into the blood. The amount of CO or 0_2 moved through the alveoli into the blood per minute is the diffusion constant times the difference between the mean partial pressure of the gas in the alveoli and in the blood. This constant depends on the lung surface area and the thickness of the membranes, but it is independent of gas pressures. In the single breath test using CO, this constant is calculated from the rate at which the carbon monoxide partial pressure falls while a breath is held. In the steady state procedure, it is calculated from the measured uptake rate of CO and the average partial pressure in the alveoli.

A.2. If the subject repeatedly inspires a gas mixture containing a fraction of carbon monoxide, then the partial pressure of CO in his alveoli (P_{ACO}) will increase until a steady state is attained in which P_{ACO} does not change with additional breaths. However, as the subject inspires, P_{ACO} increases slightly and as he expires P_{ACO} decreases slightly, yet the value at end expiration is exactly the same as on the previous breath if the subject is in the steady state. These fluctuations of the respiratory cycle are quite small compared to the average P_{ACO} and can be disregarded during test calculations.

A.3. In the Collins Steady State System, P_{ACO} is measured using an End Tidal Sampler (see Figure 1). As the subject inspires normally, the reduced pressure at the mouth is transmitted to the outside of the condom, expanding it. This action pulls in a small amount of gas expired just before the start of a normal inspiration, thus an "end tidal sample." The gas from the condom is pumped through the CO analyzer which monitors P_{ACO}. This gas will provide a

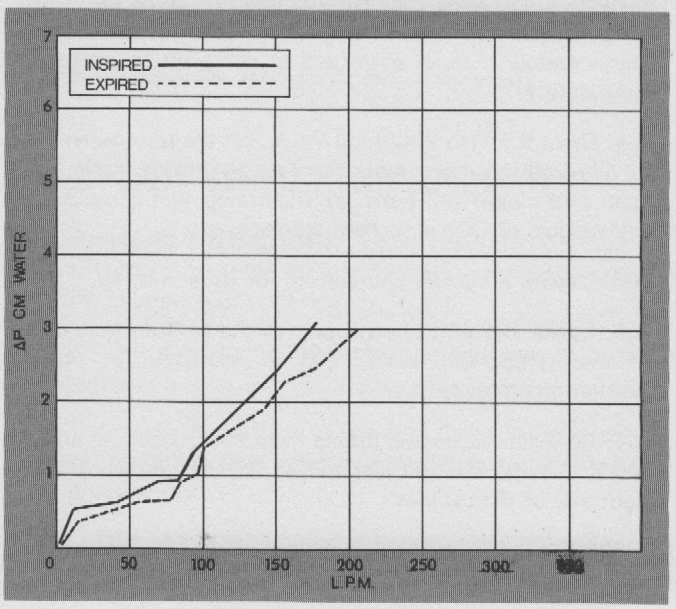


Figure 2 - Flow-Resistance Curve of Rahn-Otis End Tidal Sampler

good measure of the P_{ACO} actually in the alveoli only if the subject is breathing slowly and regularly. If the subject breathes too rapidly and shallowly, the CO pulled into the condom will be mixed with inspired gas from the deadspace. The basic test procedure is described in the following paragraph.

A.4. A large balloon is filled with a gas mixture containing 0.1% carbon monoxide. The patient is connected to the circuit and inspires normally from the balloon. For the first few minutes, until the subject reaches the steady state, the expired gas is directed through tubing past a valve guarding the expired gas balloon and into the atmosphere. Once the steady state is attained, which may take five minutes or more in patients with severe obstructive lung disease, the subject's expirate is switched into a balloon which collects the expired gas. At the same time, the system's spirometer is monitored and the CO analyzer is set to monitor the end tidal sample. After a few minutes, the subject is removed from the breathing circuit and the CO analyzer then measures the CO concentration in the expired gas balloon. After this concentration is determined, the uptake rate is calculated by assuming that inspired and expired volumes are equal to the volume monitored on the spirogram. Alveolar carbon monoxide pressure is taken from a series of values recorded during the sample collection period and the CO diffusion capacity is then calculated. A sample calculation is included at the end of this manual.

III. ADJUSTMENTS AND CALIBRATIONS

III.A. GENERAL

A.1. Connect the main power cord to a proper outlet.

A.2. Push the **MAIN POWER** switch.

A.3. Push the **ANALYZER POWER** switch and set the CO analyzer to **STAND BY**. The CO analyzer must be turned on *at least* two hours before analysis to permit the thermostated analysis chambers to come up to operating temperature.

A.4. Open the Free Breathing Valve, lift the spirometer bell to mid-position, then close the Free Breathing Valve. The open and closed positions are illustrated in Figure 3. No bell weights or CO_2 absorbent are necessary.

A.5. Prepare the paper and pens in the usual manner.

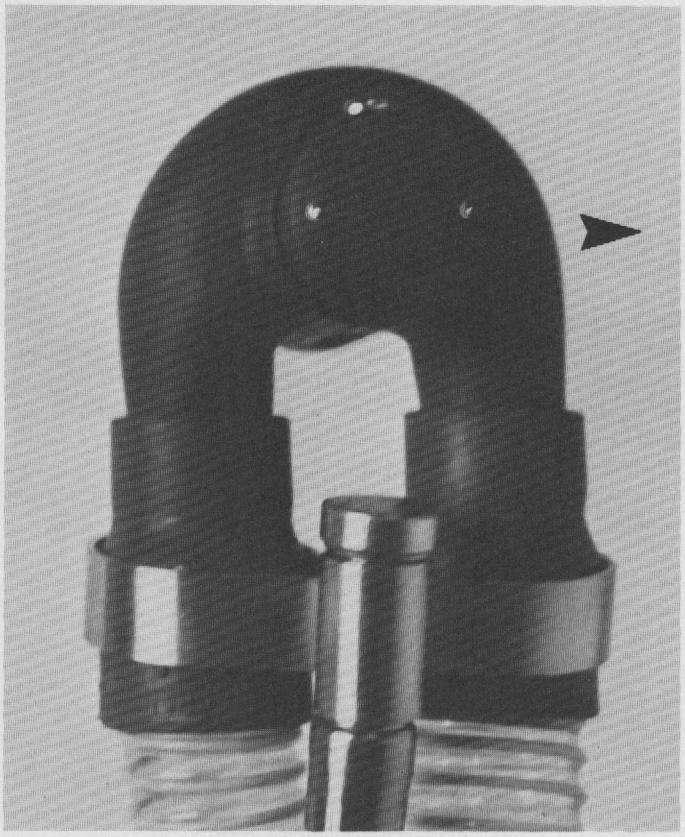
A.6. Lower the ventilograph pen to the bottom inch or so of the kymograph paper. This is necessary for proper ventilation computation.

A.7. Connect the plastic tubing from the CO tank regulator (0.1% CO and balance air) to the **CO IN** petcock on the right side of the cabinet.

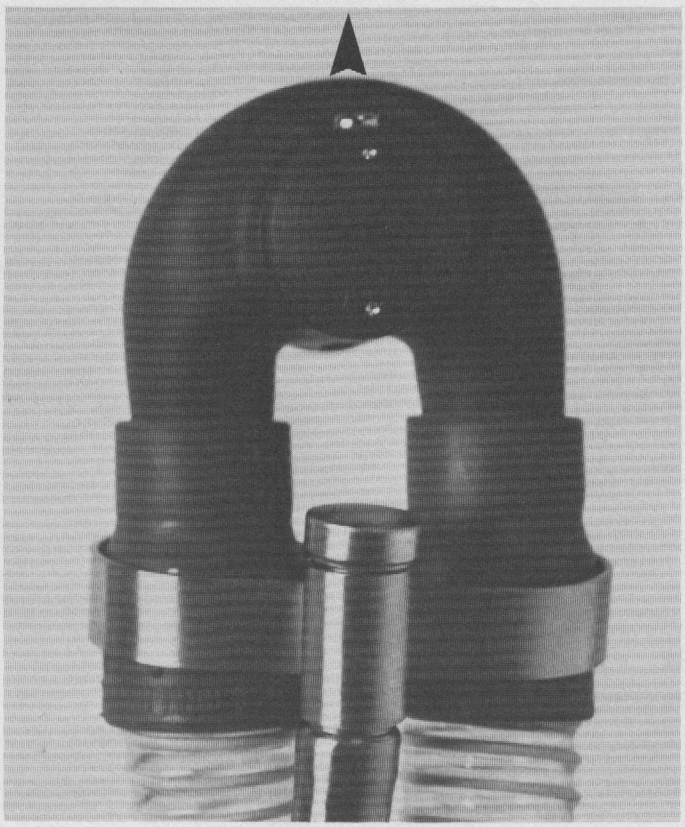
III.B. EMPTYING BALLOONS

NOTE: This procedure is *always* required when gas has remained in the balloons for more than one-half hour.

B.1. Push in the **RV-BB** Valve to the **RV** position.



OPEN POSITION



CLOSED POSITION

Figure 3 - Open and Closed Positions of Free Breathing Valve

B.2. Push in the slide valve on the End Tidal Sampler mouthpiece. This allows the box to vent freely to room air.

B.3. Evacuate both balloons by turning the knob on the Steady State Control Panel to **EMPTY.**

B.4. When both balloons are empty, close the End Tidal Sampler slide valve by pulling out. Turn the knob on the Steady State Control Panel to **OFF.**

III.C. FILLING INSPIRATORY BALLOON WITH 0.1% CO AND BALANCE AIR

C.1. The **RV-BB** Valve should still be in the **RV** position. This must always be done when the balloon is filled, otherwise the pressure inside the box will force the spirometer bell to move up and out of the water seal.

C.2. Move the CO and Box Vent Valve to **CO OPEN** to allow the box to vent.

C.3. Open the **CO IN** petcock on the right side of the cabinet.

C.4. Open the CO tank main valve followed by the regulator valve.

C.5. As the balloon is filling, push in the End Tidal Sampler slide valve once or twice for a few seconds to flush out dead air in the breathing tube.

C.6. Do not permit a CO flow of more than 20 L./min. (or a pressure of 4 psi) into the balloon to avoid development of excessive pressure inside the box. At this rate, it will take about five minutes to fill the balloon.

NOTE: Proper filling can be checked by inspection through the box window. The balloon should be filled until it is well rounded and its edges touch the sides of the box, but it should not appear to be under pressure. Meteorological balloons vary somewhat in size, but, without pressure, they hold approximately 100 liters.

CAUTION: NEVER LEAVE THE CO TANK REGULATOR VALVE UNATTENDED AS AN OVER FILLED BALLOON CAN RUPTURE THE BOX.

C.7. When the balloon is filled, proceed in the following order:

a. Close the CO tank main and regulator valves.
b. Close the **CO IN** petcock and wait until no more gas escapes, then turn the CO and Box Vent Valve to **CO CLOSE.**
c. Return the **RV-BB** Valve to the **BB** position by pulling out.
d. Make sure the End Tidal Sampler slide valve is pulled out.

III.D. ZEROING THE CO ANALYZER

D.1. Set the CO analyzer control to the **0.1%** range.

CAUTION: THE BUTTONS ON THE PUSH BUTTON CONTROL PANEL ENERGIZE SOLENOIDS AND SHOULD NOT BE LEFT ON *CONTINUOUSLY* FOR MORE THAN TEN MINUTES.

D.2. Push in the **AIR** and **GAS-PMP** buttons. The sampling flow produced by the gas pump is now indicated by the **CO & He** flow tube. Turn the needle valve on the flow tube to 150-200 ml./min. During this procedure, the spirometer bell may fall slightly.

NOTE: For the entire steady state procedure, perform all calibrations and readings at this flow rate. A change in flow alters the calibration because the pressure in the sample is changed.

D.3. Unlock the CO analyzer **FINE ZERO** control and adjust it until the meter reads exactly **0.**

III.E. ADJUSTMENTS WITH INSPIRED GAS

E.1. Push in the **INS-GAS** and **GAS-PMP** buttons and run the sample pump until a steady reading is obtained (usually one half to one minute).

E.2. Unlock the CO analyzer **GAIN** control and adjust it until the meter reads exactly **100.**

E.3. Zero the CO analyzer again by performing Steps III.D.1. and III.D.2.

E.4. Adjust the CO analyzer **GAIN** control again by performing Steps E.1. and E.2.

E.5. Repeat this procedure (Steps E.3. and E.4.) until no further adjustments are needed. A small adjustment may be required if the cells inside the CO analyzer were not completely flushed the first couple of times. If the CO analyzer cannot be adjusted properly, consult the CO analyzer manual.

E.6. When all adjustments are made, lock the CO analyzer **FINE ZERO** and **GAIN** controls, then push the **GAS-PMP** and **OFF** buttons.

E.7. Record the settings of the **FINE ZERO** and **GAIN** controls for future reference.

E.8. Readjust the spirometer bell, if necessary.

IV. STEADY STATE CO DIFFUSION TEST

IV.A. PATIENT PROCEDURE

A.1. Record the room temperature and barometric pressure at the beginning of each test.

A.2. Give the patient full instructions on how to perform the test.

A.3. Attach the patient to the End Tidal Sampler mouthpiece. Since the slide valve is pulled out, the patient is free to breathe room air.

A.4. Turn the kymograph control switch to **ON** and set the speed selector to **32** mm./min.

A.5. Close the **CO & He** flow tube needle valve.

A.6. Push in the **ALV** and **GAS-PMP** buttons. The pump

will now sample from the alveolar bag (condom) on the End Tidal Sampler.

A.7. Turn the knob on the Steady State Control Panel to the first **FLUSH** position, then push in the End Tidal Sampler slide valve. Respiratory excursions should now be visible on the kymograph. Allow the patient to breathe in this position for two minutes.

NOTE: Although the patient is not breathing through the soda lime canister, the slope may be slightly upward reflecting a respiratory ratio (RQ) of about 0.8 - 0.9 or slightly downward due to a warming of the box.

A.8. During this two-minute period, adjust the flow from the End Tidal Sampler by opening the **CO & He** flow tube needle valve for a flow of about 200ml./min. or until the alveolar bag (condom) expands and contracts properly as shown in Figure 4.

A.9. After a steady alveolar (end tidal) CO reading has been obtained (about two minutes for normal patients) in the first **FLUSH** position, turn the knob to **COLLECT**.

A.10. Record the CO reading every fifteen seconds for up to three minutes of collection. Record the average alveolar sample reading. Turn the knob to the final **FLUSH.**

NOTE: This may be called **FINAL** on some units.

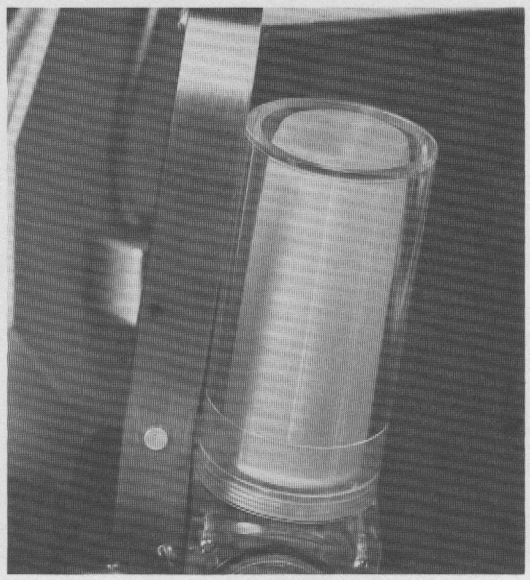
A.11. Pull out the End Tidal Sampler slide valve, remove the patient and turn off the kymograph.

A.12. Push in the **EXP-GAS** and **GAS-PMP** buttons to sample the mixed expired gas from the expired gas balloon. Wait for a steady CO reading and record.

A.13. Push the **OFF** and **GAS-PMP** buttons and return the Steady State Control knob to **OFF.**

FLOW TOO HIGH
CONDOM WILL NOT EXPAND

INCORRECT FLOW



FLOW TOO LOW
CONDOM WILL NOT CONTRACT

CONDOM CONTRACTS
EXPIRATION

PROPER FLOW

CONDOM EXPANDS
INSPIRATION

Figure 4 - Proper Expansion and Contraction of Condom

IV.B. CALCULATION THEORY

B.1. The diffusing capacity (D) for a membrane is defined as the volume of gas (V) that crosses the membrane per minute divided by the mean partial pressure on one side of the membrane (P_A) minus the mean partial pressure on the other side (P_B), often called "back pressure." This is expressed as

$$D = \frac{V/min.}{\bar{P}_A - \bar{P}_B}$$

where P is expressed in mmHg.

B.2. For the lung, the diffusing capacity (D_L) when referenced to O_2 is expressed as

$$D_{LCO} = \frac{O_2 \text{ uptake/minute}}{\bar{P}_{AO_2} - \bar{P}_{CO_2}}$$

where $\bar{P}_{AO_2}$ is the mean alveolar (or "forward") pressure and $\bar{P}_{CO_2}$ is the mean capillary "back pressure."

B.3. For a normal male, this would then become approximately

$$D_{LO_2} = \frac{250 \text{ ml./min.}}{105 \text{ mmHg} - 90 \text{ mmHg}} = 16.7 \text{ ml./min./mmHg}$$

Calculation of $\bar{P}_{CO_2}$ is complicated by theoretical and technical difficulties. However, the use of CO as a tracer gas almost eliminates this problem because the affinity of hemoglobin for CO is approximately 230 times greater than it is for O_2 making the "back pressure" practically zero. Therefore,

$$D_{LCO} = \frac{\dot{V}_{CO}}{P_{ACO}}$$

where $\dot{V}_{CO}$ is the CO uptake per minute and P_{ACO} is the partial pressure of CO in the alveolar gas. $\dot{V}_{CO}$ is simply the amount of CO (in ml./min. STPD) removed from the inspired gas.

B.4. P_{ACO} can be calculated from P_{aCO_2} using the alveolar equation (Physiologic Dead Space method of Filley, et al.) or it can be measured directly by end tidal sampling (method of Bates, et al.) as described here.

To obtain

$$D_{LCO} = \frac{\dot{V}_{CO}}{P_{ACO}}$$

we have to first determine $\dot{V}_{CO}$ which is

$$\dot{V}_{CO} \text{ (ml./min.)} = \frac{\% \text{ Inspired CO} - \% \text{ Expired CO}}{100} \times \dot{V}_E \text{ ml./min. STPD}$$

where $\dot{V}_E$ STPD is the minute ventilation and

$$P_{ACO} \text{ (mmHg)} = \% \text{ End Tidal CO} \times \text{BP} - 47$$

where BP is the Barometric Pressure and 47 is the Vapor Pressure of water at 37°C.

IV.C. ACTUAL CALCULATIONS

C.1. $$\dot{V}_E \text{ STPD (L./min.)} = \frac{\text{Vent. Vol. for Coll. Time (L.)} \times 25 \times \text{STPD Fact.}}{\text{Collection Time (min.)}}$$

where 25 is the ventilograph factor and

$$\dot{V}_{CO} \text{ STPD (ml./min.)} = \dot{V}_E \text{ STPD (L./min.)} \times 1000(A) \times \frac{100(B) - \% \text{ Expired CO}}{1000(C) \times 100(D)}$$

where 1000(A) is the factor to change $\dot{V}_E$ STPD from L. to ml., 100(B) is the initial CO meter reading, 1000(C) is the factor to correct the CO percentage because the initial CO

concentration was 0.1% (or 1000 ppm) rather than 100, and 100(D) is to correct the percentage to a fraction. As a result,

$$\dot{V}_{CO}\ STPD\ (ml./min.) = \frac{Vent.\ Vol.\ X\ 25\ X\ STPD\ X\ (100 - \%\ Expired\ CO)}{Collection\ Time\ X\ 100}$$

$$P_{ACO} = \frac{\%\ End\ Tidal\ CO\ X\ (BP-47)}{1000(C)\ X\ 100(D)}$$

where BP = Barometric Pressure, 47 is the Vapor Pressure of water at 37°C, 1000(C) and 100(D) are the same correction factors applied above.

C.2. Plugging these two formulas into our original D_{LCO} formula and simplifying, we find

$$D_{LCO}\ (ml./min./mmHg) = \frac{Vent.\ Vol.\ X\ 25{,}000\ X\ STPD\ Fact.\ X\ (100 - \%\ Exp.\ CO)}{Collection\ Time\ X\ (BP-47)\ X\ \%\ End\ Tidal\ CO}$$

This is the simplified formula you may use for actual D_{LCO} calculations.

IV.D. SAMPLE CALCULATION

D.1. Record the following for calculation: (Refer to Figures 5 and 6 and Table I)

Temperature (°C)	27		
Barometric Pressure (mmHg)	756		
STPD Correction Factor (From Table I)	.869		
Collection Time (min.)	3		
Ventilograph Volume (L.)	.73		
Initial CO Meter Reading	100		
End Tidal CO Meter Readings (Record every 15 seconds for up to 3 minutes)	32.0		
	31.5		
	32.0		
	32.5		
	32.0		
	32.0		
Averaged End Tidal Reading	32.0	Corrected End Tidal CO Meter Reading (%) (From Figure 6 - Use For Calculation)	28.0
Expired CO Meter Reading	58.5	Corrected Expired CO Reading (%) (From Figure 6 - Use For Calculation)	53.5

$$D_{LCO}\ (ml./min./mmHg) = \frac{Vent.\ Volume\ X\ 25{,}000\ X\ STPD\ Fact.\ X\ (100 - \%\ Exp.\ CO)}{Collection\ Time\ X\ (BP-47)\ X\ \%\ End\ Tidal\ CO}$$

$$= \frac{.73\ X\ 25{,}000\ X\ 0.869\ X\ 46.5}{3\ X\ 709\ X\ 28.0}$$

$$D_{LCO} = 12.38\ ml./min./mmHg$$

D.2. After the calculation has been completed, refer to Table 2 which gives predicted norms for Steady State D_{LCO}.

D.3. A D_{LCO} worksheet is included at the end of this manual. You may remove it to make additional copies for future calculations.

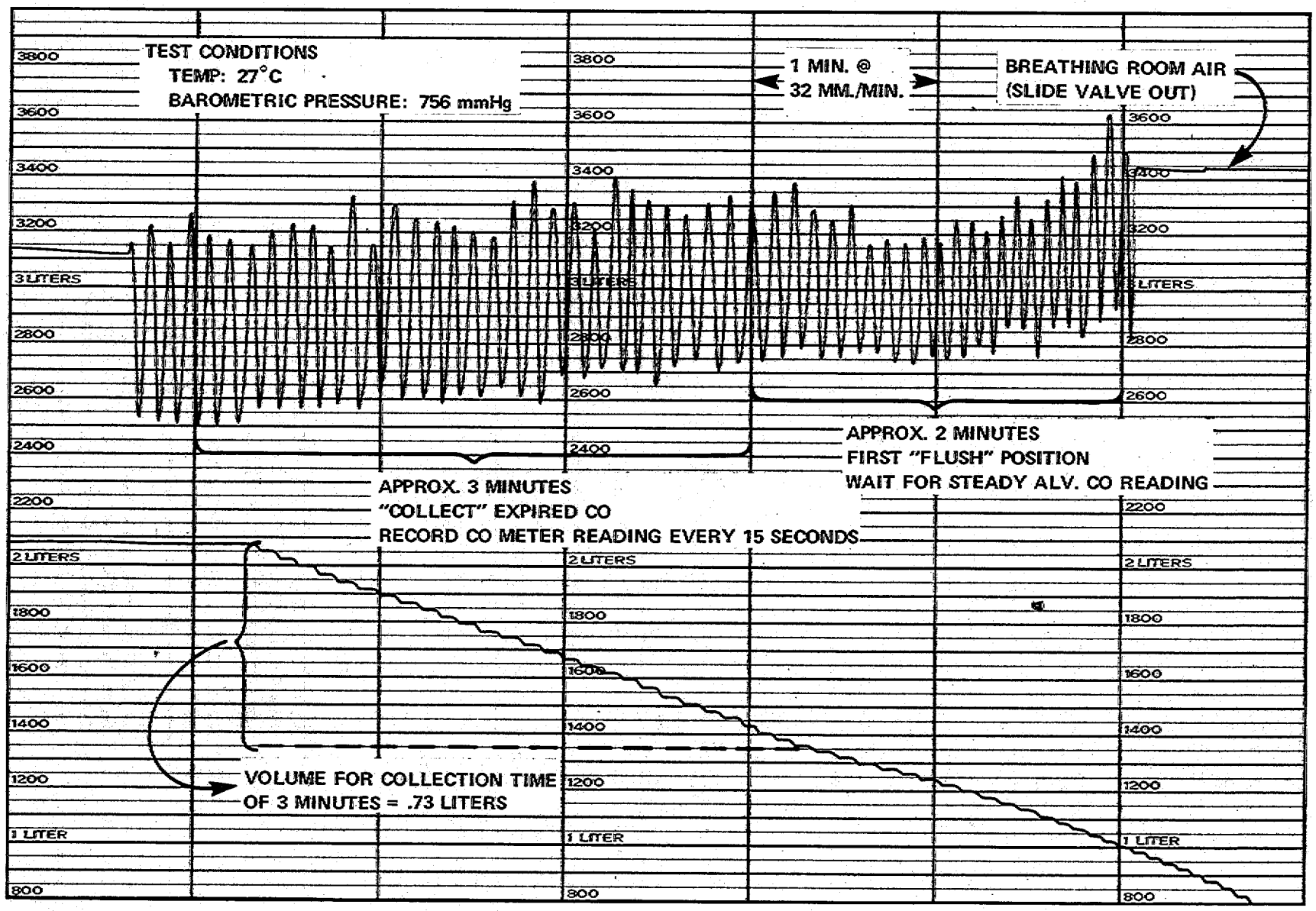
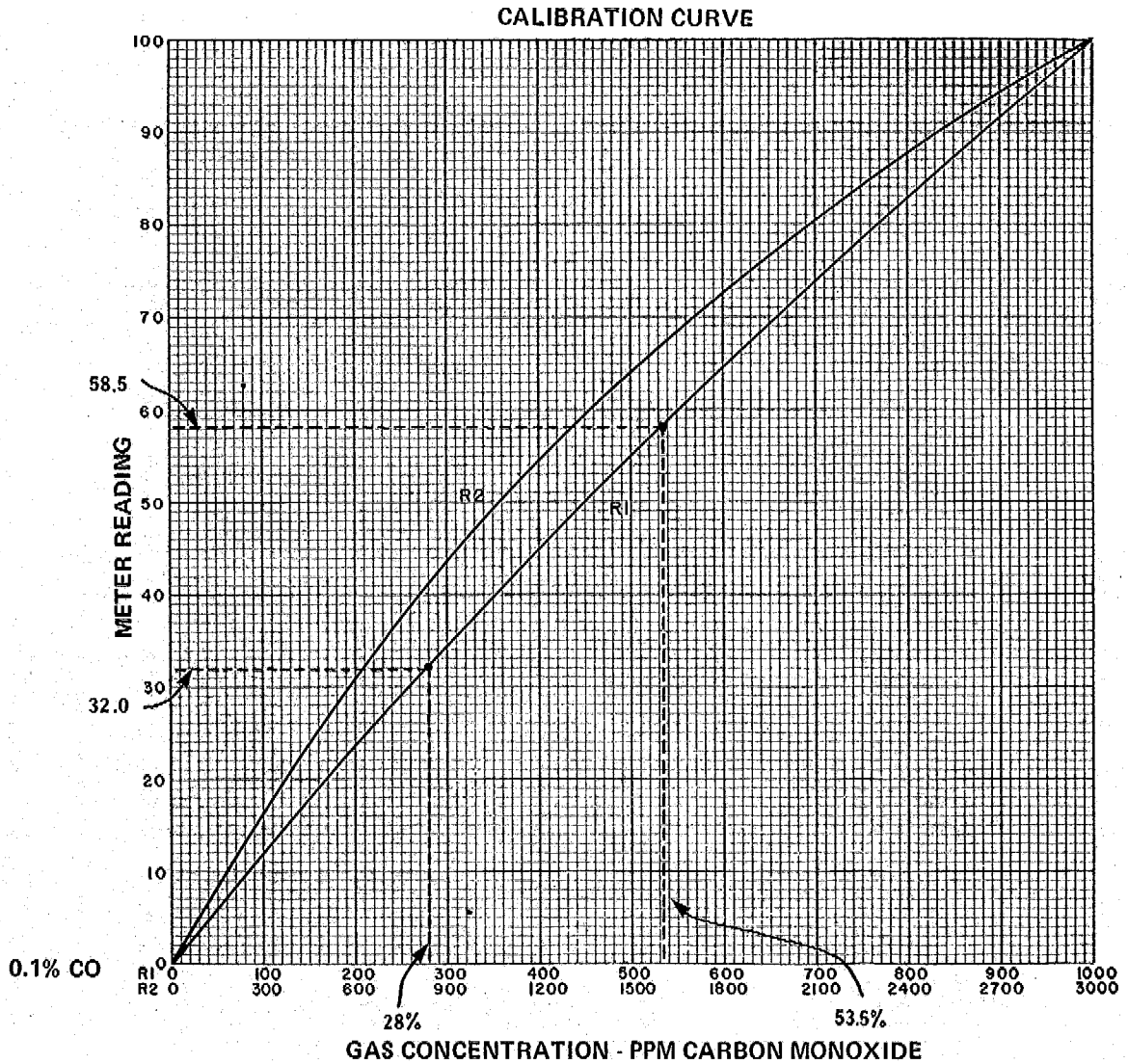


Figure 5 - Sample Steady State $D_{L_{CO}}$ Tracing



NOTE: THIS CALIBRATION CURVE IS ONLY A SAMPLE. REFER TO THE CURVE SHIPPED WITH YOUR ANALYZER.

Figure 6 - CO Analyzer Calibration Curve

V. REFERENCES

Bates, D. V.; Macklem, P. T.; and Christie, R.V.: *Respiratory Function in Disease* (Second Edition), W. B. Saunders Company, Philadelphia, 1971, pp. 75-95.

Bates, D. V.; Boucot, N. G.; and Dormer, A. E.: *The Pulmonary Diffusing Capacity in Normal Subjects,* Journal of Physiology (London), Vol. 129: pp. 237-252 (1955).

Filley, G. F.; MacIntosh, D. J.; and Wright, G. W.: *Carbon Monoxide and Pulmonary Diffusing Capacity in Normal Subjects at Rest and During Exercise,* Journal of Clinical Investigation, Vol. 33: pp. 530-539 (1954).

TABLE 1

(STPD)

Factors for Reducing Volume of Moist Gas to Volume by Dry Gas at 0°, 760 mm.*

Observed Barometric Reading, Uncorrected for Temperature	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	29°	30°	31°	32°
700	0.855	851	847	842	838	834	829	825	821	816	812	807	802	797	793	788	783	778
702	857	853	849	845	840	836	832	827	823	818	814	809	805	800	795	790	785	780
704	860	856	852	847	843	839	834	830	825	821	816	812	807	802	797	792	787	783
706	862	858	854	850	845	841	837	832	828	823	819	814	810	804	800	795	790	785
708	865	861	856	852	848	843	838	834	830	824	821	816	812	807	802	797	792	787
710	867	863	859	855	850	846	842	837	833	828	824	819	814	809	804	799	795	790
712	870	866	861	857	853	848	844	839	836	830	826	821	817	812	807	802	797	792
714	872	868	864	859	855	851	846	842	837	833	828	824	819	814	809	804	799	794
716	875	871	866	862	858	853	849	844	840	835	831	826	822	816	812	807	802	797
718	877	873	869	864	860	856	851	847	842	838	833	828	824	819	814	809	804	799
720	880	876	871	867	863	858	854	849	845	840	836	831	826	821	816	812	807	802
722	882	878	874	869	865	861	856	852	847	843	838	833	829	824	819	814	809	804
724	885	880	876	872	867	863	858	854	849	845	840	835	831	826	821	816	811	806
726	887	883	879	874	870	866	861	856	852	847	843	838	833	829	824	818	813	808
728	890	886	881	877	872	868	863	859	854	850	845	840	836	831	826	821	816	811
730	892	888	884	879	875	871	866	861	857	852	847	843	838	833	828	823	818	813
732	895	890	886	882	877	873	868	864	859	854	850	845	840	836	831	825	820	815
734	897	893	889	884	880	875	871	866	862	857	852	847	843	838	833	828	823	818
736	900	895	891	887	882	878	873	869	864	859	855	850	845	840	835	830	825	820
738	902	898	894	889	885	880	876	871	866	862	857	852	848	843	838	833	828	822
740	905	900	896	892	887	883	878	874	869	864	860	855	850	845	840	835	830	825
742	907	903	898	894	890	885	881	876	871	867	862	857	852	847	842	837	832	827
744	910	906	901	897	892	888	883	878	874	869	864	859	855	850	845	840	834	829
746	912	908	903	899	895	890	886	881	876	872	867	862	857	852	847	842	837	832
748	915	910	906	901	897	892	888	883	879	874	869	864	860	854	850	845	839	834
750	917	913	908	904	900	895	890	886	881	876	872	867	862	857	852	847	842	837
752	920	915	911	906	902	897	893	888	883	879	874	869	864	859	854	849	844	839
754	922	918	913	909	904	900	895	891	886	881	876	872	867	862	857	852	846	841
756	925	920	916	911	907	902	898	893	888	883	879	874	869	864	859	854	849	844
758	927	923	918	914	909	905	900	896	891	886	881	876	872	866	861	856	851	846
760	930	925	921	916	912	907	902	898	893	888	883	879	874	869	864	859	854	848
762	932	928	923	919	914	910	905	900	896	891	886	881	876	871	866	861	856	851
764	936	930	926	921	916	912	907	903	898	893	888	884	879	874	869	864	858	853
766	937	933	928	924	919	915	910	905	900	896	891	886	881	876	871	866	861	855
768	940	935	931	926	922	917	912	908	903	898	893	888	883	878	873	868	863	858
770	942	938	933	928	924	919	915	910	905	901	896	891	886	881	876	871	865	860
772	945	940	936	931	926	922	917	912	908	903	898	893	888	883	878	873	868	862
774	947	943	938	933	929	924	920	915	910	905	901	896	891	886	880	875	870	865
776	950	945	941	936	931	927	922	917	912	908	903	898	893	888	883	878	872	867
778	952	948	943	938	934	929	924	920	915	910	905	900	895	890	885	880	875	869
780	955	950	945	941	936	932	927	922	917	912	908	903	898	892	887	882	877	872

*From Peters and Van Slyke: *Quantitative Clinical Chemistry,* Baltimore: Williams and Wilkins Co., Vol. 2 reprinted 1956.

TABLE 2

PREDICTED NORMS FOR STEADY STATE D_{LCO}*

MEN			WOMEN		
1	2	3	1	2	3
HT (cm.)	AGE (yrs.)	D_{LCO} SS_2	HT (cm.)	AGE (yrs.)	D_{LCO} SS_2
155	20	23.8	145	20	20.7
	30	21.0		30	18.2
	40	18.2		40	15.7
	50	15.4		50	13.2
	60	12.6		60	10.7
	70	9.8		70	8.2
160	20	24.1	150	20	21.1
	30	21.3		30	18.6
	40	18.6		40	16.0
	50	15.8		50	13.5
	60	13.0		60	11.0
	70	10.1		70	8.5
165	20	24.5	155	20	21.5
	30	21.7		30	18.9
	40	18.9		40	16.4
	50	16.1		50	13.9
	60	13.3		60	11.4
	70	10.6		70	8.9
170	20	24.9	160	20	21.9
	30	22.1		30	19.4
	40	19.3		40	16.8
	50	16.5		50	14.3
	60	13.7		60	11.8
	70	10.9		70	9.2
175	20	25.2	165	20	22.2
	30	22.4		30	19.7
	40	19.6		40	17.2
	50	16.9		50	14.6
	60	14.1		60	12.1
	70	11.3		70	9.6
180	20	25.6	170	20	22.6
	30	22.8		30	20.1
	40	20.0		40	17.5
	50	17.2		50	15.0
	60	14.2		60	12.5
	70	11.6		70	9.9
185	20	25.9	175	20	22.7
	30	23.2		30	20.0
	40	20.4		40	17.7
	50	17.6		50	15.2
	60	14.8		60	12.7
	70	12.0		70	10.2

*Bates and Christie, *Respiratory Function in Disease*, 1966.

STEADY STATE $D_{L_{CO}}$ WORKSHEET

DATA

Temperature (°C) _____

Barometric Pressure (mmHg) _____

STPD Correction Factor _____

Collection Time (min.) _____

Ventilograph Volume (L.) _____

Initial CO Meter Reading _____

End Tidal CO Meter Readings _____

_____

_____

_____

_____

_____

_____

_____

Averaged End Tidal CO Meter Reading (Use Corrected Value For Calculation) _____

Corrected End Tidal CO Meter Reading (%) (Use For Calculation) _____

Expired CO Meter Reading (Use Corrected Value For Calculation) _____

Corrected Expired CO Meter Reading (%) (Use For Calculation) _____

CALCULATION

$$D_{L_{CO}}\ (\text{ml./min./mmHg}) = \frac{\text{Vent. Vol. X 25000 X STPD Fact. X (100-\% Expired CO)}}{\text{Collection Time X (BP-47) X \% End Tidal CO}}$$

$D_{L_{CO}}$ = _____

$D_{L_{CO}}$ = ml./min./mmHg

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