

Leshner & Associates, Inc.
PO Box 949
Elkton MD 21922
www.expertlabs.com

Infant Breathing Model <https://youtu.be/EYpqQj8aHXo>

Specifications:

| | |
|------------------------|---|
| Volume - Lung | Cyclic between 100 and 65 ml (35 ml tidal volume) – adjustable |
| Volume – Trachea | 10 ml total (8 ml + 2 ml additional volume in 280 mm of 3 mm ID tubing) |
| Breathing Rate | Adjustable – 45/min nominal |
| Flow Resistance | 25 cm H ₂ O @ 1000 ml/min (with manakin or head-form) |
| CO ₂ Supply | Flow @ 56 ml/min = 92 on the steel float (corrected for density) |
| Sample | Flow @ 75 ml/min = 97 on the steel float |
| Manakin | Head mass = 1 Kg – Total mass = 4 Kg – breathing passages (2 nares) - 3 mm dia. |
| Face Head-form | Mass = 360 g (1 Kg suspended from Lifter) – breathing passages 3 mm |
| Hemisphere – 5” Dia. | Mass = 360 g (1 Kg suspended from Lifter) – breathing passage 6.3 mm |
| Flowmeters | CO ₂ and Sample – FM 1050 - tube 406, Analyzer – FM 1000 - tube 009 |
| Electrical | 110 VAC, Fuse 10 A, Internal power supply for motor, 12VDC |
| Pump | MEDO 110 VAC |

Vertical Lifter (Patent Pending)

| | |
|-------------------|--|
| Sample thickness | 0 to 300 mm |
| Depth measurement | 0 to 1 inch travel in .001” increments |
| Mass without head | 640 g |
| Mass with head | 1000 g |

Optional Accessories

| | |
|---------------------|--|
| Pressure transducer | +/- 15 cm H ₂ O, +/- 10 mV output |
| Flowmeter | 0 – 1000 ml/min, +/- 1 mV output |
| Data Acquisition | 4 channel, PC connection |

Operating Instructions



Front panel

The front panel has switches to power the sample pump and motor. (The motor has a small delay before starting – it is normal).

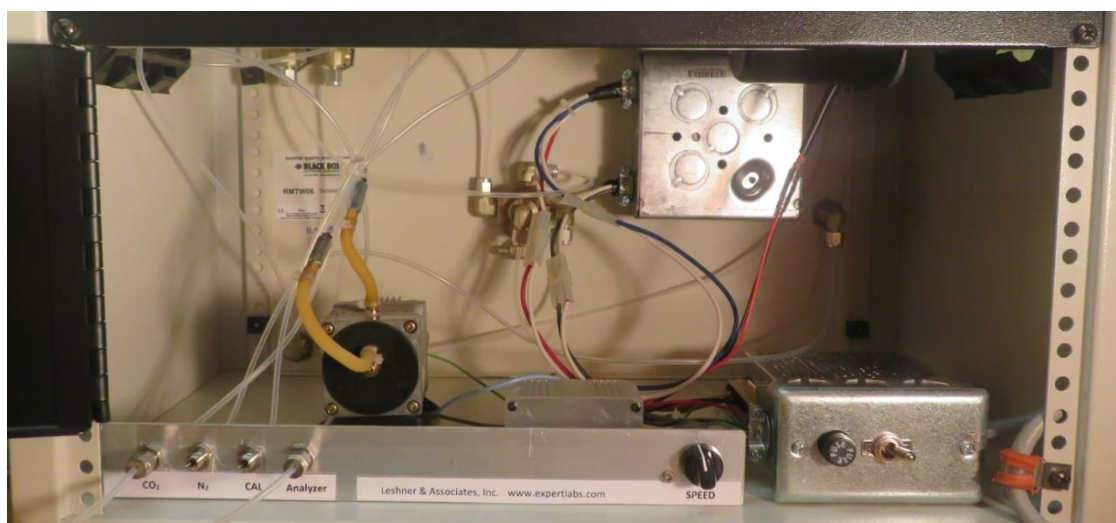
The large flowmeters control and display the flowrate of CO₂ and the sample. The small flowmeter displays the flow to the analyzer. This flowmeter is in the circuit for sample, zero and calibration gas. It is only used to confirm sample flow to the analyzer.

The selector valve has three positions – N₂, Sample and Cal.

Rear Panel



The rear panel has gas connections for CO₂, N₂, Calibration Gas and the sample out to the analyzer. Inside the enclosure are the motor, sample pump, speed control, power supply, fuse and power switch.



Calibration

1. Connect Calibration gas to rear of breathing apparatus.
2. Turn selector valve to CAL
3. Adjust gas pressure to 5 – 10 psi for mid-range on the analyzer flowmeter
4. Adjust analyzer to match CO₂ cal gas concentration

Zero Check

1. Connect Nitrogen gas to rear of breathing apparatus
2. Turn selector valve to N₂
3. Adjust gas pressure to 5 – 10 psi for mid-range on the analyzer flowmeter
4. Adjust analyzer to zero

Sampling

1. Turn selector valve to SAMPLE
2. Switch on Sample Pump
3. Switch on Motor
4. Adjust CO₂ flow to 92 on the steel ball (corrected for density)
5. Adjust Sample flow to 97 on the steel ball
6. Allow analyzer to stabilize for a few minutes
7. Record CO₂ concentration
8. If the measurement continues to change, record again

It is good practice to start with a free-breathing baseline condition and then introduce a material sample. Return to the baseline condition between each material sample repetition or change in material.

Note: Whether using the manakin or headform and lifter, the face may continue to “sink in” over several minutes and the CO₂ will continue to increase in response. Some measurements may take 3 to 5 minutes or longer for the sample material to stabilize and the CO₂ to settle to an equilibrium value..

Trachea

The trachea has a fixed volume of 8 ml, and the sample is drawn from the center of the trachea. The tubing connecting the lung to trachea and trachea to the manakin or head-form adds approximately 2 ml additional volume comprising 300 mm of tubing with an inside diameter of 1/8 inch (3 mm). Total volume is 10 ml. If the physical setup requires longer tubing, the measured CO₂ concentration could be biased a bit higher due to a greater dead volume.

Manakin

The manakin is a toy doll with breathing passages connected to the nares of the nose. The head is weighted to a mass of 1 Kg. The Manakin body is weighted with an additional 3 Kg. Weighting of the body is not a factor in CO₂ re-breathing, but the weight helps to maintain a head/face position on a material sample.

CO₂ re-breathing measurements will tend to be sensitive to small variations in the head/face orientation. This is believed to be due to variations in the “seal” between the nose and sample. Creases and discontinuities in the sample surface will also cause measurement variability. Multiple measurements are needed to determine a range of potential outcomes.

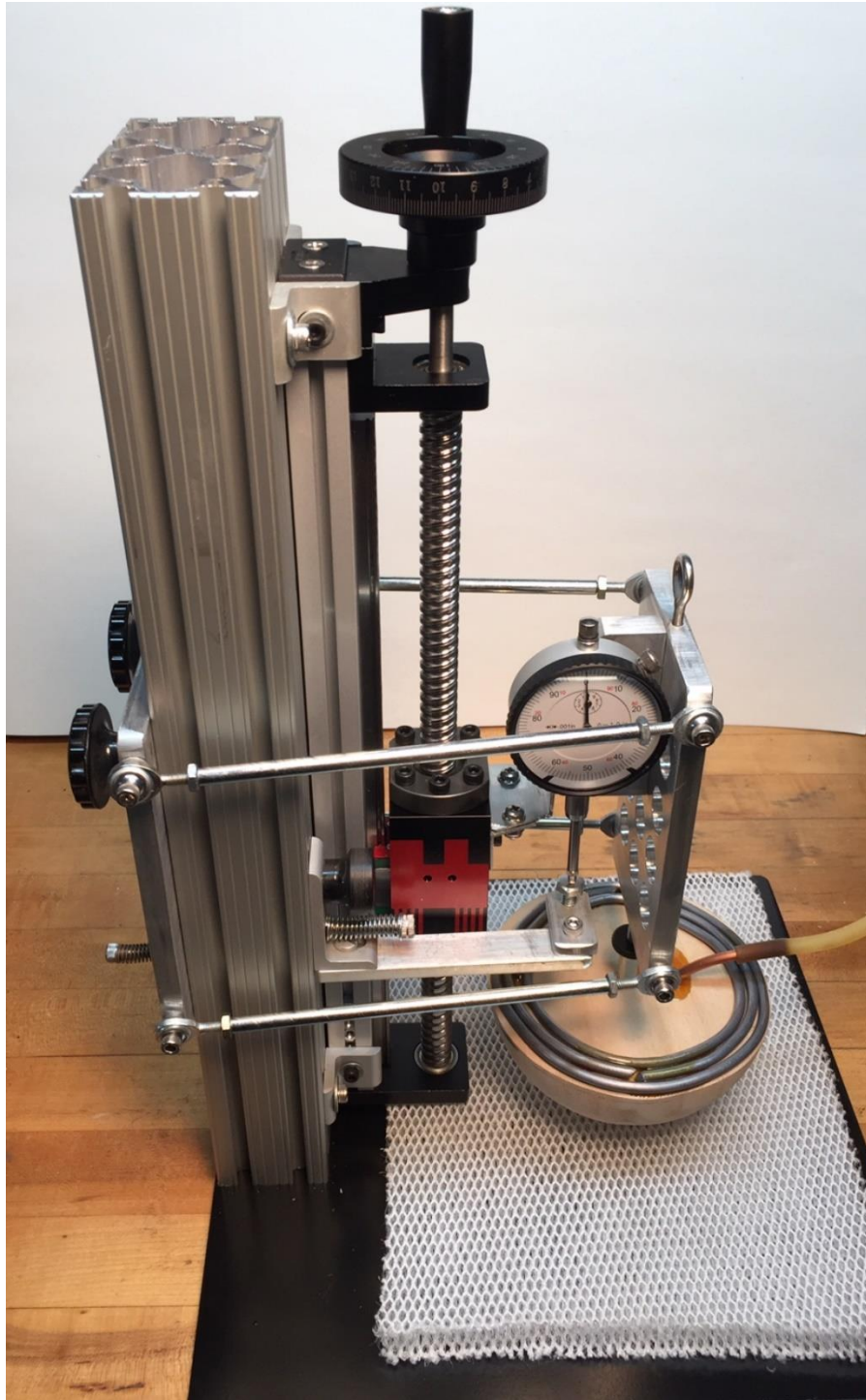




Lifter

The lifter is patent pending. Its purpose is to apply a head-form repeatably onto a sample of material, in a vertical orientation. The lifter is also equipped to measure the depth of penetration as the head-form is gradually released to penetrate into the sample under its own weight. Both the face and hemisphere head-forms are weighted to produce a total mass of 1 Kilogram (lifter + head-form) on the sample.

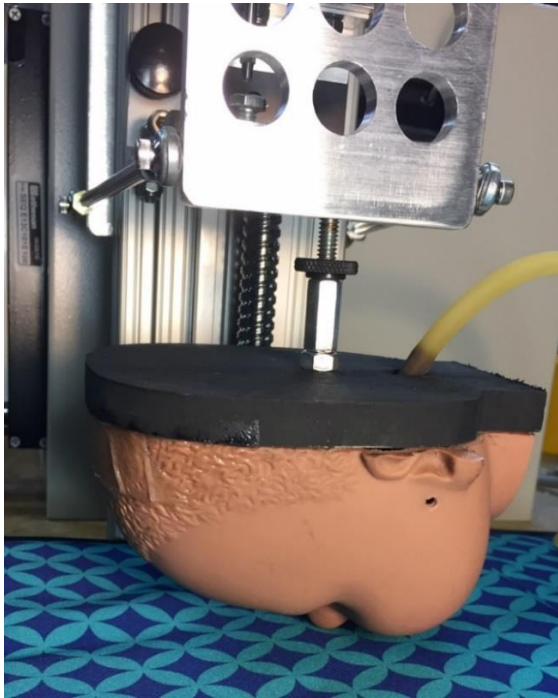
The height of the lifter assembly is adjustable to accommodate samples of different thickness. Start with the the arms just above horizontal and end up just below horizontal after the measurement, keeping the head-form trajectory vertical during placement. Gradual release of the head-form into the sample avoids any inertial effects during placement.



Head-Forms

Two head-forms are provided to use with the lifter. The face is the same shape as the face of the manakin and it is also configured to breathe through the nares of the nose. The hemisphere head-form breathes through a single opening at the bottom, $\frac{1}{4}$ inch in diameter.

The hemisphere head-form represents a worst-case (most closely coupled) interaction between the face and sample material being tested.



Lateral Head-form Support

The lateral support facilitates measurements in products that are not flat. A standard camera tripod and adjustable swivel provides the pivot for the arm and adjustment for the head position. The end of the arm is weighted to provide the desired force on the sample as shown below.

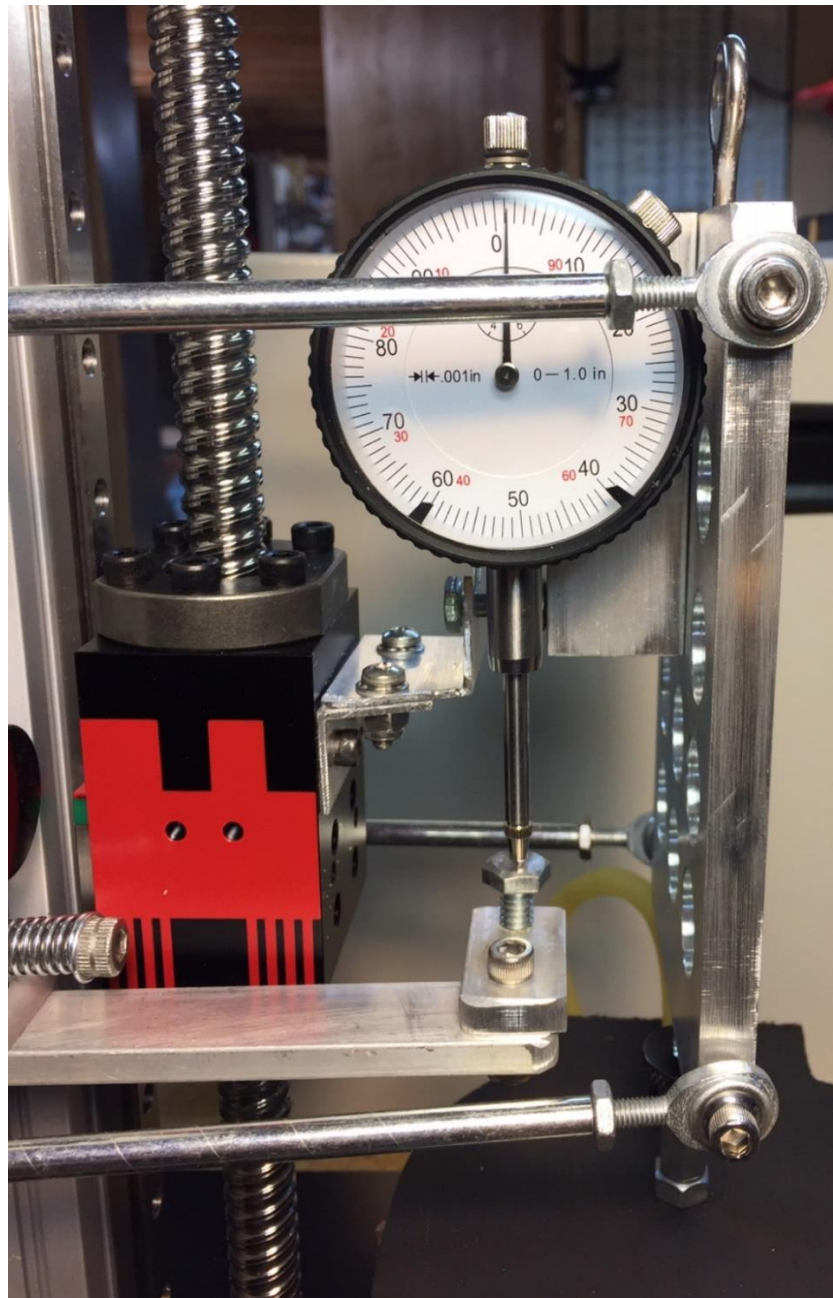




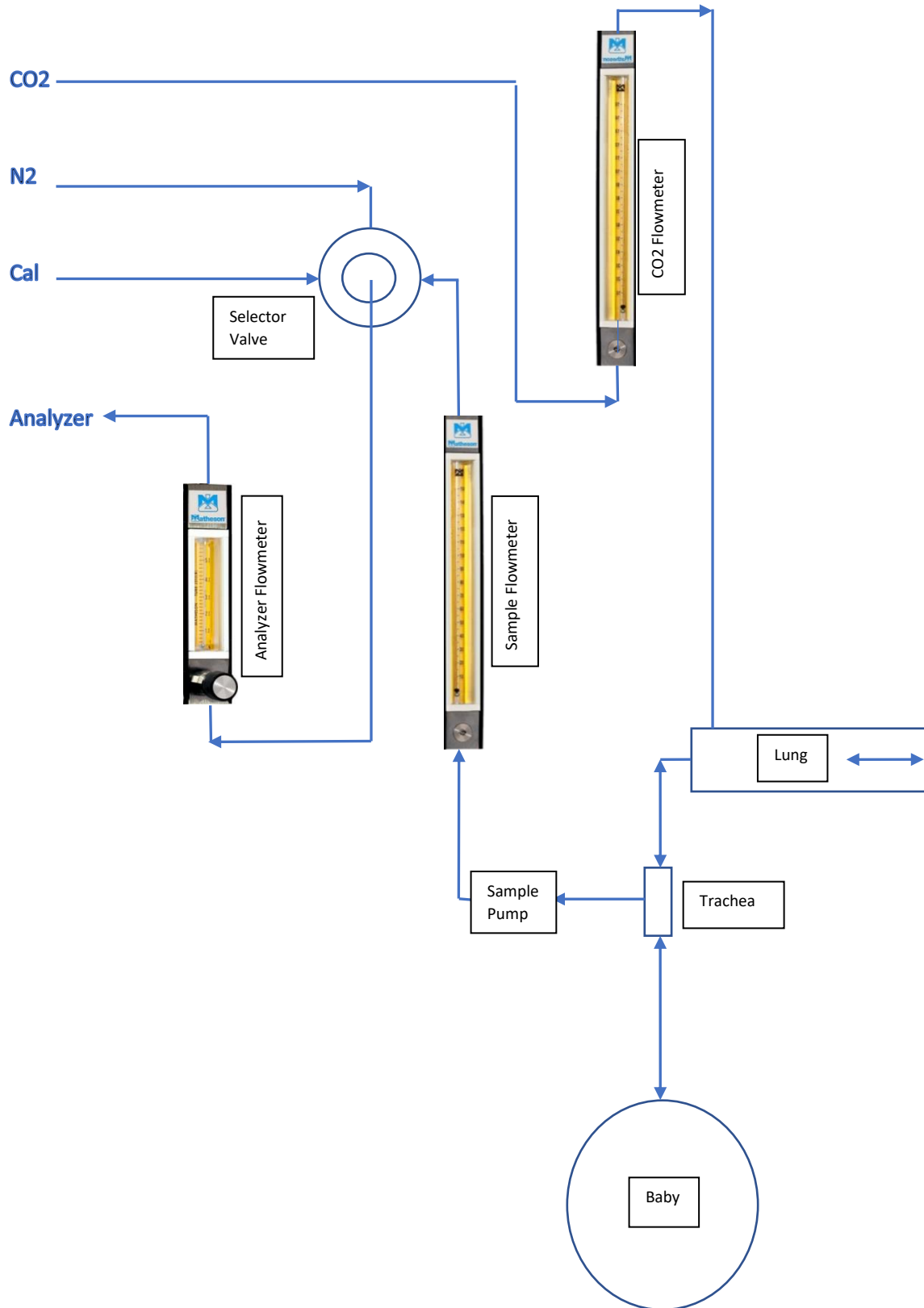
Depth of penetration measurement

The lifter is equipped with a dial indicator and adjustable anvil. The anvil is mounted on a sliding bracket with a knob to use for coarse adjustment, and a screw-thread on the end for fine adjustment. The anvil is adjusted to zero the dial indicator as the head-form touches the sample material. As the head-form is slowly released, the dial indicator records the penetration depth.

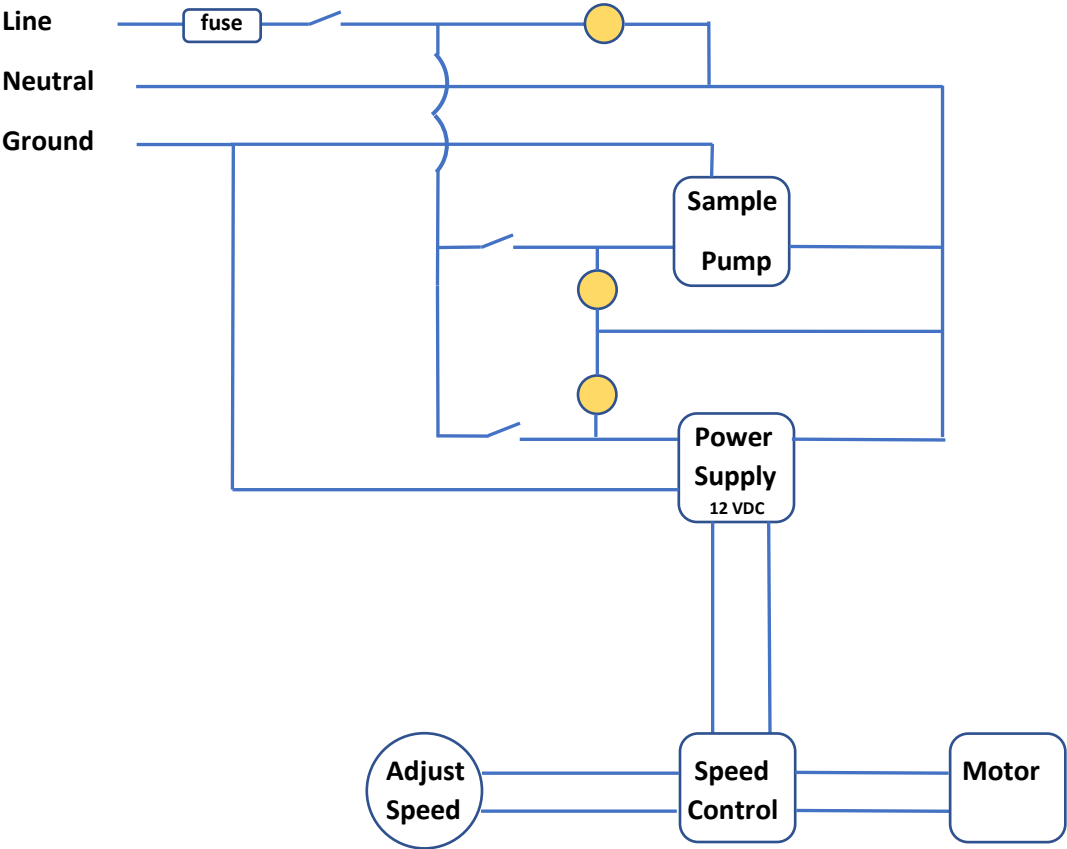
Depth of penetration may be an important factor in the effectiveness of a seal between the face and material being tested and is expected to be a factor in CO₂ re-breathing.



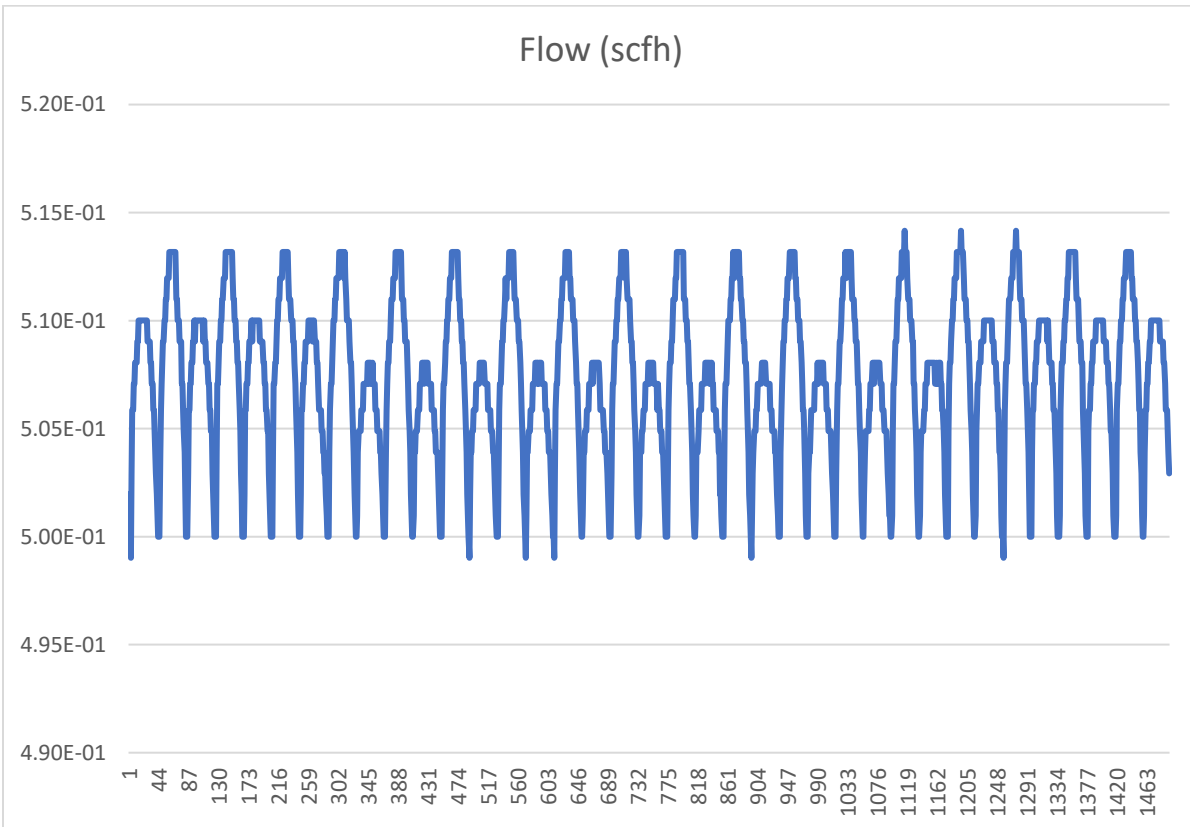
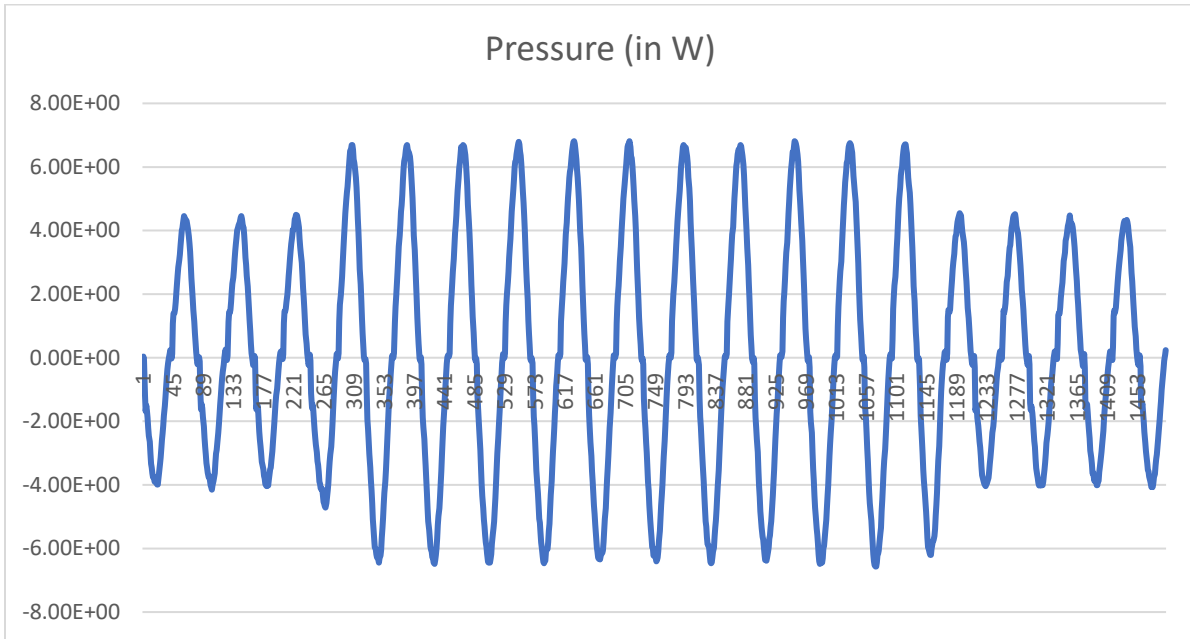
Flow Schematic



Electrical Schematic



Data Acquisition



References:

[Forensic Engineering Evaluation of CO2 Re-Breathing in Infant Bedding Materials](#), Michael D. Leshner, Journal of the National Academy of Forensic Engineers Vol. XXIX No. 2 December 2012.

[Carbon dioxide rebreathing induced by crib bumpers and mesh liners using an infant manikin](#), Matthew R. Maltese and Michael Leshner, BMJ Paediatrics Open, bmjpo-000374, April 2019.