

PERFORM Operating Document

MOXUS – Resting Metabolic Rate

PC-POD-CP-005-v05

Version	Reason for Revision	Date
05	Modified: Introduction / 5.6 / 5.11 / 6.1.13 / 7.4 / 7.6 / 9.1 / section 12 / 13.1.4.2. Added: 3.5 / 3.6 / 7.9. Removed: 5.13 / note after 6.2.14 / 13.1.1.6.	June 16, 2021

1. Introduction

The content of this PERFORM Operating Document (POD) provides guidelines for use and cleaning procedure for the MOXUS metabolic system. This system functions as a cart used to acquire breath-by-breath data for the purpose of measuring resting metabolic rate (RMR). The primary variable of interest for the measurement of RMR is Resting Energy Expenditure (REE) measured in kilocalories per minute. This POD applies to all users of the unit and is the responsibility of all users to ensure that this POD is followed.

2. Main Components of MOXUS Metabolic System

- 2.1 Oxygen Analyzer S-3A/I** – provides continuous and accurate measurement of oxygen concentrations from 0-100%.
- 2.2 Carbon Dioxide Analyzer CD-3A** – provides continuous and accurate measurement of carbon dioxide concentrations from 0-15%.
- 2.3 Flow Control R-I Pump** – Used in conjunction with oxygen analyzer S-3A/I and carbon dioxide analyzer CD-3A. Contains a flow meter, pump, and needle valve.
- 2.4 4.2 L Active Mixing Chamber** – Where expired air is led to and sampled continuously at a flow of 0.25 L/min.
- 2.5 Canopy Pump** – Pumps air from the canopy hood to the system.
- 2.6 Calibration and Reference Gases** – used for gas calibration.

- 2.7 Canopy Hood** – Placed over participants' head during the measurement of RMR. Enables gases to go from canopy hood to system.

3. System Setup

- 3.1** Prior to conducting a test, the system must be turned on for at least 16 hours. Distributors recommend leaving the system on unless a large gap exists between testing days.
- 3.2** Make sure that the inspiratory hose is connected to the pneumotach.
- 3.3** Make sure that the expiratory hose is connected to the mixing chamber.
- 3.4** Make sure that the 3-way valve on the side of the Canopy pump is in the horizontal position.
- 3.5** Turn on Medgraphics Metabolic Cart to obtain values from barometer.
- 3.6** Make sure Dessicant beads are blue (and not pink). If pink, contact area supervisor.

NOTE: The setup for the hoses and 3-way valve is necessary to calibrate the system, yet will be altered once the system is setup for the use of the canopy hood.

4. System Check

- 4.1** Open both gas tanks (approximately 5 turns counter clockwise). Right gauge should read > 500 psi.
- NOTE: Should psi read <500, the gas tank is close to empty.
- 4.2** Turn the range knob on the right of the Oxygen Analyzer S-3A/I to the "TC" setting. The value displayed should be 6.790 ± 0.003 [range: 6.787-6.793]. If the displayed value falls outside of this range, wait and allow time for the value to oscillate and stabilize. Proceed only after you have obtained a stable reading within the range specified.
- 4.3** Turn ON the Flow Control R-I pump. Adjust the black knob below the flow meter until the bottom of the lower silver float ball is set at the 2 on the graduated meter. This represents a flow rate of approximately 175 ml/min.
- 4.4** Wait 5 minutes.
- 4.5** While you wait, turn the range knob on the right of the Oxygen Analyzer S-3A/I to the "% O₂" setting. Verify the Oxygen Analyzer S-3A/I display indicates a stable reading of about 20.93% [range: 20.50-20.98]. If necessary, adjust by moving black knob in middle of Oxygen Analyzer S-3A/I to "Calibrate", unlock "zero" knob (moving switch to left), then move "zero" knob to attain desired value, move middle knob back to "Sample", and re-lock "zero" knob (moving switch to the right).
- 4.6** Verify the Carbon Dioxide Analyzer CD-3A display indicates a stable reading of about 0.03% CO₂ range [0.0-0.15]. Adjust if necessary.

- 4.7** Once 5 minutes has elapsed, proceed with System Leak Check:
- 4.7.1** Keeping the Flow Control R-I pump power ON, temporarily disconnect the small-diameter sample tube from the Mixing Chamber with a quarter turn (counter clockwise).
 - 4.7.2** Using your finger, block the opening of the tube.
 - 4.7.3** Verify that both silver float balls on the flow meter drop completely to the bottom of the graduated meter and stay there with no bouncing (i.e. zero flow).
 - 4.7.4** Remove finger and verify that the silver float balls return to a setting of 2 on the flow meter and that the analyzer readings return to approximately 20.93% and 0.04%.
 - 4.7.5** Re-connect the sampling tube to the Mixing Chamber with a snug fit.

NOTE: If leak check does not pass it means that there is outside air somewhere in the system, therefore, system is not accurate. Since a leak is present, pinch off each tube moving to the back of the cart while making sure that each time you pinch a tube the silver float balls fall to zero. If while pinching the silver float balls do not drop to zero, tighten the tubing and retry the leak check.

5. Software Setup

- 5.1** Open the MOXUS software located on the laptop desktop.
- 5.2** Wait for “Initializing System” box to disappear before proceeding.
- 5.3** Select TOOLS → HARDWARE DX → Select the following settings:
 - 5.3.1** “Data Channel Units” = “Cal Values”.
 - 5.3.2** “System Mode” = “MOXUS”
 - 5.3.3** “Volume Source” = “Pneumotach”
 - 5.3.4** “Controls” = “Automatic”
- 5.4** De-select all other boxes if checked. Click “Exit”. Box will appear with the following message: “WARNING! SYSTEM SETTINGS CHANGED. SAVED DATA MUST BE RE_OPENED WITH THE SAME SYSTEM SETTINGS. Do you wish to save this change?”. Click “Yes”. The software will automatically re-initialize.
- 5.5** Select FILE → PROPERTIES → SETUP tab → If necessary, change “Standard Calibration Gases” values to: Air Tank (%) = 0.03 (CO₂), 21.03 (O₂); Ex. Tank (%) = 3.99 (CO₂), 16.00 (O₂).
- 5.6** FiO₂ and FiCO₂ inspired gas values are taken from previous calibration, no need to adjust.
NOTE: FiO₂ = 20.93% and FiCO₂ = 0.04% are typical values for fresh outdoor air.
- 5.7** Confirm that the Mixed Volume Delay is set at 6.9 L. This is for the supplied breathing valve and tubing (2.7 L) and the mixing chamber (4.2 L).

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- 5.8 The default analyzer time delays are 3 seconds for the CO₂ Analyzer CD-3A and 3.3 seconds for the O₂ Analyzer S-3A/I.
- 5.9 Confirm that the calibration syringe volume is set to the actual volume the syringe contains on the calibration certificate (i.e. 2994 ml).
- 5.10 Confirm that the volume corrected “V_t + V_e only” is calculated in BTPS (preferred) or STPD.

NOTE: All metabolic data [VO₂, VCO₂, etc.] is always presented and saved in STPD without regard to this selection box. Click on “Save” if changes are made.

- 5.11 Select AVG INTERVAL tab. Choose the averaging interval for the test by sliding the bar to the desired setting. Slide to 30 seconds, if needed.

NOTE: By setting the averaging interval to 0 seconds you will get breath-by-breath data. However, the exhaled breaths are still sampled from the mixing chamber.

- 5.12 Click on “Ok” or “Save” if changes are made.

6. Calibration

6.1 O₂ and CO₂ Calibration

- 6.1.1 Make sure that the black knob on the far right of the Oxygen Analyzer S-3A/I is switched to “%O₂”.
- 6.1.2 In the software, click on “Calibrate”.
- 6.1.3 Under “Valve Control” click “Calibrate Air”.
- 6.1.4 Make sure that the psi on left gauge of tank with concentrations of 21.03% O₂ and 0.03% CO₂ is set at 15 psi.
- 6.1.5 On the Oxygen Analyzer S-3A/I, wait for value to stabilize. Once stabilized, if value is not 21.03, move black knob in the middle of the box to “Calibrate”. Unlock switch on “Zero” knob by moving it to the left. Adjust with “Zero” knob until value on display is at 21.03. Move black knob back to “Sample”. Lock switch on “Zero” knob by moving it to the right.
- 6.1.6 On Carbon Dioxide Analyzer CD-3A, wait for value to stabilize. Once stabilized, if value is not 0.03, move black knob in the middle of the box to “Calibrate”. Unlock switch on “Zero” knob by moving it to the left. Adjust with “Zero” knob until value on display is at 0.03. Move black knob back to “Sample”. Lock switch on “Zero” knob by moving it to the right.
- 6.1.7 Under “Valve Control” click “Calibrate Exp”.
- 6.1.8 Make sure that the psi on left gauge of tank with concentrations of 16.00% O₂ and 3.99% CO₂ is set at 15 psi.
- 6.1.9 Visually inspect O₂ analyzer display once values are stabilized to make sure it is close to 16.00%. If not close to 16.00%, check if needle on gauge is at 15psi. If needle is not at 15 psi adjust knob on gas tank until value reaches 15 psi then re-check the value on the analyzer display. If not at 16.00 after adjustment, adjust value by moving black knob in the middle of the Oxygen

Analyzer S-3A/I to “Calibrate”. Unlock switch on “Zero” knob by moving it to the left. Adjust with “Zero” knob until value on display is at 16.00. Move black knob back to “Sample”. Lock switch on “Zero” knob by moving it to the right.

- 6.1.10 On the Carbon Dioxide Analyzer CD-3A, unlock switch on “Span” knob by moving it to the left. Move black knob in the middle of the box to “Calibrate”. Adjust with “Span” knob until value on display is at 3.99. Move black knob back to “Sample”. Lock switch on “Span” knob by moving it to the right.
- 6.1.11 Under “Valve Control”, select “Sample Air” to sample room air.
- 6.1.12 Wait about 10 seconds to allow the O₂ and CO₂ readings to stabilize. Check that the values are reasonable. Nominal indoor ambient O₂ is 20.70 to 20.98 and CO₂ is 0.02 to 0.15; however, your typical values may be slightly outside these ranges.
- 6.1.13 Record the average O₂ and CO₂ readings taken directly from the O₂ and CO₂ analyzers for later use. Record in fiO₂ and fiCO₂ box on worksheet.
- 6.1.14 Click “Standby”.

6.2 Software Calibration

- 6.2.1 Verify that the R-I Pump is turned ON and the bottom of the lower silver float ball is set at 2 on the graduated meter.
- 6.2.2 Calibration gas values previously entered into the “Properties/Setup” window will appear when you select the O₂ and CO₂ channels and click “Reset”. If needed, enter new values as follows:
 - 6.2.2.1 In the “Low Cal Value” box for O₂ channel enter “16.00”.
 - 6.2.2.2 In the “High Cal Value” box for O₂ channel enter “21.03”.
 - 6.2.2.3 In the “Low Cal Value” box for CO₂ channel enter “0.03”.
 - 6.2.2.4 In the “High Cal Value” box for CO₂ channel enter “3.99”.
- 6.2.3 Click the box next to “O₂Mix” to check the box.
- 6.2.4 Click on “LO Cal” button. The program will record and average the output signal from the Oxygen Analyzer S-3A/I for approximately 60 seconds. Simply wait until the cycle is complete (i.e. the box next to “O₂Mix” will become deselected).
- 6.2.5 Click the box next to “O₂Mix” to check the box again.
- 6.2.6 Click on “HI Cal” button. The program will run through the same 60-second cycle and the “Status” box will read “Calibrated”.

NOTE: If the channel indicates “Error” press the “Save” button, if available, and repeat the software calibration steps. Several repetitions may be necessary.

- 6.2.7 Click “Save” and “Exit”.
- 6.2.8 Click on “Calibrate”.
- 6.2.9 Click the box next to “CO2Mix” to check the box.
- 6.2.10 Click on “LO Cal” button and wait for the 60-second cycle to complete.
- 6.2.11 Click the box next to “CO2Mix” to check the box again.
- 6.2.12 Click on “HI Cal” button and wait for the 60-second cycle to complete.
NOTE: If the channel indicates “Error” press the “Save” button, if available, and repeat the software calibration steps. Several repetitions may be necessary.
- 6.2.13 Click “Save” and “Exit”.
- 6.2.14 Use the cylinder wrench to shut off the gas supply to both tanks by securely tightening the main cylinder valve in a clockwise direction.

7. Flow Calibration

- 7.1 Click “Calibrate”.
- 7.2 Under “Pneumotach” click “Calibration”.
- 7.3 Attach 3L syringe directly on mouth port of breathing valve.
- 7.4 Pull out the lever on the 3L syringe taking approximately 7 seconds to do so. Push the lever back in taking approximately 7 seconds to do so. Do this at least 5 times making sure to apply a full stroke each time, stopping against the mechanical limits of the syringe. After the first 2 strokes, the volume of each stroke measured by the computer is displayed. When the space of strokes, within the box, is full of complete strokes, look at the displayed volume of strokes and verify if they are consistent (within 60ml).
NOTE: The volume may not be accurate (it may be completely erroneous) at this time, but the displayed volumes should be consistent. If the volumes are not consistent, then the strokes may not have been full strokes or there may be a leak in a tube or a leak (or a backflow) in a component of the breathing valve.
- 7.5 When volumes are consistent, click “Ok” and repeat the strokes of the syringe, again in the same manner. This second set of strokes is called verification, and should display accurately and reliably the volume of the syringe.
- 7.6 After at least 5 strokes, verify that the average error is within 60 ml and the mean percent error is within $\pm 2\%$. Typically, $\pm 1\%$ or better can be achieved. Record % Error on worksheet.
NOTE: If the error is greater than $\pm 2\%$, click on the “Calibrate” button to re-calibrate the system. You will be prompted to pump the calibration syringe at least another 5 times. Once again, be careful to avoid bumping the plunger on either end of the stroke.
- 7.7 If so, click “Ok”.

- 7.8 Click “Save” and “Exit”.
- 7.9 Disconnect 3L syringe.

8. Canopy Setup

- 8.1 Remove plastic protective cover from the canopy hood.
NOTE: The plastic drape is attached to the canopy hood by Velcro that is permanently glued to canopy hood.
- 8.2 Remove inspiratory tube from pneumotach (side on which arrow is pointing) and expiratory tube from mixing chamber.
NOTE: Arrow indicates the direction of flow.
- 8.3 Take the short yet large corrugated hose and, on the back of the cart, attach one end of hose to the pneumotach (side on which arrow is pointing) and the other end to Mixing Chamber input.
- 8.4 On the hole located at the narrow end of the canopy hood (i.e. end closest to mouth), attach canopy connector on each side of the hole (inner and outer part of the hole) of the canopy hood. The connector will unscrew in 2 parts; then fit through the hood and screw parts together.
- 8.5 Connect the supplied 7/8” corrugated hose to the Canopy Connector.
- 8.6 Connect the other end of the 7/8” corrugated hose to the Pneumotach (side on which arrow is not pointing towards) using the supplied connector (white plastic piece about fist size).
- 8.7 Change the 3-way valve on the side of the Canopy pump to the vertical position (clockwise turn).

9. Software Setup for Canopy

- 9.1 Select TOOLS → HARDWARE DX → Select “Canopy System Option”.
- 9.2 Should the test last 30 min or longer, you may want to select “Sample Inspiratory Air”, which will allow for automatic sampling of inspiratory O₂ and CO₂ concentrations every 10 minutes.
NOTE: The initial inspiratory O₂ and CO₂ concentrations should be recorded (during calibration) and entered (when entering participant information) as described. These values will be used for the initial 10 min of the study. These initial values will also be applied for the entire study if the “Sample Inspiratory Air” checkbox is un-selected.
- 9.3 Click “Exit”. A message will appear asking if you would like to save this change. Click “Yes”.
- 9.4 The program will re-initialize.

10. Entering Participant Information

10.1 Click on “Subject Data”.

10.2 Enter participant information. All information in bold is required.

NOTE: For multiple tests on the same participant conducted on the same day, add a numeral (or other identifier) after the “Subject Name” for each test. Do not use special characters such as “/”, “.”, “,”, etc.

10.3 Enter the average ambient [inspiratory] fiO_2 and fiCO_2 concentrations previously recorded during calibration.

10.4 Click “Ok”.

11. Start Test: RMR Measurement

11.1 Turn on Canopy Pump.

11.2 Click on “Start Study”.

11.3 Wait for flow to stabilize.

11.4 Adjust flow rate to approximately 27.5 L/min (between 25-30 L/min). To do so, SLOWLY turn the black knob on the canopy pump. A clockwise rotation of the knob decreases the flow; counter-clockwise rotation of the knob increases the flow.

NOTE: **Do not turn the knob to completely shut off airflow through the canopy.**

11.5 Place canopy on participant.

11.6 SLOWLY adjust feCO_2 to 0.75-0.80 (no < 0.6 no > 1.0).

11.7 Instruct participant not to move and that they must remain awake during measurement.

11.8 When ready, click on “Start Study”.

11.9 When finished, click “End Study”.

12. Saving Reports

12.1 Right click on # symbol located at the top right corner.

12.2 Click “export to excel”.

12.3 Once dialogue box opens, save file as participant full name and date (YYYYMMDD).

12.4 Click “Open”.

12.5 Go to Computer → C-Drive → AEI Technologies.

13. Cleaning/Disinfecting and Inspecting Tubing and Canopy Hood

NOTE: Precautions prior to cleaning/disinfecting:

- Wash hands before and after cleaning equipment.
- Wear protective clothing (i.e., laboratory coat), protective eyewear, and gloves.
- Adequate ventilation is required during cleaning/disinfection procedure.

13.1 Tubing and tubing attachments

13.1.1 Cleaning

13.1.1.1 Submerge in mild detergent with neutral pH (Neutrad) and warm tap water (22°C to 43°C) and soak for 5 minutes. Prepare the solution according to instructions provided by the manufacturer of cleaning product.

13.1.1.2 Rinse with warm tap water (38°C to 49°C).

13.1.1.3 Place in a basin full of warm tap water (38°C to 49°C). Move water inside tubing for 1 minute.

13.1.1.4 Repeat 2 more times.

13.1.1.5 Rinse under running tap water for 1 minute.

13.1.2 Disinfection

13.1.2.1 Submerge in a liquid chemical solution (glutaraldehyde CIDEX). Prepare the solution according to instructions provided by the manufacturer of cleaning product. **MANDATORY** - Wear protective clothing (i.e., laboratory coat), protective eyewear, and gloves.

13.1.2.2 Soak in solution for 45 minutes.

13.1.2.3 Remove from solution and submerge in 1500ml of tap water for at least 1 minute.

13.1.2.4 Repeat step above.

13.1.2.5 Dry the outside with paper towel.

13.1.2.6 Let dry overnight.

13.1.3 Inspection

13.1.3.1 Visually inspect for any defects prior to storing.

13.1.4 Storing

13.1.4.1 Using gloves, place in a clean plastic bag.

13.1.4.2 Write the number of times the tubing/tubing accessories has been used on the plastic bag.

NOTE: Tubing and tubing attachments can be re-used 100 times.

13.2 Canopy Hood

13.2.1 Cleaning

13.2.1.1 Clean canopy with mild detergent and tap water.

13.2.1.2 Wipe dry.

13.2.2 Inspection

13.2.2.1 Visually inspect for any defects prior to storing.

13.2.3 Storing

13.2.3.1 Using gloves, place in large plastic bag.