Oxymax

Open Circuit Indirect Calorimeter

Columbus Instruments has a long history as the world's premier supplier of quality lab animal open-circuit calorimeter systems. Oxymax is the best selling device of its kind in the marketplace. It has a track record of reliable, consistent, performance and is mentioned in 100s of scientific research articles. While normally employed for mice or rats, Oxymax has been scaled for applications employing chicken eggs to horses.

Oxymax is offered in configurations of 1 to 32 chambers. It is a fully automated system by way of a connected personal computer and supports numerous set-up options that accommodate a diverse range of applications.

In production for over 25 years, Oxymax has grown and adapted to meet the expanding needs of the research in which it is employed. A wide range of sensor types are offered as well as adaptation to both positive and negative ventilation methods. Oxymax is suitable for use with enclosed chambers, masks or canopies.

The measurement of many other parameters may be added to any Oxymax system to extend it well beyond basic calorimetry. These additional parameters include, activity, feeding mass, drinking (licks and/or volume) body temperature, heart rate, urine collection/monitoring and special treadmills for monitoring metabolic performance under exercise.

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Oxymax principle of operation

Columbus Instruments Oxymax system is an open-circuit indirect calorimeter. Energy expenditure [EE] is derived by assessment of the exchange of oxygen for carbon dioxide that occurs during the metabolic processing of food. The relationship between the volume of gas consumed (oxygen) and of that produced (carbon dioxide) reveals the energy content of the foodstuff utilized by the subject. This ‘calorific value’ is then applied to the volume of gases exchanged to compute EE.

1] $VO_2 = ViO_2i - VoO_2o$
2] $VCO_2 = VoCO_2o - ViCO_2i$
3] $RER = VCO_2/VO_2$

Where:
Vi = Mass of air at chamber input per unit time
Vo = Mass of air at chamber output per unit time
O_2i = Oxygen fraction in Vi
CO_2i = Oxygen fraction in Vi
O_2o = Carbon Dioxide fraction in Vo
CO_2o = Carbon Dioxide fraction in Vo

Oxymax measures only one flow: either Vi or Vo. The unmeasured flow is derived by relying on the fact that N2 does not take part in respiratory gas exchange. The volume of N2 is equal at both inlet and outlet of the chamber:

(assume Vi as the measured flow)
N2i = 1 - O2i - CO2i
N2o = 1 - O2o - CO2o
$ViN_2i = VoN_2o$
$Vo = ViN_2i/N_2o$

Substituting into **1]** & **2]**:

4] $VO_2 = ViO_2i - [ViN_2i/N_2o]O_2o$
5] $VCO_2 = [ViN_2i/N_2o]CO_2o - ViCO_2i$

Heat is calculated by first assessing the calorific value of the food being metabolized. The calorific value is tied to RER in a manner tabulated by Lusk (1928). For the accepted range of nutritional RERs (0.707 to 1.0), the heat available is 4.686 to 5.047 Kcal/LiterO_2 . Oxymax, interpolates the calorific value (Cv) by straight line approximation for values within the RER range. The resulting calorific value is applied to the obtained figure for oxygen consumption for derivation of Heat.

6] Energy Expenditure = $Cv \bullet VO_2$

Users may implement a preferred method for derivation of EE based on equations entered into Oxymax. Likewise, users may specify any applicable units to the presentation of data.

Technologies employed by Oxymax

- **Mass flow measurement**
- **Paramagnetic or Zirconia Oxide O_2 sensing**
- **Push or Pull ventilation**
- **Single or Multiple Gas Sensors**

As an indirect calorimeter, Oxymax relies on accurate measurements of gas concentrations and flow. Flow is measured by a mass thermal transfer technique that yields data formatted in terms normalized to scientific STP (760 mmHg and 0˚ Centigrade). It is the measurement of mass, not volume, that allows Oxymax to be employed under various atmospheric conditions without the need to account for environmental pressure or temperature.

The measurement of oxygen may be performed by these technologies supported by Oxymax:

- Paramagnetic Sensing [standard speed]
  Provides full 0-100% range
- Zirconia Oxide [high speed]
  Provides full 0-100% range and high speed response

Carbon Dioxide is sensed by single beam non-dispersive IR (NDIR). Carbon Dioxide sensing is available with a standard response sensor or an optional high-speed sensor to match the capabilities of the associated oxygen sensor.

The combination of the Zirconia Oxide based oxygen sensor and high speed single beam NDIR carbon dioxide sensing provides a chamber measurement in 45-60 seconds. Standard sensors provide a measurement in two minutes.

Removal of water vapor is accomplished by the employment of materials with hydroscopic properties that isolate the sample gas from the drying media. This prevents the sample gas composition from being altered by interaction with the drying media as well as providing reduced volume within the drying pathway. Reduced volume within the drying pathway improves response time and provides very high accuracy measurements of sample gas composition.

Oxymax supports both push and pull flow methodologies. Systems may be configured with single or multiple gas sensors. Systems equipped with a single set of gas sensors, sequentially scan the chambers with a pneumatic multiplexer. These systems have a dwell time of 45 seconds to 2 minutes before advancing to the next chamber. Higher data through-put is accomplished with an increasing number of gas sensors. Optimal performance is achieved with one set of gas sensors assigned to each animal chamber. In such case, data may be recorded at intervals as short as 10 seconds with all chambers operating in parallel.

Features Common to Oxymax All Systems ...

Mass Flow Measurement

All flows relating to assessment of gas exchange are measured by the mass flow principle. Mass flow is a direct measurement of the *mass* of flowing media, not volume. Unlike volume, that is susceptible to the effects of temperature and pressure, mass measurement provides a consistent and comparable unit of measurement. The mass measurement technique, as employed by Oxymax, has been standardized such that all applicable flows are reported under STP conditions (760 mmHg and 0^{o} Centigrade). Additionally, the monitoring of air delivered to each chamber is monitored by a common mass flow device. Thus negating the possibility of error that might arise from observing multiple devices. Lastly, Oxymax not only monitors the flow of air delivered to the chamber but also *controls* the flow. Control of the flow eliminates the need for compensatory mechanisms to account for error due to any variation in the source of air that might otherwise detract from the accurate measurement of the rate of delivery.

Chambers Meet Long-term Housing Rules

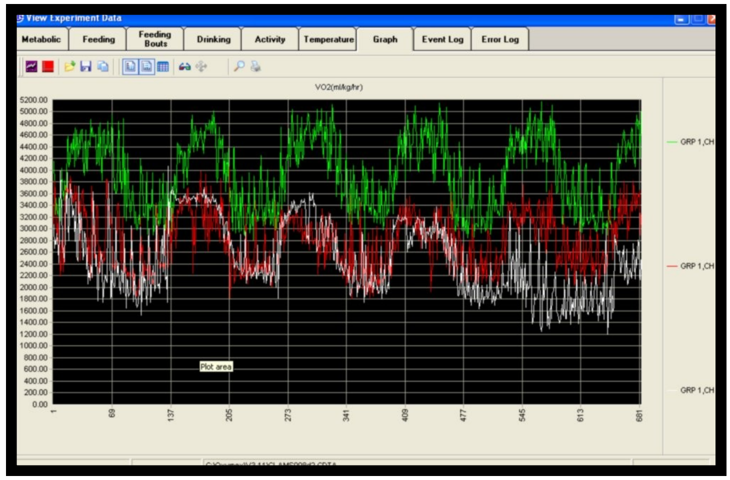
The use of a calorimeter for an extended period mandates an animal environment that complies with guidelines for long-term housing. All Oxymax Standard Chambers comply with the guidelines stipulated in the U.S. Department of Health and Human Services “Guide for the Care and Use of Laboratory Animals”.

Minimal Retention of Evolved Gases

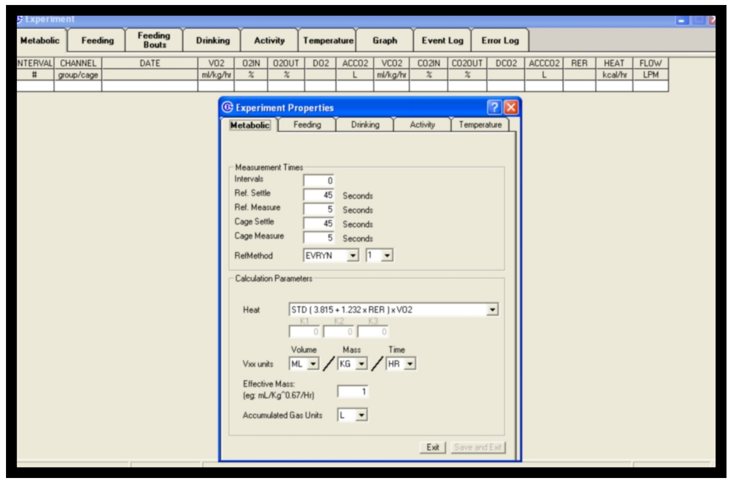
Open-circuit calorimetry requires some measurable difference between the composition of the incoming air and chamber effluent. Evolved CO2, if allowed to accumulate within the animal environment, can cause physiological changes that can impair the animal as well as the collection of meaningful data. Oxymax employs sensors with the ability to accurately detect changes in gas composition as small as 0.001%. This level of precision requires a minimal differential for the assessment of gas exchange. Typically, composition differences of 0.2%-0.5% comprise the full working range required by Oxymax to provide an accurate measurement.

Ease of Operation

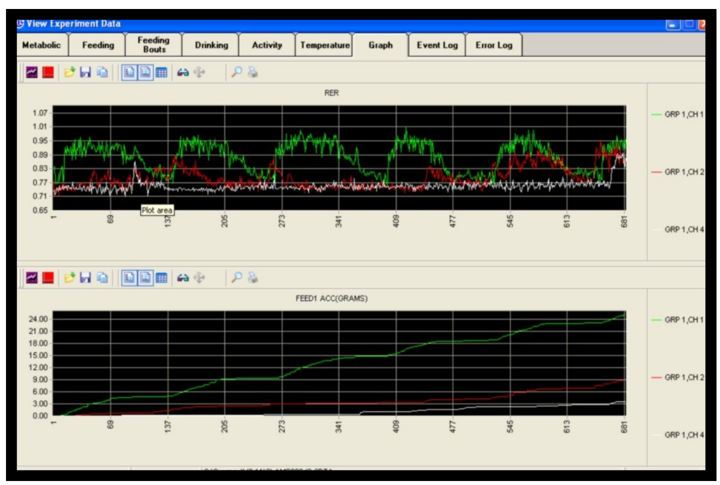
All hardware and software aspects of Oxymax have been subjected to years of client critique and review. Connections of both cables and hoses have been reduced to a minimum. The software includes guided sequences for calibration and set-up. Data organization, formatting and export have been streamlined to facilitate linking with popular data reduction/review programs. Hundreds of thousands of hours of operation by end-users are a testament to the product’s performance.



Oxymax Experiment Graph of VO₂



Oxymax Experiment Configuration Screen



Oxymax Experiment Graph of RER & Feeding

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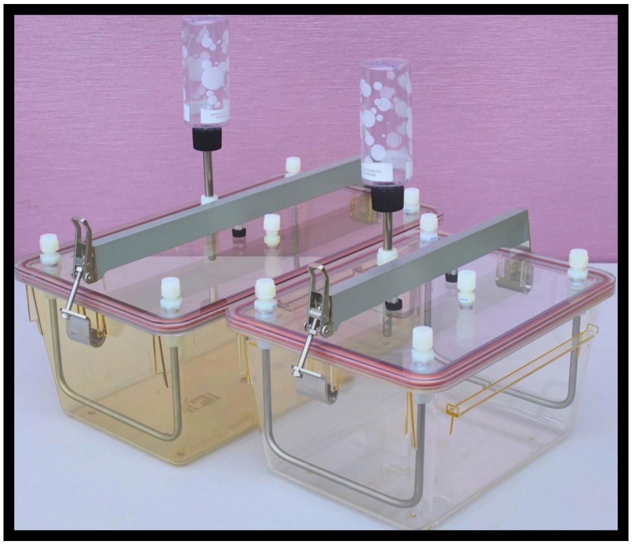
Flexibility and Adaptation

Oxymax supports a wide range of chamber types and configurations. Standard chambers are offered by Columbus Instruments for support of common lab animals. Custom chambers have been constructed for many other animals. Columbus Instruments specializes in custom chamber design for open circuit indirect calorimetry.



Standard Oxymax Chambers

High throughput systems can be constructed with up to 32 chambers. The addition of supplementary parameters, measured concurrently with calorimetry, maximizes animal use and reduces repeated testing. Augmenting Oxymax with feeding, drinking, activity, body temperature, heart rate and other parameters creates a Comprehensive Lab Animal Monitoring System for Home Cages (**CLAMS-HC**).

CLAMS-HC

Oxymax is equally applicable to large animal research. Systems have been constructed for many species ranging from mice to horses.

Oxymax Primate Chamber

Large Animal Enclosure

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