Oxymax/CLAMS

Comprehensive Lab Animal Monitoring System

for

Rats and Mice

Features .....

- **Activity**
  X,Y & Z axis monitoring
- **Feeding**
  Mass monitoring
- **Drinking**
  Volume Monitoring
- **Body Mass**
  Resolves 0.1g
- **Running Wheel**
  Rotation Monitoring
- **Sleep Detection**
  Scores Events and Duration
- **Waste Collection**
  Mass monitoring and freezing
- **Food Access Control**
  Mass & Event monitoring
- **Environmental Control**
  of Temperature and Lighting
- **Calorimetric Assessment**
  by Oxymax
- **Environmental Monitoring**
  of Temperature and Humidity
- **Temperature & Heart Rate**
  by Telemetry

12-Chamber Mouse System with Calorimetry, Activity, Feeding and Drinking Monitoring

Columbus Instruments **C**omprehensive **L**ab **A**nimal **M**onitoring **S**ystem **CLAMS** is the premiere system of its kind. Incorporating sub-systems for open circuit calorimetry, activity, body mass, feeding, drinking, food access control, running wheel, urine collection, sleep detection, body core temperature and heart rate in an optional environmental chamber: Oxymax/CLAMS is the *one-test solution* for simultaneous multi-parameter assessment of 1 to 32 test animals.

Oxymax/CLAMS is constructed on a semi-custom basis incorporating parameters and features specific to your research. Any system can be expanded by way of more chambers and/or features at any time.

Operation of Oxymax/CLAMS and data collection is performed by an integrated program. The resulting secure datasets can be exported to Comma Separated Value (CSV) files and provide the link between Oxymax/CLAMS and your existing data analysis tools. Additional data reduction tools allow for the de-collating of data by parameter to facilitate analysis from a parameter perspective. All data can be reviewed graphically & numerically in real-time during collection.

Oxymax/CLAMS provides fully automated operation for experiments lasting up to three days. Food and water may be replenished during experiment execution without the need for system restart.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Calorimetric Assessment by Oxymax

Columbus Instruments Oxymax system is the leading open-circuit indirect calorimeter for lab animal research. Heat is derived by assessment of the exchange of oxygen for carbon dioxide that occurs during the metabolic process. 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 heat. Oxymax, when equipped with optional methane sensing, is applicable to ruminant animals. A modified equation is then employed for heat.

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 N_2 does not take part in respiratory gas exchange. The volume of N_2 is equal at both inlet and outlet of the chamber:

(assume Vi as the measured flow)
$N_2i = 1 - O_2i - CO_2i$
$N_2o = 1 - O_2o - CO_2o$
$ViN_2i = VoN_2o$
$Vo = ViN_2i/N_2o$

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] $Heat = Cv \bullet VO_2$

Users may implement a preferred method for derivation of heat based on equations entered into Oxymax/CLAMS.

Technologies Employed by Oxymax

As an indirect system calorimeter, Oxymax relies on accurate measurements of gas concentrations and flow. Flow is measured by a mass technique that yields data formatted in terms normalized to scientific STP (760 mmHg and 0^o 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 any of three technologies supported by Oxymax:

- An electrochemical cell
  Inexpensive with 5-22% operating range
- Paramagnetic Sensing
  Provides full 0-100% range
- Zirconia Oxide
  Provides full 0-100% range and high speed response

Carbon Dioxide and, optionally, Methane are sensed by single beam non-dispersed IR (NDIR). Carbon Dioxide sensing is available with a standard response sensor or an optional high-speed sensor.

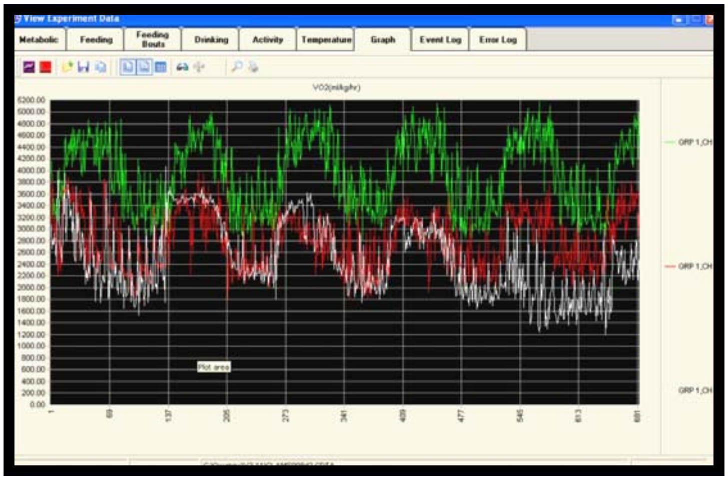
The combination of the Zirconia Oxide based oxygen sensor and high speed single beam NDIR carbon dioxide sensing provides a chamber measurement in 45-60 seconds. Standard sensor response for all other combinations is two minutes.

Removal of water vapor is accomplished by the employment of materials with hydroscopic properties that prevent direct contact of sample gas with the drying media. This prevents possible alteration of the sample composition as well as providing reduced volume within the drying mechanism. Reduced volume within the dryer improves response time and accuracy of gas composition readings.

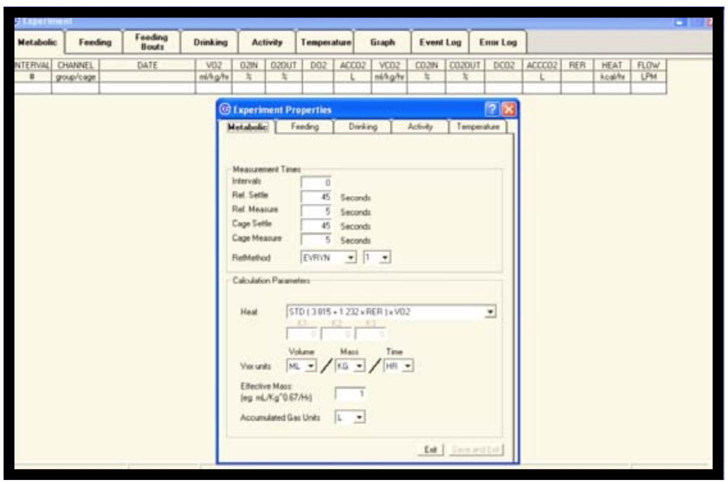
Oxymax supports both positive (push) and negative (pull) flow methodologies. Systems may be configured for single or multiple flow meters. Oxymax/CLAMS supports concurrent execution of any combination of push/pull ventilation methods as well as various combinations of flow metering. Mixed species testing or testing of animals with large variations in body mass may be conducted simultaneously in an appropriately configured system.

Oxymax provides the most flexible and expandable platform on the market for basic indirect calorimetry as well as being supportive of complex and custom applications ranging from mice to horses.

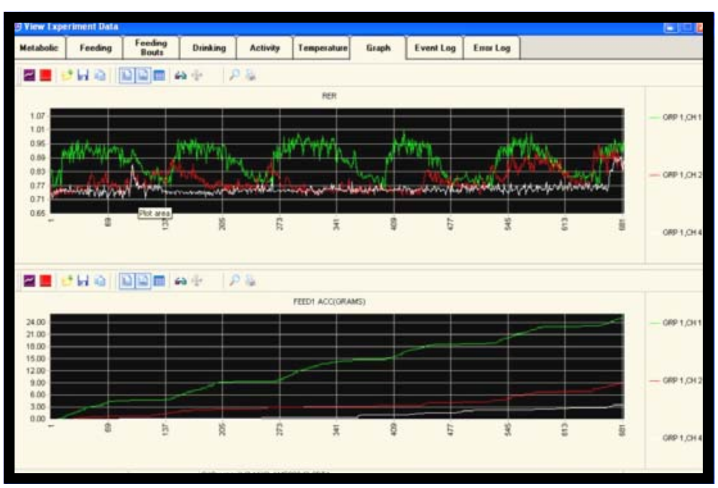
Features of CLAMS equipped with Calorimetric Assessment by Oxymax ...



Oxymax Experiment Graph of VO_2



Oxymax Experiment Configuration Screen



Oxymax Experiment Graph of RER & Feeding

• 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, 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 Rule •

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 indirect calorimetry requires some measurable difference between the composition of the incoming air and chamber effluent. Evolved CO_2, 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 0.3%-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 over two decades of client critique and review. Connections of all 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.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Oxymax/CLAMS [Example data snippet from chamber 1 of a 16 chamber system]

Int	Ch	Date	VO2	O2 In	O2 Out	ΔO2	O2 Acc	VCO2	CO2 In	CO2 Out	ΔCO2	CO2 Acc	RER	Heat	Flow
#	#	Time	ml/kg/h	%	%	%	ml	ml/kg/h	%	%	%	ml		Cal/h	L/m
19	01	7/19/06 16:00	4810	20.94	20.66	0.28	535.4	3239	0.043	0.281	0.237	422.3	0.816	0.5	0.597
20	01	7/19/06 16:18	4695	20.94	20.67	0.27	565.4	3804	0.043	0.273	0.230	446.7	0.810	0.5	0.597
21	01	7/19/06 16:35	4342	20.94	20.69	0.25	594.0	3483	0.043	0.253	0.210	469.7	0.802	0.5	0.597
22	01	7/19/06 16:53	4753	20.94	20.66	0.28	622.7	3918	0.043	0.280	0.237	493.1	0.824	0.5	0.597
23	01	7/19/06 17:10	4564	20.94	20.68	0.26	652.1	3592	0.043	0.260	0.217	516.8	0.787	0.5	0.597
24	01	7/19/06 17:28	3316	20.94	20.75	0.19	676.9	2852	0.043	0.215	0.172	537.1	0.860	0.3	0.597
25	01	7/19/06 17:45	3605	20.94	20.73	0.21	698.8	3130	0.044	0.233	0.189	556.0	0.868	0.4	0.597
26	01	7/19/06 18:03	5539	20.94	20.62	0.32	727.7	4736	0.044	0.330	0.287	580.8	0.655	0.6	0.597
27	01	7/19/06 18:20	4956	20.94	20.65	0.29	760.8	4301	0.044	0.304	0.260	609.3	0.868	0.5	0.597
28	01	7/19/06 18:38	4936	20.94	20.65	0.29	792.0	4466	0.044	0.314	0.270	637.0	0.905	0.5	0.597
29	01	7/19/06 18:55	5186	20.94	20.63	0.31	823.9	4645	0.046	0.326	0.281	665.8	0.896	0.6	0.597
30	01	7/19/06 19:13	5077	20.94	20.64	0.30	856.3	4795	0.045	0.335	0.290	695.6	0.944	0.5	0.597
31	01	7/19/06 19:30	5003	20.94	20.64	0.30	888.1	4654	0.047	0.328	0.281	725.4	0.930	0.5	0.597
32	01	7/19/06 19:48	5232	20.94	20.63	0.31	920.4	4958	0.047	0.346	0.299	755.7	0.948	0.6	0.597
33	01	7/19/06 20:05	5058	20.94	20.64	0.30	952.9	4802	0.047	0.337	0.290	786.5	0.949	0.5	0.597

Column Heading Legend (left page):

Int-Interval Number
Ch-Chamber Number
Date/Time-Date and Time of Sample
VO2-Rate of Oxygen Consumption [vol/mass/time]
O2 In-Oxygen Concentration at Chamber Inlet
O2 Out-Oxygen Concentration at Chamber Outlet
ΔO2-Oxygen Concentration Difference [O2 In-O2 Out]
O2 Acc-Accumulative Oxygen Consumption
VCO2-Rate of Carbon Dioxide Consumption [vol/mass/time]
CO2 In-Carbon Dioxide Concentration at Chamber Inlet
CO2 Out-Carbon Dioxide Concentration at Chamber Outlet
ΔCO2-Carbon Dioxide Concentration Difference [CO2 Out-CO2 In]
CO2 Acc-Accumulative Carbon Dioxide Consumption
RER-Respiratory Exchange Ratio [VCO2/VO2]
Heat-Rate of Heat Production
Flow-Mass of Ventilating the Chamber

Column Heading Legend (right page):

Feed Status-Dynamic: Animal is Feeding , Stable: Reading Obtained
Feed-Mass of Food Consumed During Interval
Feed Acc-Accumulative Food Consumption
VDM-Volume of Water Consumed During Interval
VDMAcc-Accumulative Volume of Water Consumed
X-Tot-Total Number of X-axis IR-Beam Breaks
X-Amb-Number of Ambulatory X-axis IR-Beam Breaks
Y-Tot-Total Number of Y-axis IR-Beam Breaks
Y-Amb-Number of Ambulatory Y-axis IR-Beam Breaks
Z-Tot-Number of Vertical (Rearing) Motions
Wheel-Number of Running Wheel Rotations
Core Temp-Body Core Temperature as Measured by Telemetry
Heart Rate-Heart Rate as Measured by Telemetry

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Oxymax/CLAMS [Example data snippet from chamber 1 of a 16 chamber system]

Int	Ch	Date	Feed1 Status	Feed1	Feed1 Acc	VDM1	VDM1 Acc	X-Tot	X-Amb	Y-Tot	Y-Amb	Z-Tot	Wheel	Core Temp	Heart Rate
#	#	Time		g	g	ul	ml	Count	Count	Count	Count	Count	Count	˚C	BPM
19	01	7/19/06 16:00	Dynamic	0.00	0.09	0	00.36	1255	458	826	280	24	0	36.6	492
20	01	7/19/06 16:18	Dynamic	0.00	0.09	0	00.36	584	318	329	138	25	0	36.5	413
21	01	7/19/06 16:35	Stable	0.02	0.11	0	00.36	934	287	499	154	7	0	36.5	480
22	01	7/19/06 16:53	Stable	0.00	0.11	0	00.36	576	289	383	137	25	0	36.5	487
23	01	7/19/06 17:10	Stable	0.00	0.11	0	00.36	744	185	589	104	0	0	36.5	445
24	01	7/19/06 17:28	Stable	0.00	0.11	0	00.36	216	207	177	69	1	0	36.5	422
25	01	7/19/06 17:45	Dynamic	0.00	0.11	0	00.36	165	94	108	43	0	0	36.5	396
26	01	7/19/06 18:03	Stable	0.00	0.11	0	00.36	629	372	431	198	64	0	36.5	440
27	01	7/19/06 18:20	Stable	0.00	0.11	0	00.36	1455	608	954	336	43	0	36.6	465
28	01	7/19/06 18:38	Dynamic	0.00	0.11	0	00.36	1476	825	1022	475	99	0	36.6	484
29	01	7/19/06 18:55	Dynamic	0.00	0.11	60	00.42	1764	1058	1299	704	114	15	36.7	545
30	01	7/19/06 19:13	Stable	0.02	0.13	120	00.54	1730	969	1234	615	170	0	36.7	552
31	01	7/19/06 19:30	Stable	0.00	0.13	80	00.62	1896	1237	1282	687	221	45	36.7	560
32	01	7/19/06 19:48	Stable	0.00	0.13	40	0.68	1933	1146	1278	619	149	87	36.8	565
33	01	7/19/06 20:05	Dynamic	0.00	0.13	40	0.72	2060	1254	1337	719	102	10	36.8	538

• Secondary Activity Measurements •

In addition to the above data, Oxymax/CLAMS creates a secondary activity file that bins data at a shorter (user defined) interval. This secondary file provides very high temporal resolution of animal activity measurements. Typical bin times for the secondary activity file is in the range of 10-30 seconds.

• Secondary Feeding Measurements •

Oxymax/CLAMS creates a secondary feeding activity file that is event driven. Unlike an interval file, an event driven file creates a data entry for each animal visit to the food hopper. An entry in this file identifies the moment of occurrence and the mass of food consumed. In this way, every feeding bout is scored by Oxymax/ CLAMS. Additionally, the operator may group bouts into meals by adjusting a temporal window initiated at bout conclusion. A new bout occurring within this period is grouped with the preceding bout.

• Additional Measurements by Oxymax/CLAMS •

Not shown in the above data set but available in Oxymax/CLAMS:

Mass of Urine [per Interval and Accumulative]
Animal Chamber Temperature [˚C]
Room/Enclosure Temperature [˚C]
Room/Enclosure Humidity [%RH and Dew Point]
Room/Enclosure Illumination [Light/Dark]
Gas Sample Humidity [%RH and Dew Point]

• Numerical data formatting •

Internally, Oxymax/CLAMS performs arithmetic operations in accordance with the precision of the sensors. Presentation of data is structured by the client. In the above dataset O_2 data and Heat have been presented with limited resolution whereas other parameters have been formatted for higher resolution presentation.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS equipped with Food Consumption Monitoring

• Food Delivery Concepts and Methods •

Oxymax/CLAMS allows for three methods of food delivery mechanisms. Each one designed to accommodate special needs:

Overhead Feeder - Most vavriums house animals in a cage that affords ad libitum access to food contained in an overhead wire mesh suspension. Oxymax/CLAMS can accommodate this most common of food delivery methods with our Overhead Feeder implementation. This method lacks any secondary mechanics for a precise accounting for spilled food and allows foraging. However, it does afford the animal a familiar environment for food delivery and monitoring.

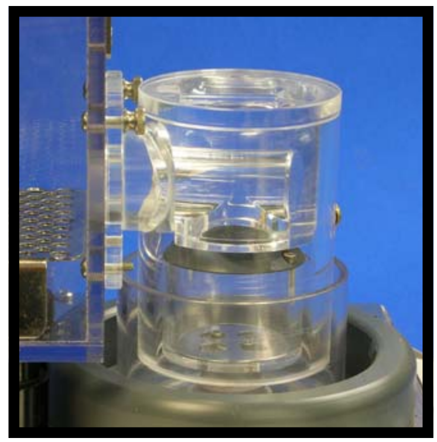
End-Side Feeder - Researchers accustomed to standard metabolic chambers marketed for a number of decades will recognize this concept as an adaptation of this classic design. The feeder is affixed to the side of the chamber by way of a short corridor. Placement of the animal's head within the fixture allows access to food that resides in a hopper. As implemented by Oxymax/CLAMS, two concentric hoppers provide a means of scavenging spilled food. The entire hopper assembly resides on the measuring mechanism and, by way of retaining the spilled mass, accounts for food dropped by the animal during eating. Sizing the corridor to the animal under test minimizes foraging by assuring that only the animal's head has access to the food hopper.

Center Feeder - Similar in design to the above End Feeder, the Center Feeder system also provides two concentric hoppers resting on a common measuring mechanism. The larger, outer hopper, performs scavenging of spilled food while the inner hopper contains the food. Unlike the End Feeder, the Center Feeder concept delivers the food to the animal on a spring-loaded plate. As food is consumed, the plate raises the remaining diet to a level that continues to be easily assessed by the animal. Researchers knowledgeable in the "coach potato" characteristics of Ob-type animals will appreciate a concept that maintains near-effortless access to food.

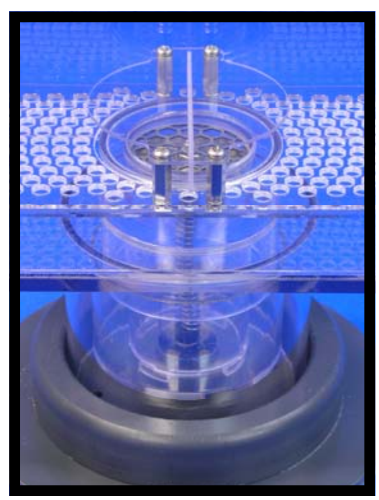
• Mass Measurement •

Regardless of the delivery mechanism, Oxymax/CLAMS monitors the removal of food from any of the above feeders with a mass resolution of 0.01g. Oxymax/CLAMS employs special electronic balances manufactured by Mettler-Toledo. A world leader in electronic balance technology. These balances have been altered by Columbus Instruments to operate in a networked environment without detracting from the class leading accuracy, reliability, stability and drift free performance of the Mettler-Toledo product.

Oxymax/CLAMS Overhead Feeder Detail



Oxymax/CLAMS End-Side Feeder Detail

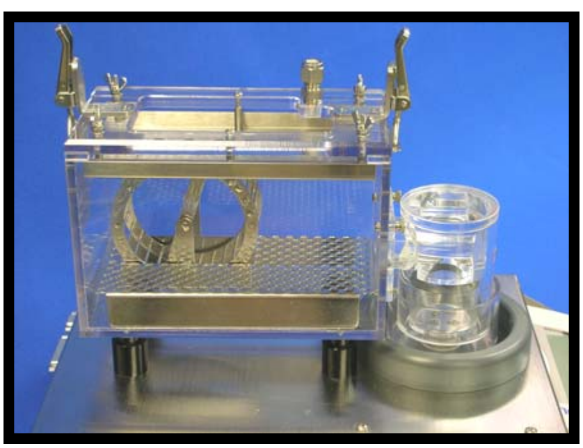


Oxymax/CLAMS Center Feeder Detail

Features of Oxymax/CLAMS equipped with Food Consumption Monitoring

Center Feeder Chamber Overview

Chamber Equipped with two Center Feeders



Oxymax/CLAMS End-Side Feeder Overview

• Feeding Bout Detection and Scoring •

Oxymax/CLAMS continuously monitors for disturbance of the feeder by animal contact. At the moment of disturbance detection, Oxymax/CLAMS makes an initial, but unconfirmed, entry into a log file to identify the start of a potential feeding bout. The most recent valid mass reading from the balance is then recorded. Some time later, the balance will return to a stable state indicating that the animal has backed away from the feeder. The moment of restoration of balance stability is entered into the log file along with current mass reading. Oxymax/CLAMS then compares the difference in the two mass readings to detect food removal. An indicated loss of mass exceeding a user set threshold, typically -0.01g or -0.02g, validates the bout and the entry remains in the log file. A mass difference not meeting the threshold requirement causes the removal the entry from the log file and no bout is scored.

• Multiple Feeders •

Oxymax/CLAMS supports monitoring multiple feeders in a common environment. Such capability might be employed for food preference evaluation or for "switching" the animal between diets of varied composition over the course of testing to investigate influence on behavior and/or energy utilization.

• Diet Composition •

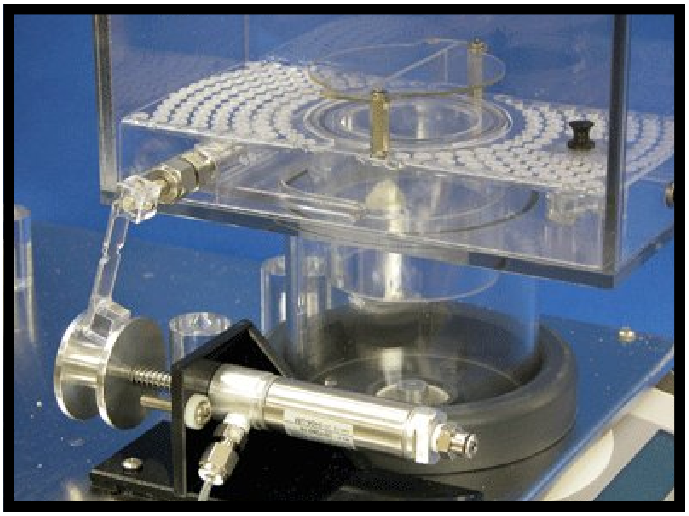
All Oxymax/CLAMS feeders can accommodate the wide range of diets employed in today's research. High fat diets are made available to the animal with the same ease as granular or powdered food stock. Many liquid diets can be made available to the animal and monitored by use of our Volumetric Drinking Monitor.

Teflon Center Feeder for High Fat Diets

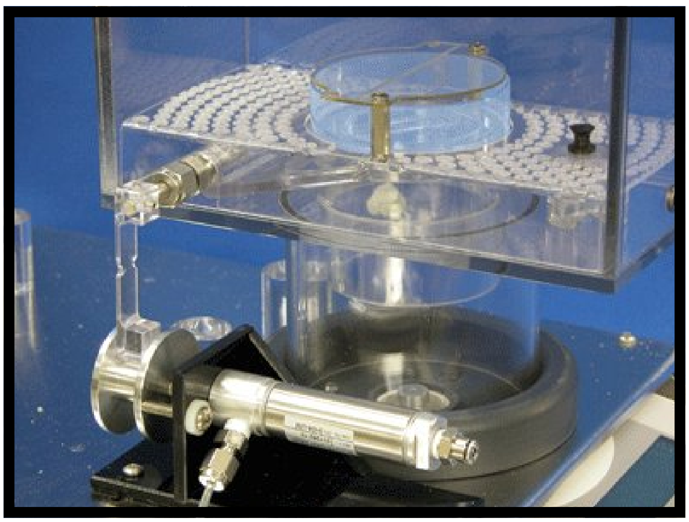
Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

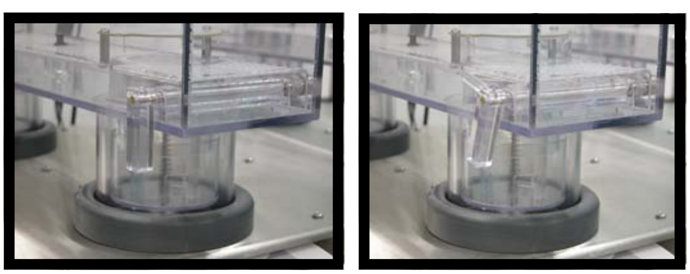
Features of Oxymax/CLAMS equipped with Food Access Control



Automated Center Feeder Access Control for Mouse Chamber (open)

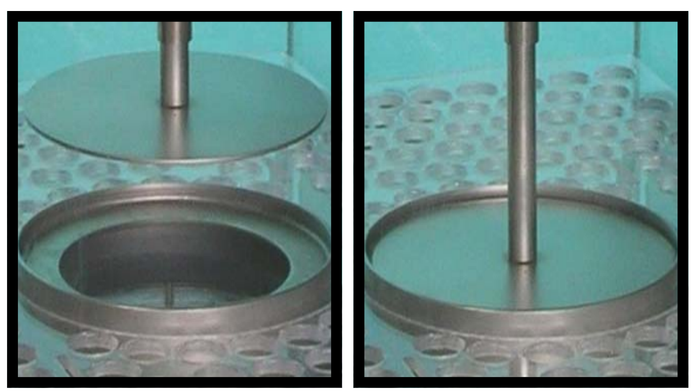


Automated Center Feeder Access Control for Mouse Chamber (closed)



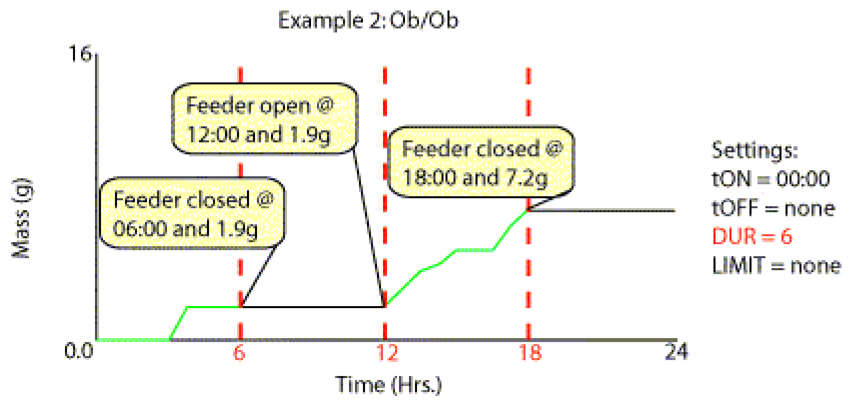
Manual Food Hopper Access Control (Left: open Right: closed)

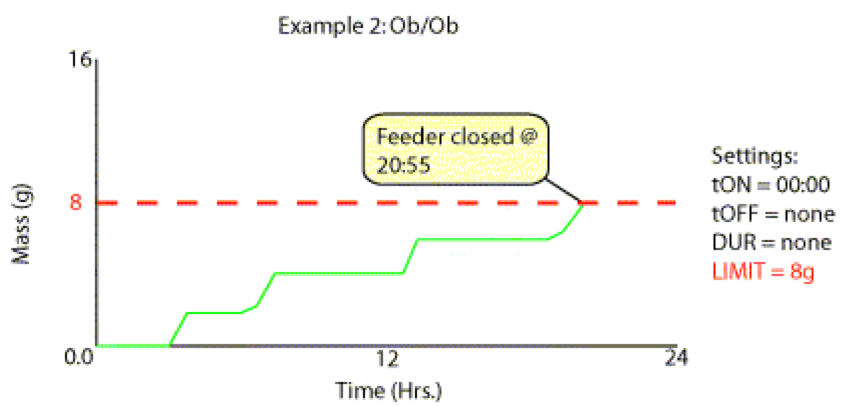
Custom Automated Food Hopper Access Control for Center Feeder Rat Chamber

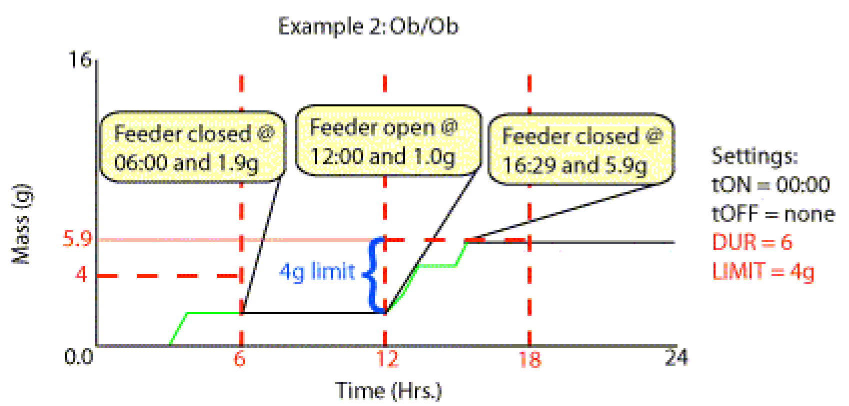


Automated Food Hopper Access Control (Left: open Right: closed)

Features of Oxymax/CLAMS equipped with Food Access Control







• Food Hopper Access Control •

Oxymax/CLAMS can be equipped with the ability to deny food hopper access by way of a movable barrier. The barrier mechanism may be operated either *manually* or *automatically* by way of a computer controlled pneumatic actuator. When computer controlled, the barrier may actuated by a pre-set time schedule or by way of a consumption threshold based on mass in accordance with a caloric restriction protocol.

• Access Control by Time •

Shown at top left is a plot depicting the most basic form of Oxymax/CLAMS Food Hopper Access Control. In this example, access to the food hopper is granted/denied in a 12 hour period. Access is granted for the first 6 hours and denied in the second 6 hours. The period repeats for the duration of the experiment. The example shows an animal that consumed a total 1.9g of food during period one and a an accumulated total of 7.2g at the conclusion of the second period.

• Access Control by Mass •

Shown at left is a plot depicting Oxymax/CLAMS ability to restrict Food Hopper Access Control based on a running tabulation of food consumed. In this example, access to the food hopper is granted at the start of the experiment. In the course of, approximately, 20 hours the animal had four feeding episodes. During feeding episode four, access was denied following the crossing of an 8 gram mass limit imposed by the operator. Access was denied for the remainder of the experiment. Oxymax/CLAMS supports the ability to resume food hopper access following a user imposed latency.

• Access Control by Time & Mass •

The combination of food hopper access by a combination of the above basic control schemes leads to complex protocols for implementation in a controlled feeding regiment. In the case of the scenario at bottom left, the operator has imposed a 12 hour period (6 hours granted & 6 hours denied) as well as placing a 4 gram consumption limit on the animal. During the 12-18 hour access period the animal exceeded the 4 gram consumption limit well in advance of the onset of access denial. The result is a total of 5.9 grams of food consumed in 24 hours.

• Yoked/Paired Feeding Paradigms •

Oxymax/CLAMS supports operator configurations of the Food Hopper Access Control mechanism that allow complex yoked/paired feeding paradigms. The feeding activity pattern of one animal may be imposed on others for the purpose of caloric intake matching by employing the unique capabilities of Food Hopper Access Control.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS equipped with Activity Monitoring

• Multiple Axis Measurement •

Oxymax/CLAMS may be configured with single, dual or triple axis detection of animal motion using IR photocell technology. Interruption of a IR beam will accrue one “count”. Coverage in a single plane may be implemented with IR photocells located in the X or XY direction. The height of these beams is such that they intersect the animal midway vertically. Placement of IR photocells at a height above the animal detect rearing or jumping (Z-axis). Systems may be configured for X, XY, XZ or XYZ coverage.

• Activity Scoring •

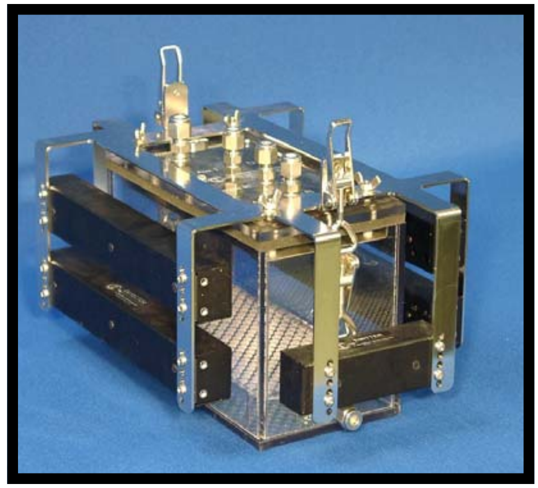
Oxymax/CLAMS employs Columbus Instruments Opto-M3 Activity Monitor and patented (Pat: #4,337,726) process for the tabulation of activity counts associated with ambulation. The method scores counts as ambulation when the animal traverses the cage, breaking a series of IR beams in sequence. Repeated interruptions of the same IR beam do not incur ambulatory counts. All beam interruptions are scored as Total Activity. Subtraction of Ambulatory counts from the Total count provides counts associated with Stereotypy (grooming, scratching, etc …).

Activity data is tabulated at two intervals by Oxymax/CLAMS. The first interval is concurrent with the period over which calorimetric measurements are performed. This interval can be lengthy as it is dependant on the number of chambers in an Oxymax/CLAMS configuration. A secondary, shorter, interval provides very high temporally resolved animal activity. Typical bin times for this process are in the range of 10-30 seconds. High resolution actigrams can be generated from this secondary activity dataset.

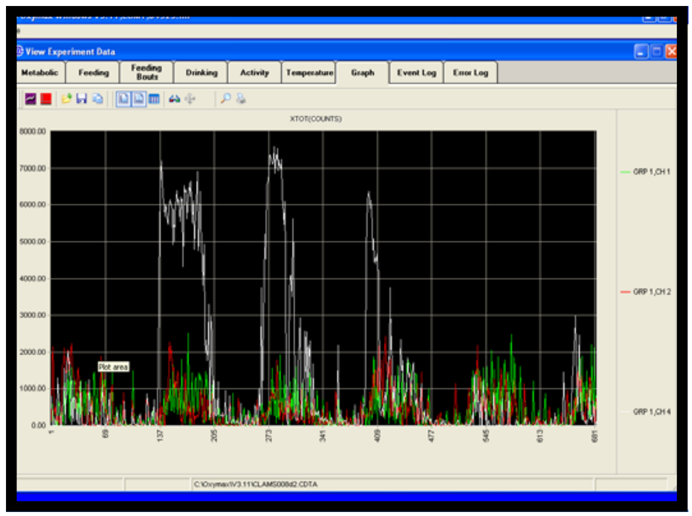
Oxymax/CLAMS tabulates Total and Ambulatory count data for each axis as well as independent scoring of the secondary high temporal resolution dataset.

• Activity Sensor Sizes •

Oxymax/CLAMS configured for mice employ IR photocell sensors that provide 1/2” (1.27cm) beam spacing. 16 IR beams intersect the chamber in the X and Z-axis. The Y-axis is monitored by 8 IR beams. Systems configured for rats employ IR photocell sensors that provide 1” (2.54cm) beam spacing. 12 IR beams intersect the chamber in the X and Z-axis. The Y-axis is monitored by 8 IR beams. Oxymax/CLAMS configurations for dual-species use may be implemented with both 1/2” and 1” IR photocell arrays or by all 1” photocell arrays that can be shared across the two applications. The latter configuration provides an economical solution for clients that work with both rats and mice.



Mouse Chamber with XY&Z Axis Photocells



Oxymax/CLAMS Activity Screen

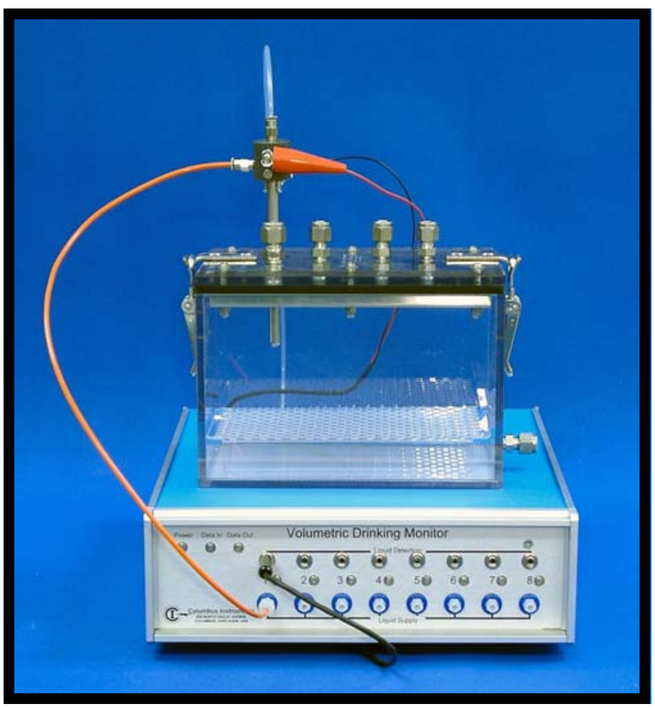
Mouse Chamber with X&Z Axis Photocells

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS equipped with Volumetric Drinking Monitoring

Oxymax/CLAMS Sipper Tube in place



Oxymax/CLAMS Volumetric Drinking Monitor

• Drinking Monitoring Methods •

Liquid consumption monitoring can play a key roll in the full evaluation of animal metabolic performance. Oxymax/CLAMS supports two mechanisms for monitoring liquid consumption: Lick and Volume.

• Lick Monitoring •

Lick detection is implemented on the standard conductivity principle where a small, imperceptible current passes through the animal from the sipper tube to a conductive floor. Each contact with the sipper tube accrues one count. Oxymax/CLAMS tabulates this figure for each measurement interval.

• Volume Monitoring •

Volume monitoring is implemented with Columbus Instruments patented (Pat: #6,463,879) Volumetric Drinking Monitor [VDM] system. In this design, what appears outwardly to be a standard sipper tube is presented to the animal. Internal to the tube is a second, electrically isolated, water delivery tube. Bridging the inner and outer tube is a droplet of water proximal to the open tip of the sipper. A small AC current passes through the droplet indicating that water is available to the animal. Licking the droplet wicks it away from the internal conductive pathway. This “open circuit” causes the drinking controller to replace the droplet by actuation of a precision micro-pump. Each actuation of the pump delivers 20 μL of liquid to re-construct the bridging droplet. Counting and scoring the number of pump actuations provides a measure of water consumption with a resolution of 20 μL.

Multiple VDM sipper tubes may be presented to an animal for preference testing and/or agent delivery. Oxymax/CLAMS software allows you to assign sipper tubes to chambers and identify the media delivered by the tube. The use of standard sipper tube design eliminates any need to train animals to a unique drinking environment. VDM can tolerate certain viscous materials. This may allow VDM to be employed for the delivery and monitoring of a liquid diet. Consult Columbus Instruments about the unique use of VDM for this application.

• Lick and Volume Monitoring •

Combining lick detection with volume monitoring is possible in some situations. Please contact Columbus Instruments if you have a need to combine these two methods of water intake monitoring.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS with Waste Collection, Freezing and Monitoring

• Urine Collection •

Waste collection is facilitated by custom chambers that incorporate a series of sub floors. The animal walks on a perforated floor that allows for the passage of urine and feces. A second, sub floor, is fabricated as a carefully woven non-wetting surface that allows for the passage of waste that is separated and collected. Oxymax/CLAMS allows for the removal of the holder while the experiment is in progress. This allows for analysis of the collected urine without disturbing the animal or the experiment.

• Waste Mass Monitoring •

In addition to collection, Oxymax/CLAMS can be equipped with the ability to monitor the mass of waste collected. In this configuration, the glass waste holders are placed on a mass sensors. Oxymax/CLAMS reads the masses and reports changes related to increased waste collected.

• Waste Chilling/Freezing •

Oxymax/CLAMS provides waste freezing as an alternative to monitoring. In this configuration, the glass urine holder is held at a low temperature, typically +5 to -5˚C. The design of the holder allows the removal of the waste while the experiment is in progress. This allows for analysis of the collected waste without disturbing the animal or the experiment.

Waste Monitoring

8-Station Oxymax/CLAMS with Waste Monitoring

Waste Freezing Station

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS with Telemetry

• Telemetry •

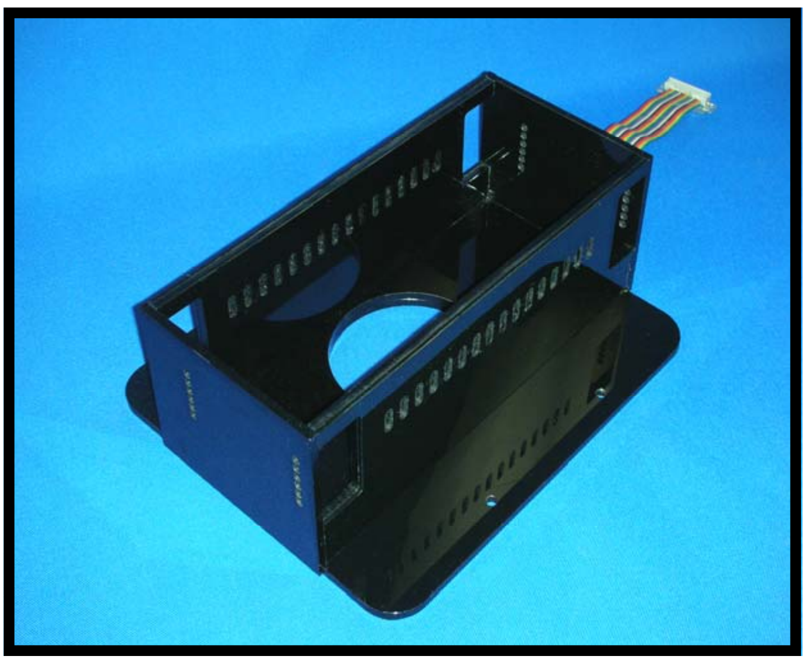
Oxymax/CLAMS supports the monitoring of body core temperature and heart rate by way of an implanted transmitter. Suitable for both rats and mice, the transmitters measure:

Temperature: 15.5 x 6.5 mm , 1.1 grams
Temperature and Heart Rate: 26 x 6.5mm , 1.5 grams

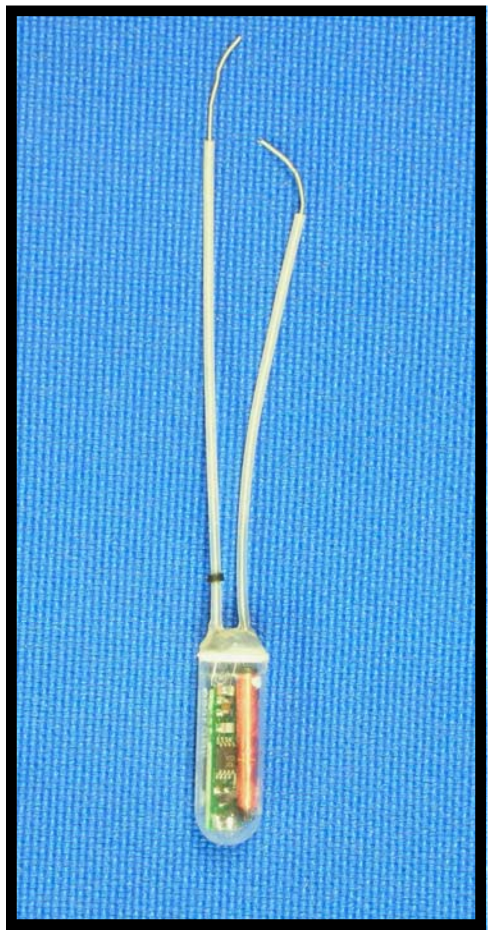
The transmitters require no internal power source. An external field is generated by an antenna system that, momentarily, charges the transmitter. The transmitter remains powered for a brief period. While powered, the transmitter conveys its data back to the antenna. Following transmission, the transmitter goes dormant while it awaits another charge/transmit cycle. This process occurs once every four seconds in Oxymax/CLAMS.

Externally energizing the transmitter removes the need for a battery and its associated size/mass as well as the requirement for periodic battery replacement. Additionally, the consistent energizing cycles assure repeatable performance that will not degrade as might otherwise be experienced with a battery operated transmitter that loses power over time. This also eliminates the need for re-calibration due to fluctuation in delivered power to the measurement circuitry.

Temperature Transmitter



Oxymax/CLAMS Telemetry Antenna
(all other components removed for clarity)



Temperature and Heart Rate Transmitter

Features of Oxymax/CLAMS with Running Wheel Capability

• Running Wheels for Mice •

Oxymax/CLAMS can be equipped with running wheels with rotation monitoring. Running wheels for mice are sized such that they fit within the standard mouse chamber. Shown at right are typical wheels for mice. These measure 94mm insides diameter x 33mm wide. A magnet located along the perimeter of the wheel provides a field that is sensed by a detector that, in turn, conveys rotation information to Oxymax/ CLAMS. Placement of a running wheel within the chamber does not interfere with food or water access.

• Running Wheels for Rats •

Rat running wheels are available in 30cm and 35cm diameters. Their widths are 10cm and 15cm respectively. These are too large for placement within the animal chamber. These wheels are appended to the end of the rat chamber. A hole between the two compartments allows animal passage. As with the mouse wheel, a magnet located on the wheel provides a field that is sensed by a detector that, in turn, conveys rotation information to Oxymax/CLAMS. Running wheel placement does not interfere with food or water access.

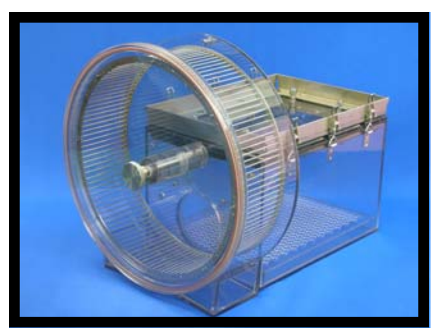
8-Station Rat Oxymax/CLAMS with 30cm Running Wheels

Rat 30cm Running Wheel with Rotation Detection Interface

←

Rat 35cm Running Wheel

→



Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529

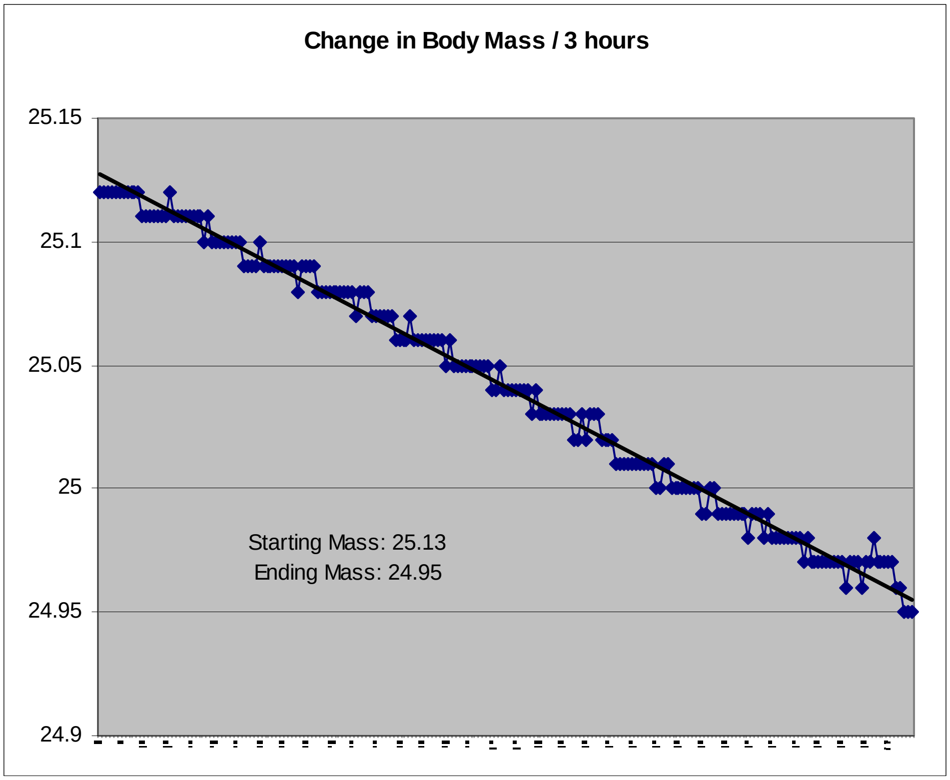
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS with Body Mass Monitoring

• Body Mass Monitoring •

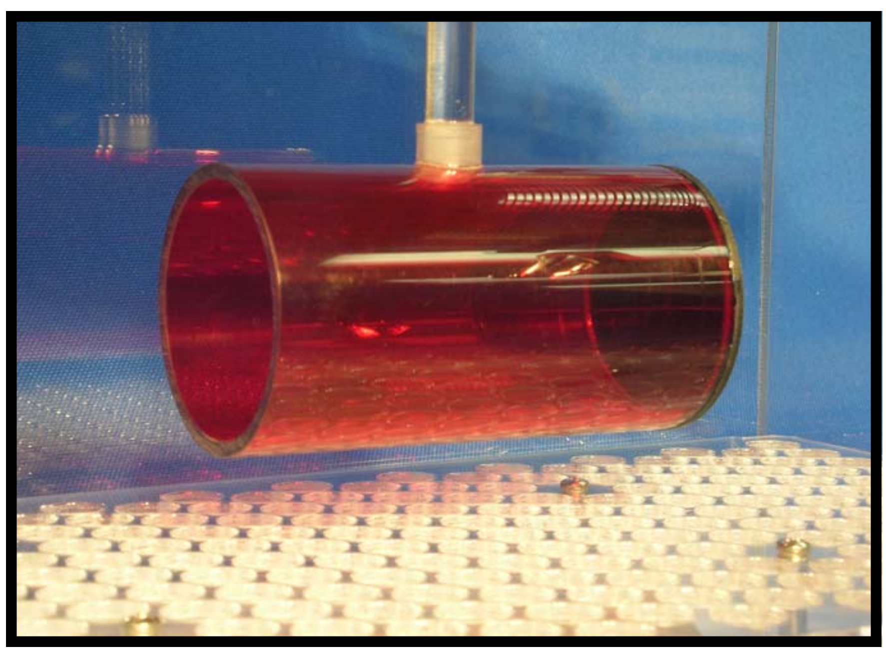
Oxymax/CLAMS can be equipped with the ability to periodically monitor body mass. This option is implemented using the same high quality Mettler-Toledo electronic balances employed for food mass monitoring. In this configuration, the animal is provided with an appealing cubby-hole fabricated from a translucent tube. The diminished lighting within the tube offers an environment conducive to nesting. The cubby-hole is supported by a mechanism affixed to an electronic balance. Oxymax/CLAMS monitors the animals entry into the cubby-hole and, once settled, the animal's mass is recorded.

Due to the "animal-driven" nature of the measurement method, body mass measurements can not be performed on a fixed schedule.



This feature also provides an enriched animal testing environment ....

Cubby-Hole Style 1



Cubby-Hole Style 2

Columbus Instruments

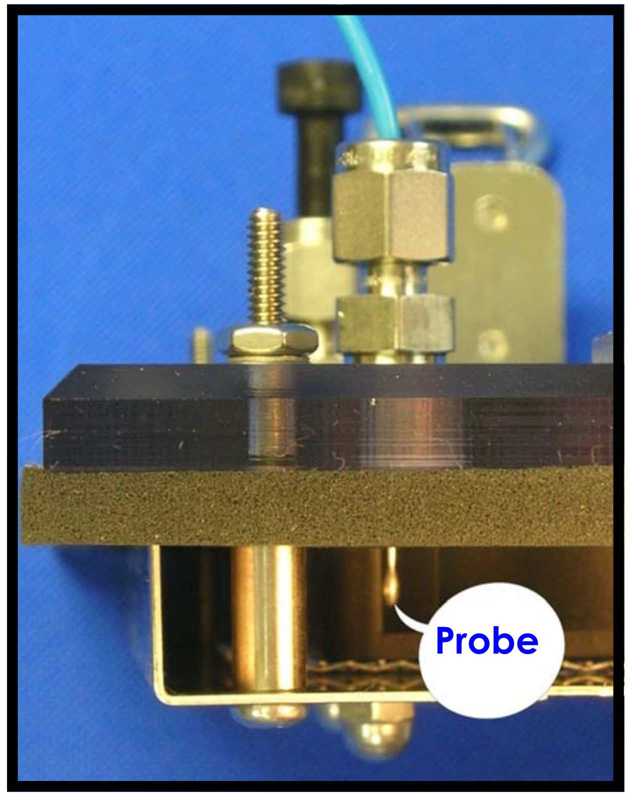
Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS with Animal Chamber Temperature Monitoring

• Animal Chamber Temperature •

Oxymax/CLAMS can be equipped with a multi-channel thermometer interface for monitoring animal chamber temperature with an accuracy of ±0.1 ˚C. "Iso-Thermex" supports T-type thermocouple probes that are mounted in the lid of the animal chamber. Temperature measurements are recorded along with all other parameters and become part of the dataset.

16 Channel T-Type Thermocouple Interface



Temperature Probe in place

Features of Oxymax/CLAMS with Calorimeter Validation Sub-System

"OxyVal" Indirect Calorimeter Validation Unit

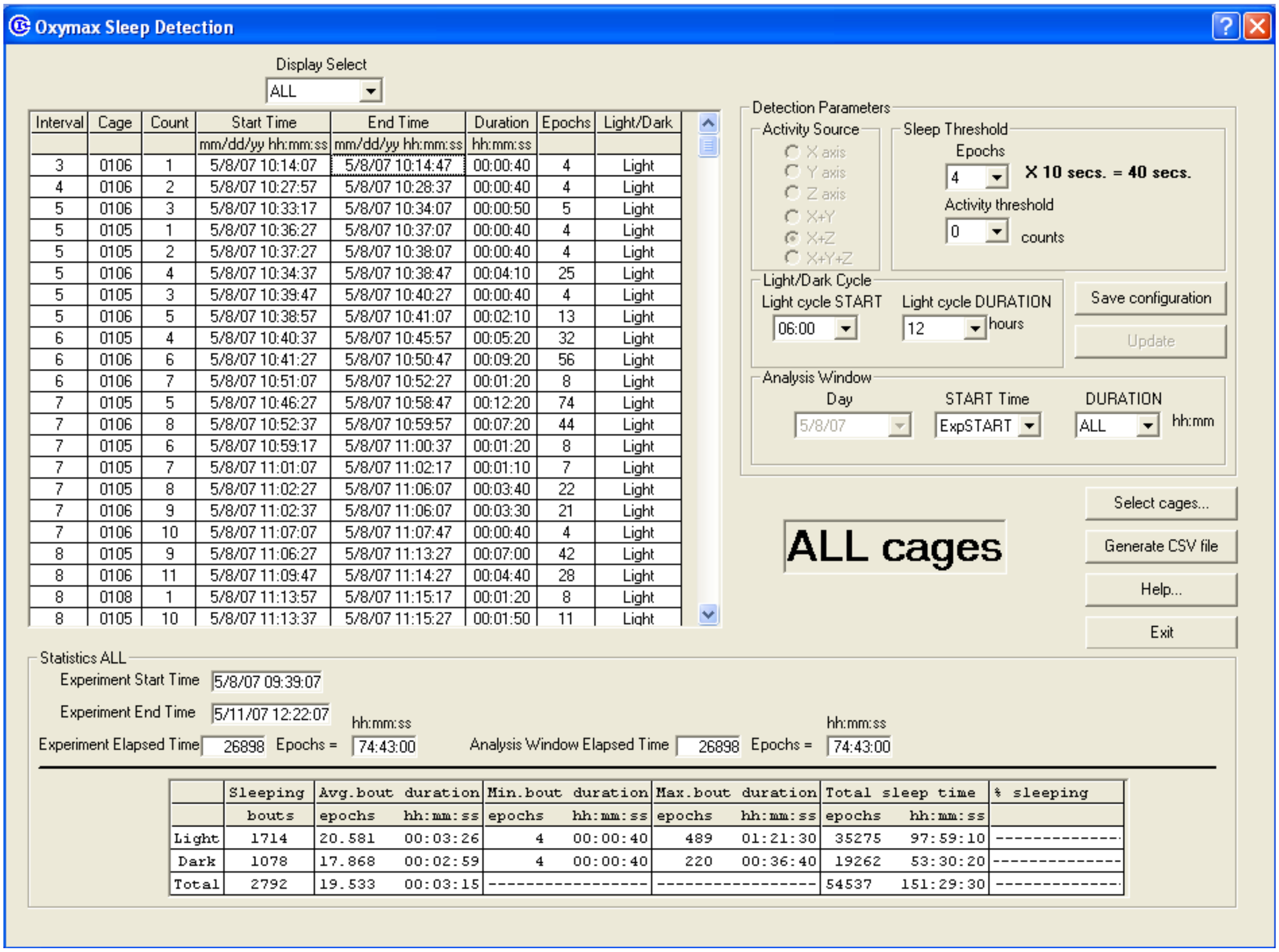
• Indirect Calorimeter Validation •

Can you reliably compare data from last year with data taken last week? How about data from chamber 2 with data taken from chamber 23? Has some systemic error crept in by way of a change in calibration gas that may put your present data into question? OxyVal provides a tool for checking and validating an indirect calorimeter by delivery of a ***very*** precise and equal amount of diluent gas to each block of 8 chambers. The resulting VO_2, VCO_2 and RER data may be compared across chambers and or across time to validate consistent indirect calorimeter performance. This "whole-system" approach assists with GLP compliance by providing a highly stable frame of reference for any multi-channel open circuit indirect calorimeter. OxyVal provides both piece of mind and documented evidence that your Oxymax/CLAMS is providing reliable and repeatable calorimetric data.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Features of Oxymax/CLAMS with Sleep Detection/Analysis



• Sleep Detection •

Sleep Detection is a native function in Oxymax/CLAMS. In application, the operator specifies a set of criteria based on activity and time that establishes a threshold below which causes the triggering of the onset of a sleep event. Activity is sensed by the traditional IR beam method. Beam interruptions are scored as "counts". A high count infers an active subject whereas a low count infers a sedentary animal. A count of zero infers that the animal is motionless within the spatial resolution of the IR beam monitor. Oxymax/CLAMS Sleep Detection function works in time slices called "epochs". The operator configures the sleep detection algorithm by describing the number of consecutive epochs during which the activity counts are equal to or less than a user defined threshold. Oxymax/CLAMS then flags the episode and tallies the sleep events over a user specified Analysis Window. Continued activity below the threshold infers a continuous sleeping bout.

• Sleep Analysis •

Sleep Analysis may be performed on single or user grouped animal data. Data tabulated within the user specified Analysis Window is sub-divided into any occurring light and dark sessions. The resulting data from the analysis includes:

- Number of Sleep Bouts
- Average Sleep Bout Length in Epochs & Time formats
- Minimum Sleep Bout Length in Epochs & Time formats
- Maximum Sleep Bout Length in Epochs & Time formats
- Total Sleep Time in Epochs & Time formats
- Percent Time Sleeping within the Analysis Window

Once tabulated, the resulting analysis report may be exported from Oxymax/CLAMS into a CSV (comma separated value) file for additional manipulation by other programs or for presentation.

Oxymax/CLAMS data analysis: CLAX

• CLAMS data eXamination Tool •

Oxymax/CLAMS can generate copious amounts of data. The CLAMS data eXamination Tool (CLAX) assists in the analysis of this data by presenting it in a meaningful fashion. CLAX allows for organizing animals within an experiment into treatment groups and provides tools for data trimming to remove information collected during animal acclimation. Data samples can also be sub-grouped into data collected during light or dark periods. The resulting trimmed and re-organized data may then be subjected to further analysis by CLAX.

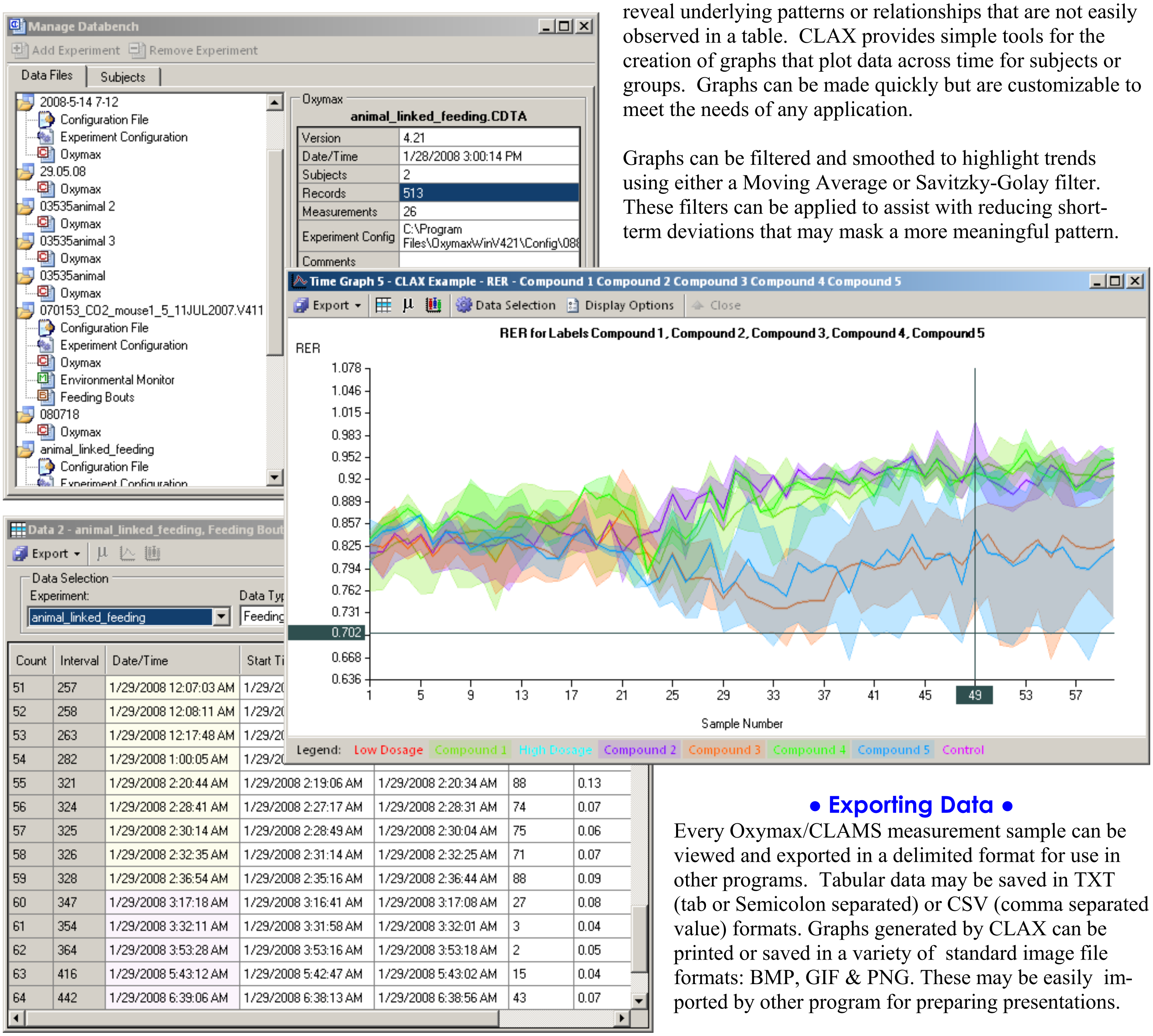
• Data Analysis •

CLAX allows for the simultaneous analysis of files from several experiments. It's simple to compare experiment results from several dozens of subjects. CLAX can open and analyze files from the Oxymax/CLAMS acquisition software version 3.03 or greater, meaning most existing Oxymax/CLAMS users can also use CLAX.

• Graphical Analysis •

Visual representation of data in a graphical format can often reveal underlying patterns or relationships that are not easily observed in a table. CLAX provides simple tools for the creation of graphs that plot data across time for subjects or groups. Graphs can be made quickly but are customizable to meet the needs of any application.

Graphs can be filtered and smoothed to highlight trends using either a Moving Average or Savitzky-Golay filter. These filters can be applied to assist with reducing short-term deviations that may mask a more meaningful pattern.



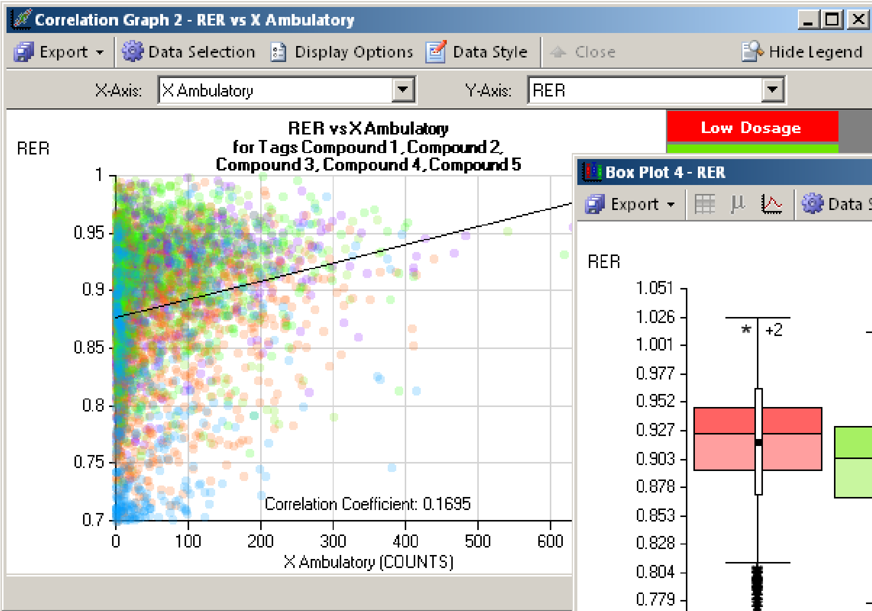
• Exporting Data •

Every Oxymax/CLAMS measurement sample can be viewed and exported in a delimited format for use in other programs. Tabular data may be saved in TXT (tab or Semicolon separated) or CSV (comma separated value) formats. Graphs generated by CLAX can be printed or saved in a variety of standard image file formats: BMP, GIF & PNG. These may be easily imported by other program for preparing presentations.

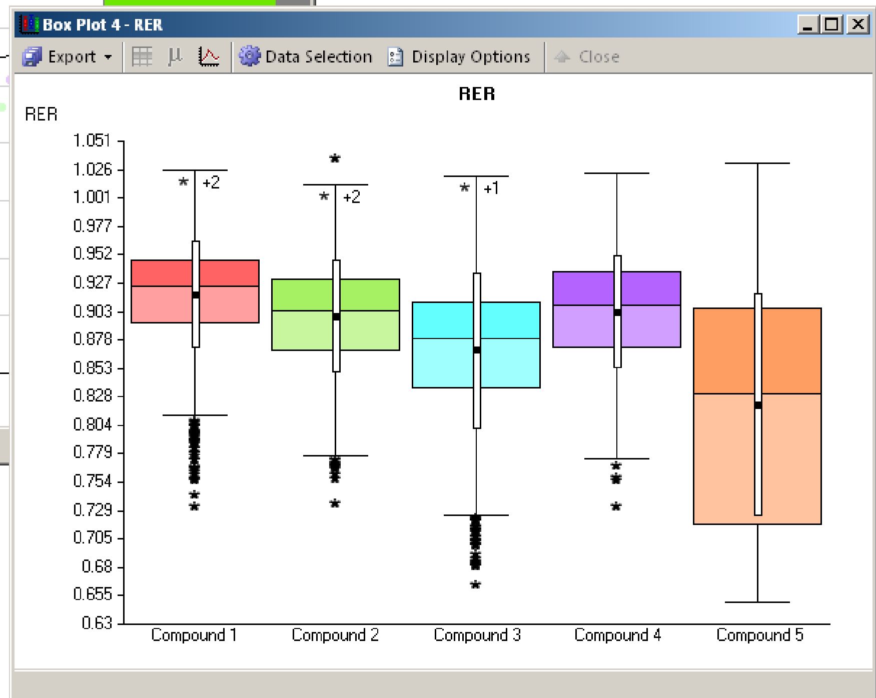
Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Oxymax/CLAMS data analysis: CLAX



Are you an Oxymax/CLAMS user?
Contact Columbus Instruments to add CLAX to your existing Oxymax/CLAMS.

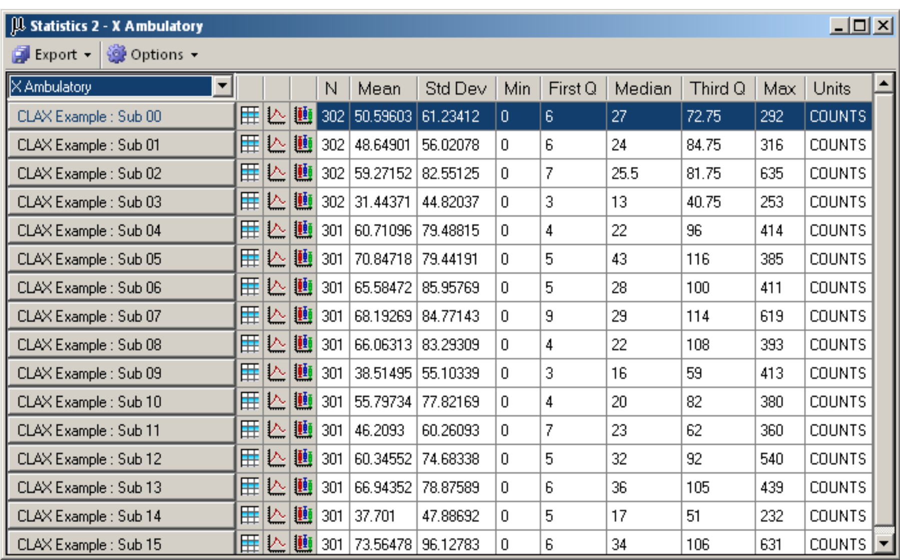


• Correlation •

CLAX can also plot measurements against each other for a subject or user-defined group. This method of analysis can reveal relationships that would otherwise go unnoticed when looking at one measured parameter. CLAX also quantifies linearity and correlation between measurements by providing best straight line fit as well as R^2 and Pearson coefficient. A number of plot variations help to visually represent the data in a manner that highlights strong relationships.

• Comparative Analysis •

Box and Whisker plots are available within CLAX. These provide graphical representation of the statistical distribution of data for subjects or user-defined groups.



X Ambulatory	N	Mean	Std Dev	Min	First Q	Median	Third Q	Max	Units
CLAX Example : Sub 00	302	50.59603	61.23412	0	6	27	72.75	292	COUNTS
CLAX Example : Sub 01	302	48.64901	56.02078	0	6	24	84.75	316	COUNTS
CLAX Example : Sub 02	302	59.27152	82.55125	0	7	25.5	81.75	635	COUNTS
CLAX Example : Sub 03	302	31.44371	44.82037	0	3	13	40.75	253	COUNTS
CLAX Example : Sub 04	301	60.71096	79.48815	0	4	22	96	414	COUNTS
CLAX Example : Sub 05	301	70.84718	79.44191	0	5	43	116	385	COUNTS
CLAX Example : Sub 06	301	65.58472	85.95769	0	5	28	100	411	COUNTS
CLAX Example : Sub 07	301	68.19269	84.77143	0	9	29	114	619	COUNTS
CLAX Example : Sub 08	301	66.06313	83.29309	0	4	22	108	393	COUNTS
CLAX Example : Sub 09	301	38.51495	55.10339	0	3	16	59	413	COUNTS
CLAX Example : Sub 10	301	55.79734	77.82169	0	4	20	82	380	COUNTS
CLAX Example : Sub 11	301	46.2093	60.26093	0	7	23	62	360	COUNTS
CLAX Example : Sub 12	301	60.34552	74.68338	0	5	32	92	540	COUNTS
CLAX Example : Sub 13	301	66.94352	78.87589	0	6	36	105	439	COUNTS
CLAX Example : Sub 14	301	37.701	47.88692	0	5	17	51	232	COUNTS
CLAX Example : Sub 15	301	73.56478	96.12783	0	6	34	106	631	COUNTS

• Descriptive Statistics •

One the more basic features of CLAX is its ability to provide basic descriptive statistics on data that has been grouped by subject, measurement, group or light/dark sessions. These basic statistics include:

- Arithmetic Mean
- Standard Deviation
- "Five-Number Summary"
  - Median
  - Minimum and Maximum
  - First and Third Quartiles

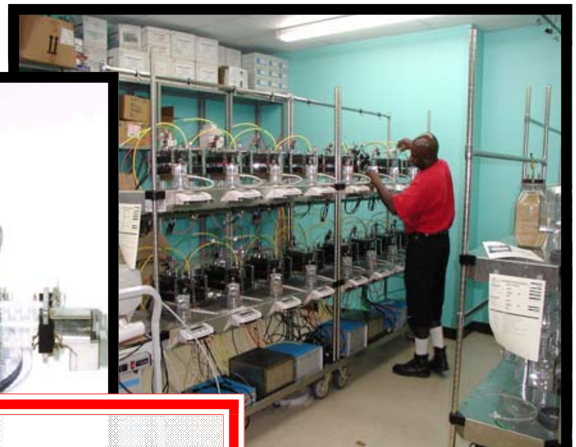
The resulting statistics are presented in a tabular format for additional processing or publication using CLAX's export capability.

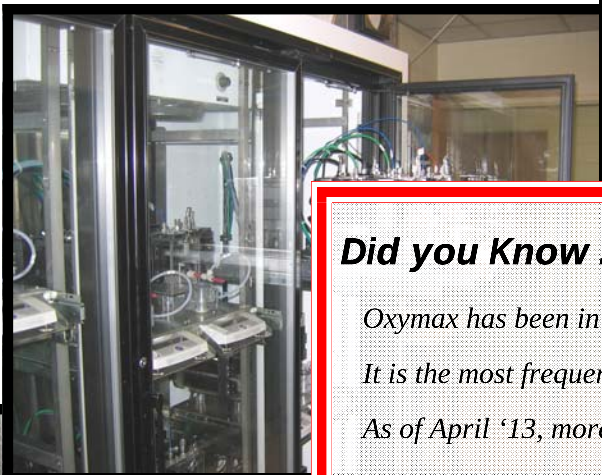
Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

Customization: May we build an Oxymax/CLAMS for you?

No single Oxymax/CLAMS configuration can meet everyone's research requirements. Customization is the key to fitting Oxymax/CLAMS to your application. Configurations of 1 to 32 chambers are possible. Upgrades to more features and expansion to more chambers can be implemented at anytime.



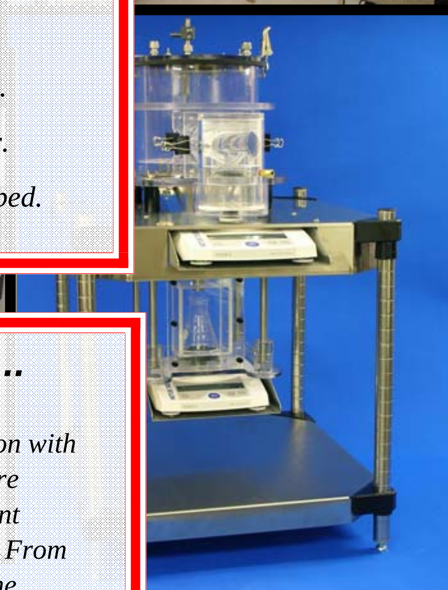


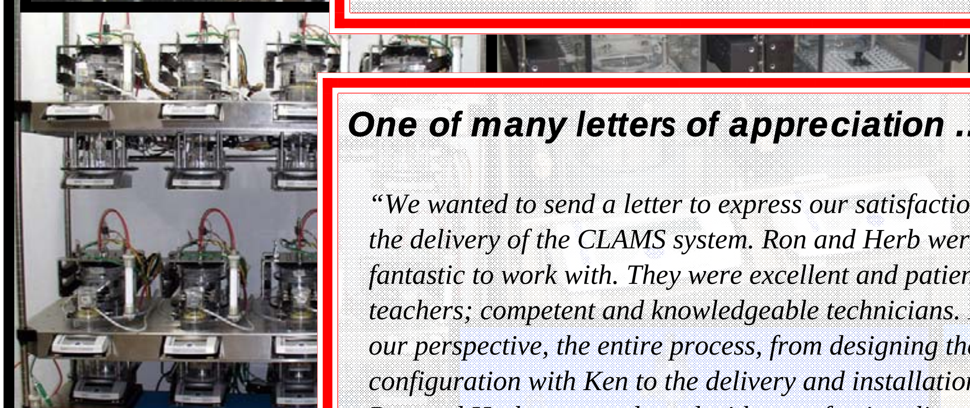
Did you Know ...

Oxymax has been in production for over ***25*** *years.*

It is the most frequently cited indirect calorimeter.

As of April '13, more than 525 systems have shipped.





One of many letters of appreciation ...

"We wanted to send a letter to express our satisfaction with the delivery of the CLAMS system. Ron and Herb were fantastic to work with. They were excellent and patient teachers; competent and knowledgeable technicians. From our perspective, the entire process, from designing the configuration with Ken to the delivery and installation with Ron and Herb was conducted with a professionalism that was much appreciated. I'm certain we'll continue to be in touch as we work with the system, but I wanted to share our initial enthusiasm."

Sincerely,
T. R.

Columbus Instruments

Toll Free [US]: (800) 669-5011 Tel: (614) 276-0861 Fax: (614) 276-0529
Email: Ken_Kober@colinst.com WebSite: www.colinst.com

131010