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Energy Efficiency of a Large Animal Vivarium: A University of Houston Research Study

White Paper Series

Energy Efficiency of a Large Animal Vivarium: A University of Houston Research Study

This white paper is based on the study completed at the University of Houston by: Dr. Nicole A. Monts de Oca, Dr. David W. Brammer, Dr. Mitzi Laughlin, and John Jenkins. Contributing authors also included Dr. Cynthia Lockworth from MD. Anderson Cancer Center in Houston and Dr. Iris Bolton from the University of Texas Medical Branch in Galveston.

Standards & Guidelines: A Performance Based Approach

In the past, standards and guidelines favored a set air change rate per hour (ACH) in vivaria regardless of actual conditions. These air change rates were typically much higher than necessary and therefore may overventilate a macroenvironment containing few animals, thereby wasting energy, or underventilate a microenvironment containing many animals, allowing heat, moisture and pollutants to accumulate. Over the last several years support for tying ventilation rates directly to current conditions has grown and changes have been made to the standards and guidelines to support this approach.

The 2012 edition of the ILAR guide now states, "…variable volume systems may offer design and operational advantages, such as allowing ventilation rates to be set in accordance with heat loads and other variables."

The Association for Assessment and Accreditation of Laboratory Animal Care International (AAALAC) believes in performance based criteria and interprets the 8th edition of the current ILAR guide to allow for an air exchange rate below the previous guideline of 10–15 ACH. The council will assess overall air quality and air exchange rates using performance based criteria that will take into consideration a variety of circumstances. AAALAC states that assessment will be made via the HVAC reports and onsite evaluations.

Variable air volume (VAV) system offer considerable advantages over a constant volume (CV) system, however they should always provide a minimum amount of air exchange recommended for general use laboratories (Bell 2008; DiBerardinis et al. 2009).

Animal Holding Room Design

The study at the University of Houston involved two animal holding rooms (Room A and Room B), which were designed similarly. Fresh air was supplied through radial diffusers located on the ceiling in the center of each space. The exhaust vents were located low in the corners of each room. The rooms were negatively pressurized at all times and the rectangular shape prevented the creation of dead space for the air to become stagnant.

The airflow control valve manufactured by Phoenix Controls adjusted airflow based on information collected by both a temperature sensor and a humidity sensor within the room. Aircuity's centralized demand control ventilation system was installed in both rooms and varied the ACH based on current conditions. The system monitored the following parameters: relative humidity, carbon dioxide, particles ranging in size from 0.3 to 2.5 μm, and total volatile organic compounds (TVOCs). Aircuity continually monitored both rooms, adjusting ventilation rates based on current conditions. When an event occurred, ventilation rates increased until the air was determined to be clean again, at which point airflow returned back to the set minimums.

The two holding rooms contained the maxi-mum number of non-human primates that could be supported by each room. Room A housed 2 juvenile and 15 adult monkeys and Room B housed 13 juvenile monkeys. The volume of Room B was 3,060 ft^3 and Room B was smaller at 2,340 ft^3, however in both rooms the housing density was 180 ft^3 of air/animal.

Experiment Design

Data was collected from each room for a period of 60 days (April 1 – May 30, 2014). Each room operated 30 days on constant flow rate (CFR) ventilation and 30 days on demand control (DCV). The flow rate in each room during the CFR phase was set at 12.75 ACH calculated on supply, and the flow rate during the DCV phase had a minimum rate of 3.97 ACH. The maxi-mum flushing rate for both rooms was 20 ACH. All ACH were calculated on fresh air of the supply air.

Airflow and Demand Control Ventilation Events

Room A was set at 652.61 CFM for the CFR mode. In demand control ventilation mode Room A had a minimum flow rate of 101.71 CFM and averaged 102.38 CFM over the month of May with a peak of 379.28 during a 13 minute event. There were 11 DCV flushing events for May in Room A with an average time of 16.3 minutes. The room was only above baseline 0.4% percent of the time.

Room B was set at 468.27 CFM for the CFR mode. During DCV mode in April, Room B had a minimum flow rate of 103.83 CFM and averaged 111.82 CFM over the month with a peak of 781.87 during a 42 minute event. In the month of April there were 40 DCV events. There were only 2 days without events. The average time of events in Room B was also longer than those of Room A at 38.9 minutes. Room B was above baseline 3.6% of the time.

	Room A	Room B
CFR Mode CFM	652.61	468.27
DCV Min. Flow	101.71	103.83
DCV Average	102.38	111.82
DCV Peak	379.28	781.87

Fig. 1 Holding room ventilation levels.

In both rooms, 96.1% of the demand control ventilation flushing events occurred during staff occupied hours (49 of 51 events). The majority of the events were associated with sanitation, which generally occurred between 7:30am – 12pm. The DCV events were triggered by a rise in either TVOCs, small particles or both. The TVOC level rose quickly as the sanitation process began and returned to baseline once the sanitation process concluded. Small particles also rose during the sanitation process, but the time for them to return to baseline was variable.

Research Conclusions

Temperature

The study demonstrated that the HVAC system was very capable of tightly regulating temperature in the rooms during both CFR and DCV phases. Temperature fluctuation did not exceed 1.6 degrees Fahrenheit.

TVOCs

Ammonia is the most prevalent airborne contaminant in animal facilities and can have detrimental effects on the health of animals and humans alike. The odor threshold is 2 ppm and irritation levels are between 30 ppm and 60 ppm. Assuming all of the TVOCs detected in the rooms were ammonia, the levels in the two rooms were below 0.4% ppm 99% of the time during both ventilation modes.

Antigen Control

Most allergens are carried in particles ranging from 0.3 to 15 µm in aerodynamic diameter, with a significant portion found on particles <4 µm. The particulate sensor used in this study measured particles 0.3 to 2.5 µm in size. The small-particle numbers observed throughout the entire study were below the flushing threshold >99% of the time in Room A and >95% of the time in Room B. All staff wore PAPR while the rooms were being cleaned.

Energy Savings

In constant volume ventilation mode the rooms were being overventilated the majority of the time. As stated previously Room A was above baseline only 0.4% of the time and Room B was above 3.6% of the time. When taking into account the university's utility cost, $4.60/CFM, operating the vivarium rooms using centralized demand control ventilation instead of constant volume airflow, saves $2,080 per room annually. Based on a vivarium facility that contains 19 rooms, the savings amount to $39,500. The Aircuity system helped the university to save energy and enhance the IEQ while adhering to current standards and guidelines.

About the University of Houston

The University of Houston is a Carnegie-designated Tier One public research university recognized by The Princeton Review as one of the nation's best colleges for undergraduate education. UH serves the globally competitive Houston and Gulf Coast Region by providing world-class faculty, experiential learning and strategic industry partnerships. Located in the nation's fourth-largest city, UH serves more than 40,900 students in the most ethnically and culturally diverse region in the country. For more information about UH, visit http://www.uh.edu.

About Aircuity

Aircuity is the smart airside efficiency company providing building owners with sustained energy savings through its intelligent measurement solutions. By combining real-time sensing and continuous analysis of indoor environments, the company has helped commercial, institutional and lab building owners lower operating costs, improve safety and become more energy efficient. Founded in 2000 and headquartered in Newton, MA, Aircuity's solutions have benefitted organizations such as the University of Pennsylvania, Eli Lilly, Masdar City, the Bank of America Tower and the University of California-Irvine. For additional information on the company and its solutions, please visit: http://www.aircuity.com.

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