Cut Costs By Controlling Airflow

One technology ripe for reducing ach in labs is air monitoring and ventilation control. The idea is to reduce ach by monitoring the air in the laboratory with a suite of multiple sensors, and then provide higher ach only when needed. Demand control ventilation has caught on in other applications, and as one example illustrates, applying it to a lab space can result in ballooning savings.

BY FRANK TRAKNYAK, P.E.

Biotech laboratory facilities consume up to 10 times more energy than commercial facilities. This is partly because lab buildings require 100% outside air at high volumetric flow rates for safety reasons, as mandated by regulations, codes, and standards. The National Institute of Health (NIH) states, "Laboratory buildings should be designed with 'once through' 100% outdoor air systems that automatically compensate for filter loading. Laboratory air shall not be recirculated."

To give a visual perspective on the volume of air that a typical laboratory uses, I would like to compare it to something tangible, such as the volume of a zeppelin like the Hindenburg, which was over 800 ft long and over 7 million cu ft in volume. A laboratory with a floor space of 100,000 sq ft with a 12-ft ceiling, and a 12-ach airflow rate would fill the entire volume of two Hindenburgs in one hour. This constitutes over 14 million cubic feet of 100% outside air in one hour that must be conditioned, supplied to the spaces, and immediately exhausted into the atmosphere. The cooling load would be almost 2,000 tons of refrigeration (based on a summer design day in Houston).

Many factors drive the actual quantity of air introduced in labs, including:

- The amount of fume hood exhaust
- The amount of air used to achieve pressurization control
- The quantity of air required to satisfy the space cooling load
- The ventilation rate required to remove contaminants in a lab

The first three items above will drive the airflow rate to the appropriate ach in order to satisfy these factors and cannot be reduced. The technology discussed herein is only intended to address the fourth item above.

USING IT WHEN YOU NEED IT

The cost of fossil fuels continues to rise, and consequently so does the cost of electricity. This drives up the operating cost of both laboratories and vivariums. Many would argue that it would be far more beneficial to use money on research and development as opposed to the operating costs of facilities. For example, volumetric airflow rate is measured in ach, and the majority of the time the ach requirement in a lab can be half as much or even less, unless a safety event occurs that requires dilution of that air. So why pay for twice the energy when you don't need to? The ach can be reduced by monitoring the air in the laboratory and by providing higher ach only when needed, such as during a chemical spill, high heat loads, high fume hood demand, or high animal occupancy in a vivarium.

Similar concepts have been successfully implemented in parking garages measuring CO, and in buildings such as offices, courthouses, and schools, that measure CO_2 concentrations. Another application that is required by mechanical codes is the monitoring of refrigeration machine rooms. Laboratories have much

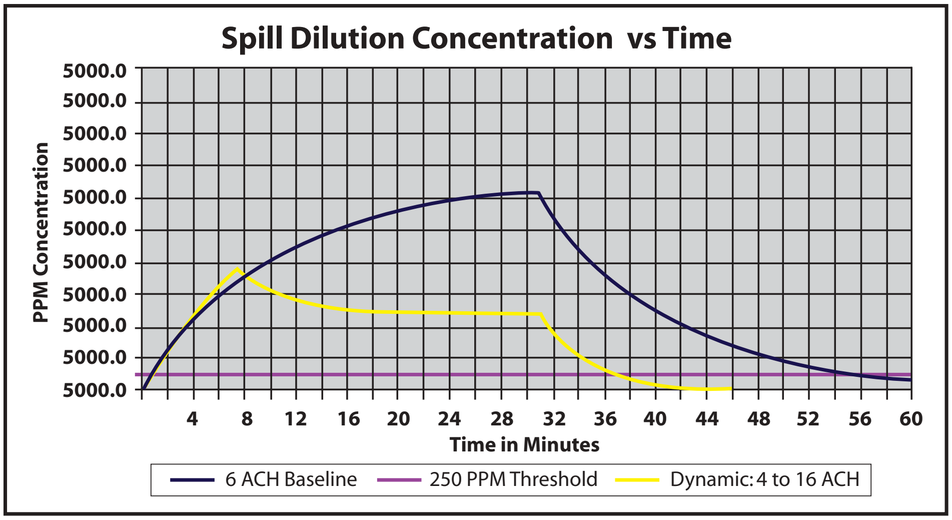

TABLE I. Graph of dilution rates as a function of time based on NIH calculations (Table courtesy of Aircuity).

more dangerous chemicals and gases than do refrigeration machine rooms, so why don't we monitor labs?

Normally the lab can operate at low ach with some adjustments to thermal requirements and changes in hood sash heights. In the event that a spill occurs, such as someone dropping a hazardous chemical in the lab, a sensor would pick it up and immediately switch to 12 to 20 ach or more to increase the air dilution until the emergency event is under control. Once the air returns to a safe level, the system can be reset back down to the low normal operating ach.

This would inherently make conditions safer because one can exponentially increase the ach to a much higher rate to dilute the air. Hypothetically speaking, if a lab is traditionally set to 10 to 12 ach for proper air dilution, and the new system can go from 6 to 60 ach, then the air will consequently be diluted much quicker and more effectively. The higher ach would only be introduced during emergency conditions, and

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thermal and humidity control would not be a priority. Therefore, the equipment controlling temperature and humidity only needs to be sized for normally low ach conditions and not oversized.

MEETING STANDARDS

Facilities performing research with animals must follow the Animal Welfare Act CFR 9, Parts 1, 2, and 3. Facilities that are funded by NIH must follow *The Guide For the Care and Use of Laboratory Animals*, which is known as simply *The Guide* and is a document issued by the Institute of Laboratory Animal Research (ILAR).

The Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) uses *The Guide* for accreditation. *The Guide* indicates that recycled air, although it saves energy, is discouraged because many animal pathogens can become airborne or travel on formites, which represents a great risk of cross contamination, particularly in the case of non-human primate and biohazard areas. *The Guide* recommends a 10- to 15-ach airflow rate in vivariums. Several factors contribute to the high airflow rates in vivariums, including:

- The species and associated heat generation. Specific temperature ranges, based on the species, must be maintained with rh between 30% and 70%.
- Particles such as dust, animal dander, and other formites.
- Toxic or odor causing gases such as ammonia.
- Toxic volatile organic compounds (TVOC).

So how can air monitoring be used in vivariums if such high airflows are stated? *The Guide* says calculated ventilation rates based on cooling loads (in accordance with *1993 ASHRAE Handbook – Fundamentals*) might be substantially less than 10 ach and are allowed "provided that they do not result in harmful or unacceptable concentration of toxic gases, odors, or particles in the primary enclosures." All these can be monitored using the appropriate sensors.

For lab spaces, ASHRAE, OSHA, and prudent practices state that 4 to 12 ach is normally adequate if primary containment such as fume hoods are used. Four ach is the minimum recommended unoccupied ach in a lab per NFPA 45 and OSHA standards.

THE CASE FOR DEMAND VENTILATION

Air is monitored for CO_2 in schools, office buildings, courthouses, etc., and used to control the HVAC system. This is known as demand ventilation. Why is demand ventilation not used in laboratories where toxic and flammable chemicals are used?

This technology utilizes a central suite of sensors integrated into a BAS for monitoring and control of up to 30 zones. Sensors can be selected for the specific known gases that will be used in the lab or can be selected for a wide variety of gases and toxins and switched out at a later time if certain known gases will be utilized. One can also monitor labs using individual dedicated sensors for each lab; however, this drives the cost up. Dedicated sensors may be warranted for high hazard or special labs.

There is no way of detecting every possible substance or compound; however, in laboratories the use of a photo-ionization detector (a type of TVOC sensor) can accurately detect hundreds of commonly used laboratory chemicals. This sensor, coupled with a laser-based particle sensor to identify aerosol vapors and smoke along with specialty gas sensors (for acids and other toxic gases), will encompass the majority of airborne chemicals of concern.

Oxygen depletion that may cause suffocation can also be monitored. Labs or bottle storage closets, along with other areas that contain large amounts of gases that can displace oxygen if they leak or purge, can be monitored. Conversely, oxygen enrichment environments that may create explosive conditions can be detected. This technology is derived from the same concept as demand ventilation in office buildings, schools, and courthouses, but it looks at much more than CO_2.

Why dilute clean air with clean air? A case study indicated that 0.07% of the time, the air in labs remained clean, yet the maximum airflow was introduced in the space 24/7/365. Why not provide the high number of ach only when it is needed?

Harvard University is conducting performance testing on the technology to validate air monitoring systems and to better understand airflow rates that laboratories actually need.

Typically, a lab requires 8 to 12 ach (not including spaces containing laboratory animals which may be as high as 15 ach) but may only need to operate at 4 to 6 ach. The NIH requires 15 ach for animals, and the CDC (according to *Guidelines for Environmental Infection Control in Health-Care Facilities*) requires 12 ach for airborne infection isolation and for a protective environment.

EMBRACING EMERGING TECHNOLOGY

As noted earlier, a key way of conserving energy and saving money for labs is minimizing ach through the EMS by continuously sampling air and providing the proper amount of ach to satisfy environmental conditions. This allows a lab to constantly run a lower number of ach. If someone in the lab dropped a hazardous chemical, a sensor would recognize that and immediately switch to 12 to 20 ach or more to increase the air dilution until the emergency event is under control.

> The higher ach would only be introduced during emergency conditions, and thermal and humidity control would not be a priority. Therefore, the equipment controlling temperature and humidity only needs to be sized for normally low ach conditions and not oversized.

Table 1 shows spill dilution concentration vs. time for various ach, illustrating how a dynamic system that responds to a spill would provide a much safer atmosphere in a shorter period of time than a system that only provided a 6 ach baseline.

Because this is a relatively new concept, some have hesitated to learn more about it, but everyone should be mindful of emerging technology. In this case, such a system would be useful for several reasons including safety, energy conservation, and liability.

While safety should always be a lab's number one priority, lab managers, engineers, and owners should also be interested in the system's legal aspects. The system, which would monitor spikes in environmental conditions such as chemical hazards, would document that the lab meets safety thresholds at any given time. The owner could then have historical documentation that can be used to demonstrate that safe environmental levels were maintained. Furthermore, if there was an incident then the times, durations, location, and actions taken could be recorded.

ACTUAL INSTALLATIONS AND APPLICATIONS

In the last 5 to 10 years, a concept called demand control ventilation (DCV) was introduced into HVAC controls systems. DCV is a new concept in laboratories and was introduced within the last year, so it's still in its infancy stage.

According to Aircuity, a manufacturer of this technology, only two installations of its OptiNet™ multiplexed lab facility monitoring and control system currently exist. One is at Harvard University in Cambridge, MA, and the other is in Lawrence Livermore National Labs in Berkley, CA. However, two of these monitoring systems have been proposed for future projects in Houston.

I recently designed a laboratory air monitoring system for a client in Cambridge, using sensors manufactured by MSA Instruments. The total area of my client's labs was 220,000 sq ft with 58 different types of labs for 24 different user groups. The sensors were located within the individual labs. These labs were designed as a VAV system, and the sensors were selected for monitoring specific gases and chemicals that were going to be used in those labs.

The system was a continuously monitored system designed with audible and visual alarms that were tied into the BAS. Chemicals and gases were measured down to the parts per billion (ppb). The system has three levels of status (alarm modes), with corresponding visual light beacons. These alarm modes are as follows:

- A green light indicates normal system status.
- An amber light indicates trouble with the system or that a gas or chemical was detected and reached a low level range measured to a specific ppb, and an alarm was sent to the BAS. This mode lets everyone know that a low-level gas detection exists. The BAS has the capability to automatically page the principal researcher and other key personnel to notify them of the problem.
- A red light indicates that the chemical and gas detected in the amber alarm mode has continued to rise and has reached a specific critical level in ppb. During this condition, an alarm signal is sent to the BAS. In addition to the red light beacon, an audible evacuation siren is enabled, and the ventilation supply and exhaust system switches to emergency purge mode. Depending on the hazard, the emergency purge mode airflow rate would go from 8 ach to 30 or 40 ach.

Many gases are used in these labs that could displace oxygen if inadvertently released; therefore, oxygen depletion is also monitored. Additionally, these labs could potentially have explosive atmospheres, so the explosive levels of gases and chemicals are also monitored, as are oxygen enrichment levels.

One specialty lab used hydrogen sulfide so a specific sensor was used that could measure hydrogen sulfide down to 2 ppb.

In addition to system monitoring, a lab occupant is able to press a panic button during evacuation, placing the system into red alarm mode.

CONCLUSION

This technology provides a minimum quantity of air to save energy, provides additional air (on rare occasions) during an incident for safety purposes, and provides a means of documenting the IAQ of the lab or vivarium to ensure that it has been maintained at a safe level.

Just imagine the energy saved by eliminating the energy required to condition the volume of one of the two Hindenburg zeppelins per hour. An owner must ask, "Can I afford not to provide a dynamic air monitoring system for energy, safety, and logistical purposes?" **ES**

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