The Great Fume Hood Debate

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By Paul Livingstone Wednesday, October 21, 2009

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For decades the assumption was that a safer fume hood was one with high air flow. But air flow is expensive, and vendors and researchers are designing ways to save money while continuing to protect the operator.

For decades, the ubiquitous laboratory fume hood was as immutable as the internal combustion engine, resisting efforts to build a better mousetrap. And for a good reason: as a safety device, it protects users from harmful fumes by trapping them through a combination of air flow and physical barriers. A little like the brakes on an automobile, fume hoods aren't a perfect barrier, but it is a proven technology that works for most situations. Complete protection could be achieved through other means, such a glove box, but in the interest of operator comfort and speed, the fume hood relies on a high-throughput of coherent air—whether in linear and vortex form—to divert potentially hazardous gases from compounds used in processes ranging from materials coatings to organic chemistry. Upon exiting the lab, diffusion eliminates the pollution.

The basic type of hood that's been in use since the 1950s, the constant-air volume (CV) hood, operates at a nominal face velocity of 100 feet per minute, and will provide the necessary protection for chemicals listed in the ASHRAE standard that governs hood testing. It features a few basic parts, including a fire suppression system, fans, baffles, and ducts to incite and direct air flow, and a movable window-like face called a sash.

Simple enough, right? Not quite. The automobile brake analogy breaks down here: fume hoods require electric fans to operate, and this is expensive. The average fume hood, which initially costs several thousand dollars, will rack up what some estimate to be as much as $300,000 in energy costs over the course of its lifetime. Many labs operate multiple hoods, and doubling the number of hoods in a lab more than doubles the amount of air volume required. As a consequence, fume hoods can often represent as much as 50% of a lab's operating costs. More than 750,000 are likely in use in the U.S. today, representing thousands of megawatts consumed and an energy cost in the billions.

In a recent survey of its readers, *R&D Magazine* found that most fume hood operators pay close attention to the energy question. Nearly half of the readers surveyed manage the lab and most of the respondents work at a private lab. The research being done at these labs varies widely, but our readers tended to be involved the materials or biotechnology sectors.
Most of the readers surveyed work at a small company, less than 100 employees. As a result, most of these companies operate less than 10 fume hoods. But even at these small private labs energy reduction is a top priority. This is probably because more than 60% of the readers operating fume hoods are using traditional constant-air volume (CV) hoods. Most respondents considered making a change in the approach to their work—green chemistry, for example—or by choosing a different type of fume hood that provides the same level of protection but uses less energy.

Many fume hoods conform to a standard six-foot-wide by about 30-inch deep footprint suitable for most laboratories. This limits some of what vendors can do to maximize efficiency, but how air flow is handled is wide open to innovation. On left, Nuaire's NU-156 vertical laminar flow wet process polypropylene fume

Vendors, testers, and researchers are alert to this need, and the push is on to find more efficient air handling solutions. The CV hood may soon be too costly for emerging lab needs.

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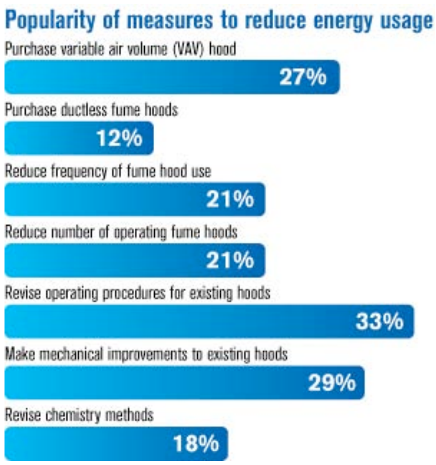
hood, and, on right, AirClean Systems' new Independence ductless fume hood. Images: Nuaire and AirClean Systems

Taming the energy beast

K. Dan Milgrim, vice president of fume hood and laboratory ventilation systems at **ALC-Collegedale**, Ooltewah, Tenn., has noticed two trends from his years as a lab designer and engineer. The first is that the customer is more sophisticated now, and wants energy savings. The second is that he is increasingly seeing an increase in lab equipment density, and a decrease in electricity consumption.

“There is more and more equipment in a given lab and all of those pieces are using some sort of power,” he says. Because most of this equipment is designed to use as little power as possible, the pressure is on to do the same to the biggest energy hog, the fume hood. A good example of the reason why this need has become pressing can be found in California, where Cal/OSHA mandates a 100 fpm face velocity level for all ducted fume hoods. The result of 85,000 hoods operating to this specification is an estimated consumption of 18 trillion BTUs per year at an operating cost of $400 million.



***R&D Magazine* asked fume hood operators what solutions would be useful for saving electricity costs incurred by fume hoods. The answers reflected the desire to both upgrade the fume hood technology and reduce waste on the operator side.**

Laboratories are typically designed around a specified number of hoods, and are equipped with a system of intakes, fans, ducts, and exhaust systems to handle the volume. Saving energy with such a system is difficult because all hoods must operate if one is being used. During the energy crisis of the 1970s the auxiliary air hood was invented. According to our survey, some R&D Magazine readers do still use these hoods; they were touted as a solution to the problem of high energy use, but because it drew in unconditioned air, it ended up freezing operators in many northern climes. Those that could condition air lost the energy advantage.

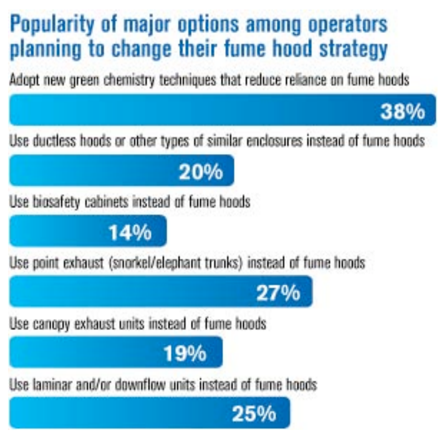
Variable-air volume (VAV) became the next step, and for some conditions it works wonders. The concept is simple: when the hood is not in use, it does not draw air. For off-the-shelf purposes, according to Gerhard Knutson, owner of **Knutson Ventilation Inc.**, Minneapolis, Minn., the approach is inadequate because VAV requires sophisticated engineering. But for some new labs, the higher capital costs of VAV is justified by major dividends in energy savings.

“There are an awful lot of labs that work 10 hours a day. In the middle of the night nothing is going on and a tremendous amount of energy savings is sitting there almost free for the picking,” says Knutson.

Also popular are two-speed (or dual position) systems, which are initially more cost-effective than VAV, yielding some of the savings with a lower investment. CV, dual-position, and VAV remain as commonly marketed hoods.

The latest option—ductless—emerged in force in the 1970s as a way to avoid almost all air-handling costs by trapping harmful compounds with activated carbon. For many methods they have caught on, but some chemicals cannot be trapped by these filters, which have a limited lifetime.

In 2007, at the behest of Pacific Gas & Electric utility, fume hood experts Dale Sartor of **Lawrence Berkeley National Laboratory** and Rishabh Kasliwal of **Cogent Energy Inc.** conducted a study that quantified potential energy savings from revised usage strategies in two different California laboratories that relied on fume hoods. Their study aimed to evaluate the effects on energy costs of reducing the number and size of fume hoods, restricting the sash opening, and operating two-speed hoods both occupied and un-occupied, VAV systems, and high-performance hoods. As part of their effort, they designed the Berkeley Hood, a second-generation VAV system equipped with a sensor-based auto sash closure. In extensive testing of its Berkeley Hood in laboratory situations in 2007, Sartor found that more than 1,500 kW-h from the fans and cooling systems could be saved through the installation of this hood and the implementation of a strong sash management program. In terms of the actual kilowatt-hours saved, the margin was relatively modest, but it did add up to more than $1,000 per year and long-term savings of 30%. When multiplied against multiple fume hoods and the number of years a fume hood is typically in active service, the estimated savings can be tremendous: more than $174,000 for one of the universities evaluated.



***R&D Magazine*'s readers, while recognizing the need to eventually upgrade to new fume hoods or fume hood procedure, are greatly interested in methods that reduce emissions and use of resources.**

The battery of tests from the American Society of Heating, Refrigeration & Safety Engineers (ASHRAE) was intended to help others determine hood performance, but developing them was a painstaking prcoess.

“The person doing the testing was actually disturbing the measurement and this distorted the test. It was necessary to get the investigator out of the way,” says Knutson. In a way, he says, it’s analogous to the Heisenberg Uncertainty Principle because performing the measurement changes the system. The solution was to use a cloud projector and a mannequin equipped with a sensor at the mouth. This setup clearly showed the type of vortices that would form around the body due to whatever comes into the hood. However, the results of the mannequin tests showed a lot of variance, so they widened their field of view and took into account the room air and how it affected the performance of the hood. It turns out this effect was substantial; the best way to mitigate the effect without having to increase volume flow (and thereby reduce efficiency) was to reduce the sash opening.

“What one has to realize when testing the size of the hood opening is that the smaller the opening the better the hood works,” say Knutson. “For a system to have a nice energy consequence it is beneficial, provided the operator can work in that environment, to have the sash at 18 inches.”

The marketplace responds
Answering the call for better efficiency, vendors are increasingly offering systems that save energy through lower air volume while at the same time adhering to changing regulations and testing standards.

At **Kewaunee Scientific Corp.**, Statesville, N.C., the push is toward high-performance hoods.

The new GreenFumeHood line from Erlab is representative of hoods that rely on filtration rather than diffusion. The energy savings are tremendous, but some applications are still off-limits for these hoods. Image: Erlab

“There has been a proliferation of high-performance hoods on the marketplace that use less volume and less energy,” says Vice President of Sales and Marketing Dana Dahlgren. Kewaunee’s representative fume hood, the LV, is so named because its Roman numerals stand for 55 fpm, face velocity of the hood.
“I’ve been with Kewaunee for 25 years, and the standard has always been 100 fpm. A number of technologies have come into play for VAV, but it places a lot of restrictions on the user,” says Kurt Rindoks, vice president of engineering and product development. A clean sheet design was required for the LV hood, and it involved changing the baffle configuration entirely from the previous standard, which was a Cartesian design (only vertical and horizontal). Also, a new V-shaped air foil was designed to enhance the physical protection barrier by creating a flush air seal. The bypass was also re-engineered. The sash positions remains at 18 inches, but it adjusts automatically through a proximity sensor. The net effects of these measures yielded a hood that draws just half as much air as before.

VAV hoods also work for applications that use highly hazardous substances. Polypropyene fume hoods from Nuaire, Plymouth, Minn., are designed for very corrosive methods, such as semiconductor work, trace metal analysis and acid digestion, that would damage steel-framework hoods. As a consequence, the company recommends 100 fpm for optimum performance, but its bypass and VAV hoods have passed inspection down to 80 fpm.

According to Terry Thompson, polypro sales manager at **Nuaire**, an interest in conserving energy has led many of its customers to pursue after-product purchases, such as sensors that can tell if a person has left the hood. But it's the hood choice that remains the most important decision. Sometimes, it's more of a headache for a company to delay R&D than it is to endure higher energy costs.

“The operating costs factor in greatly, but what is just as important is the purchasing of the right hood for the right application. The replacement of a hood ordered for the wrong application could lead to a new hood being ordered, not to mention the downtime for hood removal and re-installation,” says Thompson.

According to Les Goldsmith, national sales manager at **Envirco**, Sanford, N.C., the DC motors that will be used in the next-generation of products to be released by Envirco at the end of 2009 will reduce power usage from 200 to about 80 W, saving costs at the fume hood and improving reliability.

Meanwhile, **Air Master Systems**, Muskegan, Mich., sells a high-performance fume hood that operates at 60 fpm and is intended to provide the same containment without any increase in footprint while at the same time claiming 40-60% energy savings. The achievement is due in part to an altered baffle design. Not satisfied with offering a high performance design, the company is seeking growth in the ductless market. They are one of three partners working with **Erlab**, Rowley, Mass., to market the company’s GreenFumeHood line of ductless fume hoods.

“In my opinion, in 10 years green fume hoods will account for 50% of the market,” says Darryl Coenen, a sales representative with Air Master Systems.

Ductless hoods have been both steadily improving in performance and market share. According to Karl Aveard, vice president of communications at Erlab, Inc., 70% of fume hoods in use in France, where Erlab's headquarters are, are ductless. In the U.S., they account for a small fraction of hoods in use, but that ratio is slowly changing, and companies like **AirClean Systems**, Raleigh, N.C., have for a long time manufactured ductless hoods for American markets. The company’s new Independence fume hood is directed to architects and engineers for first-install applications and features an in-house operating system.
Aveard, who is an ASHRAE committee member and has been designing laboratories since 1984, was skeptical when he first heard of the ductless design. Like many engineers, he was accustomed to the necessity of ducted designs. But recent improvements won him over, and earlier this year he joined Erlab’s new Massachusetts office to help them develop and market their GreenFumeHood line.

Rigorous testing is crucial to the safe, efficient operation of a fume hood. In addition to evaluating its hoods under ASHRAE 110-1995 methods, Kewaunee Scientific Corp., left, also conducts dynamic tests that measure disturbances in airflow that originate from outside the hood. In developing its Berkeley Hood, right, researchers at Lawrence Berkeley National Laboratory used the mannequin

“Previous generations of filtration technology are very task specific. You had to know exactly what chemicals to use and numerous different media filters were needed," he says.

approach pioneered by ASHRAE engineers.The system measures air quality at the lips. Images: Kewaunee Scientific Corp. and Lawrence Berkeley Lab.

The GreenFumeHood's Nutridyne filters represent a major improvement. Erlab and AirClean have both established proprietary filter fabrication methods that achieve better bonding of the carbon. There are still about 14 commonly used chemistry substances that cannot be handled safely in a ductless fume hood, but hundreds of others can, and given the low energy costs and the ability for these hoods to be installed in nearly any type of lab space, they remain a viable choice.

Asking the right questions

With so much attention being paid to energy-efficient solutions for new labs, the operating cost of fume hood can't be ignored. They are crucial for safe laboratory operation, but solutions that allow lab managers to do more with less are being aggressively pursued.

Still, progress in fume hood design and usage can be frustratingly deliberate. Even convincing a chemist to decommission a hood that's not in use can be difficult, says Milgrim. Some of the readers surveyed for this article are still using hoods made in the 1960s.

"[Fume hoods] haven't changed much over the years. They've gotten better and they've gotten safer, but it's still a basic box with negative pressure," says Milgrim. It's hard to place a limit on what designers can do, but the economics dictate a careful progression. Margins are not huge for fume hood manufacturers, says Milgrim, and pioneering a new system is a significant risk.

Still, the savings are there to be taken if the right questions are asked. The lab's mission must be clear. What chemicals will be used? What position will the sash be at? What is the usage schedule?

With the answers to these questions in hand, the buyer can work with vendors to find a solution. Most companies are accustomed to custom requests and available options are numerous. Education is also important. Improper sash use, for example, can sabotage energy savings from even the best VAV systems.

"Hoods are a tenuous protection device. That brought home to me the reason why education of the users is so important," says Milgrim. "Sash management is so much more important than anything else. Good sash management and good vis-to-vis control design is absolutely the best energy saving strategy a lab can have."

Published in R & D *magazine: Vol. 51, No. 6, October, 2009, p.8-14.*

ASafeDrive, LLC released a highly-innovative mobile platform device—ASafeDrive. The new technology, now available for $0.99 at the Apple App. Store within iTunes or at www.asafedrive.com, specifically aims to help commuters maintain vehicle speeds within legal limits throughout the Los Angeles area and across the United States.