PRACTICAL APPLICATIONS FOR INNOVATIVE HVACR MECHANICAL SYSTEMS ENGINEERS

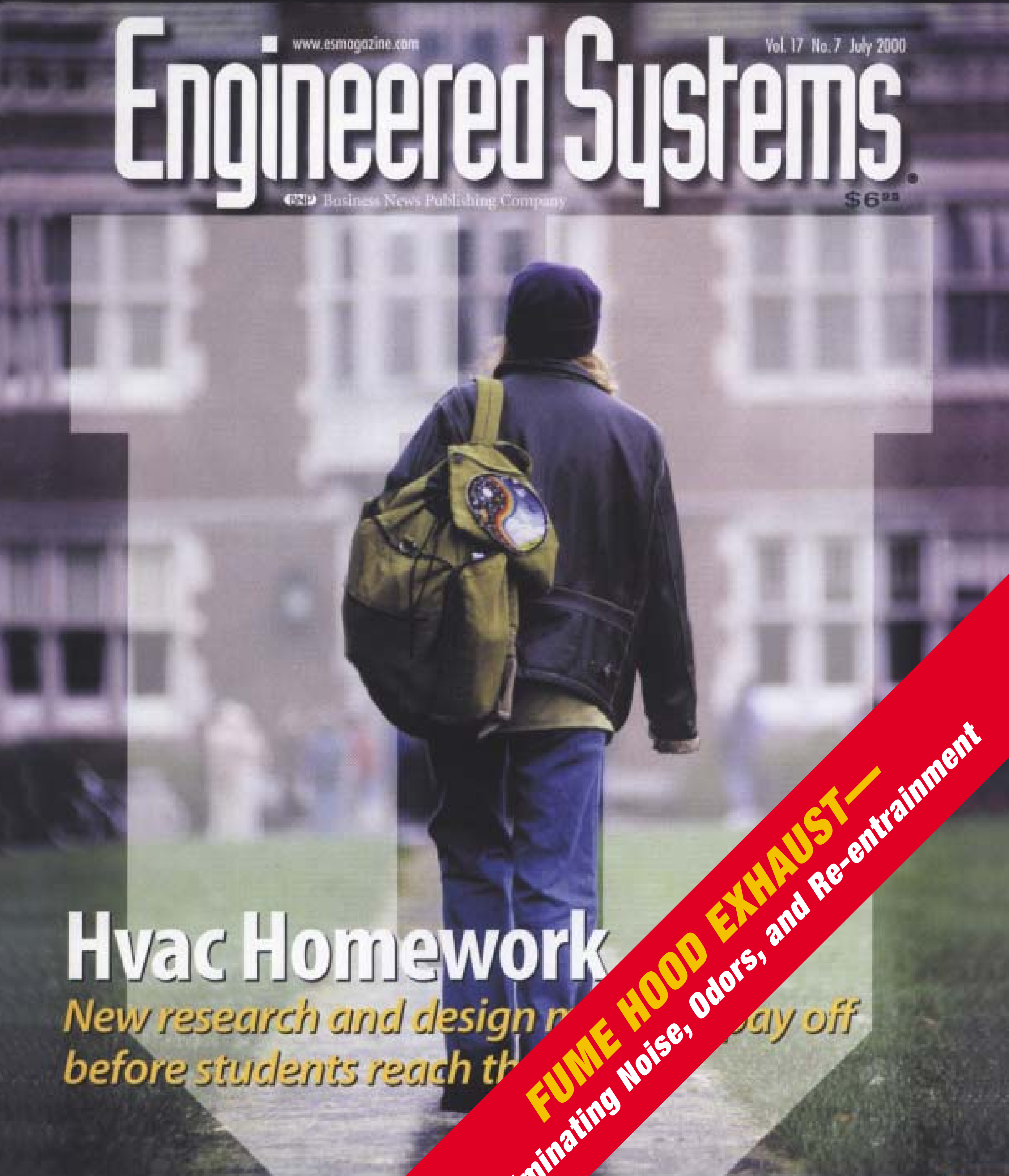
www.esmagazine.com

Vol. 17 No. 7 July 2000

Engineered Systems®

BNP Business News Publishing Company

$6.95



Hvac Homework

New research and design n... pay off before students reach th...

FUME HOOD EXHAUST—

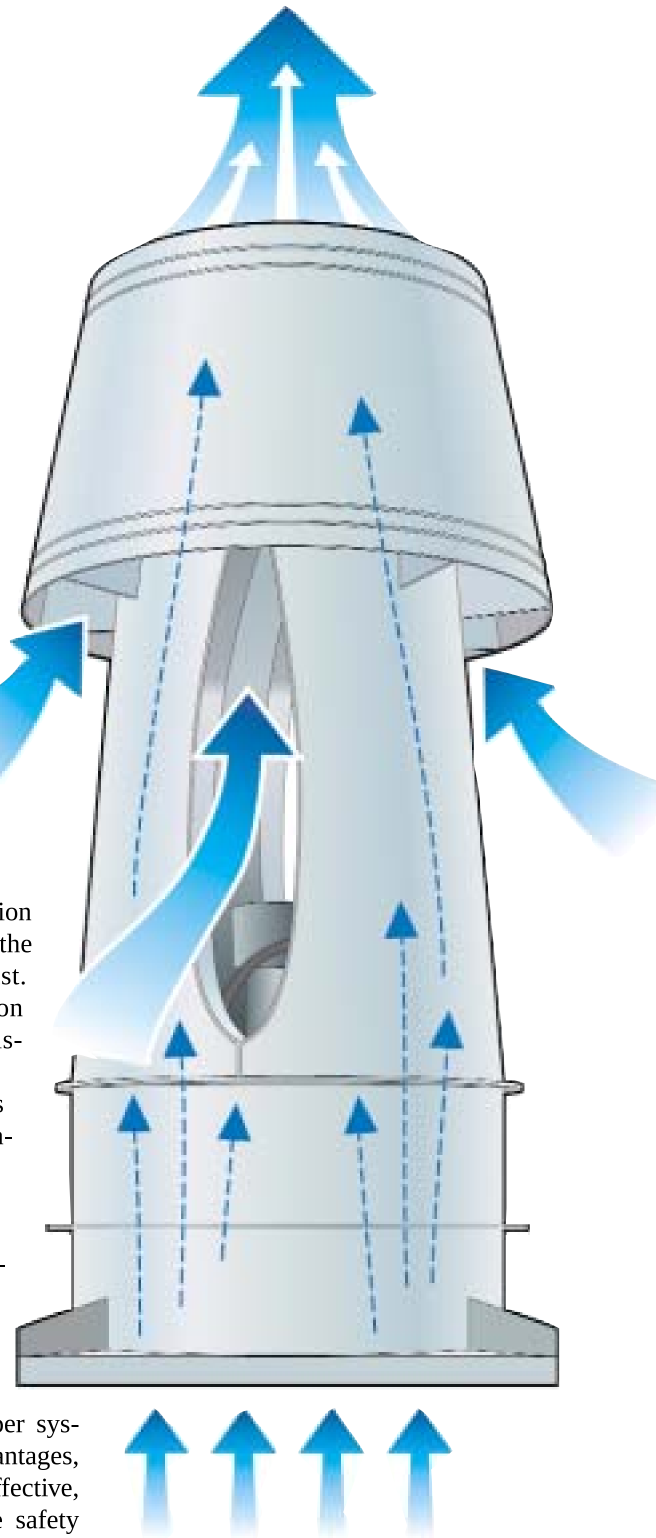
Eliminating Noise, Odors, and Re-entrainment

COLLEGE ISSUE: LAB VENTILATI... / CHILLERS / OUTSOURCING, PT. II

Exhausting the possibilities

The last battle in lab ventilation happens on the roof, where traditional foes include noise, odors, and re-entrainment. These days, advanced computer evaluations and other design and equipment advancements are new weapons in fighting the good fight for effective and unobtrusive fume exhaust.

BY VICTOR A. NEUMAN



While the fume hood and related equipment have received significant attention recently, another critical component of a safe and efficient laboratory workstation fume hood exhaust system is the outlet end – the roof exhaust. That's where the workstation exhaust must ultimately be discharged into the atmosphere – away from the building and its occupants, and away from adjacent buildings.

In addition, the roof exhaust system must also permit compliance with appropriate ordinances for pollution, noise, and/or odor. This article will look at various methods used for achieving these objectives, the alternatives for selecting the proper system with advantages and disadvantages, and what to look for in a cost-effective, energy efficient system to ensure safety standard and code compliance.

To ensure worker safety, standard/code compliance, and maintain a "good neighbor" policy with regard to laboratory workstation fume hood exhaust systems, there are generally four goals to achieve: eliminating re-entrainment of exhaust discharge into the facility; eliminating atmospheric pollution to comply with applicable laws; achieving these objectives without generating objectionable noise levels at the property line and in the lab; and considering the roof line and its related aesthetic issues.

Of these, effective plume height exhaust – basically preventing re-entrainment – is the primary consideration, because if exhaust fumes are brought back into the building or neighboring buildings, the system is not safe no matter how quiet or unobtrusive it may be.

Exhausting the possibilities

New exhaust technology reaches from the computer studies to the roof. Here, a trio of mixed-flow impeller fans (Strobic Air Corp., Harleysville, PA) are used atop a modern building. In some cases, this approach can do the lob of several traditional tall stacks with more aesthetic results.

SMALL NICHE, TIGHT STANDARDS

Recently, alleged problems have led to substantial legal costs and fines associated with litigation in the area of lab ventilation. Problems such as these may also potentially be caused – or exacerbated — on the roof, where exhaust is ultimately removed from the building as atmospheric discharge.

In the past few years, standards at virtually all levels have become more stringent with regard to sources of pollution; they are likely to get stronger. For laboratory workstations and their exhaust systems in particular, ANSI/AIHA Z9.5 (American National Standards Institutes/American Institute of Hygienic Association) as well as ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.) 110, and NFPA (National Fire Prevention Association) 45 are widely used in the industry to determine applicable standards and practices. These organizations provide guidelines with regard to building air intake and exhaust design, indoor air quality (IAQ), and re-entrainment issues of contaminated exhaust entering doors, windows, and outside air intakes.

The issue of designing efficient laboratory fume hood exhaust systems – starting at the workstation and ending at the roofline – is a relatively narrow specialty. There are not many consulting engineering firms in the country who understand all of the complex problems involved, and there are also not many manufacturing firms producing equipment needed to address issues including re-entrainment, pollution abatement, noise generation, odor control, and aesthetic considerations.

EVALUATION STUDIES PROVE THEIR VALUE

Many organizations faced with building or renovating laboratory facilities have turned to highly specialized consultants that provide wind and noise studies to help determine, beforehand, the probability and location of potential re-entrainment or unwanted noise problems.

To pursue this subject further, some consulting engineering firms provide building audits for facility managers and building owners. These are essentially feasibility studies that might include computer simulation of a building's laboratory fume hood exhaust system, taking wind and noise studies into consideration. Many times these organizations develop mathematical models of major exhaust and outdoor air intakes, as well as air intakes of surrounding buildings. Models are used to simulate typical and worst-case scenarios to predict possible re-entrainment.

More complex building configurations may require wind tunnel studies, where campus building models are rotated on a turntable in the tunnel to visually observe the exhaust plume characteristics under different wind speeds and directions. The importance of wind studies should not be underestimated when considering re-entrainment of roof fan exhaust. Some areas to look at include detailed operating system parameters integrated into a physical model to simulate site conditions. Building fresh air intakes and pedestrian and outdoor gathering areas should be identified. (These are considered "receptor sites.") Environmental conditions, wind data, and topography should be factored into the model. In essence, the goal is to determine the worst-case exhaust discharge criteria.

In addition to re-entrainment issues, which we will return to shortly, circumstances may dictate the use of noise studies as well. Exhaust acoustics are considered part of a building's aesthetics. Acoustical analysis of exhaust and ventilation systems early on, prior to installation, can minimize the acoustic impact on surrounding areas. Obviously, facility managers don't want mechanical sound of any exhaust fan to be heard within a building or at the property line whenever possible; exhaust fan noise should not be detectable in adjacent buildings either.

As one might expect, there are few architectural acoustics firms who perform these kinds of studies. One of them, Kvernstoen, Kehl and Associates (Minneapolis), has performed noise studies at laboratory facilities throughout the country. Kvernstoen gathers noise information with meters positioned at various locations surrounding a facility. The goal is first to determine existing noise levels with the understanding that "this is what exists – anything above that level will be noticed and could be perceived as a problem." Local codes for permitted noise levels at the property line – especially at night – must also be considered.

Once preliminary studies are done, defined noise limits are set for specific areas surrounding the building. The next step is usually to consult the roof exhaust fan manufacturer to determine two things: what levels of sound are generated by the proposed exhaust fans; and, second, if those exceed recommended noise levels, what options are available for abating noise at the fans and reducing discharge noise.

In general, there are two basic types of roof exhaust fans/systems used for laboratory fume hood ventilation applications. More traditional centrifugal fans generally use belt-driven motors, and they require tall exhaust stacks for efficient operation. These installations can be maintenance-intensive, and the stacks may also require extensive guy wires and mounting hardware.

The other type of roof exhaust fan is known as a mixed-flow impeller system. Fan stacks associated with this technology are substantially smaller than centrifugal fan stacks; the fans use direct drive motors which may eliminate maintenance and may perform as quietly or quieter than its counterparts. This type of system also tends to have a more expensive first cost, although energy reduction generally provides a reasonably fast return on investment.

NOISE ABATEMENT ALTERNATIVES

If mixed-flow impeller-type fans are employed, there are accessories available to reduce sound generated at the property line if necessary. These typically include acoustical screens and/or louvers, and in-line silencers. In general, one of these methods would solve the noise problem.

A chevron screen wall diverts noise up and away from the building and surrounding areas, substantially reducing noise at street level. Acoustical screens/louvers – which also absorb noise – otherwise function in much the same manner, attenuating noise through use of complex airflow patterns. In-line silencers (or newer nozzle silencers) use a combination of sound absorption material as well as special airflow patterns through the fan exhaust nozzles that provide for increased fan efficiency and passive noise abatement, generally permitting the highest degree of attenuation.

Steve Kvernstoen of Kvernstoen, Kehl and Associates says that intake air vents and exhaust outlets can be equally noisy. His firm uses data and models to predict sound that might occur in various places. “This gets somewhat complex because we have shadowing of the building element, not the roof itself, that creates an ‘acoustic shadow’ for people close to the building,” he explained. “We analyze any elements on the roof (penthouses, other equipment, or parapets) that may create an acoustical shield which can, in some circumstances, eliminate the need for abatement.”

CONTROLLING ODORS IN THE NEIGHBORHOOD

With regard to odor control, this may be considered in two distinct areas: toxic and non-toxic. Toxic odors are those that are regulated by OSHA and other government agencies. Non-toxic odors are either completely safe or safe in the amounts that are likely to be generated. Even “safe” materials like carbon dioxide may have limits beyond which their emissions would be regulated.

In general, however, there are not too many regulations imposed on laboratory exhaust because of the minute amounts of harmful fumes emitted into the atmosphere.

Tolerance standards for toxic odors have also sharply decreased in recent years. Government agencies are continually establishing more stringent standards; allowable exposure limits are dropping to lower and lower levels. These allowable exposure limits are expressed over Short Term Exposure Limits (STEL) for short amounts of time and Time Weighted Averages (TWA) for longer periods of time. The actual measurement will usually be in parts per million (ppm).

CONSIDER DILUTION FOR ODOR CONTROL

Several ways to address odor control issues exist. In the past, many communities were tolerant about odors associated with research and/or manufacturing. For example, the odor of a fertilizer factory or refinery was termed “the smell of money” and was accepted because of jobs and other economic benefits. Today, most communities no longer tolerate odors and originators are increasingly coming under attack. Neighbors are more likely to complain about the health risks to children rather than tolerate what they consider to be a slight nuisance. As a further complication, the American Industrial Hygiene Association reports that the perception of odors can vary by more than 10,000 times from person to person.

There are a number of methods to control exhaust odors from laboratory workstation fume hoods, including wet scrubbing, charcoal filtration, thermal oxidation, and dilution. With regard to the first three methods, they are generally not required for most laboratory applications and are considered “overkill.” On the other hand, dilution is an efficient method of odor control that has not quite received the recognition it deserves. One reason could be that unlike the other methods mentioned, which can accurately predict the amount of chemical materials that will be removed from an exhaust stream, odor control by dilution is harder to predict quantitatively. The theory of operation is simple: add fresh air to the odor-laden air until the odor is no longer perceptible or objectionable.

Dilution works in most cases and with most kinds of offensive odors. To control odor by dilution, fresh air is mixed in with the effluent-laden air until the desired parts per million (ppm) level is reached. Dilution can be achieved directly by diluting the exhaust air before it leaves the exhaust fan. Dilution may also be achieved indirectly, when the exhaust is diluted by the atmosphere after it leaves the fan and before it reaches the property line or the intakes of nearby supply air handlers.

The most efficient and cost-effective method to accomplish dilution is to use an exhaust fan that is specially designed for this purpose. This design draws the odor-laden exhaust from the fume hood into a ductwork system and carries it to an appropriate discharge point of the building’s roof. At the roof, fresh air is drawn into the exhaust fan to mix with and dilute the odiferous exhaust. This technique is known as direct dilution, and is very effective when the resulting odiferous exhaust/outside air mixture is ejected from the exhaust fan upwards at high velocity.

Wind tunnel studies have shown that the most effective technique is to project the diluted airstream upwards at velocities in excess of 3,000 ft/min (fpm) and with high mass to maximize momentum. A typical centrifugal fan exhaust system, to ensure dilution, might require a stack as tall as 100 ft to disperse the plume of odor from the fan. However, the cost and complexity of such a structure, and its unsightliness, work against it. Also, for retrofit situations where employees at the site or its neighbors have previously complained of the odor, a tall stack is a daily reminder of the presence of the odor.

ANOTHER OPTION: HIGH-VELOCITY FANS

Today, an alternative solution is to use a special, high velocity, mixed-flow, impeller-type fan – designed exclusively for this purpose – that draws the necessary amount of outside air into the primary exhaust stream within the fan system, resulting in a 3,000 to 6,000 fpm exit velocity. The jet velocity at the fan exit induces additional amounts of outside air to be drawn into the plume. This injection of raw ambient air causes immediate relief of odor perception by dilution, and it blasts the odor-laden air high into the atmosphere. Often the use of such a system is enough on its own to solve an odor problem. If it isn't, then you must look towards combining dilution techniques with one or more of the other previously mentioned methods.

Besides odor control, dilution technology also prevents re-entrainment back into the lab and neighboring buildings. Because of the high ratio (up to 75%) of outside air that mixes with plenum exhaust air, the possibility of re-entrainment of laboratory fume hood exhaust is reduced significantly. A diluted exhaust stream, combined with a jet-velocity air flow plume, generally helps prevent re-entrainment into the building in all but the most difficult environments.

Facility engineers and managers should be particularly aware of fume hood exhaust roof fans with small airflows. Fans with less than 2,000 cfm of air have difficulty pushing through the turbulent flow of air on a building's roof. Whenever possible, fans bearing chemical-laden air should be chosen with exhaust flows in excess of this amount; the larger the exhaust flow, the better for dilution purposes. Also, stack or nozzle exit velocities should be in excess of 3,000 fpm. ANSI Z9.5 has set this exit velocity as a minimum benchmark to prevent exhaust downwash to the roof level (with possible contamination of outside air intakes and thus re-entrainment) at wind velocities in the 10 to 15 mph range.

Dilution levels vary for each application and are generally a direct function of chemical quantities being used. Exhaust from laboratory fume hoods might have to be diluted 1,000 to 5,000 times.

Exhaust from diesel motors or emergency generators might have to be diluted 10,000:1 in order to eliminate odor complaints. Odors from mercaptans and hydrogen sulfide (which smell like rotten eggs) are particularly annoying, even in extremely low concentrations. The facility engineer dealing with these substances must be prepared to provide large amounts of dilution, possibly coupled with other air treatment methods.

While space limitations prohibit lengthy discussions about other methods of odor treatment, most of which are more well known and widely used than dilution, selection of an odor-control technology generally encompasses a number of disciplines including prevention, minimization, and masking. With prevention, the source of the odor is substituted with a nonodor-causing material. Minimization can be used to reduce the amount of odor causing it to evaporate at a slower rate.

Masking simply adds a pleasant odor to the air to hide or mask the objectionable odor and can impart false security, particularly where toxic exhausts are concerned. Selecting an effective odor control technology depends on the compounds causing the odors and their concentrations, as well as the airstream flow rate, moisture content, and variability.

ARCHITECTS NEED TO BE CONCERNED

With regard to designing or renovating a new laboratory facility, most architects involved with building design depend on consulting engineers for guidelines in many disciplines. For example, architects need to know whether a building exhaust system has variable or constant volume, or what kinds of air changes will be required in the building. These and other subjects are not generally in the purview of a designing architect.

Architects involved in designing a new laboratory facility should require a computer model first, followed by actual testing of the design once the approval cycle is completed. They should also seek wind tunnel studies and computer wind models to determine airflow patterns with regard to roof exhaust and possible re-entrainment issues as well as neighborhood pollution and/or odor issues.

In many states, the architect (as well as the facility owner) may be considered ultimately responsible for consequences of re-entrainment. This is because in most cases the architectural firm signs a contract with the building owner, and the owner may have recourse to the architect as coordinator for the entire design-contracting- construction effort.

AESTHETIC ISSUES CAN ALSO BE IMPORTANT

On the other hand, most architects are also quite concerned with the aesthetics of a building, looking to equipment manufacturers in that area to determine what products and system configurations are most useful to prevent re-entrainment while minimizing tall exhaust stacks and associated guy wires, roof curbs, and other mounting hardware. And since they are typically less than 15 ft high, mixed flow impeller designs generally fit into the aesthetics of the building's roof line in a far more pleasing manner than do tall exhaust fan stacks.

In addition, many states and municipalities have ordinances or other architectural restrictions pertaining to exhaust stack height.

In planning building renovation or new construction, consider working with professional laboratory planners who understand the implications associated with all of the issues discussed here. In the long run, not only may serious operational problems be eliminated, but substantial savings can be realized in overall systems. **ES**

Neuman is the former western regional manager for GPR Planners/Collaborators, Inc. (Irving, CA). Write to him at **victor_neuman@hotmail.com.**

Strobic Air

TRI-STACK™

ROOF EXHAUST SYSTEMS

For pollution abatement and odor control *(quietly)...*

Tall stacks are good, but Tri-Stacks™ are best!

Tri-Stack systems are ideal for new construction and direct replacement of conventional centrifugal exhaust fans. Tri-Stack systems feature unique design, high efficiency operation for lower system static pressure, reduced energy costs and provide two-year payback in most installations. Tri-Stacks are also virtually maintenance free, operating continuously – without periodic maintenance – for years under normal conditions.

Contact us today for full technical details or to discuss your application.

Low profile, quiet solutions for roof exhaust problems for ***laboratory workstations*** *and* ***industrial processing***

- ***Prevent re-entrainment***
- ***Eliminate odor***
- ***Reduce noise at the property line***
- ***Comply with architectural/aesthetic ordinances***
- ***Lower energy costs***

First we invented the technology. Then we perfected it.

Strobic Air Corporation®

160 Cassell Road, P.O. Box 144
Harleysville, PA 19438
Tel: 1-215-723-4700
Toll Free: 1-800-SAC-FANS
Fax: 1-215-723-7401

A subsidiary of MET PRO CORPORATION

For design/applications tips, visit our web site: www.strobicair.com
www.met-pro.com/strobic.html • E-mail: tristack@strobicair.com