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Managing biosafety laboratory workstation exhaust

Consider mixed flow impeller technology for safety, efficiency, and economy

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Re-entrainment of laboratory workstation fume hood exhaust has received widespread attention in the past few years. The main reason for this concerns growing public awareness of pollution issues, mostly as a result of broad news coverage of multi-million dollar lawsuits focused on indoor air quality (IAQ). These lawsuits resulted from worker claims that dangerous research laboratory workstation fume hood or process exhaust either remained in the work area, or that roof exhaust gases were being re-entrained into the work area from building windows, doors, ventilation system intakes, and other sources.

In addition to recent litigation against a few FORTUNE 500 industrial organizations, and even a nationally known American university hospital with regard to IAQ and employee health problems, articles published in the general press have cited laboratory researchers who died as a result of contracting glioma, a form of brain cancer, allegedly as a result of work place conditions associated with laboratory workstation exhaust.

While many of these problems occurred at chemical and/or petrochemical research facilities, the possibility of exhaust re-entrainment at hypersensitive biosafety level (BSL) research laboratories is ominous. BSL laboratories present a unique set of problems with regard to re-entrainment issues in particular, and pollution abatement issues in general. As a result they are governed by rigid codes and standards formulated by a number of organizations including the American National Standards Institute (ANSI), American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE), the Center for Disease Control (CDC), the National Institutes of Health (NIH), and the U. S. Department of Health and Human Services (DHHS).

No matter what kind of research is being conducted at a BSL laboratory, it is imperative that the workstation fume hood exhaust system is given proper consideration. This issue must be taken seriously – not only for reasons of worker (and neighbor) health, but also from the perspective of possible litigation against virtually everyone associated with the facility. Laboratory workstation exhaust re-entrainment can be caused by many factors such as inefficient roof fans, poor exhaust stack design and/or location, position of building air intakes, weather and wind conditions, and other factors which will be discussed here.

Biosafety laboratory level requirements

Biosafety laboratory levels (BSL) are graded from 1 to 4, with standards set by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE), the American National Standards Institute (ANSI), U.S. Center for Disease Control (CDC), National Institutes of Health (NIH), U.S. Department of Health and Human Services (DHHS), and the American Society of Mechanical Engineers (ASME). These organizations set guidelines that identify and list specific agents as to classes of laboratory required for their use. Within each of the levels, there may be further defining criteria dependent upon the type of work being conducted, the degree of hazard associated with that work, and other factors.

With regard to the specific substance classifications, bloodborne pathogens such as the AIDS virus would generally require a Level 2 laboratory when research is handled in a clinical setting. However, if a laboratory is growing large quantities of AIDS virus for study, it may be required to be a Level 3 facility. Also, at Level 3, such agents such as tuberculosis and anthrax would be used since they are readily transmitted by aerosol generation; microorganisms (bacteria), which have a fairly serious consequence of disease but are also contractible by aerosol means, would typically be used in Level 3 laboratories as well. Level 4 is generally reserved for the most exotic viruses.

European BSLs have adopted the standards and guidelines governed by the CDC and NIH.

Implications of roof exhaust re-entrainment

While roof exhaust re-entrainment can be a serious problem, many of its negative implications may not be widely known. In fact, not only can the health of building workers be affected by exhaust re-entering the building but the legal consequences can extend well beyond their employers. For example, in some cases building owners, consulting engineers, heating, ventilation, and air conditioning (HVAC) contractors, and even architects have been named as defendants in lawsuits associated with employee illness allegedly caused by harmful IAQ.

Low profile mixed flow impeller exhaust systems on building roofs are aesthetically pleasing, and may help comply with applicable building codes as well as eliminate negative implications associated with tall exhaust stacks.

BSL laboratory workstation exhaust may be harmful

Roof exhaust re-entrainment at biosafety level laboratories may be insidious at times – but is often dangerous. This is especially true at Biosafety Level 3 and 4 laboratories where highly contagious microorganisms may be present. Biosafety laboratory levels are graded from 1 to 4, with many different Standards set by the organizations previously mentioned. These organizations mandate guidelines that identify and list specific agents as to classes of laboratories required for their presence. The different levels are essentially determined by the degree of risk associated with exposure to various infectious agents within the laboratories. For example, Level 1 agents are usually not placed on the list but are assumed to include all fungal, viral, rickettsial, chlamydial, and parasidic agents which have not been included in higher Biosafety levels. For the most part these agents can be handled safely in the laboratory without special equipment using techniques generally acceptable for non-pathogenic materials. Typical examples include certain influenza strains, infectious canine hepatitis viruses, and other "low-risk oncogenic viruses," according to the *University of California, San Diego Biosafety Handbook.*

Biosafety Level 2 bacteria are considered of "moderate potential hazard to healthy human adults and the environment." Some agents listed may cause disease by contact or respiratory routes, but they are self-limiting and do not cause a serious illness. For example, common cold viruses (rhinoviruses) are considered Level 2 agents. Other examples include streptococcus pneumonica, staphylococcus aureus, poliovirus, etc. There is a specific list of bacteria, fungal, and parasitic agents, along with viruses and prions and moderate risk oncogenic viruses that are clearly defined in the infectious agents list of the *UCSD Biosafety Handbook.*

With regard to more serious (and potentially lethal) diseases that may be transmitted via inhalation, laboratories handling them must conform to Biosafety Level 3 standards. These standards are also defined for bacterial agents, fungal agents, parasitic agents, and viral agents, but include more virulent and toxic forms than Biosafety Level 2 materials.

Biosafety Level 4 agents are considered "dangerous and exotic…and pose a high individual risk to aerosol transmitted laboratory infections which result in a life threatening disease, or related agents with unknown methods of transmission." According to the infectious agents list, these agents require the most stringent conditions for their containment and are "extremely hazardous" to laboratory personnel or may even cause serious epidemic diseases. Not only are facilities and equipment critical in operation of Biosafety Level 4 laboratories, but the guidelines also call for "staff with a level of confidence greater than one would expect in a college department of microbiology, and who have had specific and thorough training and handling dangerous pathogens…"

Special exhaust requirements at BSL laboratories

Biosafety level laboratories (mainly levels 3 and 4) must incorporate many special design and engineering features to prevent microorganisms from being discharged into the environment. These design features could include specially shielded isolation rooms under negative pressure with sophisticated airflow, temperature, pressure, and humidity control and monitoring systems; they would also require 100% conditioned "makeup" air to prevent re-use of the ambient air within an enclosed facility.

Obviously the exhaust streams into the atmosphere (and the neighborhood) from laboratory workstations at these facilities must be treated carefully. For one reason, they may be highly toxic (or noxious) or both. Their danger to people covers a broad spectrum which might be mildly annoying to seriously unhealthy. In many cases even if the odors are not toxic, public tolerance for toxic odors has sharply decreased in recent years, partly because government agencies are continually setting more stringent standards, with allowable exposure limits dropping lower and lower. Obviously there is *no room for tolerance* with regard to possible contamination from some agents that are exhausted at BSL Level 3 and 4 facilities.

With regard to BSL laboratories and re-entrainment implications, Level 4 Biosafety laboratories are categorized with two different methods: "suit" laboratories and "glove box" laboratories. Glove box laboratories usually contain Class 3 biological safety cabinets. The entire laboratory is also housed inside a solid perimeter wall that serves as a physical barrier to keep microorganisms within the laboratory. BSL 4 laboratories are not too common, with probably only a few dozen in use around the world. These facilities incorporate many special design and engineering features to prevent microorganisms from being discharged into the environment. For example, a dedicated air supply and exhaust system is critical to safety as well as performance at BSL 3 and 4 laboratories. The heating, ventilation, and air conditioning (HVAC) system would typically be independent of all other supply and exhaust systems within the building; in other words, the air inside the research facility portion of the building must be fully conditioned and never re-used. In addition to conditioned "makeup" air, these laboratory facilities require safe and reliable methods of exhausting their workstations' fume hoods to eliminate re-entrainment and "containment" possibilities.

When specifying any workstation fume hood exhaust system for a biosafety level laboratory, redundancy in case of failure of any part of the exhaust system is critical. The pressure differentials on a Level 4 laboratory may require significant directional airflow differences from Level 2 laboratories. Also, Level 3 and Level 4 laboratories would typically be under negative pressure for safety reasons. In these cases the laboratories would incorporate an outside bypass damper to obtain the static pressure needed to overcome the effects of a highly efficient fume hood exhaust fan. By upsizing slightly from what is required of a mixed flow impeller fan, adequate static pressure is usually available. By using the bypass damper to add outside air at the rooftop, a constant volume is maintained in the biosafety laboratory.

Achieving desired airflow and pressure differentials is essential when designing and building BSL laboratory containment facilities. Exhaust systems at Level 4 laboratories typically incorporate high efficiency particulate air (HEPA) filters, usually mounted in series and placed as close as possible to the laboratory to minimize ductwork runs and the possibility of contamination reaching the roof mounted exhaust fans. This is obviously a critical area when, for example, an animal colony might be infected with a virus because of its propensity to migrate and infect other animal colonies. Mixed flow impeller systems permit regulated air flow in Level 3 and Level 4 laboratories. The self regulation introduction of outside air allows opening and closing of laboratory workstation fume hoods with uniform air flow.

With regard to IAQ and exhaust "containment" vs. re-entrainment, this is a popular and controversial subject. Some probable causes of "containment" include building ventilation/ductwork configuration and the equipment used at the laboratory workstation such as its exhaust fume hood and exhaust fan. IAQ problems – and lawsuits that might be associated with them – have been caused by both containment and re-entrainment issues.

Mixed flow impeller technology at BSL laboratories

At a Level 3 or 4 Biosafety laboratory – with possible serious implications associated with re-entrainment – and the high costs of energy required to condition makeup air, the use of mixed flow impeller technology for laboratory workstation fume hood exhaust has proved to be a practical solution to both of these issues. This technology offers substantial advantages over conventional centrifugal roof exhaust fans with dedicated, tall exhaust stacks on the roof (for preventing re-entrainment and efficiently exhausting the laboratory workstation environment).

Key factors for facility planning

Many biotech laboratories throughout the world study diseases in animals to help facilitate cures for human diseases. In addition to the dangers of possible viral contamination for humans (or other animals in a controlled environment), the use of animals for research usually creates odor control problems as well. Consequently there are three

EVERYTHING OLD IS NEW AGAIN

Mixed flow impeller technology is essentially based on a unique fan blade design configured for optimum performance in virtually all combinations of low pressure/high flow, high pressure/low flow, and other operating combinations to meet a wide variety of performance criteria. The technology originated in the late 19th century as a combination of axial, radial, and centrifugal flow technologies which existed for many years prior to that point. When it was originally developed it provided about 70% total efficiency (TE) performance (remarkable for that time); today its performance is more in the 80%+ TE region. Interest was revived in this technology a few decades ago, mainly as a result of increasing pressures for eliminating air pollution and improving indoor air quality. Over the past ten years or so it has been refined to such a high degree that most of the problems associated with centrifugal type fans have been eliminated. Modern mixed flow impeller systems accomplish the same purpose but do so a lot more efficiently (thanks, in part to their outstanding aerodynamic stability), and with substantial savings in operating and installation costs.

Characteristics of mixed flow impeller technology systems

Mixed flow impeller systems operate on a unique principle of diluting contaminated exhaust air with unconditioned, outside ambient air via a bypass mixing plenum. The resultant diluted process air is accelerated through an optimized discharge nozzle/windband where nearly twice as much additional fresh air is entrained into the exhaust plume before leaving the fan assembly. Additional fresh air is entrained into the exhaust plume after it leaves the fan assembly through natural aspiration effect. The combination of added mass and high discharge velocity minimizes the risk of contaminated exhaust being re-entrained into building fresh air intakes, doors, windows, or other openings.

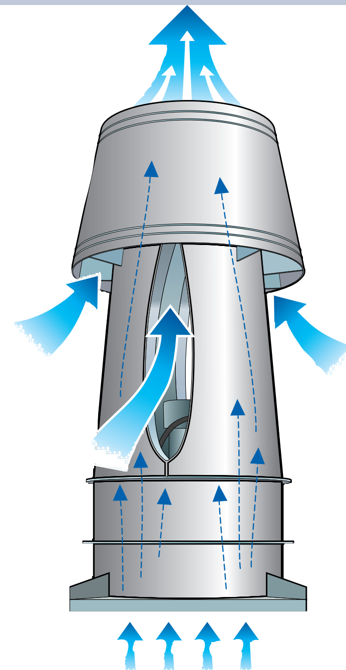
As an example, a mixed flow fan moving 80,000 CFM of combined building and bypass air at an exit velocity of 6300 feet per minute can send an exhaust air jet plume up to 120 feet high in a 10 MPH crosswind. This extremely high velocity exceeds ANSI Z9.5 Standards by more than twice the minimum recommendation of 3000 FPM. Because up to 170% of free outside air is induced into the exhaust airstream, a substantially greater airflow is possible for a given amount of exhaust – providing excellent dilution capabilities and greater effective stack heights over conventional centrifugal fans without additional horsepower.

Mixed flow impeller systems also reduce noise, use less energy, and provide enhanced performance with faster payback over conventional laboratory fume hood exhaust systems. A typical reduction of \$.44 per CFM at \$.10/kilowatt-hour provides an approximate two year R.O.I. Energy consumption for mixed flow fans is about 25% lower than conventional centrifugal fans with substantially reduced noise levels, particularly in the lower octave bands. They also conform to all applicable laboratory ventilation standards of ANSI/AIHA Z9.5 as well as ASHRAE 110 and NFPA 45, and are listed with Underwriters Laboratory under UL 705.

Mixed flow systems are designed to operate continuously with a minimum amount of required maintenance, providing years of trouble free performance under normal operating conditions. Direct drive motor bearings have lifetimes of L_{10} 100,000 hours. (This refers to a "sample" of 100 motors in which the bearings in ten motors {10%} would fail within a 100,000-hour timeframe. It is a baseline for comparison of motor bearing lifetimes.) Once a motor is integrated into a belt drive configuration, the bearing life can drop as low as L_{10} 40,000 hours. Non-stall characteristics of the system's mixed flow wheel make it ideally suited for constant volume or variable air volume (VAV) applications, along with built-in redundancy, and design flexibility. VAV capabilities are achieved via the bypass mixing plenum or by using variable frequency drives to provide optimum energy savings.

Virtually maintenance free operation (there are no belts, elbows, flex connectors, or spring vibration isolators to maintain) eliminates the need for expensive penthouses to protect maintenance personnel under adverse conditions. Consequently, additional savings of several hundreds of thousands of dollars may be realized in a typical installation.

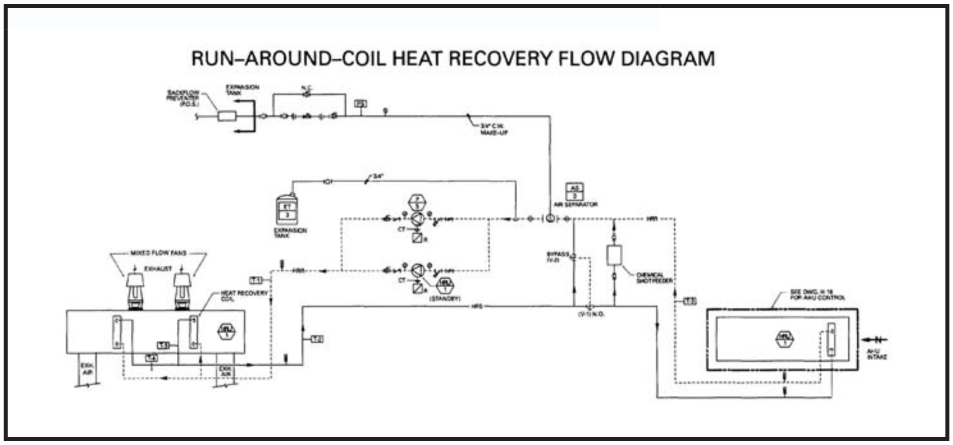
Mixed flow impeller systems are available with a variety of accessories that add value, reduce noise, and/or lower energy costs substantially. For example, accessory heat exchanger glycol/water filled coils for use in 100% conditioned makeup air facilities add exhaust heat to intake ventilation air to save thousands (or hundreds of thousands) of dollars in energy costs.



Typical mixed flow impeller system showing exhaust airflow mixing with – and diluted by – outside ambient air prior to atmospheric exhaust

key factors to consider when planning a new research facility – or retrofitting an existing facility: they include exhaust re-entrainment prevention, exhaust odor elimination in the neighborhood, and energy costs for system operation and building conditioning. Use of mixed flow impeller technology provides positive solutions to all of these issues, and others as well; it offers a practical, logical, and cost-effective approach where none exists now.

For example, until a few decades ago, most laboratory fume hood exhaust applications were handled by rooftop centrifugal fans with individually dedicated tall exhaust stacks. While this approach was adequate for many years (mainly because there weren't any practical alternatives), it also left much to be desired and thus presented a number of compromises at best. Among them are the need for expensive, complex mounting hardware (for the fans as well as their exhaust stacks), maintenance-intensive belt drives, inefficient performance (with regard to both pollution abatement and re-entrainment issues), high en-



A heat exchanger/mixed flow exhaust system schematic for exhausting laboratory workstation fume hoods while recovering ambient heat prior to atmospheric discharge.

ergy consumption, and undesirable noise levels at the property line. Add these shortcomings to a relatively new concern in many locations: that is, the sight of tall exhaust stacks on a building's roof which usually imparts negative connotations in a community – in other words, another neighborhood polluter!

Mixed flow impeller technology offers many special advantages

This situation has been changing rapidly, with continuing advances in mixed flow impeller technology (as applied to roof exhaust systems). Laboratory workstation fume hood exhaust systems incorporating mixed flow impeller technology virtually eliminate all of these compromises. Their low profile design (typically about 15' high vs. 25'+ for a conventional exhaust stack in many installations) eliminates the need for structural reinforcements on the roof. Because they are substantially shorter (and constructed modularly) than the tall, unsightly stacks they replace, their simplicity also helps reduce installation time and costs significantly. In fact, in many retrofit applications there is virtually no downtime associated with their installation.

Mixed flow impeller systems are designed to operate continuously for years with minimal maintenance. Unlike centrifugal-type exhaust fans there are no belts, elbows, flex connectors, or spring vibration isolators to maintain. In addition, expensive penthouses on the rooftop are not needed to accommodate maintenance personnel under adverse conditions.

In most cases centrifugal-type fans are mounted on rooftops, fully exposed to the elements. Consequently, for maintenance purposes many organizations construct "penthouses" to enclose these fans for weather protection, and to protect their maintenance workers from the elements. Penthouses can be quite expensive ($50,000 is not an unreasonable construction estimate). Mainly, however, working inside a penthouse can subject maintenance personnel to exposure to noxious and/or toxic fumes while adjusting or changing a belt.

Modular construction of mixed flow fans cuts installation time substantially– in fact, in many retrofit applications workflow at the laboratory workstation is not even interrupted – and the fans can be installed in as few as four hours, without the need for cranes, helicopters, or other heavy construction equipment. As a result, additional savings of several hundreds of thousands of dollars – over centrifugal type fans– may be achieved.

With regard to vibration issues – a key consideration with any roof exhaust system –mixed flow impeller fans offer substantial advantages over conventional centrifugal fans. Vibration can be broken down into two components: radial and axial. Because the radial vibration characteristics of mixed flow impellers parallel the building's roofline, there is a substantially lower axial component of vibration forced vertically onto the roof. On the other hand, in a conventional centrifugal exhaust system, the high radial component of vibration is forced directly down into the roof, thus necessitating requirement for complex, expensive mounting hardware to help protect the fan as well as the roof structure.

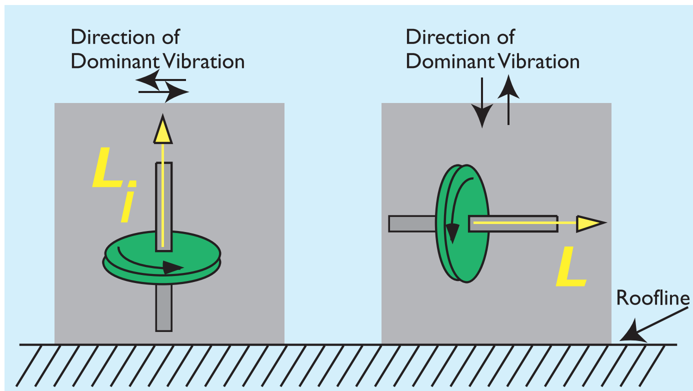


Figure A
Typical Mixed Flow Fan

Figure B
Typical Centrifugal Fan

The typical mixed flow fan transmits vibration parallel to the roofline.
The typical centrifugal fan transmits vibration directly down to the roof.

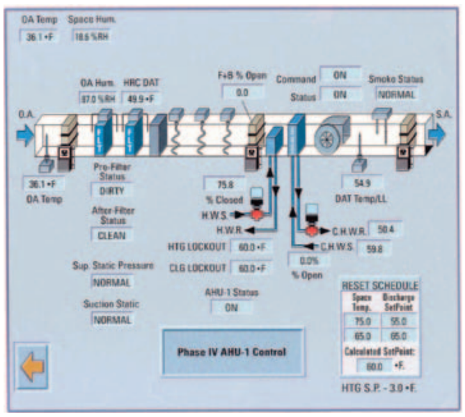
Low operating costs help the bottom line

Mixed flow impeller fans typically consume about 25% less energy than conventional centrifugal fans, and offer faster payback periods as well. Typical energy reduction is $0.44 per cubic foot per minute (CFM) at $0.10/kilowatt-hour, providing an approximate two-year return on investment in many installations. These numbers do not include the substantial energy savings they can provide for conditioned makeup air facilities required at virtually all Level 3 and 4 BSL facilities.

Ambient heat recovery saves thousands

In these "closed loop" facilities mixed flow impeller technology laboratory workstation fume hood exhaust systems can provide significant energy savings. Whenever any enclosed workspace requires 100% conditioned makeup air, savings in the thousands or even hundreds of thousands of dollars a year may be achieved by recovering ambient heat or cooled air from workstation fume hood exhaust before it is dispersed into the atmosphere.

By using heat recovery coils filled with a solution of glycol and water, heat or cooling energy is removed before workstation exhaust (along with ambi-



This status monitor screen for a mixed flow impeller/heat exchanger system shows outside air temperature at 36.1° F (2.3° C).

ent temperature room air) is discharged into the atmosphere. This "conditioned" air is added to the makeup air brought into the building's intake ventilation system. For each 1° F of heat added to makeup air by this method, energy costs are lowered about 3%. For colder climates, annual heating energy cost reductions of 30% or more are not usual. Similar savings, although not quite as dramatic, could be achieved for cooling.

Costs for 100% conditioned makeup air can be very high, in many laboratory environments exceeding $4/ft^3/year. Since energy costs represent a substantial part of a laboratory's operating budget – and since these costs have been rising rapidly – it makes sense to investigate the potential savings for both new construction and retrofitting.

The dilution solution for pollution abatement

Mixed flow impeller fans operate on a unique principle of diluting contaminated building or laboratory exhaust air with unconditioned, outside ambient air (See sidebar). A typical mixed flow fan moving 80,000 CFM of combined building and bypass air at an exit velocity of 6300 FPM can send a combined exhaust air jet plume up to 120 feet high in a 10 MPH crosswind. This extremely high velocity exceeds ANSI (American National Standards Institute) Z9. 5 Standards by more than twice the minimum recommendation of 3000 FPM. The jet plume disperses exhaust pollutants – and odors – high enough into the atmosphere to meet applicable pollution abatement laws and eliminate odor. Through their powerful vertical plumes – and exhaust stream dilution – mixed flow impeller fans prevent re-entrainment into the building's intake air ventilation system, doors, and windows.

Stack height aesthetics

Another consideration when retrofitting or designing new rooftop exhaust systems for laboratory workstation fume hoods, includes the aesthetics of stack height. Obviously the lowest possible profile not only eliminates the "smoke stack" look and negative connotations perceived by many people as mentioned previously, but may actually be required (in some jurisdictions) to conform to applicable ordinances. There are communities that restrict total building height and, by inference, the height of exposed stacks and other rooftop equipment. Elimination of tall, unsightly stacks (which are either prohibited by code or undesirable) is a worthwhile goal.

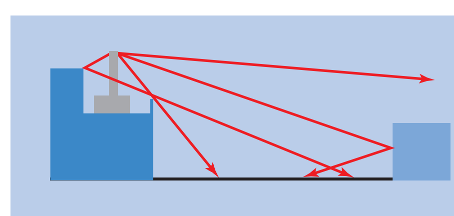
Fan noise can also create problems

The subject of fan noise – while not directly associated with IAQ – is also generating more interest since people are becoming more aware of unwanted noise from hundreds of sources in their daily lives. Many municipalities have laws that regulate noise beyond property lines. Centrifugal-type dedicated roof exhaust systems are generally noisier than mixed flow impeller-type systems (on a direct CFM comparison basis) because the mixed flow fans are typically in the mid-to-upper 80% efficiency range vs. the mid-to-upper 50% efficiency range for centrifugal fans (based on total efficiency – TE). Since sound is a function of efficiency, mixed flow technology fans are inherently quieter. In addition, noise generation caused by peripheral blade tip speeds also plays a role in performance sound levels, and mixed flow impellers rotate at substantially slower speeds than centrifugal fans for the same amount of work.

Most buildings contain at least two different noise sources with regard to exhaust and ventilation fans – the supply fans that provide conditioned air (HVAC) and the laboratory workstation/process exhaust fans mounted on the roof. Each of these systems is usually independent; and each requires a separate set of standards and criteria with regard to noise generation and/or minimization.

Exhaust acoustics are considered part of a building's aesthetics. Acoustical analysis of exhaust and ventilation systems early on, prior to installation, can help minimize the acoustic impact on surrounding areas. Obviously facilities managers do not want mechanical sound of exhaust fans to be heard within a building or at the property line whenever possible; exhaust fan noise should not be detectable in adjacent buildings as well.

To eliminate possible noise problems, many organizations, when building a new facility or refurbishing an existing one, look to independent noise study experts to help make determinations as to exhaust system operating noise levels, usually at the property line.



Sound path analyses are used to determine acoustic levels and patterns prior to system installation.

TABLE 1: Fan sound calculations

Frequency	63Hz	124Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
Sound power split	-3	-3	-3	-3	-3	-3	-3	-3
Corrections for four fans running	6	6	6	6	6	6	6	6
Corrections for 48 in. outlet silencer	0	-5	-11	-14	-15	-15	-10	-6
Sound pressure levels	88	96	91	89	87	84	84	91
Corrections for 150 ft. distance	-41	-41	-41	-41	-41	-41	-41	-41
Sound-pressure levels (150 ft. distance)	47	55	50	48	46	43	43	50
'A' scale corrections	-26	-16	-9	-3	0	1	1	-1
dB'A' spectrum (150 ft. distance)	21	39	41	45	46	44	44	49
Net sound level (150 ft. distance)	**53 dB'A'**							
Field reading (150 ft. distance)	**50 dB'A'**							
Corrections for 300 ft. distance	-47	-47	-47	-47	-47	-47	-47	-47
Sound pressure levels (300 ft. distance)	41	49	44	42	40	37	37	44
'A' scale corrections	-26	-16	-9	-3	0	1	1	-1
dB'A' spectrum (300 ft. distance)	15	33	35	39	40	38	38	43
Net sound level (300 ft. distance)	**47 dB'A'**							
Field reading (300 ft. distance)	**40 dB'A'**							

Typical sound specifications based on distances of 150 ft. and 300 ft. Using these numbers, objectionable sounds may be abated by introducing sound attenuators.

This is a narrow specialty, and there are only a few architectural acoustics firms that perform these kinds of studies. One of them, Kvernstoen, Kehl and Associates, in Minneapolis, has performed noise studies throughout the country. Their engineers and technicians gather 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 (which are also becoming more stringent) for permitted noise levels at the property line – especially at night – must also be considered.

Both intake and exhaust outlets can be equally noisy. Kvernstoen Kehl uses data and models that predict sound that might occur in various places. This can become complex because "shadowing of the building element, not the roof itself" creates an "acoustic shadow" for people close to the building. As a result the company analyzes all elements on the roof (penthouses, other equipment, or parapets) that can create an acoustical shield and thus possibly eliminate the need for external abatement.

Once preliminary studies are completed, 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 first, what levels of sound are generated by the proposed exhaust fans; and, second, if they exceed recommended noise levels, what options are available for abating noise at the fans and reducing discharge noise.

Noise abatement alternatives

If mixed flow impeller type fans are employed, and noise is still an issue, there are also accessories available to reduce sound generated at the property line. These typically include acoustical screens and/or louvers, chevron screen walls, and nozzle silencers that use a combination of sound absorption material as well as special airflow patterns for passive noise abatement.

Conclusion

There are hundreds of pollution control standards that must be addressed when considering dedicated roof exhaust systems. In addition to guidelines from the Occupational Safety and Health Act (OSHA) and regulations from the Environmental Protection Agency (EPA), there are ventilation standards of American National Standards Institute (ANSI), American Industrial Hygiene Association (AIHA), ASHRAE, National Fire Prevention Association (NFPA), and others; there are also Underwriters Laboratory standards to be met.

While hundreds of exciting medical breakthroughs have been achieved by diligent research at sensitive biotech laboratory facilities, one must be aware of the negative implications associated with them as well with regard to potential dangers to workers and neighbors. This issue has become especially more important in light of today's litigious culture, as well as ever-more-stringent environmental and safety laws set by regulatory agencies at all levels. Whether planning a new BSL laboratory (or, for that matter, any research facility) or retrofitting an existing laboratory, mixed flow impeller technology offers an attractive approach for workstation exhausting requirements. Its proliferation at research facilities of all kinds over the past few decades is indicative of the many benefits the technology offers.

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