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The Science of Safe Laboratories:

UNDERSTANDING VENTILATION SYSTEMS

BY KASEY FULMER

SAFETY FIRST: As the wheels of scientific progress ceaselessly turn, work in laboratories worldwide continues to be dynamic, exciting, and yes, potentially hazardous. In this ever-evolving scientific landscape, the importance of an effective laboratory exhaust system cannot be overstated. For lab managers and facilities personnel, understanding the functionality of these systems and their integration with the broader heating, ventilation, and air conditioning (HVAC) infrastructure is not merely a professional mandate, it's a vital component of risk mitigation.

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Critical Components

A chemical fume hood is an enclosure designed to draw air away from the laboratory space, capturing and exhausting potentially harmful emissions. As an essential component of laboratory safety, its functionality depends heavily on several factors, including directional airflows and air changes per hour (ACH).

Directional airflows are required for controlling the movement of contaminants within a building's lab. By strategically establishing proper airflow patterns, such as negative pressure zones and unidirectional flows, facilities can effectively contain airborne particles, hazardous gases, and fumes generated during experiments, redirecting them away from occupied areas. This proactive approach prevents the spread of contaminants throughout the building and minimizes the risk of exposure to lab personnel.

Lab ACH also plays a critical role in ensuring a safe and healthy environment. Higher ACH values can be desirable as they effectively remove airborne contaminants and introduce fresh, clean air. Fume hoods play a crucial role in determining lab ACH, as they typically require a substantial ventilation rate. Leveraging this advantage, fume hoods can help achieve desired ACH values without the need for additional general exhaust equipment. Integrating fume hoods into the lab's ventilation system also effectively removes contaminants at the source, ensuring the air remains clean and safe for lab occupants.

Understanding and managing these variables is the first step in risk mitigation. A fume hood, however, is only as good as the exhaust system supporting it, which in turn, is part of the larger HVAC infrastructure of the building.

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The Role of HVAC in Lab Safety and Quality

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The HVAC system's role in managing the overall building pressure relationships can significantly impact the performance of the fume hood. Negative pressure in the lab, relative to adjoining areas, ensures that air—and any contaminants—flow into the lab, not out of it, when doors are opened. When fume hoods are on and operating, air is pulled through them via a blower, creating a negatively pressurized environment to protect users from harmful vapors. Engineering the mechanisms for proper air exchange and filtration for a lab as well as the adjacent building spaces is a highly complex undertaking.

Secondly, the HVAC system can help manage the temperature and humidity within the lab. An optimal indoor climate ensures that the performance of the fume hood and the comfort of laboratory personnel are not compromised. Electrical appliances contribute to higher temperatures in the rooms where they are operated; therefore, climate control and ventilation must be monitored and maintained in a perfectly balanced system. Such balance requires an advanced exhaust system that is capable of communicating with building management systems (BMS). This integration enables effective communication and coordination between the exhaust system and the broader infrastructure, ensuring optimal performance and streamlined operations.

Finally, a well harmonized integration facilitates superior energy management.

With advanced HVAC systems capable of adjusting ventilation levels based on occupancy and actual need, total energy consumption can be significantly reduced. This reduction not only translates to cost savings, but also decreases the overall environmental footprint of the lab. Saving costs by reducing energy consumption is a win-win situation, aligning with the cutting-edge laboratories currently being installed at top-tier institutions and setting new benchmarks in sustainability and innovation.

Achieving Excellence in Air Quality Management

The secret of creating a harmonious integration lies in the design phase, considering the HVAC system and the laboratory exhaust system in tandem, rather than as separate entities. The inclusion of variable air volume (VAV) controls, for instance, can adjust fume hood exhaust and room supply volumes based on real-time requirements. Likewise, adopting innovative technologies like predictive analytics and internet of things (IoT) can help monitor and optimize these systems in real-time. Building and facility managers of our nation's universities must carefully consider technology solutions that seamlessly integrate with any BMS. Such integration ensures compatibility and ease of operation, even in those institutions that currently operate indoor airflow without such a system.

Laboratories undergoing renovations and new installations require flexible yet innovative exhaust solutions that are more effective and efficient than ever before. Optimal performance while achieving energy efficiency is possible without cutting corners.

Fume hood selection should focus on critical variables such as face velocity, rate of air going through the fume hood (CFM) and the types of applications to be used.

Rooftop blowers should provide status indicators and diagnostics such as RPM, temperature, and alarm codes; they should also be flexible enough to accept signals from alternative types of BMS.

The safety and efficiency of a modern laboratory hinge on the effective integration of fume hoods, exhaust systems, and HVAC infrastructure. As stewards of these critical spaces, lab managers and facilities personnel carry the crucial task of understanding, managing, and optimizing these systems. After all, the breadth of safety in a laboratory is as indispensable as the breadth of innovation it fosters.

ABOUT THE AUTHOR: Kasey Fulmer is the product specialist for fume hoods, furniture, and exhausters at Labconco Corporation. Fulmer has worked with architects, lab planners, and individual fume hood operators in his role at Labconco from the initial design phase to installation. He has a Bachelor of Science in Mechanical Engineering from University of Missouri-Kansas City.