FUME HOODS 101

Understanding the Fundamentals of Safe Laboratory Containment

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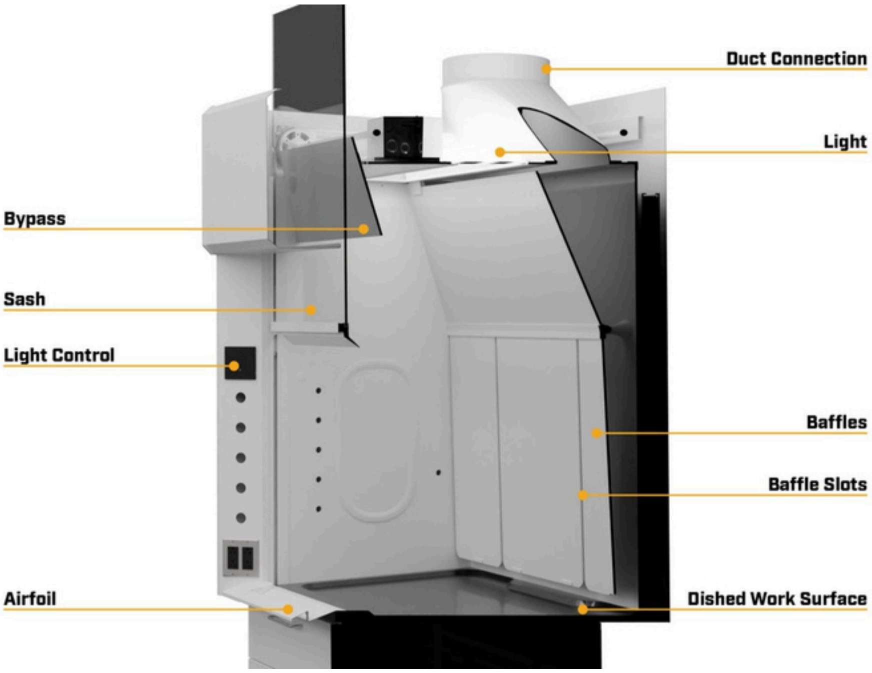
FUME HOODS: THE BASICS

In the world of chemistry and materials science, things can get messy, smelly, and often a bit toxic. Managing the contaminants in the lab space is key to maintaining safety. Fume hoods perform a key role in controlling airborne contaminants generated by lab processes.

A fume hood is a ventilated enclosure designed to capture, contain, dilute, and exhaust hazardous fumes, vapors, and particulate matter. By drawing air away from the user and out through an exhaust system, it creates a physical and pneumatic barrier between the user and the chemistry. Physically, a fume hood comprises a box with a movable sash, an exhaust duct connection to provide ventilation, baffles to influence the airflow, an airfoil to sweep contaminants from the worksurface, a monitor or controller to indicate safe airflow, a light fixture to illuminate the interior, and electrical and plumbing fixtures required for the processes (see Figure 1).

A fume hood should be used when handling volatile liquids or gases, odorous chemicals, toxic or flammable materials, and dusty powders that could become airborne. Other hazards entail risks that require alternative containment devices. For example, work with biological agents is performed in a biosafety cabinet (BSC), which uses HEPA filters to remove contaminants from the exhaust air. A glovebox is used where total isolation is required due to the extreme toxicity of the materials or process. A laminar flow hood employs a HEPA filter to provide clean air for the sample but provides limited to no protection for the user. It is vital to understand the risks involved to ensure the right device is selected to protect the user.

Figure 1
Diagram of common fume hood components.



TYPES & CONFIGURATIONS

Not all fume hoods are created equal; different types serve different applications. Most standard chemical processes can be performed in a general-purpose fume hood, which is equipped with corrosion-resistant liners suitable for most applications. Perchloric acid hoods are intended for use with perchloric acid. Since perchloric acid can form explosive salts and is incompatible with organic materials, special liners and a wash-down system for the hood and ductwork are required. Radio-isotope hoods are intended for work involving radioactive substances. The liners are typically stainless steel for washability and reinforced to support lead lining. Acid digestion hoods are designed for processes involving heating acids. The fumes generated are buoyant and highly corrosive, requiring an acid-resistant polypropylene construction and modifications to manage the high heat load. Additional highly customized hoods are available for specialized use. However, the correct hood must be selected for the application.

Once the correct hood is selected for the application, the hood configuration can be considered. While this is highly influenced by the hood type, several options are generally available for fume hood size and sash configuration. Fume hoods can be broadly divided into two categories based on size: bench-top and floor-mount hoods. Bench-top hoods are installed on casework or benches with the work surface at the tabletop level. Floor-mount hoods are installed at floor level and are taller than bench-mount hoods to accommodate larger apparatus and equipment. In the past, floor-mount hoods were erroneously referred to as “walk-in” hoods because of their size. However, users should never enter a floor-mounted fume hood while it is in active operation.

For sash configuration, three main types predominate, although more complex custom configurations also exist. The most common configuration is a vertical sash: a single glass panel that slides up and down to increase or reduce the opening. Another common configuration is a horizontal sash, which consists of multiple glass panels that slide left or right in a track to increase or reduce the sash opening. Combination sashes, or combo sashes, incorporate horizontal glass panels mounted in a track assembly that can move vertically. Combo sashes provide flexibility for the user to determine the sash opening. An advantage of horizontal panels is that they can be used as a splash shield between the user and the processes inside the hood while working.

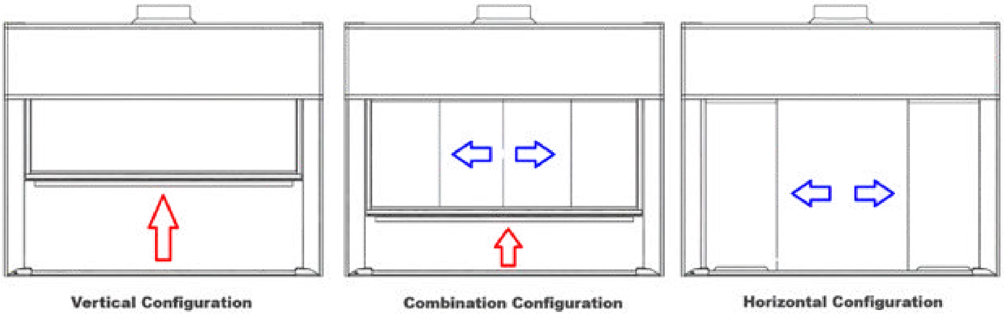


Figure 2
Diagrams of typical sash configurations.

BEST PRACTICES FOR SAFETY

A fume hood is only as safe as the person using it. Best practices should be followed to maximize containment, which include:

- **Verify Exhaust Before Use:** Always check the hood's airflow using the provided monitor, controller, or indicator to ensure it has the appropriate exhaust.
- **Heads Up:** Keep your head out of the hood interior to prevent the user's breathing zone from entering the contaminated area.
- **The 6-Inch Rule:** Always perform work at least 6 inches inside the sash to ensure vapors are captured.
- **Keep it Low:** Keep the sash at the marked "working height" (usually 18 inches) or below. Lower is typically better.
- **Clutter is the Enemy:** Do not use the hood as a storage cabinet. Large items block airflow and create "dead zones." Large equipment should be placed on blocks and spaced from the rear baffle slots to minimize impact on airflow.
- **Slow Transitions:** Avoid rapid movements in front of the hood, which can "pull" contaminated air out into the room. Walkways should be spaced a minimum of three feet from the sash opening.

Following these basic steps will increase the safety and efficacy of the fume hood. Further instruction and guidance should be provided by the facility's Environmental Health and Safety (EH&S) staff.

PERFORMANCE & ENERGY

Prior to initial use, fume hood performance must be verified by testing. The primary method for fume hood performance testing in North America is prescribed by the ASHRAE 110 standard. ASHRAE 110 outlines the procedure to measure and verify the face velocity to ensure proper exhaust volume and face velocity (ANSI/ASHRAE 110-2016). It goes on to provide methods for visualizing the airflow utilizing smoke generators to determine weak performance areas. Most critically, it prescribes a method for introducing a tracer gas into the fume hood interior and measuring the escape into the breathing zone of a manikin positioned at the hood face. The tracer gas test simulates a user performing a general process in the hood and defines a quantitative measure of fume hood performance.

While ASHRAE 110 provides a base test method, more rigorous revisions of the test method exist to provide stringent benchmarking and enhanced safety, including the University of Wisconsin (UW) test method that introduces additional challenges, such as cross drafts and loading the interior volume. Recurrent testing is generally recommended at a minimum on an annual basis to ensure the hood continues to operate according to specification.

However, safety comes at a cost. Fume hoods are widely recognized as one of the largest energy consumers in laboratory environments. A typical 6' bench-top hood operating continuously consumes as much energy as three to four average homes because of the massive amount of conditioned air it exhausts (Mills and Sartor, 2005). To mitigate this, many modern labs use Variable Air Volume (VAV) systems that reduce airflow when the sash is closed or the space is unoccupied. VAV systems require additional sensors, controls, and valves compared to conventional ventilation. The upfront capital cost and the ongoing degradation and maintenance required must be balanced against the promised energy savings to determine if a VAV system is appropriate. Typically, VAV systems are installed in labs with high fume hood density, where the expected energy consumption is high enough to justify the additional cost. Above all, the reduced airflow must not impair the ability of the hoods and ventilation to provide adequate safety for the users. Safety must always come first.

Fume hoods are important tools for controlling contaminants in labs. Understanding the components, types of fume hoods, and airflow characteristics will help users select the right tool for the job. Correct implementation and use of fume hoods protect safety while facilitating research and enabling discoveries.

REFERENCES

Wilburn Larson is an Industrial Hygienist for Kewaunee Scientific. He helps design, test and support fume hoods and related equipment.

Wilburn is a member of ASHRAE, NFPA, ASTM and active in SEFA where he works to shape new standards regulating laboratory equipment and design.

ABOUT THE AUTHOR

ANSI/ASHRAE Standard 110-2016, Methods of Testing Performance of Laboratory Fume Hoods.

Mills, E., & Sartor, D. (2005). Energy use and savings potential for laboratory fume hoods. Energy, 30(10), 1859–1864. https://doi.org/10.1016/j.energy.2004.11.008

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