Laboratory guide to

Fume Hoods

An industry service publication

Selecting the Proper Fume Hood

About this guide

This guide was developed to serve as an aid in selecting a laboratory fume hood ventilation system. The information presented is generic in nature and compiled with help from experienced architects, laboratory consultants, engineers and laboratory hood users. The basic understanding of hood systems you gain should prove valuable to you as you discuss your needs with safety officers, engineers and hood manufacturers.

What is a laboratory fume hood?

A **laboratory fume hood** is a safety device purposed to capture, contain and remove undesirable effluents (generated within the hood during a laboratory procedure), preventing their escape into the laboratory. This is accomplished by drawing contaminants within the hood's work area away from the operator, so that user exposure is minimized or eliminated.

The flow of protective air into a hood is created by an exhaust blower that "pulls" air from the laboratory room into and through the hood and exhaust system. The speed of this "pull" at the opening of the hood is measured as face velocity. A rear baffle, lower air foil and/or other aerodynamically designed components control the pattern of air moving into and through the hood. Contaminated air within the hood is then diluted with room air and exhausted through the hood's duct system to the outside where it can be adequately dispersed at an acceptably low concentration, or filtered and recirculated back into the room in the case of filtered fume hoods.

The proper selection and set-up of a chemical fume hood is critical to the health and safety of laboratory personnel. This document attempts to assist the reader in defining responsibilities among the various professionals involved in laboratory design, explain the differences in mechanical systems required to provide safe airflow through a fume hood, and identify the most prevalent types of fume hoods based on application.

Our method

As you read through the material, remember you are selecting a **laboratory hood system**. A fume hood does not function alone. A variety of factors external to a hood influences its performance. Likewise, a hood and the applications performed inside it can also affect its surroundings. When selecting a fume hood, you must consider the whole picture—the laboratory space, the building's ventilation system, the hood's location in the room, to name a few.

While this guide will raise the questions necessary to identify your specific hood requirements, it may not answer every question. Only you, your safety officer or industrial hygienist, and a qualified design consultant can identify your laboratory's unique challenges and set up a proper **Chemical Hygiene Plan**.

Defining Responsibility

All fume hood application projects must start with an engaged environmental health and safety person(s) familiar with the procedures, chemicals, and risks associated with the application. The United States Code of Federal Regulations 29, 1910.1450 defines the safety responsibility as lying with the owner, and is largely performance based. This is a Federal Regulation enforceable by OSHA. It notes that "…the employer shall assure that laboratory employees' exposures to…substances do not exceed the permissible exposure limits…"[1] The employer (owner, or institution) needs to make their own plan on how to do this, which shall include a **Chemical Hygiene Plan** (CHP), and a Chemical Hygiene Officer (CHO) responsible for executing the plan. The CHP should include a risk assessment, required hood types, certification schedule, pass/fail criteria for testing, test methods, minimum hood airflows, room air exchange rate, and more.

If a lab planner or architect is commissioned to assist in lab design, one of their responsibilities is the development and documentation of the owner's project requirements. As it relates to chemical fume hoods, they often advise the owner of the need to execute the risk assessment process and CHP development. The lab planner will assist the owner in the specification of fume hoods that meet the material of construction, dimensional, and containment criteria detailed in the CHP. Being the conduit of information between the owner's safety team and the mechanical design consultant, the architect is also responsible for converting safe airflow criteria to mechanical system design criteria. This is done by converting the face velocity criteria defined in the CHP to minimum volumetric rate (CFM) requirements from the basis of the design fume hood manufacturer.

The mechanical engineer or mechanical consultant is responsible for designing a mechanical system and building controls that meet the safe airflow criteria as provided by the architect, as well as all other mechanical system design factors. This includes the sizing and selection of basis of the design mechanical system equipment.

Once the fume hood is installed and mechanical system operational, an air balancing should take place to ensure that all building airflows are consistent with the mechanical design. Following the air balancing of the building, a fume hood certification procedure shall be commissioned by the Chemical Hygiene Officer (owner), to ensure the safe airflow and containment criteria defined in the CHP was achieved.

Who is responsible for what?

The proper selection and set-up of a chemical fume hood is critical to the health and safety of laboratory personnel.

This document attempts to assist the reader in defining responsibilities among the various professionals involved in laboratory design, explain the differences in mechanical systems required to provide safe airflow through a fume hood, and identify the most prevalent types of fume hoods based on application.

1. 1910.1450(c) Permissible exposure limit

Laboratory Exhaust Systems and Types of Hoods

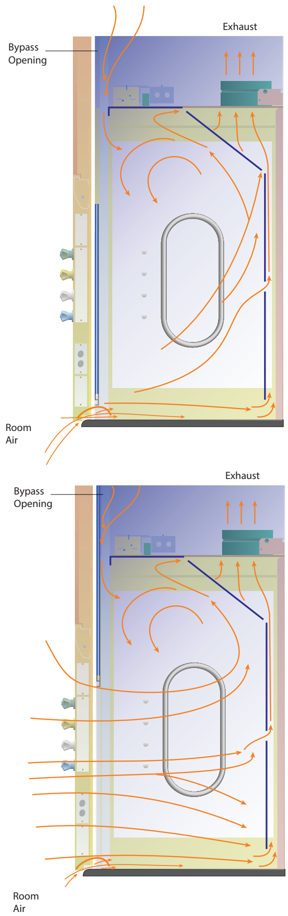

Figure 1: Bypass hood with sash open and closed

Bypass

Bypass hoods are designed so that as the sash is closed, the air entering the hood is redistributed through alternate openings above and below the sash (**Figure 1**). This minimizes the potential for high velocity air streams typically encountered in non-bypass hoods, which can cause significant turbulence within the hood. Reduction in face velocity fluctuation is accomplished by utilizing bypass openings above the sash and below the lower air foil. The size of the bypass will depend on the type of mechanical system serving the hood (see CAV and VAV below). This allows the face velocity in bypass hoods to reach proper levels that might otherwise be detrimental to various laboratory procedures.

Reduced air volume (RAV)

A variation of the bypass hood, the **RAV hood** uses a bypass restriction to partially obstruct the bypass opening above the sash to reduce the air volume exhausted. Less air exhausted means a higher conservation of energy. RAV hoods are often used in conjunction with a sash stop which limits the height the sash may be opened during normal use. This smaller opening means the hood demands less air volume to achieve a safe face velocity (**Figure 2**). Alternatively, these hoods may use combination sashes to achieve lower air volumes. Since these hoods require less air volume than bypass hoods of the same size, they require smaller blowers, which can be another cost saving advantage.

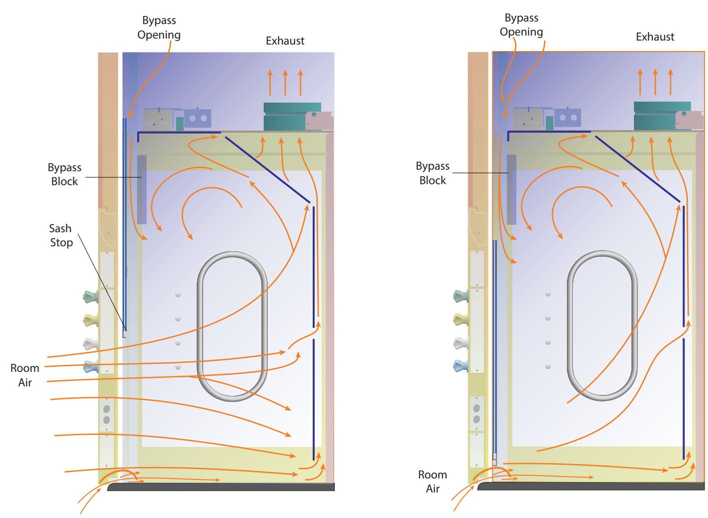

Figure 2: Reduced air volume hood with sash stop and bypass block shown with sash open to sash stop position and sash closed

Auxiliary Air

Developed out of the need to reduce energy consumption in laboratories, the **auxiliary air** design has inadvertently put energy reductions ahead of user safety. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards* is the foundation for, and is cited in, the *Federal Register 29 CFR 1910* which is enforceable by OSHA. According to this publication (section 9.C.2.9.3.5) "they [auxiliary air hoods] were intended to introduce unconditioned or untempered air, as much as 70% of the exhausted, directly to the front of the chemical hood. Ideally, this unconditioned air bypasses the laboratory and significantly reduces air-conditioning and heating costs. In practice, however, many problems are caused by introducing unconditioned or slightly conditioned air above the sash, all of which may produce a loss of containment."

The purpose of a fume hood is to protect laboratory personnel when working with hazardous chemicals or vapors. *Prudent Practices* also states "quantitative tracer gas testing of many auxiliary air fume hoods has revealed that, even when adjusted properly and with the supply air properly conditioned, significantly higher personnel exposure to the materials used may occur than with conventional (non-auxiliary air) hoods. They [auxiliary air hoods] should not be purchased for new installations, and existing ones should be replaced or modified to eliminate the supply air feature." This sentiment is also shared with other respected standards such as ANSI Z9.5 as it states in section 3.2.1 that "auxiliary supplied air hoods are not recommended…"

Should you encounter an auxiliary air fume hood, there are steps to replace them. Begin with conducting a Health and Safety risk assessment to determine the required fume hood volumetric rate, face velocity, and containment criteria for the application. Include this in the Chemical Hygiene Plan for the lab space. Next, identify a new fume hood that meets the safe airflow criteria defined in the Chemical Hygiene Plan. High Performance fume hoods and/or reduced sash openings should be explored due to typical limitations on mechanical system supply air capacity. Most fume hood manufacturers will have air volume (CFM) and related face velocity (fpm) information readily available.

After the proper hood is identified, determine all the needed changes to the building's ventilation system to supply safe airflow. This includes decommissioning the auxiliary air supply to the hood, adjusting the supply air to the laboratory and fume hood exhaust (potentially replacing the exhaust blower). In the simplest cases, the current exhaust air minus the auxiliary air, is equal to (or greater than) the minimum airflow for the new system. Under these circumstances, after eliminating the auxiliary air supply, the only mechanical system change is a reduction to the fume hood exhaust air. Alternatively, a more radical redesign will include evaluating sophisticated variable air volume controls with your mechanical system overhaul.

The result is a balancing of the supply and exhaust without the use of auxiliary air, and a much safer laboratory environment. Certification of the newly installed fume hood will ensure the fume hood and system is operating properly and is ready for use.

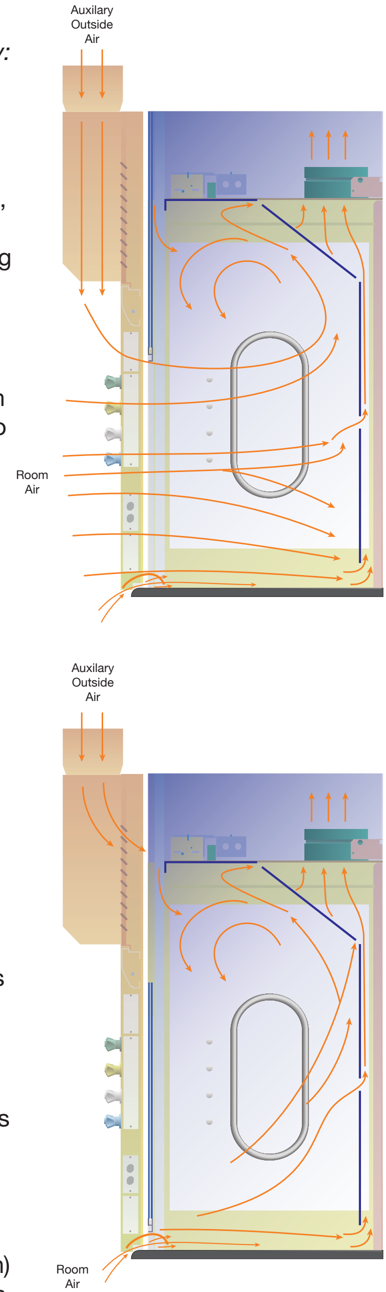

Figure 3: Auxiliary air hood with sash open and closed

High Performance

Another variation of the bypass hood, the **High Performance** hood (also referred to as a "Low Velocity" hood) relies on containment-enhancing features to maintain safety while reducing energy consumption. These design features, which vary by manufacturer, may include small fans which introduce air that acts as a barrier in the operator's breathing zone; a combination of aerodynamic and anti-turbulence elements such as a dual baffle system with a pattern of variable-sized slots to provide laminar flow through the hood, turbulence reducing airfoils, slotted sash handles, and many others (**Figure 4**). By definition, the advanced containment of a High Performance hood is required to be tested at face velocities no greater than 60 feet per minute (fpm) while maintaining a full open sash of 25 inches or greater. (SEFA 1)

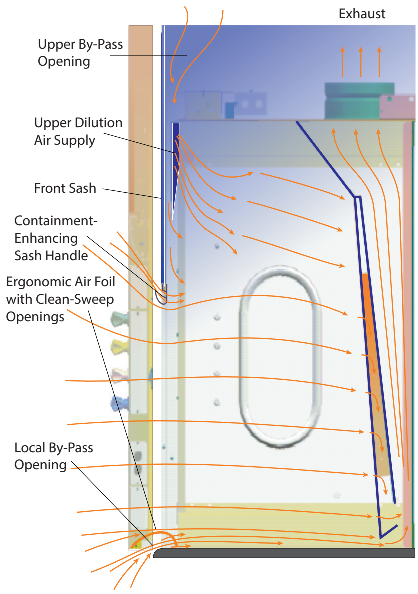

Figure 4: High performance bypass airflow design

Hood Mechanical Systems: CAV, VAV, and Filtered

Constant Air Volume (CAV)

Types of CAV hoods:

- **Bypass**
- **RAV**
- **Auxiliary Air**
- **High Performance**

Hoods prepared for a Constant Air Volume (CAV) mechanical system are always of the bypass type, and are designed so that as the sash is closed, the air entering the hood is redistributed through alternate openings. For a hood to function on a CAV mechanical system, the sash shall not act like a valve or a throttle. With constant airflow (volumetric rate) across all sash positions, an open bypass hood will not induce a change in static pressure, but will see an increase in face velocity with reduced sash openings.

Variable Air Volume (VAV)

Variable air volume (VAV) hoods vary the amount of exhaust air while maintaining a constant face velocity. To do this, various methods are used such as including having a valve or damper in the duct work that opens and closes based on airflow and sash position, as well as varying blower speed to meet air volume demands. When multiple hoods share one common exhaust blower, both methods may be used.

Fume hoods with VAV systems generally include a modified bypass system with bypass restriction that ensures that sufficient airflow is maintained to adequately contain and dilute fumes even at low sash positions (**Figure 5**).

VAV hoods have electronics that are connected to the building's heating, ventilation and air conditioning (HVAC) system for monitoring hood exhaust air and controlling laboratory air supply from a central location.

Face velocity is often-times specified as a strict requirement as it pertains to fume hood operator safety. One major benefit of the VAV hood is that they offer a consistent face velocity regardless of sash position. In addition, most VAV systems feature a monitor or alarm to alert the operator of unsafe airflow conditions.

Initial start-up costs may be higher due to building alterations, but VAV hoods can offer substantial energy savings over traditional constant volume hoods. With sashes in the closed position, hoods on a VAV system will consume significantly less air than their CAV counterparts. When considering energy reductions, importance must be placed on determining the lowest airflow required to maintain safety while the hood is in the closed position. This is often referred to as the "VAV minimum" and this determination is the responsibility of the laboratory's Chemical Hygiene Officer. Standards such as ANSI Z9.5, however, can provide helpful guidance as it relates to these minimums. In section 3.3.2 of this standard, it is stated "where attempting to save energy… minimum fume hood flow rates in the range of 150-375 hood air changes per hour (ACH) have been used to control vapor concentrations inside the hood interiors." An overstatement cannot be made when outlining that this is just guidance provided by the standard; the required ACH for specific applications may be found to require more or less than these values upon completion of a thorough risk assessment.

Types of VAV hoods:

- **Restricted Bypass Varieties**
- **RAV**
- **High Performance**

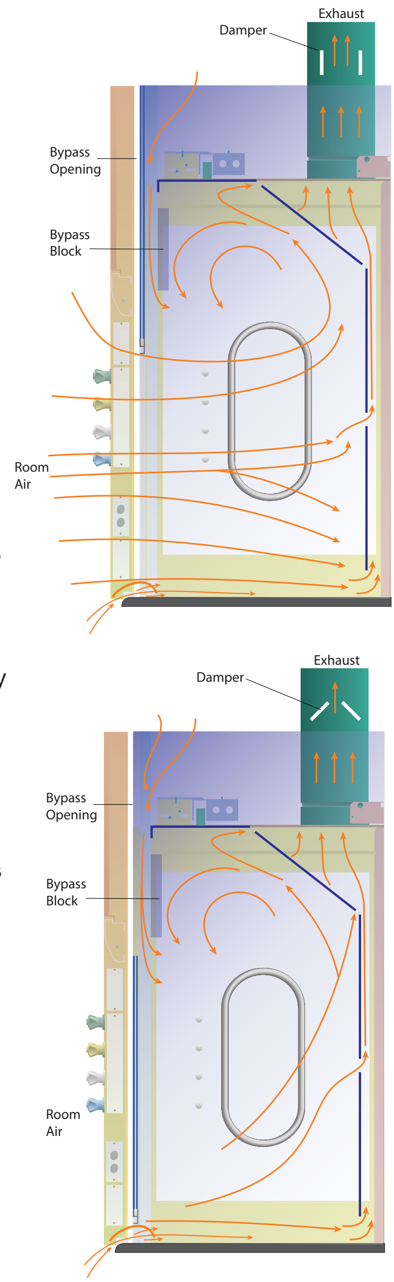

Figure 5: Variable air volume hood with damper control and modified bypass

Ductless (Filtered) Fume Hoods and Enclosures

As the name implies, **ductless fume hoods and enclosures** are not connected to an exhaust system. These hoods utilize filters to trap vapors and fumes before air is recirculated to the room. The filters are usually made of specially treated or activated carbon media that treat or adsorb chemical fumes including certain organic solvents, ammonia, acids and formaldehyde. Filter types and capacities can vary widely between manufacturers. Since these enclosures recirculate filtered air back into the laboratory, they often have a built-in mechanism to alert the user to unsafe concentrations of chemicals detected in the exhaust area of the filters.

Filtered fume hoods can be identified by one of three classifications defined by SEFA 9, which refers to the DH (ductless hood) classification. This classification is dependent on the presences of chemical sensors and additional means of backup filtration. The lowest classification, DH I, requires the hood to have a filtration device designed to control non-toxic chemicals, nuisance odors and particulates. The next classification, DH II, meets the same requirements as the DH I but is equipped with a chemical sensor to determine if chemical break-through is occurring. Finally, the DH III meets the same requirements as the DH II but is also equipped with a secondary back up filter, of the same type and efficacy as the primary filter, to provide a period of operational safety after primary filter break-through is detected.

Echo Filtered Fume Hood

Ductless fume hoods and enclosures can provide a practical solution for laboratories where ducting may not be feasible. Since ductless hoods are portable, they may be suitable for temporary installations and stored out of the way when not in use. Since the use of filters means ducting isn't required, these hoods can be placed on adjustable height base stands and easily lowered for use by wheelchair-bound individuals. Ductless hoods and enclosures are recommended only for applications where a chemical assessment has confirmed the compatibility of the filters with the application in which they will be applied. Since different filters may be required for different chemicals, the enclosures are generally restricted to repetitive applications and procedures involving a limited number of chemicals. Filtered fume hoods and ductless enclosures are not recommended for highly toxic or carcinogenic materials. The careful and regular monitoring by a safety officer is essential to the safe operation of these ductless hoods.

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Printed in the U.S.A.
Product design subject to change without notice.

3-53-03/03/2021