

Scientific Equipment & Furniture Association

**SEFA 1-2020**

**Laboratory Fume Hood Standard**

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## Foreword

### SEFA Profile

The Scientific Equipment and Furniture Association (SEFA) is an international trade association comprised of manufacturers of laboratory furniture, casework, fume hoods and members of the design and installation professions. The Association was founded to promote this rapidly expanding industry and improve the quality, safety and timely completion of laboratory facilities in accordance with customer requirements.

### Selecton and Management Guide to Exposure Control Devices

In 2018 SEFA published the *Selection and Management of Exposure Control Devices in Laboratories*. This is a comprehensive guide for all types of exposure control Devices (ECD's) and is designed to assist end-users, specifiers, lab planners and architects in determining the most appropriate ECD's for particular lab environments. This guide is published as an appendix to SEFA 1.

### SEFA Standards

SEFA and its committees are active in the development and promotion of Standards having domestic and international applications. Standards are developed by the association taking into account the work of other standard writing organizations. Liaison is also maintained with government agencies in the development of the specifications.

SEFA's Standards are developed in and for the public interest. These practices are designed to promote a better understanding between designers, architects, manufacturers, purchasers, and end-users and to assist the purchaser in selecting and specifying the proper product to meet the user's particular needs. SEFA's Standards are periodically updated. The Standards are numbered to include an annual suffix which reflects the year that they were updated. SEFA

encourages architects to specify this Standard as follows: "SEFA 1-2020 Fume Hood Standard."

**PLEASE NOTE ON NOVEMBER 7, 2025 AT SEFA'S ANNUAL CONFERENCE THE MEMBERSHIP UNANIMOUSLY APPROVED CHANGING THE NAME OF THIS DOCUMENT FROM "SEFA RECOMMENDED PRACTICES" TO "SEFA STANDARD."**

### Glossary of Terms

SEFA has developed a Glossary of Terms (SEFA 4-2020) for the purpose of promoting a greater understanding between designers, architects, manufacturers, purchasers and end users. The terms defined by SEFA are frequently used in contracts and other documents, which attempt to define the products to be furnished or the work involved. The Association has approved this Glossary in an effort to provide uniformity among Standard contains definitions which differ from those in the Glossary of Terms, then the definitions in the specific Standard should be used.

SEFA encourages all interested parties to submit additional terms or to suggest any changes to those terms already defined by the Association. The definitions should be used to help resolve any disputes that may arise or to incorporate the applicable terms in any contract or related documents.

### SEFA Disclaimer

SEFA uses its best effort to promulgate Standards for the benefit of the public in light of available information and accepted industry practices. SEFA does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with SEFA Standards or that any tests conducted under its Standards will be non-hazardous or free from risk. SEFA encourages the use of third party independent testing.

**Note : Testing as described in this document must be performed and documented by a SEFA-approved third-party testing facility. Visit us at [sefalabs.com](http://sefalabs.com) for the most current list of SEFA-approved test labs.**

## 1.0 Purpose

The purpose of this Standard is to provide architects, engineers, planners, specifiers, manufacturers and end users with the Industry Standard Practices. This Standard covers the design, construction, installation, testing, maintenance and safe use of laboratory fume hoods.

## 2.0 Scope

This Standard provides a comprehensive single source of knowledge pertaining to laboratory fume hoods. Since the laboratory fume hood is integral to the Laboratory Ventilation System, these practices will address the entire system as it relates to the laboratory fume hood.

A Laboratory Ventilation System includes the Supply Air System; the Exhaust Air System (which includes room air exhaust in addition to the laboratory fume hood exhaust); the Laboratory; the Laboratory Fume Hood, and other ventilated enclosures.

## 3.0 Laboratory Fume Hood Defined

A Laboratory Fume Hood is a safety device specifically designed to carry undesirable effluents (generated within the Hood during a laboratory procedure) away from laboratory personnel and out of the building, when connected to a properly designed laboratory ventilation system. A Laboratory Fume Hood shall be made primarily from flame resistant materials including the top, three fixed sides, and a single face opening. Face opening is equipped with a sash and sometimes an additional protective shield. Face opening will have a profiled entry and usually an airfoil designed to sweep and reduce reverse airflows on the lower surface. A Laboratory Fume Hood will be equipped with a baffle and, in most cases, a bypass system designed to control airflow patterns within the hood and manage the even distribution of air at the opening. The bypass system may be partially blocked to accommodate Variable Air Volume (VAV) Systems. A Laboratory Fume Hood will be set on a bench, a pedestal or on the laboratory floor.

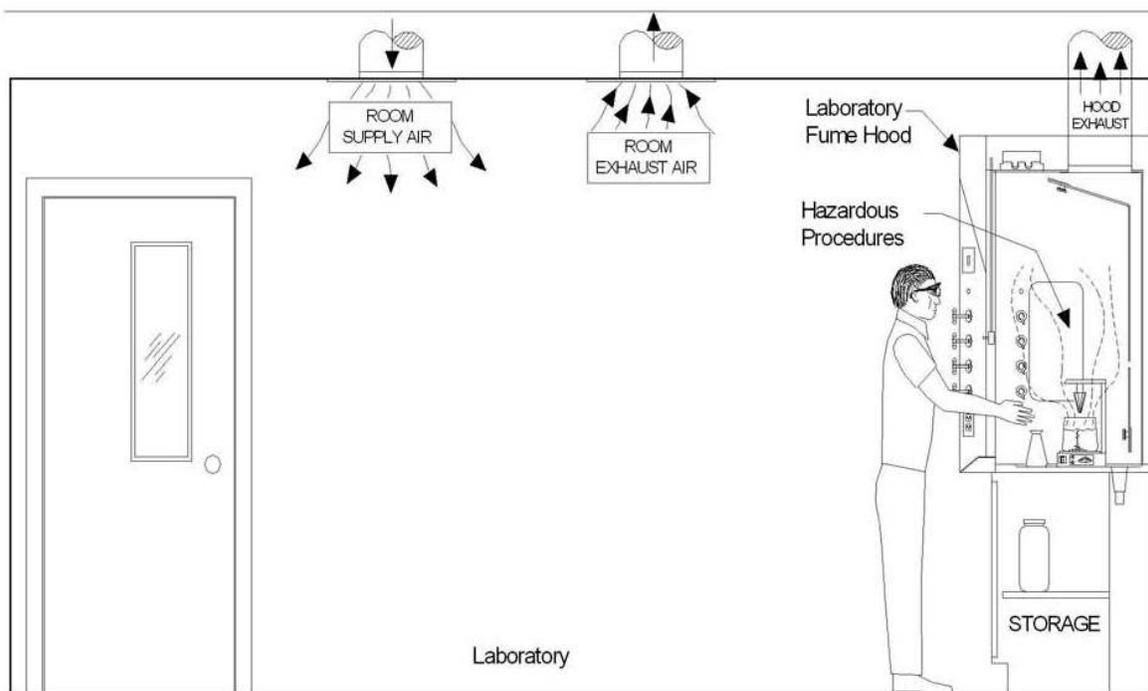


Fig. 1 Typical Constant Volume Laboratory Ventilation System

A Laboratory Fume Hood is given here as the proper terminology. Other widely used terms include --- Fume Hood, Chemical Hood, Chemical Fume Hood, Hood, and Fume Cupboard.

Laboratory fume hoods are perhaps the most widely used and misused safety devices. Fume hoods are available in many shapes, sizes, materials, and finishes. Their flexible design enables them to be configured to accommodate a variety of chemical procedures. However, the flexibility offered by different designs and operating configurations can result in varying levels of performance and operator protection. Great care must be employed by the user when using a laboratory fume hood. Consult the manufacturers' s for Specific Operation, Safety and Maintenance Guidelines.

### **3.1 Family of Ventilated Laboratory Safety Devices**

The laboratory fume hood is part of the ventilated laboratory safety device family and can be sub-categorized by type. (See Figure 2)Each type is connected to a laboratory ventilation system. These "other" systems are described in Section 8.0.

### **3.2 ASHRAE-110 Protocol**

This practice is organized to be consistent with the ASHRAE 110 protocol. "As Manufactured" issues in this practice are directed to fume hood practices that are pertinent to the hood manufacturers' location. "As Installed" identifies those that occur in a newly constructed or renovated laboratory prior to the user occupying the lab. The "As Used" section helps with issues after the installation is complete and how the hood is to be or is being used.

## **4.0 Laboratory Fume Hood - As Manufactured**

There are a wide variety of fume hood designs. Underwriter's Laboratories (UL) Standard 1805 outlines requirements for the structural integrity, the flame and chemical resistance, the plumbing piping and electrical wiring of the fume hood

structure. SEFA recommends the fume hood be classified under UL standard 1805. They generally share a number of similar characteristics and components. The hood depicted in Figure 3 below, shows generalized components of laboratory fume hoods.

## **4.1 Components of Laboratory Fume Hoods**

### **4.1.1 Hood Exterior**

The hood exterior is the external "skin" and is usually made of painted steel. Some hood exteriors are made of stainless steel, polypropylene, wood, or phenolic. The exterior front of the hood is an important design element for fume containment. Properly designed laboratory fume hoods will have a contoured entry, which assists airflow into the hood and could improve hood performance.

The enclosure of the hood is designed to protect against chemical attack. However, if the exterior surfaces of your hoods exhibit corrosion or deterioration, investigate the source.

The airfoil sill is a radiused or angled air vane positioned on the leading edge of the work surface. The sill is designed to enable smooth flow over the work surface and provide a bypass opening when the sash is lowered or closed. Some flush sills employ a trough for spillage containment and slots to direct airflow over the work surface.

### **4.1.2 Hood Interior**

Fume chamber and baffles shall be constructed of materials that are resistant to the chemical fumes, vapors and condensation particulate that may collect and deposit on the interior surface of the fume chamber and baffles. Consideration should be given to the desired color and specifications of liner materials that are resistant to the chemical exposure and corrosion resistance in the fume chamber. Typical liner materials are fiber reinforced thermoset composite – epoxy and polyester, phenolic resin, stainless steel type 304 and 316, thermoplastics – polyvinyl chloride, high density polyethylene, polypropylene and melamine, chemical resistant mineral board,

## Types of Ventilated Devices

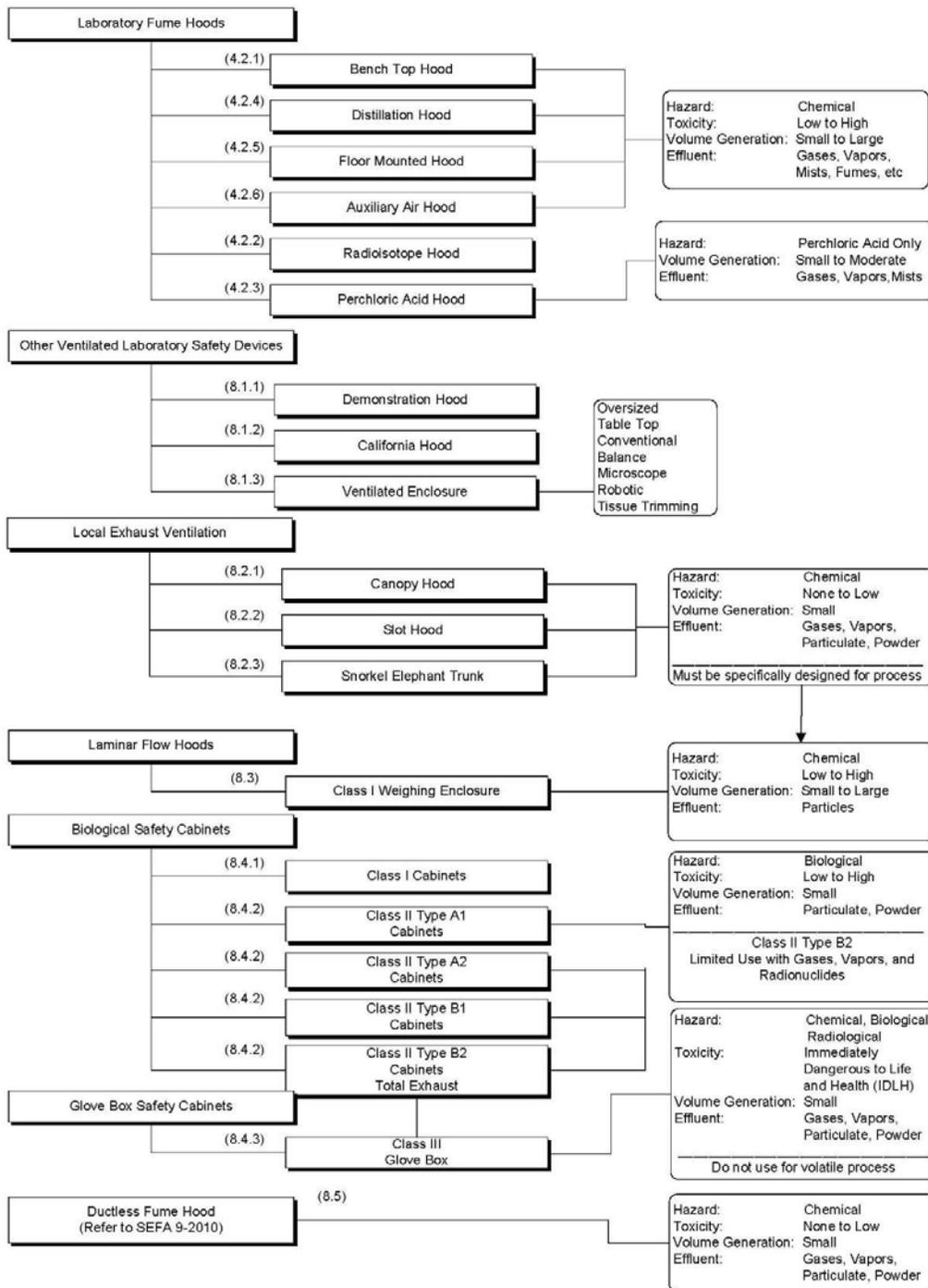


Fig. 2

and sheet steel. Liner materials should be flame retardant, self-extinguishing and have a flame spread rating of 25 or less in accordance with ASTM-E84.

If the fume hood liner is not rated at 25 or less in accordance with ASTM-E84 or there is a high risk potential of fire hazard in the fume chamber, for safety reasons the fume hood should be equipped with automatic fire suppression and alarm system or, in some cases, local jurisdiction may require fire suppression system, wet or dry.

### 4.1.3 Hood Baffle

The baffle in the rear of the hood interior is designed to control airflow distribution within the hood and through the face opening. The baffle slots are sometimes adjustable. The location, size, shape and configuration of baffle slots significantly affect the performance of the laboratory fume hood. (See: Knutson, Gerhard W. "Effect of Slot Position on Laboratory Fume Hood Performance", Heating/Piping/Air conditioning Feb. 1984: 93-96).

### 4.1.4 Hood Exhaust Collar

The exhaust collar that connects the hood to

the exhaust duct is located behind the baffle at the top of the interior liner. The collar should be made of a corrosion resistant material, or a material appropriate for the fume hood application. The design of the exhaust collar can affect the hood static pressure drop and noise level, e.g. "bell-mouth" duct collars can reduce the turbulence associated with the airflow transition from the hood chamber to the exhaust system ductwork.

The number of exhaust collars varies depending on the length of the hood. Typically hoods longer than six feet have more than one exhaust collar for connection to the exhaust ducts.

### 4.1.5 Hood Bypass

Open Bypass: On hoods equipped with a vertical rising sash, an open bypass is used to divert air from the face opening when the sash is lowered. Diverting air through the bypass redirects the volume of air entering the face of the hood and, thus, limits variation to the face velocity. Bypasses are generally designed to limit the increase in face velocity. The velocity, when measured at the sash opened six inches, shall be no more than three times the velocity at the sash fully opened. Limiting the increase in face velocity is important

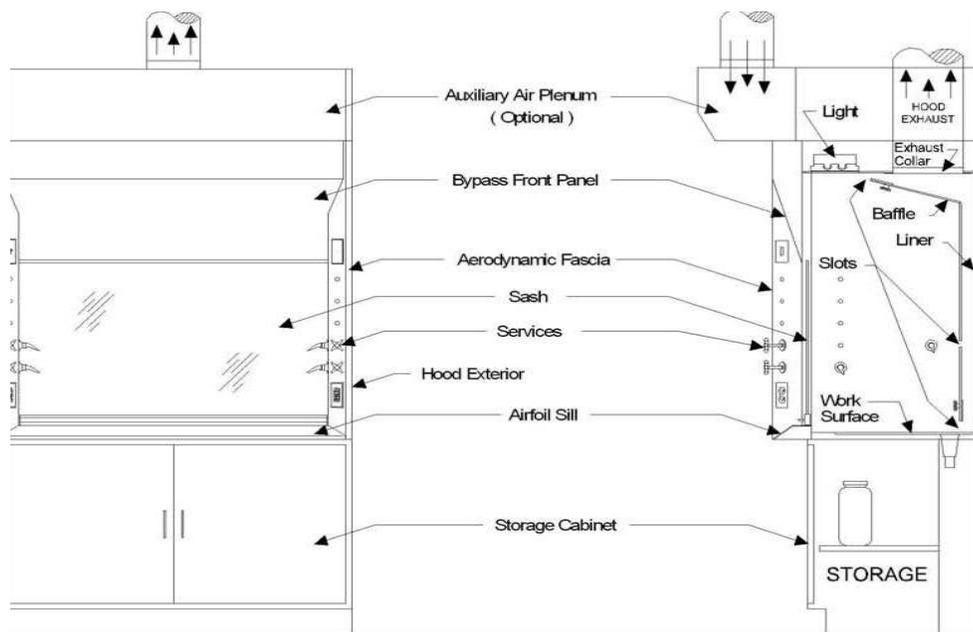


Fig. 3 Typical Components of a Bench Top Hood

as excessive face velocity can cause significant turbulence within the hood and interfere with experiments and apparatus in the hood. This helps maintain a constant exhaust volume.

**Restricted Bypass:** The restricted bypass serves the same function as the open bypass, but the bypass is smaller. This is done to reduce the amount of air required by the laboratory fume hood in the operating mode for VAV systems, horizontal, and combination sashes. Eliminating the bypass completely is not recommended due to the potential risk of contaminate leakage.

Minimum exhaust volume is recommended at 25cfm per square foot of work surface. (See: latest edition of NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals.)

#### 4.1.6 Hood Sash

**The sash is a moveable panel(s), most typically transparent, provided on fume hoods to restrict the opening and provide a protective barrier between the operator and the experiment. Sashes are available in a variety of configurations that enable vertical and/or horizontal movement of sash panels. Regardless of configuration, the sash shall be designed to move freely and not bind. Force to open the sash shall be reasonable for the size and weight of the sash.**

Typically a five foot hood with a vertical rising sash shall require approximately five pounds of force to operate the sash. An additional one pound of force may be required for each additional linear foot of fume hood width.

Sashes are typically designed so that closing the sash does not restrict the area beneath the airfoil sill. This leaves the area beneath the airfoil open when the sash is fully closed.

Sash height limiting devices (also known as sash stops) are sometimes provided to limit the vertical opening of the sash. Sash stops are used to provide a safe operating condition based upon having limited available fume hood exhaust air volume. The opening at which the sash stop limits the sash opening is called the “operating sash opening” or the “design sash opening”.

If the sash stop is defeatable, the sash can be opened to the “maximum sash opening” or the “load sash position”. ASHRAE 110 testing should be performed at both, the design opening and the maximum opening. If fume containment is unacceptable when the sash stop is bypassed, a warning label should be mounted on the fume hood clearly identifying the operating sash height and the potential dangers on bypassing the sash stop.

Sash types are generally referred to as vertical, horizontal or combination depending on the allowable movement of the sash panels. (See: Figure 4).

**Vertical Sash:** A vertical sash has one or more panels that can slide up and down to a height required by the operator. The sash controls the opening area and it is generally advisable to lower the sash below the breathing zone of the operator during generation of hazardous contaminants. Hoods may be equipped with sash stops to restrict the opening height of the sash. Vertical sashes may also be designed split into multiple vertical rising sashes.

**Horizontal Sash:** A horizontal sash has typically two or more panels that slide horizontally across the hood opening. The sash panels slide in tracks located at the top and bottom of the face opening. Horizontal sashes are used to restrict the maximum opening area of the face, but allow access to the top interior of the hood enclosure.

**Combination Sash:** A combination sash has horizontal sliding sash panels positioned in a vertically sliding sash frame. The combination sash provides the convenience of both vertical sash operation and horizontal sash operation.

Horizontal and combination sash panels should be used as a barrier from hazards within the hood. The sash panel should be placed between the operator and the hazard whenever feasible.

**Telescoping Sash** – Two or more vertically moving sash elements whose movements are linked.

### 4.1.7 Hood Work Surface

Work surfaces are typically made of a material that provides good heat and corrosion resistance and is easily cleaned and decontaminated. The work surface should have a recessed area. The dished or recessed area is designed to provide containment of small spills and provide demarcation of the recommended work area inside the hood. Refer to SEFA 3 – Standard for Work Surfaces.

### 4.1.8 Hood Lights

Most fume hoods are equipped with some type of light. Lights come in a variety of designs depending on the anticipated use of the hood. Most lights are fluorescent tubes housed outside the hood chamber and separated by a vapor resistant safety glass panel in the top of the hood. Access to re-lamping these types of lights should be from the hood exterior. The light shall be designed to provide a minimum of 80 foot candles on any part of the bench level (36" from the floor) work surface. Incandescent vapor proof lights as well as incandescent and fluorescent explosion proof lights are optional and available as specified.

Many manufacturers offer electronic ballasts and energy efficient T8 or T5 bulbs.

### 4.1.9 Hood Services

Many hood manufacturers can equip hoods with a variety of amenities or services. The more popular services include electrical outlets, sinks, fixtures and plumbing for gas, vacuum, and air. For increased safety, controls for these services should always be accessible from outside the hood opening.

**Service Fixtures:** All service fixtures shall be installed so that service supply lines can be connected or disconnected, either by design of the piping assembly or through an access panel in the hood interior or exterior. All service valves shall be accessible for maintenance. All service fixture controls (e.g., gas, air, water, vacuum) should be external to the hood interior, clearly identified and within easy reach. All internal service fixture outlets shall be corrosion resistant to the application. (See SEFA 7— Standard for Laboratory Fixtures.)

Connections for services will vary, depending on

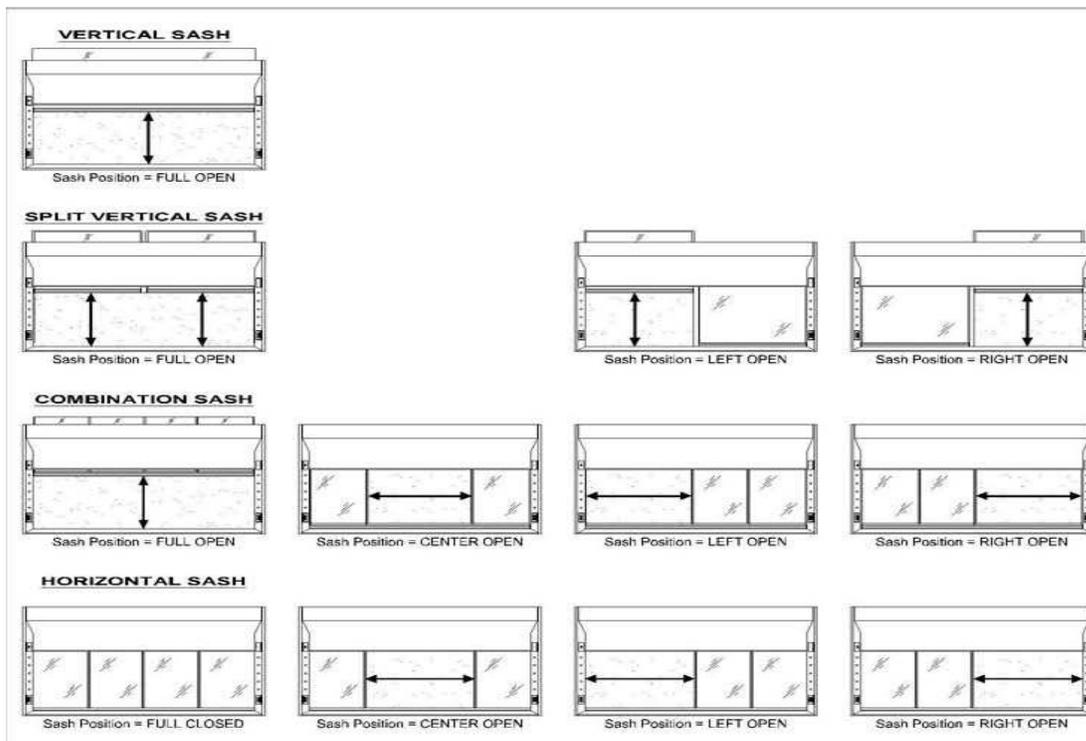


Fig. 4 Typical Sash Configuration for Different Sash Types

the point of origin and number of fixtures. Service lines may be brought in from below, down from the ceiling, or from the back wall.

Typical piping requirements are as follows:

- Water – copper.
- Gas – wrought iron or steel (galvanized or black) or yellow brass (containing not more

than 75% copper). (See: Uniform Building Code, 2000 Edition, International Association of Plumbing and Mechanical Officials, 20001 Walnut Drive, South Walnut, CA 91789 www.iapmo.org).

- Air – copper – black iron can be used as an alternate.
- Vacuum – copper – black iron can be used as an alternate.
- Specialty Gas – appropriate materials as specified.

NOTE: Check your regional or local codes for jurisdiction and material allowance. There are regional differences.

Electrical Receptacles: All electrical receptacles should be readily accessible. Provisions shall be made so that all electrical wiring will be isolated and physically separated from vapors handled within the hood interior after the fume hood is installed. The receptacle shall be installed with the ground outlet above the power slots. If electrical receptacles are within fume hood interior, they should be installed per NFPA and UL recommendations.

NOTE NFPA allows electricians inside hood. (See: NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals, latest edition).

Flammable materials are used successfully in most hoods. In an extreme case, such as specifying a laboratory fume hood for highly volatile, flammable, hazardous procedures and use (for a complete list, request NFPA - National Fire Protection Association Publication #497M), follow NEC codes. NEC divides materials into classes and groups according to the type of explosive

agent that may be present. In addition, if there is a very high risk of fire, the fume hood should be equipped with a fire suppression system. Sufficient air volume must be exhausted through the hood to dilute flammable effluents below the lower explosive limit level. See NFPA 45 for more information on minimum recommended exhaust volumes. (See: NFPA 70 National Electrical Code, 2002 Edition, NFPA).

Fire Suppression Systems:

- Any fire suppression system used in a chemical fume hood should be compliant with local codes and regulations, and NFPA 17.
- Any fire suppression system should be rated for fire classes A, B, C with manual and thermal activation triggers. Other water or liquid based systems may be acceptable if appropriate testing and certification are available.
- No fire dampers of any kind should ever be installed in a chemical fume hood exhaust system.
- Flammable materials should never be stored directly below a chemical fume hood in anything but an NFPA specified, UL listed or FM approved solvent storage cabinet.

#### 4.1.10 Hood Monitor

All hoods shall have some type of monitor for indicating face velocity or exhaust flow verification. The monitor can be a simple pressure gage connected to a Pitot tube in the exhaust duct, one of many electronic monitors, or a vaneometer. Regardless of the monitor installed, it should provide clear indication to the hood user whether exhaust flow or face velocity is within design parameters.

A ribbon taped to the bottom of the sash is not acceptable.

## 4.2 Types of Laboratory Fume Hoods

### 4.2.1 Bench-Top Fume Hoods

A bench-top fume hood is a hood that is generally placed on a bench-top or above a storage cabinet.

Bench-top hoods are available in different sizes to accommodate a variety of chemical processes. The critical dimensions for a hood include length, depth and interior height;

however, hood size is generally determined by the overall width of the hood. A five foot hood includes the width of the face and the side panels and is not a measure of the opening width. Side panels range in width from two to eight inches depending on the design and hood manufacturer.

Bench-top hoods can have vertical, horizontal or combination sash types and open or restricted bypasses depending on the sash type.

Bench-top hoods can be used for a wide variety of chemical procedures. The bench-top hood is appropriate for use with small to moderate quantities of low to highly toxic materials.

Depending on the materials of construction and operating configuration, this type of hood can provide effective containment, and exhaust of gases, vapor, mists, fumes and other aerosols having low particle mass.

#### **4.2.2 Radioisotope Fume Hood**

A fume hood used for Beta and Gamma radiation shall be referred to as a radioisotope hood. A radioisotope hood has the general characteristics of a bench-top fume hood except the work surface and interior lining must be type 304 stainless steel with covered seamless welded seams for easy cleaning and decontamination. The hood design is identical to other hood types in nearly all other respects. Horizontal sash panels are not appropriate for this fume hood type.

The work surface shall be dished to contain spills and cleaning liquids and shall be properly reinforced to support lead shielding and shielded containers. The load-bearing capacity shall be 200 pounds per square foot (90.71 Kg m<sup>2</sup>) minimum up to a total weight of 1,000 pounds (453.6 Kg) per fume hood or base cabinet section.

#### **4.2.3 Perchloric Acid Fume Hood**

A perchloric acid hood has the general characteristics of a bench-top hood; however, the

interior lining must be covered and welded seamless stainless steel (other non-reactive material such as CPVC or polypropylene have been used when heat is not a concern). Non reactive and corrosion resistant material should extend all the way through the exhaust system.

In addition, the hood, duct, and fan must have a water wash down system to remove perchlorates and prevent the build-up of potentially explosive perchlorate salts. Drain outlet shall be designed to handle a minimum of 15 gallons (56.8 liters) per minute. The work surface on perchloric acid hoods typically has a water trough at the back of the hood interior under the baffle. The fume hood liner in a perchloric acid fume hood shall have no access holes such as those which may be used for plumbing access. Access panels should be considered in the lab layout for access through the hood exterior. In nearly all other respects, however, the design of perchloric acid hood is the same as conventional or bypass fume hoods.

A perchloric acid hood shall never be tied to a manifold system.

#### **4.2.4 Distillation Fume Hood**

A distillation fume hood is designed for use with tall apparatus and procedures that involve small to medium quantities of low to high toxicity materials. A distillation hood has the same components as a bench-top hood with the exception that the design provides a greater interior height. The hood is suitable for work that can be conducted in a bench-top hood; however, the greater interior height enables use of larger apparatus.

The distillation hood is mounted on a pedestal that elevates the work surface to a height between 12 and 18 inches above the floor.

Distillation hoods can have vertical rising sashes or horizontal sliding panels. Generally, more than one sash panel is used on a vertical rising sash. The vertical sash design generally enables a rather large opening and care must be taken in determining the maximum allowable sash opening and required exhaust flow to provide a safe operating condition and ensure effective fume containment.

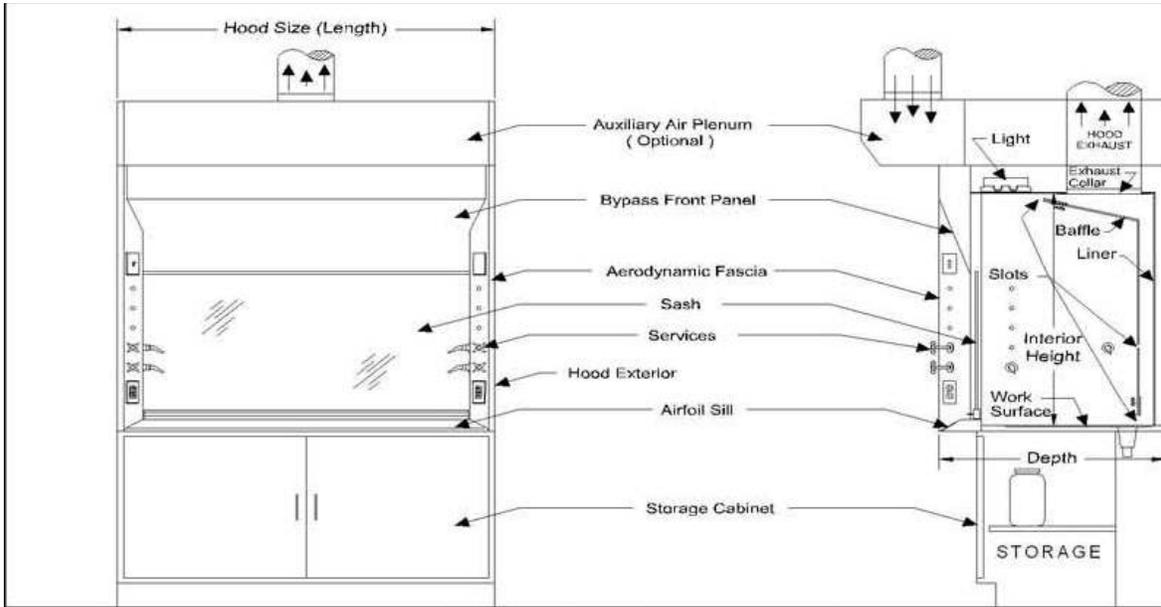


Fig. 5 Typical View of Bench Top Fume Hood

#### 4.2.5 Floor Mounted Fume Hood (Commonly known as a Walk-in Fume Hood)

A floor-mounted hood is used for large apparatus and storage of containers that pose some hazard, but will not fit into an approved storage cabinet. A floor-mounted hood is suitable for the same type of work conducted in bench-top hoods and distillation hoods.

Floor mounted hoods are typically equipped with horizontal sliding sashes, although some models are equipped with multiple vertical sliding sashes. Horizontal sashes are recommended on hoods

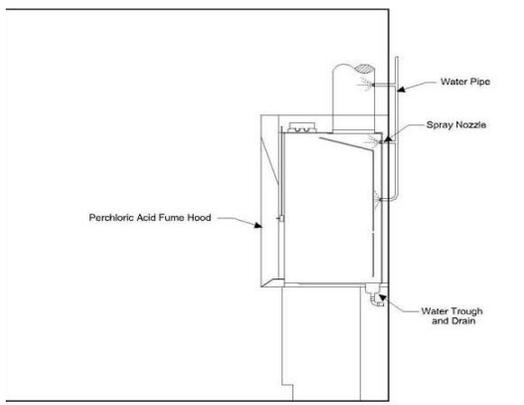


Fig. 6 Typical View of Perchloric Acid Fume Hood

over eight feet in width.

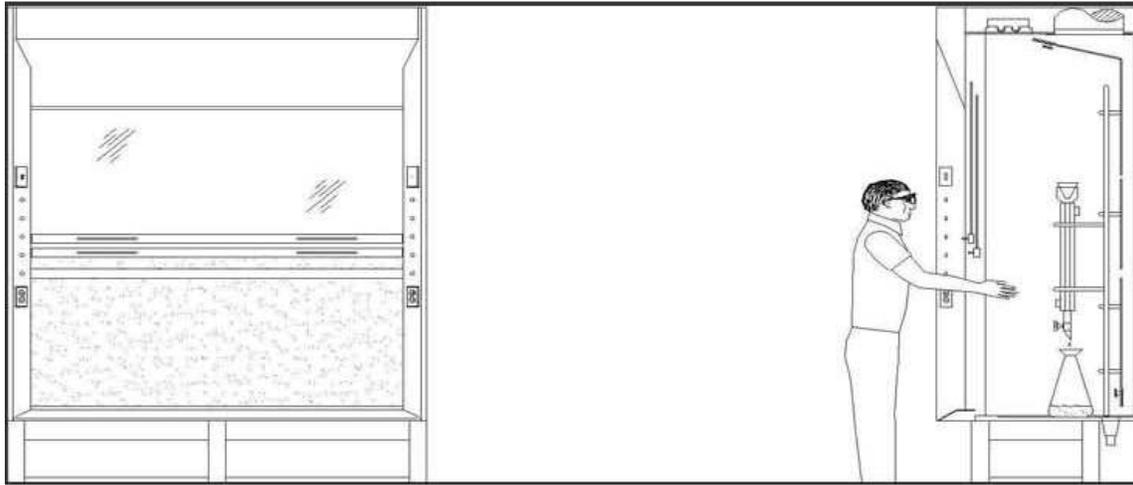
The name “walk-in hood” implies that the hood can be entered; however, the name is a misnomer, as the same safety precautions should be applied to this hood, as those required for a bench-top hood. The hood must never be entered during generation of hazardous materials or while concentrations exist within the enclosure. For this reason, we refer to these structures as floor mounted fume hoods.

Floor mounted hoods are particularly susceptible to variations in face velocity across the opening and room air disturbances due to the large opening area afforded by the hood design. For this reason, it is prudent not to use a floor mounted hood for work with highly toxic materials.

It is recommended that only one sash be fully opened during hood operation on floor mounted hoods with multiple vertical sashes. Both sashes are to be fully opened during set up only.

#### 4.2.6 Auxiliary Air Fume Hood

The auxiliary air system, when added to a standard laboratory fume hood, shall function to reduce the consumption of conditioned room air. The auxiliary air is typically introduced exterior to



**Fig. 7 Typical View of Distillation Fume Hood**

the fume hood face and enters the fume hood through the face with the sash(es) open.

With the sash(es) closed, auxiliary air shall be drawn into the fume hood interior in such a manner as to aid in the dilution of heat and fumes generated in the work area.

NOTE: Consideration should be given to preconditioning and filtering auxiliary air.

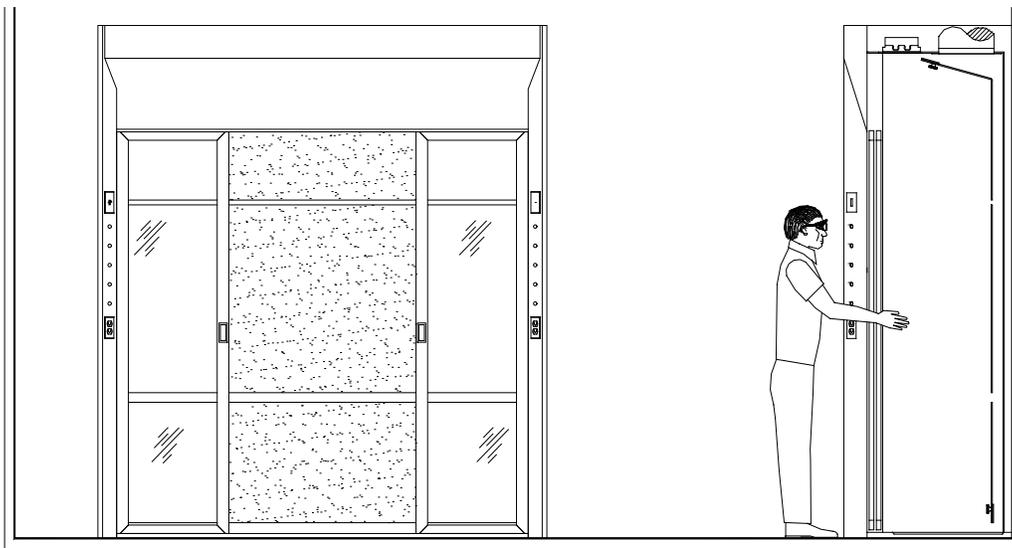
Auxiliary air fume hoods shall also conform to the following requirements:

- Provide safe capture and efficient removal of fumes from the hood when operated at air ratios specified by the manufacturer.

- Capture the percentage of auxiliary air specified by the manufacturer when operated with the sash(es) open or closed.

- Capture, contain and carry away fumes generated in the work area when operated at a condition of imbalance between the auxiliary air and room air as specified by the manufacturer.

- Function in accordance with the performance characteristics listed above when tested by



**Fig. 8 Typical View of Floor Mounted Fume Hood**

appropriate evaluation procedures.

- Never pressurize the hood chamber with auxiliary air.

The manufacturer shall include auxiliary air static pressure data for all standard catalog models.

### 4.3 Energy Efficient Fume Hood

Energy efficient fume hood (also known as Low Exhaust Volume, or LEV fume hoods) designs can offer significant reductions in the volume of exhaust air required to safely operate the fume hood. Energy efficient hoods can be divided into two categories: Low Flow Fume Hoods and Low Velocity Fume Hoods.

- Low Flow Laboratory Fume Hoods are hood designs that provide a reduction in the required exhaust air volume, when compared to the volume required for the same size fume hood to operate with a face velocity of 100 FPM through a fully opened vertical sash, e.g: a typical 6' wide bench mounted fume hood requires approximately 1100 CFM of exhaust flow to achieve an average face velocity of 100 FPM through a fully opened vertical sash. A 6' wide hood operating at less than the volumetric exhaust flow would be classified as a Low Flow fume hood.
- Low Velocity Laboratory Fume Hoods are hood designs that provide a reduction in the required exhaust air volume, when compared to the volume required for the same size fume hood to operate with a face velocity of 100 FPM through a fully opened vertical sash and provides containment levels equivalent or superior to ASHRAE 110 tracer gas test ratings of 4.0 AM 0.05, and 4.0 AI/AU 0.10, with a face velocity of 60 FPM or less through the fully opened vertical sash. Low Velocity Fume Hoods are also referred to as High Performance Fume Hoods and High Efficiency Fume Hoods.

**NOTE: Low Flow hoods which achieve a reduction in volumetric flow by restricting the sash opening area do not qualify as Low Velocity or High Performance fume hoods unless they also meet the performance**

**requirements listed above through the maximum sash opening. The “maximum sash opening” shall be considered a vertical sash opening not less than 25” high off the fume hood work surface.**

Energy efficient fume hoods often feature new designs and features not found on traditional fume hoods, including redesigned bypass systems, new baffle configurations, low profile airfoil sills and aerodynamic sash frame designs. Some manufacturers offer unique electrical and mechanical “safety controls” which are integral to the superstructure of the energy efficient fume hood. These control systems often enhance the safety afforded to the fume hood operator during use. The maintenance of these safety control systems should be performed in accordance with the manufacturer’s guidelines to ensure safe and proper operation of the fume hood.

Energy efficient fume hoods are available in bench mounted, floor mounted, distillation and specialty hood types. Energy efficient fume hood designs are appropriate for almost all of the same applications as traditional fume hood designs. While energy efficient fume hoods can be integrated into any type of laboratory ventilation system, most often these style fume hoods are installed on Constant Air Volume (CAV) systems. However, these hoods can operate on Variable Air Volume (VAV) systems and Switched Two-State systems. The return-on-investment period should be evaluated when deciding which type of system to use.

It has been determined that there is no direct statistical correlation between a fume hood’s average face velocity and the containment levels provided by the fume hood. (See: Hitchings, Dale T. “Laboratory Fume Hood Testing: Face Velocity Does NOT Equal Safety” Laboratory Safety & Environmental Management 3.6 (1995)). On a properly designed fume hood, a lower face velocity can actually enhance fume hood performance through aerodynamic design and reduced turbulence. SEFA recommends the ANSI/ASHRAE 110 test to evaluate the performance of all laboratory fume hoods, including the energy efficient fume hoods. Currently, there are no special tests outlined in the ASHRAE standard for

fume hoods operating at reduced exhaust flows. Energy efficient fume hood designs are tested to the same standard as traditional fume hood designs. However, the ASHRAE Standard allows for owners, engineers and/or architects to specify specific challenges to any fume hood design to investigate the fume hood's ability to perform under less than ideal conditions. Tests have been performed with the hood chamber loaded with equipment and apparatus, thermal challenges within the fume hood chamber, cross drafts, walk-by traffic, etc.

#### **4.4 Testing of Laboratory Fume Hoods - As Manufactured**

The ASHRAE 110 test is a method of testing the performance of laboratory fume hoods. There are three test procedures incorporated into the 110 test; the first is the face velocity grid test, the second is the flow visualization or smoke test and the third is the tracer gas containment test. The ASHRAE 110 is the recognized method for evaluating the performance of fume hoods; ASHRAE has defined three modes, As Manufactured (AM), As Installed (AI), and As Used (AU). The ASHRAE test should be conducted by an authorized person cognizant of each of the three test procedures.

##### **4.4.1 Face Velocity**

Face velocity shall be adequate to provide containment. Face velocity is not a measure of safety.

Refer to ASHRAE 110 – 1995 (or latest edition) for velocity measurement procedures.

Face Velocity Guide –The most widely accepted range of average face velocities is 60 FPM to 100 FPM. The measured deviation across the face may vary + 20 FPM. (For more information on this topic, refer to Section 12.0 Regulatory and Industry Consensus Standards.)

##### **4.4.2 Containment Testing – As Manufactured**

The manufacturer shall provide standard (AM) test data for all standard hoods. This should be done in accordance with the most current ASHRAE 110

Standard. The AM testing demonstrates what the hood is capable of doing under controlled conditions. The report shall verify that all laboratory fume hood types specified have been tested to ASHRAE 110-1995 (or most current edition) procedures and have achieved AM 0.05.

AM 0.05 can be achieved with a properly designed laboratory fume hood. It shall not be implied that this exposure level is safe. Safe exposure levels are application specific and should be evaluated by properly trained personnel.

The ASHRAE 110 Standard includes procedures for:

Inspection of the Hood;  
Evaluation of Laboratory Conditions;  
Airflow Visualization;  
Airflow Velocity Measurements; and  
Tracer Gas Containment Tests.

##### **4.4.3 Static Pressure - Bench Mounted Fume Hood**

See Industrial Ventilation Manual for Static Pressure Measurement Procedures. (See: Ind. Ventilation: A manual of recommended practice, 24th Edition, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240 [www.acgih.org](http://www.acgih.org))

With sash at full-open position, static pressure loss through the fume hood shall be no more than ¼ inch (6.35 mm) of water gauge when the fume hood operates at face velocity of 60 feet per minute (.30 m/s), ½ inch (12.70 mm) of water gauge at 100 feet per minute (.51 m/s), ½ inch (12.70 mm) of water gauge at 120 feet per minute (.62 m/s). The manufacturer shall state the design static pressure loss for all standard catalog models. For all constant volume laboratory fume hoods equipped with a bypass, static pressure loss and exhaust volume shall be relatively constant regardless of sash position. The velocity when measured at the sash opened six inches, shall be no more than three times the velocity at the sash operating opening.

## 5.0 Laboratory Fume Hoods - As Installed

### 5.1 Location in Laboratory

Laboratory fume hood exhaust systems should be balanced with room exhaust systems and may be used in conjunction with room exhaust to provide the necessary room ventilation. Constant operation of a fume hood will also provide fume control during non-working hours. If the laboratory control system provides for proximity sensors at the fume hoods, reducing the face velocity through the open sash when users are not present at the fume hood face, fume control must still be maintained.

Laboratory fume hoods should be so located within the laboratory to avoid crosscurrents at the fume hood face due to heating, cooling or ventilating inlets.

Sufficient makeup air must be available within the laboratory to permit fume hoods to operate at their specified face velocities.

Other location factors to be considered are as follows:

Number and types of fume hoods in the laboratory space;

Location and number of ingress/egress aisles and/or laboratory space exterior doorways;

Frequency and/or volume of expected fume hood users;

Location of laboratory safety equipment.

### 5.2 Safety Considerations

Laboratory fume hoods are potential locations for fires and explosions due to the types of experiments conducted in these units. As such, fume hoods should be located within the laboratory so that in the event of a fire or explosion within the fume hood, exit from the laboratory would not be impeded. Laboratory fume hoods should be located away from high traffic lanes within the laboratory because personnel walking past the sash opening

may disrupt the flow of air into the unit and cause turbulence, drawing hazardous fumes into the laboratory.

Sufficient aisle space should be provided in front of the fume hood to avoid disruption of the work or interference with the operating technician by passing personnel.

Safety devices such as drench showers, eye wash stations, fire extinguishers, first aid kits and fire blankets should be located convenient to the fume hood operating personnel and plainly labeled as to their use and function.

Other safety factors to be considered:

Type of research being conducted;

Proximity to associated bench mounted or free standing instrumentation machines;

Type and number of associated fume hood enclosures;

Number of research and/or student users in laboratory space.

Refer to SEFA 2 Standard for Installation.

Refer to SEFA 7 Standard for Laboratory Fixtures.

### 5.3 Fume Hood Evaluation – As Installed

Precondition for Testing: The test of the fume hood should be performed after the installation is complete, the building ventilation and control system has been balanced and all connections made. The testing should be performed in conditions appropriate for occupation of the lab space.

It is recommended that the user make provisions to have the following test performed on all laboratory fume hoods. These tests should be performed by qualified personnel to verify proper operation of the fume hoods before they are put to use. Testing should be repeated at least annually, or whenever a significant change in the hood system occurs. Any unsafe conditions disclosed by these tests should be corrected

before using the hood. It is recommended that hoods be tested in accordance with ASHRAE 110-1995 (or most current edition) before put into service. Some form of annual certification should be incorporated at the owners discretion.

The ASHRAE 110 test is a method of testing the performance of laboratory fume hoods. There are three test procedures incorporated into the 110 test; the first is the face velocity grid test, the second is the flow visualization or smoke test and the third is the tracer gas containment test. The ASHRAE 110 is the recognized method for evaluating the performance of fume hoods; ASHRAE has defined three modes, As Manufactured (AM), As Installed (AI), and As Used (AU). The ASHRAE test should be conducted by an authorized person cognizant of each of the three test procedures.

### 5.3.1 Room Conditions

Check room conditions in front of the fume hood using a thermal anemometer and a smoke source to verify that the velocity of cross drafts should be less than 50% of the face velocity, not to exceed 30 FPM. Any cross drafts that exceed these values shall be eliminated before proceeding with fume hood test. Crosscurrents of sufficient magnitude can have a detrimental effect on the ability of a fume hood to contain and exhaust air contaminants. It is therefore advised to keep crosscurrents in the vicinity of the face of a fume hood to a minimum.

### 5.3.2 Sash Operations

**Check operation by moving sash(es) through its (their) full travel. Sash operation shall be smooth and easy. Vertical rising sashes shall hold at any height without creeping up or down, unless designed otherwise. Force to open the sash shall be reasonable for the size and weight of the sash. Typically a five foot hood with a vertical rising sash shall require approximately five pounds of force to operate the sash. An additional one pound of force may be required for each additional linear foot of fume hood width.**

### 5.3.3 Evaluation of Low Air Flow Monitor

On fume hoods with low flow warning devices, verify that monitor functions properly and indicates unsafe conditions.

### 5.3.4 Face Velocity

Determine specified average face velocity for fume hood being tested. Perform the following test to determine if fume hood velocities conform to specifications.

Face velocity shall be adequate to provide containment. Face velocity is not a measure of safety.

Refer to ASHRAE 110 – 1995 (or latest edition) for velocity measurement procedures.

Face Velocity Guide – The most widely accepted range of average face velocities is 60 FPM to 100 FPM. The measured deviation across the face may vary + 20 %. (For more information on this topic, refer to Section 12.0 Regulatory and Industry Consensus standards.)

### 5.3.5 Containment Testing – As Installed

SEFA recommends the ASHRAE 110-1995 (or most current edition) test.

## 5.4 Trouble Shooting

When fume hood test procedures detect improper function, the cause is frequently due to insufficient quantity of air flowing through the hood, or due to room cross drafts blowing into or across the face of the fume hood, or a combination of both. The following suggestions are offered to help pinpoint and correct the problems.

### 5.4.1 Insufficient Airflow

Insufficient airflow through the fume hood can be caused by one or more of the following conditions. Each condition should be checked, and eliminated if possible to determine which one or combination of conditions may exist:

- Double-check your readings.
- Check airflow velocity meter type. When was it calibrated last? Is the battery good? Was the instrument zeroed before taking readings?
- Check to make sure the instrument is recommended for low air velocities in the 50 to 150 feet per minute (.25 to .76 m/s.) range.

If possible, verify readings with another air velocity meter or by checking air volume using a pitot tube traverse of exhaust duct. Low airflow through the fume hood can be caused by a large negative room static pressure as a result of inadequate makeup air being brought into the room. With the fume hood and other exhaust unit in operation, check room static pressure by:

- Verification using inclined manometer.
- Checking inrush of air into the room through a door or an open window.
- Checking ventilation system balance and verify the quantity of makeup air.
- Verify that fume hood baffles are in an open position.
- Insure that baffle openings are not blocked with large or bulky apparatus. Improper sizing or operation of exhaust unit or both may be the cause.
- Confirm exhaust unit rotation is correct. Make and model is as specified.
- Supply voltage is correct.
- Motor horsepower and speed is appropriate.
- Exhaust unit inlet and outlet conditions are suitable.
- Check for special or bulky equipment that interferes with airflow through the fume hood.

#### 5.4.2 Room Cross Drafts

Cross drafts in front of the fume hood face can cause the fume hood to lose containment and

present a safety hazard to laboratory space occupants. Cross drafts in front of the fume hood should be kept to a minimum at all times and specifically when the fume hood is being used by an operator. Each of these issues should be investigated when cross drafts are suspected of causing poor fume hood performance.

Air moving through an open door located adjacent to the fume hood can cause cross drafts.

An open window or room air supply grill located to one side or across from the fume hood can cause disturbing cross drafts.

High velocity air from ceiling-mounted diffusers or room air supply can cause cross drafts or downdrafts.

Cross drafts can occur when thermal gradients in the lab space are caused by the introduction of supply air at a significant  $T$ , compared to the ambient temperature in the lab space. The proper operation of the building reheat controls, the position of the lab space thermostats and the supply register location can all affect the creation of these thermal gradients. Room conditions such as these should be avoided, if at all possible, by the location of the fume hood or changing the design of or modifying the location of supply air diffusers. The velocity of the cross drafts should not exceed 50% of the face velocity or 30 FPM.

#### 5.4.3 Exhaust Unit and Duct Considerations

Where laboratory building design permits, the exhaust unit should be located on the roof of the building to provide a negative pressure in that portion of the duct system located within the building.

The exhaust unit should be sized to exhaust the volume of air necessary to attain the selected fume hood face velocity at the total system static pressure loss. Care should be taken to ensure the exhaust unit has sufficient stack velocity and orientation to reduce the possibility of re-entrainment of contaminated exhaust air into the lab building, or an adjacent building's supply air intakes.

Exhaust units should be sized to achieve the lowest practical angular speed of the impeller, thereby avoiding high impeller tip speed and minimizing noise associated with this revolving member.

Ductwork shall be designed and constructed in accordance with approved standards (ASHRAE, NFPA, SMACNA) and regulations, for minimal friction losses within the duct, smooth interior surfaces are recommended.

Elbows, bends and offsets within a duct system should be kept to a minimum and should be long sweep in design configuration in order to minimize static pressure losses. When practical, a straight run of duct from the fume hood duct collar for as long a length as possible, is preferred.

Fume hood and other exhaust devices shall not interconnect with re-circulating systems.

#### **5.4.4 Make-up Air**

Make-up air is a ventilation term indicating the supply of outdoor air to a building replacing air removed by exhaust ventilation systems. In general, laboratories require four to twelve total volume changes per hour. Refer to OSHA 1910.1450, Page 492 and NFPA 45, 2000, Page 45-27, A.6.3.3. Special applications may require more air changes per hour.

A sufficient quantity of makeup air must be available to allow fume hoods to develop required face velocities.

Consideration must be given to the makeup required for air changes in each specific laboratory involved. This data must be coordinated with fume hoods and ventilation equipment.

In order to provide a balanced and functioning system, all factors such as fume hood exhaust volume, air change data, makeup air systems and auxiliary air performance, if applicable, must be considered.

Due to the possibility of toxic and/or hazardous material being handled within laboratories, air exhausted from these laboratories should not be re-circulated.

Laboratories using chemicals should operate at a slight negative pressure as compared to the remainder of the building.

#### **5.4.5 Laboratory Fume Hood Inspection and Maintenance**

Inspection procedures should include instrument verification of fume hood face velocity, which should be equal to the velocity recorded at the time of the ASHRAE 110-95 (or latest edition) performance test and fume hood commissioning.

Inspection procedures should consist of a physical examination of liner condition and cleanliness, baffle and sash operation and condition, counter balance cables, light operation and condition, and service fixture function.

Inspection results should be recorded and reported to the proper authority for any required action. Where extremely hazardous or corrosive conditions exist or when filters are present in the system, the inspection frequency should be increased appropriately. Velocity and pressure sensing detectors should be tested at each inspection. Low-flow or no-flow alarms of the visible or audible type should be tested for correct operation at least at each inspection. Fan belts should be inspected regularly.

#### **5.5 Maintenance**

Fume hood maintenance procedures consists primarily of clean up, adjustments, lubrication and replacement of worn, damaged or nonfunctioning parts. Use good housekeeping in laboratory fume hoods at all times. Periodically clean sash(es), exterior and interior surfaces, including light panel. Replace lamps periodically to maintain adequate illumination.

Clean up should be accomplished by, or under the supervision of a knowledgeable laboratory safety officer and should include removal of the baffle for clean up of all interior surfaces.

Lubrication of sash guides, cables, pulley wheels, sprockets, chains and other working parts should be accomplished as required or in accordance with manufacturer's recommendations.

Flush all spills immediately using neutralizing compounds as required and clean thoroughly.

## 6.0 Laboratory Fume Hoods - As Used

### 6.1 Safe Work Practices

The employer is responsible for ensuring that the hood meets satisfactory safety standards. A hood operator is responsible for ensuring that the hood is used in a safe manner and according to your organization's safety guidelines. A hood operator is also responsible for helping their organization maintain proper operation of the hood systems.

The following guidelines are provided to help reduce your potential for exposure when working with hazardous materials.

- Plan for conducting experiments.
- Wear appropriate personal protection.
- Verify proper system operation.
- Utilize proper work practices.

### 6.2 Plan for Conducting Experiments

Prior to conducting potentially hazardous procedures in a laboratory fume hood, evaluate the hazards and consult with a Safety Officer to develop appropriate safety protocols and evaluate whether the hoods and systems have the capability to provide adequate protection. In addition, follow the guidelines provided in your Chemical Hygiene Plan. If the guidelines are inadequate or inappropriate, help develop or amend procedures with your Chemical Hygiene Officer.

Prior to starting an experiment in a hood, answer the following questions:

**What are the characteristics of the hazards associated with the procedure?**

**Is this the right type of hood?  
Will the hood accommodate the equipment and experimental apparatus?**

**Is the hood capable of capturing and exhausting the contaminants?**

**What are the hood capabilities and limitations?  
What special precautions are required?**

**Verify that the ventilation system is working properly.**

For example, if you are going to conduct a procedure involving use of heated perchloric acid, you must use a perchloric acid hood and the exhaust system must be equipped with a water wash down system. Failure to use a perchloric acid hood with a water wash down system could result in a future explosion or fire. Another example is to be cautious with a heat generating processes. Generated velocity due to the heat in a hood could result in counterproductive airflow. Is the fume hood liner resistant to the heat loads?

### 6.3 Wear Appropriate Personal Protection

Prior to conducting experiments wear appropriate personal protective apparel as required by the Chemical Hygiene Program and safety protocols. It is generally accepted that at a minimum, the appropriate apparel for working at a laboratory fume hood includes approved eye protection, lab coat, gloves, long pants and shoes (preferably safety shoes, open shoes such as sandals are not recommended).

Ensure that clothing and glove materials are appropriate for work with the hazards. For example, vinyl gloves provide excellent resistance to formaldehyde, but poor resistance to chloroform.

If unsure of the appropriate type of personal protective equipment required, consult with your Chemical Hygiene Officer.

### 6.4 Fume Hood Evaluation - As Used

The ASHRAE 110 test is a method of testing the performance of laboratory fume hoods. There are three test procedures incorporated into the 110 test; the first is the face velocity grid test, the second is the flow visualization or smoke test and the third is the tracer gas containment test. The ASHRAE 110 is the recognized method

for evaluating the performance of fume hoods; ASHRAE has defined three modes, AS Manufactured (AM), As Installed (AI), and As Used (AU). The ASHRAE test should be conducted by an authorized person cognizant of each of the three test procedures.

Safety considerations require that a schedule of inspection and documentation be set up for every laboratory fume hood at least annually.

An inspection record should be maintained. This record may be in the form of a label attached to the fume hood, and/or a log maintained by the Laboratory Director or Health Safety Director. Include sash operation, low airflow monitor, and containment test evaluations.

Before generating hazardous materials within the hood, you should ensure that the hood system is in good working order.

Check the hood integrity and verify adequate exhaust flow or face velocity. At a minimum, check the hood inspection notice to ensure that the hood has been recently tested and operation was satisfactory at the time of the tests.

As hoods are part of a mechanical system, it is possible that operational problems could develop between routine performance tests and preventative maintenance activities. Report alarms or suspected operational problems immediately.

If any problems are suspected with hood operation, immediately contact your Chemical Hygiene Officer or follow your facility's procedure for reporting problems.

Verifying proper system operation without a hood monitor is very difficult. All hoods shall have some type of monitor to verify proper exhaust flow and/or average face velocity. If your hood does not have a monitor, request one.

## **6.5 Utilize Proper Work Practices**

Ultimately the ability of the hood to provide adequate protection depends on the user. By utilizing proper work practices, the potential for exposure can be reduced. Limitations inherent

in many hoods and systems make proper work practices required to optimize containment.

### **6.5.1 Proper Location of Equipment and Apparatus**

The location of equipment and apparatus effects the airflow patterns within the hood. Vortices form downstream of a person standing at the opening. When obstructions are placed directly in front of the operator or improperly located within the hood, the problems with reverse flow and turbulence can be exacerbated.

The following guidelines are provided for properly locating equipment and apparatus within the hood:

Always locate equipment as deep into the hood as practical and at least six to eight inches beyond the plane of the sash. For hoods that have a recessed work area, equipment and apparatus should not be placed on the raised ledge in front of the work area.

Equipment should never extend beyond the plane of the sash or restrict the sash from closing.

Elevate equipment two to three inches above the work surface to provide flow beneath and around the equipment.

Ensure that elevated equipment is stable. Plexiglas or stainless steel slotted shelves can be used to elevate equipment and apparatus above the bottom slot in the baffle. Slotted or perforated shelves minimize disruption to airflow patterns.

Excessive equipment and apparatus in the hood should be avoided. As a rule of thumb, no more than 50% of the work surface should be covered by equipment, apparatus or other bulky obstructions.

Caution is advised when placing equipment requiring electrical power in the hood. The equipment must be properly grounded to reduce the potential for sparks. Power cords should be plugged in a properly grounded and approved outlet.

High heat loads create thermal drafts which increase face velocity through the bottom of the fume hood opening and thus lower face velocities at the top of the fume hood opening. Excessive heat loads can cause the fume hood to lose containment. If high heat loads are expected during the normal operation of the fume hood AU ASHRAE testing should be conducted under the same conditions to test fume hood performance.

If a distillation rack (also known as “lattice rack” or “monkey bars”) is installed in the fume hood, the rack should be positioned in such a location that it is accessible from the operating sash opening.

### 6.5.2 Desired Operator Position and Movements

The hood user should always be aware of locations within the hood where concentrations of contaminants can accumulate. The user should never allow his head to break the plane of the sash because this will cause contaminated air to pass through the breathing zone.

When materials are being generated in the hood, ensure that you slowly approach and withdraw from the hood. The wake zone created by movement near the hood opening can withdraw materials from within the hood.

Rapid arm and body movements near the hood opening should be avoided.

### 6.5.3 Proper Configuration of Vertical and Horizontal Sliding Sashes

The vertically sliding sash should always be lowered as much as possible to protect the user and to minimize visual obstruction from sash handle. Raise the sash to full open position for set-up purposes only.

Reducing the sash to below the user’s breathing zone provides a protective barrier between the researcher and the experiment.

As air enters the opening of a hood with horizontal sash panels, turbulent vortices develop along the vertical edges of the sash panels. The vortex, readily visualized using smoke, can extend deep into the hood and draw contaminants toward the edges of the sash panels.

High concentrations can develop near the edge of the sash panels regardless of the generation location within the hood. Although escape is not usually observed, rapid movements near the sash edge or turbulence resulting from cross drafts could cause escape.

A horizontal sash panel provides an effective barrier to splashes or explosions, but remember

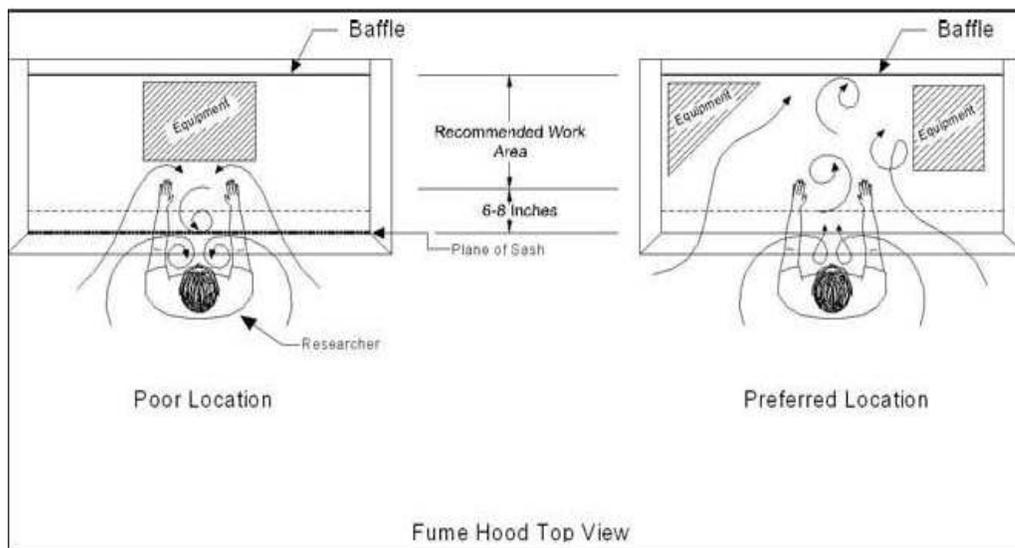
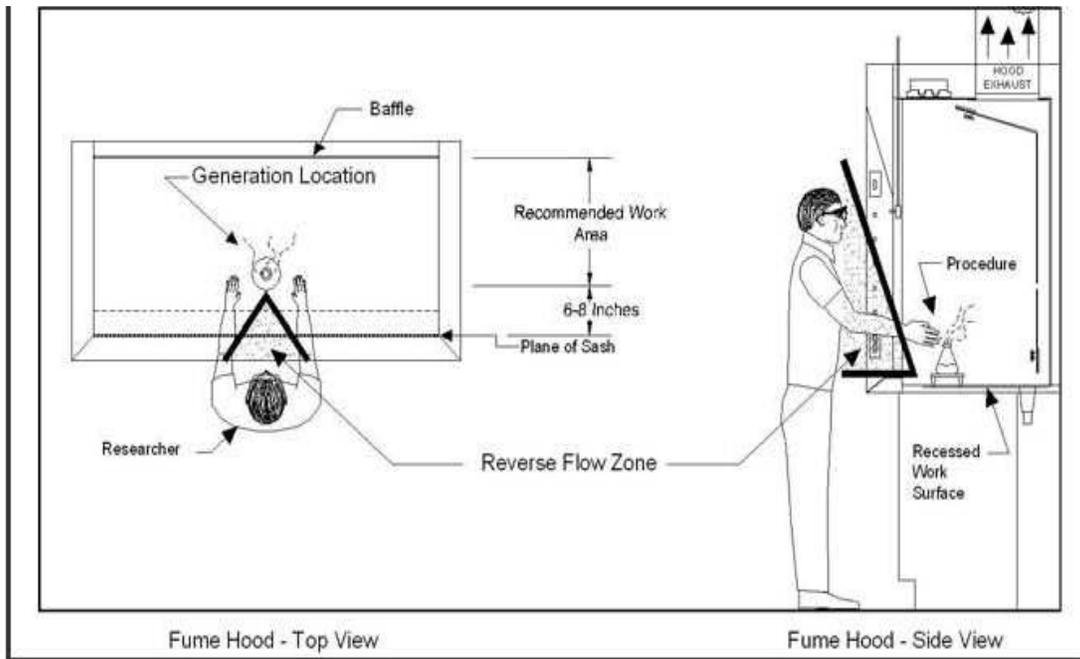


Fig. 9 Diagram Showing Effects of Locating Equipment, Materials and apparatus in the Fume Hood



**Fig. 10 Diagram of Proper Locations for Generating Hazardous Material within the Hood**

that high concentrations can develop inside the sash panels. As a general rule, you should avoid rapid movements near the vertical edges of the sash panels.

Avoid rapid withdrawal from the hood.

#### **6.5.4 Reduce Pedestrian Traffic Near The Hood**

A person walking past the hood can generate significant cross drafts. When generating hazardous materials in the hoods, attempt to divert or limit traffic past the hood. Inform other laboratory personnel about the work being conducted in the hood.

#### **6.5.5 Ensure Hoods are Cleaned and Decontaminated**

Following procedures involving highly toxic, potent or radioactive materials, the hood interior should be cleaned and decontaminated. Contaminated hoods should be clearly labeled. Maintenance personnel should also be informed of the potential for duct contamination. In several cases, maintenance personnel have been injured while working on hood systems that have been

used for work with perchloric acid and appropriate decontamination methods had not been followed.

#### **6.5.6 Do Not Store Materials In The Hood**

Laboratory fume hoods should not substitute for an approved chemical storage cabinet. Hood performance is impaired by excessive storage of materials in the hood and the available work surface is reduced.

#### **6.5.7 Summary of Proper Work Practices**

The following list summarizes guidelines for working in a chemical hood:

Always work at least six inches beyond the plane of the sash. The farther the work is into the hood the better.

Avoid rapid withdrawal from the hood.

Close horizontal panels on combination sashes before opening the sash vertically.

Always close the sash when not working in the hood.

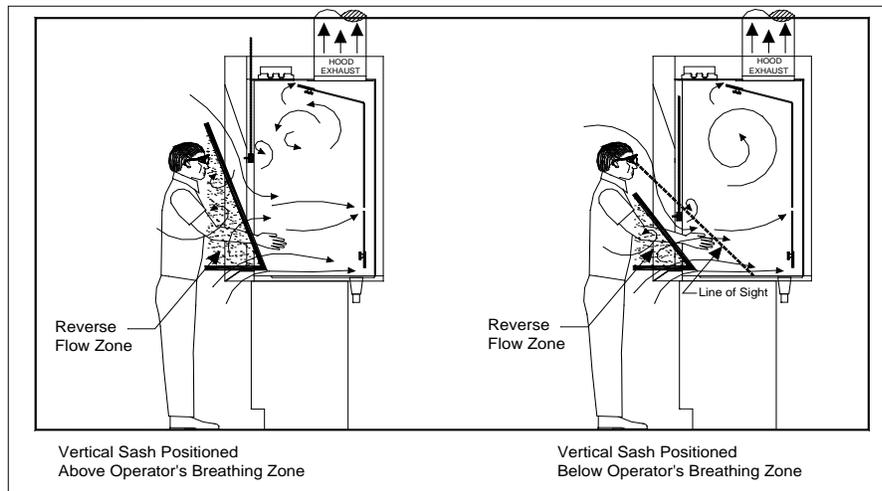


Fig. 11 Diagram Showing Effects of Lowering Sash Below Operators Breathing Zone

Baffles should only be adjusted per manufacturer's recommendation. If baffle settings are modified, it is recommended that the fume hood is tested to the ASHRAE 110 standard under all baffle configurations.

Elevate contaminants and equipment above the surface of the hood to enable flow beneath and around the obstructions.

If equipment and material storage is necessary, locate along the sidewalls or well away from the point of contaminant generation. Do not store any equipment that restricts the closing of the sash or blocks the bottom slot of the baffle directly in front of the user.

Keep movements in the hood and in front of the hood to a minimum.

Keep motion in the lab to a minimum while working in the hood. Traffic past the hood can generate considerable cross drafts.

Ensure head and upper body remains outside the plane of the hood opening at all times.

Always attempt to slowly approach and withdraw from hood. Open and close the sash slowly.

## 6.6 Responsibilities for Ensuring Proper Hood Performance

Ensuring performance of laboratory fume hood systems is the combined responsibility of:

- materials being used in the fume hood.
- Ensure proper selection and use of hoods.
- Determine protocol for proper operation.

- Ensure users are informed of hood capabilities and limitations (Training).

- Develop and review safety standards periodically.

- Conduct and/or review periodic hood performance tests.

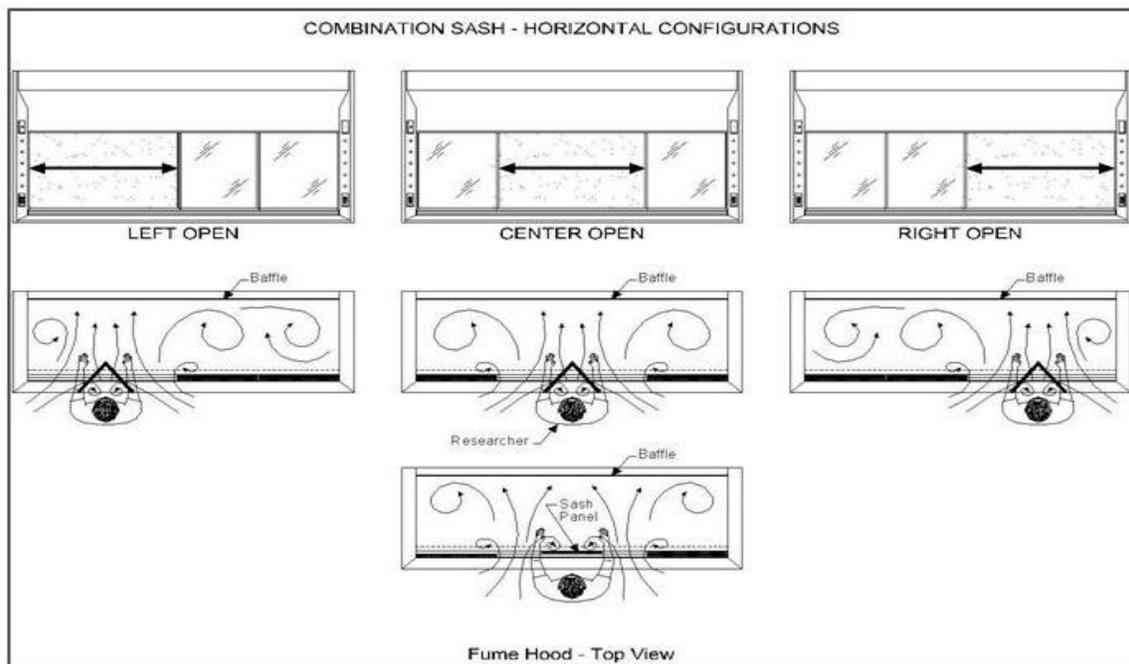
- Review all requests for new hoods.

- Confirm that hood performs as required.

### 6.6.4 Laboratory Design Team and Engineering Identify needs.

- Design appropriate building system (architectural, mechanical, electrical, plumbing, structural etc.).

- Design and specify appropriate fume hood system.



**Fig. 12 Diagram of Airflow Patterns for Different Horizontal Sash Configurations**

Assist with pre-qualification of construction team.

Review all proposed changes.

Prepare "as built" documents.

Ensure design intent is achieved and commissioned.

### 6.6.5 Construction Team

Construct and install in accordance with contract documents, and regional, local and national codes.

Provide coordinated effort to meet design and performance requirements.

Coordinate field changes with other appropriate team members.

### 6.6.6 Controls Manufacturer

Supports design and specification of appropriate fume hood control system.

Provide product in accordance with specifications and contracts.

Provide start-up of fume hood control system.

Provide training in proper operations and maintenance for product.

Although your organization's management is ultimately responsible for the health and safety of laboratory personnel, a team approach is required to ensure proper performance of laboratory fume hood systems.

| Group   | Responsibility   |
|---|--|
| <b>Management (6.6.1)</b>   | <b>Ensure health and safety of laboratory personnel</b>  |
| <b>Principal Research Investigators (6.6.2)</b>                             | <b>Provide information about hazards and scientific procedure</b>  |
| <b>Health and Safety (6.6.3)</b>  | <b>Develop Safety Operating Procedures (SOP)</b>   |
| <b>Lab Design Team And Engineering (6.6.4)</b>                              | <b>Identify needs and design/specify appropriate building system, fume hoods and laboratory components</b>                           |
| <b>Construction Team (including laboratory fume hood installer) (6.6.5)</b> | <b>Construct/install in accordance with contract documents</b>   |
| <b>Controls Manufacturer (6.6.6.)</b>                                       | <b>Provide Product(s) in accordance with contract documents</b>  |
| <b>Building System Commissioning (6.6.7)</b>                                | <b>Verify function of lab controls and the ability of the system to meet all required set points</b>                                 |
| <b>Operations and Maintenance (6.6.8)</b>                                   | <b>Develop and implement Operations and Maintenance Program</b>  |
| <b>Laboratory Personnel and Laboratory Fume Hood Users (6.6.9)</b>          | <b>Comply with Standard Operating Procedures (SOP)</b>   |
| <b>Laboratory Fume Hood Manufacturer (6.6.10)</b>                           | <b>Provide product(s) in accordance with contract documents. Provide product(s) that perform in accordance with safety standards</b> |

The following list provides a summary of responsibilities for each group involved with ensuring proper operation of laboratory fume hood systems.

### 6.6.1 Management

Provide commitment to health and safety.

Provide leadership.

Direct and coordinate activities.

Allocate sufficient resources.

### 6.6.2 Principal Research Investigators

Identify personnel risks and characterize scientific procedures.

Evaluate hazard potential.

Work with Health and Safety to develop safety protocols, training programs, and select appropriate hoods.

Submit all requests for new hoods to Health and Safety.

Inform Health and Safety of significant changes in research activities.

Support (embrace) Health and Safety's Standard Operating Procedures.

### 6.6.3 Health and Safety

Develop and manage the Chemical Hygiene Plan (Standard Operating Procedures).

Administer Laboratory Fume Hood Safety Program.

Determine exposure control requirements. Provide hood operators with MSDS information on

### 6.6.7 Building System Commissioning

Verify fume hood flow rate.

Verify function of controls.

Verify ability to meet design set points for temperature, airflow, and room pressurization.

### 6.6.8 Operation and Maintenance

Ensure regular maintenance on all system components.

Ensure proper operation within specified tolerances.

Ensure no unauthorized changes to hood systems.

Ensure maintenance personnel are familiar with hazards and safe work procedures.

Ensure maintenance personnel are fully trained.

### 6.6.9 Laboratory Personnel and Hood Users

Understand the hazards.

Understand the capabilities and limitations of hoods.

Verify proper operation prior to use.

Use proper work practices in compliance with SOP.

Report suspected operational problems.

### 6.6.10 Hood Manufacturer

Hood is built to specifications.

Hood performs as expected "as manufactured."

Technical information associated with hood design.

Hood shall be manufactured in conformance with SEFA-1.

Provide product training and verification as

requested.

Provide basic safety precautions posted clearly on the fume hood.

Provide troubleshooting assistance when hood fails to meet expectation "as installed."

## 7.0 Laboratory Ventilation Systems

Laboratory ventilation systems include both exhaust and supply duct systems. The purpose of a laboratory exhaust system is to exhaust a specific volume of air from laboratory fume hoods or other exhaust devices and safely transport the contaminated air from the building in a manner that reduces the potential for re-entrainment of exhaust fumes into the fresh air intake in the building. According to a number of industry standards, the supply air system must make up the air exhausted from the laboratory with 100% fresh outside air, conditioning it to provide a safe and comfortable work environment for the lab space occupants. The amount of supply air delivered to a laboratory is controlled to satisfy the demand for minimum ventilation (ACH) rate, hood flow demand or cooling / heating load demand, whichever is greater. In order to maintain the negative pressure requirement, the total exhaust volume for a lab must always exceed the supply air volume by a specific volumetric offset or the flows must be controlled by a pressure differential control system. The volumetric offset method is the most common. If the total of all hood exhaust is less than the maximum possible supply flow, an additional exhaust device, normally referred to as the general exhaust valve, is required.

Many factors affect the performance of hoods and laboratories, none of which receives more discussion than the airflow control strategy. The flow control strategy significantly impacts laboratory fume hood containment, room pressurization and energy usage.

### 7.1 Airflow Control Strategy

There are three main airflow control strategies for laboratories with fume hoods.

The first and most widely used, Constant Volume (CV), has been in use since the early 20th century. Second is Two-State Control (2SC), introduced in the 1960's. And finally, Variable Air Volume (VAV) has been gaining popularity and effectiveness since the 1980's. Specific applications are well suited to each. The energy efficient fume hood designs can be used on any of these systems and can further reduce the total volumetric flow requirements of the HVAC system.

### 7.1.1 Constant Volume (CV)

Constant volume systems are designed to exhaust a constant volume of air from the laboratory fume hood regardless of hood use, sash position or operating mode. Caution must be exercised by the designer and commissioning agent to ensure that sash stops and flows are properly selected, and you consult with the hood manufacturer for proper airflow requirements.

### 7.1.2 Two-State Control

Two-state fume hood control is simply a low/high volume control system. This control approach gains energy efficiency over CV systems to the extent that the hoods remain in the low flow level.

The low and high volumes are changed by various methods such as a sash position switch, light switch, and user presence sensors, the most common of which are sash switches and wall (manual) switches. Sash switches are used to change the flow based on the open area of the fume hood sash.

The energy savings of the two-state approach is improved over constant volume, but may require an audible alarm that reminds a hood user to close the sash. The use of controls also adds more maintenance costs to the system, compared to a CV system.

### 7.1.3 Variable Air Volume (VAV) Systems

A variable air volume fume hood control system is designed to vary the hoods' exhaust rate to maintain a constant average face velocity throughout the sash travel. The complexity of this system requires fast, stable control systems, which

are more expensive, on an installed cost basis, than constant volume control systems. Energy savings can be further improved to potentially offset these higher costs.

Room pressurization is commonly maintained by adjusting the make up air to a fixed offset relative to the total exhaust flow. A small percentage of facilities choose to maintain pressurization by controlling the pressure differential.

If the minimum total hood flow for a laboratory is lower than the exhaust flow required to maintain the negative pressure in the lab, a general exhaust device may be required to provide minimum ventilation and proper temperature control. In this case, the total exhaust (hoods plus general exhaust) airflow rate is increased to overcome the added supply requirements.

Below is a diagram of a simple VAV system. (See: Figure 14).

### 7.1.4 Summary of Air Control Strategies

The cost of operating a laboratory fume hood is very significant and will continue to be a major concern until alternative forms of renewable energy are readily available. As of early 2002, the range of first pass estimates range from \$4 to \$7 per CFM per year to operate the laboratory ventilation systems. Reducing flows when appropriate, through the use of an energy efficient fume hood design and/or through a usage-based flow setback, can result in significant cost savings.

One of the primary goals of the designer is to provide a safe environment for researchers. Meeting this objective requires containment at hoods and at the room level. Room pressurization is an important consideration for laboratories.

## 7.2 Room Pressurization

The standards and guidelines stress the importance of room pressurization for laboratory spaces. Laboratories that use laboratory fume hoods should be maintained at a relative negative pressure to corridors and other adjacent spaces in the building (with the exception of clean room

laboratories that may operate under positive pressure).

### 7.3 Diversity

Diversity is used by engineers in designing systems based on its practical or maximum expected use, not its total possible use. When diversity is applied to sizing of systems, the design capacity is less than the sum of peak demands.

Both existing and new laboratories can benefit from applying diversity to the HVAC design. Diversity allows existing facilities to add fume hood capacity using the current HVAC systems. Diversity design in new construction allows the facility to reduce capital equipment expenditures by downsizing the mechanical systems during the design phase.

Diversity can be applied only after providing the required number of air changes in the laboratory and the minimum flow to control room temperature. For these reasons, some laboratories cannot reduce the total hood exhaust flow capacity.

For either type of facility, designers must develop a solution that best fits the customers' needs. However, some designers are hesitant to use diversity since the savings are only realized when

the sashes are lowered. Often, this has led to systems with methods of "forced" diversity that have proven problematic.

Mechanical sash stops prevent a user from opening a sash beyond a predetermined maximum setting. Unfortunately, users often override these mechanical stops for everyday activity and for setting up experiments. This can create a dangerously low face velocity profile if the controller is not sized for full sash opening and if the fume hood is not designed to operate at lower face velocities. Insure that low flow alarms are working properly.

A system that automatically switches between standard and setback flow can provide greater diversity than other systems. (See: Varley, J.O.–ASHRAE Trans. 1993, Vol. 99, Part2, Paper number DE-93-18-2, 1072-1080, 2figs., 3tabs., 6refs. AND in Laboratory HVAC, 1995, 45-51 ISBN 1-883413-25-7. See also: Parker, J.A., Ahmed, O., and Barker, K.A. –ASHRAE Trans., 1993, Vol. 99, Part 2, Paper number DE-9-18-3, 1081-1089, 11figs., 2 tabs.) The hood design should be tested to the ASHRAE 110 Standard at the setback flow if the setback can occur through an open sash.

Some Factors Affecting Diversity:

Control Method

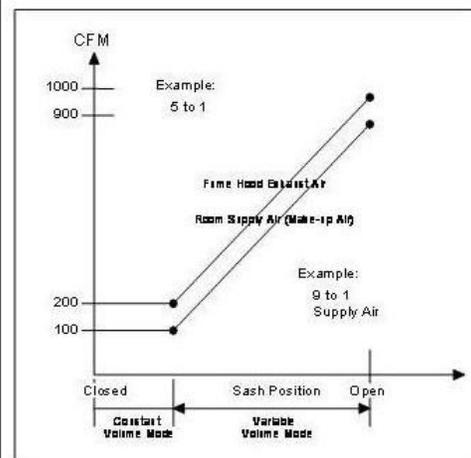
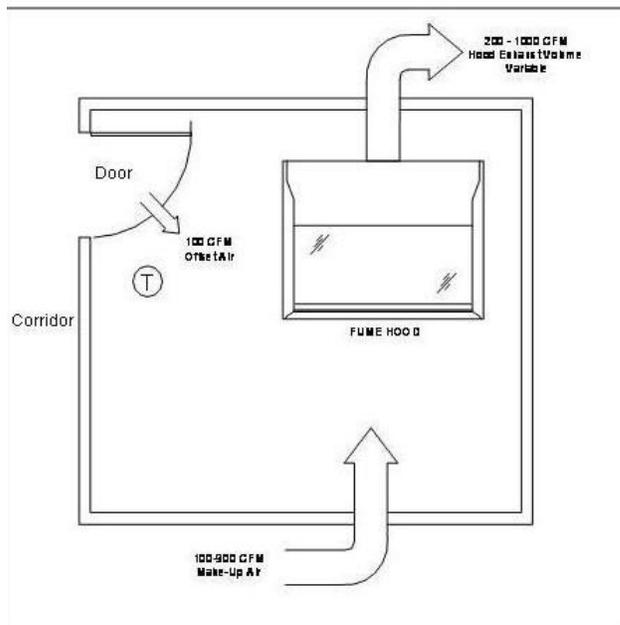


Fig. 14 Simple VAV

Constant Volume CV  
Variable Air Volume VAV  
Two State Controls

Usage Pattern

Number of users per fume hood  
Fume hood usage type  
User compliance

Sash  
Sash type  
Sash management

Airflow Requirements

Face velocity  
Cooling airflow rate  
Minimum ventilation rate

Number of Floors and Size of Building

Fume Hood Density  
Number of fume hoods per lab  
Number of fume hoods per manifold.

Chemical Hygiene Officer to evaluate your specific application.

## 8.0 Other Ventilated Laboratory Safety Devices

All ventilated devices used in a laboratory are safety devices and should be carefully examined for application and safe working practice. Some experts believe that all ventilated enclosures should be called a laboratory fume hood and tested to fume hood standards. This is not possible because many enclosures are suitably made of flammable materials, are sized for their application and operate safely for the intended purpose, but not as a fume hood.

Products described in this section are not fume hoods by the definition in Section 3. Testing of these products is not covered in the ASHRAE 110-1995 (or most current edition) Standard. As such great care must be taken to insure that the product being evaluated is functioning safely for the intended purpose. It is not possible for SEFA to presuppose all applications and as such this

section is intended to be used as a guideline only, not a definitive source. Contact your Chemical Hygiene Officer to evaluate your specific application.

## 8.1 Special Purpose Hoods

Special purpose hoods are hoods that are modifications of fume hoods. As such, they fail to meet the exacting definition of a fume hood and shall be classified as a special purpose hood. Common modifications to fume hoods include: baffle designs, sash configurations and locations, size, and materials. Special purpose hoods are designed specifically for that purpose, where a fume hood tends to serve a more general application. Special purpose hoods shall be designed, tested, and operated with their respective intended purpose in mind.

### 8.1.1 Demonstration Hood

Examples – Multi Sided, Pass Through Hood, Dual Entry Hood, Trifacial Hood

#### Description

A demonstration hood is a bench hood that provides visibility of the hood interior from multiple sides. Often a demonstration hood provides access from two or more sides. Demonstration hoods may or may not have a baffle system.

#### Purpose or Application

A demonstration hood is typically used by educators who interact with students via demonstration of experiments. A demonstration hood may or may not function as a fume hood because they typically deviate from traditional baffle systems, sash arrangements and often do not utilize front airfoils.

#### Reference Organization

None

#### Testing Recommendations

Some hoods may be tested using the ASHRAE 110-1995 (or most current edition) Standard.

Others will require test modifications due to size, sash location, and when to test for multiple sash positions. Consideration must be made to the toxicity of the experiment and acceptable exposure levels. The manufacturer should make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

#### **Additional Comments**

Contact your Chemical Hygiene Officer for safe exposure levels and for testing recommendations before working in a demonstration hood.

### **8.1.2 California Hood**

#### **Description**

A California hood is an enclosure that has access to at least two sides, and it usually provides visibility from all four sides similar to a demonstration hood. A California hood differs from a demonstration hood in that it is taller than a bench hood (floor-mounted height), is always set atop a pedestal, and comes equipped with a distillation rack.

#### **Purpose or Application**

A California hood is used when large distillation apparatus is required and fumes from the distillation should not be present in the open laboratory.

#### **Reference Organization**

None

#### **Testing Recommendations**

ASHRAE testing must be modified because the hood opening is much larger than a bench laboratory fume hood and has multiple sash configurations. Containment levels for California hoods are normally unfavorable to fume hood specifications since the hood rarely has a baffle system, and has unique sash configurations. The manufacturer should make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter

integrity test if a filter is part of the system.

#### **Additional Comments**

Contact your Chemical Hygiene Officer for safe exposure levels, special considerations during set-up and tear-down, and for testing recommendations before working in a California hood.

### **8.1.3 Ventilated Hoods and Enclosures**

A ventilated enclosure is a general term used to describe any special purpose hood that is otherwise not specifically described as a California hood or demonstration hood.

#### **8.1.3.1 Oversized Hood**

##### **Description**

Laboratory fume hoods are sometimes built in large, non-standard sizes to accommodate a specific application. Generally, laboratory fume hoods as long as twenty feet reflect the basic tenet of a laboratory fume hood, but larger structures may not. These larger structures shall be referred to as oversized hoods and not a laboratory fume hood.

##### **Purpose or Application**

Oversized hoods are often designed to accommodate a specific piece of equipment that must be housed in the hood during the experiment. Sometimes the scale of the work done in the hood determines the desired size of the hood.

##### **Reference Organization**

None

##### **Testing Recommendations**

Extensive knowledge of the testing apparatus or experimentation, or work being done in the hood is required for determining the safe testing methods of an oversized hood. Contact your Chemical Hygiene Officer before working in an oversized hood. The manufacturer should make

recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system. Testing an oversized hood will require extensive interpretations of the ASHRAE 110-1995 (or most current edition) test procedure. Oversized hoods may require more and different diffuser locations, and sash arrangements must be considered before testing.

#### **Additional Comments**

Contact your Industrial Hygienist for safe exposure levels, proper use of sash positions, special considerations during set-up and tear-down, operating procedures and for testing recommendations before working in an oversized hood

#### **8.1.3.2 Table Top Hood**

Examples – Portable Hood, Down Draft Hood (A Down Draft Hood is a Table Top Hood that is vented down through the table top into an exhaust fan system).

#### **Description**

A portable hood is a ventilated enclosure that is small (usually less than 15 cubic feet of working space), is often made of alternate materials (such as epoxy, polycarbonate, acrylic or sheet metal) for mounting on a tabletop.

#### **Purpose or Application**

Used primarily in educational laboratories to control nuisance contaminants or small, microscale experiments.

#### **Reference Organization**

None

#### **Testing Recommendations**

A table top hood may be tested to the ASHRAE 110-1995 (or most current edition) test if the hood is large enough to contain the apparatus and a sash is apparent. If not, evaluate containment by modifying the test methods or by smoke visualization. The manufacturer should make

recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

#### **Additional Comments**

Do not use this product for anything but nuisance vapor protection, unless otherwise certified by your Chemical Hygiene Officer.

#### **8.1.3.3 Conventional Hood**

Examples – Flat Front Hood, Thin Wall Hood

#### **Description**

A conventional hood is a ventilated bench mounted enclosure that exhibits a square entry profile, and usually lacks a bypass, and airfoil.

#### **Purpose or Application**

Used primarily in educational laboratories to control nuisance contaminants or small, microscale experiments.

#### **Reference Organization**

None

#### **Testing Recommendations**

A conventional hood may be tested to the ASHRAE 110-1995 (or most current edition) test if the hood is large enough to contain the apparatus and a sash is apparent. If not, evaluate containment by modifying the test methods or by smoke visualization. The manufacturer should make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

#### **Additional Comments**

This product should be used with caution. Contact your Chemical Hygiene Officer for the proper application, set-up and use of a conventional hood.

#### **8.1.3.4 Balance Enclosure Description**

A balance enclosure is a ventilated enclosure designed to specifically house a laboratory balance. These enclosures require good visibility and are typically made of transparent materials such as acrylic, polycarbonate, or glass. Balance enclosures should include baffles, tapers, slots or airfoils to reduce turbulent airflow. Access to the balance enclosure is usually from the sides; however, other access depends upon the accessibility needs.

##### **Purpose or Application**

Exposure to fumes from a balance is usually low; however, the proximity of the user's breathing zone to the use of a balance could result in unacceptable exposure levels. It is best to house the balance in a ventilated enclosure. Balance enclosures are designed to protect users and the laboratory environment by directing the airflow away from the breathing zone of the user and exhausting the contaminated air out of the room.

##### **Reference Organization**

None

##### **Testing Recommendations**

The manufacturer should provide testing data and make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

##### **Additional Comments**

None

#### **8.1.3.5 Microscope Enclosure Description**

A microscope enclosure is a ventilated enclosure designed to specifically house a laboratory microscope and to provide adequate protection to the user of the microscope. These enclosures require good visibility and are typically made of transparent materials such as acrylic, polycarbonate, or glass. Microscope enclosures should include baffles, tapers, slots or airfoils to reduce turbulent airflow. Access to the

microscope enclosure is usually from the front and/or sides and should provide sufficient room for the user to perform necessary operations comfortably. Individual designs vary with the size and style of the microscope and application.

##### **Purpose or Application**

Exposure to fumes from a microscope is usually low; however, the proximity of the user's breathing zone to the use of a microscope could result in unacceptable exposure levels. It is best to house the microscope in a ventilated enclosure. Microscope enclosures are designed to protect users and the laboratory environment by directing the airflow away from the breathing zone of the user and exhausting the contaminated air out of the room.

##### **Reference Organization**

None

##### **Testing Recommendations**

The manufacturer should provide testing data and make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

##### **Additional Comments**

Provisions may be necessary to allow electrical connection of the microscope. Proper care must be exercised to avoid a spark within the chamber, which may contain flammable effluents.

#### **8.1.3.6 Robotic Enclosure Description**

A robotic enclosure is a ventilated enclosure designed to specifically house a laboratory robot or automated equipment and to provide adequate protection to the laboratory personnel near the robot. Robotic enclosures are typically made of transparent materials such as acrylic, polycarbonate, or glass. Robotic enclosures may or may not have a baffle system. Individual designs vary with the size and style of the robotic equipment and application.

### **Purpose or Application**

Exposure to fumes from a robot is usually low; however, the proximity of the user's breathing zone to the use of a robot could result in unacceptable exposure levels. It is best to house the robot in a ventilated enclosure. Robotic enclosures are designed to protect users and the laboratory environment by directing the airflow away from the breathing zone of the user and exhausting the contaminated air out of the room.

### **Reference Organization**

None

### **Testing Recommendations**

The manufacturer should provide testing data and make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

### **Additional Comments**

Proper care must be exercised to avoid a spark within the chamber, which may contain flammable effluents.

#### **8.1.3.7 Histopathological Enclosures**

Examples – Autopsy, Necropsy Enclosures, Tissue Trimming Enclosures, Tissue Staining, Fixing, Embedding Enclosures

#### **Description**

A histopathological enclosure is a hood specifically designed to enclose histopathological operations such as autopsy, necropsy, tissue trimming, tissue staining, fixing, slide and sample preparation. A histopathological enclosure shall provide adequate protection to the user and to the laboratory personnel. Histopathological enclosures are typically made of transparent materials such as acrylic, polycarbonate, or glass. Histopathological enclosures usually have a baffle system. Individual designs vary with the equipment and application.

### **Purpose or Application**

Histopathological enclosures are used to protect the users and their environment from potentially hazardous and noxious aerosols that may be present or formed during the histopathological operation. The histopathological enclosure shall exhaust the contaminated air out of the room and away from laboratory personnel.

### **Reference Organization**

None

### **Testing Recommendations**

The manufacturer should provide testing data and make recommendations for the specific testing of this product including a velocity profile, smoke visualization, and a filter integrity test if a filter is part of the system.

### **Additional Comments**

Proper care must be exercised to avoid a spark within the chamber, which may contain flammable effluents.

## **8.2 Local Exhaust Ventilation**

### **8.2.1 Canopy Hood Description**

A canopy hood is a ventilated enclosure suspended directly above the work area.

#### **Purpose of Application**

Canopy hoods are receiving hoods. As such a canopy hood shall be used when there is a force, such as heat, to deliver the contaminant to the receiving hood.

#### **Reference Organization**

See the Industrial Ventilation Manual for further details. (Industrial Ventilation: A Manual of, 25th Edition, or most current edition, American Conference of Governmental Industrial Hygienists, 1330 Kemper Meadow Drive, Cincinnati, OH 45240 [www.acgih.org](http://www.acgih.org))

### Testing Recommendations

The manufacturer should make recommendations for the specific testing of this product including a velocity profile, smoke visualization.

### Additional Comments

A canopy hood must be positioned to receive the contaminant. Proximity to the delivering source must be considered when using a canopy hood. Contact your Chemical Hygiene Officer for the proper positioning and use of a canopy hood.

### 8.2.2 Slot Hood Description

A slot hood is a local exhaust ventilation device that is positioned adjacent and at a right angle to the work area.

### Purpose or Application

A slot hood is used only for the removal of nuisance vapors or particulate. A slot hood is preferred to a canopy hood when the nuisance vapor is at room temperature.

### Reference Organization

None

### Testing Recommendations

Contact your Chemical Hygiene Officer for proper use of a slot hood. The manufacturer should make recommendations for the specific testing of this product including exhaust volume and smoke visualization.

### Additional Comments

A slot hood must be positioned to receive the contaminant. Proximity to the delivering source must be considered when using a slot hood. Contact your Chemical Hygiene Officer for the proper positioning and use of a slot hood.

### 8.2.3 Snorkel

Examples – Elephant Trunk, Spot Collector, Extractor

### Description

A small, localized ventilation hood usually connected by flexible duct to an exhaust fan.

### Purpose or Application

Snorkel hoods are used for ventilating laboratory equipment and heat or nuisance vapor exhaust only.

### Reference Organization

None

### Testing Recommendations

Contact your Chemical Hygiene Officer for proper use of a snorkel hood. The manufacturer should make recommendations for the specific testing of this product including a exhaust volume, and smoke visualization

### Additional Comments

A snorkel hood has an effective capture range of about one hood diameter away from the hood. Do not use a snorkel hood for anything but heat or nuisance vapor removal unless otherwise certified by your Chemical Hygiene Officer.

## 8.3 Exhausted Laminar Flow Hoods

Examples: Clean Hoods, Class 10 Fume Hoods, Clean Air Chemical Hoods, Trace Metals Analysis Hoods, Push/Pull Hoods.

### Description

An exhausted laminar flow (ELF) hood is one that is designed for critical operations where both a clean air (class 10+) process environment is necessary, along with adequate protection to the user, from fumes and particles. ELF hoods are ventilated cabinets, which contain an integral HEPA/ULPA filtered supply air source. ELF hoods are usually 100% outside ducted, but may be recirculated in cases where particle entrapment is the principle objective. ELF hoods contain vertically closing sashes, baffle systems and often localized exhaust systems within the unit.

### **Purpose or Application**

ELF hoods are used to protect operators from potentially hazardous fumes, typically associated with acid digestion or solvent parts cleaning, while creating clean environmental conditions required for these types of critical processes.

### **Reference Organization**

ISO 14644-1, ISO 14644-7 and ASHRAE 110-1995.

### **Testing Recommendations**

Because ELF hoods are hybrids between negative and positive pressure environments, strict attention to balance testing is crucial. Testing to be done against ASHRAE 110-1995 and ISO 14644-21 or most current versions.

### **Additional Comments**

ELF hoods are often constructed in corrosion resistant materials, such as polypropylene, because of the harsh conditions often present within these critical processing environments. Further, clean room compatible materials often dictate non-shedding materials of construction. Finally, various critical processes, such as trace metals analysis, require metal-free environments, due to data collection concerns.

## **8.4 Biological Safety Cabinets**

### **8.4.1 Class I Cabinets**

#### **Description**

A ventilated cabinet that provides personnel and environmental protection. It is characterized by an unrecirculated inward flow of air away from the operator through a limited fixed access opening. Exhaust air must be HEPA filtered if recirculated back into the laboratory. It may or may not be vented via a remote ventilation system. This cabinet does not offer product protection.

#### **Purpose or Application**

Personnel and environmental protection.

#### **Reference Organization**

NSF International provides some information

in NSF Standard 49. (See: NSF49-2002 Class II (Laminar Flow) Biohazard Cabinetry, NSF International)

#### **Testing Recommendations**

None

#### **Additional Comments**

There are no nationally recognized specifications/standards governing construction and performance for these configurations.

## **8.4.2 Class II Cabinets**

#### **Description**

A ventilated cabinet that provides personnel, product and environmental protection. It is characterized by a limited fixed inward airflow access opening that provides personnel protection, a vertical downward HEPA filtered work zone that provides product protection and HEPA filtered exhaust providing environmental protection. They are divided into types by NSF and identified in Standard 49.

- **Class II Type A1 cabinets (Formerly designated Type A)**

Minimum of 75 FPM (.36m/s) inflow. HEPA filtered down flow mixed with recycled air.

May exhaust some or all HEPA filtered air back into the laboratory.

May have positive pressure duct systems.

- **Class II Type A2 Cabinets (Formerly designated Type B3)**

Minimum of 100 FPM (0.5m/s) inflow. HEPA filtered down flow mixed with recycled air.

May exhaust some or all HEPA filtered air back into the laboratory.

Has negative pressure duct systems.

- **Class II Type B1 Cabinets**

Minimum of 100 FPM (.5m/s) inflow.

HEPA filtered, largely uncontaminated recirculated air.

Exhausts most contaminated air to atmosphere through a dedicated duct system.

Has negative pressure duct system or surrounded by a negative pressure duct system.

- **Class II Type B2 Cabinet (Total Exhaust)**

Minimum of 100 FPM (.5m/s) inflow.

HEPA filtered, non-recirculated, down flow air.

HEPA filtered exhaust air to atmosphere.

Has negative pressure duct system or surrounded by a negative pressure duct system.

**Purpose or Application**

Refer to the Center for Disease Control (CDC) and the National Institute of Health (NIH) for application information. (Center for Disease Control and Prevention, 1600 Clifton Rd. Atlanta, GA 30333 [www.cdc.gov](http://www.cdc.gov), National Institutes of Health, Bethesda, MD, 20892 [www.nih.gov](http://www.nih.gov))

**Reference Organization**

NSF International Standard No. 49.

**Testing Recommendations**

Construction and Performance Specifications for Class II cabinets are defined by the NSF International Standard No. 49.

**Additional Comments**

None

**8.4.3 Class III Cabinets**

Examples: Glove Box

**Description**

Provides absolute personnel protection, environmental protection and may provide product protection. It is characterized by a totally enclosed, gas-tight, negative pressure, HEPA filtered, ventilated workspace accessed through attached rubber gloves and purged interchange chambers. Exhaust air is treated by double HEPA filtration and/or incineration.

**Purpose or Application**

**Reference Organization**

The American Glove Box Society. (The American Glove Box society is a relevant organization an is listed in section 11.0 of this document.

**Testing Recommendations**

None

**Additional Comments**

There are no nationally recognized specifications/ standards governing construction and performance for these configurations. Some additional information can be found in NSF Standard 49.

**8.5 Ductless Hoods**

**(See: SEFA 9-2010 s for Ductless Enclosures)**

A ductless hood recirculates air back into the laboratory from the hood chamber.

Examples: Ductless Fume Hoods, Ductless Fume Cabinets

**Description**

A ductless hood is an open faced enclosure designed to protect the user from laboratory

and industrial airborne contaminants, similar to a laboratory fume hood, but is not connected to a duct system (although options are available for

connecting to a duct system). Instead, the air is recirculated back to the room atmosphere. The ductless hood's scope of use is limited to the capacity and capability of the filtration system. The objective of the filtration system is to reduce the levels of solids, gaseous or vapor constituent to that below the acceptable TLV limit at the exhaust.

The benefits of a ductless hood include:

Low installation cost  
Portability  
No permit for exhausting outside the building

### Reference Organization

(USA) SEFA 9-2010;

ANSI/AIHA Z9.5-2000 or most current version, Proposed Performance Standard section on Ductless Fume Hoods.

(Canada) CAN CSA Z316.5 Performance Standard.

(France) AFNOR NFX 15-211 Performance Standard.

(England) BSI Specification for recirculatory filtration fume cupboards.

(Germany) DIN 12927 Laboratory Furniture – Ductless filtering fume enclosures.

(Australia) AS2243.9 Approved Code of Practice on Safety in Laboratories - Recirculating Fume Cabinets (Ductless Fume Cabinets)

## 9.0 Terms and Definitions

**A&E** – The “Architect and Engineer.” Generic term refers to designers of laboratory building and ventilation systems.

**ACFM** – Actual cubic feet per minute of gas opening.

**ACGIH** – The American Conference of Governmental Industrial Hygienists; association supports or produces TLV list, Industrial Ventilation Manual, bioaerosol documents.

**ACH, AC/H (air changes per hour), N** – The number of times air is theoretically replaced during an hour.

**Acceptable Indoor Air Quality** – Air in which there are no known contaminants at harmful levels as determined by appropriate authorities and air with which 80% or more of the people do not express dissatisfaction.

**Access Opening** – That part of the fume hood through which work is performed; sash or face opening.

**Air Flow Monitor** — Device installed in a fume hood to monitor the airflow through the fume chamber of a fume hood

**Air Foil** — A horizontal member across the lower part of the fume hood sash opening. Shaped to provide a smooth airflow into the chamber across the worksurface.

**Air Volume** — Quantity of air expressed in cubic feet (ft<sup>3</sup>) or cubic meters (m<sup>3</sup>).

**Auxiliary Air** — Supply or supplemental air delivered to a laboratory fume hood to reduce room air consumption.

**Baffle** — Panel located across the rear wall of the fume hood chamber interior and directs the airflow through the fume chamber.

**Bench Hood** – A fume hood that is located on a work surface. (See superstructure)

**Bypass** – Compensating opening in a fume hood that functions to limit the maximum face velocity as the sash is raised or lowered.

**Combination Hood** – A fume hood assembly containing a bench hood section and a floor mounted section.

**Combination Sash** – A fume hood sash with a framed member that moves vertically housing two or more horizontal sliding transparent viewing panels.

**Counter Top** – (See Work surface)

**Cross Drafts** – Air draft that flows parallel to or

across the face opening of the fume hood.

**Damper** – Device installed in a duct to control airflow volume.

**Diversity** – Operating a system at less capacity than the sum of peak demand (ANSI Z9.5)

**Duct** – Round, square or rectangular tube used to enclose moving air.

**Duct Velocity** – Speed of air moving in a duct, usually expressed in feet per minute (fpm) or meters per second (mps).

**Exhaust Collar** – Connection between duct and fume hood through which all exhaust air passes.

**Exhaust Unit** – Air moving device, sometimes called a fan, consisting of a motor, impeller and housing.

**Face** – Front access or sash opening of laboratory fume hood. Face opening measured in width and height. See sash or access opening.

**Face Velocity** – Average speed of air flowing perpendicular to the face opening and into the fume chamber of the fume hood and expressed in feet per minute (fpm), measured at the plane of the face or sash opening.

**Fan** – Air moving device, usually called an exhaust unit, consisting of a motor, impeller and housing.

**Fan Curve** – A curve relating pressure vs. volume flow rate of a given fan at a fixed fan speed (rpm).

**Filter** – Device to remove particles from air.  
**Friction Loss** – The static pressure loss in a system due to friction between moving air and the duct wall; expressed as inches w. g. 100 feet, or fractions of VP per 100 feet of duct.

**Fume Chamber** – The interior of the fume hood measured width, depth and height constructed of material suitable for intended use.

**Fume Cupboard** – British term for laboratory fume hood.

**Fume Removal System** – A fume hood exhaust engineered to effectively move air and fumes consistently through fume hood, duct and exhaust unit.

**Gauge Pressure** – The difference between two absolute pressures, one of which is usually atmospheric pressure; mainly measured in inches water gauge (in. w. g.).

**Glove Box** – Total enclosure used to confine and contain hazardous materials with operator access by means of gloved portals or other limited openings; this device is not a laboratory fume hood.

**Grille** – A louvered or perforated face over an opening in an HVAC system.

**Hood** – A device which encloses, captures, or receives emitted contaminants.

**Hood Entry Loss** – The static pressure loss, stated in inches w. g., when air enters a duct through a hood. The majority of the loss is usually associated with a vena contracta formed in the duct.

**Hood Static Pressure** – The sum of the duct velocity pressure and the hood entry loss; it is the static pressure required to accelerate air at rest outside the hood into the duct at duct velocity.

**HVAC** – Heating Ventilating and Air Conditioning. Ventilation systems designed primarily for temperature, humidity, odor control, and air quality.

**Inches of Water (inch w.g.)** – The pressure exerted by a column of water one inch in height at a defined reference condition such as 39°F or 4°C and the standard acceleration of gravity.

**Indoor Air Quality (IAQ)** – The study, evaluation, and control of indoor air quality related to temperature, humidity, and airborne contaminants.

**Industrial Ventilation (IV)** – The equipment or operation associated with the supply or exhaust of air, by natural or mechanical means, to control occupational hazards in the industrial setting.

**Laboratory** – The net assignable area in which diverse mechanical services and special ventilation systems are available to control emissions and exposures from chemical operations.

**Laboratory Fume Hood** – See definition in Section 3.0.

**Laboratory Module** – A basic unit of space usually accommodating a two person laboratory operation.

**Laboratory Ventilation** – Air moving systems and equipment which serve laboratories.

**Laminar Flow (Also Streamline Flow)** – Airflow in which air molecules travel parallel to all other molecules; flow characterized by the absence of turbulence.

**Laminar Flow Cabinet** – Name applied to clean bench or biological enclosures. This device is not a laboratory fume hood.

**Liner** – Interior lining used for side, back and top enclosure panels, exhaust plenum and baffle system of a laboratory fume hood.

**Local Exhaust Ventilation** – An industrial ventilation system that captures and removes emitted contaminants before dilution into the workplace ambient air can occur.

**Loss** - Usually refers to the conversion of static pressure to heat in components of the ventilation system, viz., “the hood entry loss.”

**Low Flow Laboratory Fume Hoods** – Fume Hood designs that provide a reduction in the required exhaust air volume, when compared to the volume required for the same size fume hood to operate with a face velocity of 100 FPM through a fully opened vertical sash.

**Low Velocity Laboratory Fume Hoods** – Fume Hood designs that provide a reduction in the required exhaust air volume, when compared to the volume required for the same size fume hood to operate with a face velocity of 100 FPM through a fully opened vertical sash and provides containment levels equivalent or superior to ASHRAE 110 tracer gas test ratings of 4.0 AM 0.05,

and 4.0 AI/AU 0.10, with a face velocity of 70 FPM or less through the fully opened vertical sash. Low Velocity Fume Hoods are also referred to as High Performance Fume Hoods and High Efficiency Fume Hoods.

**Make-up Air** – (See Replacement and Compensating Air). Air needed to replace the air taken from the room by laboratory fume hood(s) and other air exhausting devices.

**Manometer** – A device which measures pressure difference; usually a u-shaped glass tube containing water or mercury.

**Microorganism** – A microscopic organism, usually a bacterium, fungus, or protozoan.

**Minimum Transport Velocity (MTV)** – The minimum velocity which will transport particles in a duct with little settling; the MTV varies with air density, particulate loading, and other factors.

**Natural Ventilation** – The movement of outdoor air into a space through intentionally provided openings, such as windows, doors, or other non-powered ventilators, or by infiltration.

**Occupied Zone** – The region within an occupied space between 3” and 72” above the floor and more than two feet from the walls for fixed air conditioning equipment. (From ASHRAE Standard 55-1981).

**Odor** – A quality of gases, vapors, or particles which stimulates the olfactory organs; typically unpleasant or objectionable.

**Outdoor Air (OA)** – “Fresh” air mixed with return air (RA) to dilute contaminants in the supply air (SA).

**Particulate Matter** – For these s, small lightweight particles that will be airborne in low-velocity air [approximately 50 fpm (.25m/s)].

**Pitot Tube** – A device used to measure total and static pressures in an air stream.

**Plenum** - A low velocity chamber used to distribute static pressure throughout its interior.

**Plenum Chamber** – Chamber used to equalize airflow.

**Pressure Drop** – The loss of static pressure between two points; for example, “The pressure drop across an orifice is 2.0 inches w.g.”

**Register** – A combination grille and damper assembly.

**Relative Humidity (RH)** – The ratio of water vapor in air to the amount of water vapor air can hold at saturation. A “RH” of 100% is about 2.5% water vapor in air, by volume.

**Replacement Air** – (Also, compensating air, make-up air) Air supplied to a space to replace exhausted air.

**Respirable Particles** – Those particles in air which penetrate into and are deposited in the nonciliated portion of the lung.

**Return Air** – Air which is returned from the primary space to the fan for recirculation.  
**Room Air** – That portion of the exhaust air taken from the room.

**SCFM (Standard Cubic Feet Per Minute)** – Airflow rate at standard conditions; dry air at 29.92 inches Hg gauge, 70 degrees F.

**Sash** – A moveable panel or door set in the access opening/hood entrance to form a protective shield and to control the face velocity of air into the hood.

**Scrubber, Fume** – A device used to remove contaminants from fume hood exhaust, normally utilizing water.

**Service Fixture** – Item of laboratory plumbing mounted on or fastened to laboratory fume hood.

**Sulfur Hexafluoride (SF6)** - Tracer gas widely used for ASHRAE testing.

**Slot Velocity** – The average velocity of air through a slot. It is calculated by dividing the total volume flow by the slot area; usually  $v_s = 2,000$  fpm.

**Smoke Candle** – Smoke producing device used to allow visual observation of airflow.

**Spot Collector** – A small, localized ventilation hood usually connected by a flexible duct to an exhaust fan. This device is not a laboratory fume hood.

**Stack** – The device on the end of a ventilation system, which disperses exhaust contaminants for dilution by the atmosphere.

**Standard Air** — Standard Conditions STP Dry air at 70 degrees F, 29.92 in Hg.

**Static Pressure (SP)** – The pressure developed in a duct by a fan; SP exerts influence in all directions; the force in inches of water measured perpendicular to flow at the wall of the duct; the difference in pressure between atmospheric pressure and the absolute pressure inside a duct, cleaner, or other equipment.

**Static Pressure Loss** – Measurement of resistance created when air moves through a duct or hood, usually expressed in inches of water.

**Suction Pressure** – See Static Pressure (Archaic. Refers to static pressure on upstream side of fan.)

**Superstructure** – That portion of a laboratory fume hood that is supported by the work surface.

**Supplemental Air** – Supply or auxiliary air delivered to a laboratory fume hood to reduce room air consumption.

**Thermal Anemometer** – A device for measuring fume hood face velocity utilizing the principle of thermal cooling of a heated element as the detection element.

**Threshold Limit Value** – Time Weighted Average (TLV-TWA) – The time weighted average concentration for a normal 8-hour workday or 40-hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

**Titanium Tetrachloride** – Chemical that generates white fumes used in testing laboratory fume hoods.

**Total Pressure (TP)** - The pressure exerted in a duct as the sum of the static pressure and the

velocity pressure.

**Total Suspended Particulate Matter** – The mass of particles suspended in a unit volume of air (typically one cubic meter) when collected by a high-volume sampler.

**Transport Velocity** – Minimum speed of air required to support and carry particles in an air stream.

**Turbulent Flow** – Airflow characterized by transverse velocity components, as well as velocity in the primary direction of flow in a duct; mixing velocities.

**TWA (Time Weighted Average)** – The average exposure at the breathing zone.

**Variable Air Volume (VAV)** – In HVAC system, the supply air volume is varied by dampers or fan speed controls to maintain the temperature; in hoods, the exhaust air is varied to reduce the amount of air exhausted.

**Velocity Pressure** – Pressure caused by moving air in a laboratory fume hood or duct, usually expressed in inches of water.

**Velocity (V)** – The time rate of movement of air; feet per minute.

**Volume Flow Rate (Q)** – The quantity of air flowing in cubic feet per minute, cfm, scfm, acfm.

**Work Space** – The part of the fume hood interior where apparatus is set up and fumes are generated. It is normally confined to a space extending from six inches (15.2 cm) behind the plane of the sash(es) to the face of the baffle, and extending from the work surface to a plane parallel with the top edge of the access opening.

**Work Surface** – The surface that a laboratory fume hood is located on and supported by a base cabinet. In the fume chamber, the surface is recessed to contain spills.

## 10.0 Basic Calculations

An excellent source for engineering principles of ventilation can be found in Industrial Ventilation,

a manual of . This manual is prepared by the American Conference of Governmental Industrial Hygienists. The manual (27th Edition) is available for purchase from the ACGIH website [acgih.org](http://acgih.org). It highlights the general principles of ventilation (including basic calculation) supply systems, exhaust systems, principles of airflow, fans, construction guidelines, and testing of ventilation systems.

This manual should be used in concert with the SEFA s.

## 11.0 Relevant Organizations

SEFA recognizes and acknowledges the importance of government agencies that produce documents concerning laboratory ventilation, laboratory fume hoods and laboratory safety. These agencies include:

### **AABC Associated Air Balance Council**

1000 Vermont Avenue, NW  
Washington, DC 20001  
[www.aabc.com](http://www.aabc.com)

### **ACGIH American Conference of**

Governmental Industrial Hygienists  
1330 Kemper Meadow Drive  
Cincinnati, Ohio 45240  
[www.acgih.org](http://www.acgih.org)  
<http://www.acgih.org>  
(513) 742-2020

### **ADC Air Diffusion Council**

230 North Michigan Avenue  
Chicago, IL 60601  
[www.flexibleduct.org](http://www.flexibleduct.org)

### **AGA American Gas Association**

1515 Wilson Blvd.  
Arlington, VA 22209  
[www.aga.com](http://www.aga.com)

### **AGC Associated General Contractors of America**

1957 E. Street, NW  
Washington, DC 20006  
[www.agc.org](http://www.agc.org)

**AGS American Glove Box Society**

P. O. BoX 9099  
Santa Rosa, CA 95405  
www.gloveboxsociety.org  
(800) 530-1022

**AHA American Hardboard Association**

1210 W. Northwest Highway  
Palatine, IL 60067-1897  
www.domensino.com/aha/  
(847) 934-8800

**AIA The American Institute of Architects**

1735 New York Avenue, NW  
Washington, DC 20006-5292  
www.aia.org  
(202) 626-7300

**AIHA American Industrial Hygiene Association**

2700 Prosperity Ave., Suite 250  
Fairfax, VA 22031  
www.aiha.org  
(703) 849-8888

**AMCA Air Movement & Control Association**

International, Inc.  
30 W. University Drive  
Arlington Heights, IL 60004-1893  
www.amca.org  
(847) 394-0150

**ANSI American National Standards Institute**

11 West 42nd Street 13th Floor  
New York, NY 10036-8002  
www.ansi.org  
(888) 267-4683  
(212) 642-4900

**AHRI Air Conditioning, Heating, and Refrigeration Institute**

4301 Fairfax Drive, Suite 425  
Arlington, VA 22203  
www.ari.org  
(703) 524-8800

**ASCE American Society of Civil Engineers World Headquarters**

1801 Alexander Graham Bell Drive  
Reston, VA 20191-4400  
www.asce.org

(800) 548-2723  
(703) 295-6000

**ASCET American Society of Certified Engineering Technicians**

P. O. Box 1348  
Flowery Branch, GA 30548  
Wwww.ascet.org  
(777) 967-9173

**ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers**

1791 Tullie Circle, NE  
Atlanta, GA 30329-2305  
www.ashrae.org  
(800) 527-4723  
(404) 636-8400

**ASME American Society of Mech. Eng.**

345 East 47th Street  
New York, NY 10017-2392  
www.asme.org  
(800) 843-2763 (US and Canada)  
011-(800)-843-2763 (Mexico)  
(973)822-1170 (Outside NA)

**ASPE American Society of Plumbing Engineers**

3617 Thousand Oaks Blvd., Suite 210  
Westlake Village, CA 91362-3649  
www.aspe.org  
(805) 495-7120

**ASSE American Society of Sanitary Engineering**

28901 Clemens Road  
Westlake, OH 44145  
www.asse-plumbing.org  
(440) 835-3040

**ASTM American Soc of Testing & Materials**

100 Barr Harbor Drive  
West Conshohocken, PA 19428-2959  
www.astm.org  
(610) 832-9500

**BSI British Standards Institution**

389 Chiswick High Road  
London W4 4AL United Kingdom  
www.bsi-global.com  
+44 (0)20 8996 9000

**CALOSHA California Division of Occupational Safety and Health**

455 Golden Gate Avenue 10th Floor  
San Francisco, CA 94102  
www.dir.ca.gov/dosh  
(800) 963-9424— (916) 274-5721

**CDC Center for Disease Control and Prevention**

1600 Clifton Road  
Atlanta, GA 30333  
www.cdc.gov  
(404) 639-3311

**CSI Construction Specification Institute**

99 Canal Center Plaza, Suite 300  
Alexandria, VA 22314  
www.csinet.org  
(800) 689-2900

**CETA Controlled Environmental Testing Association**

1500 Sunday Drive, Suite 102  
Raleigh, NC 27607  
www.cetainternational.org

**CSA Canadian Standards Association**

5060 Spectrumway, Suite 100  
Mississauga, Ontario L4W 5N6  
www.csa.ca  
(800) 463-6727

**DIN German National Standard**

DIN Deutsches Institut für Normung e. V.  
10772 Berlin, Germany  
www.din.de

**EJCDC Engineers' Joint Contract Documents Committee**

American Consulting Engineers Council  
1015 15th Street, NW  
Washington, DC 20005  
www.ejc.org

**EPA Environmental Protection Agency**

401 M Street, SW  
Washington, DC 20460  
www.epa.gov  
(202) 260-2090

**FM Factory Mutual System**

1151 Boston-Providence Turnpike  
P. O. Box 9102  
Norwood, MA 02062-9102  
www.factorymutual.com  
(781) 762-4300

**FS Federal Specifications General Service Administration**

Specifications and Consumer Information  
Distribution Center (WFSIS)  
Washington Navy Yard Building 197  
Washington, DC 20407  
http://apps.fas.gsa.gov

**IBC International Conference of Building Officials**

5360 Workman Mill Road  
Whittier, CA 90601-2298  
www.icbo.org  
(800) 423-6587

**IEEE Institute of Electrical and Electronics Engineers**

345 E. 47th Street  
New York, NY 10017-2394  
www.ieee.org  
(800) 678-4333  
(212) 705-7900

**ISA Instrumentation, Systems, and Automation Society**

67 Alexander Drive  
Research Triangle Park, NC 27709  
www.isa.org  
(919) 549-8411

**ISO Int'l Organization for Standardization**

Case Postal 56 - 1, ch. de la Voie-Creuse,  
Case postale 56  
CH-1211 Geneva 20, Switzerland  
www.iso.org  
+41 22 749 01 11

**MCAA Mechanical Contractors Association of America**

1385 Piccard Drive  
Rockville, MD 20850-4329  
www.mcas.org  
(301) 869-5800

**MSS Manufacturers Standardization Society of the Valve and Fittings Industry**

127 Park Street, NE  
Vienna, VA 22180-4602  
www.mss-hq.com  
(703) 281-6613

**NEBB National Environmental Balancing Bureau**

8575 Grovemont Circle  
Gaithersburg, MD 20877  
www.nebb.org  
301-977-3698

**NEC National Electrical Code**

One Batterymarch Park  
P. O. Box 9101  
Quincy, MA 02269-9101  
www.nfpa.org

**NEMA National Electrical Manufacturers Association**

1300 N. 17th Street, Suite 1847  
Rosslyn, VA 22209  
www.nema.org  
(703) 841-3200

**NFPA National Fire Protection Association**

One Batterymarch Park  
P. O. Box 9101  
Quincy, MA 02269-9101  
www.nfpa.org  
(800) 344-3555—(617) 770-3000

**NIH National Institute of Health**

Bethesda, Maryland 20892  
www.nih.gov

**NSPE National Society of Professional Engineers**

1420 King Street  
Alexandria, VA 22314  
(703) 684-2800

**NSF NSF International**

789 North Dixboro Road  
Ann Arbor, MI 48105  
www.nsf.org  
(734) 769-8010

**OSHA Occupational Safety and Health Administration**

U.S. Department of Labor  
200 Constitution Avenue, NW  
Washington, DC 20201  
www.osha.gov  
(202) 219-8148

**PDI Plumbing and Drainage Institute**

45 Bristol Drive, Suite 101  
South Easton, MA 02375  
www.pdi-online.org  
(800) 589-8956  
(508) 230-3516

**SMACNA Sheet Metal & Air Conditioning Contractors'**

National Association  
4201 Lafayette Center Drive  
P. O. Box 221230  
Chantilly, VA 20151-1209  
www.smacna.org  
(703) 803-2980

**UL Underwriters Laboratories Inc.**

333 Pfingsten Road  
Northbrook, IL 60062  
www.ul.com  
(800) 704-4050  
(847) 272-8800

## 12.0 Regulatory and Industry Consensus Standards

The potential for chemical exposure of personnel in laboratories has resulted in the promulgation of a wide variety of standards for ensuring proper operation of laboratory fume hood systems. The requirements and value of the information contained in the different standards will vary depending on your responsibilities.

A few of the relevant standards are briefly described below.

### 12.1 (ACGIH) American Conference of Governmental Industrial Hygienists

The ACGIH produces a wide variety of useful literature; however, two particularly useful guides are the Threshold Limit Values for Chemical Substances and Physical Agents and Biological

Exposure Indices (TLV Guide) and the Industrial Ventilation: A Manual of . The TLV Guide provides an excellent source of guidelines to assist with control of occupational hazards.

The Industrial Ventilation Manual provides one of the best sources of information on hood and ventilation system design.

(ACGIH) Industrial Ventilation (24th Edition) p. 10-40 "Supply Air Distribution – For typical operations at a laboratory fume hood, the worker stands at the face of the hood and manipulates the apparatus in the hood. The indraft at the hood face creates eddy currents around the worker's body, which can drag contaminants in the hood back to the body and up to the breathing zone. The higher the face velocity, the greater the eddy currents. For this reason, higher face velocities do not result in as much greater protection as might be supposed."

p. 10-40 "Selection of Hood Face Velocity – The interaction of supply air distribution and hood face velocity makes any blanket specification of hood face velocity inappropriate. Higher hood face velocities will be wasteful of energy and may provide no better or even poorer worker protection."

"For projected new building, it is frequently necessary to estimate the cost of air conditioning early, before the detailed design and equipment specification are available. For that early estimating, the following guidelines can be used. Hoods near doors are acceptable if 1) there is a second safe egress from the room, 2) traffic past hood is low, and 3) door is normally open.

## 12.2 ANSI/AIHA Z9.5 – 1992

The American National Standards Institute (ANSI) published Z9.5 An American National Standard for Laboratory Ventilation, "to provide guidance in the selection, design, operation and use of laboratory ventilation system."

This standard is best suited for health and safety and engineering personnel responsible for ensuring proper use and design of laboratory fume hood systems.

The standard provides non-regulatory guidelines and recommendations.

It is the responsibility of an organization to determine the applicability of the recommendations.

A few of the recommendations include:

Develop a Laboratory Ventilation Management Program (LVMP). The program should include specific procedures for ensuring proper selection, design, operation, maintenance and use of laboratory fume hood systems.

Designate a cognizant person to administer the LVMP. Maintain Permanent Records of Performance.

| Condition   | CFM/Sq. Ft. Open Hood Face |
|---|----------------------------|
| Ceiling panels properly located with average panel face velocity <40 fpm. Horizontal-sliding sash hoods. No equipment in hood closer than 12 inches to face of hood. Hoods located away from doors and traffic ways.  | 60                         |
| Same as above; some traffic past hoods. No equipment in hoods closer than six inches to face of hood. Hoods located away from doors and traffic ways.   | 80                         |
| Ceiling panels properly located with average panel face velocity <60 fpm or ceiling diffusers properly located; no diffuser immediately in front of hoods, quadrant facing hood blocked, terminal throw velocity <60 fpm. No equipment in hood closer than six inches to face of hood. Hoods located away from doors or traffic ways. | 80                         |
| Same as three above; some traffic past hoods. No equipment in hoods closer than six inches to face of hood.   | 100                        |

Conduct initial and routine system performance tests.

The ASHRAE 110 Test is the preferred test for initial evaluation of performance.

Routine performance tests should be conducted at least annually or whenever a significant change in the hood system occurs.

New and renovated hoods must be equipped with flow measurement devices.

Supply air velocities (cross drafts) should be limited to less than 50% of target face velocity near hood openings.

The ductwork must be compatible with chemical effluents, sized to ensure 2,000 fpm duct velocities and designed to ensure safe transport and exhaust of materials generated in the hood. All ducts should be under negative pressure within the building.

The sound pressure level of noise should be limited at worker locations to below 85 dBA. Room noise should be limited to below a noise criterial curve rating of 55 dBA.

The catastrophic potential of each laboratory should be determined.

Lab personnel should be trained in proper work practices.

Further recommendations are provided for design and use of bypass fume hoods, VAV hoods, auxiliary air hoods, floor mounted hoods, perchloric acid hoods, and glove boxes.

ANSI /AIHA Z9.5 Committee issued a clarification letter to address this topic:

p. 1 – 3

Discourage the use of a numerical pressure differential between rooms as a basis for design. Although it is true that the difference in pressure is the driving force that causes airflow through any openings from one room to another, specifying quantitative pressure differential is a poor basis for design. What is really desired is an offset air volume. Attempts to design using direct pressure differential measurement and control vs. controlling the offset volume results in either short or extended periods of the loss of pressure

when the doors are open or excessive pressure differentials when doors are closed, sufficient to affect the performance of low pressure fans. The direct pressure control systems are also hard to stabilize, and can cause building pressure problems and result in excessively large volume offsets in porous rooms. The need to maintain directional airflow at every instant and the magnitude of airflow needed will depend on individual circumstances. For example, “clean” rooms may have very strict requirements while teaching laboratories may only need to maintain directional airflow during certain activities or emergency conditions. In the later cases, one would simply use the appropriate offset to maintain directional airflow as needed and operational procedures during emergencies (i.e., close doors during a chemical spill).

The amount of offset should be based on two considerations:

The airflow required to keep the room negative (or in some positive) with regard to surrounding air spaces. The 10% offset suggested in the comments may be appropriate in some cases, but has no general validity.

The required “stringency” of the requirement for direction of airflow into or out of any openings in the walls. If the requirement is stringent, two seldom considered factors become important. First, if there is any appreciable temperature difference between the lab and the adjoining space, when a door is opened there will be a thermal exchange of warmer air flowing in one direction at the top of the doorway, and cooler air flowing in an opposite direction near the floor. An airflow velocity of at least 40 fpm is required to inhibit this exchange under normal conditions, a flow rate of 100 fpm is more positive. If there is no airlock, and if there is a definite but not stringent need for direction of airflow, this phenomenon should be made a design consideration.

For situations less than those requiring stringent control, VAV systems should be adequate. The offset volume should be based on the cfm needed to provide at least 50 cfm, (100 fpm is better) through the doorway opening. The increased offset volume can be operated by a mechanical optical switch at or near the door. The volume of

offset air required is not related to the ventilation rate of the laboratory.

### 12.3 ANSI / ASHRAE 110 – 1995

The American Society of Heating, Refrigeration and Air Conditioning Engineers' ANSI / ASHRAE 110 Method of Testing Performance of Laboratory Fume Hoods provides guidelines to conduct qualitative tests to evaluate hood performance and quantitative tests to measure air velocities and containment capability.

The standard is best suited for persons responsible for ensuring proper operation of laboratory fume hoods, typically health and safety, engineering and maintenance.

The standard provides methods for:

Inspecting the hood and operating environment.

Airflow visualization (smoke tests).

Measurement of face velocity.

Tracer gas containment tests.  
Limited evaluation of variable air volume operation.

Suggested tests for evaluating dynamic conditions (worker movement, traffic past the hood, etc.).

The standard also describes three methods of specifying the tests:

"As Manufactured" (AM) Tests - AM tests are conducted at the manufacturer's facility to evaluate hood design. AM tests enable pre-purchase evaluation of hood performance and provide critical operating specifications required for proper design of laboratory ventilation systems.

"As Installed" (AI) Tests – AI tests are conducted after experimental apparatus have been placed in the hood. The tests are used to determine hood limitations and the need for special work practices.

"As Used" (AU) Tests - AU tests verify the function of the hood in the condition that the user has established the hood.

### 12.4 ASHRAE Handbook Applications 1999

p. 30.10

Face Velocity.

"If the face velocity (design and operation) must be maintained at 100 fpm (0.5/s) + 10%, this average may be allowed to deteriorate to 85 fpm (0.47 m/s) before correction and then the face velocity must be returned to 100 fpm (0.5/s). Individuals reading may not vary more than + 15% with the hood empty or + 25% with research equipment in the hood.

p. 30.5

"All laboratory fume hoods and safety cabinets should be equipped with visual and audible alarms to warn the laboratory workers of unsafe airflows."

p. 13.11

"In order for the laboratory to act as a secondary confinement barrier ..., it must be maintained at a slightly negative pressure with respect to adjoining areas to contain odors and fumes. Exceptions are sterile facilities of clean spaces that may need to be maintained at a positive pressure with respect to adjoining spaces."

### 12.5 NFPA 45, 2000

p. 5-12

"6.4.5. Laboratory fume hood velocities and exhaust volumes shall be sufficient to contain contaminants generated within the hood and exhaust them outside of the laboratory building. The hood shall provide confinement of the possible hazards and protection for personnel at all times when chemicals are present in the hood."

P 45 – 28

Appendix "A-6.4.6. Laboratory fume hood containment can be evaluated using the procedures contained in the ASHRAE 110, Method of Testing Performance of Laboratory Fume Hoods. Face velocities of 0.4 m/sec to 0.6 m/sec (80 fpm to 120 fpm) generally provide containment if the hood location requirements and laboratory ventilation criteria of this standard are met."

p. 45-13

A measuring device for hood airflow shall be provided on each laboratory hood. The measuring device for hood airflow shall be a permanently installed device and shall provide constant indication to the hood user of adequate or inadequate hood airflow.

p. 45 – 12, Sections 6.3.3, 6.4.1

“Laboratory units in which chemicals are present shall be continuously ventilated. Air exhausted from laboratory fume hoods and other special local exhaust systems shall not be recirculated.”

Differential pressure control versus volumetric offset – Room pressurization has been approached using two different methods:

Differential pressure control, and Volumetric offset control.

## 12.6 OSHA 1910.1450

In 1990, The Occupational Safety and Health Administration (OSHA) published 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories (Federal Register, Volume 55, No. 21 pages 3327-3335). The standard became effective May 1, 1990 and contains a variety of regulatory requirements and recommendations for laboratories.

The law requires that laboratory facilities have a written Chemical Hygiene Plan that ensures protection for laboratory personnel, proper operation of laboratory fume hood systems and training of all laboratory personnel in safe work practices.

Chemical Hygiene Plan (CHP)

With few exceptions, all laboratories must develop a written CHP.

The standard requires designation of a Chemical Hygiene Officer.

The Chemical Hygiene Officer must develop, implement and administer the CHP.

The CHP must be capable of preventing

overexposure of laboratory personnel to all potential chemical hazards.

The CHP must be readily available to all employees.

The CHP must include:

Protocols for identifying hazardous procedures.

Standard Operating Procedures for working with hazardous chemicals

Basis for selection of appropriate exposure control methods.

Measures to assure proper functioning of laboratory fume hoods.

Methods to evaluate system operation upon installation and routinely (recommended quarterly).

The standard recommends installation of monitors on all hoods.

Requires training and dissemination of employee information on all potential hazards.

Federal Register – OSHA

p. 3332. Paragraph G, Quality

“...airflow into and within the hood should not be excessively turbulent.” (200)

“...hood face velocity should be adequate (typically 60 – 100 lfm).” (200,204)

Note: Reference to page numbers in Prudent Practices for Handling Hazardous Chemicals in Laboratories are given in parenthesis i.e., (200)

p. 484. Paragraph (B) Hoods

“...each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 203).”

p. 484

“4. Ventilation ... direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building ...”

## 12.7 Prudent Practices

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (1995), Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories, National Research Council.

p. 178

"In most cases, the recommended face velocity is between 80 and 100 feet per minute (fpm). Face velocities between 100 and 120 fpm may be used for substances of very high toxicity or where outside influences adversely affect hood performance. However, energy costs to operate the fume hood are directly proportional to the face velocity. Face velocities approaching or exceeding 150 (fpm) should not be used, because they may cause turbulence around the periphery of the sash opening and actually reduce the capture efficiency of the fume hood."

p. 192

"In all cases, air should flow from the offices, corridors, and support spaces into the laboratories. All air from chemical laboratories should be exhausted out-doors and not recirculated. Thus, the air pressure in chemical laboratories should be negative with respect to the rest of the building unless the laboratory is also a clean room."

p. 200

"2. Hoods should be evaluated before use to ensure adequate face velocity (typically 60 – 100 lfm) ...and the absence of excessive turbulence..."

p. 203

"If the hood and the general ventilating system are properly designed, face velocities in the range of 60 – 100 fpm will provide a laminar flow of air over the floor and sides of the hood. Higher face velocities (125 fpm or more), which exhaust the general laboratory air at a greater rate, are both wasteful of energy and likely to degrade hood performance by creating air turbulence at the hood face and within the hood. Such air turbulence can cause the vapors within the hood to spill out into the general laboratory atmosphere."

p. 204

"The optimum face velocity of a hood (also called the capture velocity) will vary depending on its configuration. As noted above, too high a face velocity is likely to increase the turbulence within the hood and cause gases or vapors to spill from the hood into the room."

p. 180

"Make sure that a continuous monitoring device for adequate hood performance is present and check it every time the hood is used."

p. 206

"After the face velocity of each hood has been measured (and the airflow balanced if necessary), each hood should be fitted with an inexpensive manometer or other pressure – measuring device (or a velocity-measuring device) to enable the user to determine that the hood is operating as it was when evaluated. This pressure measuring device should be capable of measuring pressure differences in the range of 0.1-2.0 in. of H<sub>2</sub>O and should have the lower pressure side connected to the duct above the hood and the higher pressure side open to the general laboratory atmosphere."

## 12.8 Handbook of Laboratory Safety

p. 117

"If there are administrative, classroom, or service areas within the same building as laboratories, the entire laboratory area should be at a modest negative pressure with respect to these spaces so that any airflow that exists will be from the non-research areas into the space occupied by laboratories."

"...the design of the air exhaust system from a laboratory must be done carefully to provide continuing replacement of fresh air in the room. The fume hood system and the supplementary exhaust system should be interlocked to ensure a stable room air balance at all times."

**Please refer to the latest editions for all reference materials.**

# SEFA 1 - APPENDIX

## Selection and Management of Exposure Control Devices in Laboratories



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Without the knowledge, expertise and diligence of these dedicated professionals, this document would not have been realized.

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# 1 Acronyms

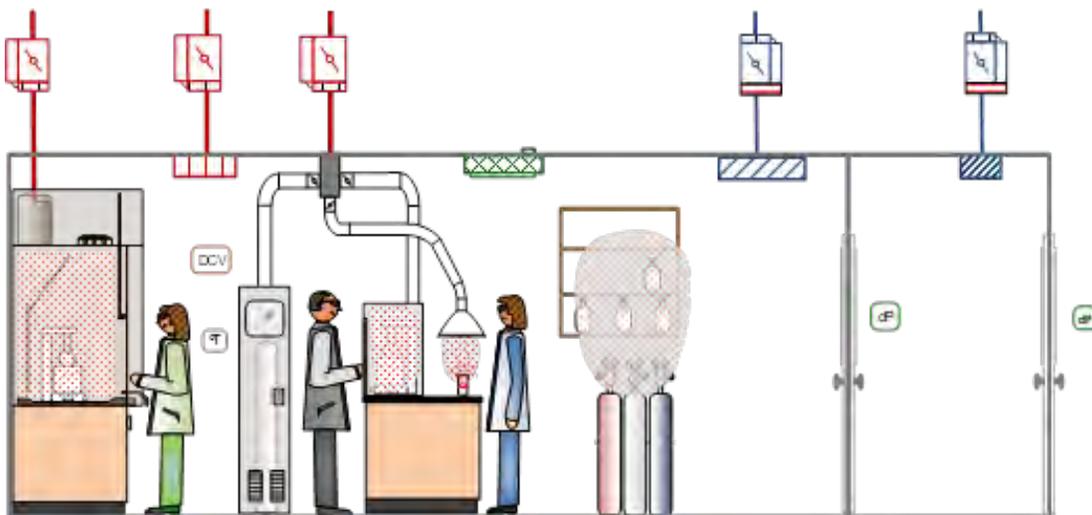
|                         |   |
|-------------------------|---|
| <b>AHU</b>              | <b>Air Handling Unit</b>  |
| <b>ANSI</b>             | <b>American National Standards Institute</b>                                    |
| <b>AIHA</b>             | <b>American Industrial Hygiene Association</b>                                  |
| <b>ASHRAE</b>           | <b>American Society of Heating Refrigeration and Air Conditioning Engineers</b> |
| <b>ASSE</b>             | <b>American Society of Safety Engineers</b>                                     |
| <b>BAS</b>              | <b>Building Automation System</b>   |
| <b>BSL</b>              | <b>Biosafety Level</b>  |
| <b>BSC</b>              | <b>Biological Safety Cabinet</b>  |
| <b>CAV</b>              | <b>Constant Air Volume</b>  |
| <b>CFD</b>              | <b>Computational fluid dynamics</b>   |
| <b>CFM</b>              | <b>Cubic Feet of Air Per Minute</b>   |
| <b>Cx</b>               | <b>Commissioning</b>  |
| <b>DP</b>               | <b>Difference in pressure between two adjacent spaces</b>                       |
| <b>ECD</b>              | <b>Exposure Control Device</b>  |
| <b>ECTI</b>             | <b>Exposure Control Technologies, Inc.</b>                                      |
| <b>EH&amp;S</b>         | <b>Environmental Health and Safety</b>  |
| <b>EXF</b>              | <b>Exhaust Fan</b>  |
| <b>FHPT</b>             | <b>Fume Hood Performance Test</b>   |
| <b>FPM</b>              | <b>Feet Per Minute</b>  |
| <b>Gex</b>              | <b>General Exhaust</b>  |
| <b>HEPA</b>             | <b>High-Efficiency Particulate Arrestor</b>                                     |
| <b>HES</b>              | <b>Hazard Emission Scenario</b>   |
| <b>HVAC</b>             | <b>Heating, Ventilation and Air Conditioning</b>                                |
| <b>IDLH</b>             | <b>Immediately Dangerous to Life and Health</b>                                 |
| <b>LET</b>              | <b>Laboratory Environment Test</b>  |
| <b>LVMP</b>             | <b>Laboratory Ventilation Management Program</b>                                |
| <b>O&amp;M</b>          | <b>Operations and Maintenance</b>   |
| <b>Qex, Qs &amp; Qt</b> | <b>Exhaust Flow, Air Supply Flow, Transfer Airflow</b>                          |
| <b>Riser</b>            | <b>Vertical length of duct from lower floors to penthouse</b>                   |
| <b>SEFA</b>             | <b>Scientific Equipment and Furniture Associations</b>                          |
| <b>VAV</b>              | <b>Variable Air Volume</b>  |
| <b>VFD</b>              | <b>Variable Frequency Drive</b>   |
| <b>VBE</b>              | <b>Ventilated Balance Enclosure</b>   |
| <b>VEE</b>              | <b>Ventilated Equipment Enclosure</b>   |
| <b>VSE</b>              | <b>Ventilated Safety Enclosure</b>  |
| <b>VVE</b>              | <b>Variable Volume Exhaust</b>  |

## 2 INTRODUCTION

The Scientific Equipment & Furniture Association (“SEFA”) is a global, not-for-profit trade association whose Executive Members are among the world’s largest manufacturers of laboratory furniture and equipment. SEFA was formed in 1988 and currently has 165 members in 22 countries. SEFA’s essential purpose is to promote the use of “Laboratory Grade” furniture, fixtures and equipment. To insure that laboratory grade equipment is used it is important that industry representatives refer to SEFA’s Standards for laboratory grade furniture and fixtures.

Exposure control devices (ECDs) provide the main engineering control for preventing overexposure of personnel to airborne hazards generated within laboratories. ECDs can be ventilated as a part of a laboratory ventilation system or operate independently with internal fans that return filtered air back to the lab environment. In either case, proper performance means preventing overexposure through control, capture and removal of airborne hazards at or near the source. The chemical fume hood (sometimes call fume cupboard) is the primary and predominant ECD used in labs, but other types are also used including biological safety cabinets (BSCs), ventilated safety enclosures (VSEs), snorkel exhaust, slot hoods, gloveboxes, and many other special purpose devices. Each type of ECD is different in design to accommodate the application and can offer different levels of protection for users. Ensuring adequate protection requires: understanding the functional requirements of the users; understanding the characteristics of the physical process; selecting the appropriate ECD; ensuring proper design of the laboratory and the ventilation systems; and, maintaining operation within specifications verified or validated to provide satisfactory performance.

The performance of an ECD can be affected by four primary factors including its design, how it is operating, how it is used and the operating environment. The ECD must be appropriate for the intended application and utilized by people trained in proper work practices. All ECDs must be tested and maintained to ensure they perform properly and provide adequate protection for people working in the lab. The evaluation of performance and procedures used to verify proper operation must be appropriate for each device. In addition, the lab environment and supporting ventilation systems must be properly designed, tested and maintained to ensure proper performance at all possible operating modes. For the purposes of this document, the ECDs together with the components of the exhaust and air supply systems that affect ECD performance are referred to collectively as the ECD System. See Figure 1 for a diagram depicting different ECDs in a laboratory and other ECD System components that may affect performance.



**Figure 1 Side view of lab depicting various ECDs and Lab Ventilation Components**

In addition to providing the primary means of protecting people working in labs, the ECD Systems can also be the greatest consumer of energy in laboratory buildings. The operation of ECD Systems is typically attributed to 50% to 85% of annual energy consumption depending on the volume of airflow, efficiency of the systems and need to condition the supply/replacement air. Poor selection, improper design, component malfunction and/or failures of ECD Systems increase the probability and/or severity of unacceptable impact to the health of people, harm to the environment, loss of property, increased liability, wasted energy and inefficient utilization of resources. The ANSI/AIHA Z9.5 American National Standard for Laboratory Ventilation requires laboratory management to establish a Laboratory Ventilation Management Plan (LVMP) to ensure proper selection, operation, use, and maintenance of laboratory ventilation equipment used to control airborne hazards generated during laboratory scale procedures.

## **2.1 Purpose**

The primary purpose of this Manual is to help select and manage performance of ECDs used to control exposure to airborne hazards generated in laboratories. This Guide compliments SEFA guidelines (i.e. SEFA-1, SEFA-9, SEFA-11) for fume hoods and other exposure control devices (ECDs). This document is not intended to duplicate other standards and guidelines but instead expand the available information to help users better provide safe, efficient and sustainable laboratory environments. This Guide intends to help stakeholders increase the probability of: providing adequate protection for lab occupants; meeting the demand for ventilation; minimizing energy consumption and; reducing expenditures.

## **2.2 Scope**

There are many types of ECDs commonly available for laboratories. These ECDs are applied to help control overexposure to airborne hazards generated during “laboratory-scale” activities. Many different types and sources of airborne hazards exist in laboratories and the selection and use of the appropriate ECD can be critical to achieving adequate safety performance. This Guide describes different types of ECDs, their intended use, and methods for managing performance. General laboratory safety practices are not included except where they may relate to the ECD System’s proper function or effectiveness to control airborne hazards. This guide does not apply to comfort and air conditioning unless there are possible effects on control of airborne hazards and ECD performance.

## **2.3 Regulatory Basis and References**

Laboratory facilities are required to ensure proper functioning and performance of ECDs used to protect people working in labs. This Guide provides information to support selection and use of different types of ECDs commonly found in laboratories. The information contained herein is meant to compliment the Scientific Equipment and Furniture Association, 5th Edition, Desk Reference, the ANSI/ASSE Z9.5-2012 “American National Standard for Laboratory Ventilation”, the ANSI/ASHRAE 110-2016 Method of Testing Performance of Laboratory Fume Hoods, the Public Works and Government Services of Canada, PWGSC Standard MD15128 Laboratory Fume Hoods, the European Standard EN14175 Fume Cupboards. Additional resources include OSHA regulatory documents such as the OSHA 1910.1450 Laboratory Standard, the NSF International (The National Sanitation Foundation) NSF/ANSI 49 - 2008, Biosafety Cabinetry: Design, Construction, Performance, and Field Certification and ECD product guides from SEFA member manufacturers.

In all cases, facility management and environmental health and safety personnel should be consulted

with questions or for guidance on risk assessment, ECD application, performance criteria and regulations regarding health, safety and the environment. Where national, state, or local laws require a higher (specific or additional) requirements than mentioned herein, these requirements must be followed first and foremost. However, where national, state, or local laws are less stringent or less comprehensive, SEFA recommends consideration and application of the most appropriate engineering controls and measures available.

### 3 ECD TYPES AND APPLICATION

ECDs are manufactured, installed and operated to meet the functional requirements of the users and provide the primary engineering control for mitigating the risk of personnel exposure to airborne hazards in laboratories. Selection and use of appropriate ECDs requires consultation with stakeholders including researchers, lab managers, health and safety personnel, ventilation engineers and facilities maintenance personnel. Considerations during selection should include:

- The hazards and processes
  - o Airborne Effluent Properties
  - o Exposure Limits and Concentration Levels of Concern
  - o Characteristics of Generation
  - o Quantities
- User-specific needs;
- Type, size and construction of the ECD;
- Required performance capabilities;
- Ventilation system and airflow control requirements;
- Operating modes, and
- Potential impact of changing environmental conditions.

There are many different types, models and sizes of ECDs. In addition, ECDs include many different features, components and sub-systems. Some ECDs are designed exclusively to provide personnel protection, whereas other designs incorporate special filtration and/or isolation features to provide both personnel and product protection. In addition, certain ECDs are equipped to handle a wide variety of effluent including gases, vapors and aerosols, but other ECDs may only be suitable for handling particulates. In general, the major types of ECDs include:

- Chemical Fume Hoods;
- Biological Safety Cabinets (BSCs);
- Ventilated Safety Enclosures (VSE);
- Snorkels (Spot Exhaust);
- Downdraft Tables;
- Slot Hoods,
- Canopy Hoods, and
- Glovebox/Isolators.

Other types of devices may include ductless enclosures, special purpose devices and custom equipment enclosures. SEFA 9-2010 provides guidance on ductless enclosure. Regardless of the type, any ECD utilized in labs to control exposure must be included in the LVMP. Figure 2a and 2b list major types and models of ECDs and recommended application. Additional information about suggested application of each device can be found in subsequent sections of this document.

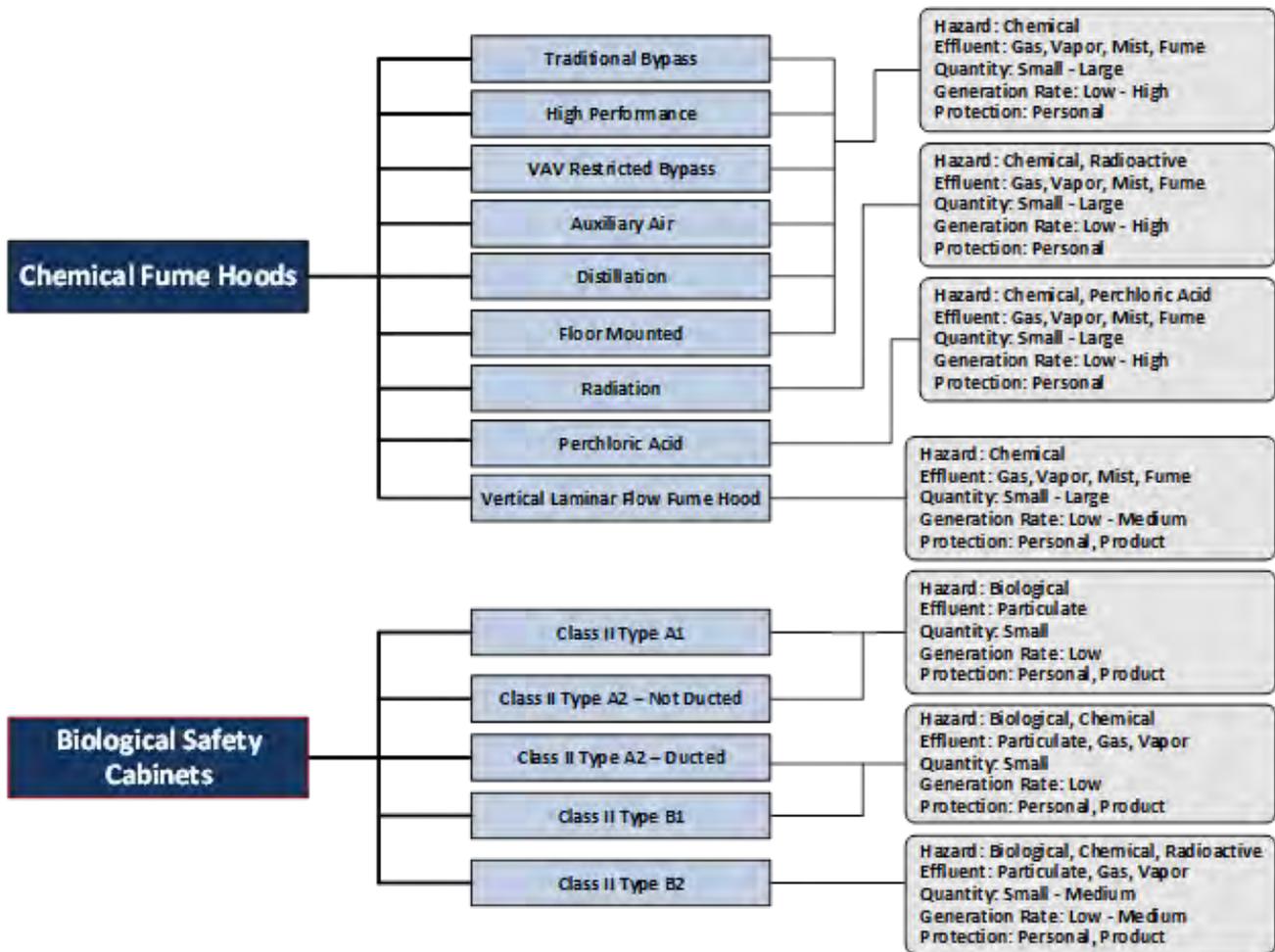
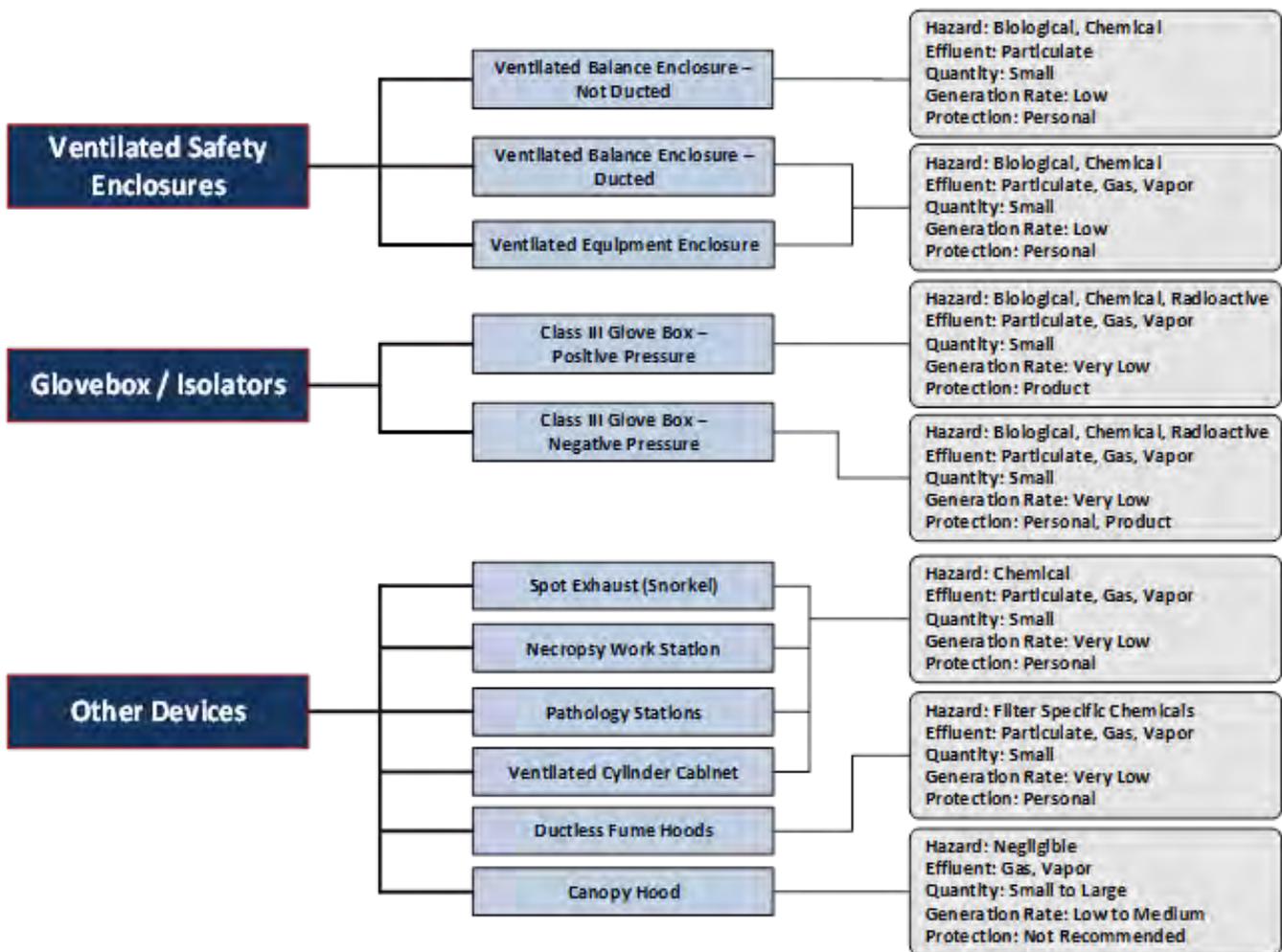


Figure 2a - Major Types of ECDs and Typical Application.



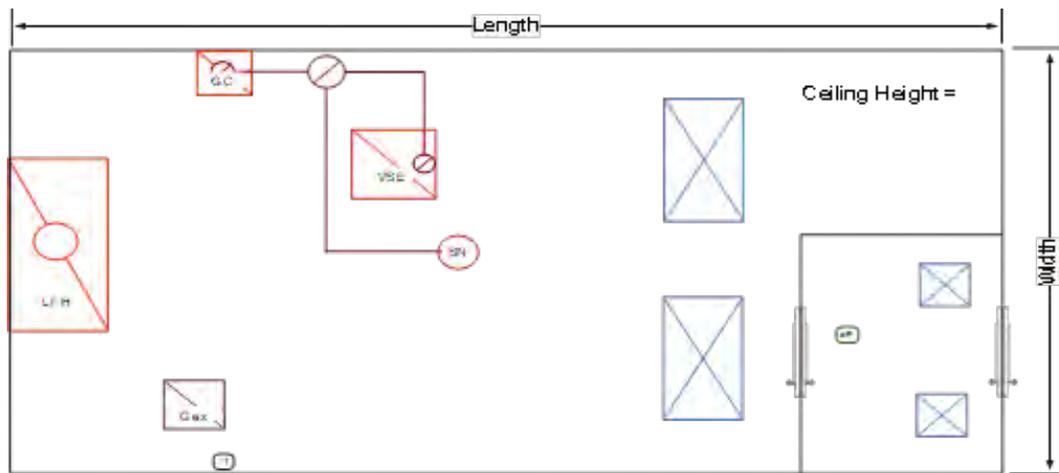
**Figure 2b - Major Types of ECDs and Typical Application.**

### 3.1 Ventilation and Energy Consumption

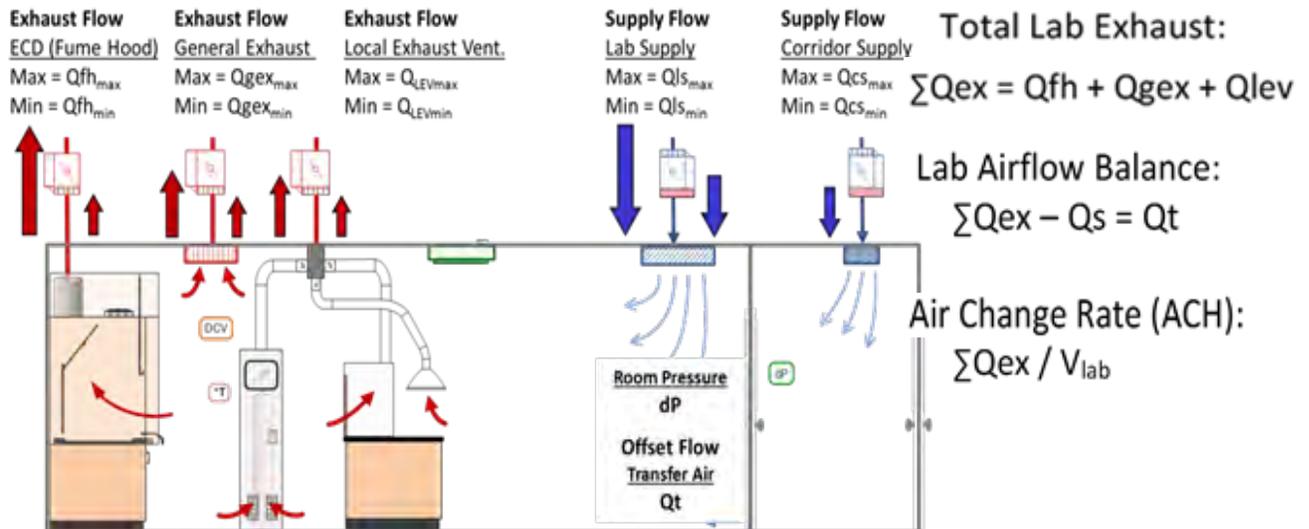
ECDs and laboratories utilize airflow to contain and capture contaminants, dilute and remove contaminants, isolate the laboratory from adjacent areas and control space temperatures. The volume of airflow required to provide adequate protection depends on the risk, the design of the ECD employed and the operating modes. ECDs, such as chemical fume hoods, typically require greater exhaust flow than ventilated balance enclosures or snorkel exhaust devices. Furthermore, variable air volume (VAV) fume hoods and other types of ECDs can vary the exhaust flow depending on their utilization and available modes of operation. Modulation of flow through fume hoods and other devices affects the volume of airflow through the laboratory resulting in variable air change rates and varying airflow patterns with potential adverse effects on ECD performance and lab air balance. Energy consumption is a function of numerous factors including flow and system static pressure. Minimizing the volume of airflow and system resistance when and where possible is desirable, but never at the expense of safety. Safety is an inviolable constraint and the performance requirements can dictate the minimum airflow and operating specifications for ECDs and laboratories.

Figure 3A and 3B depict an example lab showing the plan and elevation diagrams indicating the location and type of ventilation devices located therein. Proper performance requires specification

of the minimum and maximum flow for each exhaust and supply device for the range of possible operation.



**Figure 3A - Top view or plan view of lab showing location of major ventilation components**



**Figure 3B Side view of laboratory showing exhaust and air supply flow**

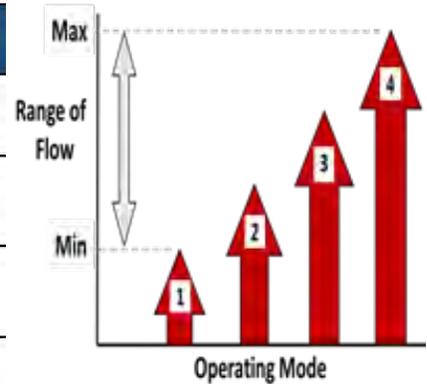
Airflow specifications are required for all ECDs, the general exhaust, the air supply and the offset volume (transfer air) required to maintain space pressurization. Negative pressurization may be critical to provide isolation to prevent contaminant escape or to minimize contaminant infiltration. The flow specifications for ECDs and the lab environment depend on numerous factors including the risk of exposure and the overall demand for ventilation. Improper airflow specifications can lead to poor performance of ECDs and deleterious operating conditions.

Modulation of exhaust flow must be balanced with mechanically supplied, properly conditioned, replacement air plus or minus the transfer air required for the desired lab pressurization. Changes in the exhaust for any device requires an immediate and commensurate change in supply flow to compensate and maintain balance. It is usually preferable to maintain a constant offset volume to maintain space pressure relationships regardless of changes in operating modes. For a laboratory containing a VAV

fume hood that also modulates general exhaust and air supply flow to control room temperature, there can be a variety of operating modes, sequences of operation and a significant range of flow. The total flow through the lab can vary from low when unoccupied to maximum with the fume hood in use and where high conditioning loads requires extra supply. Table 1 describes four common operating modes that demonstrate the impact on total airflow for a lab with a VAV fume hood and VAV terminal reheat, air supply systems.

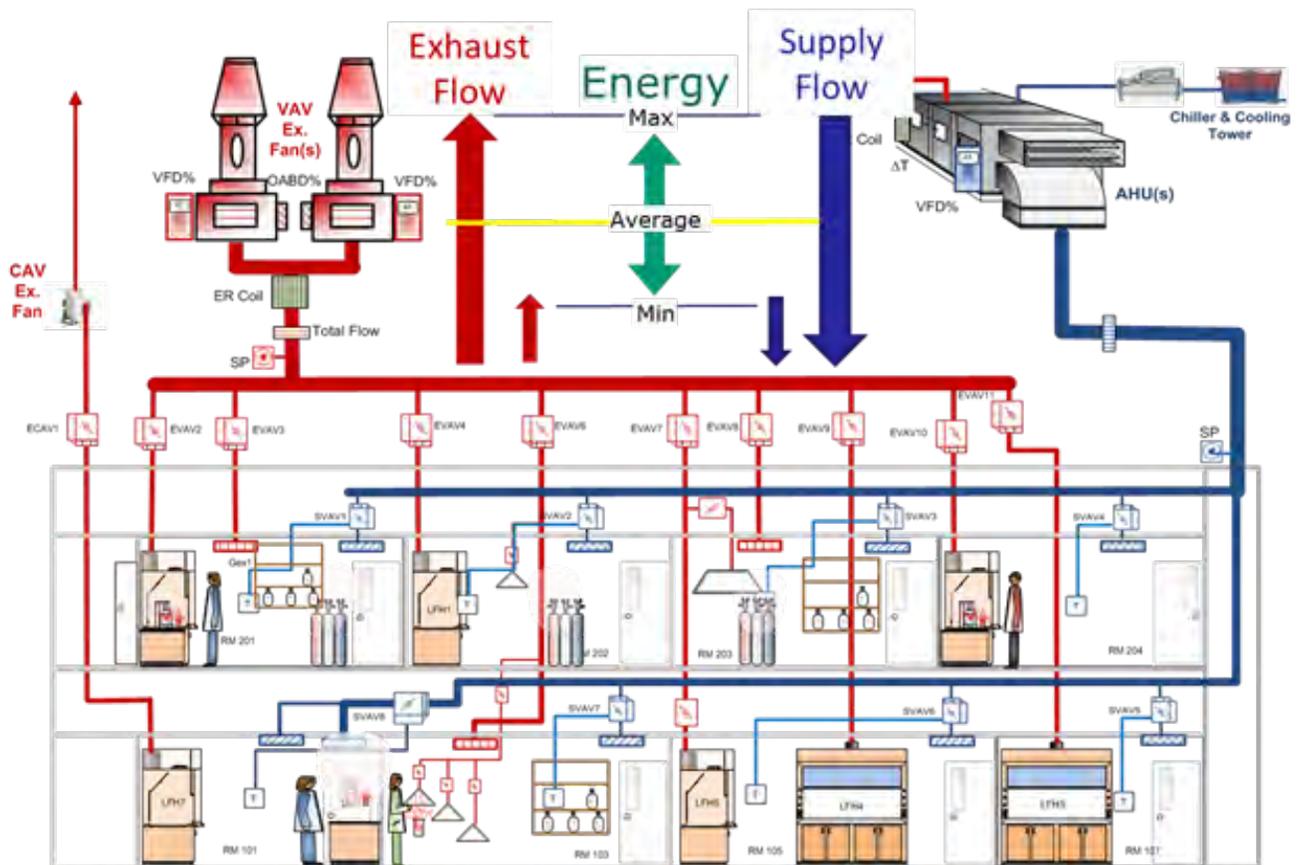
**Table 1 Operating modes and impact on total airflow through lab**

| Mode | Operating Condition   |
|------|---|
| 1    | Unoccupied Lab – Sashes Closed – Min. Conditioning Required |
| 2    | Occupied Lab – Sashes Closed – Max. Conditioning Required   |
| 3    | Occupied Lab – Sashes Open – Min. Conditioning Required     |
| 4    | Occupied Lab – Sashes Open – Max. Conditioning Required     |



Theoretically, the ECD Systems are operating properly when the change in flow through an ECD and the laboratory translate to an equivalent change in flow at the exhaust fan units and air supply units serving the laboratory. The total airflow through the systems can vary depending on the aggregate operating mode for all spaces where minimum flow corresponds to all spaces operating at the lowest flow mode and the highest airflow results when all spaces are operating at the mode corresponding to the highest flow. The energy consumption is a function of the total flow through the systems and energy can generally be reduced by decreasing the average flow over time. The diagram in Figure 4 depicts an ECD System where the range of flow modulation can be related to energy consumption. The average operation over a period of time should correlate closely with the demand for ventilation.

For effective management of both safety and energy consumption, the criteria for ECD selection and establishment of airflow specifications should focus on mitigating risk and satisfying the demand for ventilation without excess or unnecessary ventilation. The safest and most efficient operation results when the ECD Systems modulate flow to meet and track changes in the demand for ventilation. Unfortunately, many systems suffer due to improper or inadequate evaluation of risk, improper specification of airflow and failure of the controls to properly modulate air supply and exhaust fans over the range of flow dictated by the demand for ventilation. Failure to properly modulate flow can compromise both safety and energy efficiency. This understanding is key to achieving safe, energy efficient and sustainable labs. The following section describes risk and methods to evaluate the demand for ventilation.



**Figure 4 Diagram depicting ECD Systems and energy use corresponding to the range of airflow modulation.**

### 3.2 Ventilation for Protection of Personnel

ECDs are designed and operated for different purposes and they offer varying levels of protection depending on their design, use, operation, and the impact of environmental conditions such as room air turbulence, temperature gradients and pressurization. The location of air supply fixtures, ECDs and general exhaust together with the resulting airflow patterns are critical to support ECD performance, provide adequate dilution and facilitate contaminant removal from the lab environment. Sources of extraneous concentrations in the lab environment may include escape from ECDs, poorly sealed storage containers, leaking gas cylinders, and analytical equipment operating outside ECDs. Where the ECDs provide primary protection through source capture, the airflow through the lab environment provides secondary protection through dilution and removal of extraneous contaminants. Figure 5 depicts a laboratory with a fume hood to provide capture, containment and removal of hazards generated therein and relies on dilution and removal of contaminants concentrations in the lab exterior to the fume hood.



- The impact of the airborne hazards on the ECD System. Some materials like acids may degrade the duct and components leading to premature degradation and inadequate performance. The materials of construction can be critical to long-term performance.

- The need for training and enforcing use of proper work practices.

The level of required protection typically depends on the process, the severity of the airborne hazards, the exposure limits, the quantities of materials used in the process and the characteristics of generation including the rate and type of effluent. These characteristics define a hazard emission scenario that can be used to specify an ECD and determine appropriate operating specifications for the laboratory and ECD System. The hazard emission scenario must stay within the boundaries dictated by “laboratory scale” work (i.e. substances in containers used for reactions, transfers and other applications that are designed to be easily handled by one person). The ECD must be appropriate for the application, operate properly and provide adequate performance over the range of possible operating conditions. The level of protection afforded by an ECD system is ultimately based upon the ability to control and limit concentrations of airborne contaminants where people could be exposed. The rate of contaminant accumulation equals the rate of generation minus the rate of removal. The following section describes risk factors and information to help specify appropriate ECDs.

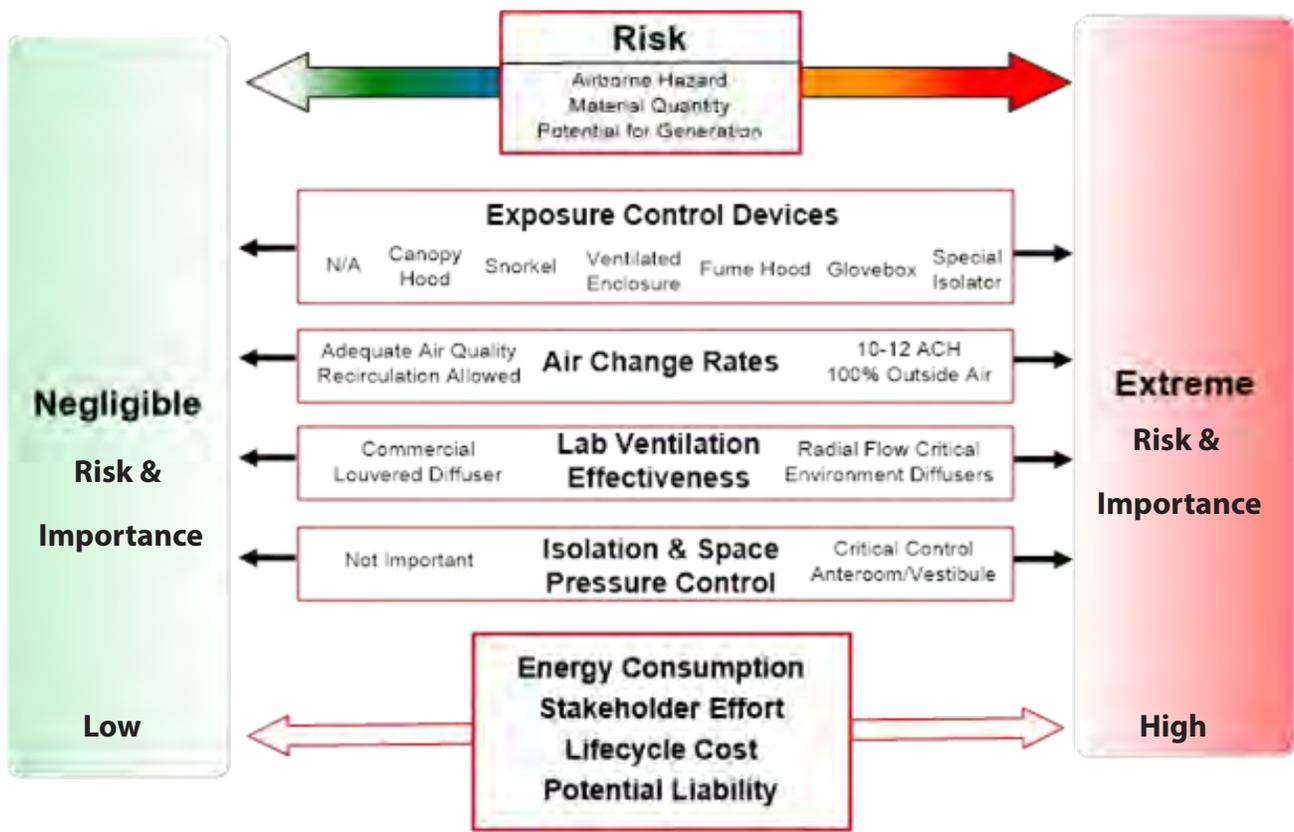
## **4 RISK AND ECD PERFORMANCE REQUIREMENTS**

### **4.1 Spectrum of Risk**

There are many possible hazards in laboratories particularly where activities involve chemical, biological and/or radioactive materials. People can be exposed to airborne hazards through inhalation, contact with the skin or ingestion of food or drinks contaminated through contact. The risk or potential for exposure to an airborne contaminant is a function of many factors that depend largely on the how the contaminants are generated, the magnitude of the resulting concentration, and the duration of the concentration in the occupied space. The potential for exposure and risk of suffering adverse effects (health or otherwise) is subject to an even more complex interaction of variables that include not only the type of hazard and the dose (concentration times duration), but also the susceptibility of the exposed individual.

The spectrum of risk of exposure to airborne hazards in labs can range from negligible to extreme. ECD Systems are employed to reduce the risk to people, property and the environment by controlling airborne hazards, limiting accumulation of unsafe concentrations and minimizing the duration of unsafe concentrations. Some ECDs are also used to minimize potential and effects of explosions and high-pressure gas release. As shown in Figure 6, the range of risk can be associated with the design and operating requirements of the ECD System and other factors including energy consumption, stakeholder effort, operating costs and potential liability.

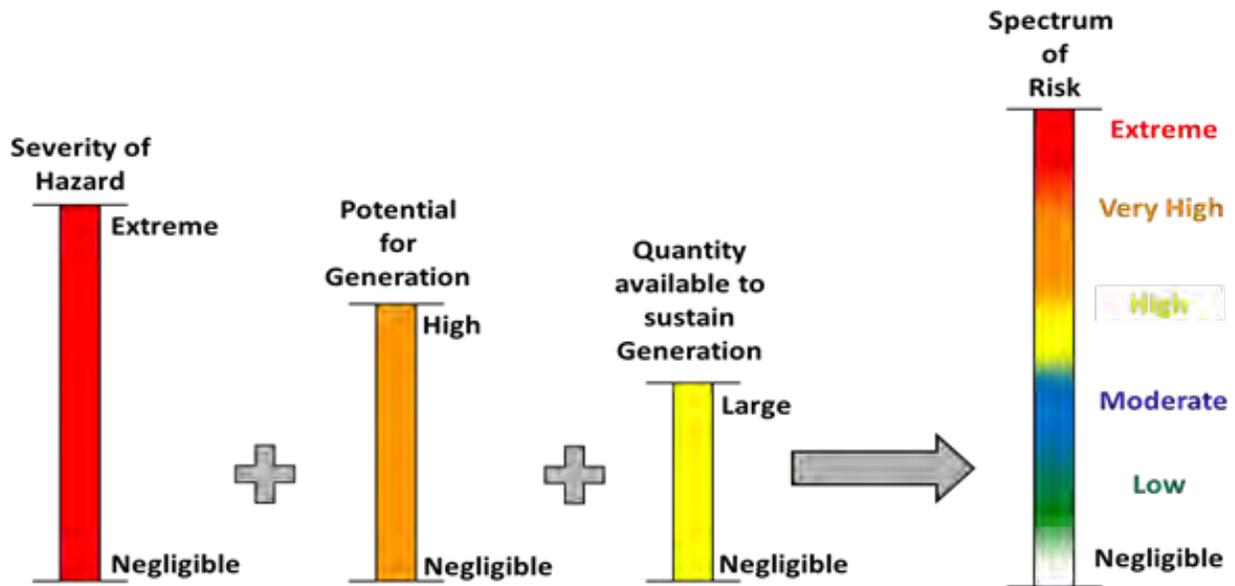
## Range of Risk to People, Property, Environment



**Figure 6 Relationships that correlate with the spectrum of risk from airborne hazards in labs.**

The risk can be characterized as a function of the type and quantity of airborne hazards, the rate of generation, the duration of generation and the severity of exposure. Characterization enables better selection and design of the ECDs, establishment of airflow specifications and configuration of the lab supply and exhaust devices to maximize effectiveness of ECD Systems. Exposure and the risk of adverse health effects can be based on the potential magnitude of the airborne concentration, the potential residence time of the concentration, the severity of the hazard and the duration of exposure. As such, risk factors include the severity of the hazards, the quantities of materials, the rate of generation, the duration of generation and effectiveness of the ECD system to capture, dilute and remove the airborne contaminants. The severity of the hazard indicates the maximum allowable concentration, the potential for generation indicates the rate of generation and the quantity of material indicates the potential duration of generation. Figure 7 shows the risk as a function of the hazard, the potential for generation and quantity of the material available to sustain generation.

In this context, risk is an estimate of the probability that unsafe concentrations of airborne hazards may exist. The range of risk is always greater than zero and less than 100%. Risk can't be 100% because it would then be a certainty and it can't be zero as it would then cease to be a risk. No algorithm may accurately calculate risk, but there is value in understanding and characterizing the factors influencing the level of risk.



**Figure 7 Risk factors that indicate the risk of a hazardous airborne concentration.**

#### 4.1.1 Airborne Hazard and Severity

The characteristics of airborne hazards and the concentration levels of concern are critical to evaluating risk and ensuring appropriate design and operation of an ECD System. Airborne hazards (effluent) are present in concentrations of gases, vapors, particulates and other types of aerosols typically composed of chemical, biological and/or radioactive materials. The characteristics of the effluent can affect the type of ECD, need for filtration, materials of construction, capture velocities and duct transport velocities. The following categories can be used to help characterize the hazardous effluent.

- **Gas** – A substance that exists in the gaseous state and lacks inherent volume and shape at normal atmospheric conditions. Examples: oxygen or helium.
- **Vapor** - A substance in the gaseous state that is a liquid at standard temperature and pressure, exerting a partial pressure that can be condensed into the liquid form. Examples: formaldehyde, xylene and acetone.
- **Fume** - Condensed solid particles produced by physicochemical reactions such as combustion, sublimation, or distillation. Examples: fumes from spectroscopy samples and laser surgical procedures.
- **Mist** - Airborne liquid droplets associated with the disruption of a liquid. Examples include sonication, spraying, mixing, and violent chemical reactions.
- **Particulate** - Solid particles (Silica gel, Aluminum oxide) or nanoparticle products that are temporarily suspended in a volume of air. Deposition of suspended particulates is dependent on particle size and turbulence.

The hazardous materials can be further classified by type, physical properties, negative effect of exposure and exposure limits. There are many different types of materials and methods to classify the hazard associated with the materials of concern. Some examples of type and effect include:

- **Carcinogen** – Materials that are known cancer causing agents.
- **Flammable** – Materials with a higher risk of catching fire.
- **Reactive** – Materials that violently react with certain substances such as water or oxygen.
- **Corrosive** – Materials that can easily destroy or damage materials of construction or surface materials the contaminants contacts such as metal, plastic or skin.
- **Explosive** – Materials that may explode when subject to high heat, sparks or other ignition sources.

The concentration level of concern that may lead to adverse health effects may be associated with exposure limits published by organizations such as the United States Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienist (ACGIH) and other groups including material producers. Hazards can be described as acute or chronic where acute hazards have more immediate effects from exposure and where chronic hazards may exhibit effects after repeated exposure or after some prolonged latency period.

The severity of the hazard is based on the potential effects from overexposure and range from negligible to immediately dangerous to life and health (IDLH). Exposure limits are typically reported as concentration in mass per unit volume (i.e mg/m<sup>3</sup>) and parts per million (ppm). Negligible health hazards may have concentrations with a level of concern greater than 1000 ppm (< 1 g/m<sup>3</sup>) whereas extreme hazards may be associated with concentrations of concern less than 1 ppm (1 mg/m<sup>3</sup>). However, these definitions for the hazard level may vary and be subject to the authority having jurisdiction, the prevailing standard (regulatory and institutional) or referenced source.

As the application and protective capability of ECDs can vary, understanding the risk can be critical to selecting the appropriate ECD and establishing operating specifications that enable the required control and performance. In the absence of the requisite information, the choice of ECD and operating specifications can be based on a worst-case scenario and account for the ability of the user to safely conduct the hazardous procedure. Most labs will operate within a definable range hazard where a concentration levels of concern (LOC) can be associated with a level of risk from negligible to extreme. The LOC then defines the criterion for performance. For example, a concentration LOC of 0.1 ppm indicates that the ECD must be capable of preventing escape greater that 0.1 ppm.

#### 4.1.2 Quantities of Materials

The quantity of material is important to consider as large amounts of materials can potentially contribute to a long duration of generation. Local regulations, national fire codes, and mechanical building codes often set limits on the maximum quantities of materials that can be stored and/or used in laboratories. Refer to table 2 for example classifications of material quantities that might represent a range anticipated for a small lab. Note that all things may be relative as a minute quantity per Table 3 may represent a very large quantity of a highly hazardous material. It is important to understand the hazards when establishing the volume or mass of material associated with rather arbitrary descriptions such as minute, small, moderate, large or extra-large.

**Table 2 Range and quantity of materials used in laboratory scale procedures**

| <b>Description/Quantity</b> | <b>Volume</b>    | <b>Mass</b>       |
|-----------------------------|------------------|-------------------|
| <b>Minute</b>               | <b>&lt; 1 mL</b> | <b>&lt; 1 mg</b>  |
| <b>Small</b>                | <b>&lt; 1 L</b>  | <b>&lt; 1 g</b>   |
| <b>Moderate</b>             | <b>&lt; 1 mL</b> | <b>&lt; 10 g</b>  |
| <b>Large</b>                | <b>&lt; 10 L</b> | <b>&lt; 100 g</b> |
| <b>Extra Large</b>          | <b>&lt; 50 L</b> | <b>&lt; 500 g</b> |

#### 4.1.3 Airborne Hazard Generation

Health and safety staff should consult with laboratory managers, Principal Investigators (PIs) and other stakeholders to characterize procedures, evaluate means of generation, estimate the potential rates of generation and consider future changes in activities. Airborne hazards can be generated during a variety of activities where the rate may be subject to the process and the mechanism affecting generation. The following categories can be helpful for characterizing hazardous procedures:

- **Storage:** Emissions may occur from improperly sealed or degraded storage containers. The rate and quantity of generation may be small, but not negligible. Complaints of odors may indicate escape of small concentrations from inadequately sealed containers. Note that some chemicals may pose hazards below the odor threshold.
- **Closed Process:** Materials are contained in process apparatus, which may include beakers, flasks, tubing, equipment, etc. The volume of material that could be released during a catastrophic incident such as accidental over pressurization, damage to the system or leaks should be estimated.
- **Normal Process:** A normal process typically involves procedures that result in low volume generation and where little energy is added to the process. Pouring and weighing of materials and pipetting are examples of a normal process where generation of materials is typically through diffusion and/or evaporation.
- **Complex Process:** A complex process generally involves procedures that apply significant energy and produce a larger volume of airborne contaminants. Such processes might involve volatile reactions, stirring and mixing, heating and boiling, bulk material transfers and weighing. The application of energy complicates the determination of contaminant generation rates.
- **Leaks to Catastrophic Failure:** Partial or total sudden release of material resulting from a physical defect such as worn gaskets, rupture in connective tubing, pinhole in a structural weld, etc.

There are no standardized categories that relate to the generation rates associated with the range of laboratory procedures. Research conducted by Exposure Control Technologies, Inc., now known as 3Flow™ indicates the generation rates shown in Table 3 lists different types of processes and associated generation rates. In the absence of information about generation rates, the worst-case rates for normal operating conditions should be used to determine the hazard emission scenario.

**Table 3 Typical ranges for laboratory scale generation rate**

| <b>Category</b>                       | <b>Generation Range (lpm)</b> | <b>Possible Source</b>                                   |
|---------------------------------------|-------------------------------|--|
| <b>Storage and Closed Process*</b>    | <b>&lt;0.1</b>                | <b>Fugitive emissions from leaky containment vessels</b> |
| <b>Normal Process</b>                 | <b>0.1 - 1</b>                | <b>Open containers, evaporation</b>                      |
| <b>Complex Process</b>                | <b>1 - 10</b>                 | <b>Boiling/mixing/stirring</b>                           |
| <b>Leaks to Catastrophic Failure*</b> | <b>&lt;0.1 to &gt;1400</b>    | <b>Leaking or Failed Compressed Gas Cylinders</b>        |

\* Note: Worst case release from catastrophic failure should be estimated.

## **4.2 Hazard Emission Scenario**

As described above, the appropriate ECD and the required level of performance depend on the types of hazards, exposure limits, quantities of materials used in the processes and estimates of the rates of generation. These combined characteristics define the hazard emission scenario that can be used to select the ECD. A hazard emission scenario can also be used to test and validate ECDs and establish the required operating specifications. Hazard emission scenarios can and should be used to further aid the ECD specification process.

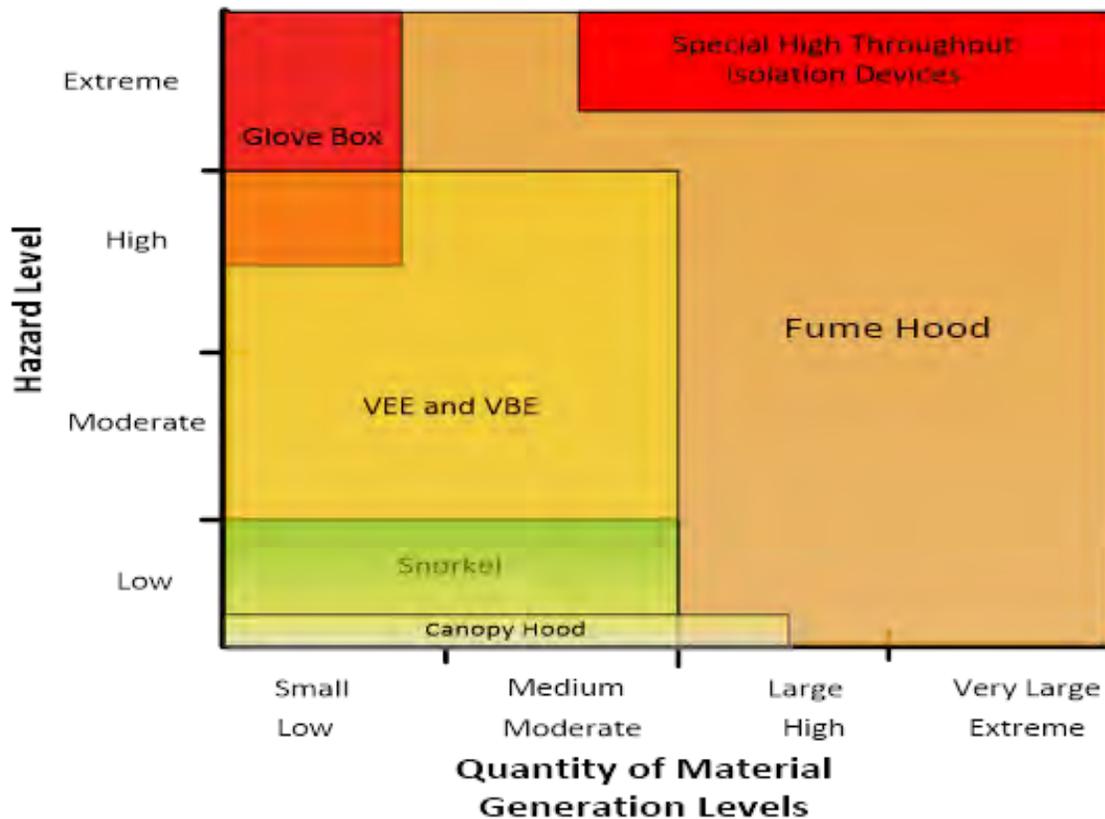
## **4.3 ECD Performance Criteria**

After considering the risk factors, the performance criteria define the required level of containment or protection afforded the user. The hazard emission scenario together with the performance criteria are used to select the ECD and determine appropriate tests to challenge the device and validate adequate performance under the prevailing operating conditions.

# **5 SELECTION AND SPECIFICATION OF ECDs**

## **5.1 ECD Performance Capabilities**

Figure 8 shows a diagram representing increasing hazard levels on the y axis and increasing generation potential (as a function of both the rate and quantity of material) on the x axis. The different types of ECDs are shown on the diagram to simply represent their application according to the hazard level and generation potential. The diagram provides only a representation of typical areas of application and determining thresholds would be subject to the process and capabilities of the ECDs.



**Figure 8 ECD applications as a function of hazard level and generation potential.**

Fume hoods provide the widest range of protection for hazard emission scenarios that include small to very large quantities of low to extremely hazardous materials generated at rates from less than 0.1 liter of gas per minute (lpm) to as much as 10 lpm. Snorkel exhaust devices are used for negligible to low hazards with correspondingly low generation rates. Unducted BSCs and VSEs equipped with HEPA filtration are only appropriate for protecting people from exposure to small quantities of low to highly hazardous particulates at up to moderate rates of generation. Ventilated Safety Enclosures (VSE) can be used for low to high hazards with low to moderate rates of generation. Gloveboxes provide the greatest protection for airborne materials of high to extreme hazards, but only for small quantities with very low rates of generation. Finally, special isolators combine the throughput of fume hoods and protection of a glovebox are used for high to extreme generation rates of high to extreme hazards.

### 5.2 ECD Application Risk Matrix

ECD Application Risk Matrices shown in the following tables 4, 5 and 6 can be used to match the ECD to the hazard emission scenario. The risk factors consider the type of material, the characteristics of the hazard, quantities and the potential for generation. Please note that it is important to consider that the user must understand the capabilities of limitations of the devices and how application of proper work practices can impact the effectiveness and ability to provide adequate protection. Refer to the Risk Matrices provided below for chemical fume hoods, BSCs and other types of ECDs.

Table 4 ECD Application Risk Matrix for different types of fume hoods

| Fume Hood Risk Matrix   |                    |            |            |            |            |             |               |                    |           |                    |              |       |            |           |          |           |           |                |   |
|-------------------------|--------------------|------------|------------|------------|------------|-------------|---------------|--------------------|-----------|--------------------|--------------|-------|------------|-----------|----------|-----------|-----------|----------------|---|
| ECDS                    | Hazard Level       | Quantity   | Generation | Chemical   | Biological | Radioactive | Radioisotopes | Product Protection | Gas/Vapor | Particulate/Powder | Nanoparticle | Acute | Carcinogen | Flammable | Reactive | Corrosive | Explosive | Heated Process |   |
|                         | Chemical Fume Hood | High       | Very Large | Very Large | ✓          | (1)         | ✓             |                    |           | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Radioisotope Fume Hood  | High               | Very Large | Very Large | ✓          |            | ✓           | ✓             |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Perchloric Fume Hood    | High               | Very Large | Large      | ✓          |            |             |               |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Laminar Flow Fume Hood  | High               | Very Large | Very Large | ✓          |            |             |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Filtered Fume Hood      | Medium             | Medium     | Low        | ✓          |            |             |               |                    | ✓         | ✓                  |              |       |            |           |          |           |           |                |   |
| Auxiliary Fume Hood     | High               | Very Large | Very Large | ✓          |            |             |               |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Distillation Fume Hood  | High               | Very Large | Very Large | ✓          |            | ✓           |               |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Floor Mounted Fume Hood | High               | Very Large | Very Large | ✓          |            | ✓           |               |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         | ✓        | ✓         | ✓         | ✓              | ✓ |
| Educational Hood        | Medium             | Large      | Large      | ✓          |            |             |               |                    |           |                    |              |       |            |           |          |           |           |                | ✓ |

Notes: (1) See Table 5 for application with Biological Materials

Table 5 ECD Application Risk Matrix for different types of BSCs

| Biological Safety Cabinet Risk Matrix |                  |            |          |            |             |               |                    |           |                    |              |       |            |           |          |           |           |        |     |
|---------------------------------------|------------------|------------|----------|------------|-------------|---------------|--------------------|-----------|--------------------|--------------|-------|------------|-----------|----------|-----------|-----------|--------|-----|
| ECDS                                  | Bio Hazard Level | Generation | Chemical | Biological | Radioactive | Radioisotopes | Product Protection | Gas/Vapor | Particulate/Powder | Nanoparticle | Acute | Carcinogen | Flammable | Reactive | Corrosive | Explosive | Heated |     |
|                                       |                  |            | ✓        | ✓          |             |               | ✓                  |           |                    | ✓            | ✓     | ✓          | ✓         |          |           |           |        |     |
| Class I                               | 1-3              | Very Low   | ✓        | ✓          |             |               |                    |           | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        |     |
| Class II Type A1                      | 1-3              | Low        |          | ✓          |             |               | ✓                  |           | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        |     |
| Class II Type A2                      | 1-3              | Low        |          | ✓          |             |               | ✓                  |           | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        |     |
| Class II Type A2 Ducted               | 1-3              | Low        | ✓        | ✓          |             |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           | ✓      | ✓   |
| Class II Type B1                      | 1-3              | Low        | ✓        | ✓          |             |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           | ✓      | ✓   |
| Class II Type B2                      | 1-3              | Medium     | ✓        | ✓          | ✓           |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           | ✓      | (1) |
| Class III                             | 1-4              | Very Low   | ✓        | ✓          | ✓           |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        | (1) |

Notes (1) Potential for use with very small quantities of flammable materials such as ETOH.

Table 6 ECD Application Risk Matrix for other types of ECDs (1)

| Other ECD Risk Matrix        |           |           |            |          |            |             |               |                    |           |                    |              |       |            |           |          |           |           |        |   |
|------------------------------|-----------|-----------|------------|----------|------------|-------------|---------------|--------------------|-----------|--------------------|--------------|-------|------------|-----------|----------|-----------|-----------|--------|---|
| ECDs                         | Hazard    | Quantity  | Generation | Chemical | Biological | Radioactive | Radioisotopes | Product Protection | Gas/Vapor | Particulate/Powder | Nanoparticle | Acute | Carcinogen | Flammable | Reactive | Corrosive | Explosive | Heated |   |
| Glove Box                    | High      | Medium    | Very Low   | ✓        |            | ✓           |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        |   |
| Ventilated Enclosure         | Low       | Medium    | Low        | ✓        |            | ✓           |               | ✓                  | ✓         | ✓                  |              |       |            | ✓         |          |           |           |        | ✓ |
| Ventilated Balance Enclosure | High      | Low       | Very Low   | ✓        |            | ✓           |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          |           |          |           |           |        |   |
| Canopy Hood                  | Very Low  | Low       | Low        | ✓        |            |             |               |                    | ✓         |                    |              |       |            |           |          |           |           |        | ✓ |
| Flexible Spot Exhaust        | Low       | Low       | Low        | ✓        |            |             |               |                    | ✓         | ✓                  |              |       |            | ✓         |          |           |           |        | ✓ |
| Slot Hood                    | Low       | Low       | Low        | ✓        |            |             |               |                    | ✓         | ✓                  |              |       |            | ✓         |          |           |           |        | ✓ |
| Downdraft Necropsy Table     | Low       | Medium    | Low        | ✓        |            |             |               |                    | ✓         |                    |              |       |            | ✓         |          |           |           |        |   |
| Histology Station            | Low       | Medium    | Low        | ✓        |            |             |               | ✓                  | ✓         |                    |              |       |            | ✓         |          |           |           |        |   |
| Ventilated Wet Bench         | Medium    | Medium    | Medium     | ✓        |            |             |               | ✓                  | ✓         | ✓                  |              | ✓     | ✓          | ✓         |          |           |           |        | ✓ |
| Gas Cabinet                  | Very High | Medium    | Very Low   | ✓        |            |             |               |                    | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         |          |           |           |        | ✓ |
| Special Isolator             | Very High | Very High | Very High  | ✓        |            |             |               | ✓                  | ✓         | ✓                  | ✓            | ✓     | ✓          | ✓         |          |           |           |        | ✓ |

Notes: (1) Please note that there are can be exceptions to this guidance based on professional guidance and application

## 6 ECD TYPES, DESIGN, CONSTRUCTION AND OPERATION

ECDs serve as the primary means of protecting personnel and should be considered an integral part of the building HVAC system. ECDs must be manufactured, installed and operated per specific requirements and for specific applications. Selection of the appropriate ECD requires input and consultation with a variety of stakeholders including health and safety personnel, mechanical engineers, researchers, operations/maintenance and others. Considerations during the design process should include:

- User-specific needs identified during the Laboratory Demand Ventilation Assessment;
- The type of ECD needed to perform a specific operation;
- Specific containment and ECD size requirements; and
- Satisfactory performance testing of potential ECD/control-system configurations.
- Change Management

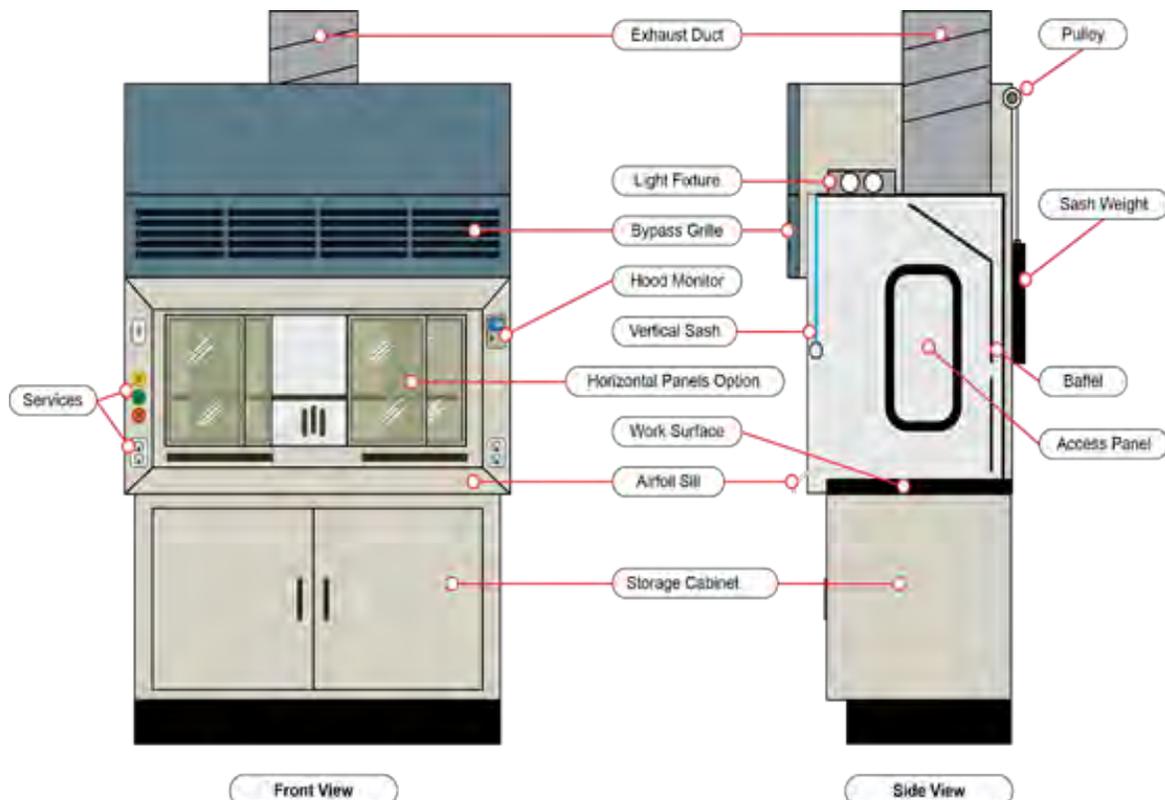
The following describes ECDs and potential applications.

### 6.1 Standard Laboratory Fume Hood

**Description** - Laboratory fume hoods are 4-sided enclosures designed to protect users from hazardous chemical substances. Fume hoods are accessed using a moveable sash at the front opening in which the user inserts his/her hands and arms. Safe fume hood operation is obtained through proper aerodynamic design, adequate face velocity and in the case of a variable air volume (VAV) hood; appropriate minimum flow with the sash closed and the impact of the lab environment. Fume hoods come in various sizes and configurations depending on the need of the user and the processes occurring within the hood. See Figure 8 for a diagram of a standard fume hood.

**Applications** - A fume hood's primary objective is to protect users from exposure to toxic fumes, vapors and gases. When used correctly, the sash can provide additional protection against splashes, fires or minor explosions that may occur within the hood. Specialized fume hoods are necessary when working with radioisotopes and perchloric acid.

**Limitations** - Fume hoods should not be used for biohazard containment; refer to the section on Bio-Safety Cabinets when using hazardous or infectious biological agents. Also, fume hoods are not appropriate for the most highly hazardous airborne materials. Consider using a glove box or specialized containment enclosure where any exposure cannot be tolerated.



**Figure 9 – Standard Laboratory Fume Hood Components**

### 6.1.1 High Performance Fume Hood

**Description** - A high performance (HP) fume hood is a bypass fume hood operated at face velocities 30% to 40% less than traditional fume hoods. High performance fume hoods incorporate enhanced aerodynamic design features, particularly the airfoil sill, sash handle, side posts and baffles, that enable equivalent containment at reduced face velocities (as low as 60 fpm). The primary benefit of a HP fume hood is the reduction in total hood exhaust flow at the design opening and potential for reduced energy use while maintaining containment.

**Applications** - High performance fume hoods can be used in the same manner as a standard laboratory fume hood.

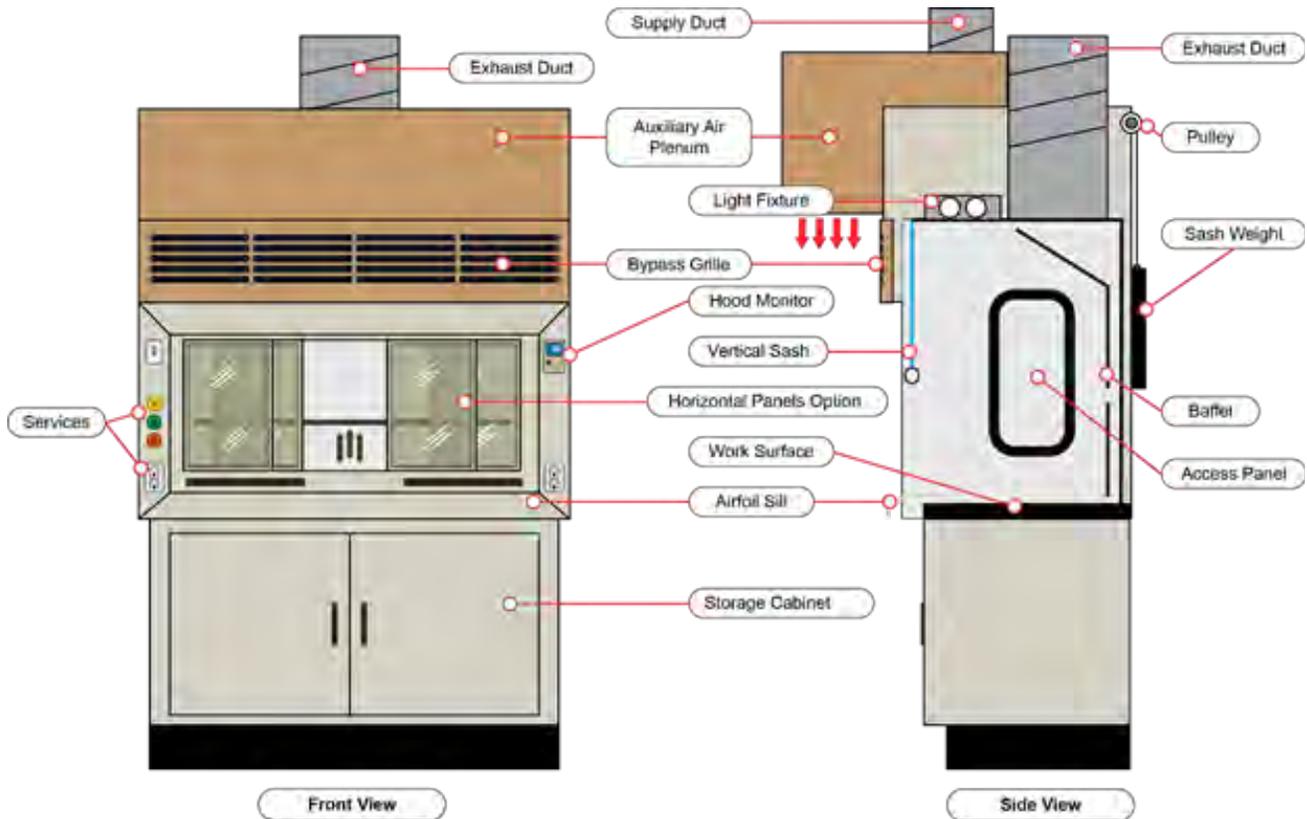
**Limitations** - The same limitations for standard fume hoods apply to high performance fume hoods.

### 6.1.2 Auxiliary Air Fume Hood

**Description** - An auxiliary air hood equipped with an air supply plenum mounted over the sash opening (See Figure 10). The auxiliary air supply is designed to direct either unconditioned, or in some cases conditioned or tempered outside air to the outside plane of the hood sash. The objective is to reduce fume hood energy consumption by reducing the volume of conditioned laboratory make-up air necessary for the hood to operate.

**Applications** - The commentary section in ANSI/AIHA Z9.5-2012 states, "Auxiliary supplied air hoods are not recommended unless special energy conditions or design circumstances exist."

**Limitations** – Same limitations as standard fume hoods with a greater possible risk of exposure due to the auxiliary air creating excessive turbulence in the breathing zone. Careful balance between exhaust flow and the auxiliary air flow is critical to maintain performance.



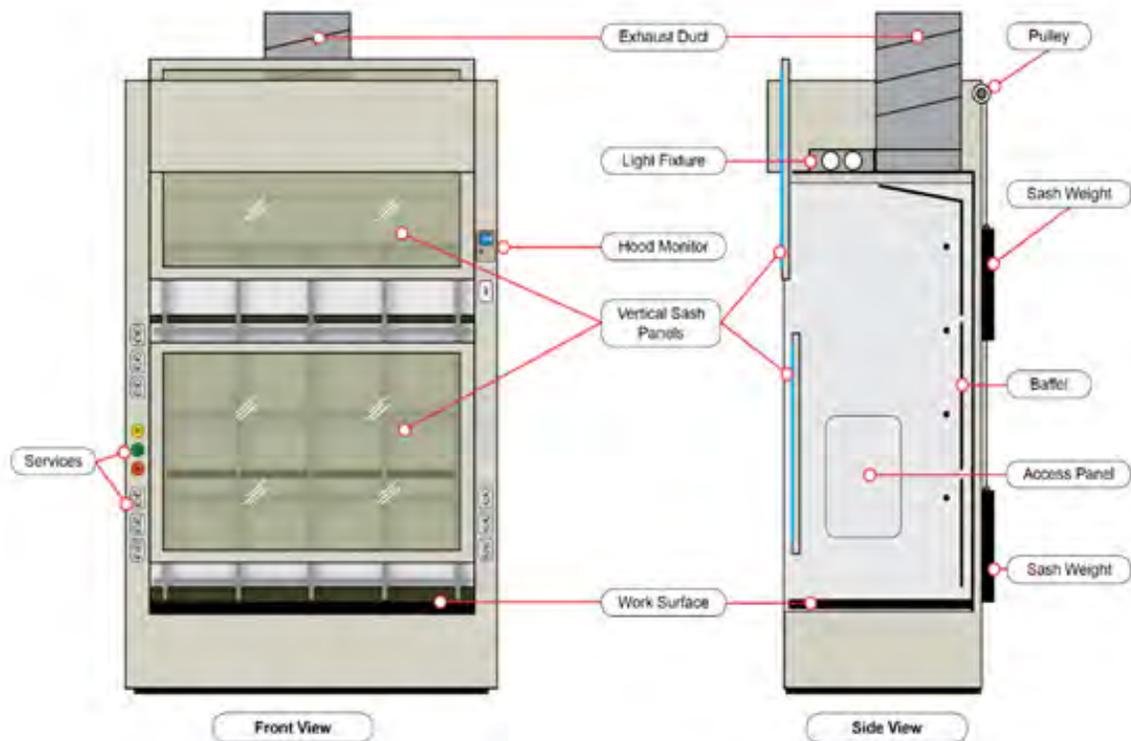
**Figure 10 Auxiliary Air Fume Hood**

### 6.1.3 Distillation Fume Hood

**Description** - Distillation hoods have many of the same components as a standard bench top hood but are constructed with a greater interior height for use with larger equipment and apparatus (See Figure 11). The hoods can be equipped with vertical rising sashes or horizontal sliding panels. Generally, if equipped with a vertical sash then more than one sash panel is used. The vertical sash design generally enables a larger opening than horizontal sash configurations.

**Applications** - Typically used for large distillation processes or large equipment and processes that won't fit inside of a standard fume hood.

**Limitations** - The same limitations for standard fume hoods apply to distillation fume hoods.



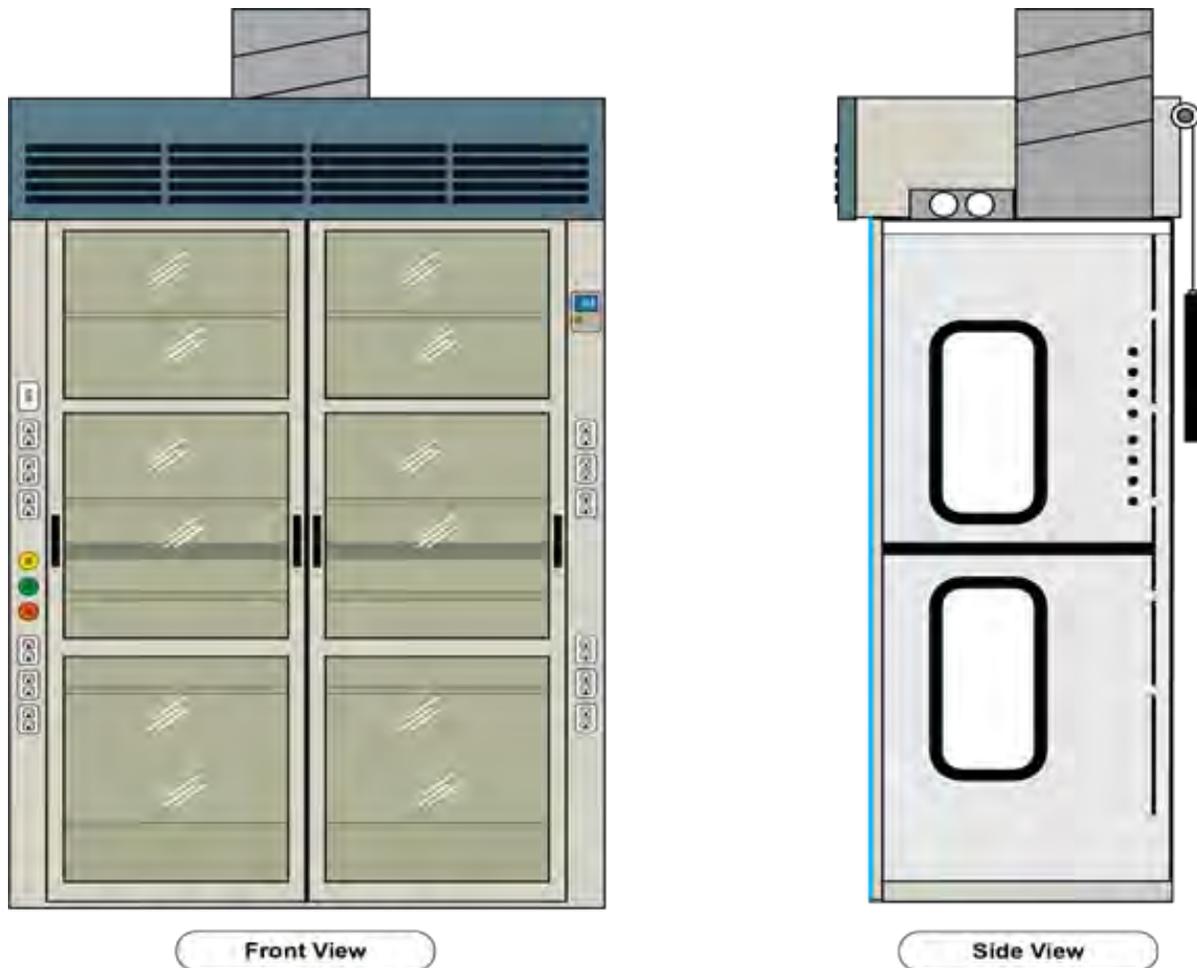
**Figure 11 Distillation Fume Hood**

#### 6.1.4 Floor Mounted Fume Hood

**Description** - Floor mounted hoods, often inappropriately described as “walk - in” hoods, are used to accommodate large apparatus that cannot fit inside of a standard size fume hood. A floor mounted hood is designed so that large equipment can be “wheeled” into the hood if necessary. See Figure 12 for an example of a floor mounted fume hood.

**Applications** – Floor mounted fume hoods can be used in the same manner as a standard laboratory fume hood.

**Limitations** - The same limitations for standard fume hoods apply to floor mounted fume hoods.



**Figure 12 Floor Mounted Hood**

### 6.1.5 Perchloric Acid Laboratory Fume Hood

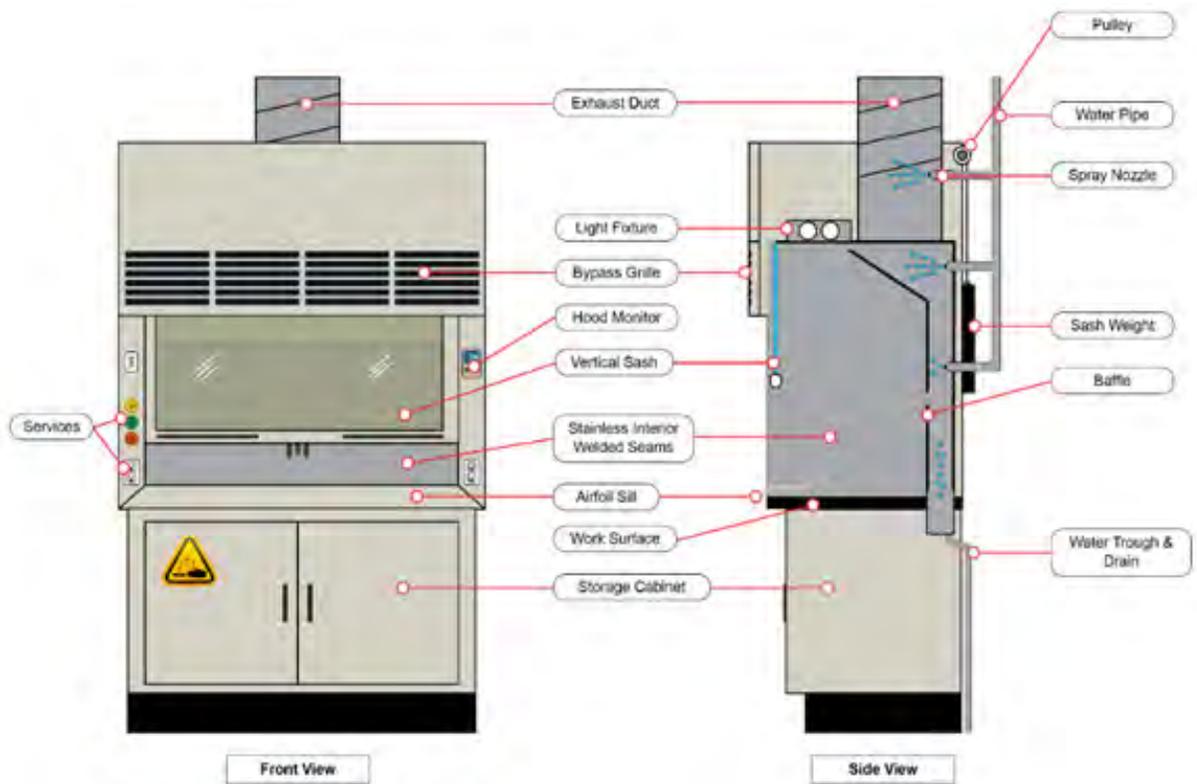
**Description** - Perchloric acid fume hoods and their exhaust systems are specifically designed for perchloric acid applications and should not be used for other procedures (See Figure 13). Often made using 316 stainless steel, or type 1 PVC, perchloric hoods are equipped with water wash down systems to prevent accumulation of perchlorate salt deposits. A trough along the back of the work surface collects the water from the wash down system and is connected to an approved drainage system.

**Applications** - Used in laboratory processes that require perchloric acid to be heated or aerosolized.

**Limitations** - Should not be used in applications other than those requiring perchloric acid or with materials that may be reactive with perchlorates and potential residue.

#### 6.1.5.1 Acid Digestion Laboratory Fume Hood

**Description** – Same as PVC Perchloric Acid Fume Hood in construction, except the sash material has been changed to Lexan in lieu of safety glass.



**Figure 13 Perchloric Acid Fume Hood**

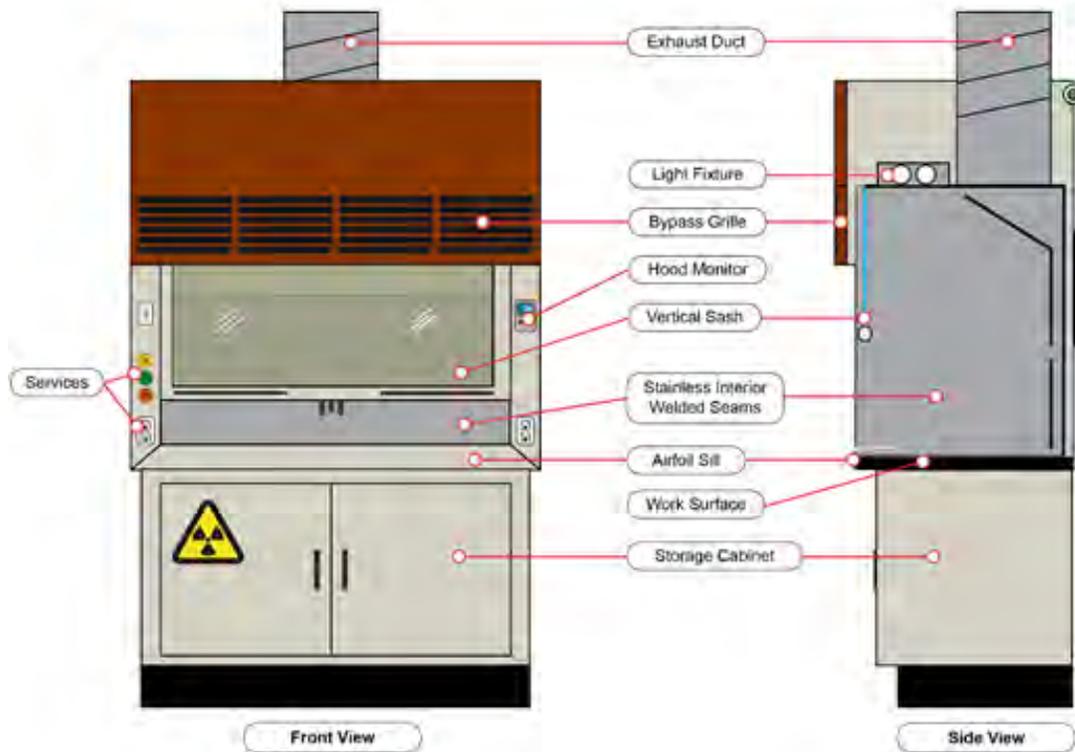
**Applications** - Used for non-perchloric acid digestions with mineral acids.

### 6.1.6 Radioisotope Fume Hood

**Description** - Radioisotope hoods are constructed of solid, resistant materials to chemical agents and covered corners for easier decontamination. Normally, the external and internal surfaces are made of stainless steel or plastic resins (epoxy). The surfaces exposed to the radioactive material should be smooth and sealed at the essential junctions to prevent accumulation of radioactive particles and allow for easy cleaning and decontamination. See Figure 14 for an example of a radioisotope fume hood.

**Applications** - Radioisotope fume hoods are used to avoid radiation exposures of workers or researchers manipulating radioactive substances. Typical radioactive hoods should meet all requirements for constant volume bypass-type or VAV fume hoods and may or may not be equipped with HEPA filter systems.

**Limitations** - A radioisotope fume hood can be operated similarly to standard fume hoods, with special precautions for high radioactive concentrations.



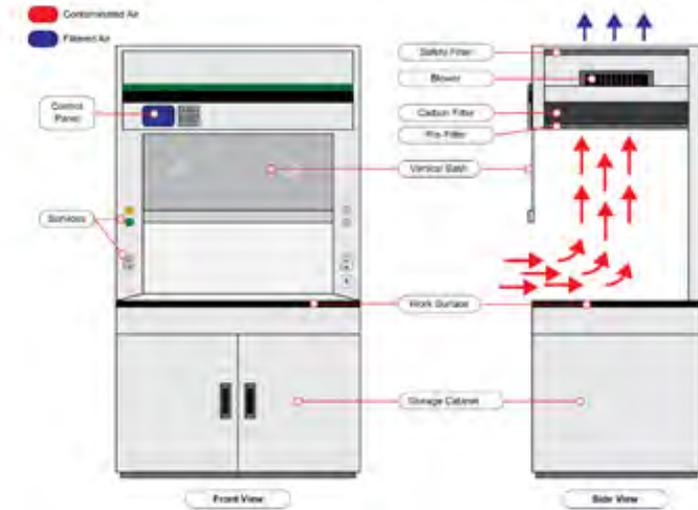
**Figure 14 Radioisotope Fume Hood**

## 6.2 Ductless “Filtered” Fume Hood

**Description** - A filtered fume hood is an enclosure equipped with filtrating technology that feature filters specific to the types of chemicals being utilized (See Figure 15). Air that enters through the opening of the device creates a barrier between the personnel and the chemicals. The integral ventilation system draws the particles and molecules towards the filtration system, preventing hazardous material from being released into the laboratory space. This filtration and release of the air into the lab space in some cases may help to refresh the ambient air in the lab.

**Applications** – Generally, filtered fume hoods can be used for specific processes that match up with the hood’s filter type. Chemical process volumes are typically limited to 500 ml/s or less per chemical. Some hoods have the ability to monitor filter effectiveness or filter life.

**Limitations** – Filtered fume hoods require routine filter replacement dependent upon the type of filter and volume of chemical use in the hood. No extreme heating processes should be conducted within the hood. Hood use is restricted by type of filtration. Note that some materials cannot be adequately filtered and may even poison some filter media rendering it useless for other applications. Take careful note of the manufacturers installation, application and instruction for use and maintenance manuals.



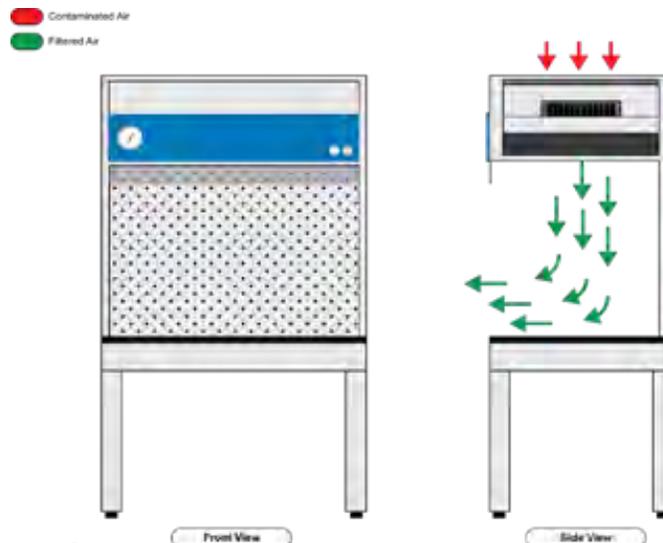
**Figure 15 Ductless “Filtered” Fume Hood**

### 6.3 Laminar Flow Clean Bench

**Description** - Also called clean benches, laminar flow hoods use HEPA filtered air to provide a sterile, contamination free environment for working with critical processes or products. Laminar flow hoods can provide either horizontal or vertical airflow depending on the design configuration. See Figure 16 for an example.

**Applications** - Often used for working with non-hazardous materials which require a clean, particle-free work area. These laminar flow clean benches are different than laminar flow fume hoods in that they only offer product protection where as a laminar flow fume hood can provide product protection and personnel protection by also capturing and exhausting airborne hazards.

**Limitations** - Laminar flow hoods do not offer personnel protection and are not designed for working with biological hazards, aerosols, or toxic chemicals.



**Figure 16 Laminar Flow Clean Bench**

## 6.4 Biological Safety Cabinet (BSC)

BSC's are used to provide effective primary containment for work with pathogens. There are three classes of BSC: Class I, Class II and Class III. Selection of the proper class of BSC requires careful evaluation of the activities to be conducted in the device.

Biological safety cabinets shall meet minimum standards for cabinet classifications in NSF/ANSI STD 49: 2016 for personnel, environmental, and product safety and shall be listed and identified by a distinctive NSF seal. Field re-certification, performed by an NSF 49 accredited technician and conducted per the procedures outlined in NSF 49, will be required once the cabinet is installed. Cabinet classification shall be determined in consultation with the laboratory managers. These types of cabinets have special design requirements depending on their intended use including:

- Protecting personnel from harmful agents inside the cabinet.
- Protecting the product, experiment, or procedure from contamination by the laboratory environment, leading to invalidated test results.
- Protecting the laboratory environment from contaminants inside the cabinet.

### 6.4.1 Class I

**Description** - Class I cabinets have un-recirculated airflow away from the operator that is discharged to the atmosphere after filtration through a HEPA filter.

**Applications** - For use with BSL 1-3 agents. Provides operator protection but does not protect the material within the cabinet from contamination.

**Limitations** - Class I BSC's, provide environmental and personnel protection only. They do not provide product protection. Routine testing and replacement of HEPA filters is required. Flammable or explosive materials should not be used within biological safety cabinets

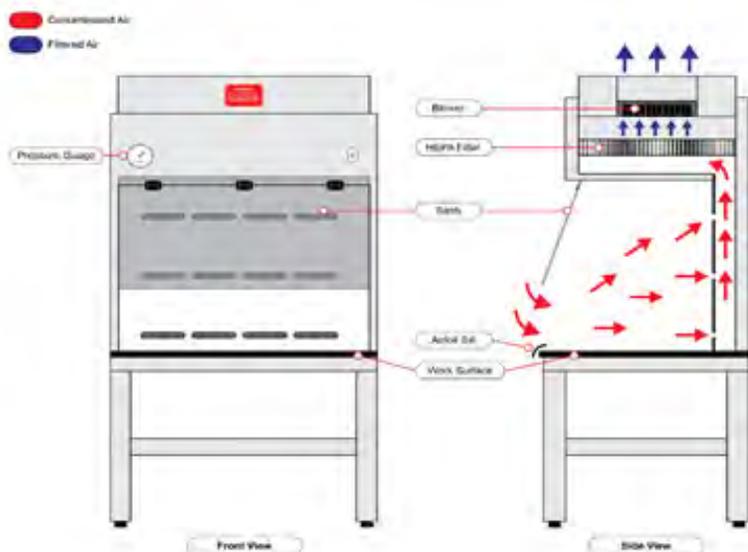


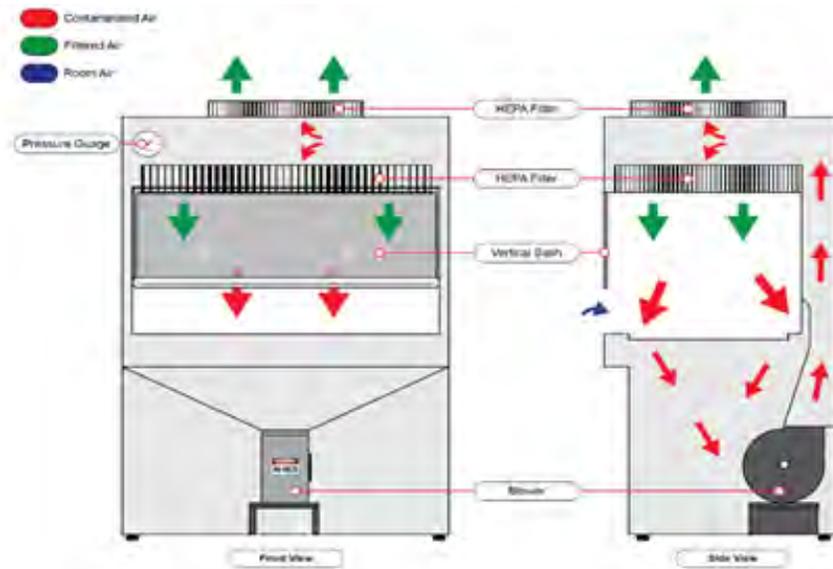
Figure 17 Class I Bio - Safety Cabinet

## 6.4.2 Class II, Type A1

**Description** – Approximately 70% of air is recirculated after passing through a HEPA filter; Approximately 30% is exhausted to the room after filtration.

**Applications** - Typically used for biosafety levels 1 – 3.

**Limitations** - Not suitable for low levels of volatile toxic chemicals. Routine testing and replacement of HEPA filters is required. Flammable or explosive materials should not be used within biological safety cabinets.



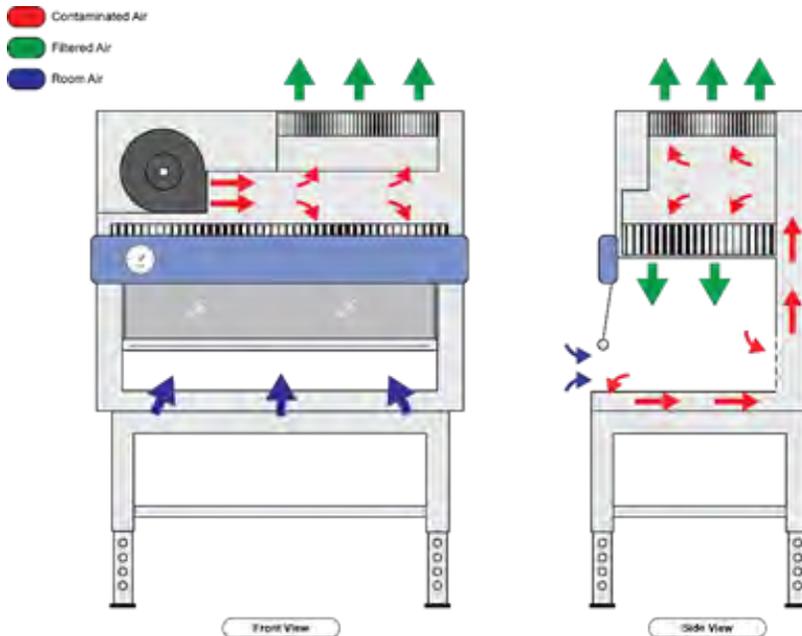
**Figure 18 BSC Class II, Type A1**

## 6.4.3 Class II, Type A2

**Description** – Approximately 70% of air is recirculated after passing through a HEPA filter; Approximately 30% is either exhausted to the room or building exhaust system after filtration (See Figure 19).

**Applications** - For use with low to moderate risk biological agents (biosafety levels 1 – 3). Type A2 can be used for work with small amounts of chemicals if vapors are non-hazardous, won't affect work due to recirculation, and cabinet is exhausted via building exhaust system.

**Limitations** - Routine testing and replacement of HEPA filters is required. Flammable or explosive materials should not be used within biological safety cabinets.



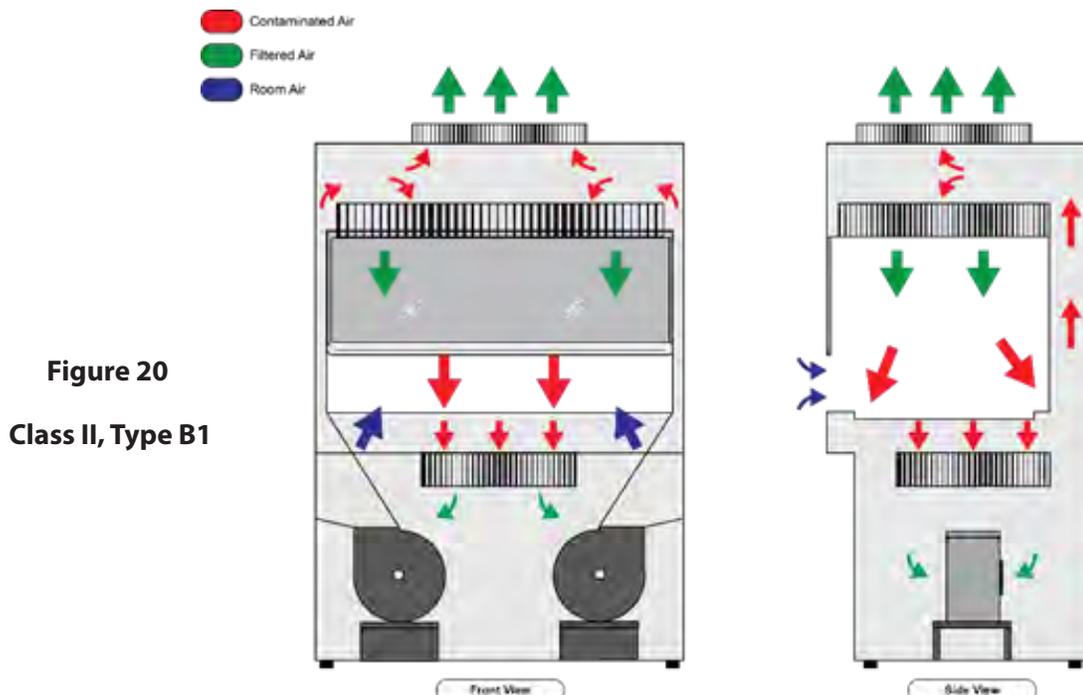
**Figure 19**  
Class II, Type A2

#### 6.4.4 Class II, Type B1

**Description** – Approximately 40% of air is recirculated after passing through a HEPA filter; Approximately 60% is exhausted into building exhaust system after filtration (See Figure 20).

**Applications** - For use with low to moderate risk biological agents (biosafety levels 1 – 3).

**Limitations** - Routine testing and replacement of HEPA filters is required. Flammable or explosive materials should not be used within biological safety cabinets.



**Figure 20**  
Class II, Type B1

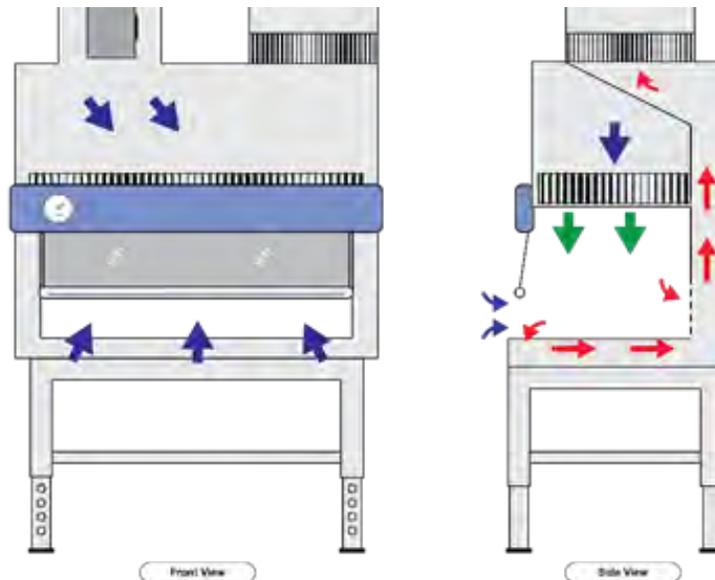
#### 6.4.5 Class II, Type B2

**Description** - 0% of air is recirculated; 100% is exhausted into building exhaust system. See Figure 21 for an example of the airflow patterns for a B2 Cabinet

**Applications** - For use with low to high risk biological agents (biosafety levels 1 – 3) and volatile chemicals.

**Limitations** - Routine testing (at least annual) and replacement of HEPA filters is required when necessary. Flammable or explosive materials should not be used within biological safety cabinets.

**Figure 21**  
**Class II, Type B2**



#### 6.4.6 Class II, Type C1 BSCs

**Description** - Class II Type C1 BSCs have the following characteristics:

- They typically maintain an average minimum inflow velocity of 100 fpm through the work access opening, but the inflow velocity can vary depending on the risk and performance requirements;
- They have HEPA/ULPA filtered downflow air composed largely of uncontaminated recirculated inflow air;
- They exhaust contaminated downflow air from a region of the work area via an internal dedicated exhaust plenum and blower, and then through HEPA/ULPA filter(s);
- Have all biologically contaminate ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums; and
- May exhaust HEPA/ULPA filter air either back into the lab or via a canopy connection to an external system that exhausts to the atmosphere.

**Applications** - For working with low to high risk biological agents (biosafety levels 1 – 3) and volatile chemicals when connected to an external exhaust system.

#### 6.4.7 Class III

**Description** - Class III biosafety cabinets are gas tight glove boxes designed for working with a variety of high risk materials/agents. The exhaust air must be double HEPA-filtered or HEPA-filtered and incinerated. The supply air can also be HEPA filtered as well.

**Applications** - For working with chemical carcinogens, high concentrations of low to moderate risk agents, highly infectious or hazardous materials.

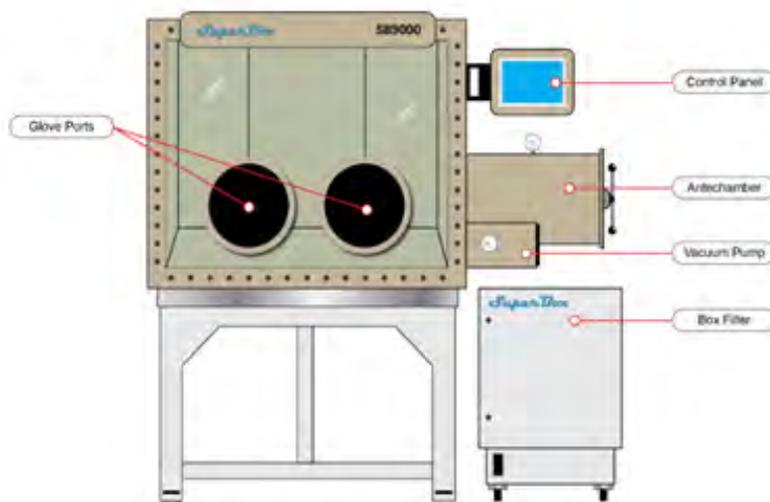
**Limitations** - Often need to be custom built to meet exact use specifications. Require strict monitoring and filtering capabilities.

### 6.5 Glove Box

**Description** - Glove boxes are tightly sealed, fully enclosed systems often required to ensure total containment of chemical and biological contaminants where a separate atmosphere is desired. Built into the sides of the glovebox are gloves that the user can place their hands into the gloves and perform functions inside the box without breaking containment. See Figures 22 and 23 for examples of different glovebox configurations.

**Applications** - Two types of gloveboxes exist; one allows a person to work with hazardous substances and the other allows manipulation of substances that must be contained within a high purity inert atmosphere (such as argon or nitrogen). It is also possible to use a glovebox for manipulation of items in a vacuum chamber.

**Limitations** - Glove boxes have several parameters and performance criteria that must be set and monitored to ensure containment. These parameters include pressure, alarm set points for oxygen and moisture, filter leak tests, evacuation time for the antechamber and regeneration intervals.



**Figure 22**  
**Glove Box**



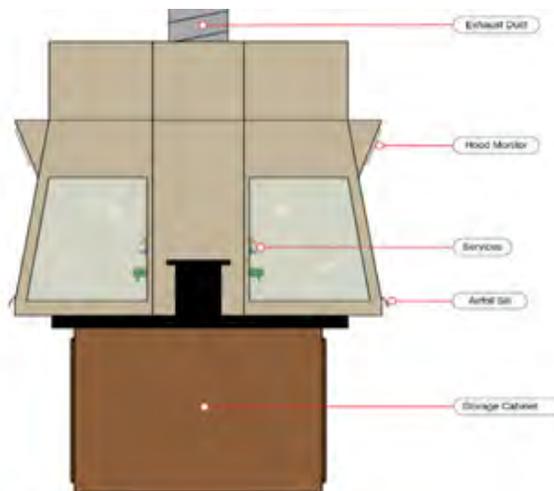
**Figure 23**  
**Photograph of Glove Boxes**

### 6.6 Teaching Hood (Educational Hood)

**Description** - A teaching hood sometimes called a California hood, demonstration hood, or pass-through hood, are special fume hoods with viewing glass or sashes on multiple sides. The purpose of this hood is to allow full visibility of the processes being conducted in the hood. The hoods often are not equipped with baffles to keep the flow of air into the hood uniform across the sash opening.

**Applications** - Designed to allow students to view demonstrations as well as allowing teachers to supervise student use. Can be used to transfer chemicals from one room to another without leaving the fume hood.

**Limitations** - The same limitations for standard fume hoods apply to teaching fume hoods. Use with only one of the two sashes open at one time.



**Figure 24 California Hood - Teaching Hood**

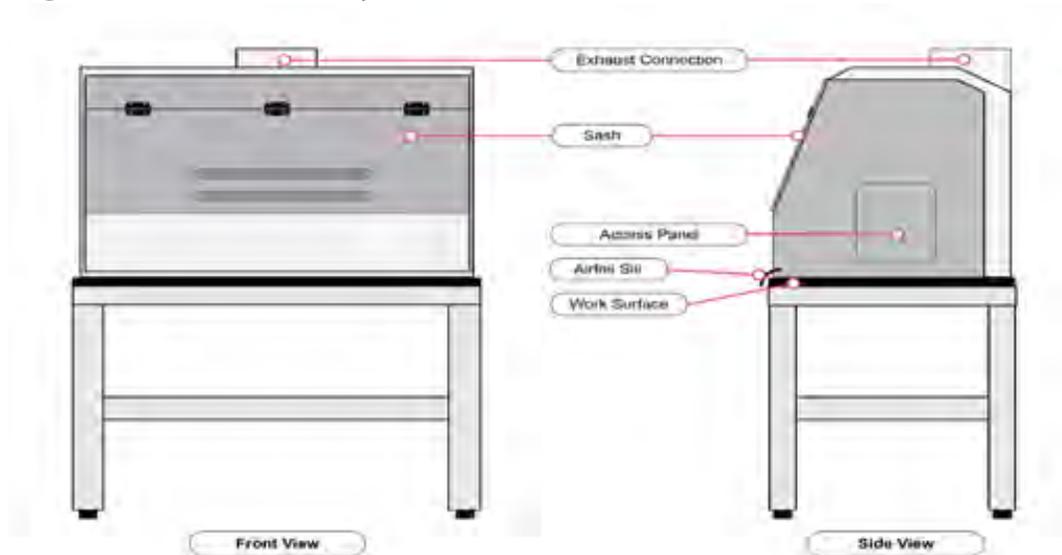
## 6.7 Ventilated Safety Enclosure (VSE)

**Description** - Ventilated enclosures are typically smaller than standard fume hoods and can usually be placed on a countertop or benchtop surface. Ventilated enclosures can be ducted into an existing building exhaust system or in certain applications, non-ducted models exhaust HEPA filtered air back into the lab space.

**Applications** - A ventilated enclosure is suitable for operations that are largely unattended but will emit small volumes of potentially hazardous materials or excessive heat.

**Limitations** - The same limitations for standard fume hoods apply to ventilated enclosures. Filtered units require routine filter testing and maintenance.

**Figure 25 Ventilated Safety Enclosure**



**Figure 26 Photograph of  
Ventilated Equipment Enclosure**



### 6.7.1 Ventilated Balance Enclosure (VBE)

**Description** - While similar in design to standard ventilated enclosures, VBE's provide exceptional containment characteristics along with a turbulence-free environment necessary for weighing of materials and compounds. They are typically transparent and operated at lower face velocities than chemical lab hoods to reduce balance disturbance and loss of material.

**Applications** - VBE's are specifically designed for providing exposure protection during the weighing and handling of potent materials and compounds.

**Limitations** - The same limitations for standard fume hoods apply to ventilated balance enclosures. Filtered units require routine filter testing and maintenance.



**Figure 27**

### **Ventilated Balance Enclosure**

## **6.8 Canopy Exhaust Hood**

**Description** – Typically built using corrosion resistant materials, canopy hoods are usually wall or ceiling mounted. They are hard ducted into the building's ventilation system and are comprised of a large, typically rectangular metal opening.

**Applications** - Canopy exhaust hoods are receiving hoods provided for the removal of steam, heat and negligible hazards from specific laboratory apparatus such as furnaces, ovens, and sterilizers.

**Limitations** - Should not be used for personal protection. Not for removing hazardous fumes or vapors.



**Figure 28 Canopy Hoods**

### **6.9 Flexible Spot Exhaust (FSE)**

**Description** - Flexible Spot Exhaust or snorkel ducts, consist of a bell mouth and articulated connection to the building exhaust system.

**Applications** - Best used to remove fumes or heat from laboratory instrumentation or processes not appropriate for conduction inside a fume hood or other ventilated enclosure such as gas chromatographs and other analytical bench-top instrumentation with potential for low volume discharge of low hazard materials.

**Limitations** - FSE's have limited capture effectiveness and application must be limited to point source generation. The capture effectiveness is a function of the proximity to the contaminant source and the design of the hood inlet. Successful FSE bench applications are highly specific to the mass of the contaminant and the velocity and angle of emission.



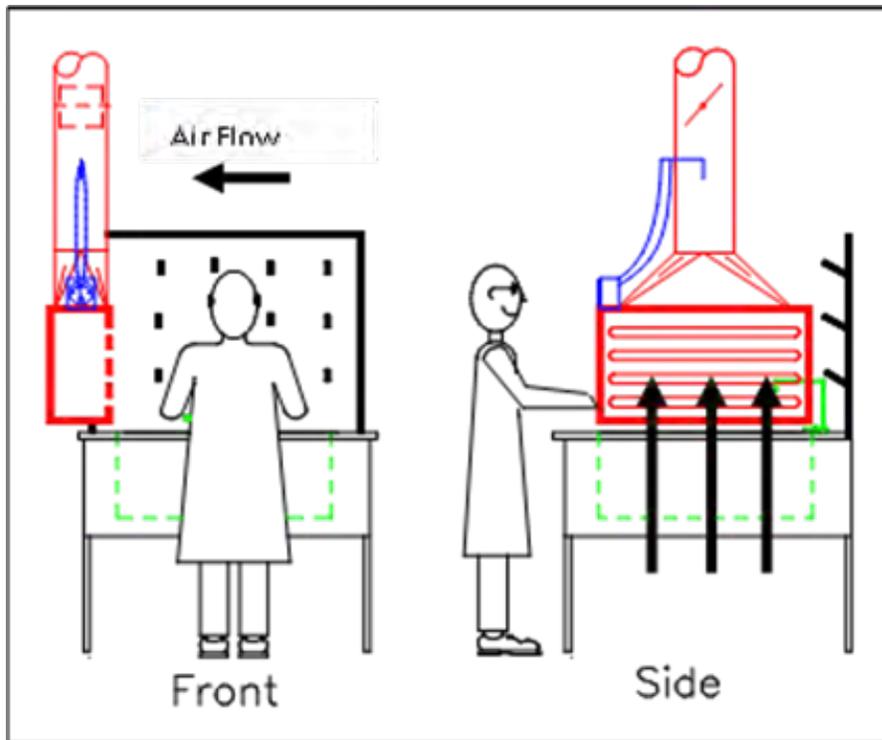
**Figure 29 Flexible Spot Exhaust**

## 6.10 Slot Hood

**Description** - Slot hoods are typically wall mounted, hard ducted exhaust devices constructed of either metal or plastic slots.

**Applications** – Commonly used in darkrooms and acid dipping operations.

**Limitations** - Slot hoods provide a limited range of capture. In addition, the orientation of the user with respect to the opening can also influence capture. Locate a slotted hood so that the direction of airflow does not create significant eddy zones or low pressure areas that could bring concentrations into the breathing zone of the operator.



**Figure 30**  
**Slot Hoods**

## 6.11 Downdraft Table (Necropsy Table, Histology Station)

**Description** – Downdraft tables are ventilated tables which allow unobstructed top access while limiting release of chemicals and odors into the lab space. Downdraft tables protect personnel and the working environment by drawing contaminated air away from the work area. The workstation operates under negative pressure to exhaust fumes, aerosols and the other chemical irritants or odors through a properly configured exhaust system.

**Applications** - Downdraft tables provide protection during animal necropsies, surgeries, specimen dissections, gross dissections/tissue grossing, perfusions and preparation of histological slides as well as other histology work. A histology station, also known as a tissue grossing station, is a ventilated work bench designed for surgical and medical experiments. These stations are composed of a sink, removable perforated dissecting trays that create downdraft exposure control and a ventilation connection for the station to be hard ducted into the building's ventilation.

**Limitations** - Limited by low containment capabilities and generally not recommended for use with high hazard chemicals and compounds unless capture effectiveness is tested and confirmed.



**Figure 31 Downdraft Necropsy Table**

## 6.12 Ventilated Wet Bench

**Description** - Ventilated wet benches are typically enclosed and hard ducted to the building's exhaust system and are manufactured from polypropylene or stainless steel. Some benches are equipped with a vertical sash depending on the application and some may also be equipped with sinks. Wet benches operate with a cross flow exhaust system to draw hazards away from the user. See Figure 32 for a photo of a ventilated wet bench.

**Applications** - A ventilated wet bench can be used for both semiconductor industrial processes as well as medical processes.

**Limitations** - Containment capabilities may be subject to design and should not be used for work with high hazard chemicals and compounds where performance is not tested and confirmed.



**Figure 32  
Ventilated Wet Bench**

### 6.13 Wet Process Workstation

**Description** - WPS provide protection for personnel from large scale acid and solvent usage. Unlike conventional chemical fume hoods, WPS have full-unit-width under-worksurface exhaust plenum/spill containment tubs, allowing for large volumes of heated process chemical baths to be recessed down under work surface, with fumes captured locally and brought down and away under the station work surface, and out rear exhaust. WPS are typically placed in cleanrooms or clean labs due to critical processes performed within, so also provide process protection due to unique station physical design which allows work surface to be 'washed' by HEPA filtered air above. WPS may have vertically or horizontally closing sashes, or hinged eye shields with fixed access openings. WPS often have some degree of automation incorporated into functionality.

**Applications** - Critical parts processing with acid, base, and solvents, often at elevated temperatures for semiconductor processes, electronics manufacturing, Biomedical, nanotech, medical devices, military, aerospace and other critical processes.

**Limitations** - Due to larger scale of chemical use in WPS, adequate chemical waste must be planned for. Most WPS have onboard waste systems, each dedicated to particular waste stream used in WPS, with materials of construction carefully selected for compatibility with precise chemistry, concentration, and temperature to be contained. Multi levels of safety interlocks must be included in WPS or otherwise station use should be limited to lower volumes of usage more similar to a chemical fume hood.



**Figure 33 Wet Process Workstations**

## 6.14 Hazardous Gas Storage Cabinet

**Description** - Typically constructed of metal and approximately five-feet tall, the hazardous gas storage cabinets are used to house compressed cylinders. There is often a glass window constructed on the top of the cabinet to view the gas containers inside.

**Applications** – Storage in these cabinets can include; corrosive solids or liquids, toxic liquids or solids, flammable solids or liquids, organic peroxide formulations, oxidizer solids or liquids, pyrophoric solids or liquids, toxic or highly toxic solids or liquids, unstable solids or liquids, water-reactive solids or liquids. These cabinets can be required by fire codes to increase the maximum allowable quantities, separate incompatible materials, and should be locked to prevent unauthorized access. For further information refer to SEFA 11 – 4.2

**Limitations** - Leak detectors and low-exhaust flow alarms, as well as a gas purge system, should be required to provide for safe exchange of cylinders.

## 6.15 Flammable Liquid Storage Cabinet

**Design and Construction** – Venting of storage cabinets is not required for fire protection purposes, but venting may be required to comply with local codes or authorities having jurisdiction. Non-vented cabinets should be sealed with the bungs supplied with the cabinet or with bungs specified by the manufacturer of the cabinet. If cabinet venting is required, the cabinet should be mechanically vented to the outside and:

- Both metal bungs must be removed and replaced with flash arrestor screens (normally provided with cabinets). The top opening serves as the fresh air inlet.
- The bottom opening must be connected to an exhaust fan by a length of rigid steel tubing that has an inside diameter no smaller than the vent opening.
- The fan should have a non-sparking fan blade and non-sparking shroud.
- The cabinet should exhaust directly to the outside (the cabinet should not be vented through the fume hood).
- The cabinets should be conspicuously marked, “Flammable - Keep Fire Away.”

**Application** - Used to organize and store flammable liquids in approved closed containers. To guard liquids from their auto ignition temperature of the liquids stored in the event of a fire. Flammable Liquids storage cabinets are often used to increase the maximum allowable quantities, to separate incompatible materials, and should be locked to prevent unauthorized access. For further information refer to SEFA 11 – 4.1

**Operation** - The operating specifications for these cabinets include flow, static pressure and containment.

## 6.16 Special Purpose Devices

Special purpose hoods are defined as any hood that does not conform to the specific types described above. Special hoods may be used for operations for which other types are not suitable (e.g., robot sampling equipment, liquid nitrogen dewars, ETO sterilizers). Other applications might present



**Figure 34**  
**Ventilated Flammable Gas**  
**Cabinets**

opportunities for achieving contamination control with less bench space or less exhaust volume (e.g., using the hoods as special mixing stations, evaporation racks, heat sources, or ventilated worktables).

## **7 ECD SYSTEM MANAGEMENT PLAN**

ECD systems are complex, costly to install, and require diligent efforts to select, operate, maintain and ensure proper use and application. Installation of ECD Systems can be associated with 15% to 30% of the costs to construct a laboratory building and their operation often accounts for as much as 60% to 80% of annual energy consumption and utility costs. Depletion of energy resources and resultant increase in energy costs advocates for efficient energy use as a prominent, but secondary criterion to lab safety. Finally, significant time and effort are required from numerous stakeholders including laboratory personnel, EHS, facilities engineering, facilities maintenance, management, and outside contractors to ensure proper performance and provide safe, productive, energy efficient and sustainable laboratories.

Failure to properly select, design, operate, use and maintain ECD systems may:

- Increase the potential for unacceptable impact to the health of people;
- Increase potential for harm to the environment;
- Increase potential for premature degradation of the ECDs;
- Increase potential for loss of productivity and operational efficiency;
- Increase unnecessary energy consumption and operating costs;
- Increase the risk of non-conformance with regulatory and industry standards; and
- Increase the risk of liability.

### **7.1 ECD Management Program Description**

To help ensure that a framework exists for organizations to provide safe and efficient operation of laboratory ventilation systems, the ANSI/AIHA Z9.5-2012 American National Standard for Laboratory

Ventilation requires laboratory facilities to implement a Lab Ventilation Management Plan (LVMP). The LVMP is intended to ensure proper design, operation, and maintenance of lab ventilation systems. In this document, an ECD Management Program serves as the equivalent of an LVMP and should be implemented where hazardous airborne contaminants may be found in laboratory environments. The following elements should be included in a written ECD Management Program:

Program management and stakeholder coordination;

Risk assessment process to understand and characterize the airborne hazard, associated risk, and level of protection required;

ECD selection process;

ECD system design and operating specifications;

Performance testing to validate and verify proper performance of the ECD system prior to use with hazards (sometimes referred to as commissioning);

Maintenance and routine testing program in compliance with THE MAINTENANCE PLAN;

Training for all stakeholders including users operating ECDs and personnel involved with selection, design, operation, maintenance and testing of ECDs;

Management of Change process capable of ensuring ECD systems remain appropriate for the hazardous processes and provide proper performance;

Documentation and recordkeeping; and

Review and revise annually or as necessary to maintain relevance and use.

The elements of the ECD Management Program are shown in Figure 35 below.



**Figure 35 - Elements of a Comprehensive ECD Systems Management Program**

## 7.2 Program Management and Stakeholder Coordination

Responsibilities for implementation and execution of the ECD Management Program are at the discretion of the facility management. Depending on the number and type of ECDs, risk associated with the applications and complexity of the systems; the responsibilities for execution of the tasks of the ECD Management Program may be assigned to one or more stakeholder groups including Environmental Health and Safety (EHS), Facility Engineering, Facility Managers, Lab Managers and Lab Professionals.

A responsible person or ECD program coordinator should be available for overseeing the ECD Management Program and should review the program regularly (usually annually) and its implementation. Control of frequency, execution, documentation, and records of all tasks and services should be included in the site ECD Management Program.

### 7.2.1 Hazard Emission Risk Assessment

The risk assessment process should be developed to identify and characterize the hazards and procedures that may lead to the need for an ECD System. This information defines the hazard emission scenario for determining the required performance criteria (acceptable level of control) and selecting an appropriate ECD system. The emission scenario shall indicate the type of airborne contaminant, the characteristics of the airborne contaminant's concentration (e.g. gas, vapor, particulate, or other aerosol), the quantity of material used in the process, and the potential method and rate of generation.

### 7.2.2 Selection of ECD's

Where the risk assessment process indicates a need for an ECD due to a hazardous airborne contaminant, the ECD system selected for use must be appropriate for the hazard emission scenario and capable of meeting the required performance criteria under normal and expected operation conditions. This may or may not be effective for a catastrophic event and this should be taken into account when selecting an ECD System.

An inventory and description of the types and application of site specific ECDs should be included as part of the ECD Management Program.

### 7.2.3 ECD Design and Operating Specifications

The ECD system must be designed and have the attributes appropriate to achieve the required performance criteria when operated in accordance with the established operating specifications. The requirements for design, construction and operation of the ECD systems shall be included in the ECD Management Program and align where applicable with relevant industry standards (e.g. SEFA, ANSI etc). The operating specifications for all commercially manufactured, pre-engineered or custom designed ECD systems must be provided by the manufacturer or determined by the assigned stakeholder.

The operation of the ECD system must be monitored and there must be a means to notify ECD users and other stakeholders when the ECD systems fail to operate within the operating specifications and tolerances necessary for proper performance. Where possible, the systems must be designed and operated to minimize energy consumption, but at no time can energy efficient operating modes adversely affect performance and the ability to protect users.

### 7.2.4 ECD Performance Verification

All ECD systems must be tested following installation and prior to use with hazardous processes. The performance tests shall verify that the ECD systems are operating in accordance with the specifications

and meet the required performance criteria. The performance tests must be appropriate for the ECD system and conform to relevant site standards and guidelines. Proper performance of the ECD system must be verified under all possible modes of operation and the prevailing operating conditions, associated specifically with the laboratory environment and the ventilation systems must be determined and documented.

All ECD systems should be subject to re-tests to verify performance following any major change to the configuration of the ECD, physical design of the laboratory, physical design of the ventilation systems or changes in airflow specifications that could impact performance. The extent of the modifications that justify the need for tests to verify performance should be included in the ECD Management Program.

### 7.2.5 Maintenance and Routine Testing

All ECD Systems should be maintained according to a Maintenance Plan. The Maintenance Plan includes provision for preventative maintenance and tests to verify that all components are in good working order and operating in accordance with specifications that prevailed at the time of the original commissioning. The maintenance procedures should be appropriate for the ECD systems and cover all operating modes. The procedures should be conducted on a defined frequency to identify and rectify operational deficiencies before performance of the ECDs are compromised.

All maintenance activities and routine tests should be conducted and documented in accordance with applicable standards. The individual standards for maintenance and testing of each type of ECD should include requirements for test equipment, calibration, procedures and training of personnel required to execute the maintenance and testing. All systems, components, labs and ECDs should be evaluated at least annually or as frequently as indicated in the maintenance program to maintain performance within acceptable tolerances. Requirements for verifying proper function of all monitors and alarms should also be included in the ECD Maintenance Program.

### 7.2.6 Training of Personnel

The continuous training of personnel is critical for the successful implementation and operation of an ECD program. All stakeholders involved in the ECD Management Program including safety, facility operators, lab managers and laboratory associates should receive initial and periodic training to ensure the safe and efficient operation of the ECD Systems. Individual stakeholders should also receive training specific to their responsibilities. A training course should be required for all users and cover work practices, operational capabilities and performance limitations of the ECD systems.

Following initial training, the effectiveness of training and need for refresher training should be evaluated annually or as needed to demonstrate conformance with the ECD Management Program. All stakeholders should be alerted to any changes that may have occurred to application or operation of the ECD systems.

Training topics need to be both general in nature to provide an overview of the ECD management process and describe employee responsibilities and more specific with targeted training as required for the sub-groups of stakeholders. Training should be provided for:

- Facility Managers
- HVAC and Controls Engineers
- Building Operators and Maintenance

- Environmental Health and Safety Managers
- Lab Managers
- Researchers.

### 7.2.7 Management of Change

While systematic implementation of maintenance, testing and reporting is important, the methods by which changes to the systems or changes to the procedures are handled can be even more critical. The ECD Management Program should include or reference relevant Management of Change plans and include a process or processes wherein changes in use of the ECD's systems are considered.

The Management of Change plan should cover modifications to ECD systems, operating specifications and performance requirements. Maintenance, testing and reporting requirements should reflect the implemented changes. The Management of Change plan associated with the ECD Management Program should include a sample structure of personnel, departments and other various interests that are critical to the Management of Change process.

**Initiated Change:** An initiated change occurs when an individual or department seeks a modification to the laboratory ventilation system. Initiated changes should follow the MOC process and return to risk assessment and evaluation of hazardous procedures.

**Reactive Change:** A reactive change is in response to an unplanned change, such as equipment or component failure. This type of change may require an expedited approval process due to immediate concerns for safety and possible damage to the ventilation system. Incidents should be well documented as well as evaluated for prevention of future issues.

The MOC program establishes accountability by providing the procedures and a system of checks and balances to fully document changes that may affect the ECD System. MOC procedures can be conducted any number of ways such as: paper forms, electronic forms, online database system, mobile phone application, etc. These procedures can be summarized as follows:

- Assess conditions that have changed
- Request for ECD change or change to operating environment that might impact performance of the ECD
- Informal review
- Detailed evaluation
- Approval
- Planning and updates
- Implementation
- Follow-up

### 7.2.8 Documentation and Record Keeping

Documentation describing the location and types of ECDs, descriptions of systems, engineering drawings, flow specifications, commissioning results, maintenance efforts and routine test results should be stored, readily accessible and remain up to date. The location of the documents and records should also be specified as part of the ECD Management Plan. Although not an inclusive list, the records and documents should include:

- Basis of Design Documents and As-built drawings;
- Commissioning reports;
- Testing and Air Balance reports;
- Results of "As installed" and Periodic Routine Test reports;
- Maintenance logs; reported problems and corrective actions;
- System modifications including equipment replacement or changes in operational specifications, flow set points or sequences of operation.

### 7.3 Responsibilities for the ECD Management Program

It is up to a laboratory's management to provide leadership, allocate resources and assign responsibilities for overseeing and executing tasks of the ECD Management Program. The Table below provides a list of responsibilities recommended for assignment to one or more stakeholder groups such as Environmental Health and Safety (EHS), Facility Engineering, Facility Maintenance, Lab Personnel, Purchasing and Space Planning.

| Group or Department  | Suggested Responsibility   |
|--|--|
| <b>Head of R &amp; D Operations, Lab Managers, Reserachers and ECD Users</b> | <ul style="list-style-type: none"> <li>• Provide information on use of hazardous materials;</li> <li>• Provide information about procedures, work practices, duration of use, changes in hazardous operations and materials etc;</li> <li>• Provide information and participate in ensuring appropriate safety systems are available;</li> <li>• Provide notification of any ECD Systems which are not operating properly;</li> <li>• Utilize ECD Systems in accordance with operating requirements and safety guidelines;</li> <li>• Provide notification of changes in the work activities or to the laboratory which may necessitate a change, repair, modification of, addition to or removal of ventilation equipment;</li> <li>• Follow the guidelines in the Management of Change for any modifications to laboratory equipment, operations or procedures; and</li> <li>• Follow all safety and health procedures associated with the safe operation of ECD Systems; attend all required health and safety trainings assigned relative to job function and activities performed.</li> </ul> |
| <b>Environmental Health and Safety (EHS)</b>                                 | <ul style="list-style-type: none"> <li>• Assist researchers with recognition and evaluation of hazards;</li> <li>• Establish control objectives, safety requirements and suitable control strategies;</li> <li>• Assist with selection of the appropriate ECD systems to ensure adequate protection for personnel and the environment;</li> <li>• Assist with ensuring testing protocols of ECD systems are being properly performed, and routine testing and certification dates are being enforced;</li> <li>• Review and provide written final acceptance of testing of ECD systems before use and following periodic tests to verify proper operation;</li> <li>• Communicate findings of testing protocols;</li> <li>• Maintain records associated with testing ECD Systems; and</li> <li>• Assist with review of proper work practices and safety training</li> </ul>  |

| <b>Group or Department</b>                           | <b>Suggested Responsibility</b>  |
|--|--|
| <b>Facility Engineering and Facility Maintenance</b> | <ul style="list-style-type: none"> <li>• Ensure ECD systems have the capability to provide safe, dependable and efficient operation;</li> <li>• Ensure proper design, installation, and commissioning of systems;</li> <li>• Maintain up-to-date system documentation;</li> <li>• Ensure all stakeholders understand the operation, capabilities, limitations and testing requirements of the ECD systems;</li> <li>• Ensure testing protocols of ECD systems are being properly performed and routine testing dates are being enforced;</li> <li>• Provide notification of scheduled testing of ECD systems;</li> <li>• Periodically inspect the entire ECD system;</li> <li>• Perform preventative and repair maintenance as necessary to ensure proper operation of the ECD systems;</li> <li>• Identify, report and document deficiencies and the required repairs / modifications to fix the deficiency. Such inspections should be integrated and documented as part of the maintenance plan; and</li> <li>• Perform, or arrange to be performed, all necessary repairs / modifications to any equipment which affects the ECD system's ability to meet performance requirements.</li> </ul> |
| <b>Purchasing</b>                                    | <ul style="list-style-type: none"> <li>• Ensure ECD systems are approved prior to purchase; and</li> <li>• Work with stakeholders to establish purchase requirements for ECD systems to promote standardization.</li> </ul>  |
| <b>Space Planning</b>                                | <ul style="list-style-type: none"> <li>• Ensure safety and engineering issues are considered in any space allocation decisions.</li> </ul>   |

## 8 References Sources

- ACGIH - Industrial Ventilation: A Manual of Recommended Practice for Design
- ACGIH - Industrial Ventilation: A Manual of Recommended Practice for Operation and Maintenance, 2007
- ANSI/AIHA® Z9.5 – 2012 American National Standard for Laboratory Ventilation
- ANSI/ASHRAE 110 – 2016 – Method of Testing Performance of Laboratory Fume Hoods
- ASTM F 1412-16 (American Society for Testing and Materials) Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems
- EN 14175-3 March 2004 - Fume Cupboards Part 3: Type test methods
- EN 14470-1 - Safety Cabinet Standard for Flammable Products
- IBC International Building Code
- IFC International Fire Codes
- National Environmental Balancing Bureau (NEBB) 2009 - Procedural Standards for Fume Hood Performance Testing
- NFPA 30 2015 Flammable & Combustible Liquids Code
- NFPA 91 2015 Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists and Combustible Particulate Solids
- NFPA 45 2015 Standard on Fire Protection for Laboratories Using Chemicals
- NFPA I 2015 Fire Code
- NSF/ANSI 49 – 2016 Biosafety Cabinetry: Design, Construction, Performance, and Field Certification
- OSHA 29 CFR 1910.106 Flammable Liquids
- Prudent Practices in the Laboratory: handling and management of chemical hazards - 2011
- PWGSC 15128 Laboratory Fume Hoods – Guidelines for Building Owners, Design Professionals, and Maintenance Personnel
- PWGSC 15129 Perchloric Acid Fume Hoods and Their Exhaust Systems
- UL 1275 Standard for Flammable Liquid Storage Cabinets
- SEFA Desk Reference 5th Edition

## 9 Relevant Organizations

SEFA recognizes and acknowledges the importance of government agencies that produce documents concerning laboratory ventilation, laboratory fume hoods and laboratory safety. These agencies include:

### **AABC Associated Air Balance Council**

1000 Vermont Avenue, NW, Washington, DC 20001

[www.aabc.com](http://www.aabc.com)

### **ACGIH American Conference of Governmental Industrial Hygienists**

1 330 Kemper Meadow Drive, Cincinnati, Ohio 45240

[www.acgih.org](http://www.acgih.org) <http://www.acgih.org>,

(513) 742-2020

### **ADC Air Diffusion Council**

230 North Michigan Avenue, Chicago, IL 60601

[www.flexibleduct.org](http://www.flexibleduct.org)

### **AGA American Gas Association**

1515 Wilson Blvd., Arlington, VA 22209

[www.aga.com](http://www.aga.com)

### **AGC Associated General Contractors of America**

1957 E. Street, NW , Washington,DC 20006

[www.agc.org](http://www.agc.org)

### **AGS American Glove Box Society**

P. O. Box 9099, Santa Rosa, CA 95405

[www.gloveboxsociety.org](http://www.gloveboxsociety.org)

(800) 530-1022

### **AHA American Hardboard Association**

1210 W. Northwest Highway, Palatine, IL 60067-1897

[www.domensino.com/aha/](http://www.domensino.com/aha/)

(847) 934-8800

### **AIA The American Institute of Architects**

1735 New York Ave. NW Washington, DC 20006

[www.aia.org](http://www.aia.org)

(202) 626-7300

### **AIHA American Industrial Hygiene Association**

2700 Prosperity Ave., Suite 250, Fairfax, VA 22031

[www.aiha.org](http://www.aiha.org)

(703) 849-8888

### **AMCA Air Movement & Control Association International, Inc.**

30 W. University Drive Arlington Heights, IL 60004-1893

[www.amca.org](http://www.amca.org)

(847) 394-0150

**ANSI American National Standards**

Institute 1 1 West 42nd Street 13th Floor, New York, NY 10036-8002  
www.ansi.org  
(888) 267-4683

**AHRI Air Conditioning, Heating, and Refrigeration Institute**

4301 Fairfax Drive, Suite 425, Arlington, VA 22203  
www.ari.org  
(703) 524-8800

**ASCE American Society of Civil Engineers**

World Headquarters - 1801 Alexander Graham Bell Drive Reston, VA 20191-4400  
www.asce.org  
(800) 548-2723

**ASCET American Society of Certified Engineering Technicians**

P. O. Box 1348, Flowery Branch, GA 30548  
www.ascet.org  
(777) 967-9173

**ASHRAE American Society of Heating, Refrigerating and Air Conditioning Engineers**

1791 Tullie Circle, NE, Atlanta, GA 30329-2305  
www.ashrae.org  
(800) 527-4723 - (404) 636-8400

**ASME American Society of Mech. Eng.**

345 East 47th Street New York, NY 10017-2392  
www.asme.org  
(800) 843-2763 (US and Canada)  
011-800-843-2763 (Mexico)  
(973)822-1 170 (Outside NA)

**ASPE American Society of Plumbing Engineers**

3617 Thousand Oaks Blvd., Suite 210, Westlake Village, CA 91362  
www.aspe.org  
(805) 495-7120

**ASSE American Society of Sanitary Engineering**

28901 Clemens Road, Westlake, OH 44145  
www.asse-plumbing.org  
(440) 835-3040

**ASTM American Soc of Testing & Materials**

100 Barr Harbor Drive West Conshohocken, PA 19428-2959  
www.astm.org  
(610) 832-9500

**BSI British Standards Institution**

389 Chiswick High Road, London W4 4AL United Kingdom  
www.bsi-global.com  
+44 -8996 9000

**CALOSHA California Division of Occupational Safety and Health**

455 Golden Gate Avenue 10th Floor San Francisco, CA 94102 [www.dir.ca.gov/dosh](http://www.dir.ca.gov/dosh)  
(800) 963-9424 — (916) 274-5721

**CDC Center for Disease Control and Prevention**

1600 Clifton Road, Atlanta, GA 30333  
[www.cdc.gov](http://www.cdc.gov)  
(404) 639-3311

**CSI Construction Specification Institute**

99 Canal Center Plaza, Suite 300, Alexandria, VA 22314  
[www.csinet.org](http://www.csinet.org)  
(800) 689-2900

**CETA Controlled Environmental Testing Association**

3801 Lake Boone Trail, Suite 1900, Raleigh, NC 27607  
[www.cetainternational.org](http://www.cetainternational.org)  
(919) 792-6339

**CSA Canadian Standards Association**

5060 Spectrum Way, Suite 100, Mississauga, Ontario L4W 5N6 [www.csa.ca](http://www.csa.ca)  
(800) 463-6727

**DIN German National Standard**

DIN Deutsches Institut für Normung e. V. 10772 Berlin, Germany  
[www.din.de](http://www.din.de)

**EJCDC Engineers' Joint Contract Documents Committee**

**American Consulting Engineers Council**

1015 15th Street, NW, Washington, DC 20005  
[www.acec.org](http://www.acec.org)  
(202) 347-7474

**EPA Environmental Protection Agency**

401 M Street, SW, Washington, DC 20460  
[www.epa.gov](http://www.epa.gov)  
(202) 260-2090

**FM Factory Mutual System**

1151 Boston-Providence Turnpike, P. O. Box 9102, Norwood, MA 02062-9102  
[www.factorymutual.com](http://www.factorymutual.com)  
(781) 762-4300

**Federal Specifications**

**General Service Administration Specifications and Consumer Information**

Distribution Center (WFSIS)  
Washington Navy Yard Building 197, Washington, DC 20407  
<http://apps.fas.gsa.gov>

**IBC International Conference of Building Officials**

5360 Workman Mill Road, Whittier, CA 90601-2298

[www.icbo.org](http://www.icbo.org)

(800) 423-6587

**IEEE Institute of Electrical and Electronics Engineers**

345 E. 47th Street, New York, NY 10017-2394

[www.ieee.org](http://www.ieee.org)

(800) 678-4333 - (212) 705-7900

**ISA Instrumentation, Systems, and Automation Society**

67 Alexander Drive, Research Triangle Park, NC 27709 [www.isa.org](http://www.isa.org)

(919) 549-8411

**ISO Int'l Organization for Standardization**

Case Postal 56 - 1, ch. de la Voie-Creuse,

CH-1211 Geneva 20, Switzerland

[www.iso.org](http://www.iso.org)

+41 22 7490111

**MCAA Mechanical Contractors Association of America**

1385 Piccard Drive Rockville, MD 20850-4329

[www.mcas.org](http://www.mcas.org)

(301) 869-5800

**MSS Manufacturers Standardization Society of the Valve and Fittings Industry**

127 Park Street, NE, Vienna, VA 22180-4602

[www.mss-hq.com](http://www.mss-hq.com)

(703) 281-6613

**NEBB National Environmental Balancing Bureau**

8575 Grovemont Circle, Gaithersburg, MD 20877

[www.nebb.org](http://www.nebb.org)

301-977-3698

**NEC National Electrical Code**

One Batterymarch Park - P. O. Box 9101, Quincy, MA 02269-9101

[www.nfpa.org](http://www.nfpa.org)

**NEMA National Electrical Manufacturers Association**

1300 N. 17th Street, Suite 1847, Roslyn, VA 22209

[www.nema.org](http://www.nema.org)

(703) 841-3200

**NFPA National Fire Protection Association**

One Batterymarch Park, P. O. Box 9101 Quincy, MA 02269-9101

[www.nfpa.org](http://www.nfpa.org)

**NIH National Institute of Health**

Bethesda, Maryland 20892

[www.nih.gov](http://www.nih.gov)

**NSPE National Society of Professional Engineers**

1420 King Street, Alexandria, VA 22314

(703) 684-2800

**NSF NSF International**

789 North Dixboro Road, Ann Arbor, MI 48105

[www.nsf.org](http://www.nsf.org)

(734) 769-8010

**OSHA Occupational Safety and Health Administration**

**U.S. Department of Labor**

200 Constitution Avenue, NW, Washington, DC 20201

[www.osha.gov](http://www.osha.gov)

(202) 219-8148

**PDI Plumbing and Drainage Institute**

45 Bristol Drive, Suite 101, South Easton, MA 02375

[www.pdi-online.org](http://www.pdi-online.org)

(800) 589-8956 - (508) 230-3516

**SMACNA Sheet Metal & Air Conditioning Contractors' National Association**

4201 Lafayette Center Drive, P. O. Box 221230, Chantilly, VA 20151-1209

[www.smacna.org](http://www.smacna.org)

(703) 803-2980

**UL Underwriters Laboratories Inc.**

333 Pfingsten Road, Northbrook, IL 60062

[www.ul.com](http://www.ul.com)

(800) 704-4050 - (847) 272-8800