**Chemical Fume Hood Safety Training**

* *Learning Modules*
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**Chemical Fume Hood**

**Introduction**

A chemical fume hood is the primary means of controlling inhalation exposure in the laboratory. Hoods are designed to contain the releases of mists, fumes, and toxic gases during the experimental process. This is typically accomplished using a three-side cabinet with a movable sash opening at the front.

A fume hood can protect workers from inhaling chemical fumes by constantly pulling contaminated air into the hood and exhausting it out of the building. An exhaust fan situated on the top of the laboratory building pulls air and airborne contaminants in the hood through ductwork connected to the hood and exhausts them to the atmosphere.

Hoods may also protect users in case of a fire or explosion by helping to physically contain an event, although this provides a limited amount of protection and caution should always be used when working with pyrophoric and/or volative chemicals and mixtures.

Figure 1 illustrates the basic structures of a standard fume hood.



Figure 2 illustrates the air flows of a fume hood.



There are two primary considerations when selecting laboratory fume hoods: (1) The safety of the operator and (2) work load requirements.

**Important! Chemical vs. Biological**

**All work with hazardous materials must be conducted in a certified fume hood, gas cabinet, or glove box.**

**All work with hazardous biological agents must be used in an approved biological safety cabinet.**

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**Components of the Fume Hood**

The components of a fume hood include airfoil, baffles, sash, work surface, and bypass.



* **Airfoil** - The function of the airfoil is to streamline airflow into the hood, preventing turbulent eddies at the face that can carry contaminants out of the hood. It can be found along the bottom of the sash.
* **Baffles** - These are the slots at the back of hood. They help to keep a uniform airflow across the face of the hood. They are adjustable according to the density of the vapor.
* **Sash** - A movable glass barrier that opens or closes the face of the hood.
* **Work Surface** - The area under the hood where work is performed or an apparatus is placed.
* **Bypass** - Bypass maintains a constant face velocity independent of the sash position. It is located above of the sash.
* **Face** - The imaginary plane running from the bottom of the sash to the work surface. Hood face velocity is measured across this plane.
* **Exhaust Plenum** - The exhaust plenum helps to distribute airflow evenly across the hood face.

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**Types of fume hoods -** Fume hoods can be divided into several types, depending on design and function.

* **Constant Air Volume (CAV)** - The volume of airflow within the hood is maintained constantly. All air enters through the sash opening. The airflow increases and decreases inversely proportional to the opening of the sash height.
* **Variable Air Volume (VAV)** - Hoods that maintain a constant face velocity regardless of the height of the sash. The exhaust volume is adjusted when the sash is moved so that the average face velocity is maintained within set parameters.
* **Bypass Hoods** - This type of hood is similar to CAV. The only difference is that it has an air bypass that provides an additional source of ambient air when the sash is closed.
* **Auxiliary Air Hood** - This type of hood is similar to a bypass hood. The only difference is that the air is supplied from a dedicated duct that brings in air from outside of the building.
* **Radioactive Hood** - CAV, VAV, bypass, and auxiliary hoods can be used for radioactive materials. The only requirement is that the interior work surface must be stainless steel. The hood shall be certified for radioactive applications and a radiation sticker must be affixed at the front of the hood.
* **Perchloric Acid Hood** - A perchloric acid hood is a specialized hood with a built-in water wash down system. When perchloric acid is heated above ambient temperature or at concentrations above 72°, it vaporizes and condenses on the hood, duct, and fan components. The condensed vapors can react with organic materials and form explosive perchlorate salts and esters. *It is essential to wash down the hood after each use to remove the buildup of shock-, heat-, and friction-sensitive perchlorates*.
* **Ductless/Recirculating hood** - Hoods that re-circulate air back into the laboratory through HEPA or charcoal filters.
* **Vertical/Horizontal Sash Hood** - Horizontal sash hood is the most popular type, with a sash that moves horizantal to the work surface. Vertical hood has a sash that moves left and right.
* **Walk-in Hood** - Hoods that have two to four sashes reaching from floor to ceiling, and can have vertical or horizontal sashes.
* **Clean Benches** (May also be called **Laminar Flow Hood**) - The discharged air goes directly into the workroom and creates unidirectional airflow through a HEPA filter; also provides product protection.
* **Biosafety Cabinet (BSC)** - BSC must be used with good microbiological techniques. Cabinets must be certified for performance upon installation using National Sanitation Foundation (NSF) Standard #49, section 6. Re-certification must be conducted annually or when moved. There are three classes of BSC.
	+ Class I, A type that recirculates the air through HEPA filters into the laboratory.
	+ Class II and III are hard-ducted exhausting contaminated air out of the building.
* **Gas Cabinet** - Toxic and flammable gases such as arsine, phosphine, silane, selenide, hydrogen chloride, ammonia, hydrogen phosgene, and nickel carbonyl should be used in a gas storage cabinet. Hazardous gases in a gas cabinet are vented through a scrubbing system. It allows only inert gases to be exhausted to the atmosphere.

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**Design and Construction**

**Design Criteria**

* The effectiveness of the fume hood depends upon on its maintenance, proper location, and prudent work practices.
* A fume hood must be located so that persons exiting the laboratory do not have to pass in front of the fume hood.
* Any potentially dangerous procedures of an experiment must be conducted in a fume hood. The fume hood must be situated on the side of the room farthest from the door.
* A fume hood must not be situated directly opposite occupied work stations.
* Windows in the laboratory must be closed to avoid breezes coming in and adversely affecting the proper functioning of the hood. Turbulence caused by these wind currents can carry contaminated air outside the sash into the operator's breathing zone.
* Safety devices such as safety shower, eye wash station, and fire extinguisher should be located near the fume hood for availability to the operating personnel.
* A fume hood is an integral part of the laboratory's air balancing system which must be maintained constantly.

**Construction Criteria**

The design criteria for fume hood construction include:

* Minimum 18 gauge, type 316 stainless steel.
* Duct velocities should maintain between 1,600-2,000 linear feet per minute (fpm) to minimize noise, static pressure loss, and blower power consumption within a duct system.
* Slope all horizontal ducts down the fume hood to prevent condensation.
* Any new duct should have no leakage and be tested at negative pressure, 1.5 times its operating pressure, for a minimum of 60 minutes.
* The exhaust blower should be located at the roof of the point of final discharge. This setup can provide a negative pressure in that portion of the duct system located within the building.
* Any new exhaust blower should be oriented in an up-blast orientation.
* Hood exhaust on the roof must be located away from air intakes to prevent re-entrance of exhaust contaminants.
* Fume hood exhaust stacks must extend at least 7 feet above the roof. The discharge must be directed vertically upward.
* The discharge from the exhaust stacks should have a velocity of at least 3,000 fpm.
* All plumbing utilities must have a shut-off valve or cock valve adjacent to the hood.
* Lighting fixtures or any electrical equipment should give off less heat than a fluorescent bulb and be explosion-proof.
* Sash may be horizontal, vertical, or a combination, and should be able to completely close off the hood face.
* Sash should be made of safety glass: Laminated safety glass for standard use when internal temperature is anticipated to be less than 160F; tempered safety glass when internal temperatures are anticipated that will result in sash surface temperatures greater than 160F.

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## Fume Hood Performance Indicators

**Static Pressure Gauge** - Static pressure gauges measure the difference in static pressure across an orifice in the duct, or between the laboratory and the fume hood exhaust duct. It is mounted on the front of the hood above the sash.

**Flow indicator** - Flow indicators constantly measure the face velocity of the hood. It points to red if the hood is not functioning properly.

**Face Velocity Monitor** - This device has an LED readout of the face velocity and usually is found on the top corner of the hood opening. It continually monitors the face velocity of the hood.

**Alarm-Equipped Hood** - This alarm equips the hood sash to sound an alarm due to how open the sash is. When the sash is raised above 20 inches from the base, a buzzer will sound and a red light will begin flashing, alerting the hood user that the face velocity is below 100 feet per minute. The alarm will turn off once the sash is lowered below 20 inches.

**Vendor Performed Testing (twice per year):**

**Airflow Velocity Test** – Specification is 0-500 fpm. An average of ten inflow grid readings is taken to indicate performance.

**Airflow Smoke Patterns** – 3 items are tested: Inflow at Front Opening, No External Turbulence at Front Opening, and Smoke Containment.

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**Fume Hood Operating Guidelines**

1. Conduct all operations that may generate air contaminants at or above the TLV (threshold limit value) inside a hood.
2. The ideal average face velocity is required of 80 to 120 fpm +/- 20% at a sash opening of 18". Tested by an outside vendor, twice a year.
3. If an "Out of Order" sign or orange sticker indicating Lockout/Tag out is posted on the sash, laboratory personnel must not work in the hood until the hood has been fixed and the "Out of Order" sign or orange sticker is removed.
4. Perform work with the sash height at 18".
5. The work area should be at least 6 inches behind the face of the hood.
6. Position apparatus as far back in the hood as possible to still be able to work safely. Airflow is not as efficient at the front of the hood if objects are obstructing the airflow.
7. Keep laboratory doors closed when working in the hood.
8. The fume hood should be free of clutter. Large pieces of equipment or storage of chemicals in the fume hood could create a dead zone and block airflow.
9. Large equipment (such as a gas chromatograph) that emits gases or fumes should have a dedicated hood for that equipment's specific use.
10. Foot traffic, rapid body movement, an open window or door may cause air currents to form across the face of the hood, which may reduce the performance of the hood by pulling air out of the face of the hood into the breathing zone.
11. The chemical vapors generated in the hoods are exhausted into the atmosphere. Seal all the chemical containers not in use to minimize pollution. Never use the hood to vent excess chemical waste.
12. Never put your head inside a hood while operations are in progress.
13. Clean up spills as soon as possible. Keep sash clean and clear.
14. The hood is not a substitute for personal protective equipment. Personnel should wear gloves, safety glasses, apron, lab coat, and other approved safety equipment as appropriate.
15. Report airflow problems, unusual noise, and problems with the physical structure of the hood to Laboratory Supervisor.
16. Do not block the slots in hood baffle with containers or apparatus.
17. Locate sources of ignition or spark outside of the hood.
18. Clean all chemical residues from the hood chamber after each use.
19. Do not use a hood for any function for which it was not intended. Certain chemicals or reactions require specially constructed hoods.
20. Keep chemical hood sashes lowered with an air gap between three and six inches when the hood is not in use.

Next Module

**When is a Fume Hood Necessary?**

* A review of the physical and chemical characteristics, quantity and toxicity of the materials to be used; and volatility of the chemicals should be assessed prior to using any chemicals.

**Common Misuses and Limitations**

* **Particulates** - A fume hood is not designed to contain high velocity releases of particulate contaminants unless the sash is fully closed.
* **Pressurized Systems** - Gases or vapors escaping from pressurized systems may move at sufficient velocity to escape from the fume hood.
* **Explosions** - The hood is not capable of containing explosions, even when the sash is fully closed.
* **Perchloric Acid** - A conventional fume hood must not be used for perchloric acid. Perchloric acid can deposit on ductwork and as a result may cause an explosion.
* **Microorganisms** - Work involving harmful microorganisms, such as mycobacterium tuberculosis and hanta virus, should be done in a biological safety cabinet.
* **Highly Hazardous Substances** - A well designed fume hood contains 0.999-0.9999% of the contaminants released when used properly. It is highly recommended to use a glove box or gas cabinet to contain highly hazardous substances.
* **Pollution Control** - An unfiltered fume hood is not a pollution control device, as all contaminants released from the experimental procedures will be vented to the atmosphere. Apparatus used in hoods should be equipped with condensers, traps, or scrubbers to contain and collect waste solvents, toxic vapors or dusts.
* **Waste Disposal** - A fume hood is not used for waste disposal. Cap all waste containers that might release gases, vapors, or mists. It is a violation of government regulations to intentionally send regulated waste up the hood stack.

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**Biosafety Cabinets -** A Biological Safety Cabinet (BSC) is the principal device used to provide containment of infectious splashes or aerosols generated by many microbiological procedures. Biosafety cabinets can be used for work with biological agents assigned biosafety levels 1 through 4.

**Types of BSC**

Three types of BSCs (class I, II, and III) are used in microbiological labs.

**Class I ventilated cabinet for personnel and environmental protection** - Incorporates an un-recirculated inward airflow away from the operator that exhausts all air to the atmosphere after being filtered through a High Efficiency Particulate Air (HEPA) filter. Class I cabinets are suitable for work where no product protection is required.

**Class II cabinet has an open front with inward flow for personnel, product and environmental protection** - Air flowing downward over the working surface is filtered by a HEPA filter for product protection. The cabinet exhaust air is also filtered through a HEPA filter. It provides personnel, product, and environmental protection.

**Class III is a totally enclosed, ventilated cabinet of leak-tight construction** - This kind of cabinet is suitable for highly hazardous agents, especially for Biosafety Level 4.

**Biological Safety Cabinet (BSC) Prudent Practices -** The design, construction, and use of biological safety cabinets is different from chemical fume hoods. **Prudent work practices are very important to prevent a laboratory accident.**

* Do not use a BSC cabinet for hazardous chemicals. Class II Type A is used when working with infectious agents requiring biosafety level 2 or 3 containment. It is not for use with volatile or toxic chemicals or radionuclides, since the HEPA filtered cabinet exhaust is discharged into the work place.
* Do not use open flame in a BSC. Bunsen burner must never be used in a BSC. Because BSC recycles air, the concentration of gas in the cabinet will accumulate and increase the risk of explosion. Furthermore, the heat produced by a Bunsen burner creates eddy currents which can force contaminates back into the laboratory.
* Decontaminate the cabinet interior before and after use.
* Turn the blower on for 15 minutes before use and leave it on for 15 minutes after use to purge the cabinet.
* Wear lab coat and gloves when working with hazardous microorganisms.
* Always use the correct sash opening height.
* Place work a minimum of six (6) inches into the recess area.
* Use proper aseptic technique.

Reference: University of North Texas, Risk Management Department, Training Program

Take Quiz

**CHEMICAL FUME HOOD QUIZ**

Name: Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

CIRCLE THE CORRECT RESPONSE

1. The primary means of controlling inhalation exposure in the laboratory is by using a
	1. Chemical Fume Hood
	2. Biological Safety Cabinet
2. Basic structures of a standard fume hood include:
3. Sash
4. Baffles
5. Air Foil
6. All of the Above
7. Effectiveness of the fume hood depends upon:
8. Cleanliness, Volume of the Fan, and Location
9. Maintenance, PPE usage, and Height of work surface
10. Maintenance, Location, and Work Practices
11. Vendor performed testing consists of:
12. Static Pressure and Face Velocity Monitoring
13. Airflow Velocity Testing and Airflow Smoke Patterns
14. Static Pressure and Audible Alarm Monitoring
15. What is the correct working Sash height?
16. 12”
17. 14”
18. 18”
19. 20”
20. Where should the optimum work area be located, at a minimum, behind the face of the hood?
21. 2”
22. 4”
23. 6”
24. 8”
25. Keep chemical hood sashes lowered with an air gap between three and six inches when the hood is not in use.
26. True
27. False
28. A fume hood is used for waste disposal.
29. True
30. False
31. Chemical Fume Hoods and Biological Safety Cabinets can be used interchangeably.
32. True
33. False
34. In a Biological Safety Cabinet, the blower should be turned on for how many minutes prior to and after use?
35. 5 minutes
36. 10 minutes
37. 15 minutes
38. 60 minutes