

C12 Safety Guidelines for Fume Cupboards

1. Introduction

Fume cupboards (hoods) are installed in most of the research laboratories where toxic or volatile chemical operations are involved. They are a type of safety device specifically designed to carry chemical fumes, vapors, mist and aerosol, generated during a laboratory procedure, away from the laboratory personnel and out of the building. They also serve as physical barrier between users and hazardous sources offering a measure of protection against inhalation, chemical spills and run-away reactions. The purpose of this document is to provide laboratory personnel at the Science Park with basic information on safety requirements for design, installation, testing, operation and maintenance of laboratory fume cupboards.

2. Standards and Recommended Practices

The efficiency and safety performance of a fume cupboard depends on many factors including its design and construction, location in laboratory, as well as rapport with the whole laboratory ventilation and exhaust system. Regular testing and inspections are needed for ensuring its performance and make necessary correction when needed. A variety of standards and recommended practices regarding fume cupboards are useful reference for laboratory personnel. Some of them are listed below:

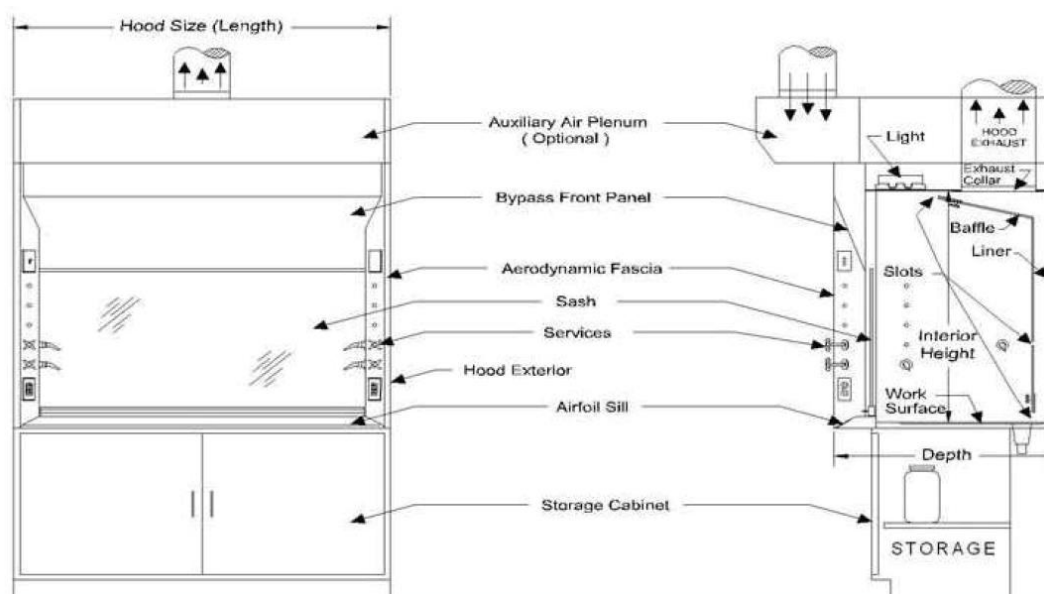
- a) ANSI/ASHRAE 110: Methods of Testing Performance of Laboratory Fume Hoods – This standard is published by the American National Standards Institute and the American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. It covers the most widely accepted methods of testing the performance of laboratory fume hoods. Three useful test procedures including face velocity grid test, flow visualization or smoke test, and tracer gas containment test are described in this standard.
- b) ANSI/AIHA Z9.5: Laboratory Ventilation – This standard is published by ANSI and American Industrial Hygiene Association. It covers a variety of laboratory ventilation requirements including hood monitoring, face velocities and exhaust.
- c) NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals – This standard is issued by the National Fire Protection Association. It provides recommendations on hood construction, location, fire protection, inspection,

C12 Safety Guidelines for Fume Cupboards

testing, maintenance and exhaust as well as use of specialty hoods in the laboratories.

- d) SEFA 1: Laboratory Fume Hoods Recommended Practices – Published by the Scientific Equipment & Furniture Association, this document covers useful information such as fume hood design requirements, face velocities and testing methods, etc.
- e) AS/NZS 2243.8: Safety in Laboratories, Part 8: Fume Cupboards – It is the Australian/New Zealand Standard specifies requirements for fume cupboards relating to their safety performance, along with recommendations and procedures for their selection, installation, testing and use.
- f) BS EN 14175: Fume Cupboards – It is the British Standard published by British Standards Institution which consists of several parts covering fume cupboard's type test, safety performance requirements and on-site test methods.

3. Components of a Fume Cupboard



A fume cupboard consists of several components tied together for providing effective function to capture and remove contaminants from the work area. The

C12 Safety Guidelines for Fume Cupboards

typical components of a conventional fume cupboard are shown in the above diagram.

3.1 Exterior

The exterior of a fume cupboard is usually made of painted steel.

3.2 Interior

The interior lining material shall be chemical resistant (in particular to the chemicals to be handled), corrosion resistant and flame retardant. Typical materials are epoxy, polyester, phenolic resin, stainless steel 304, stainless steel 316 and polypropylene.

3.3 Baffle

Baffle is a moveable partition with slot opening in the rear of the fume cupboard to control the airflow distribution within the hood and through the face opening.

3.4 Sash

The sash is a moveable panel or panels to restrict the opening and provide a protective barrier between the operator and the experiment. By using the sash to adjust the front opening, airflow across the fume cupboard can be adjusted to the point where capture of contaminant is maximized. Each cupboard has its optimum sash configuration called “operating sash opening” or “design sash opening”. Sash is available in three configurations including vertical, horizontal; and combination of vertical and horizontal.

3.5 Airfoil

Airfoil is located along the bottom and side edges of the fume cupboard. The airfoil streamlines the airflow into the fume cupboard preventing the creation of turbulent eddies that can carry vapors out of it.

3.6 Work Surface

Work surfaces are typically made of a material that provides good heat and corrosion resistance and is easily clean and decontaminated. The work surface should have a recessed area for providing containment of small spill.

3.7 Exhaust Collar

The exhaust collar that connects the fume cupboard to the exhaust duct is located behind the baffle at the top of the interior liner. The design of exhaust collar can affect the hood static pressure drop and noise level.

C12 Safety Guidelines for Fume Cupboards

3.8 Bypass

Bypass is used to divert air from the face opening when the sash is lowered. It is designed to limit the increase in face velocity.

3.9 Auxiliary Air Plenum

Auxiliary air plenum is installed in some fume cupboards designed to reduce the amount of room air exhausted by the fume cupboard by introducing a source of supply air into the cupboard. The consumption of conditioned room air is reduced and hence the energy is saved.

3.10 Lighting

Lighting can be either housed inside the chamber and separated by a vapor resistance glass panel at the top of the interior wall or mounted inside hood liner with flameproof and corrosion-proof properties. The adequate illumination at the work surface should be provided.

3.11 Service Fixtures

A fume cupboard is usually equipped with a variety of amenities or services. It includes electrical outlet, sinks, fixtures and plumbing for gas, vacuum, air and water. All fixture controls should be external to the fume cupboard, clearly identified and within easy reach. All internal service fixture outlets shall be corrosion resistant or have a corrosion resistance finish.

3.12 Air Flow Monitor

The newly installed fume cupboards at the Science Park are incorporated with air flow monitor tied to alarm system for indicating the instant face velocity and giving audible alarm when the air flow deviates from the set point.

4. Types of Fume Cupboards

There are different types of fume cupboards available for different operations. Laboratory Person In-Charge should purchase/select appropriate types and models of fume cupboards to meet their own research purposes.

4.1 Conventional Fume Cupboard (Bench-Top Fume Cupboard)

Conventional fume cupboard is the most common type of fume cupboard that is generally placed on a bench-top or above a storage cabinet. It can be used for a variety of chemical operations involving small to moderate quantities of materials

C12 Safety Guidelines for Fume Cupboards

having low to highly hazardous properties. Constant air volume (CAV) and variable air volume (VAV) are two different operation modes for fume cupboards.

- a) CAV – this type of fume cupboard operates with a face velocity that varies with the sash opening. It is usually incorporated with bypass opening to reduce the turbulence inside the cupboard and prevent excessive face velocity.
- b) VAV – this type of fume cupboard operates with a face velocity that maintains within a preset range across the sash opening. It is capable of varying the exhaust air volume in proportion to the sash opening by either changing the speed of the exhaust blower or by adjusting the damper in the exhaust duct.

4.2 Floor Mounted Fume Cupboard (Walk-in Fume Cupboard)

Floor Mounted fume cupboards are used for applications which require large apparatus. They are floor mounted without any work surface. This facilitates the transfer of equipment and materials into, and out from the hood.

This type of fume cupboard is particularly susceptible to variations in face velocity across the opening and room air disturbance due to the large opening area afforded by the hood design. Thus, it is prudent not to use a floor mounted fume cupboard for work with highly toxic materials.

4.3 Ductless Fume Cupboard (Re-circulatory Fume Cupboard)

Ductless fume cupboard does not require any exhaust ducting and relies on filtration system to retain the airborne contaminants before the air is recirculated to the laboratory.

As filter effectiveness changes across the lifetime and difficult to guarantee, this type of fume cupboard is only suitable for small-scale and low toxicity chemical operations. Ductless fume cupboards must have signage prominently posted on them informing operators and maintenance personnel about allowed chemicals, types of filters in place, filter replacement schedule, and the potential risk of filter break-through.

4.4 Other Fume Cupboards

There are other types of fume cupboards that are designed for specific operations. All these special purpose fume cupboards bare the general characteristics of a conventional fume cupboard with some modifications on the design or material used.

C12 Safety Guidelines for Fume Cupboards

- a) Perchloric acid fume cupboard – perchloric acid reacts violently with organic materials. Dried perchloric acid is also highly explosive. Therefore, it requires built-in water wash down systems on entire duct work and the area behind the baffle to prevent perchlorate salt deposits. The interior lining must be covered and welded seamless stainless steel or other non-reactive material such as chlorinated polyvinyl chloride or polypropylene. Non-reactive and corrosion resistance material should extend all the way through the exhaust system.
- b) Radioisotope fume cupboard – it is constructed specifically to protect users from radioactive materials. The work surface shall be dished to contain spills and be properly reinforced to support lead shielding and shield containers. Interiors are made of 304 stainless steel with covered corners to aid in decontamination. Horizontal sash panels are not appropriate for this hood type.
- c) Distillation fume cupboard – it is characterized by a low work surface height which results in a large working height for the operator. This allows tall distillation equipment to be installed and mounted in the work chamber.

5. Installation of Fume Cupboards

The performance of a fume cupboard in a laboratory is affected by the room layout and supply air distribution. The overall exhaust system performance depends on the fan and duct layout as well as fan type and discharge conditions. The installer must carry out on-site commissioning tests after installation to ensure that the performance of the fume cupboard meets with relevant international standards.

5.1 Location

Fume cupboards shall be installed at appropriate locations of the laboratories according to the manufacturer's instructions and in compliance with relevant international standards. In general:

- a) They should be located away from high traffic lanes, cross-draughts, air inlets and other sources of disturbance;
- b) There should be at least 1 m between the sash and any traffic route so as to preserve an undisturbed zone in front of the fume cupboard;
- c) They should not be located directly opposite a biological safety cabinet or another fume cupboard unless the distance between them is at least 3 m;
- d) They should not be sited in a position where a person requires to pass in front of them when leaving a laboratory;

C12 Safety Guidelines for Fume Cupboards

- e) They should be located at a distance of least 1.8 m from an opposite bench, opposing wall or other large obstruction;
- f) The distance between the side of a fume cupboard and a wall or architectural column protecting beyond the plane of sash should be at least 0.3 m;
- g) The distance between the sash of a fume cupboard and a doorway should be at least 1.5 m; and
- h) The distance between the side of a fume cupboard and a doorway should be at least 1 m.

5.2 Supply Air

Before a new fume cupboard is put into operation, adequate supply of make-up air must be provided to the laboratory. A fume cupboard exhausts a substantial amount of air, additional make-up air must be brought into the laboratory to maintain a proper air balance.

- a) Supply and exhaust volume should be such that the laboratory is slightly negative pressure in relative to corridors and outside.
- b) The air exhausted shall not be recirculated to other laboratory areas.
- c) The make-up air distribution system should be designed and installed such that the supply air diffusion devices are properly located to avoid air currents that would adversely affect the performance of the fume cupboards.
- e) Supply air intake location should be chosen so as to avoid drawing in chemicals or products of combustion coming either from the laboratory building itself or from other structures and devices.

5.3 Exhaust System

The whole exhaust system including ductwork, exhaust fan and exhaust stack must be properly selected and installed.

- a) Each fume cupboard should be separately ducted to the roof of the building preventing from any possible compatibility issues.
- b) As far as possible, ductwork should follow the most direct route from the fume cupboard to the point of discharge.
- c) Exhaust ducts should be maintained under negative pressure to reduce the possibility of contaminants leaking into the building.
- d) Fire dampers are not allowed in fume cupboard exhaust ducts.

C12 Safety Guidelines for Fume Cupboards

- e) Damper for adjusting the fume cupboard air velocity may be incorporated into the ductwork.
- f) Ductwork should have no pockets where airborne gases or particles can be trapped.
- g) Elbows, bends and offsets within a duct system should be kept to a minimum for reducing static pressure losses.
- h) Exhaust fans must be located at the point of final discharge. They should be readily accessible for maintenance and inspection.
- i) Ductwork and fans shall be constructed of materials compatible with the chemicals being transported.
- j) Fans shall be sized to provide adequate exhaust air flow. The static pressure losses of fume cupboard and associated ductwork shall be included in the determination of fan size.
- k) Fans of centrifugal type should be considered as they are more efficient and generate less noise than other types.
- l) A permanently plumbed-in drain should be connected to the lowest point of each fan casing to permit disposal of condensate, rainwater and liquid used for cleaning the exhaust system.
- m) Exhaust stack shall be located so as to ensure acceptable dilution and dispersion of exhaust air and to preclude exhaust re-entry through air intakes and building openings. This represents a minimum exhaust stack height of 3 m above the exhausting unit or any roof lines and will be as far away from supply air intakes as possible.
- n) Exhaust stack must be directed vertically upward and the discharge should have a minimum exit velocity of 10 m/s. Cone type reducer should not be used to achieve this velocity. Rain caps that divert the exhaust back towards the roof must not be used.
- o) Each exhaust fan and duct system should be labeled to identify the fume cupboard in the laboratory to which they are connected.

6. Performance Tests on Fume Cupboards

Testing of a fume cupboard should be performed after the installation is complete, the building ventilation and control system has been balanced and all connections

C12 Safety Guidelines for Fume Cupboards

are made. Performance test for a fume cupboard should be conducted at least annually, or whenever a significant change in the fume cupboard system is made. Tests shall be carried out by qualified personnel. Any unsafe conditions disclosed by these tests should be corrected before using the fume cupboard.

ANSI/ASHRAE 110 provides thorough protocols for fume cupboard performance test including face velocity measurements, airflow visualization (smoke test) and tracer gas containment. It also defined three modes, i.e. As Manufactured (AM), As Installed (AI) and As Used (AU). For the AI test, a fume cupboard is installed in the laboratory and tested empty. For the AU test, the assessment is conducted with equipment and tools remaining in the fume cupboard and used by the laboratory users. Many regulatory organizations use face velocity as the only performance standard for fume hood testing. But by all means, this does not guarantee that the fume cupboard's performance is optimal when it meets face velocity standards.

6.1 Face Velocity

Face velocity is a measurement of the speed at which air enters a fume cupboard face opening. The recommended average face velocity usually ranging from 0.3 to 0.9 m/s depending on manufacture's specification. The testing should be done at "design sash opening" position. During the measurement, the doors to the laboratory should be closed. The anemometer used should be calibrated and the measurement should be done along the plane of sash with equally spaced grid points. Each individual readings must be within $\pm 20\%$ of the average face velocity.

6.2 Smoke Test

The purpose of the smoke test is to provide visual evidence of fume containment within the fume cupboard. A smoke stream is created at various points in the fume cupboard area such as around the entire perimeter of face opening, around any equipment or apparatus and along the internal walls. The direction of smoke flow is then carefully observed. The performance is acceptable when the smoke travels straight to exhaust without reverse flow or eddies and no escape from the confines of fume cupboard.

6.3 Tracer Gas Containment

The tracer gas containment test involves the release of gas (sulfur hexafluoride) inside the fume cupboard while a gas monitoring device is placed in the estimated breathing zone of a laboratory user positioned in front of the fume cupboard. The device measures the presence of the tracer gas at user's breathing zone outside the fume cupboard.

C12 Safety Guidelines for Fume Cupboards

7. General Safe Work Practices for Fume Cupboards

The level of protection provided by a fume cupboard is affected by the manner in which it is used. No fume cupboard, however well designed, can provide adequate containment unless safe work practices are followed. Laboratory personnel shall adopt the following safety practices during the operation of fume cupboards:

- a) Ensure the fume cupboard exhaust is switched on before commencement of works. If the fume cupboard is fitted with an airflow monitor, verify whether adequate face velocity is attained or not. If there is no airflow monitor installed, check the fume cupboard inspection records to ensure that it has been tested and operation performance was satisfactory at the time of the tests.
- b) Clear all unnecessary chemicals and apparatus inside the fume cupboard. Do not use the fume cupboard as storage area. Excessive storage of materials or equipment can cause eddy currents or reverse flow resulting in contaminants escaping from the fume cupboard.
- c) Elevate the equipment 5 to 10 cm above the work surface to provide flow beneath and around the equipment. Ensure the elevated equipment is stable.
- d) Do not place electrical receptacles or other spark sources inside the fume cupboard when flammable liquids or gases are present.
- e) Wear appropriate personal protective equipment and work at least 15 cm beyond the plane of sash.
- f) Keep your face outside the plane of the fume cupboard during operation. Use the sash for partial protection when working with hazardous materials. The sash height should be kept as low as possible.
- g) Care should be taken with the use of paper products, aluminum foil and other lightweight materials within the fume cupboard. It has potential risk for those materials entering the exhaust duct and affecting the fume cupboard's performance.
- h) Do not use the fume cupboard as a waste disposal mechanism.
- i) Limit pedestrian traffic past the fume cupboard, particularly during hazardous experiments. Inform other laboratory personnel about the work conducted in the fume cupboard.
- j) Always attempt to slowly approach and withdraw from the fume cupboard. Open and close the sash slowly.

C12 Safety Guidelines for Fume Cupboards

- k) Clean the work surface and remove all unnecessary items from the hood after work.
- l) Keep the sash closed when not in use. Fume cupboard can be turned off if adequate laboratory ventilation can be maintained when the fan is not running.
- m) Report any defects or problems regarding a fume cupboard to the Laboratory Person In-Charge and stop using it until the problem is fixed. Post a notice “DO NOT USE” on the sash to remind other laboratory personnel.

8. Regular Maintenance and Testing of Fume Cupboards

The maintenance and testing of fume cupboards should be carried out at least annually to ensure they are operating safely. Where extremely hazardous or corrosive conditions exist, the inspection frequency should be increased appropriately. For those fume cupboards and associated exhaust systems that are purchased and installed by individual laboratory tenants, schedules for annual inspection, maintenance and testing shall be developed and maintained by the respective Laboratory Persons In-Charge. For those that are owned by HKSTP, Lab FMO of the Science Park will be responsible for the maintenance services. Regular inspection, maintenance and testing of fume cupboards should include the following items:

- a) Periodically clean the sash, exterior and interior surfaces, and light panel.
- b) Inspection procedures should consist of a physical examination of liner condition and cleanliness, baffle and sash operation and condition, light operation and condition, and service fixture function.
- c) Measure the face velocity and compare the result to the specifications of individual fume cupboard.
- d) Low flow alarm should be tested for correct operation.
- e) The emergency isolator (if any) should be tested.
- f) Lubrication of sash guides, cables, pulley wheels and other working parts should be accomplished as required or in accordance with manufacturer's recommendations.
- g) Replacement of worn, damaged or nonfunctioning parts as necessary.

C12 Safety Guidelines for Fume Cupboards

- h) The inspection results should be recorded and a label should be attached to each fume cupboard showing its unit number, inspection dates, average face velocities and the names of inspectors.