Chemical Fume Hood Guide:

Design, Construction, Maintenance, Health and Safety

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Introduction

UCSB has adopted the following policies and procedures for the design, installation, renovation, maintenance, and dismantling of chemical fume hoods on the UCSB campus and affiliated facilities. This document was prepared by Environmental Health & Safety and reviewed by representatives from Design and Construction, Physical Facilities and Budget and Planning.

These guidelines reflect federal, state, local, and University health and safety regulations and policies. The guidelines do not stand alone, but must be incorporated with other applicable standards into the design and construction of a fume hood. Any questions not addressed here should be addressed by consulting the references cited below; particularly the OSHA requirements cited in the *California Code of Regulations* and the *ANSI / AIHA National Standard for Laboratory Ventilation*. In this way, those who use and maintain chemical fume hoods will be ensured of an adequate level of protection from the possible harmful effects of laboratory chemicals.

References

Air Movement and Control Association, Inc. (AMCA)

American Industrial Hygiene Association, *American National Standard for Laboratory Ventilation, Z9.5-2003*

American Conference of Governmental Industrial Hygienists (ACGIH), Industrial Ventilation Manual, 2001 edition.

American National Standard Institute, *Fundamental Governing the Design and Operation of Local Exhaust Systems*, ANSI Z9.2, 2006

American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), *Fundamental Handbook, 2005 ed.*

California Code of Regulations, Title 8, Section 5154.1., Section 5209, 5143.

California Code of Regulations, Title 24.

National Fire Protection Association (NFPA), *Standard for the Installation of Blower and Exhaust Systems*, NFPA No. 91-2004.

Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA)

Uniform Building Code as modified by Title 19, *California Code of Regulations*.

<u>Construction, Installation, and Renovation</u>

Listed below are policies and procedures to be followed as part of the fume hood construction, installation, or renovation process. These guidelines are divided into nine categories: Laboratory Design, Supply Air, Variable Air Volume Systems, Fume Hood Construction and Installation, Ductwork, Exhaust Fan, Exhaust Stack, Plumbing, Electrical and Sashes. A justification for each requirement is provided as appropriate.

I. Laboratory Design

A. Laboratories with fume hoods must be designed to have no recirculation of air to that lab or any other spaces.

   Recirculation of lab air will result in indoor air quality problems.

B. Fume hoods must be located so that persons exiting the lab do not have to pass in front of the hood.

   Potentially dangerous portions of experiments are usually conducted in a fume hood. Many lab fires and explosions originate in fume hoods. A fire or explosion in a fume hood located adjacent to a path of egress could trap someone in a lab. Also, turbulence from passing traffic can adversely affect hood performance.

C. There must be two exits from rooms where new fume hoods are to be installed. If this is not feasible, the fume hood must be situated on the side of the room furthest from the door. Note that per Fire Code, labs greater than 200 ft^2 in area are required to have a second fire exit. In many cases the exit can be into an adjacent room which then exits to outside or an exit corridor.

   A fire or chemical hazard, both of which often start in a fume hood, can render an exit impassable. For this reason, all labs with fume hoods are required to maintain two unblocked routes of egress.

D. Fume hoods must not be situated directly opposite occupied work stations.

   Materials splattered or forced out of a hood could seriously injure anyone seated across from it.

E. Windows in labs containing fume hoods must be fixed closed.

   Breezes coming in through open lab windows can adversely affect the proper functioning of a hood. Turbulence caused by these wind currents can easily bring the contaminated air inside the hood out into the lab. Note that hood face velocities are only about 1 mile/hr.

F. The use of magnetic hold-opens on fire-rated lab exit doors is allowed and encouraged. These must be connected to the building fire alarm system, such that the door closes automatically when a building fire pull station is activated.

Without these hold-opens lab users tend to illegally wedge their fire doors open. If the overall flow of air is into the lab (see IIB), odors should not migrate to the corridor. However, use of hold-opens may not be appropriate in labs that use highly toxic gases and other materials.

II. Supply Air

A. Before a new fume hood is put into operation an adequate supply of make-up air must be provided to the lab.

A fume hood exhausts a substantial amount of air. For this reason additional make-up air must be brought into the room to maintain a proper air balance.

B. Supply and exhaust volumes should be such that the lab is slightly negative (~10%) in pressure relative to corridors and outside. The air balance should be such that air flows into the room through openings, including open doors.

Negative relative pressure will restrict any hazardous materials odors to inside the lab.

C. Ceiling and wall diffusers for distribution of make-up air should be directed so that the incoming supply air flow has no influence on the directional air flow at the fume hood.

Misdirected air currents could cause turbulence at the fume hood opening impairing its proper operation.

D. Supply air diffusers must be so designed so as to provide less than 50 fpm terminal throw velocity at 6 feet above the floor.

Larger velocities would disrupt laboratory work at benchtops, lab instruments and cause discomfort to lab personnel.

E. New fume hoods will not have an on/off control accessible in the laboratory.

Fume hoods are an integral part of the entire room's air balancing system which must be maintained. When a fume hood is turned off the lab can become under positive pressure. Labs must be maintained under negative pressure.

F. Supply air intake locations must be located a minimum of 50 feet from the discharge point of any fume hood. Intakes should also not be located in the vicinity of loading docks, generators or other devices generating harmful emissions.

   Re-entrainment of emissions will cause obvious indoor air quality problems.

III. Variable Air Volume Systems

A. Properly designed Variable Air Volume (VAV) systems are allowed, e.g. the “Phoenix” system. Use of motion sensors at the hood to setback the face velocity to a minimum of 60 ft/min during periods of non-use are permitted.

   The primary incentive for using VAV is energy savings. However, designers must keep in mind that it is required to maintain a minimum number of air changes in a lab, through a combination of air exhausted through the hoods and through general exhaust. Therefore, energy savings may not be realized since the exhaust fans may have to run close to maximum anyway to maintain the air change criteria. This is particularly true in cases where there are a limited number of hoods within a system.

B. The use of “diversity” (defined below) to attain proper face velocities at any building hood can be very problematic – EH&S must be consulted before any use of diversity is approved. Fan systems should ideally be sized large enough to drive all building hoods simultaneously at full face velocity (sash full open).

   Hood-use diversity is based on the assumption that not all building VAV hoods are being used at any one time, and therefore building fans do not need to be sized to drive all the hoods at full-velocity simultaneously. In an academic environment, diversity often does not work and results in multiple low-flow alarms, because: a) poor sash management by users consumes more exhaust air than the capacity allowed by diversity, b) inevitable deteriorations in system performance, or addition of more building hoods result in insufficient air for already under-sized system, c) users over-ride annoying low-flow alarms by permanently disengaging the alarm function, d) due to nuisance alarms, users permanently engage the “Emergency” button to provide maximum air flow, thereby “stealing” air from adjacent labs, and so exacerbate the shortage of air for all hoods within the zone.

C. Retrofitting of existing hoods to VAV is not recommended. If done the bypass feature on the hood must be closed off.

   From experience, the difficulties and costs to retrofit an old hood to VAV is not worthwhile. Given the high cost of VAV controls relative to the cost of a new hood, it is cost effective to install a new hood which is VAV compatible. The bypass feature on existing hoods is useless with VAV, and must be blocked off to stop treated air from being wasted through this opening.

D. Per the Cal-OSHA fume hood safety standard, hoods with the motion-sensor activated seback (see A. above) are required to pass a one-time tracer gas capture test per Section 7, Tracer Gas Test Procedure, of ANSI/ASHRAE 110-1995 with a hood performance rating of 4.0 AU 0.1 or less. There are outside vendors that can perform this testing. Sulfur hexafluoride is the gas specified in the ASHRAE standard, however Cal-OSHA has approved the use of nitrous oxide as a substitute given its much smaller impact as a greenhouse gas.

IV. Fume Hood Construction and Installation

A. Air velocity at the hood face must average 100 - 120 linear feet per minute (**SASH FULLY OPEN** for constant air volume hoods with bypass feature). All measurements (9 minimum) must fall within 70 - 140 fpm. Building or room exhaust fans must be sized large enough to attain these standards.

B. The number of "air changes per hour" for a given lab must be determined on a case-by-case basis. Consult EH&S on this issue. **The minimum number of air changes for science or hazmat labs is six**, contingent on EH&S approval.

Air changes alone is a poor criteria for lab ventilation design. There are many factors which can affect the desired volume of lab air, including types of chemicals in use, heat load, type of fume hood, etc.

C. Chemical storage cabinets directly under a newly installed or renovated fume hood shall be ventilated to the fume hood exhaust.

Cabinets shall be vented using stainless steel flexible ducting connected above the hood at the exhaust duct collar. All penetrations must be sealed.

D. Supply or auxiliary air hoods are unacceptable.

It is very difficult to keep the air supply and exhaust of supply hoods properly balanced. In addition, the supply air is intemperate, causing discomfort for those working in the hot or cold air stream. As a result, the supply vent is often either shut or blocked off. Finally, the presence and movement of the user's body in the stream of supply air creates turbulence that degrades the performance of the hood.

E. Constant air volume (CAV) fume hoods with bypass are recommended.

These hoods permit a stable air balance between the lab's ventilation system and fume hood exhaust by incorporating an internal bypass feature. This allows a constant volume of air to be exhausted through the hood regardless of sash position. CAV with Self-Closing-Sash may be used for energy conservation and added safety feature, contingent upon approval by EH&S.

F. Variable air volume (VAV) systems are acceptable if properly designed.

G. Portable, non-ducted fume hoods are not allowed except for limited uses as approved by EH&S.

Non-ducted fume hoods utilize filters which may become overwhelmed in the event of a spill. Also, the filters are typically not changed out as needed. Breakthrough can also occur as the contaminant is dislodged with the sudden change in air flow velocity associated with turning the blower on and off. In addition, an adequate level of protection cannot be assured for different classes of chemicals.

H. Interior fume hood surfaces must be constructed of corrosion-resistant, non-porous, non-combustible materials such as stainless steel or special composite or polymer materials.

Corrosive materials can eat through many types of materials, shortening fume hood life. In addition, some materials, when exposed to direct flame, emit noxious and toxic fumes.

I. The work surface inside the fume hood must be of the recessed type. With a recessed-type work surface spills can be effectively contained by the retaining lip.

J. Plastic or fiberglass hoods are unacceptable.

Although some plastic- and fiberglass-containing construction materials may be non-combustible, when involved in a fire they generate large quantities of dense, potentially toxic smoke. This smoke presents a safety hazard to both building occupants and fire fighters.

K. Per the Cal-OSHA standard, an airflow indicator must be provided at the fume hood – these are typically standard equipment on a hood. A sensor with an associated audible/visual alarm is required. Manufacturer instructions should be followed regarding installation, minimum and maximum air flow, etc.

L. There must be a horizontal bottom airflow inlet at the front of the hood.

The airfoil at the front of the hood floor assures a good sweep of air across the hood floor toward the back of the hood. This minimizes the generation of turbulent eddy currents at the entrance to the hood.

M. Baffles with adjustable horizontal slots should be present at the rear and top interior of the fume hood to provide at least two (preferably three) slots, adjustable in width, to attain reasonably uniform face velocity. Baffles should be adjusted in such a way that less than a +10% variation in face velocity measured with the sash in its maximum open position can be obtained.

N. Instrumentation used to measure air pressure or air velocity shall have been calibrated within one year of their use.

O. Newly installed or renovated hoods must pass a test of their capture efficiency. Test each hood using the SAMA LF10 Performance criteria, after installation and HVAC system is balanced and operating normally. EH&S can perform this test .

P. Where feasible, chemical fume hood exhaust fans should be connected to emergency power in case of a power failure.

If hood exhaust fans are placed on emergency power, an equivalent volume of supply air must also be provided, otherwise it may be difficult or impossible to open the laboratory doors for emergency exiting. Less than full speed operation of the hood fans while on emergency power is an option but EH&S must be consulted for approval.

Q. Noise from fans, ductwork and air velocities shall not exceed 65 dBA inside the lab area.

V. Ductwork

A. Gang ducting of fume hoods is not recommended unless required by special conditions or in new buildings properly designed for this purpose, i.e. using a roof plenum. These must be properly designed with final approval from EH&S.

It is difficult to keep each fume hood on a common duct balanced and working properly. If the fume hoods are in different ventilation zones within the building, air balancing becomes virtually impossible. Additionally, if the fan serving a gang-ducted system shuts down, chemical contaminants can "backflow" from one lab to another. The entire system must be shut down during servicing and repair work, causing considerable user inconvenience.

B. Fume hood ducts connected to new fume hood installations or renovations must meet current fire codes regarding fire shafting.

C. Slope all horizontal ducts down towards the fume hood (Guideline: 1/8" to the foot).

Liquid pools, which results from condensation, can create a hazardous atmosphere if allowed to collect.

D. Design criteria for fume hood exhaust duct construction include:

- minimum 18 gauge, Type 316 stainless steel. Coated galvanized steel may be considered for non-hospital installations under special conditions. However, special attention to quality control is required.
- heliarc inert gas with Type 316 welded seams.
- Follow SMACNA Round Industrial Duct Construction Standards for duct supports and reinforcement using stainless steel material.
- Follow SMACNA 1995 (2nd ed.) HVAC Duct Construction Standards using Type 316 stainless steel for exhaust stack on roof.

E. New duct installations must be tested at negative pressure, 1 1/2 times its operating pressure (per SMACNA) . Test should show zero leakage.

F. Fire dampers are not allowed in hood exhaust ducts.

G. A damper for adjusting the hood air velocity may be incorporated into the ductwork. Consult EH&S for details. Dampers should not be easily accessible to laboratory personnel, e.g. in core areas.

H. Duct velocities should be designed to fall within 1000 - 2000 ft/min to control vapors, gases, smoke and minimizing noise. This is also an economically optimum velocity range.

VI. Exhaust Fan

A. New exhaust fans should be oriented in a straight up-blast orientation – not horizontally, nor with any turns in the ductwork before exhausting upward.

Other types of fan orientations increase the work load required from the fan.

B. Exhaust fans must be located at the point of the final discharge. An exhaust fan located at other than this point can pressurize the duct with contaminated air, fume hood ducts must be maintained under negative pressure.

C. Fans shall be constructed of materials compatible with the chemicals being transported in the air through the fan. If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Flammability Limit, the fan construction shall be as recommended by AMCA's *Classification for Spark Resistant Construction.*

D. For new buildings where multiple hoods are serviced by single fans, it is recommended that a minimum of 10-20% extra fan capacity be designed in to accomodate future hood additions that departments may need.

VII. Exhaust Stack

A. Fume hood exhaust stacks must extend at least seven feet (10 ft. is preferred) above the roof or at least two feet above the top of a parapet wall, whichever is greater. Discharge must be directed vertically upward.

B. Discharge from exhaust stacks should have a velocity of at least **3,000 fpm**. However, tall stacks may be permitted to have a lower exit velocity, if justified.

A sufficient discharge velocity is necessary to adequately disperse contaminants.

C. Hood exhausts on the roof should be located at least 50 ft. away, and preferably down-wind, from air intakes to prevent the re-entrainment of exhaust fumes.

D. Rain caps which divert the exhaust toward the roof are not allowed; high velocity discharge or concentric duct self-draining stacks, or equivalent, may be used.

E. Exhaust stacks should be secured with earthquake restraints.

VIII. Plumbing

A. All plumbing utilities must have a shut-off valve or cock adjacent to the hood.

B. If remote control fittings are used for hood utilities, the extension rod shall be solid stainless steel with a monel coupling and set screw.

C. Hot or cold water supplies must be connected to a non-potable industrial water system. If industrial water is not available in the building, then a reduced pressure type backflow device shall be used on each water system. A single device may serve several hoods.

D. Waste outlet should be connected into the building's laboratory waste plumbing lines, if present.

IX. Electrical

A. Electrical outlets must be outside the hood.

The atmosphere inside a fume hood may contain flammable gases or vapors which can ignite, resulting in a fire or explosion. for this reason, any activity—including plugging into and unplugging from an electrical outlet—which may produce a spark, must be performed outside the hood.

B. Lighting fixtures should be of the fluorescent type.

Fluorescent bulbs give off less heat than conventional bulbs. They help maintain a safe and comfortable work area inside the hood.

C. Light fixtures should be sealed and vapor tight, UL-listed, and protected by a transparent impact resistant shield.

The potential for flammable or combustible atmospheres requires explosion-proof electrical equipment.

X. Sashes

A. Sashes may be either horizontal, vertical, or a combination, and should have the capability to completely close off the hood face.

B. Sashes should be made of safety glass:

- Laminated safety glass for standard use when internal temperature is anticipated to be less than 160° F.
- Tempered safety glass when high internal temperatures are anticipated that will result in sash surface temperatures greater than 160°F.

Polycarbonate (Lexan) is not suitable for fume hood sashes due to poor chemical resistance to some commonly used reagents. In addition, it is a combustible plastic which is not intended for use when safety glass is required as a fire stop.

Special Use Hoods

I. Perchloric Acid

Perchloric Acid is a very strong oxidizer which, in contact with organic materials, can form an explosive reaction product. For this reason, special construction materials are required for chemical fume hoods in which substantial quantities of perchloric acid are used. For additional information or consultation, contact Environmental Health & Safety at extension 8787.

II. Iodination Mini Hoods

Iodination Cabinets or Mini Hoods are recommended by the Radiation Safety Division for iodination procedures. The Radiation Safety Division should be consulted (x-3588) on all matters involving iodination procedures and safeguards including the installation and relocation of iodination mini hoods.

Servicing and Dismantling

I. Before a fume hood is serviced or dismantled

Lab personnel must:

1. Remove all equipment in the hood which may impede or impair access.
2. Remove all chemicals and radioactive materials in the hood which may pose a hazard.
3. If necessary, decontaminate the interior of the hood as appropriate. Consult EH&S if needed for decon procedures.
4. If necessary, don protective clothing (i.e., goggles, respirator, gloves, coveralls, arm guards).
5. If the hood fume needs to be turned off, notify laboratory workers and post a Caution Notice on the hood (Copy attached).

The iodination mini hood housed within a fume hood should be shut down and covered with plastic whenever the fume hood requires servicing. This includes roof servicing.

II. Fume Hood Service Procedure

The following procedures are to be followed by anyone who must service any part of a fume hood system at UCSB.

A. Locate on the roof the fume hood and fan or motor to be serviced and the room in which it is housed. Zone Engineers have hood-to-fan information. A specific fume hood and the room in which it is housed can be identified by either the tag fixed to the ductwork near the fan or by a stamp on the ductwork near the fan or by a stamp on the ductwork adjacent to the fan. Notify Preventive Maintenance at Facilities if identification is missing

B. Communicate to lab personnel the need to service the fan or hood and obtain permission to shut down the hood. If lab personnel are not available, contact the building manager or MSO to obtain permission to shut down the hood.

Do Not Turn Off Fan Without Permission From An Authorized Person

C. Fill out a Caution Notice (see last page) and fix it to the hood sash. Then shut down the fan.
Note: Information on the tag should include:

1. Date of shutdown
2. Expected duration of shutdown
3. Reason for shutdown
4. Your name
5. Your supervisor's or engineer's phone number

D. If there are other fans *without* a 7 to 10 foot extension in the immediate area of the fan that is to be serviced, those fans must also be turned off. Alternately, a respirator and safety glasses supplied by your supervisor are to be used (consult EH&S at x-8787.) Notify EH&S of any fume hood fans without a 7 to 10 foot extension to initiate the process of having these installed.

E. After service is completed, restart the fan and remove the notice form the fume hoods.

Testing and Certification

The requirements for testing and initial certification of new campus hoods are described above. Existing hoods are required by Cal/OSHA regulations to have their performance tested and certified on an annual basis.

A. EH&S is responsible for performing the annual testing and certification of campus fume hood performance to meet OSHA and campus requirements (see pg. 7 for general air velocity requirements). EH&S is responsible for maintaining testing and certification records.

B If hood performance is significantly outside the limits of acceptable performance, EH&S will post the hood as off-limits for continued use and inform lab personnel. All deficiencies in hood performance are referred to Facilities Management for correction. After FM has performed repairs or adjustments to the hood, EH&S will retest and certify the hood if acceptable.

CAUTION

OUT OF ORDER
DO NOT USE

Date of shutdown: ____________

Expected duration: ____________

Responsible Person: ___________

Department: ________ Phone: _______