Laboratory Ventilation Management Program

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Stanford | Environmental Health & Safety
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1. Introduction

Laboratory ventilation refers to general exhaust in labs and all engineering controls used to prevent hazardous exposures, like chemical fume hoods, biosafety cabinets, and snorkel exhaust hoods. General exhaust is the once-through movement of air through spaces that is used to maintain the quality of a laboratory environment where hazardous chemicals are used.

1.1 Purpose

This Laboratory Ventilation Management Program (LVMP) provides a framework to ensure that Stanford laboratories are safe and healthy work environments through guidance on selection of exposure control devices (ECD), requirements for set-points and flow rates, descriptions of preventative maintenance, and risk-based application of energy management initiatives.

The purpose of this LVMP is to delineate the laboratory ventilation program's scope and provide procedural guidance for anyone who is affected by or has responsibility for the ventilation of laboratories at the university.

1.2 Scope

The LVMP applies to all of Stanford University (SU), including on- and off-campus sites.

Questions about the details of this program should be referred to labventilation@lists.stanford.edu.

2. Objectives

Achieving the LVMP's three key objectives will help Stanford realize the goal of operating laboratories safely, with greater energy efficiency, and in a way that maximizes equipment lifetime and operation.

2.1 Laboratory Safety

The primary objective of the Laboratory Ventilation Management Plan (LVMP) is to ensure the safety of our laboratories. The purpose of laboratory ventilation systems is to remove contaminants from the air and thereby ensure that the laboratory is a safe and healthy work environment. Laboratory safety requirements must be met and will not be compromised to meet other objectives.

2.2 Energy Efficiency

Laboratory ventilation uses high ventilation rates and once-through air, consuming an exceptional amount of energy and making it an outsized contributor to the university's carbon footprint. An important objective of the LVMP is to increase energy efficiency in laboratories through prudent identification and implementation of energy management initiatives.

2.3 Equipment Lifetime and Operation

Finally, laboratory ventilation is a complex and intricate system that requires maintenance and careful planning. The LVMP describes appropriate maintenance procedures and methods to reduce overall maintenance and operating costs and increase the lifetime of the equipment. It also addresses actions to ensure building-wide systems and ECD integrity is preserved during renovation and system alterations.

3. Relevant Requirements

3.1 External Requirements

Several regulatory and non-regulatory standards prescribe specific safety criteria for laboratory ventilation. Regulatory codes include the California Fire Code (CFC), California Mechanical Code (CMC), and various Cal/OSHA standards. Non-regulatory standards include ASHRAE standards (62.1, 55, 110); NSF 49; and Biosafety in Microbiological and Biomedical Laboratories (BMBL).

The California Energy Code (Title 24) applies to laboratory buildings and ventilation equipment.

3.2 Internal Requirements

In order to meet regulatory requirements, non-regulatory standards and best practices, Stanford publishes the Facilities Design Guidelines (FDG) and the Laboratory Design Guide (LDG). The LVMP complements the FDG and LDG by providing supporting information by providing equipment performance specifications, testing/certification procedures, and risk assessments.

4. Roles and Responsibilities

The stakeholder groups identified in this section have varying responsibilities with regard to laboratory ventilation. This section is limited to responsibilities as they pertain to laboratory ventilation; there are other responsibilities enumerated in other program documents, such as the Chemical Hygiene Plan.

4.1 Laboratory Personnel, Principal Investigators/Supervisors, and Administration

Lab workers include faculty, staff (including postdoctoral fellows, research assistants, visiting scholars), and students who conduct research or other operations in the lab space. This group is directly impacted by the decisions made about the ventilation provided to a specific lab or group of labs. Principal Investigators (PIs) and Laboratory Supervisors oversee lab workers and direct the work in the lab. For the purposes of this document, Laboratory Supervisors include both staff leads and faculty managers in Shared Facilities. PIs / Lab Supervisors have overall responsibility over the type of work conducted, including the selection of chemicals, biohazardous agents, radioactive isotopes and other hazards used in their labs. Another subgroup of lab workers who have additional responsibilities are department chairs, deans and departmental safety representatives, who allocate and monitor use of lab space.

4.1.1 Laboratory Personnel

Laboratory workers are directly involved in lab work and use ECDs regularly. It is their responsibility to:

1. Use ECDs properly to maximize ventilation effectiveness and provide a safe working environment (Section 9).
2. Maintain good housekeeping practices, which ensures ventilation effectiveness and provides a safe working environment.
3. Implement recommended practices that maximize the energy efficiency of ventilation.
4. Recognize malfunctioning equipment and report it to the PI / Lab Supervisor.

4.1.2 Principal Investigators / Laboratory Supervisors

In order to provide a safe working environment and ensure ECDs are selected, used, and maintained appropriately, PIs and Lab Supervisors are responsible for:

1. Training lab personnel on the proper use of ECDs.
2. Maintaining ECDs are in proper working order by:
    a. Requesting equipment maintenance from the Building Manager for university- or department-managed equipment.
    b. Contracting out equipment maintenance for lab-managed equipment (Section 7).
    c. Ensuring SU Performance Standards are provided to vendors and followed (Section 7.3 and Appendix 10.2).
3. Inspecting the laboratory to ensure good housekeeping practices are being followed.
4. Notifying building management, local safety staff, and Environmental Health & Safety (EH&S) when laboratory operations change such that the risk assessment for ventilation must be updated (Section 5).

4.1.3 Academic Administration

Academic Administration like Department Chairs, Deans, and senior administration manage Laboratory Supervisors and Principal Investigators. Like PIs/Lab Supervisors, the Academic Administration is responsible for providing a safe and healthy work environment and thereby is responsible for supporting the Laboratory Supervisors in maintaining such an environment. Responsibilities specific to laboratory ventilation include:

1. Allocate space to ensure adequate quantities and types of ECDs are available for personnel.
2. Allocate funds for lab modifications when ventilation needs updating or expansion.
3. Identify lab spaces or buildings that are ideal for energy upgrades.
4. Support energy upgrades in areas identified by Sustainability staff.
5. Encourage PIs to consider adding the cost of ECD purchase, installation, and maintenance into their grants so that grant money can be used to fund these items.

4.2 Building Managers and Local Safety Staff

Building managers, local facility managers, and local safety staff are critical to managing ventilation that meets the operational needs.

4.2.1 Building / Facility managers

Building and facility managers oversee the daily operation and management of assigned facilities and programs, including scheduling and assigning work to building staff and coordinating with staff, subcontractors, and/or vendors. Their responsibilities for lab ventilation include:

1. Scheduling SU or department-managed ECD maintenance and repair.
    a. Some departments or units may also assign coordination of testing certification and maintenance of laboratory-owned/managed ECDs to building or facility managers.
    b. Ensure SU Performance Standards are provided to vendors and followed (Section 7.3 and Appendix).
2. In collaboration with Sustainability and local safety staff, communicate ventilation changes to lab personnel.
3. Recognize malfunctioning equipment and place work orders.
4. Notify EH&S when PIs alert them of a change that will necessitate a reevaluation of ECD needs.
5. Notify EH&S and Facilities Operations of anticipated changes to ventilation.

4.2.2 Local Safety Staff

Local safety staff are personnel assigned by their department or school to implement institutional safety programs and initiatives. In some areas, local safety staff are known as University Safety Partners (USP). Other units may assign safety duties to building managers and facilities personnel. Responsibilities include:

1. Coordinate with EH&S to conduct facility risk assessments and identify operational needs.
2. Coordinate with Sustainability / Energy Management (SEM) to implement energy management initiatives.
3. Observe laboratory housekeeping and assist the lab group in correcting findings.
4. Manage change as it relates to the ventilation risk assessment (Section 5).
5. Coordinate with EH&S on housekeeping findings and changes to building ventilation or ECDs.

4.3 Lands, Buildings, and Real Estate (LBRE)

LBRE includes staff in Project Management, Facilities Operations, and Sustainability/Energy Management. Within these groups, staff design laboratory spaces, conduct/coordinate facility maintenance, and lead energy management programs.

4.3.1 Project Management

LBRE Department of Project Management is responsible for overseeing large construction projects including renovations, fit-ups, and new construction. Smaller projects may be managed locally within a school or unit by school or departmental personnel. The lab ventilation responsibilities for all project management include:

1. Provide the Facilities Design Guide and Laboratory Design Guide to all contractors tasked with facility design.
2. Engage with PIs / lab supervisors to understand facility needs.
3. Select ECDs appropriate for the work (Section 6). EH&S is available for consultation.
4. Consider Life Cycle Cost and implement energy management initiatives where indicated.
5. Seek review of construction plans from relevant groups such as EH&S and LBRE facilities operations and sustainability.
6. Commission all ECDs used for personnel protection by performing testing and certification. Ensure SU Performance Standards are provided to vendors and followed (Section 7.3 and Appendix)
7. Account for impacts to the ventilation system and up/downstream ECDs when sizing and renovating.

4.3.2 Facilities Operations

The LBRE facilities operations group includes technical staff who directly maintain and service lab ventilation equipment and coordinate preventive maintenance programs. Their responsibilities include:

1. Provide mechanical support and allocate the operational budget.
2. Coordinate annual testing and certification of all LBRE-managed ECD (Section 7).
    a. Ensure performance specifications are used (Appendix 10.2). If a performance specification is not available, submit the testing Standard Operating Procedure to EH&S for approval.
3. Coordinate maintenance of all failed units identified above.
4. Service equipment to address mechanical or other failures.
5. Review construction plans for serviceability, compatibility with existing equipment, and ventilation system capacity.

4.3.3 Sustainability / Energy Management

The LBRE Sustainability / Energy Management staff are responsible for identifying, promoting, and implementing energy conservation opportunities in campus laboratories. Their lab ventilation responsibilities include:

1. Identify opportunities for energy savings through ventilation upgrades. Calculate the time for return on investment.
2. Re- and retro-commission buildings.
3. Track projects and energy savings to inform future projects.
4. Coordinate with EH&S staff for risk assessments and regulatory interpretation.

5. Coordinate with local safety staff for ventilation needs and operational requirements.
6. In collaboration with building managers/local safety staff, communicate ventilation changes to lab personnel.
7. Provide training material for lab personnel on energy-efficient use of ECDs.
8. Interpretation of regulations and non-regulatory standards relating to energy use and sustainability.

4.4 Environmental Health and Safety (EH&S)

Environmental Health and Safety (EH&S) includes staff that provide direct support to lab groups and subject-matter experts.

EH&S responsibilities for lab ventilation include:

1. Updating the LVMP, as appropriate.
2. Observe housekeeping conditions, ECD maintenance documentation, and adequacy/availability of ECDs during lab visits.
3. Provide training materials on safe and sustainable general ventilation and ECD use practices (Section 9).
4. Determine performance specifications for ECDs; provide recommendations about ECD selection and placement. See LDG.
5. Determine commissioning and testing / certification requirements for ECDs (Appendix 10.1 and 10.2).
6. Conduct risk assessments to determine ventilation adequacy. A ventilation risk assessment may be requested by contacting the SU Chemical Hygiene Officer.
7. Interpretation of regulations and non-regulatory standards relating to building codes and safety.

4.5 Healthy Laboratories Group

The Healthy Laboratories group is a cross-functional group of personnel from EH&S, LBRE, and School of Medicine Office of Facilities Planning and Management. The Healthy Laboratories group is tasked with overseeing the LVMP. Responsibilities include:

1. Identifying opportunities for coordination between units to facilitate good ventilation management.
2. Contributing updates to the Facilities Design Guide and Laboratory Design Guide.
3. Promulgating information on laboratory ventilation design, management, and use to campus stakeholders.

4.6 Responsibilities Summary Table

Stakeholder Group	Role	Responsibilities
Laboratory workers, supervisors, and administration	● Directly involved in laboratory operations and planning	● Use ECDs correctly ● Identify malfunctioning equipment and notify the appropriate party ● Contract vendors to maintain and repair lab-managed ECDs ● Maintain service and certification records for lab owned ECDs
Building managers and Local Safety staff	● Provides facility support ● Implements institutional safety programs	● Recognize malfunctioning equipment ● Place work orders for equipment service ● Notify EH&S of planned changes to ventilation
Lands, Buildings, and Real Estate (LBRE)	● Provides facility support ● Plan, design, direct infrastructure improvements and maintenance	● Provide preventive and corrective maintenance for building ventilation systems and LBRE-managed ECDs ● Select, install, and commission appropriate ECDs ● Maintain service and certification records for LBRE-owned ECDs ● Incorporate sustainable design ● Identify opportunities for reduced energy use
Environmental Health & Safety (EH&S)	● Provides institutional oversight of lab work ● Manages LVMP oversight	● Maintain LVMP ● Determine performance and testing specifications for ECDs. ● Train users in proper use of ECDs ● Perform risk assessment ● confirm that lab ventilation is appropriate for hazards
Healthy Laboratories Group	● Cross-functional collaboration	● Collaboratively identify and address improvements, updates, and revisions

5. Laboratory Risk Classifications

The primary purpose of laboratory ventilation is to remove airborne contaminants and provide fresh air to the lab. The laboratory risk classification described in this section identifies the lab risk level based on the probability of generating the airborne contaminants and the associated hazard level of the contaminants. These risk levels will be used for "control banding," which is the identification of appropriate controls for a given risk level; in this case the control is ventilation, and the risk level is as described above. Please note that laboratories have other hazards (e.g., lasers or moving parts) that are not expected to significantly contribute airborne contaminants and are not considered here. This risk assessment applies only to hazards that can be controlled by ventilation and does not describe the overall risk of work in a laboratory.

The risk bands described in Section 5.1 may be useful for all stakeholders described in Section 4.

- Laboratory workers or supervisors may use the risk bands to gain a better understanding of the risk in their laboratory; they may also use them to determine ways to reduce risk and shift work to a lower risk band.
- Building managers, safety staff, and EH&S may use the bands to determine the appropriateness of exposure control devices (ECDs) and the air change rate of the general exhaust ventilation. They may also use this assessment for targeted outreach to labs including consultation, lab visits, or air monitoring.
- Project managers (both LBRE and department level) may use the bands to select appropriate ECDs and general ventilation rates during design and construction of laboratories.
- The Office of Sustainability and Energy Management may use these risk bands to identify the appropriate application of energy management initiatives.
- LBRE may use this assessment to identify risk-appropriate prioritization and frequency of testing, certification, and maintenance of ECDs and building ventilation equipment.

5.1 Risk Band Classifications

To identify the appropriate risk band, consider the hazardous materials and hazardous processes that are stored or occur in a room. As shown in Table 5.1, these risk bands apply to a room based on the type of hazards and work. Detailed descriptions of the risk bands are provided following the table. Upon review of the hazards and processes in a space, apply the risk band associated with the highest risk work to the entire room or zone, depending on the extent of zone control for the ventilation system.

Housekeeping practices should be considered when selecting a risk band. Rooms with poor housekeeping practices may be categorized as a more significant risk band (e.g., rooms with yellow-level hazards and poor housekeeping may be categorized as orange).

Table 5.1: Risk bands and associated hazards/processes

Risk Band	Hazards/processes
Green	• No chemicals stored or used; AND • No biohazardous materials used; AND • No radioactive isotopes stored or used
Yellow	• Fewer than 300 chemicals stored or fewer than 500 solid-only chemicals; OR • Biosafety level 1 (BSL1); OR • Work with recombinant nucleic acids; OR • Level C quantities of radioisotopes stored or used
Orange	• Cryogens stored or used; OR • Fewer than 1000 chemicals stored or used; OR • BSL2/2+ work; OR • Nanomaterial use and/or synthesis • Level B quantities of radioisotopes stored or used; OR • Volatile radioisotopes stored or used (e.g., radioiodine)
Red	• *Special hazards* • Level A quantities of radioisotopes stored or used; OR • Volatile Radiochemistry (e.g., work in the Cyclotron); OR • Chemical storage rooms; OR • Work with potent compounds/chemical synthesis of potent compounds; OR • Nanomaterial use outside of local exhaust ventilation; OR • BSL3 work; OR • All animal procedures, housing, or behavioral study; OR • Special regulation areas (e.g., toxic gas storage/use, FDA GMP facilities)

5.1.1 Green Band

The green risk band represents the lowest risk work with regard to airborne contaminants. To qualify for this band, a room must have no chemicals, no biohazardous agents, and no radioactive isotopes in storage or in use.

Many rooms that qualify for the green band may be referred to as "dry labs" or "laser labs" in iSpace. Some laser labs store and use compressed gases (which are chemicals and qualify for yellow, orange, or red band), so the chemical inventory should be confirmed prior to applying the green risk band.

5.1.2 Yellow Band

The yellow risk band represents low to moderate risk level work with respect to potential airborne contaminants. To qualify for the yellow band:

- Chemical storage must be limited to fewer than 300 containers.
    - If only solid chemicals are stored in the room, then up to 500 containers are allowable.

    - Please note that cryogenic liquids and nanomaterial use or synthesis are **not** included here.
- Work with biohazardous agents classified as Biosafety Level (BSL) 1 or work with recombinant or synthetic nucleic acids (e.g., DNA or RNA) may occur in these rooms.
- Storage and work with radioactive isotopes up to Level C quantities is also allowable.
    - Level C is defined as less than or equal to 200 times the Quantity of Licensed Material (QLM) for a given isotope (Table 3.1 of the Radiation Safety Manual).

5.1.3 Orange Band

The orange band represents a moderate to high risk level work with respect to potential airborne contaminants.

The orange band applies when:

- Chemical storage is limited to fewer than 1000 containers; OR
- Nanomaterials are used or synthesized inside of a closed system or under local exhaust ventilation; OR
- Cryogenic liquids are stored or used in a room; OR
- Working with biohazardous agents up to BSL2/2+ that presents potential for aerosol transmissible disease (ATD); OR
- Radioisotopes up to Level B quantities are stored or used; OR
    - Level B quantities are less than or equal to 10,000 times the Quantity of Licensed Material (QLM) for a given isotope (Table 3.1 of the Radiation Safety Manual).
- Volatile radioisotopes, such as radioiodine (131I), are stored or used.

5.1.4 Red Band

The red band represents the highest risk level of work with respect to potential airborne contaminants. The red band applies when any of the following hazards or processes are present:

- Storage or use of Level A quantities of radioisotopes; OR
    - Level A quantities are greater than 10,000 times the Quantity of Licensed Material (QLM) for a given isotope (Table 3.1 of the Radiation Safety Manual).
- Volatile radiochemistry work (chemical synthesis using chemicals labelled with radioactive isotopes), such as work that occurs in Stanford's Cyclotron facility; OR
- Rooms that are designated as "chemical storage" or "gas storage" rooms in iSpace; OR
    - Rooms with 1000 or more chemical containers are considered chemical storage rooms and qualify for the red band based on regulatory requirements, best practices, and risk for unnoticed release.
- Rooms where potent compounds are synthesized, purified, or used; OR
    - Potent compounds are defined by the pharmaceutical industry as compounds that have an Occupational Exposure Limit (OEL) of 10 ug/m3 or less.

    - Stanford research is typically earlier in the drug development cycle and OELs and toxicological data are unknown, so at SU, a potent compound is any novel chemical or biologic with designed, known, or suspected pharmacological activity.
- Areas where nanomaterials may be used outside of a closed system or local exhaust ventilation; OR
- Work with BSL3 indigenous or exotic agents; OR
- Certain regulatory standards require specific ventilation rates and exposure control devices for work. In these special hazard areas, the red band applies. These include the cyclotron, Food and Drug Administration Good Manufacturing Practices (FDA GMP) facilities, and rooms where toxic gases are stored or used.

5.2 Methods to Identify Hazards

Various databases and signage exist to identify the hazards listed in Table 5.1 for selection of the appropriate risk band.

5.2.1 Chemicals

The number of chemical containers and the types of chemicals can be identified by:

- Review of ChemTracker records
- Review of Life Safety Box information posted outside every room that stores chemicals

Storage and use of cryogenic liquids can be found in ChemTracker records or by viewing the laboratory. Cryogenic liquids are stored in dewars that range in size from approximately 2 feet to 5 feet tall and are often easily found in a cursory inspection of the laboratory.

Often the synthesis and use of nanomaterials can be discovered only on interview with building management, local safety staff, or the PI. Some nanomaterial use can be identified when Carbon Nanotube (CNT) is in the ChemTracker record. The hazards list in BioRaft can also be used to identify nanomaterial work areas.

Synthesis or use of potent compounds can often be discovered only by interview with building management, local safety staff, or the PI. Other methods include review of the PI lab website where key terms may be “potent compounds”, “pharmaceutical compounds”, “drugs”, “drug therapies”, or “medicinal chemistry”.

5.2.2 Biohazardous Agents

Storage and work with biohazardous agents or non-exempt recombinant DNA can be identified by reviewing the Administrative Panel on Biosafety (APB) records and door signage.

BSL1 work is not easily identified, as this work does not require APB approval.

BSL2, 2+, and 3 work and work with recombinant DNA covered by the “NIH Guidelines For Research Involving Recombinant Or Synthetic Nucleic Acid Molecules (NIH Guidelines)” require APB approval, so a record and door signage will be available.

BSL2, 2+, and 3 work typically occurs in a Biosafety Cabinet (BSC), which can be easily identified on cursory inspection of the laboratory (See section 6 for examples of BSCs). This equipment is also listed in Sunflower as capital equipment.

Contact labventilation@lists.stanford.edu to request information on the location of work with biohazardous agents to inform a risk assessment.

5.2.3 Radioactive isotopes

Work with any radioactive isotope requires a Controlled Radiation Authorization (CRA) from the Health Physics (HP) group at EH&S. Rooms where radioactive isotopes are stored or used can be identified by reviewing the CRA database or by viewing required door signage.

The relative hazard of a particular radioisotope can be measured by their “Quantity of Licensed Material Requiring Labeling” (QLM, see NRC 10.CFR.20. Appendix C). Stanford defines work with ≤ 200x the QLM value to be “C level”, ≤ 10,000x to be “B level”, and > 10,000x to be “A level”.

CRA levels may be identified by contacting labventilation@lists.stanford.edu.

5.2.4 Animals

Rooms where personnel work with animals can be identified by review of the Administrative Panel on Laboratory Animal Care (APLAC) database. The Research Compliance Office can identify spaces that are used for procedures, housing, or behavioral studies. Contact labventilation@lists.stanford.edu for this information.

6 Selection of Ventilation Equipment

There are many different types of ECDs with a variety of features and purposes. Most ECDs provide personal protection from airborne hazards, while others may also include features, like filters and specific airflow patterns, that provide product protection. Still others may provide only facility protection or aid occupant comfort.

Given the critical role that ECDs play in personal safety and research operations, it is vital to select appropriate ECDs for the type of work and hazard level. Appropriate selection and installation will necessitate collaboration between all stakeholders listed in Section 4. Selection considerations include types of hazardous materials and processes, user specifications and needs, and future operational needs.

The tables below provide information on the appropriate selection of ECDs based on the hazardous materials and processes. User specifications and needs should be gathered during the design phase of renovation or construction and will include information about the type of work, hazards, number of occupants, and types of equipment. Future operational needs should also be considered at this time and the user should consider the evolution of their work and how that may impact their ECD needs.

Below are the main types of ECDs, their sub-types, descriptions, applications, and limitations of each type. This section is adapted from the Scientific Equipment and Furniture Association’s

(SEFA) document “Selection and Management of Exposure Control Devices in Laboratories”; further information can be found in that document.

6.1 Fume hoods

Laboratory fume hoods are also known as chemical fume hoods and are defined by Cal/OSHA 8 CCR 5154.1 as “[a] device enclosed except for necessary exhaust purposes on three sides and top and bottom, designed to draw air inward by means of mechanical ventilation, operated with insertion of only the hands and arms of the user, and used to control exposure to hazardous substance.” Fume hoods are used to control exposures to hazardous substances like chemicals and radioisotopes but are not appropriate for biohazardous agents. Five main types of fume hoods, their uses, and their limitations are described in Table 6.1. The performance standard for all types of fume hoods is in Appendix 10.2.1. All fume hoods must meet the requirements in the Laboratory Design Guidelines.

Table 6.1: Fume Hood Types: Applications & Limitations

Subtype	Description	Applications	Limitations
Benchtop (traditional)	Mounted to a bench or cabinet for work at waist height, may have vertical, horizontal, or combination sash. The most common type at Stanford.	Work with toxic gases, vapors, fumes. Sash can provide some protection from splash, fire, or minor explosions.	• Will not provide adequate protection from all splash, fire, explosions - appropriate PPE and procedure planning necessary. • Not for containment of biohazardous agents. • May not be adequate for some highly hazardous chemicals. For work with large quantities of flammables, explosion-proof lights may be required.
Floor-mounted	Mounted to the floor for large and tall equipment. Sash may be horizontal or vertical.	Same as above.	As above, plus: • Often inaccurately called a “walk-in” hood, but head and body should never enter the hood while hazardous materials/processes are present. • Shelving must have large, open spaces to allow airflow.
Radioisotope	Typically, external and internal surfaces are	For work with radioisotopes that	Same as benchtop type, plus:

Subtype	Description	Applications	Limitations
	constructed of stainless steel or epoxy. Has coved corners and smooth, sealed surfaces to prevent radioisotope accumulation and easy decontamination. May be equipped with HEPA and carbon filters on the exhaust. Should be capable of bearing load of 200 lbs/ft2. Sash should be vertical.	pose an airborne exposure hazard.	• Consider the effect on face velocity when placing radioisotope shields.
Perchloric acid	Constructed of 316 stainless steel or type 1 PVC, has a wash-down system to remove explosive perchlorate salts. Shall be provided for work with open, heated, perchloric acid. Must be provided a drainage system and compatible ductwork and fan. Should not be manifolded with other ECDs.	For work with heated, open perchloric acid.	Same as benchtop type, plus: • Must not be used with chemicals incompatible with materials of construction or chemicals reactive with perchloric acid/perchlorate salts.
Acid digestion	Same as PVC perchloric acid hood, sash is plastic (e.g., Lexan) instead of glass.	For digestions with mineral acids other than perchloric acid. Acid digestion with hydrofluoric acid (HF) requires a non-glass sash to avoid etching and retain transparency.	Same as benchtop type, plus: • Materials of construction must be compatible with chemicals used.
Ductless / filtered	EH&S MUST APPROVE - ductless hoods are rarely appropriate. Functions similarly to a traditional fume hood, but instead of a duct to building exhaust, a fan/blower unit draws air from the interior to a series of filters intended to remove chemical	Allowed in very few circumstances. Only for very low hazard materials used in very low quantities, with no variability in process. May be used only for a limited number of pre-approved chemicals.	Filters must be replaced and maintained regularly. Filters must be selected for the chemicals used. Filtration may not be adequate. Some chemicals may poison the filter media and dramatically decrease filtration effectiveness. No high heat processes.

Subtype	Description	Applications	Limitations
	gases, vapors, aerosols, and fumes.		

6.2 Biosafety Cabinets

Biosafety cabinets (BSCs), also called tissue culture (TC) hoods, are used for both personal and product protection when working with biohazardous agents, cells, or tissues. Requirements for BSCs are provided in 8 CCR 5154.2 and the Laboratory Design Guide. Selection of the correct type of BSC depends on the biosafety level (BSL) of the agents used, use of other hazardous materials, and necessity for personal, product/experiment, or room protection. The performance standard for BSCs is in Appendix 10.2.3.

Table 6.2: Biosafety Cabinet Types: Applications & Limitations

Type	Description **Recirculation / exhaust type**	Applications	Limitations
Class I	Air is drawn from the open sash to a HEPA filter, where it is discharged to the room.	For use with BSL 1-3 agents. Provides only personnel and environmental protection.	Does not provide product protection. Volatile hazardous chemicals must not be used.
Class II	Air is drawn from the open sash. Air is HEPA filtered before recirculation or discharge.	BSL 1-3 agents. Provides personnel, product, and environmental protection.	Not for work with > 1 mL volatile hazardous chemicals.
Type A1	70% recirc/30% discharged to room		
Type A2	70% recirc/30% discharged to room or thimble exhaust	Above and may be used for small quantities (<10 mL) of volatile chemicals.	Not for work with >1 mL volatile hazardous chemicals when air is discharged to room. No use of flammable or explosive chemicals.
Type B1	30% recirc/70% discharged to room or hard-ducted exhaust		

Type	Description Recirculation / exhaust type	Applications	Limitations
Type B2	This is the preferred type when hazardous chemicals must be used with biohazardous agents. 100% discharged to hard-ducted exhaust		No use of flammable or explosive chemicals.
Class II, Type C1	May be operated in recirculating type A mode or discharge to exhaust system in type B mode.		Same as the type it is operated as (above).
Class III	A gas-tight glove box with double HEPA-filtered or HEPA-filtered and incinerated exhaust.	May be used for BSL 1-4 agents and/or chemical carcinogens.	Custom built device - limitations determined by manufacturer

6.3 Other ventilated enclosures

Chemical fume hoods and biosafety cabinets are the most common ECDs on campus, but several other ventilated enclosures are available for equipment that is not appropriate for fume hoods or BSCs.

Table 6.3: Other Ventilated Enclosure Types: Applications & Limitations

Type	Description	Applications	Limitations
Glove box	Tightly sealed enclosure for total containment of chemicals or biological/biohazardous agents. May be provided with a separate atmosphere. Objects inside are manipulated using gloves mounted on the face. Materials added and removed through an antechamber,	For work with highly toxic materials or experimental applications for which total containment is required. Often also used for chemicals or biological agents that require a separate atmosphere.	Not for work with processes with high generation rates. Requires regular maintenance, including apparatus for atmosphere regulation. Gloves are not resistant to all chemicals and need regular replacement and may require additional gloves

Type	Description	Applications	Limitations
	which is typically provided vacuum and gas. Vacuum is discharged to building exhaust.		for chemical compatibility.
Gas cabinet	Fully enclosed with a hinged door for access. The performance standard for gas cabinets is in Appendix 10.2.2.	Storage of hazardous and toxic gases. Plumbing should be provided from the gas cabinet to the fume hood, equipment, or tool where the gas is used.	For storage only.
Laminar flow clean bench (horizontal or vertical flow)	HEPA filters provide uncontaminated air to the work surface for sensitive processes.	For work with non-hazardous materials that require a clean/particle-free work environment. Provides only product protection.	Not for work with hazardous chemicals, volatile radioisotopes, or biohazardous agents - does not provide personnel protection.
Ventilated enclosure	Often custom-built enclosures for equipment. Ducted to building exhaust. Filtered and recirculated models must be approved by EH&S prior to purchase / installation.	For processes or equipment that generates small quantities of toxic or malodorous gases, aerosols, vapors, or fumes.	Not for containment of biohazardous agents, unless specified by manufacturer. May not be adequate for some highly hazardous chemicals. Filtered models are rarely approved, suffer from same limitations as ductless fume hoods (section 6.1)
Ventilated Balance	Ducted to building	For weighing	Not for

Type	Description	Applications	Limitations
enclosure	exhaust, operated at low face velocities for a low-turbulence environment for weighing chemicals.	potent/highly toxic compounds or malodorous chemicals.	containment of biohazardous agents. May not be adequate for some highly hazardous chemicals. Filtered models are rarely approved, suffer from same limitations as ductless fume hoods (section 6.1)
Wet process station/Acid wet bench	Provides both personnel and product protection, typically used in a clean room. Has tubs for processing with under-unit exhaust plenum and waste drain/storage area. Waste level detection/alarm often needed. May have vertical or horizontal sash or a hinged eye shield. Typically, exhaust is sized to provide 100 fpm face velocity, similar to a chemical fume hood. Process automation is common.	For critical parts processing with acid, base, or solvents. Typically used for chip or semiconductor processing.	Each bench or tub should be used for only one chemical or class of chemicals. Eye shield provides some splash protection but is not adequate alone. Not for work with biohazardous materials.
Hot cells	Lead-shielded ECD. The cell is enclosed in a "cave" of lead bricks supported by a rigid frame. The interior surfaces are made of stainless steel. A window of leaded glass provides inside viewing. They often come with remote manipulators. The window should be	For radiochemistry or the manipulation of large quantities of radioactive material. The hot cell is designed to shield workers from Curie-levels of gamma-emitting radioisotopes and protect them from any radioactive gases, aerosols, or particulates.	Maintenance can be difficult, expensive, and time-consuming. Not many vendors on the market. Not for work with biohazardous materials.

Type	Description	Applications	Limitations
	able to drop down for access to equipment inside the cell once radiation levels are sufficiently low. 20-fold air change per hour recommended. Should be leak-tight with walls that are smooth, impervious, unbroken and the corners curved. Permanent installation of components is discouraged.		
BioBUBBLE	bioBUBBLE is a brand of soft-walled pressurized enclosures of varying size. Depending on the configuration it can be used to enclose small benchtop equipment or a large-scale room.	BioBUBBLE is a negative, positive, and convertible pressure containment enclosure. Has soft-walled rooms and are powered by 50-100 air changes per hour of HEPA-filtered exhaust. It provides high levels of contaminants for all BSL-2 & BSL-3 (biosafety), ABSL-2, & ABSL-3 (animal), and P2, & P3 (plants) level applications.	The cost and maintenance can be expensive. Annual certification is needed. Not for work with radioactive material or flammable or hazardous chemicals.

6.4 Non-enclosed ventilation devices

As a general rule, ECDs with a greater degree of enclosure provide a greater degree of protection. However, some processes or equipment are too large for a fume hood or ventilated enclosure or require a large open work surface to accomplish the task. Additionally, processes with low hazard chemicals may not require a fume hood, but occupants desire some control for nuisance odors. Non-enclosed devices can be used for low-hazard, low-generation rate, and low generation velocity hazards.

Table 6.4: Non-Enclosed Ventilation Device Types: Applications & Limitations

Type	Description	Applications	Limitations
Snorkel trunk / spot exhaust	Provides spot exhaust via an articulated arm with a terminal hood - typically round bell-mouth style.	Best for control of nuisance odors or low generation rate, low-hazard materials. Typically provided as source exhaust for equipment that is not appropriate for enclosure in a chemical fume hood (e.g., gas chromatograph). Provided appropriate design per ACGIH with 80-100 fpm at 6”-9” from face, may be used for supplemental control of soldering fume or for waste anesthetic gas (WAG) control.	Limited capture effectiveness and limited capture distance. Must be used no more than 6”-9” from source. For use with low hazard, low generation rate materials. Not for use with biohazardous agents.
Duct stub / snorkel stub / duct drop	Short extension from building exhaust system, often capped or partly closed by damper	Used to provide local exhaust to a piece of equipment, often exhaust lines from vacuums or instruments. Control of nuisance odors.	Limited airflow, dedicated to one piece of equipment. Limited personnel protection capacity.
Canopy hood	Typically constructed of stainless steel. Often rectangular fixed hood above a bench or equipment.	For the removal of heat or nuisance odors. Typically placed above furnaces or autoclaves.	Not for personnel protection. Must not be used to remove hazardous aerosols, fumes, or vapors.
Necropsy table / downdraft table	Ventilated table with unobstructed top access. Hard-ducted to building exhaust, fumes and vapors are drawn down and away from the user’s breathing zone.	For necropsy, specimen dissection, tissue grossing, perfusions, and histology work.	Limited capture distance and effectiveness. Not for work with highly hazardous chemicals without testing and certification. Limit quantities of chemicals.

Type	Description	Applications	Limitations
Slot hood	Wall- or equipment-mounted device with slots.	Used to for personnel protection with large open vats of hazardous chemicals, typically for dipping operations (e.g., plating)	Limited capture range, dependent on quantity and temperature of open chemicals. Airflow design must consider operator location.

6.5 Veterinary Exposure Control Devices

Veterinary work carries risk of exposure to unique hazards in research, namely waste anesthetic gases and animal dander/allergens. Control of those hazards is a central component of the Laboratory Animal Occupational Health Program (LAOHP). The following ECDs are available to control those hazards and to contain nuisance odors.

Table 6.5: Veterinary Exposure Control Device Types: Applications & Limitations

Type	Description	Applications	Limitations
Bedding disposal unit	Portable, HEPA filtered station for dumping used bedding.	Provides personnel protection from particulates during cage bedding changes and disposal.	Requires appropriate filter maintenance.
Animal transfer station	HEPA filtered station that provides research subject and personnel protection.	For cage changes where an uncontaminated work area is needed.	Not for use with hazardous chemicals.
Active waste anesthetic gas control	Provides negative flow to capture waste anesthetic gas from a nose cone and induction chamber. Outlet can go to building exhaust or a pre-weighed charcoal canister. Units include EVAC4 or Vet Equip.	For use with a CX-R or Posi-Vac nose cone and hooded induction chamber. Charcoal canister may be used for isoflurane, ducted building exhaust required for nitrous oxide.	Dependent on proper work practices and use of appropriate nose cone and induction chamber.
Ventilated cage rack	Cage rack system that actively pulls air from each cage in the system. Exhaust air	In negative mode, for removal of nuisance odors and particulates (e.g., allergens) from	Available for small animals only. In positive mode, provides protection for

Type	Description	Applications	Limitations
	may be HEPA filtered and recirculated to the room or ducted to the building exhaust. May be operated in positive or negative mode.	cages. In positive mode, provides uncontaminated, filtered air for immunocompromised animals.	the subject, not personnel.

6.6 ECD accessories

In addition to the ECDs themselves, there are accessories that are essential to proper operation and utility and can enhance ease-of-use.

6.6.1 Lattice frame

Most fume hood users will conduct small-scale chemistry experiments that require glassware to be clamped in place. While some may use a ring stand, often the most convenient option is a fixed lattice frame, frequently called “monkey bars”. Users may rearrange some bars to fit their specifications.

6.6.2 Sash stops

To ensure operation at an appropriate sash height, fume hoods with a vertical sash must be purchased with a sash stop installed. A sash stop blocks the vertical path of the sash so that the open face area is limited, typically to 18” in height. Most users prefer a sash stop that can be overridden temporarily to allow larger equipment to easily be arranged inside the hood.

6.6.3 Tissue screens

During the course of normal operations, researchers often use paper towels and other tissues in their chemical fume hoods. These tissues can easily be swept up by the airflow through the hood and carried into the baffles and beyond, into the exhaust ductwork or even to the fan. To prevent this and reduce maintenance costs and fume hood outages, tissue screens should be installed at the baffle opening closest to the work surface inside of a fume hood.

6.6.4 Airflow monitors

All fume hoods are required to have a functional airflow monitor (AFM) that produces an audible or visual alarm when the airflow drops below 80% of the setpoint. Stanford strongly recommends combination audible / visual alarms.

Some fume hoods and other ECDs may have a magnehelic gauge instead of a digital AFM. A magnehelic gauge is an analog device that measures the air pressure across the face, which is proportional to the air flow.

An AFM may also be found on other ECDs like BSCs and downdraft tables.

6.6.5 Zone Proximity Sensors and Automatic Sash Closures

Laboratory fume hoods are high-energy consumers - the energy used to power one fume hood for one year is equivalent to the annual energy used by a typical house. To minimize the impact, in combination with Variable Air Volume (VAV) systems there are two common accessories that can safely reduce airflow when the user is not working at the fume hood.

Zone proximity sensors (ZPS) are mounted above fume hoods and use radar, image processing, or other technology to detect when a user is at the front of the chemical fume hood. When no user is detected for a specified time period, the airflow rate may go into a lower setback mode of 60 fpm face velocity. When a user is detected, the airflow rapidly increases to the standard 100 fpm face velocity.

Automatic Sash Closure (ASC) devices also detect the presence of a fume hood user and when a user is not detected after a specified time period, will shut the sash. By closing the sash, the open area for air to pass through is reduced, thereby reducing the total volume of air and the amount of energy used to move and condition it. ASCs also offer safety benefits in that better containment is achieved by a greater degree of enclosure and the risk of splash outside the hood is reduced.

ZPS and ASC are used only with Variable Air Volume (VAV) hoods and are both discussed further in section 8.3.2 and 8.3.4. These two measures are mutually exclusive, only one should be installed on a fume hood. Requirements for ASCs or other energy-saving measures is further described in Appendix 10.4.

6.7 Change Management

ECD needs change over the lifetime of a laboratory as research evolves, locations change, and equipment and new hazards are added to the lab. The PI and lab researchers are responsible for understanding the applications and limitations of the ECDs in their lab. When the research needs change such that new, updated, or altered ECDs are needed, it is also the PI’s responsibility to contact EH&S and the building manager to coordinate a hazard and needs assessment and to ensure appropriate installation and configuration.

EH&S, building management, and the HVAC shop should coordinate with one another when changes are planned to ductwork or when ducted ECDs are added or removed.

7. Maintenance of ECDs

Timely and appropriate maintenance of Exposure Control Devices (ECDs) is critical to ensuring the desired performance specifications are met. Some maintenance tasks such as general cleaning and pre-use inspection should be conducted periodically by the user. Other maintenance tasks are more complicated and must be performed only by a qualified technician.

7.1 User Maintenance Tasks

In order to keep ECDs in proper working condition, users should conduct the following periodic maintenance:

1. Prior to work, check the airflow monitor (AFM), where available. If the system is off, plug in the alarm or contact the building manager for maintenance. If the monitor is alarming (audible or visual), lower the sash to the marked working height. If this does not correct the alarm, do not use the ECD and contact:
   a. The building manager for chemical fume hoods or other ventilated enclosures.
   b. A vendor for biosafety cabinets (Section 7.3).
2. Prior to work, check the annual certification sticker and verify that the unit has been tested and certified within the last year. If it is out of date, contact:
   a. The building manager for chemical fume hoods or other ventilated enclosures.
   b. A vendor for biosafety cabinets (Section 7.3).
3. Periodic cleaning of the work surface and sash. Please note that BSCs should be decontaminated before and after work with appropriate disinfectant. If the disinfectant is corrosive (e.g., bleach), then the surface should be cleaned with water and 70% ethanol or isopropanol after initial disinfection.

7.2 Professional Maintenance Tasks

Most ECD maintenance is complex, may affect other units in the building, and requires a skilled technician.

7.2.1 ECD Testing and Certification

All ECDs used to prevent harmful exposures must be tested on installation, at least annually, and when alterations or maintenance occur (Cal/OSHA 8 CCR 5143). When testing is triggered by a new installation or renovation, the project manager is responsible for testing.

LBRE manages required maintenance and testing for chemical fume hoods and gas cabinets. All other ECDs are locally managed and PIs or building managers are responsible for contracting annual testing from a reputable vendor.

Stanford has performance standards for many equipment types, provided in the Appendix. Vendor service must be compliant with these standards.

Table 7.1 ECD testing matrix

ECD type	Required testing	Frequency	Responsible Party	SU Standard
Chemical fume hood, all types	• Face velocity testing, • Qualitative smoke capture,	Annual and after changes to the	LBRE	Appendix 10.2.1

ECD type	Required testing	Frequency	Responsible Party	SU Standard
	• AFM alarm response testing	exhaust system		
Gas cabinet	• Face velocity testing	Annual and after changes to the exhaust system	LBRE	[Appendix 10.2.2](#)
Biosafety cabinet, all types	• NSF 49	Annual[1] and after BSC moves	Lab owner	[Appendix 10.2.3](#)
BioBUBBLE	• Varies, contact EH&S	Annually	Lab owner	TBD
Acid wet benches Solvent benches Ducted laminar flow hoods	• Face velocity testing, • Qualitative smoke capture, • Face velocity alarm response testing	Annual and after changes to the exhaust system	Lab owner	TBD
Laminar flow hoods	• No testing required, lab may elect for downflow velocity and/or aerosol challenge test for product protection verification	As desired	Lab owner	None
Necropsy/ Downdraft tables	• Capture velocity/total airflow; qualitative smoke capture	Annual and after changes to the exhaust system	Lab owner	TBD
Slot hoods	• Capture velocity/total airflow; qualitative smoke capture	Annual and after changes to the exhaust system	Lab owner	TBD
Snorkel trunks	• When used for personnel protection: Capture velocity/total airflow;	Annual and after changes to the exhaust system	Lab owner	TBD

ECD type	Required testing	Frequency	Responsible Party	SU Standard
	qualitative smoke capture			
	• When used for nuisance odor control, no testing required	Not required	N/A	N/A
Equipment enclosures (including ventilated balance enclosures)	• When used for personnel protection: Capture velocity/total airflow; qualitative smoke capture	Annual and after changes to the exhaust system	LBRE	TBD
	• When used for nuisance odor control, no testing required	Not required	N/A	N/A

[1] BSCs in BSL3 facilities must be tested and certified twice annually

7.2.2 ECD Preventive and Corrective Maintenance

LBRE and outside vendors perform a variety of crucial preventive and corrective maintenance on ECDs.

Proper function of the building mechanical system is fundamental for upstream ECDs to meet performance specifications. In lab buildings, LBRE performs major maintenance during HVAC shut-downs, which occur 1-4 times per year. Maintenance tasks include:

- Variable Frequency Drive (VFD) maintenance
- Parts replacements (e.g., belts)
- Inspection of dampers and actuators, if equipped
- Inspection of electrical connections

In addition to periodic user maintenance and annual professional testing and certification, fume hoods and biosafety cabinets require the following maintenance schedules in Tables 7.2 and 7.3, respectively.

Table 7.2 Fume Hood Preventive Maintenance Matrix

Type	Frequency	Responsibility
Visual inspection	Annual	LBRE, performed by testing/certification vendor
Change lightbulbs	As needed	LBRE, requested via ticket
Alarm airflow verification (non-networked devices)	Annual	LBRE, performed by testing/certification vendor

Table 7.3 Biosafety Cabinet Maintenance Matrix

Type	Frequency	Responsibility
Visual inspection	Annual	BSC owner, performed by testing/certification vendor
Change work surface lightbulbs	As needed	
Change UV bulb	Manufacturer's specifications, not required[1]	
Change filter	As needed, identified during annual testing/certification	
Change blower	As needed	

[1] Do not rely on UV bulbs for sterilization, see "BSC Use and Safety".

7.3 Preferred Vendors

Any vendor may be selected for ECD installation, testing, certification, and certain maintenance tasks. The SU Performance Specifications (Appendix 10.2) must be provided prior to work. There are preferred vendors for some ECD types:

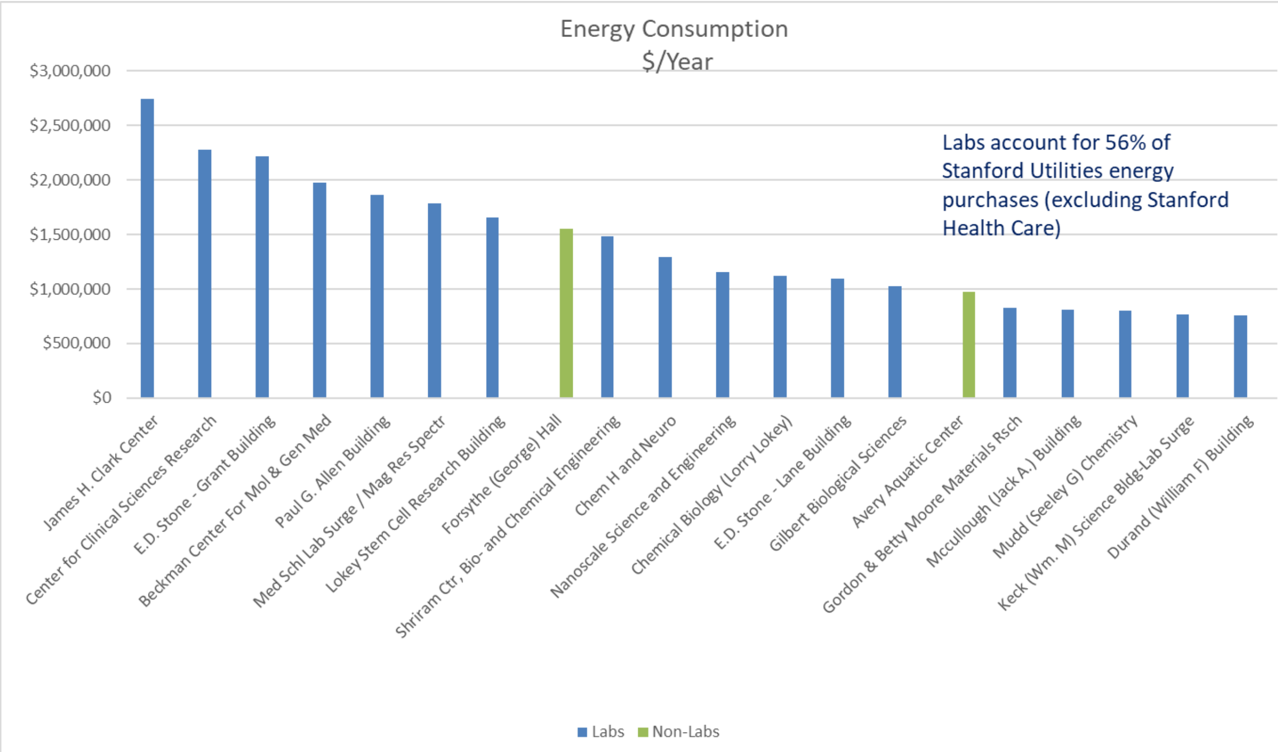
- Biosafety cabinets (BSCs): TSS is the designated vendor for installations, cabinet certifications (required annually), decontamination, and any other needs that may arise. AABC is also acceptable. https://ehs.stanford.edu/services/biosafety-cabinet-usecertification
- Fume hoods: Vendors are selected by LBRE, typically TSS or AABC.
    - ASHRAE 110 test: TSS is the only pre-approved vendor for an ASHRAE 110 test using nitrous oxide instead of sulfur hexafluoride (SF6). Stanford has a Cal/OSHA variance for this environmentally-friendly substitution, which requires highly specialized and sensitive equipment. EH&S must approve any other vendor before they are contracted.

8. Energy Management Strategies

The sustainability strategy for laboratory ventilation is to use as little energy as possible to provide a safe working environment for researchers, building maintenance staff, and the occupants of neighboring buildings and outdoor areas.

Laboratory buildings use many times more energy for heating, cooling, and ventilation as homes or offices. This is because laboratories with potential airborne hazards require 100% outside air (rather than using a portion of recirculated air), which is heated or cooled, distributed to labs, and then sent out an exhaust stack. At Stanford, 18 laboratory buildings account for approximately 50% of the total annual energy consumption, out of 700 total buildings.

Figure 8.1: Energy Consumption of top 20 most energy intensive buildings



Fortunately, there are a number of efficiency measures that can be applied to reduce the energy burden of ventilating laboratory spaces without compromising the conditions required to minimize exposure to airborne hazards.

8.1 Whole Building

Exhaust stacks and air handling units are the two foundational components of any lab building ventilation system. The following three measures are implemented as appropriate:

- Use variable-speed control on the air handling unit(s).
- Customize exhaust stack volume and velocity based on typical wind conditions.
- Vary exhaust stack velocity based on real-time wind conditions.
    - Stanford is in a temperate climate with highly regular wind patterns. In most cases, velocity can be based on typical conditions.

8.2 General Ventilation Measures

8.2.1 Assign appropriate occupancy and space type

When designing research buildings, project teams should carefully consider the researchers' needs and future plans to select the appropriate fire code occupancy type. The SU Fire Marshal's Office (SUFMO) is available for consultation. An important factor to consider is that "L" type (lab suite) occupancies may be more expensive to build and offer less flexibility to match ventilation to actual working conditions.

Similarly, designers and building managers should review the hazards in a room when assigning space types such as "laboratory". Some spaces, like computer labs, do not require laboratory ventilation (See Section 5). The room designation and corresponding air change rate should be reviewed periodically to ensure both match the existing needs (Section 6.6).

8.2.2 Sensor-based air change rates

Advances in sensor technology allow Stanford to set ventilation rates based on true need, depending on the building code, hazard types, and real-time occupancy. The purpose of lab ventilation is to promptly remove airborne contaminants to ensure occupant safety and comfort. When personnel are not present the ventilation purpose is not being realized and ventilation rates can be safely reduced to conserve energy and reduce greenhouse gas emissions.

In the absence of room occupancy sensors, labs must have a minimum of 1 cfm/sqft (cubic foot per minute per square foot) of 100% outside air at all times (equivalent to 6 Air Changes per Hour (ACH) for a 10 foot ceiling).

Following a risk assessment, when room occupancy sensors are installed, the ventilation minimum may be reduced during non-working hour periods of non-occupancy (Appendix 10.3).

8.3 Fume Hood Measures

The typical fume hood consumes the same amount of energy annually as the average home. Simple measures increase energy efficiency without sacrificing safety. In fact, many energy efficiency measures also improve safety.

8.3.1 Select VAV fume hoods

Variable air volume (VAV) fume hoods keep the face velocity constant by varying the total quantity of exhausted air based on the position of the sash. In combination with good work practices (i.e., keeping the sash as low as feasible and closing the sash when not in use), significant energy savings can be achieved.

8.3.2 Face velocity unoccupied setback

Fume hoods protect users by drawing air through the sash and away from the user to prevent hazardous emissions from entering the general lab air. Concentrations of airborne contaminants vary with distance from where the emissions are produced. Thus, fume hood performance is more vital when a user is actively working with hazardous materials. So, when a user steps away from the fume hood, it is both safe and practical to reduce the face velocity.

Stanford installs Zone Proximity Sensors (ZPS) on VAV fume hoods that monitor for user presence in front of the hood and signal the fan to reduce face velocity from 100 fpm (feet per minute) to 60 fpm (setback mode) after a specified time after the user has left fume hood with the sash open. The ZPS signals the fan to restore the 100 fpm face velocity immediately when a user is detected.

Unoccupied face velocity setback measures are not needed where Automatic Sash Closures (ASCs) are employed (Section 8.3.4).

To ensure adequate contaminant capture in setback mode, fume hoods outfitted with this technology shall be subjected to an ASHRAE 110 test at both 100 fpm and 60 fpm on commissioning. Records shall be retained for 5 years (Appendix 10.1).

8.3.3 Maximum fume hood face velocity

Above 150 fpm face velocity, air turbulence can increase in fume hoods and cause eddies that may allow airborne contaminants to escape. Fume hoods must have an average face velocity of at least 100 fpm, but it should not exceed 150 fpm (Appendix 10.2.1).

By limiting the upper face velocity, contaminant capture is enhanced, making work safer and energy use is limited to necessary expenditures.

8.3.4 Good sash management

Fume hoods with VAV controllers use the most air and energy when the sash is open. Additionally, an open sash limits the safety features of that sash. When closed, the fume hood contains contaminants better and provides good splash protection. Good sash management can be achieved in two ways:

1. Users shut the sash when not actively working (Section 9.1.1).

   Even when face velocity setback measures are engaged, shutting the sash enhances safety and reduces energy consumption.

2. Install Automatic Sash Closure (ASC) devices. ASCs use a proximity sensor to detect when a user is at the hood face. Following a prescribed amount of time after the user leaves, the sash will lower. Optical sensors detect if there are objects in the sash path.

   ASCs or other fume hood energy management measures are mandatory in some situations (Appendix 10.4). ASCs and face velocity setback are not employed in tandem - select one. For greatest safety and energy management payback, ASCs are preferred to unoccupied face velocity setback.

8.3.5 Horizontal sliding sash

Horizontal sliding sashes limit the open area of the fume hood face to a smaller maximum opening than vertical sliding sashes. Limiting the open area reduces the amount of air and energy used.

Provided proper use (Section 9.1.1), horizontal sliding sashes may also be safer than vertical types for the following reasons:

1. A smaller face opening may contain contaminants better.
2. A single sash panel should be placed in front of the user. When used this way, the sash can provide splash protection for the entire torso and head of the user.

8.3.6 Decommission unused hoods

Hoods that are unused for long periods of time (e.g., longer than one year) may be candidates for decommissioning. Decommissioning should be considered carefully as chemical fume hoods are required or recommended for most work with chemicals and may be expensive to install. Contact EH&S (650-723-0448) prior to decommissioning fume hoods.

8.3.7 Modified ASHRAE 110 testing

The ASHRAE 110 test is strongly recommended for commissioning chemical fume hoods and is required for commissioning hoods that use an unoccupied face velocity setback mode (Section 8.3.2, Appendix 10.1). The standard ASHRAE 110 test uses sulfur hexafluoride (SF6), which is a potent greenhouse gas (GHG). To mitigate this impact, Stanford strongly encourages that nitrous oxide (N2O) be used - this is referred to as the modified ASHRAE 110 test.

Cal/OSHA approved a variance for Stanford to perform the modified test with N2O, but the instrument detection performance specifications are rigorous. While the modified test is preferred, selection of any vendor other than TSS must be approved by EH&S, which will evaluate the vendor’s SOP and instrument performance to ensure compliance with the variance.

ASHRAE 110 records must be retained for five years.

8.4 Vivaria Measures

Animal housing rooms often require high air change rates to control allergens and odors. Allergens can be well-controlled by housing animals in individually ventilated cages operated in negative pressure mode (Section 6.5). The improved odor/allergen control can also allow the general ventilation rate of the room to be operated at levels required for animal welfare.

8.5 Clean Room Measures

Clean rooms are suites or rooms designed to have very low air particle concentrations to allow for sensitive work, like chip or wafer production. These areas can consume large amounts of energy to maintain the environment. By applying the following measures, energy consumption can be minimized, and the clean room environment maintained at appropriate levels for the type of work (i.e., chemical use, particle count levels).

8.5.1 Right-size room classification

Select the highest room classification necessary for the type of work (i.e., an ISO class 5 is preferred to an ISO class 4, where feasible). Lower nominal-level clean rooms have lower particle counts and therefore consume more energy.

8.5.2 Vary room classification within a suite

Clean room suites typically have a wide variety of work with a range of room specifications. Energy consumption can be minimized, and all specification goals met by varying room classification within a suite to match the needs of the type of work conducted in each room.

8.5.3 Unoccupied filtration setback

Despite preventive actions like gowning, most particulate matter in clean rooms is brought in by and on users. When users are not present, particulate counts are expected to be lower. Fan speeds on the filters may be reduced when occupants are not present, as detected by occupancy sensors. Please note that setback of once-thorough general room ventilation is described in Section 8.2.2.

8.5.4 Demand-control particle filtration rates

Particle counters may be used to signal fan speed to increase or decrease particle filtration rates so that clean room specifications are met in a dynamic manner. This measure can reduce energy use when particle counts are low, and improve clean room performance when particle counts are high.

8.6 Implement Continuous Commissioning

Continuous Commissioning (CCx) leverages findings from regular preventive maintenance, sensors, remote monitoring, and building automation to identify ventilation issues and correct them quickly. Stanford’s CCx program uses new analytic and fault detection tools and a Scrum/Agile workflow to resolve ventilation problems that are identified by Skyspark fault detection algorithms.

9. Training and Use

9.1 Proper ECD use

Engineering controls like Exposure Control Devices (ECDs) are designed to function properly and provide adequate protection with minimal additional effort on the part of the user. However, the protective capabilities of all ECDs can be limited by improper use. Additionally, users can take simple steps to minimize the energy use of their ECDs. Correct use of fume hoods and BSCs is described here; for all other ECDs, follow manufacturer’s instructions.

9.1.1 Laboratory Fume hoods

Training on the correct use of laboratory fume hoods is found in the Chemical Safety for Laboratories course (EHS-1900 in STARS), which is required for chemical users engaged in research work. Laboratory fume hoods are most protective and use the least amount of energy when:

- Insert only hands and arms into the fume hood, **never** put the head or face in.
- The sash is kept as low as feasible during work and no higher than the operating height arrow that is marked on the side.
- The sash is closed when not actively using the fume hood.
- Work with hazardous materials is performed at least 6 inches from the front opening (the face).
- The amount of aerosols generated in the fume hood are limited, typically by using the minimum quantity, closing containers, and capturing aerosols and vapors in a trap.
- Equipment and bulky objects are kept elevated from the benchtop surface to allow air to easily flow under and to the back of the hood.
- Quick motions near the fume hood are limited. Move hands and arms in and out of the hood slowly and limit motion nearby, like people walking past the fume hood.
- If operable windows are present, they must remain closed. Local fans must be kept away from fume hood openings to minimize cross-drafts.

9.1.2 Biosafety Cabinets

Correct use of Biosafety Cabinets (BSCs), also known as tissue culture (TC) hoods is described in detail in the Biosafety Cabinet Use and Safety factsheet and training is provided in the Biosafety course (EHS-1500 in STARS). The Biosafety course is required for all employees, students, and others who use biological materials, including recombinant DNA. The following is notable information for safe and energy efficient use:

- Insert only hands and arms into the BSC, **never** put the head or face in.
- Confirm the BSC has been tested and certified in the past 12 months by checking the sticker above the sash (every 6 months in BSL3 facilities).
- BSCs are not fume hoods and must not be used with hazardous volatile chemicals. Limit use of hazardous volatile chemicals in recirculating BSCs that discharge to the room to no more than 1mL. Up to 10 mL of these substances may be used in BSCs with a ducted or thimble connection to discharge the air.
- Turn on the BSC for at least three to five minutes before beginning work to “purge” the interior. Keep the sash open whenever the BSC blower is on to prevent undue stress on the motor and increase the service life.
- Disinfect the surface with alcohol prior to work.
- Move arms in and out slowly, perpendicular to the face opening to reduce disruption of the air curtain.
    - Minimize movement around the BSC.
- Perform all operations at least 4 inches from the front grille on the work surface. Never place objects on the grille, which will disrupt the air curtain. Work as far back as practical and keep aerosol-generating equipment (e.g., vortexers, centrifuges) near the back.

- Never use an open flame in the BSC, which can disrupt the protective airflow patterns and may void the manufacturer's warranty.
- A vacuum flask system is the recommended method to protect a central building vacuum system during the aspiration of infectious fluids in the BSC.
- For BSC clean-up, apply an appropriate disinfectant using wipes instead of spray bottles to minimize solvent vapor concentrations being re-circulated in the hood. Keep the cabinet sash open to allow for alcohol evaporation, at least 10 minutes.
- Turn off the blower and close the sash.
- UV lamps are not recommended nor required. If disinfection with UV lamps is desired, turn the lamp on only when the sash is shut, stay as far away from the sash as feasible, and turn the lamp off after no more than 30 minutes.

9.1.3 Maximize effectiveness of general laboratory ventilation

Laboratories are designed with sophisticated ventilation systems to remove contaminants and provide a safe, healthy, and comfortable work environment. To maximize the effectiveness of general laboratory ventilation and minimize energy consumption:

- Use the smallest quantity and least hazardous material that is feasible for the work.
- Use point exhaust (local exhaust at the source) for work with hazardous materials (i.e., minimize work on the open bench).
- Keep lab doors closed.
    - Laboratories are designed so that air flows from areas of low hazard to high hazard. When doors are left open, the desired pressure differential and containment may be lost.
- Separate laboratory and office space in different rooms.
    - Separating lab and office space provides a functional barrier to minimize or eliminate potential exposure to airborne hazards. Labs also use large quantities of once-through air, while offices use less air, which also may be recirculated. By reducing the footprint of the lab, energy is saved.

9.2 Recognition of service need

Building managers, facilities staff, safety staff, and lab owners & users are responsible for recognizing when ECDs require maintenance. Indicators of service need include:

- Air flow monitors (AFM) or other sensors are alarming and cannot be silenced by operating the ECD properly.
    - Unplugged AFMs may also indicate that users were unable to silence the alarm and inappropriately continued work and/or took the sensor out of service.
- Visible damage to the sash or surfaces. Cracked sashes and damage or corrosion to surfaces.
- Sash is difficult to move. Sashes should require no more than 5 pounds of force to operate.

10 Appendix - Operational Tools

10.1 Commissioning

10.2 Certification - Performance Standards

10.2.1 Fume hoods

10.2.2 Gas Cabinets

10.2.3 Biosafety cabinets

10.3 General Exhaust Ventilation Setback Instructions

10.4 Memo - Title 24 Requirement for Fume Hood Automatic Sash Closure