UTSA Laboratory Safety

BIOLOGICAL SAFETY CABINET GUIDE

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Purpose

The aim and scope of this document are to establish guidelines for the Biological Safety Cabinet use, along with training protocols at UTSA. All employees or students who may utilize a biosafety cabinet in the course of their duties should familiarize themselves with this document. Non-UTSA individuals are not permitted to use biosafety cabinets owned by the University unless they have received appropriate training. This Program and Procedures encompass all types of biosafety cabinets, including Class I, Class II, and Class III cabinets. Users of biosafety cabinets must be capable of identifying and mitigating potential hazards and must understand safe practices for installation, storage, relocation, and operation of this equipment. Biosafety cabinets are indispensable tools for various laboratory activities, providing a controlled environment for working with potentially hazardous materials. However, the improper use of biosafety cabinets can lead to serious illness, contamination, or fatalities. It is crucial for all individuals working with biosafety cabinets to be aware of these hazards and to implement appropriate safety measures to mitigate risks effectively.

A. The following document outlines the proper protocols for utilizing a biosafety cabinet as well as annual certification requirements and service protocols. All individuals who use a biosafety cabinet at UTSA must adhere to these procedures.

B. This document covers the types of cabinets and the proper techniques for working in them.

C. This policy also covers guidance in selecting new cabinets and the procedure for decommissioning old biosafety cabinet equipment.

Responsibilities

A. **Principal Investigator:** Individual responsible for ensuring that biosafety cabinets are certified and that all researchers working in laboratory are informed on biosafety cabinet procedures and bloodborne pathogens training.

B. **Lab Safety Staff:** Lab Safety is responsible for advising researchers on biosafety cabinet purchasing, recertifications, procedures for use and service.

C. **Institutional Biosafety Committee (IBC):** This committee reviews, sets policy and provides oversight of recombinant DNA work and biohazardous materials used on campus.

D. **Facilities Management:** Responsible for notifying Lab Safety before moving Biosafety Cabinets. BSCs must be decontaminated before moved and taken out of service until recertified.

Definitions

I. **Biological Safety Cabinet (BSC):** A BSC is the primary barrier protection for individuals working with biohazardous materials. Laboratory procedures that could create airborne biohazards should always be performed in a BSC as it protects the laboratory workers and the environment from aerosols or droplets that could spread biohazardous material. The common element to all classes of BSCs is the high efficiency particulate air (HEPA) filter. This filter removes particles with aerodynamic diameters of 0.3 microns (the most penetrating particle size) with an efficiency of 99.97%. Particles with aerodynamic diameters both larger and smaller than 0.3 microns~ which includes the majority of bacteria and viruses- are removed with virtually 100% efficiency. It is important to note, however, that HEPA filters are "particle filters" that do not remove vapors or gases.

II. **Laminar Flow/Clean Benches:** Laminar flow/clean benches are devices that look similar to a biosafety cabinet, but only protect the product from contamination. These devices direct air toward the operator and should never be used for handling biological, hazardous, toxic, or sensitizing materials.

III. **Chemical (Fume) Hoods:** Chemical (Fume) hoods are designed for working with chemicals and should never be used for handling biological materials. Biological materials may not be effectively contained within the hood, leading to potential exposure for laboratory workers and cross-contamination with surrounding areas.

IV. **Certification**: Certification involves performance and safety tests that are conducted annually by an NSF-49 certified outside contractor to ensure that the biosafety cabinet is working according to the NSF-49 Safety Standard. These tests include measurement and/or correction of air velocities, patterns, balance, HEPA filter leakage and filtration system efficiency.

V. **Environmental Protection:** Any aerosol generated within the biosafety cabinet is removed from the air by HEPA filters before the air from the cabinet is discharged either inside or outside the facility.

VI. **Personnel Protection:** Any aerosol generated within the biosafety cabinet is contained within the cabinet and away from the person doing the work.

VII. **Product Protection:** Air at the work surface of the biosafety cabinet has been filtered so that it is free of airborne particles and organisms that could contaminate the work.

VIII. **Air Curtain (Barrier):** The unidirectional movement of air parallel to the plane of opening and at a velocity greater than that on either side, thereby creating an impedance to transverse movement of airborne particulates through the opening.

Use

Biosafety Cabinet Operational Procedures:

1. Ready the work area. Operate cabinet blowers for five minutes before beginning work to allow the cabinet to purge or remove particulates from the cabinet.
2. Disinfect the work area. Wipe the work surface, interior walls, and surface of the window with a suitable disinfectant such as 70% ethanol, 10% bleach solution, an iodophor, or quaternary ammonium compound.
3. Assemble material. Introduce only those items that are required to perform the procedures and arrange them in a logical order. Each item should be wiped with a disinfectant prior to placing it into the cabinet to reduce the introduction of contaminants. The flow of work should proceed across the work surface from clean to contaminated areas. Similarly, pipette tip discard trays containing disinfectant, biohazard bags, sharps containers, etc., should be placed to one side inside the BSC.
4. Wear protective clothing. Laboratory coats or solid front gowns should be worn over street clothing and long-cuffed latex or other appropriate gloves (e.g., nitrile, vinyl) should be worn for hand protection. The cuffs of the gloves should be pulled up and over the cuffs of the coat sleeves.
5. Perform procedures slowly by moving items in and out of the cabinet using a straight in and out motion and avoiding side to side motions. Avoid rapid movements. After placing arms/hands inside the BSC, manipulations should be delayed permitting the cabinet to stabilize and allow the flow of air to remove surface contaminants from your arms/hands.
6. Do not block the front grille with paper, equipment, etc., as this may cause air to enter the workspace area instead of being drawn through the front grille and into the HEPA filter. Arms should be raised slightly, and operations should be performed on the work surface at least four inches from the front grille. The middle third area is ideal. Likewise, no operations or equipment should block the rear exhaust grille. Any equipment generating aerosols such as a microcentrifuge, vortex or blender should be placed near the rear of the cabinet. A disinfectant-soaked towel can be placed on the work surface to contain any spills or splatters that may occur.
7. Open flames inside the cabinet create turbulence that can disrupt the pattern of air and compromise the safety of the operator and affect product protection (i.e., cause contamination). Flames can also damage the interior of the cabinet

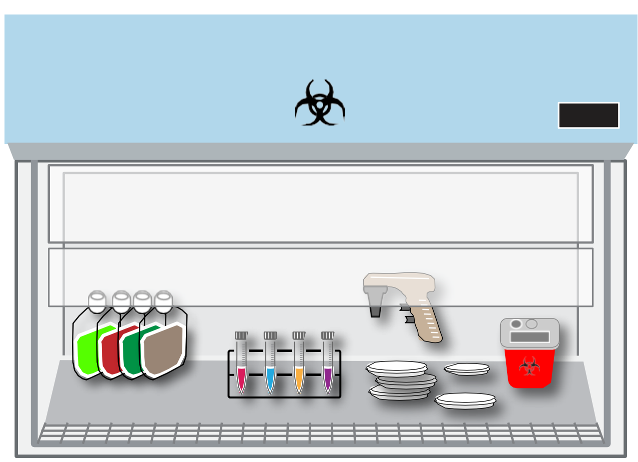
as well as the HEPA filters. For this reason, open flames are not allowed in any biosafety cabinet at UTSA. To sterilize tools such as a loop or needle, consider the use of disposable, sterile tools. (See Section 4.9 Dangers of Natural Gas)

8. If culture media or other fluids need to be aspirated, suction or aspirator flasks should be connected to an overflow collection flask containing disinfectant (the aspirated materials can then be discarded as noninfectious waste).
9. When work is completed all items within the cabinet should be wiped down with disinfectant and removed from the cabinet. Do not use the interior of the BSC as a storage area since stray organisms may become "trapped" and contaminate future experiments. The interior surfaces of the cabinet should be cleaned with a disinfectant. Let the blowers operate for five minutes with no activity inside the cabinet to purge the cabinet of contaminants.
10. Investigators should remove their gowns and gloves and thoroughly wash their hands before exiting the laboratory.

How to use a biosafety cabinet properly?

a. Set up the workflow from “clean to dirty.” (FIG 3)
b. Limit movement of “dirty” items over “clean” ones.
c. Place materials 3-5 inches away from front and back grills; set sash at 8-10 inches above base.
d. Minimize hand movements inside the cabinet.

FIG 1: How to set up the BSC for work.



When to use a biosafety cabinet?

BSCs are always required for manipulations of airborne transmitted pathogens (e.g., influenza virus), biological materials that are likely to create aerosols, and when working with high concentrations of infectious agents.

How to clean and disinfect a biosafety cabinet?

a. Use appropriate disinfectant for a required contact time.
b. Use a final rinse of 70% EtOH to remove any residual bleach or disinfectant.

Registration of Biosafety Cabinets

BSCs are required to be listed in SciShield or Campus Optics under the Lab Equipment tab. Model number, Serial number, Room location, PI, Contact Person, and Certification Tag information should be listed.

Biosafety Cabinet Annual Certification

All BSCs at UTSA must be certified annually by an authorized contractor. The Laboratory Safety Division coordinates this testing annually. Currently, the BSCs on campus are certified by an external contractor. The certifications follow the NSF/ANSI 49 standard for biosafety cabinets. The contractor will test down flow and inflow velocities, air flow patterns, the HEPA filter and perform a cabinet leak test to ensure that the BSC is working properly. The Lab Safety Division maintains a complete inventory of BSCs, including historical certification and Service records in SciShield or Campus Optics.

Lab Safety Division will pay for ONE testing/recertification for each BSC on campus per fiscal year (Sept 1-Aug 31), unless repair requires recertification. If a PI moves a BSC within the same fiscal year after certification, then the PI will be responsible for paying for the 2nd testing/recertification of that BSC within the FY in addition to the decontamination and moving services.

Guidelines for when BSC certification must be performed:

1. Before initial use of brand new BSC to verify the cabinet is effective.

2. After moving BSC from one location to another, even if it is just a few inches, it is very easy to compromise the containment system.
3. After replacement of HEPA filters or repair of internal components (i.e. blower motor)
4. At least annually to assure that the filters are not plugged, damaged, or leaking.
5. After possible contamination.
6. Following a large spill or accident inside the BSC.
7. When requested by Lab Safety/Biological Safety Manager.

Guidelines for when a BSC Testing results in a Failure:

1. The BSC must be placed out of service and have appropriate signage.
2. Lab Safety Division will obtain quote for repairs/remediation ASAP.
3. Lab Safety Division will obtain Purchase Order and forward it to contractor to schedule the repair ASAP.
4. After repairs are done, recertification if needed.
5. If BSC is not able to be repaired or no longer supported by the manufacturer, the BSC will be taken out of service.
6. Records of these actions are to be maintained in SciShield or Campus Optics.

Guidelines for Calling for Service for BSC:

To save time/money from unnecessary service calls, before calling for Service:

1. Check that the BSC is properly plugged into the wall outlet.
2. Check for Alarm notices on the display. Some units have safety features that will alarm for any alarm condition such as UV light, window low/high, Blower RPM failure, airflow pressure alarm, power on reset, etc.
3. Check for recent power outages. Many B2 cabinets have safety features that will lock the unit/prevent it from being turned on if there is power interruption. This is to keep air which is unable to be removed out of the building from coming back into the cabinet. Try resetting the breaker box if there is a recent power outage.
4. Check with Facilities to see if they are working on the ventilation system. Facilities sometimes work on fans on the roof without notifying building occupants. This interruption of airflow could cause the B2 to shut down. Call Facilities (ext. 4262 or after hour ext. 5277) to see if they are working on the building exhaust fans on the roof.

Training- Use of Biological Safety Cabinets

Since BSCs are one of the most critical pieces of equipment to protect the user, as well as the product and the environment, it is important to understand how BSC functions and their limitations. The effectiveness of the BSC depends on proper use, appropriate work practices, continued maintenance, and annual certification. To support the BSC training provided by the PI, the Lab Safety Division also provides online BSC awareness training as part of the Biosafety training module.

Classification – Biological Safety Cabinets

Class I BSC's are not used very often but tend to be used to enclose equipment or procedures which have the potential to generate aerosols. They provide an inward flow of unfiltered air, similar to a chemical fume hood, which protects the worker from the material in the cabinet. The environment is protected by HEPA filtration of the exhaust air before it is discharged into the laboratory or to the outside via the building exhaust.

Class II BSC's are the most common type of BSC and can be used with biosafety level 1, 2 and 3 agents. Class II (Types A2, B1, B2, and B3) biological safety cabinets provide personnel, environment, and product protection. Air is drawn around the operator into the front grille of the cabinet, which provides personnel protection. In addition, the downward laminar flow of HEPA-filtered air provides product protection by minimizing the chance of cross-contamination along the work surface of the cabinet. Because cabinet air has passed through the exhaust HEPA filter, it is contaminant-free (environment protection), and may be recirculated back into the laboratory (Type A) or ducted out of the building (Type B).

Class III BSC's are designed for working with level 4 agents and provide maximum protection. The cabinet is gastight with a non-opening view window and has rubber gloves attached to ports in the cabinet that allow for manipulation of materials in the cabinet. Air is filtered through one HEPA filter as it enters the cabinet, and through 2 HEPA filters before it is exhausted to the outdoors. This type of cabinet provides the highest level of product, environmental, and personnel protection.

TABLE 1: Classification – Biological Safety Cabinets

Type	Face Velocity (lfpm)	Airflow Pattern	Radionuclides/Toxic Materials	Biosafety Levels	Product Protection
Class I open front	75	In at front; rear and top thru HEPA filter	NO	2,3	No
Class II, Type A2	100	70% recirculated thru HEPA; exhaust through HEPA	No	2,3	Yes
Class II, Type B1	100	30% recirculated thru HEPA; exhaust thru HEPA; hard ducted	YES	2,3	Yes
Class II, Type B2	100	No recirculation; total exhaust via HEPA; hard ducted	Yes	2,3	Yes
Class II, Type B3	100	Same as IIA, but plenum under negative pressure to room; exhaust air is ducted	Yes	2,3	Yes
Class III	NA	Supply air inlets and exhaust thru 2 HEPA filters	Yes	3,4	Yes

Location of Biological Safety Cabinets within the Laboratory

The ideal location for the BSC is remote from the entry (i.e. the rear of the laboratory away from foot traffic), since people walking parallel to the face of a BSC can disrupt the air curtain. The air curtain crated at the front of the cabinet is quite fragile, amounting to a nominal inward and downward velocity of 1 mph. Open windows, air supply registers, portable fans or laboratory equipment that creates air movement (e.g. centrifuges or vacuum pumps) should not be located near the BSC. Similarly, chemical fume hoods must not be located close to BSCs.

Dangers of Natural Gas use in a Biological Safety Cabinet

BSCs are designed to protect workers, their products, and their environment. Certain BSCs recirculate air within the cabinet. Most BSCs at UTSA are recirculating. Open flames are not required in the near microbe-free environment of a BSC. On an open bench, flaming the neck of a culture vessel will create an upward air current which prevents microorganisms from falling into the tube or flask. An open flame in a BSC, however, creates turbulence which disrupts the pattern of HEPA-filtered air supplied to the work surface. The use of natural gas or other flammable gases within these BSCs may allow flammable gases to concentrate, potentially leading to an explosive atmosphere.

The use of open flames within a BSC may alter the airflow pattern used to protect product and personnel. This table outlines which BSCs recirculate air and the procedures to increase safety and prevent flammable gas explosions within BSCs.

TABLE 2: BSC's recirculate air.

BSC Type	% Recirculated Air
Class II Type A1	**70**
Class II Type A2	**70**
Class II Type B1	**30**
Class II Type B2	**0**

BSCs that recirculate air are commonly found at UTSA. To determine the type of cabinet, locate the unique serial number on the cabinet which will also contain the BSC type. If unable to locate this information, contact Lab Safety for assistance, LabSafety@utsa.edu.

i. Use of gas in BSCs has led to fires, compromised HEPA filters, destroyed cabinets, and injured workers.
ii. Certain types of BSCs are designed to contain, not exhaust, most of the air within a cabinet. This makes them prone to the buildup of materials within a cabinet.
iii. If a gas leak occurs (e.g. valve left on or tube leak) inside a recirculating biological safety cabinet, over time the gas would become more concentrated and could reach explosive levels. Since it is within a BSC, the user may not detect the leak and, upon ignition, it could explode. Therefore, natural gas or other flammable gases should not be used within recirculating BSCs.
iv. The high efficiency particulate air (HEPA) filters, responsible for providing a sterile environment in the cabinet, can act as a dense mass of combustible material during an uncontrolled fire inside the cabinet.
v. The heat convection currents generated by the open flame compromise the carefully controlled airflow pattern responsible for protecting product and personnel.
vi. Heat generated by an open flame can damage the HEPA filter and/or the filter's adhesive. This can produce leaks in the filter, adverse flow patterns in the cabinet and potential user exposure.
vii. Use of an open flame within the BSC inactivates manufacturer's warranties on the cabinet. Cabinet manufacturers will assume no liability in the event of fire, explosion, or worker exposure due to the use of flammable gas in the cabinet. Additionally, the UL (Underwriters Laboratories) approval will automatically be voided.
viii. Regulatory and Manufacturer Recommendations:

NIH/CDC: National Institutes of Health and the Centers for Disease Control and Prevention: "Open flames are not required in the near microbe-free environment of a biological safety cabinet. On an open bench, flaming the neck of a culture vessel will create an upward air current which prevents microorganisms from falling into the tube or flask. An open flame in a BSC, however, creates turbulence which disrupts the pattern of HEPA-filtered air supplied to the work surface."

NSF/ANSI Standard 49: Service valves allow inert gases, air, or vacuum lines to be plumbed into the BSC. Although many users connect gas to a service valve in the cabinet, this practice should be avoided because open flames in a Class II BSC disrupt the airflow, and there is the possibility of a buildup of flammable gas in BSC's that recirculate their air.

<u>The Baker Company (BSC manufacturer)</u>: The Baker Company does not endorse the use of flammable gases within BSCs under any conditions. There are alternatives to open flames such as small electrical incinerators, use of disposables, and proper aseptic technique.

<u>NuAire (BSC manufacturer):</u> NuAire doesn't recommend the use of natural gas within the BSC and assumes no liability for its use. USE AT YOUR OWN RISK. The Bunsen burner flame within the BSC not only contributes 8 to heat build-up; it also disrupts the laminar air stream, which must be maintained for maximum efficiency. If the procedure demands use of a flame, a Bunsen burner with on-demand ignition is strongly recommended. Do not use constant flame gas burners. During use, the Bunsen burner should be placed to the rear of the workspace where the resulting air turbulence will have a minimal effect.

Natural gas and flame use in BSCs

UTSA concurs with the national and international agencies mentioned above and does not support any natural gas use or open flame use in any BSC on UTSA campuses, even those with 100% exhaust. Users are encouraged to switch to safer alternative methods.

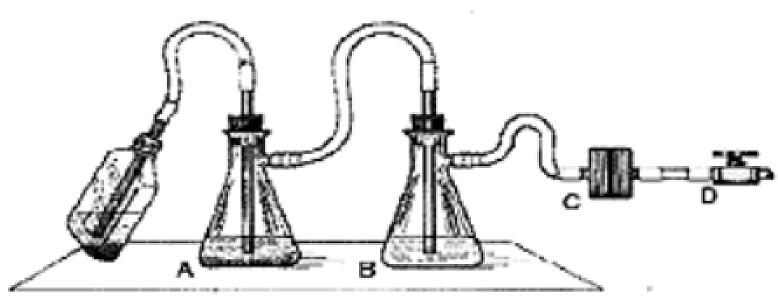
Protection of Vacuum Systems Used in Tissue Culture Work

When laboratory vacuum is used to manipulate biohazardous materials, a suitable trap should be employed to insure that building vacuum lines do not become contaminated. When house vacuum is used, the system should include in-line HEPA filter as near as practical to each point of use or service cock. An approved reservoir and filtration apparatus for vacuum systems is described below:

Vacuum filtration or aspirating supernatants into collection flasks are common laboratory procedures. During vacuum filtration or aspiration procedures building and/or laboratory vacuum systems should be protected. A simple bench-top aerosol/fluid trap can protect building/laboratory vacuum systems. The basic vacuum trap consists of a disposable cartridgetype filter or equivalent installed in-line with a collection/overflow vacuum flask system. The aerosol/fluid trap consists of one or two vacuum flasks, preferably plastic, (size dependent on amount of fluid that may accidentally be aspirated out of the collection flask), thick-walled plastic tubing (to prevent tubing collapse), rubber stoppers, and a HEPA a filter (prevents unwanted potentially biohazardous fluid and aerosols from entering vacuum systems. Use an appropriate disinfectant solution shown to be effective on the biohazardous material under study. When the filter or overflow flask requires routine changing, they can be safely removed by clamping the line between the filter and the vacuum source before disconnecting the tubing from the source. The filter and vacuum flask should be decontaminated by autoclaving if they have been in contact with potentially biohazardous material.

This is one method to protect a house vacuum system during aspiration of infectious fluids. The left suction flask (A) is used to collect the contaminated fluids into a suitable decontamination solution; the right flask serves as a fluid overflow collection vessel. A glass sparger in flask B minimizes splatter. An in-line HEPA filter (C) is used to protect the vacuum system (D) from aerosolized microorganisms. See diagram:

FIG 2: Primary Containment for Biohazard



CDC: Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets 2nd ed.

Suggested Product:

FIG 3: Whatman In-line HEPA filter protects the vacuum line from overflow.

NOTE: Each BSC that has a working vacuum line does have a large HEPA filter outside of the cabinet to protect the vacuum line. These large HEPA filters are installed and maintained by Facilities. However, The Whatman In-line HEPA filter is much easier and cheaper to replace. If there is overflow from the flask, it will be caught by the Whatman In-line filter before it gets to the larger filter outside of the cabinet.

Use of UV Light in a Biosafety Cabinet

i. Lab Safety recommends that BSCs be disinfected with the appropriate disinfectant (i.e., 10% bleach or 70% ethanol), instead of using UV light. UV light within BSCs is intended to destroy microorganisms in the air or on exposed surfaces. However, relying only on UV light may give personnel working in BSCs a false sense of security.
ii. The UV light attracts dust and debris and thus reduces the transmission of the germicidal effect. UV lights have limited penetrating power and are only effective when the lamps are properly cleaned, maintained, and checked to ensure that the appropriate intensity is being emitted. If UV lights are used, they must be tested yearly to ensure that the appropriate wavelength for decontamination is emitted (254nm). NSF, the certifying agency for BSCs stopped requiring the testing of UV lights, as they do not consider them an effective decontamination source.
iii. In addition, many people allow the UV light to surpass their effective life span. When the terminal ends are blackened even slightly, they have lost their effectiveness even though they still glow blue violet. If not used properly, UV light can also cause serious eye and skin injury. If UV lights are used within your BSC, it can be harmful to the eyes and skin and should therefore be turned off when occupying the room. UV light can bounce off the reflective surfaces inside the BSC and affect people and materials in close proximity.

Biosafety Cabinet Decontamination and Decommissioning

BSCs shall be decontaminated before the cabinet is: 1. relocated; 2. repaired; or 3. taken out of service. Decontamination is recommended as a prudent practice (1) after a gross spill of infectious material or (2) before the cabinet activity is changed from work with moderate-risk or high-risk infectious materials to work with noninfectious materials. All BSCs must be decontaminated prior to disposal. Lab Safety will coordinate with external contractor to have the biosafety cabinet decontaminated. Once Decontamination is completed, a tag will be placed on the unit. The Department will have to arrange with Surplus or Movers to have the BSC relocated or Surplus. Lab Safety will remove it from inventory in SciShield or Campus Optics.

Biological Safety Contact Information

- Mohammad Khan, Biological Safety Manager, 210-458-5807
- Kimberly Moore, Lab Safety Specialist, 210-458-6419
- Cynthia Galindo, Physical & Engineering Safety Coordinator, 210-458-6507

Key References

1. UTSA Biological Safety Plan
2. University of Massachusetts Amherst Biological Safety Cabinet Management Program, Document ID EHS.BSC.08.01
3. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention and National Institutes of Health. 2nd Edition Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets. Washington: US Government Printing Office, 2000.
4. University of Maryland, College Park, MD. Environmental Health and Safety Website: Biological Safety Cabinets Manual http://www.des.umd.edu/biosafety/rest/manual.pdf
5. CDC-NIH Guidelines, 2nd Edition of Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets: http://www.cdc.gov/od/ohs/pdffiles/BSC-3.pdf
6. World Health Organization's Laboratory Biosafety Manual
7. NSF/ANSI Standard 49, Biohazard Cabinetry; published by NSF International, P.O. Box 130140, Ann Arbor, Michigan 48113-0140, USA
8. NFPA 54, National Fuel Gas Code
9. NFPA 45, Standard on Fire Protection for Laboratories using Chemicals.
10. USC Environmental Health & Safety (https://ehs.usc.edu/fact-sheets/)

APPENDIX A: SUMMARY OF BSC PROGRAM EXPENSES

The Laboratory Safety Division will pay for the certification of BSCs on UTSA campuses to comply with NSF/ANSI 49 specifications.

Costs covered by the Lab Safety Division:

- Initial certification after installation of new BSC.
- Annual recertification, one time per fiscal year.
- Costs for repairs of BSCs, according to OSHA/NSF/ANSI Standards, and manufacturer's specifications, by an outside vendor using NSF 49 accredited technicians. Repairs include:
    - Troubleshoot visits
    - Sash repair/replacement
    - Decontamination for repair
    - Blower motor repair/replacement
    - Electronics repair/replacement (i.e., speed controller)
    - Any other costs associated with making the BSC pass certification requirements
    - Costs for recertification after major repairs

Costs NOT covered by the Lab Safety Division:

- Decontamination fee to relocate a BSC, surplus a BSC, or suspect BSC contamination.
- Facilities fee to relocate BSC.
- Recertification fee after BSC relocation, if BSC has been certified within the fiscal year.
- BSC disposal fee with external contractor.
- UV or Fluorescent bulbs and ballasts.

APPENDIX B: Chemical Fume Hoods, Ductless Fume Hood, BSCs, Laminar Flow Hood Diagrams and their mechanism

Figure 1. Chemical Fume Hood

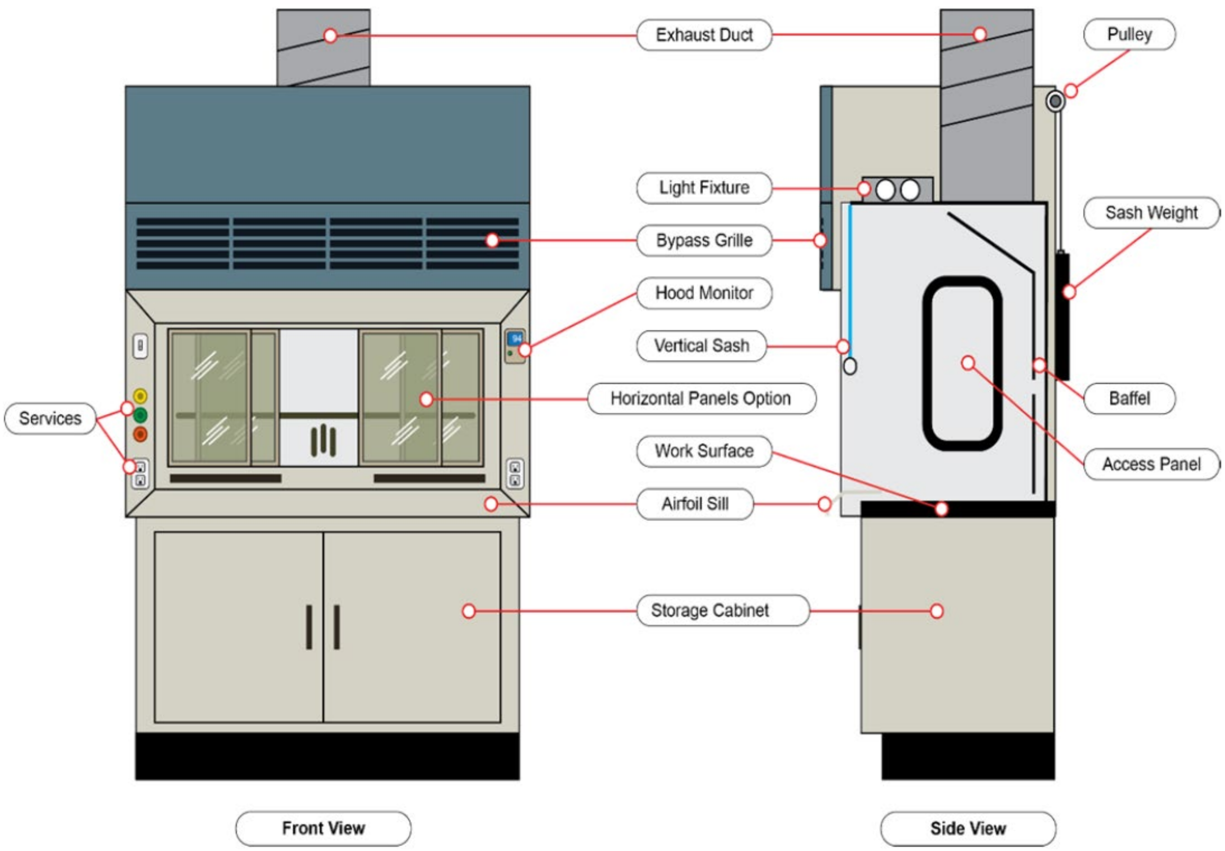


Figure 2. Ductless/Capture Fume Hood

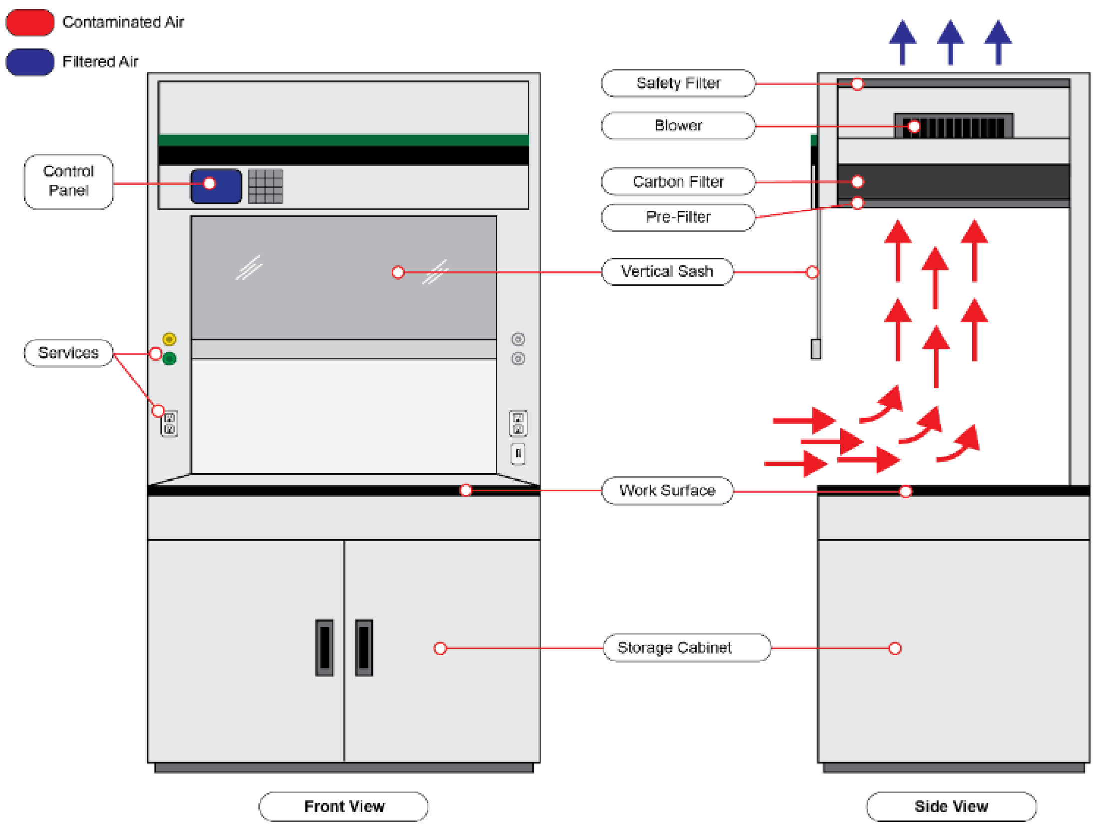


Figure 3. Biological Safety Cabinet Class II/Type A2

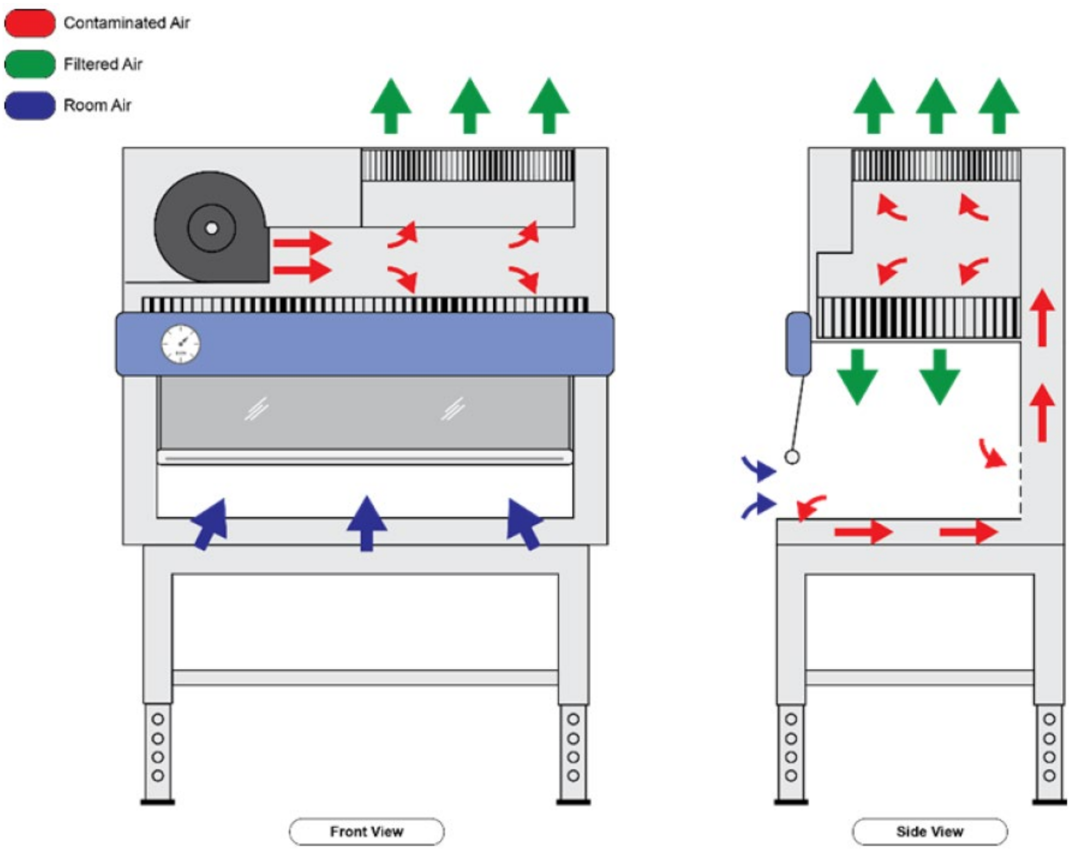
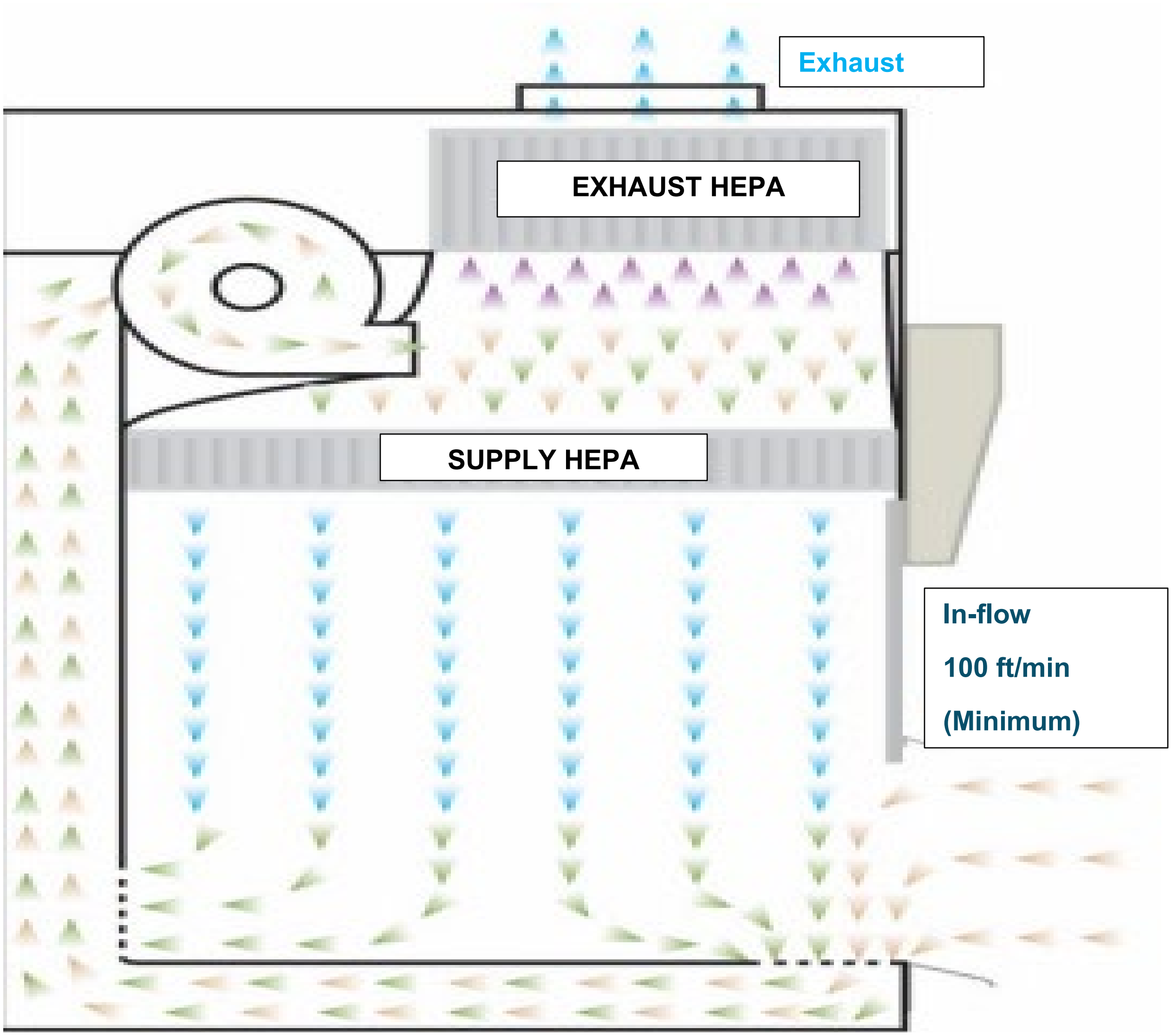


Figure 4: Air In-Flow 70% Recirculated, 30% Exhausted



- HEPA FILTERED AIR
- ROOM AIR
- CONTAMINATED RECIRCULATION AIR

Figure 5. Biological Safety Cabinet Class II/Type B2

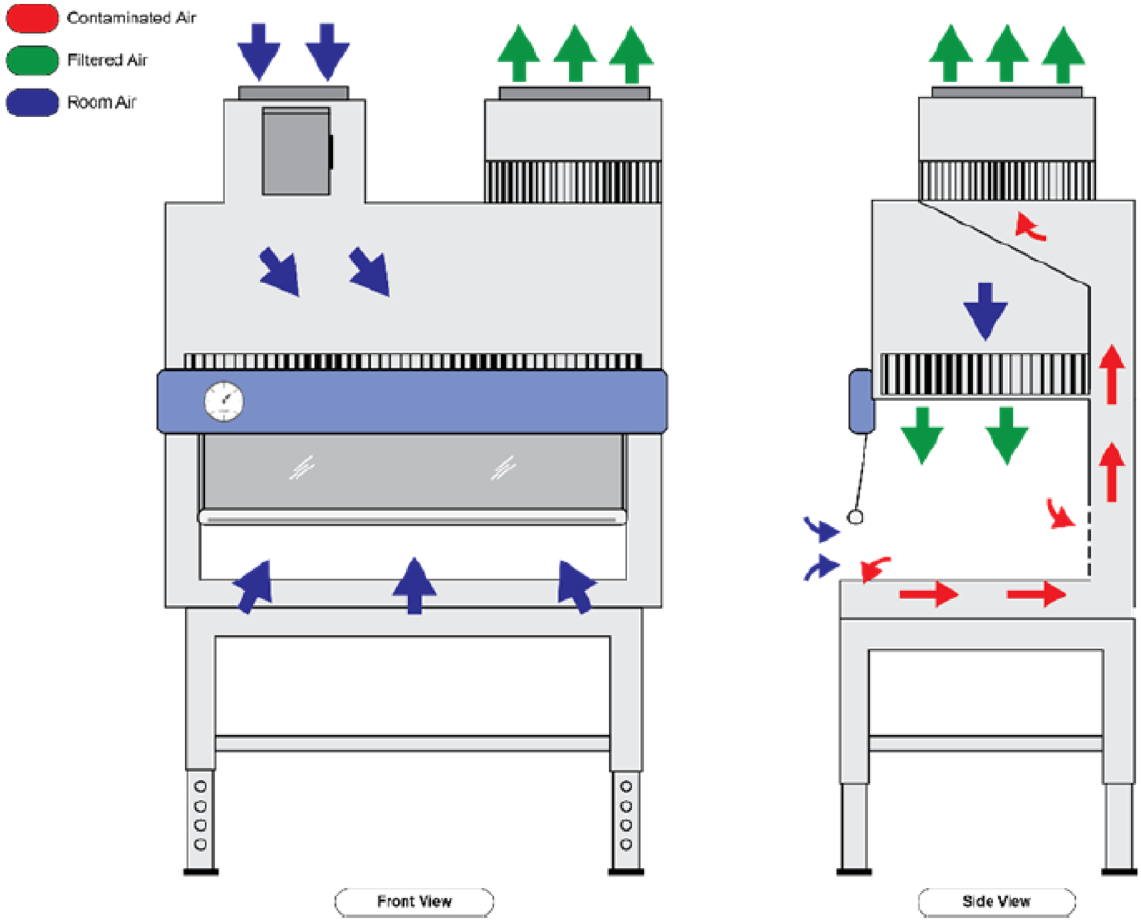


Figure 6: Laminar Flow Hood or Clean Bench