GUIDANCE

Laboratory Equipment – Containment and Extraction

This document outlines the differences between the several types of laboratory equipment for containment and extraction across our campuses i.e. laminar flow cabinet, biological safety cabinet, fume cupboard and glove box. While these may look similar their purpose, function, and operation differ significantly. This document will not only help you to distinguish between them but also choose the right equipment for the work you are carrying out.

The terms laminar flow cabinet, biological safety cabinet and fume cupboard are often used interchangeably and can cause confusion, knowing the type of enclosure needed and the terminology used will ensure:

- Protection of personnel
- Preserve integrity of your research
- Protection of the environment and workspace

The enclosure you select for various laboratory applications should be listed in the chemical and/or biological/ GM risk assessment.

Laminar Flow Cabinets

Laminar flow cabinets use High-Efficiency Particulate Air (HEPA) filter (HEPA filters, filter out any aerosols and particulates thereby preventing the release of hazardous biological materials into the environment). Laminar flow cabinets only protect the application or product from contaminants. They **do not** protect the laboratory worker. Therefore, they must not be used when handling potentially infectious or hazardous substances.

Laminar flow cabinets operate by directing clean, HEPA filtered air across the worksurface and towards the laboratory worker and as such should only be used for non-hazardous processes requiring a clean environment. Some variations also include UV light, which can be useful for molecular applications (DNA/ RNA work) where UV is used as a secondary decontamination step to avoid DNA contamination in reactions.

- **Horizontal:** Where the air is pushed through a HEPA filter and is directed horizontally across the worksurface, from back to front, towards the operator.
- **Vertical:** Where the air is pushed through a HEPA filter and is directed vertically from the top of the enclosure, from top to bottom, towards the operator.

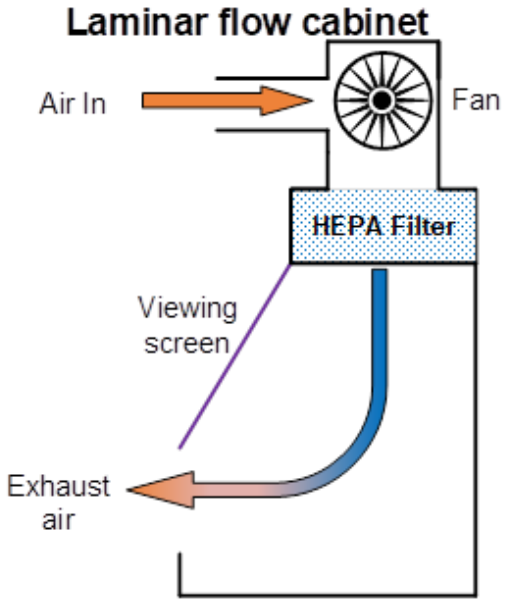

Figure 1: Image showing air flow in Laminar flow cabinet.

Laminar flow cabinet uses include, but not limited to:

- Media preparation
- Plant tissue culture
- Sterile non-hazardous work
- Non-pathogenic cell cultures
- PCR

Microbiological Safety Cabinets

The term microbiological safety cabinets (MSC)/ biological safety cabinets (BSC) can be used interchangeably, and both refer to the same piece of equipment. For this guidance note the term MSC will be used.

MSCs can be used to provide personnel, product and environmental protection for work involving hazardous biological particulates such as viruses and bacteria. They are designed to create a barrier between the laboratory worker and the potential hazardous material within the cabinet. All MSCs have one common feature, the exhaust air is passed through a HEPA filter. Filtered air may be released outside through ductwork (this is the preferred option) or recirculated into the workplace.

MSCs are broken down into three different classes offering different levels of biological protection.

- **Class I MSCs**: These are designed to provide personnel protection and environmental protection and do not provide product protection.
- **Class II MSCs**: These are designed to protect laboratory workers, the environment, and the product being handled.
- **Class III MSCs**: These offer maximum protection against highly infectious microbiological agents and hazardous operations.

These are covered in more detail below.

Class I Microbiological Safety Cabinets

Class I MSCs are designed to provide personal protection and environmental protection but do not provide product protection. This type of MSC is suitable for work with all categories of biological agent, except HG4.

Class I MSCs have a sash and work opening and operate under negative pressure. Unfiltered room air is drawn through the work opening away from the laboratory worker and across the work surface, the air is then filtered and exhausted.

Class I MSCs are typically used for, but not limited to:

- Culture aeration
- Tissue homogenization
- Enclose equipment such as centrifuges
- Where aerosols may be generated but product protection is not required

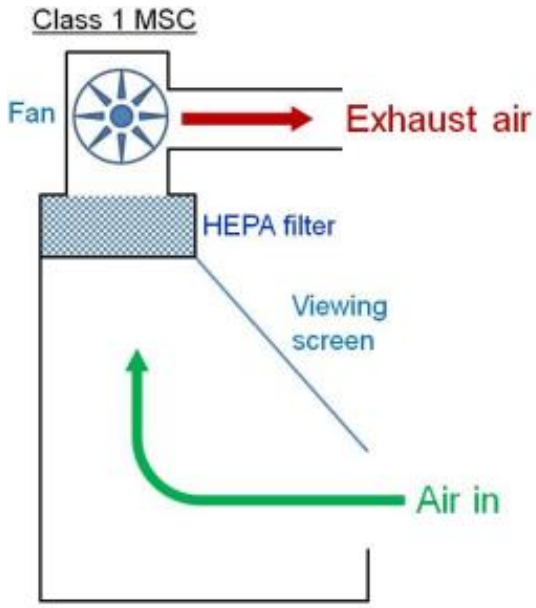

Figure 2: Class I MSC. Image from Edinburgh University Biosafety Training Institute Biosafety practitioner module D

Class II Microbiological Safety Cabinets

Class II MSCs are the most common type used within in the University, they are designed to protect laboratory workers, the environment, and the product being handled. This type of MSC is suitable for work with all categories of biological agent, except HG4.

Class II MSCs operate by drawing in air safely around the operator which flows under the work surface (providing personnel protection), and HEPA filtered air flows downward onto the work surface (providing product protection). The exhaust air is then HEPA filtered before it is either recirculated into the laboratory or released into the atmosphere through ductwork (providing environmental protection). HEPA filters are designed to trap particulates and infectious agents but do not capture volatile chemicals or gases. If the exhaust HEPA-filtered air is connected to laboratory ductwork venting outside, it can be used for handling odorous samples and limited amounts of volatile/ toxic chemicals (if they do not interfere with the work when recirculating).

The most common Class II MSCs used in the university are recirculating and are therefore only provide protection against biological agents, not chemicals.

Class II MSCs are typically used for, but not limited to:

- Any microbe (bacteria, fungi, virus, or prion agent) or eukaryotic cell line rated as risk group 2.
- Viral based vector systems.
- Fluids or tissue specimens from human or wild animals, including urine and faecal samples.
- Allergens associated with laboratory or wild animals, or their carcasses.
- Invasive plant species or genetically altered plant strain.

Class 2 MSC

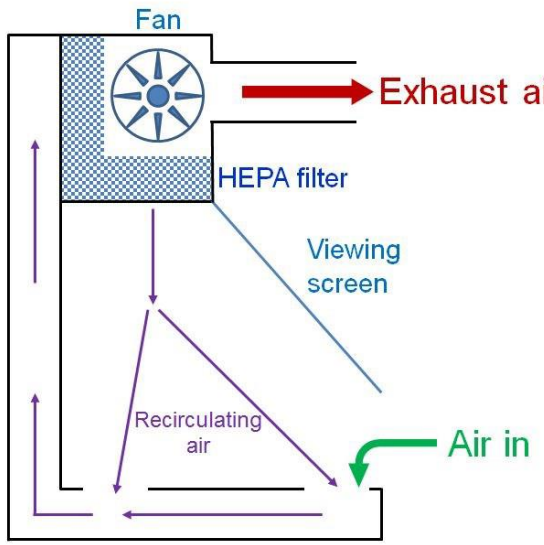

Figure 3 Class II MSC. Image from Edinburgh University Biosafety Training Institute Biosafety practitioner module D

Class III Microbiological Safety Cabinets

Class III MSC's, often referred to as glove boxes, provide a barrier between the user and the work area. They offer maximum protection against highly infectious microbiological agents and hazardous operations.

Class III MSCs are totally enclosed, gas tight enclosures where the laboratory worker is separated from the work by long heavy-duty gloves attached to ports allowing direct manipulation of materials isolated inside. They have a non-opening view window and are equipped with a dunk tank or a double-door pass-through box for the passage of materials. This setup ensures the safety of the environment and the worker by preventing the release of hazardous materials into the surrounding area.

Class III MSCs operate under negative pressure, which is maintained by an exhaust system exterior to the cabinet. This negative pressure ensures that if a breach occurs, the containment performance remains uncompromised, and the risk of exposure to hazardous materials is minimised. The supply and exhaust air, pass through HEPA filters, with the exhaust air passing through two HEPA filters or a HEPA filter and an air incinerator before being exhausted to atmosphere.

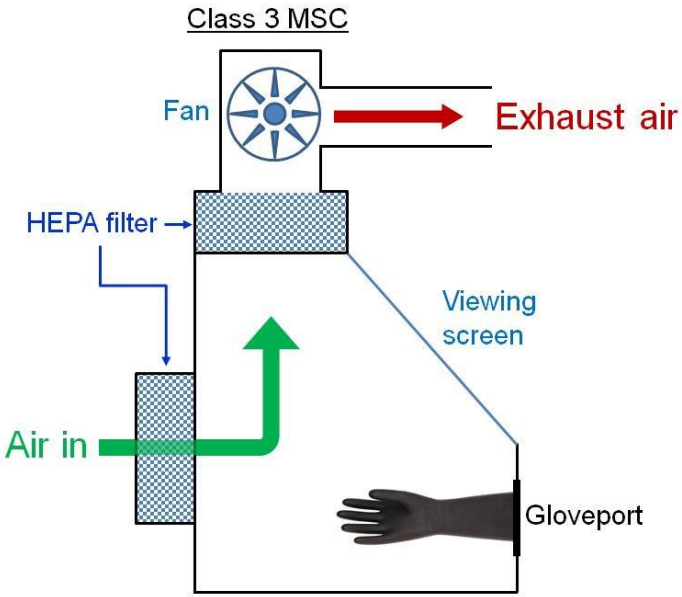

Figure 4 Class III MSC. Image from Edinburgh University Biosafety Training Institute Biosafety practitioner module D

Class III MSC's are crucial for working with:

- Any biosafety level 4 agents, other dangerous materials, such as aerosols of pathogens or toxins.
- Where certain strains of dangerous pathogens are handled e.g., multiple drug resistant.
- Where there is an airborne route of transmission for the Hazard Group 3 agent (e.g. Mycobacterium tuberculosis).
- Where a procedure is used which generates a significant aerosol.

Fume Cupboards

The term fume cupboard/ fume hood can be used interchangeably, and both refer to the same piece of equipment. For this guidance note the term fume cupboard will be used.

A fume cupboard is a ventilation system that provides protection of laboratory workers from hazardous chemicals including dusts, fibres, fumes, mists, gases, and vapour generated by laboratory experiments or procedures. They are usually made of steel or chemical-resistant polypropylene and have a sash that can be adjusted to control airflow into the cupboard.

Fume cupboards operate by drawing air into the cupboard from the laboratory through the sash opening, across the work surface and through ductwork. The airflow within the cupboard creates a barrier between the user and airborne contaminants, providing protection against inhalation exposure. The hazardous substances are contained in the cupboard and the air is either released and diluted into the atmosphere (ducted fume cupboard) or filtered and recirculated. Proper and undisrupted airflow is critical within a fume cupboard (see SOP-10101 Safe Use of ducted fume cupboard).

When using a fume cupboard that recirculates exhaust air it is essential that it has the correct type of filter fitted, this prevents contaminated air entering the laboratory. HEPA filters and a range of activated carbon filters and wet scrubbers are available.

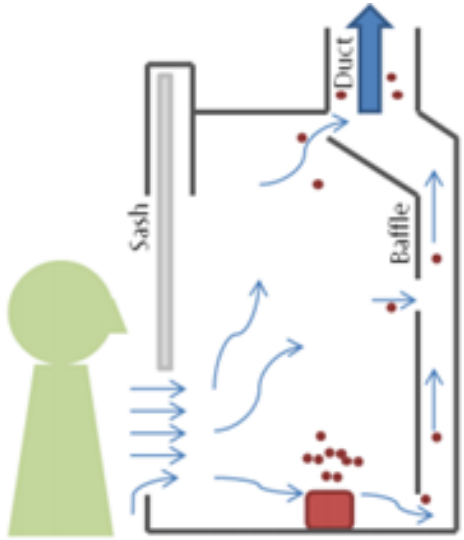

Figure 5 Fume cupboard.

Fume cupboards can be used to handle the following, but not limited to:

- Odorous materials.
- Toxic gases.
- Reactive materials.
- Corrosive, flammable, toxic and volatile materials.
- Chemicals that can spatter.
- Aerosols.

Glove Boxes

There are several different types of glove boxes, such as a chemical glove boxes or anaerobic boxes or chambers. A chemical glove box offers a higher level of containment than a fume cupboard and can protect (depending on type) the user from high hazard chemicals such as carcinogens/ mutagens. Anaerobic chambers are used for culturing anaerobic bacteria.

Glove boxes can be used to protect the user, the products/ substances handled and the environment. They are essentially a sealed container designed to fully protect the users while allowing them to manipulate objects within a specific environment or atmosphere.

Glove boxes have a main chamber which is the user's work area, it is hermetically sealed so no external air can leave or enter it. The chamber is accessed via a pair of gloves firmly attached to the wall of the glove box. Any instruments and products are transferred into the main chamber via one or more transfer locks which are integrated into the glove box, therefore eliminating any risk of containment failure. Some glove boxes also come equipped with an inlet and an outlet airlock to guarantee safety and avoid contamination.

Essentially the air inside is filtered or replaced with sterile air or inert gases which are passed into the chamber to provide the required work conditions/ atmosphere. This may be controlled by regulators and valves to allow the temperature and pressure (either positive or negative) to be adjusted, and sensors to allow the oxygen and humidity levels to be checked. The surplus air/ gases are exhausted externally usually through an appropriate filter or scrubber depending on the gases/ activities being used. Glove boxes used to protect users from hazardous chemicals should not be exhausted into the laboratory.

The two common types of glove boxes:

- **Isolation Boxes**: These work by containing positive pressure, providing an inert gas atmosphere to maintain product sterility.
- **Containment Boxes**: These work by containing negative pressure, where the air is exhausted out through an appropriate filter or scrubber and used when working with or where hazardous materials maybe produced such as vapours, fumes, or dusts.

Glove Boxes uses include, but not limited to:

- Working with hazardous chemicals such as carcinogens/ mutagens.

- Performing delicate tasks that require a sterile environment.
- Handling radioactive materials.
- Using anaerobic bacteria.

Summary

	Laminar Flow Cabinet	Biological Safety Cabinet / Microbiological Safety Cabinet	Fume Cupboard / Fume Hood	Glove Boxes
What is it used for?	To protect the product from environmental contaminants. Not suitable for infectious or hazardous substances.	To remove biohazard particles such as bacteria and viruses from the laboratory and environment.	To extract hazardous chemicals from the laboratory.	• To isolate hazardous chemicals/ materials from laboratory worker and environment. • To provide specific atmospheres.
Who/ what do they protect?	Product	User, Product and Environment	User	User, Product and Environment
Types	• Horizontal • Vertical	• **Class I** – Personnel Protection • **Class II** – Personnel and environment protection • **Class III** – Personnel, environment, and product protection	• Ducted • Recirculating	• Isolation • Containment
What are the common uses?	Media preparation, plant tissue culture, sterile non-hazardous work.	Microbiology, virology, handling hazardous biological material	Odorous materials, toxic gases, corrosive, flammable chemicals, reactive, toxic, and volatile materials	• Working with hazardous chemicals such as carcinogens/ mutagens, radioactive materials. • Performing delicate tasks that require a sterile environment.