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Factors to Consider When Selecting a Biosafety Cabinet

Introduction

Users often have a large choice when selecting a safety cabinet and may be confused by the multitude of features and design styles which are offered.

This article adopts the point of view that no safety cabinet design is perfect and seeks to independently and objectively explain the pros and cons of each design style, so that the user may make his or her own assessment in deciding which cabinet is more suitable for his or her own application and ergonomics.

Selection Based on Agents Used Inside the Cabinet

1. If the laboratory work involves only microbiological agents, then general type of biosafety cabinet can be used. The HEPA filter installed inside the cabinet is effective in blocking out bacteria and virus from escaping from the cabinet. Please be mindful of the biosafety level and the type of protection (operator or operator and product protection) required.

2. If both microbiological and trace amounts of non-corrosive chemicals are present, then a ducted biosafety cabinet must be used, because the HEPA filter can't block the chemical vapor, which if not ducted outside will accumulate in the lab, and create a hazardous situation.

3. If the work involves cytotoxic drug, such as cancer drug, then a Cytotoxic Safety Cabinet should be used. This cabinet is designed to protect the technicians who change the HEPA filter of the cabinet from exposure to cytotoxic agents embedded on the HEPA filter.

It should be noted that fume hood and laminar flow cabinets are not biosafety cabinets and should not be used when pathological microbiological agents are present.

Fume hood is designed to duct the corrosive chemicals outside the building but it's not equipped with HEPA filter so microbiological agents placed inside fume hood will be ducted outside, contaminating the environment.

Nevertheless, a ducted biosafety cabinet should not be used when corrosive chemicals are present because they will damage the HEPA filter and the blower of the biosafety cabinet. Meanwhile, fume hood uses corrosion resistant external plastic blower.

Laminar Flow cabinets are designed to provide only product protection by blowing a stream of HEPA-filtered clean air across the work zone, towards the operator. If airborne microbiological and toxic chemicals are present on the work zone, then they will be blown out straight on the operator's face, creating a very hazardous condition.

Selection Based on Biosafety Level

Selection of biosafety cabinet should also be done based on the degree of lethality and medium of transmission or the microbiological agents, which is classified under four categories of Biosafety Level (BSL):

	Lethality	Medium	Cure	Ex
1	Safe	Liquid	Yes	BS*
2	Some	Liquid	Some	HIV
3	Serious	Airborne	Some	TBC
4	Extreme	Airborne	None	Ebola

*BS: Bacillus Subtilis

Agents classified as BSL-1 and 2 can be handled on open bench, without Biosafety Cabinets, as long as there is no aerosol generation, or else a Biosafety Cabinet is still required.

Because BSL-2 agents can be transmitted via liquid, the user must be careful with handling sharp objects.

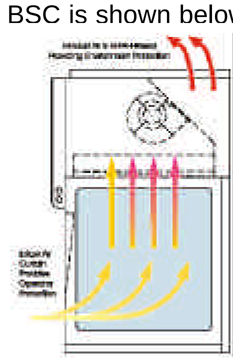
Tip-1: If a Biosafety Cabinet is used, then the user must select a cabinet that has <u>no sharp edges</u>, especially on the interior parts that has to be cleaned every day. If a user cut the finger when cleaning the cabinet, then he/she can get infected by lethal liquid-borne agents like HIV.

Selection Based on Biosafety Cabinet Classification

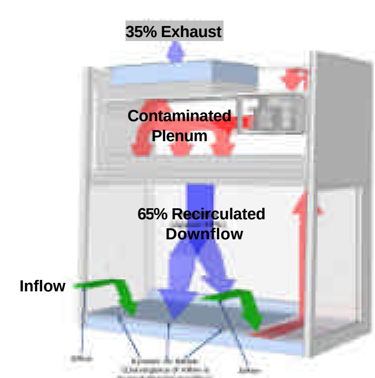
Based on the protection provided and the Biosafety Level the cabinet is suitable for, there are three different classes of Biosafety Cabinets (BSC):

Class	Protection	BSL
I	Operator	1-3
II	Operator & Product	1-3
III	Operator & Product	1-4

<u>Class I BSC</u> has inflow that gives operator protection but outside air will contact the sample on the work zone so it offers no product protection. Because of this application limitation, despite the cost is slightly less than Class II due to lower demand, many people are switching to Class II. Therefore, Class I cabinet availability in the market is limited. The airflow of a Class I BSC is shown below:

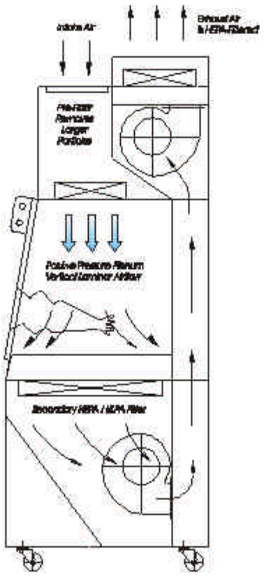


<u>Class II BSC</u> has inflow to protect the operator and a clean HEPA-filtered downflow to protect the product on the work tray as shown below. Because of dual protection offered Class II, is the widely used cabinet in the industry.



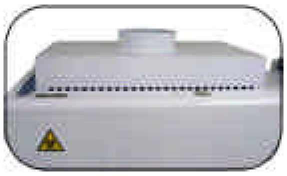
Tip-2: The old design Class II BSC, referred to Class II Type A1 by NSF 49:2002 standard, has the positively pressured contaminated plenum bordering the ambient air. This is a dangerous design because if the plenum wall sealant fails, the contaminated air will be pumped outside to the lab environment. It is highly recommended that the user choose the Class II Type A2 cabinet that has the positive pressure contaminated plenum surrounded by negative pressure provided by the blower. In this case, if the plenum wall is punctured or the HEPA filter gasket fails, then the leakage will be pulled back by the blower and will not escape outside.

Class III BSC has a completely closed front so work has to be done through integrated glove. The cabinet is hermetically sealed and materials come in/out the work zone thru double-door pass box. The product inside the cabinet is protected by a stream of HEPA-filtered air. The work zone itself is under negative pressure so contaminants are continuously removed from the work zone and filtered by an exhaust HEPA filter before passing a second HEPA filter as shown below or incinerator and finally the contaminants-free air is exhausted into the lab. This cabinet is used when maximum protection is required when handling BSL-4 agents such as Ebola, Junin, Marburg, Lassa, and Sabia virus.



Selection Based on Recirculation of Chemical Fumes

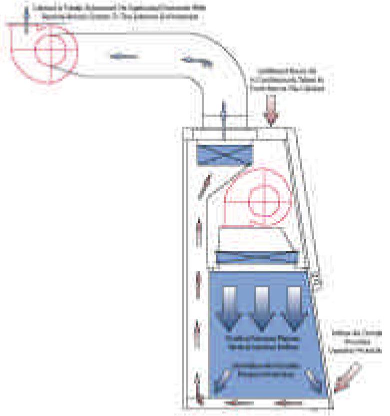
If the user allows recirculation of chemical fumes inside the work zone, then a Class II (European Norme 12469:2000 terminology) or Class II Type A2 (NSF:49:2002 terminology) can be connected to a thimble duct exhaust collar as shown below.



Thimble duct means that the collar has perforations to allow outside air to be pulled in as opposed to hard duct that has no holes. The exhaust collar is then connected to a duct tube connected to an external blower.

Why thimble duct must be used instead of hard duct? The Class II Type A2 can create its own balanced inflow and downflow using its internal blower. If this cabinet is ducted and the external blower suction is too strong, then the inflow become too strong and downflow become too weak, causing product protection failure. Therefore, the thimble duct must be used, where the extra suction will draw the air from the room and not from the cabinet's plenum.

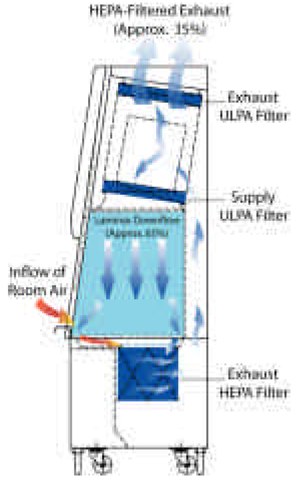
If no recirculation of the chemical fumes is allowed, then a Class II Type B2 cabinet with hard ducting shall be used. The cabinet's internal blower only provides downflow and the inflow is created by external blower. This cabinet is difficult to install and maintain because the external blower must be manually balanced with the internal blower, or else either the operator or product protection will fail.



Cytotoxic Safety Cabinet

The cytotoxic drug preparation, such as chemotherapy drug, requires product and personnel protection that are typically offered by Class 2 BSCs. In addition to that, cytotoxic drug is a very hazardous toxic that can endanger the service technician who performs the filter changing of the cabinet. Unlike microbiological agents, the cytotoxic agents can not be neutralized by decontamination using formalin or hydrogen peroxide vapor, thus still posing a lethal threat to the service technician even after decontamination has been performed.

The unique feature about the cytotoxic cabinet is that the first exhaust filter, located underneath the work tray, can be sealed and removed when the cabinet is still running, so the negative pressure protects the service technician.



Selection Based on HEPA Filter

One of the most important components of a BSC is the HEPA filter. Based on the construction the two different kinds of HEPA filters:

1. Filter with aluminium separator
2. Minipleat separatorless filter

Tip-3: The filter with aluminium separator is an old design where the filter media has to share filter area with the aluminium separator. This reduces the dust holding capacity and reducing the filter life. Moreover, the sharp aluminium separator used can damage the filter causing dangerous filter

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leakage. Typically this kind of filter has wooden frame construction that can swell when subjected to moisture. Many of the long established cabinets are still using this type of filter. Therefore, it is recommended to select a cabinet that use the modern minipleat separatorless filter has no aluminium separator so it has larger effective media area, longer life, no risk of damage from the aluminium separator, and it typically has aluminium frame that can resist moisture better than wood.

Based on the filter efficiency, the filter can be classified as:

1. High Efficiency Particulate Air (HEPA) filter that is 99.99% efficient at MPPS (typically at 0.30 micron).

2. Ultra Low Penetration Air (ULPA) filter that is 99.999% efficient at MPPS (typically at 0.12 micron).

MPPS: Most Penetrating Particle Size, which is the specific particle size to most easily penetrate the filter. This represents the worst case scenario for the filter, and the filter has higher efficiency at other particle sizes.

Tip-4: ULPA filter is 10 times more efficient than the HEPA filter, thus a cabinet with ULPA filter can provide better operator, product, and environmental protection.

Selection Based on Possibility to Block Inflow Grille

The operator and product protection is created by the air curtain from both the inflow and downflow that goes into the front air grille, so the user need to select a cabinet design that can prevent accidental blocking on the grille by operator arms or samples.

There are several ways to prevent the inflow grille blocking:

1. Use raised arm's rest
2. Put arm's rest above inflow grille
3. Curve the inflow grille up (like an A-shape)
4. Curve the inflow grille down (like a V-shape)
5. Put the inflow grille lower than the front nosing of the cabinet and the work tray.

Below is the picture showing a combination of raised arm's rest and curved inflow grille to prevent accidental blocking:

Selection Based on Airflow Alarm

There are different possibilities for alarms and control system used by biosafety cabinets:

1. Simple switches to turn on the blower and lights, LEDs, and a buzzer to indicate airflow failure when it's already fail.

2. Analog needle to indicate the airflow velocity. This gives a general idea how far is the current airflow velocity from fail point.

3. Digital microprocessor display that indicates the airflow velocity value in m/s or fpm. The more advanced system has an interactive micropro-cessor-controlled LCD screen that enables the user to diagnose the status of the cabinet and program different features such as setting the experiment timer.

Selection Based on Front Window Mechanism, Material, and Angle

BSC has different window mechanism:

1. Hinged window. The advantage is the ease to get the nominal aperture opening height because it is fixed. However, the operator must attach an optional front cover to cover the aperture when the UV light is on.

2. Manual sash window. The operator must observe the correct nominal window opening height, as indicated by guide mark and supported by sash alarm and standby (lights off) mode. The sash window can lowered all the way down before the UV light is activated.

3. Motorized sash window. This is similar to the manual sash window version, but the user just need to press one or two buttons to move the window. Typically, two buttons are used for safety to ensure that both of the operator's hands are outside the path of the traversing window.

If the sash window is accidentally smashed, containment failure will occur. However, some safety cabinets are equipped with laminated safety glass. As shown below, even if the glass is smashed, the laminated safety glass will retain it's shape, preserving containment

With respect to ergonomics, the front window can be:

1. Vertical window. This is common on older cabinets. It is easier to design to manufacture, but not very comfortable for the user.

2. Sloped window. Newer cabinet design employ this sloped window that provides better operator visibility into the work zone and increase the size of the work zone.

Selection Based on Cleanability

For safety, the BSC need to be surface decontaminated before and after use, and after a large spillage occurs. Therefore, the Cleanability

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factor plays an important role in selecting a Biosafety Cabinet:

1. Single piece vs. divided tray
The single piece tray can be formed to contain spillage so it won't drip down to the drain pan as shown below. However, the single piece tray is heavy.

The divided tray is lighter to lift so it's easier for the user to dean the drain pan, but it can not contain spillage as good as the single piece tray as shown below:

2. Smooth radiused curves and angle are easy to clean:

3. The surface behind the sash window needs to be easily cleaned. This can be accomplished by tilting the sash window up as shown below:

Selection Based on Ergonomics

To provide operator comfort for working for an extended period of time in a day, there are several ergonomics considerations to bear in mind when selecting a biosafety cabinet, for example:

1. Position and angle of the display and control panel. A control panel located on the middle of the cabinet is easier to see and reach, especially for left-handed people rather than if its' located on the right corner of the cabinet.

2. The light intensity of the cabinet shall exceed 1000 lux but with minimal glare for proper yet comfortable illumination of the work space

3. Position of the UV light that is not on direct line of sight of the operator, to avoid eye irritation.

Selection Based on Testing

There are several standards in the world that govern the testing procedure of the biosafety cabinets. The two major international standards:

1. NSF 49:2002. The National Sanitation Foundation (NSF) International is a non-profit organization based in Ann Arbor, Michigan. Standard 49 is used in the United States but also adopted by customers from other countries such as China and South America.

2. The European Norm (EN) 12469 is the latest international standard developed as a direct consequence of the European Union's harmonization efforts. It replaces previous standards such as the German standard DIN 12950, the British standard BS 5726 and the French standard NF X44-201.

Although the testing procedure between those two standards are quite similar, the NSF49 standard is generally more stringent than EN 12469 by having a more detailed downflow grid, higher inflow requirement, lower noise level limit, and more stringent microbiological performance envelope testing as well as pressure leak testing.

The microbiological test is the ultimate test because it determines how well the cabinet provides operator and product protection by using life bacteria, as it is primarily intended to be used for. There are three tests performed:

1. Operator protection. A stream of 100-800 million bacteria is sprayed behind the front window and no more than 10 of them should escape through the front opening of captured by agar plate/impingers, even when the downflow is raised and inflow is lowered.

2. Product protection. A stream of 1-8 million bacteria is sprayed in front of the window and there should be less than 5 of them captured on the agar plates covering the entire work zone, even when the inflow is raised and downflow is reduced.

3. Cross contamination. A stream of 10-80 thousand bacteria is sprayed at one side of the cabinet and no more than 2 of them should land on the agar plates placed 14 inches (35 cm) from the cabinet side wall.

Because of the realistic nature of the microbiological test, it is highly recommended to select a cabinet that has passed these tests.