Biological Safety Cabinets: For Your Safety and for Research Protection

Today's Biological Safety Cabinets (BSCs) are highly effective at controlling and containing aerosols and some cabinet types can even contain volatile compounds. The U.S. Centers for Disease Control and Prevention (CDC) classifies BSCs into three classes (Table 1). These classes and the types of BSCs within them are distinguished in two ways: the level of personnel and environmental protection provided and the level of product protection provided. The most commonly used BSCs are Class II cabinets due to their ability to offer protection to both the user and the sample(s) being worked with. These cabinets are used to work with infectious microorganisms, research applications involving the use of sterile tissues, cell cultures, helping to maintain sterility of cell lines, along with efforts to minimize cross-contamination, for example. In order to maximize the laboratory productivity while maintaining the highest level of safety, these cabinets have become a crucial component within laboratories.

CABINET TYPES

NSF International (formerly the National Sanitation Foundation), a non-government organization that develops standards and certifies materials for different applications, designated three classes of BSCs: Class I, Class II, or Class III (Table 1) and four types of Class II BSC: Type A1 (formerly A), Type A2 (formerly A/B3), Type B1, and Type B2 (Table 2). Each type's requirements are defined by NSF/ANSI 49 Standard (2009). About 95% of all BSCs installed are Type A2 cabinets. From the 54 BSCs currently in use at UT Arlington, 98% are Type A2 cabinets.

Table 1: The Classification of BSCs

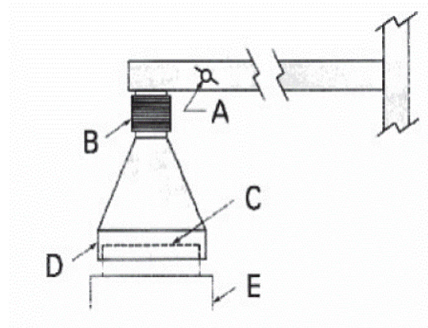
BSC Class	Protection Provided	Biosafety Level
I	Personnel and environment, but no product/sample protection	1 – 3 – Suitable for working with moderate to severe potential hazards
II	Personnel, environment, and product/sample protection	1 – 3 – Suitable for working with moderate to severe potential hazards
III	Personnel protection against highly infectious microbiological agents and hazardous materials. Maximum protection is provided for the environment and worker	3, 4 – Suitable for working with severe, exotic, and dangerous potential hazards

Table 2: The Types of Class II BSCs

Class II, Cabinet Type	Exhaust	Work with volatile toxic chemicals and radionuclides
Class II, Type A1	HEPA-filtered BSC exhaust returned to the room	Not suitable
Class II, Type A2	HEPA-filtered BSC exhaust returned to the room	Not suitable
Canopy connected, Class II, Type A2	HEPA-filtered BSC exhaust air is completely exhausted through the canopy connection, and vented out of the building	Minute quantities allowed as an adjunct to microbiological stidies
Class II, Type B1	HEPA-filtered BSC exhaust air is completely exhausted through the direct duct, and vented out of the building	Minute quantities allowed as an adjunct to microbiological stidies
Class II, Type B2	HEPA-filtered BSC exhaust air is completely exhausted through the direct duct, and vented out of the building	Allowed as an adjunct to microbiological stidies

Class II, Type A2 BSCs are the most commonly used cabinets in biosafety level (BSL) 1, 2, and 3 laboratories. Type A2 BSCs are designed with higher inflow velocities of 100 ft/min to help control hazardous gases and vapors more effectively than Type A1 cabinets. Air is drawn from the front and rear grills under the work surface, up inside the rear wall and into the blower plenum. From this space, the contaminated air is pulled into either the down flow blower or the exhaust blower. Therefore, part of the air is exhausted into the laboratory and part is recirculated back into the BSC chamber. Type A2 BSCs can also be connected to a "thimble" duct or canopy hood, allowing use with minute quantities of volatile toxic chemicals and trace amounts of radionuclides (Pictures 1 and 2).

Picture 1. Canopy (thimble) unit for ducting a Class II, Type A BSC



Picture 2. A. balancing damper, B. flexible connector to exhaust system, C. cabinet exhaust HEPA filter housing, D. canopy unit, E. BSC.

Note: There is a 1" gap between the canopy unit (D) and the exhaust filter housing (C), through which room air is exhausted.

Due to their ease of installation and reliable design, recirculated Type A2 cabinets (see Picture 3) are recommended for particulate contamination and hazards including biological agents (viruses and bacteria) at BSLs 1, 2, and 3. However, the preferred choice when using minute quantities of toxic chemicals are the canopy connected Type A2 BSCs. BSCs can also be hard connected to the building exhaust system as seen in Picture 4.

Picture 3: Class II, Type A2 BSCs at UT Arlington

Picture 4: Class II, Type A2 BSCs hard connected to exhaust

The primary purpose of a BSC in a biolaboratory is to protect the laboratory worker and the surrounding environment from pathogens. All exhaust air is HEPA-filtered as it exits the BSC, removing harmful microorganisms. This is in contrast to a laminar flow clean bench, which blows unfiltered exhaust air towards the user and is thus not safe for work with pathogenic agents. Neither are most BSCs safe for use as fume hoods. Likewise, a fume hood fails to provide the environmental protection that HEPA filtration in a BSC provides. However, most classes of BSCs also have a secondary purpose: to maintain the sterility of materials worked inside.

MEETING THE STANDARDS

NSF International (www.nsf.org) uses a consensus process described by the American National Standards Institute (ANSI) to develop the NSF/ANSI Standard 49 'Class II (laminar flow) biosafety cabinetry.' This standard has been developed to minimize the hazards inherent in working with agents assigned to BSL 1, 2, or 3. This standard defines a Class II BSC as "A ventilated cabinet for personnel, products, and environmental protection having an open front with inward airflow for personnel protection, downward HEPA filtered laminar airflow for product protection, and HEPA filtered exhausted air for environmental protection." As such, this standard includes basic requirements for design, construction, and performance. Therefore, standards for BSCs have been developed, which need to be met by manufacturers in order to ensure the highest quality and safety standards. Therefore, the emphasis of the NSF is on demonstrating the successful containment of biological aerosols.

CONTAMINATION CONTROL

Contamination is a major issue associated with all experimental procedures in biolaboratories. Contaminating microorganisms can be detrimental to important experimental data, furthermore, as the air is circulated, there is always the possibility of the user inhaling contaminants carried in it. It is also essential to prevent contamination of the air exhausted out of the building which can have potentially harmful effects on the environment.

HEPA FILTERS

Control of airborne particles became possible with the development of high efficiency particulate air (HEPA) filters which can effectively remove microscopic contaminants from the air. The use of filters is critical in preventing the spread of airborne bacteria and viruses, and therefore in the prevention of infection. HEPA filters are generally rated as being at least 99.97% effective at removing 0.3 µm-sized particles. A typical HEPA filter is made of a single sheet of borosilicate fibers treated with a wet-strength water-repellent binder. The filter medium is pleated to increase the surface area, and may be divided by corrugated separators. Careless handling of the filter can damage the medium, resulting in leaks and reducing its efficiency. For this reason, filter integrity must be certified after a BSC is initially installed and after it has been relocated.

ULTRAVIOLET LIGHT

Ultraviolet (UV) lights, often regarded as biocidal devices, are a common accessory in many BSCs. The CDC does not recommend the installation of UV lamps in BSCs and the American Biological Safety Association supports this position, citing the safety risk to personnel, shallow penetration of UV light, reduced effectiveness in high relative humidity, and the frequent need to clean and replace the bulb. Even when UV light is used for contamination control in BSC, work surfaces need to be decontaminated with an appropriate liquid decontaminant before beginning work and after completion of the experiment in a BSC. Some users prefer the addition of a UV light to help ensure decontamination. After finishing work, the window of the BSC needs to be closed before the UV light is activated.

WORK PRACTICES

As with work on open bench tops, work performed within a BSC must be performed carefully and safely. To avoid contamination and the risk of personnel exposure, the CDC advises investigators to follow best practices to reduce and control splatter and aerosol generation, such as keeping clean materials at least 12 inches (30 cm) from aerosol-generating activities and arranging the work flow "from clean to contaminated". It is advisable to avoid the use of open flames in a BSC because they can cause disruption of the airflow inside the cabinet and jeopardize the contaminate-free environment of the BSC.

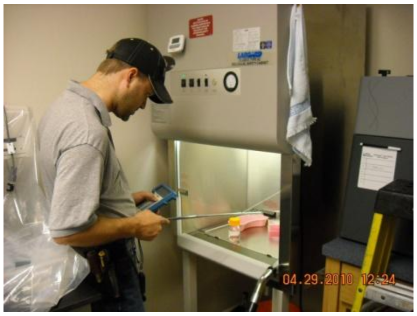
Before a BSC is relocated or HEPA filters replaced, the cabinet must be decontaminated. Gas decontamination involves filling the BSC with a poisonous gas, most commonly formaldehyde gas (Pictures 5 and 6).

Picture 5: BSCs being prepared for gas decontamination

Picture 6: BSCs tightly sealed and ready for gas decontamination

MAINTENANCE/ SERVICE

BSCs need to be maintained regularly. During this check, the air flow (Picture 7) and the filter capacities (Picture 8) are controlled. The filters have a limited life time. Depending on the lab environment and the type of samples used, the filter air flow-through is reduced over time. Recent cabinets measure the air flow-through constantly. If the flow-through is too low, there will be an alarm. Changing the filter needs to be limited to trained persons as the filter is potentially contaminated. When an UV light is used, this lamp should be checked and changed as well. UV lights decrease their power over time, resulting in suboptimal disinfection of the working area.



Picture 7: Certification Technician checking the air flow of a BSC **Picture 8:** Certification Technician checking the HEPA filter of a BSC

The CDC and the National Institutes of Health (NIH) recommend in Biosafety in Microbiological and Biomedical Laboratories, Fifth Edition (revised 2009), that BSCs be certified at the time of installation, any time the BSC is moved, has a filter replaced, and annually thereafter. This certification ensures that a BSC is in a good working order.

Environmental Health & Safety Office (EH&S) keeps an inventory of BSCs on the UT Arlington campus, monitors due dates, sends reminders to the principal investigators for the annual certifications, and maintains these records. Compliance with the safety guideline of annual certification for BSCs (and any new units purchased), repair maintenance, replacement parts and/or decontaminations of BSCs is the responsibility of the UT Arlington departments, including payment. EH&S needs to be notified at 817-272-2185 when any new BSCs have been purchased.

Keeping biological safety cabinets in good working order makes UT Arlington a safer place to work and learn!

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