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Demystifying Biological Safety Cabinets – Getting the Most Out of the Primary Engineering Controls Used in Microbiology Laboratories

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Abstract

In an effort to protect operators from biologic and other laboratory hazards and often to protect the in-process materials from the operator, engineering controls (EC) have been developed and evolved over the years. Engineering controls eliminate or reduce the potential exposure of a product or hazard through the use of engineered equipment or machinery.

Introduction

A primary engineering control (PEC), such as a fume hood or biological safety cabinet (BSC), is applied at the "point of use." The secondary engineering control, the facility design, is designed to facilitate the operation of the PEC. For example, in a sterile manufacturing facility, the PEC, such as a laminar flow workbench, is placed in a clean room. In a microbiology laboratory, the PEC, such as a BSC, is placed in a biological safety level 2 (BSL2), BSL3, or BSL4 laboratory (1).

The principal PEC used in microbiology laboratories is the BSC. Unfortunately, the BSC has been around for so long that users often take for granted that they will always work and that every BSC is appropriate for all applications. BSCs can be quite effective, but only if properly chosen, correctly installed, and appropriately set up and maintained. This article will analyze the different types of biosafety cabinetry available, along with the proper venting options and the rationale for proper selection. We will then describe the role certification has in assuring proper setup and performance from installation through decommissioning.

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Basic Concepts

BSCs are described in detail in NSF/ANSI 49 (current version 2004a) (2) and the CDC/NIH booklet *Primary Containment for Biohazards: Selection, Installation, and Use of Biosafety Cabinets* (3). This article is intended to summarize the information contained in those documents and to relate field experience to assist in applying the information.

BSCs are divided into three different classes based on function and design. All three classes use airflow through high-efficiency particulate air (HEPA) filters to protect the environment from particulate hazards and, in some cases, to provide an ISO (International Standard Organization) class 5 (class 100) clean work environment. In situations where volatile materials are used, external venting is required due to the limitation of the HEPA filters. Prior to review of the three classes of BSCs, HEPA filters and airflow are discussed.

HEPA Filters

The HEPA filter is the cornerstone of all BSC designs. The Institute of Environmental Sciences and Technology publishes a series of recommended practices for contamination control. Recommended practice IEST-RP-CC001.4 (4) is the current national guide for purchasing and specifying HEPA filters. This document defines a HEPA filter as "a throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle collection efficiency of 99.97% (that is, a maximum particle penetration of 0.03%) for 0.3-micrometer mass median diameter particles when tested in accordance with MIL-STD-282" (5). It is important to understand that the 0.3 µm size rating is for a "mass median" diameter particle. Traditionally, HEPA filters have been tested with mass-concentration devices (aerosol photometers). Some European filter manufacturers and, more recently, some domestic manufacturers have been rating HEPA filters with discrete-particle counters. When particle counters are used, we should refer to a "count median"

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particle size. HEPA filters are rated for their ability to filter out the most penetrating particle. A penetrating particle is any particle that makes its way through the HEPA filter.

HEPA filter manufacturers refer to the most penetrating particle size (MPPS), when efficiency testing filters. When using particle counter technology, the MPPS is generally referred to as being "between 0.1 and 0.2 µm count median diameter" (compared to 0.3 µm mass median diameter for filters tested with a photometer). It is easy to envision how particles larger than the MPPS are filtered more effectively through impaction, interception, and sieving. What people generally do not understand is that particle collection through diffusion actually favors particles smaller than the MPPS. Therefore, HEPA filters are rated at the size where penetration is at its worst case (MPPS). It is inaccurate to state "down to 0.3 µm," because particles below that size are generally removed at a higher efficiency than the filter rating.

HEPA filters have been proven effective in removing most any particulate contamination. For example, they have been shown to be very effective in removing virus particles that are smaller than 0.3 µm (6). They are not, however, effective at filtering gases and vapors. This is why BSCs used with volatile materials must be vented outdoors. Cabinet designs are influenced by the degree to which volatile materials are used.

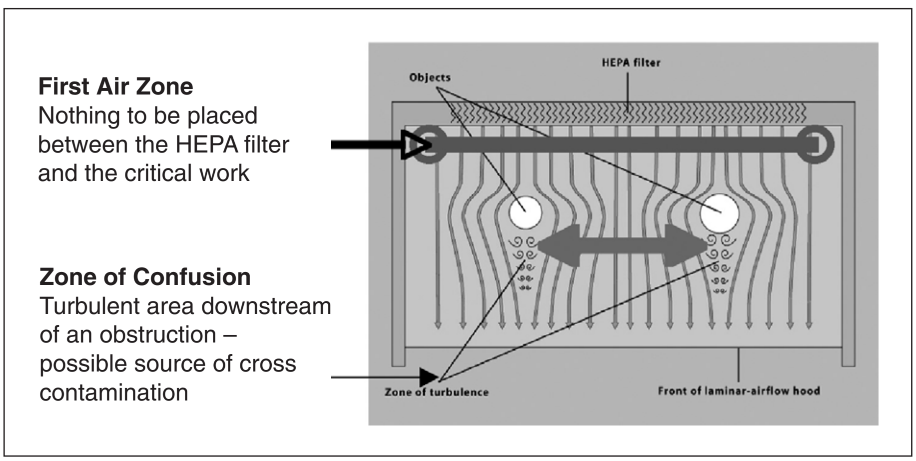
NSF standard 49 specifies the use of either a type "C" or "F" filter per the IEST-RP-CC001 document. The current version of IEST-RP-CC001 lists 11 filter types, "A" through "K." The type "C" filter is 99.99% efficient against 0.3-µm mass median diameter particles and is also leak tested using polydispersed aerosol. The efficiency test determines the overall efficiency at the MPPS, while the leak test is intended to find individual points of penetration at all sizes. Type "F" filters use a particle counter efficiency test for a minimum of 99.999%, when tested at the lower end of the efficiency at either 0.1 to 0.2 µm or 0.2 to 0.3 µm particle size.

Unidirectional Airflow

Cabinet classes differ as to how they manipulate the internal airflow depending on the intended purpose of the cabinet. The specific airflow pattern used for each class of cabinet is discussed in the cabinet classification section below. The design characteristic that is common for all cabinets that depend on a sterile work environment is unidirectional airflow (laminar flow). By definition, unidirectional airflow is air that flows in a single pass in a single direction through an air device or clean zone with generally parallel streamlines. By showering the work area with uniform airflow and using well-placed air returns, process-generated contamination can be controlled and environmental contamination eliminated from the work area. All class II cabinets use unidirectional airflow as an integral tool for good aseptic technique. Using the concepts of "first air," nothing is ever placed between the HEPA filter and the critical work zone. This area is bathed with a unidirectional shower of particulate-free air, maintaining a contamination-free process. By proper positioning of the product within the work zone, unidirectional airflow can also be used to prevent cross-contamination within the work zone.

Cabinet Classification and Venting Requirements

Cabinet selection is based on the needs of your operation. Many different airflow configurations are available to accommodate a variety of needs. It is important to select the appropriate design for your application. The biggest source of problems associated with biosafety cabinets is related to venting outside the building. External venting is expensive and often stressful to the building HVAC (heating, ventilation, and air conditioning) system. An externally vented BSC becomes an integral component of the building ventilation system, and its performance, therefore, is dependent on the performance of the building as a whole. If your application does not require external venting, select a cabinet that vents back into the room.



The only application that can truly justify external venting is one in which volatile materials may be used. External venting is not necessary for *Mycobacterium tuberculosis* or any other biological agent. The HEPA filter will protect the room from any viable particulate hazard.

All of the BSCs described here can be used for work with biological agents assigned to BSL1 through BSL4, depending on the facility design. It should be noted that BSL4 agents should only be used in maximum-containment laboratories and that class I and class II cabinets are only acceptable in maximum-containment laboratories when operators are wearing one-piece positive-pressure containment suits.

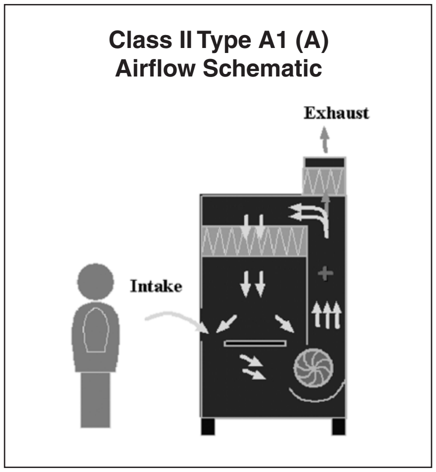
Class I BSC

The class I cabinet provides personnel and environmental protection but no product protection. Unfiltered room air is drawn across the work surface and discharged to the outside atmosphere or back into the room after passing through a HEPA filter. Traditionally, class I cabinets relied on an external blower to generate all of the airflow, ensuring the entire ductwork would operate under negative pressure. More recently, class I cabinets have been introduced with an internal blower that allows venting back into the room. External venting is only needed for applications using volatile materials. If a class I cabinet with an internal blower is vented outside the building, it should be connected to the building exhaust system with a canopy connection. Class I cabinets with no internal blower must be connected to a traditional "hard" connection. A hard connection is often referred to as a "direct connection," where the duct is sealed to the hood. class I cabinets are suitable for work where no product protection is required.

Class II BSC

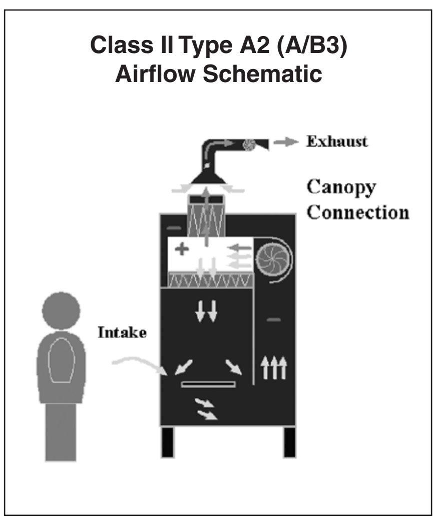
NSF/ANSI 49 describes a class II BSC as a ventilated cabinet for personnel, product, and environmental protection having an open front with inward airflow for personnel protection, downward HEPA-filtered laminar flow for product protection, and HEPA-filtered exhausted (either back into the laboratory or outside of the building) air for environmental protection. There are four types of class II cabinets.

Class II Type A1 BSC (prior to 2002, designated Type A)



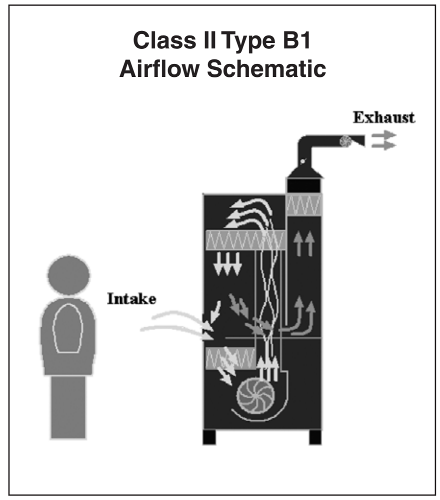
The Type A1 cabinet has HEPA-filtered downflow air that is a portion of the mixed downflow and inflow air from a common plenum. The type A1 cabinet is the only class II cabinet that may have external contaminated plenums under positive pressure relative to the room. It is also the only class II cabinet that can have an intake velocity as low as 75 fpm (0.38 m/s). The cabinet's specific set points will be determined based on robust microbiological testing. Type A1 cabinets are not suitable for work with hazardous volatile materials.

Class II type A2 BSC (prior to 2002, designated type A or B3, depending on venting)



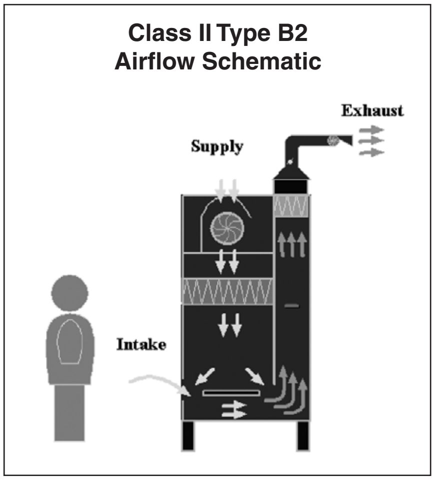
Like the type A1 cabinet, the A2 cabinet has HEPA-filtered downflow air that is a portion of the mixed downflow and inflow air from a common plenum. Unlike the A1, the A2 must have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative-pressure ducts and plenums. Additionally, the A2 must maintain a minimum intake velocity of 100 fpm (0.51 m/s). The higher intake velocity is required for all biosafety cabinets that are used to contain volatile hazardous materials. Type A2 cabinets can be used for work with minute quantities of volatile hazardous materials required as an adjunct to microbiological studies, if properly exhausted to the outside environment and if the volatile materials will not interfere with the work when recirculated in the downflow air.

Class II type B1 BSC



Type B1 cabinets have HEPA-filtered downflow air composed largely of uncontaminated recirculated inflow air. Most of the contaminated downflow air is exhausted through a dedicated duct exhausted to the outside atmosphere after passing through an exhaust HEPA filter. All biologically contaminated ducts and plenums are under negative pressure or surrounded by negative pressure. The minimum intake velocity is 100 fpm (0.51 m/s). Type B1 cabinets may be used for work treated with minute quantities of volatile hazardous materials used as an adjunct to microbiological studies, if work is done in the direct-exhausted portion of the cabinet or if the volatile materials will not interfere with the work when recirculated in the downflow air. It should be noted that the dedicated exhaust plenum for all current B1 designs is at the rear of the work surface, making it impractical for most operators to work in the direct-exhaust portion.

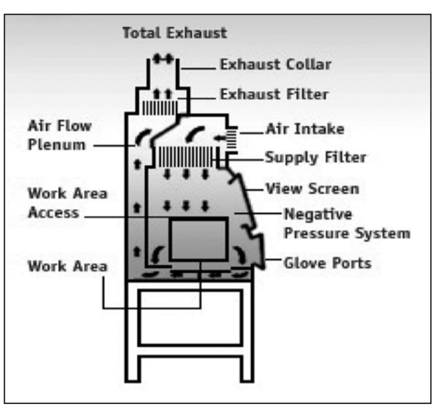
Class II type B2 BSC



The B2 cabinet is often referred to as a “total exhaust” cabinet. HEPA-filtered downflow air is drawn from the laboratory or pretreated outside air. All inflow and downflow air is exhausted to the outside through an exhaust HEPA filter without recirculation. All contaminated ducts and plenum are under negative pressure or surrounded by directly exhausted negative-pressure ducts and plenums. The minimum intake velocity is 100 fpm (0.51 m/s). The B2 cabinet may be used for work with volatile hazardous materials as required as an adjunct to microbiological studies. This cabinet is a great choice if you really need the flexibility to work with volatile materials. Otherwise, it exacts a large penalty in energy costs and air balance challenges for little gain. All class II cabinets have been validated to be effective against biological agents, so B2 cabinets should be reserved for applications where volatile material recirculation must be avoided.

Class III BSC

A class III cabinet is a totally enclosed, ventilated cabinet of leak-tight construction. Operations are conducted through attached rubber gloves. The class III cabinet is generally reserved for the most hazardous applications, typically placed in a BSL4 laboratory. The class III cabinet is the most cumbersome to work in because there is always a physical barrier between the operator and the work. A class III cabinet will employ redundant treatment of the exhaust, either double HEPA filtration or a HEPA filter and incineration. Class III cabinets are not covered in detail in this paper because they are not germane to a typical microbiology laboratory.



Installation and Venting Considerations

Type A1 and A2 cabinets were designed to be vented back into the laboratory. Because the internal recirculation blower also exhausts air from the unit, type A cabinets do not need to be vented externally unless volatile materials will be used. The A1 cabinet is not intended for use with volatile materials, so there really is no good reason to vent an A1 cabinet outside the building unless the operation includes foul odors. The A2 cabinet can be used with materials treated with minute quantities of volatile materials, so external venting may make sense in certain applications.

Cabinets vented back into the room should be positioned so that a minimum of 3 in. (7.6 cm) of clearance is provided between the exhaust opening on the top of the cabinet and the ceiling. A clearance of less than 3" (7.6 cm) has been shown to reduce the exhaust flow out of the cabinet, which will decrease the inflow velocity at the work access opening. Some older-design cabinets can only be tested for intake velocity by measuring the exhaust velocity at the top of the unit. For those cabinets, a minimum of 12 in. (30.5 cm) of clearance between the exhaust opening and the ceiling must be provided. The field certifier or cabinet manufacturer should be able to guide you on this issue.

All class II cabinets should be located out of traffic patterns and away from room air currents. The air barrier at the front access opening is susceptible to influence by any type of air movement. Consideration should also be given to all other devices that might move air. Examples include room supply air vents, ventilation fans from electronic devices, swinging room doors, and doors from equipment, such as refrigerators, autoclaves, and incubators. Standard room fans or window-mounted air conditioners should never be used near a class II BSC.

When an A1 or A2 cabinet is externally vented, it should be done through a properly functioning exhaust canopy. No type A cabinet should ever be hard connected to an exhaust system. It should be noted that prior to 1992, most type A cabinets were hard connected. At that time, there was no official method available to measure intake velocity on canopy-connected (called thimble at that time) type A cabinets. Since the release of the 1992 version of NSF49, methods and acceptance criteria have been available for testing an installation with a canopy connection. In a canopy connection, a gap is present between the hood and the duct. The gap acts as a pressure release point between the hood and the duct work. Every time you open and close a door to a room, the pressure differential between that room and surrounding environments changes. The gap between the hood and the duct work acts as a buffer so this pressure differential change is not expressed as a “puff” of air out of the front of the cabinet. The canopy connection also mitigates any air balance concerns between the externally mounted fan and the hood fan. Therefore, it is no longer acceptable to hard connect a type A cabinet.

An exhaust canopy provides a minimum of a 1 in. (2.5-cm) gap between the BSC and the ductwork. This gap is designed to be negatively pressurized, ensuring that all the exhaust from a BSC is captured and carried away by the facility exhaust blower. The canopy design must be validated to maintain acceptable inflow velocities at the front access opening, even when the flow through the exhaust canopy is completely stopped. An additional advantage of the canopy connection is that it is easier to balance than a hard-connected system, and it also isolates the BSC from fluctuations in the exhaust system.

All type B cabinets must be vented outside the building. Neither of the type B designs incorporates an internal blower that exhausts air from the cabinet; therefore, an external blower must be used. The exhaust blower should be placed on the roof or in an equipment room just below the roof to ensure negative pressure throughout the entire duct run. Ideally, an individual duct and exhaust blower will be provided for each hood. The best concept is to keep the system as simple as possible. However, in some cases, hoods must be ganged together on a common system. Building automation systems should be carefully evaluated under a variety of conditions over time to verify that the BSC operation will not be compromised.

Dampers should be placed in the duct run to balance the airflow and to decontaminate the system for servicing. The balancing damper can be an ordinary manual balancing damper or an automatic damper connected to a building automation system, if more than one hood is on the duct run. The decontamination damper needs to be gas tight and should ideally be located as close to the cabinet as possible. While the decontamination damper can be used for both tasks, it is better to use two separate dampers. That way, the exhaust system does not need to be rebalanced every time the hood is decontaminated.

Ensuring proper performance

Class II BSCs boast the most robust, all-encompassing industry-based performance assurance program of all the engineering controls in use today. Thanks to leadership from the NIH back in the early 1970s, the non-profit group NSF International developed the cornerstone of the BSC quality system we still use today. NSF/ANSI 49 is the standard for materials, design, construction, and performance of class II BSCs. Annex A details tests that are performed at the factory and then independently validated by NSF International in Ann Arbor, MI. Upon successful completion of these tests, airflow set points are published for each successful cabinet model. All future hoods of that model are set to the same set points until there is a design change or the cabinet is relisted. Relisting is required every 5 years. Annex F details field certification tests. Field certifiers set the cabinets up to the set points that have been validated by NSF. Validation that the design works is done through microbiological testing at NSF. The field certification is simply verification that the cabinet is set to the same parameters that were validated microbiologically.

Factory/NSF testing (Annex A)

The true performance of a BSC is determined through a series of three different microbiological tests. Personnel protection (no aerosols escape from the cabinet) is tested with 1×10^8 to 8×10^8 *Bacillus subtilis* spores for 5 minutes. Product protection (no aerosols cross over the access opening onto the work surface from the room) is tested with 1×10^6 to 8×10^6 *B. subtilis* spores for 5 minutes. Cross-contamination (spores do not pass from one side of the cabinet to the other) is tested with 1×10^4 to 8×10^4 *B. subtilis* spores for 5 minutes. At the successful completion of the microbiological tests, the airflow velocities are documented, and these become the official set points for all future cabinets of this model, at least until the next relisting date. The microbiological testing results are the true determining factor in BSC performance, so it is very important that the field certification process matches these velocity set points precisely. NSF will list the airflow velocity set point along with the exact test equipment and procedures that were used to determine them. The field certifier must then repeat the EXACT procedures with the SAME type of test equipment.

NSF validation includes the following tests:

- Microbiological tests
- Inflow velocity test
- Downflow velocity test
- Airflow smoke patterns test
- Cabinet integrity tests
- HEPA filter leak test
- Noise level test
- Lighting intensity test
- Vibration test
- Stability tests
- Drain spillage trough leakage
- Motor/blower performance
- Electrical safety

Field testing – certification (Annex F)

Like the cabinets themselves, field certifiers are accredited by NSF International. A complete listing of NSF qualified certifiers is available on the website http://www.nsf.org. Industry-based test protocols are described in Annex F of NSF/ANSI 49 and should serve as the basis of each certification company's standard operating procedures (SOPs). Since many microbiology laboratories follow current good manufacturing practice (cGMP) or current good laboratory practice (cGLP), it is considered good practice to have a copy of their testing SOPs on file.

The following tests are considered mandatory for a certification to be eligible for the statement "field certified in accordance with NSF/ANSI 49":

- Downflow velocity profile test
- Inflow velocity test
- Airflow smoke patterns test
- Site installation assessment tests
- HEPA filter leak test
- Cabinet integrity test (A1 cabinets only, at installation and when moved or when a panel is removed)

The foundation for certification of any class II cabinet is to set the inflow and downflow velocities to the set point determined by the cabinet manufacturer and validated by NSF. Cabinet designs change over the years, and set points will also change as the model designs change. For some model lines, there are as many as 10 or more different set points for the same model, depending on the manufacture date. It is not unusual to see two hoods in the same laboratory with the same model number, but because they were made a few years apart, they were certified to different airflow set points. For cabinets listed by NSF after 1992, a data plate on the front of the cabinet will guide the certifier to the specific procedures and set points to use. For cabinets without a data plate, the manufacturer or the owner's manual may have to be consulted. It should also be noted that test procedures have evolved over the years, so newer cabinets are often tested using different procedures than older hoods, but every cabinet must be tested using only the procedures and equipment that were validated for that particular model. Testing a cabinet to set points that were validated with older methods using newer methods not validated for that cabinet will potentially result in a cabnet being set up wrong. Therefore, it may not perform properly.

After airflows are properly set, a visual smoke pattern test should be performed to verify the cabinet is integrated properly into the facility. Crossdrafts in the room and influences from the HVAC system pose a real threat to the performance of the cabinet. Airflow velocity testing equipment measures velocity but does not determine direction. It is possible to have disruptive air patterns within the cabinet even when the velocities are within specifications. Visual smoke pattern testing provides the final assurance that all airflow patterns are proper.

In 2002, NSF/ANSI 49 introduced a new section in Annex F. Site installation assessment tests have been added to the list of mandatory tests. This section provides specific criteria for setting alarms and other basic functions to ensure the cabinet is integrated properly into the facility. Exhaust alarms must produce audible and visual signals within 15 seconds when the exhaust volume decreases by 20%. Additionally, interlocks for type B2 cabinets must be activated within the same 15 seconds. Sash alarms must produce an audible alarm when the sash is opened an inch above the manufacturer's intended height. This criterion was previously left up to the discretion of the certifier. In addition to the alarms, tests should be conducted to verify that the duct work is under negative pressure relative to the room. Site installation tests are considered mandatory and should be done at every certification.

As the cornerstone of the BSC, it is important that the HEPA filter be integrity tested at every certification using the proper test equipment. An aerosol photometer and a Laskin nozzle aerosol generator must be used to challenge the filter. In some industries, particle counters are used, sometimes even without any additional challenge aerosol above the ambient particulate concentration. This is not considered acceptable for BSC testing. The critical nature of the HEPA filter as used in this application demands that only the most robust tests be used for verification of the filter's integrity. Historically, the oil used in the Laskin nozzle generator was DOP (dioctyl phthalate); however, it had been listed as a possible carcinogen, so effective alternatives were validated. The most common material used today is PAO (polyalphaolefin, CAS no. 68649-12-7). The certifier should document specifically what upstream aerosol challenge was used and that no leaks in excess of 0.01% (0.005% for probe-tested filters) of that challenge have been found. If leaks were found, the certifier must indicate how they were repaired. The initial penetration should also be documented.

A cabinet integrity test is mandatory for cabinets with a biologically contaminated plenum under positive pressure to the room (class II type A1). The test does not need to be done at every certification; it only needs to be done at installation, when panels are removed, and after relocation. The most common cabinet integrity test is the soap bubble leak test. The cabinet is pressurized to 2 in. W.C. (500 Pa) for a minimum of 30 minutes. If the pressure drops by greater than 10%, all welds, seams, joints, and penetrations are sprayed or brushed with a liquid leak detector. Leaks are indicated by the presence of bubbles, similar to looking for leaks in an old tire inner tube. It should be noted that this used to be a mandatory test for all class II BSCs, but since 2002, it is only required on the type A1 cabinet.

In addition to the mandatory tests detailed above, the following tests are considered optional tests that may provide value for certain applications. NSF refers to them as "worker comfort and safety tests":

- Lighting intensity
- Vibration
- Noise level
- Electrical safety tests

Facilities that are cGMP or cGLP compliant, as well as others concerned about product sterility, should also require the certifier to perform a particle count survey to confirm maintenance of ISO class 5 conditions. This test is not covered in NSF/ANSI 49. Particle-counting protocols are discussed in ISO 14644-1 (7). In addition to counts taken under "at-rest conditions," a test should be performed under "dynamic operating conditions" within 12 in. (30.5 cm) upstream of exposed product. This test is not considered mandatory under NSF, so not all certifiers perform the test without a specific request, but it should be done for applications where sterility is important.

Certification documentation

One quick and easy way to evaluate a certification contractor is to look at the documentation that is provided. The product of a certification company is the technician and his test equipment that is sent to your site, along with the actual tests that are performed. The only tangible item left behind is the certification report and other necessary documentation, such as calibration reports for the certification test equipment. If the owner of the certification company is the best certifier in the world but never visits your site and the technician sent is not well trained, the owner's skills and knowledge do you no good at all. Therefore, it is imperative that you ask for and receive the training records and qualifications for the actual technician that tests your hoods. If you are a large facility served by multiple technicians, you should have the records for all of the technicians and every supervisor, as well. If you seek additional information or guidance on selecting and evaluating field certifiers, recommended practice IEST-RP-CC019.1, *Qualifications for Organizations Engaged in the Testing and Certification of Cleanrooms and Clean-Air Devices,* may be a great reference source (8).

Certification reports should have value beyond the basic concept of pass or fail. A certification report that merely has a series of check-off boxes without the actual data required to determine passing or failure is not in compliance with NSF nor does it give the user good value for the certification investment. The best example of the value of reported data is the airflow test, specifically the exhaust flow measurement needed for intake velocities on type B2 cabinets. A hard-ducted cabinet is an integral component of a building's HVAC system. An HVAC engineer or balancing professional should be able to pick up the certification report and learn a lot about the demands of the BSC on the building. Without these data, the information is lost and the report is of little or no diagnostic value.

A certification report should provide at least the following:

- Calibration certificates should be provided for all test instruments used. The model and serial number of each test instrument should be listed in that section of the report. At a minimum, certification test equipment should be calibrated annually. Ideally, equipment that is transported from site to site in the back of a van or pick-up truck should be calibrated more frequently.

- Airflow – statement of the method used, each of the individual velocity readings, testing location, all calculations, average downflow velocity, average inflow velocity, exhaust volume for all externally vented cabinets, acceptance criteria, along with the results, and a pass or fail declaration
- HEPA filter leak test – the actual challenge aerosol used (DOP or PAO) along with the specific challenge concentration (minimum of 10 µg per liter), as-found leak results, as-left leak results, information regarding patching, if necessary, and a pass-or-fail declaration
- Airflow smoke pattern test – the specific generator used to create the visible smoke, a description of the tests along with the pass-or-fail declaration
- Site installation assessment tests – statement of which tests were done and at what values they were performed and a pass or fail declaration
- Soap bubble leak test (A1 cabinets only) – statement of which test was performed, what values it was performed at, and a pass-or-fail declaration
- Non mandatory tests – location of each reading, each of the individual counts taken, all of the calculations and averages, and a pass or fail declaration

Air balancer – certifier relationship

Quite often, the services of both air balancers and certifiers are required, especially for new installations and facilities that have sophisticated building automation systems. Certifiers are mandated by their accreditation to test and certify to the nominal set points using methods established by the manufacturer and verified by NSF. Air balancers are usually committed to balance the BSC exhaust duct work as part of the entire building HVAC system. Balancers typically use a pitot traverse of the duct for measurement of the total exhaust volume. While a duct traverse is considered an accurate method of airflow measurement, it does not relate to the methodology and, therefore, the nominal set point acceptance criteria established by NSF. For the purposes of air balancing using a duct traverse, NSF has listed a "nominal set point" to be used by the air balancer. This information is most likely only available for hoods listed by NSF since 2002.

Summary

BSCs are available in a variety of styles and configurations to meet a multitude of demands encountered by a modern microbiology laboratory. Proper selection and placement within the laboratory is necessary to ensure the laboratory's needs are met. The primary factor that must be weighed in order to make an appropriate decision is whether volatile materials are going to be used. For cabinets that are used only with biohazardous agents and are not augmented with volatile toxic chemicals or radionuclide, there is no need to vent externally if the proper cabinet is selected.

All primary engineering controls need to be certified at least annually. NSF International maintains the national accreditation program to assure the end-user that the certifier is properly trained and has passed both a written and a practical examination to demonstrate his or her knowledge. Not all certifiers are accredited, so it is a good idea to verify the qualifications of your provider. To avoid confusion, make sure the proper specifications are used by both the balancer and the certifier. The balancer should balance to the concurrent balance value using a duct traverse, and the certifier should certify the nominal set point using one of the NSF-approved methods for that cabinet.

Acknowledgement

All figures provided courtesy of the Eagleson Institute, Sanford, ME.

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