



*NSF International Standard /  
American National Standard*

## **NSF/ANSI 49 - 2019**

**Biosafety Cabinetry: Design,  
Construction, Performance,  
and Field Certification**

*Informative Annex 1  
(formerly Annex E)*



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## Informative Annex 1 (formerly Annex E)

### Biosafety cabinet selection, installation, use, lifespan, and decommissioning

*The information contained in this Annex is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this Annex may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to this Standard.*

#### Contents

- I-1.1 Institutional safety consultation
- I-1.2 Risk assessment procedure
- I-1.3 BSC Class and Type selection
- I-1.4 Site review before BSC purchase
- I-1.5 BSC arrival inspection and field certification
- I-1.6 Cleaning and disinfection of BSC work area
- I-1.7 BSC use practices and procedures
- I-1.8 Moving a permanently installed BSC
- I-1.9 BSC lifespan
- I-1.10 BSC decommissioning process
- I-1.11 Definitions

#### I-1.1 Institutional safety consultation

A biosafety professional should be consulted prior to a biosafety cabinet (BSC) purchase. Some institutions have BSC purchases approved by the biosafety professional after consultation with the user, architect and engineer. Biosafety professionals that perform this function should have training and field experience that includes methods used to control biohazards and knowledge of the design, application, and testing of BSCs.

Issues that may be considered include:

- risk assessment;
- selecting which kind of BSC is required and if it should be exhausted; and
- assessment of the laboratory environment and the proper location of BSCs within it.

**I-1.1.1** If there is a window in the laboratory, it should remain closed at all times. Cabinets should not be located where room ventilation air inlets blow across the front opening or onto the exhaust filter.

#### I-1.2 Risk assessment procedure

**I-1.2.1** Risk assessments encompass four main elements:

- hazard identification;
- exposure assessment;
- dose-response assessment; and
- risk characterization, and risk management (job analysis).<sup>1</sup>

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<sup>1</sup> Risk Assessment of Biological Hazards, Fleming, D.O., p. 81-91, 2006. In D.O. Fleming and D.L. Hunt(ed.), *Biological Safety: Principles and Practices*, 4<sup>th</sup> ed. ASM Press, Washington, DC.

**I-1.2.2** Risk assessment team members may include:

- investigator / scientist;
- laboratory staff;
- animal care staff when appropriate;
- animal veterinarian when appropriate;
- plant pathogen, or plant pest containment expert when appropriate; and
- occupational health and biosafety professionals.

**I-1.2.3** Risk assessment hazards considered:

- animal hazards;
- agent / pathogen / recombinant hazards;
- chemical hazards; and
- radiological hazards.

**I-1.2.4** Agent / pathogen / recombinant's factors associated with risk of disease or injury:

- virulence;
- infectious dose;
- route of infection (portal of entry);
- toxigenicity;
- agent's host range;
- if the agent is endemic or exotic to the environment it is in;
- availability of effective preventive measures; and
- availability of effective treatment.

**I-1.2.5** Factors associated with worker's risk of exposure:

- worker's work activity; diagnostic, research, or production scale;
- worker's proficiency, attitude, and safety awareness; and
- worker's age, sex, pregnancy, race, immune status, and medications.

**I-1.2.6** Risk management plan includes:

- biosafety containment level assignment to the facility and microbiological practices;
- safety equipment;
- engineering controls;
- personal protective equipment;
- work practices – standard operating procedures (SOPs);
- emergency procedures;
- work schedule – calendar; and
- investigation protocols that include all risk management plans.

**I-1.2.7** Investigation protocol review includes:

- committee (IBC / IRB / IACUC) review, as appropriate;
- meetings with workers to discuss approved protocols;
- training;
- dry runs without agent / pathogen / recombinant; and
- regular audits.

**I-1.2.8 Risk management analysis table**

Risk factors	Assessment level	
	Decrease <	> Increase
<b>Pathogen disease potential</b>		
known, classified		
suspected, classified		
known, unclassified		>>>
unknown		>>>>
<b>Pathogen aerosol potential</b>		
tissue procedure	<<<	
culture procedure		>>>
concentration procedure		>>>>>>
animal / nonshedder	<<<	
animal / shedder		>>>>>>
<b>Pathogen infectious route</b>		
respiratory		>>>>>>
mucous membrane		>>>
parenteral	<<<	
other	<<<	
<b>Disease severity</b>		
moderate		>>
severe		>>>
life threatening / lethal		>>>>>>>>
<b>Disease prophylaxis</b>		
none		>>>>>>>>
vaccine	<<	
immune globulin	<<<	
antibiotics	<<<	
antivirals	<<<	
<b>Other factors</b>		
livestock pathogen		>>>
poultry pathogen		>>>

**I-1.2.9 Risk assessment of BSCs exhaust system pressurization in the event of an exhaust system failure**

**I-1.2.9.1 Introduction**

This Section pertains to Types A1, A2, and C1 BSCs connected to an exhaust system via a canopy connection. In the event of an exhaust system failure, these Types of BSCs will positively pressurize the system. This pressurization will be present as long as the BSC continues to operate in an alarm state.

The purpose of this Section is to review:

- the different BSC Types, and their specific reaction to an exhaust system failure;
- the amount of positive pressure that may be encountered;
- the duration of operation of the BSC in an alarm state; and
- the factors that should be considered in performing a risk assessment of these BSCs and their exhaust system.

Because of the unique nature of individual exhaust systems, and the laboratory devices that are connected to them (i.e., BSCs, fume hoods, other ventilated enclosures, and canopies), no definitive answers as to system layout, or which BSC should be used can be given. It is up to the user and their facility's Safety Officer(s) to understand how these BSCs behave during a system failure, perform an appropriate risk assessment for their system, and for their facility's building engineers to establish the compatibility of the BSCs for their particular installation.

### I-1.2.10 Background

ANSI/AIHA Standard Z9.5-2012<sup>2</sup> states:

#### **“5.4.2 Exhaust System Ductwork**

##### *5.4.2.1 Design*

*....Systems and ductwork shall be designed to maintain negative pressure within all portions of the ductwork inside the building when the system is in operation.”<sup>2</sup>*

While this requirement covers the system when in normal operation, nothing is said about the exhaust system or BSC function during a catastrophic failure. When an exhaust system fails, there are going to be risks involved, no matter which Type of BSC is connected to that system, and how the different Types respond to that failure should be understood and evaluated as part of the risk assessment.

### I-1.2.11 Canopy-connected Type A BSCs

Canopy-connected Type A BSCs are designed to redirect the cabinet's exhaust back into the laboratory via opening(s) or relief valve(s) that open during an exhaust system failure. Modern canopy design (particularly low profile / high efficiency models) do not exhaust all of the BSC's air through the connection's air gap(s) / relief valves; some air flows into the exhaust system, creating pressure in the duct. This pressure should typically be 0.001 to 0.01 inches w.g. at the canopy's connection to the exhaust system, depending on the canopy design, BSC exhaust volume, and possible obstructions around the canopy's openings. Type A BSCs must, by NSF requirements,<sup>3</sup> continue to operate, under an audible and visual alarm state, until the exhaust system recovers, or the BSC's blower(s) is shut off or loses electrical power. The BSC can be started or restarted, indicating an active canopy alarm, only providing particulate containment, directing any gases and vapors back into the laboratory.

Factors to consider in the risk assessment of the use of canopy-connected Type A BSCs in a common or ganged exhaust system include:

<sup>2</sup> ANSI/AIHA Standard Z9.5-2012: *Laboratory Ventilation*. American Industrial Hygiene Association. 3141 Fairview Park Drive, Suite 777, Falls Church, VA 22042. <[www.aiha.org](http://www.aiha.org)>

<sup>3</sup> NSF/ANSI Standard 49 – 2017. 789 N Dixboro Rd., Ann Arbor, MI 48105. <[www.nsf.org](http://www.nsf.org)>

- are the only devices connected to the exhaust system canopy-connected Type A BSCs, or are other ventilated devices (i.e., fume hoods, other ventilated enclosures, and canopy hoods) connected to the system?
- are there a large number of Type A BSCs connected to a single system connected to other types of devices? More BSCs will displace more air into the exhaust system, increasing the risk of backflow into other devices;
- are BSCs allowed to operate continuously, or unattended? If so, this increases the risk of some cabinets to continue to operate unobserved during an exhaust system failure; and
- do all BSC users understand that under no circumstances are the BSCs to be used when a canopy alarm is displayed, and the unit(s) should be turned off until the exhaust system is restored?

### **I-1.2.12 Canopy-connected Type C1 BSCs**

Canopy-connected Type C1 BSCs can be configured to direct its exhaust during an exhaust system failure either:

- back into the laboratory; or
- into the exhaust system.

#### **I-1.2.12.1 When configured to direct its exhaust back into the laboratory**

In this configuration, the Type C1 performs similar to a canopy-connected Type A. As in the Type A, BSC operation during an exhaust alarm will only provide particulate containment, directing any gases and vapors back into the laboratory. Unlike the Type A BSCs, the Type C1 must, by NSF requirements, shut off its blowers within a maximum of 5 minutes, under audible and visual alarm state, unless the exhaust system recovers, or the BSC's blower(s) are shut off. If shut down, the BSC cannot be restarted until the exhaust system recovers.

The risk assessment of Type C1 BSCs in this configuration, is similar to the canopy-connected Type A, except that the Type C1 will automatically shut its blowers off within 5 minutes of an exhaust system failure, and its blowers cannot be started until the exhaust system recovers.

#### **I-1.2.12.2 When configured to direct its exhaust back into the exhaust system**

In this configuration, the Type C1 will continue to operate for a programmed interval of 0 to 5 minutes. During this interval, all of the BSC's exhaust flows into the exhaust system, creating pressure in the duct. This pressure should typically be 0.01 to 0.1 inches w.g. per 100 feet of duct, depending on the BSC, its exhaust volume, and the design of the exhaust system utilizing a sealed and pressure tested duct.

Factors to consider in the risk assessment of the use of Type C1 BSCs configured to direct their exhaust into a common or ganged exhaust system during a failure of that system include:

- are the only devices connected to the exhaust system canopy-connected Type C1 BSCs, or are other ventilated devices (i.e., fume hoods, other ventilated enclosures, and canopy hoods) connected to the system?
- are there a large number of Type C1 BSCs connected to a single system connected to other types of devices? More BSCs will displace more air into the exhaust system, increasing the risk of backflow into other devices;
- is the programmed interval (15 seconds to 5 minutes) the BSCs operates under an exhaust alarm the minimum required for the users to secure any bio- or chemical hazards?

### I-1.3 BSC Class and Type selection

I-1.3.1 Selecting the proper BSC should be done in several stages:

- a) Select the proper Class and Type of BSC required, based on the type of protection needed.
- b) Establish, if possible, all of the different tasks to be done within the BSC.
- c) Establish, if possible, all of the different chemicals that may be used in the BSC.
- d) If the BSC is to be connected to an exhaust system, is it compatible with the BSC's requirements?
- e) If the exhaust system malfunctions, does the user understand its impact on the BSC's ability to maintain personnel and environmental protection, i.e., containment?

These five stages are reviewed in the questions that follow (Sections I-1.3.1.1 to I-1.3.1.5), and the various configurations of Class II BSCs are shown in Figures 35, 37, 38 and 40.

#### I-1.3.1.1 Question one: What needs to be protected?

- only the material being worked on (product protection)?
- only the technician and the laboratory (personnel and environmental protection)?
- or to protect all three (personnel, product, and environmental protection)?

If all that is needed is product protection, then a unidirectional flow clean-air device (Clean Air Bench),<sup>4</sup> which is not a BSC, may be the unit of choice. Clean air devices use high efficiency particulate air (HEPA) or ultra low penetration air (ULPA) filter(s) to remove particulates from room air. This filtered, particulate-free air then flows through an enclosed work area, in a horizontal or vertical direction. These devices bathe the materials inside in filtered air, and then the air is typically discharged into the laboratory. While these devices protect the product from airborne contaminants, any aerosol generated in the work area will be discharged into the laboratory. As such, they cannot be used with toxic or biohazardous materials.

For personnel and environmental protection only, the Class I BSC enclosure offers a simple and economical solution. Room air sweeps around the operator and through the work area. This contaminated air is then HEPA/ULPA filtered and discharged into the laboratory or exhausted outside of the building via an external mechanical exhaust system. The Class I BSC will protect the operator and the lab, however, because room air constantly washes over the work area, the product is exposed to airborne contaminants.

Personnel, environmental, and product protection is most efficiently provided by a Class II BSC. The inflow of air around the operator provides personnel protection, HEPA/ULPA filtered air flowing downward through the work area provides product protection, and the discharge of exhaust HEPA/ULPA filtered air provides environmental protection.

#### I-1.3.1.2 Question two: What are all of the different types of work to be done in a Class II BSC?

One of the most difficult tasks in selecting a BSC is trying to foresee all the different types of work that will be taking place in it. It is critical to decide what things need protection, both now and in the future. All too often users purchase a clean air device or Class I BSC for current applications, only to find these devices are unsuitable as their work requirements change.

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<sup>4</sup> IEST RP CC002, latest revision.



### I-1.3.1.3 Question three: What types and quantities of chemical vapors will be generated in the BSC?

As important as the preceding question, the user must also foresee the types and quantities of chemical vapors that will be generated in the cabinet. Because chemical vapors can freely pass through HEPA/ULPA filters, both Class I and Class II BSCs must be exhausted out of the laboratory when used with these types of chemicals. For the Class II BSCs, Types B1 and B2 must be direct connected to an external exhaust system in order to operate properly; Types A1, A2, and C1 can be converted to operate in either a canopy ducted or recirculating mode, depending on the users' requirements. The airflow patterns of Types A1, A2, B1, B2 and C1 BSCs are shown in Figures 35, 37, 38 and 40, respectively.

Class II BSCs typically do not feature explosion-proof electrical components in their work area or internally. Therefore, use of flammable or explosive materials in quantities above their explosive limit are not recommended.

Types of chemicals used in cabinet should be considered as some can destroy the filter medium, housings and gaskets causing loss of containment.

The percentage of air in the work area that is recirculated within the BSC versus exhausted varies, based on the BSC Type, subtype, and in some cases, where the chemicals are released in the work area.<sup>5 6 7</sup>

When flammable or explosive chemicals are to be used in a BSC, it is the users' responsibility to:

- be fully cognizant with the properties of chemical(s) and the hazards associated with them;
- calculate the highest percent of recirculation that may occur in the BSC being used;
- ensure the concentration of chemical(s) released in the work area do not exceed their explosive limit;
- utilize the lowest quantities of the chemical(s) required for the procedure being performed; and
- have appropriate spill / splash cleanup procedures in place before using the chemical(s).

### I-1.3.1.4 Question four: If the BSC requires an exhaust system, is there an appropriate location for the cabinet and its ductwork?

If a BSC is going to recirculate its HEPA/ULPA filtered air back into the laboratory, then the user has some freedom as to where the unit can be installed, provided it is out of major traffic areas, and there are no other air handling devices in the area, as shown in Figure 34.

If a BSC must be connected to an external mechanical exhaust system, their compatibility must be established *before* the BSC is selected. The exhaust system configurations of Type A, Type B, and Type C1 BSCs are shown in Figures 36, 39 and 41, respectively:

- directly ducting Types A and C1 cabinets is not permitted; they shall only be exhausted through a properly designed and fitted canopy exhaust system;
- canopy-connected Types A and C1 require a consistent, low static pressure. While a dedicated exhaust system is preferred, they may share a common exhaust system with other exhausted laboratory devices, if properly balanced;

<sup>5</sup> Industrial Ventilation: A Manual of Recommended Practice for Design. "Industrial Ventilation – Dilution Ventilation for Health". American Conference of Governmental Industrial Hygienists, Inc., Cincinnati, OH. 28<sup>th</sup> edition 2013 or latest edition.

<sup>6</sup> 2007 ASHRAE Handbook: Heating, Ventilating and Air-Conditioning Applications. "Industrial Applications – Chapter 14 Laboratories". American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA. or latest edition.

<sup>7</sup> ASHRAE Laboratory Design Guide: Planning and Operation of Laboratory HVAC Systems, Second Edition. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA. 2015 or latest edition.

- Type B BSCs require a higher static pressure that must increase as their exhaust filters load. They must be on a dedicated exhaust system, and not be ganged with other Type B BSCs, or other exhausted laboratory devices requiring a lower static pressure (e.g., fume hoods, canopy-connected BSCs);
- it is generally not an accepted practice to allow a BSC to positively pressurize an exhaust duct in normal operation. In some cases, however, it may be acceptable for the Type C1 to displace its exhaust air into a failing exhaust system for an interval of up to 5 minutes. To mitigate potential risks, the following procedures should be performed before configuring such an installation:
  - a) A risk assessment of the installation should be performed. The risk assessment should include evaluation of any other devices that are connected to the same exhaust system, such as other BSCs or laboratory fume hoods. Pressurizing a duct during an exhaust system failure may add risk with any other devices using the same exhaust system.
  - b) The duct must be verified to meet or exceed Seal Class A, as described in HVAC Air Duct Leakage Test Procedures – 2012.
  - c) If these criterion cannot be met, the Type C1 may be reconfigured to either shut its blowers off within 15 seconds during exhaust system failure or the canopy may be reconfigured to direct exhaust air back into the laboratory during exhaust system failure. Alternatively, the Type C1 may be disconnected from the exhaust system if a risk assessment allows.
- the exhaust duct must be placed so it can penetrate ceilings and floors without disturbing other ventilation or plumbing systems; and
- the exhaust system must minimize excessive lengths and elbows.

**I-1.3.1.5 Question five: If the exhaust system malfunctions, does the user understand its impact on the BSC's ability to maintain personnel and environmental protection, i.e., containment?**

For a Type A BSC fitted with a properly designed canopy connection, reduction or elimination of the exhaust air should not significantly affect the airflow patterns within the BSC. Personnel and product protection of the BSC will remain unchanged; however, chemical vapors generated in the BSC will be exhausted into the laboratory via the openings or slots in the exhaust canopy.

For a Type B BSC, a significant loss of exhaust airflow will result in an alarm, turning off the cabinet blower(s). This stops the flow of air into the front of the BSC (inflow), negating personnel protection, potentially allowing materials in the work area of the BSC to escape into the laboratory.

Type B BSCs have operational and maintenance issues that must be considered:

- these cabinets exhaust as much as 1200 cubic feet per minute of conditioned room air making them relatively expensive to operate; and
- the higher static air pressure required to operate Type B cabinets may also result in additional construction costs associated with heavier gauge ductwork and higher capacity exhaust fan.

For a Type C BSC fitted with a properly designed canopy connection, reduction or elimination of the exhaust air should not significantly affect the airflow patterns within the BSC while its blowers are in operation. Personnel and product protection of the BSC will remain unchanged, and chemical vapors generated in the BSC will be exhausted either back into the room, or into the exhaust system, depending on the configuration of the canopy.

If a Type C1 BSC directs its exhaust into the room during a system failure, the shutdown time of the BSC blowers can be lengthened from 15 seconds to up to 5 minutes.

If a Type C1 BSC directs its exhaust into the external exhaust system during a system failure, the default shutdown time of the BSC blowers can be lengthened from 15 seconds to up to 5 minutes, provided:

- a risk assessment indicates the BSC, the work being done in it, and the exhaust system it is connected to is appropriate; and
- the BSC is connected to an exhaust duct that has been verified to meet or exceed Seal Class A, as described in HVAC Air Duct Leakage Test Procedures – 2012.

NOTE — **air recirculation:** An informational calculation comparing the volumes of air that are recirculated internally through the BSC’s supply filter and work area, as opposed to being exhausted from the BSC.

Calculated by dividing the volume of air recirculated by the total volume of air directed to both the supply and exhaust HEPA filters, and expressed as a percentage, it provides a relative value for different cabinet types (70% for Type A, 30% for Type B1, 0% for a Type B2, etc.). Originally these relative values were calculated from the airflow specifications of NIH-03-112c: Class II Type 1 Safety Cabinet: 1974, and NCI Specification General Purpose Clean Air Biological Safety Cabinet: 1976.

As BSC design has evolved, inflow and downflow velocities and volumes have changed, thus changing the air (percent) recirculation values; they should not be used as a strict design requirement.

**Table I-1.1  
Characteristics of Type A1 and A2 BSCs**

	<b>Type A1 (Figure 35)</b>	<b>Type A2 (Figure 36)</b>
intended purpose	Routine microbiological work. Work with volatile organic chemicals on the work surface permitted as an adjunct to microbiological research if the BSC is canopy-connected to external exhaust and permitted by risk analysis.	Routine microbiological work. Work with volatile organic chemicals on the work surface permitted as an adjunct to microbiological research if the BSC is canopy-connected to external exhaust and permitted by risk analysis.
airflow pattern	Room air is drawn in through the sash opening, protecting the operator. HEPA/ULPA filtered air flows down through the work area, protecting the product. Both bodies of air flow through a common plenum to the cabinet blower(s). A portion flows out of the cabinet via an Exhaust HEPA/ULPA filter, and the remainder recirculates through a Supply HEPA/ULPA filter before flowing down through the work area.	Room air is drawn in through the sash opening, protecting the operator. HEPA/ULPA filtered air flows down through the work area, protecting the product. Both bodies of air flow through a common plenum to the cabinet blower(s). A portion flows out of the cabinet via an Exhaust HEPA/ULPA filter, and the remainder recirculates through a Supply HEPA/ULPA filter before flowing down through the work area.
air recirculation	Varies by model.	Varies by model.
inflow	Minimum 75 ft/min (0.38 m/s) average.	Minimum 100 ft/min (0.51 m/s) average.
downflow	Varies by model, typically 50 to 80 ft/min (0.25 to 0.40 m/s) average.	Varies by model, typically 50 to 80 ft/min (0.25 to 0.40 m/s) average.
biological containment	All NSF-Listed BSCs must pass the same biological containment tests.	All NSF-Listed BSCs must pass the same biological containment tests.
exhaust system	Canopy connection as needed.	Canopy connection as needed.

**Table I-1.1  
Characteristics of Type A1 and A2 BSCs**

	<b>Type A1 (Figure 35)</b>	<b>Type A2 (Figure 36)</b>
exhaust system type	Canopy-connected Type A BSCs may be ganged into a multiple-cabinet exhaust system, if all BSCs are balanced properly.	Canopy-connected Type A BSCs may be ganged into a multiple-cabinet exhaust system, if all BSCs are balanced properly.
exhaust system function	To convey the BSC exhaust air, plus an additional volume required by the canopy through the ductwork.	To convey the BSC exhaust air, plus an additional volume required by the canopy through the ductwork.
exhaust system volume	Greater than Type B1, less than Type B2.	Greater than Type B1, less than Type B2.
exhaust system negative static pressure at BSC	Typically, 0.25 inches w.g. (62 Pa).	Typically, 0.25 inches w.g. (62 Pa).
exhaust system reserve capacity	Static pressure requirements will not change as the cabinet filters load.	Static pressure requirements will not change as the cabinet filters load.
cabinet flexibility	Can be connected or disconnected from exhaust system as needs change.	Can be connected or disconnected from exhaust system as needs change.
cabinet cost	Less than Type B.	Less than Type B.
installation cost	Much less than Type B if recirculating; less than Type B if canopy-connected.	Much less than Type B if recirculating; less than Type B if canopy-connected.
electrical cost (BSC only)	Slightly more than Type B2.	Slightly more than Type B2.
tempered air loss	If recirculating in lab; none. If canopy-connected, typically 75 CFM/ft (7 m <sup>3</sup> /m) of BSC width or less.	If recirculating in lab; none. If canopy-connected, typically 100 CFM/ft (9 m <sup>3</sup> /m) of BSC width or less.

**Table I-1.2  
Characteristics of Type B1 and Type B2 BSCs**

	<b>Type B1 (Figure 37)</b>	<b>Type B2 (Figure 38)</b>
intended purpose	Type B1 cabinets may be used for routine microbiological work. Work with volatile organic chemicals on the work surface permitted as an adjunct to microbiological research if permitted by risk analysis. A majority of the downflow air is directly exhausted from the rear portion of the cabinet.	Type B2 cabinets may be used for routine microbiological work. Work with volatile organic chemicals on the work surface permitted as an adjunct to microbiological research if permitted by risk analysis. All downflow air is directly exhausted from the work area with no recirculation.
airflow pattern	Room air is drawn in through the sash opening, protecting the operator. HEPA/ULPA filtered air flows down through the work area, protecting the product. The room air, and a portion of downflow air in the front of the work area is recirculated through a supply HEPA/ULPA filter before flowing down through the work area. The air in the rear of the work area flows out of the cabinet via an Exhaust HEPA/ULPA filter.	Room air is drawn in through the sash opening, protecting the operator. HEPA/ULPA filtered room air flows down through the work area, protecting the product. Both bodies of air are drawn out of the cabinet via an Exhaust HEPA/ULPA filter.
air recirculation	Varies by model; less than 50%.	None.

**Table I-1.2  
Characteristics of Type B1 and Type B2 BSCs**

	<b>Type B1 (Figure 37)</b>	<b>Type B2 (Figure 38)</b>
inflow	Minimum 100 ft/min (0.51 m/s) average.	Minimum 100 ft/min (0.51 m/s) average.
downflow	Varies by model, typically 50 to 80 ft/min (0.25 to 0.40 m/s) average.	Varies by model, typically 50 to 80 ft/min (0.25 to 0.40 m/s) average.
biological containment	All NSF listed BSCs must pass the same biological containment tests.	All NSF listed BSCs must pass the same biological containment tests.
exhaust system	Required.	Required.
exhaust system type	Must have dedicated ductwork and exhaust blower for each BSC.	Must have dedicated ductwork and exhaust blower for each BSC.
exhaust system function	Must pull exhaust air through the Cabinet's Exhaust HEPA/ULPA filter and then through ductwork.	Must pull exhaust air through the Cabinet's Exhaust HEPA/ULPA filter and then through ductwork.
exhaust system volume	B1 is approximately 20% less than a Type A.	B2 exhausts 100% or more air than any other BSC Type.
exhaust system negative static pressure at BSC	Typically 0.7 inches w.g. H <sub>2</sub> O (170 Pa) minimum.	Typically 1 to 2.5 inches w.g. (249 to 622 Pa) H <sub>2</sub> O minimum.
exhaust system reserve capacity	Static pressure requirements may increase up to 0.3 inches w.g. H <sub>2</sub> O (74 Pa) H <sub>2</sub> O as exhaust HEPA/ULPA filter loads.	Static pressure requirements may increase up to 2.5 inches w.g. (622 Pa) as exhaust HEPA/ULPA filter loads.
cabinet flexibility	Must be permanently connected to an exhaust system to function properly.	Must be permanently connected to an exhaust system to function properly.
cabinet cost	More expensive than Type A.	More expensive than Type A.
installation cost	More expensive than a canopy-connected Type A and require a dedicated exhaust fan.	Most expensive. Higher exhaust volumes require larger ductwork and higher capacity dedicated exhaust fan.
electrical cost (BSC only)	Slightly more than a Type B2.	Typically lowest of any BSC.
tempered air loss	Equal to a canopy-connected Type A. Typically 50 to 100 CFM/ft (4.6 to 9.3 m <sup>3</sup> /m) of BSC width.	Typically 175 CFM/ft (16.3 m <sup>3</sup> /m) of BSC width.

**Table I-1.3**  
**Characteristics of Type C1 BSCs**

	<b>Type C1 (Figure 39)</b>
intended purpose	Type C1 cabinets may be used for routine microbiological work. Work with volatile organic chemicals on the work surface is permitted as an adjunct to microbiological research if the cabinet is connected to an exhaust system, and is acceptable after performing a risk analysis. Typically, a majority of the downflow air is directly exhausted from the center portion of the cabinet.
airflow pattern	Room air is drawn in through the sash opening, protecting the operator. HEPA/ULPA filtered air flows down through the work area, protecting the product. The room air, and a portion of the downflow air in the work area is recirculated through a supply HEPA/ULPA filter before flowing down through the work area. Typically, the air in the center of the work area flows directly out of the cabinet via an Exhaust HEPA/ULPA filter.
air recirculation	Varies by model; typically less than 50%.
inflow	Minimum 100 ft/min (0.51m/s) average.
downflow	Varies by model, typically 50 to 80 ft/min (0.25 to 0.4 m/s) average.
biological containment	All NSF listed BSCs must pass the same biological containment tests.
exhaust system	Canopy connection as needed. If BSC exhaust is to be directed into the exhaust duct during a system failure, the ductwork must be sealed and tested for leakage.
exhaust system type	Canopy-connected Type C1 BSCs may be ganged into a multiple-cabinet exhaust system, if all BSCs are balanced properly.
exhaust system function	To convey the BSC exhaust air, plus an additional volume required by the canopy through the ductwork.
exhaust system volume	Greater than Type B1 Less than Type B2.
exhaust system negative static pressure at BSC	Typically 0.25 inches w.g. (62 Pa).
exhaust system reserve capacity	Static pressure requirements will not change as the cabinet filters load.
cabinet flexibility	Can be connected or disconnected from exhaust system as needs change.
cabinet cost	More expensive than Type A; similar to Type B.
installation cost	Much less than Type B if recirculating; less than B1 if connected to a ganged exhaust system; similar to Type B1 if connected to a dedicated system.
electrical cost (BSC only)	Similar to a Type A2.
tempered air loss	If recirculating in lab; none. If canopy-connected, typically 75 CFM/ft (7 m <sup>3</sup> /m) of BSC width or less.

### **I-1.3.2 BSC width**

Having decided which Class and Type of BSC is the best, the user should now decide on the width of the BSC. When deciding the width, the user should mark out an area of benchtop equal to the inside (work area) dimensions of the model they are interested in. The user(s) should perform several "dry runs" of their procedures in this area. If the user can work in this defined space, then the cabinet is the proper width, if not, the user may want to try working in the dimensions of the next larger model. If the user does decide on a larger model, however, be sure that the BSC can be transported to and installed in the laboratory through the existing freight elevators, hallways and doors. It is important to remember that BSC widths typically refer to the internal work area. The external width of the BSC may be significantly greater than the work area width. The BSC should be installed with at least 6 inches (150 mm) of unobstructed space on each side. For example, a typical BSC with a 4 foot (1219 mm) workspace may have an outside width of 4.5 feet (1,372 mm). When 6 inches (150 mm) of space is allowed on each side of the BSC for servicing, the width needed to install the BSC is 5.5 feet (1,676 mm).

### **I-1.3.3 BSC options**

#### **I-1.3.3.1 Service valves**

Service valves allow inert gases, air or vacuum lines to be plumbed into the BSC. Many models allow for the easy installation of these valves in the field, however, it is generally less expensive and easier to have the required number of valves installed when the unit is ordered. Although many users connect natural gas to a service valve in the cabinet, this practice should be avoided if possible, because open flames in a Class II BSC disrupts the airflow, and there is the possibility of a buildup of flammable gas in BSCs that recirculate their air.

#### **I-1.3.3.2 Electrical outlets**

Most BSCs have electrical outlets installed in the work area as standard equipment. Specialized outlets, such as ground fault circuit interrupters (GFCIs) should be installed and tested by the cabinet manufacturer.

Typically the outlets in the work area are limited in their amperage rating. This is due to the amperage requirements of the BSC's motor, lighting, and other electrical components.

Variations in line voltage from the laboratory wall outlet may affect the cabinet airflows. A voltage regulator may need to be installed in order to reduce the potential of variations in airflows.

#### **I-1.3.3.3 Ultraviolet lighting**

Germicidal (or UV) lamps are often installed as an adjunct to surface disinfection. UV lighting is not recommended in BSCs. While their usefulness is a subject for debate among users and manufacturers, they should be installed and tested by the manufacturer during assembly of the unit.

#### **I-1.3.3.4 IV bar**

Because intravenous (IV) bars or rods have a significant impact on the airflows in the work area, always use the IV bar recommended by the manufacturer.

#### **I-1.3.3.5 Base stands**

Base Stands or supports shall be considered at the time of specification. Some models of cabinets can weigh up to 900 pounds (408 kg). The BSC must be attached to a manufacturer recommended base stand to support the unit's weight. All base stands have a maximum height specified by the manufacturer to prevent overturning of the BSC; this maximum should never be exceeded.

### **I-1.3.3.6 Mobile installations**

Mobile base stands with and without lift capability have been used when the BSC is operated in multiple locations in the same or adjoining laboratories. Proper cabinet operation should be confirmed by airflow smoke pattern tests at each site of use. If the cabinet is relocated to another facility, or subjected to excessive shock, or vibration, or both, during moving, the BSC should be recertified to ensure it is functioning in a proper manner.

## **I-1.4 Site review before BSC purchase**

### **I-1.4.1 Consultation**

Investigators should consult with a biosafety professional and request a risk assessment of the proposed investigation to ensure that an appropriate BSC is used for the work. Purchase of NSF/ANSI 49 listed Class II BSCs is recommended, but alternative containment equipment may be suggested for special tasks.

### **I-1.4.2 Site assessment**

The investigator should thoroughly examine the intended installation site to ensure it will meet the requirements for proper cabinet operation.

#### **I-1.4.2.1 Location of the BSC**

The cabinet should be located away from traffic patterns, doors, fans, ventilation registers, fume hoods and any other air-handling device that could disrupt its airflow patterns. All windows in the room should be closed. Figure 34 shows the preferred location for the cabinet. The BSC should be located at the wall furthest from and facing the entry door. If this is not possible, the BSC should be located on the side wall perpendicular to the hinge side of the door.

#### **I-1.4.2.2 Clearances**

BSCs not connected to an exhaust system should have at least (12 inches [300 mm]) clearance from the filter face and any overhead obstructions when the cabinet is in its final operating position, to allow for testing of the Exhaust HEPA/ULPA filter. At least 12 inches (300 mm) clearance is required if the use of a thermal anemometer exhaust velocity measurement is needed when calculating cabinet inflow velocity.

All BSCs should be placed in a laboratory at a location that provides a minimum of:

- 6 inches (150 mm) from adjacent walls or columns;
- 6 inches (150 mm) between two BSCs;
- 6 inches (150 mm) space between both sides of the cabinet and 6 inches (150 mm) behind the BSC to allow for service operations;
- 40 inches (1020 mm) of open space in front of the BSC;
- 60 inches (1520 mm) from opposing walls, bench tops and areas of occasional traffic;
- 20 inches (510 mm) between BSC and bench tops along a perpendicular wall;
- 100 inches (2540 mm) between two BSCs facing each other;
- 60 inches (1520 mm) from behind a doorway;



- 40 inches (1020 mm) from an adjacent doorway swing side; and
- 6 inches (150 mm) from an adjacent doorway hinge side.

### **I-1.4.2.3 Exhaust requirements**

If the BSC is to be connected to an external mechanical exhaust system, first examine the location to ensure that it is compatible with the cabinet's exhaust outlet. The area directly above the cabinet's exhaust outlet should be clear of structural elements, water and utility lines, or other fixed obstructions. There should be enough clearance to allow for the passage of a 10 inches (250 mm) or 12 inches (300 mm) diameter duct. Avoid cabinet locations that require either an elbow directly on top of the cabinet's exhaust connection or an excessive number of elbows to clear other items.

### **I-1.4.2.4 Electrical requirements**

The electrical outlet that the BSC plugs into should have a dedicated circuit breaker. This will prevent the accidental shutdown of the cabinet, should another device overload the circuit.

Some larger cabinet models, when operated at 115 volts, will require a circuit rated for 20 ampere service. As the electrical plugs and sockets for 115 volts, 15 and 20 ampere ratings are different configurations; the user should confirm that the site outlet socket matches the BSC plug.

NOTE — Some cabinets do not operate properly when connected to a ground fault circuit interrupter (GFCI). Consult with the BSC manufacturer about compatibility of their model with a GFCI outlet, if one is present.

### **I-1.4.2.5 Service line requirements**

All service lines to the BSC should meet local building codes, and be equipped with an easily accessible external shut-off valve, should disconnection be required.

#### **I-1.4.2.5.1 Connecting service valves to flammable materials**

NOTE — The use of flammable gases or solvents should be avoided in a BSC. Open flames in the cabinet will disrupt the airflow in the cabinet and may damage the HEPA/ULPA filters. Flammable gases or solvents may reach explosive concentrations in recirculating cabinets or ductwork. If the user feels that their procedure requires the use of an open flame or flammable materials they should contact their institution's safety office.

#### **I-1.4.2.5.2 Connecting service valves to high pressure service**

The use of air or gases under high pressure should be avoided as they may seriously disrupt the airflow patterns in the cabinet.

#### **I-1.4.2.5.3 Connecting service valves to a central (house) vacuum**

If service valves are to be connected to a central (house) vacuum source, appropriate devices, such as disinfectant traps, or in-line filters, or both, should be installed to prevent contamination of the vacuum system.

### **I-1.4.2.6 Roof exhaust systems**

Roof exhaust systems serving BSCs should have a stack that extends straight upward at least 10 feet (3 m) above the roof surface or have a stack with a smaller diameter trailing end to produce higher velocity flow to avoid reentrainment by the building, and should be increased in elevation when necessary to avoid the influence of surrounding structures.<sup>8</sup> Raincaps or any other structure that deflects the straight upward flow of the discharged air should be avoided. No precipitation can enter the stack when air is being

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<sup>8</sup> ASHRAE/AHIA Z9.5

exhausted at normal stack velocities. To take care of precipitation during periods when system is shut off, a 1 inch (25 mm) hole can be drilled in the lowest point of the fan casing and the water allowed to drain onto the roof. It is recommended that roof exhaust fans be energized by direct-connected electric motors to avoid failures caused by slipping and breaking of belts. Another advantage of direct-connected fans is the ability to use the motor nonfunction to activate an alarm in the laboratory, whereas when a malfunctioning belted fan is employed, the motor can be operating when the fan is idle. A diagram illustrating a recommended roof exhaust facility is shown in Figure 40 – High velocity fans.

### **I-1.4.3 Prepurchase checklist**

The investigator should notify building management to arrange for feasibility assessment of laboratory alterations and BSC location. The investigator and biosafety professional should discuss the following points about the BSC and its delivery:

- ensure all arrangements are planned in advance of the BSCs arrival;
- get a written price quote for the entire package, including the BSC Model number, optional equipment, canopy exhaust connection, etc. Work out the details about shipping and delivery with the manufacturer's representative at the time of purchase;
- determine the costs for shipping and delivery because there may be additional costs depending on the location and level of difficulty of delivery;
- ensure that the sales representative clarifies in writing what is included in "shipping and delivery." Does it include delivery of the BSC to the receiving dock of the building or to the laboratory? Does it include BSC set-up in the work area, and removal of cartoning / crating materials?
- if not covered in the purchase price, the customer will have to get facility personnel, or hire moving contractors to uncrate and move the BSC;
- ensure the corridor pathways are clear for delivery to the laboratory;
- will the BSC fit through door jams?
- will the BSC travel around sharp, narrow corridors and corners?
- will the elevators in the building accommodate the BSC?
- does the BSC have to be brought up steps?
- the moving contractor should be advised that the BSC shall be lifted onto its stand or leg extensions (working position) with a hydraulic lift; and
- responsibility for removal and proper disposal of all packing materials must be established.

## **I-1.5 BSC arrival and certification**

**I-1.5.1** When the BSC arrives, inspect it carefully. Compare the invoice with the delivered equipment. Check for any damage or missing materials and report them immediately to the proper carrier and the BSC supplier regardless of how insignificant they may first appear. Be careful of sharp crating material and let the loading dock personnel help check for damage.

**I-1.5.2** Arrange for field certification after the BSC is installed. Building operations personnel may be needed to connect the BSC to laboratory plumbing, electrical, and supply / exhaust air ventilation systems.

## **I-1.6 Cleaning and disinfection of BSC work area**

### **I-1.6.1 Dos and don'ts of disinfectant efficacy**

- do evaluate the cleaning processes and frequencies for ability to control organisms separately from the disinfectant efficacy study;
- do design a meaningful study that represents use in the facility;
- do consider additional studies if quality metrics indicate current agents are no longer controlling microorganisms in the area using prescribed disinfection methods;
- don't expect the disinfectant study to replace routine cleaning, disinfection and monitoring programs;
- don't rely on disinfectant studies to establish that cleaning frequencies and processes to control organisms are sufficient and acceptable; and
- don't wait until there is a problem to evaluate the disinfectants being used in the facility.

### **I-1.6.2 Surface disinfectants**

#### **I-1.6.2.1 Halogens (hypochlorous acid [HOCl]) – Active ingredient**

- chlorine bleach oxidizing disinfectant that is sporicidal;
- stainless steel is corroded by chlorine bleach. Sodium hypochlorite must be neutralized with sodium thiosulfate or followed by use of a disinfectant or sterile water;
- 1:5 dilution of Clorox™ with water (10,000 ppm) is needed to inactivate Mycobacteria in sputum);
- 1:100 dilution with water (500 ppm) must be made fresh daily and combined with a nonionic detergent;<sup>9</sup>
- 1:50 dilution stored at room temperature in a closed plastic container will deteriorate to the equivalent of a 1:100 dilution after 1 month (Amer. J. Infect. Control 17:1, 1989);
- bleach mixed with acid cleaner produces chlorine gas – 1 ppm TLV; and
- bleach mixed with ammonia-containing cleaner produces monochloramine and dichloramine irritants.

#### **I-1.6.2.2 Chlorine dioxide**

- tuberculocidal, bactericidal, virucidal and fungicidal.

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<sup>9</sup> National Institutes of Health Laboratory Safety Monograph: A Supplement to the NIH Guidelines for Recombinant DNA Research. US Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, July 1978.

**I-1.6.2.3 Quaternary ammonium salts**

- each compound exhibits its own antimicrobial characteristics;
- chemical names of quaternary ammonium compounds used in healthcare are alkyl dimethyl benzyl ammonium chloride, alkyl didecyl dimethyl ammonium chloride, and dialkyl dimethyl ammonium chloride;
- newer quaternary ammonium compounds are referred to as twin-chain or dialkyl quaternaries (e.g., didecyl dimethyl ammonium bromide and dioctyl dimethyl ammonium bromide);
- a quaternary detergent cleaner is used in maximum containment (BSL-4) facility showers;
- most common institutional disinfectant sold under hundreds of trade names; and
- use dilution ranges from 0.5 to 3% depending on the compound.

**I-1.6.2.4 Phenolics**

- EPA registered as tuberculocidal;
- many trade names and concentrations of amyphenol and phenyl phenol;
- allergies, skin absorption; and
- phenolics are not sporicidal.

**I-1.6.2.5 Alcohols**

- flammable;
- alcohols are not sporicidal and must be used as a sterile solution to prevent spread of fungal spores;
- 70% alcohol sprayed on the work surface of an operating BSC becomes ineffective within seconds; and
- alcohol attacks acrylic, polypropylene, PVC, and polycarbonate plastics over time.

**I-1.6.2.6 Iodophores**

- often used at a 0.5% concentration;
- Wescodyne™ diluted 1:213 with water is an effective BSC surface disinfectant;
- nonstaining, but will leave a brown residue; nontoxic;
- active against gram negative and gram positive bacteria, viruses, fungi, yeast, M. tuberculosis and many bacterial and fungal spores; and
- used on work surfaces, water baths, and incubators.

**I-1.6.2.7 Peroxides (stabilized) hydrogen peroxide 6 to 25%**

- often used to sanitize surfaces in the food industry; and
- sporicidal agent recommended by cleanroom industry.

**I-1.6.2.8 Peracetic acid**

- sporicidal agent recommended by cleanroom industry.

## **I-1.7 BSC use practices and procedures**

### **I-1.7.1 Ergonomics**

**I-1.7.1.1** Ergonomics is important for proper BSC use and user health and safety. An evaluation of normal work practices should be performed with each user when working in a BSC.

**I-1.7.1.2** Evaluation criteria should be at a minimum: proper user posture, effective work zone layout for work practices, and correct vision or sightlines.

**I-1.7.1.3** User accommodations include a six-way articulating chair with seat and back controls for personalized adjustment to assure proper user posture. Feet should rest on the floor, chair foot support or foot rest. Fully support an individual's back is fully supported with proper chair adjustments.

**I-1.7.1.4** Forearm / armrest supports are available on some BSCs to provide forearm support on the work access opening. Periodic mini-breaks during BSC work should be taken by resting your forearm to avoid stress and fatigue.

**I-1.7.1.5** Effective work area layouts will minimize reach to avoid neck and shoulder stress and fatigue. Rotating tables are available to minimize reach.

**I-1.7.1.6** Always prepare your work procedure to eliminate glare and bright reflections on the sash window and keep the sash sightlines clear to your work zone.

### **I-1.7.2 BSC practices**

- BSC must be properly certified before use;
- BSC must be positioned in an area with no drafts or foot traffic;
- do not bypass any sash closure or position alarms; and
- do not block or restrict any grill(s) or discharge openings.

**I-1.7.3** Do not modify a BSC in a way that may compromise its containment unless approved by appropriate safety personnel for the following modifications:

- installing a water faucet;
- connecting a drain to sewage system;
- installing waste cans under or in the work surface;
- installing other devices (i.e., centrifuge) into the work surface; and
- positioning cables, hoses etc., through the work access opening.

### **I-1.7.4 BSC techniques**

- have proper BSC training including proper aseptic technique before use;
- decontaminate BSC work surface before use;
- ensure that sash is at the proper height depending on BSC model;
- do not use an open flame;
- do not use high pressure gases;
- do not use volatile chemicals without a risk assessment by qualified chemical safety personnel system (refer to Section I-1.3.1.3);
- do not place large objects on the BSC work surface;

- do not place fan-cooled devices in the BSC work area;
- minimize room activity;
  - activity in the room should be held to a minimum. Unnecessary activity may create disruptive air currents as well as interfere with BSC operation. A person walking past the front of a BSC may cause draft velocities up to 175 ft/min (89 m/s), which can disrupt the air inside the BSC.
- utilize unidirectional air flow;
- keep two important facts in mind: (1) air supplied to the work area through a supply filter from the top, is contaminant free; and (2) airborne contamination generated in the work area is controlled by flow of airstreams in a top-to-bottom direction;
- a solid object placed in the sterile air stream will disrupt the air flow and consequently, the capability to control lateral movement of airborne particulates. A cone of turbulence will extend below the object and uniform flow of the air stream will not be regained until for approximately equal to three to six times the size of the object. Within this cone of disturbed air, particles may be carried laterally by multidirectional eddy currents;
- transfer of viable materials and manipulations which may generate aerosols should not be performed above sterile materials;
- employ aseptic technique;
- do not assume that the BSC will prevent contamination when performing procedures. BSCs will control airborne contamination of viable agents (i.e., microorganisms), but the BSC will not eliminate contact transmission of contamination. Contamination control procedures such as aseptic technique is required to obtain maximum benefit from the BSC;
- open bottles, tubes or flasks should be kept as parallel as possible to the downflow air to minimize capture of particulates. This precaution is merely good aseptic technique;
- equipment in direct contact with agents must remain in the cabinet until bagged or until surface-decontaminated. Trays of discard pipettes must be covered before removal from the BSC;
- when there is a spill or splatter of agent in the work area, all surfaces and items in the BSC should be surface-decontaminated before materials are removed;
- using natural gas to flame flask or tube necks is not recommended. A gas burner flame in BSC also contributes significantly to the heat build-up inside the BSC and also disrupts the sterile supply air stream. If a procedure demands use of a flame, a Bunsen burner with an on-demand ignition is recommended. Do not use a constant flame gas burner. Bunsen burners must be placed near the rear of the workspace where air turbulence will have a minimal effect;
- a plastic-backed absorbent paper should be placed on the work surface during mixing procedures and replaced whenever significant spills occur and when the work is completed;
- vials should be opened with a tool specifically designed for that purpose. Vials should be vented with a filter needle to eliminate internal pressure or vacuum;
- before opening ampoules, make sure that no liquid remains in the tip of the ampoule. A sterile gauze pad should be wrapped around the neck of the ampoule before it is opened; and
- a collection vessel should be available on the work surface for discard of solutions.

**I-1.7.5 BSC start up procedure**

- a) Follow manufacturer's startup procedure. If cabinet alarm condition is present, investigate root cause before continuing;
- b) Inspect air intake grilles for obstructions and foreign materials and remove any obstructions. Remove all items from the work area;
- c) Adjust view screen to proper height;
- d) Turn on blower and allow 5 minutes to purge the air;
- e) Wash hands and arms with mild, nonantimicrobial soap for 30 seconds. Put on a rear-fastening, long-sleeved gown with gathered cuffs. Put on a pair (or two pairs) of appropriate long sleeve (11.5 to 12 inch) gloves (nitrile gloves are recommended for biological work). Consider, when appropriate, disposable sleeve protectors and a second or third pair of appropriate gloves. This will minimize the shedding of skin flora into the work area and also protect hands and arms from viable microbial contamination. Before and after work in a BSC, hands and arms should be washed mild, nonantiseptic soap;
- f) Disinfect the interior surfaces of the BSC by wiping down with appropriate disinfectant for an appropriate contact time. 70% alcohol is not considered an appropriate disinfectant because it has no effect on fungal spores;
- g) Place a plastic-backed pad on the work surface without covering the air intake / exhaust grills. This will prevent spills from hitting the stainless steel surface and creating aerosols;
- h) Put all items for the experiment in the BSC and keep clean items segregated from dirty items by 12 inches (300 mm). Organize the material so that dirty "contaminated" items will not be passed over (cross contaminate) clean items;
- i) Exercise care that no items be placed over the front intake grills. Materials should be arranged so that clean materials are separated from dirty (used) virus materials. Passage of contaminated materials over noninoculated cultures or clean glassware should be avoided to prevent contamination. Transfer of viable materials should be performed as deeply into the cabinet (away from open face) as possible;
- j) Allow air to stabilize for 5 minutes before starting work. This will rid the area of all "loose" contamination that may have been introduced with the items;
- k) Work from "clean" to "dirty" areas and work at least 6 inches (150 mm) back from rear of the front air intake grill;
- l) Move arms in and out of the work access opening perpendicular to the front of the BSC in a slow steady motion to minimize disruption of the front air curtain;
- m) Minimize penetration of the work opening air curtain;
- n) A minimum number of needed items should be placed into the BSC to prevent overloading. Work should be planned to minimize the number of times an operator's hands and arms must enter and leave the air curtain. Ideally, have everything needed for your procedure placed in the BSC before starting, so that nothing needs to pass in or out through the front air curtain until the procedure is completed. Do not raise your hands inside the BSC above the top level of the sash height. If you raise your hands above the sash height, air may flow up your hands to elbows and possibly out of the BSC;

- o) Know your "safe working area". BSC safe working area is the work tray or depressed area. All work should be performed on or above the work tray. The area on or above and within 6 inches (150 mm) from the rear of the front grill is a nonsafe working area;
- p) This is a general operational guideline to control airborne contaminants of low to moderate risk.<sup>10</sup> Procedure protocols defined in terms of the barrier or control concepts unique to BSCs must be developed for maximum safety and protection; and
- q) For preparation of antineoplastic drugs, the following procedures summarize the OSHA Technical Manual TED 1-0.15A, Section VI, Chapter 2 "Controlling Occupational Exposure to Hazardous Drugs". This document should be reviewed before preparing antineoplastic drugs in a BSC.<sup>11</sup>

#### **I-1.7.6 Terminal purging and wipedown**

- a) Following completion of work, allow the BSC to run for a 5 minute period without personnel activity to purge air in the work area;
- b) Decontamination of the interior surfaces should be repeated after removal of all materials, cultures, apparatus, etc. Check grills and diffuser grids for spilled or splashed materials that may support fungus growth in the workspace; and
- c) The interior surfaces of the workspace should next be disinfected with an appropriate disinfectant for an appropriate contact time. Use of chlorine bleach in the BSC will damage the BSC stainless steel work surface. Most surface disinfectants require a specific contact time, depending upon the microbiological agents used within the BSC. Consult appropriate disinfectant documents for proper application and suitability against the material used in the BSC.

#### **I-1.7.7 Use the following procedure to effectively clean or surface disinfect the BSC work zone surfaces:**

- a) Raise the sliding sash window to a full-open position.
- b) Silence the audible alarm during the cleaning process.
- c) Wipe all surfaces in parallel strokes from clean to dirty.

#### **I-1.7.8 Paper catch prefilter**

Some BSCs have a paper catch filter installed behind the rear divider panel of the work zone. This area forms the return air path to the motor / blower. If the airflow is blocked, performance of the BSC can be compromised. Therefore, the paper catch should be checked and cleaned no less than weekly or daily if paper products are used for procedures. Removed paper must be properly discarded as contaminated hazardous waste.

#### **I-1.7.9 BSC shut down**

- a) Turn off blowers and lights. Do not use cabinet as a depository for any lab equipment or materials during periods of nonoperation.
- b) Close the sash window.
- c) If antineoplastic agents are prepared in the BSC, it is recommended that the BSC run 24 hours per day. This lessens the possibility that contaminants may escape.

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<sup>10</sup> Technical Report No. FPS 56500000001, by Dow Chemical USA., National Cancer Institute, May 1, 1972.

<sup>11</sup> <[www.osha.gov/dts/osta/otm/otm\\_vi/otm\\_vi\\_2.html](http://www.osha.gov/dts/osta/otm/otm_vi/otm_vi_2.html)>.



## **I-1.8 Moving a permanently installed BSC**

**I-1.8.1** It is a common practice to move permanently installed BSCs to other locations within a laboratory or to other laboratories. Despite the apparent simplicity of the job, there are certain conditions that must be met prior to moving this equipment. BSCs should not be moved without consultation with a biosafety professional.

**I-1.8.2** Existing BSCs and ancillary equipment, such as canopy connection exhaust ducting, gas, electric and vacuum connections, should be cleared for maintenance by a biosafety professional prior to disassembly. Depending on circumstances of the move, (i.e., cabinet use, new location, etc.), BSCs may be required to be space decontaminated before the move. After a BSC is moved, it should be certified according to applicable performance standards.

## **I-1.9 BSC lifespan**

The current lifespan of a BSC is approximately 15 years. Use of modern day BSCs began in the early 1970s with BSCs that were manufactured to the NIH-03-112C Standard and subsequently the NSF/ANSI 49. BSCs manufactured in the 1970s, 1980s, and early 1990s have provided over 15 years of service. Several considerations should be made of BSCs in this age group:

- will the BSC need extensive service? (i.e., HEPA/ULPA filter replacement, blower / motor replacement, will the electrical wire harnesses need replacement, etc.);
- can an older BSC be commissioned after it has been in storage or purchased as a resale?
- will original test reports be available or will the BSC be commissioned to current NSF Standards?

After 15 years, replacement parts may or may not be available due to electrical or mechanical changes at the factory or industrial part suppliers. For example, magnetic ballasts and T12 fluorescent bulbs may not be available. In addition, today's BSCs have evolved through the years with many improvements in containment, ergonomics, serviceability, and energy efficiency. That should be considered in a BSC repair versus replacement decision.

## **I-1.10 Decommissioning process**

**I-1.10.1** No BSC should be sent to a landfill or a recycling facility as a BSC, it should be disassembled per requirements contained in this Section.

### **I-1.10.2 Decontamination and personal protective equipment (PPE)**

- after a review of the BSC hazard use, the cabinet may be considered chemically contaminated and requiring special decontamination procedures, not the standard gaseous sterilization. Follow Section I-1.10.2.3;
- all decommissioned BSCs used with pathogens should be space decontaminated;
- BSCs to be decommissioned that were used with chemical agents should have a hazard review made to determine whether special decontamination practices and PPE should be followed;

- for those BSCs used with biological agents such as prions or biological toxins, that may not be inactivated via gas decontamination, the filters should be incinerated and 10% bleach or other appropriate disinfectant applied to all remaining contaminated surfaces. Obtain prior approval of the Facility Safety Officer; and
- PPE should be used as directed by the Facility Safety Officer or the biosafety safety professional.

### **I-1.10.3 Metal parts**

- all metal parts of less than 30 pounds (13 kg) per item should be removed from the lab and taken to an appropriate metal recycling container; and
- metal parts in excess of 30 pounds (13 kg), including the unit chassis, should be taken to a designated area in the facility to be picked up by a commercial recycling vendor.

### **I-1.10.4 Glass windows**

All glass safety windows and sashes should be taken to the designated glass container. Remove all parts that are not press fit or glued to the glass edges or surfaces.

### **I-1.10.5 Wiring**

All accessible wiring should be taken to a wiring recycling container.

### **I-1.10.6 Electrical ballasts**

All lamp ballasts should be taken to the ballast collection center at the institution.

### **I-1.10.7 Lamps**

- all fluorescent lamps should be taken to the lamp container area at the institution; and
- all ultraviolet lamps should be handled as mercury-containing waste.

### **I-1.10.8 Labels**

All warning, identification and field certification labels should be removed and destroyed.

### **I-1.10.9 Used HEPA/ULPA filters**

**I-1.10.9.1** HEPA/ULPA filters that have been decontaminated are often burned in an incinerator. This disposal method is also effective for HEPA/ULPA filters containing toxic chemicals. Factors to be considered when incinerating filters include, but are not limited to, composition of the waste, feed rate, combustion temperature and dwell time in the primary chamber.

**I-1.10.9.2** HEPA/ULPA filters may be placed in heavy plastic bags, such as those used to bag-out filters from contaminated filter housings. The bagged filters can be chemically decontaminated in situ by cutting small holes in the bag and delivering appropriate disinfectant or neutralizing agent by inserting a garden-type spray through the hole and spraying the filter media. The holes can be sealed with duct tape and shipped to an incinerator or sanitary landfill. This chemical method may be appropriate for filters containing agents (i.e., toxic chemicals) that cannot be inactivated by the usual space decontamination procedures.

**I-1.10.9.3** Decontaminated HEPA/ULPA filters may be safely buried in a sanitary landfill because they no longer pose a hazard.

## I-1.11 Definitions

**I-1.11.1 accessible:** Fabricated to be exposed for cleaning and visual inspection using simple tools (screwdriver, pliers, open-end wrench, etc. [also see definition of "readily accessible."])

### I-1.11.2 airflow

**I-1.11.2.1 air curtain:** a artificially created stream of moving air that is drawn across a threshold or other opening to create a barrier.

**I-1.11.2.2 downflow velocity:** The velocity of HEPAfiltered air as it flows downward through the work area, providing product and cross contamination protection. The velocity is measured in a plane 4 inches (100 mm) above the bottom edge of the sash, when it is in its normal operating height.

**I-1.11.2.3 downflow velocity profile:** The individual downflow velocities as measured and averaged, on a predetermined grid pattern. Airflow velocities and the average of the airflow through the work area may be calculated as a whole (uniform) or may be separated into two or more adjoining areas (zoned) with averages calculated for each zone.

**I-1.11.2.4 inflow:** The velocity or volume of air that flows from the room into the front access opening, providing an air barrier to prevent the escape of aerosols generated in the cabinet's workzone.

**I-1.11.2.5 unidirectional airflow:** Air traveling through an area in a single pass in the same direction at a uniform speed to minimize potential cross contamination from aerosols.

**I-1.11.2.6 nonuniform (zoned) downflow:** A downflow velocity profile comprised of several contiguous zones. The average downflow velocities vary from zone to zone.

**I-1.11.2.7 uniform downflow:** A downflow velocity profile wherein the individual point velocities are all approximately the same.

**I-1.11.3 biohazard:** a contraction of the words biological and hazard): Infectious agent(s), or part thereof, presenting a real or potential risk to the well-being of humans, or animals, or plants, or any combination thereof directly through infection or indirectly through disruption of the environment.

**I-1.11.4 biosafety cabinet nominal width:** The interior sidewall to sidewall width. The cabinet nominal width is expressed in 12 inches (300 mm) increments for cabinets with an interior sidewall to sidewall width greater than 33 inches (840 mm). Cabinets with an interior sidewall to sidewall width of 33 inches (840 mm) or less are classified to the nearest 6 inches (150 mm). This definition is provided for the purpose of determining the required downflow velocity grid spacing requirements and personnel protection slit sampler positioning.

### I-1.11.5 biosafety cabinet shell penetrations / cable ports

**I-1.11.5.1 sealed service penetration:** A structure that seals an adjustment fixture, or test connection, or both, that passes from a contaminated area of the cabinet to the outside environment (e.g., an exhaust damper (choke) adjustment shaft in a Type A BSC) meeting the requirements of Section N-1.1. Its installation is durable, not typically requiring service, or replacement, or both, and its function is to allow the certifier to make the necessary adjustments or test measurements without releasing contaminants.

**I-1.11.5.2 user-modified pass through:** A structure that allows the user to pass wiring, cables, tubing, etc. from the outside environment into the work area of the cabinet. Portions of this pass through structure may be permanently attached to the work area of the cabinet, not typically requiring service, or replacement, or both, but the retaining element(s) for the various cables, tubes, etc. are readily replaceable by the user. Its functions are to retain the object(s) the user has installed in the pass through, and prevent the escape

of contaminants via the pass through. The pass through shall bear cautionary labels both interior and exterior referencing use.

**I-1.11.5.3 sealed service pass through:** A structure that allows wiring, cables, tubing, etc. to pass from the outside environment into a contaminated area of the cabinet (e.g., electrical wires for the fan in a Type A BSC). Its installation is durable, not typically requiring service, or replacement, or both. Its functions are to immobilize the items passing through it, and to provide a seal meeting the requirements of Section N-1.1.

**I-1.11.6 biosafety cabinet carcass, hull, chassis, shell, body:** The outside of the cabinet exposed to the environment after removing any decorative or dress panels, providing a barrier between the inner, potentially contaminated areas and the environment.

**I-1.11.7 Biosafety Levels (BSLs):** The essential elements of the four BSLs for activities involving infectious microorganisms and laboratory animals are summarized in *Biosafety in Microbiological and Biomedical Laboratories*.<sup>12</sup> The levels are designated in ascending order, by degree of protection provided to personnel, the environment, and the community. Standard microbiological practices are common to all laboratories. Special microbiological practices enhance worker safety, environmental protection, and address the risk of handling agents requiring increasing levels of containment. BSLs should not be considered the same as microorganism Risk Groups.

**I-1.11.7.1 Biosafety Level 1 (BSL-1):** Basic BSL-1 laboratory is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment. BSL-1 laboratories are not necessarily separated from the general traffic patterns in the building. Work is typically conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required, but may be used as determined by appropriate risk assessment. Laboratory personnel must have specific training in the procedures conducted in the laboratory and must be supervised by a scientist with training in microbiology or a related science.

**I-1.11.7.2 Biosafety Level 2 (BSL-2):** Containment BSL-2 laboratory builds upon BSL-1. BSL-2 is suitable for work involving agents that pose moderate hazards to personnel and the environment. It differs from BSL-1 in that:

- laboratory personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures;
- access to the laboratory is restricted when work is being conducted; and
- all procedures in which infectious aerosols or splashes may be created are conducted in BSCs or other physical containment equipment.

**I-1.11.7.3 Biosafety Level 3 (BSL-3):** High Containment BSL-3 laboratory is applicable to clinical, diagnostic, teaching, research, or production facilities where work is performed with agents that may cause serious or potentially lethal disease through inhalation route exposure. Laboratory personnel must receive specific training in handling pathogenic and potentially lethal agents, and must be supervised by scientists competent in handling infectious agents and associated procedures. Secondary barriers for this level include controlled access to the laboratory and ventilation requirements that minimize the release of infectious aerosols from the laboratory.

**I-1.11.7.4 Biosafety Level 4 (BSL-4):** Maximum Containment BSL-4 laboratory is required for work with agents that pose a high individual risk of life-threatening disease, aerosol transmission, or related agent with unknown risk of transmission. Agents with a close or identical antigenic relationship to agents requiring

<sup>12</sup> Centers for Disease Control and Prevention, *Biosafety in Microbiological and Biomedical Laboratories (BMBL)*, 5<sup>th</sup> Edition, December 2009. <[www.cdc.gov/biosafety/publications/bmb15/index.htm](http://www.cdc.gov/biosafety/publications/bmb15/index.htm)>

BSL-4 containment must be handled at this level until sufficient data are obtained either to confirm continued work at this level, or redesignate the level. Laboratory staff must have specific and thorough training in handling extremely hazardous infectious agents. Laboratory staff must understand the primary and secondary containment functions of standard and special practices, containment equipment, and laboratory design characteristics. All laboratory staff and supervisors must be competent in handling agents and procedures requiring BSL-4 containment. Access to the laboratory is controlled by the laboratory supervisor in accordance with institutional policies.

There are two models for BSL-4 laboratories:

- Cabinet Laboratory where all handling of agents must be performed in a Class III BSC; and
- Suit Laboratory where personnel must wear a positive pressure protective suit.

BSL-4 Cabinet and Suit Laboratories have special engineering and design features to prevent microorganisms from being disseminated into the environment.

**I-1.11.8 cabinet classification:** Although this Standard covers only Class II BSCs, Class I and Class III BSCs are currently defined and known to be commercially available. BSCs can be used for work with biological agents assigned to BSLs 1 through 4, depending on the facility design as described in *Biosafety in Microbiological and Biomedical Laboratories*.<sup>10</sup> Special note should be taken that BSL-4 agents should only be used in Maximum Containment Laboratories and that Class I and Class II BSCs are only acceptable in Maximum Containment Laboratories with positive pressure containment suits.

**I-1.11.8.1 Class I:** A Class I BSC provides personnel and environmental protection without product protection. Personnel protection is provided as a minimum velocity of 75 ft/min (0.38 m/s)<sup>13</sup> of unfiltered room air is drawn through the front opening and across the work surface. The air is then passed through a HEPA/ULPA filter in the exhaust plenum, providing environmental protection.

**I-1.11.8.2 Class II:** Class II (Type A1, A2, C1, B1, and B2) BSCs are partial barrier systems that rely on the movement of air to provide personnel, environmental, and product protection. Personnel and product protection is provided by the combination of inward and downward airflow captured by the front grille of the cabinet.

Side-to-side cross-contamination of product is minimized by the internal downward flow of HEPA/ULPA filtered air moving towards the work surface and then drawn into the front and rear intake grills. Environmental protection is provided when cabinet exhaust air is passed through a HEPA/ULPA filter. When used as designed, the cabinet exhaust air may be recirculated to the laboratory (Type A1, A2, and C1 BSCs) or discharged from the building via a canopy connection (Type A1, A2, and C1 BSCs). Exhaust air from Types B1 and B2 BSCs must be discharged to the outdoors via a sealed connection.

All Class II cabinets are designed for work involving procedures assigned to BSLs 1, 2, and 3. Class II BSCs may be used with procedures requiring BSL-4 containment if used in a BSL-4 suit laboratory by a worker wearing a positive pressure protective suit.

Class II BSCs provide the microbe-free work environment necessary for cell culture propagation and also may be used for the formulation of nonvolatile antineoplastic or chemotherapeutic drugs.

**I-1.11.8.2.1 Class II Type A1 cabinets (formerly designated Type A)** – cabinets that:

- maintain minimum average inflow velocity of 75 ft/min (0.38 m/s) through the work access opening; containment may fail when people walk by the work opening.

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<sup>13</sup> Barbeito MS, Taylor LA. *Containment of Microbial Aerosols in a Microbiological Safety Cabinet*. Appl. Microbiol. 16:1255-29, 1968.

- have HEPA/ULPA filtered downflow air that is a portion of the mixed downflow and inflow air from a common plenum (i.e., a plenum from which a portion of the air is exhausted from the cabinet and the remainder supplied to the work area);
- may exhaust HEPA/ULPA filtered air back into the laboratory or to the environment through an external exhaust system connected to the cabinet with a canopy connection; and
- have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums.

If working with volatile chemicals, the unit may be canopy-connected to external exhaust system if permitted by a chemical risk assessment (refer to Section I-1.3.1.3).

NOTE — Type A1 BSCs manufactured prior to 2010 are not suitable for work with volatile chemicals due to the contaminated positive pressured plenums that are not surrounded by negative pressure plenums.

**I-1.11.8.2.2 Class II, Type A2 cabinets (when exhausted to the environment were formerly designated Type B3) – cabinets that:**

- maintain a minimum average inflow velocity of 100 ft/min (0.51 m/s) through the work access opening;
- have HEPA/ULPA filtered downflow air that is a portion of the mixed downflow and inflow air from a common exhaust plenum;
- may exhaust HEPA/ULPA filtered air back into the laboratory or to the environment through an external exhaust system connected to the cabinet with a canopy connection; and
- have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums.

If working with volatile chemicals, the unit must be canopy-connected to external exhaust system if permitted by a chemical risk assessment (refer to Section I-1.3.1.3).

**I-1.11.8.2.3 Class II Type B1 cabinets – cabinets that:**

- maintain a minimum average inflow velocity of 100 ft/min (0.51 m/s) through the work access opening;
- have HEPA/ULPA filtered downflow air composed largely of uncontaminated recirculated inflow air;
- exhaust contaminated downflow air from a region of the work area via an internal dedicated exhaust plenum and through HEPA/ULPA filter(s) to an external exhaust system with a direct connection and exhausted to the atmosphere; and
- recirculate the balance of the downflow and inflow air through a supply HEPA/ULPA filter(s); and
- have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums.

Type B1 cabinets may be used for work with volatile chemicals if permitted by a chemical risk assessment (refer to Section I-1.3.1.3).

**I-1.11.8.2.4 Class II, Type B2 cabinets** – cabinets that:

- maintain a minimum average inflow velocity of 100 ft/min (0.51 m/s) through the work access opening;
- have HEPA/ULPA filtered downflow air drawn from the laboratory or the outside air (i.e., downflow air is not recirculated from the cabinet exhaust air);
- exhaust all inflow and downflow air to the atmosphere through an external exhaust system connected to the cabinet with a direct connection after filtration through a HEPA/ULPA filter without recirculation in the cabinet or return to the laboratory; and
- have all contaminated ducts and plenums under negative pressure or surrounded by directly exhausted (nonrecirculated through the work area) negative pressure ducts and plenums.

Type B2 cabinets may be used for work with volatile chemicals if permitted by a chemical risk assessment (refer to Section I-1.3.1.3).

**I-1.11.8.2.5 Class II, Type C1 cabinets** – cabinets that:

- maintain a minimum average inflow velocity of 100 ft/min (0.51 m/s) through the work access opening;
- have HEPA/ULPA filtered downflow air composed largely of uncontaminated recirculated inflow air;
- exhaust contaminated downflow air from a region of the work area via an internal dedicated exhaust plenum and blower, and then through HEPA/ULPA filter(s);
- recirculate the balance of the downflow and inflow air through a supply HEPA/ULPA filter(s);
- have all biologically contaminated ducts and plenums under negative pressure or surrounded by negative pressure ducts and plenums; and
- may exhaust HEPA/ULPA filtered air either back into the laboratory or via a canopy connection to an external system that exhausts to the atmosphere.

If working with volatile chemicals, the unit must be connected to an external exhaust system. Type C1 cabinets may be used for work with volatile chemicals if permitted by a chemical risk assessment (refer to Section I-1.3.1.3).

**I-1.11.8.3 Class III:** The Class III BSC was designed for work with highly infectious microbiological agents and other hazardous operations. It provides maximum protection for the environment and the worker. It is a gas-tight (no leak greater than  $1 \times 10^{-7}$  cc/s with 1% test gas at 3 inch pressure water gauge) enclosure with a viewing window that is secured with locks, or requires the use of tools to open, or both. Access for passage of materials into the cabinet may be through any of the following: a dunk tank that is accessible through the cabinet floor, a double-door pass-through box that can be decontaminated between uses, integrated double door autoclaves and portable docking stations with double sealing connecting mechanisms that can be decontaminated between uses. Reversing that process allows materials to be removed from the Class III BSC. Both supply and exhaust air are HEPA/ULPA filtered. Exhaust air must pass through two HEPA/ULPA filters in series, before discharge to the outdoors. Airflow is maintained by an exhaust system exterior to the cabinet, which keeps the cabinet under negative pressure according to manufacturer design pressure criteria. Sometimes because of laboratory conditions an optional exhaust fan may be required. This exhaust fan should generally be kept separate from the exhaust fans of the facility ventilation system. If a cabinet exhaust system is required it should be equipped with an appropriate alarm system which both notifies the cabinet user and shuts down the cabinet exhaust system in the event of a facility exhaust system failure.

Rubber glove / sleeves or equivalent glove material, are sealed to ports in the cabinet and allow direct manipulation of the materials isolated inside. The glove material shall be compatible for use with the materials being used in the cabinet. The exhaust system for the cabinet shall provide inflow to the cabinet arm port in the event of a rubber glove / sleeve breach. The minimum breach velocity shall be measured with a hot wire in the middle of the arm port and shall be no less than 100 ft/min (0.51 m/s). It is not a requirement for the work area to be free of turbulence or cross contamination.

**I-1.11.9 calibration:** Comparison of the measurement of a standard or instrument of unknown accuracy with another standard or instrument of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the unknown standard or instrument.

**I-1.11.10 canopy connection:** A BSC exhaust connection where there are one or more openings or gaps in the connection between the BSC and the external exhaust system.

**I-1.11.11 certification, cabinet design:** Cabinet design certification is formal validation by a qualified design testing organization that a designated cabinet model meets all the requirements of Annex N-1 of this Standard.

**I-1.11.12 certification, cabinet field:** Cabinet field certification is formal verification by a qualified field testing certifier that an installed cabinet meets all the requirements of Annex N-5 of this Standard.

**I-1.11.13 chemical resistance:** Capability of materials to maintain their original surface characteristics under prolonged contact with cleaning compounds, decontaminating agents, and normal conditions of the use environment.

**I-1.11.14 closed:** Fabricated with no openings exceeding 0.031 inch (0.79 mm).

**I-1.11.15 concurrent balance value:** This value is determined using the duct traverse measurement method as specified in ASHRAE 111-2008, a minimum of 7.5 duct diameters downstream of a direct connected BSC. Prior to determining the concurrent balance value, it shall be confirmed that the cabinet is operating at its nominal setpoints for inflow and downflow velocity  $\pm 3$  ft/min. The primary DIM method shall be used for setting the inflow velocity. The accuracy of the DIM shall be better than or equal to  $\pm 3\%$  and  $\pm 7$  ft<sup>3</sup>/min. The static pressure is also measured approximately two duct diameters from the cabinet exhaust connection. Appropriate filter load and tolerance values shall be added to the base static pressure value to accommodate filter loading: 0.3 in w.g. shall be added for Type B1 cabinets and 0.7 in w.g. shall be added for Type B2 cabinets. The resulting values may be used for design and balance exhaust / supply HVAC requirements.

**I-1.11.16 decontamination:** Inactivation or destruction of infectious agents or neutralization of toxic agents to an acceptable level.

**I-1.11.17 direct connection:** A BSC exhaust connection where the connection between the BSC and the external exhaust system is air tight with no designed gaps or openings.

**I-1.11.18 direct inflow measuring device (DIM):** A volumetric airflow measuring device consisting of a capture hood with a sensing component that provides a readout as a single value for volumetric flow rate and meets the requirements of Annex N-2.

**I-1.11.19 high efficiency air filters** (for use in Class II BSCs):

**I-1.11.19.1 high efficiency particulate air (HEPA) filter:** A throwaway, extended / pleated medium, dry-type filter with the following:

- rigid casing enclosing the full depth of the pleats;



- minimum particulate removal of 99.99% for thermally generated monodisperse dioctylphthalate (DOP) smoke particles or equivalent with a diameter of 0.3 µm (Type C);
- minimum particulate removal of 99.99% and determination as the lower efficiency when tested for particle size ranges of 0.1 to 0.2 µm or 0.2 to 0.3 µm in accordance with IEST-RP-CC007 (Type J);
- minimum particulate removal of 99.995% and determination as the lower efficiency when tested for particle size ranges of 0.1 to 0.2 µm or 0.2 to 0.3 µm in accordance with IEST-RP-CC007 (Type K);
- maximum pressure drop of 1 in w.g. (250 Pa) when clean and operated at rated airflow capacity; and
- no area showing a penetration exceeding 0.01% when scan tested with a polydisperse aerosol having a light scattering median size of 0.7 µm and a geometric standard deviation of 2.4.

These filters conform to all the performance and construction requirements of a Type C, a Type J, or a Type K filter respectively, contained in IEST-RP-CC001.4. Filter media shall be tested in accordance with the methods of IEST-RP-CC021 with performance levels to meet the minimum efficiency requirements as specified above and the pressure drop requirements as required by the specific application.

**I-1.11.19.2 ultra-low-penetrating air (ULPA) filter:** A throw away, extended / pleated medium, dry-type filter with the following:

- rigid frame enclosing the full depth of the pleats;
- minimum particle removal of 99.999% and determination as the lower efficiency when tested for particle size ranges of 0.1 to 0.2 µm or 0.2 to 0.3 µm when tested in accordance with IEST-RP-CC007;
- maximum pressure drop of 1 inch w.g. (250 Pa) when clean and operated at rated airflow capacity. ULPA filters may have higher airflow resistance than HEPA/ULPA filters for the same rated airflow; therefore, care shall be taken to ensure that the pressure drop is compatible with the cabinet motor / blower capability; and
- no area showing a penetration exceeding 0.01% when scan tested with a polydisperse aerosol having a light scattering median size of 0.7 µm and a geometric standard deviation of 2.4.

This filter conforms to all requirements of a Type F filter contained in IEST-RP-CC001.4, HEPA/ULPA filters.

**I-1.11.20 leak tight:** Free of leaks at 2 in w.g. (500 Pa) of air pressure as described in Annex N-1.

**I-1.11.21 nominal set point velocities:** The cabinet downflow and inflow velocities that the manufacturer designates as the settings at which the cabinet is intended to operate and the settings at which it passed the tests listed in Section 6.7 and Section N-1.7.

**I-1.11.22 polydisperse aerosol:** Aerosol with a light scattering median size of 0.7 µm and a geometric standard deviation of Section 2.4.

**I-1.11.23 readily accessible:** Fabricated to be exposed for cleaning and visual inspection without using tools.

**I-1.11.24 readily removable:** Capable of being taken away from the main unit without using tools.

**I-1.11.25 removable:** Capable of being taken away from the main unit using simple tools (screwdriver, pliers, open-end wrench, etc. [also see *readily removable*]).

**I-1.11.26 sash:** A fixed or sliding window located at the front of the BSC, that forms a barrier between the operator and the work area.

**I-1.11.27 sealed:** Fabricated with no openings that will permit entry or leakage of air (leak-tight).

**I-1.11.28 smooth:** A surface free of pits and inclusions, with cleanability equal to or exceeding the following.

**I-1.11.28.1 interior work surfaces and exposed interior surfaces:** Number 3 (100 grit) finish on stainless steel.

**I-1.11.28.2 other interior surfaces and exterior surfaces:** Commercial grade cold-rolled, hot-rolled, or combination cold / hot-rolled steel free of visible scale.

**I-1.11.29 surfaces**

**I-1.11.29.1 interior work surfaces:** Surfaces used when performing a task, operation, or activity.

**I-1.11.29.2 exposed interior surfaces:** Exposed interior surfaces, other than work surfaces, that are subject to splash, spillage, or airborne contamination during normal use.

**I-1.11.29.3 other interior surfaces:** Interior surfaces not exposed to splash or spillage but exposed to vapor, or volatile toxic substances, or both.

**I-1.11.29.4 exterior surfaces:** All exposed surfaces not defined as interior.

**I-1.11.30 toxic:** Having an adverse physiological effect on biological systems.

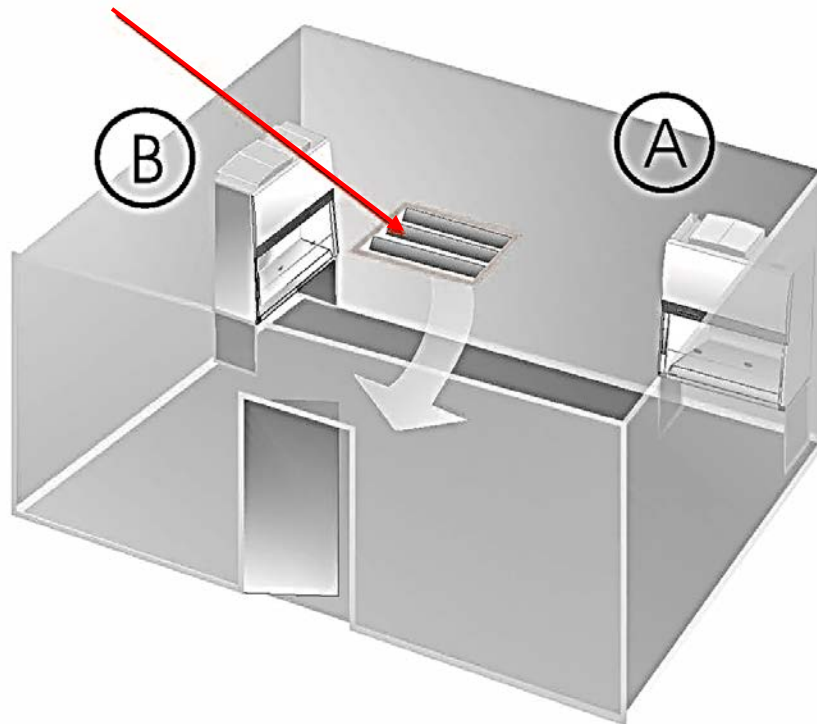
**I-1.11.31 visible medium:** A visible aerosol that is sufficiently neutrally buoyant in air to see air disturbances without influencing them. Examples include chemical ventilation tubes and thermally generated aerosol. The delivery velocity of the visual medium should be slow enough to assure that there is no interference to the air flow under test.

**I-1.11.32 w.g. (water gauge):** Another common name for the inch of water column. The word "gauge" after a pressure reading indicates that the pressure stated is actually the difference between the absolute or total pressure and the air pressure at the time of the reading.

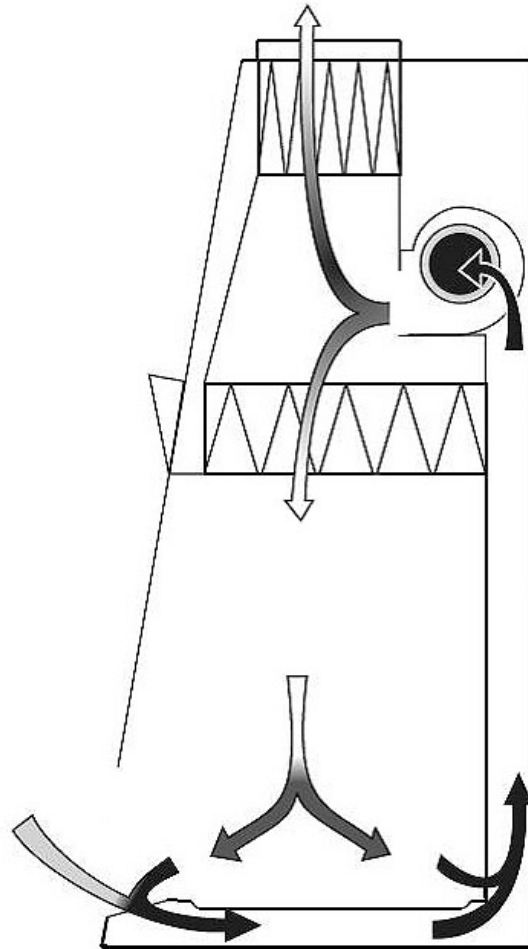
**I-1.11.33 work area:** The horizontal plane inside the cabinet extending from sidewall to sidewall and from back wall to the inside of the sash at a point approximately 2 inches (5 mm) above the lower level of the sash.

**I-1.11.34 work tray:** The solid floor of the work area identified by the manufacturer as the location for the user's activity. This is differentiated from work area.

Location A shows the preferred location. Location B is an alternate location. The air supply register(s) above or near the cabinet's location should be redirected away from the cabinet face.



**Figure 34**  
**Suggested laboratory locations for Class II BSCs**

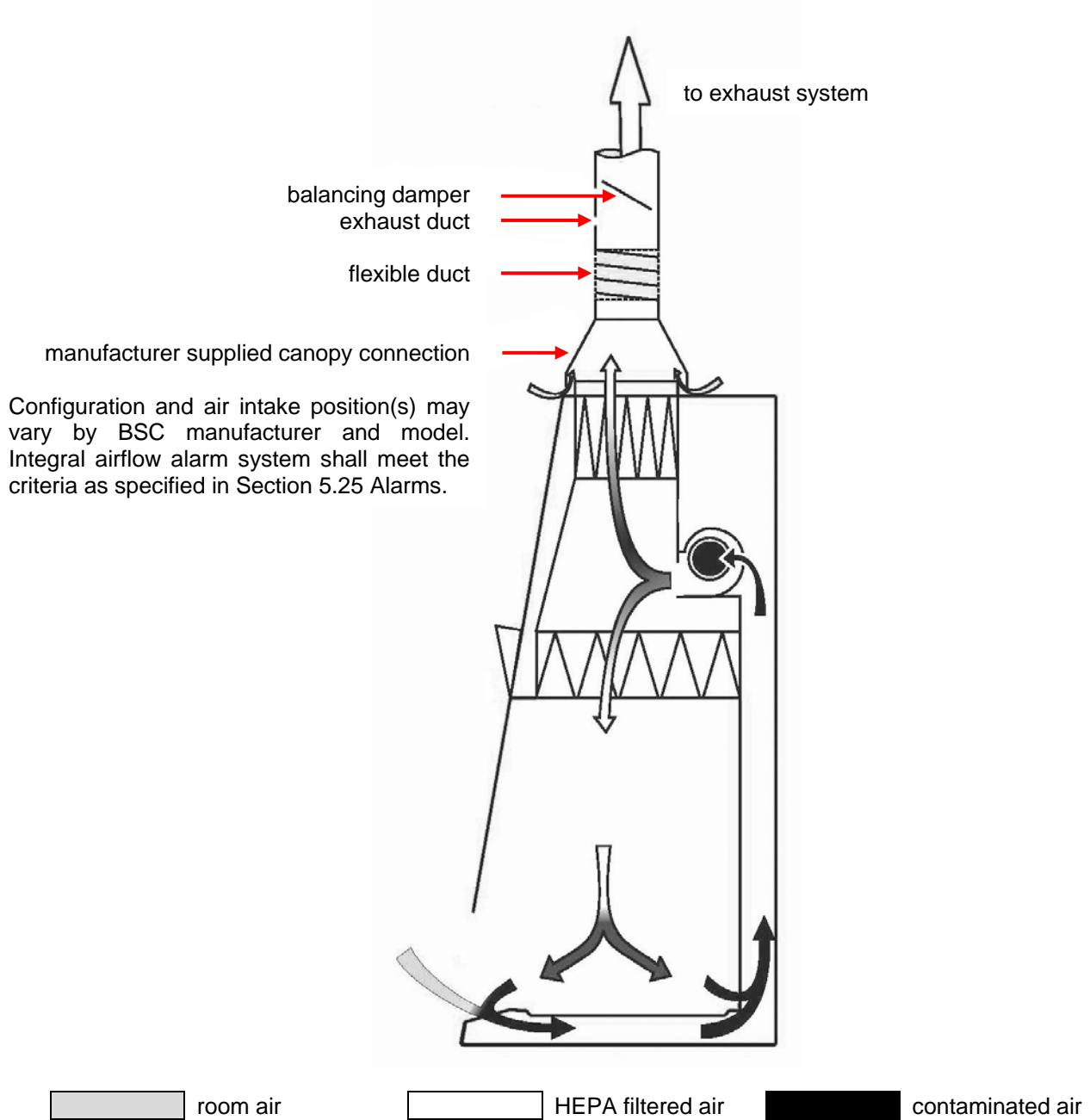


benchtop configuration

 room air       HEPA filtered air       contaminated air

NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

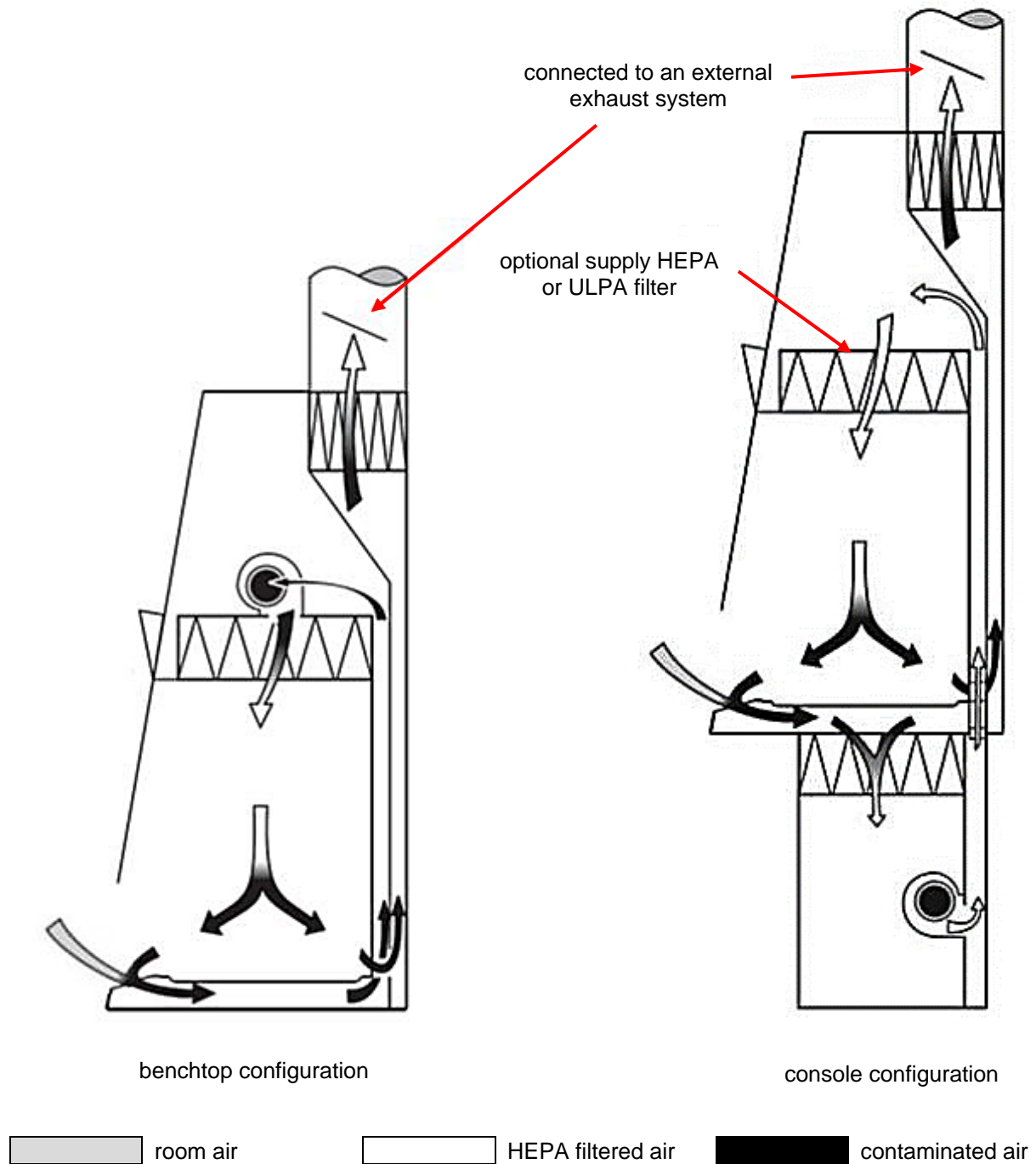
**Figure 35**  
**Airflow patterns for Class II Type A1 and A2 BSCs**



Configuration and air intake position(s) may vary by BSC manufacturer and model. Integral airflow alarm system shall meet the criteria as specified in Section 5.25 Alarms.

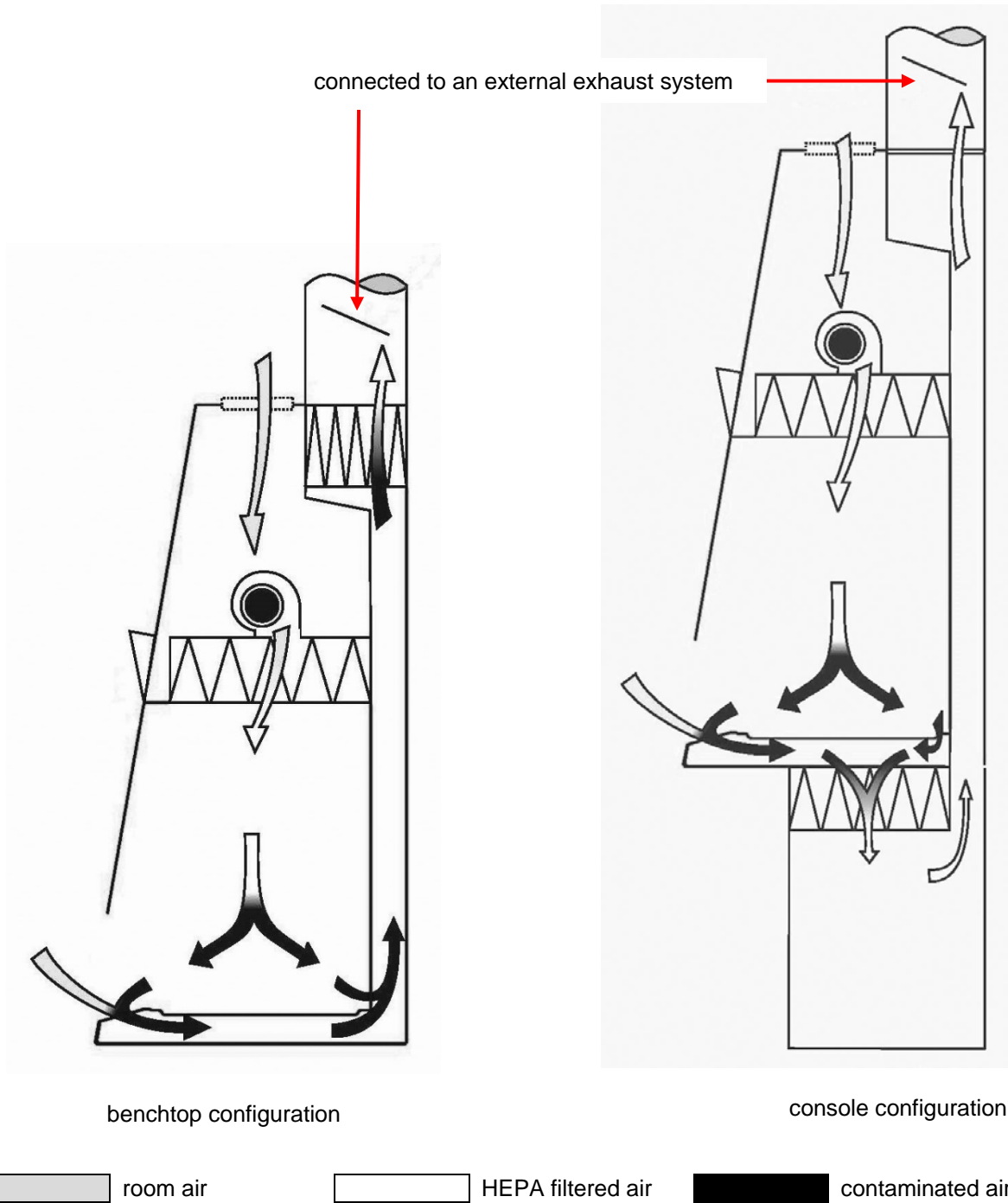
NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

**Figure 36**  
**Suggested Type A exhaust system**



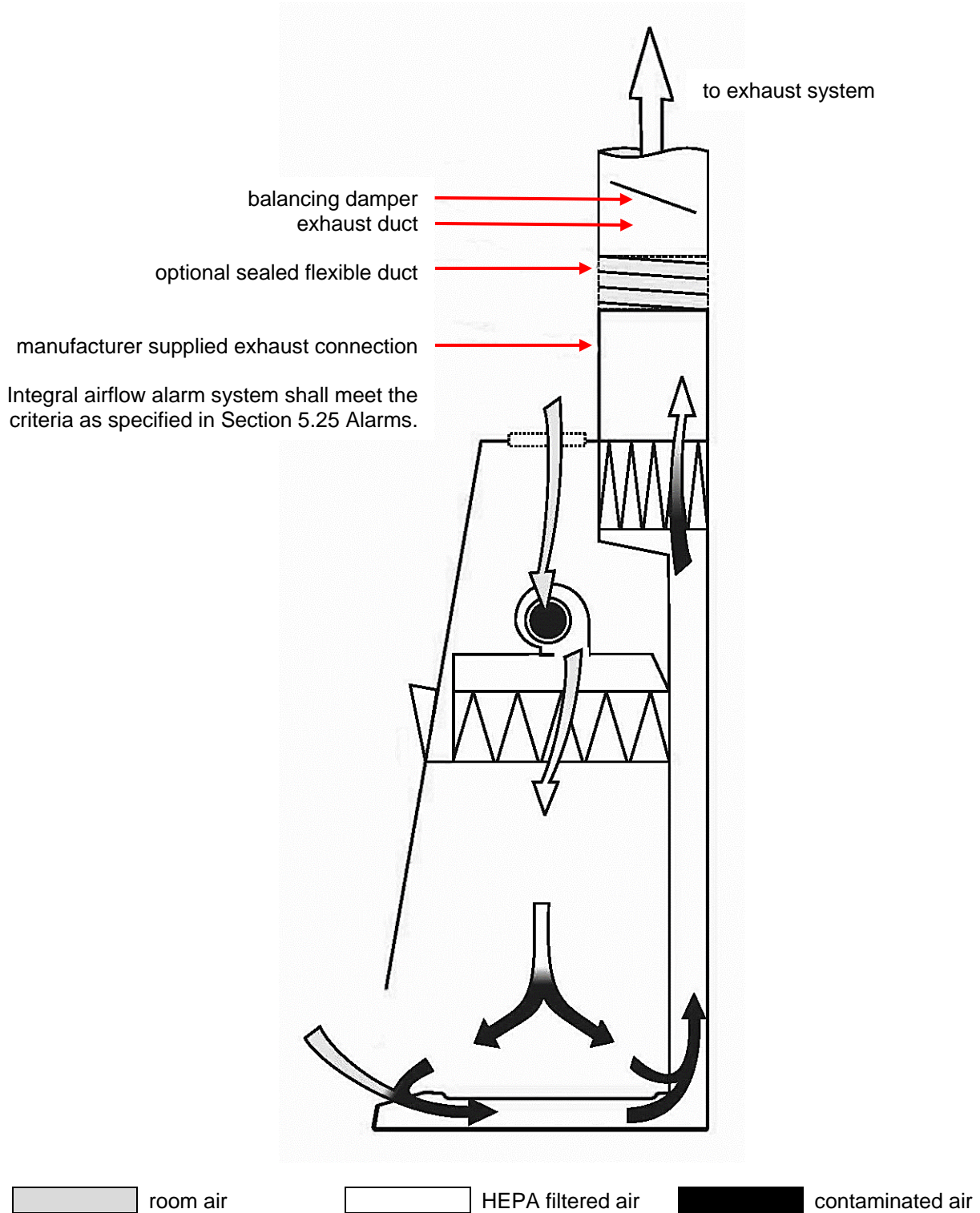
NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

**Figure 37**  
**Airflow patterns for Class III Type B1 BSCs**



NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

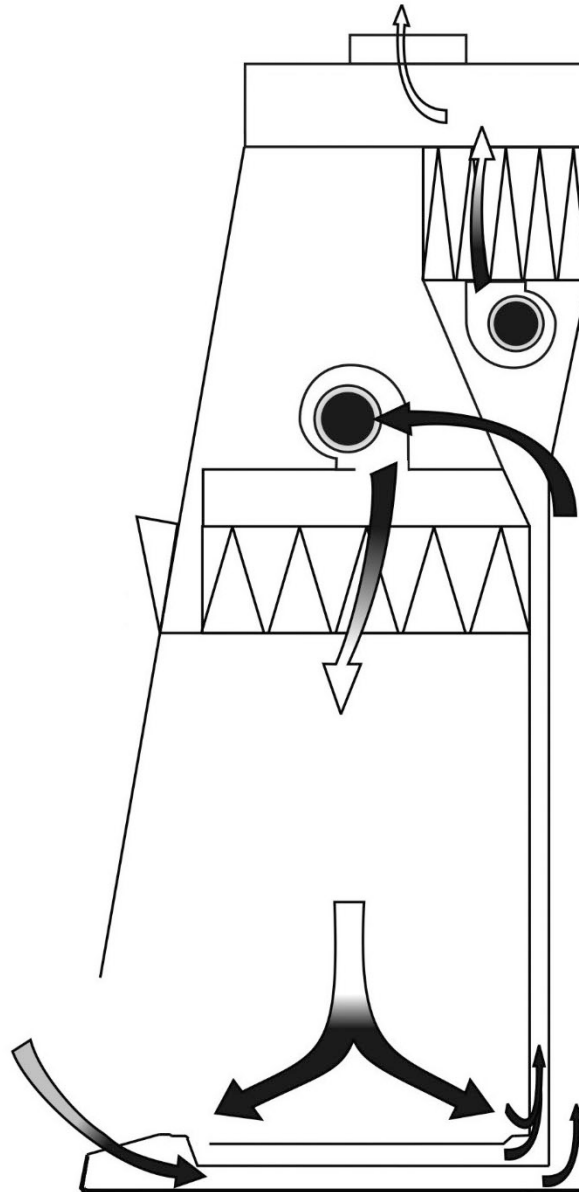
**Figure 38**  
**Airflow patterns for Class II Type B2 BSCs**

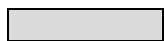
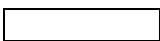



NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

**Figure 39**  
**Suggested Type B exhaust system**

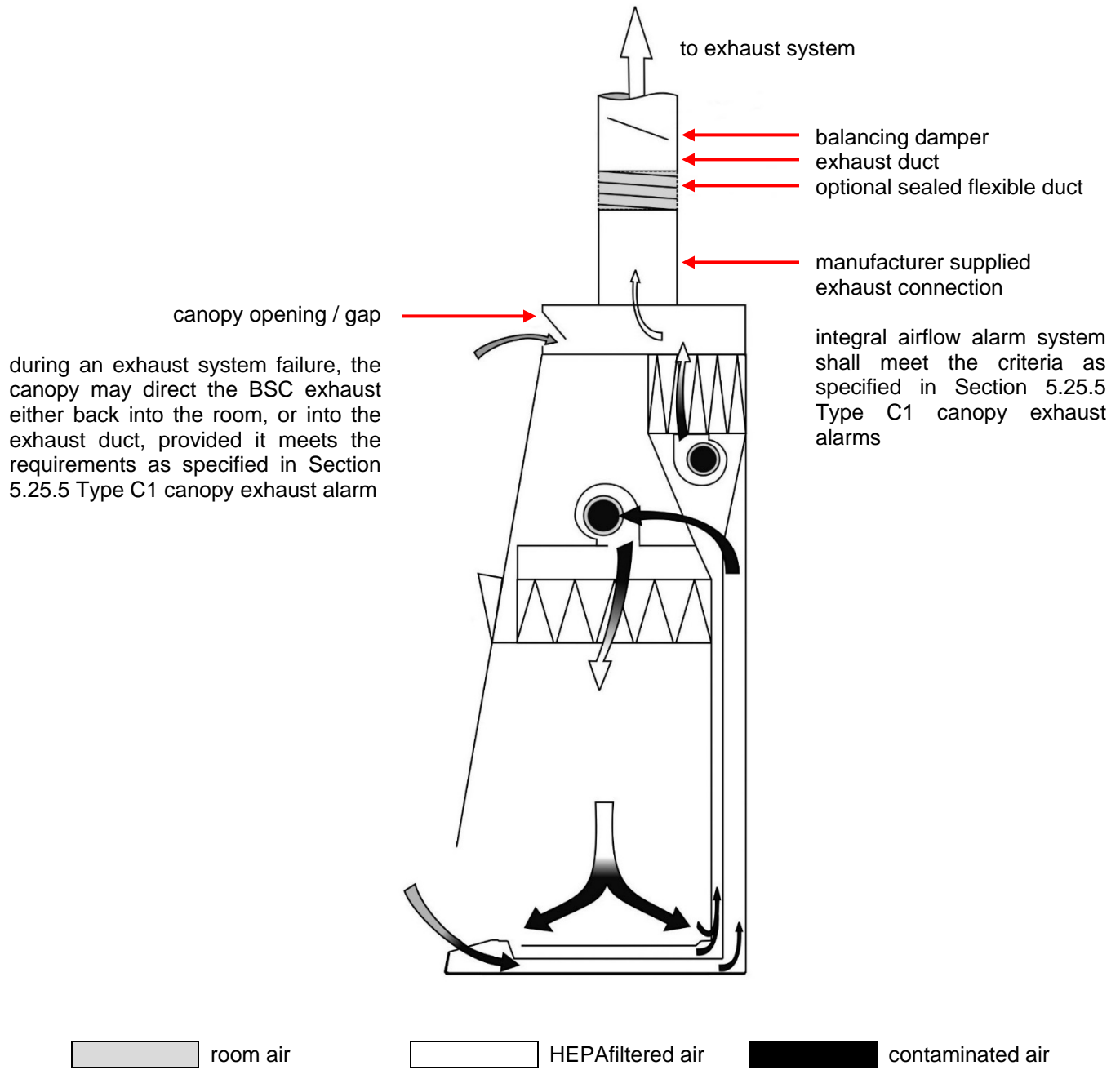




 room air       HEPA filtered air       contaminated air

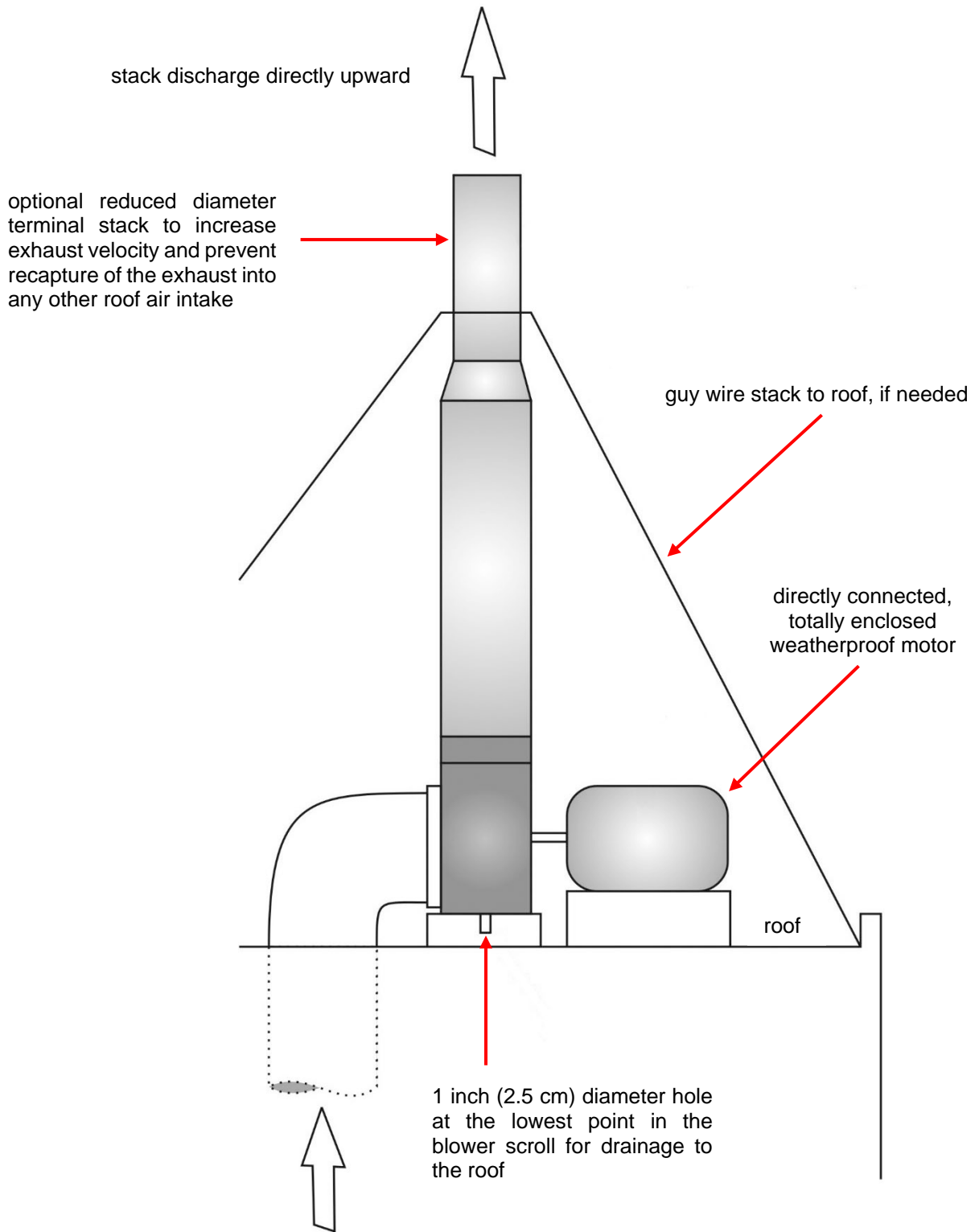
NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

**Figure 40**  
**Airflow patterns for Class II Type C1 BSCs**



NOTE — The simplified diagram illustrates airflow patterns only. All areas of the BSC containing contaminated air under positive pressure must be jacketed by negative pressure.

**Figure 41**  
**Suggested Type C exhaust system**



**Figure 42**  
**Exhaust stack and blower**



***THE HOPE OF MANKIND rests in the ability of man to define and seek out the environment which will permit him to live with fellow creatures of the earth, in health, in peace, and in mutual respect.***