LABORATORY LAYOUT AND DESIGN CONSIDERATIONS FOR

BIOSAFETY CABINET INSTALLATION

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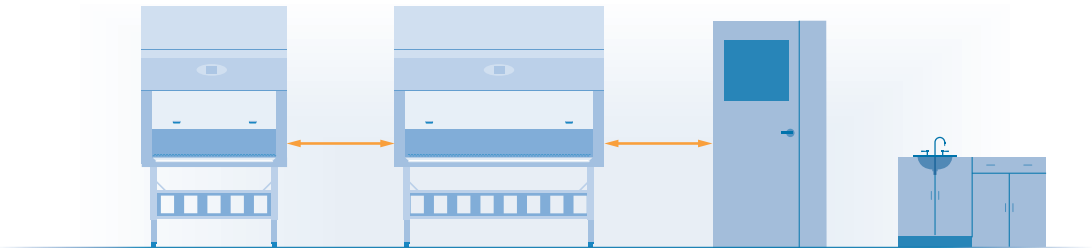

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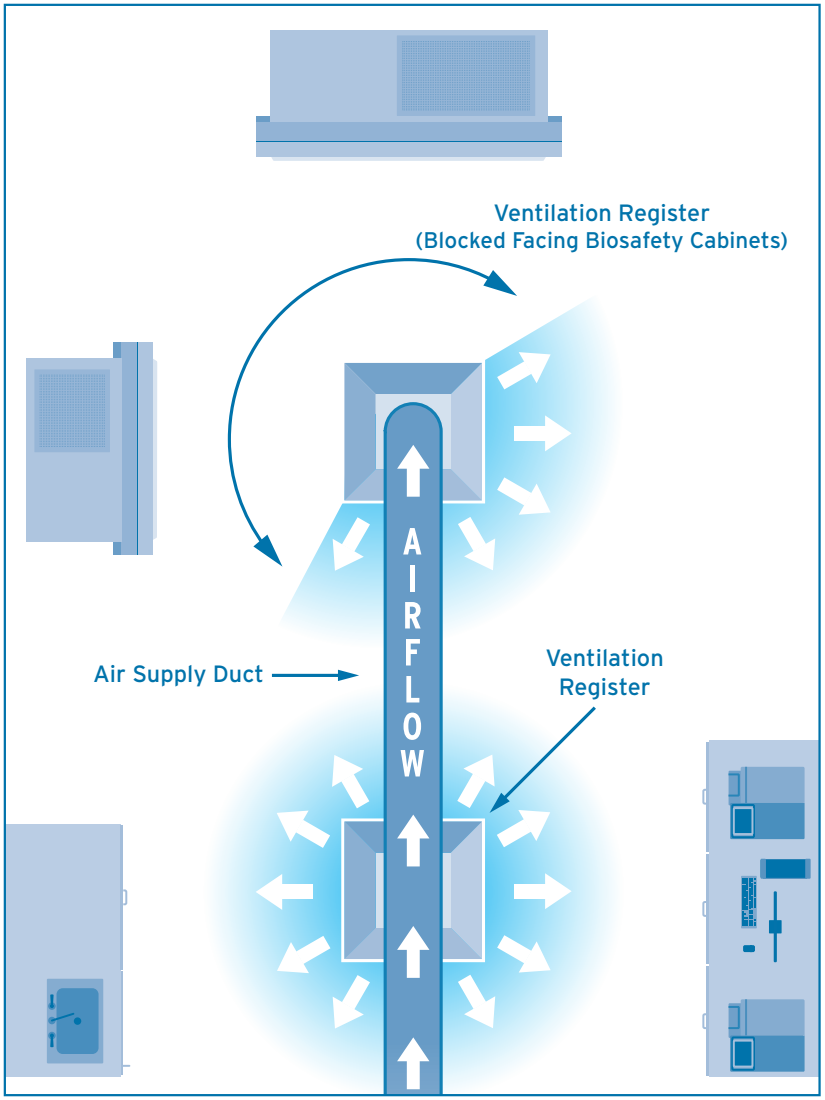
LABORATORY LAYOUT AND DESIGN CONSIDERATIONS FOR BIOSAFETY CABINET INSTALLATION

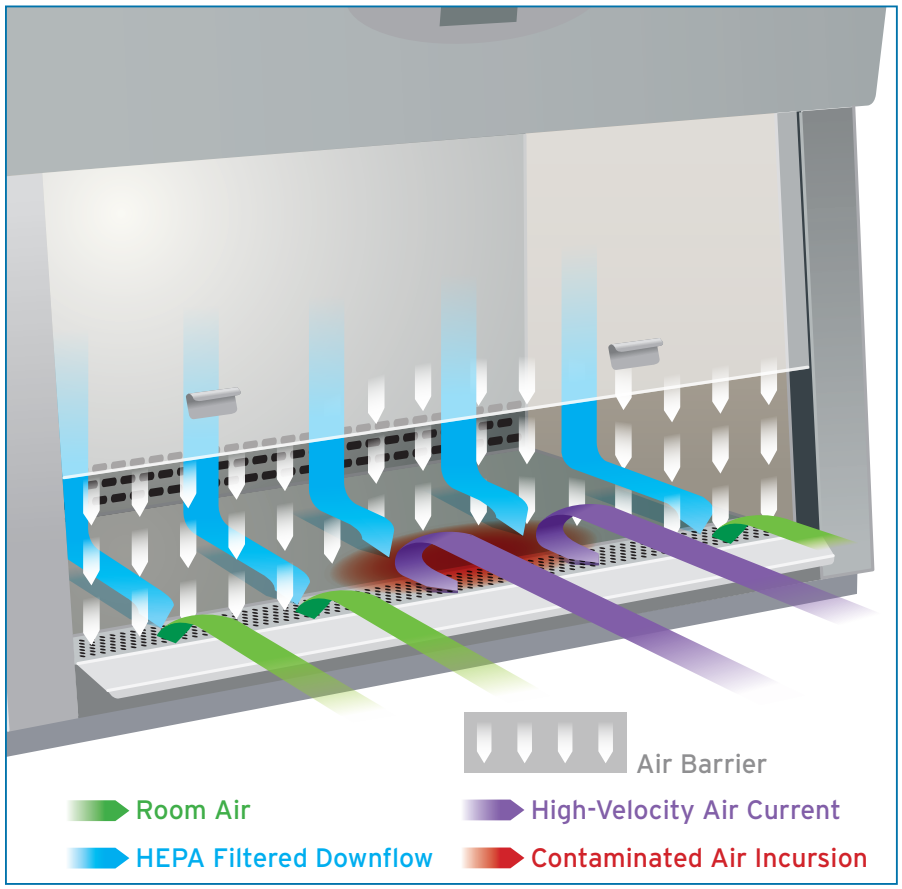
When designing or renovating a laboratory space the proper placement of equipment, especially biosafety cabinets (BSCs) and other devices that are impacted by airflow and personnel patterns, it is important to ensure their containment performance and to allow for appropriate process flow for both scientific procedures and safety purposes. In this article, we will compare different BSC placement best practice recommendations visually and propose example placements of specific equipment based on common laboratory uses within the bounds of those clearances. This information is not meant to be used in place of discussions with laboratory users or review of their documented needs such as can be found in a feasibility study, basis of design (BOD), or program of requirements (POR). It is meant to be a conversation starter for architects, engineers, and lab planners to begin discussions with their clients about the biosafety and biocontainment best practices for lab layout and placement of containment devices, specifically BSCs, in relation to other scientific equipment, building features, and lab furnishings.



Biosafety Cabinet Placement Best Practices

Biosafety and biocontainment guidance documents[1-3] describe generally where to avoid placing BSCs, including near areas with high personnel traffic, windows that can open, fans, doors, chemical fume hoods, building air supply vents, and other equipment that can disturb

the airflow of the BSC's work access opening or the room generally. They also explain that BSCs should have enough space around all sides to access, maintain, and test the BSC's airflow and filter components[1-3]. However, some go further to recommend and depict this space needed around a BSC and in relation to walls, doors, benchtops and other equipment or building features (often referred to as the "clearance") that should be protective of the BSC's personnel and product protection[3-5].



An air barrier formed by balanced room air inflow and HEPA-filtered downflow from the biosafety cabinet (BSC) is critical to containment. A strong air current perpendicular to a BSC work access opening can cause disruption of the air barrier necessary to protect personnel and work product. The resulting incursion of room air may cause contamination of the cabinet interior.

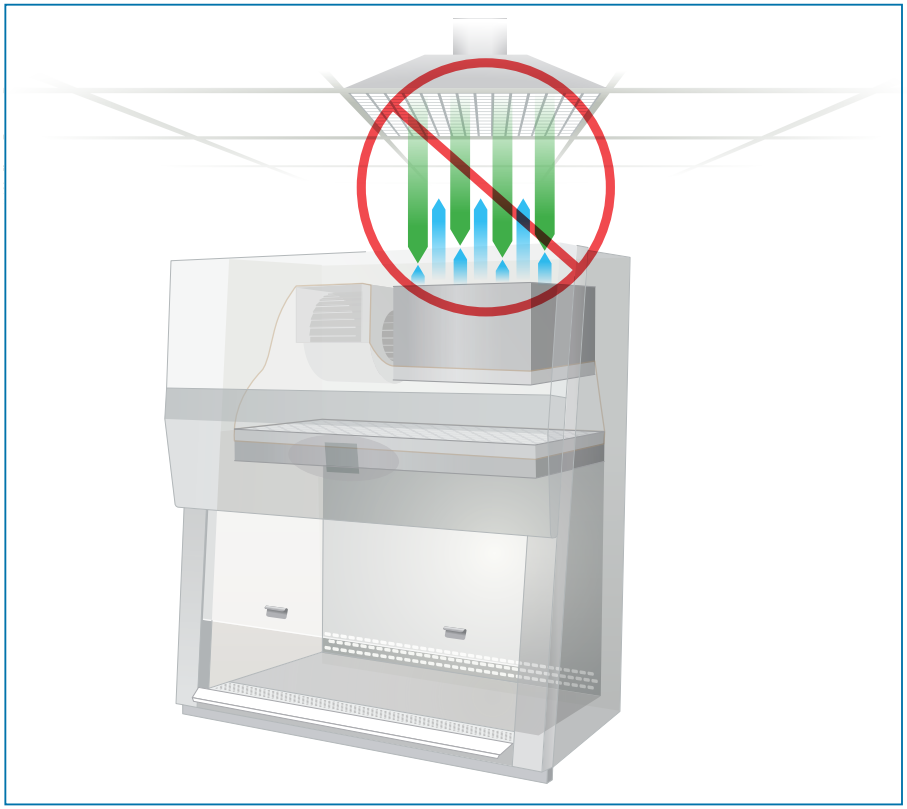
There are several organizations that recommend specific clearances for BSCs, beyond these general recommendations of areas of the lab to avoid, to prevent issues with the cabinet's performance based on its location in the laboratory. These guidelines come from a federal institution, the National Institutes of Health (NIH)'s Design Requirements Manual (DRM)[4], a public health and safety consensus standards organization, the NSF / ANSI 49[3], and certain BSC manufacturers[5-6]. The Baker Company and NuAire Inc., both manufacturers of biosafety cabinets, conducted hands-on testing of their BSC's airflow and containment performance based on some of the clearances given in the NIH DRM and NSF guidelines to evaluate the suitability of those clearance distances for their equipment[5-6]. NuAire Inc.'s evaluation tested only placement of BSCs side by side and BSCs adjacent on perpendicular walls and found that NSF's recommended clearances of 6" were more than sufficient[6]. The Baker Company evaluated other clearances including distance to walls and doors to the sides of the BSC, distance of walls and other BSCs in front of the BSC, and overhead clearance[5]. The concordance of their results with either the NIH DRM or NSF guidelines varied depending on the specific clearance tested[5].

Which set of BSC clearances best practices are selected for a given design project will depend on the organization's risk assessment, their acceptance criteria, the BSCs chosen for the lab, and sometimes the funding source for the project. Architects and

engineers must be aware of these best practices documents and the client's requirements when designing laboratory spaces especially if federal review and approval is necessary during the design and/or renovation process because of the project's funding source(s). The largest, most conservative clearances are typically found within the NIH DRM[4] and it should be noted that some of these clearances vary substantially amongst these documents by up to 42 inches[3-6]. Not accounting for adequate space around a BSC can disrupt plans for an already adequately sized or designed lab room layout leading to either **1)** having to resize the lab spaces with BSCs in them or **2)** removing bench space, cabinetry, or other necessary scientific equipment from the room to accommodate the additional BSC clearance needs. Understanding the client's risk assessment and regulatory needs, as well as these best practice guidelines, when initially scoping and laying out lab spaces can save time and headache later on in a design or renovation project.

Laboratory Layouts Including Recommended BSC Clearances

The NIH DRM, NSF, and The Baker Company guidelines all agree on just one BSC clearance measurement, that there should be 40 inches of undisturbed space in front of the BSC[3-5]. The NIH DRM guidelines recommend a distance of 48 inches between BSCs along a perpendicular wall[4] (not demonstrated in a figure), however NuAire Inc.'s testing on BSCs in this configuration demonstrated no personnel or product protection impacts on BSC's that were just a few inches apart[6]. NuAire Inc. recommends that NSF's minimum 6 inches of clearance be used for BSCs on adjacent walls[6]. The remaining clearances, displayed visually in the figures below, differ by organization or are only listed in one or two of the documents. The lab floorplans presented here are meant to provide visual representations of BSC clearances as they may be found in an actual lab space and should not be substituted for review of and compliance with any regulatory guidelines or requirements and/or the lab users' described space, equipment, or biosafety needs. Clearance arrows that are not assigned a capital letter in figures 2-4 have been described in previous figure(s) and were not redefined in subsequent figures.



Avoid placing a biosafety cabinet (BSC) near a source of air currents which may disrupt the operation of the BSC. For example, airflow from the facility's ventilation can cause disruption of the BSC's exhaust outflow. The resulting insufficient exhaust velocity may jeopardize laboratory personnel and work product.

Figure 1:
This figure depicts a lab room (10 feet by 12.5 feet) with one 6-foot Class II Type B2 BSC, a sink, and a stacked incubator.

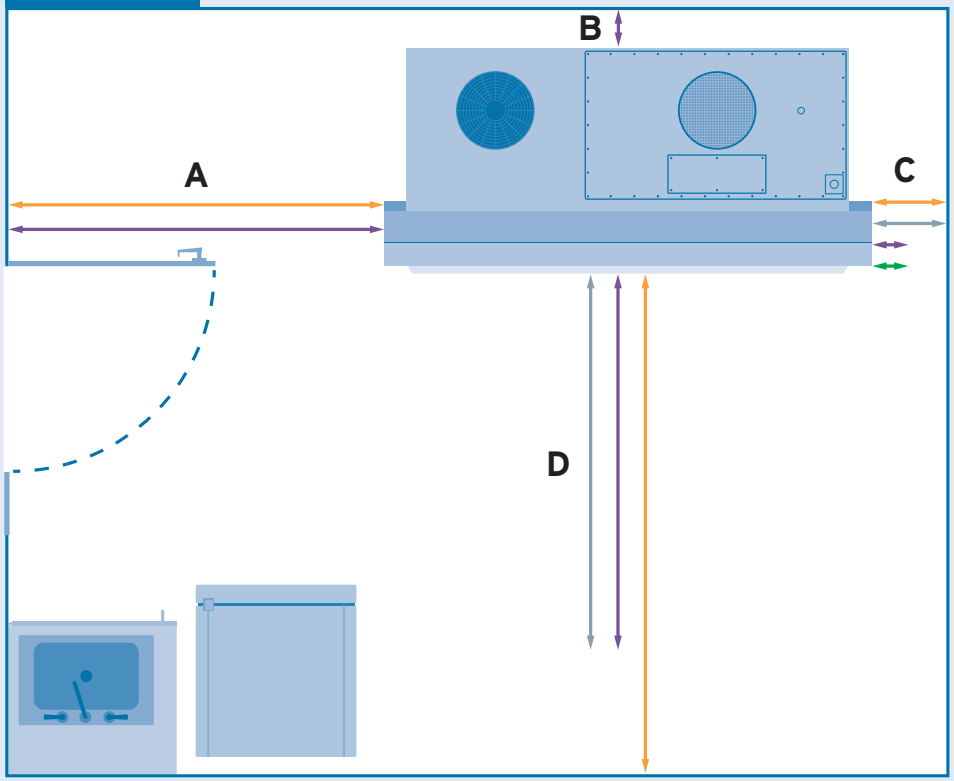
A) Both the NIH DRM and NSF guidelines describe that a BSC should be located at least 60 inches from the entry into a lab behind the doorway[3,4].

B) The NSF guidelines note having 6 inches of clearance behind the BSC[3].

C) The NIH DRM and The Baker Company detail a 12-inch clearance between a BSC and a side/adjacent wall or column[4,5], whereas the NSF guidelines and NuAire testing suggest a 6-inch clearance could be sufficient[3,6].

D) The NIH DRM defines a clearance of at least 80 inches between a BSC and its opposing wall[4], however NSF and The Baker Company propose only 60 inches of clearance is needed[3,5].

FIGURE 1



A. Space From Entry Into Lab Behind Doorway
← 60″ NIH → ← 60″ NSF →

B. Space Behind a BSC
← 6″ NSF →

C. Distance to Side / Adjacent Wall or Column
← 12″ NIH → ← 12″ Baker → ← 6″ NSF → ← 6″ NuAire →

D. Distance to BSC From Opposing Wall
← 80″ NIH → ← 60″ NSF → ← 60″ Baker →

Figure 2:

This figure depicts a lab room (12 feet by 21.5 feet) with one 6-foot Class II Type A2 BSC, one 4-foot Class II Type A2 BSC, benchtops with laboratory equipment and a sink, a stacked incubator, and cold storage devices.

A) Both the NIH DRM and NSF guidelines note that there should be 60 inches of clearance between a BSC and a benchtop or an area with occasional traffic in front of the BSC[3,4].

B) The NIH DRM describes a clearance of 40 inches between BSCs along a parallel wall[4]. The Baker Company and the NSF guidelines and NuAire Inc. propose substantially shorter clearances (12 inches[5] and 6 inches[3,6], respectively) for BSCs side by side.

C) The NIH DRM notes needing 40 inches of distance between a BSC and benchtop on a perpendicular wall[4], whereas NSF suggests this clearance should be 20 inches[3].

FIGURE 2

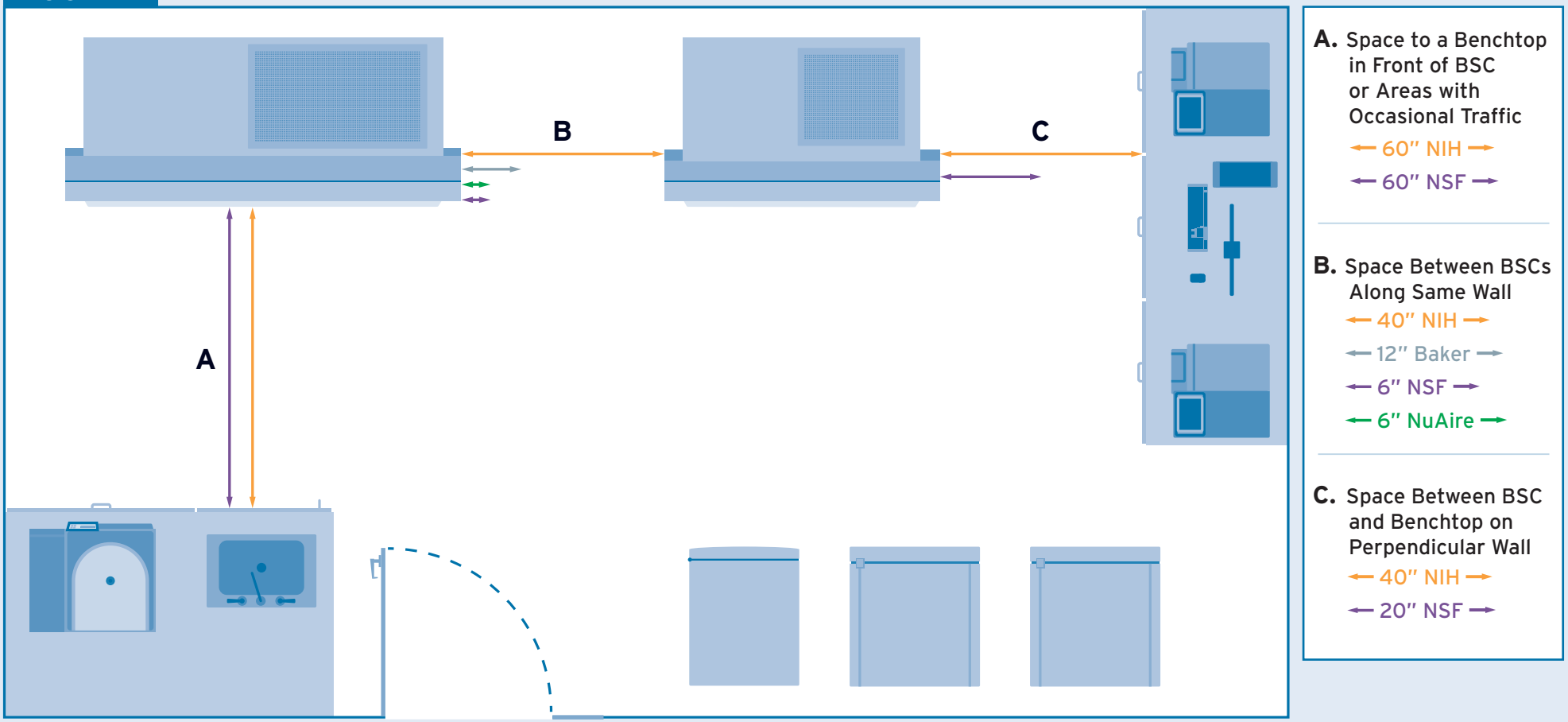


FIGURE 3

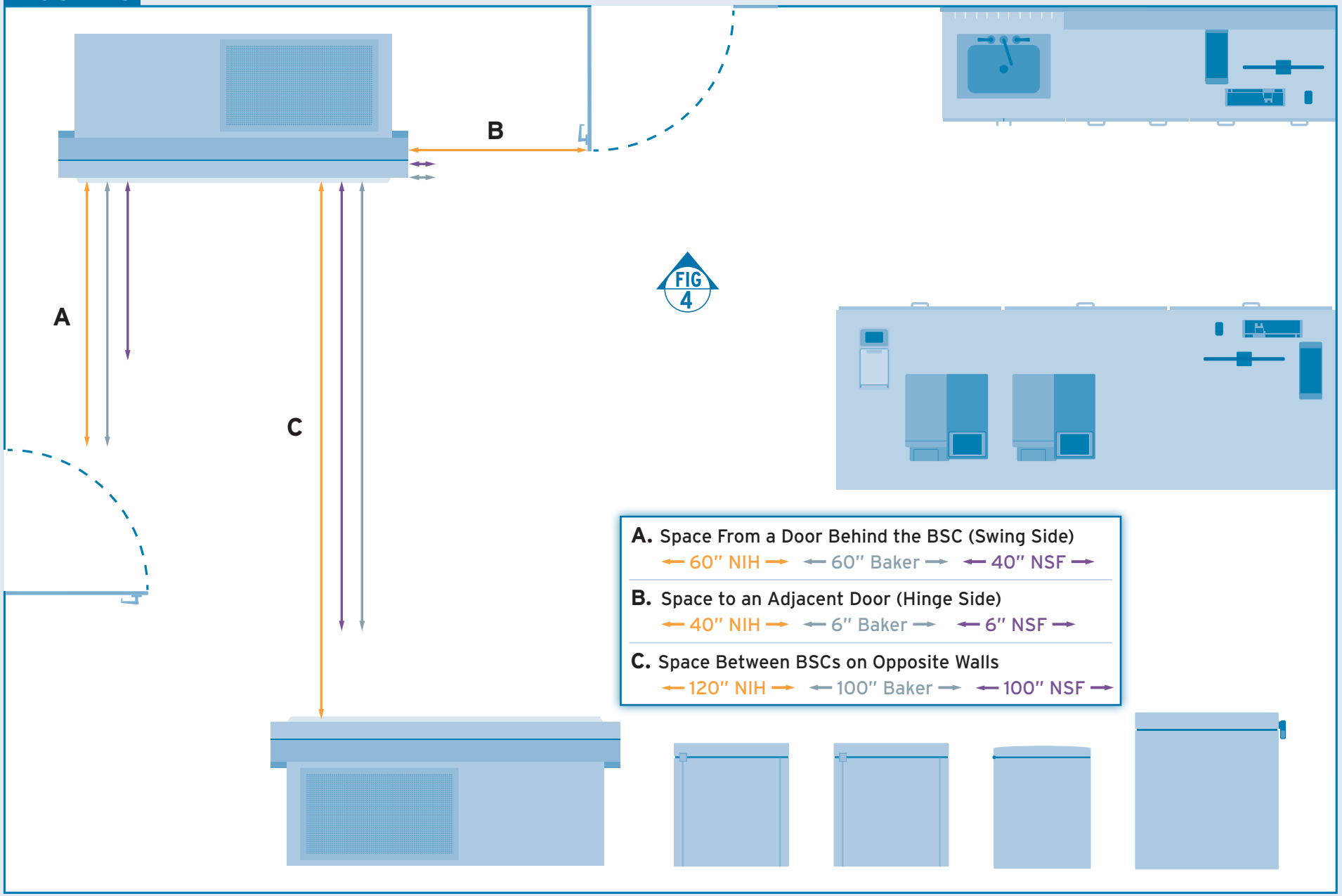

B
A
C
FIG 4
A. Space From a Door Behind the BSC (Swing Side)
← 60" NIH → ← 60" Baker → ← 40" NSF →
B. Space to an Adjacent Door (Hinge Side)
← 40" NIH → ← 6" Baker → ← 6" NSF →
C. Space Between BSCs on Opposite Walls
← 120" NIH → ← 100" Baker → ← 100" NSF →

Figure 3:

This figure depicts a lab room (16.5 feet by 24.5 feet) with two 6-foot Class II Type A2 BSCs, benchtops with laboratory equipment and a sink, two stacked incubators, and cold storage devices. Note: The NIH DRM does not recommend placing BSCs near doorways, but if it is absolutely necessary, describes the clearances noted in A and B in this figure based on the orientation of the door[4].

A) Both the NIH DRM and The Baker Company describe a clearance of at least 60 inches from a door behind the BSC's front face to the "swing" side of the door[4,5]. NSF proposes 40 inches of clearance in this configuration[3].

B) The NIH DRM details a clearance of 40 inches between a BSC and an adjacent door's "hinge" side[4], however NSF and The Baker Company propose only 6 inches of clearance are needed[3,5.]

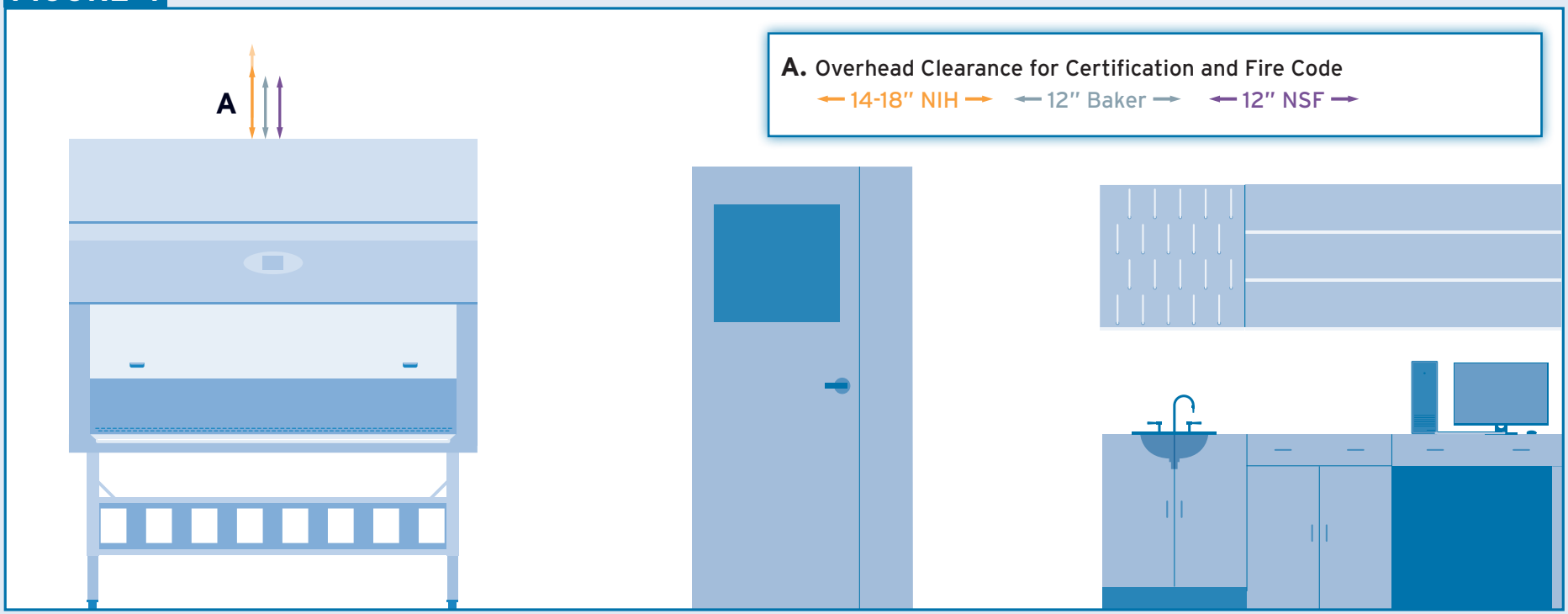
C) The NIH DRM notes at least 120 inches of clearance between BSCs located on opposing walls[4], whereas NSF and The Baker Company suggest this clearance can be 100 inches[3,5].

Figure 4:

This figure shows the elevation of the plan north wall of Figure 3.

A) The NIH DRM describes an overhead clearance of 14-18 inches for the BSC for certification purposes and to comply with necessary distances away from fire sprinklers[4]. NSF and The Baker Company note needing a 12-inch clearance above the BSC for access and testing during certification[3,5].

FIGURE 4



Overall Conclusions

It is important to understand relevant recommendations and standards, biosafety cabinet manufacturer recommendations, and lab user needs when designing or renovating a laboratory space. Evaluating the lab's layout and identifying the proper placement and necessary clearances of BSCs is critical to ensure their biocontainment performance is maintained. Several organizations provide recommendations on BSC clearances which are depicted visually in this article. These distances can differ substantially and will impact lab layout and the amount of space required for a lab based on the scientific equipment needed in that room. Which BSC clearance best practices should be followed will depend on the client's needs, risk assessment, and project funding source and can vary based on the specific lab design or renovation project. Ensuring that all members of the design team understand these BSC clearance guidelines at the start of the project can save time and avoid lab design and layout issues later on.

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