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BSC ERGONOMICS AND ADA COMPLIANCE

ACCOMMODATING THE USER FOR ENHANCED PRODUCTIVITY

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Because of the increased incidence of work-related musculoskeletal disorders among laboratory workers, the principles of ergonomic design and compliance with the Americans with Disabilities Act (ADA) are becoming increasingly important topics in the design of the biological safety cabinet (BSC). Ergonomics and ADA compliance have not yet been described in a thoughtful or meaningful way for users of the machine and therefore are not well understood.

"WORK-RELATED MUSCULOSKELETAL DISORDERS ACCOUNT FOR ONE-THIRD OF ALL REPORTED OCCUPATIONAL INJURIES AND ILLNESSES."

This article seeks to provide guidance to users on setting up the BSC for the height and reach of the various people who will be using it. The user will have a better understanding of what to look for when selecting an ADA-compliant BSC and of how the Thermo Scientific BSCs compare to other commonly used BSCs in terms of ergonomics and ADA compliance.

Ergonomics and work-related injuries in the lab

In the case of BSCs, most designs attempt to address ergonomics and ADA compliance through options and accessories that allow the height of the cabinet work surface to be adjusted. While these accessories may offer the user greater flexibility with the BSC, there is little to no information available to guide the user in properly setting up an ergonomic workspace.

Work-related musculoskeletal disorders account for one third of all reported occupational injuries and illnesses and constitute the largest job-related injury and illness problem in the United States.[1] In August 1996, the National Institute for Occupational Safety and Health (NIOSH) conducted a health-hazard evaluation of two in vitro cell-line screening project laboratories and found that 46.5 percent of the product-laboratory employees met the NIOSH case definition for potential work-related upper-extremity musculoskeletal disorders.[2]

The study concluded that there are several ergonomic hazards associated with using traditional BSCs that can cause upper-extremity musculoskeletal disorders (UE-MSD), including working in a static, extended posture for long periods of time; limited visibility at the sight line; leaning forward to see work; and lack of knee/leg space under the cabinet. User discomfort leads to fatigue and risks the user's safety and productivity.

The relative value of BSC ergonomics to an individual user will certainly vary. The NIOSH health-hazard assessment (HHA) was conducted with laboratories whose workers experience 6,000 to 11,000 repetitive motions per day for two to three hours at a time. Heavy users of BSCs have a greater potential risk for work-related injury than do users who work in their BSCs less often with fewer repetitive motions.

BSC users who are at greater risk for work-related upper-extremity musculoskeletal disorders will find value in newer, more advanced BSC designs. As a result, modern laboratories should evaluate their current work processes and installed base of BSCs to assess the value of newer ergonomic BSC designs that improve employee productivity and reduce workplace injuries.

Optimizing the BSC workstation

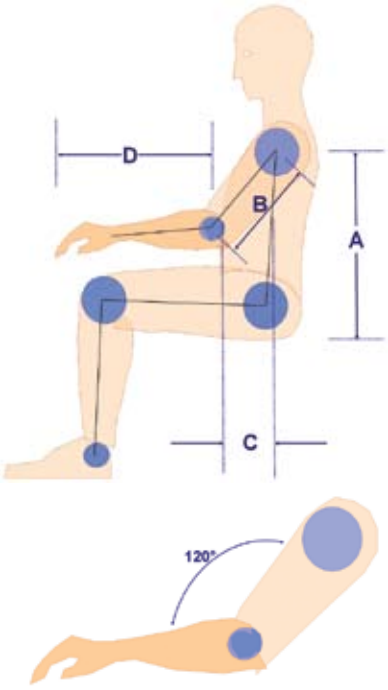
Most of the findings within the NIOSH report relate to the proper seated working position in front of the BSC. For this reason, a portion of this article is devoted to optimizing the setup of the complete BSC workstation, which consists of cabinet, chair and footrest.

Assessing the fit of a BSC must begin by describing a typical user. The anthropometric database published by the U.S. military compiled data on the sizes of more than 4,000 men and women and is used as the basis of this analysis.[3] The average body dimensions of the male and female with average height and of the male and female with heights two standard deviations above and below the average are used.

Currently, most BSC designs require the use of an adjustable chair and footrest for proper seated posture. The lowest height settings for the most commonly available BSCs provide work surface heights from 29 to 30 inches above the floor. For our calculations, we will use a BSC work surface height of 30 inches above the floor. A comfortable reach into the cabinet is assumed to be ideal where the angle of the upper arm and forearm does not exceed 120°.

Using the dimensions from the anthropometric database as illustrated here, ideal ergonomic position and chair height setting can be assessed by analyzing the individual's distance from seat to shoulder while in a seated position. Assuming the maximum comfortable reach forward of 120°, seat height can be calculated for six different user types in four commonly used BSCs (Table 1).

With the BSC work surface height at 30 inches above the floor, and the seat heights set as above, the reach onto and over the work surface can be estimated when reaching into the cabinet at the arm extension of 120°. Generally speaking, the farther a person can reach into the BSC without awkward positioning, the greater flexibility and access that person has to the interior workspace.



Maximum Comfortable Extension

These guidelines on proper seat adjustment, while relating to only one aspect of BSC ergonomics, will allow the user to optimize the work height of the cabinet in order to maximize reach and usability of the BSC. The Thermo Scientific BSC, when optimized as a complete workstation, will accommodate one of the farthest reaches into the working chamber of any BSC offered today.

	Female			Male		
	4' 9"	5' 4"	5' 9"	5' 4"	5' 9"	6' 2"
Distance from seat to shoulder (A)	21.4"	22.9"	24.5"	23.3"	24.9"	26.2"
Distance from shoulder to elbow (B)	12.1"	13.2"	14.3"	13.3"	14.5"	15.5"
Vertical distance to elbow with 120° extension (B_v*)	10.5"	11.4"	12.4"	11.5"	12.6"	13.4"
Distance from seat to bottom of arm (A – B_v)	*10.9"*	*11.5"*	*12.1"*	*11.8"*	*12.3"*	*12.8"*
Height of Access Opening						
Thermo Scientific Herasafe KS or 1300 Series A2		32.0"			32.0"	
BSC "A"		31.9"			31.9"	
BSC "B"		31.1"			31.1"	
Resulting Seat Height						
Thermo Scientific Herasafe KS / 1300 Series A2	**21.1"**	**20.5"**	**19.9"**	**20.2"**	**19.7"**	**19.2"**
BSC "A"	**21.0"**	**20.5"**	**19.8"**	**20.1"**	**19.6"**	**19.1"**
BSC "B"	**20.2"**	**19.6"**	**19.0"**	**19.3"**	**18.7"**	**18.3"**

Table 1▲ Recommended seat height for six different user types in front of four commonly used BSCs.

**The cosine of 30° is 0.866, which is the ratio of vertical distance from shoulder to elbow at a 120° extension to the distance from shoulder to elbow.*

Raising the bar on ADA compliance

BSC ergonomic attributes and ADA compliance are often associated with one another in terms of appropriate settings for BSC work surface height. According to the U.S. Department of Labor, "The Americans with Disabilities Act (ADA) prohibits discrimination against people with disabilities in employment, transportation, public accommodation, communications, and governmental activities."[4] Many institutions are interested in designing laboratories that will effectively accommodate all users, and they seek out BSC designs that facilitate this.

The label "ADA compliant" has been applied to many products, including buildings, benches and Web sites. What most buyers of lab equipment do not fully understand is that the ADA is applicable not only to impairments in physical mobility, but also to hearing, vision, mental and emotional impairment. The term "ADA compliant" as it relates to BSCs is most often promoted to address only the concerns of individuals in wheelchairs.

True BSC compliance with the ADA should offer benefits to employees with impairments in physical mobility, sight and hearing. For example, an employer's provision to offer wheelchair-accessible BSCs to a person with visual impairment would not be helpful in complying with the requirements of the ADA.

This article looks at the accessibility and usability of BSCs from three different manufacturers for wheelchair-bound users. These attributes are assessed and compared in relation to ADA compliance criteria.[5] The ADA requires the establishment of design criteria, or ADA Accessibility Guidelines (ADAAG), for the construction and alteration of facilities covered by the law. While ADAAG is not directly applicable to biosafety cabinet design, it does provide helpful guidance regarding what features are important for accommodating a variety of users.

There are three elements described in ADAAG that apply to biosafety cabinet usefulness for individuals in wheelchairs: forward reach, clearance underneath the cabinet, and access to the controls and display.

Forward reach – Section 4.2.5 states that the maximum high forward reach allowed shall be 48 inches (1,220 mm) and the minimum low forward reach is 15 inches (380 mm). The applicable guidance for a BSC would be:

- *The space under the biosafety cabinet must be greater than or equal to the desired reach distance in the work area. If the reach from the forward bottom edge of the BSC is 25 inches, the space underneath it must extend at least 25 inches back from the forward bottom edge. (See Figure 5(b) in ADAAG).*

- *The maximum reach from the forward bottom edge of the BSC is less than or equal to 25 inches (635 mm).*

- *The maximum reach height for BSC controls on the front of the cabinet should be 48 inches (1,220 mm).*

Knee clearances – Section 4.32.3 states that knee spaces should be at least 27 inches (685 mm) high, 30 inches (760 mm) wide and 19 inches (485 mm) deep. The applicable guidance for a BSC would be:

	Female			Male		
	4' 9"	5' 4"	5' 9"	5' 4"	5' 9"	6' 2"
Distance from abdomen to midbody (C)	4.3"	4.4"	4.6"	4.4"	4.7"	4.8"
Distance from shoulder to elbow (B)	12.1"	13.2"	14.3"	13.3"	14.5"	15.5"
Horizontal distance from shoulder to elbow at 120° (B_h*)	6.0"	6.6"	7.2"	6.6"	7.2"	7.8"
Distance from elbow to fingers (D)	16.0"	17.4"	18.6"	17.5"	19.0"	20.3"
Distance from abdomen to fingers (reach)(B_h + D – C)	17.8"	19.6"	21.2"	19.8"	21.6"	23.2"
Span from BSC front to Worksurface						
Thermo Scientific Herasafe KS or 1300 Series A2		6.5"			6.5"	
BSC "A"		6.2"			6.2"	
BSC "B"		8.5"			8.5"	
Resulting reach over worksurface						
Thermo Scientific Herasafe KS / 1300 Series A2	11.3"	13.1"	14.7"	13.3"	15.1"	16.8"
BSC "A"	11.5"	13.4"	14.9"	13.5"	15.3"	17.0"
BSC "B"	9.2"	11.1"	12.6"	11.2"	13.0"	14.7"

Table 2 ▲ Calculated reach into BSC for six different user types in four commonly used BSCs.
**The cosine of 30° is 0.866, which is the ratio of vertical distance from shoulder to elbow at a 120° extension to the distance from shoulder to elbow.*

- *The space under the BSC must be at least 27 inches (685 mm) high.*
- *The space under the BSC must be at least 30 inches (760 mm) wide.*
- *The space under the BSC must be at least 19 inches (480 mm) deep.*

Height of tables or counters – Section 4.32.4 states that the tops of accessible tables and counters shall be from 28 inches to 34 inches (710 to 865 mm) above the floor or ground. The applicable guidance for a BSC would be:

- *The BSC work surface must be from 28 inches (710 mm) to 34 inches (865 mm) high.*

For the most commonly used BSCs, a manual or electric-powered adjustable stand provides maximum flexibility for setting the height to accommodate the wheelchair in the space under the cabinet. The advantage of using an electric adjustable-height stand in the lab is that the working height of the cabinet is infinitely adjustable (within the minimum-maximum range) with the touch of a fingertip at any time after the cabinet is installed.

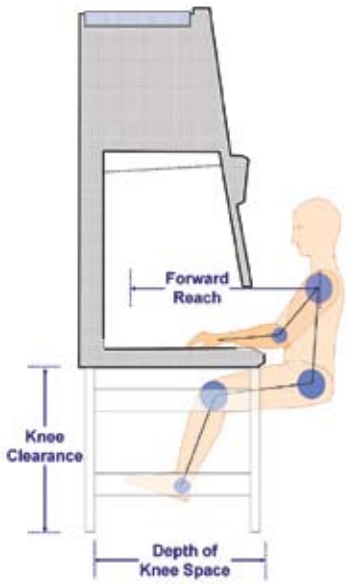
In the case of the Thermo Scientific electric adjustable stand, memory settings in the controller allow lab personnel to set their own optimum working height at first use, minimizing the inconvenience of having to set the proper height at each work sitting. This is a significant advantage over the more commonly used manual adjustable-height stands, where height adjustments cannot be made without the use of a mechanical lift that supports the weight of the cabinet.

When BSCs are assessed for other parameters such as knee space, reach, and accessibility of controls, the Thermo Scientific BSCs offer significantly greater range of motion for the physically impaired.

In seeking to bring the benefits of the Class II BSC to the largest number of disabled users, the design of the Thermo Scientific Herasafe KS delivers a contained and clean workspace with maximum flexibility in controls and information display. First, the display is placed on the rear wall of the workspace and does not require the user to change his or her working position or posture to see any displayed information on BSC status or performance.

The easy-to-clean display is positioned 15.75 inches (400 mm) above the work surface to avoid disruption to airflows or product safety. Second, the unique handheld controller completely liberates the location of the BSC controls from the cabinet and allows the user to place the BSC controls wherever it is easiest for the user to manage. Users with limitations in reach can carry the controller with them. Left-handed or right-handed users can use whichever hand they are most comfortable with.

Users in wheelchairs do not need to roll all the way up to the cabinet to open the window and then back to collect their supplies. They can use the controller from a comfortable distance to open the window and bring the cabinet to its operational state and collect their supplies to begin work. The Thermo Scientific Herasafe KS brings unparalleled flexibility to disabled users of BSCs.



In conclusion, as advanced design concepts are incorporated into the design and development of Class II BSCs to make them usable and accessible to more diverse populations, it is important to note that the same features that accommodate disabled users will serve to help nondisabled users as well. The benefits of flexible work surface height, easily viewed display and easily accessed controls will help to reduce musculoskeletal demands for high-productivity users. Modern labs considering investment in equipment should give careful consideration to ergonomics, as these features benefit everyone.

		Thermo Scientific Herasafe KS	Thermo Scientific 1300 Series A2	BSC "A"	BSC "B"
Knee Space	≥ 30" wide	Yes	Yes	Yes	Yes
	≥ 27" deep	Yes (w/ WS at 30.25")	Yes (w/ WS at 30.25")	Yes	Yes
	≥ 19" deep	Yes	Yes	Yes	Yes
	As deep as work area	Yes	Yes	No	No
Work Area	Available work surface height within 28 to 34"	Yes	Yes	Yes	Yes
	Max reach ≤ 25"	Yes	Yes	No	No
Controls and Display	Max reach height less than 48"	Yes	No	No	No

Table 3 ▲ Comparing ADA compliance among four commonly used BSCs.

References

1. 29 CFR, Part 1910. *Ergonomics Program: Proposed Rule*, *Federal Register* 64, no. 225: 65769 (1999).
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