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Ergonomic Considerations In The Development Of A Class II, Type A/B3 Biological Safety Cabinet

By Robert L. Jones, Jr., Product Development Manager, The Baker Company; and Dennis Eagleson, President, The Baker Company, P. O. Drawer E, Sanford, ME 04073

INTRODUCTION

The laboratory workplace is changing. More attention is being given to laboratory personnel, their work environment and ergonomics, the science of fitting the workplace to the worker. The Baker Company has developed the SterilGARD® III Advance° biological safety cabinet in response to these changes. This cabinet, used in laboratory investigation and protocols involving agents of low and moderate risk, includes a number of design features that improve worker productivity and comfort while being used during repetitive tasks.

A Baker Company design team was charged with researching ergonomics issues associated with biological safety cabinets and making recommendations as to a new cabinet design. The team considered cabinet shape, worker position, lighting, containment and a number of other issues in composing design criteria. What resulted is the industry's first Class II, Type A/B3 biological safety cabinet that recognizes the principles of ergonomics and worker comfort and is built with Baker's reputation for performance.

DEFINITION

The word "ergonomic" comes from the Greek "ergon" meaning "work" and "nomos" meaning "law." Ergonomics is the study of the body at work and the body's interaction with its work environment. The proper application of ergonomics must take into account biomechanics, the study of body forces and movement and anthropometry, or the study of human body measurements especially on a comparative basis.

The proper application of ergonomics can alleviate worker discomfort, improve productivity, reduce absenteeism and negate medical costs.[1] Through applied product engineering, ergonomics provides equipment adapted to the biomechanics and anthropometrics of the human, instead of the human having to improperly adapt to the product.[2]

PROBLEMS IN THE LABORATORY: A STUDY

Only in recent years has ergonomics moved to the forefront of public awareness. This growing awareness is directly linked to the working world's ever-burgeoning use of technology, most specifically, computers. While the majority of study conducted regarding ergonomics has been in the office setting, work in the laboratory is also a source of repetitive motion injury, thereby providing opportunity for workstation improvement as well.

Repetitive tasks are inherent to laboratory research. In addition, most labs are typically designed to support production, research and sterility, not worker comfort. Unfortunately, this ignores the fact that worker comfort directly impacts production. Although the National Institutes of Health and OSHA have recognized lab work as an occupation with risk for musculoskeletal disorders and repetitive stress injuries (RSIs), ergonomics in the biomedical research laboratory has not received the level of attention conferred to non-laboratory settings. According to OSHA, RSIs are the largest single category of injury in the workplace. Worker's compensation claims from RSIs represent an estimated $20 billion a year in lost-time compensation costs alone. Total costs are estimated to be $120 billion annually when lost productivity and other indirect costs are considered.[3]

As one laboratory discovered, researchers who use biological safety cabinets and fume hoods are at risk for RSIs. Immunex Corp. in Seattle, Wash., found five risk factors observed in labs:

- contact stress,
- force,
- repetitiveness,
- static loading and
- vibration.

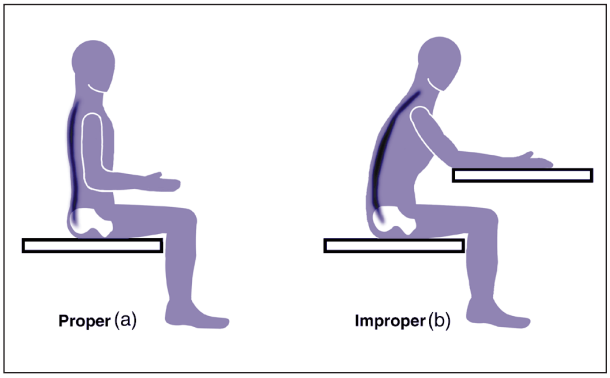

Figure 1, a,b
Proper Posture. *A properly designed workstation allows the worker to maintain proper posture in the double "S" curve position (a, left). Improper posture (b, right) can compromise vascular supply and increase muscle stress and strain due to hunching forward and rounding of the shoulders. (IAC Industries)*

Poor posture and positioning were the most common problem observed. Work at the biosafety cabinets required researchers to hold their heads and arms in a forward position with shoulders rounded forward. Such a static posture can compromise the vascular supply, compress nerves in the arms and increase muscle stress and strain. This hunched-forward position, compromising the ideal "double S" curve of the spine, is further exaggerated when the feet are placed on the ring-style footrest common to many lab stools. Proper posture is the "neutral" position, or the position that requires the least amount of muscle force and allows maximum room for blood flow. This proper posture should be: ears over shoulders, shoulders in line with hips, forearms 90 degrees or more from the upper arms and wrists in neutral position.[4]

Immunex found that the use of an industrial-height footstool allows technicians to achieve the best possible posture and position at the static biological safety cabinet. The footstool allows the user to plant his feet firmly in front to give a solid, three-point base of support. Providing an adjustable lab stool with enhanced lumbar support was also an important improvement. This style of lab stool provides employees working in a forward position (such as at a biosafety cabinet) with needed support during rest periods.[5]

THE BAKER DESIGN PREMISE

Conscious of problems in the laboratory, the Baker Company design team conducted its own research when developing the SterilGARD® III Advance°, surveying lab workers and ergonomics experts including William H. Moore, Ph.D., Professor of Ergonomics, University of Southern Maine. The team also utilized Mannequin™, ergonomic design software allowing three-dimensional modeling of the human body in relation to design criteria input into the program. Through the collection of this data, the team was able to determine the ideal settings for workers seated or standing at a biological safety cabinet.

During their research, the Baker Company team observed many of the same risk factors which appeared in the labs at Immunex. The team wrote design criteria for the new SterilGARD® III Advance° to address those problems:

- The distance between the front of the cabinet and the front of the solid work surface is minimized to allow the worker to position himself/herself close to the cabinet's work tray and to operate in the natural 8-14" reach range.
- The viewscreen slope is 10° forward of vertical to allow a natural, "neutral" head-over-shoulders position and also minimizes light reflection and glare.
- Switches, alarms and gauges are at eye level when an investigator is standing in front of the cabinet to allow ease in operation.
- Petcocks, electrical outlets and other services inside the work area are positioned toward the front to reduce lab personnel's need to reach and stretch repetitively out of the head-over-shoulders position.
- An infinitely adjustable bench permits a range of work surface heights from 27 3/4" to 39 1/2", allowing adjustability for worker comfort.
- An optional adjustable footrest allows lab personnel to establish comfortable positioning beneath the cabinet.
- An optional armrest provides a large radius surface area on which forearms may rest, eliminating pinch point areas and nerve impingement.
- Depth of drain pain is reduced.[6]

ELEMENTS BEHIND ERGONOMICS

Failure to outfit and setup a laboratory workstation properly can encourage the development of RSIs. The proper chair adjusted to the correct setting and tables and work surfaces set at a comfortable height can improve worker comfort and productivity. In addition, attention to environmental and user/equipment interface factors will create the most ideal "ergonomic" work situation.

CHAIR

A worker who is seated for prolonged periods requires both support and adjustability from his or her chair. While traditional office chairs were quite static, newer chairs are dynamic in their movement and adjustability. Even so, workers who have access to these chairs rarely know how to adjust them properly for the ideal work position.[7] As seen in Baker's research, when a worker is not seated properly at the cabinet or work station, a number of conditions can occur:

- When the chin is dropped or raised, muscles have to work harder to support the head; compensating for a too high or too low head position puts strain on neck and back muscles.
- When a worker never makes contact with the chair back, the trunk works harder to balance the body. The pelvis is rotated backward and the lower curve of the spine is rounded out, causing a slump. The spine is not able to do its structural work and is rotated out of the ideal double "S" curve.
- If the feet are not in contact with a firm surface, the legs become a load on the spine or the worker will stretch his or her ankles and legs to make contact with the floor.
- If the seat pan of the chair is tilted too far forward, the legs do more work to push the body back into the chair.
- If the seat pan is tilted too far back, the knees are positioned over the thighs, rotating the pelvis back and rounding out the spine. This reduces structural capacity of the spine.
- Ideally, thighs should be horizontal and parallel to the floor. [8]

When establishing an ergonomic workstation, attention should be given to selecting the proper chair.

- A chair should have at least five legs for stability if on casters.
- Casters must allow for easy movement when seated.
- Seat height should be pneumatically adjustable while seated.
- Seat width of 17-20" suffices for most people and should be deep enough to permit the back to contact the lumbar backrest without impinging nerves in the backs of knees.
- The front edge should be padded and contoured into a waterfall design behind the knees.
- The seat slant should be adjustable (0 to 10°).
- The seat should swivel easily.[9]

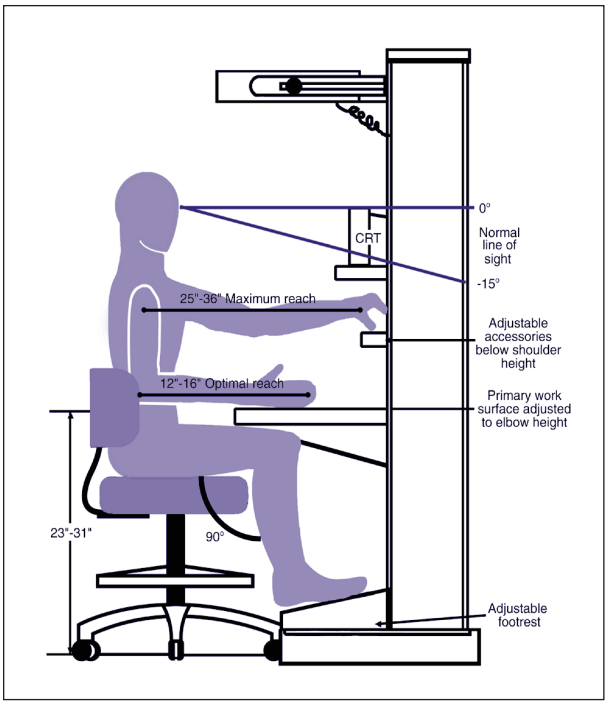

Figure 2
A Comfortable Workstation. *An ergonomically correct office workstation is based on anthropometrics of the worker. When properly used, the head is positioned over the shoulders, the thighs are horizontal and parallel to the floor, the work surface is at the proper height, and the work area does not exceed the maximum reach of the worker. (IAC Industries)*

In addition to the above description, the National Institutes of Health offer these specifications for an adjustable chair:.[10]

For table height 25" (63.5 cm)	Chair height 15-20" (38.1-50.8 cm)
For table height 38" (96.5 cm)	Chair height 28-33" (71.1-83.8 cm)
Fabric	Vinyl
Seat Area	16" deep (40.6 cm) x 15" wide (38.1 cm)
Angle between seat pan and back rest (fore/aft adjustability)	105°
Backrest height	7-10" (17.8-25.4 cm)
Backrest area	8-10" (20.3-25.4 cm) high x 14" (35.6 cm) wide

TABLES AND WORK SURFACES

When the appropriate chair has been chosen for an ergonomic workspace, attention must then turn to the primary work surface and its height and adjustability.

The primary work surface must have sufficient space to handle all equipment. A general recommendation is that the work surface top should be at least as large as a standard office desk, 30" deep by 60" wide. The Baker Company offers the largest unobstructed, useable work surface in the biological safety cabinet industry, with interior dimensions measuring 22 9/16"deep by 46" wide (70" wide in the SG603 model).

When considering work surface height, under-table height and knee clearance should not be ignored. Knee spaces should allow a worker to feel uncrowded and to allow some changes of position. The knee space should be at least 19" deep by 30" wide by 27" high to comply with the requirements of the Americans with Disabilities Act.[11] The optional adjustable stand offered with the SterilGARD® III Advance° meets and exceeds ADA requirements with dimensions of 27 7/8" deep and 47 7/8" wide. In addition, Baker has reduced drain pan depth to approximately 3", greatly increasing leg room over typical cabinets where drain pan depth can be as much as 9". This increases leg room and allows arms to be in the neutral position, reducing contact stress.

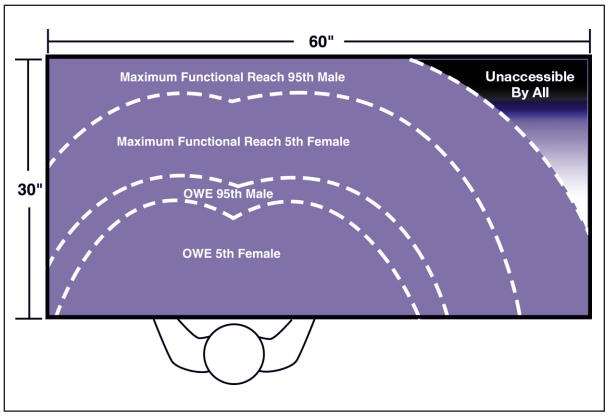

Figure 3
The Optimum Work Envelope. *The primary work surface should take into account the maximum reach of both male and female workers. This prevents hunching of the shoulders and repetitive stretching which increases muscle fatigue and rotates the spinal column out of the ideal double "S" curve. (IAC Industries)*

ENVIRONMENTAL FACTORS

While the focus on developing an ergonomic workplace may fall on physical objects, much can be done in the work environment to make it more adapted to the worker.

Proper lighting is important to the ergonomic workstation. Bright lights should be kept out of the worker's field of vision. Monitors and viewscreens should be tilted when possible to avoid glare from overhead sources. Overhead lighting should be flicker free to reduce eyestrain.

Air flow in the work environment is also important. Maintaining fresh air in the work place as well as keeping dust in the area to the minimum will improve worker productivity. This goes hand-in-hand with comfortable temperature and humidity. Ideal settings are from 68-72° F, with a 30-50 percent relative humidity.[12]

In response to its research, Baker has adopted several design features that address lighting problems. The SterilGARD® III Advance° angled viewscreen reduces glare and the light source at the top front of the work area is flicker-free and is angled down and away from the worker. Baker also encourages lab personnel to wear dark-colored lab coats to reduce reflection and glare in the viewscreen.

ERGONOMICS LEGISLATION

While physical, environmental and human factors can create an ill-fitting workplace, certain changes in these factors can improve the ergonomics quotient of a given setting. Unfortunately, each work situation is different from the next. Thus, workplace standardization is important.

To this end, the Occupational Safety and Health Administration is currently drafting a proposal on ergonomics in the work place. This proposal is in response to Congressional action in November, 1998, when Congress funded a study by the National Academy of Sciences. The NAS had reported that "workers who face high physical stress, such as heavy lifting or repetitive motion, have high rates of work related musculoskeletal disorders (WMSDs) and that 'compelling evidences' exist that reducing biomechanical stress on the job reduces the risk of injuries."[13]

On March 4, 1999, Charles N. Jeffress, Assistant Secretary of Labor for OSHA, stated "This nation cannot afford to wait any longer to address the serious issue of work-related musculoskeletal disorders. Too many workers and their families are suffering needlessly, and too many businesses are having to foot the bill. We need to complete an ergonomics proposal that provides a flexible framework to help guide employers in addressing WMSDs in a sensible, practical manner."[14]

The proposed regulations are undergoing further governmental review throughout the spring and summer. The regulatory text will then be revised and a period of public comment and hearings will be scheduled for late 1999. The final rules should be enacted in the year 2000.[15] For more information on the proposed OSHA regulation, visit the OSHA website at www.osha-slc.gov.

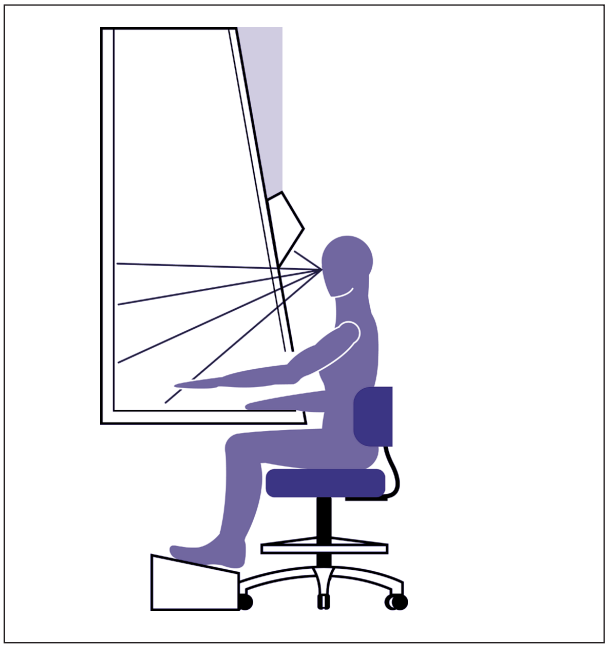

Figure 4
SterilGARD® III Advance°. *The SterilGARD® III Advance° biological safety cabinet includes many ergonomic design features which can improve worker comfort and productivity. (The Baker Company)*

THE SterilGARD® III ADVANCE°

For nearly five decades, The Baker Company has remained at the forefront of engineering, testing and production of reliable laboratory contamination control equipment. Baker capabilities continue to set industry standards for pharmaceutical, biotechnology, life science and hospital/clinical applications.

The SterilGARD® III Advance° is the culmination of more than three years of research into ergonomics issues in the laboratory setting. This biological safety cabinet offers a variety of features and benefits that address worker comfort and productivity.

SUMMARY OF DESIGN FEATURES AND BENEFITS

Angled viewscreen	Slanted viewscreen sloped 10° to create more natural head position and to reduce glare.
Reduced width of front grille & airfoil	Reduced front grille depth and a slim profile lower plenum combine to move the work surface closer to the front and to the researcher's lap for better arm position as well as to create a larger work surface. Aerodynamically designed airfoil at the front opening facilitates the flow of room air into the front grille, ensuring no room air flows into the work area.
UniPressure Preflow Plenum™	Delivers quieter, more efficient performance and offers optimum protection from particulates with a unique integration of supply and exhaust HEPA filters.
Footrest	Ergonomic adjustable footrest is available as an option allowing comfortable positioning beneath cabinet.
Armrest	Optional armrest across cabinet front improves support and comfort; stands up to disinfection procedures and does not interfere with airflow.
Control positions	Eye-level control panel positioned to face down toward the user for greater visibility and easier access.

SUMMARY OF DESIGN FEATURES AND BENEFITS CONTINUED...

Service fixture position	Plumbing and drainage connections are located toward the front of the cabinet and within arm's reach for comfort in use. Three plugged penetrations are provided to accommodate optional petcocks inside the cabinet, one in the right side wall and two in the left. The petcock and penetrations are offset for easier access and use.
Adjustability	Optional stand with telescoping legs allows continuous work surface adjustment from 27 3/4" to 39 1/2".
Reduced heat in canopy	Energy-saving fluorescent lighting with solid-state ballasts reduce flicker, minimize heat output, improve eye comfort and extend lamp life by as much as 50 percent.

CONCLUSION

Productivity in the laboratory environment can be improved through an understanding of ergonomics. The proper application of ergonomics in the biological safety cabinet design may alleviate worker discomfort, improve productivity, reduce absenteeism and negate medical costs.

The Baker Company developed the SterilGARD® III Advance° based on ergonomics, anthropometric data, laboratory surveys and consultation with ergonomic experts. SterilGARD® III Advance° offers laboratory managers a solution to problems related to worker comfort and productivity.

Design features.
An angled viewscreen, a continuously adjustable stand, eye-level controls and other design features combine to make the SterilGARD® III Advance° the solution to problems related to worker comfort and productivity in the laboratory.

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THE BAKER COMPANY

P.O. Drawer E Sanford, Maine 04073
(207) 324-8773 • 1-800-992-2537 • FAX (207) 324-3869