Evaluation of Class II Biological Safety Cabinet Side to Side Placement in Laboratories

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Bill Peters, Dan Hillman, and Ron Trower submitted a poster entitled "Evaluation of Class II Biological Safety Cabinet Side to Side Placement in Laboratories" to the American Biosafety Association (ABSA)'s 55th Annual Biosafety and Biosecurity Conference that took place from October 18 – 24, 2012, in Orlando, Florida, United States. This document is a reproduction of the test results that had formed the basis for that poster presentation. It has been modified for layout and design. It is made available here for historical reference only.

Containment performance of Biological Safety Cabinets (BSC's) is primarily based on the cabinets work access opening airflow dynamics. The work access opening airflow design pattern, velocity and balance of downflow to inflow or the push/pull effect are designed, manufactured and tested to maximize containment performance. However, as cabinet work access opening airflow dynamics are optimized for containment, as with any airflow, it can be influenced by airflow velocities generated within the laboratory environment they operate. Airflow movement within laboratories are generated by Heating, Ventilation and Air Conditioning (HVAC) supply and exhaust grills (both by velocity and thermal gradients) as well as laboratory personnel both in traffic and interaction with other laboratory equipment (doors, etc.).

Guidelines have long recognized the importance of BSC placement to minimize these laboratory environmental influences and have provided guidance in the following documents:

- NSF/ANSI 49:2011, Annex E, Biosafety Selection, Installation, Lifespan and Decommissioning
- CDC/NIH Biosafety in Microbiological and Biomedical Laboratories (BMBL), 5th Edition
- CDC/NIH Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets, 3rd Edition

However, in 2010, the National Institutes of Health (NIH) Office of Research Facilities (ORF) revised their Design Requirements Manual (DRM) for BSL-3 laboratories. In the revision, a new Biological Safety Cabinet (BSC) placement guide (Appendix I) was provided and specified the following new requirements:

- Provide a minimum of 40 inches space in front of BSC
- Provide a minimum of 12 inches from adjacent walls or columns
- Provide a minimum of 80 inches from opposing walls and/ of 60 inches from opposing bench or areas of occasional traffic
- Provide a minimum of 40 inches between BSC and bench tops along perpendicular wall
- Provide a minimum of 120 inches between two BSC's facing each other
- Provide a minimum of 40 inches between two BSC's
- Provide a minimum of 60 inches from behind a doorway and 40 inches from an adjacent doorway

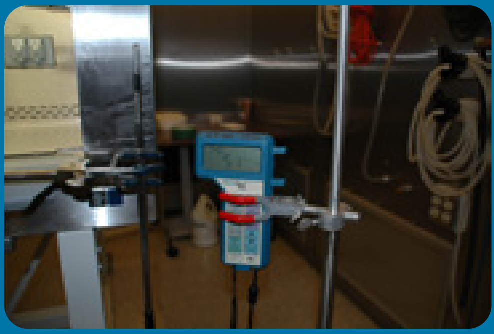
Some of these new requirements are in line with current published standards. However, some are not and particularly the requirement of having a minimum of 40 inches between two BSC's. NSF/ANSI 49 that recommends 6 inches of clearance between cabinets as well as adjacent walls and surfaces and the Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th edition that recommends adequate clearance should be provided behind and on each side of the cabinet to allow easy access for maintenance.

From our understanding as presented at a preconference course during the 2010 ABSA conference, these new requirements were developed from a study using Computational Fluid Dynamics (CFD) on a chemical fume hood. While there are some similarities between a chemical fume hood and a BSC in regards to airflow dynamics, there are also some major differences. The capture ability of a BSC is significantly greater due to the work access opening airflow dynamics including the combination of a fixed sash height, high air change rate, having a down flow velocity within the work zone and a front grill. Together these items provide the containment performance due to the push/pull effect of the work access airflow dynamics.

If you review the actual airflow velocities and their distribution at the required average inflow velocity of greater than 100 fpm (.51 m/s) for Class II, type A2, B1, B2 BSC's over the work access opening. You can see that within 1 inch of the work access opening, velocities range over 100 fpm with a stronger pull near the bottom of the work access opening and lower velocities as you approach the sash. As you continue to move away from the work access opening, velocities decrease ranging under 75 fpm at 2 inches and ranging 50 fpm or less from 3 inches. Velocities at this level have no impact and are considered normal room air currents. Given that most all BSC's today have sidewall thicknesses of at least 2 inches or greater, an airflow velocity of 75 fpm is not great enough to overcome higher airflow velocities of another cabinet placed directly beside it. There cannot be any effect from one BSC to another placed side by side due to the low airflow velocities at this point.

Thermal anemometer reading of 116 fpm within 1 inch.

Thermal anemometer reading of 73 fpm within 2 inches.



Thermal anemometer reading of 51 fpm within 3 inches.

Method

BSC containment was measured by bacterial aerosol challenge testing (NSF/ANSI 49 Annex A.6) at various wide range tolerance points on two cabinets placed both directly side by side and adjacent. The results were compared to the known wide range containment performance of the cabinet model tested.

Materials

- Clean room
- Nuaire Labgard ES model NU-425-400 (2) BSC's
- Aerosol challenge of bacillus subtilis used at a concentration level of no less than 5.0 x 10^8 for personnel protection and 5.0 x 10^6 for product protection
- Collison CN-31 nebulizers
- Mattson-Garvin and New Brunswick slit samplers
- Typticase soy agar provided in petri dishes
- Ace glass impingers
- Stainless steel cylinders
- TSI model 8386
- Shortridge model ADM-870 Flowhood
- Pacific power source power supply

Procedure

1. Set NU-425-400 cabinets per test either side to side or adjacent as close as possible
2. Adjust power supply voltage to 115 Vac, 60 Hz
3. Adjust airflows on each BSC to within +/-2 fpm of desired setpoint
4. Run bacterial aerosol challenge test in triplicate
5. Plate out results and incubate for 24 hours
6. Record test results

Personnel protection test of side by Product protection test of side by side BSC's side BSC's.

Personnel protection test of side by Product protection test of side by side BSC's side BSC's.

Personnel protection test of adjacent BSC's.

Product protection test of adjacent BSC's.

Results

NSF/ANSI 49 pass/fail criteria was used for each test point.

Personnel Protection Test

- Control plate must contain greater than 300 CFU's*
- Slit sampler totals must not exceed 5 CFU's
- Impinger totals must not exceed 10 CFU's

Product Protection Test

- Control plate must contain greater than 300 CFU's
- Agar plate totals must not exceed 5 CFU's

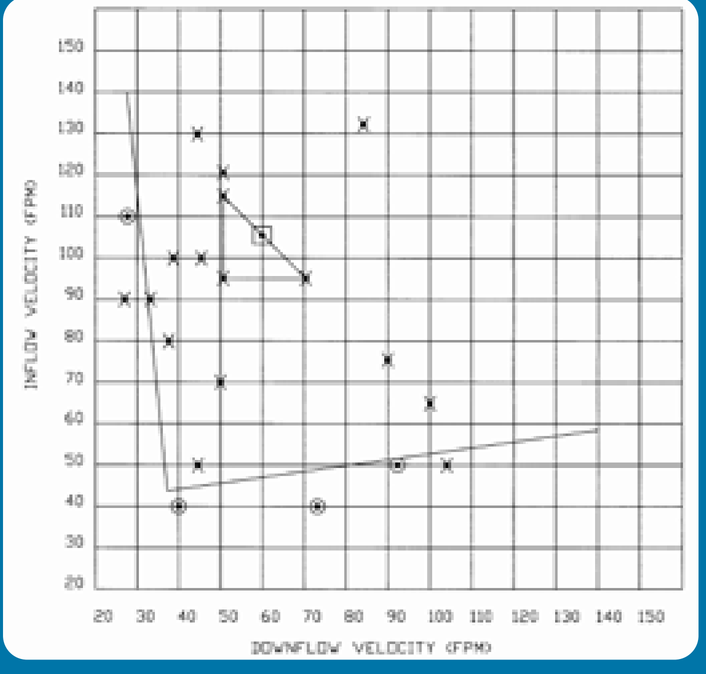
**Colony Forming Unit*

The test results are indicated by placing each test point on a downflow/inflow performance chart. Chart 1 represents the known wide range containment performance of the test cabinet model NU-425-400. The square box represents the nominal airflow setpoint of 60 fpm downflow and 105 fpm inflow. The triangle represents the 3 standard NSF tolerance testing points as follows:

Downflow	Inflow	Test Type
50 fpm	115 fpm	product
70 fpm	95 fpm	personnel
50 fpm	95 fpm	personnel / product

The rest of the testing points represent wide range tolerance points that were tested for personnel, product or both. "X" indicates a passing test and "O" represents a failing test. The outside lines represent the 95% confidence limits for pass/fail containment performance. As you can see, a cabinet's containment ability is far greater than the standardized NSF testing. However, as inflow decreases, the cabinet's ability to contain also decreases as it would become more susceptible to outside airflow disruptions.

Chart 2 represents the testing results for the side by side cabinet placement. The cabinets were first tested at the standard NSF tolerance and nominal points. Then additional tolerance testing was performed at ±5 fpm outside the NSF tolerance points. In addition, one last lower point of 40 fpm downflow/85 fpm inflow was tested for both personnel and product. All the test points passed indicating no compromise of containment performance when the cabinets were placed directly side by side.



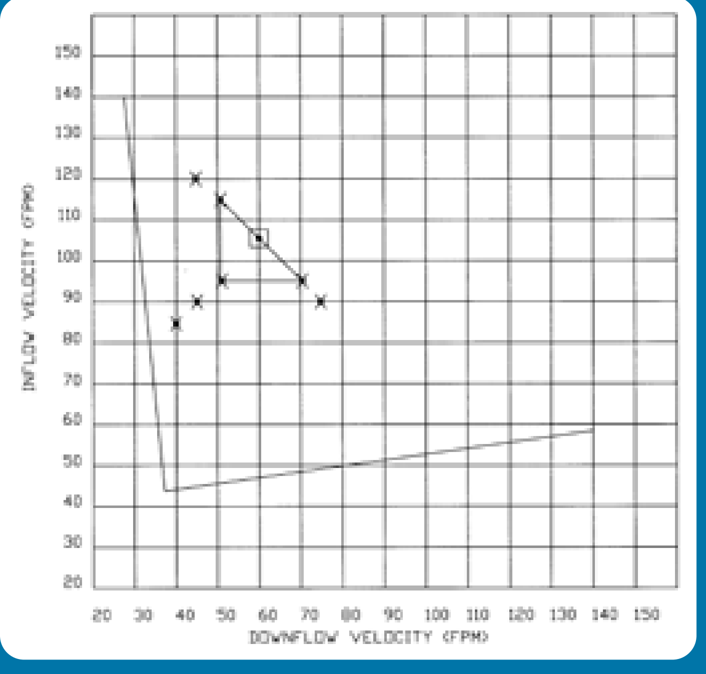
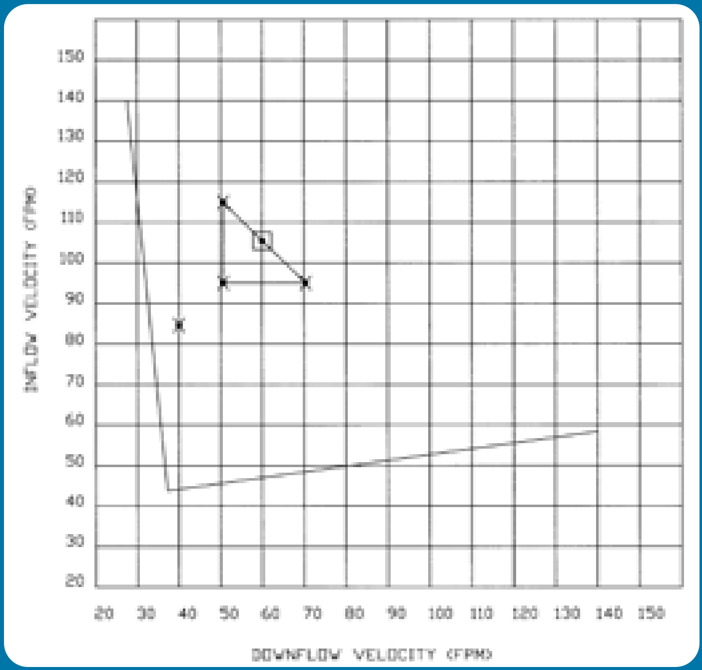


Chart 3 represents the testing results for the adjacent cabinet placement. In this configuration, the cabinets work access openings were actually further apart due to the control center design. Because of this, we limited our testing to only the standard NSF tolerance and nominal points as well as the lower point of 40 fpm downflow / 85 fpm inflow. All the test points passed indicating no compromise of containment performance when the cabinets were placed directly adjacent to each other.



Conclusion

Placement of BSC's directly side by side or adjacent to each other does not compromise containment performance. Following the current NSF/ANSI 49 recommendation of 6 inches clearance between cabinets as well as adjacent walls and surfaces will provide maximum containment performance. As always, service and decontamination requirements should be evaluated based on cabinet manufacturer limitations and/or requirements.

References:

1. NIH design Requirements Manual, Division of Technical Resources, Office of Research Facilities, Revision 5/12/10
2. NSF/ANSI 49:2011, Annex E, Biosafety Selection, Installation, Lifespan and Decommissioning
3. CDC/NIH Biosafety in Microbiological and Biomedical Laboratories (BMBL), 5th Edition
4. CDC/NIH Primary Containment for Biohazards: Selection, Installation & Use of Biological Safety Cabinets, 3rd Edition

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