NU-620-Performance Evaluation

Single Sided Animal Transfer Station

When designing the next generation of ATS there were many things NuAire considered. The original ATS NuAire produced from the early 2000's was designed to replace horizontal laminar flow hoods that were being used in cage changing operations. These units were not mobile and provided product protection but no personnel protection. The NU-612 was mobile and provided product protection and improved allergen control for the user with a large 14" access opening. The NU-612 had an inflow of 10-20 FPM providing improved allergen control. The work access opening airflow pattern had a strong negative flow into the grill on the lower half and a positive flow on the upper half. Recently a high level of concern in the animal science industry to minimize allergen exposure has caused primary engineering control performance to increase average inflow velocity. NuAire's current ATS, the NU-619, has a higher inflow velocity of 20-30 FPM offering full containment on a negative airflow pattern over the entire work access opening while still maintaining product protection. To further improve ATS containment performance increasing the average inflow velocity along with critical design elements was our goal for the next generation ATS.

With the NU-620 NuAire has designed a unit that provides both sterility for the animal and allergen containment for the user in the familiar ATS footprint. The design we found that achieved this was to permanently close off the rear of the unit, modify the side window, redesign the worktray, and add a much more powerful blower\motor to the exhaust side of the unit. Closing off the rear of the unit allows the redesign of the worktray moving slots that would be in the rear of the cabinet to the front of the cabinet. The new worktray looks much more like a BSC (biological safety cabinet). In addition the new blower\motor nearly doubled the amount of air moving through the exhaust. This increase in airflow coupled with the fact that the unit is moving all that air through only one side of the unit creates an incredible increase in performance. The unit is now moving nearly double the air through less than half the access area. In addition we changed the side window. Through the testing it was found that the area on the side of the unit was a weak point for containment. The balance of downflow to exhaust air was not enough to provide the containment desired with airflow alone. It was decided to lower the side window slightly. This creates a physical barrier at the weak point and leaves open area where there is enough exhaust flow to achieve proper containment. The challenge was to achieve the containment while leaving the large access area that users have become accustomed to. The only way to achieve this was through significant design and airflow changes.

Calculation of Inflow

For this unit NuAire devised a calculated method to determine the inflow. In this case the desired value was 105 FPM. This is the generally accepted inflow for a BSC. To obtain this value it is assumed that the downflow (60 FPM) from the supply filter plus the desired airflow through the front access (105 FPM) would be the amount of air we would need to pull through the exhaust. An example of the calculations for all three sizes is illustrated below.

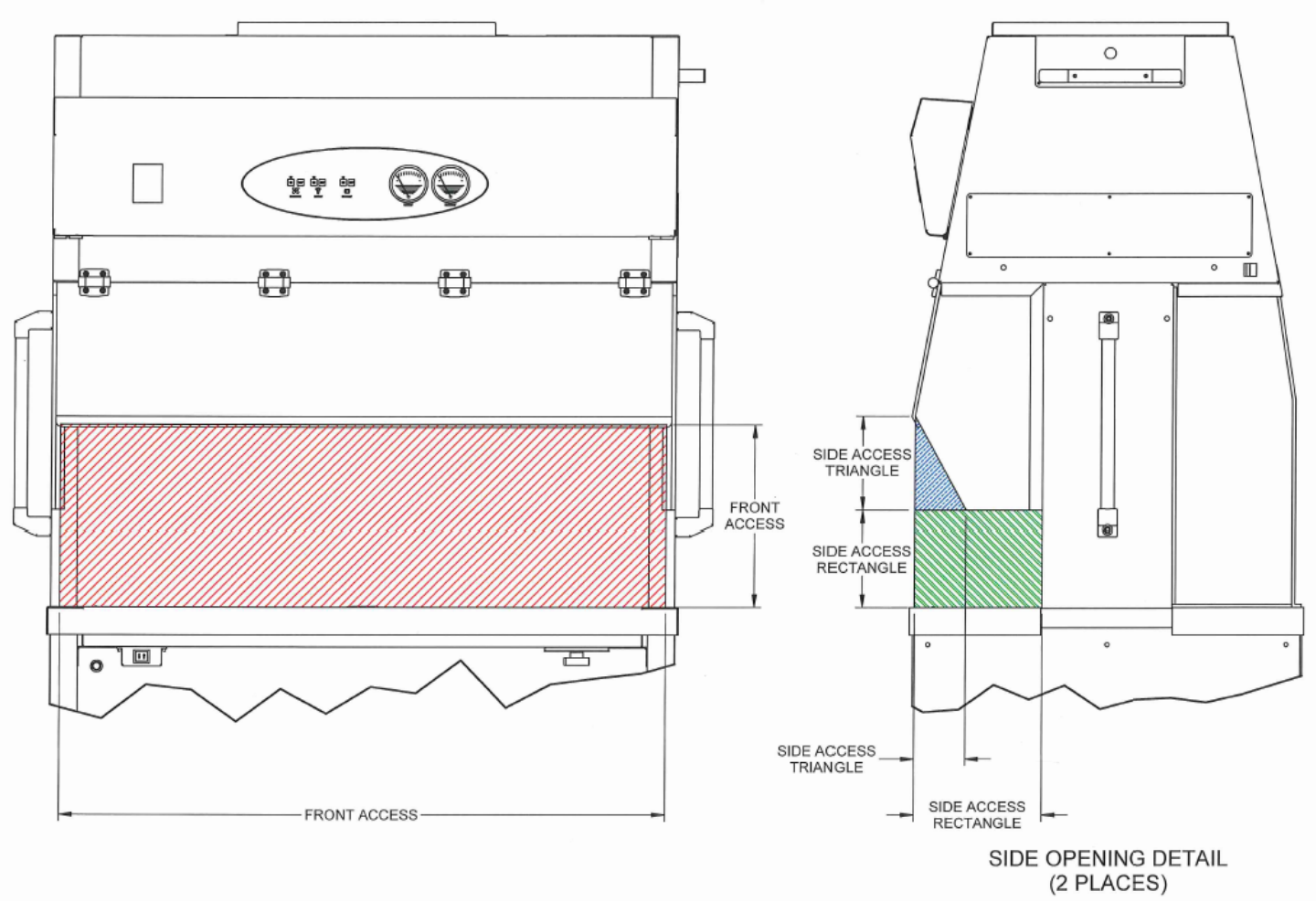
620-300			
Downflow FPM	**60**		
Downflow CFM	191	3.19	Supply Filter Area
Inflow CFM	513	4.89	Window Access Area
Inflow FPM	**105**		
Exhaust CFM	**705**		

NuAire, Inc. | 2100 Fernbrook Lane | Plymouth, MN 55447 | U.S.A | ph: 763.553.1270 | fx: 763.553.0459 | tf: 800.328.3352 | www.nuaire.com

620-400			
Downflow FPM	60		
Downflow CFM	225	3.75	Supply Filter Area
Inflow CFM	574	5.47	Window Access Area
Inflow FPM	105		
Exhaust CFM	799		

620-500			
Downflow FPM	60		
Downflow CFM	293	4.88	Supply Filter Area
Inflow CFM	697	6.64	Window Access Area
Inflow FPM	105		
Exhaust CFM	990		

To use the 620-400 as an example the downflow of 60 FPM is used and the supply HEPA is 13.5 x 40 or 3.75 square feet. Multiplying the 60 FPM by the filter area of 3.75 calculates the supply HEPA is adding 225 CFM to the system. The inflow is calculated by adding not only the front access but also the sides. The diagram below illustrates the access area. It consists of the rectangular front access, two smaller rectangles (one on each side), and two triangular sections (one on each side). The sum of this area for the 620-400 is 5.47 square feet. Using this value and multiplying by the 105 FPM desired for inflow results in an inflow of 574 CFM. Taking the sum of the downflow and the inflow is 799 CFM. This is the value to which the exhaust system will be set.

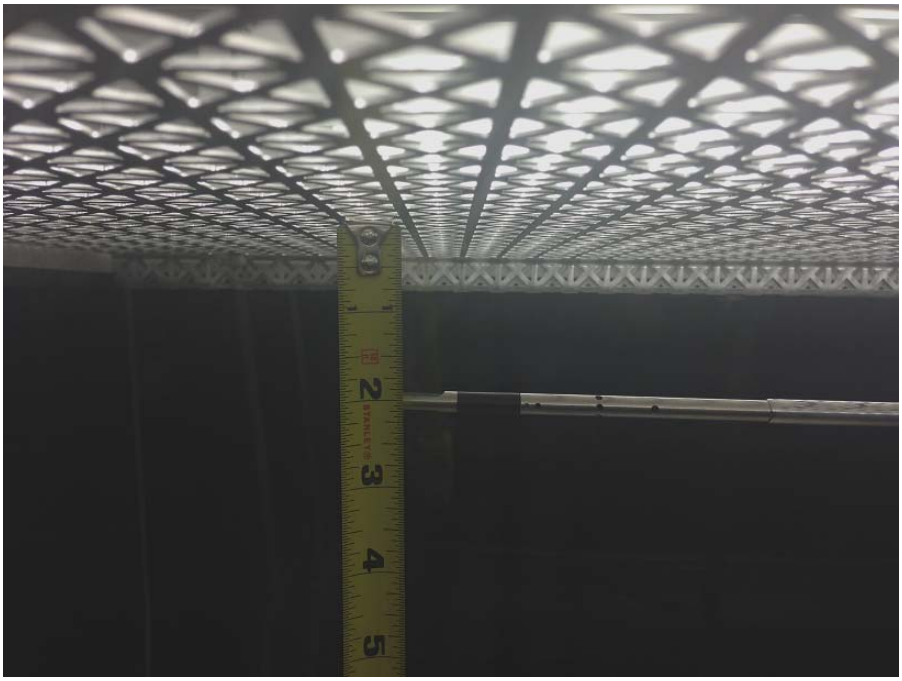


NuAire, Inc. | 2100 Fernbrook Lane | Plymouth, MN 55447 | U.S.A | ph: 763.553.1270 | fx: 763.553.0459 | tf: 800.328.3352 | www.nuaire.com

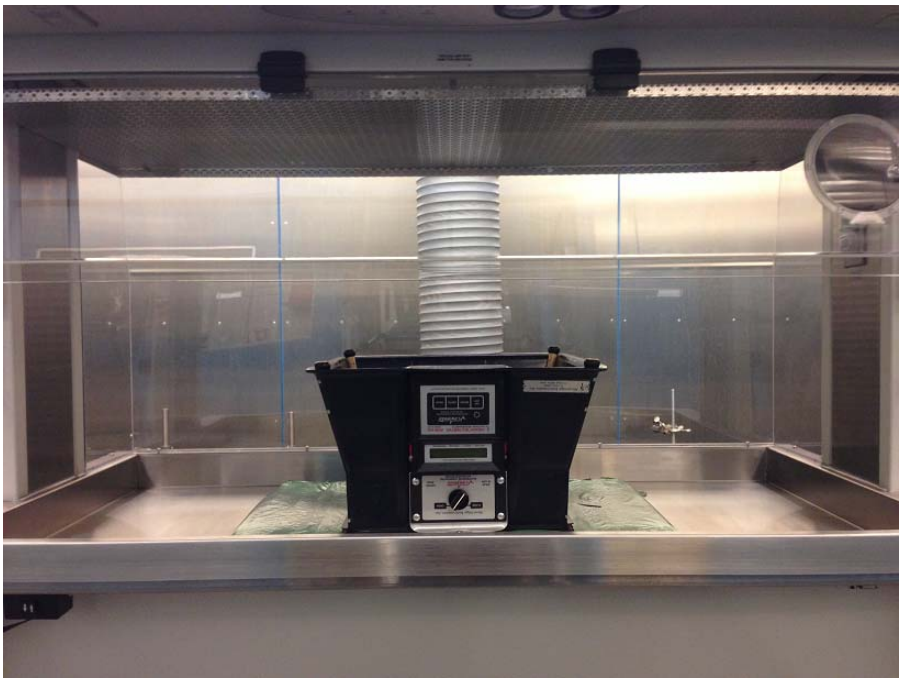
Airflows

There are two values that must be set in a 620. The downflow provided by supply impeller through the supply HEPA and the exhaust flow provided by the exhaust blower through the exhaust HEPA.

The downflow is measured on a 6” x 6” grid 2” from the supply diffuser.



The exhaust flow is measured with a DIM (Direct Inflow Measuring) device placed over the exhaust opening and sealed off so that all the airflow into the exhaust chamber is flowing through the device.



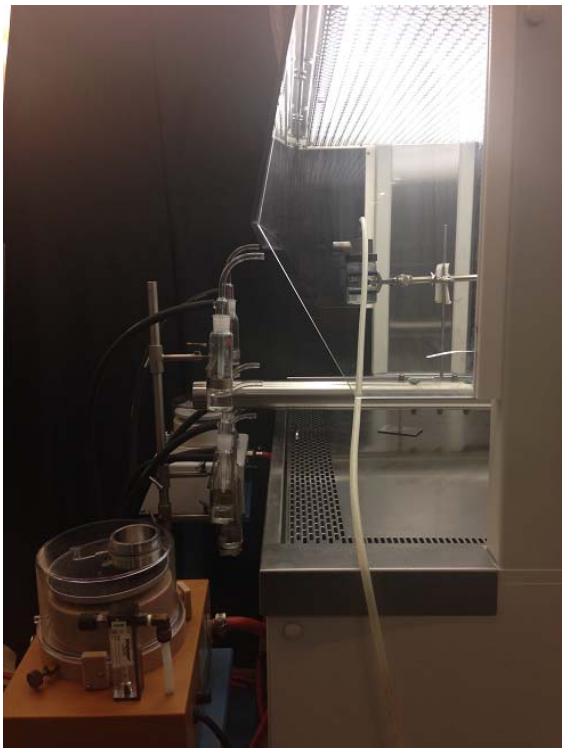
Smoke Testing

Prior to further biological testing the units were evaluated by smoke testing. The units were tested for both containment (personnel protection) and sterility (product protection). A video with examples of the testing can be found on the NuAire YouTube page if you follow the link. http://youtu.be/GzgLKinNjvw

Biological Testing

The biological testing was performed in accordance with a modified NSF\ANSI 49 biological testing procedure. Since a station of this type does not have a standard for design, construction, and testing NuAire decided to use NSF 49 as it is widely accepted. NuAire chose to run the personnel and product protection tests not only at nominal airflow but to also perform and pass the tolerance tests. These tests are high inflow/low downflow (115/50) for product protection. In addition low inflow/low downflow (95/50) and low inflow/high downflow (95/70) for personnel protection.

Below is the setup for the personnel protection test. A concentration of Bacillus in nebulized and directed from the inside of the cabinet towards the outside of the cabinet. On the outside of the cabinet are 6 impingers set at different heights and spacing and two slit samplers on the right and left side of the unit. The locations of these samplers and the test procedure were all done according to NSF 49. After the test the fluid in the impingers is filtered and along with the plates from the slit samplers is incubated overnight. The next day any colonies are counted and per the NSF standard the test allows 10 colonies maximum from the impingers and 5 colonies total between both of the slit samplers. There is a control plate under the worksurface and the nebulizer is weighed before and after the test to ensure an adequate challenge was produced. All of the tests were run in triplicate to ensure they are valid. The test results are detailed later in the report.



Below is the setup for the product protection biological test. In this case the Bacillus is on the outside of the cabinet directed towards the inside of the cabinet. Agar plates are placed inside the cabinet. After the test the plates are incubated overnight and any colonies are counted. The NSF standard allows a maximum of 5 colonies total to be considered passing. There is a control plate under the worksurface and the nebulizer is weighed before and after the test to ensure an adequate challenge was produced. All of the tests were run in triplicate to ensure they are valid. The test results are detailed later in the report.

NuAire, Inc. | 2100 Fernbrook Lane | Plymouth, MN 55447 | U.S.A | ph: 763.553.1270 | fx: 763.553.0459 | tf: 800.328.3352 | www.nuaire.com

Test Results
Personnel Protection Test

Low Inflow\High Downflow (95/70)
This test is a worst case scenario for personnel protection where the condition is inflow 10 FPM below nominal and downflow 10 FPM above nominal. Results for the 620-400 are below followed by the 620-500.

Model:	**620-400**	Date:	3/11/2014		
Access Opening:	14"	Dissemination Rate:	0.97	mls/5 min.	
Inflow Velocity:	95 FPM	Applied psi:	20		
Downflow Velocity:	69 FPM	Technician:	Bette		
Motor Volts:	DNFL 5.61 VDC	Notebook:	0031	Page:	69
Modifications:		Test Method:	NSF Standard 49		
Exhaust:	784 CFM				

Personnel Protection Test (10^8)

Bacillus: 5.7×10^8 (688) Date: 3/11/2014

Acceptance Criteria:
Challenge: 1-8 x 10^8 B. subtilis spores in 5 minutes.
AGI Samplers: Maximum 10 CFU's (colony forming units) on 6 AGI's per test.
Slit Samplers Plates: Maximum 5 CFU's on two plates per test.

Test Run	1	2	3
Control	>300	>300	>300
Left Slit:	0	2	1
Right Slit:	0	0	0
Impingers:	0	2	0
Initial wt. of Nebulizer:	459.1	457.8	456.2
End wt. of Nebulizer:	457.8	456.2	454.5
Sprayed Spores:	1.3g	1.6g	1.7g

Model:	**620-500**	Date:	3/17/2014		
Access Opening:	14"	Dissemination Rate:	.97	mls/5 min.	
Inflow Velocity:	95 FPM	Applied psi:	20		
Downflow Velocity:	69 FPM	Technician:	Bette		
Motor Volts:	DNFL 6.54 VDC	Notebook:	0031	Page:	69
Exhaust:	975 CFM 7 VDC	Test Method:	NSF Standard 49		

Personnel Protection Test (10^8)

Bacillus: 5.7×10^8 (688) Date: 3/17/2014

Acceptance Criteria:
Challenge: 1-8 x 10^8 B. subtilis spores in 5 minutes.
AGI Samplers: Maximum 10 CFU's (colony forming units) on 6 AGI's per test.
Slit Samplers Plates: Maximum 5 CFU's on two plates per test.

Test Run	1	2	3
Control	>300	>300	>300
Left Slit:	0	1	1
Right Slit:	0	0	1
Impingers:	5	1	2
Initial wt. of Nebulizer:	460.3	459.3	458.2
End wt. of Nebulizer:	459.3	458.2	456.3
Sprayed Spores:	1.0g	1.1g	1.9g

Personnel Protection Test

Low Inflow\Low Downflow (95/50)
This setup tests the balance of the cabinet. In this situation both the downflow and inflow are lowered 10 FPM from nominal. Results for the 620-400 are below followed by the 620-500.

Model:	**620-400**	Date:	3/10/2014		
Access Opening:	14"	Dissemination Rate:	0.97	mls/5 min.	
Inflow Velocity:	95 FPM	Applied psi:	20		
Downflow Velocity:	51 FPM	Technician:	Bette		
Motor Volts:	DNFL 4.85 VDC	Notebook:	0031	Page:	68
Modifications:		Test Method:	NSF Standard 49		
Exhaust:	713 CFM				

Personnel Protection Test (10^8)

Bacillus: 5.7×10^8 Date: 3/10/2014

Acceptance Criteria:
Challenge: 1-8 x 10^8 B. subtilis spores in 5 minutes.
AGI Samplers: Maximum 10 CFU's (colony forming units) on 6 AGI's per test.
Slit Samplers Plates: Maximum 5 CFU's on two plates per test.

Test Run	1	2	3
Control	>300	>300	>300
Left Slit:	2	0	3
Right Slit:	1	0	0
Impingers:	1	0	1
Initial wt. of Nebulizer:	457.7	456.4	454.9
End wt. of Nebulizer:	456.4	454.9	453.2
Sprayed Spores:	1.3g	1.5g	1.7g

Model:	**620-500**	Date:	1/21/2014		
Access Opening:	14"	Dissemination Rate:	.97	mls/5 min.	
Inflow Velocity:	95 FPM	Applied psi:	20		
Downflow Velocity:	50 FPM	Technician:	Bette		
Motor Volts:	DNFL 5 VDC	Notebook:	0031	Page:	60
Modifications:		Test Method:	NSF Standard 49		
Exhaust:	827 CFM				

Personnel Protection Test (10^8)

Bacillus: 5.2×10^8 Date: 1/21/2014

Acceptance Criteria:
Challenge: 1-8 x 10^8 B. subtilis spores in 5 minutes.
AGI Samplers: Maximum 10 CFU's (colony forming units) on 6 AGI's per test.
Slit Samplers Plates: Maximum 5 CFU's on two plates per test.

Test Run	1	2	3
Control	>300	>300	>300
Left Slit:	1	0	0
Right Slit:	1	2	0
Impinger Top:	0	0	1
Impinger Middle:	1	0	0
Impinger Bottom:	1	0	0
Initial wt. of Nebulizer:	459.0	457.4	455.8
End wt. of Nebulizer:	457.4	455.8	454.2
Sprayed Spores:	1.6g	1.6g	1.6g

Product Protection Test

High Inflow\Low Downflow (115/50)
This setup tests for the extreme situation where the downflow is 10 FPM below nominal and the inflow is 10 FPM above nominal. Results for the 620-400 are below followed by the 620-500.

Model:	**620-400**	Date:	3/28/2014		
Access Opening:	14"	Dissemination Rate:	0.97	mls/5 min.	
Inflow Velocity:	115 FPM	Applied psi:	20		
Downflow Velocity:	50 FPM	Technician:	Bette		
Motor Volts:	DNFL 6.79 VDC	Notebook:	0031	Page:	71
Modifications:		Test Method:	NSF Standard 49		
Exhaust:	815 CFM 4.64 VDC				

Product Protection Test (10^6)
Bacillus: 5.8 x 10^6 (689) Date: 3/28/2014

Acceptance Criteria:
Challenge: 1-8 x 10^6 B. subtilis in 5 minutes.
Agar Sampler Plates: Maximum 5 CFU's per test

Control	>300	>300	>300
Front 1	0	0	0
Front 2	0	0	0
Front 3	0	5	0
Front 4	0	0	0
Front 5	0	0	0
Back 6	0	0	0
Back 7	0	0	0
Back 8	0	0	0
Initial wt. of nebulizer:	458.1	457.1	455.9
End wt. of nebulizer:	457.1	455.9	454.6
Sprayed Spores:	1.0g	1.2g	1.3g

Model:	**620-500**	Date:	1/22/2014		
Access Opening:	14"	Dissemination Rate:	.97	mls/5 min.	
Inflow Velocity:	115 FPM	Applied psi:	20		
Downflow Velocity:	50 FPM	Technician:	Bette		
Motor Volts:		Notebook:	0031	Page:	60
Modifications:		Test Method:	NSF Standard 49		

Product Protection Test (10^6)
Bacillus: 5.2 x 10^6 Date: 1/22/2014

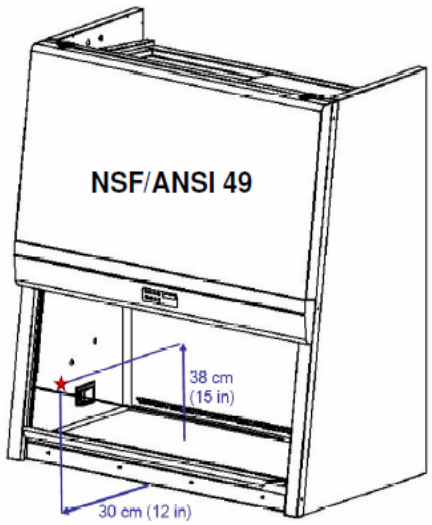
Acceptance Criteria:
Challenge: 1-8 x 10^6 B. subtilis in 5 minutes.
Agar Sampler Plates: Maximum 5 CFU's per test

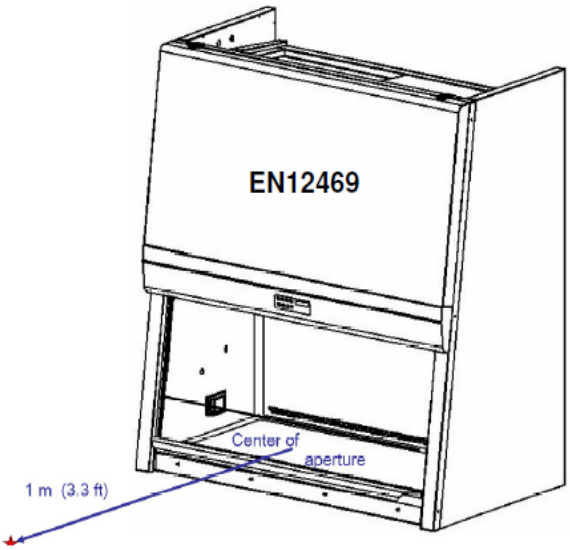
Control	>300	>300	>300
Front 1	0	0	0
Front 2	0	0	0
Front 3	0	0	0
Front 4	0	0	0
Front 5	0	0	0
Back 6	0	0	0
Back 7	0	0	0
Back 8	0	0	0
Initial wt. of nebulizer:	454.7	453.2	451.9
End wt. of nebulizer:	453.5	451.9	450.3
Sprayed Spores:	1.2g	1.6g	1.6g

NuAire, Inc. | 2100 Fernbrook Lane | Plymouth, MN 55447 | U.S.A | ph: 763.553.1270 | fx: 763.553.0459 | tf: 800.328.3352 | www.nuaire.com

Noise Testing

Included below is data from the noise testing. For comparisons sake is should be known that there are two different ways manufacturers are testing their units. Some are testing to the NSF 49 standard and others to the EN 12469 standard. The advantage of testing to the EN standard is that the microphone is placed much lower and further away from the unit. This can result in readings that are as much as 3 dB (A) different between the two methods. The diagram below details the difference between the two test methods. For reference the dB (A) for both test methods is included. The tests were performed in a cleanroom which is a small room with a low ambient noise level.





620-400		**620-500**	
60/105		60/105	
Ambient	33	Ambient	34
NSF49	64	NSF49	65
EN12469	62	EN12469	64

One thing to consider if comparing this information against other units is the performance factor. The 620-400 is moving over 1000 CFM of air. That fact must be considered if comparing the unit against others. The airflows could be changed to make the unit quieter but the performance would suffer. This unit was designed with performance as the top priority.

Conclusion

The NU-620 was designed to provide high levels of *both* product and personnel protection. Through extensive testing we found the only way to accomplish these goals was to change to a single sided design. Then we validated the unit by smoke and biological testing. The biological testing was performed at the tolerance airflows per the NSF 49 standard. This ensures better performance under dynamic conditions. Where the original NuAire ATS was built to replace a horizontal laminar flow hood the NU-620 is designed more closely to a biological safety cabinet. While the NU-620 is *not* a substitute for a Class II, Type A2 Biological Safety Cabinet it is designed and tested to these standards. While it is not a Class II BSC the NU-620 is a high performance ATS that provides excellent product protection for animals as well as allergen containment for users.