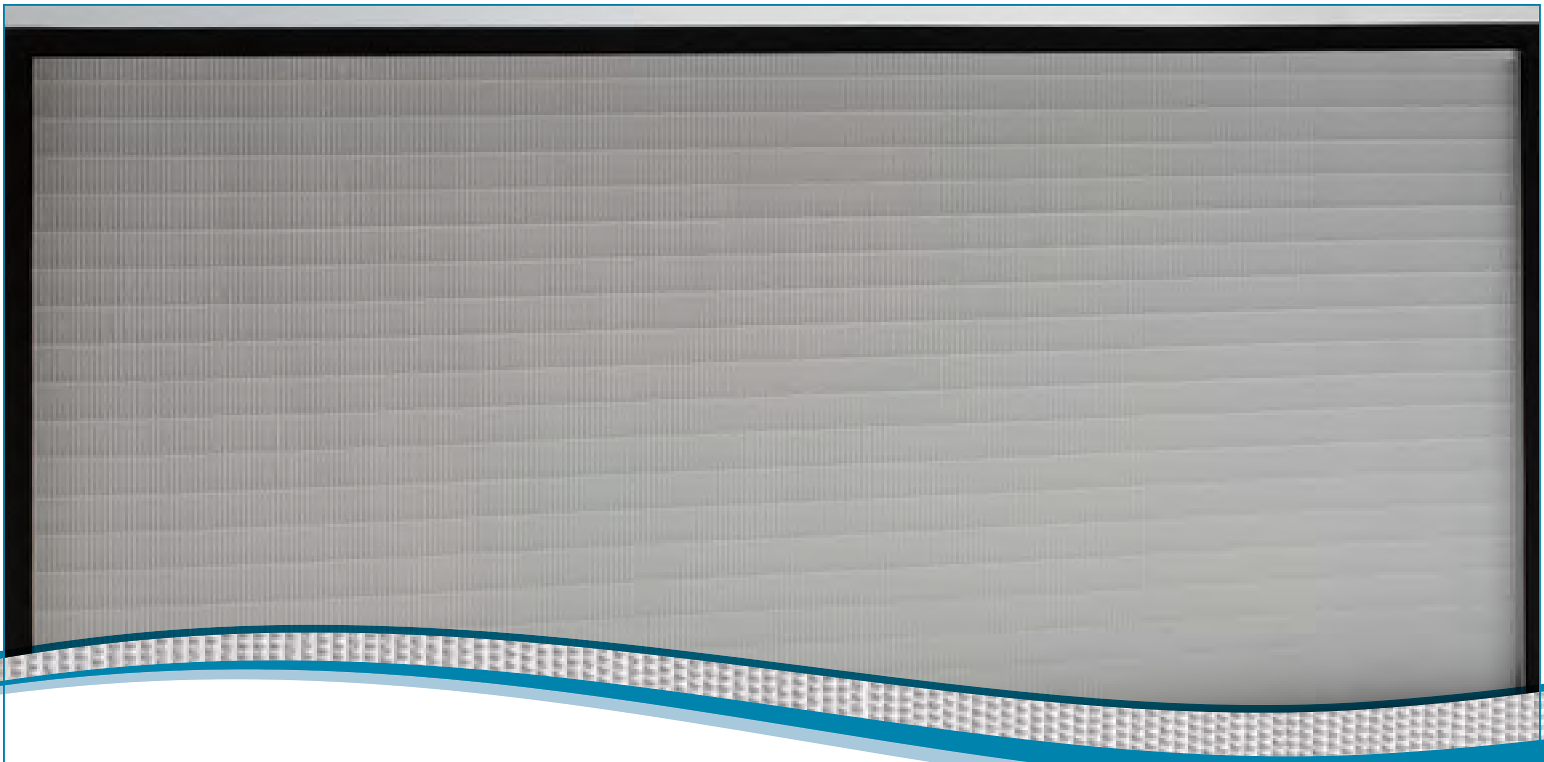

HOW LONG DO HEPA FILTERS LAST?

CLASS II, TYPE A2 BIOLOGICAL SAFETY CABINET
HEPA FILTER LOADING CAPACITY

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CLASS II, TYPE A2 BIOLOGICAL SAFETY CABINET

HEPA FILTER LOADING CAPACITY

WILLIAM PETERS - VICE PRESIDENT OF ENGINEERING

How Long are HEPA Filters supposed to last?

The life of a HEPA filter for a Biological Safety Cabinet (BSC) is an important subject when considering the life cycle cost of any BSC. HEPA filter loading capacity has always been a major concern for the design and performance of a BSC. Not only in terms of replacement cost, but also laboratory safety through the replacement process, down time, and associated costs.


Metal Frame HEPA Filter

With the use of new energy efficient motor technologies, expected HEPA filter loading capacity of BSC's may be reduced but still meet the NSF/ANSI 49 requirements. The discussion below provides a short explanation as to the requirements, what has changed, why it changed and what information is required from manufacturers to assure at a minimum the same HEPA filter loading capability. The energy savings obtained by using some of the new energy efficient motor designs of today may be offset by replacing the HEPA filters more often.

History

The first major BSC specification developed by the National Institutes of Health (NIH) dating back to August 1973 included a specification for filter loading capacity. The NIH-03-112 specification scope and objective was to provide procurement specification for a safety cabinet that included downflow (which was new back then) along with inflow to provide both product and personnel protection. The cabinets would be used in biological research or production as an aid to control airborne contaminants, which may represent a low to medium risk hazard to scientific personnel and/or be deleterious to the equipment.

The specification provided requirements for design, construction and performance of the original Class II, Type 1 (now type A1/A2) BSC's. Section 3.5.6 and 3.5.7.1 covered both the fan and motor respectively.

Fan and motor performance were specified by the following requirements:

3.5.6.3 Total fan delivery shall fall off no more than 10% as a result of 50% increase in the pressure drop across the filter.

3.5.7.3 The motor shall be sized to operate the fan at a static pressure sufficient to meet the requirements of paragraph 3.5.6.3.

To satisfy the above requirements, a fan curve provided by the fan manufacturer along with operational BSC static pressures and motor torque information provided by the motor manufacturer at the nominal airflow set point was plotted to theoretically calculate the loading capacity of the system. In this case, the system refers to the fan, motor and filters (with the specific pressure drops) of the individual BSC.

The NIH specification remained the only BSC specification until June 1976, when the National Sanitation Foundation (NSF) adopted Standard 49 Class II (Laminar Flow) Biohazard Cabinetry. The NSF Standard was based on the NIH specification; so many parts were nearly identical, if not the same including the fan and motor requirements as stated below.

4.21.2 Total air delivery shall fall off no more that 10% as a result of 50% increase in the pressure drop across the filter without readjusting the fan speed control.

4.22.1.2 The motor(s) shall be sized to operate the fan(s) at a static pressure sufficient to meet the requirements of item **4.21.2.** Fan motors shall be UL or CSA listed.

Again to satisfy the above standard requirements, cabinet manufacturers submitted a fan curve with the appropriated motor and static pressure information was provided to NSF as evidence of compliance to the standard requirement.

In the late 1980's an NSF task group was formed to develop a test method to demonstrate compliance to the standard versus providing theoretical evidence of compliance. The motor blower performance task group based the current test method on the Air Movement and Control Association (AMCA) publication 210, laboratory methods of testing fans for rating purposes. The basis of the test was to load the cabinet airflow system and measure the static pressures of the fan per AMCA, then measure airflow fall off to determine compliance to the statement above. The test method was officially updated in the 1992 revision of the standard and remains the same today per NSF/ANSI 49, Annex A.12, Motor / Blower Performance.

Understanding the basis for the Specification:

The design and performance basis for both of the above specifications was the use of an AC PSC motor and a forward curved fan. The AC PSC motor has an inherent design characteristic of increasing motor RPM with more resistance (Torque) or when used in a cabinet with a forward curved fan will increase RPM of the fan with more static pressure caused by particulate loading on the HEPA filters of the BSC. So, by specifying that no more than a 10% fall off of total air delivery from a 50% increase in static pressure assured the correct fan, motor and HEPA filters were designed into the BSC. The 50% increase in static pressure is considered the baseline without readjusting the fan speed control knowing that the fan speed control would add additional capacity to the system. Although, not specified by NSF, the additional capacity was virtually guaranteed using AC PSC motors and forward curved fans. Manufactures, provided what additional capacity they could offer that basically indicates how much particulate load can be applied to the system and still maintain cabinet airflows at a level to provide containment.

Using available AC PSC motors, forward curved fans and HEPA filters with average pressure drops, most manufacturers were able to attain 180% increase in pressure drop or static pressure across the filter with no more than a 10% fall off in total air delivery. The 180% increase in pressure drop then became the *de facto* industry standard being used and published by most manufactures and written into most all architectural, governmental, university and private industry BSC specifications.

The following statement in some form represents this specification used today:

> Cabinet motor/blower shall be positioned so as to create even filter loading, thereby prolonging the life of the HEPA filters, and shall deliver over 50% of the initial HEPA filter static pressure with no more than a 10% decrease of total CFM. Equip each cabinet with a voltage compensating motor speed controller that automatically compensates for voltage changes to maintain constant voltage to motor. Speed controller will permit manual or automatic adjustment to deliver over 180% of the initial HEPA filter static pressure with no more than a 10% decrease of total CFM.

HEPA Filter Life:

Since actual filter loading in the field is based upon the laboratory environment the BSC is used in, actual life of the HEPA filters will vary for each installation. If the BSC was installed in a clean room, theoretically the filters will last forever. If the BSC was installed in an environment that has or generates a lot of particulates, the filters won't last as long. To establish average filter life in a standard life science laboratory, historical data was reviewed as to when replacement HEPA filters were ordered. Based on NuAire data and knowing our AC PSC motor design provides a 180% increase in pressure drop, it was found that filters were lasting an average of 7 years.

Wood Frame HEPA Filter

Using 7 years as a benchmark for 180% increase in pressure drop, the following chart was then established equaling average filter life to percent increase in pressure drop or filter loading capacity. As you might note, the chart is not linear, but is similar to that of a fan curve that allows more loading of new filters, then tends to trail off as the loading increases.

Percent Increase in Pressure Drop*	Average HEPA Filter Life (Years)
50%	3 Years**
100%	5 Years
180%	7 Years***
250%	10 Years

* Percent increase testing based on NSF/ANSI 49, Annex A.12 motor blower performance test methods
** Base line NSF requirement assuming more capacity is available
*** Industry standard requirement based originally on designed usage of AC PSC motor

NEW Energy Efficient Motor Technology

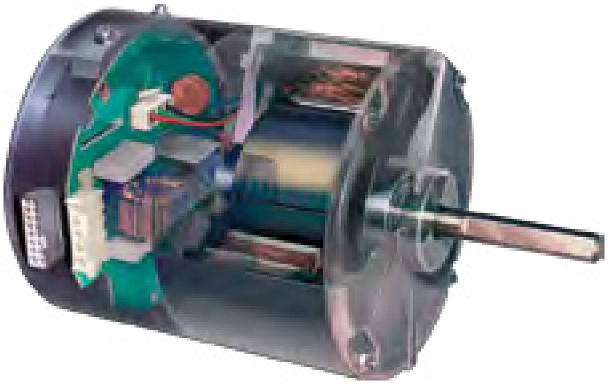
AC PSC versus New Motor Technologies

New motor technologies are being designed into most BSC's today primarily as a way to reduce energy consumption. AC 3-phase, DC ECM and DC motors are being used into cabinets today, these technologies offer increased energy efficiency ranging from 40% to 80%. However, most all of these new motor technologies don't provide the older AC PSC motor technology inherent capabilities to increase rpm (torque) with greater filter loading [resistance]. Instead, these new motors must be used with an airflow feedback loop control system or a motor feedback control system. Both methods are valid and provide adequate airflow control to keep the cabinets' airflow within the recommended airflow containment performance range.

Utilizing these new motor technologies with the necessary control capability can reduce the designed filter load capacity of the system and still meet the NSF requirement for motor / blower performance. In other words, the original requirement of the NSF standard didn't allow the fan (motor) speed control to be changed making sure the AC PSC motor was sized correctly with the fan using its inherent capability to increase rpm (torque) with more resistance or filter loading. The new energy efficient motors require the use of an integrated control system to increase rpm (speed) to compensate for HEPA filter loading. The NSF standard does not restrict usage of a control system or place additional requirements with its use. The standard today, still only requires that the total air delivery shall fall off no more that 10% as a result of 50% increase in the pressure drop across the filter. The additional capacity of 180% that was virtually guaranteed with the use of an AC PSC motor may not be present anymore, unless the product specifications for the BSC indicate the requirement or manufacturer provides this information within the specifications of the BSC.

Advantages of DC ECM Motor Technology

The DC ECM new motor technology actually increased the filter loading capability. The DC ECM motor was optimally incorporated and implemented with a specific forward curved fan for each width/volumetric size of cabinet. The DC ECM motor design provides additional capacity in terms of motor rpm that provides a 250% increase in pressure drop or static pressure filter loading capacity. In addition to the increased filter load capacity, energy costs have been reduced by 50 % and the system is quieter in terms of noise and vibration. The DC ECM motor, when properly designed and engineered into the BSC, provides the lowest life cycle cost in terms of energy, filter load capacity and reliability.



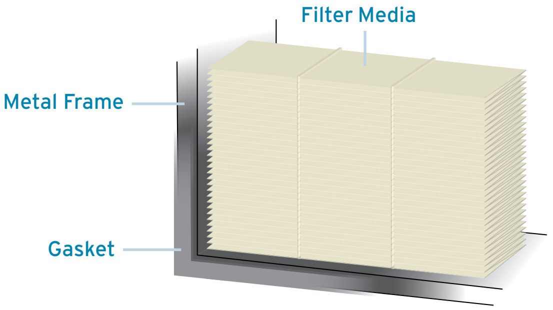
Ultra High Efficiency ECM Motor

Other Considerations: Size and Type of Supply and Exhaust Filters

HEPA Filters

Metal Frame HEPA Filter

HEPA Filters (99.99%) retain or trap only particulates. [To learn more, see NuAire Technical Bulletin entitled "Use of HEPA Filters in Biological Safety Cabinets"] Fumes, chemicals, gases, and vapors penetrate through HEPA Filter Media. As with any media-type filter, the surface area or the size of the filter and the number of air exchanges through the filter will ultimately determine how effective the filter is at retaining particles.



ULPA Filters

ULPA Filters (99.999%) create more resistance in the airflow dynamics of the cabinet, requiring a larger blower or multiple blowers to maintain proper airflows. ULPA filters typically cost more, contain higher grade dense fiberglass media and must be replaced more often than a HEPA filter. For biological applications, there is no advantage in using a ULPA filter compared to a HEPA filter. [See Technical Bulletin]

Controlling Airflow

Airflow in a Class II, Type A2 BSC consists of both down flow for product protection and inflow for personnel protection. The airflow velocities of both down flow and inflow are designed and balanced in a common plenum to provide optimal containment performance.

Common airflow plenum means particles generated in the cabinet work zone will be pulled into the blower and discharged into the positive pressure common plenum for distribution of both supply and exhaust airflow. Particle distribution within the common plenum is ideally spread evenly to minimize the generation of high/low airflow velocities within the cabinet work zone. An exhaust choke or damper is provided as a means to balance the down flow to exhaust flow (inflow).

Even particle distribution along with balancing down flow to inflow will provide maximum cabinet containment performance and extend HEPA filter life.

Electronic Airflow Control System [Motor Speed Controller]

Along with the many benefits already mentioned of using DC ECM motors. The DC ECM has the ability to be programmed to provide constant air volume even as the HEPA filter loads with particulates. In addition, the airflow control system can be fine tuned to assure maximum containment performance along with maximum allowable HEPA filter use.

Advantages of NuAire

NuAire incorporates our technical knowledge and the best of the new DC ECM technology to give you a better Value, Lower energy costs, longer filter life, and reduced noise and vibration. NuAire uses the largest HEPA filters with the most pleats per square inch; an electronic airflow control system; internal exhaust damper; and individually selected, optimally determined forward-curved fans for each model size/width. We are the only manufacturer to give these features insuring you the best performance, quality, reliability, service and cost saving technologies.

William Peters
Vice President of Engineering

To learn more or to speak with someone at NuAire please visit nuaire.com or call 763-553-1270.