NAFA®
National Air
Filtration
Association

BEST PRACTICE GUIDELINES

Filtration for Libraries, Archives and Museums

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Filtration for Libraries, Archives and Museums

NAFA guidelines provide advice on achieving the cleanest air possible based on the design limits of existing HVAC equipment and with consideration of the impact on energy and the environment. Our guidelines are created and updated to collect and supplement existing information. However, we go beyond the "bare minimum," publishing best practices based on the experience and expertise of our membership, as well as current mandates and research provided by governmental and scientific communities.

For a more complete explanation of principles and techniques found in this guideline, visit www.nafahq.org to purchase the *NAFA Guide to Air Filtration*. If you have any questions or comments about this publication, please contact NAFA Headquarters.

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ABOUT US

Our Mission:
The National Air Filtration Association (NAFA) mission is to be the global source for expertise, education & best practices in air filtration.

What can NAFA membership do for you?
NAFA brings together air filter and component manufacturers, sales and service companies, and HVAC and indoor air quality companies. By becoming a member, you can:

- Meet with industry thought leaders
- Strengthen your network
- Share best practices
- Receive up to date industry information
- Access professional development, certification and education

Be a part of something bigger
As a NAFA member, you are a part of a support system that shares the common goals of supporting industry growth and creating healthier communities. Following the coronavirus pandemic, we are more aware than ever of the important role that our members play in a well society. We know that our work is important to maintaining healthy, happy communities.

Benefits of Membership

As a member of NAFA, you'll have access to a host of benefits that offer networking, learning, and advertising opportunities. Here are just a few of our most popular benefits:

- Annual conferences and webinars
- Professional development programs (CAFS and NCT Level I & II certification)
- Air Media magazine
- Best practices guidelines
- Clean Air Award recognition program
- Library of resources, manuals, seminars, and training.
- NAFA advertising and sponsorship programs
- Exposure through NAFA social media and a listing on the NAFA website
- NAFA volunteer and leadership opportunities

...and more!

Click here to become a member today!

CAFS & NCT Certifications

Educate your team
Attract new customers
Be known as a leader in your industry

Now more than ever, customers seek professionals with the credentials for quality assurance and knowledge to ensure that their complex needs will be met. Addressing this concern, NAFA offers two certification programs to increase the level of education and professionalism in the industry.

The NAFA Certified Air Filter Specialist (CAFS) program
CAFS is the first education and certification program offering an extensive examination on the principles, methods and applications of air filtration. It differentiates professionals who have demonstrated a high level of professionalism and a thorough, up-to-date understanding of air filtration technology. The CAFS exam is pass/fail, and is based on the NAFA Guide to Air Filtration.

NAFA Certified Technician (NCT) Program
This open-book exam is based on the NAFA Installation, Operation, and Maintenance of Air Filtration Systems manual. This program was designed to increase the knowledge of technicians, facility managers, and building owners.

Both certifications are renewable on an annual basis pending successful completion of continued education requirements. While the exams are open to members and nonmembers alike, test fees are dramatically reduced for members. To find out more about the cost, study aids, test dates/locations, and requirements, visit the weblinks below.

CAFS information page

NCT information page

About This Publication

1 PURPOSE

This best recommended practice establishes air filtration guidelines for the removal of particulate and gaseous contaminants for the protection and long-term preservation of historical documents and artifacts in Libraries, Archives and Museums (LAMs). The recommendations in this guideline are considered by NAFA to be "best practice" in contrast to "minimum standards" put forth by other organizations. They serve to provide the conscientious Facility Manager with the necessary guidelines to make measurable differences of air quality in his/her building.

2 SCOPE

This best recommended practice identifies air quality issues associated with LAMs. It also establishes design criteria and performance specifications for new construction, as well as existing ventilation systems. This shall include methodology for contaminant removal by filtration and associated system maintenance.

3 BACKGROUND

The owners and operators of LAMs face challenges for the preservation of building contents due to industrialization and urbanization, which cause increased amounts of molecular and particulate contamination. Degradation of artifacts over the years has led to the recognition of the need to improve the quality and cleanliness of the indoor air environment in these facilities.

Research has led to the development of new measuring techniques that allow for more specificity in filtration requirements. At the same time, technological advances have allowed for increased filtration efficiencies within existing HVAC system limitations. Utilization of these changing technologies allows for effective system upgrades.

The primary focus of this guideline is the removal of molecular and particulate contaminants known to be of concern in the degradation of articles stored within a facility. It must be noted that relative humidity and the number of air changes per hour also play an integral part in the overall performance of the HVAC system.

BACKGROUND (CONTINUED)

Molecular Contaminants

The primary contaminants of concern are sulfur dioxide, nitrogen dioxide and ozone. These contaminants are known to chemically attack artifacts, causing permanent, irreversible damage. The type of damage and severity depends upon the amount of contamination and the artifacts' materials of construction. There may be other molecular contaminants present that are specific to individual applications and/or geographic locations that may also be detrimental in LAMs. For example, in new construction, there could be levels of formaldehyde that would require additional controls.

Particulate Contaminants

There are two major concerns with particulate contaminants: non-viable and viable particles. Non-viable particles cause soiling of the artifact. Cleaning of many artifacts is not an option, as it can often result in damage. Viable particles, usually in the form of airborne fungal spores, bacteria, and molds can also deteriorate artifacts, especially if temperature and humidity are not maintained at proper levels. There is also the potential that molecular contaminants could attach to particulates as a transport mechanism. The size range of particles of concern is the "accumulation" size particulate defined as ranging from 0.1 to 2 microns.

***#296 Same as A, Ibid Kadowalki Size Distribution of Total Aerosols, 1976.*

The table below shows possible preservation targets for most collections.

Building Air Quality Control	Potential Preservation Target (Years)*			
		In Enclosures with Emissive Materials		In Enclosures without Emissive Materials	
	In Rooms	without sorbent	with sorbent**	without sorbent	with sorbent**
Natural ventilation or HVAC system with moderate-efficiency particle filter, no gas filter	1-10	<1	10-100	10-100	>100
HVAC system with gas and good-efficiency particle filters, building membranes that are good gas barriers, and basic control of visitor flow	10-100	<10	10-100	>100	>100
HVAC system with gas and high- efficiency particle filters.*** Building membranes that are good to very good gas barriers, and limited access.	>100	<10	10-100	>100	>100

*Notes: * Adverse effects of water vapor and hypersensitive materials are excluded, e.G. Cellulose acetate, cellulose nitrate, certain dyes (such as alizarin crimson, turmeric yellow and basic fuchsin), lead, natural rubbers, silver, and polyurethane magnetic tapes. **Efficient sorbent (enclosures are assumed to have an air exchange rate of once per day). *** Assuming periodic replacement of the filters.*

***Tetreault, J. 2003. Airborne Pollutants in Museums, Galleries, and Archives: Risk Assessment, Control Strategies and Preservation Management, Canadian Conservation Institute.*

NAFA Best Practice Recommendations

NAFA BEST PRACTICE RECOMMENDATIONS

Pre-filtration should achieve a MERV 8 or higher, as tested in accordance with ASHRAE Standard 52.2-2017 at system rated airflow.

Molecular filtration should consist of a media bed(s) that is capable of reducing contaminants of concern to the levels listed below. Air flow through the molecular filter bed may vary with filter type, for proper reduction of molecular contaminants do not exceed manufacturer's maximum rated air flow. This media bed would consist of both an activated carbon media and a media capable of removing sulfur dioxide and formaldehyde. This can be accomplished in various ways, but most commonly with a potassium permanganate impregnated media or a specialty-treated carbon media.

RECOMMENDED LIMITS

It is important to note that there is no known level of molecular contamination that is considered "safe." The recommendations below are based upon levels which can be achieved and measured and can operate within the constraints of the current HVAC system. While accurate measurements of these levels can be achieved with various types of gas monitors, in-use measurement of pollutant levels in LAM's is very seldom seen due to its expense and need for a skilled operator. The manufacturer of the molecular filtration system can often provide the information on monitoring if desired, and may also offer alternative methods for determining system performance.

There are two test standards for molecular filters that can help determine both media and filter performance on various chemical contaminants. ASHRAE 145.1-2015 for Loose Granular Media and ASHRAE 145.2-2016 for Air Filtration Devices. Consult your NAFA Certified Air Filter Specialist to determine the type of molecular filtration system suitable for your HVAC system.

Fine particulate filters should achieve a MERV 15 or higher, as tested in accordance with ASHRAE Standard 52.2-2017. Refer to NAFA 52.2 User's Guide for further information.

Contaminant	Recommended limits	Parts per billion
Nitrogen Dioxide	5 micrograms per cubic meter	2.6 ppb
Ozone	4 micrograms per cubic meter	2.0 ppb
Sulfur Dioxide	2.7 micrograms per cubic meter	1 ppb
Formaldehyde	5.0 micrograms per cubic meter	4 ppb

**Architectural and Design Standards for Presidential Libraries.

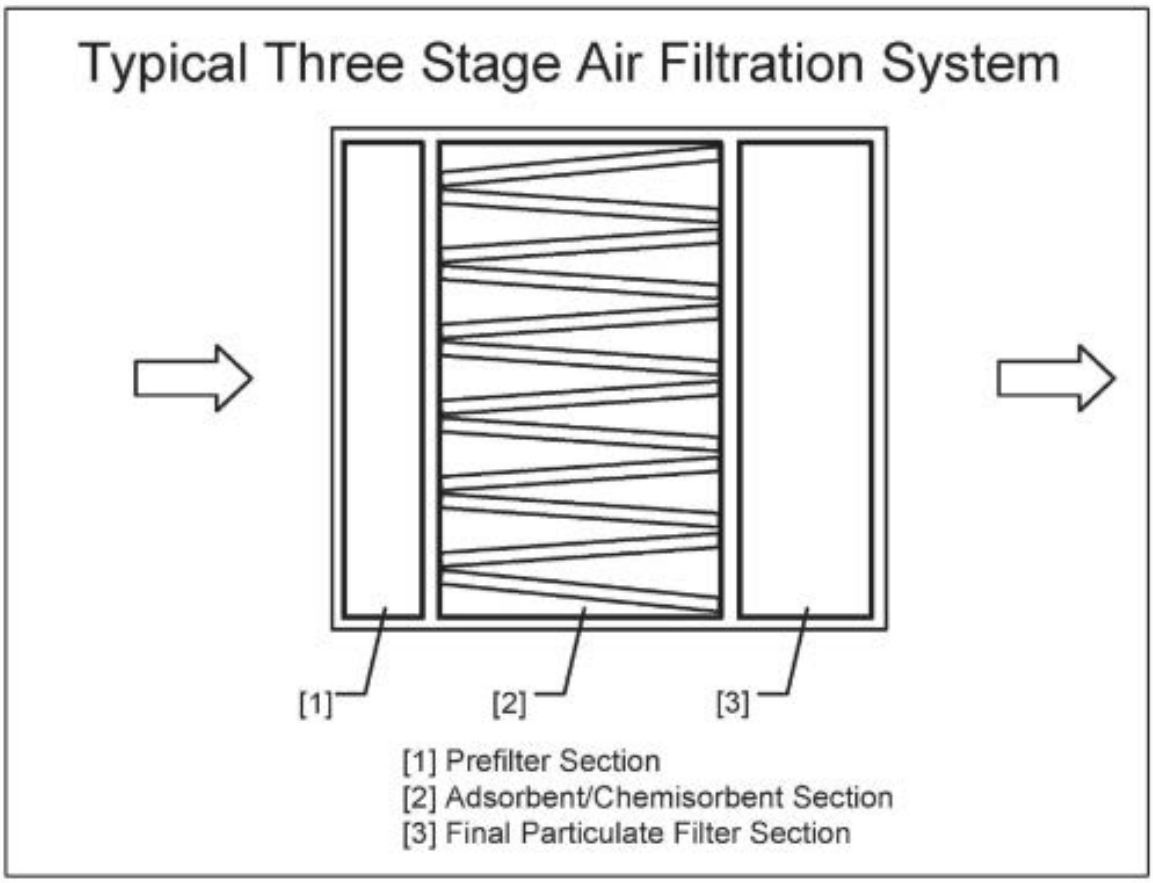
* Normally, acetic and formic acid are not regarded important indoor air pollutants, but the museum environment involves special situations, where objects are displayed in rather airtight cases, thus allowing a build-up of emitted compounds from the materials present in the case. Furthermore, in smaller display cases this build-up will result in concentrations higher than in the ambient gallery air because of a large surface to volume ratio. This whole problem is similar to materials deterioration observed in military extended time storage facilities , and in storage of electronic equipment.

NAFA Best Practice Recommendations (continued)

VENTILATION SYSTEM

A properly designed LAM HVAC system consists of three stages of filtration. The first stage involves pre-filtration, the second stage is molecular filtration and the third stage is high efficiency filtration. The purpose of the pre-filtration stage is two-fold: first, to remove large particulate thereby protecting the rest of the HVAC components and second, to protect the molecular filters from particulate contamination, which would reduce their effectiveness. The molecular filter is designed to reduce the level of chemical contaminants of concern. A high efficiency filter is used to remove those contaminants in the accumulation size range of 0.1 to 2 microns.

Proper installation of filters is critical to achieving the desired level of performance. Reference NAFA publication Installation, Operation and Maintenance of Air Filtration Systems for proper methods and component manufacturers' guidelines.



Installation, Operation & Maintenance

The following identifies some of the more important factors to consider when installing, operating and maintaining an HVAC Filtration system. As a supplement to manufacturers' guidelines, see NAFA's Installation, Operation and Maintenance of Air Filtration Systems manual or consult a NAFA CAFS.

Installation of Filters & System Integrity

Maintaining integrity of the filter system is vital for the efficacy of the HVAC system and imperative for air filtration performance as unfiltered air by-pass is a key contributor to poor IAQ.

A positively sealed filtration system will prevent unfiltered air bypass, maintain system pressure, and provide consistent filtration system efficiency. After each filter installation, the system must be checked to ensure that there are no possible leaks or gaps in and around the filters. This includes filter frames, fastening devices, caulking and gaskets.

NAFA recommends having a NAFA Certified Air Filtration Specialist (CAFS) inspect the installation for system integrity at least annually.

When changing or modifying the model or design of a filter system consult the manufacturer's specifications of the air handling system. Consideration must be given for:

- Size
- Fit
- Media area
- Airflow rate
- Initial and final pressure drop of the new filter system

Maintenance

A preventive maintenance program should include a monthly inspection of the filtration system. Use the following checklist as a starting point:

_____ Filters
_____ Filter hardware
_____ Fastening devices
_____ Caulking
_____ Gaskets
_____ Ductwork

Removing and replacing damaged or defective filters, filter hardware, gaskets and duct insulation will keep unfiltered air from bypassing the filter system. Keeping the coils and blower clean and free from dirt and debris will improve airflow, increase system efficiency, reduce electrical consumption, and maintain overall design performance. Scheduled filter maintenance will keep the HVAC system working efficiently with clean, conditioned air and a reduction in contaminant levels.

Additional information regarding maintenance of HVAC and filter systems may be found in the ANSI/ASHRAE/ACCA Standard 180, "Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems."

Installation, Operation & Maintenance (continued)

Monitoring of Airflow and Pressure Drop

As a filter loads with contaminants the resistance to air flow through the filter increases. This increase is referred to as "pressure drop" or "differential pressure."

As an example, in a draw-through system, as the filters load and the resistance increases, the fan pressure is lower on the downstream side. Hence the pressure "drop" downstream of the filters.

This drop or differential can be measured with a pressure sensing device such as a manometer or magnehelic gauge. All HVAC units should have a pressure-sensing device installed to accurately monitor the pressure drop across the filter bank. In extreme temperature conditions, a magnehelic gauge is recommended over a manometer. When a filter has exceeded its useful life based on pressure drop or Life Cycle Costing, it should be replaced. Leaving a filter in service after this point may increase operational and energy costs and could damage the HVAC system.

Most molecular filters, over time, will not increase in pressure drop. Some particulate medias, when impregnated with sorbent, could increase in pressure drop. This is not indicative of the service life of the sorbent. Service life of a molecular filter is a function of types and concentration of contaminants and filter design. Most manufacturers offer testing services to determine remaining filter service life. It is important to note that as the media life decreases, so does the efficiency of the molecular filter. Molecular filters are often recommended for change out before media is 100% spent.

Filter Service

The servicing of filtration products is a dirty business. It is best practice that service technicians have a safe work environment and use the correct personal protective equipment (PPE). Outer layer clothing should be weather appropriate in line with the climatic conditions. PPE includes:

- Eye protection
- Masks
- Gloves
- Coveralls
- Safety Boots
- Hearing Protection
- Hard hat

In addition, service technicians should have a good working knowledge of:

- HVAC systems
- Ladder safety
- Confined space entry
- Risk management
- Shut down procedures
- Lock-out procedures.

The use of specialized procurement devices (pictured above) should be used for safely adding, and removing product from difficult access points, such as a roof.

Installation, Operation & Maintenance (continued)

Training

The servicing of air filtration products is becoming more technical and requires specialized skills. It is for this reason that NAFA introduced the Certified Technician (NCT) Program in 1999 to increase expertise and professionalism to the air filtration industry. The NCT enables facility managers and building owners the opportunity to certify their employees on all aspects of filtration service and Indoor Air Quality.

For additional information visit the NAFA website: www.nafahq.org or contact a local NAFA member.

Disposal

Disposal of particulate filters should always be done in a safe and careful manner. The service technician should follow that same PPE guidelines outlined under filter service so that exposure to any potentially harmful contaminants can be avoided.

Molecular filters should be disposed of in accordance with any local, state, federal or provincial regulations. Refillable molecular filters, depending on the type of media may sometimes be returned to the manufacturer for recycling. NAFA recommends that technicians performing the work be certified to NAFA Certified Technicians (NCT) standards.

You care about your employees and your patrons.

You care about the environment and your community.

You care about the fiscal health of your institution.

Indoor air quality matters.

COSTS OF POOR AIR QUALITY

Lost productivity
Decreased Health
Increased absenteeism
Increased Equipment Maintenance/Replacement
Increased Energy

BENEFITS OF IMPROVED AIR QUALITY

Reduced absenteeism
Increased productivity
Improved health, wellness and satisfaction

KEY RECOMMENDATIONS FOR YOUR HVAC SYSTEM

- Run the HVAC whenever the space is occupied.
- Direct the clean/cleaned air into the breathing zone in each occupied space.
- Return air vents should pull air from the room and not directly from the clean air inlet.
- Maintain temperature and humidity design set points.
- Set the HVAC system to bring in as much outside ventilation air as possible.

KEY RECOMMENDATIONS FOR FILTER MAINTENANCE

- To achieve the recommended MERV 13-equivalent or better levels of performance (which removes ≥85% of 1-3 μm particles), a combination of filters/air cleaners can be used.
- Use only air cleaners for which evidence of effectiveness and safety is clear.
- When upgrading filters, carefully monitor to ensure your current system can handle the upgrade (e.g. pressure drop).
- Upgrading both pre-filters and filters may cause unacceptable pressure drop. It may not be necessary to upgrade both.
- Consider using the AHAM Clean Air Delivery Rate (CADR) for sizing air-cleaners for your space.
- Confirm filters are sealed in their frames, preferably with gaskets to prevent filter bypass.
- Personnel changing filters should wear PPE. Dispose of spent filters immediately and in a safe manner.

DID YOU KNOW?

Studies with SARS CoV-1 have shown that toilet flushing can generate airborne droplets and aerosols that could contribute to transmission of pathogens. Remember to:

- Keep toilet room doors closed, even when not in use.
- Encourage putting the toilet seat lid down, if there is one, before flushing.
- Keep bathroom fans running continuously and vent separately, where possible.

Glossary

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers. ASHRAE is an international organization that sets standards and guidelines for the heating, ventilating, air conditioning, and refrigeration industry.

CAFS: Certified Air Filter Specialist accreditation granted by NAFA to those who pass an exam on air filtration.

HEPA: High Efficiency Particulate Air filter – describes a filter that achieves a minimum of 99.97% efficiency on 0.3 micrometer particles or similar challenge.

HVAC&R: Heating, Ventilating, Air Conditioning and Refrigeration.

LAM: Libraries, Archives and Museums.

MERV: Minimum Efficiency Reporting Value refers to the lowest efficiency of a filter when tested in accordance with ANSI/ASHRAE Standard 52.2 2012.

NAFA®: *R*egistered acronym for the National Air Filtration Association, the trade association for air filter manufacturers and distributors, worldwide.

Nitrogen dioxide: NO2

Non-viable: Not capable of living.

PPM: Parts per million refers to the concentration of a substance within another substance. One ppm is equivalent to 1 milligram of something per liter of air (mg/l).

Sulfur dioxide: SO2

Viable: Capable of living, developing or germinating under favorable circumstances.

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Architectural and Design Standards for Presidential Libraries. Part 3 Sec. 43.B., Sec 45.a.b.

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As a global source for expertise, education & best practices in air filtration, we provide these guidelines with one important goal in mind: **To support best practices and ensure the cleanest air possible for our employees, our customers, and our community.** While the information provided is the property of NAFA and is protected by copyright and intellectual property laws, we strongly encourage the use and dissemination of this information - in print or electronically - to those within our industry.

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