

# TECHNICAL BULLETIN ASHRAE 52.2 Appendix J



High efficiency air filters are used to remove sub-micron particles including contaminants such as bacteria, fungi, manmade particle such as dust and fibers, and more critical airborne infectious agents transferred from person to person such as rhinovirus (common cold) and flu. They also remove droplet nuclei, produced through sneezing, coughs and conversation which carry various infectious agents from person to person.

## Critical Particle Sizes

Sub-micron particles are the most critical size of consideration because 99% of all airborne particles are under 1-micron in size. They are capable of penetrating deep into the human lung. Larger particles are typically removed from the air by prefilters or gravitational and other natural forces. The human body's respiratory system has mechanisms in place that remove these larger particles before they enter the alveoli of the lungs where they cause the most damage.

*Knowledgeable users are specifying...*

***The filter shall have a Minimum Efficiency Reporting Value of MERV (X) when evaluated under the guidelines of ASHRAE Standard 52.2-2012. It shall also have a MERV-A of (XA) when tested per Appendix J of the same standard.***

*(X - Substitute required value per application recommendations)*

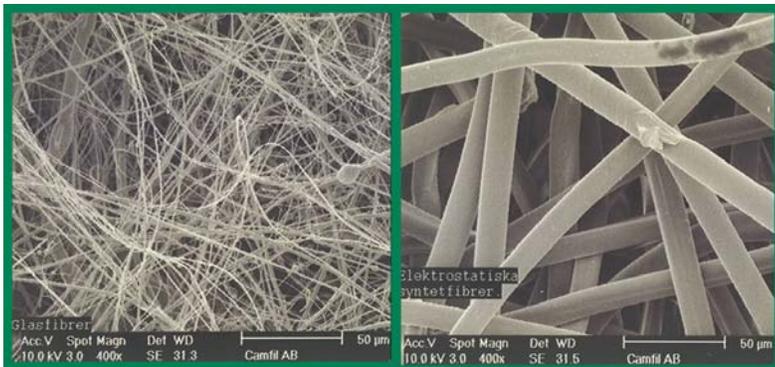
## Particle Capture Mechanisms

Air filter manufacturers use different particle capture technologies to provide clean air. For commercial filters, the primary capture mechanisms are mechanical and electrostatic.

In 1999, ASHRAE introduced Standard 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. MERV, or minimum efficiency reporting value, was established to allow users a way to evaluate one filter versus another. The higher the MERV, the more

efficient the air filter. Users could also evaluate a filter's effectiveness in removing contaminants by particle size, either through the broad spectrum of the single number MERV or by reviewing the complete particle-size-versus-efficiency curves that are a part of the standards reporting process.

Other design handbooks and standard materials for HVAC system design adjusted their filter efficiency recommendations based upon their specific contaminants of concern, and recommended the proper MERV filtration. As an example, all cognizant design authorities recommend MERV 14 for the final filter in medical facility HVAC systems. A MERV 14 filter has an efficiency of 48% at 0.3 micron particle size. The standard filter selection for office buildings is a MERV 13, which has an efficiency of 31% at 0.3 micron particle size. Both of these filters have excellent sub-micron particle capture efficiency.



Fine fibers (left), manufactured from micro glass, capture particles through diffusion and interception. Sub-micron particles are held in place by Van De Waals force. Efficiency is consistent throughout the life of the filter.

The coarse fibers of electret media (right) require a charge to attract and hold particles. Once the fibers become insulated with contaminant, or lose their charge, the filter efficiency drops. Filter fiber size is always an efficiency consideration.

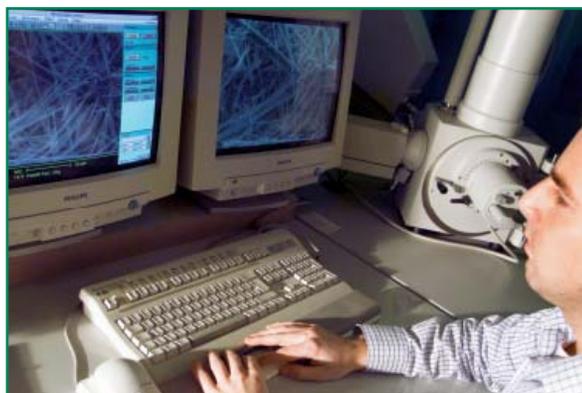
### Fine Fiber Mechanical Filtration

Mechanical filters use straining, diffusion and interception and have removal efficiencies up to 98% on particles 0.3 micron in size (one three-hundredth the diameter of a human hair). Mechanical filters will also maintain their published efficiency over time. A filter that has an initial efficiency of MERV 13 will maintain MERV 13 efficiency throughout the life of the filter.

When considering high efficiency mechanical filters (MERV 11 to MERV 16), the primary principles of particle removal for 1-micron and smaller are diffusion and interception. These principles require the application of fine media fibers, 0.6 to 2 micron in size, to attract and hold sub-micron particles. The higher the efficiency of the filter for sub-micron particles, the smaller the diameter of the filter fiber. Smaller fibers, such as microfine glass, are more difficult to produce from the natural materials used for fine fiber air filters, so manufacturing costs increase alongside the cost of the filter.

### Coarse Fiber Electret Filtration

Coarse fiber filters incorporate mechanical principles and also use an electrostatic charge to enhance particle capture efficiency to obtain a MERV of 11-15 when tested per ASHRAE Standard 52.2. Coarse fibers are much larger, in the 2 to 20 micron range, so the filter fiber's size in relationship to sub-micron particles, limits its mechanical ability to capture these contaminants. The primary mechanical principle used is straining. This principle removes larger particles from the airstream. Media manufacturers impart a charge on the media, or design the media so that a charge is induced



All Camfil 5-Star products incorporate fine fiber technology to ensure that those products maintain their published efficiency throughout the life of the filter. Our R&D department reviews fiber size and evaluates media alternatives on a continuous performance assurance program.

through airflow friction. This increases the filter's efficiency in the sub-micron particle range using the capture force of electrostatic attraction.

It also produces the desired MERV, at least temporarily, when tested per ASHRAE Standard 52.2. This larger media fiber size costs less to manufacture than fine fiber media and is the primary driving force behind air filter manufacturer offerings.

Independent research by cognizant authorities and doctoral programs have looked at the performance of coarse fiber filter products (electrostatic) over time and have concluded that these products experience a drop in efficiency as the filters load with particulate, or as the charge naturally dissipates. A coarse fiber filter may operate at a MERV 13 at installation and may decrease in efficiency to a MERV 9 over a relatively short period of time.

### Development of Appendix J

The ASHRAE 52.2 Standard Committee has been debating the issue of filters that drop in efficiency since the first version of the Standard in 1999. The Standard Committee is comprised of a congress of filter and filter media manufacturers who were unable to develop a consensus of how to best address this problem in the body of the Standard. The division was clearly along the lines of each manufacturer's interests.

Although Committee quorums were in favor of addressing the issue in the Standard, full consensus is preferred and agreement could not be reached.

An alternative solution suggested placing an optional test method outside the body of the Standard as an Appendix. In that manner, manufacturers and users who want confirmed assurance that their filters will perform as expected through their entire life in the system would have an authority-defined method of determining whether a specific filter would drop in efficiency. Defined as a 'conditioning step', the procedure was included with Standard 52.2 as an informative appendix.

Appendix J is titled *Optional Method of Conditioning a Filter Using Fine KCL Particles to Demonstrate Efficiency Loss That Might be Realized in Field Applications*. The Committee incorporated ASHRAE-funded research, independent papers and the knowledge from members of the Committee to author the Appendix.

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## ASHRAE 52.2 - Appendix J

### Appendix J Testing Aerosol

The most critical component of the procedure was the selection of the aerosol to simulate field loading of a filter. Potassium chloride aerosol (KCl) was selected to reproduce the fall-off in efficiency that electret filters may experience in real-life application. The selection was based upon extensive research and within the Appendix, the Committee states "The 'conditioning step' described herein is representative of the best available knowledge of real-life filter efficiency degradation at the time of the publication of this procedure."

The procedure spans eight pages and mirrors most of the procedures prescribed in the Standard, with the exception of a 'conditioning step' where the KCl is aerosolized using a strict protocol and introduced to the filter in a standard ASHRAE test duct.

Particle counts are taken upstream and downstream of the test filter, with the 'conditioning step' being repeated until the filter shows no further signs of significant drop in efficiency or the filter reaches final resistance because of dust loading. The corresponding particle ranges for the 'conditioning step' are the same as the particle ranges listed in the main body of the Standard and the same mathematics are applied to obtain a value defined as MERV-A.

### Recommendation

Camfil recommends that all filter users request this optional testing step to ensure that they are receiving the particle removal efficiency they are expecting throughout the life of the filter. Use the following

statement in a request for a quote or new construction specification to ensure the efficiency of particle removal required:

The filter shall have a Minimum Efficiency Reporting Value of MERV (X) when evaluated under the guidelines of ASHRAE Standard 52.2-2007. It shall also have a MERV-A of (XA) when tested per Appendix J of the same standard. (X - Substitute required value per application recommendations).

### Industry statements

Every air filter probably has an application wherein it may excel, but some salespeople may make statements that are misleading or confusing in their zeal to promote their products.

Camfil has summarized some of these statements and provided additional points of consideration. Please contact Camfil with your specific concerns if they are not addressed herein.

*Electrostatic filters will drop in*

*efficiency and as the dirt loads, the dirt becomes part of the filter and the filter efficiency increases.*

The statement is misleading at best. As filters load with contaminant, the captured contaminant becomes part of the filter and the dirt acts as a straining mechanism to remove larger particles. Studies show that the filters do not increase or regain efficiency in the critical sub-micron particle size range which constitutes 99% of all airborne particles.

*Coarse fiber air filters have a lower resistance to airflow than fine fiber filters.*

Sometimes true. But not a consistent statement when considering that coarse fiber filters typically rise in pressure drop faster than do fine fiber filters.

Filter pressure drop involves many factors; the two most critical factors are amount of media area and filter configuration. There is

a wide variance across all available filters and one manufacturer may have a lower resistance to airflow than another, whether they are using coarse or fine fibers to obtain the same MERV.

Literature, with supporting test reports, from the manufacturer should always be reviewed to ensure the best value.

There are studies that show that a coarse fiber filter increases in resistance to airflow faster than a fine fiber product, but that is only true of some products, not all.



With multiple air filter testing laboratories around the world, Camfil evaluates our products and competitive products on a daily basis. Tests are performed on virtually every type of air filter, from low-level arrestance type HVAC grade filters to the ULPA filters used in the highest level of cleanrooms. Flat sheet testing and discharge, dust collection cartridges and media, and carbon products may be evaluated in other Camfil testing rigs.

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The best avenue for users to determine the best value is to seek life-cycle cost data based upon actual filter installations.

*Fine fiber filters shed and coarse fibers do not, thus fine fibers create a health hazard.*

Studies have shown that both types of filters shed, but this is primarily during the initial days of installation as the filter clears itself of manufacturing dusts.

Certain manufacturers have raised concern that the glass fibers of the fine fiber media may be carcinogenic. This was based on a single study over 20-years ago where glass fibers were implanted into a rat and the rat developed cancer. The amount of fibers that was implanted was the equivalent of implanting a basketball into a human being. Also, airborne fibers are not implanted; they are inhaled and typically removed by the body's natural protection systems.

Also, glass fibers have proven to be soluble, again, by the body's normal means of protection.

As a result of that single study, glass has been one of the most studied items in relation to its safety than virtually any other product. Not one study has reached the conclusion that glass is a carcinogen. The same may not be claimed for the coarse or synthetic fibers used in electret media filters, not even the solubility of the fiber components.

*The test does not have repeatability from one testing laboratory to another test laboratory.*

At least eight manufacturers or regional location laboratories were round-robin tested to ensure the repeatability of the procedure.

One laboratory showed inconsistent results in relation to the results at

the other facilities. Upon committee member review, there were inconsistent design discrepancies at the non-conforming facility when compared to the other laboratories.

Additional concerns have been voiced with regard to environmental conditions. Environmental conditions were eliminated as a concern because testing must now be done within controlled temperature and humidity ranges.

*There would be a cost or costs associated with manufacturers being required to perform this optional test.*

Air filter manufacturers have one thing to sell: clean air. Reputable manufacturers have testing laboratories to ensure their products perform as advertised, and most manufacturers also have ASHRAE 52.2 test ducts.

The expense to these manufacturers is minimal because the optional testing requires time, not more equipment. The Appendix J option uses the same equipment as the standard MERV test. Camfil has tested every one of our products, and most of our competitors' filters, for MERV-A performance.

Some of our laboratories run 24-hours per day. We consider it a small expense to provide what the end user requires: clean air.

The only proof to ensure performance is testing per both the standard and optional appendix.

It has also been stated that some products would require re-design or modification; this is only an expense if the filter is not performing to published values in the first place.

Statements about literature changes or updates as an expense; hardly a factor in today's digital document producing world.

The true expense is poor filter performance in a user's application where they are expecting a standard of performance and product manufacturing care.

*As an Appendix, the MERV-A option has not been subject to peer review.*

In order to obtain American National Standards Institute (ANSI) status, a document has to be presented to industry experts for peer review. Most, if not all of those experts are on the ASHRAE Committee that developed the Appendix.

Peer review is an ANSI process that was introduced to ASHRAE documents in the late 90's to consolidate efforts in cross-over standard writing organizations.

Only items that are within the standard body itself are subject to the peer review process. The most important reviewer of this process at this point is the end user.

After inspection of the text and logic, we find most users are accepting the option and requiring it in their request for quotes and in specifications for their new construction projects.

### References

ASHRAE Standard 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*

*ASHRAE Test Guide*, Camfil