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BALANCED EFFICIENCY IN AIR FILTERS

Mechano-electret air-filter media provides optimal filtration and energy performance.

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Air filters perform an important function in commercial and institutional facilities: removing respirable particles such as microorganisms, dust and allergens from the air. At the same time, air filters have an effect on the energy consumed by the HVAC system, based on the filter media's resistance to air flow.

Not all air filters are created equal. Indeed, there are marked differences among various types of filters, and especially filter media when it comes to air cleaning and energy use. Depending on the filter media used, even two filters rated at MERV 8, for example, can vary widely in both particle-capture performance and energy consumption.

Engineers and specifiers of commercial HVAC systems should consider both the filtration efficiency and the energy efficiency of different filter media technologies to determine the best option for achieving both IAQ and energy-conservation goals. Two options include: filter media that captures particles only via mechanical methods; and filter media that uses an electret charge to enhance its mechanical capture methods.

Because air filters are more than just a commodity, it is likely that the result of an evaluation will point to synthetic media filters with a combination of a robust mechanical structure and an electret charge.

Mechanical capture methods

Air filters capture particles on the filter media, which is the material within the filter that removes particles from the air. This capture requires the particle to collide with the filter media fibers and subsequently to adhere to those fibers. The four primary methods of mechanical particle capture are:

1. Impingement—Captures high-density particles as they resist change in air-flow direction around the filter media fibers and collide with the fibers.

2. Interception—Captures particles based on forces of attraction as particles come into direct contact with the filter media fibers.

3. Diffusion—Captures very small particles at lower air velocities due to Brownian Motion, which increases the probability that particles will contact fibers and stay attached to them. [*Editor's Note: Brownian Motion is a random movement of microscopic particles suspended in liquids or gases resulting from the impact of molecules of the surrounding medium.*]

4. Straining—Occurs when the smallest dimension of a particle is greater than the distance between adjoining filter media fibers.

Some air filters rely only on these mechanical methods to capture particles. There are several disadvantages to this from

<< Preventing bypass air is crucial when installing new filters.

an air-cleaning and energy-consumption standpoint.

First, filter media designed to provide only mechanical particle capture begins its life at its lowest particle-removal efficiency and relies on the building of the dust cake in the filter to increase efficiency.

Second, filter media that uses only mechanical capture methods is not particularly effective in capturing submicron E1 particles (very fine particles in the 0.3–1.0 micrometer range).

Third, mechano-only filter media tends to create significant drag or resistance because its filtration mechanisms cause disruption of the particles in the air stream. The more resistance, the higher the pressure drop and the more energy is needed to push the air through the filters.

Electret-treated filter media

Mechano-electret filters enhance the mechanical capture methods of the filter media by electrostatically charging the filter media so that it better attracts particles that have a natural charge or that pick up a natural charge as they pass through the air.

There are several IAQ and energy-consumption benefits of imparting an electret charge to a filter with a robust underlying mechanical structure.

First, a well-designed filter using electret-charged media can be manufactured to provide high initial and high sustained efficiency over the filter lifecycle.

Second, the electrostatic effects created in an electret-charged media are particularly useful in increasing the capture efficiency for submicron particles. This is because, while submicron particles are much smaller than the void spaces in most commercial electret-charged media, the electrostatic forces within the media structure allow those particles to be removed with high efficiency.

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Third, filters with mechano-electret filter media almost always deliver lower air-flow resistance in the same filter construction as filters with mechanical-only media. This can translate into reduced energy consumption and costs.

It is important to remember that electret treatments are an enhancement of an underlying mechanical structure. The combination of different electret treatment patterns/charge distributions and different mechanical structures means that all filters with electret-charged media are not created equally. That is why it is important to look for electret-charged filter media with a gradient density structure in which the media's fibers are more loosely packed on the upstream side and more densely packed on the downstream side. This structure helps to reduce air-flow resistance, enhance dust loading and prevent face loading of the filter.

Beyond MERV

Industry professionals turn to MERV when it comes to evaluating the filtration efficiency of both mechanical-only and mechano-electret filter media. The Minimum Efficiency Reporting Value is assigned to filters based on their minimum fractional-particle size efficiency, as determined by ASHRAE Standard 52.2.

This standard test measures the efficiency of the filter media over three particle size ranges: E1 (very fine particles in the 0.3–1.0 micrometer range), E2 (fine particles in the 1.0–3.0 micrometer range), and E3 (coarse particles in the 3.0–10.0 micrometer range). E1, E2 and E3 efficiencies represent the measure of filter-media particle-capture performance and give users a more complete picture of what the filter will actually do.

High-capacity pleated filters typically have an extended filter life.

High E1 and E2 efficiencies are critical to providing good IAQ. However, many pleated filters today (especially commonly used MERV 8) have very low E1 and E2 efficiencies. In fact, under ASHRAE Standard 52.2, there is no minimum requirement threshold for E1 particulate capture below a MERV 13 rating. Be wary when attention is diverted away from poor E1 and E2 performance and instead is focused on MERV and the non-standard "MERV-A" test.

The non-standard MERV-A test was included in the updated ASHRAE Standard 52.2-2007 as an optional Appendix (Appendix J). This optional test "conditions" the filter media to negate its electret charge and subjects the media to extreme fine particle loading of KCl (potassium chloride). This fine-particle loading is many times what a typical filter would be exposed to over its real-world, installed, useful life. It represents a worst-case scenario that is likely never to happen. In addition, differences in environmental conditions and lab-to-lab variances have been uncovered, leading to the conclusion that techniques that "condition" the filter media are not repeatable.

More important, it is good to know that it is impossible to isolate the structural and physical properties of an electret-charged filter media from the charge distribution without impacting other filtration mechanisms and/or other filtration properties.

Be careful not to confuse the results of ASHRAE 52.2 Standard testing versus those results of testing done under the optional Appendix J method, which should be reported as MERV A. When choosing a filter, ask to see ASHRAE 52.2 test reports and request an energy cost analysis of a filter with mechano-electret filter media versus one of the same MERV rating that utilizes mechanical-only filter media.

Conclusion

High E1 and E2 efficiencies are critical to providing good IAQ. Most of the respirable dust and particles people breathe into their lungs is 3.0 microns and smaller. Lung-damaging dust, for example, can be as small as 0.5 microns, while some bacteria can be as small as 0.3 microns. That is why it is so important to consider filters with mechano-electret filter media and to look beyond a filter's MERV at the Fine Particle Efficiency rating as a true measure of a filter's performance. It is equally important to review the filter media's energy consumption performance. Even at the same MERV (MERV 8, for example), there may be marked advantages in the energy consumption of electret-charged filter media versus mechanical-only filter media.

From high filtration efficiencies to reduced energy requirements, there are many reasons to select air filters with filter media that has a good balance of a robust mechanical structure and an electret charge.

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