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Pleat Filter Media: Working Through the Maze

By Michael Gross

The maze of filtration media continues to be complex. The industry debate about the effectiveness of charged vs. non-charged media persists, and a new test method, published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has established new performance measurements. These are two recent developments that, when well understood, can make navigating the maze of available choices easier when selecting a pleated air filter.

Pleat filter applications are found in a variety of residential and commercial heating, ventilating and air-conditioning (HVAC) systems, ranging from home A/C/furnace units to high-rise office building units to industrial process air systems. There are important considerations and differences between pleat filters and filter media that should be understood when selecting pleat filters for any application. As with most any filter, there are many attributes that must be considered when choosing a pleated filter for a HVAC system. Important factors include:

- Filtration efficiency – how well the filter removes contaminants of interest
- Dust-holding capacity – how much dust the filter holds and how long the filter lasts
- Pressure drop – how the filter affects air flow and energy costs
- Moisture resistance – how high humidity and moisture affect the filter
- Temperature limitations – how the filter performs at application temperature
- Flammability – how the filter performs in flammability tests

Filtration Efficiency

First, let's discuss two forms of filtration mechanisms – mechanical and electrostatic. Mechanical filtration is dependent on the size of the fiber, size of the particles being filtered and

the physical structure of the media. With mechanical filtration, efficiency tends to build over time as particulates are collected—the filtration efficiency gets higher as the filter gets dirty. This media relies on straining, impaction, interception and diffusion—mechanisms beyond the scope of this article—for its effectiveness.

The electrostatic charge mechanism works due to the attractive forces between the fibers of the filter and the particulates they are capturing. The filter fibers are charged, through various processes, to create a charge differential that generates the attractive force. Filtration efficiency due to the electrostatic charge is highest when the filter is clean. As particulates collect in the filter and cover the charged fibers, filtration efficiency due to the charge will tend to diminish. However, charged media employ both mechanical and electrostatic filtration mechanisms. The electrostatic charge mechanism provides high initial efficiency and the mechanical filtration mechanism provides increasing filtration efficiency over time. The key for the filter media manufacturer is to provide the right fiber structure and electrostatic charge combination to optimize filtration efficiency throughout the entire life of the filter. Due to the variety of fiber forming and electrostatic treating technologies, there are many types of charged media available with differing levels of filtration efficiency from mechanical and electrostatic mechanisms.

Performance Evaluations

The two most common industry measures of HVAC filter performance are the ASHRAE Standard 52.1-1992, initiated in 1968 and last revised in 1992, and ASHRAE Standard 52.2-1999 which was just published last year after 12 years of development. Each test method provides different measures. ASHRAE 52.1 determines the pressure drop, arrestance (the percentage of the weight of ASHRAE loading dust that the filter can capture), dust spot efficiency (a measure of the ability of the filter to remove atmospheric dust from the test air), and dust-holding capacity. ASHRAE 52.2 determines the pressure drop and the fractional particle

size efficiency (PSE) of the filter and assigns a Minimum Efficiency Reporting Value (MERV). The MERV number is assigned to a filter based on its PSE in three different particle size ranges – 0.3 to 1 micrometer, 1 to 3 micrometers and 3 to 10 micrometers. Using the ASHRAE 52.2 protocol, filters are classified by their efficiency in removing various sized particulates from the air that passes through the filter. With this information, filters can be chosen for filtering specific types of particles at desired efficiencies, according to particle size (see Chart: Typical Particles & Dispersoids).

MERVs range from 1 (the least efficient) to 16 (the most efficient), indicating particle size filtration efficiency on a pre-determined scale. The higher the MERV, the more efficient the filter in the ASHRAE 52.2 Test. MERVs, obviously, are one of the key factors used to determine which filter is best suited for a specific application. However, it is only one piece of the equation.

Considerations regarding the dust-holding capabilities of pleat filters are also key to determining which media to use. The ASHRAE 52.1 standard measures dust holding performance in grams at a specified final pressure drop. It is important to compare dust holding capacities between filters at the same final pressure drops to make accurate comparisons of projected filter life.

The ambient environment conditions in which the media will be used can have an impact on filter selection. What types of dust are targeted? What about smoke? Do you need to filter fumes? Is bacteria a factor and, if so, what types?

Moisture or humidity is also a critical factor, particularly if the filter is used to capture bacteria. Moisture is a key component for bacterial growth; therefore a filter that resists moisture may be preferred. Some filtration media is made with hydrophobic fibers, meaning it does not absorb moisture. Other filtration media, made with hydrophilic fibers, will absorb and retain moisture.

Temperature also affects a filter's application. The range of air temperature a filter is exposed to in operation can affect filter performance. Different fibers have different limitations in their operating temperatures.

Flammability requirements are also important. Does the application require UL Class I or II rated filters to conform to building code or governmental regulations?

By making a critical evaluation of environmental conditions, HVAC requirements and filter media capabilities, the appropriate filter can be identified to ensure optimum filtration performance.

Filtration Benefits: Charged vs. Non-charged

The media used in pleated air filters include a wide range of materials -- including fiberglass, polyester, cotton, paper and synthetic nonwovens. Some filters use a combination of these media. Some fiber types can be effectively electrostatically charged and others cannot.

But is pleat filter media more effective when it has been enhanced with an electrostatic charge? Recent field tests and ASHRAE 52.2 tests conducted on filters made with electrostatically charged pleat media with a gradient density fiber structure and uncharged pleat media with a uniform structure (see Figure: Micrographs of Filter Media) show the charged media performs better. The combination of the gradient structure and electrostatic charge provides a means of achieving high initial efficiency (due mostly to the charge) and sustained high efficiency (due mostly to the structure). This is demonstrated in ASHRAE 52.2 composite minimum efficiency curves for three different filters made with charged-mechanical and uncharged-mechanical media (see Figure: Fractional Efficiency vs. Particle Diameter). The composite minimum efficiency curves in these figures represent the lowest efficiency at each particle size that a filter achieves during the entire duration of the ASHRAE 52.2 test. Further, the field test results confirmed that the filtration efficiency of filters made with the charged

media maintained the level of filtration, in actual use, indicated by the ASHRAE 52.2 MERV designation.

Summarizing, the selection of the right filtration media for a pleat filter depends on considering all the factors pertinent to a specific filtration application. And while the decision maze is complex due to the number of factors to consider, the information available from manufacturers and ASHRAE Standard Tests 52.1 and 52.2 make it possible to select the best pleated filter with the appropriate filter media for any environment. Fortunately for the filter user, filter distributors stand ready to provide manufacturer's information on the filtration performance, features and attributes of filters and filter media along with recommendations for appropriate applications for these products.

Michael L. Gross is a Market Manager of Filtration Products for Kimberly-Clark Corporation in Roswell, Georgia. He has an engineering degree from the Georgia Institute of Technology and an MBA from Georgia State University. Kimberly-Clark is a leading provider of nonwoven rolled filtration media.

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