Realizing Higher Performance, Improved Processability, and Lower Costs With Next-generation HEPA/ULPA Filter Media

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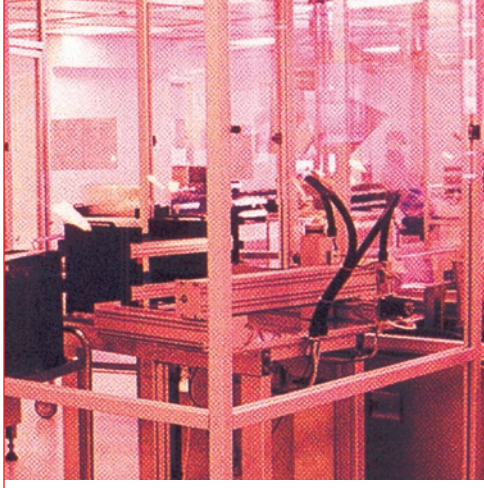


Abstract

Airborne dust and chemicals continue to be serious problems, with deleterious effects on human health and on industrial processes that rely on clean air. These facts underline the importance of effective air filtration systems.

This report emphasizes that filter media plays a key role in filter performance. It does so by defining the important performance metric, known as gamma, for measuring filtration effectiveness. This metric serves as the platform for measuring the importance of other media properties such as filter manufacturing and operating costs, and the energy costs. These properties, along with the processability of filter media, all add up to the total cost of ownership. Introduced here is a new generation of filtration media designed to bring together these media properties in order to optimize the total cost and performance of an air filtration system.

Environmental concerns

The air we breathe usually contains large amounts of fine particles and chemicals. Estimates say that indoor air alone can contain millions of contaminant particles per liter. These often can negatively impact human health, contributing to disorders and diseases at a growing rate, as shown by the increasing prevalence of problems such as childhood asthma. The European Commission estimates that approximately 370,000 people die prematurely due to the presence of fine dust annually. For this reason, the EC has recently adopted a new directive on air quality which limits the average concentration of fine dust particles to max 2.5 micrometers (PM2.5).

Pollution can also adversely affect industrial processes that depend on supplies of clean air, causing substantial manufacturing defects as well as premature wear and tear on process equipment.

These factors — and regulatory responses such as a global trend toward stricter controls on dust emissions — point to an increasing need for filtration systems with high-quality performance.

Filtration solutions

Filtration involves the removal of harmful particles from the air before the point where they threaten particular individuals or manufacturing processes. Until pollution can be fully controlled at the source of emission, air filtration remains a vital answer for successful management of airborne contaminants.

Filtration systems are designed in order to ensure a certain level of cleanliness required by specific applications. For example, cleanrooms found in electronics fabrication, hospitals, and other demanding applications, require high efficiency particulate air (HEPA) and ultra low penetration air (ULPA) filtration. Thus, filtration systems are specified by the amount of recurring contaminants and the amount of room air renewals needed.

One element critical to determining the performance of such systems is the filter media.

Media performance (and lower energy usage)

Filter media are porous or permeable substances — such as paper or nonwovens — positioned to catch and hold certain particle sizes. Filters are designed to meet a certain level of efficiency at a given airflow. In order to meet a given filtration efficiency, media has to be selected carefully.

When air is pushed or pulled through a filter, a gradient or pressure drop is created. The pressure drop and media performance is directly related to the media face velocity (velocity of air passing through). Stated more broadly, performance is the ability to deliver required filtration efficiency at a given airflow with a certain pressure drop.

In a technical context, media filtration performance is expressed in a gamma (also referred to as alpha) value. This value states the relationship between the penetration of a given filter media at a specific velocity and the subsequent pressure drop.

$$Gamma = -9.8 \times 100 \times \frac{\log \frac{Penetration\ (\%)}{100}}{Pressure\ drop\ (Pa)}$$

Penetration and efficiency are inversely related, with penetration assumed to be 100% minus efficiency.

The formula shows that the greater the pressure drop, the greater the amount of energy needed by a fan or ventilator to push or pull a given amount of air through a filter, the lower the gamma value. The higher the gamma value, the less energy needed. Thus higher gamma values are optimum in terms of the amount of energy consumed.

In short, filter media is a critical component of filter design because it plays a primary role in determining the overall total cost for operating a filtration system over its working life.

Media processability

The cost of producing filters consists of more than the material costs of the various components such as frames, adhesives, and media. Considering the cost of machine time and labor, the manufacturing steps associated with preparing and integrating media into each filter can account for significant cost factors. Media processability is therefore a major part in the cost of filter production.

There is both a qualitative and quantitative aspect to media processability. Quality refers to the ease of pleating the media while producing the “ideal” pleat profile. The speed at which media can be pleated with the least amount of wasted time and scrap is a quantitative factor.

System design and operation

The total cost of ownership consists of the hardware (filter elements, housing, fans, installation, etc.) and operating costs of the filtration system. The operational expenses depend upon the level of filtration efficiency required. The choice of media has a direct impact on operating costs because selecting a high-gamma filter media may lessen the initial cost of building a filtration system. For instance, a lower pressure drop can translate into smaller motors for air handling equipment.

As stated earlier, the operational costs relate to the energy needed to deliver a specified amount of air. The smaller the pressure drop across a filter, the less energy and expense consumed in order to accomplish filtration.

Optimizing media design

For all the reasons given above, filter manufacturers have for some time been requesting an improved class of filter media for their users in HEPA and ULPA applications.

This media would incorporate critical characteristics such as high gamma and high efficiency for reduced pressure drop and high performance. It would optimize processability for improved running time, throughput, and yield. Finally, it would allow reductions in manufacturing efforts and costs for filter makers, in air handling system costs for designers, and in operating costs for users.

Fortunately, a new generation of filter media designed to answer these requirements has recently been developed and is being adopted by leading filter manufacturers.

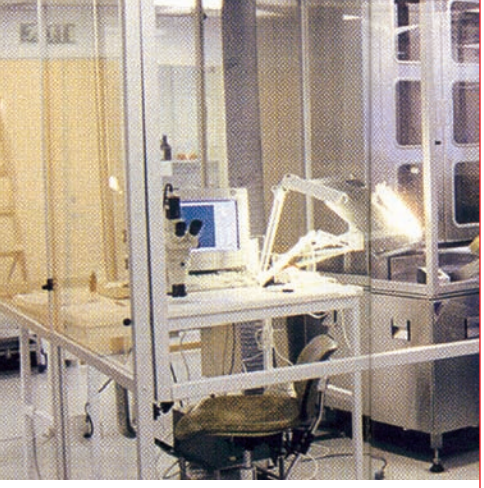
Next-generation filter media

Newer filter media with higher standards for media performance, processability, and cost efficiency are now helping provide improved HEPA/ULPA filtration for cleanrooms and critical spaces in electronics fabrication, pharmaceutical production, hospitals, food processing, and other industrial uses.

Through an extensive development effort involving many pleating trials, coupled with an investment program in advanced media manufacturing equipment, Hollingsworth & Vose has designed its new PerForm™ line with significantly improved processability.

As a result of this and other improvements, pleater machine setup times are reduced. These media run fast, with a clean pleat formation on rotary pleating equipment. Expensive pleater scrap is greatly reduced.

These advantages in processability also bring benefits for performance. Designing PerForm media with a superior pleat definition improves laminar flow characteristics. (See figure 1) This clean pleat formation contributes to a lower pressure drop in a given filter, compared to the same filter with inferior pleat definition.



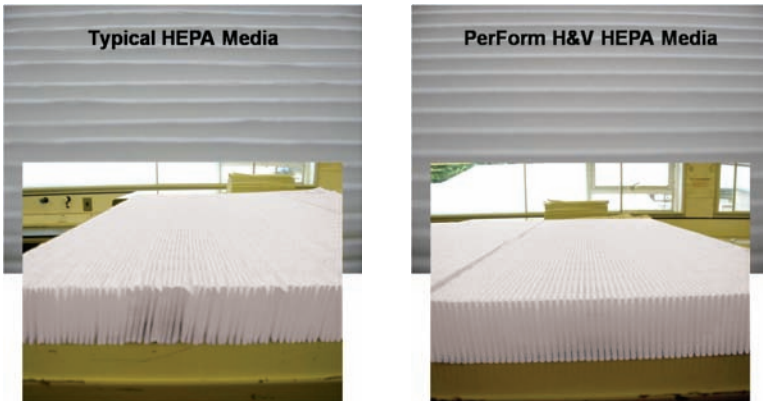
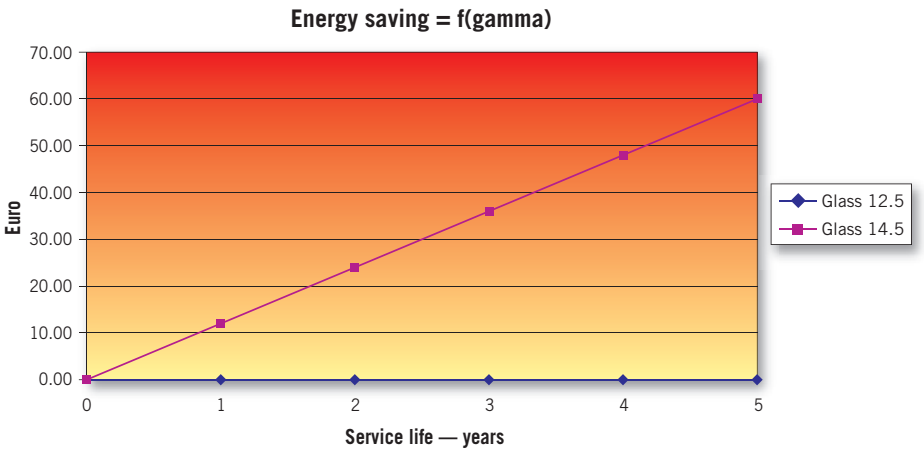


Figure 1.

The PerForm product family is offered in grades ranging from sub-HEPA through ULPA performance. Compared to standard media, this media offers efficiencies at a 9% to 16% lower pressure drop.

As mentioned previously, this brings economic benefits. As a rule of thumb (depending on the cost of electrical energy), reducing filter pressure drop by 1 Pa creates an air handling equipment energy saving of approximately 1 (currently about $1.55 U.S.) per filter per year. Based on this assumption, the accompanying graph shows energy savings for a filter containing 10 m² of media; it contrasts one microglass-based media with a gamma value of 12.5 against another showing a higher gamma value of 14.5.



Comparing newer high-gamma, low-pressure-drop media versus standard filter media, it is clear that the savings obtained can be significant. With an average gamma media value of 14.5, PerForm media displays the highest gamma in its class, and should deliver equivalent high levels of savings.

The PerForm media product line (see overview chart below) has been designed to reduce both total cost of ownership and total cost of manufacture. It offers filter makers the opportunity to optimize the lifetime, cost, energy impact, and value of their most advanced designs.

Product family overview

Perform Grade ref	HC3393	HC4393	HB5793	HB5493	HB5593	HB5693	HB5893	HA8393
Grammage, gsm	70	70	70	70	70	70	70	75
Air Resistance	210	235	260	280	295	315	360	385
DOP Pen, %	0.100	0.30	0.015	0.008	0.005	0.002		
CNC, cm/s							1.3	1.7
CNC, Pen, %							0.0002	0.00011

About H&V

Established in 1843, Hollingsworth & Vose Company is a global leader in developing, manufacturing, and supplying technically advanced engine, high efficiency, and liquid filtration media; battery materials; and industrial nonwovens. H&V adds value to customers' products by inventing next-generation materials with superior performance. H&V's expertise and process capabilities include wet-laid, dry-laid, meltblown, nanofiber, and composite technologies. The company operates manufacturing sites and research centers in the Americas, Europe, and Asia.

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