Trends in
AIR FILTRATION

For

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Trends in Air Filtration

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Introduction

During the past decade people have become much more aware about the environment and environmental concerns. Knowledge about the exterior and interior environment has increased significantly, resulting in tougher demands for protecting the environment and providing a healthier, more comfortable and more productive indoor climate in public areas, commercial buildings and manufacturing facilities.

At the same time, manufacturing and process industries have become more and more advanced, requiring cleaner, more efficient and more economical air processes.

All these trends are clearly reflected in today's choices of air filters for air handling systems. Stricter requirements for filter performance – and increased concerns about the hygienic aspects of filter design and use – are other apparent developments.

In addition to improving indoor air quality, air filters are used to protect sensitive manufacturing processes and components, and to prevent harmful emissions of particles, gases or microorganisms to atmosphere. Since filters must meet increasingly tough performance requirements, a serious need has emerged to find new test methods that can document their true efficiency. Concerns about conserving energy – and reducing costs – have led to new guidelines for cost and environmental analyses of filters.

Pollution and health

Studies from several countries have shown adverse effects on health at ever-lower levels of air pollution and a considerably stricter view has been taken of the harmful effects of air pollutants over the last few decades. The situation with regard to outdoor air pollutants in Europe has improved substantially in recent decades, particularly in relation to concentrations of sulphur dioxide and other contaminants related to combustion.

Despite this improvement, it is likely that present-day levels in many places are associated with adverse effects on health. New problems have arisen through the increased use of new chemicals in various products. More efficient motors and cleaning systems in vehicles have reduced most pollutants in exhaust fumes, measured by weight, while their content of ultra-fine particles has increased sharply. The total quantity of fine toxic particles in outdoor air is increasing as a result of this trend, along with the growing number of vehicles on streets and roads today.

We spend 90 percent of our time indoors and the vision should be that nobody gets sick because of the indoor air environment. In its document "*The right to healthy indoor air*", the World Health Organisation [1] establishes that breathing healthy indoor air is a human right. The document states that ignorance about Indoor Air Quality (IAQ) is not excused, and that all groups, individuals or organisations associated with a building have a responsibility to work for acceptable air quality.

Asthma and allergies have increased dramatically over the last few decades and affect one third of all children in developed countries. Although genetic factors contribute to the development of allergy and asthma, genetics alone cannot explain the dramatic rise of the epidemic. A recently published European study, based on information from 140,000 individuals in 22 countries [2], shows that the differences between countries or geographic areas are so great, that the increase must depend, to a large extent, on the environment and lifestyles. The type and level of stimulation from the microbial environment associated with improvement in public health and hygiene may have increased the predisposition of people to develop allergies and asthma. Microbial agents, especially fungi, have been identified as a health risk in indoor air. Many microbial problems indoors are related to indoor moisture problems and could be controlled by designing and using better ventilation systems.

Fine particles – an underestimated health risk

During the 1990s the particle content of air has been one of the hottest areas of environmental medical research. It has been shown that ultra-fine particles play a major role in affecting the respiratory system. There is a direct connection between health effects and finer particles. A study conducted to investigate fine particulates, air pollution and mortality in the U.S. [3] concluded that there is a clear connection between pollution levels of fine particles (< 2.5 µm) and increased mortality caused by cardiovascular and respiratory illness. Recently published studies [4] confirm that fine particles contribute to cardiovascular disease. Their adverse effects on health are probably underestimated. In a longer perspective, the negative effects of particles will be at least twice as high as they have been assumed up to now [5].

Official requirements are under review, which will be based on particles smaller than 2.5 µm ($PM_{2.5}$), both in Europe and the United States. WHO states that it is not possible to identify a level below which the particle concentration has no harmful health effect. Instead, they refer to a dose-response correlation for adverse effects on lung function and mortality.

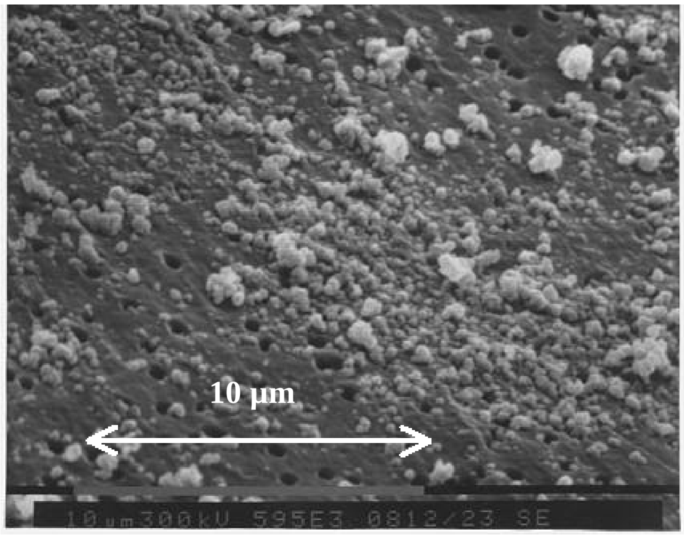

Figure 1. *Air test performed on Oxford Street in London. The concentration of ultra-fine particles from traffic exhaust fumes has increased sharply in outdoor air.*

Gas contaminants

International studies have clearly shown that sulphur dioxide, ozone and nitrogen dioxide can adversely affect people with asthma, and especially children with sensitive airways. Pollutants can strengthen the allergic reaction to inhaled allergens. These effects have also been substantiated in accepted hygienic standards and none have been substantiated under the threshold limit. Carcinogens, as PAH (Poly Aromatic Hydrocarbons) from vehicles and combustion processes also have long-term genetic health effects. Many other air pollutants, such as carbon dioxide, carbon monoxide, chlorofluorocarbons (CFCs) and volatile organic compounds (VOCs), have a high media profile because of their effect on health or the environment, but do not normally damage heritage materials.

Role of air filters

The environmental requirements for cleanrooms have increased significantly. The electronics industry must design and build systems today that will also meet manufacturing needs in the future. Technology is being rapidly developed and we know that criteria for removing particulates and gases to create ultraclean manufacturing conditions will be of decisive importance for cost-effective production.

Consequently, the microelectronics industry has led developments in this area and has been a driving force behind many air filter innovations and improvements to filters. But their technological progress and findings have benefited other industrial sectors as well.

To meet these high-tech demands, there is a need for developing new methods to test and classify Absolute filters. In 2000, the European standardization body for standards (CEN) launched EN 1822 for classification and testing of HEPA and ULPA filters. The method and classification, based on the efficiency for the most penetrating particle size (MPPS), has met with good response all over the world.

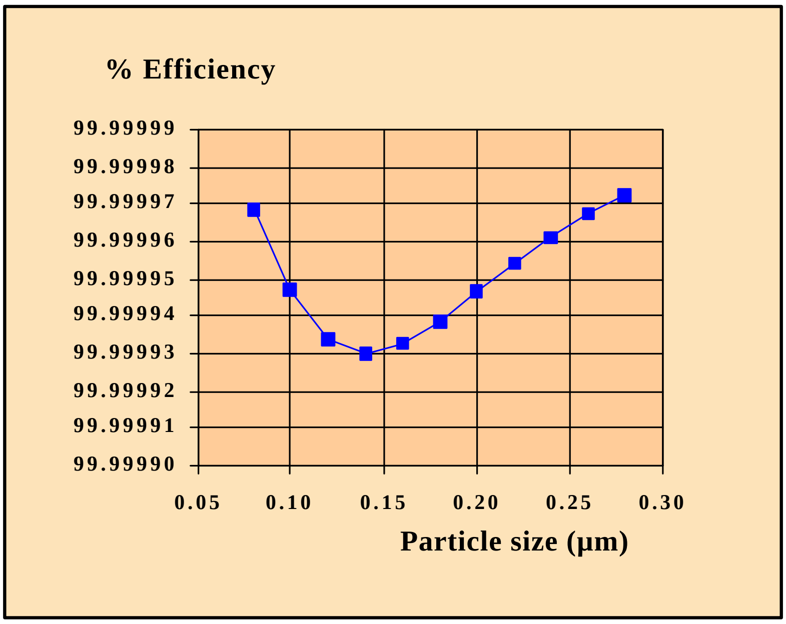

Figure 2. *Efficiency vs. particle size for a HEPA filter. This filter has a minimum efficiency for 0.13 µm particles (the* ***M****ost* ***P****enetrating* ***P****article* ***S****ize). The efficiency and MPPS vary with the type of material and velocity in the filter.*

Gas contaminants can be removed by various air cleaning processes. Activated carbon is successfully used in a lot of critical safety applications, such as in military, face gas masks, the nuclear industry and biological laboratories. Activated carbon is also successfully used to protect art treasures in museums from polluted outdoor air and sensitive components in manufacturing processes. Activated carbon is the most commonly used method to remove organic substances from air. The process employs physical adsorption with or without chemical reaction.

The development of filter designs and chemical adsorption materials has led to the design of gas filters for general ventilation systems that must meet demands for high flows and low pressure losses. In big-city environments, the requirement for filtering out gases in supply air has increased. The proposed European standard PrEN 13779 [6] recommends gas filtration in polluted outdoor environments and when good indoor air quality (IAQ) is required.

Figure 3. *Example of a chemical filter with pleated or foamed filtering material for HVAC installations requiring high air flows and low pressure losses.*

Air filters in a ventilation system can contribute to better IAQ [7] by keeping the system clean, meaning that the designed air flow is maintained, and that temperature and humidity are kept within specifications and allow fans, heating and cooling equipment to operate properly. An air filter can prevent microorganisms from entering the system and remove most outdoor contaminants. To solve IAQ problems and restore confidence in air filters, it is important that laboratory test methods reflect a filter's behaviour "in service". CEN has therefore proposed a revision of the former norm EN 779. CEN members will vote to adopt the revised version of EN 779 [8] this year.

Why revise the test method for air filters?

During the past 20 years air filters for ventilation systems in Europe have been tested in accordance with Eurovent 4/5, a number of national standards and later the European norm EN 779. These old measurement methods are no longer sufficient for the technical evaluation of air filters. The new proposed revision of EN 779 aims to introduce a new standard based on a filter's fractional particle efficiency. The method will provide more knowledge about the filters and make it possible to evaluate filter performance properties in relation to IAQ requirements and process demands.

Classification does not reflect real-life performance

Classification is also in the new revised proposal EN779 based on laboratory tests with synthetic dust and does not provide a basis for calculating the life of air filters, or assessing the filter's performance in actual application [9]. The most economical final pressure loss is in most cases below 150 Pa, while filters are classified at a final pressure loss of 450 Pa. For hygienic reasons, filters are also replaced after a certain period of time and not when the final pressure loss reaches 450 Pa. Filters never achieve the intended filter class in real life.

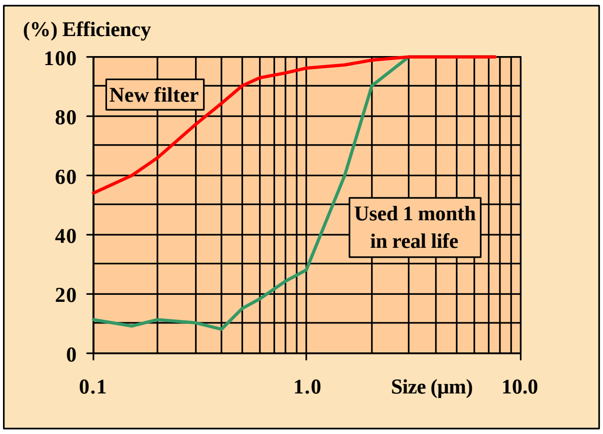

Figure 4. *The figure shows the difference between a filter's efficiency in the laboratory, compared with the result after one month in real life. An electrostatically charged filter with high efficiency in the lab will be classified as an F7 filter, but its real-life performance for fine particles could be very low.*

Certain types of filter media rely on electrostatic effects to achieve high efficiencies in a laboratory test. Exposure to particles in normal atmospheric air neutralises such charges and filter performance suffers as a result. It is important that filter users are aware of the potential for performance degradation when loss of charge occurs. It is also important that the means be available for identifying cases where the potential exists. The proposed revised EN 779 provides techniques for identifying this type of behaviour. This procedure is used to determine whether the filter efficiency is dependent on the electrostatic removal mechanism. It is also used to provide quantitative information about the importance of the electrostatic removal.

Life cycle analyses

Life cycle analyses have become an important instrument for reducing costs and the environmental impact of filters. In Europe, work is being intensively carried out to develop guidelines or requirements for Life Cycle Cost (LCC) calculations. Ventilation systems often account for the lion's share of a building's energy consumption and the pressure loss in air filters can account for a large part of the ventilation system's total pressure loss. More and more users are requiring LCC calculations when purchasing filtration systems and components. For filters, Eurovent has been a pioneer in this area and published guidelines [10] for calculating the costs of a filter during its entire service life.

The final pressure loss is decisive for sizing a filter correctly. There is an optimal final pressure loss for each operating situation, where the filter has a minimum cost. The optimal pressure loss is normally between 100 Pa and 200 Pa. The final pressure loss is therefore much lower than what is usually classified in laboratory tests. In all LCC calculations, it is important to determine the right filter quality or function in the calculation. A system without filters, or with poor quality filters, will naturally have a higher LCC.

It costs about 130 euros per year to filter one cubic meter of air per second efficiently, when a ventilation system is in constant operation. In an office environment, this air will serve about 100 people and the filtration cost will therefore be about 1.30 euros per person and year, with energy costs representing the biggest single expense.

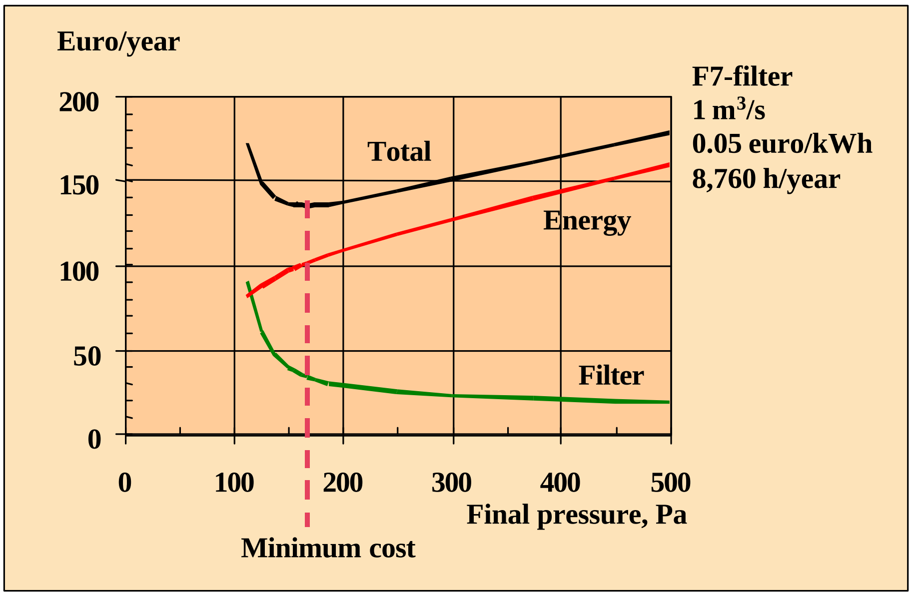

Figure 5. *A higher final pressure loss will increase the life of a filter and filter costs will be lower, while energy costs will be higher. Filter costs vary with the air flow and the concentration of outdoor air, although the optimal final pressure can be dimensioned in each case.*

Air filter installations
An air filter is used to remove contaminants and living and dead microorganisms in air but, in some circumstances, it can be a source of problems by releasing VOCs, allergens and particles when it is loaded with this type of dust. A substantial amount of research has been devoted to these problems and dirty filters, in some cases, can cause problems associated with the sick building syndrome, such as eye irritation, headaches and fatigue.

To avoid problems caused by a higher concentration of contaminants in the ventilation system, which would also provide a potential breeding ground for microorganisms and increase the likelihood of polluting emissions during the entire operating life of the system, studies [11] have shown that a filter of least F7 quality is required for supply air, and that the operating time for the ventilation system should be reduced for hygienic reasons.

New recommendations [12, 13] based on current knowledge indicate that, for hygienic reasons, inlet air should be filtered in two steps. The first filter in the air intake must be at least F5 quality but preferably F7. A filter of at least F7 quality, but preferably of F9 quality, should perform the second filtration step. If there is only one filtration step, the minimum requirement is F7 quality. A large number of VOCs are borne by particles, but for effective separation, chemical filters can be justified in an urban environment.

The risk of microbial growth is low, but to minimise the risk, the ventilation plant should be designed so that the average *RH* for three days is less than 80 % in all parts of the system. Great care is required regarding the positioning and design of the air intake to avoid drawing in local impurities, rain or snow.

The first filters must be replaced when the pressure loss reaches the specified final pressure loss, or after a maximum operating period of 8,700 hours. The filter in the second filtration step should be changed after a maximum of two years of continuous operation.

In addition, no deterioration of efficiency in real life should be accepted in any way.

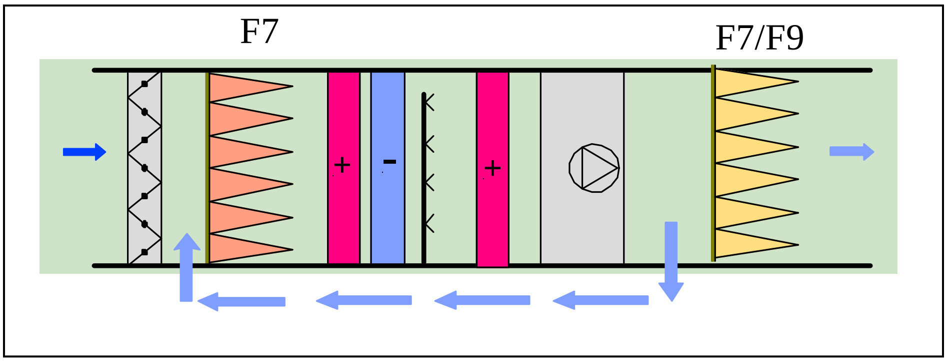

Figure 6. *For hygienic reasons, inlet air should be filtered in two steps. The first filter in the air intake should preferably be a filter of at least F7 quality and the second filter should preferably a F9 quality filter. To avoid more than 80 % RH, the air could be preheated, or some of the air could be recirculated.*

Summary

When clean production is required, or when components must be protected from impurities, there is often a correlation between good manufacturing results and clean air. Higher productivity, food that keeps longer (fast food) and performance guarantees are examples of trends that clearly impact the development of air filters. Studies about the health risks associated with fine particles have stimulated greater interest in effective filtration. Furthermore, indoor air quality has become more and more important and has even become a competitive tool for attracting building tenants or recruiting skilled personnel. The right air filter, properly maintained, is a low-cost solution to eliminate many of the problems associated with the sick building syndrome and the long-term effects of pollutants on health.

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