Air filtration in the 21st century

What is the future for filtration? Jan Gustavsson, Technical Director of Camfil Farr explains

Every day we breathe about 20 kg to 30 kg of air and consume around 1 kg of solid food and 3 kg of liquid food. We should therefore expect our air to have the same quality standards as our food and drink. 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 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 the responsibility to work for acceptable air quality.

IAQ IN FOCUS

Asthma and allergies have increased dramatically over the last few decades and affect one third of the children in developed countries. The tendency to allergies and asthma is probably hereditary, but exposure to a number of pollutants can trigger reactions. 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 better ventilation systems. Studies have shown a direct connection between health effects and finer particles. Official requirements are under review and are to based on particles smaller than 2.5µm (PM2.5). It has also been shown that smaller particles, ultra fine particles play a major role in affecting our respiratory system.

A filter is one component in a ventilation system and cannot contribute to better IAQ by itself. But if the right air filters are installed, they can contribute to better IAQ by:

- keeping the system clean, meaning that the designed air flow is maintained, and that temperature and humidity are kept within specifications;
- maintaining the efficiency of equipment, allowing fans, heating and cooling equipment to operate properly.
- preventing micro-organisms from entering the system;
- removing outdoor contaminants

Why a revised test method?

To solve IAQ problems and restore confidence in air filters, it is important that test methods reflect a filter's behaviour "in service". The European Committee for Normalisation (CEN) has proposed a revision of the former norm EN 779. CEN members will vote to adopt the revised version of EN 779 this year.

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 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:

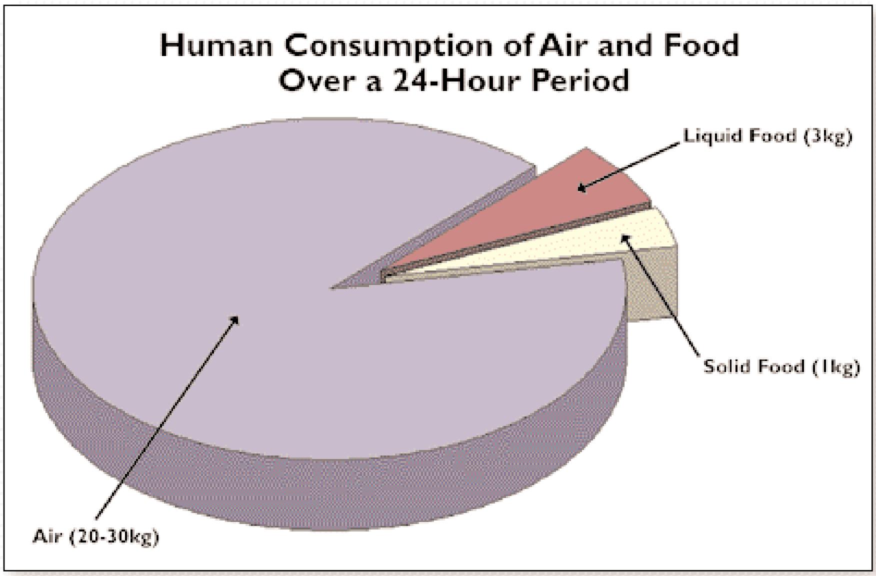
- evaluate filter performance properties in relation to IAQ requirements and process demands;
- find better agreement with lab test results and actual installations;
- obtain a faster, simpler method that is easier to understand;
- employ the same instruments and techniques for checking filters in a plant.

TEST METHOD

The new proposed standard is based on the Eurovent 4/9 particle test method from 1993. The basic design of the test rig in the former EN 779:1993 is retained, except for the "dust spot" atmospheric aerosol opacity test equipment. Instead, a challenge aerosol is dispersed evenly across the duct, upstream of the test filter. Representative upstream and downstream samples are analysed by an optical particle counter to provide filter particle size efficiency data.

To obtain results for comparison and classification purposes, particulate air filters will be tested against two synthetic aerosols: one fine for measuring filtration efficiency as a function of particle size (range 0.2 to 3.0µm), and one coarse for obtaining information about dust holding capacity and, in the case of coarse filters, the filtration efficiency with respect to coarse loading dust (arrestance). Filters with efficiencies higher than 98% are tested in accordance with EN 1822:2000 (HEPA and ULPA).

Certain types of filter media rely on electrostatic effects to achieve high efficiencies at low resistance to air flow. Exposure to some types of challenge, such as particles in normal atmospheric air, may neutralise such charges and filter performance suffers as a result. It is important that the users of the filter 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 test procedure 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 and to provide quantitative information about the importance of the electrostatic removal.



Human consumption of air and food over a 24-hour period

TESTING AND REPORTING

The report is to include a summary of the results, measured efficiencies and their uncertainties, air flow rate, pressure drop measurements and the results of dust loading measurements.

The efficiency, as a function of particle size, is determined for a new filter, after loading 30 g of dust and at final pressure drops of 250, 350 and 450 Pa. For fine (F) filters, average efficiency values are calculated and presented for different particle sizes and final pressure drops.

The dust loading, dust holding capacity and average arrestance are reported at specified final pressure drops of 150 and 250 Pa for G-filters, and 250, 350 and 450 Pa for F-filters. The summary report compiles the initial results and also includes curves of pressure drop, efficiency (0.4µm) and arrestance vs. dust fed to filter.

The testing, reporting and classification of the filter are based on a filter without any treatment, but as supplementary information, the discharged efficiency of the filter, or filter material, is also reported.

An example of a filter

DISCHARGED EFFICIENCY

The media of the filter, or from another equivalent filter, is tested according to Annex A "Electrostatic discharging procedure". This procedure is used to determine whether the filter efficiency is dependent on the electrostatic removal mechanism and is also designed to provide quantitative information about the importance of the electrostatic removal. This is accomplished by measuring the removal efficiency of an untreated filter material and the corresponding efficiency after the effect of the electrostatic removal mechanism has been eliminated (the test can be extended to larger samples or parts of the filter, or even one full-size filter).

The test is based on the elimination of the electrostatic removal mechanism. Any treatment may be used to produce a completely discharged material (isopropanol, diesel fumes, detergents or surfactants in water). The efficiencies of the untreated and discharged filter samples are calculated and reported.

Filter Type	EN 779 Class	Average (A_m) Arrestance (synth. dust) (%)	Average (E_m) Efficiency (0.4µm) (%)	Final Pa
Coarse filter	G1	$50 \leq A_m < 65$	-	250
	G2	$65 \leq A_m < 80$	-	250
	G3	$80 \leq A_m < 90$	-	250
	G4	$90 \leq A_m$	-	250
Fine filter	F5	-	$40 \leq E_m < 60$	450
	F6	-	$60 \leq E_m < 80$	450
	F7	-	$80 \leq E_m < 90$	450
	F8	-	$90 \leq E_m < 95$	450
	F9	-	$95 \leq E_m$	450

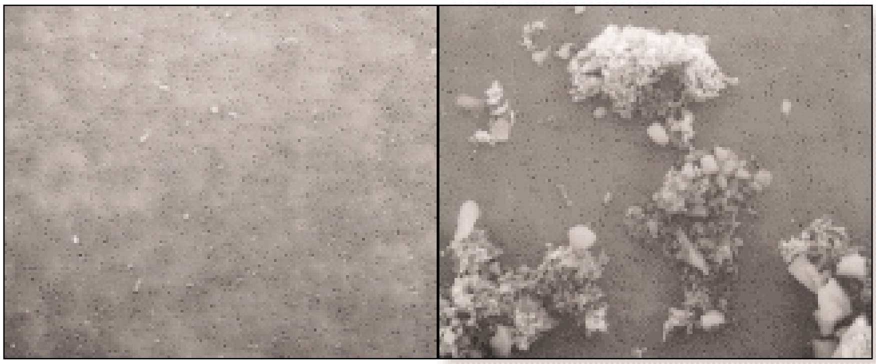
Table 1. Classification of air filters according to the proposed revised EN 779:2001. The new proposal will use the average efficiency for 0.4 µm particles, instead of the average dust spot efficiency.

CLASSIFICATION

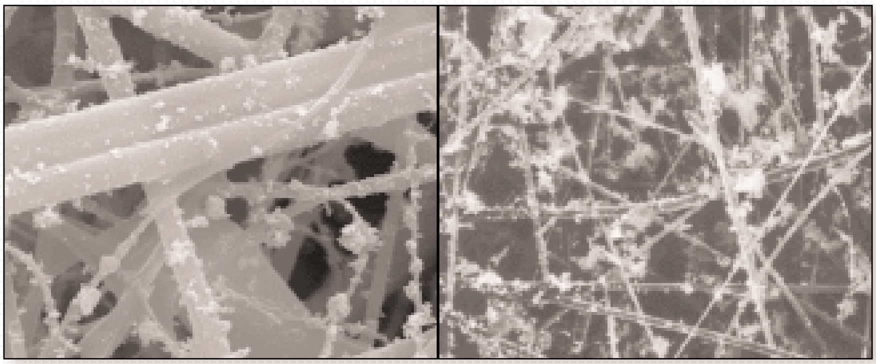
The former EN 779:1993 system, comprising groups F and G filters, has been retained, but classification is now determined from the average filtration efficiency with respect to particles 0.4 µm in diameter. Classification of F filters is based on performance with respect to 0.4mm particles because of practical evidence that EN 779:1993 classification based on the “dust-spot” opacity test would be very closely matched and the former classification system could be kept. Filters found to have an average efficiency value of less then 40% will be allocated to group G. The classification of G filters is based on the average arrestance of the loading dust. See Table 1.

Filters are classified according to their efficiency (arrestance) under the following test conditions:

- an air flow of 0.944 m^3/s (3400 m^3/h), if the manufacturer does not specify an air flow rate;
- a maximum final pressure drop of 250Pa for Coarse (G) filters;
- a maximum final pressure drop of 450Pa for Fine (F) filters.



The same magnification of atmospheric dust and ASHRAE loading dust collected on a membrane. Very few atmospheric particles are larger than 1 µm, while very few synthetic dust particles are smaller than 1 µm. The ASHRAE test dust typically shows “road dust”(silica particles) and the agglomerates of carbon black.



Collected outdoor particles on filter fibres. The distance between fibres are much larger than the size of the particles. For the coarse laboratory dust the fibers will act as a sieve, but for outdoor particles the filtration depends on diffusion and interception effects

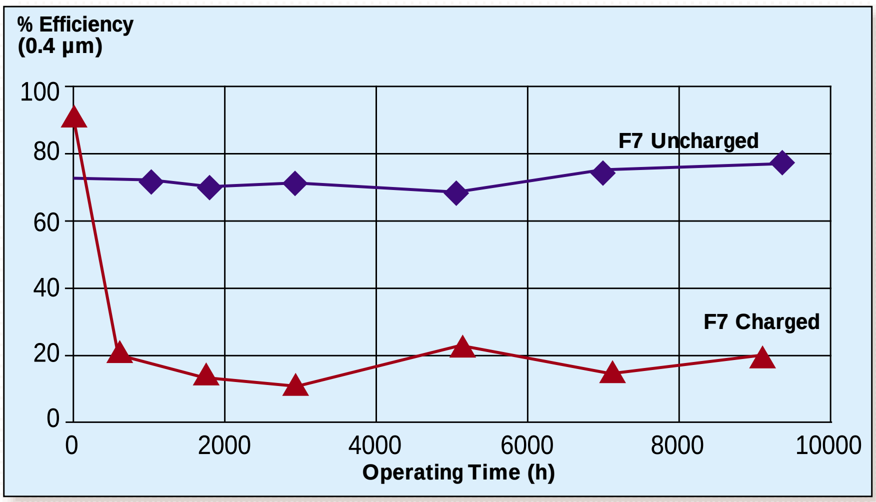
CLASSIFICATION PROBLEMS

Classification is 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. Moreover, the dust-holding capacity and average efficiency for each classification vary with the final pressure loss and air flow.

To save energy, the filter is dimensioned with a much lower final pressure loss than the one used for classification. For hygiene reasons, the filter is also replaced after a certain period of time and not when a specific final pressure loss is reached. The filter does not achieve the intended filter class in real life.

It is important to be aware of a filter's performance properties in different environments. As a filter accumulates dust, the pressure loss increases and the collected dust improves the normal separation efficiency. The opposite effect can be seen with electrostatically charged filter material.

During operation, the impurities neutralise the material and the filter's capacity to separate is reduced. There are examples when efficiency drops from 90-20% in a couple of weeks. This is the reason why the efficiency of discharged efficiency should be reported. The proposed revised EN 779 provides techniques for identifying the importance of the electrostatic removal mechanism by testing the efficiency of discharged filter material.



Example of efficiency changes in an installation with two F7 air filters. One filter maintains almost the same efficiency during the year, while the filter with electrostatically charged material drops quickly after a few weeks.

LOADING DUST

The reason for the difference in real life and laboratory is the ASHRAE test dust used for testing filters. The dust is a mixture of fine test dust, cotton linters and carbon black. This dust has been used for 30 years and many filters have been developed to meet the standard and not real-life performance.

SUMMARY

In the proposed revision of EN 779 , the efficiency and classification of a filter would be measured on normal filters without any treatment. The classification will be based on the average efficiency on 0.4µm particles. The discharged or neutralised efficiency of filter material would also be tested and reported to give an indication of a filter's performance in real conditions with normal outdoor air.

A yes for the revised EN779 will bring air filter testing into the 21st century and meet today's IAQ requirements of a good ventilation system and removing the contaminants.

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