The impact of synthetic aerosol type on the performance of general ventilation air filters

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The impact of synthetic aerosol type on the performance of general ventilation air filters

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Synthetic aerosol generation

The most recent method for assessing the performance of air filters for general ventilation (ISO 16890) uses two types of synthetic test aerosols: a liquid one made of diethylhexyl sebacate (DEHS) particles and a solid one formed by potassium chloride (KCl) crystals. The generation of these synthetic aerosols is carried out using different methods which cause their particle charge distributions to be different.

KCl aerosol generation

The solid aerosol is generated using a KCl aqueous solution. The solution is atomized, and the resulting droplets dried by means of hot dry air. The KCl particles obtained in this way are highly electrically charged, and their electric charge distribution is different from the Boltzmann distribution. The charge distribution of the aerosol challenging the test filter influences the efficiency for each particle size measured. For this reason, ISO 16890 prescribes the use of a neutralizer to bring the charge distribution of the synthetic aerosol to the Boltzmann one.

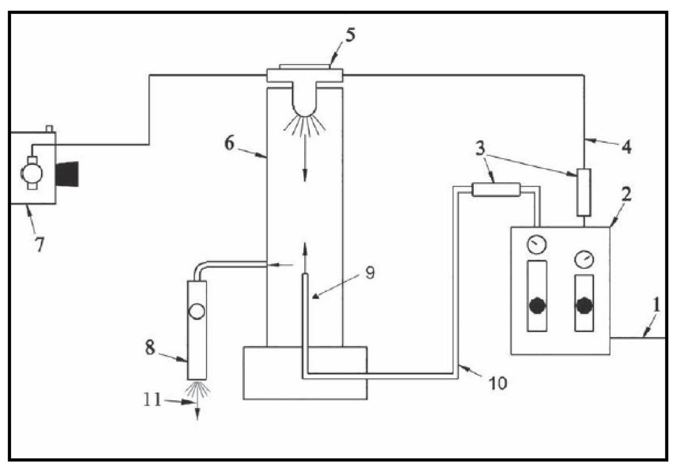

Figure 1. Schematic diagram of the solid phase aerosol particle generator system.

Key

1. Clean dry compressed air source
2. Air control panel (includes rotameters, inlet pressure gauge and needle valves for flow control)
3. HEPA filters
4. Atomizing air feed (adjustable, normally 0.5 dm^3/s)
5. Air atomizing nozzle
6. Spray tower, 305 mm ID, 1300 mm tall
7. Pump supplying solution of KCl in water (typical feed rate 0.02 cm^3/s)
9. Aerosol neutralization system (corona-discharge neutralizer)
10. Drying air (1.9 dm^3/s flow)
11. Aerosol outlet tube leading to test duct (38mm ID; can be located on the bottom of the spray tower)

DEHS aerosol generation

DEHS aerosol is generated using a Laskin nozzle. The liquid particles obtained in this way have almost no electric charges on them, but the particle charge distribution is different from the Boltzmann one.

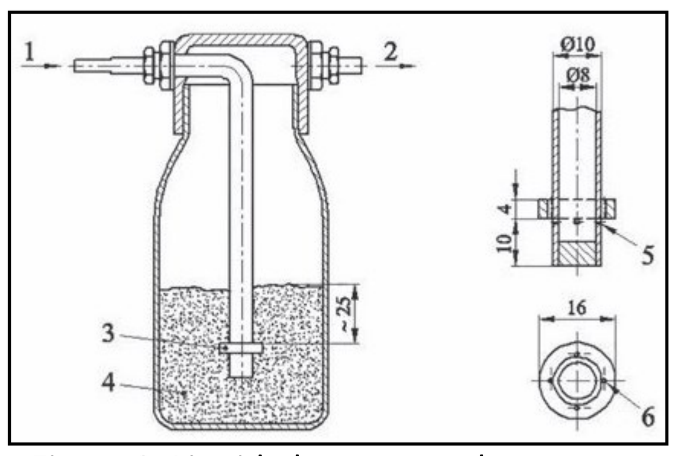

Figure 2. Liquid phase aerosol generator (dimensions in milimeters).

Key

1. Particle free air (pressure about 17 kPa)
2. Aerosol outlet to test rig
3. Laskin nozzle
4. Liquid for aerosol
5. Four Ø 1.0 mm holes 90° apart with top edge of holes just touching the bottom of the collar
6. Four Ø 2.0 mm holes next to tube, in line with the Ø 1.0 mm holes (key 5)

Electrostatic charge on manufactured general ventilation filters

The fibrous media used to manufacture general ventilation filters may or may not possess electrostatic charges on their fibers. In case the filter medium is charged, any different electric charge distributions on the synthetic aerosols produces different results. To determine the minimum fractional efficiency of the air filter, it is necessary remove the electrostatic charge by a neutralization process exposing the test filter to vapors of isopropyl alcohol (IPA) for 24 hours.

Devices tested and experimental procedure

We tested two types of filters to determine the influence of the electrostatic charge on the fibers on the fractional efficiency with the two synthetic aerosols described above. The experimental procedure consisted of: 1) determination of the initial fractional efficiency, 2) exposure to IPA vapor for 24 hours per the ISO 16890 procedure to remove the electrostatic charges on the fibers, 3) determination of the discharged fractional efficiency. The above procedure was applied to both filters of the same form without any significant difference.

Filter device tested with electrostatic charge

Pocket filter with ten pockets. White synthetic filter media. The dimensions of the air filter are: 592 x 592 x 640 mm. The air filter's initial mass is equal to 3091.5 g.

Filter device tested with electrostatic charge

Compact filter with three Vs, each V has two panels and each panel has 149 small pleats. White fiberglass filter media. The dimensions of the air filter are: 592 x 592 x 292 mm. The air filter's initial mass is equal to 5137.2 g.

Figure 3. Pocket filter tested made up of synthetic material.

Figure 4. Compact filter tested made up of fiber glass.

Results

As shown in Figure 5, when the filter medium is charged, the fractional efficiency measured with the KCl aerosol is higher than the one measured with the DEHS aerosol. The smaller the particle size, the larger the difference between the data provided by the two test aerosols. This behavior agrees with filtration theory [2], because particles with diameters below 1000 nm are more strongly affected by electric forces than larger particles.

On the other hand, a filter made with fibrous media without electrostatic charges on it does not show any significant difference between the fractional efficiency curves obtained with KCl and DEHS aerosols, as shown in Figure 6.

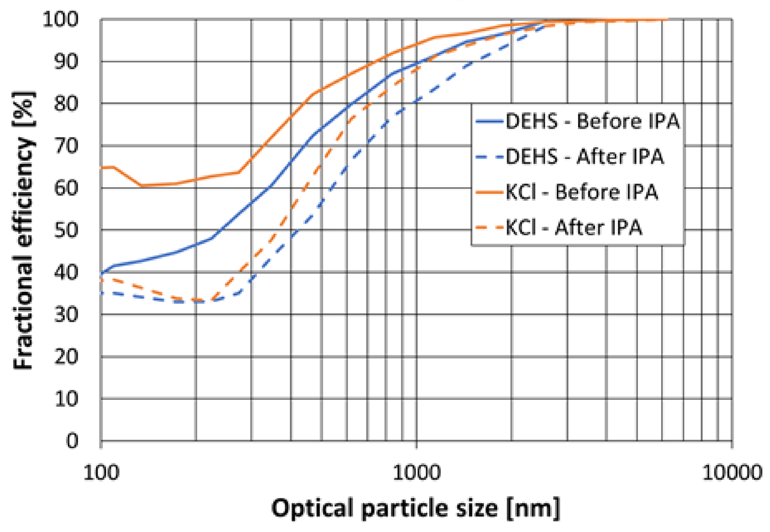

Figure 5. Fractional efficiency of a pocket filter made up of charged fibrous material tested at 3400 m^3/h.

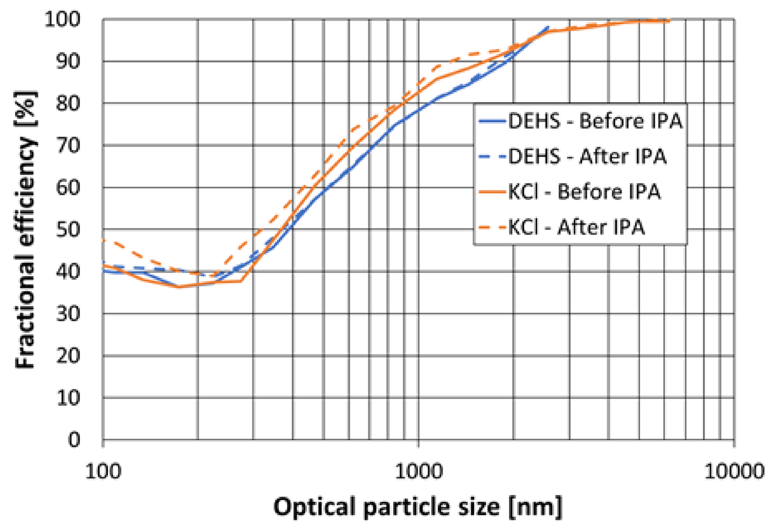

Figure 6. Fractional efficiency of compact filter made up of non-charged fibrous material tested at 3400 m^3/h.

As show in Figure 5 and Figure 6, after the neutralization process, the efficiency values decreased in filter made up of synthetic material as expected, but it is important to note that the two synthetic aerosols can provide similar data only in case the filter media is discharged or was never intentionally charged.

Facilities used to perform the measurements

Figure 7. Conditioning cabinet.

Figure 8. KCl aerosol generator.

Figure 9. DEHS aerosol generator

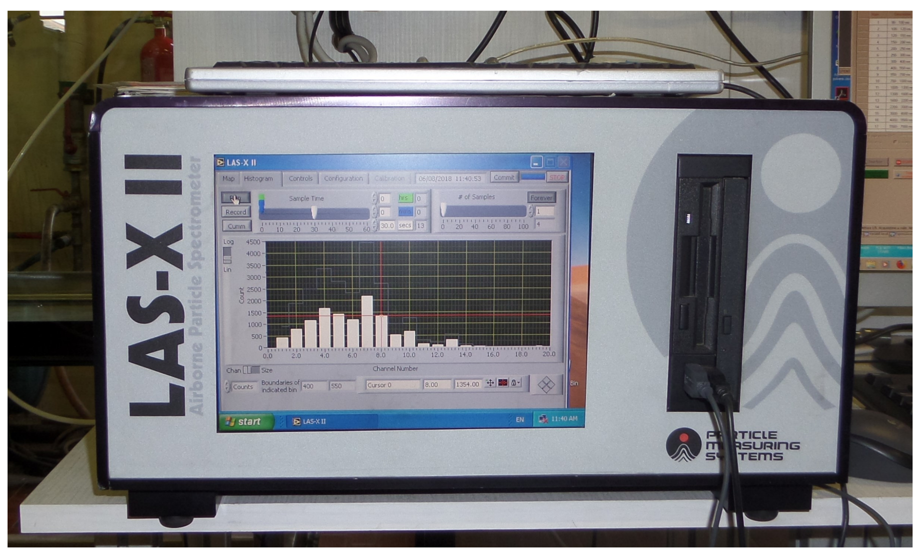

Figure 10. Particle spectrometer.

Practical interest

ISO 16890 adopts DEHS as the reference aerosol between 0.3 and 1 µm, while KCl is the reference aerosol between 1 and 10 µm, to show the effects of aerosol adhesion. DEHS and KCl may be used along the whole size range of the test method (0.3-10 µm) if the laboratory demonstrates on a reference test filter that the fractional efficiency values measured with both aerosols do not differ by more than two percentage points. Therefore, if this requirement were verified on a reference test filter without electrostatic charge, then KCl would be used to measure the efficiency of a filter with electrostatic charge, inconsistent data would be obtained in the determination of the fractional efficiency for the smallest particle size ranges. Laboratories using DEHS between 0.3 and 1 µm and laboratories using KCl in the same size range would then obtain different data. However, they could both claim that the results are valid according to ISO 16890.

References

1) ISO 16890 (all parts), *Air filters for general ventilation.*

2) R.C. Brown. Air Filtration. An Integrated Approach to the Theory and Applications of Fibrous Filters. Pergamon. 1st Edition. 1993.

Acknowledgment

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