Effect of Electronic Ionisation filters on viruses and bacteria

Introduction

The scope of this paper is to compare the most effective solution in the present state-of-the-art in air handling and contamination control technology.

According to the World Health Organization, the most prevalent transmissible diseases in the world are respiratory infections. (Household-air-pollution-and-health, 2018). This article of the World Health Organization WHO of May 2018 describes in details various issues related to household respiratory diseases: https://www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health

These infections may be transmitted from bacteria or viruses to indoor environments in different ways: direct or indirect contact with an infected surface, droplet transmission, airborne transmission through air conditioning equipment or by the vigorous air movements. Air suspended particles can carry microorganism like bacteria and viruses. Improper installation of filters or wrong type of filters used and lack of maintenance can accelerate growth of both micro organisms and endotoxins in filters. Mechanical filters usually serve as incubators for these micro organisms and if not properly maintained and regularly replaced can spread the contamination downstream to all the environments being supplied by the air flow.

Comparison between filtering solutions

The efficiency of the filter depends on the filtering material (filter media) used and the respective degree of cleanliness. This makes efficiency a variable factor. As the filter material gets clogged up the air flow passing through the filter decreases as the pressure drop across the filter increases.

The mechanical filter is a dense mesh that has been designed to capture particles of sizes related to the filtering media by intercepting and capturing by inertia impacting by diffusion and by sieve effect. Due to this continuous capturing process, the quantity of handled air decreases over time, as the filters become clogged resulting in an increase in pressure drop and energy consumption.

The mechanical (paper) filters need a very accurate and precise scheduled replacement procedures to avoid contamination. As mentioned above, in the worst case scenario, mechanical filters act as a culture medium for cultivating microbes. Toxic microbial metabolites can pass through the filter, consequently the escaping air is contaminated, and the result could be lethal.

High Efficiency Particulate Absorption (HEPA) filters are widely used to remove airborne particles of biological origin (i.e. bioaerosols) in many indoor environments, including healthcare facilities and hospitals, hotels and hospitality, schools, shops and offices buildings, aircraft cabins etc. However, the implementation of HEPA filtration results in high operational costs due to the need for regular filter replacement and additional increased power consumption due to the high pressure drop across the filtering material. This type of filter is also a perfect habitat for both viruses and bacteria.

Electronic filtration, also known as Electro Static Precipitation(ESP) such as PureAIre system is an extremely efficient technology that uses high voltage and ionization fields to capture particles from the air flow. ESP creates electric fields and electrostatic forces that are applied directly onto particles and microorganisms present in the air.

The filtration operation in the ESP device works in two phases:

- the conferring of an electric charge to particles and micro organisms carried in the air
- the electrostatic precipitation of charged particles/micro organisms

The PureAire system electrostatic filter is therefore built with two separate sections:

- an ionizing section
- a collection/precipitation section

In the first phase particles' and micro organisms' (i.e. bacteria, spores, yeasts) charging takes place in the ionisation section through electrodes generating a positive or negative corona discharge. In the second phase, the electrostatic precipitation of the previously charged particles and microbes, occurs in the collection section, on a set of parallel electrically charged collecting plates. The electric field generated between these plates captures the particles and traps them on the collection plate's surface. The contact with the plates causes the immediate destruction of any micro-organism and avoids the release of endotoxins when bacteria are lysed as happens with mechanical filters.

The main advantages of the PureAire system Electrostatic Precipitators are the followings:

- can collect particles from 0.01 µm to 100 µm and up to 99% efficiency
- operate at high flow rates, up to 3,000,000 cfm (1,400 m^3/s)
- operate at high particle loadings, 500 grams/m^3
- have low energy costs, 16 - 100 Watts/1000 m^3/h
- have very low pressure drop
- are almost zero maintenance
- environmentally friendly as there are no filters to throw away/recycle

PureAire system electrostatic filtration technologies also have specific advantages when applied to the air decontamination of critical areas in nosocomial environments where airborne diseases are aften spread. The efficiency of air filtration is high enough to collect particles of any size, including ultrafine particles. The destruction of microbes is thus managed effectively and the system is also able to remove Volatile Organic Compounds (VOCs).

The efficiency of PureAire system ESP technology in mitigating biological aerosols has been demonstrated* using both bacterial endospores and various bacterial species. This technology destroys the microorganisms transported by air flows before they risk becoming contaminants for humans. ESP is considered for this reason as an "active kill filtration". As it does not allow microbes, fungi or spores to vegetate and flourish on the filter's surface while also preventing the emission of substances in the environment arising from metabolism and destruction of the captured microbiological flora.

*PureAire FE system has been tested and accredited by a number of air hygiene institutes including ILF Berlin.

Although certain HEPA filters are also able to capture virus size particles it is worth noting that any organic material that is captured, can remain active in the filter. The use of this type of filter in buildings with centralised ventilation systems can cause “Sick Building syndrome”. However, ESPs can protect the indoor environment without filter replacement issues and without associated pressure drop concerns for rooms with classification equal or above ISO7. UV irradiation can inactivate virus and bacteria in steady conditions since the process needs time based on the intensity, that usually requires from minutes to hours to reach the lethal dose at 99%. Consequently, UV lamps are not suitable for air purification inside air handling units since the time at which the air flow and the airborne particles are exposed to the UV radiation is minimal (fraction of seconds) compared with the time needed to inactivate the microorganisms.

The capture and inactivation of airborne viruses by an electrostatic particle collector have been studied in several occasions. Here below few interesting articles:

(Department of Energy, n.d.) https://www.ncbi.nlm.nih.gov/pubmed/19731701

(Ayse Fidan Altun, n.d.) https://www.e3s-conferences.org/articles/e3sconf/pdf/2019/37/e3sconf_clima2019_02020.pdf

(Journal of applied microbiology, n.d.) https://sfamjournals.onlinelibrary.wiley.com/doi/full/10.1111/jam.14278

(Park, n.d.) http://large.stanford.edu/courses/2017/ph240/park2/

Conclusion

From the literature and from lab testing it is evident that the effect of the PureAire system active electrostatic filters against airborne viruses has been established, in addition to the hygienic and antibacterial effect as certified by the Institute of Air Hygiene of Berlin (ILH): 98-99% of bacteria present in the air are eliminated by the PureAire System active electronic filters.

As a final note, considering the size of the viruses, they fall within the field of abatement of the active electrostatic filters, as per UNI EN ISO 16890 certification. Airborne viruses are therefore captured and inactivated by active electrostatic filters.

Bibliography

Ayse Fidan Altun, M. K. (n.d.). *Web Conference*. Retrieved from Clima 2019: https://www.e3sconferences.org/articles/e3sconf/pdf/2019/37/e3sconf_clima2019_02020.pdf

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Journal of applied microbiology. (n.d.). Retrieved from SFAM:

https://sfamjournals.onlinelibrary.wiley.com/doi/full/10.1111/jam.14278

Park, S. (n.d.). *Electrostatic Precipitator: An Electric Air Filter*. Retrieved from Stanford University:

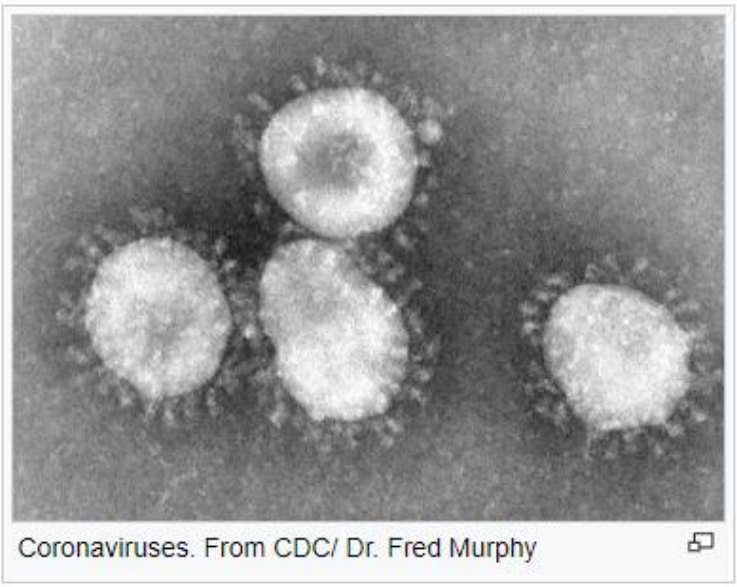
http://large.stanford.edu/courses/2017/ph240/park2/

PureAire system & Corona viruses

Evergen's PureAire system is proven to capture up to 99.5% of sub micron size particles.

An identifiable trait of Coronaviruses is the club-shaped spikes, resembling solar Coronas, that project from their cell membrane. The nucleocapsid of Coronaviruses has a helical shape, which is uncommon for positive-sense RNA viruses.

The virion shape of Covid19 Corona virus is spherical, with an average size of 125 nm.



Coronaviruses. From CDC/ Dr. Fred Murphy

Species *Human coronavirus*, *SARS coronavirus*, *Bovine coronavirus*, *Canine coronavirus*

https://microbewiki.kenyon.edu/index.php/Coronavirus

Thanks to its high collection efficiency of submicronic particles and also due to its strong electro static field force, the Ionisation field of PureAire system has an elevated antibacterial power. As can be seen below in Test A the concentration of bacteria commonly present in ambient air has been measured before the Ionisation purifier is turned on. Test B shows how the concentration of bacteria and moulds in the air are significantly reduced when the ambient air is passed through the PureAIre System Active Ionisation air purifier.

Bacterial colonies growing on a plate exposed to the air.

Unpurified air | Purified air