Electrostatic filters effects against viruses and bacteria

Introduction

The scope of this paper is to describe the proper solution in compliance with the present state of 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 air particles can carry microorganism like bacteria and viruses. Improper filtration methods like wrong type of filters or lack of maintenance can generate the growth of both microorganisms and sometimes endotoxins in filters. Mechanical filters usually serve as incubators for these microorganisms 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 used and the respective degree of cleanliness. This makes efficiency a variable factor. As the filter grows dirty, the air flow passing through the filter decreases since the pressure drop increases.

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

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

High-efficiency-particulate-air (HEPA) filtration can be used to remove airborne particles of biological origin (i.e., bioaerosols) in many indoor environments, including hospitals, office buildings, and aircraft cabins. However, the implementation of HEPA filtration bears excessive operational costs because of regular filter replacement and additional power requirements for air recirculation due to a high pressure drop across the filtering material. Although it is always installed after pre-filtering systems, this kind of filter could become a perfect habitat for both viruses and bacteria.

Electrostatic filtration is a well-known technology that uses high voltage and ionization fields to capture particles from the air flow, aka electrostatic precipitators (ESP).

ESPs bases its functioning on electric fields and electrostatic forces applied directly on particles and on microorganisms present in the air.

The filtration operation in the device develops in two phases:

- the conferring of an electric charge to particles and microorganisms carried by the air
- the electrostatic precipitation of charged particles/microorganisms.

The electrostatic filter is therefore built with two separate sections:

- an ionizing section
- a collection/precipitation section.

In the first phase particles' and microorganisms' (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 Electrostatic Precipitators (ESPs) are the followings:

- collect particles from 0.01 µm to 100 µm up to 99% efficiency
- operate at high flow rates, up to 3,000,000 cfm (1400 m3/s)
- operate at high particle loadings, 500 grams/m3
- have low energy costs, 16 - 100 Watts/1000 m3/h
- have very low pressure drop

The electrostatic filtration technologies also show 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 usefulness of 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 human being. 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.

HEPA filtration is also able to capture virus particles and it is *essential* to handle classified environments below ISO7 as a final filtering system. 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 active electrostatic filters against viruses that move in the particles airborne in air has been ascertained, 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 active electronic filters of Expansion Electronic.

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

Bibliography

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