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A Review on Development and theory of Hepa Filter

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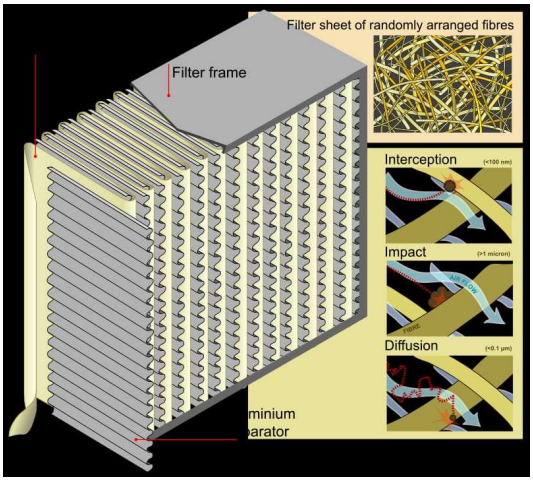
Abstract

The High Efficiency Particulate Air (HEPA) filter has become an essential component of biological safety monitoring, as well as a means of protecting cultures from airborne contamination. The HEPA filter was developed to guard against chemical, biological, and radioactive warfare agents, as well as to prevent emissions from nuclear weapons manufacturing plants. During WWII and for several years afterward, everything concerning these filters wa s classified as "secret." Many novel uses in pharmaceutical, microelectronic manufacturing, and pharmaceutical manufacturing were identified after the y were categorised and commercial production began. The importance of a thorough understanding of these filters prompted research and development efforts that helped to create the science of air filtration on a sound theoretical foundation.achieved substantial advancements in construction materials a nd production systems The tale of their creation and evolution is fascinating in and of itself, and it aids our comprehension of their capabilities and limit ations.

Keyword : HEPA filter, Test, particle, asbestos.

Introduction

The Atomic Energy Commission's (USAEC) 1952 handbook on Air Cleaning offers twhe initial descriptions of recently unclassified highefficiency filt ers. It was fashioned of "CC6 paper," which was initially designed for use in gas masks by Chemical Corps. Microasbestos fibres are combined with co arse cellulose fibres to offer mechanical strength and serve as an asbestos basis. Filtering celluloseasbestos paper is primarily done with asbestos mesh,



which isn't readily available. The Army Chemical Corps received a sheet of paper from the British Army that was a long way from a box of confiscated German gas masks in the early days of WWII, and this filter was born. Bolivian crocidolite asbestos is mixed with cellulose pulp in Navy paper.African crocidolite asbestos and esparto grass pulp are used in the Army version (CWS).Mechanical blowing can shrink the diameter of long elastic fibres in Be stos to less than 0.25 mm. Protection from war agents was also essential in operational headquarters, where wearing a private gas mask was impractical. For these conditions, the Military Chemical Corps developed the "collective protector," a mechanical blower and air purification unit. The service gas masks were built in a deepplated shape with spacers between the plates to keep them separate and operate as air passageways, including the celluloseas bestos paper utilised, because of the relatively substantial air flow required. It was the precursor of the now-

famous air cleaner, thanks to the highefficiency Particulate Air (HEPA) filter (Figure). Itwas dubbed the "absolute" filter at the time. AEC No.1 was the designation for the nuclear version of the absolute Filter.It had a design efficiency of 99.9% for all particles with a diameter of less than 0.1 mm. House hold fibres such as kraft paper, viscose, and even coarse glass were found to be viable replacements for esparto to lessen reliance on imported materials, but the Naval Research Laboratory discovered no means to create glass fibres as small as 0.25 mm diameter, that home option is accessible. Then allgla ssfextinguishingadhesive for attaching the (a) fireproof plywood filter frames, (b) aluminum corrugated separator, and (c) filter pack to the filter frame (1).

HISTORY OF HEPA FILTER

Gas masks worn by soldiers fighting in World War II inspired the HEPA filter. A sheet of paper found in a German gas mask collected chemical smoke with surprising effectiveness. It was cloned and massproduced by the British Army Chemical Corps for use in their own duty gas masks. Individual gas masks were not practical at operating headquarters, therefore they had to come up with a different solution. The Army Chemical Corps developed cellul oseasbestos paper that was deeply pleated and had spacers between the pleats for use in mechanical blowers and air purifiers. It was labelled a "absolut" air filter, and it laid the groundwork for further research into the technology's refinement.come in developing the HEPA filter.(2)

DEVELOPMENT OF HEPA FILTER TEST METHOD

Langmuir's theory had a profound effect on US filter technology, and between 1942-1945 Lamar and Sinclair developed a direct filter test that used aerosols containing dioctyl phthalate (DOP) drops. This has become the US standard method of ultra-high efficiency, or perfect, filters not used for bench testing. Duringthe initial installation of HEPA filters at the Oak Ridge National Laboratory's graphite reactor in 1950, it was discovered that HEPA filters did not achieve full performance due to damage and faulty installation during shipment.As a result, in-place testing of all filters has become commonplace with methods introduced and developed at ORNL. These tests are performed from time to time before and after the new facility is launched.(3)

AIR FILTRATION THEORY

INTERCEPTION

A block occurs when a particle following a gas streamline reaches a particle radius of a filter fiber. The particle touches and catches the fiber, thus keeping it away from the air flow.

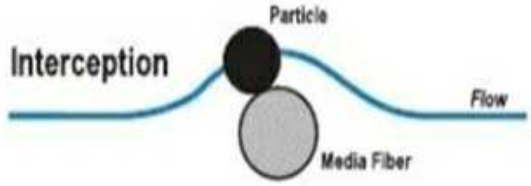


Figure: Direct Interception of a Particle

For a given particle size, there are some streamlines that can be close enough to the filter fiber to capture the particles. No more than one particle radius away from the filter fiber will contribute to the streamline interception mechanism.

INERTIAL IMPACTION

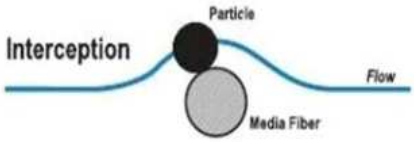


Figure: Inertial Impaction

Inertial impaction occurs when a particle is so large that it's unable to quickly suit the abrupt changes in streamline direction near a filter fiber. The particle, thanks to its inertia, will continue along its original path and hit the filter fiber. This type of filtration mechanism is most predominant when high gas velocities and dense fiber packing of the filter media is present. Figure 2 below illustrates this mechanism.

DIFFUSION

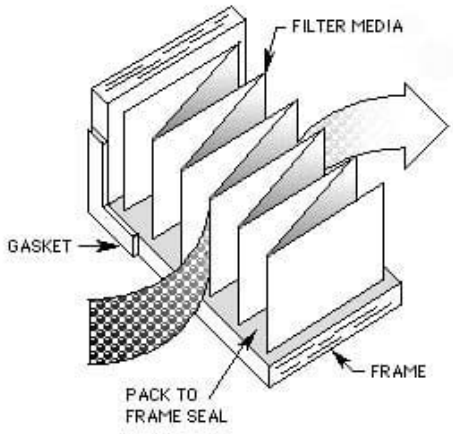
We had to quickly review the kinetic theory of gaseous gases in order to understand the diffusion method of particle capture. This theory states that air i s made up of a huge number of microscopic molecules that act like sharp spheres travelling in a straight path without clashing with each other when co mpared to their distances. In fact, these molecules collide so frequently that they travel in a zigzagging pattern. Brownian movement is the name given t o this random movement. The Brownian movement of the gas molecule causes the particle retention diffusion mechanism. Small particles with a diame ter of 0.1 m or less interact with zigzagging gas to cause random movements.Gas molecules These tiny particles collide with gas molecules, causing them to move randomly, colliding with other particles. Low air velocity and diffusion with small particles. The smaller the particle, and therefore the lower the flow, the longer it needs to be zigzagged, giving it a better chance of colliding and sticking to the filter fiber.

Figure 3: Brownian Diffusion

Particles travel through the flow, they collide with the fibers and collect(4)..

CONSTRUCTION OF HEPA FILTER

Although the construction of HEPA filters can vary greatly, most HEPA filters have a rigid frame in which a filter pack, a continuous sheet of media, is sealed by folding it into closely spaced plates. Traditional HEPA media is an all-glass paper made up of a very large number of randomly oriented micro-fibers that use some very complex mechanical principles to achieve efficacy on sub-micron particles .



In order to seal the filter pack in the frame, it is necessary to seal the filter when it is installed in the device to prevent air flow and sub-micron particles from bypassing the HEPA filter.Manufacturers of fillets, filter manufacturers have developed various methods and materials to accomplish this. The use of closed cell neoprene gaskets is probably the most common method of sealing a HEPA filter installation.Many different HEPA filter features and standards have been written for the numerous applications in which HEPA filters are used. Seismic capabilities for nuclear use, from UL-586 to ASME AG-1, with environmental testing, have all been developed to ensure the suitability of filters for specific uses.(5)

FILTER TESTING

BENCH TESTING OF NEW FILTERS

The bench test of new HEPA filters certified for biosafety service in accordance with NSF standard 49.(6). is performed by a penetrometer, called Q107, designed in the 1950s(7).aerosol U.S. It was done by Army Chemical Corps.The entire penetrometer includes a mono disperse dap aerosol generator, a device that measures the dimensions and uniformity of the particles formed, a clamping device for sealing the filter under test in a test rig, a forward light scattering photometer for measuring dap penetration, and a manometer for measuring filter resistance at a rated airflow rate.The size of DAP aerosol is 300 m. Certified HEPA filters for biosafety applications will have test efficiency and filter resistance values marked on one side of the filter frame(8).

SEARCHING FOR DEFECTS

The detailed examination that is undertaken to meet in-place acceptance criteria for biosafety cabinets is called filter scanning.This is done by routinely creating an aerosol challenge and then passing the probe of the live-reading light-scattering photometer in overlapping strokes across the entire face of the filter (taking care to include all gasket edges and housing joints). Detection of faults in the installed system is made easier by the use of direct reading aerosol detection devices because when the probe is located right in front of the leak it enters the unfiltered aerosol and the indicator scale closes. This is a boring, but very sensitive method of detecting even the slightest leak, such as a thin stain on paper(8).

APPLICATION

VACUUM CLEANERS

Figure: Air Filter for Vacuum Cleaner

Many vacuum cleaners also use HEPA filters as part of their filtration system. This is beneficial for asthma and allergy sufferers, as HEPA filters trap microscopic particles (such as pollen and dust mite feces that trigger allergy and asthma symptoms).For the HEPA filter in a vacuum cleaner to be effective, the vacuum cleaner must be designed so that all the air drawn into the machine is expelled through the filter, no air escaping from it. This is often referred to as "sealed HEPA" or sometimes "true HEPA". Vacuum cleaners are simply labeled "HEPA", they may have HEPA filters, but not all air passes through them. Finally, vacuum cleaner filters marketed as "HEPA-like" will typically use construction filters similar to HEPA, but without filtering functionality. Due to the extra density of true HEPA filters, HEPA vacuum cleaners require more powerful motors to provide adequate cleaning power.

Some newer models claim to be better than previous models with the inclusion of "washable" filters.In general, washable true HEPA filters are expensive. High-quality HEPA filter that can trap 99.97% dust particles of 0.3 micron diameter. For comparison, human hair is about 50 to 150 microns in diameter. So, a true HEPA filter effectively traps particles many times the width of human hair(9).

CONCLUSION

HEPA is good at removing larger particulate matter like pet dander, pollen, and dust mites. If you are looking for a technology that is effective at particulate removal, without emitting byproducts or other dangerous chemicals into the air than the HEPA technology is your best bet.

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