HEPA

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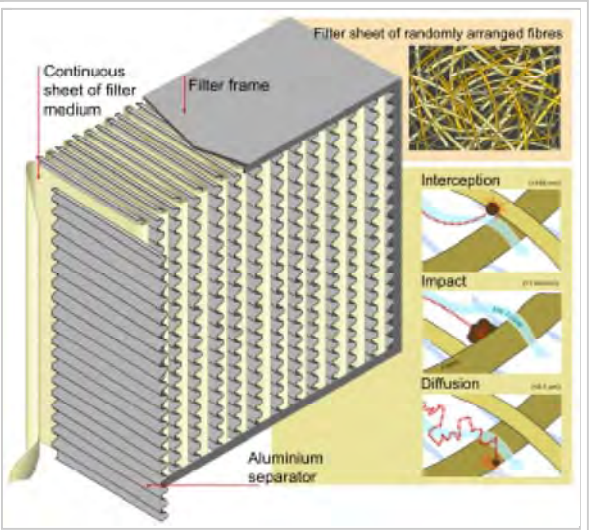
High-efficiency particulate arrestance (**HEPA**),[1][2] also sometimes called **high-efficiency particulate arresting** or **high-efficiency particulate air**, is a type of air filter. Filters meeting the HEPA standard have many applications, including use in medical facilities, automobiles, aircraft and homes. The filter must satisfy certain standards of efficiency such as those set by the United States Department of Energy (DOE).

To qualify as HEPA by US government standards, an air filter must remove (from the air that passes through) 99.97% of particles that have a size of 0.3 µm.[3]

HEPA was commercialized in the 1950s, and the original term became a registered trademark and later a generic term for highly efficient filters.[4]



HEPA filter with functional description

Contents

Function

HEPA filters are composed of a mat of randomly arranged fibres.[5] The fibres are typically composed of fiberglass and possess diameters between 0.5 and 2.0 micrometers. Key factors affecting its functions are fibre diameter, filter thickness, and face velocity. The air space between HEPA filter fibres is typically much greater than 0.3 µm. The common assumption that a HEPA filter acts like a sieve where particles smaller

than the largest opening can pass through is incorrect and impractical. Unlike membrane filters at this pore size, where particles as wide as the largest opening or distance between fibres can not pass in between them at all, HEPA filters are designed to target much smaller pollutants and particles. These particles are trapped (they stick to a fibre) through a combination of the following three mechanisms:

Interception
: where particles following a line of flow in the air stream come within one radius of a fibre and adhere to it.

Impaction
: where larger particles are unable to avoid fibres by following the curving contours of the air stream and are forced to embed in one of them directly; this effect increases with diminishing fibre separation and higher air flow velocity.

Diffusion
: an enhancing mechanism that is a result of the collision with gas molecules by the smallest particles, especially those below 0.1 μm in diameter, which are thereby impeded and delayed in their path through the filter; this behaviour is similar to Brownian motion and raises the probability that a particle will be stopped by either of the two mechanisms above; this mechanism becomes dominant at lower air flow velocities.

Diffusion predominates below the 0.1 μm diameter particle size. Impaction and interception predominate above 0.4 μm. In between, near the most penetrating particle size (MPPS) 0.3 μm, both diffusion and interception are comparatively inefficient. Because this is the weakest point in the filter's performance, the HEPA specifications use the retention of these particles to classify the filter.[6]

Lastly, it is important to note that HEPA filters are designed to arrest very fine particles effectively, but they do not filter out gasses and odor molecules. Circumstances requiring filtration of volatile organic compounds, chemical vapors, cigarette, pet, and/or flatulence odors call for the use of an activated carbon (charcoal) or other type of filter instead of or in addition to a HEPA filter.[7]

Specifications

HEPA filters, as defined by the United States Department of Energy (DOE) standard adopted by most American industries, remove at least 99.97% of airborne particles 0.3 micrometers (μm) in diameter. The filter's minimal resistance to airflow, or pressure drop, is usually specified around 300 pascals (0.044 psi) at its nominal flow rate.

A portable HEPA filtration unit used to clean air after a fire, or during manufacturing processes.

The specification usually used in the European Union is the European Norm EN 1822:2009. It defines several classes of HEPA filters by their retention at the given most penetrating particle size (MPPS):

HEPA class	retention (total)	retention (local)
E10	> 85%	---
E11	> 95%	---
E12	> 99.5%	---
H13	> 99.95%	> 99.75%
H14	> 99.995%	> 99.975%
U15	> 99.9995%	> 99.9975%
U16	> 99.99995%	> 99.99975%
U17	> 99.999995%	> 99.9999%

Today, a HEPA filter rating is applicable to any highly efficient air filter that can attain the same filter efficiency performance standards as a minimum and is equivalent to the more recent NIOSH N100 rating for respirator filters. The United States Department of Energy (DOE) has specific requirements for HEPA filters in DOE regulated applications. In addition, companies have begun using a marketing term known as "True HEPA" to give consumers assurance that their air filters are indeed certified to meet the HEPA standard.[8]

Products that claim to be "HEPA-type", "HEPA-like", "HEPA-style" or "99% HEPA" do not satisfy these requirements and may not have been tested in independent laboratories. Some of these sub-par quality filters may come reasonably close to HEPA filtration, while others will fall significantly short, making them truly inferior.[9]

Safety

HEPA filtration works by mechanical means unlike the Ionic and Ozone filtration which use negative ions and ozone gas respectively. So, the chances of potential pulmonary side-effects like asthma[10] and allergies is a much lower with HEPA purifiers.[11]

Biomedical applications

HEPA filters are critical in the prevention of the spread of airborne bacterial and viral organisms and, therefore, infection. Typically, medical-use HEPA filtration systems also incorporate high-energy ultra-violet light units to kill off the live bacteria and viruses trapped by the filter media. Some of the best-rated HEPA units have an efficiency rating of 99.995%, which assures a very high level of protection against airborne disease transmission.

Vacuum cleaners

Many vacuum cleaners also use HEPA filters as part of their filtration systems. This is beneficial for asthma and allergy sufferers, because the HEPA filter traps the fine particles (such as pollen and dust mite feces) which trigger allergy and asthma symptoms. For a 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, with none of the air leaking past it. This is often referred to as "Sealed HEPA" or sometimes the more vague "True HEPA". Vacuum cleaners simply labeled "HEPA" may have a HEPA filter, but not all air necessarily

HEPA original filter for Philips FC87xx-series vacuum cleaners

passes through it. Finally, vacuum cleaner filters marketed as "HEPA-like" will typically use a filter of a *similar construction* to HEPA, but without the filtering efficiency. Because of the extra density of a true HEPA filter, HEPA vacuum cleaners require more powerful motors to provide adequate cleaning power.

Hospital staff modelling a HEPA filter, which can be used if a patient has active tuberculosis

Some newer models claim to be better than the first models because of "washable" filters. Generally, washable true HEPA filters are expensive. Some manufacturers claim filter standards such as "HEPA 4", without explaining the meaning behind them. This refers to their Minimum Efficiency Reporting Value (MERV) rating. These ratings are used to rate the ability of an air cleaner filter to remove dust from the air as it passes through the filter. MERV is a standard used to measure the overall efficiency of a filter. The MERV scale ranges from 1 to 20, and measures a filter's ability to remove particles from 10 to 0.3 micrometre in size. Filters with higher ratings not only remove more particles from the air, they also remove smaller particles.

Vehicles

Airlines

Modern airliners use HEPA filters to reduce the spread of airborne pathogens in recirculated air. Critics have expressed concern about the effectiveness and state of repair of air filtering systems, since they think that much of the air in an airplane cabin is recirculated. Almost all of the air in a pressurized aircraft is, in fact, brought in from the outside, circulated through the cabin and then exhausted through outflow valves in the rear of the aircraft.

Motor vehicles

Some cars have cabin air filters that look like HEPA filters but which do not perform at that level. The confusion is perpetuated by guides for changing car filters which misidentify the filters as HEPA filters. The actual performance of these filters is obscured by manufacturers and difficult to evaluate, as they are not rated with the MERV system, though they typically yield MERV 8-equivalent performance.

More recently, the Tesla Model X has been attributed to have the world's first HEPA-grade filter.[12] Following the release of the Model X, Tesla has updated the Model S to also have an optional HEPA air filter.[13]

History

The original HEPA filter was designed in the 1940s and was used in the Manhattan Project to prevent the spread of airborne radioactive contaminants.[14] It was commercialized in the 1950s, and the original term became a registered trademark and later a generic term for highly efficient filters.[4]

Over the decades filters have evolved to satisfy the higher and higher demands for air quality in various high technology industries, such as aerospace, pharmaceutical drug processing, hospitals, health care, nuclear fuels, nuclear power, and integrated circuit fabrication.

See also

- Air purifier
- Clean Air Delivery Rate
- Clean room
- Electrostatic precipitator – trap particles with high voltage
- HEGA – carbon cloth filter developed by the British military against chemical warfare
- Hypoallergenic vacuum cleaner – vacuum cleaner with high efficiency air filter
- Minimum efficiency reporting value (MERV)
- Respirator
- ULPA – Removes 99.999% of dust, pollen, mold, bacteria, and particles larger than 120 nm

References

Footnotes

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General references

- TSI Application Note ITI-041: Mechanisms of Filtration for High Efficiency Fibrous Filters (http://www.tsi.com/uploadedFiles/Product_Information/Literature/Application_Notes/ITI-041.pdf)

External links

- Recommended Practice on HEPA and ULPA Filters (http://www.iest.org/StandardsRPs/RecommendedPractices/IESTRPCC001/tabid/10894/Default.aspx)

Wikimedia Commons has media related to ***High-Efficiency Particulate Arresting***.

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