LIGHTHOUSE
WORLDWIDE SOLUTIONS

CLEANROOM AIR FILTERS: CONTROLLILNG CONTAMINATION IN THE CLEANROOM

Lighthouse Worldwide Solutions

Overview

Cleanrooms require air filters in order to trap contaminants from entering the cleanrooms air supply through its HVAC system. Cleanrooms are controlled environments where the control of temperature/humidity, pressure and particles are essential for optimum operational performance. Cleanrooms are designed based on the level of cleanliness required for a given process. In the semiconductor industry where microchip manufacturing occurs the air filtration is of a higher efficiency since the microchips are very sensitive to particles and especially small particles that can wedge in between conductive circuitry on a wafer as it is been processed.

How is Contamination Controlled in a Cleanroom?

HEPA (High Efficiency Particulate Air Filter) – These filters are very effective in contamination control. They filter particles as small as 0.3 microns and are widely used in Pharmaceutical manufacturing facilities. ULPA (Ultra High Particulate Air Filter) filter particles down to 0.12 microns and are widely used in Semiconductor facilities.

Cleanroom Design – Cleanrooms are specially designed for better airflow and least contamination.

Cleaning – Cleaning is an essential element of contamination control. All such cleaning job is done as per the class of the unit and the set standards.

Cleanroom Garments – Special garments are required for clean room. ESD Aprons, hand gloves, face mask and head covers are standard garments.

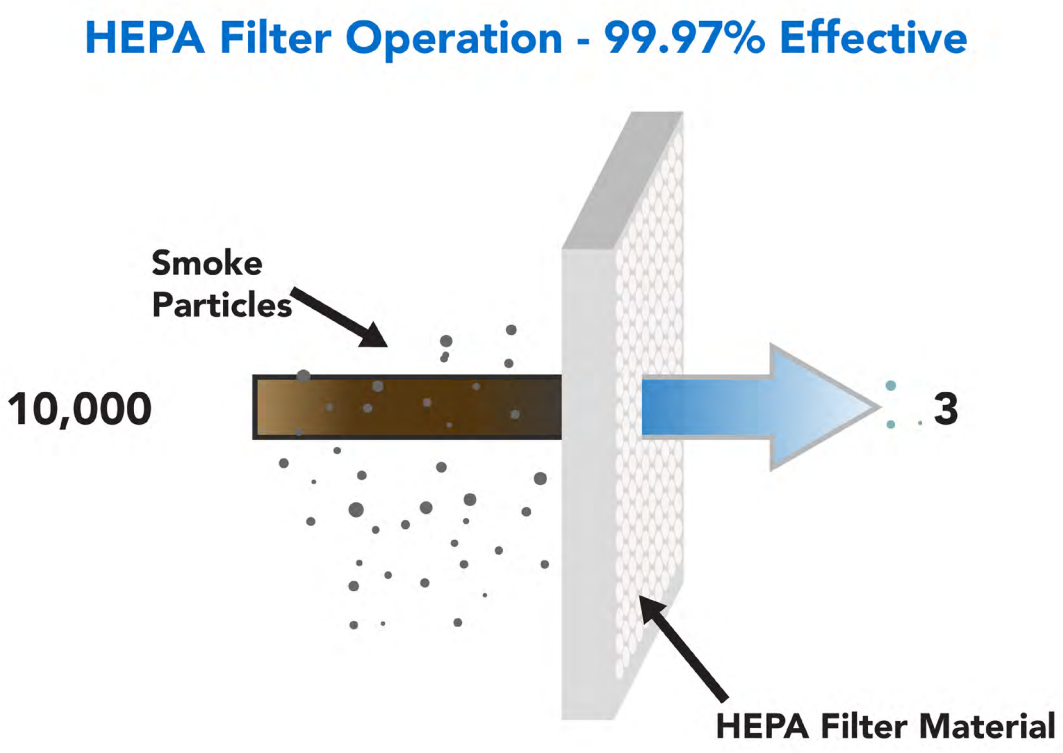
Human Behavior in Cleanroom – Contamination in a clean room can also be controlled by human behavior. There are both physical and psychological concerns when humans are present in a clean room. Fast motion is prohibited in such an environment.

Electrostatic Discharge (ESD) – Flow of electrons from one object to another creates electrostatic charge. ESD protective materials are used to prevent damage from ESD. Common products and material used for ESD protection are – wrist straps, ESD-safe aprons, ESD-safe Footwear and ESD-safe garments.

The importance of Filters in the Cleanroom

With the control of contamination within a cleanroom managed by several activities the role in which HEPA or UPLA filters play in cleanrooms is paramount.

High efficiency particulate air (HEPA) filters must meet the efficiency rating of 99.97%, on the most penetrating particles, 0.3 microns. This efficiency rating is set by the US Department of Energy in order to be a true HEPA filter.

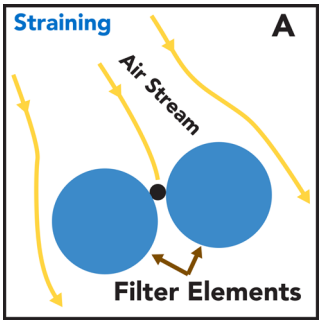


How do High Efficiency Air Filters Work?

HEPA | ASHRAE | ULPA filters capture particulate using four main methods: sieving, inertial impaction, interception, and diffusion. The type of filtration method depends on the size of the particle.

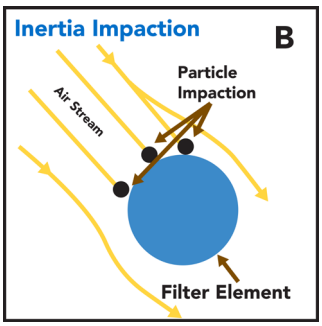
(A) Sieving/Straining

Sieving is when a large particle is trapped by a filter because it is too large to pass through the hole in between the filter fibers. Sieving is a method that all filters use to capture particles. Although, it is not the main method of filtration for HEPA filters, HEPA filters do still collect larger particles in this manner.



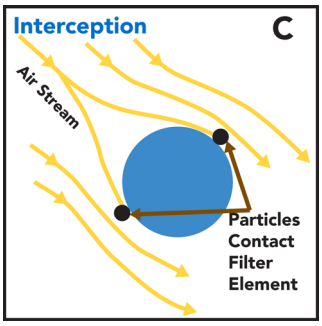
(B) Inertial Impaction

Inertial impaction happens with larger particles that collide directly with the fibers of the filter. Larger particles are unable to adjust quickly to the air stream due to inertia and continue along its original path directly into the fiber. This happens more often with larger particles because more mass equals more inertia or resistance to change paths.



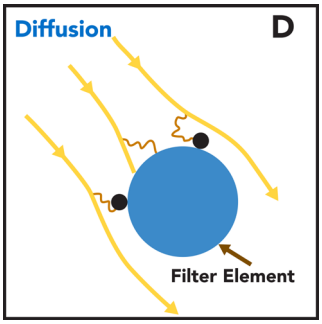
(C) Interception

Interception occurs when a particle is following a gas streamline or path and comes within one particle radius away from the fiber and brushes up against it. The fiber captures the particle and is removed from the gas flow.



(D) Diffusion

Diffusion refers to the filtration method where smaller particles move in a zigzag or random path and ends up sticking to the filter fiber. Diffusion occurs because of the Brownian theory of motion where gas particles constantly collide with each other moving in a random motion. Diffusion primarily happens to particles smaller than 0.1 microns in size and with

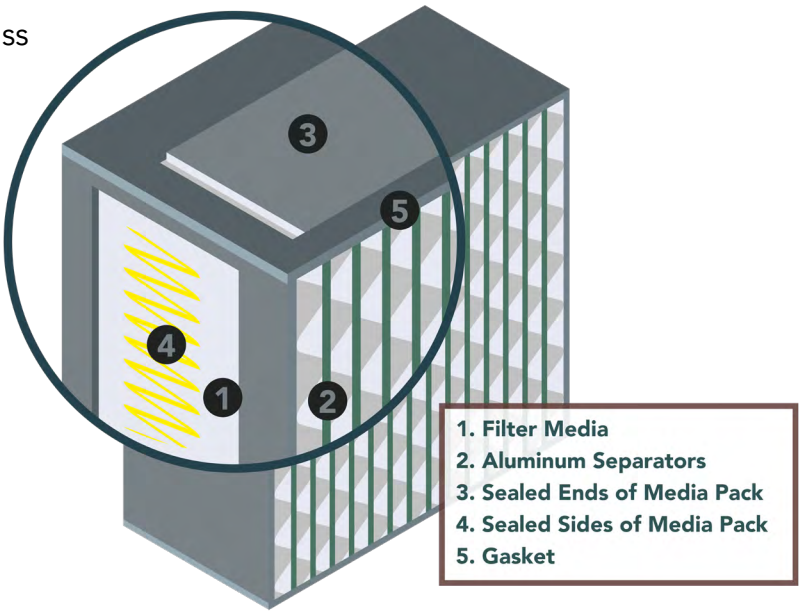


Filter Efficiency

Efficiency of a filter is calculated by measuring the particle count downstream and upstream from the filter. The downstream count is divided by the upstream count then this number is subtracted from one then multiplied by 100 to create an efficiency percentage.

Take a closer look at a HEPA filter

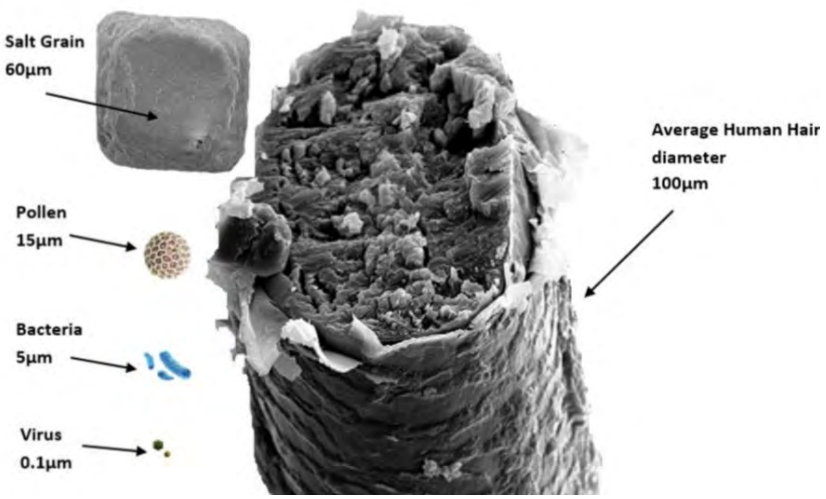
HEPA and ULPA filters are made up of tiny fibers which are meshed together and contained within a housing. These fibers are known as Filter Media. The fibers are typically composed of fiberglass and possess diameters between 0.5 and 2.0 micrometers. Key factors affecting its functions are fiber diameter, filter thickness, and face velocity.



Particle Size

To illustrate the miniscule size of particles that these filters capture, one micron is equal to one millionth of a meter. The human eye cannot see particles smaller than 40 microns. Sizes of common particles are as follows:

- **Human hair: 100-150 microns in diameter**
- **Emissions 1 – 150 microns**
- **Dust: < 100 microns**
- **Pollen: 10 - 100 microns**
- **Spores: 3 - 40 microns**
- **Mold 3 - 12 microns**
- **Bacteria: 0.3 - 60 microns**
- **Pure oxygen 0.005 microns**



HEPA Filter Specifications

As defined by the United States Department of Energy (DOE) standard adopted by most American industries, HEPA filters 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 at around 300 pascals (0.044 psi) at its nominal volumetric flow rate.

The specification used in the European Union: European Standard EN 1822-1:2009 defines several classes of HEPA filters by their retention at the given most penetrating particle size (MPPS).

European standard EN 779, on which the above table is based, remained in effect from 2012 to mid-2018, when it was replaced by ISO 16890

HEPA Class	Retention (total)	Retention (local)	Particulate size approaching 100% retention
E10	> 85%	-	>1μm
E11	> 95%	-	>0.5μm
E12	> 99.5%	-	>0.5μm
H13	> 99.95%	> 99.75%	>0.3μm
H14	> 99.995%	> 99.975%	>0.3μm
U15	> 99.9995%	> 99.9975%	>0.3μm
U16	> 99.99995%	> 99.99975%	>0.3μm
U17	> 99.999995%	> 99.9999%	>0.3μm

According to GMP, the filter has to be free of leaks. This is verified by qualification and regularly performed leak tests as per ISO 14644-3. Recommended practices for HEPA filter construction, performance, labeling and certification are maintained by the Institute of Environmental Sciences and Technology (IEST) and Underwriters Laboratories (UL). Primary requirements include:

- **IEST-RP-CC021 "Testing HEPA and ULPA Media, which governs requirements for the filter media**
- **IEST-RP-CC001 "HEPA and ULPA Filters", which governs overall filter construction and labeling requirements**
- **IEST-RP-CC034 "HEPA and ULPA Filter Leak Tests, which governs HEPA and ULPA filter penetration (leakage) tests**
- **Testing and certification to meet UL900 flammability requirements**
- **U.S. Standard MIL-STD-282**

Other test standards include:

- **ISO 14644-3 Test Methods – Used by qualifiers during installed filter leak testing**
- **ISO 29463 (2017) - High efficiency filters and filter media for removing particles from air**
- **ISO 16890 (2017) - Air filters for general ventilation**
- **PIC/s PI 032-2 GMP Guidelines**
- **EN1822 used by manufacturers of HEPA/ULPA filters**