

A Guide To Ventilated Balance Enclosures



An Industry Service Publication

Forward

This booklet was developed as a guide to selecting a balance enclosure. The information presented is unbiased and generic in nature. While this booklet should raise important questions regarding balance enclosures, it may not answer those questions. Only you and your safety officer or industrial hygienist can identify your laboratory's unique requirements.

Preface

In order to minimize exposure, workers handling and weighing toxic compounds rely on industrial hygienists and other environmental health and safety professionals to provide guidance on safety. Since laboratory workers risk exposure to many pharmacologically potent and potentially toxic compounds, engineering controls and safe work practices should be used as much as possible. One such way to reduce risk is to perform work within



Labconco XPert® Balance Enclosure

a balance enclosure, a type of ventilated cabinet. This booklet provides information on balance enclosures. (**Note:** If your application requires a chemical fume hood, Labconco's industry service publication, *How to Select The Right Laboratory Hood System*, may provide helpful reading. To request your free copy, call Labconco at 800-821-5525 or 816-333-8811.)

Balance Enclosure Basics

Since the early 1990's, various manufacturers introduced balance enclosures to address some of the shortcomings of traditional fume hoods. Designed specifically for applications in pharmaceutical, biotechnology and compounding laboratories, balance enclosures provide effective containment of airborne particulates during weighing procedures, offering an economical and effective solution. In general, design components of this relatively new type of task-specific enclosure include:

Smaller dimensions. Since balance enclosures are designed specifically for weighing operations, they do not require the height or width of a traditional fume hood. Most balance enclosures range from two feet to four feet in width compared to fume hoods, which are usually a minimum of four feet wide. In addition, the sash opening is generally of a smaller fixed height. As a result, these enclosures offer greater installation flexibility, require less bench space and use less energy.

Filtration mechanism. Balance enclosures use a High Efficiency Particulate Air (HEPA) filter, carbon filter or a combination of the two to remove toxic particulate and/or gaseous contaminants from the exhaust air. Many of these enclosures recirculate the filtered exhaust air back into the laboratory instead of to the outside, thus saving energy and installation costs. (For some applications, an Ultra Low Penetration Air (ULPA) filter may be used. See *Nanotechnology Enclosures*.)

Lower face velocities. To reduce the influence of airflow on sensitive balances, manufacturers recommend that balance enclosures be operated at the lower end of the 60-100 feet per minute (fpm) range recommended for a typical fume hood. Besides less air turbulence, lower face velocities reduce the volume of air exhausted from the laboratory, thus saving energy and tempered air.

Limited plumbing. Costly components such as gas and water service fixtures are generally not found on balance enclosures since space is limited and these services are typically not needed for powder weighing operations.

In summary, balance enclosures are designed as ventilated cabinets that provide personnel and environmental protection. As shown in Figure 1, room air is pulled into the enclosure and leaves as HEPA filtered air, thus directing unfiltered air away from the operator of the enclosure. This airflow pattern is similar to that of a fume hood, with the added benefit of a HEPA filtered exhaust outlet. This outlet may or may not be connected to a house exhaust system. Balance enclosures operate with an inflow of air, also called face velocity, of 60-100 fpm (depending on the recommendations of the manufacturer). Unlike a fume hood, the lower face velocity of a balance enclosure and aerodynamic inlet design result in minimum air turbulence and an environment in which an analytical balance, or other weighing device, can perform properly. Due to its duct-free design, smaller sash opening and lower face velocity, a balance enclosure's installation and operational costs are less than those of a traditional fume hood.

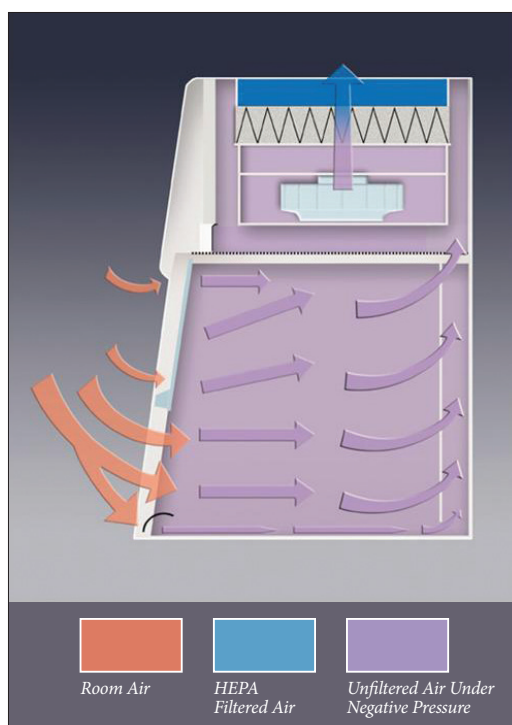


Figure 1. Balance Enclosure Airflow

HEPA and ULPA Filters

Two types of particulate filters, the HEPA and the ULPA, can be used in these enclosures. The most common type, however, is the HEPA filter. Filters can be external to the enclosure when connected to a portable exhaustor (below). Filters can also be mounted within the enclosure.



Labconco FilterMate™ Portable Exhaustor

The HEPA filter is a disposable dry-type filter, constructed of borosilicate microfibers cast into a thin sheet, much like a piece of paper. Although the media is a flat sheet, the glass microfibers form a complex three-dimensional matrix that traps particulate matter. The filter media is folded to increase its surface area and lines of glue are placed between the layers to allow the air to penetrate to the deepest part of the pleat (Figure 2).

HEPA Filter with Separatorless Construction

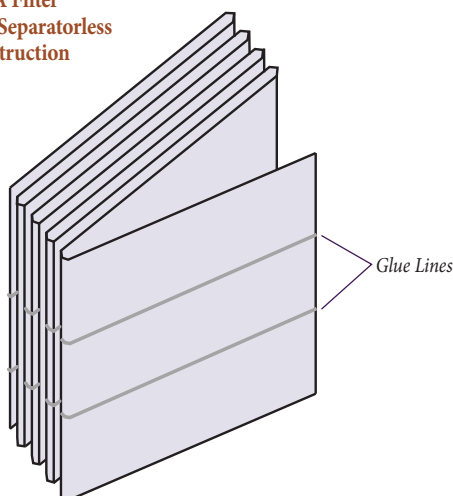


Figure 2. HEPA Filter Details

A HEPA filter is a particulate filter, retaining airborne particles and microorganisms; however, gases pass freely through the filter. HEPA filters retain particulate matter by five distinct mechanisms: sedimentation, electrostatic attraction, interception, inertial impaction, and diffusion.

Sedimentation occurs when a particle settles onto a filter fiber due to gravitational force. Electrostatic attraction is the attraction of a particle to the filter fiber due to its opposite electrical charge. These are the least effective mechanisms of particulate removal by HEPA filtration.

Interception is dependent on particle size and occurs when a particle follows the air stream onto a filter fiber and is retained. Inertial impaction occurs when a large particle leaves the air stream to be impacted directly on the filter fiber. Diffusion occurs with very small particles, and is aided by the Brownian (random) motion of the particle (Figures 3 and 4).

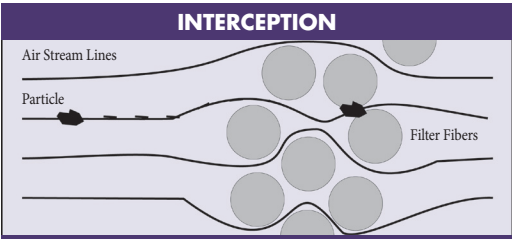
HEPA filters are rated on their ability to retain particles 0.3 micron (μm) in diameter. The filters were formerly tested using an aerosol of Dioctyl Phthalate (DOP). Now mineral oil, or similar liquid, that has a large number of 0.3 μm droplets is injected into the upstream side of the filter during operation. Readings are taken on the opposite side of the filter to quantify the number of droplets that penetrate. Thus, if a filter allows one or less droplet to penetrate the filter with an initial concentration of 10,000, the filter is rated at 99.99% efficiency.

As most aerosol droplets are larger than 0.3 μm , the collection efficiency of HEPA filters for these droplets is actually higher than its rating. Variations in filter efficiency, from 99.95% to 99.99%, for example, are usually due to the filter media used or manufacturing techniques.

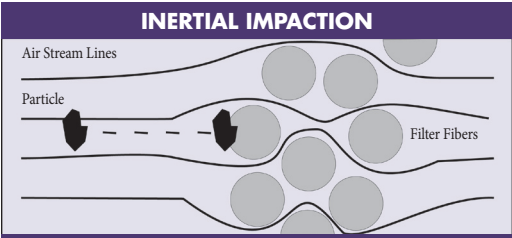
ULPA filters remove 99.999% of particles 0.12 micron (μm) in size. Use of these filters in a balance enclosure is not commonly seen but is available (see *Nanotechnology Enclosures*). Consult your safety officer for recommendations based on your specific application.

The filter life varies depending on factors such as hours of operation, cleanliness of the laboratory air and nature of the work being done. All other factors being equal, variances in filter life from one enco-

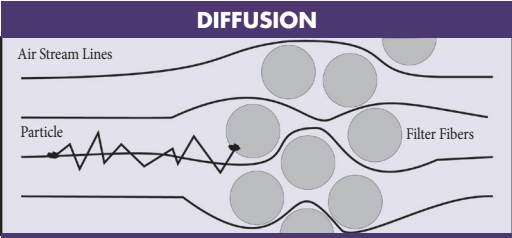
sure to the next would be the result of the power, or torque, of the motor. The greater the power of the motor, the longer the filters will last. As the filters load, resistance increases. To overcome this resistance, the torque of some motors may be adjusted to extend the life of the filter. With typical usage, HEPA filters commonly last three to five years or more before needing replacement.



Screening effect that depends on size relationship



Particle inertia causes it to leave flow stream lines and impact on fiber



Brownian motion — diffusion due to molecular bombardment

Figure 3. Air Filtration Theory Particle Collection Mechanisms

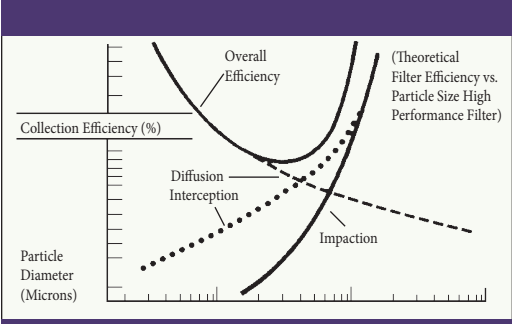


Figure 4. Relative Effect of Particle Collection Mechanism

Hazard Classification

Categorization of hazardous pharmaceutical powders has not been defined into one concise system as biosafety levels have. There are a handful of systems that have been adopted in various fields. All of these systems, though, segregate compounds based on their potency, toxicity and occupational exposure limits (OELs). One such system, SafeBridge® Consultants, Inc.’s “Characteristics of Compound Potency and Toxicity by Category,” is explained below and is shown in Table 1 (page 6).

In general, a Category 1 material can be handled openly with well-applied traditional control technology such as local exhaust ventilation. A Category 2 material requires basic containment such as local exhaust ventilation at process emission points. Category 3 materials cannot be handled openly and require a closed system, direct connections, isolation and/or combination of controls. A Category 4 material requires complete containment, a closed system and/or isolation.

Table 1. Characteristics of Compound Potency and Toxicity by Category

Category 1	Category 2	Category 3	Category 4
<ul style="list-style-type: none">• Irritant to the skin or eyes• Low acute or chronic system effects• Low potency (effects at 10-100 mg/kg or greater)• Effects that are reversible• Onset of symptoms is immediate• Not a mutagen, reproductive or developmental toxicant or carcinogen• Has good warning properties (odor threshold below a concentration which may cause toxic effects)• OEL approximately 0.5 mg/m³ or greater	<ul style="list-style-type: none">• Moderate to high acute systemic toxicity such as cardiac or liver toxicity• Reversible systemic toxicity• Moderate chronic systemic toxicity with low severity (toxicity observed at approximately 1-10 mg/kg)• Corrosive• Weak (skin or respiratory) sensitizers• Moderately absorbed via inhalation or by dermal exposure• Onset of symptoms may be immediate to delayed• Moderate degree of medical intervention (i.e. not life threatening) may be needed• May have poor or no warning properties• Not a mutagen, reproductive or developmental toxicant or carcinogen• OEL range from approximately 10 µg/m³ to 0.5 mg/m³	<ul style="list-style-type: none">• Mutagenicity• Carcinogenicity• Developmental and/or reproductive toxicity• Significant pharmacological potency (effects at or below approximately 0.01-1 mg/kg)• Sensitizers• Well absorbed by occupational exposure routes• Irreversible effects• Severe acute systemic effects• Severe chronic systemic effects• Potential need for immediate medical intervention• Poor or no warning properties• OEL range from approximately 10 µg/m³ to 30 ng/m³	<ul style="list-style-type: none">• Highly potent pharmacological activity (observed at approximately 10 µg/kg or less in animals or humans)• Irreversible effects• Mutagenicity• Developmental and/or reproductive toxicity• Well absorbed by occupational exposure routes• Severe acute or chronic systemic effects• May affect sensitive sub populations in a significant manner (i.e. asthmatics)• OEL range from approximately 30 ng/m³ or less

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Nanotechnology Enclosures

Nanotechnology is the study of matter at dimensions between one and 100 nanometers. Particles of this size are known as nanoparticulates and, at this level, matter behaves differently. Scientists continue to study the impact certain nanoparticulates can have on workers in high-exposure occupations.



Labconco XPert® Nano Enclosure

As research evolves, there is a general acknowledgment in the nanotechnology field that some risks exist. A study from the University of Edinburgh published in the *American Journal of Pathology* stated that certain types of carbon nanotubes can become lodged in the lining of the lung and eventually cause mesothelioma, the cancer generally associated with asbestos. The National Institute for Occupational Safety and Health (NIOSH) has published Current Intelligence Bulletin 63 that gives an exposure recommendation for titanium dioxide. In various forms, titanium dioxide is used in the workplace to produce products such as paints, cosmetics, plastics, paper and food. Ultrafine, or nano-sized, particles of this compound have been identified as a potential occupational carcinogen. As more discoveries are made in nanotechnology, the need for protection becomes increasingly evident.

Specialty balance enclosures that are designed for nanoparticulate capture are commercially available and differ slightly from a standard balance en-

sure. These differences could include materials of construction, ULPA versus HEPA filtration and static dissipative devices.

Performance Affecting Factors

Balance enclosures were designed to provide particulate containment while not interfering with the performance of a balance, or weighing device. In order to obtain the optimum performance of both the enclosure and the balance, there are several factors that need to be taken into consideration.

While installing a balance enclosure, its placement is a topic of great importance because balances exhibit sensitivity to vibration. Vibration can stem from instability in the work surface, equipment in the laboratory or even movement in the building. While advanced balances offer improved reliability, minimizing vibration can be accomplished by using rigid and stable work surfaces and attaching the bench to either the floor or the wall to avoid simultaneous transmission of vibrations. Tubular stands or carts that could move when touched should be avoided. Within the balance enclosure, marble, granite or epoxy balance slabs provide additional protection from vibration.

Static accumulation can present a problem in a balance enclosure when static charges exist in the materials of construction, source container or the substance being weighed. Static could also be present on the person using the balance or on the weighing utensils and vessels.

Static electricity negatively affects weighing operations in several ways. First, static electricity exerts a force, which is readily detectable by analytical balances; this, in turn, impacts their precision. Second, static can result in inconsistent sample transfers due to the movement of particulates or inaccurate readings if the sample clings to the weighing utensils or vessel. It can be a safety concern if hazardous powders that cling to the work surfaces or sides of the enclosure are left behind when the enclosure is not operating. A situation such as this one can lead to possible cross contamination or accidental exposure when cleaning the enclosure. Low ambient humidity intensifies static problems. Maintaining relative humidity levels between 45% and 60% assists in minimizing static.

Moving air within the laboratory can impact a balance reading. As such, balance enclosures should be positioned away from high traffic areas or lab equipment producing air currents.

Except for balances with temperature compensation, the accuracy and overall performance of most laboratory balances are affected by the room temperature. For best stability and performance, the room temperature should be regulated within 1° F without interruption. Minimizing the potential for temperature variation can be achieved by installing balances away from heat sources and avoiding incandescent lighting and exposure to direct sunlight. Sample and room temperatures should be nearly equal so that thermal drafts are not created within the draft shield of the balance.

The training and work practices of the professional using the conventional balance enclosure also plays a role in the safety provided by the enclosures. Both ANSI/AIHA Z9.5 and Prudent Practices recommend safe work practices to contain toxic agents in the laboratory and warn against leaning into the enclosure, blocking airflow, incorrect use of the sash and frequent opening and closing of the sash while working in the enclosure. In addition to proper use of the enclosure, the operator's weighing techniques greatly impact the level of containment.

Performance Testing

The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) sets standards in order to form a consensus for establishing heating and cooling requirements for indoor environments. ASHRAE is accredited by the American National Standards Institute (ANSI) and follows requirements proposed by ANSI for development of standards. ASHRAE 110 is a test method for which fume hoods can be evaluated and is made up of three parts (1) measurements of face velocity (2) air-flow visualization and (3) tracer gas containment. These three components help define the ability of a hood to provide adequate containment while still performing at the correct face velocities to provide user protection.

In contrast, ASHRAE does not set a regulation or have a method to test a balance enclosure. With no set regulations or standards, manufacturers can

determine what tests, if any, their enclosures will undergo. One manufacturer may test for particulate containment while the other looks at the containment of vapors. Consider the intended application for the enclosure in order to ensure applicable testing has been done.

Ducting Option: Canopy Connection

While many balance enclosures can recirculate air back into the laboratory or cleanroom, others may not. A canopy (or “thimble”) connection allows an enclosure to be connected to the outside for additional protection (See Figure 5). A canopy connection may also be necessary for volatiles or solvents with odors. The canopy's air gap provides a means of balancing air by allowing room air to enter the ductwork and mix with the filtered air being exhausted from the enclosure. A house exhaust or remote blower is required.

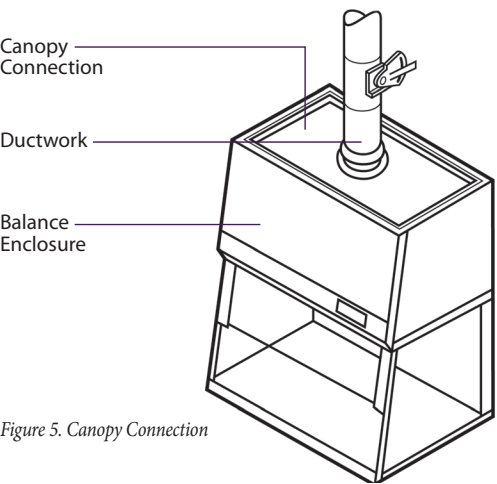


Figure 5. Canopy Connection

Marble Slabs

To ensure a vibration-free environment, the enclosure can be placed on a marble table or the balance may be placed on a marble slab inside the enclosure. A slab of marble helps ensure stability for analytical balances (Figure 6).

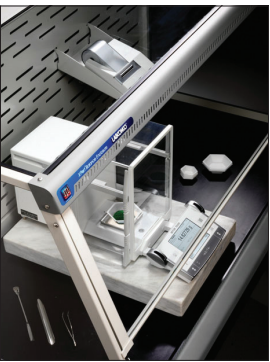


Figure 6. Analytical Balance on a marble slab.

Airflow Monitors

The rate at which air flows into an enclosure, or the face velocity, is an important factor in understanding the containment that an enclosure can provide. If the rate is too low, the enclosure will not be able to contain the particulate. If the rate is too high, the fast moving air can cause turbulence in the airstream that will ultimately result in loss of containment.

Airflow monitors can be installed to help gauge face velocity. There are several types of monitors; some can be factory installed and others need to be installed separately.



Different airflow monitors have different features. Consider the notification method, which can be audible, visual or both. Also consider the type of read-out provided and the ease of calibration.

Labconco Guardian™ 1000 Digital Airflow Monitor

Installation Considerations

Consider the space where the enclosure will be installed. To ensure proper airflow and containment, an enclosure should be located away from fans, heating and air conditioning registers, laboratory hoods, high traffic areas and doors that could interfere with its airflow patterns. All windows should remain closed, and the balance enclosure should not be installed in a location where is likely to be affected by another piece of equipment such as a biosafety cabinet or a fume hood.

Primary Consideration—Safety

Selecting the correct enclosure depends on the following:

- (1) **Type of protection required**
 - a) product protection only
 - b) personnel and environmental protection only
 - c) product, personnel and environmental protections
- (2) **Size of particulates**

A balance enclosure provides only personnel and environmental protection. It is designed for particulate capture during processes that require manipula-

tion of both toxic and hazardous powders. Some hazardous powders can be nanoparticulate-sized. In these instances, an ULPA filter may need to be considered (see *Nanotechnology Enclosures*).

If only product protection is necessary, utilize a clean bench. Clean benches can be vertical or horizontal. If both product and personnel protection is required, a biosafety cabinet or glove box could be the appropriate choice. (Reminder: Only you and your safety officer or industrial hygienist can identify your laboratory's unique requirements.)

Secondary Consideration—Application

The application for which an enclosure will be used should be considered as well. For small scale weighing applications where the source container is easy to handle and manipulate, a balance enclosure is the best option. However, if the small scale weighing should involve any nano-sized particulate, a specialized enclosure, one that includes an ULPA filter in lieu of a HEPA filter, should be considered (see *Nanotechnology Enclosures*). Some applications may require large scale weighing or bulk transfer where the source container is a drum or other such container. In these instances, a bulk powder enclosure should be considered. Many bulk powder enclosures come with manual or electric lift carts to raise the bulk container to the work surface for ease of material transfer.



Labconco XPert® Bulk Powder Enclosure

Tertiary Consideration—Cost

Understanding the costs involved in owning and operating a balance or bulk powder enclosure is important. Installation costs can range depending on whether or not ductwork installation and a remote blower are required.

Certification and maintenance costs should also be considered, such as the expense of replacing HEPA or ULPA filters.

There may be additional accessories that must be purchased in order to ensure proper use of the enclosure. These could include work surfaces, airflow monitors, marble slabs and base stands or cabinets.

Certification

Certification of enclosures plays a critical role in their performance. Certification should be performed at least annually and whenever the enclosure has been moved, serviced or when the HEPA or ULPA filters are replaced.

Selecting the right certifier is critical to ensure that the enclosure performs as it was designed. The efforts of the manufacturer's research and development and test and validation can easily be nullified by an improper or inaccurate certification.

The user should ask the certifiers about their experience in certification, attendance to technical courses or the manufacturer's training sessions. The user should also ask that certifiers describe all tests to be performed and the procedures involved. The certifier's test equipment should be annually calibrated to a National Institute of Standards & Testing (NIST) traceable standard.

Routine Maintenance Schedule

Under normal operation, balance and bulk powder enclosures require routine maintenance. The following schedule is recommended:

Weekly

Wipe down the interior surfaces of the enclosure with a disinfectant, such as a 10 percent alcohol solution, and allow to dry.

Using a damp cloth, clean the exterior surfaces of the enclosure, particularly the front and the top, to remove any accumulated dust.

Operate the exhaust system, noting the airflow velocity through the enclosure using a source of visible smoke. Airflow monitors are recommended for constant monitoring.

Monthly (or more often as required)

Using a calibrated anemometer or other approved apparatus, determine the actual face velocity through the enclosure's sash to ensure the average reading is consistent with the specified velocity for the enclosure.

The enclosure's rear baffle should be checked for any blockages to ensure that proper airflow is being maintained. Change the speed control or change the HEPA filter when the face velocity of the enclosure drops below the recommended speed for your facility. Also, if the enclosure has an airflow monitor (recommended), change the speed control or HEPA filter when prompted.

Perform all weekly activities.

Annually

Replace the enclosure's fluorescent lamps.

Have the enclosure validated by a qualified certification technician biannually.

Perform all monthly activities.

Glossary

air turbulence: Disturbances of airflow that disrupt laminar flow and can cause loss of containment in a laboratory enclosure.

airflow monitor: A monitor that ascertains the flow rate of air and alerts the user when it drops below a safe velocity.

analytical balance: A weighing tool for solids up to 200g.

anemometer: A device used to accurately measure face velocity.

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers. Test Standard 110 was developed to demonstrate a fume hood's ability to contain and exhaust contaminants released inside a fume hood.

ANSI: American National Standards Institute. Accredits ASHRAE.

biosafety cabinet: Also known as biological safety cabinet. Cabinet intended to protect the user and environment from the hazards of handling infectious material and other biohazardous material. Some types may also protect the materials being handled in them from contamination.

Brownian motion: A random movement of microscopic particles suspended in liquids or gases resulting from impact of the molecules of the suspending agent on the particles.

bulk powder enclosure: A specialty type of balance enclosure designed for transfer of large, or bulk, volumes.

canopy connection: An exhaust system with a physical gap or space between the cabinet's exhaust and the exhaust system intake. During operation, the exhaust system draws all of the cabinet's exhaust air through the duct, plus a small volume of room air through the gap. Also known as a thimble connection.

clean bench: A type of enclosure that delivers ISO Class 5 air to a work area and provides product protection only.

cleanroom: An environment, typically found in manufacturing or scientific research, that has low levels of environmental pollutants such as dust, airborne microbes, aerosol particles and chemical vapors.

diffusion: Used within this text, a phenomenon of HEPA filtration by which Brownian motion causes particles to diffuse across air stream lines impacting them on a filter fiber. One of five distinct mechanisms by which HEPA filters retain particulate matter.

diethyl phthalate: See DOP.

DOP: An oil that can be aerosolized to an extremely uniform size; i.e. 0.3 μm for a major portion of any sample; the aerosol is used to challenge HEPA filters.

electrostatic attraction: The attraction of a particle to the filter fiber due to its opposite electrical charge. One of five distinct mechanisms by which HEPA filters retain particulate matter.

face velocity: The rate of speed at which air is traveling into a laboratory enclosure.

filter efficiency: The efficiency of various filters that can be established on the basis of entrapped particles, i.e., collection efficiency; or on the basis of particles pass through the filter, i.e., penetration efficiency.

fume hood: A laboratory safety device designed to evacuate toxic or noxious fumes during use.

HEPA Filter: High-Efficiency Particulate Air filter. A disposable extended-pleated dry-type filter with (1) a rigid casing enclosing the full depth of the pleats; (2) a minimum particle removal efficiency of 99.9% for thermally generated monodisperse DOP smoke particles with a diameter of 0.3 μm ; and (3) a maximum pressure drop of 1 inch water gauge when clean and operated at its rated airflow capacity.

house exhaust: A pre-existing ducting system that includes a remote blower to evacuate effluent exhaust from laboratory enclosures.

inertial impaction: The process in which a large particle leaves the air stream to be impacted directly onto the filter fiber. One of five distinct mechanisms by which HEPA filters retain particulate matter.

interception: The process in which a particle follows the air stream onto a filter fiber and is retained. One of five distinct mechanisms by which HEPA filters retain particulate matter.

micron: A metric unit of length equal to one millionth of a meter (10^{-6}). Symbol: μm .

nanoparticulate: Any particulate 1 billionth of a meter or 10^{-9} microns (μm) in size or smaller.

protection:

environmental protection: Any aerosol generated within the cabinet is removed from the air or deactivated before the air from the enclosure is discharged.

personnel protection: Any aerosol generated within the cabinet is kept away from the technician doing the work.

product protection: The air at the work surface of the cabinet has been filtered so that it is free of airborne particulates and organisms that could contaminate the work.

rear baffle: An engineering device that helps direct airflow in a laboratory enclosure. Located in the back wall of the unit.

remote blower: A motor blower that is installed at a distance from an enclosure and is connected by ductwork.

sedimentation: The process by which a particle settles onto a filter fiber due to gravitational force. One of five distinct mechanisms by which HEPA filters retain particulate matter.

thimble connection: See canopy connection.

ULPA filter: Ultra Low Penetration Air filter. A specialty HEPA or borosilicate filter that can remove airborne particulates, 0.12 micron in size or larger, at 99.999% efficiency or greater.

Websites and References

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www.ansi.org

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