Clean Air PRODUCTS

CLEAN BENCH
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HOW TO SPECIFY A CLEAN BENCH

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If you're considering a laminar-flow clean bench to meet ISO or other manufacturing standards for particulate control, here is what you need to know to select the right horizontal- or vertical-flow bench for your application.

A clean bench (also called a laminar flow bench or laminar flow workstation) is a piece of equipment designed to create a micro-environment that meets industry standards for particulate control. Clean benches range in size from compact tabletop versions to larger cabinets. Many manufacturing environments, such as semiconductor, pharmaceutical, medical device, food, aerospace and nanotechnology production, require that products be kept free of particulate contamination. Laboratories and test and inspection areas are also common sites for clean benches. Clean benches are a convenient method of creating a Class 100 (ISO 5) or Class 10 (ISO 4) clean air environment within a larger work area.

Clean benches can be used as stand-alone solutions or they can be installed inside a cleanroom. It is often more economical to supplement a cleanroom with clean benches to create localized Class 100 or Class 10 areas, rather than make the entire cleanroom Class 100 or Class 10. When used outside a cleanroom, a clean bench does not require a worker to be gowned, although individuals often wear gloves and arm coverings when using a bench as an extra measure of protection against particulate contamination.

KEY PRINCIPALS OF CLEAN BENCH PERFORMANCE

Clean benches employ two key principals that are critical to maintaining a contaminant-free environment — laminar airflow and filtration.

Laminar airflow

Laminar flow refers to a state in which non-turbulent streams of air flow in one direction parallel to one another. Laminar airflow is the most efficient option for removing particulate contamination from a controlled area because the airflow uniformity and lack of turbulence keep clean airstreams from mixing with contaminated airstreams. An object being bathed with clean, turbulence-free, laminar airflow will remain clean and protected from nearby contamination.

Clean benches with either vertical or horizontal laminar airflow provide the cleanest working environments because HEPA-filtered air within these benches is unidirectional and turbulence-free. (Unidirectional is airflow having generally parallel stream lines, operating in a single direction with uniform velocity over its cross section.)

Filtration

The air that bathes a product in a clean bench needs to be free of contaminants. This requires filtration. Clean benches are usually classified according to the number and size of particles permitted per volume of air in a specific amount of time.

A HEPA (High Efficiency Particulate Air) filter is often used to filter the airstreams of a clean bench. To qualify as HEPA by U.S. government standards, an air filter must remove 99.97% of 0.3 micrometer particles. With the proper airflow and HEPA-filtered air, a clean bench can be rated Class 100 or ISO 5 (99.99% are typically used).

An ULPA (Ultra-Low Particulate Air) filter can be used when a Class 10 or ISO 4 rating is required. An ULPA filter removes at least 99.999% of any airborne particles 120 nanometers (0.12 micron) or larger.

CONSIDERATIONS FOR SPECIFYING CLEAN BENCHES

There are many possible configurations for clean benches. Specifying the ideal environment for a particular application will require careful decisions regarding airflow, bench design and filtration options.

Direction of laminar flow

The first decision a specifier of clean benches faces is horizontal or vertical laminar flow. Vertical and horizontal airflow benches each have strengths and weaknesses when it comes to keeping objects free from contamination. The configuration of the work piece and the nature of the work to be done will impact whether vertical or horizontal is best.

The challenge is that when an object is placed into an airstream it is not perfectly aerodynamic and will block some of the airflow creating turbulence around itself. Where there is turbulence there is a reduced air exchange rate and possible mixing with adjacent airstreams. Turbulence can extend down the air steam from the object. Then energy from the turbulent area can draw air back upstream towards the object.

Horizontal flow — Horizontal airflow is generally best when the work piece has a large horizontal surface and/or a narrow cross section perpendicular to the airflow. Horizontal airflow is also well suited for applications in which an individual must work directly over the work piece. In a horizontal flow clean bench there is constant clean airflow between the work object and the worker's hands or instruments. When using a clean bench with a standard 90 LFPM (Linear Feet per Minute) airflow velocity and a 30 in. work area, it takes less than two seconds for a complete air exchange to occur.

A typical horizontal laminar flow workstation has a tabletop and a three-sided hood. The HEPA filter is located on the vertical rear side of the work surface and is susceptible to damage. A secondary grill is sometimes needed for filter protection.

Vertical flow — Vertical flow is used for a number of reasons but the size and type of object are the primary considerations. Large objects can block the airflow in a horizontal laminar flow workstation, creating large areas of turbulence on the downstream side of the object. These turbulent areas often become contaminated as ambient air is drawn in. With vertical flow, air enters the work zone from the top and flows downward, surrounding the object within the work area. Air flows on the front, sides and rear, bathing the object on all sides with clean, filtered air.

Clean Air Products CAP301 Series horizontal laminar flow clean bench.

The general-purpose horizontal laminar flow clean bench is designed to provide Class 10 or Class 100 (ISO Class 4 or 5) environments suitable for laboratories, testing, manufacturing, inspection and pharmaceutical processing. The clean HEPA-filtered air flow outward from the cabinet, washing out particulates and preventing contamination from entering the work zone.

Clean Air Products CAP412 Series vertical-flow open-base clean bench.

A vertical laminar flow clean bench creates a mini-environment within a cleanroom. The open base allows the unit to be placed over existing work tables or equipment. Models range from open interior to exhausting clean bench with wet process to recirculating temperature control Class 10 system. Clean benches also can be used in lieu of a cleanroom; it is sometimes more cost-effective to build a lower-class cleanroom and supplement it with clean benches than to create a higher class cleanroom.

Type and positioning of work surface

Careful selection of the clean bench work surface and positioning of items on the work surface can prevent turbulence and inflow contamination.

Horizontal bench options — With a horizontal flow clean bench the work surface is solid; however, the work piece may be mounted on a platform or supports to allow the laminar airstreams to bathe the piece on all sides.

Vertical bench options — In a vertical flow clean bench, laminar flow airstreams may continue down through a perforated or rod-type tabletop. If a solid tabletop is used, the airstreams must turn.

When using a solid tabletop or a tabletop with minimum perforations, most air flows out the front of the bench. There will be some airflow compromise at this point since the flow is not completely unidirectional as it turns toward the front. There also will be an area of turbulence in the rear of the bench between the table top and back panel. While this is not ideal, it usually is not problematic if critical objects are not placed in these turbulent areas. The air will eventually clean itself but not as efficiently as in the laminar areas.

Adding perforations to the tabletop, the rear of the back panel or to a small space between the back panel and table top can minimize the turbulent area. A perforated or rod tabletop allows the airstreams to flow through the tabletop in a more laminar manner. However, this reduces the outflow of air at the front of the hood making the need for a front face shield or window even more important (see below). If holes are added to the rear of the hood, care needs to be taken to ensure that drafts from other air currents do not cross flow through the bench.

Front shield usage

Vertical laminar flow workstations — The front of a vertical flow clean bench is open and relies on the outflow of air to maintain the clean environment. Adding a rigid or flexible front face shield or front sliding window will contain the work area and help direct the filtered air towards the critical work area. The shield will reduce the open frontal area, increase the exit air velocity and help prevent infiltration of contaminated, ambient air into the clean space.

The front shield protects the vertical airstreams from the contaminated stationary air just in front of the bench. If these two air masses come in contact – one moving and one stationary – a turbulent boundary will develop that will result in the two air masses mixing. This mixing will deteriorate the laminar flow.

Horizontal laminar flow workstations — No front shield is needed in a horizontal clean bench because air flows out the end of the hood creating a wall of air. The wall of air extends beyond the end of tabletop making a semi-clean zone directly in front of the clean bench. If contamination is created, everything upstream of the contamination will remain clean as long as laminar airflow is maintained. The only area affected by the contamination would be that directly downstream of the contamination.

Size/dimensions of clean bench

The size of the clean bench will be determined by the size and configuration of the work piece and the nature of the work to be done. Also, whether the operator will be sitting or standing will impact the table height selected.

To minimize turbulence within the clean bench, objects should be placed so the smallest cross section is perpendicular

to the airflow with the air able to flow around as much of the object as possible. If the air path is long enough, the clean air will regain its uniform airflow subject to the size of the object. As a general rule, when clean air is traveling on two sides of an object the air will regain unidirectional flow at approximately three times the distance of the object's width. If clean air can only get at one side of the object, this distance increases to approximately six times the object's thickness.

Maximum Number of Particles in Air
(Particles per cubic meter)

ISO Class	Fed-Std 209E Class	Particle Size ≥ 0.1µm	≥ 0.2µm	≥ 0.3µm	≥ 0.5µm	≥1µm	≥ 5µm
ISO 1		10	2				
ISO 2		100	24	10	4		
ISO 3	(Class 1)	1,000	237	102	35	8	
ISO 4	(Class 10)	10,000	2,370	1,020	352	83	
ISO 5	(Class 100)	100,000	23,700	10,200	3,520	832	29
ISO 6	(Class 1,000)	1,000,000	237,000	102,000	35,200	8,320	293
ISO 7	(Class 10,000)				352,000	83,200	2,930
ISO 8	(Class 100,000)				3,520,000	832,000	29,300

Cleanroom classification chart

Clean benches range in size from compact tabletop versions to larger cabinets. Sizes are available from 2 ft. to 10 ft. in width, work area heights from 22 in. to 46 in. and table depths up to 48 in.

A horizontal flow clean bench takes up more floor space because the filter is located behind the unit, rather than on the top as with a vertical flow cabinet.

Cleanroom class/filtration requirements

How clean your bench needs to be depends on the particular operation. Government regulations and customer specifications may be factors in the decision.

Clean room benches are usually classified according to the number and size of particles permitted per volume of air in a specific amount of time. This is related to not just the quality of the filter, but also the airflow within the enclosure.

Class 100 (ISO 5) — Using a HEPA filter does not guarantee that the cleanroom bench interior will be Class 100 (ISO 5). You need the proper airflow within the bench.

With clean benches that need to be Class 100 (ISO 5) or better, the air discharging from the HEPA filter must be in line with the hood or side walls of the support frame to eliminate turbulence.

If turbulence exists, the resulting energy can flow along the vertical surface and draw in contaminated air from outside the bench. (The air will become turbulent if non-moving air comes in contact with the moving laminar airflow.)

Turbulence is eliminated by having the media edge of the HEPA filter in line with the edge of the hood or by putting in a secondary grill that diffuses the air so it is in shear with the bench's surfaces.

On a horizontal flow bench this would exist on all sides - hood, top, sides and table top. On a vertical flow cabinet the in shear should be on the sides and front. Face shields help the laminar flow direct the clean air towards the work surface, prevent frontal turbulence, maintain higher exit velocities and help the laminar flow fully develop.

Class 10 (ISO 4) — Many clean bench users need to get to Class 10 (ISO 4), and upgrading to a UPLA filter will typically get them there. While an ULPA filter will be more expensive than a HEPA filter, the cost is relatively small considering the overall costs of a clean bench system.

Clean Air Products CAP201 Series horizontal laminar flow clean bench

Horizontal laminar flow clean benches made from vinyl-clad steel shell are easy to clean and maintain and offer the ultimate in a Class 100 (ISO 5) working environment. Made from high-quality materials and deigned for a sleek appearance, they resist abrasion, corrosion, stains and chemicals as well as scratches and scuffs.

Configuration and construction materials options

Clean benches are available in a variety of configurations and modes of operation with additional environmental controls available as necessary depending on the type.

Vertical-flow bench options — Vertical flow clean benches are available in many different configurations, including non-recirculating airflow, partial recirculating airflow, or recirculating airflow with partial exhaust (odors can be controlled through charcoal filters or 100 percent exhaust). Exhausting units can be made of stainless steel or polypropylene. Specialty vertical flow cabinets are made of polypropylene for trace metal analysis or for applications in which concentrated acids are used.

Horizontal-flow bench options — Horizontal flow benches are available in vinyl-clad steel, stainless or painted steel with myriad options such as an ultraviolet lights, extra duplex outlets, pressure gages, removable grills and safety glass hoods. Horizontal benches can be installed on existing tabletops or ordered with stands or base storage cabinets.

Biosafety cabinets — Biosafety cabinets are a type of clean bench designed for both product and personal protection. They are typically used with biological agents. HEPA-filtered air is supplied to the work space with a slight inflow at the front of the cabinet. Contamination does not get past the front grill because a second HEPA filter cleans that air. Some units require this air be 100% exhausted. Exhausting the HEPA-filtered air from biosafety cabinets is a secondary measure of protection to ensure no biological agents within the bench enter the ambient space.

BENCH LOCATION

Where to site a clean bench will be dictated by workflow into, within and out of the clean bench and how it will interface with other operations. Additionally, a clean bench should be located away from obvious drafts, as well as areas where air velocity will exceed 100 ft. per minute (the same airflow velocity coming out of the HEPA filter). If outside air is blowing directly towards the clean bench, it will blow into the unit and contaminate the space.

There should be negative pressure around the HEPA filter and the location of the HEPA filter should be compatible with future servicing needs. Any physical restrictions that may affect bringing the bench into the space such as doors, hallways, and other equipment should be considered.

Cleanroom benches can be used inside a cleanroom or other clean space. Class 100,000 (ISO 8) or Class 10,000 (ISO 7) clean rooms can include clean benches to create Class 100 (ISO 5) or even Class 10 (ISO 4) areas. With the surrounding space clean a clean bench performs better. There is significantly less particulate contamination for the HEPA filter to handle and less ambient contamination threatening to infiltrate into the work zone.

OTHER CONSIDERATIONS

UL listing — Local codes typically require UL listing of installed electrical equipment.

Speed control switch — This blower switch will allow adjusting airflow velocity over time.

WRAPPING UP

Whether you're considering a clean bench to protect a specific activity in a laboratory, testing and inspection area or on the manufacturing floor — or to supplement an existing cleanroom — clean benches can be an ideal solution for controlling particulate in a selected work area. Clean benches can be specified from a wide range of configurations and options to achieve a cost-effective particulate-controlled environment for any product or process.

About Clean Air Products

Since 1969, Clean Air Products has been designing and manufacturing high quality cleanroom systems, components, equipment and supplies for the semiconductor, medical, pharmaceutical and aerospace/military manufacturing industries, among others. Clean Air Products offers a broad line of horizontal- and vertical-flow clean benches, with multiple standard and custom options from temperature control options to table-top designs. Applications engineering assistance is available for designing and specifying cleanroom solutions. For more information, visit www.cleanairproducts.com.

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