Dear viewers, Namaskar

Welcome to the lecture series on Food technology

Today the topic Laminar air flow cabinet shall be discussed under the following sub headings

1. **Introduction**
2. **Laminar Air Flow Cabinet**
3. **Working principle of Laminar air flow cabinet**
4. **Types of Laminar air flow cabinets**
5. **Biological safety cabinets**

1. Introduction

For many years microbiologists have attempted to devise more efficient techniques for controlling microbial contamination. These efforts have ranged from the use of cotton-plugged tubes to large germ-free isolators were used. Experience has shown that considerable care, time, and money are required to prevent contamination, culture media and other materials which must be maintained or handled in a sterile condition. When critical sterility tests or assays for low numbers of microorganisms are performed, extraneous microbial contamination cannot be tolerated.

In the 1960s due to the need for clean air in industry, laminar air flows (also known as clean benches) were first developed to provide product protection for small scale experimental procedures. Laminar flow cabinets have been used extensively in laboratory to provide an environment free from microorganisms, with excellent and consistent results. In the laboratory, airborne contamination can often influence experimental procedures and results, which is why processes should be carried out under controlled environment conditions. In order to illustrate that ability of the laminar flow cabinet to protect your products and samples, consider that normal air may contain as much as 5 million suspended particles of contaminants per cubic foot and compare this value with those in the table to the left. Laminar Flow Cabinet equipped with a state of the art filtration system can reduce airborne contamination levels greatly within the working area, depending on the filtration system of choice.

However, the most common application of the laminar flow cabinet is to provide an individual clean air environment for small items not requiring a full-size cleanroom. In the laboratory, individual laminar flow cabinets are commonly used for specialized work such as inoculation, culturing, media transfer which involves working/handling microbes etc. to eliminate airborne contamination would otherwise interfere with work processes.

There are three general areas in the field of microbiology related processes where laminar flow can be applied:

(i) "Product" protection. This area includes activities such as critical sterility tests and assays,
aseptic filling, tissue culture preparation, and other procedures which require that the material
should be kept sterile, but where personnel protection is not a problem. Standard horizontal
laminar flow clean benches can be used for these procedures.

(ii) "Personnel" protection. This includes the processing of infectious material and the inoculation of pure cultures of pathogenic microorganisms where technical personnel must be protected. For this, a laminar flow cabinet can be used.

2. Laminar Air Flow Cabinet

Laminar flow is a type of fluid (gas or liquid) flow in which the fluid travels smoothly or in regular paths, in contrast to turbulent flow, in which the fluid undergoes irregular fluctuations and mixing. In laminar flow, sometimes called streamline flow, the velocity, pressure and other flow properties at each point in the fluid remain constant. Laminar flow over a horizontal surface may be thought of as consisting of thin layers all parallel to each other.

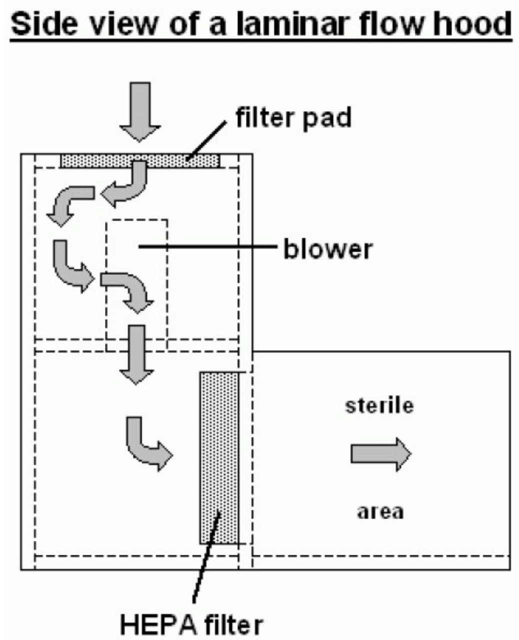
A supply fan passes air down through an ultrahigh-efficiency filter into the work area. A second fan exhausts the air through a grated work surface. Adjustment of the fans to exhaust more air than is supplied results in maintenance of a slight negative pressure which causes ambient air to move from the operator toward the exterior periphery of the work area, thereby creating a protective curtain of air. The air can be exhausted completely or can be partially recirculated if absolute filtration is employed.

Because of these characteristics of laminar flow, it has participated in clean room and clean bench technology for many decades. In general, the units consist of a bank of High Efficient Particulate Air (HEPA) filter(s) enclosed in a cabinet or hood. The air stream, at decent velocity, moves essential in parallel patterns so that the cleanliness of the air is independent of activities occurring down or cross-stream. Undoubtedly, laminar flow is the most important part of Laminar Flow Clean benches to provide an environment free from microorganisms moving inward to the workspace, with excellent and consistent results.

The most common standard referred to by most manufacturers of laminar flow systems is the US Federal Standard 209E. It is important to understand that the 209E does not apply specifically to laminar flow cabinets and that is only applies in general to air cleanliness for cleanrooms. The US Federal Standard 209E does not deal with general aspects of laminar flow cabinet construction. However, it deals with the most important aspect of cabinet performance which is the level of product protection provided (in other words the cleanliness of the air) within the working area of the laminar flow cabinet. Other standards and norms similar to the US Federal Standard 209E (dealing with cleanrooms and clean air) are the BS 5295, AS 1386, VDI 2083 and the recently released ISO standard 14664.

3. Working principle of Laminar Air Flow

Whitfield applied the principle of laminar air flow to existing clean room technology to develop the first laminar flow device. Whitfield's work indicated that total control of clean room air was essential, not only in terms of cleanliness (particle-free), temperature, and humidity, but also in terms of the direction of air flow within the room. To accomplish total control of air flow, Whitfield developed the laminar flow clean room. In this facility, large volumes of air were introduced into the room through a bank of HEPA filters. The filter bank acted as a large air supply diffuser and reduced the velocity of the supply air considerably. The air tended to leave the filter bank with minimum turbulence and in a unidirectional manner. Then, this air was exhausted from the room through a series of grilles that were equal in area to that of the inlet diffuser. Air flow was either from one wall (inlet) to the floor (exhaust), from the ceiling (inlet) to the floor (exhaust), or from one inlet wall to an opposite exhaust wall. In such a system, filtered (HEPA) air made one uniform pass through the clean room in either a vertical (downflow) or in a horizontal (crossflow) pattern.



Four advantages of this type of air flow control were obvious-

1. It provided the clean room with a self-clean-down capability to remove contamination brought into and also generated within the room;

2. It provided air flow patterns that carried air-borne contamination away from the work and the work area;
3. It reduced personnel restrictions; and
4. It reduced maintenance costs drastically.

The primary requirements for application of the laminar flow principle are: (1) that the space to be kept clean have walls or sides to maintain the laminar flow, and (2) that the air inlet and exit to the space each have an area equal to that of the cross section of the confined space.

Fox, the scientist has visualized the concept of minimum turbulence, unidirectional air flow (laminar flow) as follows: " consider several sheets of glass laid one on top of the other and
sliding down an inclined plate. While each individual sheet of glass may move down the plane with a somewhat different velocity relative to all of the other sheets of glass, each sheet of glass is confined to its own plane and does not enter the plane of any other sheet of glass. On the other hand, if the sheets were broken into small pieces and allowed to slide down the
same inclined plane, the pieces of one sheet of glass would intermix with pieces from other sheets of glass in a random manner. This latter condition is called turbulent flow . . .".

Experience with laminar flow equipment has shown that careful design, construction, and operation are necessary to obtain maximum benefits.

The design goals for laminar air flow devices are that-

1. The air flow shall be uniform in velocity and direction throughout any given cross section of the device, and
2. All air flow entering the device must be filtered through the inlet filter system.

Satisfactory application of the laminar flow principle to produce a clean environment depends upon two rather simple features-

1. Large quantities of air are introduced into the enclosure through a relatively large surface of HEPA filters; and
2. The filtered air is used in such a way as to wash the entire volume of the enclosure by a single pass through it, thereby providing clean air to the work area and carrying away work-generated contamination.

These two features, especially the latter, represent the ideal situation, and one that should always be sought, at least before critical activities are introduced into the enclosure. The critical activity is then placed within the room in such a way as to minimize any adverse effects on the ideal situation.

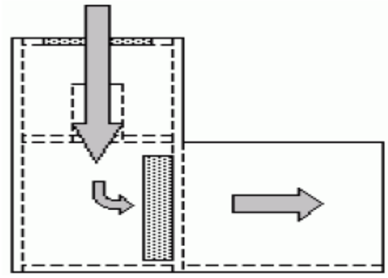
The HEPA Filter

HEPA filter stands for "**H**igh **E**fficient **P**articulate **A**ir" Filter and it is considered as the heart of all laminar flow clean benches. This filter removes particulates, generally airborne, such as microorganisms, from the air. However, it does not provide filtration to vapors or gases. The important features of HEPA filters are as follows:

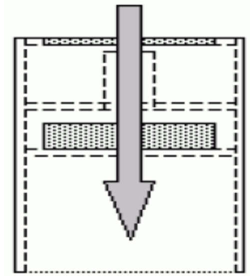
- ≅ Disposable dry-type filter, constructed of borosilicate microfibers cast into a thin sheet, much like a piece of paper.
- ≅ Particle retention is achieved by multiple mechanisms of HEPA filter working together including sieving, interception, inertial impaction and diffusion.
- ≅ Rated on their ability to retain particle 0.3 micrometers in diameter. If the filter allows one or less droplets to penetrate with an initial concentration of 10000, the filter is rated 99.99% efficiency.
- ≅ Variations in filter efficiency, for example from 99.95% to 99.99% are usually due to manufacturing techniques.
- ≅ Food, pharmacy and laboratory applications, in general, require a 99.99% filtration efficiency of HEPA filter(s).

4. Types of laminar air flow cabinets

In selecting a laminar flow cabinet, users often encounter both horizontal and vertical flow models. Here is the Information and differences between both systems in order to select an appropriate type for the specific application in the food industry.



horizontal air flow



vertical air flow

Vertical laminar (downflow) air flow

The vertical laminar air flow (Class 100) employs the basic downflow principle that supply air enters the room through a ceiling bank of HEPA filters and flows downward toward the floor in a laminar fashion. It is then exhausted from the room through a grated floor. After passing through the pre-filter (roughing filter), the return air is drawn up through plenums on either side of the room to be recirculated through the ceiling bank of HEPA filters. Thus, the room is ventilated with single-pass, unidirectional, minimum turbulence, clean air at a rate of 10 changes per minute or 600 per hour.

Normally, the vertical laminar air flow will operate within the Class 100 level of air cleanliness at air velocities up to 100 (usually 90 ± 20) feet per minute and will provide for very rapid removal of contamination generated within or introduced into the room. Under routine operating conditions, the Class 100 clean room is under a slight positive pressure that is sufficient to prevent external contamination from entering when the facility door(s) is open.

Horizonal laminar (crossflow) flow

The fundamental difference between this type and a vertical flow facility is the direction of air travel. Supply air enters the horizontal laminar air flow from a bank of HEPA filters in one wall, and is exhausted through the opposite wall. The plenums are located behind the HEPA filter bank and the grilles **in** the exhaust wall. Usually, the pre-filters are behind the exhaust grilles. The return air may travel over the ceiling, as a means of eliminating ducting, or through a side wall which has no openings, or under the floor via appropriate ducting.

The use of a vertical or horizontal laminar flow cabinet is large a matter of user preference. However, these are some minor differences to help you in your choice:

Horizontal laminar flow cabinets do not have surfaces that will cause the air stream to be deflected. In vertical laminar flow cabinets, the air stream effectively strikes the working surface, which will result in a certain degree of air turbulence. Large pieces of equipment in a horizontal laminar flow cabinet will increase turbulence, whereas in a vertical laminar flow cabinet large pieces of equipment will have a relatively insignificant effect on airflow. However, it must be noted that some degree of turbulence has an insignificant effect on laminar flow cabinet performance

How to use a laminar air flow cabinet

Before you start working in your laminar air flow cabinet you should do the following actions.

≅ Turn on the blower and wipe out the sterile area with an alcohol soaked piece of kitchen paper.
≅ Let the blower run continuously for 30 minutes. When this time has passed repeat the wipe out of the sterile area with an alcohol soaked piece of kitchen paper.
≅ Then the laminar air flow is ready for the intended use

The laminar air flow provides protection to products by ensuring that the entire workspace is solely covered with HEPA-filtered air.

However,

The laminar air flow is applicable and recommended for work with non-hazardous agents/materials where cross contamination is the most concerned issue, and therefore, particle-free air quality is required.
The laminar air flow, unlike laboratory chemical fume hood, is not designed to contain aerosols generated by the procedure. The personnel are exposed to these aerosols.

Laminar air flow is not Biological Safety Cabinets

These two cabinets, although there are not differed in appearance, are totally different and cannot substitute each other.

- ≅ Laminar air flow provides only product protection while (some type of) the Biological Safety Cabinet is capable for product, personnel and environment protection.
- ≅ Unlike biological safety cabinet, laminar flow clean bench is inappropriate for use with any potentially biohazardous materials including infectious agents, infected animal tissue and hazardous chemicals and volatile radioisotopes.
- ≅ Unlike clean bench, "mixed-contaminated" air, after passing through workspace, is drawn into front air grille of biological safety cabinet. This mechanism ensures none of contaminated air is exposed to personnel outside the cabinet.
- ≅ Unlike, laminar air flow, there is a HEPA exhaust filter in the biological safety cabinet. All air exhausted either to the room or outside is always clean and particle-free.

5. Biological Safety Cabinets

The biological safety cabinet (BSC), sometimes known as biosafety cabinet or microbiological safety cabinet (MSC), is a containment device equipped with HEPA filter(s), architected and designed to provide personnel, environment and/or product protection from biohazards.

1. Personnel protection from harmful agents inside the cabinet
2. Product protection from cross contamination occurred during the work, experiment or process
3. Environment protection from contaminants escaping from the cabinet toward outside

The classes of biological safety cabinets are classified based on their protection ability including personnel, product and environment protection, airflow velocities and patterns, and exhaust systems.

Class I Biological safety cabinet

- ≅ A Class I cabinet does not provide product protection from contaminants and any cross contamination because dirty room air is constantly drawn through front opening of the cabinet and flow across entire working area inside the cabinet.
- ≅ Personnel protection is achieved by constant movement of air into the cabinet, and thus, make contaminants being unable to spread outside.
- ≅ The cabinet is designed and suitable for work with microbiological agents assigned to biosafety levels 1, 2 and 3 where the only containment is required but not for product protection.
- ≅ Due to limit of scope and application of Class I cabinets, they are mostly considered obsolete.
- ≅ The HEPA exhaust filter installment inside the cabinet differentiates this type of BSC from conventional fume hoods which do not have HEPA filter installed, and thus, do not provide environment protection.

Class II Biological safety cabinet

- ≅ Inward dirty air is constantly drawn into an inlet air grille near front access opening and none of this dirty is passes over the work area in the cabinet. This mechanism provides protection to product on the work area.

- ≅ HEPA-filtered, vertical, unidirectional airflow is commonly seen within the work area.
- ≅ HEPA-filtered exhaust air can be either leave inside the room or exhaust to any exhaust system.
- ≅ The certain type of cabinet that is widely used in life science, clinical, hospital and pharmaceutical sectors because of its protection abilities.
- ≅ There are four subtypes, A1, A2, B1 and B2, for the Class II cabinets depended on different airflow patterns, velocities, exhaust methods and recirculation rate.
- ≅ Suitable for work with agents involving biosafety level 1, 2 and 3.
- ≅

Class III Biological safety cabinet

- ≅ The only class of cabinets provides an absolute level of safety that is suitable for work with agents assigned to biosafey level 1, 2, 3 and 4.
- ≅ Frequently specified for work involving the most lethal biological hazards.
- ≅ Always has physical barrier between personnel and product, e.g. gloves.
- ≅ During operation, negative pressure relative to ambient environment is obligated to maintain full level of containment.
- ≅ Double HEPA filtration in series or combination between one HEPA filter and air incineration are common in Class III cabinet to ensure absolute safety level.

Conclusion: Product or sample protection is important in a wide variety of modern industries. This includes the food, biotechnology, pharmaceuticals industries, in which clean air is necessary for the sterile production of products. A laminar flow cabinet provides a controlled environment in which levels of particulates, microbes, and contamination of all kinds are regulated and kept to a minimum by constant air filtration with industrial-grade filters.