THE DAIRY PRACTICES COUNCIL®

# GUIDELINES FOR ENVIRONMENTAL AIR CONTROL AND QUALITY FOR DAIRY FOOD PLANTS

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# ABSTRACT

This guideline provides an overview of what is involved in treatment of air for ventilation of dairy plants and factors to consider in establishing the level of quality needed and movement of air within a plant. Users should obtain enough knowledge to assess their basic needs and facilitate communication with engineers.

# PREFACE

This new guideline was developed by David P. Brown of the Department of Food Science at Cornell University. Dave Brown wishes to acknowledge and express appreciation to The King Co. and Mr. Bruce A. Paulson, Engineered Air-Systems, The King Co., for allowing the brochure Food Plant Process Air Conditioning to be used as a basis to develop this guideline. Appreciation also is expressed to numerous individuals who reviewed the manuscript and offered suggestions for improvement.

It is suggested this guideline is a logical companion to DPC 14, *Clean Room Technology*, DPC 56, *Dairy Product Safety (Pathogenic Bacteria)* for *Fluid Milk and Frozen Dessert Plants*, and DPC 57, *Dairy Plant Sanitation*.

# GUIDELINE PREPARATION AND REVIEW PROCESS

The Dairy Practices Council (DPC) Guideline development and update process is unique and requires several levels of peer review. The first step starts with a *Task Force* subcommittee made up of individuals from industry, regulatory and educational institutions interested in and knowledgeable about the subject to be addressed. Drafts, called "*white copies*," are circulated until all members of the subcommittee are satisfied with the content. The final "*white copy*" may be further distributed to the entire Task Force; DPC Executive Board; state and federal regulators; educational and industry members; and anyone else the Task Force Director and/or the DPC Executive Vice President feel would add strength to the review. Following final "*white copy*" review and corrections, the next step requires a "*yellow cover*" draft to be circulated to representatives of participating Regulatory Agencies referred to as "*Key Sanitarians*." Key Sanitarians may suggest changes and insert footnotes if their state standards and regulations differ from the text. After final review and editing, the Guideline is distributed in the distinctive DPC "*green cover*" to DPC members and made available for purchase to others. These guidelines represent our state of the knowledge at the time they are written. Currently, DPC Guidelines are primarily distributed electronically in pdf format without colored covers, but the process and designation of the steps remains the same. Contributors listed affiliations are at the time of their contribution.

# DISCLAIMER

## INTRODUCTION

Air is one thing common to all parts of a dairy food plant. The FDA Dairy Products Initiatives Preliminary Status Report makes the following statement: ". . .airborne contamination is strongly suspected as the cause of some pathogenic contamination. A comprehensive assessment of the air supply and utilization, both processing and ventilating air should be conducted." Air currents within the dairy food plant can move pathogens and other bacteriological contaminants existing within the plant environment into the product. (See DPC 56, Dairy Product Safety (Pathogenic Bacteria) for Fluid Milk and Frozen Dessert Plants.)

The Journal of Food Protection, September, 1989 issue states that "microorganisms in the air can exist in three ways; 1) as "passengers" on solid particles of dust, skin fragments or hair; 2) within droplets formed by the atomization of liquids by spraying, sneezing, stirring or activity; and 3) as isolated organisms resulting from the evaporation of water from droplets, or in the case of mold spores as a result of their natural method of preparation". The Journal also states that microorganisms in the dairy food processing plant air can be expected to be present in all three aerosol types. (Article: Evaluation of Air for Recovery of Biological Outbreaks in Dairy Processing Plants by Young, Kang, et al).

The environmental control system has been placed in a position critically important to the successful operation of a dairy food processing facility. Every feature, internal component and material used in an environmental control system must either contribute to control or be neutral in generation of contaminants. Even the best system must be properly maintained and sanitized to assure air purity control. This guideline will address the proper design of the environmental control system. The system should be large enough to provide access to all internal components. This allows for easy maintenance and service and for thorough inspection and sanitizing.

## CONTAMINANTS

It is obvious that potential product contaminants are extremely small. Air impurities may range in size from 0.001 to 100 microns and smoke particles from .01 to 1 microns. Bacteria are a plant-like organism ranging in size from 0.2 to 10 microns in size. The average size of a bacteria is approximately 1.5 microns. The typical mold spore is approximately 2.5 microns to 20 microns and a yeast spore size ranges from 4 to approximately 12 microns. Viruses are extremely small, normally 0.2 microns down to approximately 0.02 microns in size. A micron is 1/1000ths of a millimeter or about 1/25,000ths of an inch in diameter. In comparison, a human hair has a diameter from 50 to 100 microns.

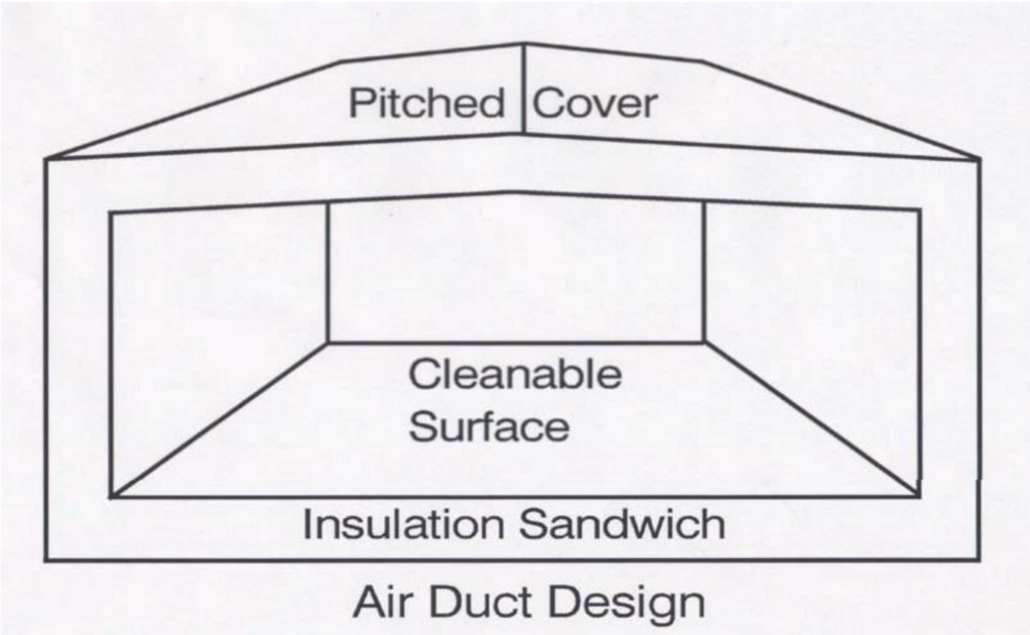
## THE ENVIRONMENTAL CONTROL SYSTEM

The environmental system controlling the air consists of diffusers, duct, grilles and dampers, but probably the most important element is the air handling unit itself. The unit provides the air moving devices, the heating and cooling, the humidification and dehumidification, and the air filtration requirements.

Standard single wall units, with exposed insulation on the interior of the unit, can act like a sponge absorbing moisture. This insulation can then become an excellent source for the growth of pathogenic organisms. Once contaminated, it is impossible to destroy these contaminants without also deteriorating the insulation itself. Even if the insulation does not become contaminated, exposed insulation may shed particles which can then be distributed into the room, possibly contributing to both product and personnel safety.

The FDA's report also states, "heating, ventilating and air conditioning systems should be designed for easy cleaning and should be periodically cleaned." Therefore, a properly designed environmental control unit should be a double wall construction. The inner liner (Figure 1) should completely enclose the insulation, isolating it from the air stream. Since the liner can also create a surface for a contamination growth, it should be sealed and be completely water-tight so the inside of the unit can be cleaned and sanitized. Generally, the liner is constructed of galvanized steel, but for some applications, stainless steel may be required.

**Figure 1. Air Duct Design**




Drains in the floor of the unit make effective sanitizing of the inside of the unit much simpler and more effective. Drains should be provided in each section of the unit. All drain pans should be completely drainable, preferably four-way pitch ( Figure 2) to the drain itself, so that no standing water is allowed.

[Standing water can provide all the growth conditions necessary for pathogenic organisms -- the moisture, the nutrients and proper temperatures.] The drain pans in the unit should be individually trapped so that contamination cannot be transferred from one section of the unit to the other. However, it is normally suggested that on the final filter section, the last section in the unit, the drain pan be simply capped. This section under normal circumstances should be dry and there is no reason for a continuous drain trap. This will eliminate the problem of the trap possibly drying out and having cross contamination between the other sections of the unit. When the final filter section requires cleaning, the cap can simply be removed and the cleaning solution either drained on to the roof or collected to be disposed of in some other manner. The cap should then be replaced after cleaning.

Component closures and supports within the unit must be specifically designed for cleanability. Flat horizontal closures must have the edges broken down so that the top can be cleaned. Pan type closures should not be allowed since they are excellent areas for accumulating contamination and are extremely difficult to clean. Closures and supports should be designed with no hidden or inaccessible areas. This allows easier inspection and cleaning of the unit interior.

## DAMPERS

1. Unit dampers should be of a single blade design. Airfoil type dampers have a hollow core, which in most cases, are not sealed at the ends. This unsealed hollow core can allow contamination to enter which can become virtually impossible to clean.

## COOLING AND HEATING COILS

The cooling coil can become one of the most contaminated components within the air handling system. Cooling coils, when in operation, are generally wet and relatively warm. Under most circumstances, these coils have collected enough airborne particulates to provide the moisture, temperature and nutrients for the growth of many organisms. Therefore, the coil must be designed so that it can also be periodically inspected, cleaned and sanitized.

**Figure 2. Drain Design**

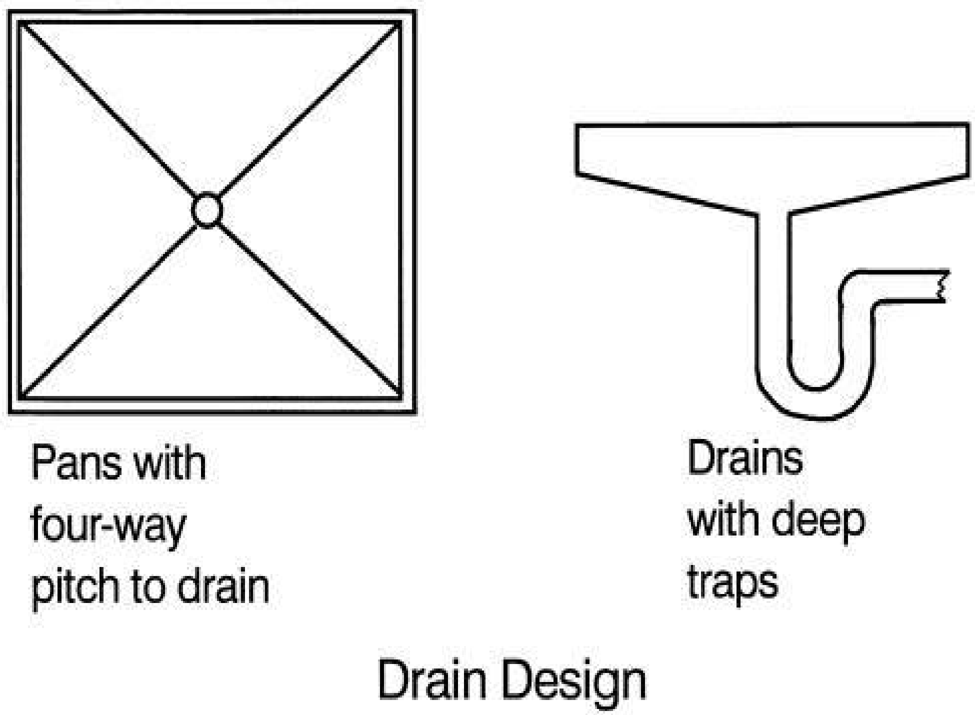
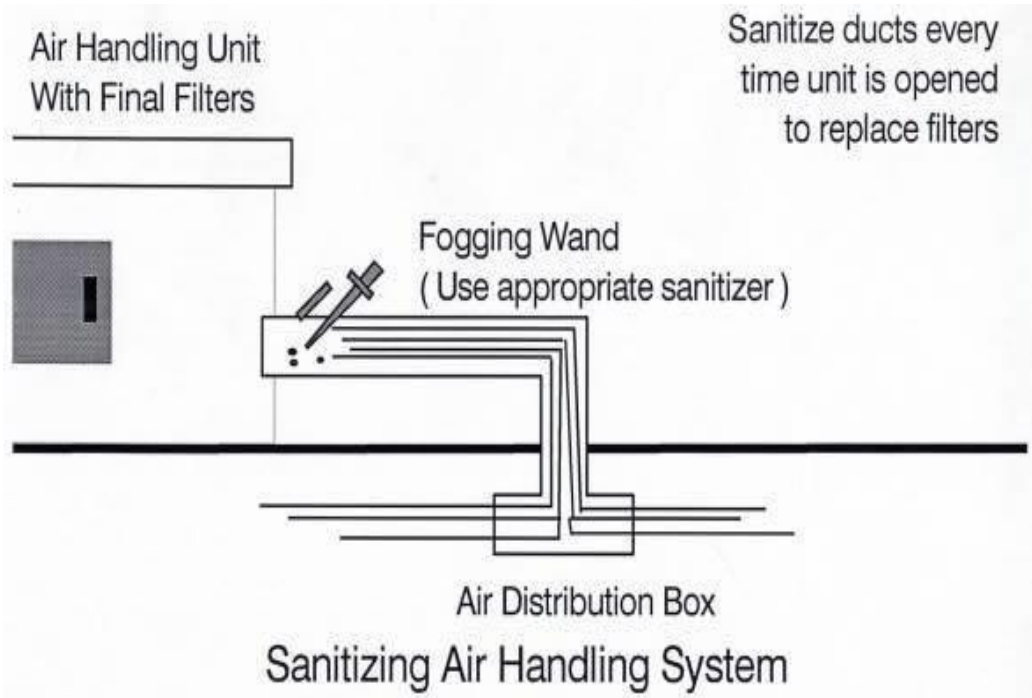


**Figure 3. Sanitizing Air Handling System**




No more than eight fins per inch should be used on a cooling coil. If more than eight fins per inch are used, cleaning becomes extremely difficult and in some cases, impossible. The type of fin is also important, since some fins tend to collect more contaminants and some, are much more difficult to clean. The most common fin designs are the spiral, ripple and flat fin. Both the ripple and spiral fin tend to collect more airborne particulate matter. Airborne matter tends to collect on the leading edge of any component within the airstream. The spiral fin, with its multiple leading edges, will collect vast amounts of contaminants. On the ripple fin, the airflow through the coil changes directions causing any airborne particulates to impinge on the fin, and accumulate. Admittedly, the ripple fin is more energy efficient on a BTU per square foot of coil basis, but it will generally accumulate more airborne particulate matter. Both the spiral and ripple finned coil are extremely difficult to thoroughly sanitize.

Ideally, the coil fins should be a flat, continuous plate design. The flat continuous fin has only one leading edge, minimizing the accumulation of contaminants. It is also much easier to clean due to the straight through flow design.

Heating coils should also have the same design features as cooling coils, even though they are not as susceptible to the collection of contaminants or the growth of bacteria since they generally operate dry.

Access should be available to both sides of the cooling coil. This is not only necessary for complete inspection of the coil, but most coils are deep enough so they will require cleaning from both sides.

## HUMIDITY CONTROL

In most areas of the dairy food processing facility, humidity control is important. The humidity should be kept as low as practical to minimize condensation formation on ceilings, walls and especially on cold surfaces of processing and filling equipment. [There are documented cases of product contamination attributed to condensation forming on processing and filling equipment and then dropping into the finished product.]

In most cases, it is not practical to try to keep the room at a dew point lower than many of the surface temperatures on some of the dairy food processing equipment. To accomplish this, the air dew point to the room would have to be kept at 35˚F (1.7˚C) or lower. A room temperature of 75˚F (23.9˚C) and a 35˚F (1.7˚C) dew point results in a 25% relative humidity. A 25% relative humidity is impractical to achieve without costly dehumidification equipment and special room construction. It has been found that humidities from 40% to 45% are low enough to minimize or eliminate most condensation formation.

## FILTERS

The major role of the air handling system is to eliminate airborne particulate contamination through the use of ultra-clean air. This is accomplished through the use of high efficiency filters. As mentioned above, most pathogenic organisms have sizes of approximately 0.2 to 10 microns in size. This size particulate is small enough that it does not have any significant settling tendencies. Therefore, in normal room air movement, these contaminants can stay airborne indefinitely. High efficiency filters are necessary to remove this airborne contamination.

The type of final filter will depend upon the application, sensitivity of the product, and the plant layout. The ultimate in filtration can be achieved through the use of an absolute or HEPA filter. The rating is 99.97% or 99.99% on a micron particle size. This filter will remove all yeast, mold and bacteria along with other particulates, down to 0.3 microns. The absolute filter is commonly used in such areas as hospitals and operating rooms, but can also frequently be used in such areas as culture rooms, starter rooms and sterile filling areas. This type filter is becoming more common in general food processing areas where sensitive products are present. Even in filling areas where a sterile filling machine has its own filtration system, it is suggested that the area around the filter also be conditioned.

As an alternative, air handling units can be equipped with what is termed a 95% or high efficiency filter as shown in Figure 4. The 95% filter will remove 95% of all particles 1 micron or larger. This is probably the most common filter used in the food processing industry. The 95% filter is capable of removing all yeast, mold and essentially 100% of all airborne bacteria. Note that even though the efficiency of the 95% filter indicates that it would not be effective on bacteria, since bacteria are smaller than 1 micron, the filter becomes very effective due to the inherent characteristics of most contaminants. Bacteria, and even some viruses, tend to agglomerate either to other bacteria or to dust and dirt particles, forming particles large enough to be removed by the 95% filter.

No matter which type of final filter is used, it should be located at the discharge of the air handling unit, downstream of the blower and any other internal components. This is important for two reasons.

First, when the final filter is located downstream of the blower (Figure 5), the final filter is maintained in a pressurized plenum. Therefore, there would be an out flow of air if there were any leakage in the unit casing. This can happen if the access doors are not tight, or if there are any other openings in the unit. In this way, contaminated air cannot be drawn in downstream of the final filter and be distributed into the room.

Secondly, it is also important to have the final filter downstream of any component in the unit that can become a source of contamination. As mentioned earlier, wet coils are an excellent breeding ground for many contaminants. Coil surfaces are not only the site of growth and dissemination of pathogenic organisms, but they can also generate contaminants harmful to personnel, such as Legionnaires Disease.

**Figure 4.  High Efficiency Filter**

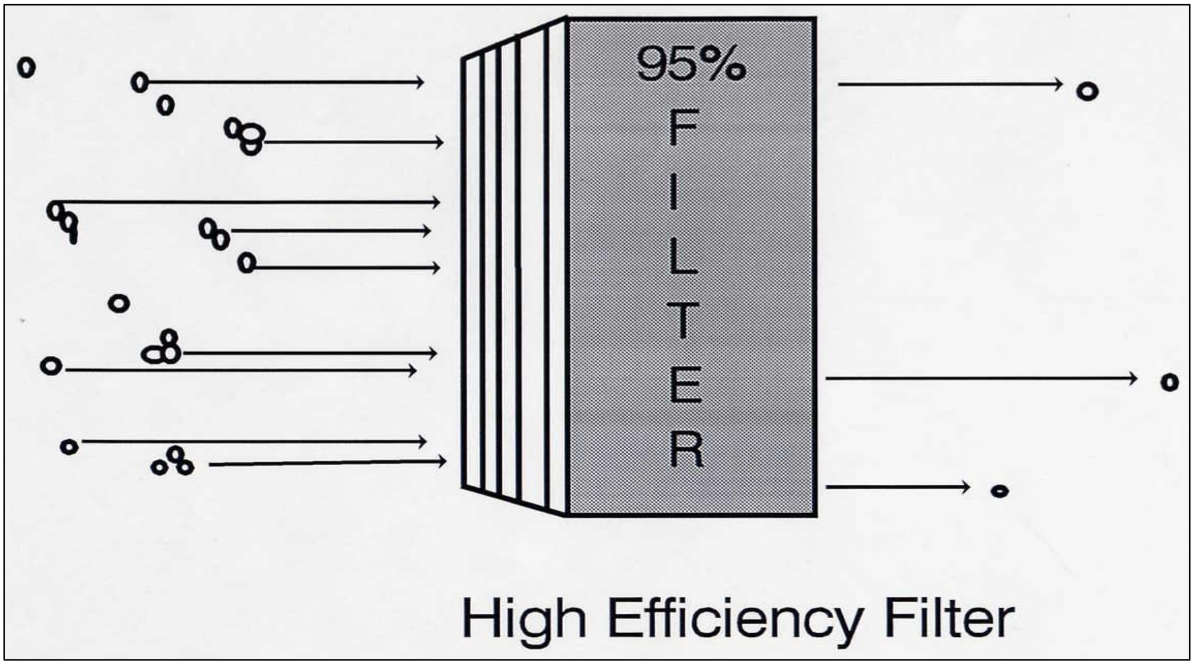
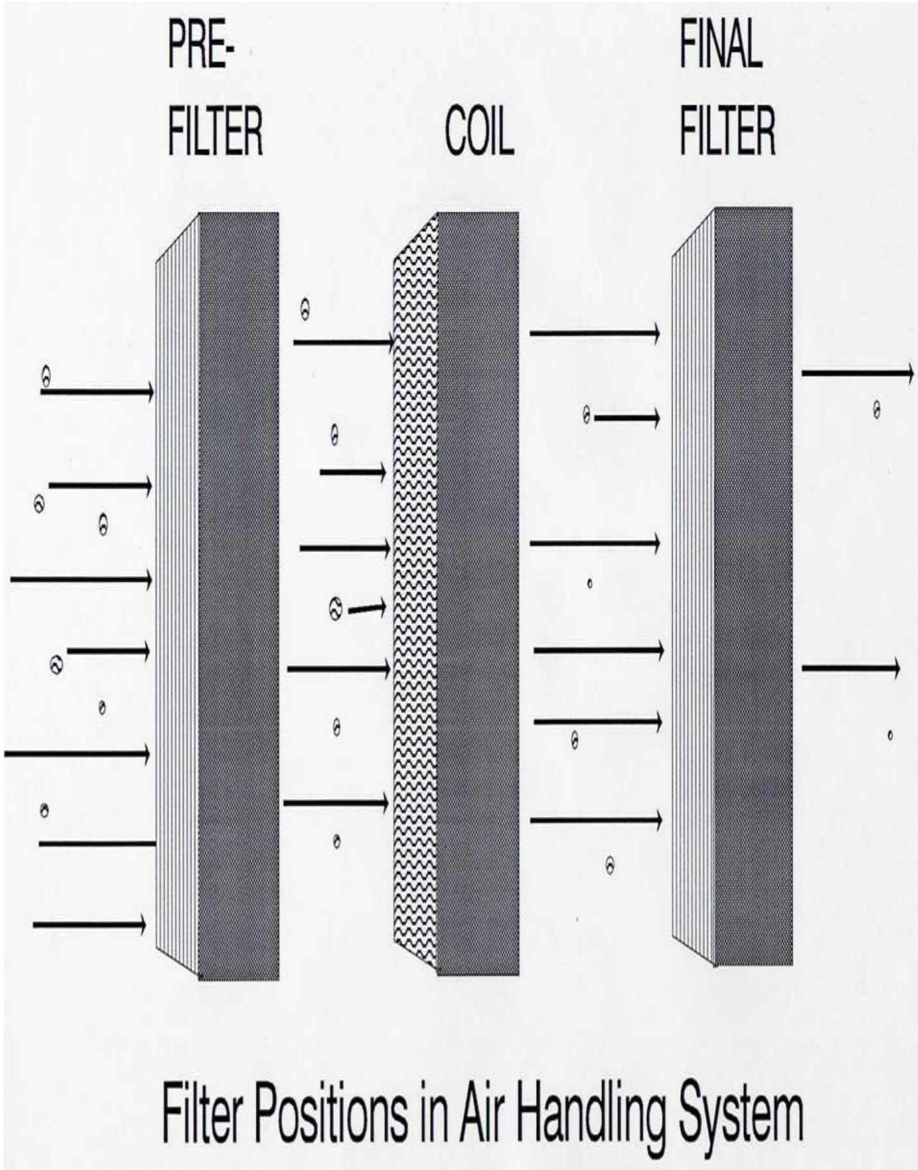


**Figure 5. Filter Positions in Air Handling System**



## PRE-FILTER

A pre-filter (Figure 5) should always be used at the inlet of the unit. The pre-filter will not only help keep the interior of the unit clean, it will also prolong the life of the final filters. There are three basic types of pre-filters; the permanent or washable, the low efficiency throw away pre-filter and the pleated or extended surface pre-filter.

The washable or permanent filter can be constructed of aluminum or stainless steel mesh. This filter is satisfactory for removing larger particles and it is designed to simply be removed from the unit, cleaned and sanitized and then returned to the unit pre-filter section.

The low efficiency pre-filter is also used primarily for removing larger particles from the inlet air stream. It is not efficient on the removal of smaller dust or dirt particles.

The most efficient of the common pre-filters is the pleated or extended surface pre-filter. Typically, these filters have a rating of 30%-35% on a 1 micron particle size. In the class of inexpensive disposable type pre-filters, the pleated filter is by far the best available.

The efficiency of the pre-filter has a direct relationship on the life of the high efficiency or absolute final filter. The following is a comparison of the life extension of an absolute final filter using various efficiencies of pre-filter.

| | |
|---|---|
| 2" Throw Away | 25% |
| Extended Surface | 35% |
| 60% Filter | 170% |
| 80% Filter | 520% |
| 90% Filter | 880% |

The exact type and efficiency of pre-filter will have to be determined by the specific application.

Most of the pre-filters and final filters available today are fabricated from fiberglass materials. Recently, many issues have been raised regarding the health and safety of fiberglass use in filters. As a result, the synthetic fiber filters have been developed and in some cases are gaining interest as an alternative.

Identification of asbestos as a carcinogen has resulted in fiberglass being one of the most thoroughly studied materials for health problems. However, there are significant differences between fiberglass and asbestos. One of the differences is that fiberglass is at least 160 times more soluble in fluids, such as in the lung than asbestos. Another difference is that fiberglass breaks perpendicular to the length of the fiber while asbestos fibers split lengthwise, resulting in even finer fibers.

The real issue involves the fiber shedding properties of fiberglass and synthetic filters. It is a proven fact that glass fibers will break off of a filter and then may be distributed downstream into the room. Studies generally show that all filters shed particles when they are new, but the amount of particles shed decreases rapidly after initial start-up and becomes essentially zero after a few hours of operation. This is true of both fiberglass and synthetic filters.

In general, epidemiological studies of workers exposed to the fiberglass have shown no statistically significant increase in lung cancer death rates compared to people living in the surrounding communities.

## SUPPLY BLOWER

The last major component in the air handling unit is the supply blower. Ideally, the blower should be arranged in a bottom horizontal discharge configuration. This configuration places the blower outlet at the bottom, so that no contaminants can collect on the inside. If a top horizontal discharge blower is necessary, the blower housing should have a drain, allowing the housing to be cleaned and sanitized.

Airborne contaminant cross contamination must be minimized by providing pressurization between the controlled area and any adjoining uncontrolled areas. As mentioned earlier, airborne dust, dirt, moisture and other particles will provide a method of transportation for contaminants. Many of these particles can also provide the nutrients for the contaminants growth. **Therefore, it is essential to have an out flow of air from all critical process areas.**

The dampers providing the outside air for pressurization can be controlled via two methods. First, the dampers can simply be manually adjusted to a fixed point. A fixed volume of outside air is probably acceptable for tight rooms and rooms which have low traffic patterns. This method is simple and generally acceptable for most dairy food process areas.

The second method modulates the outside air dampers, maintaining a specific positive pressure in the controlled room. A pressure gauge senses the differential in the room pressure and adjoining room pressure, modulating the dampers to maintain a constant room pressure. This automatic system is acceptable for rooms that have few openings and relatively low traffic patterns. However, rooms with large openings and frequent traffic flow may find the system less effective, due to its tendency to cycle.

The amount of outside air for pressurization will vary with each application. It depends upon the number of doors and openings in the area and their frequency of usage. How much outside air should be introduced into the room? As a rule of thumb, sufficient volumes of outside air should be introduced to maintain a minimum of 200 to 300 feet per minute velocity out any consistently open room penetrations, such as conveyor openings and transfer areas. this volume of outside air will provide a room pressure of approximately 0.005 to 0.01 inches water gauge pressurization. Of course, in addition to this volume of outside air, make-up air for process exhaust must be included in the total outside air volume.

## CLEAN-UP CYCLE

Outside air can also be used for the "clean-up cycle". Virtually all food processing facilities require some form of clean up. During this clean-up, large volumes of water, water vapors and heat are released into the room. This can result in completely saturating the walls, ceilings and other components within the room and potentially causing a personnel safety problem. The air handling unit's clean-up cycle is designed to bring in up to 100% outside air. At that time, exhaust units are energized. Therefore, relatively dry outside air is introduced into the room where it will absorb moisture, then the moisture-laden, warm air is exhausted. This system not only will remove the fogs and free moisture associated with clean-up, but will also help dry out the process area much faster after the clean-up cycle is complete.

## DISTRIBUTION DUCT

The other major component in the air handling system is the distribution duct. The duct must be designed completely air and water tight. The duct insulation must be installed on the exterior of the duct. In this way, the interior of the duct can be periodically cleaned and sanitized. If the duct is located on the roof, the top of the duct should be sloped for water run-off. This will prevent future service problems and possible contamination from leaking water into the duct. Of course, roof duct must also have the insulation weatherproofed. Insulation weatherproofing on the exterior of the duct can be of any material that will protect the insulation from the weather. It can actually have a galvanized or stainless steel jacket, plaster, plastic or any type of waterproof, weather-tight material.

Along the length of the duct, inspection and access doors should be installed. These inspection doors will be used for swabbing the interior of the duct, to determine its cleanliness, and also for cleaning the inside of the duct. Access doors should be of a size and location so that all the duct can be inspected and cleaned. In general, access doors should be located a maximum of 15 feet apart. They should also be located on both sides of any components within the duct, such as elbows, turning vanes, or dampers.

How should the duct be made and what should it be made of? If cost is not a consideration, the best duct for maintaining cleanability would be a round duct made of stainless steel. A round duct is much easier to clean and keep dry and there are fewer seams, cracks and crevices. Round ducts are also certainly easier to drain and are less susceptible to standing water. Rectangular duct, either stainless steel or galvanized steel, is certainly acceptable if it is made properly and is designed for inspection and cleaning.

If possible, neither the unit nor the duct work should be located within the process area. When the air handling components are located outside of the room, the exterior of the duct and the unit do not have to be cleaned or sanitized. It also allows maintenance personnel direct access to the equipment without disrupting the process or potentially contaminating the food product.

If the duct is located within the process area, it must be of a double wall type construction. Again, the inside of the duct must be of a water-tight design with the insulation on the outside. But in this application, the outside of the insulation must be covered with a material that is easily cleaned and will not deteriorate by the typical cleaning chemicals used in the room. If the top of the duct is exposed to the room, it should be pitched at a sharp angle so it does not become a flat ledge.

No matter where the duct is located, the amount of duct should be kept to a minimum. This will not only keep installation costs down, but there will be less duct to clean and maintain.

Internal duct components, such as turning vanes and dampers, should be kept to a minimum and if at all possible, eliminated completely. Turning vanes must be of a single blade type design. Airfoil type turning vanes and dampers should not be used, since they are normally not sealed and therefore, it would be impossible to clean between the two blades of the airfoil design.

## AIR DISTRIBUTION SYSTEM

Air distribution within the food process area is also a critical factor in controlling airborne contamination. As discussed earlier, contaminants require moisture for their growth. Without proper air distribution, the walls and ceilings can become and remain moist. This moisture provides an excellent medium for the contamination growth. There are documented cases of finding pathogens and other contamination on walls and ceilings, especially when the walls are continually wet. Excessive condensation can actually form droplets which can eventually fall onto equipment or into the product itself. Dry walls and ceilings will also reduce maintenance and repair costs.

For proper air distribution, a box-type ceiling diffuser (Figure 6) is suggested, preferably constructed of stainless steel. The diffuser must be insulated to prevent the formation of condensation on the exterior of the diffuser.

In lower temperature rooms, heating cable is also advisable on the bottom of the diffuser, again to prevent condensation formation. The registers on the diffuser should be of a double deflection type and be complete with a volume damper. In this way, air patterns and volumes can be adjusted to achieve optimum air distribution throughout the area. The registers should supply air horizontally across the ceiling at velocities from 800 to 1,200 feet per minute. The register size should be designed so that the air terminal velocity, at the walls, is approximately 100 to 150 feet per minute. Excessive velocity at the walls will cause a high velocity vertically down the wall, which can then possibly follow the floor causing updrafts under process equipment. The horizontal air flow type pattern will also minimize the turbulence within the room, helping reduce possible cross contamination between equipment and will help prevent the transfer of contamination from employees to the finished product.

Conversely, the standard ceiling diffusers ( Figure 7) provide a cone shaped air distribution pattern, blowing the air down toward the floor. This type of air pattern can induce room air back toward the diffuser, drawing moisture and contaminants up to the ceiling. The result can be a wet, contaminated and stained ceiling line around the diffuser. This type of air distribution can also cause excessive turbulence around equipment. The chances of cross contamination between equipment and between personnel and equipment are increased. There is a good possibility of air bouncing from the floor back up under the equipment.

**Figure 6. Box Diffuser & Horizontal Air Flow**

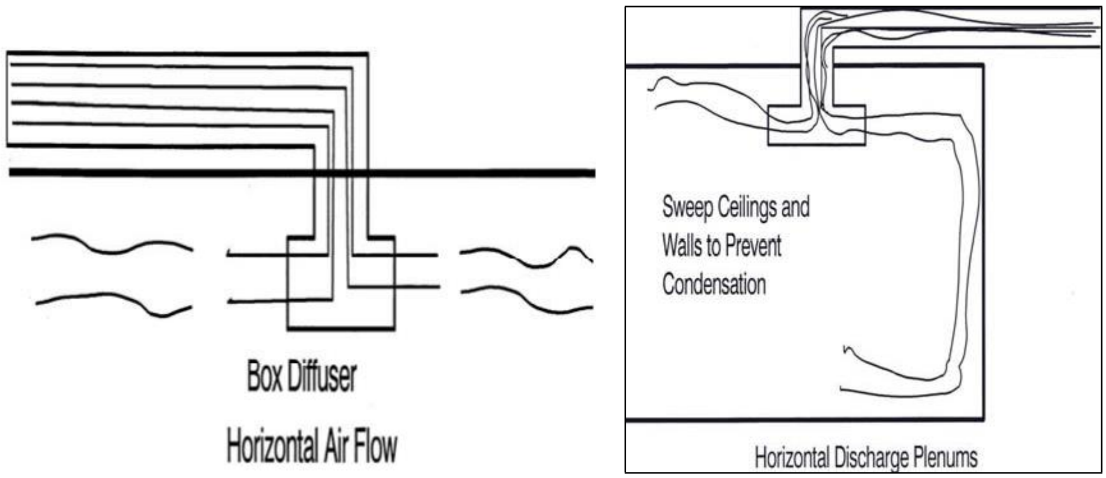
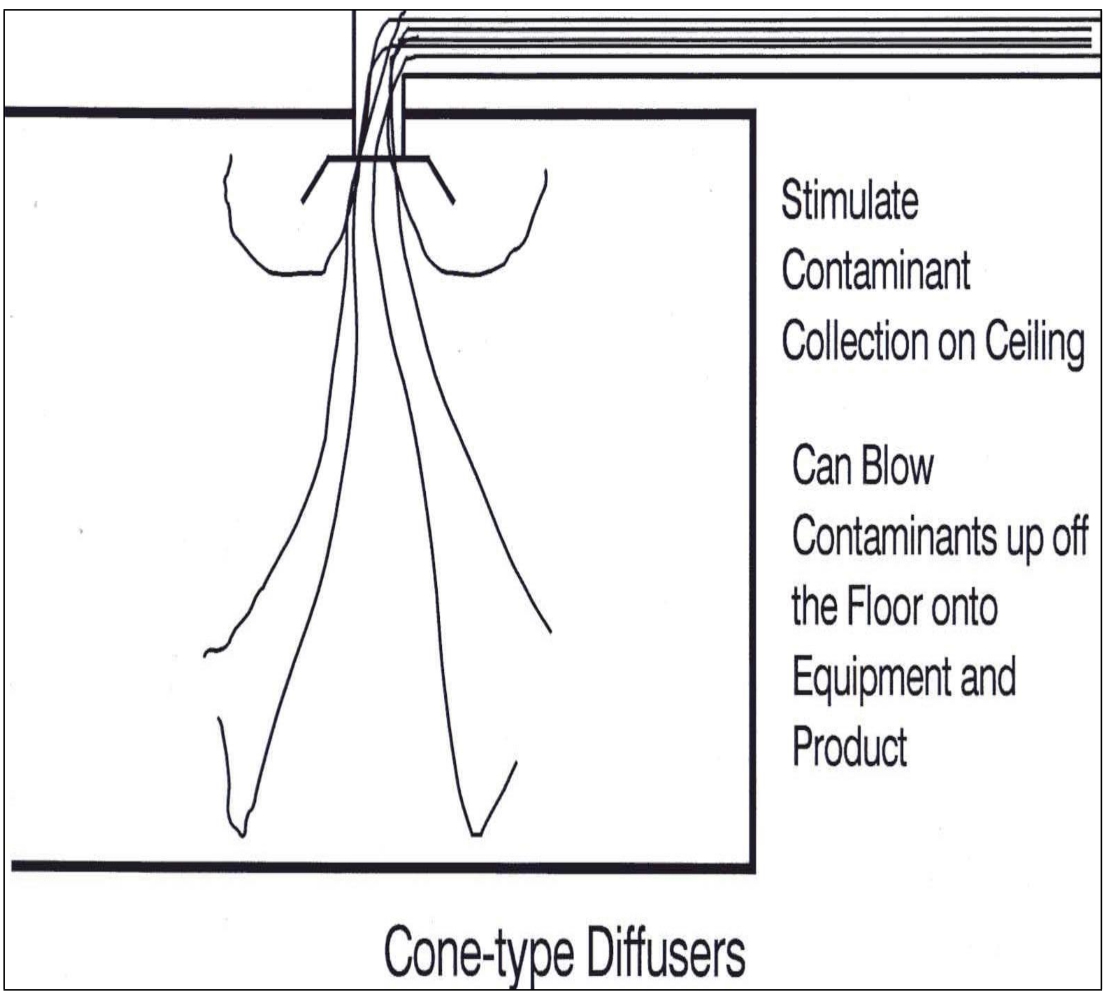



Figure 7. Cone-Type Diffusers



Under unusual conditions, there is a possibility of condensation forming on any diffuser. Therefore, diffusers should not be located over any vats, packaging machines or any piece of equipment handling a dairy product.

## SUMMARY

The selection of the best environmental control system and its respective components for a given dairy food process application will be dictated by the specific products criteria. However, no matter what the specific criteria, the air handling unit should:

1. Have a double wall, cleanable casing.
2. Have completely drainable pans.
3. Have single blade dampers.
4. Have properly designed coils.
5. Have the final filter located at the discharge of the unit.
6. Have accessibility to all components.
7. Have properly designed duct.
8. Have an air distribution system to maintain dry walls and ceilings.

## APPENDIX I - MECHANISMS OF FILTRATION

There are four main mechanism filters used to collect particles:

1. Impingement or inertial impaction: the air stream being filtered makes an abrupt change of direction as it passes around fibers in the filter. The particles continue on because of their inertia and collide with the filter fibers. This is the predominant means of collection for a washable or cleanable pre-filter and to some extent the throw away filter. This collection method is most effective for large particles at high air velocities. However, it does operate to some degree on all particles.

2. Straining: the air stream must pass between the filter fibers through a passage less than the particle diameter. This causes the particle to be stopped and held and is most often observed in the collection of large particles.

3. Diffusional effects: very fine particles are bombarded by the random motion of air molecules and driven into the filter fibers positioned across the air stream. A similar effect takes place when turbulence is present. Diffusional effects increase with decreasing particle size.

4. Electrostatic effects operates on the principle that objects with opposite electrical charge are attracted to one another. This mechanism is employed by the electronic air cleaner to attract particles to their collecting plates. Under certain circumstances, electrostatic charges may be created with thin fibrous filter media which then assist in the collection of dust and contaminants.

## APPENDIX II - PREVENTIVE MAINTENANCE

The most advanced, critically designed environmental control system will only maintain proper environmental control for a short time if it is not serviced, maintained and sanitized regularly. As mentioned earlier, there are three different types of pre-filters. Regardless of which pre-filter is used, they are generally changed or cleaned approximately every two to four weeks, depending upon the location, season of the year and the specific application. How do you know when the pre-filter should be changed? One method is to use a differential pressure gauge to determine the pressure drop across the filter. This will work satisfactorily on the pleated, higher efficiency pre-filter, but with the other two types of pre-filters, the pressure drop change is generally too low to be read accurately on a pressure gauge. More commonly the pre-filters are changed on a visual determination or simply as part of a regular maintenance schedule.

Whenever the pre-filters are changed, the inlet section of the unit should be cleaned and all insects, dirt and debris be washed out of the filter section. Filter frames, holding clips and gasketing should be checked to ensure a tight seal when the new pre-filter is installed.

The life of either the 95% or HEPA, absolute, filter will average between 10 and 16 months depending upon the quality of the pre-filter and the frequency at which the pre-filter is changed. Due to the high cost of the final filters, it is recommended that they are only changed on the basis of a differential pressure switch. Visual inspection is not a reliable method for determining final filter life. Typically a 95% filter will have an initial, or clean, pressure drop of 0.5 to 0.6 inches and should be changed when the pressure drop reaches 1.0 to 1.2 inches.

The absolute or HEPA filter will have an initial pressure drop of 1.0 to 1.25 inches. The filter should be changed when the pressure drop reaches approximately 2.0 inches water gauge.

When the final filters are changed, the final filter section itself should be completely cleaned and sanitized. This includes all of the walls, final filter frames and the drain pan of the unit. Each individual holding frame should be inspected carefully to make sure that the holding clips and the integrity of the gasket are such that they will provide a complete airtight seal when the new filter is installed. The spaces between the final filter frames should also be checked to make sure that the sealant or caulking has not deteriorated, allowing bypass between the frames.

When changing the final filters, extreme care should be taken so that the back side of the final filter does not become contaminated. The back of the filter should not be allowed to brush against the unit casing, cartons, boxes or personnel clothing. If the back side of the filter should become contaminated, it can discharge its contaminant into the room. There is virtually no way to clean the filter and therefore it would have to be replaced.

Both types of final filters should be installed so that the pleats are in the vertical position. This will prevent sagging of the filter material which can then cause early deterioration.

When comparing the efficiency of different types of filters, caution must be exercised since different test methods will give vastly different percentage efficiencies on the same filter. Also when comparing filters, its total surface area, dust holding capacity and its initial and final pressure drops should be compared.

Proper maintenance and sanitizing of the environmental control system should consist of:

1. Regular changing of the pre-filters.
2. Changing of the final filters using a differential pressure sensor.
3. Cleaning and sanitizing of the interior of the unit.
4. Cleaning and sanitizing of the interior of the distribution duct.
5. Checking the unit controls and tightening unit control terminals.
6. Checking control dampers
7. Checking blower bearings and blower belts.
8. Checking the unit casing components.

## APPENDIX III - CLEANING AND SANITIZING

The cleaning and sanitizing of the air handling unit is critical to maintaining a consistent high air quality. Of primary importance is the ability to clean the inside of the air handling unit. Periodically, the inside of the unit should be washed with a detergent and then sanitized.

The unit drains and drain traps should be periodically checked. The traps should be checked to make sure that they have an adequate water seal. Dried out drains not only prevent adequate draining of the drain pans but may allow cross contamination between unit sections.

The cleaning and sanitizing of the air distribution duct is also critical. The interior of the duct work should be inspected at least twice a year and preferably more often. The inside surfaces should be swabbed to determine the extent, if any, of contamination.

Choosing the best type of sanitizer in a food plant air handling system requires considering many factors. No single sanitizer is ideal for all uses within the food plant. Each has its advantages and disadvantages, which are related primarily to the chemical properties. Selection of a sanitizer should be based on the type of surface to be sanitized, the water hardness, the type of sanitizing equipment used, the sanitizer effectiveness and cost.

When using sanitizing compounds, it is important to remember that a thorough cleaning is essential before sanitizing. The effectiveness of a sanitizer is greatly reduced if dirt or other particles are present on the surface.

The most common sanitizers used in food plants belong to four basic groups: chlorine compounds, iodine compounds, quaternary ammonium compounds and acid-anionic surfactant germicides. Selection of the wrong sanitizer can have adverse effects on the life expectancy of the air handling unit and the resulting air quality. Your chemical representative can give you the options that best fit your application. Also see DPC 29, Cleaning & Sanitizing in Fluid Milk Processing Plants.

# APPENDIX IV - QUALITY ASSURANCE

All microbial testing should be done following **Standard Methods for the Examination of Dairy Products** 16th Ed., APHA. If sampling equipment is used that is not listed, the manufacturer's recommendations should be followed. If testing is done on a "clean room", follow the protocol of FED-STD-290E. Although sedimentation plates are easy to use, they may not be the best method for enumeration where small numbers are expected. More reliable enumeration may necessitate the use of quantitative methods. Frequency of monitoring may need to be daily, weekly, or at some longer interval based on experience and need.

There are two levels of quality assurance to be done when dealing with environmental air. The first is the testing of the air handling system to verify that it is functioning properly. Results should be evaluated compared to the performance standards of the manufacturer of the system.

The use of swabbing techniques for the air handling unit interior, duct work and equipment in the critical room can help establish a baseline to detect if a problem does occur. Air plate counts can be used to check the integrity of the air handling system. Conducting routine air plate counts can also help detect a problem before serious product contamination can occur. [The plate count results can also be first indicators of such things as holes in the final filters or air leaks around the final filters.] When testing the air from the air handling unit, the sample should be taken from the inside of the supply air duct or from the inside of the supply air diffuser. Taking a sample from a ledge outside of the duct work or outside of the register, may give a false high reading. Air flow out of the register or duct will tend to induce room backup over the sample devise.

Second is to evaluate the air quality within the area of concern. Except for clean rooms (FED-STD-209E), there are no standards for this evaluation. An average value of 275 organisms/$m^3$ has been reported for a dairy plant with normal values from 100 to 500 but values as high as 1000 organisms/$m^3$ have been encountered. These numbers might be acceptable for a receiving area but would be excessive for areas where pasteurized product is exposed or where packaging is occurring. A starting point would be to apply the same standards as for a micro laboratory of 15 organisms per 15 minutes on a sediment plate. If selective media for yeast and molds is used, this number should be reduced to 6 to 8 organisms. Specific numbers for different areas within the dairy food plant will have to be established by each operation.

If the air handling unit is functioning properly, but significantly higher numbers are encountered for the area, investigation should be initiated to find the cause(s). Things to look for would be any source of drafts, causes for air currents, sources of dust or particles, and things that might generate aerosols. The things that might generate aerosols are case washers and the use ofhigh pressure water hoses to clean equipment.

Environmental control within the food plant is certainly only one aspect of a total plant quality control program, but it is a very important part. It is critical to properly design the air handling system, provide the system with adequate maintenance, thoroughly clean and sanitize and verify the proper functioning by routine monitoring.

# APPENDIX V - GENERAL MAINTENANCE

Maintenance of the air handling unit is also important so that proper temperature, humidity and air volume are supplied at all times. Semi-annually, the complete control system should be checked and any defective components replaced immediately. All terminal contacts should be checked and retightened semi-annually since they tend to loosen due to the heating and contraction of the electrical wires.

Outside and return air dampers should be checked annually to make sure that they are working properly. Replace all rusted, corroded or ceased damper bearings and make sure all the linkage is operational.

Semi-annually, check the blower bearings and grease them as required. Note--do not over grease ball bearings.

Blower belts should be examined semi-annually for wear and proper tension. Worn belts should be replaced with a set of matching belts.

The casing of the unit should be checked annually. All door gasketing should be inspected and maintained such that it provides a positive, airtight seal. On units with section splits, inspect the seal between the sections to determine its watertight and airtight integrity. Also, clean and inspect the outside air inlet hood or louver screens to make sure that they are free of all foreign debris.

Finally, the air handling unit should run continuously, being stopped only for service or maintenance. Whenever the unit is off, there is a possibility of contaminated air migrating back up thorough the supply duct and contaminating both the supply duct and the back side of the final filters. This will cause excessive maintenance and cleaning of the interior of the duct and may also cause premature final filter change requirements.

## APPENDIX VI - GLOSSARY OF TERMS

| | |
|---|---|
| **Air Conditioning** | The act of controlling the condition of air; that is, temperature, humidity, purity and movement. |
| **ASHRAE** | American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. ASHRAE Handbooks are the recognized authority on engineering procedures and current practices relating to heating, refrigeration, air conditioning and ventilation. |
| **CFM** | Cubic feet per minute -- volumetric flow rate used to characterize the amount of air needed in a specific application. |
| **Dew Point** | The temperature at which water vapors start to condense on surfaces. |
| **DOP** | Dioctyl-phthalate is the compound used to produce 0.3 micron particles. These particles are used to calibrate filters for their efficiency using a light scattering photometer. |
| **FED-STD-209E** | Defines standard classes of air particulate cleanliness and specifies methods for verifying those air cleanliness classifications. |
| **FPM** | Feet per minute - Velocity measurement used to characterize air flow. |
| **Face Velocity** | The velocity of air as sensed at the filter in the air handling system. |
| **HEPA** | High efficiency particulate air produced with filters capable of removing at least 0.3 micron particles from air. Usually 99.97% but can be found at 99.99% and 99.999%. |
| **Humidity** | The amount or degree of moisture in the air. |
| **Inches Water Gauge (W.G.)** | Measure of pressure that may be multiplied by 0.03613 to obtain lbs./sq. inch (psi). |
| **Laminar Flow** | Continuous flow in a specific direction with no irregular movement (straight line). |
| **Make-up Air** | External air brought in to provide the needed volume of air for pressurization of an area. |
| **Media (filter)** | The material a filter is made of such as cotton, fiber glass, or synthetic fiber. |
| **Micron** | 1/25,000th of an inch or 1/1,000th of a millimeter. |
| **Pressure Drop** | Change in pressure -- usually associated with air flow through a filter. Filters are rated at 1 inch W.G. drop and are considered fouled when this reaches 2-3 inches W.G. drop. |
| **Pressurization** | Operation of a room at greater pressure than surrounding areas, resulting in an out flow of air from higher pressure area to lower pressure area. |
| **SCFM** | Standard cubic feet per minute as measured at specified conditions of 68˚F (20.0˚C) at Sea Level (29.29" of mercury). |
| **Turbulent Flow** | Random movement in a direction causing intermixing and resistance to flow. |