Mechanical Components

In this Section:

- *Fume hoods*
- *Laboratory or clean room space airflow devices*
- *Laboratory supply and exhaust air handling systems*

Fume Hoods

As set forth in the Scientific Apparatus Manufacturer's Association (SAMA) standard of laboratory fume hoods (referred to as fume cupboards in Europe and the UK crown colonies), the primary reason for using fume hoods in a laboratory is SAFETY. They are used to provide safety to the hood operator and to other personnel in the laboratory as well as the rest of the building. The fume hood provides a mechanical means of capturing and exhausting all contaminants, vapors and fumes— especially toxic and dangerous fumes.

How well this process works depends on hood design, the associated hood exhaust fan and ductwork system, the adequacy of makeup air and the proper control of all the related airflow elements. The discussions in this manual are limited to the control of the airflow elements because the other factors lie in the hands of the manufacturers of the respective equipment. It is, however, important to be cognizant of how poor decisions on the part of others can drastically affect the ability of the Auto-Flow system to perform as required.

Under its section on ventilation in laboratories OSHA gives the following guideline for hoods,

"A laboratory hood with 2.5 linear feet of hood space per person should be provided for every two (2) workers if they spend most of their time working with chemicals; Each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use; If this is not possible, work with substances of unknown toxicity should be avoided or other types of local ventilation should be provided."

Additionally, under a description of general rules related to the use of hoods the following guideline is set forth:

"Hoods should be used for operations which might result in release of toxic chemical vapors or dust. As a rule of thumb, use a hood or other local ventilation device when working with any volatile substance with a TLV of less than fifty (50) parts per million (ppm). Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made; keep materials stored in hoods to a minimum and do not allow them to block vents or airflow. Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general ventilation will be maintained when it is "off"."

Bench style Laboratory Chemical Fume Hoods

OSHA defines a "Laboratory Type Hood" as a device located in the laboratory, enclosed on five sides with a movable sash or fixed partial enclosure on the remaining side; constructed and maintained to draw air from the laboratory space and prevent or minimize the escape of air contaminants into the laboratory space; which allows chemical or biological manipulations to be conducted within the enclosure without the insertion of any part of the operator's body other than hands and arms. "Bench Style" refers to the fume hood that has its work surface about 3 feet from the floor. This style is mounted on a bench or base cabinet. SAMA simply defines a "bench mounted hood" as "a fume hood that rests on a counter top" (See Figure #1).

The following major components are associated with a typical laboratory chemical fume hood:

1. **fume hood sash**-a movable panel set in the fume hood entrance or face access opening. This panel is normally transparent to allow the operator to see the processes in the fume hood while at the same time protecting him from contaminants.
2. **work surface**-the area inside the fume hood where the apparatus rests and where the operator manipulates the process. The surface is designed to contain spills.
3. **baffles**-the panels across the back and top of the interior that control the airflow pattern of the fume hood.

4. **bypass airfoil or bypass deflector vane**-the curved or angular member at the work surface entrance of the fume hood used to direct airflow across the work surface.

5. **side airfoils**-the curved or angular members located at the sides of the fume hood used to smooth airflow into the fume hood entrance
6. **bypass vents**-the compensatory vents or slots in the top facia or lintel and/or top opening of the fume hood used to provide an airflow path into the fume hood when the sash is fully closed—usually seen in bypass or partial bypass fume hoods.
7. **duct collar**-the fitting where the fume exhaust system ductwork is connected to the fume hood; a transition from the area behind the baffles to the exhaust ductwork through which all hood exhaust passes.
8. **liner**-the interior lining used for the side, back and top enclosure panels, hood exhaust plenum, and baffle systems of a laboratory fume hood, usually constructed of corrosive resistant material.
9. **hood exhaust plenum**-the area behind the hood baffles used to equalize airflow.
10. **work space**-the part of the fume hood interior where apparatus are set up and fumes are generated. It is normally confined to a space extending from 6 inches behind the plane of the sash to the face of the baffle, and it extends from the work surface to a plane parallel with the top edge of the access opening.

CAV or Bypass Fume Hoods

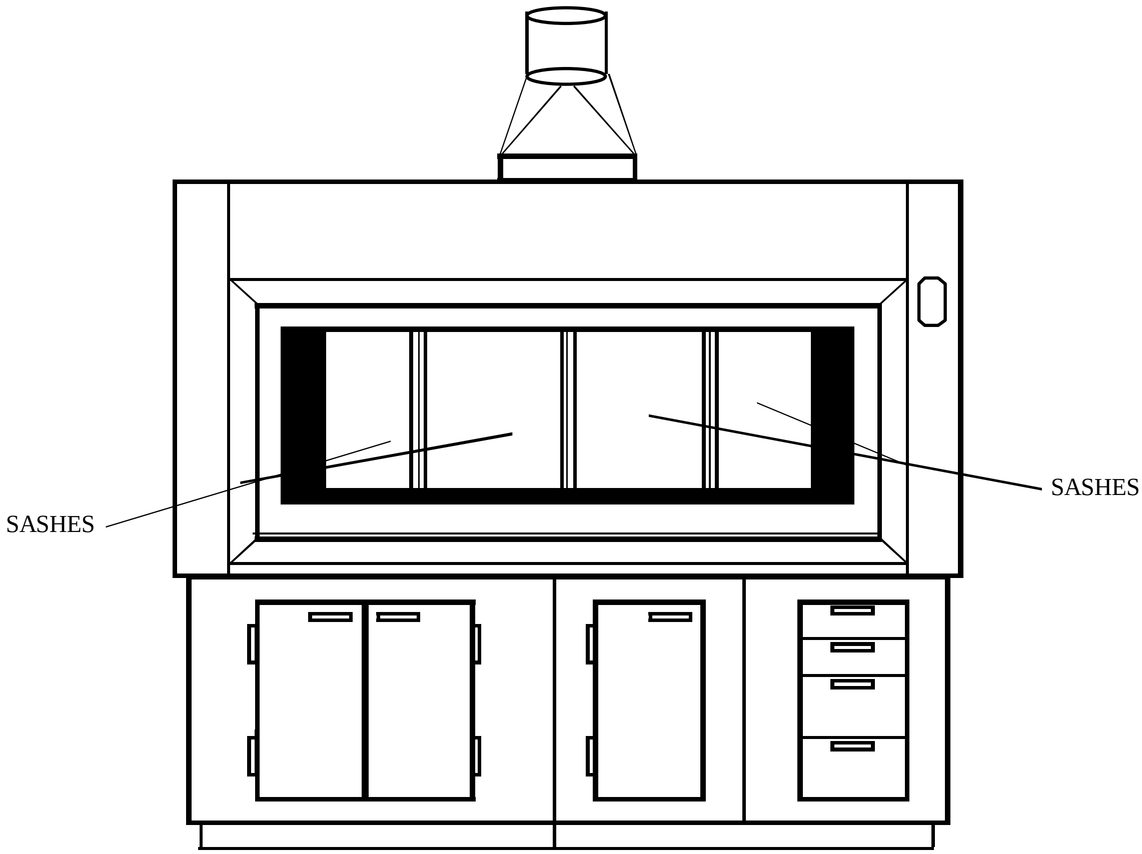


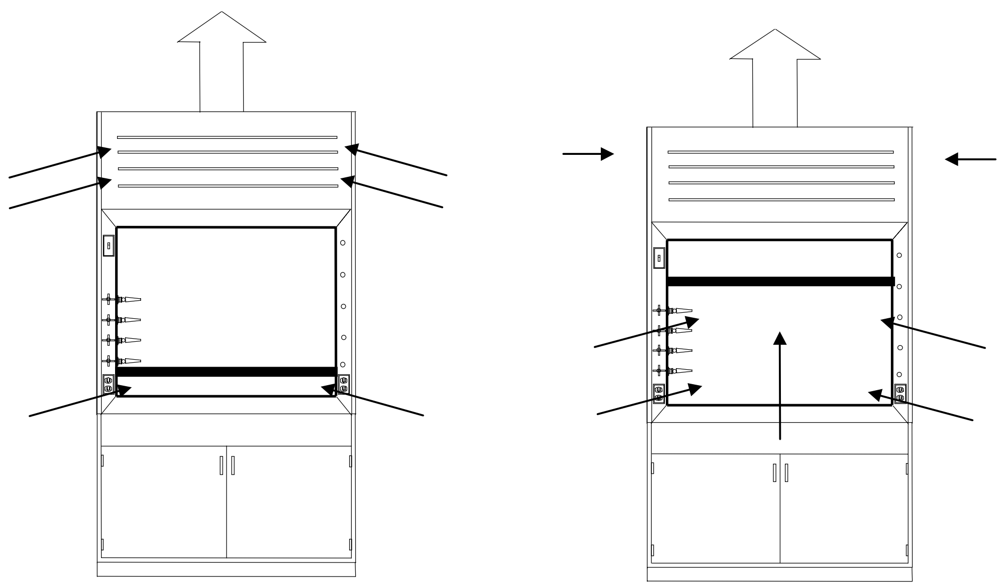
Figure 1 Fume Hood

The constant air volume (CAV) fume hood is frequently known as the conventional fume hood because it represents the oldest and simplest hood application. This hood essentially meets the standard definition of a fume hood. What makes it simple is the fact that the only control element is the sash.

Basically, the hood exhaust volume is balanced to a specified amount, usually the amount of CFM required to maintain the desired face velocity at the two-thirds sash open position. As the hood sash is *raised* above the two-thirds position, the face velocity in a 6 foot bench hood drops as much as 30 to 35 FPM. When the sash is *lowered* from the two-thirds position, the face velocity increases, in some cases as much as 50 FPM. As the sash is lowered the bypass vents in the hood lintel are uncovered, thus exposing the vents to the hood interior (See Figure #2). Airflow through the vents helps to offset the increase in face velocity because some of the now reduced air volume enters through them. However, the area of these bypass vents is not proportional to the change in area at the fume hood face so compensation is not enough to maintain the desired velocity. There is also some bypass area over the top of the hood lintel where the sash moves up through the top of the hood.

Early fume hoods did not have the small advantage of the bypass vents. The main disadvantage of a hood without a bypass is the lack of uniform face velocity over the full operating range of the hood sash. As described earlier, when the sash is at its maximum opening, the face velocity often-

Figure 2 Constant Air Volume Fume Hood



Constant volume fume hood with sash at low position = high flow and high velocity through bypass vents with some flow at higher than desired velocity through sash.

Same fume hood with sash at high position = low flow and velocity through bypass vents with higher flow at desired velocity through sash opening.

drops below the desired level necessary to maintain containment. When the sash is at its minimum position, the face velocity increases to the point where undesirable turbulence may occur. This undesired turbulence is most often referred to as the "roll effect" (See Figure #3). In the roll effect, contaminants generated inside the fume hood can become highly concentrated and actually be pushed out of the hood, through the sash, and into the lab to create a safety hazard. This turbulence can also cause problems with experiments and/or apparatus within the hood.

The second disadvantage of a hood without a bypasss involves long term stability of the hood

replaced, a large amount of conditioned air is continuously wasted. One early method of controlling this energy loss is the auxiliary air fume hood (described in detail later). The auxiliary air hood provides a makeup air source directly above the fume hood face that delivers unconditioned, or partially conditioned, air directly in front of the fume hood face. The makeup air is drawn into the open sash— or through the bypass vents when the sash is closed. The volume of makeup air is set to some amount less than the air volume required by the hood exhaust in order to ensure that all auxiliary air leaves the space through the hood.

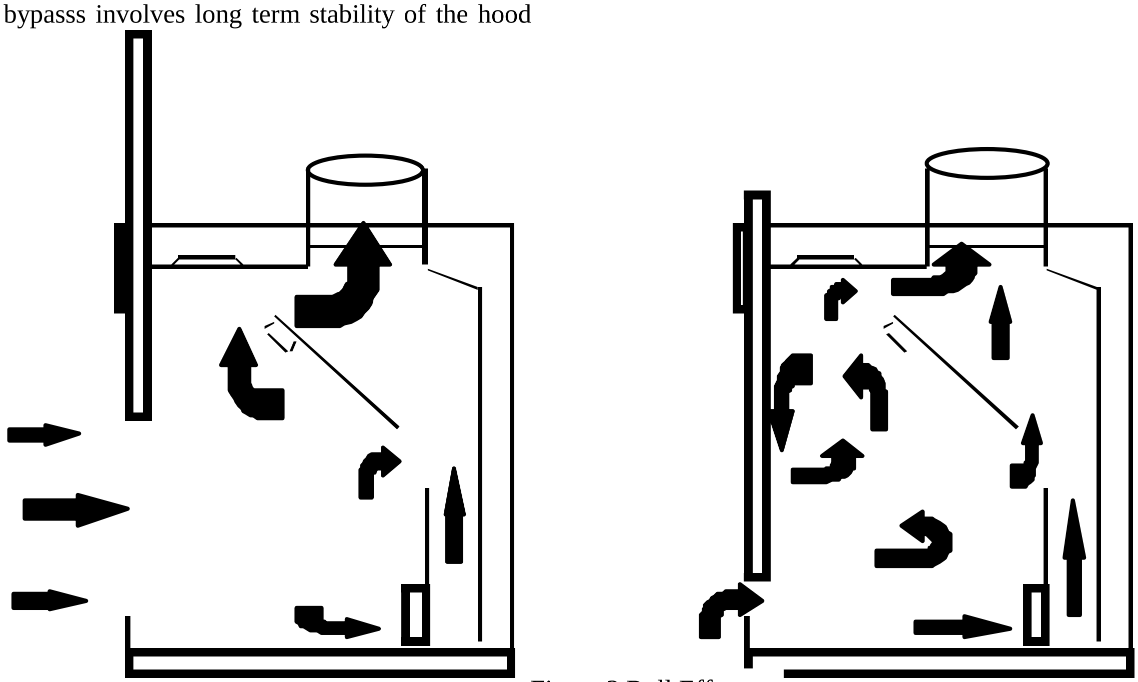


Figure 3 Roll Effect

Figure 3

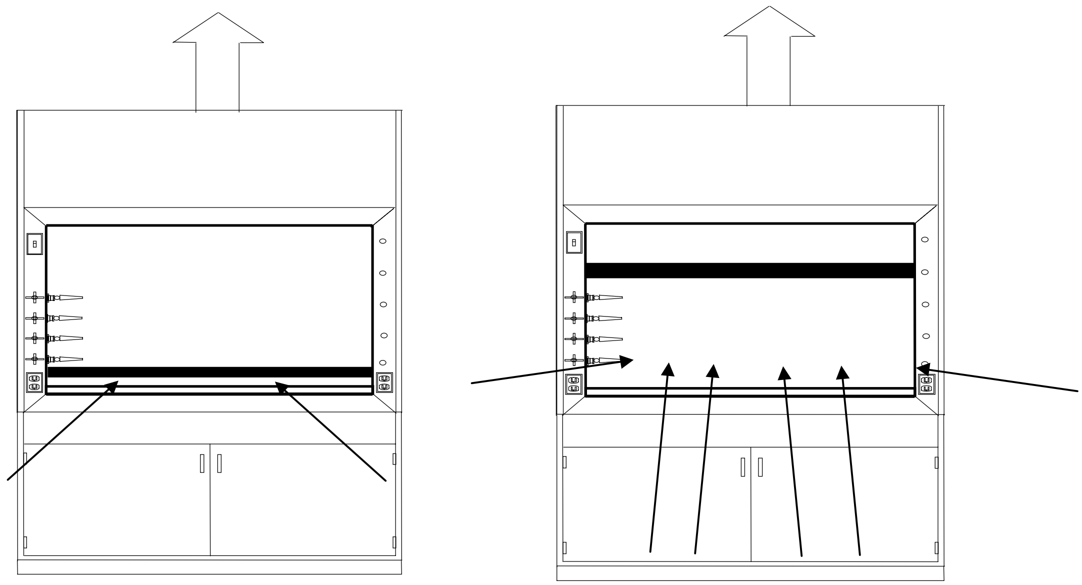
face velocity. A hood like this has a volumetric damper in its exhaust which is manually adjusted during balancing to a particular duct system static pressure in order to achieve the desired volume. The problem occurs when the exhaust system static pressure varies— hood volume varies directly with this pressure creating extreme changes in face velocity and posing a safety hazard.

The third disadvantage is associated with the energy costs of a constant volume hood. Since all of the air exhausted from the laboratory has to be

VAV Fume Hoods

A variable air volume (VAV) fume hood is very similar to the physical configuration of the bypass hood. A VAV fume hood has a means of varying and controlling the volume of air leaving the hood to maintain a constant face velocity. Also, a VAV hood has a partial or limited volume bypass hood. The hood is controlled by either measuring or calculating the face velocity and controlling the exhaust volume (See Figure #4).

This control is achieved by varying an exhaust regulating device (i.e. damper or air valve) to achieve maximum energy savings, workers must be conditioned to close hood sashes when not in use or the system must incorporate an automatic sash closure mechanism.



Variable volume fume hood with sash at low position = low flow through sash and low flow through hood

Same hood with sash at high position results in high flow through sash and high total flow through hood

Figure 4 Variable Air Volume Fume Hood

maintain the face velocity setpoint regardless of the sash position. This method results in a safer fume hood because face velocity can be maintained at its setpoint regardless of sash movement or fluctuations in exhaust system pressure, provided the system pressure does not drop below the point required to provide an adequate fume hood exhaust volume.

A VAV hood also addresses the energy waste problem because when the sash is lowered, the volume is reduced, requiring less makeup air. To

Auxiliary or Makeup Air-Type Hoods

The makeup air fume hood was originally developed to address the energy shortcomings of the CAV bypass fume hood. This fume hood incorporates a means of connecting a makeup air source to a canopy or diffuser located at the top of the fume hood and extending out from the plane of the hood opening. This canopy is connected to the hood and is provided as part of the hood itself. Its purpose is to provide a makeup air source to the room to replace the air exhausted through the fume hood.

This air source is usually unconditioned outside air (although it may be partially conditioned by heating in cold weather climates). The goal is to provide makeup for approximately 70% of the total exhaust air used by the hood (See Figure #5). This hood is also applied to some VAV applications where the amount of exhaust air leaving the hood is measured and the makeup air is regulated to provide 70% of the volume.

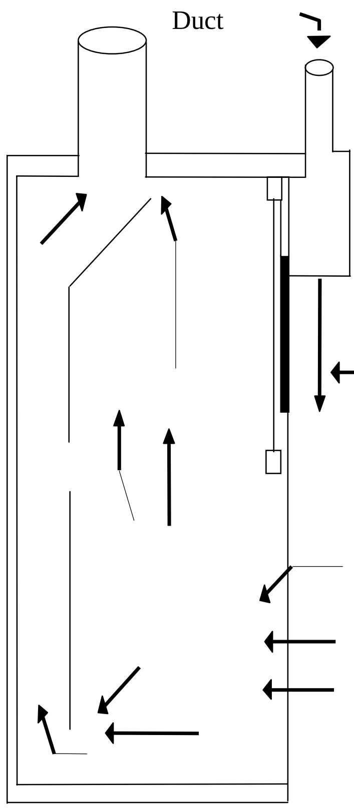


Figure 5 Makeup Air Hood

Although the auxiliary or makeup air hood frequently has lower operating costs due to the reduction in the amount of conditioned air it uses, it has several disadvantages which outweigh the benefit of energy savings.

- Safety can be compromised when there are large temperature differences between the makeup air and the room air. Stratification may occur and cause colder, heavier air to fall to the bottom of the hood and spill out, carrying airborne contaminants with it.

- People find it uncomfortable when warmer, more humid air or colder, drier air is directed over them during hood use. Temperature differences can also have an adverse effect on experiments within the hood.

- In humid climates warm moist air can easily condense on the metal and glass surfaces of the fume hood exterior and cause water damage to the furnishings.

Special Use Fume Hoods

Perchloric Acid Fume Hoods

Perchloric acid fume hoods are specially designed to be used with perchlorates. Perchlorates are powerful oxidizers and are highly corrosive. In addition, the oxidized compounds which are sometimes deposited within the fume hood and exhaust system can often be highly explosive. For this reason, these fume hoods are tightly constructed of stainless steel and/or PVC with continuously welded seams and neoprene gaskets. Exhaust systems and fans are also made of either stainless steel or PVC. Additionally, all electrical apparatus in or on the fume hood must be explosion-proof. Most hoods of this type are also connected directly to a dedicated exhaust system with wash down provisions for the fan, the ductwork, and the hood to reduce the risk of build up of oxidized compounds. These hoods are most often configured as CAV because of their special requirements.

Walk-in Fume Hoods

Walk-in fume hoods (See Figure #6) are floor mounted full height fume hoods of conventional design primarily intended to accommodate tall apparatus and permit roll-in of instruments and equipment. These hoods are configured with large vertical sashes which can be moved independently of one another so the upper or lower sections can be used individually or in combination.They can also be configured with horizontal sliding panes.

These hoods are not intended to be used by a person standing inside but are designed to allow the operator to walk into the hood to set up the apparatus then conduct experiments from the outside. Generally, walk-in fume hoods do not perform well with the sashes fully open as they are too susceptible to variations in room air currents and disturbances in laboratory traffic patterns. Active experimentation should take place only with the sashes partially or fully closed.

Additionally, baffle design and adjustment are critical in this hood due to its large face area. In some configurations, walk-in hoods may have a removable or hinged shelf at the height normally used in bench hoods. This shelf provides for flexibility of use. The shelf effectively separates the hood into two compartments. Usually, with the shelf in place, the lower compartment is only used for storage or for placement of gas cylinders. No active experimentation should take place there in this condition.

Figure 6 Walk-In Fume Hood

Combination Fume Hoods

Combination fume hoods consist of a large hood vertically divided into a walk-in section and a bench section. These hoods are designed so that each section conforms to the requirements for that type of hood as though it were an individual piece and not a combined assembly. The major considerations for this particular hood are the special baffles required for maintaining the airflow patterns in both sections of the hood and the special control considerations required for implementation of a VAV system.

Distillation Fume Hood

The distillation fume hood is very similar to the walk-in hood in design. The major difference is that the work surface is typically 18 inches above the floor (See Figure #7). This hood accommodates tall apparatus but does not allow for roll-in of equipment or for operators walking in to set up equipment. Otherwise this fume hood meets the same definition and function as a walk-in hood.

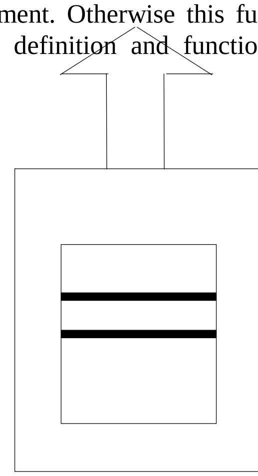


Figure 7 Distillation Fume Hood

Radioisotope Fume Hoods

Radioisotope fume hoods are designed to be used with radioactive material. These hoods are constructed of type 304 stainless steel with continuously welded seams to prevent absorption of the radioactive material. Exhaust systems and fans are also stainless steel. Some incorporate a washdown system to remove contaminants. Washdown systems are generally considered undesirable because they spread radioactive contaminants to the plumbing. These hoods also incorporate a HEPA (High Efficiency Particulate Air) and/or charcoal filter at the hood exhaust outlet for collection and absorption of airborne radioactive particles. Because of the special requirements and the possibility of radioactive contamination, these hoods are most often configured as CAV.

Miscellaneous Fume Hoods

These fume hoods do not fit the description or functional criteria of "a laboratory fume hood" and are specifically noted in the SAMA reference as "not a laboratory fume hood."

Canopy Hood

A canopy hood is defined by SAMA as "a suspended ventilating device used to exhaust only heat, water, vapor, and odors." These devices are located over sinks where apparatus are washed or where heat producing devices such as ovens or sterilizers are located (See Figure #8). They usually consist of a large metal canopy or hood, similar to the exhaust hood over a commercial grill or residential stove, which is directly connected to the exhaust system ductwork. These ventilating devices are typically on/off or continuous use CAVs .

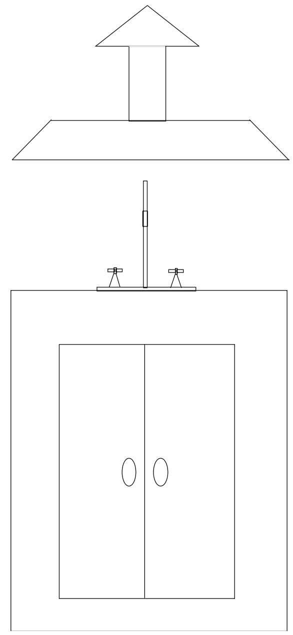


Figure 8 Canopy Hood

California-type Hood

SAMA defines the California-type hood as "a rectangular enclosure used to house distillation apparatus that can provide visibility from all sides with horizontal sliding access doors along the length of the assembly." The top of the enclosure resembles a canopy hood and is connected to an exhaust duct (See Figure #9). This device works well for containing and exhausting fumes when all its access doors are closed. However, due to its lack of baffles and complete inability to provide any kind of equalized airflow, this hood cannot be counted on as a safety device when any of its access doors are open more than a very minimal amount. This device was once considered desirable due to its easy access from all sides, but has become rare due to its poor containment capabilities when compared to a distillation hood.

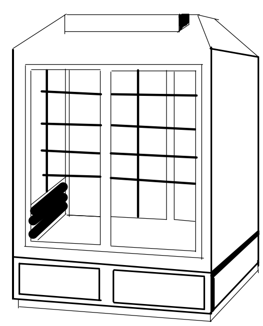


Figure 9 California Hood

Laminar Flow Hood

The term laminar flow hood is often applied to an air distribution device used on clean benches or in surgical air showers. Basically, the device is used to provide a uniform directional airflow designed to carry away airborne particles (See Figure #10). Usually these devices are used to provide HEPA-filtered supply air to the work surface only for the protection of the product or process. However, in some instances this term is applied to biological safety cabinets (described in detail later).

Demonstration Hood

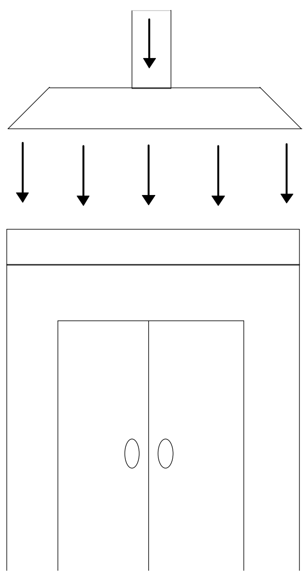


Figure 10 Laminar Flow Hood

The demonstration hood is defined as an enclosure used for demonstration purposes with visual access from at least two sides. This hood is usually used in a teaching environment. It is primarily intended to remove noxious odors and is not intended as a safety device. The demonstration hood is typically a CAV device.

Table Top Hood

This hood is a small localized unit designed for mounting on a table top. A table top hood usually ventilates down through the top of the table. This hood is most commonly used in educational facilities and is primarily designed to remove noxious odors. It is not intended to be a safety device. A table top hood is usually a CAV device.

Biological Safety Cabinets

SAMA defines the biological safety cabinet as a "special safety enclosure used to handle pathogenic microorganisms." This device is designed to protect both the researcher and the research materials. The unit is a specific form of containment apparatus designed for work with living tissues, cells, and various other biological material including bacteria, viruses and toxins. Biological safety cabinets are certified according to procedures established by the National Sanitation Foundation (NSF). These devices are grouped into three classifications according to risk potential:

- Class I (low risk)
- Class II (moderate risk)
- Class III (high risk)

The NSF Standard 49, 1992 breaks Class II into four additional categories: (A, B1, B2 & B3).

Class I

Class I is similar to a chemical fume hood but without a movable sash. All air into the cabinet is 100% exhausted to the outdoors through a HEPA filter. This cabinet does not protect the biological material. Face velocity of the cabinet must be maintained at a minimum of 75 FPM. Meets Biological Safety Level #1 (See Figure #11) .

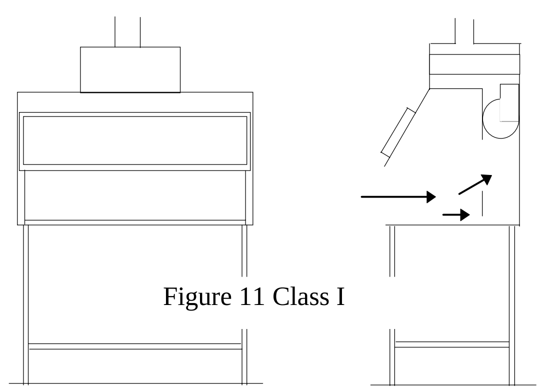


Figure 11 Class I

Class II, Type A

Class II, Type A is similar to a chemical fume hood but without a movable sash. The cabinet is supplied 70% of its air through a HEPA filter and recirculates a percentage of its exhaust through that filter. The balance of the exhaust goes outdoors through a second HEPA filter. This cabinet protects the biological substance from impurities but not from chemical fumes. Face velocity of the cabinet must be maintained at a minimum of 75 FPM. Meets Biological Safety Level #2 (See Figure #12) .

Class II, Type B1

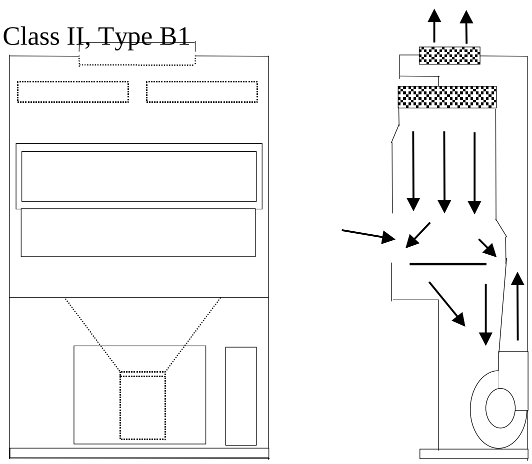


Figure 12 Class II, Type A

Class II, Type B1 has a vertical sliding sash and maintains an intake velocity of 100 FPM at an opening of 8 inches. The cabinet recirculates 30% of its air through its supply HEPA filter and exhausts 70% to the outdoors through a second HEPA filter. This cabinet protects the biological substance from impurities but not from chemical fumes. Meets Biological Safety Level #3 (See Figure #13).

Class II, Type B2

Class II, Type B2 has a vertical sliding sash and maintains an intake velocity of 100 FPM at an opening of 8 inches. The cabinet exhausts 100% of its air to the outdoors through a HEPA filter. This cabinet protects the biological substance from impurities as well as chemical fumes. Meets Biological Safety Level #3 (See Figure #14).

Class II, Type B3

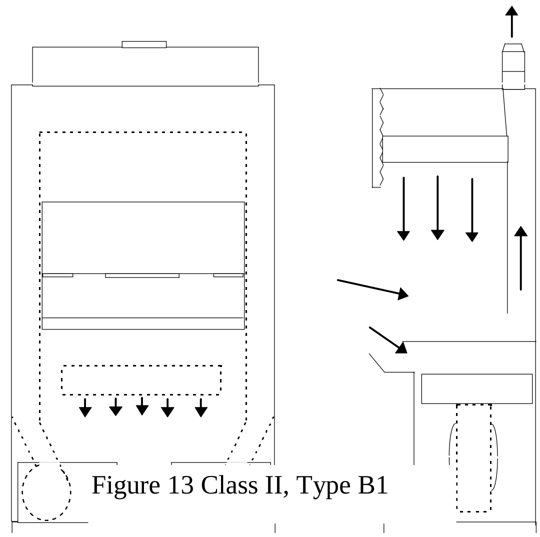


Figure 13 Class II, Type B1

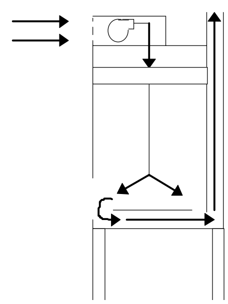


Figure 14 Class II, Type B2

Class II, Type B3 is similar to a chemical fume hood but has no movable sash. The cabinet recirculates 70% of its air through a HEPA filter and exhausts 30% to either the room or the outdoors through a HEPA filter. This cabinet protects the biological substance from impurities but not from chemical fumes. Face velocity of the cabinet must be maintained at a minimum of 100 FPM. Meets Biological Safety Level #2 (See Figure #15).

Class III

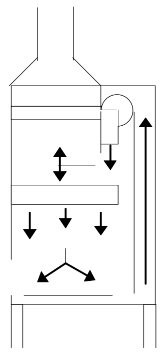


Figure 15 Class II, Type B3

Class III hoods are also called glove boxes. All air into the cabinet is drawn through a HEPA filter and all air leaving the cabinet is 100% exhausted to the outdoors through a HEPA filter. There are physical barriers (arm length gloves) between the researcher and the research material. Internal environment is controlled to maintain a constant negative pressure. Meets Biological Safety Level #4, highest level of personnel protection (See Figure #16) .

Miscellaneous Devices

Figure 16 Class III

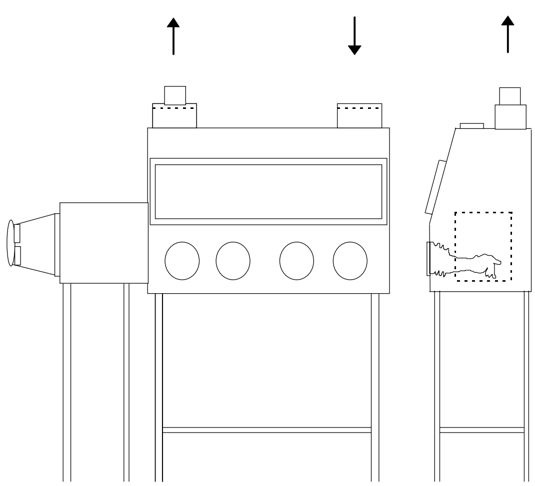


Table Top or "Slot" Exhaust

This device consists of a fixed aperture a few inches in height installed across the width of the table or bench surface at the rear (See Figure #17). The "slot" exhaust is designed to provide an exhaust source to sweep noxious odors from the table top; it is not intended to be used as a safety device. These ventilation systems are typically configured for either on/off or standby/in-use CAV operation.

Flexible "Trunk" or "Snorkel" Exhaust Pick-up

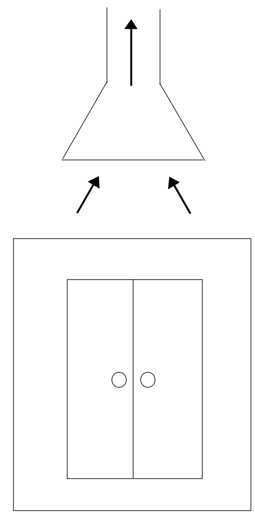


Figure 17 Table Top Exhaust

This device is referred to by SAMA as a "Spot Collector" and is defined as "a small, localized ventilation hood usually connected by a flexible duct to an exhaust fan or exhaust system" (See Figure #18) . The hood is usually positioned just above or behind the source of fumes it is intended to carry away. This device is primarily

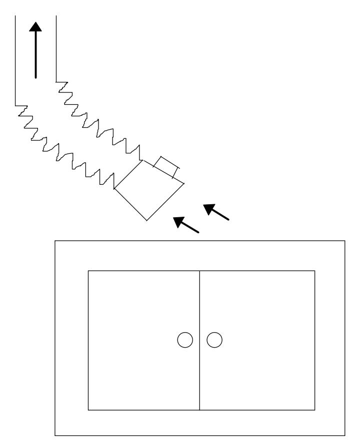


Figure 18 Flexible Exhaust Pickup

intended to exhaust noxious odors and/or heat; it is not intended to be used as a safety device. These systems are usually operated in a switched on/off CAV-controlled fashion.

Chemical Storage Cabinets or Closets

This device consists of a complete enclosure with a hinged door that provides access to the interior A small exhaust duct connection with flame arrestor is part of the cabinet or closet (See Figure #19). This unit is solely intended for use as a chemical storage device, no experimentation or manipulation of chemical processes is conducted within. This device operates in the continuous CAV mode .

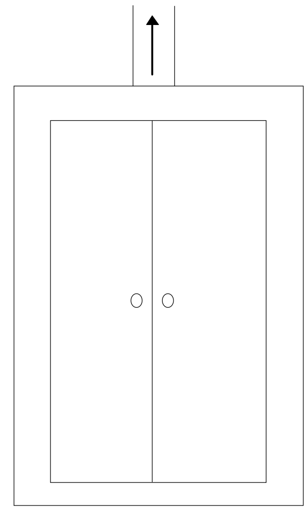


Figure 19 Chemical Storage Cabinet

<u>Laboratory or Clean Room "Space" Airflow Devices</u>

Supply or Makeup Air Delivery

Air Volume Control Devices

Commercial VAV Box

This box is an air regulating device commonly used in the commercial HVAC building control market. The unit consists of a simple butterfly blade style control damper, typically with blade edge seals, mounted in a round duct section coupled to an outlet sound attenuator (See Figure #20). In some cases a simple pitot tube array is provided in the round inlet duct connection. The unit may also be provided with an integral reheat coil in either electric or hot water tube-and-fin configuration. This device regulates airflow by modulating the position of the damper blade. It is classified as pressure independent.

Bladder Valve

This valve is an air regulating device used in the commercial building HVAC industry. The unit consists of a metal housing with round duct connections on either end and a rubber bladder inside (See Figure #21). The unit may also have a sound attenuator section at its outlet and a simple pitot array at its inlet connection. This device regulates airflow by using the internal duct pressure to inflate or deflate the rubber bladder. It is capable of changing airflow volume in an almost linear manner. The device is classified as a pressure dependent unit.

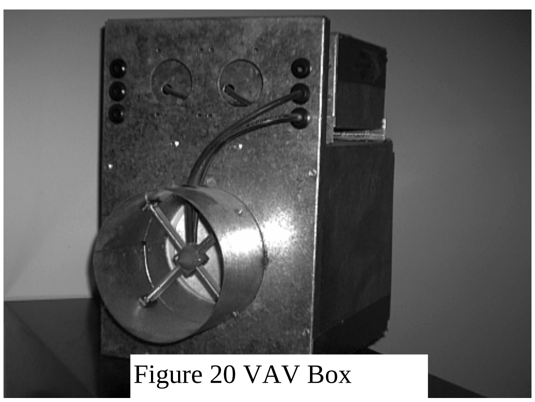


Figure 20 VAV Box

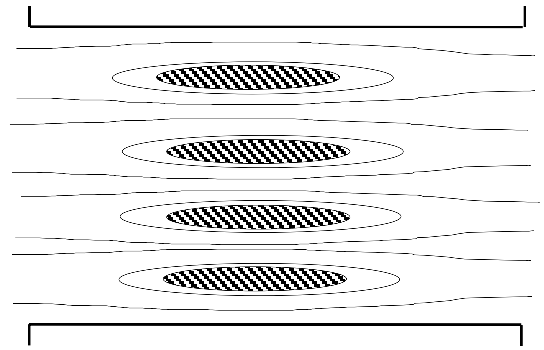


Figure 21 Bladder Valve

Linear Air Valve

This valve is an air regulating device used for precision airflow control. It consists of a round venturi-style body with a spring-loaded floating cone assembly mounted in the inlet side of the venturi. This unit regulates airflow volume by modulating the cone into or out of the venturi opening on the valve inlet. This device is generally considered pressure independent between about 0.6" w.c. to 3.0" w.c. pressure drop. It functions linearly through this range. Since the device is basically linear in operation, these valves are calibrated for specific flow ranges. Flow rate can then be accurately determined from valve position, eliminating the need for flow measuring as long as the device stays calibrated and the pressure drop is within the correct range (See Figure #22) .

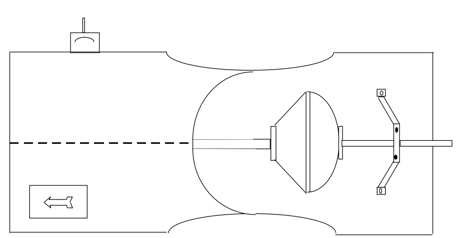


Figure 22 Linear Air Valve

Control Damper

The usual configuration of this device for room size airflow regulation is a simple butterfly blade damper much like the one used in a commercial VAV box. However, this device is not provided with an integral pitot or sound attenuator section. The damper usually consists of a round metal blade fixed to a metal shaft and mounted through bearings to a round metal body (See Figure #23). These dampers may be provided with or without blade edge seals. Flow is measured externally and the blade is modulated to perform its regulation function. The combination of measured flow rate with this damper is considered pressure independent.

Air Distribution Devices

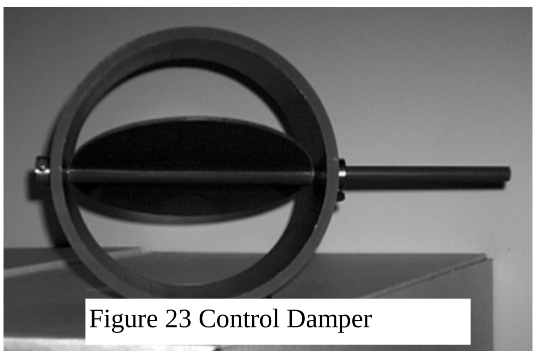


Figure 23 Control Damper

Diffuser Location

It is important to be aware of the consequences of poor diffuser location. The ASHRAE 1991 Applications Handbook, Chapter 14 on laboratories states that "Air supplied to the laboratory space must keep temperature gradients and air turbulence to a minimum, especially near the face of the laboratory fume hoods and biological safety cabinets. Air outlets must not discharge into the face of fume hoods. Also, cross flows that impinge on the side of the hood more seriously alter airflow than do cross flows in front of the hood."

Additionally, guidelines set forth in this chapter state that the terminal throw velocity of supply air jets must be less than the hood face velocity. Recommendations are that this supply velocity not exceed a rate of 1/2 to 2/3 of the fume hood face velocity. What this means is that poor diffuser design and or placement can compromise the hood's ability to function properly. In severe cases the hood may even lose containment.

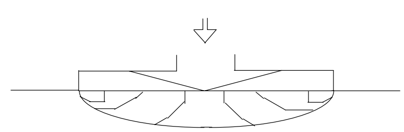
Radial Air Diffusers

These devices are the most common diffusers used in commercial HVAC. They consist of a round connection that transforms into a square element with angular baffles.The baffles direct the flow of air in four directions at a slight down angle (See Figure #24). These diffusers are not used in laboratories because they frequently create jets o Figure 24 Radial Air Diffuser flows at the fume

Total Air Diffusers

Figure 25 Total Air Diffuser

A total air diffuser is a low velocity diffuser designed to evenly and smoothly distribute air volume. These diffusers most often consist of a small plenum with a perforated grill covering a large outlet, which can be a flat ceiling type panel or a rounded profile panel (See Figure #25) . In some cases they may consist of a round drum perforated on the bottom and around the sides



which extends below the ceiling surface. These diffusers are more common in laboratories because they create fewer airflow currents in the spaces where they are used.

Laminar Air Diffuser

This diffuser is most often used in clean rooms, over clean benches in aseptic process facilities, or in hospital surgical suites (See Figure #26). This device is specially designed to provide even, consistent airflow with uniform velocity in one direction only. The device consists of a specially designed plenum and baffle configuration with a flat perforated surface.

Air Conditioning Devices

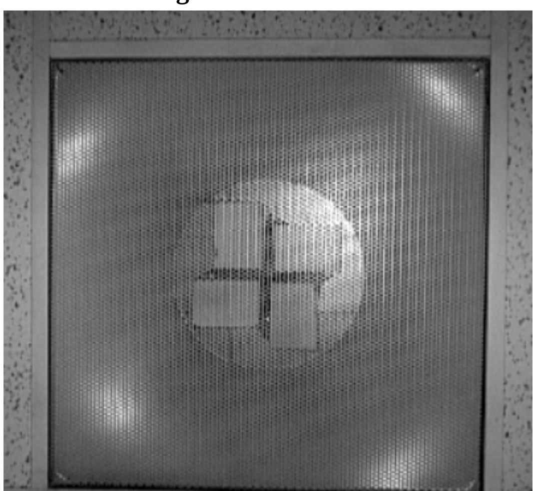


Figure 26 Laminar Air Diffuser

Cooling

Cooling is typically accomplished by one of two means— either by increasing the amount of conditioned supply air into the space or, in some less common situations, by using a recooling coil. If the volume of conditioned air is increased, the lab airflow balance has to be controlled proportionally with the increase. In re-cooling or subcooling the supply air, the airflow balance remains relatively unaffected by the change in air temperature.

Heating

Temperature control in a lab space is most often driven by the reheating process. Reheating is common because most labs exhaust more air through the fume hoods and other ventilation devices than is required for temperature offset via the makeup air.

Reheating

Reheating is accomplished by one of two means— either by modulating hot water or steam flow through a tube-and-fin coil or by modulating an electric heating element. Electric reheating is usually accomplished through on / off control of a multi-stage element. Heat may also be introduced into the laboratory by means of perimeter baseboard or radiant ceiling panels. This type of heat source is usually only seen in building perimeter labs in cold weather climates.

Humidity

Most laboratories obtain humidity control on a zone basis via the central air system. Zone humidity is measured and the humidity level of the common supply air is controlled. In some cases, a lab, or in more cases, clean rooms, may require tighter humidity control than that provided by a central system. Usually these labs are supplied by a smaller dedicated air handling system that incorporates its own humidity control. Exceptions still appear where a lab is supplied by a central system but requires secondary control of humidity to fulfill more stringent requirements.

The control is accomplished in two different stages— dehumidification for removal of moisture in the airstream and humidification to add moisture to the airstream.

Dehumidification is accomplished by subcooling with a recooling coil. In this method, the air is cooled below the temperature required for space temperature load to cause moisture to condense out of the airstream. The air is then reheated by some means in order to maintain the temperature requirements of the space. A less common method of dehumidification is to incorporate an air dryer of some sort in the supply airstream, typically a regenerative desiccant-type.

Humidification is most commonly accomplished by injecting low pressure steam into the airstream. In some rare occasions it may be accomplished by actually spraying warm water into the airstream, usually just prior to a fin-and-tube coil.

Air Filtering

Most air filtering requirements for laboratories (if required) or clean rooms are accomplished by a device known as a HEPA filter. HEPA stands for High Efficiency Particulate Air, a type of filter designed to remove and trap micron-sized particles. These filters are designed to be discarded after use and are commonly designated hazardous waste. One major point to note is that as these filters load with debris airflow through them can become restricted well before they are considered used. With this in mind, methods of controlling airflow for devices which rely on a HEPA filters need to be pressure independent to ensure proper airflow under varying conditions.

General Exhaust Air Removal

Air Volume Control Devices

Commercial VAV Box

This box is an air regulating device commonly used in the commercial HVAC building control market. The unit usually consists of a simple butterfly blade-style control damper, typically with blade edge seals, mounted in a round duct section that is coupled to an outlet sound attenuator (See Figure #20). In some cases a simple pitot tube array is provided in the round inlet duct connection. This device regulates airflow by modulating the position of the damper blade. The device is classified pressure independent.

Bladder Valve

This valve is an air regulating device used in the commercial building HVAC industry. The unit consists of a metal housing with round duct connections on either end and a rubber bladder inside (See Figure #21). The unit may also have a sound attenuator section at its outlet and a simple pitot array at its inlet connection. This device regulates airflow by using the internal duct pressure to inflate or deflate the rubber bladder. It is capable of changing airflow volume in an almost linear manner. This device is classified as a pressure dependent unit.

Linear Air Valve

This valve is an air regulating device used for precision airflow control. It consists of a round venturi-style body with a spring-loaded floating cone assembly mounted in the inlet side of the venturi. This unit regulates airflow volume by modulating the cone into or out of the venturi opening on the valve inlet. This device is generally considered pressure independent between about 0.6" w.c. to 3.0" w.c. pressure drop. They function linearly through this range. Since the device is basically linear in operation, these valves are calibrated for specific flow ranges. Flow rate can then be accurately determined from valve position, eliminating the need for flow measuring as long as the device stays calibrated and the pressure drop is within the correct range (See Figure #22).

Control Damper

The usual configuration of this device for room size airflow regulation is a simple butterfly blade damper much like the one used in a commercial VAV box. However, this device is not provided with an integral pitot or sound attenuator section. The damper consists of a round metal blade fixed to a metal shaft and mounted through bearings to a round metal body (See Figure #23). These dampers may be provided with or without blade edge seals. Flow is measured externally and the blade is modulated to perform its regulation function. The combination of measured flow rate with this damper is considered pressure independent.

Air Registers & Grills

Exhaust air registers and grills as applied to laboratories are most often seen in two different styles. The first is a perforated ceiling panel connected to a small plenum that makes the transition to the required duct connection. The other kind is best described as a linear slot pickup. This type is long and narrow. It is mounted between the ceiling grid and the ceiling panels. As with supply diffusers, though not as critical, placement of exhaust grills and registers is important. If a grill or register is mounted too closely to a fume hood or biological safety cabinet it may actually draw air out of the fume hood by creating a significant negative pressure at the top of the hood front.

Air Filtering

Air filtering in laboratory and clean room exhaust systems is most often accomplished through two different types of systems. One such system is the HEPA filter described earlier. Again it should be noted that methods of controlling airflow for devices which rely on a HEPA filter need to be pressure independent to ensure proper airflow under varying filter conditions. The other prevalent means of air filtering ,found only in clean process areas, is dust collection. Since dust collection systems are usually self contained they do not require any control. However, some of these systems exhaust air out of the controlled space, a feature that needs to be considered when ΔCFM tracking is the pressurization scheme being used.

Laboratory Supply & Exhaust Air Handling Systems

Supply Air Handling Systems

A once-through or 100% outdoor air supply is the most common laboratory central air system. Such a system ensures that air delivered to the lab as makeup or as temperature compensation volume is free of concentrated contaminants. A continuous supply of air from the system's source ensures that contaminants never get the chance to build up. The once-through system generally employs a means of filtering, preheating, cooling and humidifying the air delivered to the laboratory supply air duct system. The system can be either constant air volume or variable air volume in nature (See Figure #27) .

Another type of lab supply system is the partial recirculation system (See Figure #28). In the partial recirculation system air drawn through the room exhaust grilles is returned to the air handling unit and recirculated in varying amounts. These amounts change based on temperature control schemes associated with the unit controls, up to some maximum based on a percentage of the total supply air being delivered. This percentage differential allows a minimum amount of fresh air to be drawn into the system on a continuous basis. These units employ a means of filtering, preheating, cooling and humidifying the air delivered to the laboratory supply air duct system. This system is not very common in labs because it may allow the buildup of chemical concentration levels in the supply air system based on chemical agents released into the laboratory space.

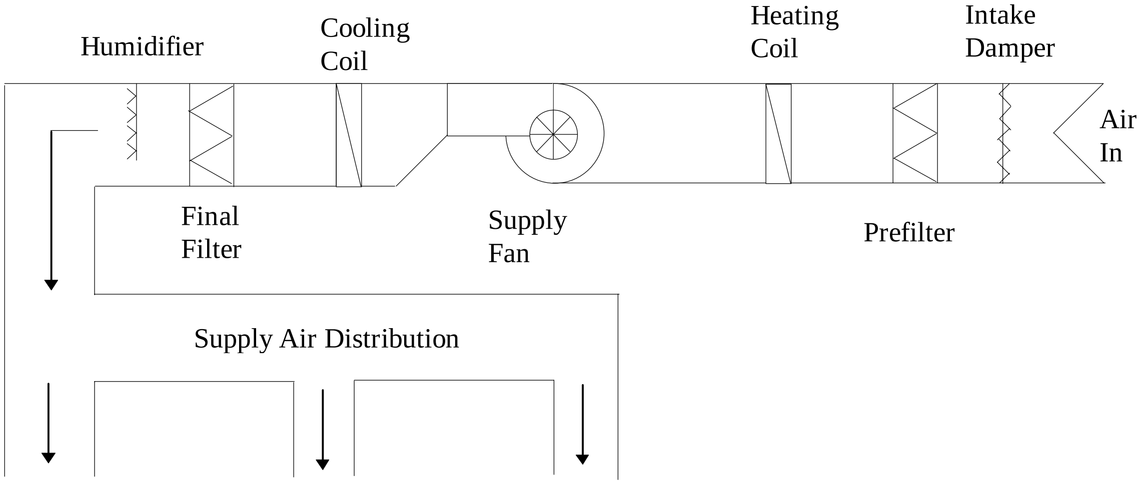


Figure 27 Once-Through System

System Volume/Pressure Control

The volume of air or amount of duct pressure maintained by the supply air system is normally regulated by one of the following means:

1. Variable Speed Motor Drive: This device changes air volume by modulating the speed of the motor that drives the fan. These fan systems are controlled via a building automation system. However, since lab pressurization and the control of lab fume hoods are based on the ability to provide makeup air quickly, consideration must be given to the specified or required fan / drive / control system performance. The fan drive and control system must be able to maintain the volume or pressure at a stable setpoint regardless of changes to system volume requirements. It must also be able to function in a responsive manner so that the lab controls are not waiting on the central system to catch up. Caution must be given to variable speed drives which have large time delays specified in speed output response—specifically, drives which require more than 5 seconds to achieve a speed change of at least 10 percent.

2. Variable Inlet Vanes: This type of volume control device consists of movable vanes on the inlet of a constant speed fan. The vanes are normally actuated by a high torque motor (typically pneumatic). Closing the vanes restricts the amount of air the fan is capable of drawing into the system. Again, the inlet vane actuator and control system must be able to maintain the volume or pressure at a stable setpoint regardless of changes to system volume requirements. They must also be able to control in a responsive manner so that the lab controls are not waiting on the central system to catch up. Problems occur in these systems when electronic or electrical actuating devices are used because operators of that kind with enough torque to do the job are notoriously slow.

3. Variable Pitch Fan Blades: Some fans of the vane axial style use variable pitch fan blades to regulate volume. These fans follow the same basic requirements and points of concern as the variable inlet vane, with the exception that this style fan is notorious for pressure surge problems if it is not properly controlled. This method is uncommon except in very large built-up central systems.

4. Constant Volume Bypass: This scheme is rare but may be used to retrofit older systems. It consists of a simple constant volume fan with a bypass duct that houses a control damper or some type of element. It regulates system volume by bypassing any unnecessary air back to the inlet side of the fan system. This system follows the same require-

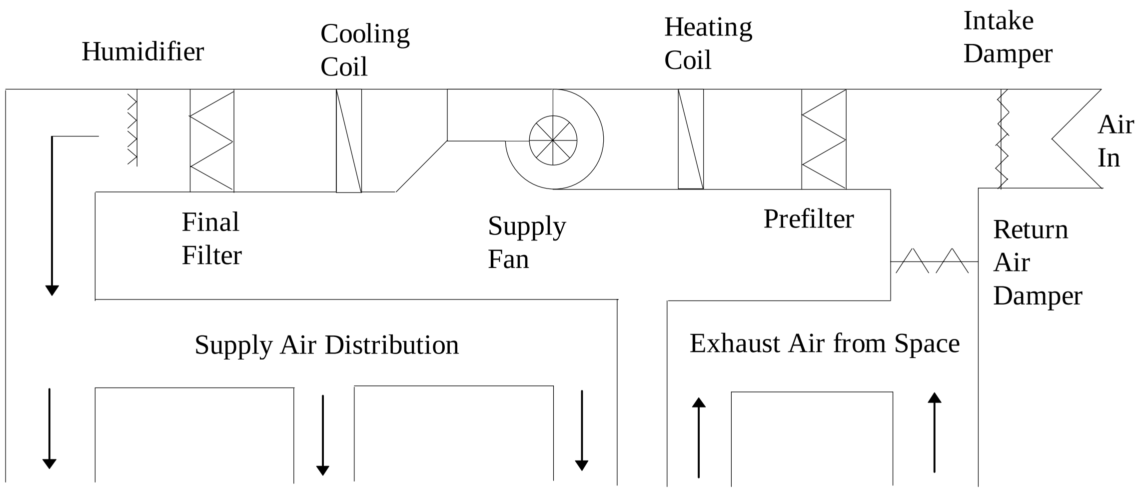


Figure 28 Partial Recirculation System

ments and concerns as the variable inlet vane system.

Exhaust Air Handling Systems

Single Unit / Single Fan

Some fume hood and ancillary exhaust devices are designed around a single fan ducted directly to a single ventilating unit. This system often operates in conjunction with a CAV fan forced to a VAV mode of operation by a modulating control damper in either the fan inlet ductwork or the outlet of the ventilating device. This arrangement is often referred to as "riding the fan curve." It is common to see this application retrofit existing fume hoods. In some cases, particularly in perchloric acid and radioisotope fume hoods, a single ducted fan may employ a variable speed drive to regulate the system volume.

Manifolded Exhaust Systems

Many facilities which have a number of multiple hood labs elect to use a manifolded exhaust system. In this system,. hood exhaust and ancillary exhaust duct connections are made to common trunks. The trunks connect to a common exhaust duct riser in multistory buildings, or to a common exhaust plenum. These plenums or risers are controlled to a constant negative static pressure setpoint. Manifolded systems are less apt to be affected by continuous changes in the exhaust volume caused by use of the fume hoods because fume hood volume is relatively small compared to overall system volume. Exhaust fans in manifolded systems are most often controlled to regulate volume in one of the following ways:

1. Variable Speed Motor Drive. This device changes air volume by modulating the speed of the motor that drives the fan. These fan systems are controlled via a building automation system. However, since lab pressurization and the control of lab fume hoods are based on the ability to provide makeup air quickly, consideration must be given to the specified fan / drive / control system performance. The fan drive and control system must be able to maintain the volume or pressure at a stable setpoint regardless of changes to system volume requirements. It must also be able to function in a responsive manner so that the lab controls are not waiting on the central system to catch up. Caution must be given to variable speed drives which have large time delays specified in speed output response—specifically, drives which require more than 5 seconds to achieve a speed change of at least 10 percent.

2. Variable Inlet Vanes. This volume control device consists of movable vanes on the inlet of a constant speed fan. The vanes are normally actuated by a high torque motor (usually pneumatic). Closing the vanes restricts the amount of air the fan is capable of drawing into the system. Again, the inlet vane actuator and control system must be able to maintain the volume or pressure at a stable setpoint regardless of changes to system volume requirements. They must also be able to control in a responsive manner so that the lab controls are not waiting on the central system to catch up. Problems occur in these systems when electronic or electrical actuating devices are used because operators of that kind with enough torque to do the job are notoriously slow.

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