

PDH Course M228

Fundamentals of Kitchen Ventilation

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Course Content

Introduction

Ventilation is the single most important factor in the design, construction and operation of commercial kitchens. Without adequate ventilation and an ample supply of clean makeup air, no kitchen will operate efficiently. There are particular objectives which the ventilation has to achieve. The objectives include the following:

- 1) The general ventilation through the kitchen has to introduce sufficient clean, cool air and remove excess hot air for the occupants to breathe adequately and remain comfortable.
- 2) The general ventilation has to provide sufficient air for complete combustion at burning appliances, otherwise chronic debilitating carbon monoxide poisoning could occur.
- 3) The general and local ventilation has to dilute and remove products of combustion from gas and oil fired appliances.
- 4) The general and local ventilation has to dilute and remove odors, vapors and steam from the cooking processes.
- 5) Local ventilation has to protect against particular hazards to health arising from some cooking fumes, such as those involving direct application of heat to the food.
- 6) The local ventilation has to be capable of being kept clean from fat residues to avoid loss of efficiency and fire risks.
- 7) The system has to be quiet and vibration free.

The amount of ventilation required in a particular cooking area depends on various factors: the type of product(s) being cooked, the structure which houses the cooking area, the type of equipment used and local code regulations. And, depending on your location, the building heat source may also play a factor.

This course will provide basic guidelines to achieve these objectives and facilitate ventilation design. Let's first understand key terminology and definitions related to kitchen ventilation systems.

Definitions

- 1) *Anemometer* -A device used to measure air velocity.
- 2) *Approved* - Acceptable to the regulatory authority based on a determination of conformity with principles, practices, codes, and generally recognized standards.
- 3) *Balance Report* - A report completed by a qualified person, who after on-site testing of a ventilation system, specifies in a report certain air volumes and the building's overall static pressure.
- 4) *Compensating Supply Air* - Air supplied through a plenum in the hood which is directed into the hoods capture area or down along the hood's perimeter.
- 5) *Convection Oven* – A gas or electric heated oven that uses a fan or blower to recirculate the heat throughout the interior of the oven
- 6) *Damper* - A plate or other device within a duct for controlling the flow of gases.
- 7) *Duct* - means an enclosure for the transmission of air and vapors.
- 8) *Grease* - means rendered animal fat or vegetable shortening in any form, associated with cooking and other food preparation.

- 9) *Grease Extractor* - A device or a system of components (usually series of baffles installed in a hood) for reducing the grease concentration from the air stream entering the system and concentrating the grease for further action.
- 10) *Grease Filter* - A device that is installed in the exhaust hood in such a way as to remove grease from the exhausted air by entrapment, impingement, adhesion, or other similar means and allow it to drain to a grease trough.
- 11) *Grease Laden Vapors/Air* - Vapors in concentrated level of above 5 mg. per cubic meter released into the air due to grease being heated to its vaporization point.
- 12) *Grease Removal Devices* - Any device for removing vapor suspended grease particles from an air stream.
- 13) *Hood* – An air-intake device connected to a mechanical exhaust ventilation system for collecting and removing cooking effluent which contains grease, vapors, fumes, smoke, steam, heat, or odors which are generated by cooking equipment and ware-washing machines.
 - *Canopy Hood* – A hood designed in a way that it's inside edge overhangs or extends the equipment on all exposed sides (usually not less than six inches beyond the outer edges of the cooking surface) and capture large surges of contaminated air.
 - *Compensating Hood* – A hood that is designed to introduce supply air through an integral plenum either directly into the hood capture area or by directing air down along the hood perimeter. This design will typically provide 60-80% of the required makeup air through four basic discharge methods: short-circuit, face-discharge, back-discharge, and down discharge. These methods may also be combined, such as a face and down discharge arrangement.
 - *Island Hood* - A canopy hood that is mounted from the ceiling with all four sides or the longitudinal sides exposed.
 - *Back-Shelf Hood* - A hood designed to be mounted behind the equipment and which does not overhang the front of the equipment.
 - *Eye-Brow Hood* - A hood designed to capture the vapors and heat escaping the open doors of equipment and which is located above and overhangs the door openings.
 - *Vent Hood* - A hood designed to capture and remove steam, fumes, and heat but not grease.
 - *Short-Circuit Hood* - A compensating hood with an integral plenum which discharges supply air directly into the hood's capture area.
- 14) *Listed Equipment* – Equipment and materials which, following evaluation and acceptance by a qualified testing agency, are placed on a list of certification. The listing shows that the equipment and materials comply with accepted national standards, which have been approved or evaluated for conformity with approved or national standards.
- 15) *Makeup Air* - Means forced and/or passive air entering a space that replaces air exhausted from the space. Makeup air consists of compensating supply air, other supply air delivered through the hood such as front face discharge and supply air delivered through ceiling and wall diffusers.
- 16) *Non-canopy Hood* – A hood that does not extend completely over the cooking equipment. A non-canopy hood is designed to be as close as possible to the cooking surface, usually 18 to 24 inches above it.
- 17) *Overshelf* - Any equipment such as a shelf, cheese-melter, bun warmer, or salamander which is located over cooking equipment and below a hood exhaust plenum.
- 18) *Plenum* – An air compartment or chamber to which one or more ducts are connected and which forms part of the supply-air, return-air, or exhaust air system.
- 19) *Portable* – Equipment having the properties of being portable, weighing less than 80 pounds, not exceeding three feet in any plane, and having utility connections designed to be disconnected or of sufficient length to permit equipment movement for cleaning.

- 20) *Recirculating System* - A system for controlling the smoke or grease-laden vapors from commercial cooking equipment that does not exhaust to the outside.
- 21) *Smoke Bomb* - A device which releases smoke in order to simulate the operation of smoke and vapor producing equipment for test purposes.
- 22) *Type I Exhaust Hood* – A hood that is designed to collect and remove all types of cooking effluent from the exhausted air.
- 23) *Type II Exhaust Hood* – A hood that is designed to collect and remove only steam, vapors, heat, or odors.
- 24) *Thermal Imaging* – A technique used in understanding the behavior of thermal plumes and for identifying visually all the convective heat coming off the appliances. A Schlieren system and CFD (Computational Fluid Dynamics) is a thermal imaging technique widely used by kitchen appliance manufacturers in developing energy efficient and comfortable ventilation systems and products.
- 25) *Water-Wash-Type Exhaust Hood* – a Type I hood which uses water to remove accumulated grease from the grease extractors.

KITCHEN EXHAUST SYSTEMS

Kitchen exhaust systems are made of a number of interdependent units. Exhaust hoods, exhaust fans, makeup air units, and packaged rooftop HVAC (Heating Ventilation Air Conditioning) units all need to operate within defined parameters to complement one another and to maintain peak performance. An effective exhaust system should get rid of:

- Heat
- particulate matter
- grease laden steam
- cooking vapors

While an exhaust hood serves that purpose, the key question is always: what is the appropriate exhaust rate? The answer always depends on the type (and use) of the cooking equipment under the hood, the style and geometry of the hood itself, and how the makeup air (conditioned or otherwise) is introduced into the kitchen.

KITCHEN HOOD TYPES

Kitchen hoods can be categorized into two basic types: backshelf or proximity hoods and canopy hoods:

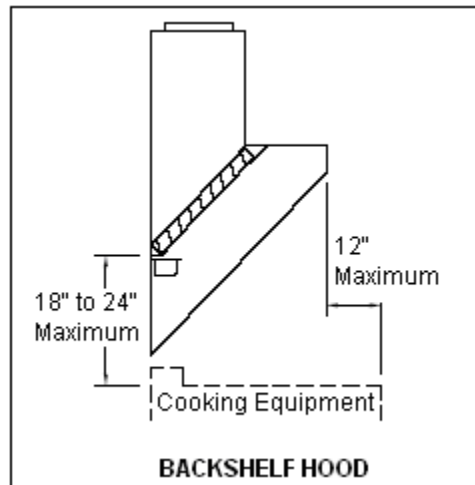
BACKSHELF HOODS

Backshelf or proximity hoods do not overhang the front of the equipment and are designed to be mounted behind the equipment. These hoods may be selected for use in applications where overhead canopies are impractical (such as a low ceiling height), or in other situations where an overhead canopy is not desirable. These are best suited for low cooking surface appliances such as griddles, grills, fryers, etc.

Key Facts

- 1) The backshelf hood is placed in close proximity to the cooking surface thus requires less exhaust than a canopy hood used in the same application. This makes the backshelf hood to be widely used in quick-service and short-order foodservice establishments that typically use fryers and griddles as their primary cooking equipment.
- 2) The backshelf hood is not suitable for tall appliances or facilities that produce large volumes of effluent or steam. These are not recommended for open flame equipment such as char-broilers.
- 3) Backshelf hoods are available as exhaust only hoods i.e. these have no provision for introducing tempered or un-tempered air integral to the hood. Makeup air is provided independent from the kitchen hood system.
- 4) The length of a backshelf should be a minimum of the length of the cooking equipment. Backshelf hoods should be located to provide a minimum of 18" and a maximum of 24" from the cooking surface

to the filters, and the distance from the front of the hood to the front of the cooking surface should not exceed 12".



CANOPY HOODS

A Hood designed in a way that it's inside edge overhangs or extends the equipment on all exposed sides.

Key Facts

- 1) Canopy hoods have a large overhang usually not less than six inches beyond the outer edges of the cooking surface, which improves the capture effect and restricts the outward expansion of the gases. (Overhang is the space between the edge of the cooking equipment and the edge of the hood in a vertical plane).
- 2) Canopy hoods with large overhang are recommended for appliances that create plume surges, such as convection and combination ovens, steamers, char-broilers and pressure fryers.
- 3) Canopy hoods require larger volumes of exhaust air than the backshelf design. As a result, they are suitable for ventilating any type of cooking operation and are flexible as to where they can be placed; i.e. next to a wall or in the center of a kitchen with a 360° cooking radius.

Canopy hoods are classified by installation characteristics i.e. installation against a wall (wall hood) installation as an island over a single line of cooking equipment (single island hood), or installation as an island over a double line of equipment placed back to back (double island hood).

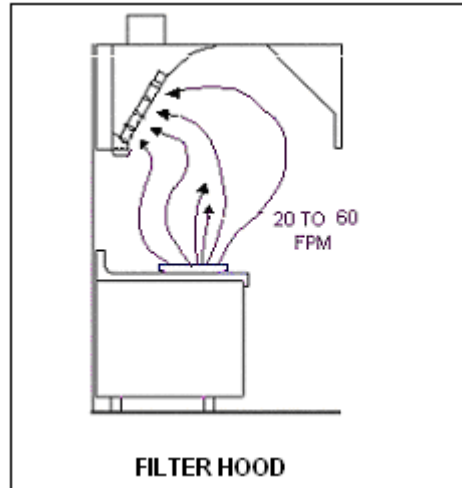
Within each classification canopy hoods are further subdivided as canopy hoods, grease extractors and high velocity hoods.

- 1) Grease Filter Hoods - Those which use removable filters and must be removed and manually washed.
- 2) Grease Extractor Hoods - Those with internal baffles and may include an internal wash system or may be manufactured as cartridges for manual washing.

Both are subject to the same standards when evaluated by an independent testing agency.

FILTER HOODS

The most frequently used hood arrangement contains metal filters, where the exhaust fan draws kitchen air into the canopy through a filter. The primary purpose of these filters is to ensure that the effluents are drawn straight into the canopy and liquid grease droplets are removed efficiently by entrapment, impingement, adhesion, or other similar means from the air stream. Pre-code filters were typically wire mesh that removed grease by impingement. Such filters are no longer permitted due to their flammability and the rapid increase in pressure drop associated with grease collecting and congealing in the filters.

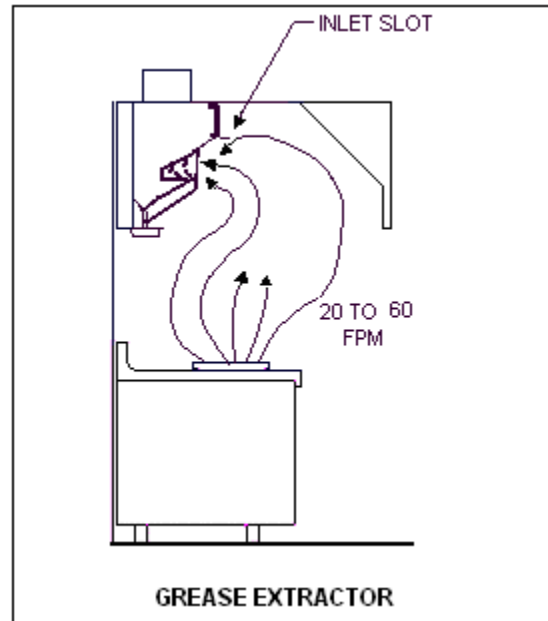


Key Facts

- 1) Maintain a 20 to 60 feet per minute velocity at the front edge. *The edge velocity is in part related to the speed of exhaust gases entering the filters but diminished by the distance away from the same filter.* Large filters will cause low air pressure drop and very low edge velocity.
- 2) The filters are installed in a vertical position to no less than 45 degrees off horizontal plane. The efficiency of these filters is approximately 50 to 60%, by weight.
- 3) Filter hoods are referred to as Bulletin 96 canopies, a reference to NFPA Bulletin 96 which governs construction requirements for commercial kitchen applications. Underwriters Laboratories establishes the standards for the filters, which are known as UL Classified Filters.

GREASE EXTRACTOR

Grease Extractor Hoods use internal baffles to remove grease and may include an internal wash system or may be manufactured as cartridges for manual washing. The Grease Extractor draws exhaust air through a linear slot and creates velocities at the front edge of the cooking equipment of 20 to 60 feet per minute. The face area of linear slot is much lower than the face area of the filter hood, which results in higher capture velocity at the front edge of the cooling equipment (or lower CFM/linear foot). The rising thermal currents are accelerated into the high velocity inlet slot. As the capture speed increases air rushes in to take its place causing a draft and thus capture.



Grease extractors reduce duct grease buildup much more efficiently compared to grease filters and are suited for applications where grease loading is high. By design grease extractors should remove in excess of 95%, by weight, of the grease produced by the cooking process. Various design options are available as listed below:

- 1) Water-wash-type hoods- Grease extractors may utilize continuous cold water sprays to clean the hood internals and to congeal grease particles in the air stream. Such systems offer an advantage when extremely high (140°F or greater) exhaust air temperatures are encountered. The cooling water spray will cause vaporized grease to congeal, yielding extraction efficiency higher than the straight centrifugal unit. Furthermore, these systems serve to regulate exhaust gas temperatures, thereby stabilizing or reducing exhaust requirements between idle and load use of the cooking equipment. Grease extractors with automatic water wash operate under the following principles:

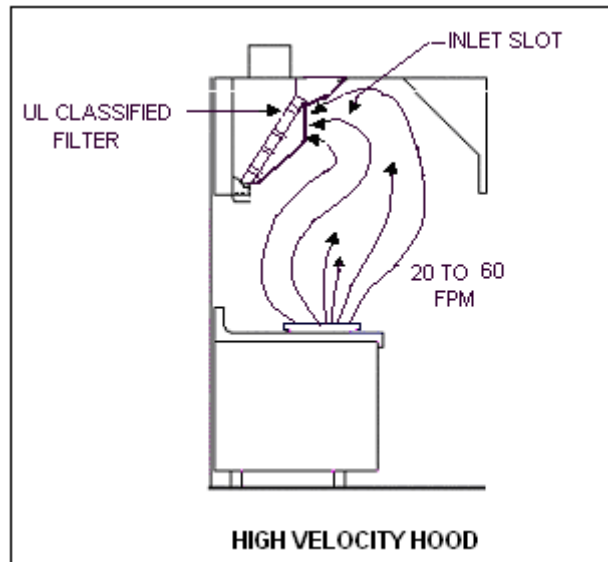
As the exhausted air moves at a high velocity past a baffle system, the heavier-than-air particles of mechanical exhaust ventilation system grease are thrown out of the air stream by centrifugal force. The extracted grease is collected in grease gutters within the hood. The accumulated grease deposit on the baffles is removed by hot detergent water, which is usually automatically sprayed onto the baffle system. This wastewater is then drained off to the sewer or other approved waste removal system. Following key points must be noted:

- Where required by code, an approved backflow prevention device and/or air gap separation should be installed when potable water is plumbed to the hood system, e.g., on the water inlet pipe, prior to the detergent pump solenoid.
 - The cleaning cycle shall be initiated when the exhaust hood is turned off. The exhaust fan normally does not operate during this sequence.
 - The wash system should be automatically activated in the event of high exhaust gas temperatures above 325°F. This will serve as a secondary back up to the fire suppression system.
- 2) Removable cartridges – Grease Extractors are also available with removable cartridges in lieu of the wash system. This allows for the cleaning of the cartridges in a dishwasher and a significant additional initial cost saving. When labor costs are high or when little shut down time is available for hood cleaning, the addition of a wash system is advantageous.

HIGH VELOCITY HOODS

High Velocity (HV) hoods combine a high velocity type slot with a filter hood. Their design incorporates the UL classified filter as the primary grease removal means. The slot opening is limited to only a few

inches (3 to 5") in order to accelerate and direct the inlet of gases, thereby improving smoke capture. The major advantages are capture with moderate 200 to 350 CFM/ linear foot and reduced system initial cost over grease extractors. They are applied in moderate grease load applications. Initial cost is slightly above the standard filter hood and below that of the "grease extractor".



EXHAUST HOOD DATA - COMPARISON

Hood Style	Filter Hood	Grease Extractor	High Velocity Hood
Per Linear Foot CFM	Greatest (250 – 400)	Lowest (150 – 350)	Moderate (200 – 350)
Static Pressure	Least (0.4 to 0.9" W.G)	High (1.3 to 1.7" W.G)	Moderate (0.7 to 1.3" W.G)
HP	Same	Same	Same
Initial Cost	Lowest	Highest	Moderate
Operational Cost*	Highest	Least	Moderate
Grease Removal	Fair (50 – 60%)	Best (90 – 95%)	Moderate (60 – 70%)

* Includes cost of energy exhaust, routine daily and periodic maintenance.

RECIRCULATING HOOD SYSTEMS (Ductless hoods or Vent-less hoods)

Recirculating hood system is a self-contained air exhaust system that removes grease, vapors, fumes, smoke, steam, and odors from the exhausted air; and then reintroduces the filtered air back into the food facility. Recirculating hood system is also known as ductless or ventless hoods and is a viable option where it is not possible to exhaust the air to the out-of-doors.

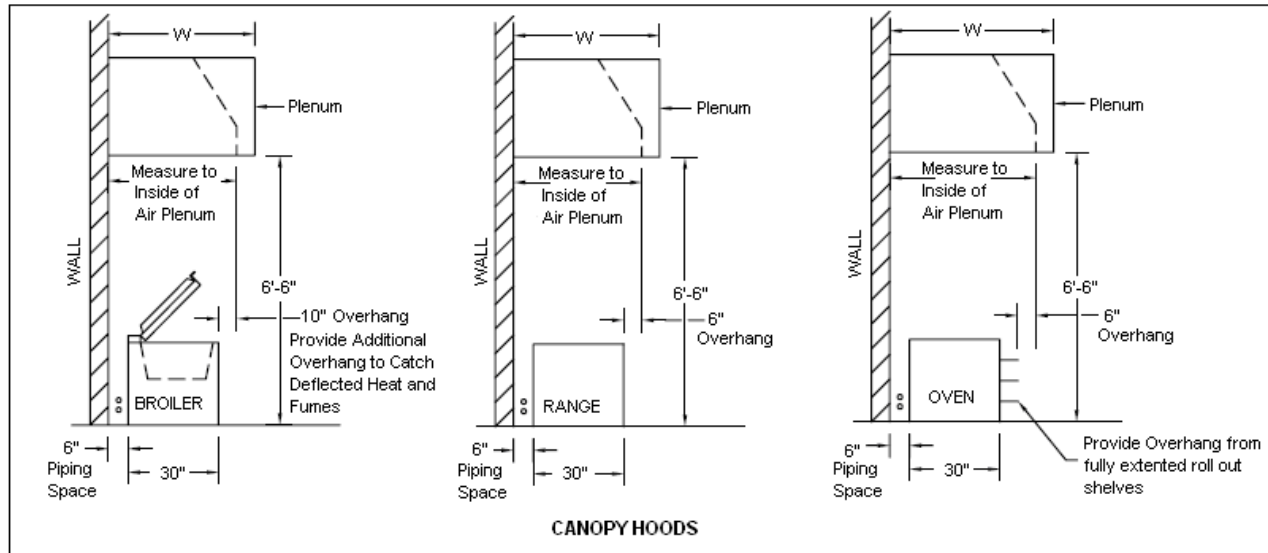
Key points

- 1) The grease, vapors, fumes, smoke, and steam are normally removed using a variety of systems such as water sprays, electrostatic precipitators, or multiple filter banks.
- 2) The odors are typically removed using activated charcoal filters. *Recirculation hood systems are not designed to eliminate heat from the exhausted air.*

FEATURES OF AN EFFECTIVE KITCHEN VENTILATION SYSTEM

The guidance given below indicates the design features and criteria which have been found suitable and effective in meeting the hood ventilation objectives:

- 1) **Cooking equipment layout:** The plan dimension of the canopy is recommended to exceed the plan area of cooking appliances. Hood must overhang, or extend a horizontal distance of at least 6 inches beyond the outer edge of the cooking surfaces on all open sides. This distance is to be measured from the inside lip of the hood. Additional overhang 10 to 12" can be helpful in improving capture effectiveness for open flame equipment such as char-broilers.



- 2) **Height limitations:** Canopies should not be so low as to form an obstruction.
 - The ceiling will determine the depth of the hood. The depth of the hood should be a minimum of 24" and should not exceed 36". *Higher hood height improves capture efficiency.*
 - Hoods are normally installed at a minimum of 6'6" and a maximum of 7'0" above the floor level in accordance with code requirements and to allow sufficient headroom for personnel. Tall equipment may require additional consideration when determining hood installation height.
 - The vertical distance between the lower lip of the hood and the cooking surface should not exceed 4 feet for optimum performance.
- 3) **Wall locations** - An integral 3 inch air space should be provided to meet NFPA 96 clearance requirements against limited combustible walls. This area is typically used for utility access for wiring, gas piping, etc. All seams, joints and penetrations of the hood enclosure shall be welded and/or liquid tight. Approved construction methods and materials shall be used for sealing joints and seams.
- 4) **Wall hood V/s Island hood** - Island hoods require more exhaust flow rate when compared to wall hoods. Island canopy hoods are more sensitive to makeup air supply and cross drafts.
- 5) **Hood Construction** -
 - The hood(s) exterior shall be constructed of a minimum of 18 gauge galvanized steel, stainless steel, or copper in compliance with the Uniform Mechanical Code. The hood(s) shall be constructed using the standing seam method for optimum strength.
 - Canopy hoods should be flashed to the ceiling and adjacent walls. The flashing shall be constructed of the same material and thickness as the hood.
 - Pop rivets, metal screws, or other similar exposed fasteners shall not be used on the internal surfaces of a hood.
 - Every hood shall be securely fastened in place by noncombustible supports.

- Exposed support hangers shall be of an easily cleanable design and construction. Threaded rods and chains are not acceptable.
 - Light fixtures installed inside exhaust hoods shall be marked, "For use within commercial cooking hoods", or equivalent.
- 6) *Cross Drafts*- Cross drafts have a detrimental affect on all hood/appliance combinations. Cross-drafts adversely affect island canopy hoods more than wall mounted canopy hoods. A fan in a kitchen, especially pointing at the cooking area, severely degrades hood performance and may make capture impossible. Cross drafts can also be developed when the makeup air system is not working correctly, causing air to be pulled from open drive-through or pass-through windows or doors.
- 7) *Side Panels and Overhang* - Side (or end) panels permit a reduced exhaust rate in most cases, as they direct the replacement airflow to the front of the equipment. They are a relatively inexpensive way to improve capture and containment and reduce the total exhaust rate. In fact, one of the greatest benefits of end panels is to mitigate the negative effect of cross drafts. Side panels are strongly recommended with the use of high heat equipment or open flame equipment such as char-broilers.
- 8) *Variable Speed Fans and Idle Conditions*- Appliances idle much of the day. Using two-speed or variable exhaust flow rates during idling would minimize operating costs. NFPA 96 (Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations) was recently amended to allow minimum exhaust duct velocity as low as 500 fpm (at the exhaust collar and ductwork). Typical design values of 1500 to 1800 fpm at the exhaust collar are still recommended for normal cooking conditions. This code change facilitates the application of variable speed systems.

AIR FLOW AND MAKEUP AIR

Air that is removed from the kitchen through an exhaust hood must be replaced with an equal volume of makeup air to dilute gas temperatures and to manage building air pressures. Typically 85% of the total air needed is supplied by a mechanical ventilation system together with 15% make up air drawn from adjoining areas. This arrangement keeps the kitchen under negative pressure.

Negative pressure means drawing air into the kitchen space, to prevent escape of cooking odors and contaminants outside the foodservice area. Kitchens that operate under a positive pressure have a tendency to push the cooking odors and effluents outside of the kitchen to the dining area. This is unacceptable, especially in places of "shared common space", i.e. mall food courts, hotels and office buildings where the operator desires a facility with fresh air and no cooking odors.

The makeup air replenishment can be either through the transfer air from the adjacent spaces or by use of integral supply with hood. Regardless of the source of makeup air, it is necessary that whoever designs your system calculates the makeup air required for your facility. Some considerations when calculating makeup air and equipment required are:

- Minimize makeup air velocities;
- Supply dedicated makeup @ 80 to 85% and balance 15 to 20% from the adjacent space;
- Maintain a slight negative pressure in the kitchen —some codes require the amount of makeup air must be adequate to prevent negative pressures in the cooking area(s) from exceeding 0.02 inches water column (4.98 PA). A slight negative pressure is allowed in the cooking area to confine odors to that area, but the negative pressure can not exceed this figure.

MAKEUP AIR STRATEGIES

There are several concepts which can be used to meet the makeup air requirements of a kitchen:

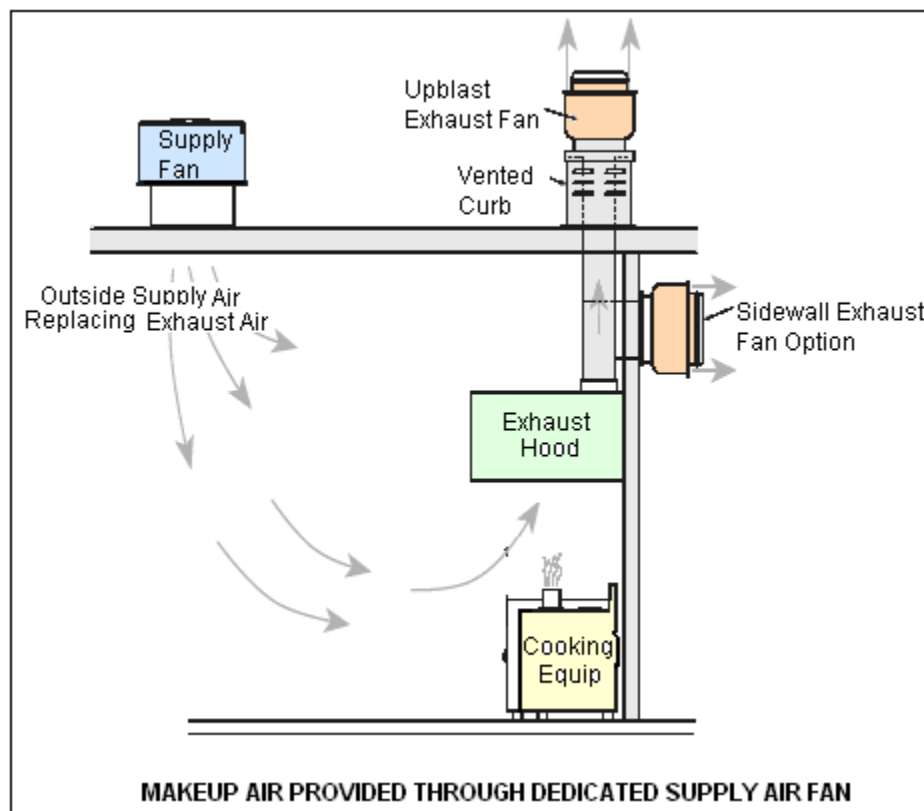
MAKEUP AIR PROVIDED THROUGH NATURAL OPENINGS

The simplest form of ventilation is natural, involving the use of windows, doorways, vents and skylights. Where such incoming air is drawn in naturally some means of control is usually required to exclude outside airborne contaminants. If a fine mesh grille is used this will restrict the ventilation, but a larger overall grille size can compensate. However, for larger installations this would require a grille so large that a mechanical system using a fan and filter would be more suitable. Passive makeup air system should only be considered where:

- 1) An adequately filtered and screened opening can deliver the required volume of air with an in-draft velocity of no more than 400 feet per minute.
- 2) Un-tempered makeup air will not create an unsanitary condition or food contamination problem due to condensation; and,
- 3) The use of unforced makeup air does not violate any applicable standard or code.

MAKEUP AIR PROVIDED THROUGH DIFFUSERS

Makeup air can be delivered to the kitchen through ceiling diffusers. In using this concept, care should be taken to assure that discharge velocities are kept to a minimum to eliminate excessive drafts what could disrupt the airflow into the kitchen hood. In most climates, to maintain a comfortable working temperature in the kitchen, it will be necessary to heat and/or cool (temper) outside air before fed into the kitchen. The figure below shows a commercial kitchen with a typical kitchen ventilation system consisting of a roof mounted up-blast exhaust fan and a supply fan. Sidewall exhaust fan arrangement can be used when penetrating the roof is not practical.



Forced air makeup systems must be connected by an electrical interlocking switch so that the makeup units operate when the exhaust fan(s) operate. Makeup air must be supplied in such a manner so as to prevent large pressure differentials between separate areas.

Regardless of the mechanism used to introduce forced makeup air, the supply air must be filtered so as to remove airborne contaminants. Makeup air must be tempered when necessary to:

- 1) Prevent condensation from being a sanitation or cross-contamination problem;
- 2) Promote comfortable conditions; and,
- 3) Comply with the applicable building code

MAKEUP AIR PROVIDED THROUGH INTEGRAL HOOD PLENUM (COMPENSATING HOODS)

Compensating hoods are designed to introduce tempered or non-tempered air directly into the kitchen through registers mounted in the hood. There are four basic makeup discharge methods:

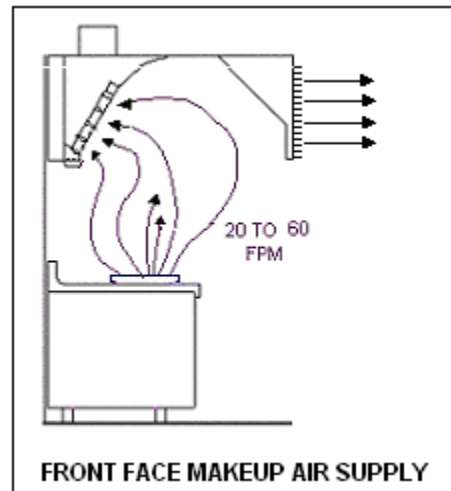
- 1) Front face supply
- 2) Air curtain supply
- 3) Short circuit (internal supply)
- 4) Back-wall supply

These methods may also be combined, such as a face and down discharge arrangement.

HOW TO INTRODUCE MAKEUP AIR

Front Face Supply

In this configuration, air is introduced through the front panel grille in a manner to allow diffusion into the space and be pulled into the hood, similar to a hood without makeup air. This arrangement is ideal in combination with evaporative cooling of makeup air and is suitable for dry climates such as Arizona.

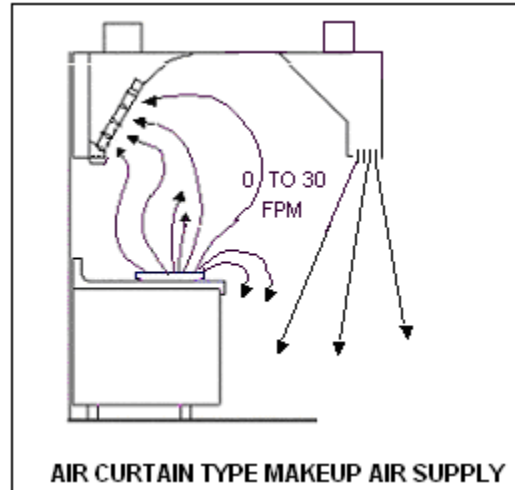


For efficient performance of the front face discharge hood, note the following:

- 1) Face discharge velocities should not exceed 150 fpm and should exit the front face in a horizontal direction.
- 2) Greater distance between the lower capture edge of the hood and the bottom of the face discharge area may decrease the tendency of the makeup air supply to interfere with hood capture and containment.

Air Curtain Supply

In this configuration, air is introduced from the bottom through down discharge grilles or slot holes, much like an air curtain.

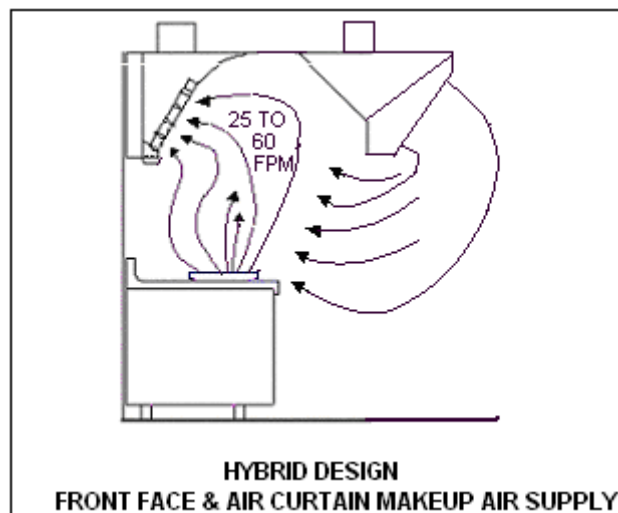


Introducing makeup air through an air curtain is a risky design option as this does not ensure that air delivered from the perimeter slot flow in a straight line - it feathers. Any smoke caught in this situation has a tendency to work its way to the outside and, because of the feathering, some of the smoke rolls into the kitchen atmosphere. Also another objection to this system is that the air velocity striking the chef is so strong that it is very annoying. The makeup air may need tempering (cold or heated) to make it comfortable for the cooking staff.

Most hood manufacturers recommend limiting the percentage of makeup air supplied through an air-curtain to less than 20% of the hood's exhaust flow. An air curtain configuration by itself is not recommended, unless velocities are kept to a minimum and the designer has access to performance data on the actual air-curtain configuration being specified.

Hybrid Design - Front Face & Air Curtain

The figure below shows the hybrid version of hood comprising the features of both front face and air curtain design. It combines a low velocity air curtain that creates makeup supply area directly in front of the hood. The air supply, working in conjunction with the lower pressure developed under the hood due to forced exhaust, causes a controlled air movement through the area between the bottom of the hood and the cooking surface. Using low velocity, the system can utilize makeup air temperatures of 45 to 50°F when allowed by code. In most localities this will reduce the energy consumption of the hood by 50% to 75% over the utilization of room air at 65° or above.



Short Circuit Makeup Air

Short circuit hoods are designed to introduce filtered un-tempered outside air directly into the hood, which reduces the amount of air removed from the kitchen, thus saving energy during the heating and/or cooling seasons. The amount of air which can be "short cycled" without affecting the capture of contaminants varies depending on the required exhaust air volume (often determined by local codes) and the amount of grease, heat and smoke generated by the cooking equipment.

Short circuit hoods have several limitations:

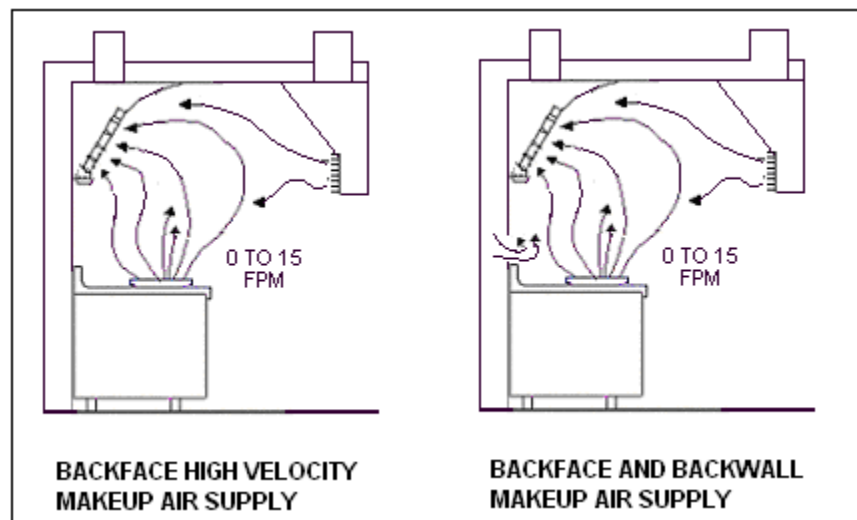
- 1) Studies have shown that the short circuit filters operate reasonably OK when the internal makeup air is not more than 15%. When short circuit hoods are operated at higher percentages of internal makeup air, they fail to capture and contain the cooking effluent, often spilling at the back of the hood.
- 2) Additional sudden flare-ups such as charbroiling, frying and opening of compartment/oven doors will emit grease vapor to the room. Use of short circuit hoods beyond low input cooking lineups such as for nursing homes, soup line-up and grills will emit grease vapor to the atmosphere and floor.

Short-circuit hoods are not recommended. This recommendation is endorsed by leading hood manufacturers, even though they may still include short circuit hoods in their catalogue.

MODERN APPROACHES

Conventional compensating hoods face typical problem of heavier contaminated particles losing below the hood and settling down to the floor. This is especially true when the makeup air temperature drawn from outside fall below freezing. Since cold air is heavier or denser, the air will prevent the contaminants from rising. Cold air does not mix well with hot air being produced at the surface of the cooking equipment. A good analogy of this is a weather front when a cold front from the north meets warm air from the south, a storm develops. The same thing is true of a short circuit hood. As the Cold air enters and falls, it will force the contaminated hot air into the room or down to the floor.

Modern kitchen hoods make use of high velocity principle with the design velocity at the makeup air slot at 1,000 to 2,000 FPM. The filter velocity is around 300 to 400 FPM. High velocity induces room air near the aspirating point resulting in nearly zero FPM at the surface edge. As the percentage of makeup air is increased above 50%, it negates the room air or drives out the contaminated gas from under the hood.



Makeup Air Provided Through a Back Wall Supply (Rear Discharge)

Make up air can be provided to the kitchen from a "back plenum". As with other local makeup air strategies, the quantity of air introduced through the backwall supply should be no more than 60% of the hood's exhaust flow. The back supply plenum may offer the advantage of meeting a "clearance to combustibles" code requirement. It may also be an option to convert a single island canopy into a more functional wall mounted canopy (without actually constructing the wall) as utility distribution can be

incorporated within the plenum. If the rear supply utilizes perforated diffusers, it is important that cleanout access be provided (as with any supply diffuser).

For areas with colder climates, the industry now offers direct gas-fired makeup air systems designed to deliver tempered makeup air for installations requiring frequent air changes. Units are available for natural and propane gas applications and for indoor or outdoor installations. A unique feature of these packages is the self-adjusting burner profile plates allowing two-speed and variable-air-volume applications. The plates ensure proper air velocity and pressure drop across the burner for clean combustion. Because the spring-loaded plates react to the momentum of the fresh air stream, no motors or actuators are needed to drive them, nor do they need to be manually set to a specific position.

RECOMMENDATIONS FOR IMPROVED EXHAUST HOOD PERFORMANCE

Makeup air should not be directed toward the hood otherwise it will interfere with the hood's ability to capture and contain the effluents. Discharge velocity at the makeup air point should be set at a design value such that the terminal velocity does not exceed 50 feet per minute (fpm) at the edge of the hood capture area. Generally codes stipulate that 10 feet horizontal or 3 feet vertical clearance exist between the makeup air intake and the exhaust outlet. Check local code requirements.

- 1) The primary recommendation for minimizing the impact that locally supplied make up air will have on hood performance is to minimize the velocity (fpm) of the makeup air as it is introduced near the hood. This can be accomplished by minimizing the volume (CFM) of makeup air through any one pathway, by maximizing the area of the grilles or diffusers through which the makeup air is supplied. Follow the steps below:
 - I. The first step in reducing the make up air requirement is to minimize the design exhaust rate. This can be accomplished by prudent selection and application of UL Listed hoods and taking advantage of the "exhaust flow" recommendations from hood suppliers for the cook line under consideration.
 - II. The second step in reducing makeup air flow is to take credit for outside air that must be supplied by the HVAC system to meet code requirements for ventilating the indoor space. Depending on the architectural layout between the kitchen and the dining room, it may be practical to transfer most of this air from the dining room to the kitchen. For example, if 2400 CFM of outdoor air that is being supplied to a 120- seat dining room can be transferred to the kitchen, the local makeup air requirement can be reduced accordingly. Supplying makeup air through dedicated displacement unit at a good distance away from the hood is an effective strategy for introducing replacement air.

Rather than supplying 80 to 85% of the exhaust rate through makeup air strategy, designers should make an effort to keep this ratio below 60% (obviously, the other 40% of the replacement air must be drawn from another source such as transfer air HVAC supply). Not only will hood performance be superior, the kitchen environment will benefit from the cooling contribution of the "recycled" dining room air. It is important to realize that the outdoor air required by code is usually conditioned before it is introduced into the dining room. So... why not use this outdoor air as a makeup air credit!
 - III. The third step in reducing makeup air flow is to select a configuration for introducing this local makeup air into the kitchen that compliments the style and size of hood. The incoming air from the ventilation system needs to be arranged so as not to adversely affect the performance of the flue at any open flued gas appliances.
 - The number and location of return air registers should be such as to provide uniform distribution of makeup air throughout the facility, taking into consideration cross drafts, room configurations, and required air flows.
 - If transfer air is not an option, it is recommended that only perforated plate ceiling diffusers be used in the vicinity of the hood, and to reduce air velocities from the diffusers at a given supply rate, the more diffusers the better!
 - The use of properly designed registers and diffusers will help to slow down the air velocity and evenly distribute the makeup air.

- The makeup air registers should be located so as to prevent a short circuiting of the air being supplied for the exhaust system.
- The make up air can be drawn in through permanent grilles, but they need to allow for between 200 and 300 fpm air flow velocity.

Consider a combination of makeup air strategies (e.g., backwall supply and perforated ceiling diffusers). This reduces the velocity of air being supplied through each local pathway, mitigating potential problems with hood capture. Effective options (at 60% or less) include front face supply, backwall supply, and perforated perimeter supply. Short-circuit supply is not recommended, and air-curtains should be used with extreme caution. The pros and cons of the different configurations have already been discussed.

- 2) Temperature of the locally supplied makeup air can also impact hood performance as air density (buoyancy) impacts the dynamics of air movement around the hood. Example: St. Paul – winter design -10°F and a summer temperature of 110° F yields a 26% to 37% variation (depending on relative humidity). This must be compensated for during the course of the year in order to maintain uniform conditions. Generally, hotter makeup air temperatures (e.g. 90°F) will affect hood performance more adversely than cooler air (e.g. 75°F). In most dry climates, such as Arizona, evaporative cooling is an effective method of maintaining make up air temperatures within a range that is comfortable for kitchen staff and does not hamper hood performance. Note that the makeup air tempered to 50°F or evaporative cooled to 84°F has a density controlled within +4.8% to -2.5%. For cold places like Chicago, the makeup air must be heated. Most codes require makeup air heating capacity be sized to provide air tempered to no less than 10°F lower than design room air temperature.

TEMPERATURE CORRECTION FACTORS

Outside Air Temp. Degree F	Density Correction Factor	Dry Air (@29.921" Hg.) Lbs/CFT	Moist Air (@29.921' HG.) Lbs/CFT
-40	1.26	.095	.095
-30	1.23	.092	.092
-20	1.20	.090	.090
-10	1.18	.088	.088
0	1.15	.086	.086
10	1.13	.085	.085
20	1.10	.083	.083
30	1.08	.081	.081
40	1.06	.079	.079
50	1.04	.078	.077
60	1.02	.076	.075
70	1.00	.075	.073
80	.98	.074	.071
90	.96	.072	.069
100	.95	.071	.066
110	.93	.070	.064
120	.92	.068	.061
130	.91	.067	.057
140	.89	.066	.05
150	.87	.065	.049

This table is used to account for variations in the makeup air load which is related directly to the air density. Since the exhaust fan is a constant volume device, it is critical that the makeup air variable be controlled.

The table provides a convenient method to determine the actual exhaust gas volumes being applied in an exhaust/makeup system. To determine the actual air volume for other than standard air at 70°F and 29.92" barometer, multiply the air volume (CFM) by the LBS/CFT dry air at the initial temperature divided by the LBS/CFT at the new temperature to equal the ACFM. Where the conditions include substantial water vapor, use the "Moist Air" values.

$CFM \times \text{Initial LBS/CFT} / \text{New LBS/CFT} = \text{ACFM @ 29.921" Hg.}$

Summarizing...

In order to provide an efficient air exchange system, the following factors should be taken into consideration when evaluating a makeup air system:

- 1) The kitchen area must be negative in pressure in relation to surrounding public areas, but may remain positive in relation to atmosphere. Exception: Health care facilities.
- 2) Makeup air injected internally to the hood does not improve capture but only serves to reduce gas temperatures under the hood.

- 3) Makeup air volume is determined by exhaust air volume. Makeup air distribution location is determined by room air change requirements and minimum 10 feet horizontal or 3 feet vertical separation from the exhaust hood.
- 4) Considerable care must be taken where doorways and windows are used for natural ventilation that fumes and dirt from surrounding premises are not drawn into the kitchen. The air needs to be drawn from an adjacent area where it is clean. Where smoking is allowed (for example in an adjoining dining room) it is advisable not to draw this air into the kitchen as make up air. Adjoining toilets and bathrooms are not allowed to be used for supplemental air.
- 5) The effective balancing of incoming and extracted air, together with removal at source of hot vapors as above should help prevent the kitchen becoming too hot. The replacement air inlets from any mechanical ventilation systems can be positioned to provide cooling air over hot work positions. If this is still not enough, some form of overhead air outlet discharging cool air or air conditioning may be required.
- 6) The exhaust and makeup air systems shall be connected by an electrical interlocking hardwired connector so that one system cannot be operated when the other system is off.
- 7) Local freestanding fans are not recommended. They may spread micro-organisms or set up air currents or turbulence affecting the efficiency of the designed ventilation systems. They also introduce other hazards such as tripping and electric shock hazards from the trailing cable. As part of a balanced ventilation system fans fixed to the structure could be considered.

SIZING AND APPLICATION DETAILS

The type of cooking that an operation does and the equipment used has a direct influence on the design and "horsepower" of the ventilation system requirements for any given facility. Some kitchens will use more ventilation energy than others simply because of the type of cooking done. For example, kitchens where fryers, char-broilers and griddles are in use generate more heat and effluent than those specializing in the preparation of lighter meals such as salads, sandwiches and soups. Ovens used for cooking pizzas and other baked foodstuffs release intense heat when the doors are opened. And, with today's popular steamers and combination oven technologies, superheated steam poses added problems for inadequate ventilation systems.

Cooking appliances are categorized as light-, medium-, heavy-, and extra heavy-duty, depending on the strength of the thermal plume and the quantity of grease and smoke produced. The strength of the thermal plume is a major factor in determining the exhaust rate. By their nature, these thermal plumes are very turbulent and different cooking processes have different "surge" characteristics. For example, the plume from hamburger cooking is strongest when flipping the burgers. Ovens and pressure fryers may have very little plume until they are opened to remove food product. Open flame, non-thermostatically controlled appliances, such as under-fired broilers and open top ranges, exhibit strong steady plumes. Thermostatically controlled appliances, such as griddles and fryers have weaker plumes that fluctuate in sequence with thermostat cycling (particularly gas-fired equipment). As the plume rises by natural convection, it is captured by the hood and removed by the suction of the exhaust fan. Air in the proximity of the appliances and hood moves in to replace it. As a rule of thumb, where the ventilation requirements of cooking equipment are not available, an approximate air flow rate in cubic feet per minute (CFM) can be calculated from the guidelines below:

Type of Cooking Equipment		Temperature Range	Exhaust Flow Rate CFM per sq-ft area of hood
Light Duty	Ovens, Roasters, Steam Kettles, Ranges, Non-grease Producing Equipment	Up to 400 deg F	50
Medium Duty	Fryers, Grilles, Griddles, Deep Fat Fryers	400 - 600 deg F	80
Heavy Duty	Solid Fuel Appliances, Char-broilers, Electric Broiler	700 deg F and above	100

Or in other words, the minimum hood face velocity shall be: 50 fpm for light; 80 fpm for medium and 100 fpm for heavy duty cooking. Static pressure typically ranges from 0.625" to 1.0" for 1 story buildings. Note that the local codes specify required minimum exhaust standards. The code requirement may exceed traditional rates per linear foot or square foot rating established by the Uniform Mechanical Code. Some local codes require 100 cfm/ft² of hood area for wall style hoods as a minimum.

Ventilation Rates for Kitchens without Hoods

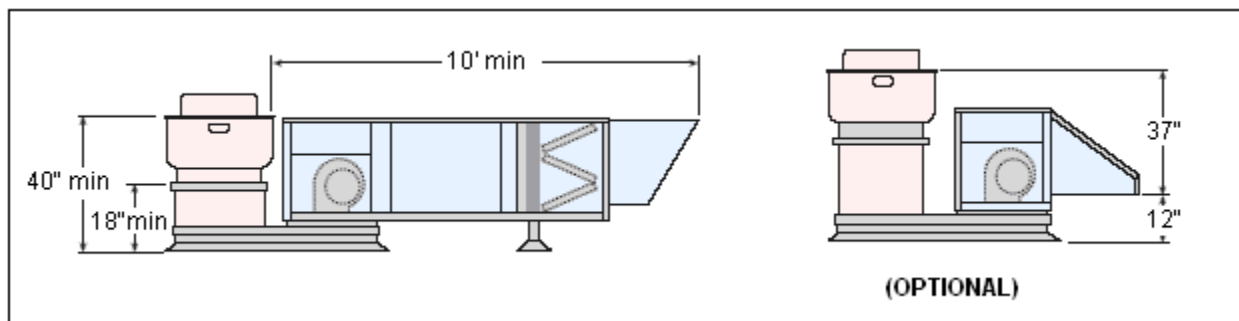
Ventilation rates are best specified as air velocities into the canopy rather than standard air changes per hour. Where canopies are not used (for examples ventilated ceilings) the ventilation rates needed can be calculated by a competent designer taking account of room sizes and usages. As a guide, a ventilation rate of not less than 3 CFM per sq-ft of floor area and not less than 30 air changes per hour (ACH) is advisable. A lower ACH figure (say 10) may be needed to avoid discomfort from draughts where the kitchen is subdivided into separate rooms (for example wash-ups, vegetable preparations).

EXHAUST FANS

NFPA Considerations- The National Fire Protection Association (NFPA) specifies minimum distance criteria for kitchen exhaust and supply fans as shown below:

- 1) Roof deck to top of exhaust fan wind band - 40" min
- 2) Roof deck to top of curb - 18" min
- 3) Supply fan intake - 10' min from all exhaust fans.

For applications where the 10' horizontal distance cannot be met, vertical separation between exhaust and supply must be at least 3 feet.



The following criteria should be used for the selection of exhaust fans operating for commercial kitchen hoods:

1. Wheel design should be the non-overloading type, i.e., backward inclined or backward curved.

2. Select adjustable belt driven fans which protect the motor from grease buildup and exhaust air heat. Use of direct drive fans prohibits accurate system balancing since volume dampers are not permitted (see dampers).
3. Fans should discharge away from building surfaces, normally vertical in direction. Most codes require that the fan discharge be located a minimum of 40" above the roof surface, at the same time the requirement for maintaining the horizontal duct run at least 18" above the roof surface is satisfied.
4. Fans should be sized with the largest diameter wheel turning at the slowest RPM permitting the most laminar air flow.

SOUND LEVELS

In many cases, the sound generated by a fan must be considered. For the fan industry, a common unit for expressing sound pressure level is the sone. *In practical terms, the loudness of one sone is equivalent to the sound of a quiet refrigerator heard from five feet away in an acoustically average room.* Sones are a linear measurement of sound pressure levels. For example, a sound level of 10 sones is twice as loud as 5 sones.

As a general guideline, choose a fan that has a sone value within the range specified. Recommended Sound Levels for Hotel kitchens and laundries, supermarkets not to exceed 7-21 Sones (or DBA - 56-72)

Note: Spaces with a hard construction (concrete block, tile floors, etc.) reflect sound. For these finishes, select fans on the lower end of the range. Spaces with soft construction or those with carpeting and drapes, etc., absorb sound. For these spaces, fans near the higher end of the range may be selected.

EXHAUST DUCTING

Exhaust ducts are designed by a constant velocity method. A minimum of 1500 and maximum of 2500 feet per minute (depending upon various codes) is mandated. 1,750 FPM is the recommended velocity to use in selecting exhaust collar sizes. Using this guideline, the exhaust pressure drop of the hood only (includes filter and duct collar losses; does not include ductwork losses) will be approximately 0.55 inch W.G.

To calculate the duct area required for a desired CFM and duct velocity:

Duct Area (in sq-ft) = Air flow in CFM / Duct Velocity in FPM

Or to calculate the duct velocity for a duct size and CFM:

Duct Velocity (in FPM) = Air flow in CFM / Duct Area in sq-ft

Shown below is the exhaust CFM per Collar using 1,750 FPM duct velocity:

CFM PER EXHAUST COLLAR AT 1,750 CFM															
	8"	10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"	32"	34"	36"
8"	778	972	1167	1361	1556	1750	1944	2139	2333	2528	2722	2917	3111	3306	3500
10"		1215	1458	1701	1944	2188	2431	2674	2917	3160	3403	3646	3889	4132	4375
12"			1750	2042	2333	2625	2917	3208	3500	3792	4083	4375	4667	4958	5250
14"				2382	2722	3063	3403	3743	4083	4424	4764	5140	5444	5785	6125
16"					3111	3500	3889	4278	4667	5056	5444	5833	6222	6611	7000

The pressure drop in the hood for the exhaust air flow is comprised of two losses: the pressure drop through the filters and the entrance losses associated with the entry of the exhaust air into the exhaust ductwork.

Filter Face Velocity F.P.M.	Filter Pressure Loss I.W.G.	Exhaust Collar Velocity F.P.M.	Exhaust Collar Pressure Loss, I.W.G.
150	0.18	1,500	0.06
200	0.33	1,750	0.09
250	0.50	2,000	0.11
300	0.73	2,200	0.16

The routing of exhaust duct is controlled by codes which require that the duct leading to the exterior of the building be the most direct possible route. Horizontal exhaust duct should be pitched either toward the hood or toward a clean out sump located at the lowest point. Usually a sump is located where the horizontal duct changes to the vertical.

Key Facts

- 1) Ducting shall be installed in compliance with local building and fire codes.
- 2) Exhaust ducts from hoods shall be totally separated from all other ventilation systems.
- 3) If the hood length exceeds 12 feet, it is necessary to provide two discharge ducts from the top of the hood to the main exhaust duct. For listed hoods, refer to the manufacturer's installation and operating conditions to determine if a distance of greater than 12 feet between ducts is permitted.
- 4) Exhaust outlets for the exhaust hood ducting shall extend through the roof unless otherwise approved by the local building official. Such extension shall be at least 24 inches above the roof surface; at least ten feet from an adjacent building, adjacent property line, or air intake into any building; and shall be located at least ten feet above the adjoining grade level. However, exhaust outlets for ducting may terminate at least five feet from an adjacent building, adjacent property line, or air intake into a building if the air from the exhaust outlet is discharged away from such locations.
- 5) Exposed duct systems serving a Type I hood shall have a clearance of at least 18 inches from unprotected combustible construction. This clearance may be reduced to not less than three inches, provided the combustible construction is protected with material required for one-hour fire-resistive construction. Hoods less than 12 inches from the ceiling or wall, including the space between the duct and the duct shaft, shall be flashed solidly. Flashing shall be of either the same materials used in the construction of the hood, or of other materials conforming to one-hour fire resistive construction. Check with your local building and fire authorities to determine other acceptable means of meeting this requirement.
- 6) A fully welded 16 gauge black iron or 18 gauge stainless steel is required by NFPA. Square or rectangular ducts are most common to meet the "fully welded construction" requirement. A circular duct requires a smaller space. If rectangular ducts are used, they should be as nearly square as possible.
- 7) All seams and joints shall have a liquid-tight, continuous external weld.
- 8) The duct take-off at the top of the hood should be transitioned. This will reduce the entrance loss and resistance offered to airflow at the ducting entrance point.
- 9) The bends and elbows of the ductwork should be kept at a minimum. When elbows are used, a radius of 2 to 2 1/2 times the duct diameter is recommended. This will minimize the resistance against which the blower must move the air.
- 10) Exhaust ducts should not be installed closer than 18" to combustible surfaces. The clearance requirements may be reduced by shielding the combustible materials with fire rated material. NFPA 96 allows joints in ductwork to be made with companion flanges and high temperature seals. However, some counties require all joints to be fully welded.
- 11) Codes require that exhaust ducts penetrating the roof extend at least 18" above the roof surface. When a duct runs horizontal to the roof the bottom of the duct must be 18" above the roof surface. The clearances from combustible requirements apply above the roof as well as below the roof and also include the roof curb. Steel pre-fabricated and insulated roof curbs are recommended. Local codes may exceed these requirements and should be consulted.
- 12) Duct systems serving a Type I hood shall be constructed and installed so that grease will not collect in any portion of the ducting. The ducting shall slope not less than 1/4 inch per linear foot toward the hood or toward an approved grease reservoir. Where horizontal ducts exceed 75 feet in length, the slope shall be not less than one inch per linear foot.
- 13) Properly designed clean out ports must be provided at specified distances and at each change of direction in the duct run. Cleanout access panels should be located on the sides of the duct with the bottom edge of the opening not less than 1" from the bottom of the duct.

MAKEUP AIR SUPPLY DUCTING

Supply air collars & ducts should normally be sized at a velocity of 1,000 FPM to not more than 1,500 FPM to avoid excessive pressure loss. Using this guideline, the supply air pressure drop for a hood with an integral plenum (does not include ductwork losses) will be approximately 0.25 inch W.G.

Shown below is the supply CFM per Collar using 1,250 FPM duct velocity:

CFM PER SUPPLY COLLAR AT 1,250 CFM															
	8"	10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"	32"	34"	36"
8"	556	694	833	972	1111	1250	1389	1528	1667	1806	1944	2083	2222	2361	2500
10"		868	1042	1215	1389	1563	1736	1910	2083	2257	2431	2604	2778	2951	3125
12"			1250	1458	1667	1875	2083	2292	2500	2708	2917	3125	3333	3542	3750
14"				1701	1944	2188	2431	2674	2917	3160	3403	3646	3889	4132	4375
16"					2222	2500	2778	3056	3333	3611	3889	4167	4444	4722	5000

DAMPERS

Exhaust - Building codes state that no damper may be used in a kitchen exhaust duct unless that damper is an integral part of a listed grease extractor or hood and damper assembly. The requirement prohibits the use of back draft, volume, smoke, fire or balancing dampers.

Makeup Air Dampers- NFPA Bulletin 91 mandates a U.L. fire damper as part of supply air plenum which introduces makeup air inside the hood cavity, i.e., short circuit. The use of back draft dampers in supply air is highly recommended especially in cold climates to prevent cold air from entering the building in off hours. Dampers in makeup air ducts for back draft, volume, smoke and/or fire control are governed by NFPA Bulletin 91 sections referring to air ducts.

HOOD FILTERS

Grease filters are designed to remove grease particles from the exhaust air stream. The most common grease filters currently in use are the baffle-type filters. These simplify the cleaning process since most of the grease deposits run off the baffles to a collection device. The old style mesh-type filters are not acceptable in new installations. NFPA 96, ANSI NSF Standard 2, and UL 1046 no longer recognize the old style mesh type filters. They may present a fire hazard and decrease airflow as they become clogged with grease.

Key Points:

- 1) Grease filters and extractors shall be of such size, type, and arrangement as will permit the required quantity of air to pass through such units at rates not exceeding those for which the filter or extractor was designed and approved. The optimum operating velocities, measured in feet per minute (FPM), vary from filter to filter.
- 2) Exhaust systems that have broken, missing, or undersized filters are prone to collect accumulations of highly combustible grease deposits throughout the entire duct system. Because of the chimney effect created in vertical ductwork, a very intense rapidly spreading flash fire can engulf the entire system. Filter equipped exhaust systems shall not be operated with damaged or missing filters.
- 3) Type I hoods shall be equipped with approved grease filters or grease extractors designed to remove grease from the exhausted air.
- 4) It is important to install filters at the ends of the hood. However, grease filters should not be installed directly over a broiler flue, or any other flue from cooking equipment. Hot gases can make the filters very difficult to clean and may damage them.
- 5) Filters shall be installed at an angle not less than 45 degrees from the horizontal and shall be equipped with a drip tray beneath the lower edge of the filter. This enables the grease to be collected in the drip tray and avoids grease dripping into food, or on food preparation surfaces.
- 6) All grease collecting equipment shall be accessible for cleaning. Filter units shall be installed in frames or holders with handles so as to be readily removable without the use of tools, except where the system is designed for in-place cleaning.

- 7) Proper hood design will keep the temperature at the filters less than 200° Fahrenheit. When the temperature at the filters is less than 200° Fahrenheit, the grease deposits will be brownish in color and can be easily removed. When the temperature exceeds 200° Fahrenheit, the grease deposits tend to bake on the filters. The color of the deposits will darken and become extremely difficult to remove.

Therefore, the manufacturer's specifications should be consulted to obtain the appropriate rates for each specific filter.

FIRE EXTINGUISHING SYSTEMS

National codes require automatic fixed type fire protection systems to protect ducts, plenums, and cooking surfaces whenever the cooking process releases grease vapors. The respective NFPA standards which cover the application are as follows:

- Exhaust systems used to remove smoke and grease-laden vapors generated by commercial cooking equipment must comply with the State Fire Prevention Code and the latest edition of ANSI/NFPA-96.
- Electrical wiring shall conform to the requirements of the National Electrical Code -NFPA #70
- NFPA 10 also encompasses requirements for portable hand type extinguishers in addition to fixed systems.
- Wet chemical system - NFPA 17A
- Water sprinkler system - NFPA 13

Key Facts

- 1) Approved automatic fire extinguishing systems shall be provided for the protection of commercial-type cooking equipment. The requirement for protection does not include equipment that does not create or generate grease-laden vapors, such as steam kettles and steam tables.
- 2) Deep fat fryers, ranges, griddles, broilers, and other cooking equipment which may act as a source of ignition for grease in the hood, grease removal device, or duct, shall be protected by approved fire extinguishing equipment installed in accordance with the fire code adopted by the jurisdiction. Necessary approvals must be obtained from the local fire authorities prior to putting equipment into operation.
- 3) National codes require that activation of the automatic fire protection system also disconnect the supply of fuel from the cooking line protected by the system. Fuel shut-off is by means of shunt trip breakers, contactors; solenoid activated or mechanically activated gas valves through a spring and cable system linkage. All shut-off devices shall be considered an integral part of the system, and shall function when the system is in operation. The automatic shut-off device must be manually reset able prior to fuel or power being restored. The application of these systems is a specialty. Codes require the system be designed and installed by certified personnel.
- 4) Exhaust hood fans shall continue to operate after the fire extinguishing system has been activated, unless fan shutdown is required by any component of the ventilation system, or by the design of the extinguishing system.
- 5) Some systems and regional codes require that exhaust and/or makeup air systems be interlocked with the automatic fire system. Generally, wet chemical, and sprinkler type systems require the exhaust fan remain operational during system activation. It is desirable, and in most localities mandatory, for activation of the fire protection system to shut off the makeup air supply which will cause the space in which the hood is located to become greater in negative pressure to prevent the migration of smoke to other areas.
- 6) A simple push button or switch control should start exhaust and makeup air systems for use by unskilled kitchen personnel. Under normal operation, the exhaust fan should start and operate an interlock with the makeup air system. Since the makeup air system may require provisions for heat, cooling or vent air, the function should be provided by a selection switch or outside air thermostat. A wash hood must incorporate the mandatory wash cycle at the end of each operation through a control cabinet supplied by the hood manufacturer.

LIGHTING

The requirement for minimum levels of lighting measured at the working surface is defined by the local health codes. Some form of lighting device is required in all canopy type hoods. The application of these lights is specifically covered under NFPA Bulletin 70, the National Electrical Code.

Key Facts

- 1) All lighting fixtures used in a commercial cooking hood must be listed for the application. U.L. has specified that the fixtures must be installed a minimum of 48" above the cooking surface.
- 2) Three types of lights bear the necessary listing for the application: 1) surface mounted incandescent; 2) recessed mounted incandescent and 3); recessed mounted fluorescent fixtures.
- 3) The National Electrical Code considers the inside portion of a hood to be contaminated air duct and prohibits the mounting of wiring or conduits inside the hood. It also requires that high temperature insulation types be used. The hood shell may be penetrated for lighting and fire equipment fixtures utilizing approved grease penetration fittings.
- 4) Both OSHA and NSF (National Sanitation Foundation) require that the globe be protected from breakage by either a removable (thus cleanable) metal guard or be a non-shattering type globe. Shatterproof glass and plastic coated globes are commonly used. The glass must be of a type that is resistant to the high temperatures.

LOCAL CODES AND STANDARDS

Canopy hood(s) shall built in accordance with National Fire Protection Association (NFPA) Bulletin #96, Uniform Mechanical Code, International Mechanical Code (IMC), International Conference of Building Officials (ICBO), Building Officials and Code Administrators (BOCA), Southern Building Code Congress International (SBCCI), and bear the National Sanitation Foundation (NSF- Standard 2) Seal of Approval. It is important that the hood manufacturer shall provide, on request, the necessary data that confirms compliance with the code authorities listed above. Commercial exhaust hood systems must comply with the latest requirements of the applicable building code.

- 1) The Uniform Mechanical Code states, "Hoods shall be installed at or above all commercial-type deep fat fryers, broilers, fry grills, steam-jacketed kettles, hot-top ranges, ovens, barbecues, rotisseries, dishwashing machines and similar equipment which produce comparable amounts of steam, smoke, grease or heat in a food-processing establishment. For the purpose of this section, a food-processing establishment shall include any building or portion thereof used for the processing of food but shall not include a dwelling unit." The installation and design of commercial kitchen hoods are governed under the mechanical code; however, many areas allow the products to be covered under the Department of Public Health. Hoods may be covered under the jurisdiction of the mechanical and health inspectors and therefore must meet both codes.
- 2) Listed ventilation equipment shall be installed and used according to the manufacturer's installation and operating instructions. A copy of the instructions Mechanical Exhaust Ventilation Systems shall be readily available for review by the enforcement officer.
- 3) Ecological Codes -Many areas, especially communities with high population density and communities with air quality problems, as determined by the EPA, may require that the air be cleaned of grease, particulate and odor before releasing the exhausted air into the atmosphere. These must be inquired about and if required designed into the job on an individual basis.
- 4) Kitchen Ventilation System Performance Testing -The phrase "hood capture and containment" is defined in ASTM F-1704 *Standard Test Method for the Performance of Commercial Kitchen Ventilation Systems* as "the ability of the hood to capture and contain grease-laden cooking vapors, convective heat and other products of cooking processes." Hood capture refers to these products entering the hood reservoir from the area under the hood, while containment refers to these products staying in the hood reservoir and not spilling out into the adjacent space. The phrase "minimum capture and containment" is defined as "the conditions of hood operation in which minimum exhaust flow rates are just sufficient to capture and contain the products generated by the appliance in idle or heavy-load cooking conditions, and at any intermediate prescribed load condition."

- 5) UL Hood and Damper Assemblies -The UL 710 testing procedure (as revised in 1992) is the nationally accepted method of determining the suitability of a manufacturer's hood for use over cooking equipment. The results of this test procedure place restrictions on how a specific hood may be used. The main restrictions include:
- The maximum cooking surface temperature over which the hood may be placed.
 - The maximum vertical distance between the front lower edge of the ventilator and the cooking equipment
 - The minimum allowable exhaust air volume
 - The maximum allowable internal make up air volume for each type of internal makeup air delivery method
 - The maximum overall length of the hood per exhaust collar location
 - Special methods of construction

DESIGN CALCULATIONS

Hood size is determined by the size and capacity of the cooking equipment. The capacity of the hood itself is expressed in cubic feet per minute (CFM) and is determined by two primary factors:

- 1) The type of cooking equipment used, i.e. fryers, ovens, char-broilers, etc.
- 2) Air flow restrictions such as walls, fabricated enclosures, etc.

These factors define the velocity and rate of expansion of the air in the generated updraft. Appliances with large, heat-radiating surfaces like char-broilers and grills, produce a stronger updraft than, say, an oven, which is designed to contain the heat it produces within a confined space.

The kitchen walls, fabricated enclosures and the type of hood system used determines how much exhaust air is needed. The more enclosed the cooking equipment, the less exhaust is needed for proper ventilation. So, an appliance that is open on all sides requires more exhaust volume than when only one side is open.

EXHAUST AIRFLOW REQUIREMENTS FOR CANOPY HOODS

The Uniform Mechanical Code separates cooking equipment into the following four categories for the purpose of calculating minimum required withdrawal airflow:

Key to formulas

A = Horizontal surface area of the hood, in square feet

D = Distance, in feet, between the lower lip of the hood and the cooking surface

P = That part of the perimeter of the hood that is open, in feet

Q = Quantity of air in cubic feet per minute (CFM)

Formula 1

For Type I hoods located above solid-fuel cooking equipment and grease burning char-broilers.

Number of Exposed Sides Formula

- 1) 4 (island or central hood) ; $Q=300A$
- 2) 3 or less ; $Q=200A$
- 3) Alternate formula ; $Q=100PD$

Formula 2

For Type I hoods located above high-temperature cooking equipment, such as deep-fat fryers and woks.

Number of Exposed Sides Formula

- 1) 4 (island or central hood) ; $Q=150A$

- 2) 3 or less ; $Q=100A$
- 3) Alternate formula ; $Q=100PD$

Formula 3

For Type I hoods located above medium-temperature cooking equipment, such as rotisseries, grills, ranges.

Number of Exposed Sides Formula

- 1) 4 (island or central hood) ; $Q=100A$
- 2) 3 or less ; $Q=75A$
- 3) Alternate formula ; $Q=50PD$

Formula 4

For Type I hoods located above low-temperature cooking equipment, such as medium-to-low-temperature ranges, roasters, roasting ovens, and pastry ovens. This formula is also used for Type II hoods located above non-grease generating equipment, such as high-temperature dish machines.

Number of Exposed Sides Formula

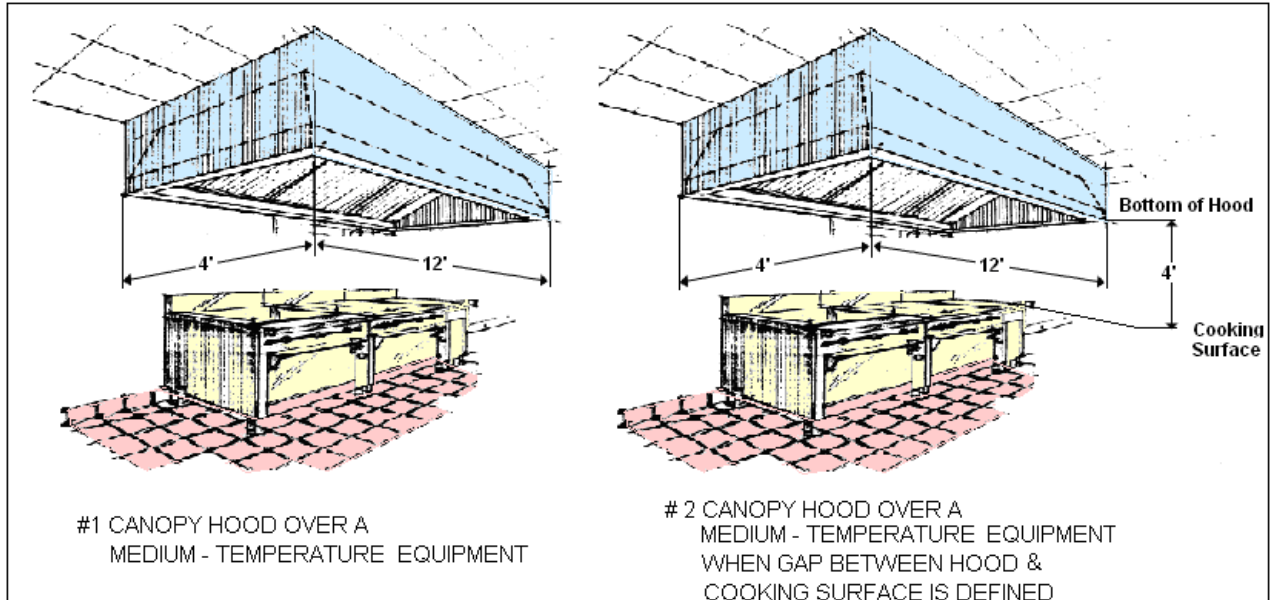
- 1) 4 (island or central hood) ; $Q=75A$
- 2) 3 or less ; $Q=50A$
- 3) Alternate formula ; $Q=50PD$

General requirements

- 1) Type I hoods for use over charcoal and other solid-fuel char-broilers shall be provided with separate exhaust systems (e.g., separate exhaust duct and exhaust fan).
- 2) When different types of cooking equipment are installed under a common hood, the entire hood shall be designed using the formula that produces the highest flow rate. For example, a single hood installed over a gas char-broiler, fryer, and range, shall be designed using the formula for the char-broiler (Formula 1).
- 3) When cooking equipment is installed back to back and is covered by a common island-type hood, the minimum airflow required may be calculated using the formula for three sides exposed.
- 4) In sizing exhaust hood airflow, the formulas are intended to meet the needs of most installations. Due to variables at each installation site, such as cross currents, alterations may be required in order to provide an exhaust system which properly removes the cooking effluent from the kitchen.

Examples

The examples #1 and #2 below will illustrate the use of the hood sizing formulas for canopy hoods. Consider a wall type exhaust hood of 4' x 12' with three sides exposed. Consider the hood is located above medium temperature category kitchen equipment. Determine the exhaust flow requirements.



Solution

For medium-temperature category use formula-3; $Q=75A$

Case #1

Since only dimensions are known the area (A) is obtained by multiplying the length times the width;

$$12 \text{ ft.} \times 4 \text{ ft.} = 48 \text{ sq- ft}$$

$$\text{Therefore, } Q=75 \times 48 = 3,600 \text{ CFM}$$

A minimum of 3,600-CFM airflow would be required for this particular hood.

Case #2

Fig #2, since the distance between the bottom of hood and cooking surface is defined, use the alternate formula -3; $Q=50PD$.

The P (perimeter) is obtained by adding together the length and width dimensions for the exposed sides, $4 \text{ ft} + 12 \text{ ft} + 4 \text{ ft} = 20 \text{ ft}$ and the D (gap) in this example is 4 ft

By inserting these figures into the formula we obtain the required CFM;

$$Q=50 \times 20 \times 4=4,000 \text{ CFM}$$

Therefore, using the alternate formula, a minimum airflow of 4,000 CFM would be required for this hood.

MINIMUM AIRFLOW CALCULATIONS FOR NON-CANOPY HOODS (BACKSHELF HOODS)

The guidelines for exhaust air quantities for backshelf or proximity hoods are tabulated below.

- 1) LIGHT DUTY (steam equipment, kettles) ; $Q = 200 \text{ L}$
- 2) MEDIUM DUTY (ranges, ovens, griddles, grilles) ; $Q = 300 \text{ L}$
- 3) HEAVY DUTY (fryers) ; $Q = 350 \text{ L}$

Note that state and local codes may require higher exhaust air flows and would in all cases supersede these guidelines.

Key to the formula

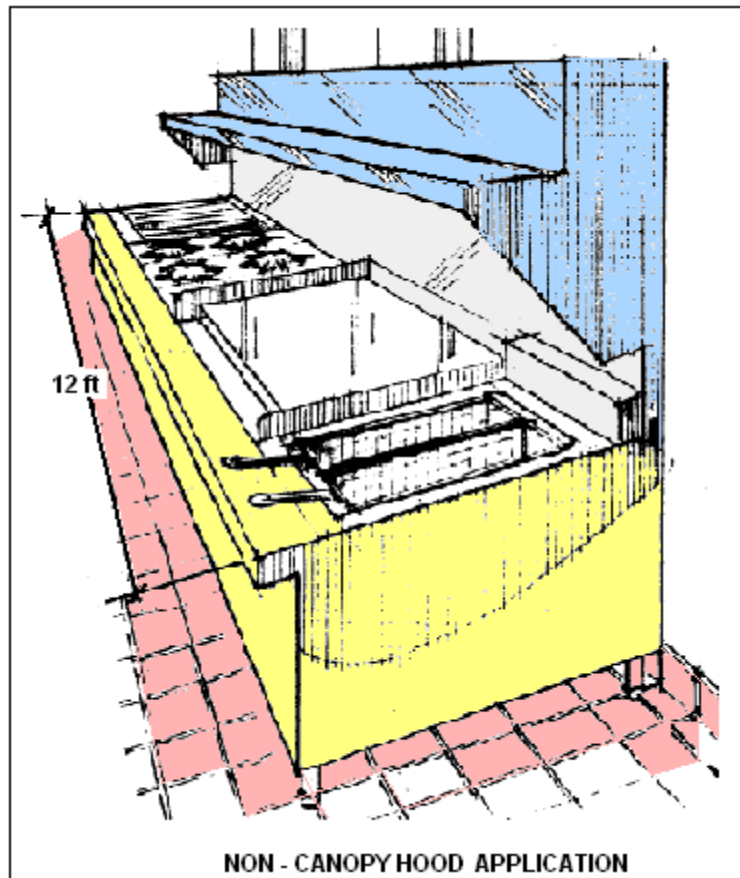
Q=Quantity of air in CFM

L=Linear footage of the cooking equipment.

Use of backshelf hoods is not recommended for open flame equipment such as char-broilers.

Example

The following example will illustrate the use of the hood sizing formula for non-canopy hoods. The linear footage of cooking equipment is given as 12 feet over a medium duty grille. Estimate the exhaust volume in CFM.



Solution

For medium duty grilles, the exhaust flow rate shall be 300 CFM per foot of hood length. By inserting the 12 feet into the formula for non-canopy hoods, $Q=300 L$, we get

$$Q=300 \times 12 = 3600 \text{ CFM}$$

Note: The above calculations only determine the exhaust flow rates. For determining the fan capacity, the static pressure need to be determined; this is a function of exhaust diameter and length of the duct. Unnecessary bends and fittings will impose higher resistance (static pressure) to the flow and demand high horsepower fan motor. Careful planning and straight routing of ductwork will result in a quieter, smoother operating, and more efficient system.

NUMBER OF FILTERS REQUIRED

The minimum required number of filters for a particular hood can be calculated by dividing the total volume of air to be exhausted, in CFM, by the optimum operating velocity of the filter, in FPM usually 300 to 400FPM. This number is then divided by the actual square footage of the standard size filter (excluding the frame). The resulting figure represents the minimum number of filters required to efficiently remove the grease from the exhausted air.

Example:

Assume an exhaust hood with a minimum required airflow of 4200 CFM. Baffle type filters with a nominal size of 16" x 20", have an actual filtering surface of 14" x 18". (Nominal size minus the frame equals the actual filtering area.) Calculate the number of filters required, considering an optimum operating face velocity of 300 FPM across the filter.

Solution

Filter Area Needed = Volume of exhaust air / Permissible face velocity

Filter Area Needed = 4200 / 300 = 14 sq-ft

Actual filter surface area (minus frame) = 14" x 18" = 252 sq-in or dividing by 144 (conversion factor for sq-ft to sq-in)

Actual filter surface area = 1.75 sq-ft

Number of filters required = Filter area needed / actual filter surface area = 14 / 1.75 = 8 filters

Therefore, in this example, 8 filters would be required to provide adequate removal of the grease. Any space in the hood not occupied by a filter should be blanked off with sheet metal. As much as possible, the blanks should be divided equally between the filters. This will ensure optimum performance and will equalize the air velocity over the entire length of the hood opening.

DUCT SIZING

- 1) The duct leading from the exhaust hood to the exhaust outlet shall be sized correctly. The velocity of the exhaust air shall be high enough to minimize condensation on the various parts of the duct system.
- 2) The following formula shall be used to determine the correct duct size:

Volume of air exhausted (CFM) = Duct area needed (sq. ft.) / Duct Velocity (FPM)

In an example of this calculation we will assume the following:

- An exhaust hood with a minimum required airflow of 3,600 CFM.
- A duct velocity of 2,000 FPM.

By inserting this data into the formula we will obtain the required duct size:

3,600 CFM = 1.8 sq. ft.

2,000 FPM

Note that the calculation guidelines above are for general information only, and are not to be used in lieu of reference to governing local codes. Additional information which may also be relevant is contained in national standards such as the International Mechanical Code published by the International Code Council, and NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations published by the National Fire Protection Association.

TEST & BALANCE

Test and balance is the final step in assuring that a project meets the design and engineering criteria. It is most often the responsibility of the contractor which furnished the exhaust fans and the makeup air unit to do the test and balance.

Air balance should be checked on an annual basis to ensure the system is performing at peak efficiency. In order to accomplish this, it is important to know the proper method used to determine the air volume required. On all ventilators the air volumes required should be listed on a label under the canopy on each section of hood. Air volume is commonly read as cubic feet per minute CFM.

Once the volume requirements are known, the velocity at the exhaust can be determined by dividing the stated volume by the area of the opening expressed in square feet.

Example: Length of exhaust slot equals 120 inches at 4 inch width; 4" X 120" = 480 square inches, divided by 144 = 3.333 square feet of slot opening.

Therefore, if the design CFM is 3500 CFM divided by 3.333 square feet, the velocity at the slot will average 1050 FPM.

A vane type air meter technically called “Anemometer” is typically employed to measure the air velocity across the hood. It is important to take minimum of 3 readings per section, and selecting the right face velocity by averaging of three readings. At this point the blower wheel speed should be increased or decreased depending on readings taken in order to coincide with design requirements.

Concluding

The primary considerations for the high performance energy efficient kitchen ventilation system are:

- 1) Exhaust fans must be capable of removing the collected airborne wastes at a rate equivalent to their generation, and makeup air units need to be capable of replacing an equivalent volume of the extracted waste fumes. Exhaust volume is determined by heat energy input of the cooking line.
- 2) Exhaust hoods should be placed above cooking equipment and have the ability to capture and contain the airborne waste matter produced by cooking equipment.
- 3) Group appliances according to effluent production and associated ventilation requirements. Specify different ventilation rates for hoods or hood sections over the different duty classification of appliances. Where practical, place heavy-duty appliances such as char-broilers in the center of a hood section, rather than at the end.
- 4) The location of makeup air units in the commercial kitchen should be positioned as far away as possible from the source of the pollutants to maximize cross ventilation. All exhaust gases should be discharged to the atmosphere through ducts and careful consideration must be given to the separation of exhaust discharge from air-intakes and from neighboring properties.
- 5) Canopies and ductwork need to be constructed from non-combustible material and fabricated so as not to encourage accumulations of dirt or grease, nor allow condensation to drip from the canopy. The ductwork needs suitable access for cleaning and grease filters need to be readily removable for cleaning/replacement.
- 6) The exhaust air volume must be greater than the heat expansion from the cooking surface plus any internally injected makeup air.
- 7) In summary exhaust for Cooking Equipment –

Description	Ventilation Rates
Ventilation Air for Kitchens without hoods	3-4 CFM/ Sq-ft
Canopy Hoods (UL Rated Hoods)	250-350 CFM/Lin. Ft. of Cooking Equip
Canopy Hoods (Non-Rated Hoods)	300-400 CFM/Lin. Ft. of Cooking Equip
Exhaust Velocity	1500 to 2500 FPM (1800 FPM Optimum)
Makeup Air	60 to 85% of Exhaust @ 1000 to 1500 FPM velocity

Remember, a hood is one of the most critical pieces of equipment in any foodservice operation. Without an effective and efficient hood, the extraction of cooking effluents could not be accomplished, and the kitchen would be a most unpleasant place to work.