A SunCam online continuing education course

Commercial Kitchen Ventilation Design Considerations

by

Steven G. Liescheidt, PE, CCS, CCPR

General:

Kitchen ventilation systems require the engineer to look at both the supply and exhaust requirements of the system in order to meet several design criteria. Codes and standards dictate the performance effectiveness of the exhaust of the kitchen as accomplished through a variety of types and styles of hoods. On the supply side of the equation there is a need to take into consideration the comfort of the kitchen workers, the airflow patterns so that they won't have an impact on the hood performance or cool off food waiting to be served and the air balance in the space under varying exhaust flow conditions. In addition to looking at the ventilation performance criteria the engineer also needs to be aware of current products on the market for hoods, fans, filtration, ductwork, controls and air distribution diffusers.

Maintenance requirements of the equipment and practical energy savings strategies are also important design considerations that need to be considered in balance with the first cost of the system.

In many projects the hoods are considered to be a part of the "kitchen consultants" responsibility of selection; however, the supply air components, fans and ducts are part of the professional engineer's system design. This has been a point of contention and problem for years in many projects partly due to the lack of timely coordination of kitchen equipment selection. Also, the lack of understanding of total kitchen ventilation by some kitchen consultants who are primarily interested in the kitchen cooking equipment and then put hood over the heat and grease producing equipment with little understanding of the total kitchen ventilation design criteria can be problematic.

There are many in the HVAC industry who believe it would be more appropriate to have the kitchen hood as part of the professional engineer's system since the engineer-of-record is responsible for the total air ventilation and exhaust system performance.

Codes and Standards:

In general, local code authorities use either the *International Mechanical Code* (IMC) or the *National Fire Protection Association* "Standard # 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations" or a combination of these two documents to establish their local codes and ordinances. It is best to have an in-depth discussion with the local code authority regarding their criteria before getting too far into the kitchen and ventilation system design.

Supply Airflow Hoods:

There are a variety of hoods that have the “makeup air” built into the hoods in an attempt to save energy and to minimize the disturbance of the hood exhaust air flow patterns. A brief discussion of each follows. As noted in the descriptions, many of these types of hoods can be problematic if not properly size and operated.

Short Circuit Internal Makeup hoods attempt to provide unconditioned raw outside air into the exhaust hood so as to minimize the amount of conditioned air from the kitchen that would be exhausted out of the hood. The primary problem with this style of hood is that it is generally not possible to get a high percentage of the exhaust air requirement directly supplied through the hood without disturbing the hood exhaust air and causing realistic spillage of the exhaust plume into the kitchen space. This then requires additional conditioned air to offset this added heat gain to the space not to mention dealing with the smoke and grease in this air that enters the kitchen work space. Although these hoods are available many industry experts and even hood manufacturers don’t recommend using this type of hood.

Air Curtain hoods use air supply nozzles in the bottom of the face of the hood in an attempt to create a curtain of air to contain the heat and effluent from the cooking process under the hood. These hoods again are not generally considered as effective as their marketing may suggest. This is mainly because the air curtain itself must be limited in capacity otherwise the heat and effluent from the cooking equipment can be drawn into the air curtain air flow and taken into the conditioned kitchen space.

Front Face Supply Discharge hoods use grilles directly on the front face of the hood to supply air into the kitchen space. These types of hoods are simply a method of attempting to reduce the supply air diffusers into the ceiling and to direct the supply air away from the hood capture air pattern. There are a variety of supply grille types used and care must be taken to direct the air away from the hood and to not use too high of discharge velocity that could entrain the exhaust air flow away from our out of the hood.

Perforated Perimeter Supply hoods have perforated diffusers in a horizontal position extended out from the vertical front face of the hoods and direct air vertically downward in front of the hood. Care must be taken to not have too high of a velocity otherwise the

air flow pattern will start to be similar to an air curtain and can cause issues with hood capture effectiveness.

Backwall Supply Rear Discharge hoods have been shown to be effective and allow a greater percentage of the makeup air to be brought in through the hood without as much disturbance of hood exhaust performance as other types of hoods.

Ceiling Diffuser Supply Air:

The alternate to all of these types of hoods is to supply air into the conditioned space through ceiling diffusers or other newer concepts like fabric air distribution systems similar to those used in laboratory and other high volume spaces where low air movement velocities are desired.

With metal diffusers care must be taken to ensure that the supply air throw out of the diffuser does not interfere with the hood operation or cause drafts that may cause other problems in the kitchen such as premature cooling of plated food waiting to be served. The fabric air distribution is similar to a displacement ventilation type supply to kitchens in that they both attempt to minimize the air velocities into the kitchen which has two benefits.

First lower air velocities in the kitchen will not disturb the performance of the hoods. Secondly, lower air velocities in the kitchen will not cause cool drafts that can pre-maturely cool of plates of food that may sit on a counter waiting to be served.

Fabric Air Distribution In Kitchen (Photo Courtesy of DuctSox Corporation)

Transfer Air:

One challenge with kitchen ventilation design is the transfer air balance when multiple hoods and hoods with variable airflow are used. The kitchen is kept at a negative pressure relative to the adjacent spaces therefore the air conditioning system for the adjacent spaces must either have a variable control on the outside air damper to modulate with the varying requirement for the ventilation air or the makeup (replacement) air unit for the kitchen must vary it's outside air quantity to maintain the pressure balance between the kitchen and the adjacent spaces. This air balance can be a controls challenge in limited budget projects where the owner is looking for simple controls to keep the perceived cost of the project down.

The tradeoff of not using appropriate control strategies is the sacrifice of proper air balance in the building and potentially higher energy cost and decreased comfort due to infiltration air through entry doors.

Ventilation Equipment:

Hoods (Island Canopy, Double-Island Canopy, Wall-Mounted Canopy, Backshelf/Proximity) types generally will be dictated by the cooking equipment layout and to some extent the type of kitchen cooking equipment being used. It is good to have early and frequent discussions with the entity doing the kitchen equipment layout since the hoods and duct and other utilities related to the cooking equipment require significant engineering and architectural coordination.

Although many designs utilize supply airflow type hoods as noted in the section above, it is also possible and many times more desirable to use exhaust only hoods and keep the supply air complete separate from the exhaust hood for the purpose of providing conditioned air and better space air velocity control.

In addition to the grease hoods there are exhaust requirements for vapor hoods over steam generating equipment, dishwasher exhaust and general exhaust that may be needed to keep the kitchen in a negative air balance relative to the rest of the building. Fans have come a long way in their design for kitchen grease hoods.

There are now hoods that have UL 762 rating for inline applications so that the fans can be kept inside the building if desired. Grease collection from the hoods has traditionally been done by grease troughs; however, there are other grease collection products that can be less maintenance intense and can keep the grease from spilling out of grease troughs onto the roof. Fan coatings for kitchen hoods have also been improved where there are "modified epoxy silicone powder" type coatings to provide easier cleaning of the fans and fan parts.


Upblast Centrifugal and Upblast Ventset (with EasyClean coating) Exhaust Fan Styles (Photos Courtesy of Loren Cook)

One factor of consideration that is often not discussed enough is that of insect control. Most codes require that the outside doors to the kitchen must have some form of insect control. A fan powered “air curtain” has proven to be one of the most effective methods to accomplish this goal. Although there is some energy consumed by the fan, the effectiveness of these products is better than other types of products such as rubber strips that can become damaged and interfere with foot traffic and allow insects in as the strips are opened to move products through the door opening. Air curtains can also be used in the entry to a restaurant to help control insects and to eliminate drafts in the dining area and waiting areas.


Entry Air Curtain Concealed in Entry Ceiling and at Kitchen Service Door (Photos Courtesy of PoweredAire, Inc.)

Exhaust Airflow:

Obviously the amount of exhaust airflow out of a kitchen will depend on the hood types and sizes installed. The safe "design" is sometimes just to put in big hoods and exhaust airflow to get the fastest approval by the inspectors and code authorities. However, the best "engineered" approach is to consider the energy usage of the application and consider the comfort of the occupants in the space and truly "engineer" the ventilation system and integrate it into the total kitchen design. However, "engineering" the system also requires more time and talent and knowledge than "designing" the system and everyone on the team, including the kitchen consultant, needs to understand this from the start of the process and work with the profession engineer-of-record who will be sealing the contract documents to get the best "engineered" system.

Code officials around the country have begun to accept and embrace the idea of using variable air volume exhaust control strategies as long as there are reliable controls and system components in place to ensure that the air flow in the hood and corresponding duct velocity will be at design levels when the cooking processes under the hood are being done. This is accomplished primarily by either using heat sensors or affluent detectors or a combination of both.

Maintenance:

Fans, filters, ductwork maintenance are all part of the design considerations that should be taken into account when kitchen ventilation systems are engineered correctly.

Obviously grease management is the primary objective. This starts with the hood sizing and selection and then the filtration system needs to be considered. Some in the industry consider the use of UV as a viable and effective method to handle grease in a kitchen hood exhaust system.

Another consideration for maintenance convenience is the use of a belt tensioner on belt drive fans. A belt tensioner allows changing of belts with no tools, extends the life of the belts and keeps more consistent fan speed for better ventilation air flow balance in the kitchen over the life of the belt.

Automatic Belt Tensioner (Photo Courtesy of Loren Cook Co.)

State-of-the-Art:

Keeping up to date with kitchen ventilation products and fundamental current "wisdom" and state-of-the-art products and system concepts is always a challenge.

Manufacturers are obviously a good source of information but like with many products in the HVAC industry care must be taken to ensure that the message being delivered is not just marketing hype about a product and not as energy efficient or as effective as the marketing literature may imply. One good test of this is to talk to as many end users of a product as possible to validate any manufacturer's claims.

One consideration for engineers would be to get involved with ASHRAE Technical Committee 5.10 which is "*concerned with the energy efficient control, capture and effective removal of airborne contaminants and heat resulting from cooking process. It is also concerned with the introduction of supply and make-up air as it influences the contaminant control process as well as the thermal environment in the kitchen."* More information about ASHRAE and TC 5.10 can be found at www.ashrae.org.

Design Considerations Checklist:

Although it is not possible in one article to document all current thinking about the "best" kitchen ventilation system design and that type of article would become dated over time anyway; it is possible to provide a checklist of design considerations that can be used to research current trends and design criteria for each project. The list below is one that can be used by the mechanical engineer for this purpose.

Kitchen Ventilation Design Considerations:

- Current codes and standards
- Space temperature, humidity and pressure control

- Hood selection pros/cons analysis
- Full and part-load cooking schedules coordination with hood sizing and control
- Grease Extraction filtration methods
- Make-Up (Replacement Air)
- Supply air strategy
- Insect control
- Exhaust fan type, controls, location
- Exhaust duct design for proper velocity and cleaning accessibility
- Energy savings strategy
- Noise control in the kitchen from mechanical equipment
- Fire protection
- Plumbing utility requirements
- Coordination with other professionals and construction trades
- Maintainability of all HVAC products
- Seismic bracing and functionality after a seismic event for critical facilities

Additional Resources:

A good source for more information on kitchen ventilation is the *Whole Building Design Guide* as found at www.wbdg.org. Use the term "*kitchen ventilation*" in the search block and several articles will be provided for additional reading.

Another resource to look at is the Food Service Technology Center (FSTC) which is involved with commercial kitchen energy efficiency and appliance performance testing. Operated by Fisher-Nickel, inc., the FSTC has developed over 35 Standard Test Methods for evaluating commercial kitchen appliance and system performance. www.fishnick.com.

In addition, ASHRAE has writings on kitchen ventilation also which can be found at the ASHRAE Bookstore at www.ashrae.org. Standard 154-2003 -- Ventilation for Commercial Cooking Operations and Chapter 31 of the 2007 ASHRAE Handbook "Kitchen Ventilation" are two good resources to read for additional information on kitchen ventilation and energy efficiency consideration.

