
# Design Considerations for Commercial Kitchen Ventilation

By John A. Clark, P.E., Member ASHRAE

Commercial kitchen ventilation (CKV) design must consider everything needed to be coordinated to form a system that will perform heat/moisture/smoke/odor/fire protection control, provide space comfort, be cost effective, and be acceptable to the local code authority. This article addresses hood selection, filter devices, replacement air systems, variable airflow systems, comfort heat/cooling, exhaust duct options, fan selections, stack outlets, sidewall outlets, utility connections, and fire protection control.

## Basic Hood Considerations

The design process for a successful kitchen ventilation system starts when the engineering design HVAC team receives the kitchen equipment information from the kitchen designer (equipment supplier). The information package should include the equipment layout, the equipment shop drawings, the dimensions of the exhaust hoods selected and the exhaust cubic feet per minute (cfm) of the selected hoods. The design engineer should check that the hood selected will provide enough overhangs. Front overhang should be a minimum of 9 in. (229 mm); side overhang should be a minimum of 6 in. (152 mm). However, on convection ovens, the overhang should be 6 in. (152 mm) past the door opening at 90° from the oven. This often translates to an 18 in. (457 mm) front overhang. Also verify that grilling and broiler units are not at the end of the hood. These high heat and smoke-producing devices should be toward the center of the hood's length.

**About the Author**

**John A. Clark, P.E.,** is a senior mechanical engineer at Karges-Faulconbridge, Inc. (KFI), St. Paul, Minn.

| Type of Hood | Minimum Exhaust Flow Rate, cfm Per Linear Foot of Hood | | | |
|---|---|---|---|---|
| | Light Duty | Medium Duty | Heavy Duty | Extra-Heavy Duty |
| Wall-Mounted Canopy, Unlisted | 200 | 300 | 400 | 550 |
| Listed | 150 to 200 | 200 to 300 | 200 to 400 | 350+ |
| Single-Island, Unlisted | 400 | 500 | 600 | 700 |
| Listed | 250 to 300 | 300 to 400 | 300 to 600 | 550+ |
| Double-Island (Per Side), Unlisted | 250 | 300 | 400 | 550 |
| Listed | 150 to 200 | 200 to 300 | 250 to 400 | 500+ |
| Eyebrow, Unlisted | 250 | 250 | Not Allowed | Not Allowed |
| Listed | 150 to 250 | 150 to 250 | — | — |
| Back Shelf/Proximity/Pass-Over, Unlisted | 300 | 300 | 400 | Not Allowed |
| Listed | 100 to 200 | 200 to 300 | 300 to 400 | Not Recommended |

Source: *2011 ASHRAE Handbook—HVAC Applications*

**Table 1:** Exhaust flow rates by cooking equipment category for unlisted and listed hood.

| Type of Grease Removal Device | Hood Static Pressure Loss, in. of Water | | | |
|---|---|---|---|---|
| | 150 to 250 cfm/ft | 250 to 350 cfm/ft | 350 to 450 cfm/ft | 500+ cfm/ft |
| Baffle Filter | 0.25 to 0.50 | 0.50 to 0.75 | 0.75 to 1.00 | 1.00 to 1.25 |
| Extractor | 0.80 to 1.35 | 1.30 to 1.70 | 1.70 to 3.00 | 2.90 to 4.20 |
| Multistage | 0.55 to 1.10 | 1.10 to 1.70 | 1.70 to 2.90 | 2.90 to 4.00 |

Source: *2011 ASHRAE Handbook—HVAC Applications*

**Table 2:** Exhaust static pressure loss of Type I hoods for various exhaust airflows. Note: Values based on 20 in. (508 mm) high filters and 1,500 fpm (7.62 m/s) through hood/duct collar.

The HVAC designer should compare the submitted exhaust values with the minimum listed UL 710 exhaust rates for capture/containment (*Table 1*). Always consider the exhaust flow recommended by the hood supplier. Then work with the equipment supplier to achieve a workable hood size and equipment layout. Most hood manufacturers also offer hood end panels. These end panels should be considered, if the hood is not next to a wall, to help minimize any effects of side drafts that disturb the rising thermal plume.

Should the hood duct connection fall under a beam or a bar joist, request that the hood duct collar be shipped for on-site installation. This will allow for a straight duct connection, rather than sharp offsets. Check with the hood supplier as to how far from the normal collar location the field installed collar can be moved.

## Other Hood Selection Considerations

The kitchen equipment designer's package often contains a Type II hood in addition to the primary Type I grease removal hood. The Type II hood collects and removes steam, condensable vapor, heat and odor. The Type II hoods have two subcategories: one removes condensate from the exhaust stream, and the other removes heat or odors. The Type II condensate unit often has a filter to cool/capture the exhaust stream moisture, as well as baffles and drainage trays to help prevent drips into the cooking food. The Type II heat unit does not have a filter. Be sure to verify if the Type II hood requires the condensate system.

Typical kitchens also have dishwashers. The pass-through type and the conveyor type require a Type II hood with collection points at the inlet and the outlet of the dishwasher. The exhaust ductwork should be stainless steel below the kitchen ceiling and either stainless steel or aluminum above the ceiling. The exhaust duct should be liquid tight and pitch back toward the dishwasher. The dishwasher fan should be an aluminum unit. Connect the operation of the dishwasher exhaust fan to the dishwasher control panel. The dishwasher control panel has auxiliary contacts for this purpose. Provide a time delay relay to allow the dishwasher fan to run for a period after the dishwasher has been turned off.

## Filter Selection

The primary purpose of a filter in the face of a hood is to prevent cooking flames from entering the exhaust duct. Also, the quantity of exhaust air keeps the filter's surface temperature not to exceed 200°F (93°C). The configuration of the filter's baffles are to facilitate condensing of the moisture and grease vapors so they can be captured by centrifugal separation as they pass through the turns and cooling surfaces. Industry reported grease extraction efficiency of filtration systems may not reflect actual performance. The filter type selected by the designer should match the expected duty of the hood (*Table 2*). Light and medium duty hoods can use simple baffle filters. These filters have a static pressure loss range from 0.25 to 1.25 in. w.c. (62 to 311 Pa.) This range also matches well with standard up-blast power roof ventilators (PRV) (up to 2 in. w.c.

[498 Pa]). The heavy and extra heavy hoods should consider using extractor filters that have a greater baffle length path, which allows for more condensing of the vapors before being centrifugally separated. A multistage water mist, scrubber and water bath also mechanically separates the grease. The fan static pressure requirement for the heavy and extra heavy hoods is more than 2.0 in. w.c. (498 Pa), which requires a special family of up-blast PRVs or centrifugal fans.

In rare special cases, consideration can be looked at using other multistage units such as electrostatic precipitators, ultraviolet destruction devices, pleated bag, pleated, bag, and HEPA filters. All these devices are expensive to install and have high maintenance costs; therefore, a cost-effectiveness study should be done by the design team.

#### Replacement Air Systems

Replacement air is required to makeup the air being exhausted by the cooking hood(s), the dish machine and the toilet exhaust systems. The source of the replacement air is from three systems; primary heating/cooling supply air, makeup air and transfer air.

Primary supply air to the kitchen area provides comfort for the working staff. This air is filtered, heated, and cooled to meet IAQ standards. The primary air can be supplied from a single source such as a rooftop unit or a main facility air-handling unit.

Makeup air is outside air introduced though the primary air system. This air is filtered, heated, and cooled to help attract and keep a cooking staff.

However, with the advent of variable exhaust requirements during non-cooking times a dedicated outdoor air system (DOAS) concept can be used to control the outdoor supply air to match the varying exhaust.

Conditioned outdoor air from the dining area can be transferred into the kitchen area for 10% to 15% of the replacement air. This air also helps control the kitchen cooking odors from getting into the dining area. This air has been treated for occupant comfort and indoor air quality. A transfer fan system may be required to prevent cooling the cooked food, if a pass through serving window is used. Any airflow through a pass through window should be less than 75 fpm (0.38 m/s) velocity.

A pressurization relationship between supply and exhaust air must be controlled to prevent cooking odors from migrating to adjacent building spaces. Avoid locating a gas water heater in a location where negative kitchen area conditions could cause a down flow of fumes from the gas water heater's stack.

#### Variable Airflow System

When there is no cooking taking place, there is reduced heat (thermal plume), no smoke, no steam, and no odor being produced. Therefore, the exhaust cfm can be reduced, which saves operational money. NFPA 96 allows the duct velocity to drop to a minimum of 500 fpm (2.54 m/s). The hood fan capacity is controlled by either optical smoke, infrared, or temperature sensors that reduce the exhaust fan speed. It is also important to reduce the replacement air in parallel with the exhaust rate to keep the facility pressure relationships constant. The 500 fpm (2.54 m/s) minimum also allows for reuse of existing grease ducts that were previously installed with higher cfm exhaust rates.

#### Comfort Heating and Cooling

The kitchen area is traditionally a hot or warm environment; therefore, cooling is the primary goal for comfort. Heating of the replacement air is required in the cooler climates; the air should be heated to a minimum of 50°F (10°C). Most building codes have adopted ASHRAE Standard 62.1 to set the outdoor air requirements for ventilation. This Standard set 15 cfm/person (7.0 L/s) for the kitchen area and 20 cfm/person (9.4 L/s) for the dining area. The energy saving trend is to reduce exhaust air, and ventilation air. The IMC 2009-2012 Section 403.3 requires 7.5 cfm/person (3.5 L/s) plus 0.18 cfm/ft$^2$ (0.08 L·s/m$^2$) of the occupied space.

*Advertisement formerly in this space.*

Reasonable kitchen air-conditioning design is a balance of spot workstation heating/cooling, occupant ventilation, space pressure relationships, and exhaust replacement air capacity. The hood perimeter replacement air supply plenum has become the choice for supply air cooling and replacement air at the hood face, according to the major hood manufacturers (*Photo 1*, Page 54). The air is discharged through perforated face panels that blow down toward the front of the cooling line. The terminal velocity at the cooks head should be at 50 fpm (.25 m/s) to avoid any feeling of a draft. The width of the plenum and its mounting height should be considered when determining the supply air to the unit. If a DOAS unit is used the air can be heated to 50°F (10°C) and cooled to 75°F (24°C), thus saving energy.

The use of four-way diffusers or two-way slot diffusers, for the general kitchen area, should not be closer than 15 ft (4.6 m) from the hood face. This distance arrangement is to avoid disturbing the hood capture of the rising thermal plume from the cooking surface.

The location of the thermal controls for the heating/cooling units is traditionally in the kitchen manager's office with the thermal space sensors located in the kitchen and dining areas. This is done to maintain control by one person only.

## Exhaust Duct Options

Type I duct construction consists of at least 16-gauge black steel or 18-gauge stainless steel. This duct must slope 0.25 in. per foot (6 mm per 0.3 m) toward the hood or an approved grease reservoir. For ducts longer than 75 ft (23 m), the slope shall be at least 1 in. per foot (25 mm per 0.3 m). Clean out doors are to be provided in the side of the duct at least every 12 ft (3.6 m) and at each change of direction.

Type II duct construction consists of rigid metal ductwork in accordance with normal SMACNA Standards. Slope is not required, however, should be considered in ducts that exhaust steam or water vapor. Slope should be provided in dish and pan washer hood ducts.

The air velocity for Type I ducts should not be less than 500 fpm (2.54 m/s) (variable flow and reuse of existing ducts) and should not be more than 2,500 fpm (12.7 m/s) (for reasonable noise levels). Duct hood exhaust collars are sized to provide a velocity of 1,800 fpm (9.1 m/s).

If the exhaust duct rises vertically for more than two stories, consider using the factory made/insulation chimney stacks rather than duct wrap/rigid fire insulation on the welded steel exhaust stack. Chimney stacks may cost more to purchase, but the labor costs to install the insulated units are less.

*Advertisement formerly in this space.*

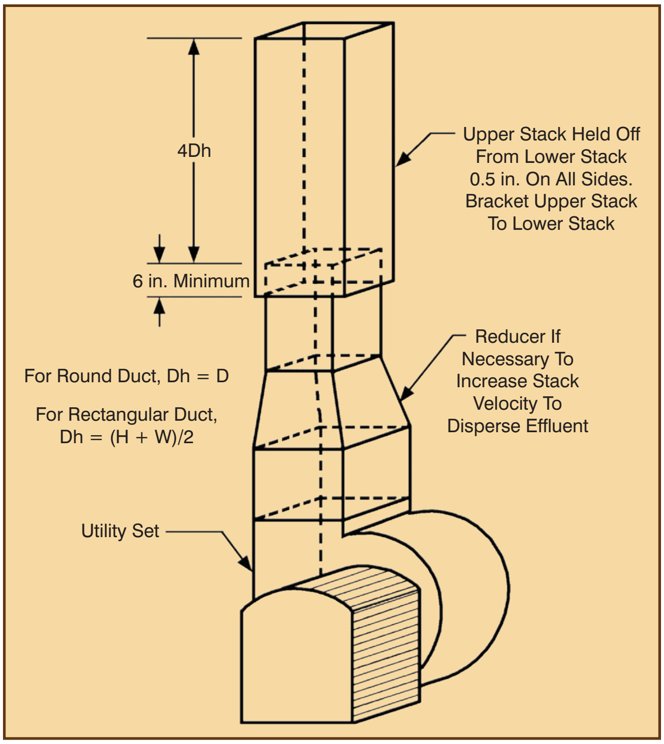


**Figure 1:** Rooftop centrifugal fan (utility set) with vertical discharge.


**Photo 2:** High velocity, vertical discharge, centrifugal roof fan with a dilution air intake.

If the Type I grease duct is to be power washed and the design is documented as such, negotiate with the authority having jurisdiction (AHJ) to avoid installing most of the duct access doors. If the AHJ still requires the access doors, consider installing them, but do not cut them thru the duct wall. This is done because cleaning accessibility is better with power wash units and also the access door gaskets are not liquid tight and allow moisture to leak into the insulation, which causes mold and mildew. The duct system should be pressure tested (1 in. w.c. [249 Pa] for 20 minutes) for leakage before the hood and fan are connected, as well as the exterior insulation applied. Also consult with the duct cleaning service as to where they need water and drain connections for the power wash duct cleaning.

## Fans

The exhaust discharge from a Type I grease duct system is required to be at least 40 in. (1 m) above the roof surface with the outlet at least 10 ft (3 m) from a supply intake. The fan most often selected to meet this criterion is an "upblast" power roof ventilator (PRV). However, this type of fan has a volume capacity limit of about 5,000 cfm (2360 L/s) and a static pressure limit of 2 to 2.25 in. w.c. (498 to 560 Pa).

A centrifugal fan has greater volume and static pressure capability. The fan can be either a utility set type or an inline type. The utility fans offer variable discharge directions that vary from horizontal to vertical. In all these fan selection cases the motor and drive is external to the fan unit. Consideration must be given for flexible duct connections, between the fan unit and the ductwork, to be fire resistant and liquid tight.

All fans must be UL 762 listed for grease exhaust and temperatures to 400°F (204°C).

All roof fans must be mounted on raised curbs so that duct stack access is available for cleaning. The PRV units use a hinged fan base with a safety cable to hold the unit steady. Utility set fans use an access panel in the curb. Provide a vented roof curb if the Type I grease duct is enclosed in a rated shaft. The curb vent is to relieve the heat from the shaft space.

## Stack Outlets

The discharge of the fan system should be arranged to prevent reentry of any of the exhaust flow into the outdoor air intakes. Horizontal and vertical distance is important and is often governed by local codes. Some code authorities will allow discharge dampers arrangements such as horizontal discharge backdraft dampers from a utility set arrangement and butterfly discharge dampers on a vertical discharge inline fan stack with a windband protector. These damper arrangements are to keep weather, birds, and animals out of the grease ducts.

A good vertical stack arrangement is shown in *Figure 1* and *Photo 2*. This vertical stack discharge velocity should not exceed a 2,000 to 2,500 fpm (10 to 13 m/s) range. Any velocity above 2,500 fpm (13 m/s) creates velocity noise that may be objectionable to neighbors. If stack odor is a problem, consider introducing outdoor air from the roof area into the fan's suction duct. This added air will dilute the stack discharge. A value of 20% is a good dilution factor.

## Sidewall Exhaust Outlets

The sidewall outlet is usually a wall louver. Provide a plenum behind the louver to reduce the exit velocity. Provide an access panel and a drain in the plenum for cleaning. Avoid louver vanes that blow down toward sidewalks

where the airflow and odors are objectionable to people in the area.

## Utility Connections

The electric connections should be installed in a flat wall panel arrangement behind the equipment. This is done to provide a space behind the equipment that is easier to keep clean. The gas solenoid must be visibly piped below the ceiling line. Some health departments require the exposed pipe to be epoxy painted to prevent rusting.

## Fire Protection Control

NPFA Standard 96 requires the Type I grease duct to have a fire-extinguishing system that protect the cooking surfaces, filters and ducts. The system may be a wet chemical or a water spray system. The type selected must be coordinated with the hood supplier. This coordination can determine if the hood comes with the internal piping factory installed or if it needs to be field installed by a fire protection contractor. All exposed piping under the hood must be stainless steel or chrome plated, and the piping penetrations to the hood must be grease tight as per NFPA 96. The activation control also must be coordinated with the fan power controls. A control point often missed is an exhaust fan restarting to remove fire and smoke in the event of a night fire, often resulting from a worker leaving something on the range top, turning off the exhaust fan system for the night, and forgetting to turn off the range controls.

The gas-fuel valve (mechanical or electrical solenoid) and or the electrical power trip for equipment located under the hood must also be coordinated with the operation of the fire protection system. In addition, the fuel and electrical trip systems require reset controls, which the designer must locate.

## Conclusion

The coordination required for a successful CKV exhaust system requires the mechanical HVAC designer to work with kitchen equipment supplier, the fire protection contractor, the controls contractor, the duct cleaning contractor, the electrical contractor, the gas piping contractor, and the HVAC contractors to complete a composite system that works together. An operational, economical, and sustainable system should be the team’s goal. ■

*Advertisement formerly in this space.*

*Advertisement formerly in this space.*