COMMERCIAL KITCHEN VENTILATION DESIGN GUIDE

Introduction

A commercial kitchen exhaust hood is only one component of the kitchen ventilation system (CKV). The CKV is a subsystem of the overall building heating, ventilating and air conditioning system (HVAC).
The air that exits the building (through exhaust hoods) must be replaced with outside air that enters the building either intentionally or otherwise.
This design guide provides information that will help achieve optimum performance and energy efficiency in CKV.

Background

If the replacement air doesn't come in or is not diffused correctly within the kitchen that means it doesn't go out the exhaust hood and the cooking plume is affected.
The solution is to specify an independent make-up air supply (MUA). The challenge is to introduce this air into the kitchen without disrupting the ability of the hood to capture and without causing discomfort for the kitchen staff. MUA air velocity impacts the ability of the hood to capture and contain cooking effluent. MUA too cold or too hot can create an uncomfortable working environment.

Fundamentals of Kitchen ventilation

The exhaust serves the purpose to capture and contain the effluent and avoid health and fire hazards. What is the appropriate exhaust rate? The answer depends on the type and use of cooking equipment under the hood. The kitchen layout, the hood shape and how the MUA is introduced into the kitchen are also factors to take in consideration.
Cooking appliances are categorised as light, medium and heavy duty depending on the strength of the thermal plume and the quantity of grease and smoke produced.

By their nature, these thermal plumes are very turbulent and different cooking process have different “surge” characteristics. For example, the plume from hamburger grill cooking is strongest when flipping the burgers. Ovens and fryers may have very little plume until they are opened to remove food products.
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 moves to replace it. If the plume is weak, draught within the kitchen will push the contaminants away from the hood.
Radiant heat is often not taken under consideration when designing exhaust rate. Some hood manufacturers base theirs calculations only on the cooking equipment category. The heat generated by char-broilers and cooktops should be exhauted at a higher rates than the ones specified by the Australian Standards. The heat can’t be captured by extending the hood overhang. It spreads towards the cooking staff which could become a health issue if not dealt with higher exhaust rates.
The design exhaust rate also depends on the hood shape and design features. Wall-mounted hoods, island hoods and lateral type hood all have different capture velocity.
Lastly, the layout of the HVAC and MUA distribution points can affect hood performance. These can be sources that disrupt thermal plumes and hinder capture and containment. Location of delivery doors, service doors, pass-through openings and drive-through windows can also be sources of cross draught. Safety factors are typically applied to the design exhaust rate to compensate for the effect that undesired air movement within the kitchen has on hood performance.

CKV System Performance Design

The calculation of exhaust airflow rate given by the Australian Standard AS 1668.2-2012 is only the start of the design of an efficient CKF.
The MUA distribution should be carefuly planned using different pathways to reduce the MUA velocity as low as possible.

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Pathways:

- Transfer air (eg., from the dining room)
- Air diffusers (ceiling mounted)
- Air registers (wall mounted)
- Hood with integrated supply air plenum
  Short circuit (internal supply)
  Air curtain supply
  Perforated front face supply
  Perforated perimeter supply
- Combinations of the above

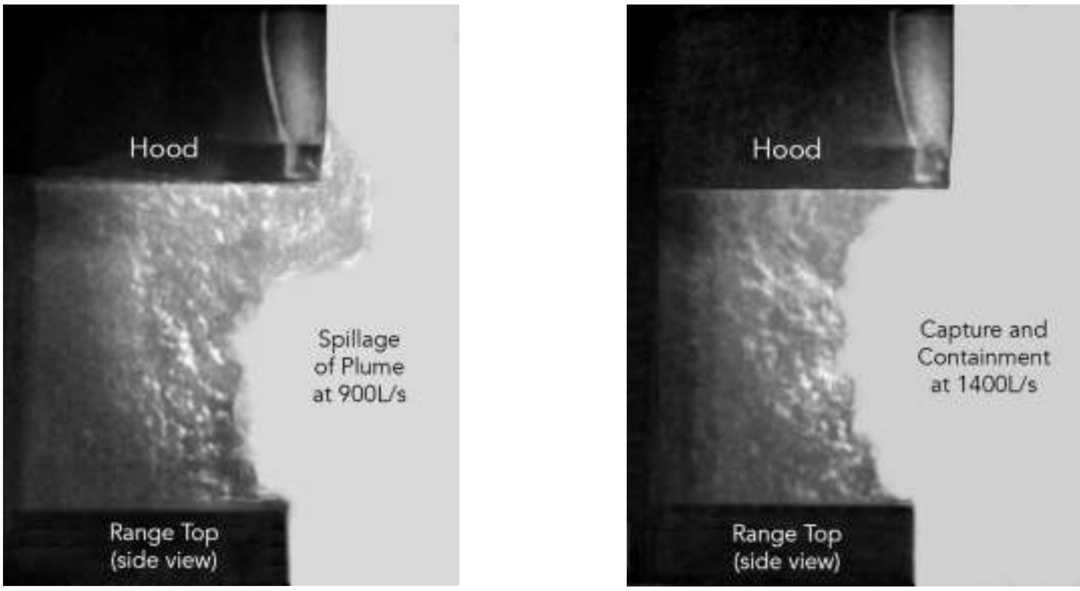


Figure 1. Schlieren images at different exhaust rates

Design Considerations

- Hood type
  Wall-mounted hoods function effectively with a lower exhaust airflow rate than island hoods. Island hoods are more sensitive to MUA supply and cross draft than wall-mounted hoods. If the kitchen designer specifies an island hood (single or double), a low or full glass panel should be mounted on the servicing wall. Side glass panels will minimise the draft effect.

Wall-mounted hoods located next to doors or openings should have partial or full side panel. They will permit a reduced exhaust rate and minimise the draught effect.
An increase in overhang should improve the ability of the hood to capture the fumes (cooking process surge) and also permit a reduced exhaust rate.
Hoods designed with better geometric features (interior angles directing the fumes towards the filters) require as much as 20% less exhaust rate compared to hoods without these features.
Hoods with filters fitted in an angle to minimise the contact with the cooking flames are to be considered. The grease filters should be tested according to AS 1530.1. They will work as a barrier against the cooking flames entering the ductwork.

- Fan selection
  Selecting the right exhaust fan will save the kitchen operator money and unnecessary noise in the kitchen. Centrifugal fans are the best option. They are very quiet and very powerful. The fan casing should be made of sturdy galvanised metal with mounting flanges. If the fan is mounted close to the hood, 6 poles motor should be selected (duct silencers are not needed with centrifugal fans) . Flexible connection should be fitted between the fan and the ductwork. It will stop the druming noise spreading to the hood. Inline and vertical discharges are available.
  We recommend to connect the fan to a speed controller. It will assist during the system commissioning to adjust the right exhaust airflow.
  A two-speed switch has the advantage of giving the choice of using the system as an “air changes” when the cooking appliances are idling (power saving).

- Exhaust air filtration
  Contaminants generated by the cooking process should be treated within the exhaust hood or as close to the hood as possible.
  The first stage should consist of honeycomb filters. They have a good efficiency for particles down to 8 microns. The advantage of these grease filters is the low resistance (25Pa) compare with baffle filters (100–120Pa). Baffle filters are only a barrier to stop the cooking flames entering the ductwork. Their efficiency is very low.

The second stage should consist of electrostatic filters. Unless UV light technology, electrostatic filters (ESP) will remove smoke and grease particles. These filters can be fitted inside the hood or within the ductwork. Behind these filters, the ductwork will stay free of contaminants. It means that the ductwork doesn't need to be cleaned. A big saving for the system operator. The risk of fire is minimised. The operator will get a cheaper premium from his insurance company.
The third stage may include ozone generators. Ozone is a powerful oxidant that will remove the remaining of the odour generated by the cooking process.

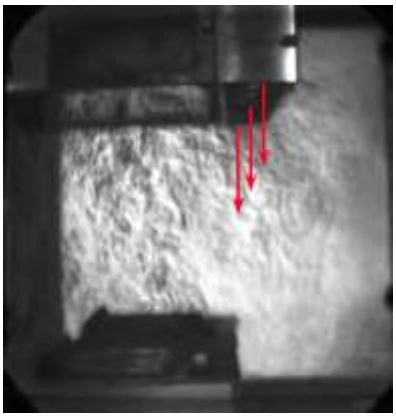
- Make-up air systems
  The strategy used to introduce replacement air can significantly impact hood performance and should be a key factor in the design of CKV. Make-up air introduced close to the hood capture zone may create local air velocities and turbulence that result in periodic or sustained failures in thermal plume capture and containment. Furthermore, the more make-up air supplied (expressed as a percentage of the total replacement air requirement), the more the negative effect.
  The primary recommendation for minimising the impact that locally supplied MUA on hood performance is to minimise the velocity (m/s) of the make-up as it is introduced near the hood. This can be accomplished by minimising the volume (l/s) of make-up air through any one pathway, by maximising the area of the grilles or diffusers through which the MUA is supplied, or by using a combination of pathways.
  The maximum air velocity approaching the hood should be less than <u>0.38 m/s.</u>
  The secondary recommendation in reducing MUA flow is to take credit for outside air that must be supplied by the HVAC system to meet code requirements for ventilating the dining room. Depending on the architectural layout between the kitchen and the dining room, it may be practical to transfer some of this air from the dining room to the kitchen.
  The third step in reducing MUA flow is to select a configuration for introducing this local make-up air into the kitchen that compliments the type and size of hood. If transfer is not an option, then a combination of make-up air strategies is to be considered.

We recommend the following option:

60% or less of air supply coming from the hood face. The balance spreaded by either ceiling diffusers (located as far away as possible from the hood) or wall registers diffusing air similar to the air transfer from the dining room.

Other type of hoods with integrated supply air plenum:
Short circuit (internal supply): Not recommended. Only 15% of the exhaust rate can be introduced without causing spillage.
Air curtain supply: Not recommended. The negative impact of an air curtain is clearly in showing in Figure 2 by the schlieren flow visualization recorded during a test of a wall-mounted hood operating over two underfired broilers.

Figure 2. Schlieren image shows the thermal plume being pulled outside the hood by the air curtain supply



Perforated front face and perimeter supply: Recommended. The face velocity should not exceed 0.76 m/s. The perforated front face discharge should exit in a horizontal direction. The perforated perimeter supply discharge should not be less than 450 mm from the lower edge of the hood. Figure 3 is showing an effective plume capture with MUA supplied through a 400 mm wide perforated perimeter supply.
Notes:
Hoods with front face air supply registers are not recommended. The air velocity is too high and too close to the capture zone.
Double island hoods should have MUA coming from two directions to feed both sides similar to a wall-mounted hood.

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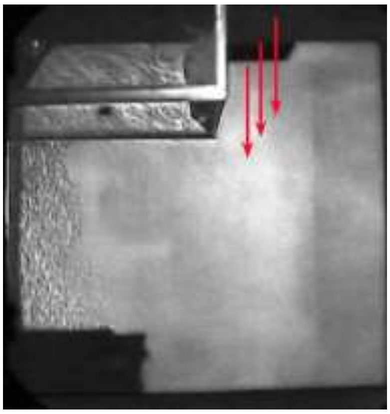
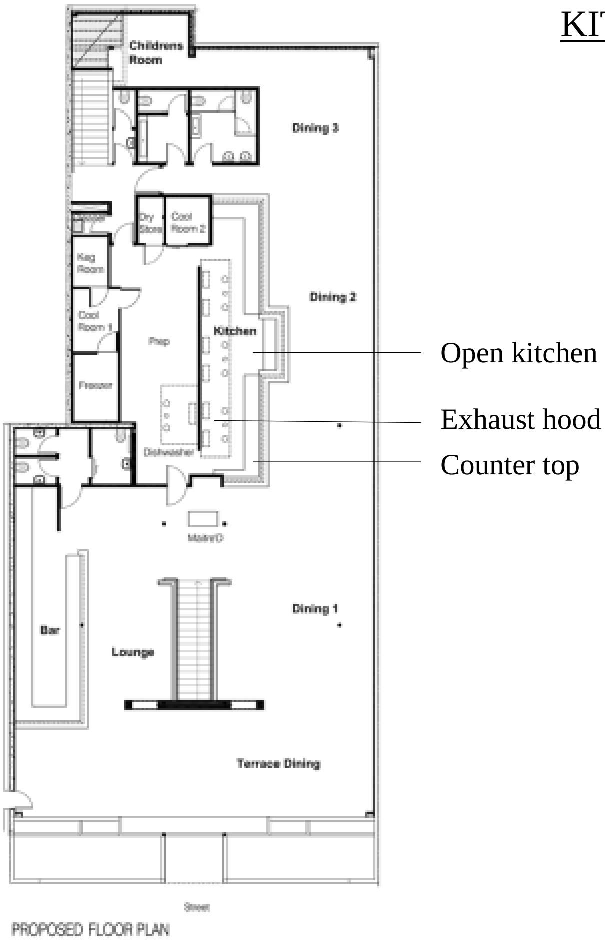
Figure 3. Schlieren image shows effective plume capture with MUA supplied through a 400 mm wide perforated perimeter supply



- Typical kitchen exhaust and make-up air design



<u>KITCHEN EXHAUST AIRFLOW RATES</u>

A. Exhaust: 5400L/s
B. Make-up air
    - Hood face: 1350L/s
    - Kitchen diffusers: 1350L/s
    - Dining room: 2700L/s