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Halton design guide for indoor air climate in commercial kitchens

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Halton design guide for indoor air climate in commercial kitchens



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Design Fundamentals

Commercial Kitchen Ventilation Systems

The commercial kitchen is a unique space where many different HVAC applications take place within a single environment. Exhaust, supply, transfer, refrigeration, building pressurisation and air conditioning all must be considered in the design of most commercial kitchens.

It is obvious that the main activity in the commercial kitchen is the cooking process. This activity generates heat and effluent that must be captured and exhausted from the space in order to control odour

and thermal comfort. The kitchen supply air, whether mechanical or transfer or a combination of both, should be of an amount that creates a small negative pressure in the kitchen space. This will avoid odours and contaminated air escaping into surrounding areas. Therefore the correct exhaust air flow quantity is fundamental to ensure good system operation, thermal comfort and improved IAQ.

Similar considerations should be given to washing-up, food preparation and serving areas.



Picture 1.

Initial Design Considerations

The modes of heat gain in a space may include solar radiation and heat transfer through the construction together with heat generated by occupants, lights and appliances and miscellaneous heat gains as air infiltration should also be considered.

Sensible heat (or dry heat) is directly added to the conditioned space by conduction, convection and radiation. Latent heat gain occurs when moisture is added to the space (e.g., from vapour emitted by the cooking process, equipment and occupants). Space heat gain by radiation is not immediate. Radiant energy must first be absorbed by the surfaces that enclose the space (walls, floor, and ceiling) and by the objects in the space (furniture, people, etc.). As soon as these surfaces and objects become warmer than the space air, some of the heat is transferred to the air in the space by convection (see picture 2).

To calculate a space cooling load, detailed building design information and weather data at selected design conditions are required. Generally, the following information is required:

- building characteristics
- configuration (e.g, building location)
- outdoor design conditions
- indoor design conditions
- operating schedules
- date and time of day

However, in commercial kitchens, cooking processes contribute the majority of heat gains in the space.

Heat Gain and Emissions Inside the Kitchen

Cooking can be described as a process that adds heat to food. As heat is applied to the food, effluent (1) is released into the surrounding environment. This effluent release includes water vapour, organic material released from the food itself, and heat that was not absorbed by the food being cooked. Often, when pre-cooked food is reheated, a reduced amount of effluent is released, but water vapour is still emitted into the surrounding space.

The hot cooking surface (or fluid, such as oil) and products create thermal air currents (called a thermal plume) that are received or captured by the hood and then exhausted. If this thermal plume is not totally captured and contained by the hood, they become a heat load to the space.

There are numerous secondary sources of heat in the kitchen (such as lighting, people, and hot meals) that contribute to the cooling load as presented in table 1.

Load	W
Lighting	21-54/m ²
People	130/person
Hot meal	15/meal
Cooking eq.	varies
Refrigeration	varies

Table 1. Cooling load from various sources



① Thermal plumes ② Radiant heat

Picture 2. Heat gain and emission inside the kitchen

Thermal Comfort, Productivity and Health

Thermal Comfort

One reason for the low popularity of kitchen work is the unsatisfactory thermal conditions. Thermal comfort is a state where a person is satisfied with the thermal conditions.

The International Organisation for Standardisation (ISO) specifies such a concept as the predicted percentage of dissatisfied occupants (PPD) and the predicted mean vote (PMV) of occupants. PMV represents a scale from -3 to 3, -from cold to hot -, with 0 being neutral. PPD tells what percentage of occupants are likely to be dissatisfied with the thermal environment. These two concepts take into account four factors affecting thermal comfort:

- air temperature
- radiation
- air movement
- humidity

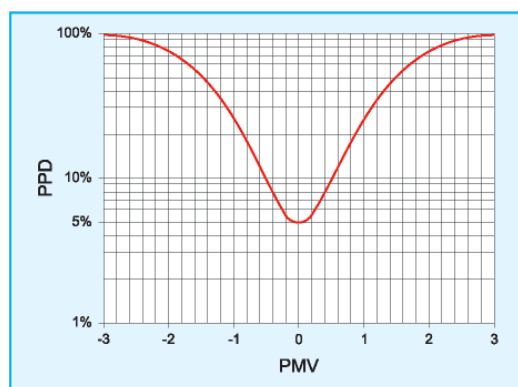


Figure 1. PPD as a function of PMV

The percentage of dissatisfied people remains under 10% in neutral conditions if the vertical temperature difference between the head and the feet is less than 3°C and there are no other non-symmetrical temperature factors in the space. A temperature difference of 6-8°C increases the dissatisfied percentage to 40-70%.

There are also important personal parameters influencing the thermal comfort (typical values in kitchen environment in parenthesis):

- clothing (0.5 - 0.8 clo)
- activity (1.6 - 2.0 met)

Clo expresses the unit of the thermal insulation of clothing (1 clo = 0.155 m² K/W).

Met is a unit used to express the metabolic rate per unit Dubois area, defined as the metabolic rate of a sedentary person, 1 met = 50 kcal/(hr.m²) = 58.2 W/m².

Assymmetric Thermal Radiation

In the kitchen, the asymmetry of radiation between the cooking appliances and the surrounding walls is considerable as the temperature difference of radiation is generally much higher than 20° C.

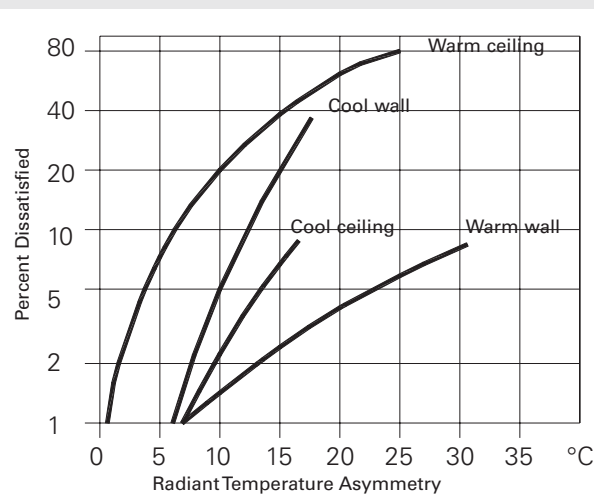


Figure 2. Assymmetric thermal radiation

Ventilation Effectiveness and Air Distribution System

The Effect of Air Supply

Ventilation effectiveness can be described as the ability of ventilation system to achieve design conditions in the space (air temperature, humidity, concentration of impurities and air velocity) at minimum energy consumption. Air distribution methods used in the kitchen should provide adequate ventilation in the occupied zone, without disturbing the thermal plume.

In the commercial kitchen environment the supply airflow rate required to ventilate the space is a major factor contributing to the system energy consumption. Traditionally high velocity mixing or low velocity mixing systems have been used. Now there is a third alternative that clearly demonstrates improved thermal comfort over mixing systems, this is displacement ventilation.

The supply air (make-up air) can be delivered to the kitchen in two ways:

- high velocity or mixing ventilation
- low velocity or displacement.

Low Velocity or Displacement Ventilation

Here, the cooler-than-surrounding supply air is distributed with a low velocity to the occupied zone. In this way, fresh air is supplied to where it is needed. Because of its low velocity, this supply air does not disturb the hood function.



Picture 3. Low velocity or displacement ventilation

With a displacement system the intensity of turbulence of about 10 %, one accepts velocities between 0.25 and 0.40 m/s, with the air between 20 and 26°C respectively with 20% of people dissatisfied.

High velocity or Mixing Ventilation

Everything that is released from the cooking process is mixed with the supply air. Obviously impurities and heat are mixed with surrounding air. Also the high velocity supply air disturbs the hood function.



Picture 4. High velocity or mixing ventilation

In the case of mixing ventilation, with an intensity of turbulence from 30 to 50 %, one finds 20 % of people dissatisfied in the following conditions:

air temperature. (°C)	20	26
air velocity (m/s)	0.15	0.25

Table 2. Air temperature/air velocity

Refer to section Effect of Air Distribution System page 39 for a detailed comparison between mixing and displacement systems in a typical kitchen environment.



Picture 5. Recommended design criteria

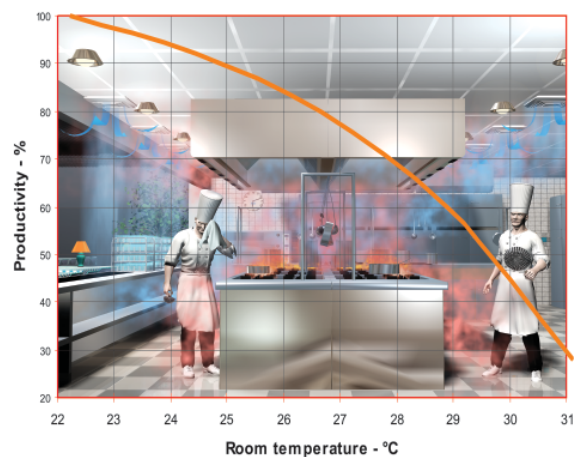
Productivity

Labour shortages are the top challenge that commercial restaurants face today. The average age of a restaurant worker is between 16 and 24 years. In a recent survey conducted by the National Restaurant Association in USA, over 52% of respondents said that finding qualified motivated labour was their main concern.

Room air temperature affects a person's capacity to work. Comfortable thermal conditions decrease the number of accidents occurring in the work place. When the indoor temperature is too high (over 28 °C in commercial kitchens) the productivity and general comfort diminish rapidly.

The average restaurant spends about \$2,000 yearly on salaries in the USA, wages and benefits per seat. If the air temperature in the restaurant is maintained at

27°C in the kitchen the productivity of the restaurant employees is reduced to 80 % (see picture 6). That translates to losses of about \$40,000 yearly on salaries and wages for an owner of a 100-seat restaurant.



Picture 6. Productivity vs. Room Air Temperature

Health

There are several studies dealing with cooking and health issues. The survey confirmed that cooking fumes contain hazardous components in both Western and Asian types of kitchens. In one study, the fumes generated by frying pork and beef were found to be mutagenic. In Asian types of kitchens, a high concentration of carcinogens in cooking oil fumes has been discovered. All this indicates that kitchen workers may be exposed to a relatively high concentration of airborne impurities and that cooks are potentially exposed to relatively high levels of mutagens and carcinogens.

Chinese women are recognised to have a high incidence of lung cancer despite a low smoking rate e.g. only 3% of women smoke in Singapore. The studies carried out show that inhalation of carcinogens generated during frying of meat may increase the risk of lung cancer.

The risk was further increased among women stir-frying meat daily whose kitchens were filled with oily fumes during cooking. Also, the statistical link between chronic coughs, phlegm and breathlessness on exertion and cooking were found.

In addition to that, Cinni Little states, that three quarters of the population of mainland China alone use diesel as fuel type instead of town gas or LPG, causing extensive bronchial and respiratory problems among kitchen workers, which is possibly exacerbated by an air stream introduced into the burner mix.

Reduction of Health Impact

The range of thermal comfort neutrality acceptable without any impact on health has been proposed as running between 17°C as the lowest and 31°C as the

highest acceptable temperature (Weihe 1987, quoted in WHO 1990). Symptoms of discomfort and health risks outside this range are indicated in table 3.

<<	< 17 °C	> 31 °C	>>
Sudden heart death	Hypertension	Hypotension	Sudden heart death
Stroke	Hypothermia	Hyperthermia	Heart failure
	Respiratory infections	Tachycardia	Heat stroke
	Asthma	Heath insufficiency	
	Overheating	Inappetence	
	Tachycardia	Hypohydrosis	
	Reduced d'exterility	Hydromeiosis	
	Indolence	Indolence	
	Restlessness	Fatigue	
	Mental slowing	Lethargy	
	Depression	Increased irritability	
		Reduced learning capacity	
		Impaired memory	

Table 3. Health effects of thermal microclimates lying outside the neutral comfort zone

Ventilation Rate

The airflow and air distribution methods used in the kitchen should provide adequate ventilation in the occupied zone, without disturbing the thermal plume as it rises into the hood system. The German VDI-2052 standard states that a:

Ventilation rate over 40 vol./h result on the basis of the heat load, may lead to draughts.

The location of supply and exhaust units are also important for providing good ventilation. Ventilating systems should be designed and installed so that the

ventilation air is supplied equally throughout the occupied zone. Some common faults are to locate the supply and exhaust units too close to each other, causing 'short-circuiting' of the air directly from the supply opening to the exhaust openings. Also, placing the high velocity supply diffusers too close to the hood system reduces the ability of the hood system to provide sufficient capture and containment (C&C) of the thermal plume.

Recent studies show that the type of air distribution system utilised affects the amount of exhaust needed to capture and contain the effluent generated in the cooking process.

Integrated Approach

Energy savings can be realised with various exhaust hood applications and their associated make-up air distribution methods. However with analysis the potential for increased energy savings can be realised when both extract and supply for the kitchen are adopted as an integrated system.

The combination of high efficiency hoods (such as Capture-Jet hoods) and displacement ventilation reduces the required cooling capacity, while maintaining temperatures in the occupied space. The natural buoyancy characteristics of the displacement air helps the C&C of the contaminated convective plume by 'lifting' it into the hood.

Third-party research has demonstrated that this integrated approach for the kitchen has the potential to provide the most efficient and lowest energy consumption of any kitchen system available today.



Picture 7. Displacement ventilation

Kitchen Hoods

The purpose of kitchen hoods is to remove the heat, smoke, effluent, and other contaminants. The thermal plume from appliances absorbs the contaminants that are released during the cooking process. Room air replaces the void created by the plume. If convective heat is not removed directly above the cooking equipment, impurities will spread throughout the kitchen, leaving discoloured ceiling tiles and greasy countertops and floors. Therefore, contaminants from stationary local sources within the space should be controlled by collection and removal as close to the source as is practical.

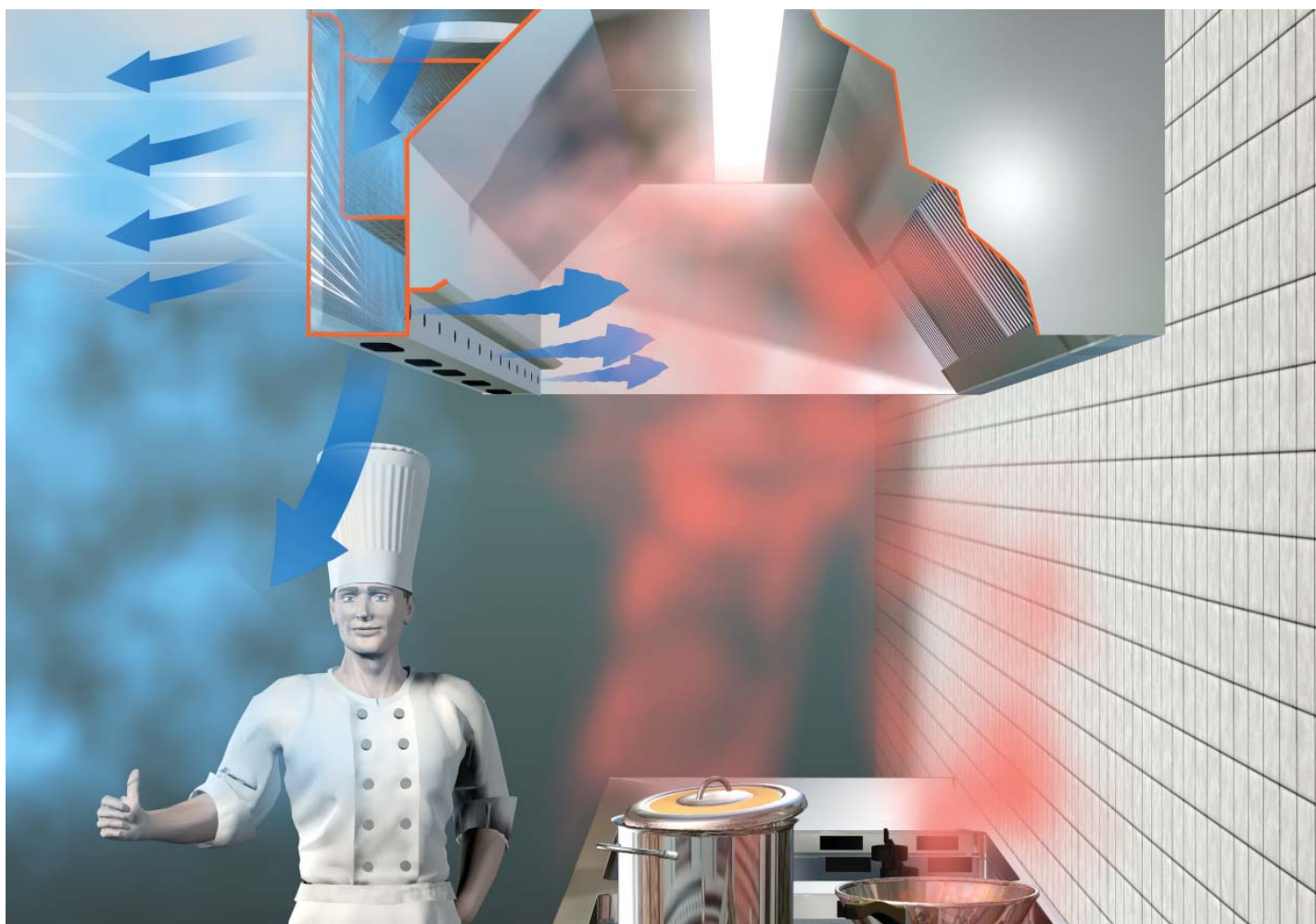
Appliances contribute most of the heat in commercial kitchens. When appliances are installed under an effective hood, only the radiant heat contributes to the HVAC load in the space. Conversely, if the hood is not providing sufficient capture and containment,



Picture 8. Cooking process

convective and latent heat are 'spilling' into the kitchen thereby increasing both humidity and temperature.

Capture efficiency is the ability of the kitchen hood to provide sufficient capture and containment at a minimum exhaust flow rate. The remainder of this chapter discusses the evolution and development of kitchen ventilation testing and their impact on system design.



Picture 9. Capture efficiency hoods

Kitchen Hoods

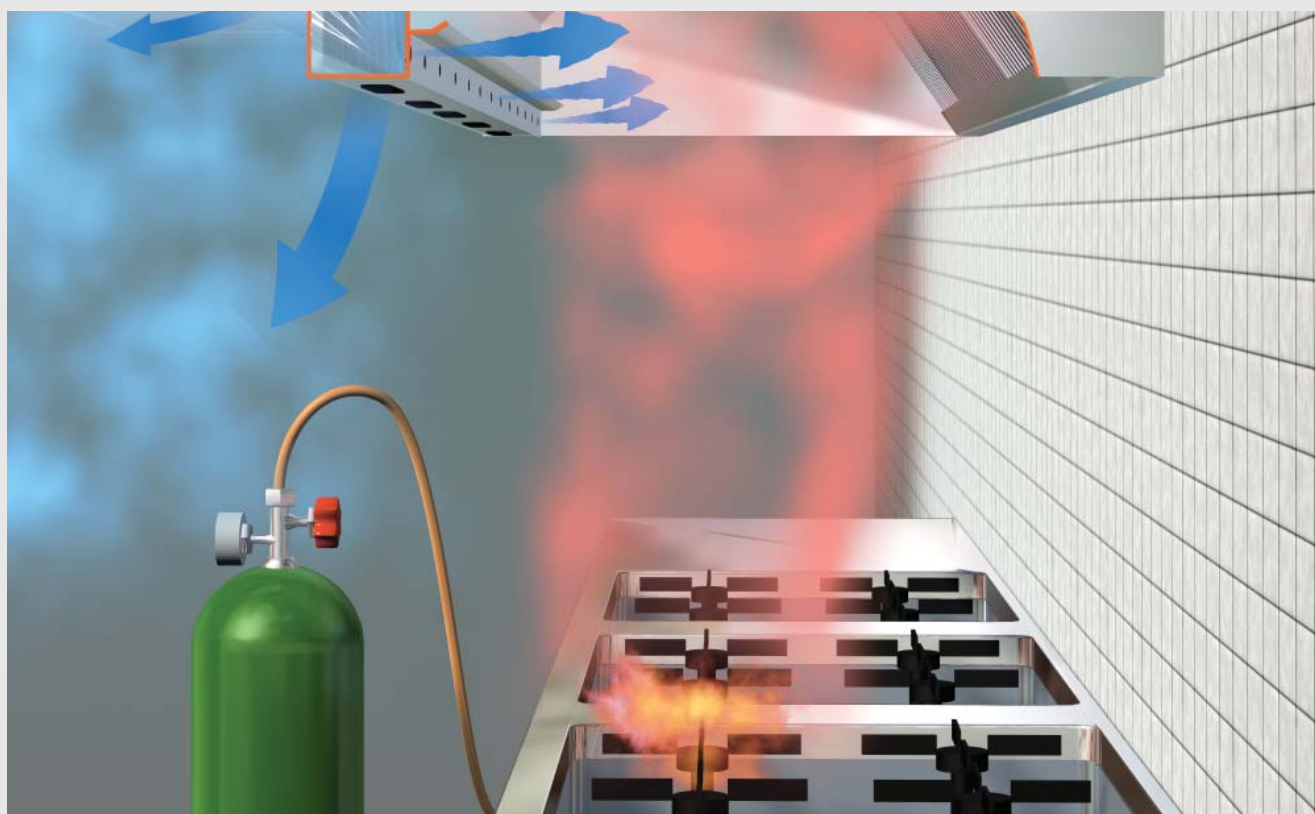
Evolution of Kitchen Ventilation System

Tracer Gas Studies

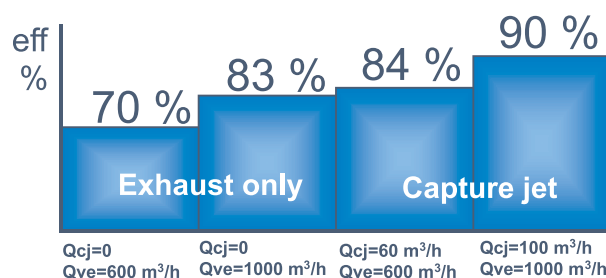
Halton pioneered the research on kitchen exhaust system efficiency in the late 1980's, commissioning a study by the University of Helsinki. At the time there were no efficiency test standards in place. The goal was to establish a test protocol that was repeatable and usable over a wide range of air flows and hood designs.

Nitrous Oxide (tracer gas), a neutrally buoyant gas, was used. A known quantity of gas was released from

the heated cooking surface and compared to the concentration measured in the exhaust duct. The difference in concentration was the efficiency at a given air flow. This provided valuable information about the potential for a variety of capture and containment strategies. The Capture Jet™ system was tested using the Tracer Gas technique and the results showed a significant improvement in capture and containment of the convective plume at lower exhaust air flows compared to conventional exhaust only hoods.



$$\text{eff} = \frac{m_e}{m_{tg}}$$



Picture 10. Tracer gas studies

ASTM F1704

In 1990, AGA Laboratories was funded by the Gas Research Institute to construct a state-of-the-art kitchen ventilation laboratory and research the interaction between cooking appliances, kitchen ventilation hoods, and the kitchen environment. In early 1993, the original Energy Balance Protocol was developed to explain the interaction between the heat loads in the kitchen. Mathematically, the energy consumed by the cooking appliance can only go three places:

- to the food being cooked
- out of the exhaust duct
- into the kitchen as heat load

In late 1993, this was introduced as a draft standard to be adopted by ASTM and was called the Energy Balance Protocol. The original protocol was developed to only examine the energy interactions in the kitchen with the goal of determining how much heat was released into the kitchen from cooking under a variety of conditions. This standard was adopted by ASTM as F1704.

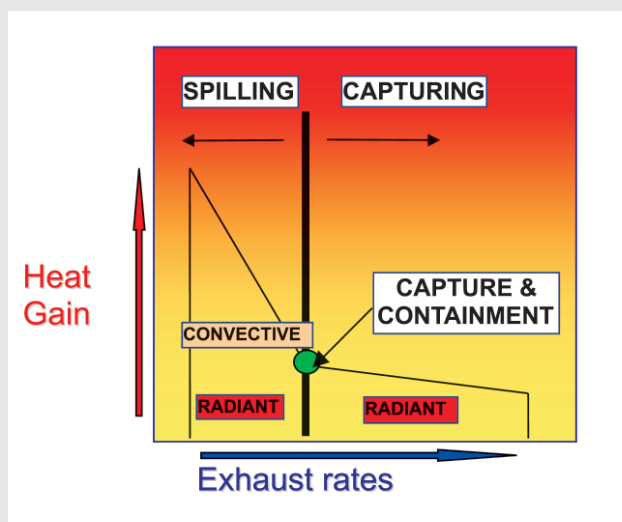


Figure 3. Capture & containment

Around 1995, the standard adopted new methods of determining the capture and containment using a variety of visualisation techniques including visual observation, neutrally buoyant bubbles, smoke, lasers, and Schlieren thermal imaging (discussed in more detail later in this section).

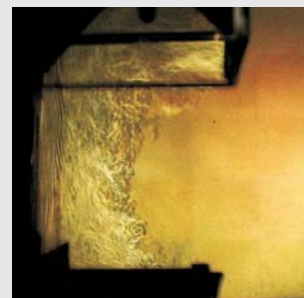
The test set up includes a hood system operating over a given appliance. Several thermocouple trees are placed from 1.8 m to 2.5 m. in the front of the hood

system and are used to measure the heat gain to the kitchen space. This enables researchers to determine the temperature of room air being extracted into the hood.

In theory, when the hood is providing sufficient capture and containment, all of the convective plume from the appliance is exhausted by the hood while the remaining radiant load from the appliance is heating up the hood, kitchen walls, floors, ceiling, etc. that are eventually seen as heat in the kitchen.

Schlieren Thermal Imaging

Schlieren thermal imaging has been around since the mid 1800's but was really used as a scientific tool starting from the late 20th century.



Picture 11. Capture Jet™ ON.

During the 1950's

Schlieren thermal imaging was used by AGA Laboratories to evaluate gas combustion with several different burner technologies. NASA has also made significant use of Schlieren thermal imaging as a means of evaluating shockwaves for aircraft, the space shuttle, and jet flows. In the 1990's Penn State University began using Schlieren visualisation techniques to evaluate heat flow from computers, lights, and people in typical home or office environments. In 1998 the kitchen ventilation lab in Chicago purchased the first Schlieren system to be used in the kitchen ventilation industry. In 1999, the Halton Company became the first ventilation manufacturer globally to utilise a Schlieren thermal Imaging system for use in their research and development efforts.

By using the thermal imaging system we can visualise all the convective heat coming off an appliance and determine whether the hood system has sufficient capture and containment. In addition to verifying capture and containment levels, the impact of various supply air and air distribution measures can be incorporated to determine the effectiveness of each. By using this technology a more complete understanding of the interaction between different components in the kitchen (e.g., appliances, hoods, make-up air, supply diffusers, etc.) is being gained.

Computer Modelling

Computational Fluid Dynamics (CFD) has been used in the aerospace and automobile industries for a number of years. Recently, CFD use has become more widespread, specifically in the HVAC industry.

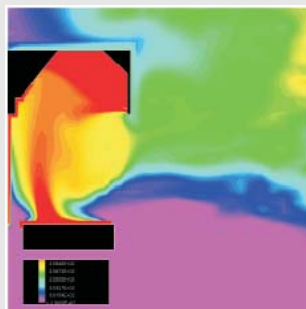


Figure 4. CFD

CFD works by creating a three-dimensional computer model of a space. Boundary conditions, in the case of kitchen ventilation modelling, may include; hood exhaust rates, input energy of the appliance, supply air type and volume and temperature of supply air. Complex formulas are solved to produce the final results. After the solutions converge, variables such as temperature, velocity, and flow directions can be visualised. CFD has become an invaluable tool for the researcher by providing an accurate prediction of results prior to full scale mock-ups or testing for validation purposes.

Conclusion of the Test Conducted by EDF:

The study on induction hoods shows that their capture performances vary in relation to the air induction rate. If this rate is too high (50 to 70%), the turbulence created by the hood prevents the efficient capture of contaminants. If the Capture Jet air rate is about 10% or lower, the capture efficiency can be increased by 20-50%, which in turn leads to an equivalent reduction in air flow rates.

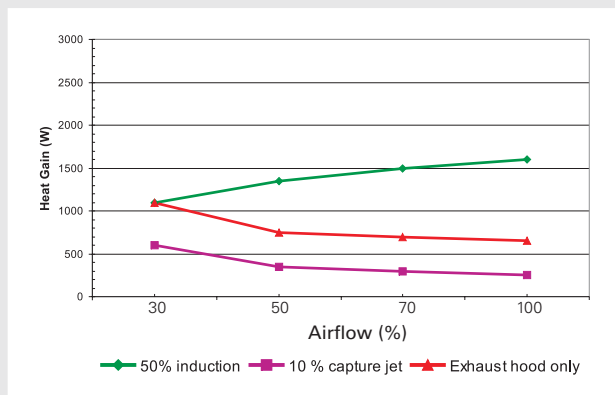


Figure 5. Capture efficiency

Consequently, the performances of induction hoods are not due to the delivery of unheated air, but to the improvement in capture.

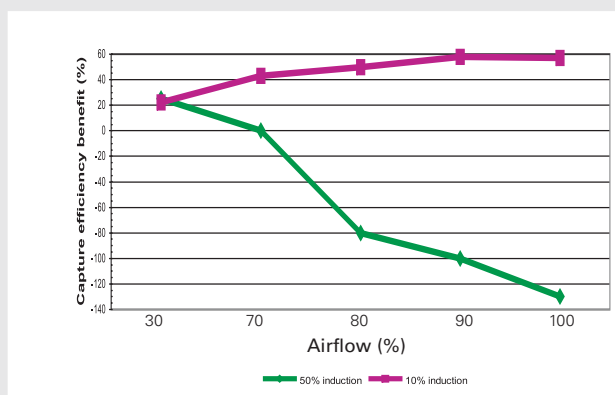


Figure 6. Capture efficiency

DEFINITION:

Induction Hood is a concept, which allows for the introduction of large volumes of untreated make-up air directly into the exhaust canopy. The ratio of make-up air to exhaust air was as high as 80%.

Grease Extraction

The convection plume from the cooking operation underneath the hood contains grease that has to be extracted as efficiently as possible. The amount of grease produced by cooking is a function of many variables including: the type of appliance used for cooking, the temperature that food is being cooked at, and the type of food product being cooked.

The purpose of a mechanical grease filter is twofold: first to provide fire protection by preventing flames from entering the exhaust hood and ductwork, and secondly to provide a means of removing large grease particles from the exhaust stream. The more grease that can be extracted, the longer the exhaust duct and fan stay clean, resulting in better fire safety. From a practical standpoint, grease filters should be easily cleanable and non-cloggable. If the filter becomes clogged in use, the pressure drop across the filter will increase and the exhaust airflow will be lower than designed.

What Is Grease?

According to the University of Minnesota, grease is comprised of a variety of compounds including solid and/or liquid grease particles, grease and water vapours, and a variety of non-condensable gases including nitrogen oxides, carbon dioxide, and carbon monoxide. The composition of grease becomes more complex to quantify as grease vapours may cool down in the exhaust stream and condense into grease particles. In addition to these compounds, hydrocarbons can also be generated during the cooking process and are defined by several different names including VOC (volatile organic compounds), SVOC (semi-volatile organic compounds), ROC (reactive organic compounds), and many other categories.

Grease Emissions By Cooking Operation

An ASHRAE research project conducted by the University of Minnesota has determined the grease emissions from typical cooking processes. Figure 7 presents total grease emissions for several appliances.

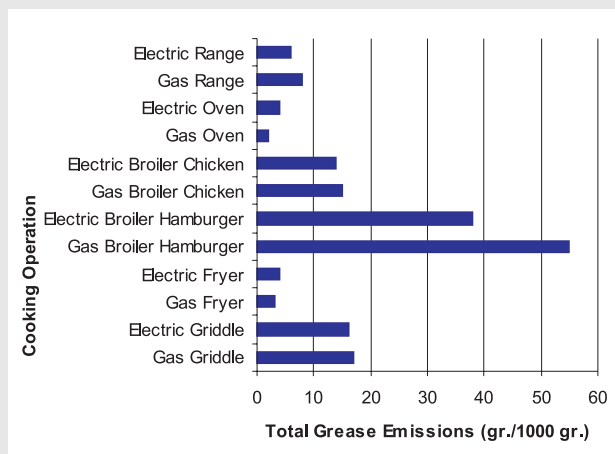


Figure 7. Total grease emissions by appliance category

Upon observing figure 7, it appears at first as if the underfired broiler has the highest grease emissions. However when examining the figure closer you see that if a gas or electric broiler is used to cook chicken breasts, the grease emissions are slightly lower than if you cook hamburgers on a gas or electric griddle. This is the reason that we are discussing “cooking operation” and not merely the type of appliance. However, we can say that, for the appliances tested in this study, the largest grease emissions are from underfired broilers cooking burgers while the lowest grease emissions were from the deep-fat fryers. The gas and electric ranges were used to cook a spaghetti meal consisting of pasta, sauce, and sausage. All of the other appliances cooked a single food product. It is expected that the emissions from solid-fuel (e.g., wood burning) appliances will probably be on the same order of magnitude as under-fired broilers, but in addition to the grease, large quantities of creosote and other combustion by-products may be produced that coat the grease duct. Chinese Woks may have grease emissions well above under-fired broiler levels due to high surface temperature of the Woks combined with the cooking medium utilised for cooking (e.g. peanut oil, kanola oil, etc.) which will tend to produce extreme grease vaporisation and heat levels table 4 presents the specific foods cooked for the appliances presented in figure 8 and figure 9.

Appliance	Food Product
Gas Griddle Electric Griddle	Beef hamburgers, 113 g, 120 mm diameter, 20% fat content
Gas Fryer Electric Fryer	French fried potatoes, par-cooked, frozen shoestring potatoes, 60 mm thick with 2.2% fat content.
Gas Broiler Electric Broiler	Beef hamburgers, 150 g, 120 mm diameter, 20% fat content
Gas Broiler Electric Broiler	Boneless, skinless chicken breast, frozen, 1115 g, 125 mm thickness.
Gas Oven Electric Oven	Sausage pizza with sausage, textured vegetable protein, mozzarella cheese, and cheese substitute. Each slice was 100 x 150 mm, 142 g.
Gas Range Electric range	Two pots of spaghetti noodles, 2.266 kg. dry weight, one pot boiling water, two pots of tomato based spaghetti sauced, 3 liters each 1.360 kg of link style sausage cooked in a frying pan.

Table 4. Description of food cooked on each appliance

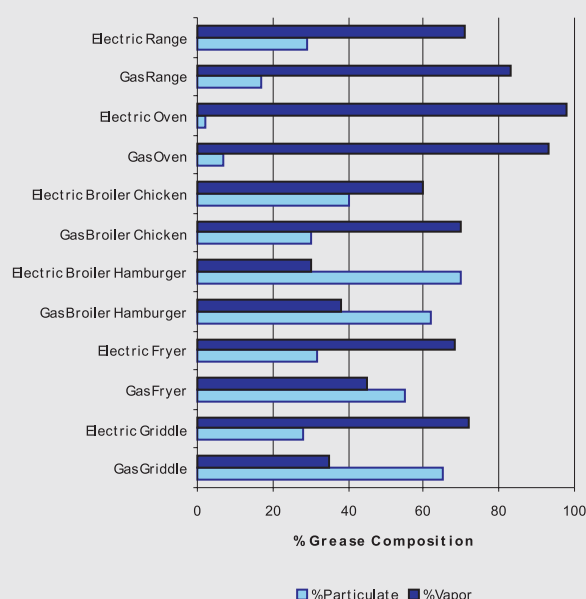


Figure 8. Particulate and vapour grease percentages by appliance category

The components of grease were discussed earlier and a breakdown of the grease emissions into the particulate and vapor phases is shown in figure 8.

Upon examining figure 8, it becomes apparent that the griddles, fryers, and broilers all have a significant amount of grease emissions that are composed of particulate matter while the ovens and range tops are emitting mainly grease vapour. If you combine the data in figure 7 with the data in figure 8 it becomes evident that the broilers have the largest amount of particulate matter to remove from the exhaust stream.

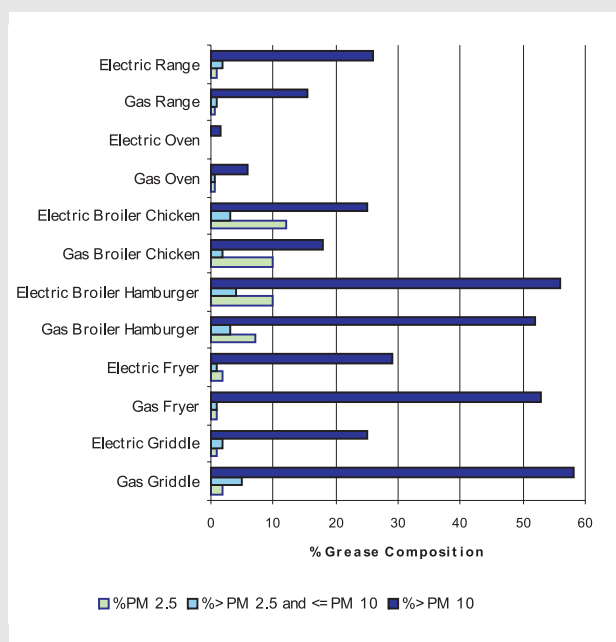


Figure 9. Particle size distribution by cooking process

The final piece of information that is important for grease extraction is the size distribution of the grease particles from the different cooking processes, presented in figure 9.

It can be observed from figure 9 that, on a mass basis, cooking processes tend to produce particles that are 10 microns and larger. However, the broilers produce significant amounts of grease particles that are 2.5 microns and smaller (typically referred to as PM 2.5) regardless of the food being cooked on the broiler.

Cyclonic Grease Extraction

One non-cloggable design of a baffle type grease extractor is a “cyclone.” The extractor is constructed of multiple cyclones that remove grease from the air stream with the aid of centrifugal force.

Figure 10 presents Halton’s KSA grease filter design. You can see the cyclonic action inside the KSA filter.

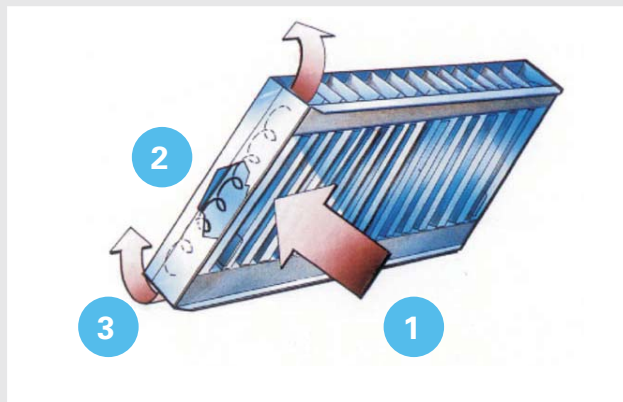


Figure 10. Halton KSA filter

1. air enters through a slot in the filter face
2. air spins through the filter, impinging grease on the filter walls
3. the cleaner air exits the top and bottom of the filter.

Filter Efficiency

VDI has set up a test procedure (September 1999) in order to compare the results of grease filters from different manufacturer.

KSA –filters were supplied by Halton to an independent laboratory. The fractional efficiency measurements were made at the flow rates of 80 l/s, 110 l/s, 150 l/s and 210 l/s.

Mechanical grease filters quickly lose grease removal effectiveness as the particulate size drops below 6 microns depending on the pressure drop across the filters.

Increasing the flow rate from 80 l/s to 210 l/s causes an increase in the efficiency.

Figure 11 presents the extraction efficiency curve for Halton’s KSA filter for four different pressure drops across the filter.

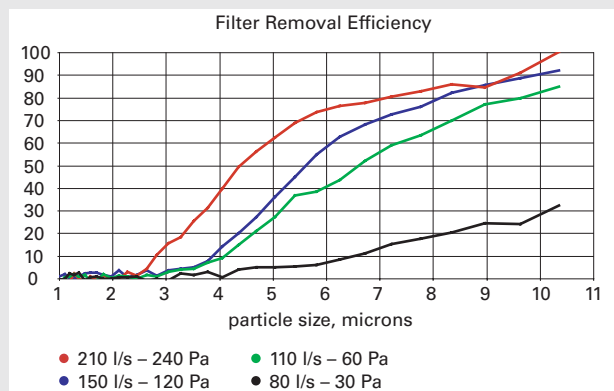


Figure 11. Grease extraction efficiency curves for KSA filter 500x330.

Comparison Test Filter Efficiency

When comparing to the other type of filters on the market like ‘Baffle filter’, the results below show that Halton has the most efficient filter on the market.

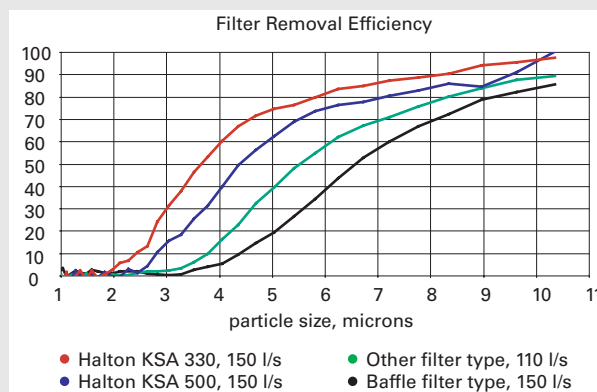


Figure 12. Comparison test filter efficiency.

Research has shown that as far as efficiency is concerned, slot filters (baffle) are the lowest, followed by baffle style filters (other type).

Note how the KSA efficiency remains high even when the filters are not cleaned and loading occurs.

Ultraviolet Light Technology

Ultraviolet Light – What Is It ?

Light is the most common form of the electromagnetic radiation (EMR) that the average person is aware of. Light is only a very small band within the electromagnetic spectrum. Cosmic rays, X-rays, radio waves, television signals, and microwave are other examples of EMR.

EMR is characterised by its wavelength and frequency. Wavelength is defined as the length from the peak of one wave to the peak of the next, or one oscillation (measured in metres). Frequency is the number of oscillations in one second (measured in Hertz).

Sunlight is the most common source of ultraviolet radiation (UVR) but there are also many other sources. UVR emitting artificial light sources can be produced to generate any of the UVR wavelengths by using the appropriate materials and energies.

Ultraviolet radiation is divided into three categories – UVA, UVB, and UVC. These categories are determined by their respective wavelengths.

Ultraviolet A radiation is the closest to the wavelengths of visible light .

Ultraviolet B radiation is a shorter, more energetic wave.

Ultraviolet C radiation is the shortest of the three ultraviolet bands and is used for sterilisation and germicidal applications.

UV technology has been known since the 1800's. In the past it has been utilised in hospital, wastewater treatment plants, and various industry applications. HALTON has now developed new applications to harness the power of Ultraviolet Technology in commercial kitchens.



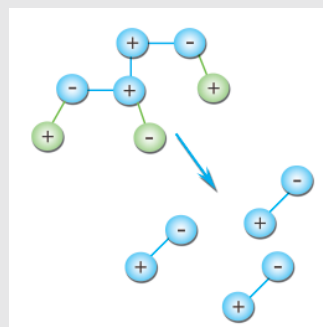
Picture 12. UVL with Capture Ray™

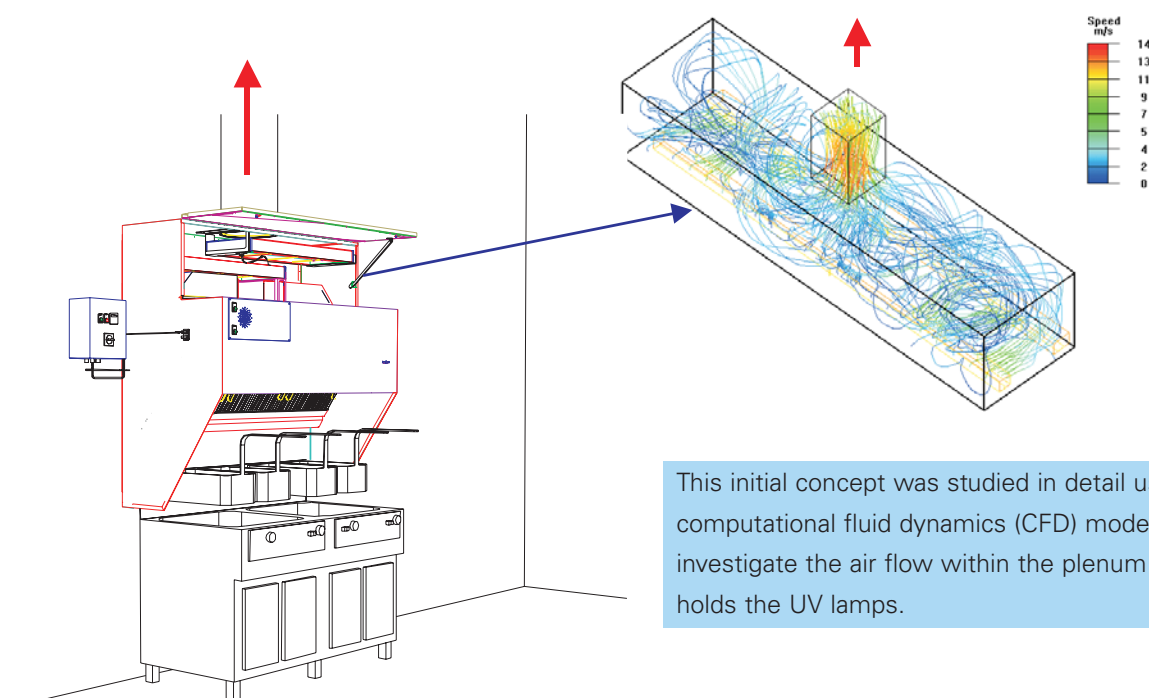
How Does the Technology Work?

Ultraviolet light reacts to small particulate and volatile organic compounds (VOC) generated in the cooking process in two ways, by exposing the effluent to light and by the generation of ozone (UVC).

As is commonly known, the effluent generated by the cooking process is a fatty substance. From a chemical standpoint, a fatty substance contains double bonds, which are more reactive than single bonds. By using light and ozone in a certain manner, we are able to attack these double bonds and consequently break them. This results in a large molecule being broken down into two smaller ones. Given enough reactive sites, this process can continue until the large molecule is broken down

into carbon dioxide and water, which are odourless and harmless. Unlike the grease that results in these small molecules, CO_2 and H_2O will not adhere to the duct and will be carried out by the exhaust air flow.





This initial concept was studied in detail using a computational fluid dynamics (CFD) model to investigate the air flow within the plenum that holds the UV lamps.

Picture 13. CFD model to investigate the air flow within the plenum that holds the UV lamps.

Evaluation of grease deposition

When the grease generated was used without the UV technology, grease did collect on the plates. Tests showed that using UV technology reduces the grease deposition on the duct walls and reduces the need for a restaurant to have their ducts cleaned.

Evaluation of odour removal -

Chemical Analysis

There was a significant reduction in the measured "peak area" of the chemical compounds. Results indicate that for cooking French fries, odours were reduced by over 55% with the UV system. For the burgers, the odour was reduced by over 45%. This initial concept was studied in detail using a computational fluid dynamics (CFD) model to investigate the airflow within the plenum that holds the UV lamps.

Conclusions

The results of this research indicate that the UV technology is effective at reducing both grease emissions and odour. Based on chemical analysis the odour was reduced for both the French fries and the burgers. The grease deposition testing concludes that there appears to be a reduction in grease build-up in

the duct. The plenum design presented utilises an exhaust airflow rate of 363 L/s with a volume of 0.6 m³ resulting in an average reaction time of 1.6 seconds in the plenum. In order to ensure effectiveness under all cooking conditions this is recommended as the minimum reaction time in the plenum. The remaining duct run from the hood to where it exits the building provides a minimum of an additional 0.4 seconds for the ozone to react with the grease to achieve a total reaction time of 2 seconds.

Benefits of Halton's Capture Ray™ System

- Reduces or eliminates costly duct cleaning.
- Reduces odour emissions.
- Specifically engineered for your cooking applications.
- Personnel protected from UV exposure.
- Monitors hood exhaust flow rates.
- Improved hygiene.
- Reduces fire risk.

Types of Hoods

Kitchen ventilation hoods are grouped into one of two categories. They are defined by their respective applications:

TYPE I: Is defined for use over cooking processes that produce smoke or grease laden vapours and meet the construction requirements of NFPA-96

TYPE II: Is defined for use over cooking and dishwashing processes that produce heat or water vapour.

Additional information on Type I and Type II hoods can be found in Chapter 30 of the 1999 ASHRAE HVAC Applications Handbook. This section presents information on engineered, low-heat hoods and commodity classes of hoods as well as an overview of the most common types of grease removal devices.

Engineered Hood Systems

This subsection presents the engineered hood products offered by Halton. These systems are factory built and tested and are considered to be high-efficiency systems.

These systems have been tested using the tracer gas technique, Schlieren visualization, and computer modeling to measure system efficiency. Common to these designs is the use of Capture Jet™ technology to improve the capture and containment efficiency of the hood.

Capture Jet™ Canopy Hoods

These wall style canopies incorporate the Capture Jet technology to prevent 'spillage' of grease-laden vapor out from the hood canopy at low exhaust rates. A secondary benefit coupled with the low-pressure loss,



Picture 9. Capture efficiency hoods

high efficiency multi cyclone grease extractor (Model KSA) is to create a push/pull effect within the capture area, directing the grease-laden vapors toward the exhaust. Performance tests indicate a reduction greater than 30 % in the exhaust rate over exhaust only devices.

Capture Jet™ fan

Where only small quantities of supply air are available, it is possible to fit a fan to the roof of the supply plenum.

Capture Jet™ double island canopy

For use over the back-to-back appliance layout. This system incorporates two Capture Jet™ canopies, back to back to cover the cooking line.



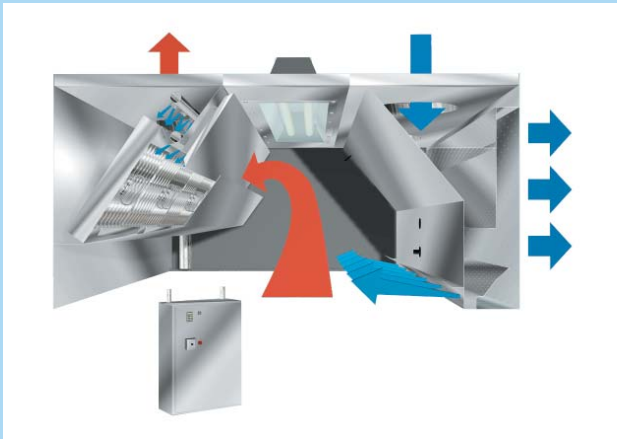
Picture 14. Island model

Capture Jet™ V bank Island

For use with a single row of appliances in an island configuration. This system incorporates the use of the jets on both sides of the V bank, directing rising heat and effluent toward the extractors.

Capture Jet™ Water Wash

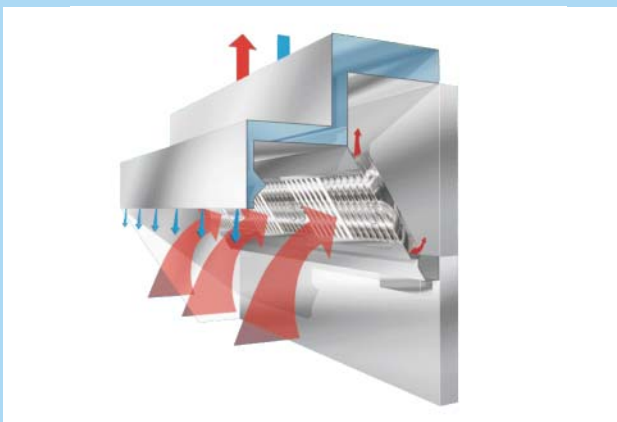
Water wash systems are often thought of in terms of grease extraction efficiency. In fact this type of system has little or no impact on the grease extraction efficiency of the hood but is a device to facilitate cleaning of the filters. The basic premise of the water wash hood is the ability to "wash down" the exhaust plenum within the hood as well as the mechanical grease extraction device. A secondary benefit is said to be an aid to fire suppression. Water wash hoods come in a variety of configurations as far as hood geometry goes. These follow fairly closely the "dry" hood styles.



Picture 15. Water wash hood

Capture Jet™ Back Shelf Hood

The Capture Jet back shelf hood incorporates the use of jets in a unique way. Due to the proximity to the cooking surface, the jet is used as an air curtain, extending the physical front of the hood towards the cooking surface without impeding the thermal plume. The result from independent testing shows a 27% decrease in exhaust over conventional back shelf design during full load cooking and a 51% reduction during idle cooking.



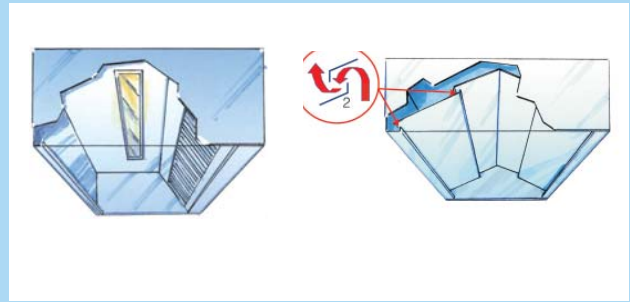
Picture 16. Back shelf hood

Basic Hood Type

There are some applications where there is no grease load from the cooking process and only small amounts of heat or water vapor are being generated. Three options are presented here depending on the application.

Exhaust Only Hoods

These type systems are the most rudimentary design of the Type I hood, relying on suction pressure and interior geometry to aid in the removal of heat and effluent.



Picture 17. Exhaust only hood

Picture 18. Condensate hood

Design of the exhaust air flow is based upon the face velocity method of calculation. We generally use 0.2 m/s for a light and 0.4 m/s for a medium cooking load.

Condensate Hoods

Construction follows National Sanitation Foundation (NSF) guidelines.

A subcategory of Type II hoods would include condensation removal (typically with an internal baffle to increase the surface area for condensation.)

Heat Removal, Non-Grease Hoods

These Type II hoods are typically used over non-grease producing ovens. The box style is the most common. They may be equipped with lights and have an aluminium mesh filter in the exhaust collar to prevent large particles from getting into the ductwork.

Other Type of Hoods (Short Cycle)

These systems, no longer advocated by the industry, were developed when the exhaust rate requirements followed the model codes exclusively. With the advent of U.L. 710 testing and a more complete understanding of thermal dynamics within the kitchen, the use of short cycle hoods has been in decline. The concept allowed for the introduction of large volumes of untreated make up air directly into the exhaust canopy. The ratio of make up air to exhaust air was as high as 80% and in some extreme cases, 90%. It was assumed that the balance drawn from the space (known as "net exhaust") would be sufficient to remove the heat and effluent generated by the appliances. This was rarely the case since the design did not take into account the heat gain from the appliances. This further led to a domino effect of balancing and rebalancing the hood that ultimately stole air-conditioned air from the dining room. In fact, testing by hood manufacturers has shown that the net-exhaust quantities must be nearly equal to the exhaust through an exhaust-only hood to achieve a similar capture and containment performance for short-circuit hoods.

Hoods Comparison Studies

In this section a variety of techniques and research findings are presented that demonstrate the performance and value that Halton's products offer the end-user. There is a discussion on the ineffectiveness of some hood designs offered by Halton's competitors followed by a discussion of how capture efficiency impacts the energy use, and energy bills, of the end-user.

KVI Case Study

Halton is using state-of-the-art techniques to validate hood performance. These include modeling of systems, using CFD, Schlieren imaging systems, and smoke visualization. All the test results presented here have been validated by third-party research.

Halton's standard canopy hood (model KVI) utilizes

Capture Jet™ technology to enhance hood performance, and consequently hood efficiency, versus the competition.

In this case study, the KVI hood has been modelled using CFD software. Two cases were modelled for this analysis: one with the jets turned off – in effect this simulates a generic exhaust only canopy hood and a second model with the jets turned on. As can be seen from observing figures 13 and 4, at the same exhaust flow rate, the hood is spilling when the jets are turned off and capturing when they are turned on.

The same studies were conducted in the third party laboratory. The Schlieren Thermal Imaging system was used to visualise the plume and effect of Capture Jet™. As one can see the CFD results are in good agreement with the Schlieren visualisation, see pictures 19 and 11.

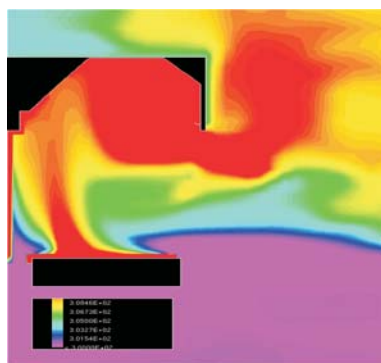


Figure 13. KVI with Capture Jet™ off

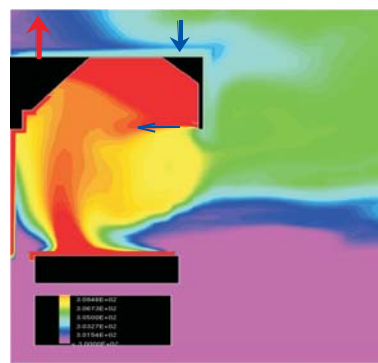
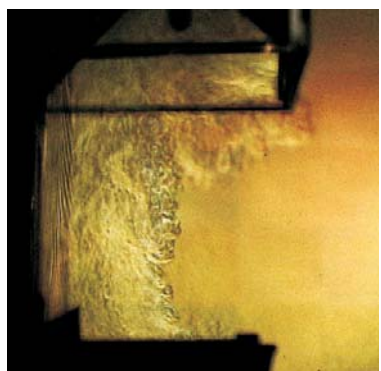
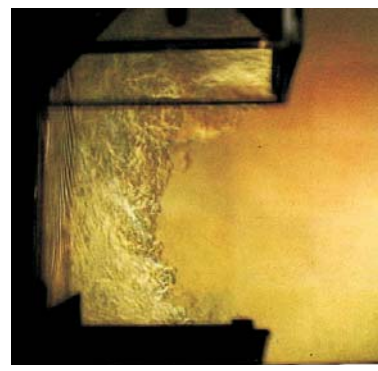


Figure 4. KVI with Capture Jet™ on



Picture 19. Schlieren Image of KVI Hood.
Capture Jet™ Off



Picture 11. Schlieren Image of KVI Hood.
Capture Jet™ On

KVL Case Study

Independent research has been performed to evaluate the capture efficiency of Halton's back shelf style (model KVL) hood.

The first set of results for the KVL hood demonstrate the capture efficiency using a Schlieren thermal imaging system. Note that the hood has been manufactured with Plexiglas sides to allow the heat inside the hood to be viewed. Pictures 20 and 21 show the results of the KVL hood with the jets turned off and on at the same exhaust air flow, respectively. Once again, it becomes readily apparent that the Capture Jet™ technology significantly improves capture efficiency. The KVL hood is spilling with the jets turned off and capturing when the jets are turned on.

Another study conducted in-house was to model these two cases using CFD in order to see if the CFD

models could predict what was observed in a real world test. Figures 14 and 15 present the results of the CFD models for jets off and jets on, respectively. Note that the jets in the KVL hood are directed downwards, where they were directed inwards on the KVI hood discussed earlier. If you were to place downwards directed jets on the KVI hood, it would actually cause the hood to spill instead of capture. This is testimony to the importance of performing in-house research and is just one value added service provided by Halton.

When you compare the CFD results to those taken with the Schlieren system for the KVL hood, you'll note that they produce extremely similar results. This demonstrates that not only can CFD models be used to model kitchen hoods but they can also augment laboratory testing efforts.



Picture 20. Schlieren Image of KVL hood.
Capture Jet™ Off



Picture 21. Schlieren Image of KVL Hood.
Capture Jet™ On

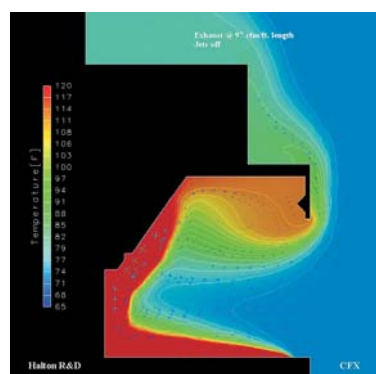


Figure 14. CFD Results of KVL Hood
With Capture Jet™ Off

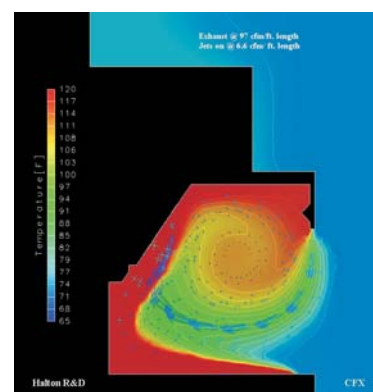


Figure 15. CFD Results of KVL Hood
With Capture Jet™ On

Ventilated Ceiling

General

The ventilated ceiling is an alternative kitchen exhaust system. The ceiling should be used for aesthetic reasons when open space is required, multiple kitchen equipment of different types is installed and the kitchen floor space is large.

The ventilated ceilings are used in Europe especially in institutional kitchens like schools and hospitals.

Ceilings are categorised as “Open” and “Closed” ceiling system.

Open Ceiling

Principle

Open ceiling is the design with suspended ceiling that consists of a supply and exhaust area.

Supply and exhaust air ductworks are connected to the voids above the suspended ceiling. Open ceiling is

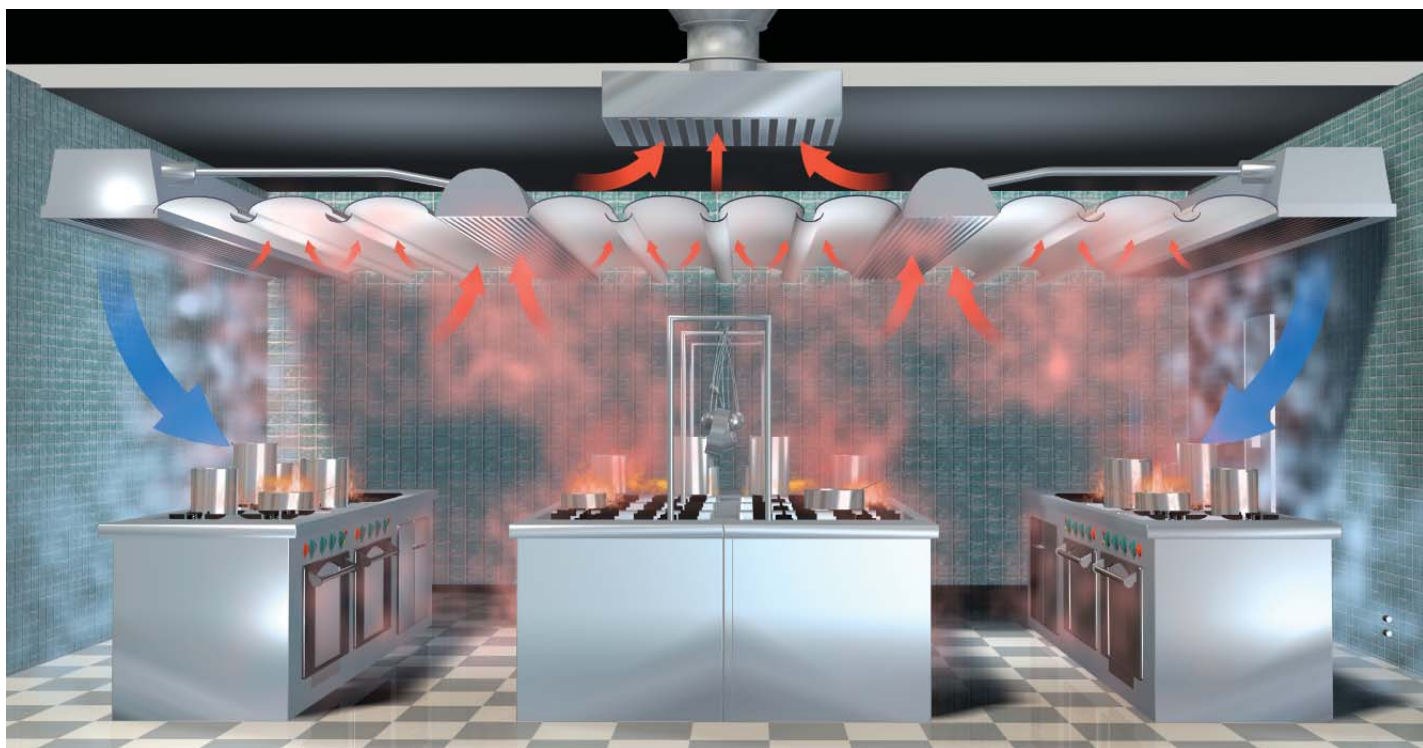
usually assembled from exhaust and supply cassettes. The space between the ceiling and the void is used as a plenum. The contaminated air goes via the slot where grease and particles are separated.

Specific Advantages

- Good aesthetics.
- Possibility to change kitchen layout.

Disadvantages

- Not recommended for heavy load (gas griddle, broiler..).
- Efficient when only steam is produced.
- Not recommended from a hygienic point of view (free space above the ceiling used as plenum – risk of contamination).
- Expensive in maintenance.
- Condensation risk.



Picture 22. Open ceiling

Ventilated Ceilings



Picture 23. Closed Ceiling

Closed Ceiling

Halton ventilated ceiling is based on Capture Jet™ installed flush to the ceiling surface, which helps to guide the heat and impurities towards the extract sections. Supply air is delivered into the kitchen through a low velocity unit.

Air distribution significantly affects thermal comfort and the indoor air quality in the kitchen.

There are also combinations of hoods and ventilated ceilings. Heavy frying operations with intensive grease emission are considered to be a problem for ventilated ceilings, so hoods are recommended instead.

Principle

Supply and exhaust units are connected straight to the ductwork. This system consists of having rows of filter and supply units; the rest is covered with infill panel.

There are various closed ceilings.

Halton utilise the most efficient ceiling, which includes an exhaust equipped with a high efficiency KSA filter, supply air unit and a Capture Jet™ system installed flush to the ceiling panels.

Specific advantages

- Draught free air distribution into the working zone. from low velocity ceiling mounted panels.
- High efficiency grease filtration using Halton KSA 'Multi-cyclone' filters.
- Protection of the building structure from grease, humidity and impurities.
- Modular construction simplifies design, installation and maintenance.
- Integrated Capture Jets within supply air sections.

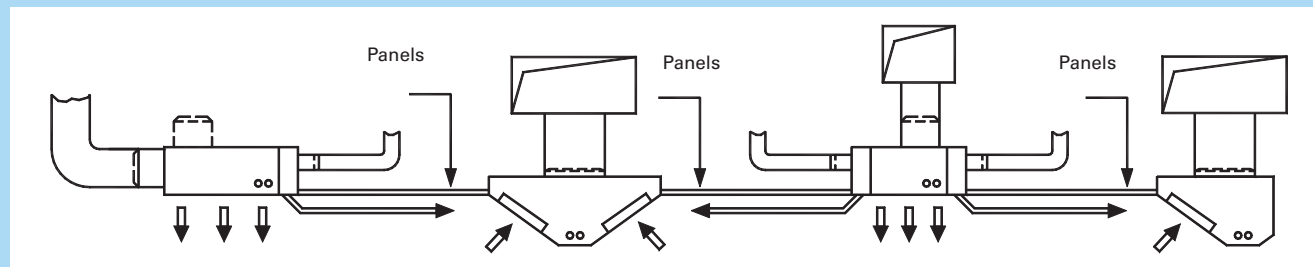


Figure 16. Closed ceiling

Ceiling Ventilation Testing

The performance of the KCE ventilated ceiling was studied by the Lappeenranta Regional Occupational Health institute. The goal was to establish a test protocol that was repeatable and usable over a wide range of air flows and ceiling designs.

Tracer Gas Studies

The measurement was carried out with a tracer gas (N_2O) released from the heated cooking surface. The concentration at different locations (P1, P2, P3, P4) was observed.

When a steady state of concentration was attained, the tracer gas was shut off.

Local air quality indices were calculated from the average breathing zone concentrations and the concentration in the exhaust duct.

The graphs aside show the concentration at different measurement points with different air flow rates (50, 100, 150%) and with different Capture Jet™ air flow rates.

The column on the left hand side shows the tracer gas concentration with Capture Jet™ and the right column without capture air.

The study shows that:

The same level of concentration was achieved with the capture jet ON as with 150% exhaust air flow rate and Capture Jet™ OFF, thus the increase of exhaust air volume increases only the energy consumption.

- The capture air prevents effectively the impurities from spreading into the space.
- The use of Capture Jet™ is crucial to the proper function of the ventilated ceiling.

Results

Without Capture Jet™ and with 150% air flow rate the pollution level is still higher than with Capture Jet™ with 100% air flow rate (see table 5). So it is not possible to get the same level even with 150% air flow rate.

The revelations are based on the concentrations of the occupied zone.

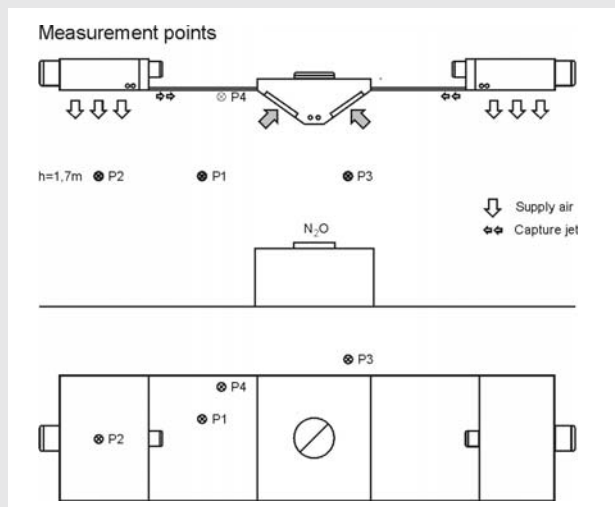


Figure 17. Tracer gas concentration with Capture Jet™. The right column without capture air.

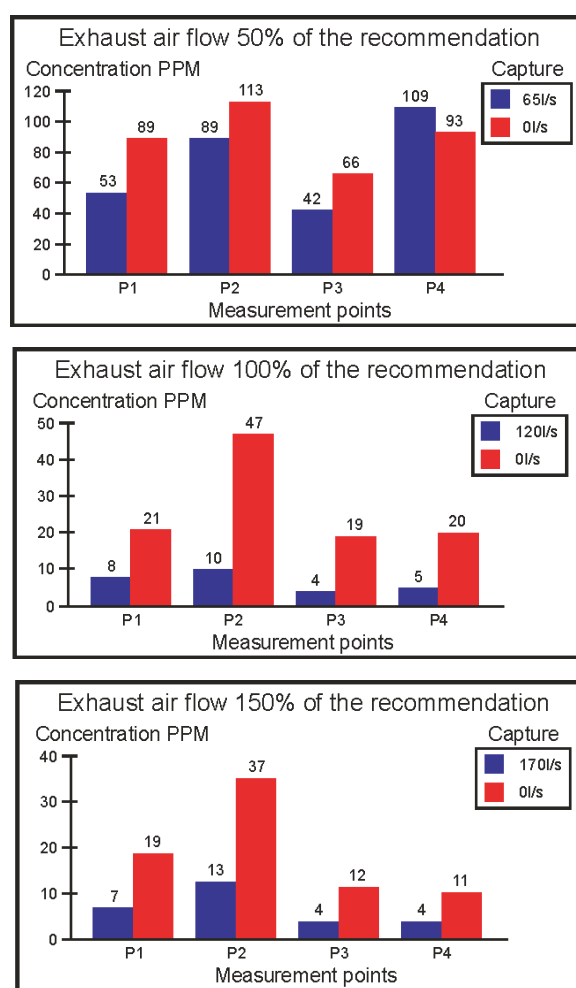


Figure 18. Concentration study conducted by the Lappeenranta regional occupational health institute.

Measured values - locations (ppm)	Air flow rate	
	100% Jets on (ppm)	150% Jets off (ppm)
P1	8	19
P2	10	37

Table 5. IAQ difference

Computer modelling

CFD works by creating a three-dimensional computer model of a space. Boundary conditions, in the case of kitchen ventilation modelling, may include ;

- Ceiling exhaust rates
- Input energy of appliance
- Supply air type and volume
- Temperature of supply air

Complex formulae are used to produce the final results.

Two cases were modelled for this analysis: one with the jets turned off and a second model with the jets turned on.

Comparison Studies

Temperature comparison:

In this case study, the KCE ceiling has been modelled using CFD software.

As can be seen from observing figures 19 and 20, at the same exhaust flow rate, the thermal comfort (lower operative temperature) in the working area is better when the jets are turned ON.

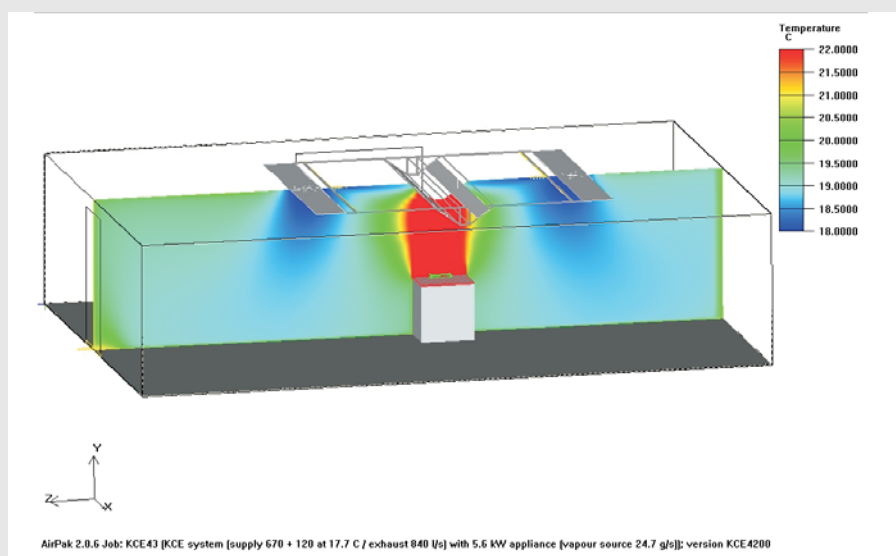


Figure 19. Capture Jet™ ON

The cold supply air will close the ceiling level and so guarantees comfortable thermal conditions in the occupied zone.

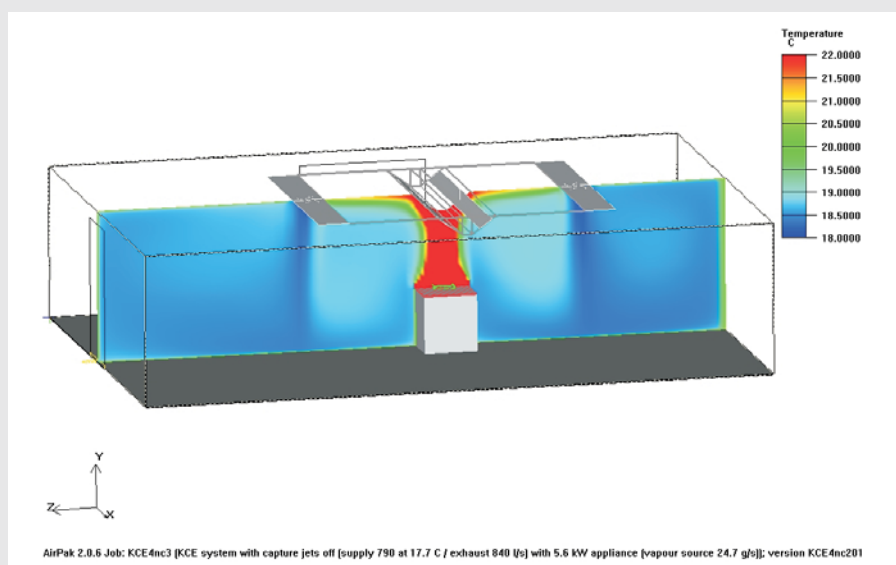


Figure 20. Capture Jet™ OFF

The part of the cold supply air is dropping down in the occupied zone and it increases the draft risk.

Concentration comparison

As can be seen from observing figures 21 and 22, there is a significant difference between the Capture Jet™ ceiling and the ceiling without the jet.

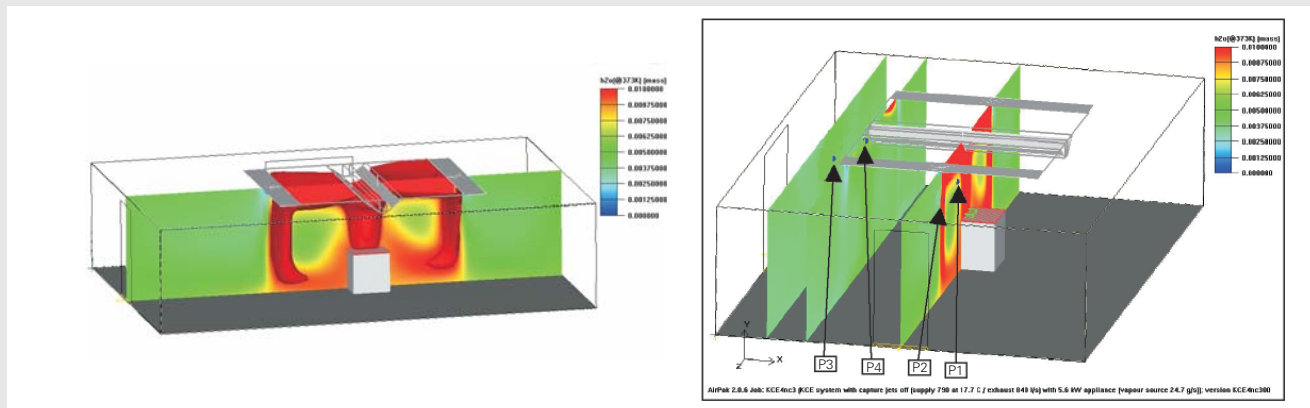


Figure 21. Capture Jet™ OFF - concentrations under the supply units increase

With Capture Jet™ off the contaminant is mixed freely with the supply air and the concentration in the working zone is increased (see table 6).

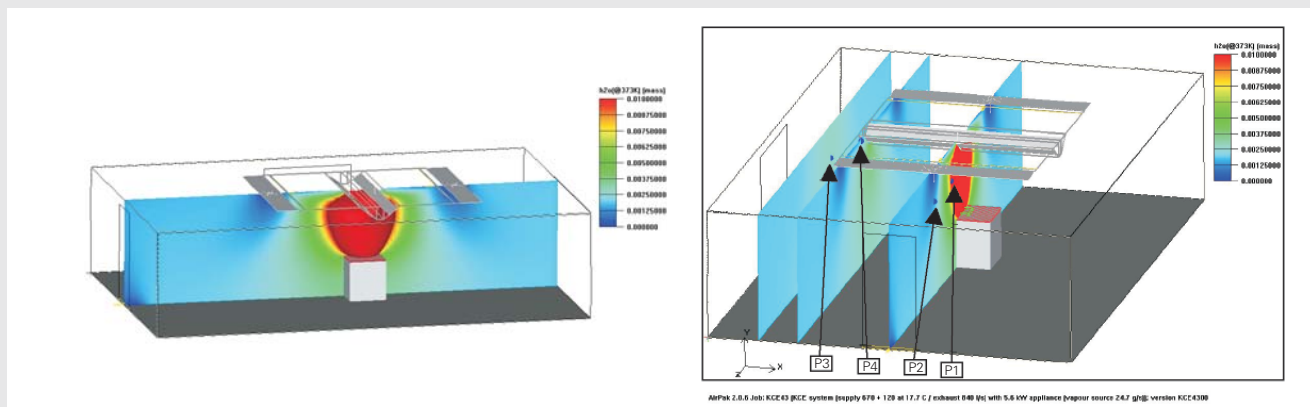


Figure 22. Capture Jet™ ON

The plume from the width of the kitchen appliance is bigger. The plume will stay near the ceiling level and the average pollution level is much lower than when the Capture Jet is OFF.

Measured values location	Jets on (ppm)	Jets off (ppm)
P1	8	21
P2	10	47
P3	4	19
P4	5	20

Table 6. Measured concentrations

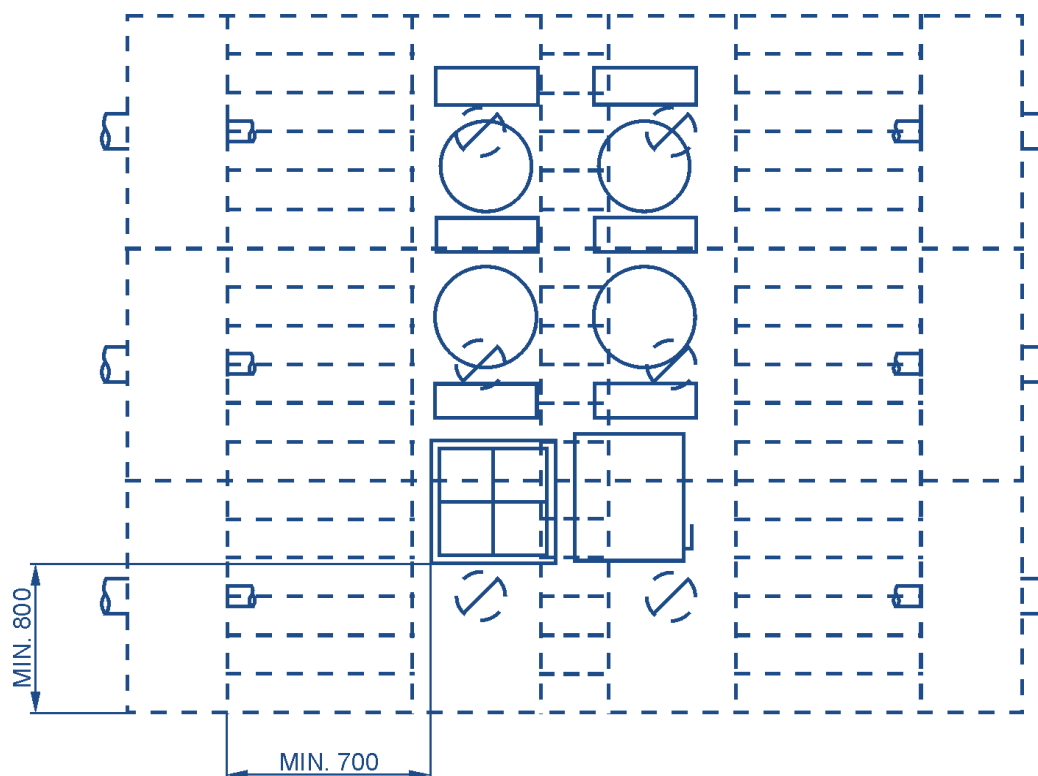
Concentrations measured at each of the points P1, P2, P3, P4 are about 4 times higher than with jet ON.

Energy saving effect

In the design process, the main idea is to reach the set target value of indoor air quality. The energy consumption is strongly depending on the target value. Thus energy consumption and the contaminant level should be analysed at the same time. Even if the exhaust rate is increased by 50% with no Capture Jet concept, it is not possible to reach as low contaminant as with the Capture Jet system. For the energy saving, this target value approach means that with the Capture Jet it is possible to reach more 50% saving in the energy consumption.

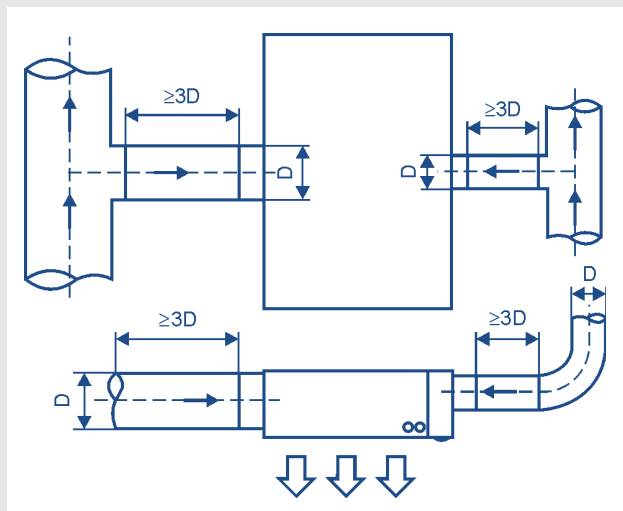
Recommended Minimum Distances

A minimum horizontal distance between the supply air unit and the edges of cooking appliances should not be less than 700 mm to ensure that there are no disturbances (mixing) between displacement air and the convection plume.



If the displacement unit is too close to the heat load from the appliances it can cause induction. The air from the supply air flow is then contaminated and reaches the floor.

Duct Installation Requirement



Design Guidelines

Design Principles

The design of the professional kitchen follows the methodology of the industrial design process. The kitchen layout design and time dependent internal loads are specified through the understanding of a specific restaurant and its food service process. Also, the target levels for the IAQ and ventilation system performance and the basic concept are to be defined at an early stage of the design.



Picture 24.

In the beginning of the kitchen design process, the designer defines the type and process type as an input. The space dimensioning includes room estimates for all functional areas, such as receiving, storage, preparation, cooking and dishwashing, that is required to produce the menu items. The space required for each functional area of the facility is dependent upon many factors. The factors involved include:

- number of meals to be prepared
- functions and tasks to be performed
- equipment requirements and
- suitable space for traffic and movement

First, the indoor air is selected by the designer together with the owner and the end-user. It means an evaluation of the indoor climate including target value adjustment for temperature, humidity and air movement. It should be noticed that if there is no air-conditioning in the kitchen, the indoor temperature is always higher than the outdoor temperature. The fact remains that when the indoor temperature and humidity are high (over 27° C and 65%), this also

affects a person's capacity to work and at the same time decreases productivity (see curve page 9). With air conditioning, it is possible to maintain ideal thermal conditions all year.

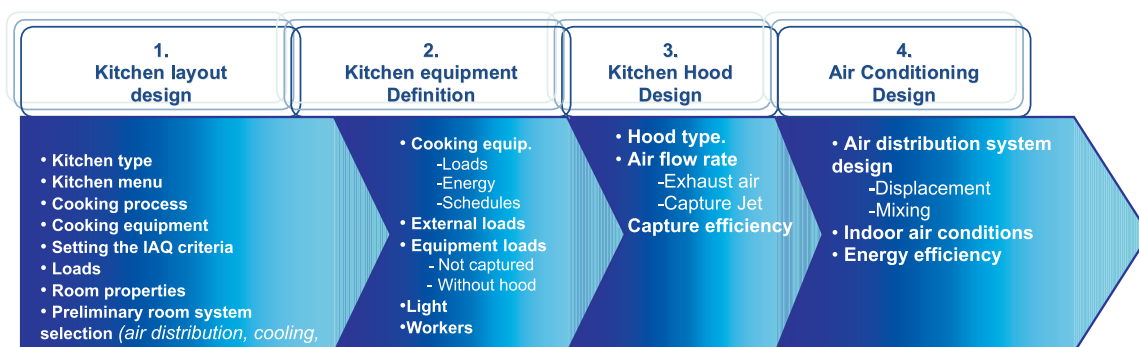
After that the ventilation strategy of the kitchen space is pre-selected which is one of the key input factors for kitchen hoods selection.

The integrated design principle is the key element when the exhaust airflow rates are optimised. According to the German guideline (VDI 1999), the application of a displacement ventilation system allows for a reduction in exhaust air flow by 15% compared to a conventional mixing ventilation system. Deciding on the strategy in the design phase has a great effect on investment costs and the energy costs of the whole system.

Based on the kitchen equipment information such as:

- heat gain (Sensible / Latent)
- maximum electrical power
- surface temperature

→ **Hoods are Chosen**



Hood Sizing

The size of the exhaust hood in relation to the cooking equipment is an important design consideration. Typically, the hood must extend beyond the cooking equipment: on all open sides for a canopy style hood and on the ends for a back shelf style system. In a typical situation, if a hood system is not capturing and containing the effluent from the cooking process, it will spill in the front corners of the hood.



Picture 25. Wrong traffic pattern

The movement of people can involve moving an object of sufficient size and speed to create secondary air currents which pirate effluent from the cooking process. While the effect of one individual is only momentary, it can be a problem if the traffic occurs continually.



Picture 26. Air draughts

Opening windows in the kitchen creates draughts and also affects the ideal shape of the thermal plume. It can be one of the most difficult problems to solve. It is difficult because it is often not suspected as the problem.

What Is the Solution

Experience has shown that such air draughts can have a much greater effective throw distance to produce a greater detrimental effect on the capture envelope than one would normally expect.



Picture 27. Right traffic pattern



Picture 28. Re-hing doors and add end panels

Front or Back Overhang - Wrong

When the cooking equipment and canopy are mounted against the wall, a rear overhang is not required. However, if the canopy is set out in a single island installation it is necessary to ensure that the proper distance of back overhang is provided in addition to the front overhang.



Picture 29. I feel hot!

When two hoods are used in back to back (double island) installation, the pair of hoods negates the need for a rear overhang. However, the need for a front overhang remains.



Picture 30. What's wrong?

Kitchen ventilation canopies require some distance of overhang on each end of canopy.



Picture 31. Help! End overhang - wrong

Overhang - Right

All canopy type kitchen ventilation requires front and end overhangs. In most instances, extending the overhang of a hood system from the typical 300 mm



Picture 32. A wall model installed as an island model. In this case, overhang on the back is needed.



Picture 14. Island model



Picture 33. The hood should extend a minimum of 300 mm beyond the cooking equipment.

will help insure capture and containment in most kitchen settings.

Recommended height from the floor to the lower edge of the canopy is 2000 mm.

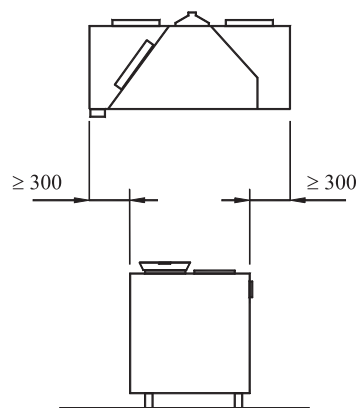


Figure 23. Wall model KV-1

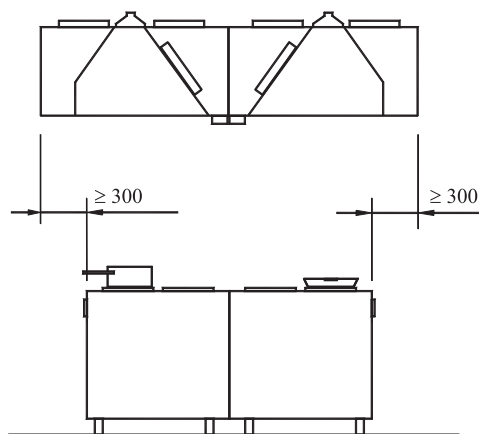


Figure 24. Island model KV-2

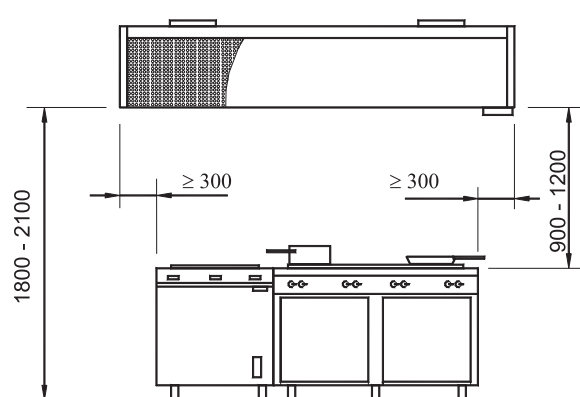


Figure 25. End overhang

Dishwashing Area Recommended Overhang

Conveyor type

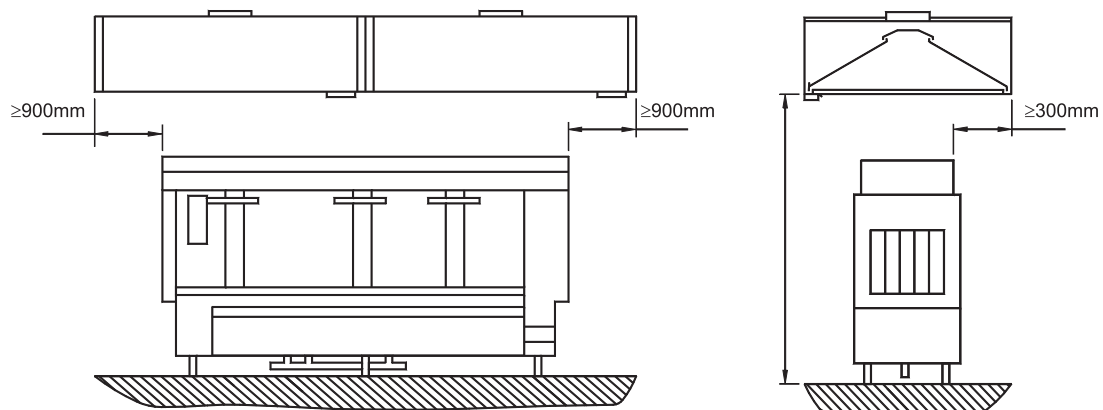


Figure 26. Conveyor type

Hood type

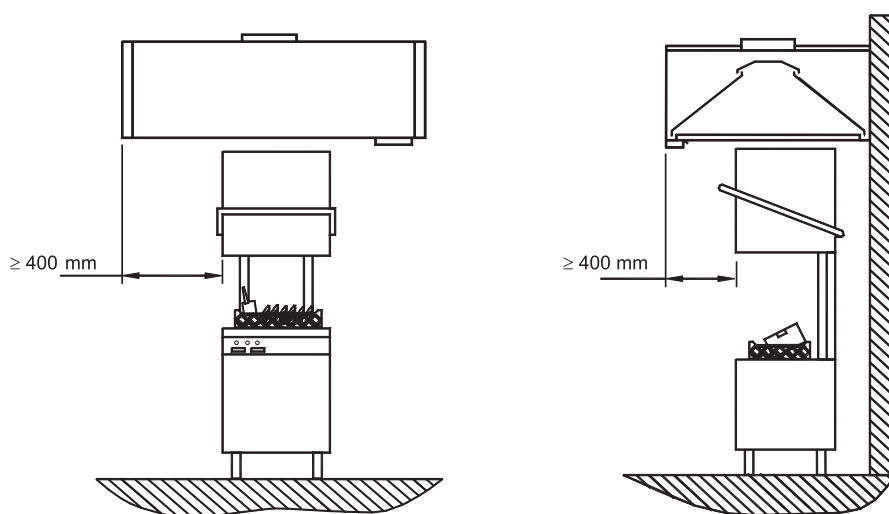


Figure 27. Hood type

Heat Load Based Design

It is still common practice to estimate exhaust airflow rate based on rough methods. The characteristic feature of these methods is that the actual heat gain of the kitchen appliance is neglected. Thus the exhaust air flow rate is the same whether the appliances under the hood are a heavy load like a wok or a light load like a pressure cooker.

These rough methods are listed for information, but should only be used for preliminary purposes and not for the final air flow calculation. They will not provide an accurate result.

- floor area
- air change rate
- cooking surface area
- face velocity method (0.3-0.5 m/s)
- portions served simultaneously

Neither of these rules takes into account the type of cooking equipment under the hood and typically results in excessive exhaust air flow and hence oversized air handling units coupled with high energy consumption rates.

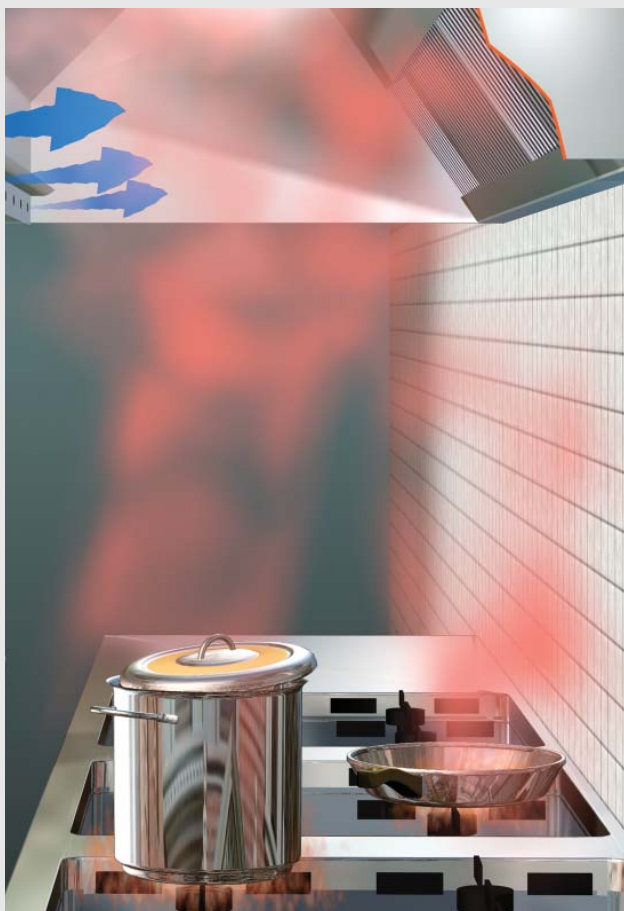
Many manufacturers of commercial kitchen ventilation equipment offer design methods for determining exhaust based on cooking appliances. Any method used is better than no quantification at all. The method of determining exhaust levels based on the heat generated by the cooking process is referred to as heat load based design and is the premise for this manual. It is the foundation of accurate and correct design fundamentals in a commercial kitchen environment.

The lower the exhaust air flow and the higher the exhaust duct temperature at full capture and containment the more efficient the hood systems is. Many designers do not consider hood efficiency. The “box is a box” syndrome is prevalent with many people. However, each and every hood system, due to internal construction and added performance variables, offers a differing efficiency when related to exhaust flows required to obtain capture and containment. This section discusses the dimensioning of hoods and gives an in-depth look at heat load based hood design.



Picture 8. Cooking process

The most accurate method to calculate the hood exhaust air flow is a heat load based design. This method is based on detailed information of the cooking appliances installed under the hood including type of appliance, its dimensions, height of the cooking surface, source of energy and nameplate input power. All this data allows the way the particular appliance emits energy into the kitchen to be calculated. Part of this energy is emitted into the space in the form of the convective plume – hot air rising from the cooking surface. The other part is rejected into the space by radiation warming up the kitchen surfaces and eventually the air in the kitchen.



Picture 34.

The amount of air carried in a convective plume over a cooking appliance at a certain height can be calculated using Equation

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r \quad (1)$$

Where

q_p – airflow in convective plume, m³/h

z – height above cooking surface, mm

Q_{conv} – cooking appliance convective heat output, kw

k – empirical coefficient, $k = 18$ for a generic hood

K_r – reduction factor, taking into account installation of cooking appliance (free, near wall or in the corner)

D_h – hydraulic diameter, mm

$$D_h = \frac{2L \cdot W}{L + W}$$

L, W – length and width of cooking surface accordingly, mm

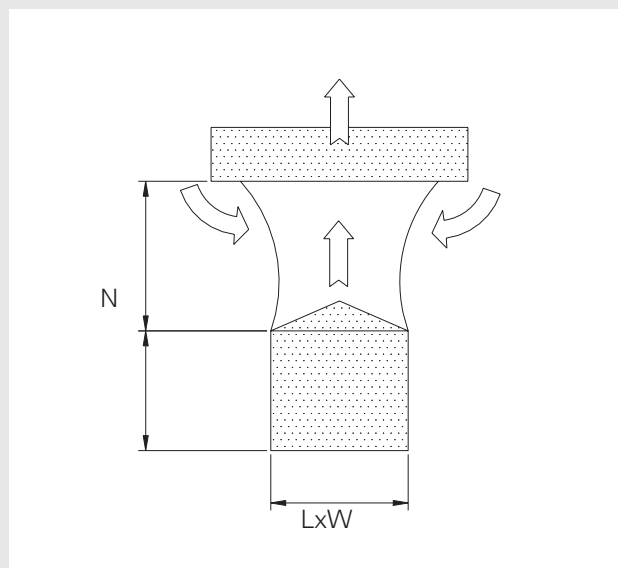


Figure 28. Hydraulic diameter

Kitchen hoods are designed to capture the convective portion of heat emitted by cooking appliances, thus the hood exhaust airflow should be equal or higher than the airflow in the convective plume generated by the appliance. The total of this exhaust depends on the hood efficiency.

$$q_{ex} = q_p \cdot K_{hoodeff} \cdot K_{ads} \quad (2)$$

Where

$K_{hoodeff}$ – kitchen hood efficiency.

K_{ads} – spillage coefficient taking into account the effect of the air distribution system on convective plume spillage from under the hood. The recommended values for K_{ads} are listed in the table 7.

The kitchen hood efficiency shown in equation 2 can be determined by comparing the minimum required capture and containment flow rates for two hoods that have been tested using the same cooking process.

Table 7 presents recommended values for the spillage coefficient as a function of the air distribution system.

For the short-cycle hoods equation 2 will change into

$$q_{ex} = q_p \cdot K_{hoodeff} \cdot K_{ads} + q_{int} \quad (2.1)$$

Where

q_{int} – internal discharge air flow, m³/h

The Heat Load based design gives an accurate method of calculating hood exhaust air flow as a function of cooking appliance shape, installation and input power, and it also takes into account the hood efficiency. The only disadvantage of this method is that it is cumbersome and time-consuming if manual calculations are used.

Hood Engineering Layout Program (HELP™) is specially designed for commercial kitchen ventilation and turns the cumbersome calculation of the heat load based design into a quick and easy process. It contains the updateable database of cooking appliances as well as Halton Capture Jet™ hoods with enough information to be able to use Equations 1 and 2 accurately to calculate hood exhaust air flow.



Type of air distribution system	K_{ads}	
Mixing ventilation		
Supply from wall mounted grills	1.25	
Supply from the ceiling multicone diffusers	1.2	
Displacement ventilation		
Supply from ceiling low velocity diffusers	1.1	
Supply from low velocity diffusers located in the work area	1.05	

Table 7. Spillage coefficients as a function of the air distribution system

Total Kitchen Ventilation System Design

A properly designed and sized kitchen hood will ensure that effluents and convective heat (warm air) from cooking process are captured; however, it is not enough to guarantee the kitchen space temperature is comfortable. The radiation load from appliances underneath the hood, heat from appliances not under the hood, people, lights, kitchen shell (heat transfer through walls and ceiling), solar load, and potential heat and moisture from untreated makeup air are to be handled by the kitchen air conditioning system. It is recommended that a negative air balance be maintained in the kitchen. A simple rule of thumb is that the amount of air exhausted from the kitchen should be at least 10% higher than the supply air flow



Picture 7.

into the kitchen. This will guarantee that the odours from the kitchen do not spread to the adjacent spaces. Equation 3 describes the air flow balance in a kitchen

$$M_s + M_{tr} = M_{Hood} \quad (3)$$

Where

M_s – mass flow rate of air supplied in the kitchen (outside supply air delivered through the air handling unit and makeup air), l/s

$M_s = M_{osa} + M_{mu}$

M_{tr} – mass flow rate of transfer air entering the kitchen from the adjacent spaces, l/s

M_{hood} – mass flow rate of exhaust air through the hoods, kg/s

The supply air temperature t_s to maintain design air temperature in the kitchen is estimated from the energy balance equation shown below:

$$M_s \cdot c_p \cdot \rho_s (t_r - t_s) + M_{tr} \cdot c_p \cdot \rho_{tr} (t_r - t_{tr}) + Q_{sens} = 0 \quad (4)$$

Where

c_p – specific heat of air = 1 kJ/(kg.°C)

ρ_s, ρ_{tr} – air density of supply and transfer air accordingly, kg/m³

t_r – kitchen design air temperature, °C

t_s – supply air temperature, °C

t_{tr} – transfer air temperature, °C

Q_{sens} – total cooling load in the kitchen, kW from appliance radiation, unhooded appliances, people, lights, solar load, etc.

In cases where the supply air temperature t_s calculated from equation 4 is below 14°C (13°C off-coil temperature with 1°C duct heat gain), the supply airflow rate M_s must be increased. The new value for M_s is calculated from the same equation 4 by setting $t_s = 14^\circ\text{C}$. In this case, we recommend incorporating a return air duct to increase supply air flow.

Since it is rare that all the equipment is simultaneously operating in the kitchen, the heat gain from cooking appliances is multiplied by the reduction factor called the simultaneous coefficient, defined in Equation 5. Recommended values are presented in table 8.

$$K_{sim} = \frac{\text{Number of appliances in use}}{\text{Total number of appliances in kitchen}} \quad (5)$$

Kitchen type	Simultaneous coefficient K_{sim}
Hotel	0.6 – 0.8
Hospital	0.7 – 0.5
Cafeteria	0.7 – 0.5
School	0.6 – 0.8
Restaurant	0.6 – 0.8
Industrial	0.6 – 0.8

Table 8. Recommended values for simultaneous coefficient.

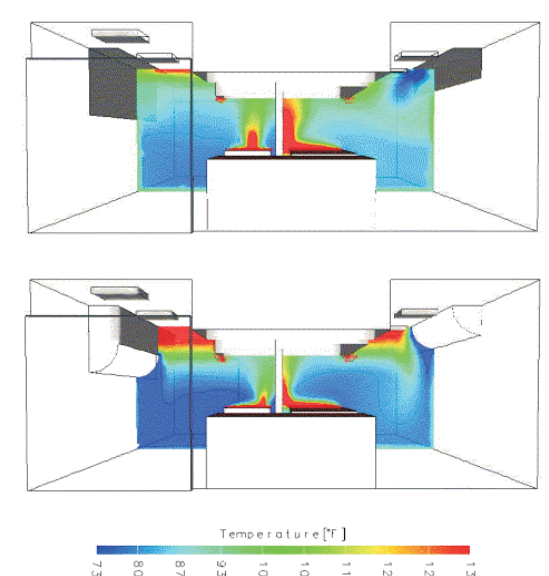
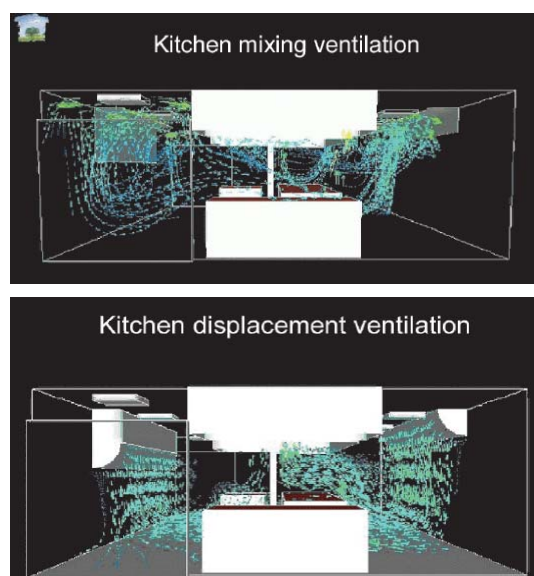
Effect of Air Distribution System

Equation 4 assumes that a mixing air distribution system is being utilised and that the exhaust/return air temperature is equal to the kitchen air temperature (assuming fully mixed conditions). Conversely, a displacement ventilation system can supply low velocity air directly into the lower part of the kitchen and allow the air naturally to stratify. This will result in a higher temperature in the upper part of the kitchen while maintaining a lower air temperature in the occupied zone. This allows for improvement of the kitchen indoor air quality without increasing the capital costs of the air conditioning system.

Picture 35 demonstrates a CFD simulation of two kitchens with mixing and displacement ventilation systems. In both simulations the kitchens have the

same appliances contributing the same heat load to the space. The supply air flow and temperatures, and the exhaust air flow through the hoods are the same in both cases. The air is supplied through the typical ceiling diffusers in the mixing system. In the case of the displacement system, air is supplied through specially designed kitchen diffusers located on the walls. As one can see, the displacement system provides temperatures in the kitchen occupied zone from 22 to 26°C while the mixing system, consuming the same amount of energy as displacement, results in 27...32°C temperatures. This 2°C temperature increase in the kitchen with the mixing air distribution system will result in approximately 10% reduction in productivity (see picture 6. page 9).

Halton HELP™ program allows kitchen ventilation systems for both mixing and displacement ventilation systems to be designed.



Picture 35. CFD simulation of a kitchen with mixing (top) and displacement (bottom) air distribution system. Air temperatures are shown.

Mixing Ventilation

Mixed air supply diffusers supply high velocity air at the ceiling level. This incoming air is “mixed” with room air to satisfy the room temperature set point. Theoretically there should be a uniform temperature from floor to ceiling. However, since commercial kitchens have a high concentration of heat, stratification naturally occurs. Consequently, the conditioned air does lose some of its cooling effectiveness, gaining in temperature as it mixes with the warmer air at the ceiling.



Picture 36. Mixing ventilation

Research has shown that if mixing diffusers are located close to the hood, the high velocity air interrupts the cooking plume, drawing some of it out of the hood (in effect causing the hood to ‘spill’) and further increasing the heat load on the space.

Displacement Ventilation

Thermal displacement ventilation is based on the natural convection of air, namely, as air warms, it will rise. This has exciting implications for delivering fresh, clean, conditioned air to occupants in commercial kitchens.

Instead of working against the natural stratification in a kitchen, displacement ventilation first conditions the occupied zone and, as it gains heat, continues to rise towards the upper unoccupied zone where it can be exhausted.



Picture 7. Displacement ventilation

According to VDI 2052, application of a Displacement Ventilation system allows for a reduction in hood exhaust airflow by 15% compared to a conventional mixing system.

Design Practice

Introduction

It is still quite common practice to estimate exhaust air flow rates based on rough methods. The characteristic feature of these methods is that the actual heat gain of the kitchen appliance is neglected. Thus, the exhaust air flow rate is the same: even when a heavy load like a wok or a light load like a pressure cooker is under the hood. These kinds of rough estimation methods do not produce optimal solutions; the size of the whole system will be oversized and so the investment costs and running costs will increase.



Picture 24.

The layout of the kitchen ventilation design was complex due to the provision of a logical structure combined with good air flow distribution and performance.

Technically it was a question of designing and providing an air conditioning installation offering conditions and a minimal variable temperature in the surrounding area ie: 23°C, 0/3°C whilst also keeping a negative pressure between the kitchen and all adjacent areas.

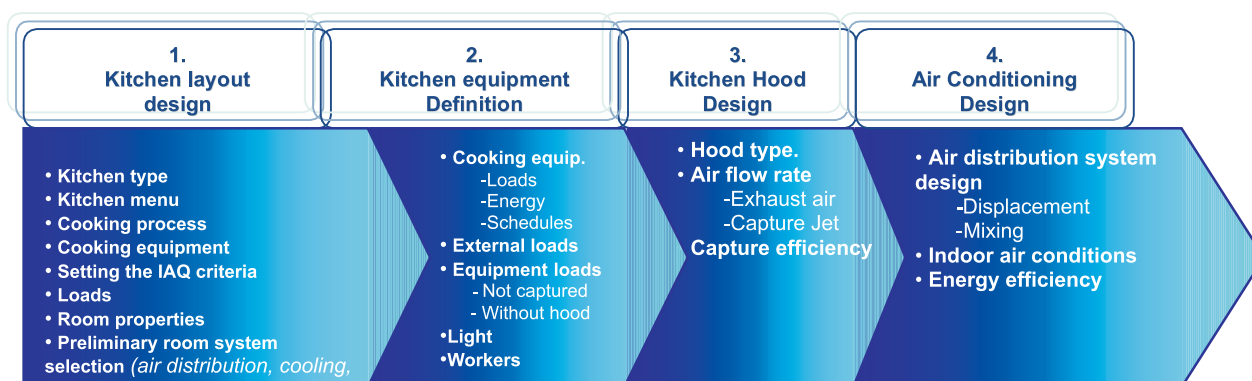
The most sensitive space to be handled turned out to be the working zone, where the airflow to extract heat and steam produced by ovens or cooking pots were important.

The steam emitted in the opening of cooking pots or the brat pan should also be captured immediately. In this case of providing sufficient efficiency in capturing pollutants, the necessity of having the lowest energy consumption for the end user had to be considered.

In tackling these constraints, it has been decided to select a model of hood using high technology offering, for the same connecting power installed in the kitchen, maximum efficiency and important energy savings.

Kitchen Design Process

The design of the professional kitchen environment follows the methodology of the industrial design process.



Phase1: Background information of the kitchen available:

- Layout, type and the dimensions of the kitchen.
- Type and properties of the cooking equipment (sizes, source of energy, input power...).
- Target level for the IAQ and ventilation system performance.
- Temperature design conditions 23°C - Relative humidity 65%
- Total design approach to consider both IAQ and energy efficiency factors (air distribution system chosen).

The kitchen is a central kitchen and its layout and dimensions are presented in figure 29.

- Dimensions of cooking area 11x8.3 - 91m², 3m high
- five people working in the kitchen

The kitchen is open seven days a week and fourteen hours a day. Simultaneous coefficient: 0.7.

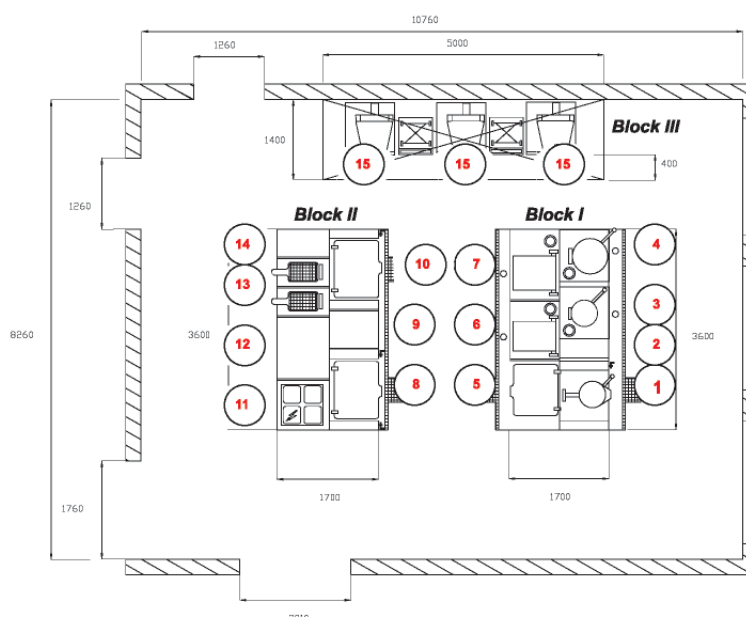


Figure 29. Kitchen lay-out

Phase 2: Kitchen equipment definition

Item	Qty	Description	Dimensions	Elec. kW	Gas kW
1	1	Kettle steamer	1200x800x900		18
2	1	Table	500x800x900		
3	1	Kettle steamer	1000x800x900		15
4	1	Kettle steamer	900x800x900	14	
5	1	Braising Pan	1400x900x900		18
6	1	Braising Pan	1000x900x900	15	
7	1	Braising Pan	1200x900x900		18
8	1	Braising Pan	1300x900x900	15	
9	1	Table	1000x800x900		
10	1	Braising Pan	1300x900x900	18	
11	1	Range (4 elements)	800x900x900	16	
12	1	Table	1000x800x900		
13	2	Fryer	400x800x900	15	
14	1	Table	800x800x900		
15	3	Convection (double stack)	100x900x1700	17	

Table 9. Cooking equipment data-base

Calculation with traditional methods for traditional hood (KVV type)

One of the rules for canopy hoods is to exhaust between 0.2 of hood face for light duty (boiler, bain marie..) and 0.5 for heavy load (broiler, bratt pan..).

Equation 1 is to calculate the exhaust airflow rate to determine the volume of air to be extracted:

$$Q = V \cdot 3600 \cdot P \cdot H \quad (1)$$

Where :

V = capture velocity, m/s

P = Perimeter of hood, m

H= distance of hood to emitting surface, m

This method does not really take into account the characteristics of the appliances. For example, the actual heat load (more exactly the convection share of the sensible load) is neglected.

Block I: 4200 x 2250 x 555

Island type hood:

$$Q = 0.3 \cdot 3600 \cdot (4.2 + 2.25 + 4.2 + 2.25) \cdot 1.1 = 15\,325 \text{ m}^3/\text{h}$$

Block II: 4200 x 2350 x 555

Island type hood:

$$Q = 0.3 \cdot 3600 \cdot (4.2 + 2.35 + 4.2 + 2.35) \cdot 1.1 = 15\,563 \text{ m}^3/\text{h}$$

Block III: 4400 x 1350 x 555

Wall type hood:

$$Q = 0.25 \cdot 3600 \cdot (4.4 + 1.35 + 1.35) \cdot 1.1 = 7029 \text{ m}^3/\text{h}$$

Total exhaust : 37 917 m³/h

Heat load based design methods

The most accurate method to calculate the hood exhaust air flow is a heat load based design. This method is based on detailed information of the cooking appliances installed under the hood including type of appliance, its dimensions, height of the cooking surface, source of energy and nameplate input power.

It should be mentioned that with the hood it is possible to extract only the convection load of the appliances while the remaining radiant load is always discharged in the kitchen.

The amount of air carried in a convective plume over a cooking appliance at a certain height can be calculated using Equation 1 page 31

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r \quad (1)$$

Kitchen hoods are designed to capture the convective portion of heat emitted by cooking appliances; thus the hood exhaust airflow should be equal to or higher than the airflow in the convective plume generated by the appliance. The total of this exhaust depends on the hood efficiency.

$$q_{ex} = q_p \cdot K_{hood\,eff} \cdot K_{ads} \quad (2)$$

Where

$K_{hood\,eff}$ – kitchen hood efficiency.

K_{ads} – spillage coefficient taking into account the effect of the air distribution system.

The recommended values for K_{ads} (VDI 1999) are listed in the table 7 page 38. Based on this table the requested exhaust airflow with wall-mounted supply ($K_{ads} = 1.25$) is 19 % higher than with low velocity.

Since it is rare that all the equipment is simultaneously operating in the kitchen, the heat gain from cooking appliances is multiplied by the reduction factor called the simultaneous coefficient (ϕ). Normally, the simultaneous factor is from 0.5 – 0.8. This means that only 50 – 80 % of the appliances are used at the same time.

Block I:

A kitchen extraction hood measuring 4200 mm x 2250 mm x 555mm is mounted 2 m above the floor. The installation height of the hood is then 1.1m above the appliances.

Item1: Kettle steamer

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

D_h – hydraulic diameter, m

$$D_h = \frac{2[1.2 \cdot 0.8]}{[1.2 + 0.8]} = 0.96 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 18 \cdot 200 \cdot 0.7 \cdot 0.7 = 1764 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[0.96])^{\frac{5}{3}} \cdot [1764]^{\frac{1}{3}} = 1160 \text{ m}^3/\text{h}$$

Item2: table: No thermic flow

Item3: Kettle steamer

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

D_h – hydraulic diameter, m

$$D_h = \frac{2[1.0 \cdot 0.8]}{[1.0 + 0.8]} = 0.888 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 15 \cdot 200 \cdot 0.7 \cdot 0.7 = 1470 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[0.96])^{\frac{5}{3}} \cdot [1470]^{\frac{1}{3}} \cdot 1 = 1013 \text{ m}^3/\text{h}$$

Item4: Kettle steamer

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

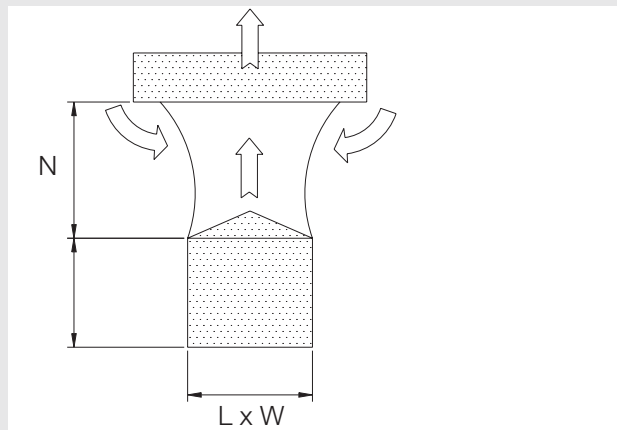
D_h – hydraulic diameter, m

$$D_h = \frac{2[0.9 \cdot 0.8]}{[0.9 + 0.8]} = 0.847 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 14 \cdot 80 \cdot 0.5 \cdot 0.7 = 392 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[0.847])^{\frac{5}{3}} \cdot [392]^{\frac{1}{3}} \cdot 1 = 623 \text{ m}^3/\text{h}$$



Item5: Braising Pan

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

D_h – hydraulic diameter, m

$$D_h = \frac{2[1.4 \cdot 0.9]}{[1.4 + 0.9]} = 1.095 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 18 \cdot 450 \cdot 0.5 \cdot 0.7 = 2835 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[1.095])^{\frac{5}{3}} \cdot [2835]^{\frac{1}{3}} \cdot 1 = 1557 \text{ m}^3/\text{h}$$

Item6: Braising Pan

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

D_h – hydraulic diameter, m

$$D_h = \frac{2[1 \cdot 0.9]}{[1 + 0.9]} = 0.947 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 15 \cdot 450 \cdot 0.5 \cdot 0.7 = 2362 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[0.947])^{\frac{5}{3}} \cdot [2362]^{\frac{1}{3}} \cdot 1 = 1263 \text{ m}^3/\text{h}$$

Item7: Braising Pan

$$q_p = k \cdot (z + 1.7D_h)^{\frac{5}{3}} \cdot Q_{conv}^{\frac{1}{3}} \cdot K_r$$

D_h – hydraulic diameter, m

$$D_h = \frac{2[1.2 \cdot 0.9]}{[1.2 + 0.9]} = 1.028 \text{ m}$$

$Q_{conv} = P \cdot Q_s \cdot b \cdot \phi \text{ in W}$

$$Q_{conv} = 18 \cdot 450 \cdot 0.5 \cdot 0.7 = 2835 \text{ w}$$

$$q_p = 18 \cdot (1.1 + 1.7[1.028])^{\frac{5}{3}} \cdot [2835]^{\frac{1}{3}} \cdot 1 = 1460 \text{ m}^3/\text{h}$$

SUMMARY BLOCK I

Item	Qty	Description	Dimensions	d _h (m)	Q _{conv} (W)	Net exhaust (m³/h)
1	1	Kettle steamer	1200x800x900	0,96	1764	1160
2	1	Table	500x800x900			
3	1	Kettle steamer	1000x800x900	0,88	1470	1013
4	1	Kettle steamer	900x800x900	0,847	392	623
5	1	Braising Pan	1400x900x900	1,018	2835	1557
6	1	Braising Pan	1000x900x900	0,947	2362	1263
7	1	Braising Pan	1200x900x900	1,028	2835	1460
TOTAL						7076

Exhaust air flow for block I :

Hood exhaust air flow should be equal to or higher than the air flow in the convective plume generated by the appliance. The total of this exhaust depends on the hood efficiency.

$$q_{ex} = q_p \cdot K_{hood\,eff} \cdot K_{ads} \cdot K_{opt} + q_{int}$$

$$K_{ads} = 1.05$$

$K_{opt} = 1.2$ – Optimisation of the equipment under the hood (In island position always 1.2).

$$q_p = 7076 \text{ m}^3/\text{h}$$

$$q_{ex} = [7076 \cdot 1 \cdot 1.05] \cdot 1.2 + 605 = 9610 \text{ m}^3/\text{h}$$

Block II:

A kitchen extraction hood measuring 4200 mm x 2350 mm x 555mm is mounted 2 m above the floor. The installation height of the hood is then 1.1m above the appliances.

Same calculation procedure as above

$$q_{ex} = q_p \cdot K_{hood\,eff} \cdot K_{ads} + q_{int}$$

$$q_{ex} = 7613 \text{ m}^3/\text{h}$$

Block III:

A kitchen extraction hood measuring 4400 mm x 1350 mm x 555 mm is mounted 2 m above the floor. The installation height of the hood is then 1.1m above the appliances.

Same calculation procedure as above

$$q_{ex} = q_p \cdot K_{hood\,eff} \cdot K_{ads} + q_{int}$$

$$q_{ex} = 1867 \text{ m}^3/\text{h}$$

Comparison of Exhaust Air flow Rates

Using a heat load based design method gives more accurate and optimized air flow rates than traditional rules.

Description	Air flow based on face velocity m³/h	Heat load based Design m³/h
Block I	15 325	9610
Block II	15 563	7613
Block III	7029	1867
Total	37 917	19 070

Table 10.

HALTON solution is the recipe for a healthy & productive kitchen environment

The Heat Load based design gives an accurate method of the calculating hood exhaust air flow as a function of the cooking appliance's shape, installation and input power, and it also takes into account the hood efficiency. The only disadvantage of this method is that it is cumbersome and time-consuming if manual calculations are used.

Hood Engineering Layout Program, Halton HELP is specially designed for commercial kitchen ventilation and turns the cumbersome calculation of the heat load based design into a quick and easy process. It contains the updateable database of cooking appliances as well as Halton Capture Jet™ hoods with enough information to be able to use Equations 1 and 2 to accurately to calculate the hood exhaust air flow.

Phase 3-4: Kitchen hood design

Intelligent Design Selection by using the HALTON HELP Software

First of all, Halton had to calculate the air flow precisely and then measure rates and adjust them above each appliance. This allows the minimal air flow that will enable the kitchen to work correctly when using a KVF hood with Capture Jet™ technology to be determined. Indeed, by introducing air at the front leading edge of the hood, at high velocity ($>4\text{m/s}$), it creates a "Venturi effect", leading the air directly towards the filters, without increasing the exhaust air flow. Compared with a traditional system of hoods, the Capture Jet™ system allows an exhaust flow up to 30 % lower, by only having 5-10% of net exhaust.

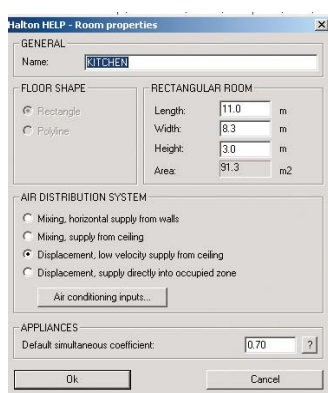


Figure 30. Halton HELP Data entry

The KVF has been installed over the cooking equipment, Block I and Block II. These hoods are classified as Island hoods.

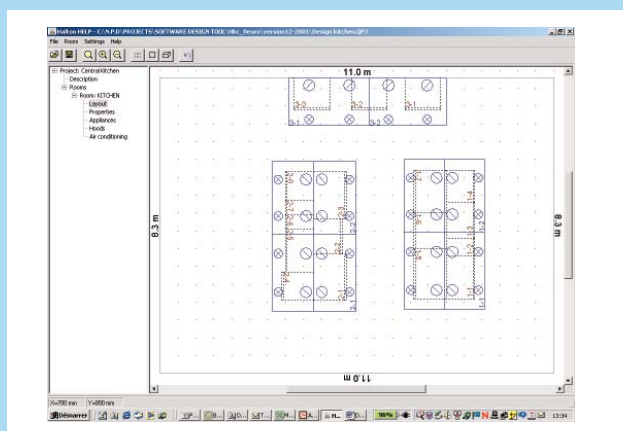


Figure 31. Halton HELP Kitchen lay-out

The other KVF hoods are installed over the other cooking equipment and they are against the wall with three sides open. These hoods are classified as wall hoods (Block III)



Figure 32. Halton HELP Air conditioning inputs

Air conditioning calculation results

HELP	
Project:	Central Kitchen Villeneuve
Location:	Paris
Designed by:	RZ
Date:	10.5.2002
AIR CONDITIONING CALCULATIONS	
Room:	Cooking
Air distribution:	Displacement, low velocity supply from ceiling
Room air temperature:	23.0 C
Room air RH max:	60 %
Maximum supply air dT:	4.0 C
Barometric pressure:	1007.75 Pa
Outdoor air temperature:	26.0 C
Outdoor air RH:	33 %
Transfer air temperature:	23.0 C
Transfer air RH:	50 %
Transfer air flow:	1395 m³/h
Occupants/light work:	3
Occupants/heavy work:	3
Incandescent light in the occup zone:	0 kW
Incandescent light near the ceiling:	0 kW
Fluorescent light in the occup zone:	3 kW
Fluorescent light near the ceiling:	0 kW
Solar heat/vertical:	0.5 kW
Solar heat/horizontal:	0.6 kW
Heat transfer through ceiling:	1.0 kW
Heat transfer through walls:	1.0 kW
Heat gain from appl. under hood:	18.2 kW
Heat gain from appl. not under hood:	0.0 kW
Total exhaust through the hoods:	15320 m³/h
General exhaust:	1631 m³/h
General exhaust temperature:	24.4 C
Supply air through the hoods:	12580 m³/h
Type of hood supply air:	Air conditioned
General supply airflow:	5602 m³/h
General supply temperature:	19.0 C
Cooling capacity with return air:	40.3 kW
Cooling capacity with 100% outdoor air:	42.4 kW
Volumetric airflows are presented at room air temperature	

Figure 33. HELP print-out

Energy and Cost Comparison Using the Halton HEAT Software



This section shows the energy and cost benefits for the end-user of utilising the Halton Capture Jet™ hood system versus the competition's exhaust only and short circuit hoods. The data entry screen for Halton HEAT software is shown in figure 34.

Figure 34. Halton HEAT Data entry screen

As shown in figure 35, we are comparing two systems: a Halton model KVI hood with Capture Jet™ technology versus an exhaust-only hood. Using Halton HELP software, it can be shown that the exhaust flow of the Capture Jet™ hood is only 19 000 m³/h. The remaining data on the screen are for the total fan pressure drop of each of the systems together with the total installed cost for the end-user, which includes the hoods, fans, labour etc. The final step on the main form is to press OK and to bring up the screen shown in figure 35.

This screen presents the annual heating, cooling and air conditioning operating costs for the three different hood types. However, in this case we have only specified inputs for the Capture Jet™ and exhaust only hoods. Pressing the Conclusion button on the tree brings up the report seen in figure 36.

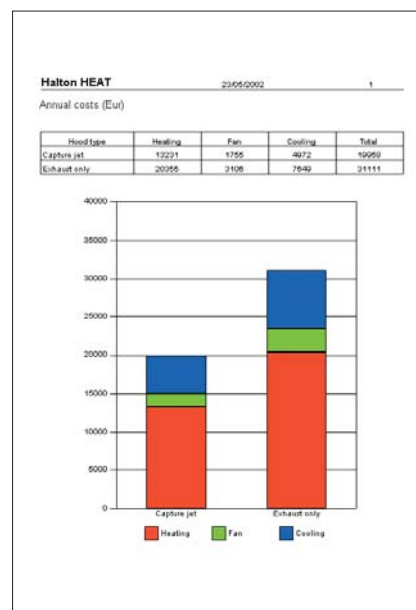


Figure 35. Halton HEAT Annual costs

The energy savings report presents the financial and environmental benefits of investing in a Halton system. In this case, the savings in air-conditioning were less than the added cost of the Halton hood providing immediate payback to the end-user. Since the Capture Jet™ hood requires a lower exhaust flow than a competitor's hood, less make-up air is required resulting in a lower air conditioning cost.

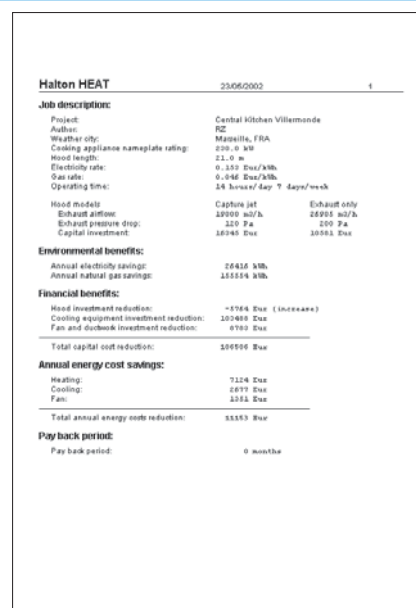


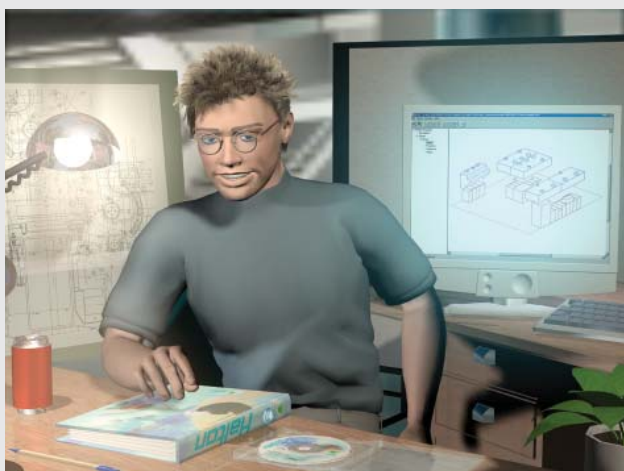
Figure 36. Halton HEAT Energy savings report

Hood type	KVF	Exhaust-only
Fan energy	1755 €	3106 €
Heating energy	13321 €	20355 €
Cooling energy	4972 €	7649 €
Total	19958 €	31111 €

Table 11. Annual cost

Upon examining the table above, it becomes apparent that the KVF hood could save over 11153 Euros in annual operating costs for Paris, France. Using the exhaust flow rate of 19 000 m³/h of the KVF hood as a basis, the exhaust only hood is calculated to need 26 905 m³/h.

The net effect is that the payback for the KVF is instantaneous.



Picture 37.

Being Helped Successfully

It was a quick decision to choose the highly efficient KVF canopy with Halton Capture Jet™ technology, which allows the canopy to operate with up to 30% lower exhaust flows than traditional hood systems.

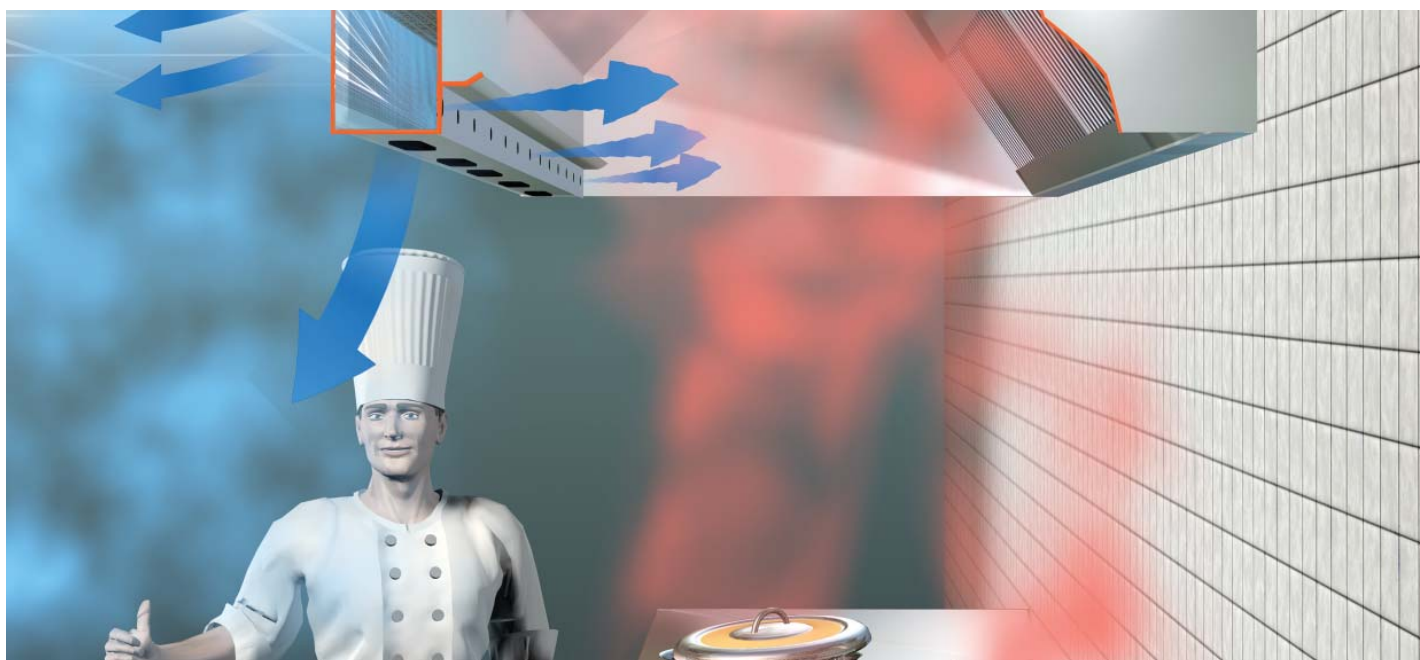
The make-up air for general ventilation is distributed directly into the working zone from the front face and from the low velocity supply diffuser at the side of the canopy.

It is indeed the only hood currently on the market capable of combining the two features below:

- Optimising the exhaust air flow rate and energy saving
- Guaranteeing the comfort of the workers and improving their productivity with better indoor air quality.

Improving Comfort

In addition to energy savings there is a net improvement in comfort due to the decrease in air volumes calculated (i.e.: limitation of draughts). Other features include increase in hood efficiency and high grease filtration efficiency. The low velocity diffusion of general supply air via the KVF also helps to improve comfort.



Picture 9. Capture efficiency hoods

Product Support Package Tools



The hallmark of Halton design is the dedication to improve indoor air quality in commercial kitchens, restaurants, hotels and bars. Halton provides foodservice professionals a complete package of tools and material for easy but sophisticated design of working indoor environments.

- Halton HIT interactive product catalogue
- Halton HELP 3D design and selection software for kitchen hoods and ventilation systems
- Halton HEAT energy analysis tool for payback time calculation and evaluation of environmental impacts
- Commercial kitchen design guide
- Detailed technical data for Halton's kitchen and restaurant ventilation range
- Halton references

Measuring Airflow & Balancing Hoods

For any ventilation system to operate properly in a commercial kitchen, the airflows have to be measured and balancing after the system has been installed to ensure that the design criteria have been met. This chapter provides information on balancing the supply and exhaust systems in a commercial kitchen.

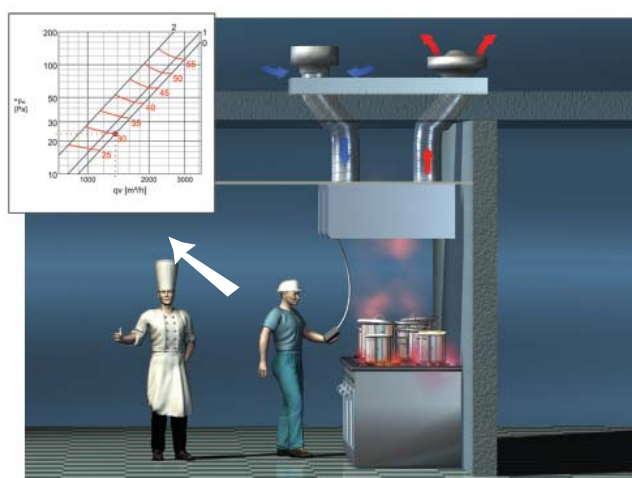


Picture 38. Traditional way

Balancing is best performed when manufacturers of the equipment are able to provide a certified reference method of measuring air flows, rather than depending on generic measurements of duct flows or other forms of measurement in the field.

Exhaust & Supply air balancing

Halton offers a variety of means for determining the exhaust flow through their Capture Jet™ hoods. Integral to all Capture Jet™ hoods is the Test & Balance Port (T.A.B.). These ports are to be used in determining both the exhaust and Capture Jet™ air flows. Each incremental size of hood has been tested through the range of operable air flows and a curve has been generated showing air flow as a function of pressure drop across the T.A.B. Regardless of duct configuration, the T.A.B. ports will give you an accurate reading of air flow.



Picture 39. Halton way

Fan and Duct Sizing

It is recommended when sizing the exhaust duct not to exceed 9 m/s for the main branch and 7 m/s for the branch runs. This is due to the noise potential for the higher velocities and by sizing for a median velocity, it gives the designer greater flexibility in changing exhaust rates up or down. The ideal duct size is a 1 to 1 ratio, trying not to exceed 2:1 whenever possible to minimise static pressure and noise. Radius elbows instead of hard 90° should also be considered for the same reason.

There are two important factors to take into account when selecting the fan: pressure and sound level.

When the fan is installed in the duct system, the pressure it creates is used to cover the total duct pressure loss. The air flow of the fan is determined at the point where the fan pressure curve and the system pressure curve intersect.

A common practice among fan manufacturers is to use the static pressure in their literature; therefore, it is adequate just to define the static pressure loss in the ductwork and total airflow to select the fan. Hood and grease extractor manufacturers give the pressure information of these products. The data on frictional and dynamic losses of the duct system can be found in various sources.

Fire Safety

The main purpose of fire protection is to protect the occupants and the fire fighting personnel in case of fire.

In commercial kitchens the biggest fire hazard exists in places where a lot of grease is released: fryers, fat cookers, charbroilers, woks...

The existence of grease and at the same time high surface temperatures can cause flames and thus cause the grease to ignite. Fire suppression systems are used precisely in these cases in many countries.

Whenever fire safety issues are concerned, local codes have to be taken into account.



Picture 40. Fire suppression system

Glossary of terms

C & C – capture and containment

CFD – computational Fluid Dynamics

Hood Capture Efficiency - the ability of the kitchen hood to provide sufficient C&C at minimum exhaust flow rate

HVAC – Heating, Ventilation, Air Conditioning

Occupied Zone – lower part of the room where people are, typically 1500 to 1800 mm from the floor.

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