WORKSHOP ON IMPROVING ENERGY EFFICIENCY & INDOOR AIR QUALITY IN COMMERCIAL KITCHENS

Friday, 28 February 2003

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PROGRAMME

8:30	am	Workshop Registration
9:00	am	Opening Speech by Deputy Director, CTBP, Associate Professor Tham Kwok Wai
9:10	am	Overview of Workshop
9:20	am	Design Fundamentals
9:45	am	Modern Hood and Ventilated Ceiling Technologies
10:30	am	Tea-Break
10:45	am	The Total Approach of Ventilation Design
11:45	am	Examples of Kitchen Design
12:45	pm	Q&A
1:00	pm	End of Workshop

Organised by:

Building and Construction Authority

NUS National University of Singapore

BCA-NUS Centre for Total Building Performance

In Partnership with:

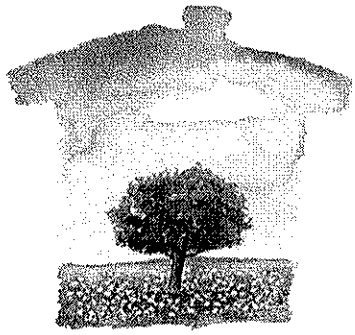
PREMAS INTERNATIONAL

PREMAS Training College

Halton

Oy Halton Group Ltd
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We care for indoor air



Halton

Halton



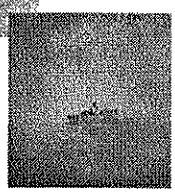










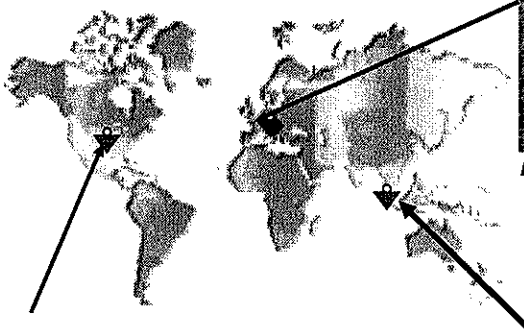


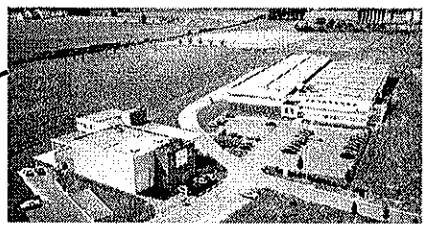
Halton's Mission

We develop, market and manufacture high quality ventilation and air-conditioning components and systems to provide a safe, healthy, comfortable, productive and energy-efficient indoor environment for people to work and live in.

SBA Kitchen Ventilation

Global Presence
Local Expertise

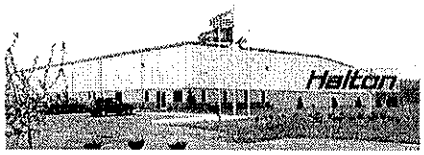




Béthune - FRANCE



Port Klang - MALAYSIA



Scottsville, Kentucky - USA

Improving Energy Efficiency
Indoor Air Quality in Commercial Kitchens

Workshop at
National University of Singapore

on 28 February 2003

PhD Risto Kosonen
Oy Halton Group Ltd Singapore

Outline of Kitchen Ventilation Presentation

1. Design Fundamentals
2. Modern Hood and Ceiling Technologies
3. Total Approach of Ventilation Design
4. Some Examples



How can we define a Professional Kitchen ?

IT'S A UNIQUE SPACE WHERE :

- *Meals are prepared*



- *Dishes and equipment are washed*

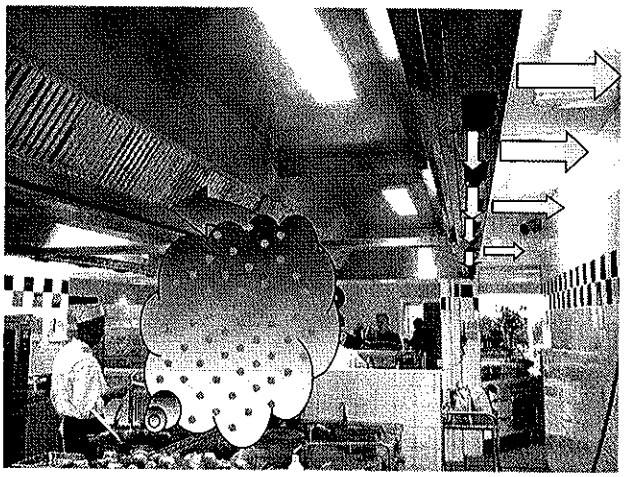


- *Foodstuff is stored*



Why do we need ventilation system in commercial Kitchens ?

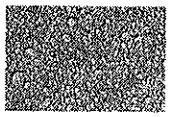
TO ENSURE THE MOST PLEASANT WORKING ENVIRONMENT



1. Remove immediately excess heat

2. Remove particules of grease , odours, exhaust gases ...

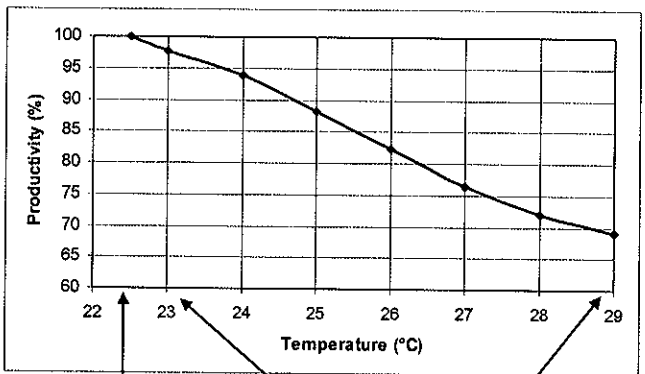
3. Remove moisture



4. Renew the air to refresh the working place and replace exhausted air

Thermal comfort, Productivity and Kitchen Ventilation





With bad system :

- ***The temperature can increase***
- ***Employees can feel more uncomfortable***
- ***This can affect both efficiency of staff and turnover***



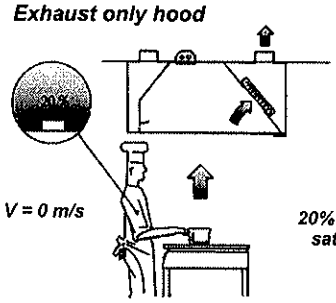
How to measure comfort in a professional kitchen ?



- *Utilized a breathing thermal mannequin*
- *Measured skin temperature and power to maintain temperature.*
- *Mean thermal vote calculated at 25 body locations.*

Satisfaction Measurement

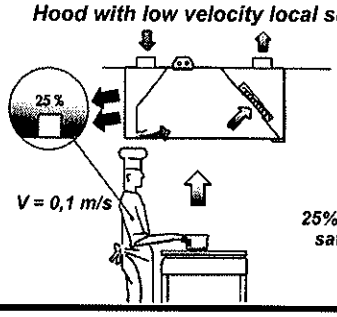
Exhaust only hood



V = 0 m/s

20% people satisfied

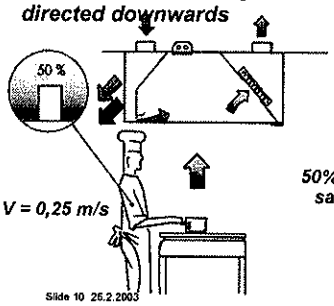
Hood with low velocity local supply



V = 0,1 m/s

25% people satisfied

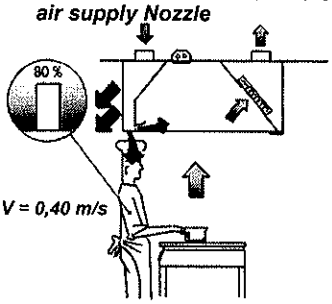
Hood with low velocity local supply directed downwards



V = 0,25 m/s

50% people satisfied

Hood with low velocitysupply + Personal air supply Nozzle



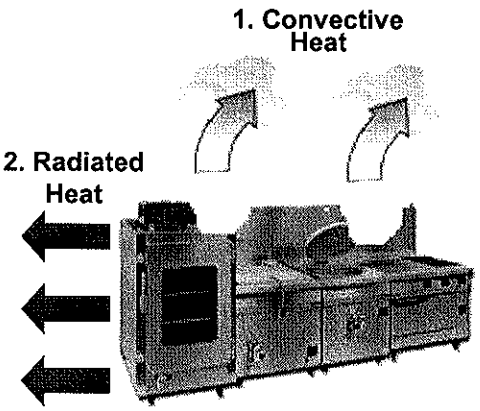
V = 0,40 m/s

80% people satisfied

Where the heat loads generated in a commercial Kitchen are coming from ?

Mainly from COOKING PROCESS and COOKING EQUIPMENT:

1. *Convective heat => can be captured by a hood.*
   (totally or partly depending on hood efficiency)
2. *Radiated heat => can not be captured by any hood.*
3. *Other :*
   - *heat transfer through windows, walls, ceiling*
   - *occupants*
   - *lights*
   - *other appliances*



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How are exhaust rates calculated in a commercial kitchen ?

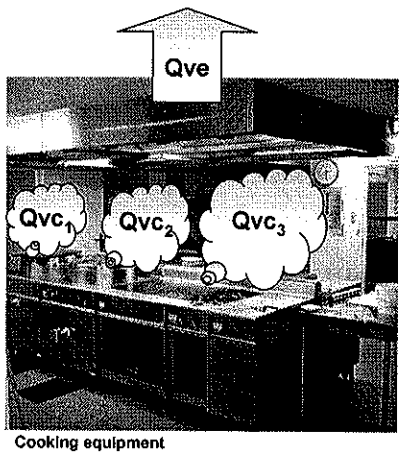
EXHAUST AIR FLOW $_{(Qve)}$ ***rate is DIRECTLY related to :***

- ***quantity of CONVECTIVE HEAT*** $_{(Qvc)}$ ***generated by the cooking equipment***
- ***EFFICIENCY*** $_{(Heff)}$ ***of the hood system***

IT'S A HEAT LOAD BASED DESIGN !!!

Qvc = Output of Cooking Equipment
$Qvc = Qvc_1 + Qvc_2 + Qvc_n$
$Qve = Qvc / H.eff$

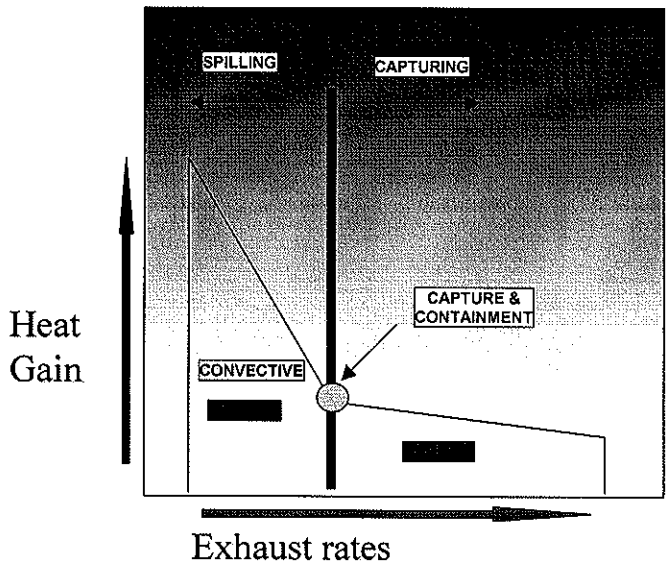
That means :
Design methods not based on cooking appliances ($m^3/h/m$, $m^3/h/m^2$, $m^3/h/meal$, face velocity) can not provide accurate results.

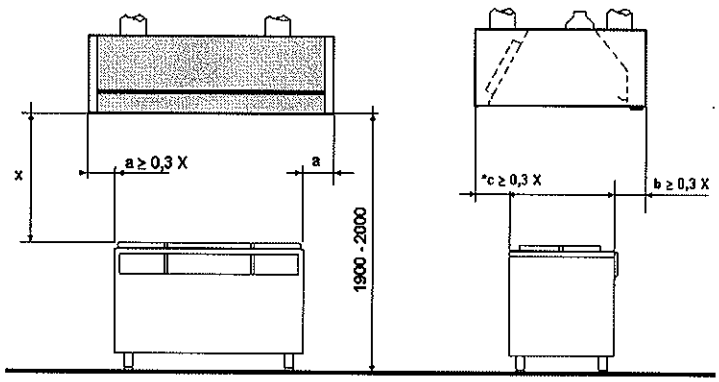


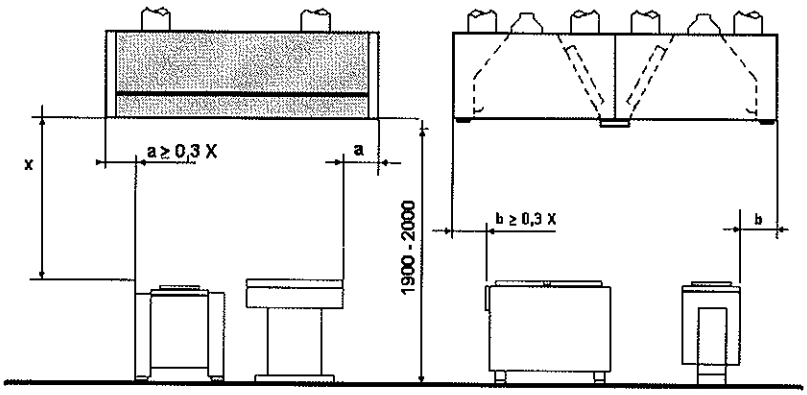
Cooking equipment

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HEAT GAIN CHARACTERISTIC -GENERIC EXAMPLE







How convective heat loads are calculated for each cooking equipment ?

- **According VDI 2052* standard**

$$Q_{s,k} = P \cdot Q_s \cdot b \cdot \varphi$$

Simultaneous Factor

Convective Fraction

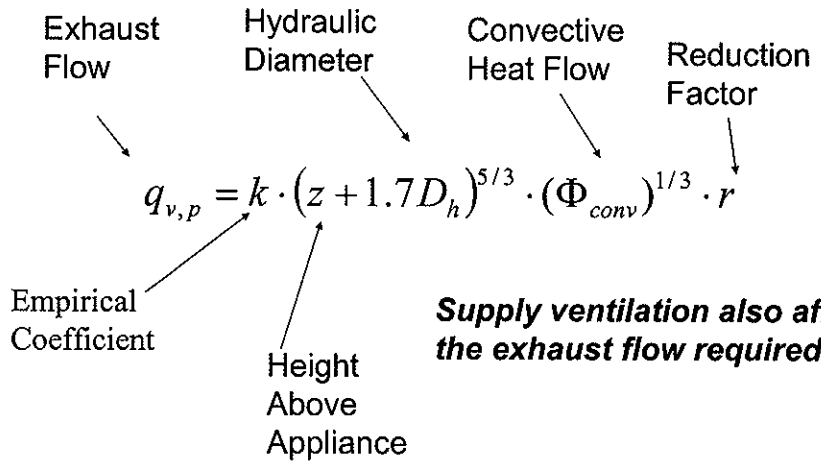
Convective Heat Flow (W)

Appliance Input Power

Appliance Sensible Factor

**Verien Deutscher Ingenieure*

VDI Standard (continued)



Supply ventilation also affects the exhaust flow required

What are the strenghts and weaknesses of VDI ?

- ***Accounts for convective plume from cooking appliance.***
- ***Accounts for different ventilation strategies (e.g. mixing versus displacement).***
- ***Neutral method not coming from hood manufacture.***

- ***Doesn't account for differences in hood design and hood efficiency between different manufacturers***

How can we define hood efficiency ?

Exhaust only Hoods (traditional system)

Qvc / Heff = Qve

If excess heat and impurities are not captured by the hood and are spread to the occupied zone.

⇩

The hood effciency is not good.

⇩

Not Comfortable working area.

Common Solution

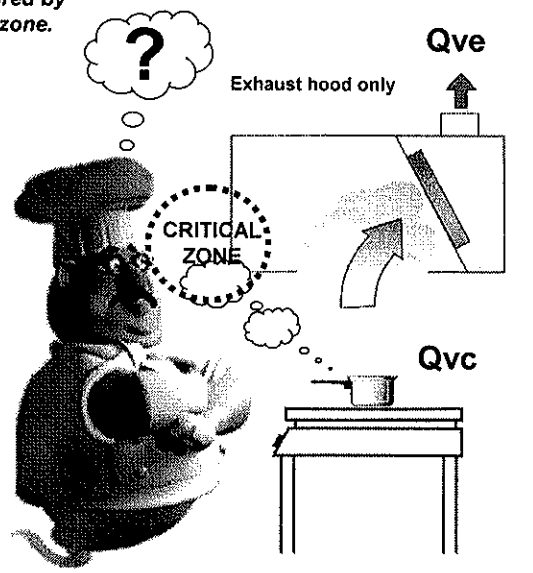
Increase exhaust air flow (Qve) to guarantee front velocity especially on Critical Zone.

⇩

Higher dilution of room air to remove load.

⇩

Higher energy consumption.



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Short Cycle system, 50 to 70% Induction

Qvc + Qvi = Qve

Designed first in USA when high exhaust rate followed exclusively the model codes.

⇩

Large volumes of untraited air is supplied directly in the hood (50 to 70% of exhaust air).

⇩

High air flow rates to guarantee acceptable efficiency and to exhaust "short circuit" air.

⇩

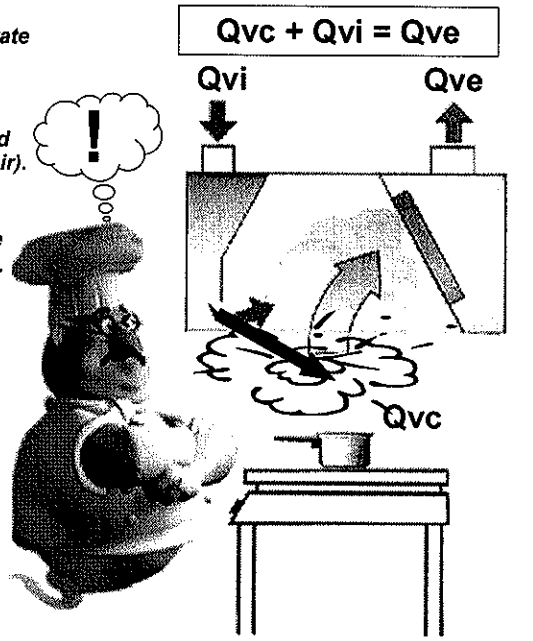
Thermal Plume (Qvc) is disturbed

⇩

Bad efficiency and bad working conditions.

⇩

System not advocated any more in Europe and USA.



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HALTON Capture Jet Hoods = High Efficiency

Capture Jet technology designed by HALTON in 80's to prevent spillage at low exhaust rates.

⇩

Use of high velocity Capture Jets to increase face velocity of the hood with lower air flow.

⇩

Capture Jets push the thermal plume towards the filters without interfering with the convective flow.

⇩

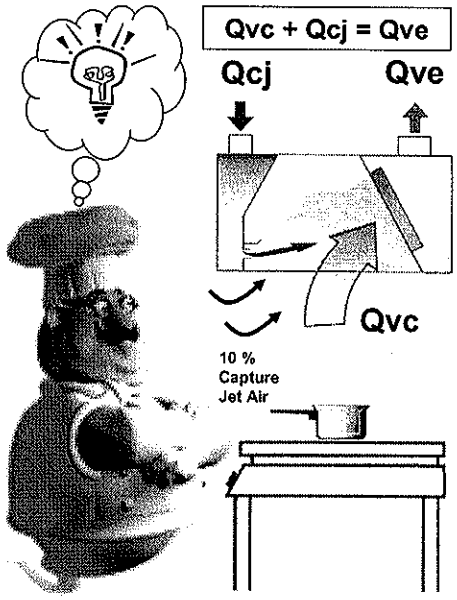
Efficiency is higher and air flow rates 35% lower compared to exhaust only hood system.

⇩

Supply/make up air is reduced as well.

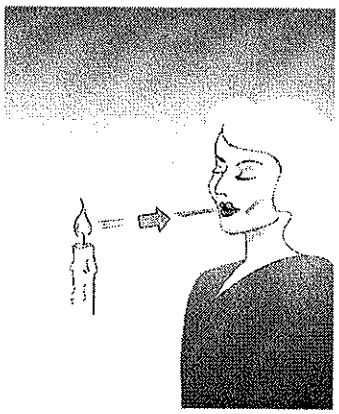
⇩

Technological and energy efficient system.



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Capture Jet System Principle



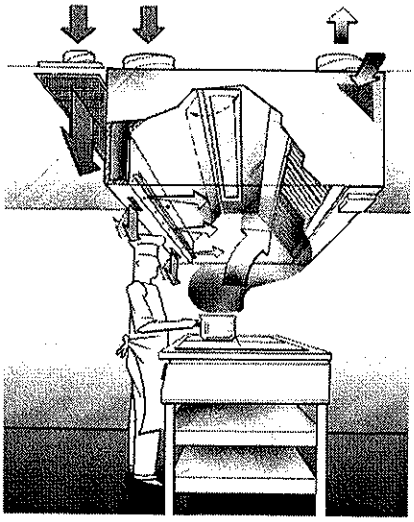
Suck out a candle : result is poor, same as exhaust system which relies on suction pressure to remove heat.

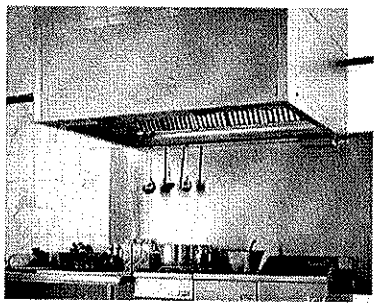


Blow out a candle = > better results, same as Capture Jet Concept.

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KVI : Capture jet canopy

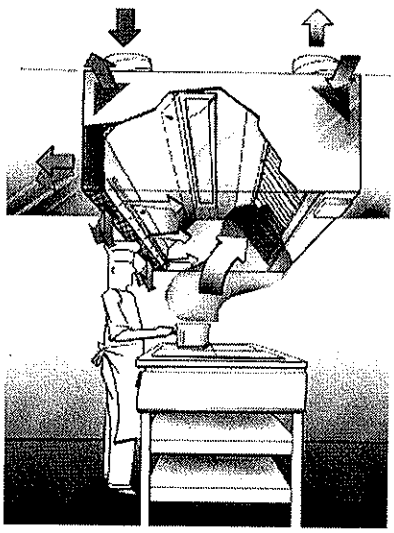


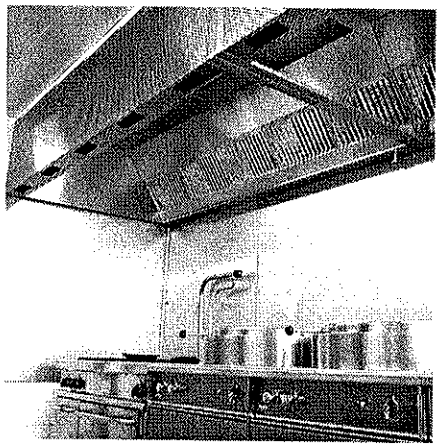




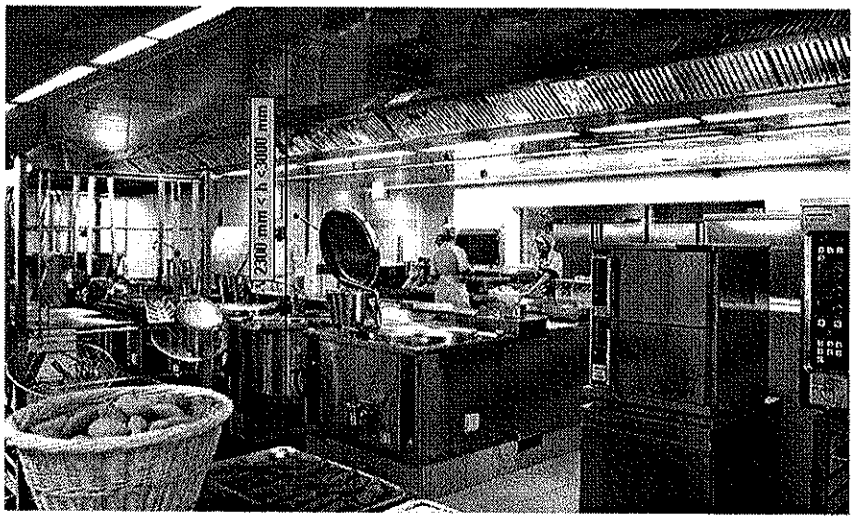
UK; Tesco store in Woodford Green

KVF : Capture jet canopy, Supply and Exhaust

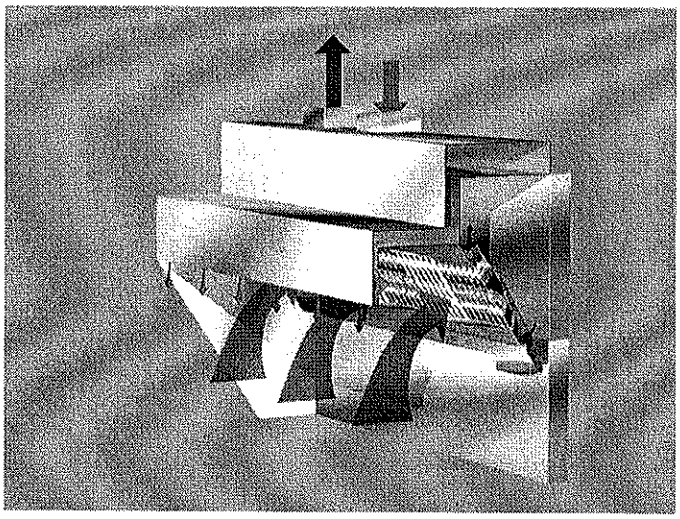




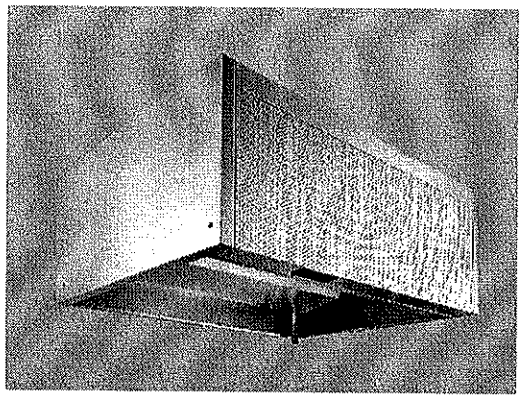
France; LEP Chenevard

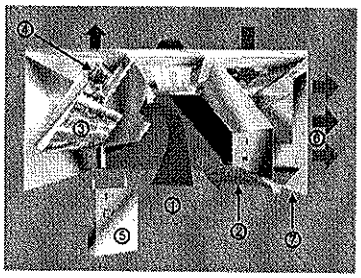


KVL : Capture Jet Backself Hood



KWF : Capture Jet Water Wash hood with Supply Air

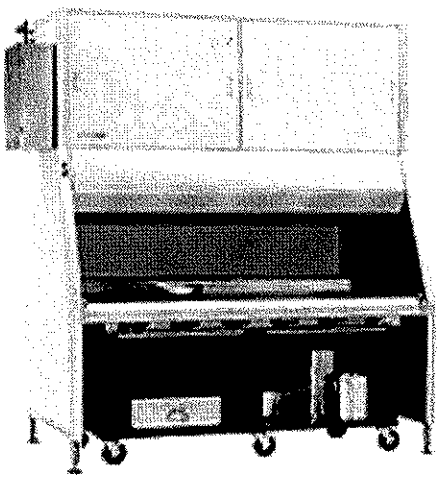




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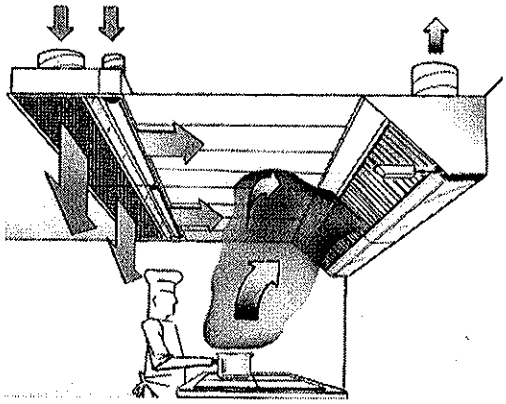
Model CanVent:

Ductless Hood Solution for Commercial Kitchens

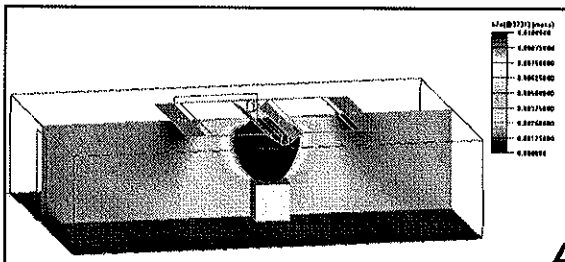


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KCE : Air Conditioning Ceiling with Capture Jet

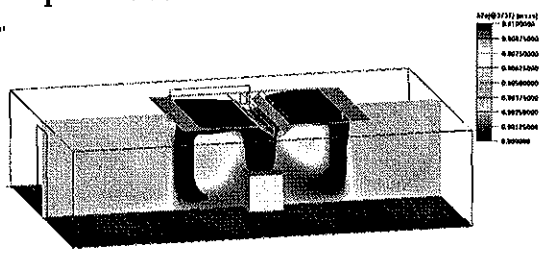






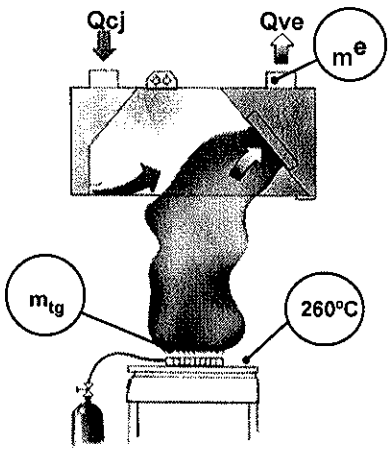
KCE
Air Conditioning Ceiling

With Capture Jet

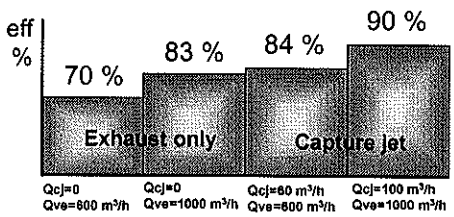


Without Capture Jet

Demonstration n°1 : Tracer Gas Study

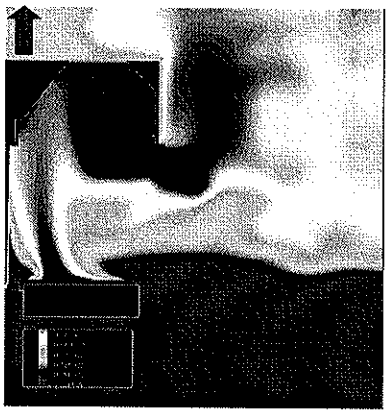


$$eff = \frac{m_e}{m_{tg}}$$

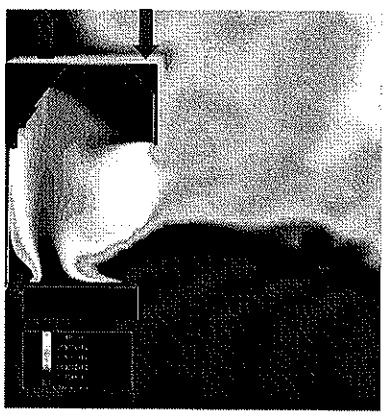


Computer Modeling (CFD)*

Computational Fluid Dynamics



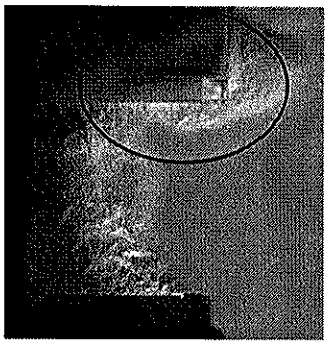
KVI with Capture Jets **OFF**
(same as hood exhaust only)
(Surface Temperature : 315°C)



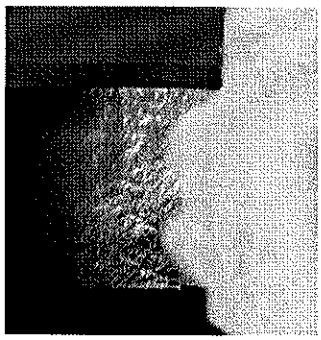
KVI with Capture Jets **ON**
(Surface Temperature : 315°C)

Schlieren Thermal Imaging

- **Visualizes changes in air density**
- **More sensitive than visualizing smoke**
- **Quickly see impact of design changes**



KVI with Capture Jets **OFF**
(same as hood exhaust only)
(Appliance : 315°C)



KVI with Capture Jets **ON**
(Appliance : 315°C)

ASTM F1704

Laboratory test to measure how much heat is released into the kitchen :

HOOD TYPE	EXHAUST RATE	CAPTURE AIR	TOTAL EXHAUST	DUCT T° RISE	HEAT GAIN
Capture Jet	1530 m^3/h	90 m^3/h	1620 m^3/h	24°C	998 W
Exhaust Only	2210 m^3/h	0 m^3/h	2210 m^3/h	17,5°C	980 W

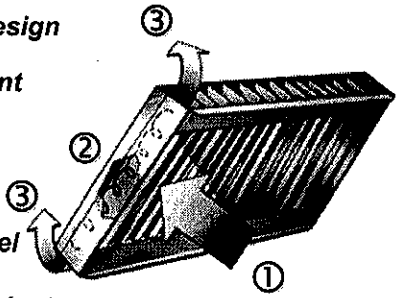
Test set up using a under fired charbroiler, 600 F surface Temperature

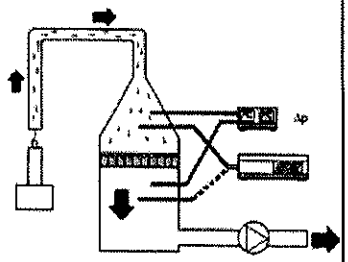
Equivalent heat gain, but capture jet hoods use 30% less exhaust to do the same job.

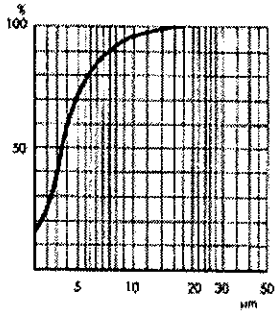
KSA Multi cyclone Grease Filter

Halton Patented Design

- *Uses cyclonic effect to improve filtration efficiency.*
- *Non-clogging design*
- *Low and constant pressure drop.*
- *Easy to clean*
- *All stainless steel*
- *93% to 98% efficient on particules between 5 and 10 microns*

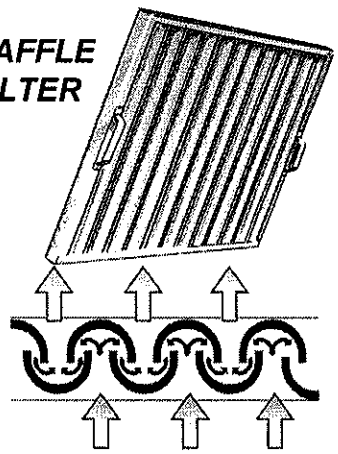






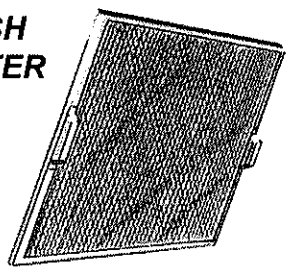
What about others conventional filters ?

BAFFLE FILTER



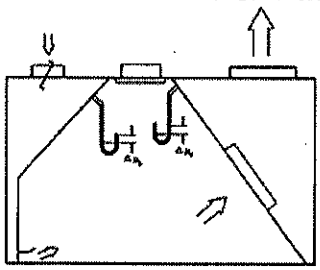
- *Higher pressure drop (125-150 Pa).*
- *Lower grease extraction efficiency.*
- *Higher noise level.*

MESH FILTER



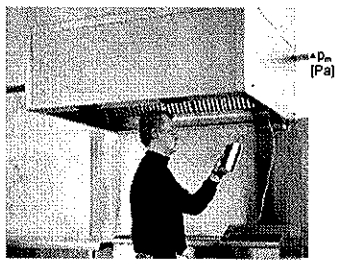
- *Low pressure drop when clean, but when dirty pressure drop increases quickly.*
- *Difficult to wash.*
- *Risk of fire when grease collected in the filter.*
- *Short live cycle.*

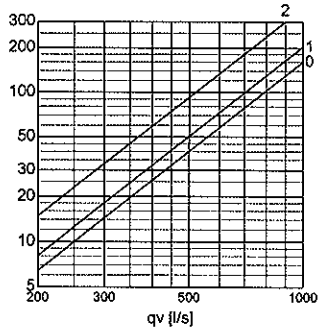
T.A.B. Test & Balance Ports



KVF-3000(E) 2001.02

qv(dpm) E									
a	0	1	2						
k	79.00	70.30	52.00						

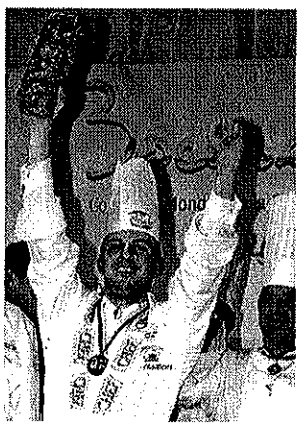




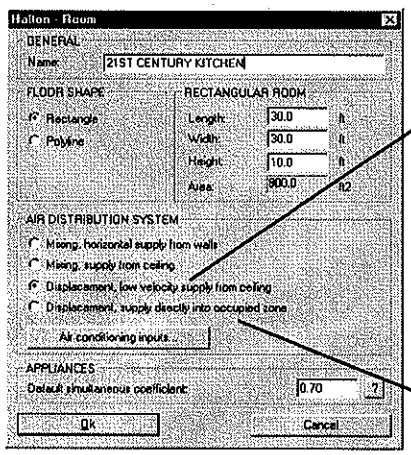
- *EASE OF BALANCING.*
- *FIELD SYSTEM FOR BALANCING AIR FLOW RATES*

IDEAS: Integrated Design, Exhaust And Supply

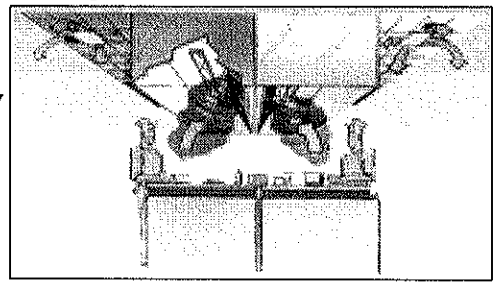
- *A 2°C temperature increase can decrease productivity 10%.*
- *31% of a restaurants expenses are for wages and salaries.*
- *5 to 10% of a restaurants expenses are for energy bills.*
- *Improved thermal comfort through integrated design approach.*
- *Improved indoor air quality = higher retention of valuable employees.*
- *Reduced training cost due to higher retention.*



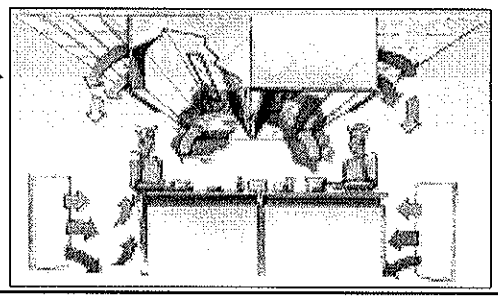
Factor effect of air distribution system



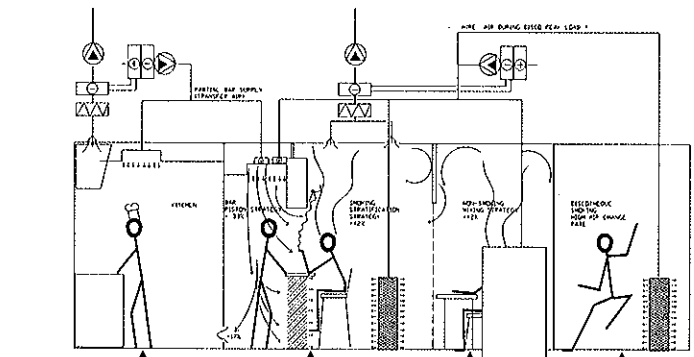
Mixing ventilation



Displacement ventilation



According new VDI - 1999, mixing ventilation system requires 15 to 20% higher exhaust rate than displacement system for the same efficiency.



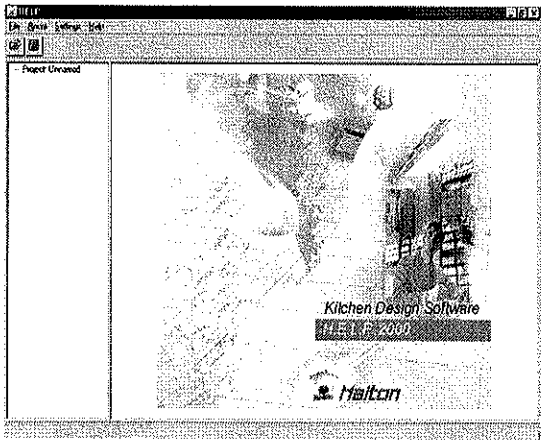
Capture Jet hood And underpressurized kitchen area

Bar area

Dining Area

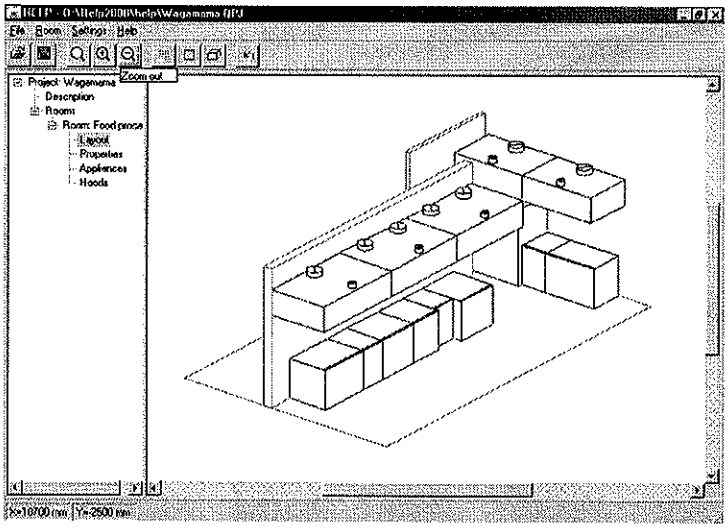
Corridor

H.E.L.P : Hood Engineering & Layout program

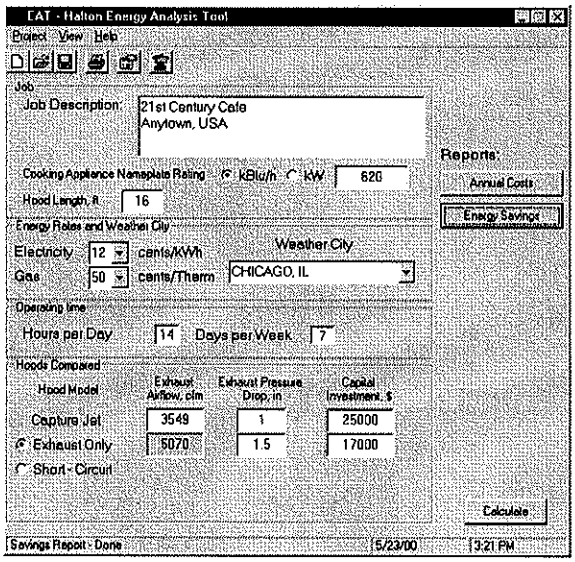


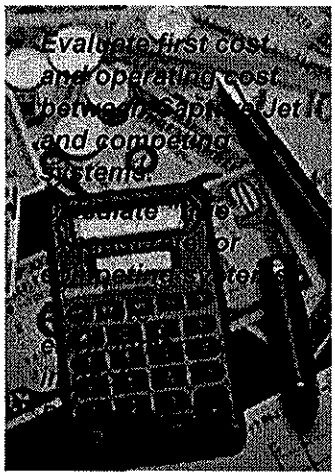
- *Heat load based design on kitchen exhaust.*
- *Effect of air distribution type factored for hood performance.*
- *Accounts for non hooded equipment.*
- *Energy savings and improved I.A.Q.*

H.E.L.P. 2000: changing your point of view

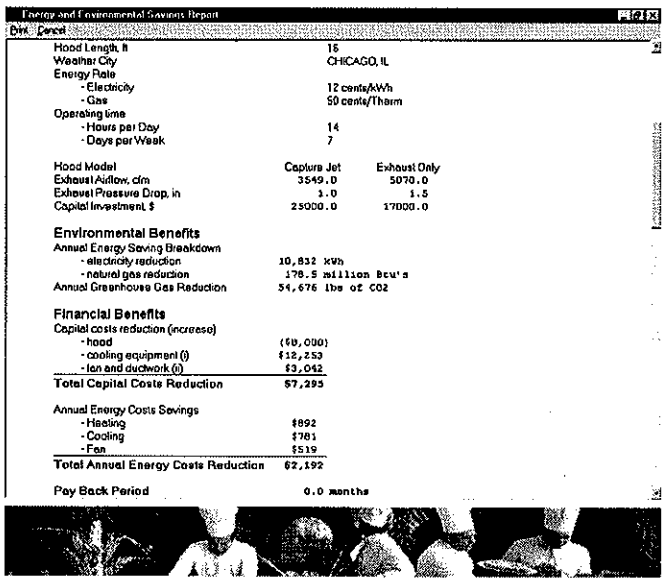


H.E.A.T : Halton Energy Analysis Tool





H.E.A.T : saving report



Energy and Environmental Savings Report

Print Cancel

Hood Length, ft	16	
Weather City	CHICAGO, IL	
Energy Rate		
- Electricity	12 cents/kWh	
- Gas	50 cents/Therm	
Operating time		
- Hours per Day	14	
- Days per Week	7	
Hood Model	Capture Jet	Exhaust Only
Exhaust Airflow, cfm	3549.0	5070.0
Exhaust Pressure Drop, in	1.0	1.5
Capital Investment $	25000.0	17000.0

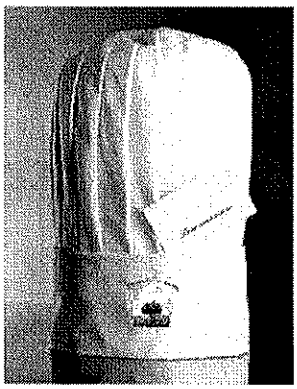
Environmental Benefits

Annual Energy Saving Breakdown	
- electricity reduction	10,832 kWh
- natural gas reduction	178.5 million Btu's
Annual Greenhouse Gas Reduction	54,676 lbs of CO2

Financial Benefits

Capital costs reduction (increase)	
- hood	($8,000)
- cooking equipment (i)	$12,253
- fan and ductwork (ii)	$3,042
Total Capital Costs Reduction	$7,295
Annual Energy Costs Savings	
- Heating	$892
- Cooling	$781
- Fan	$519
Total Annual Energy Costs Reduction	$2,192
Pay Back Period	0.0 months

We care for indoor air
in Commercial Kitchen



Halton

Halton