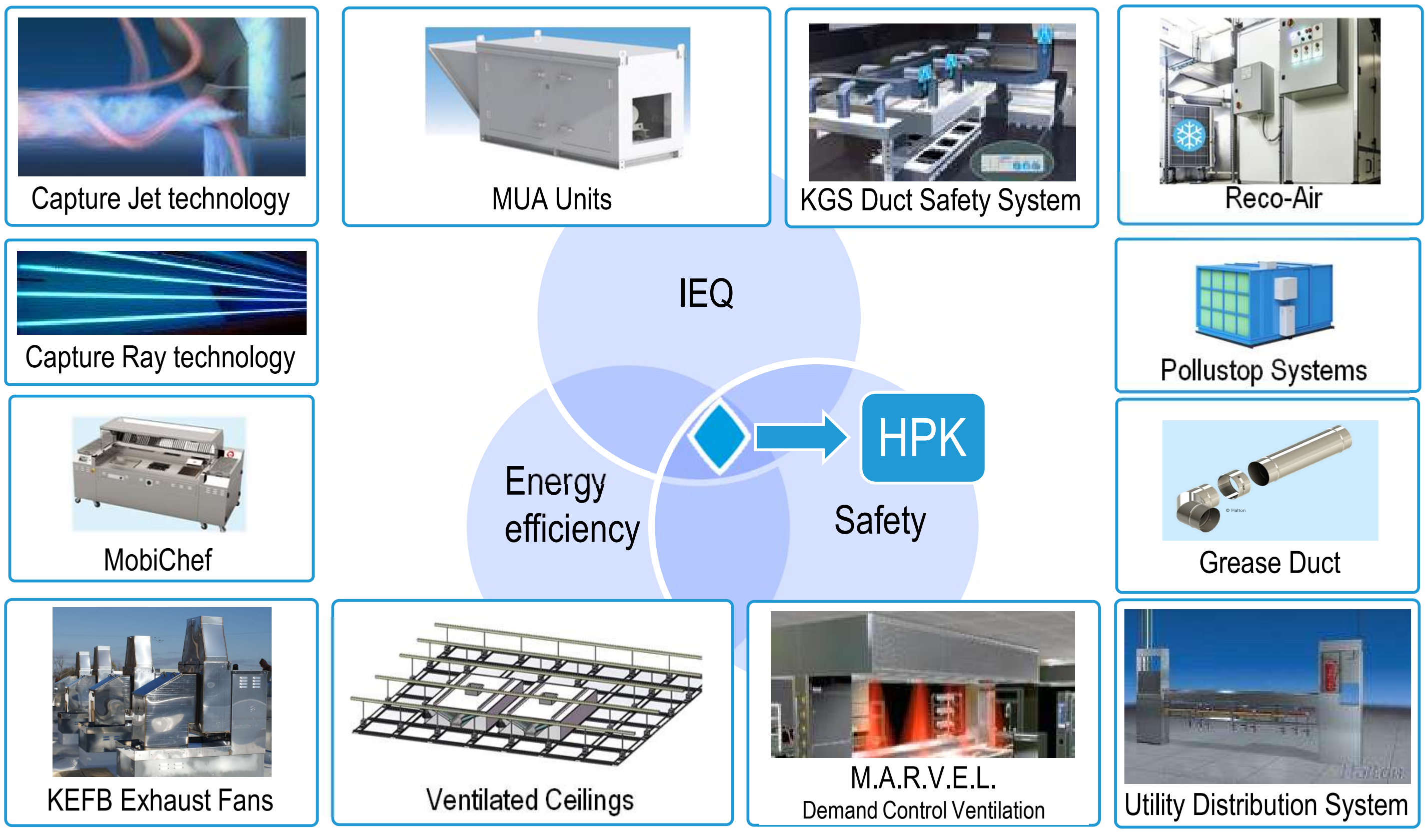
Halton - The Largest Scope of Systems and Solutions



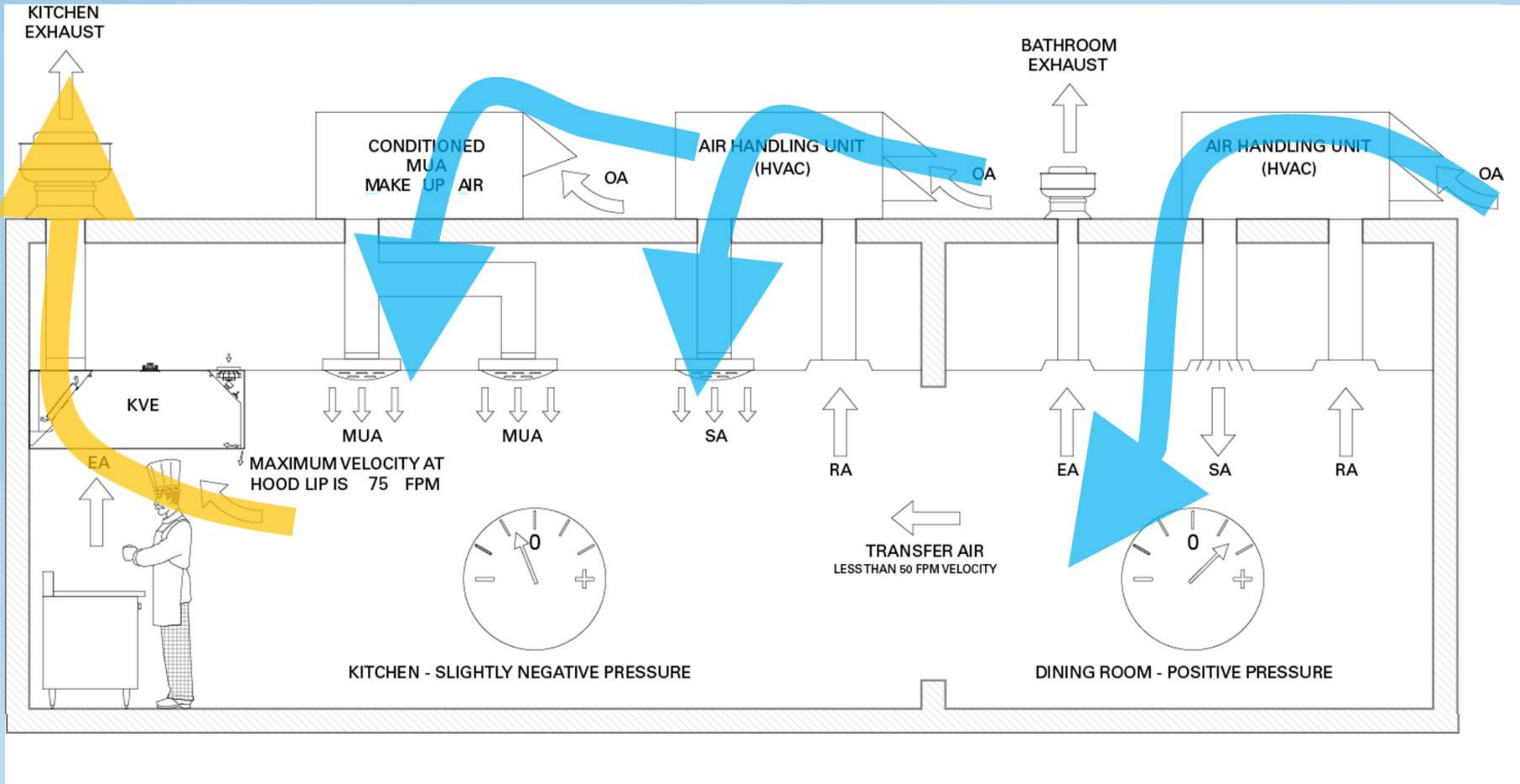
Energy Efficient Solutions for Commercial Kitchen Ventilation

Foodservice operations have one of the highest energy use intensities among buildings in the commercial sector. They contribute over 500 trillion Btu to the U.S. annual energy consumption. Today we will consider practical recommendations how to reduce energy consumption of a foodservice facility considerably and improve its indoor environmental quality.

Presentation will cover the following topics:

- Typical HVAC design / better options
- Heat load-based design – ASTM F1704 / 2474 / Impact of high-efficiency hood designs / appliance diversity and considerations
- Demand Control Ventilation Considerations
- Conclusions

Commercial Kitchen Hood Efficiency



TYPICAL KITCHEN VENTILATION LAYOUT

Thermal comfort survey

Everyone wears more clothes under thier uniforms.
When it is cold in the kitchen people opens the oven doors to get warm. When it is HOT in the kitchen I go in the freezer to cool off!!
The air quality sucks in this kitchen. We need to have to have even air flow
Thanks for doing this study. I hope someone does something about this

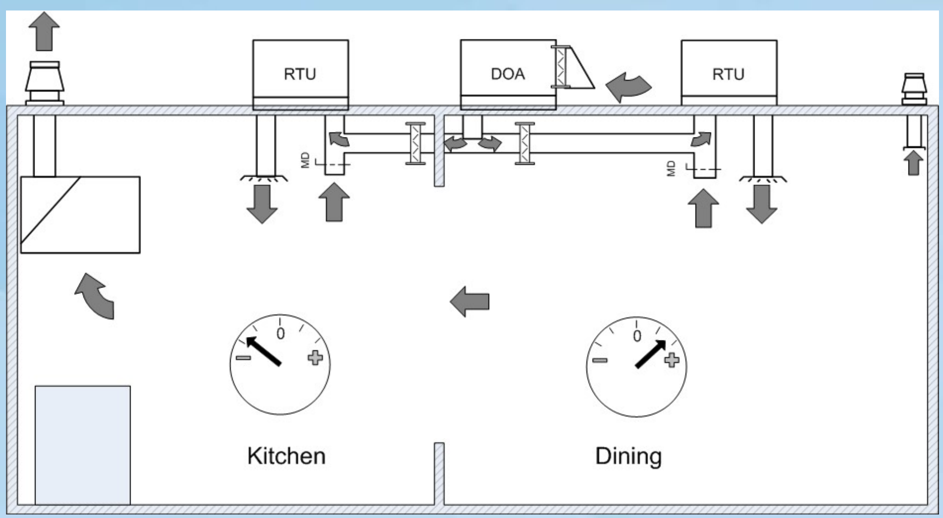
The questionnaire has now been completed.

Thank you for your time and cooperation!

PROBLEM!

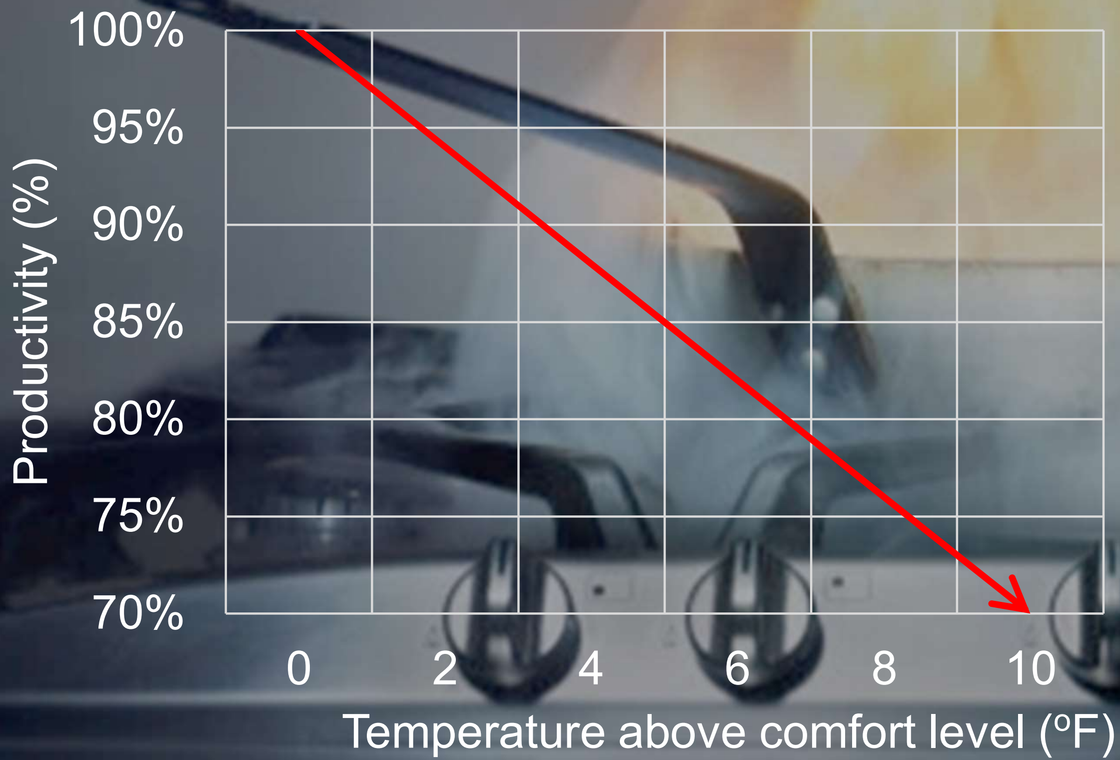
From ASHRAE report RP1469 “Thermal Comfort in Commercial Kitchens”

A Better Way Whole Building Approach



- Total requirement for outside air is calculated based on the dining room and kitchen demand.
- A dedicated outside air handling unit pre-treats all outside air for the building. OA moisture is no longer a problem.
- Control system optimizes whole building air conditioning system for minimum energy consumption

OPERATORS HAVE COMFORT EXPECTATIONS TOO

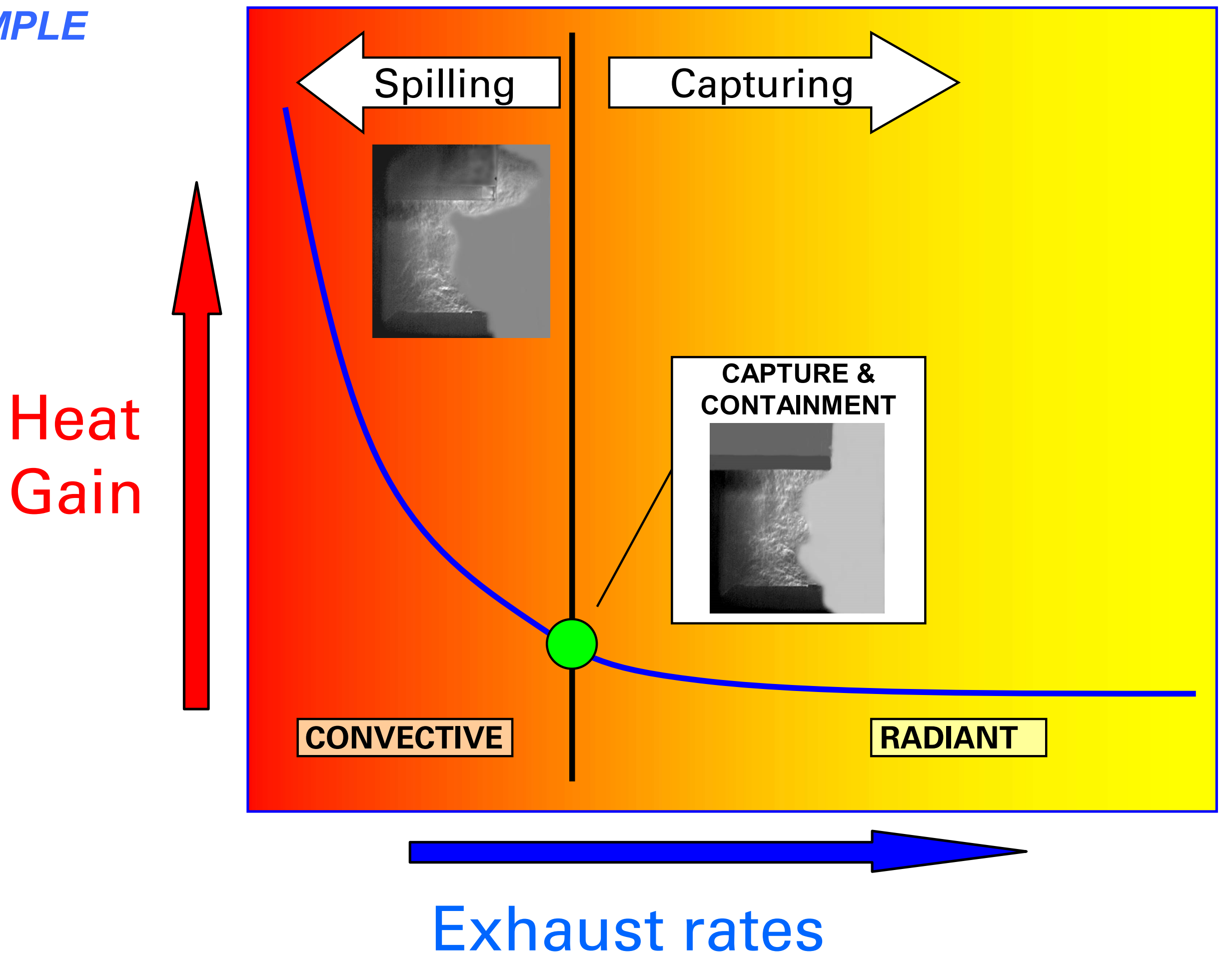


A hot kitchen drives down productivity and morale

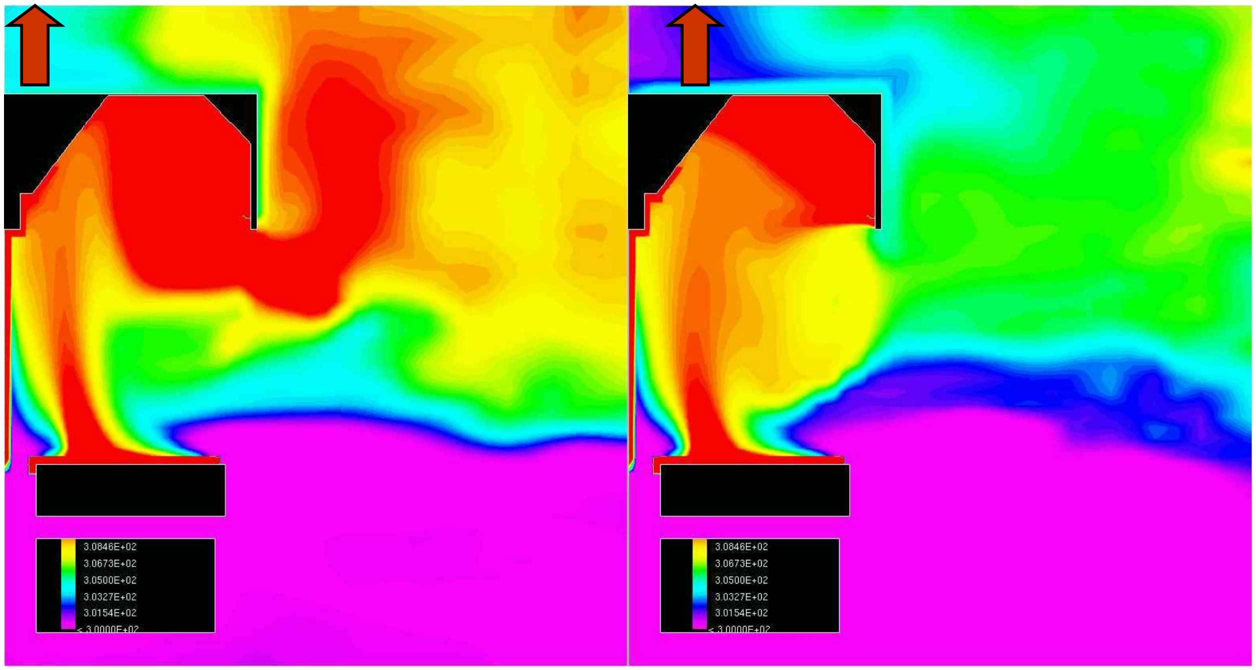
Efficient Hood Design

- Previous design methods have been based on overall hood size and positioning and ***MINIMUM UL 710 Criteria***
- Design process should start with actual heat load from cooking process
- Determine load splits and nameplate appliance ratings
- Determine most efficient hood design / location that is acceptable to clients cooking process

ASTM F 1704/2474 HEAT GAIN CURVE GENERIC EXAMPLE



High efficiency hood, CFD simulation



CFD simulation of two hoods operating at the same exhaust airflow. On the left – hood spilling convective plume from hot appliance into the kitchen. On the right – hood operating at C&C airflow.

Schlieren Thermal Imaging

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

Standard Hood w/out Capture Jets

KVE with Capture Jets
(Appliance : 600°F)

Minimize exhaust airflow

Hood exhaust airflow defines HVAC energy consumption
Reduction of hood exhaust airflow provides:

- Saving of fan motor energy consumption
- Reduction of HVAC system energy consumption to condition (heat and cool) replacement air
- Energy and environmental impact of increasing outdoor airflow by 100 cfm

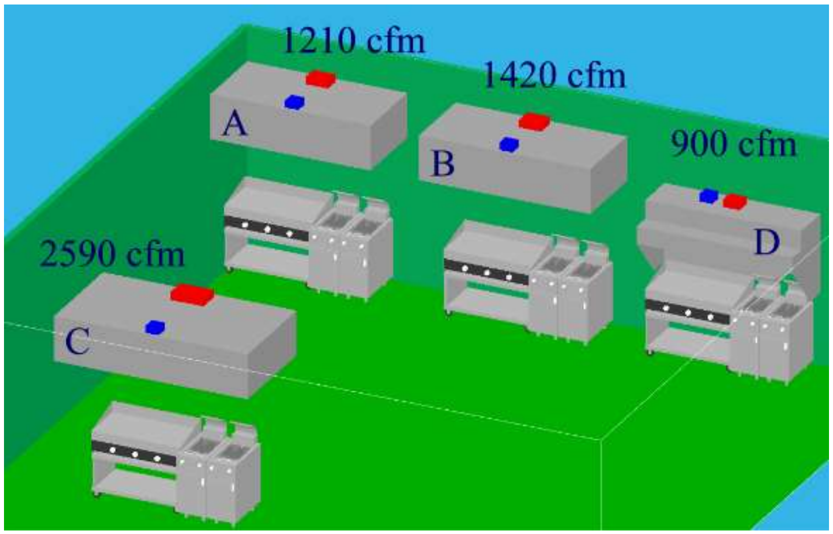
City, State	Electricity Consumption	Gas Consumption	CO^2 emissions
	kWh	Mln Btu	lb
Atlanta, GA	373	1.7	713
Chicago, IL	165	5.6	852
Las Vegas, NV	381	0.6	656
Los Angeles, CA	19	0	15
Miami, FL	1365	0	1897
Minneapolis, MN	158	8.2	1201
New York, NY	162	3.8	588
San Francisco, CA	18	0.3	49

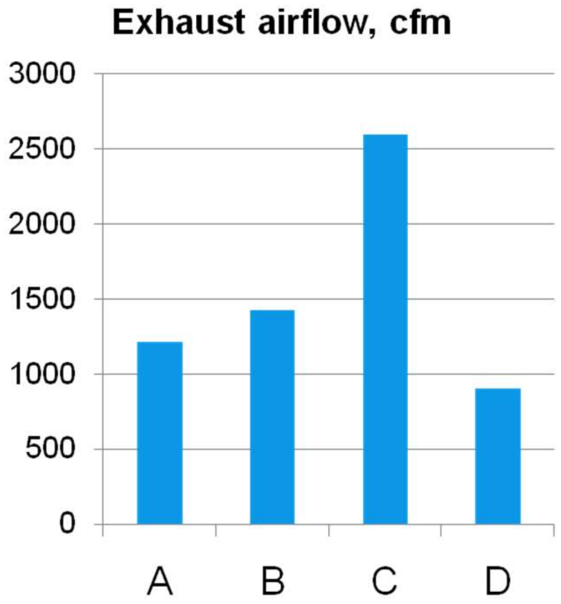
Basis for calculation: Restaurant operates from 7:00 AM to 11:00 PM seven days a week. Electricity consumption is calculated based on energy required to operate supply and exhaust fans to move additional 100 cfm of air and energy consumption by compressor of refrigeration system to cool outside air in summer down to kitchen indoor air conditions (76°F, 50% relative humidity). Calculation of gas consumption is based on amount of gas required to heat the make-up air in winter to 50°F. Carbon dioxide emissions to the atmosphere are calculated based on gas consumption as well as electricity consumption, using emission factor (CO2 emissions per unit of electricity produced) for corresponding city.

How to reduce hood exhaust airflow

- Position cooking appliances close to the walls, avoid island installations when possible
  - Enclose appliances with the walls
- Use high efficiency, close proximity hoods
- Use Demand-Controlled Ventilation (DCV)
- Use Efficient Air Distribution Systems
  - Thermal Displacement Ventilation TDV allows reducing hood exhaust airflow and improve thermal comfort

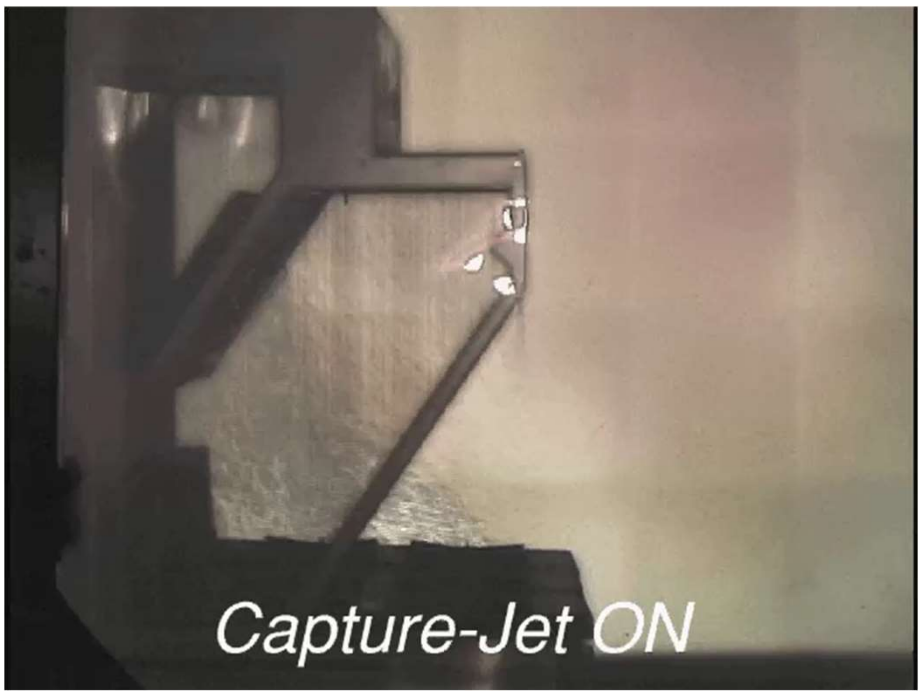
Appliance position in a kitchen and type of hood being used has a major effect on exhaust airflow

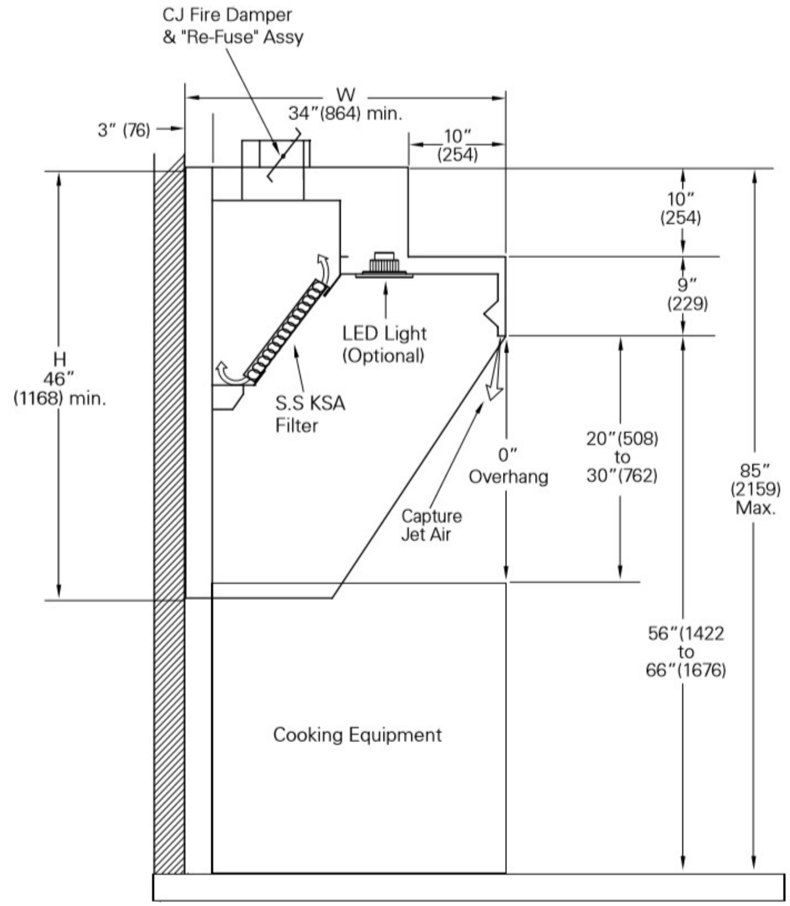




A – appliances in the corner with canopy wall hood; B – appliances at the wall with canopy wall hood; C – appliances in the middle of the space with canopy island hood; D – appliances at the wall with close proximity back-shelf hood.

Different Hood Styles





Energy Comparison

- Capital cost and energy analysis based on project specifics
- Calculated ROI on both hoods and controls
- Parameters are adjusted to local considerations and utility costs
- What is acceptable ROI to owners??

Halton Energy Analysis Tool (HEAT) Version 2020.01.0

Economic and Environmental Analysis Report

Project Name P4			
Remaining Building Life (Years), yrs	15	Energy Rate	
		Electricity, $/kWh	0.100
Total Length of Hoods, ft	25.0	Gas, $/Therm	1.000
Weather City:		Annual Rate Increase, %	2
Tampa, FL, USA		Discount Rate, %	1
Operating Hours from		Days per Week	7
08:00 AM to 10:00 PM		Hours per Day	14

	Hood Summary		M.A.R.V.E.L.
	Halton	Other	Summary
Exhaust Airflow, cfm	5,800	7,540	3,770
Fan Pressure Drop, In. WC	1.50	2.25	1.50
Fan Efficiciency, %	60	60	60
Exhaust Fan Size, HP	2.28	4.46	2.28
DCV Fan Curve			Default
Hood Cost	$35,000	$20,000	

Capital Expenditures

Hood Cost Differential	$15,000	
M.A.R.V.E.L. Cost	$25,000	
Installation Cost	$0	
Utility Rebate Credit	$0	
Cooling Equipment Savings (+)	$(20,397)	[8.2 Tons]
Fan and Ductwork Savings (*)	$(3,045)	
Total Captial Expenditures	**$16,558**	

First Year Energy Cost Savings

Cooling	$4,694	[46,938 kWh]
Heating	$352	[352 Therms]
Exhaust Fan	$1,408	[14,082 kWh]
Supply Fan	$523	[5,231 kWh]
Lights	$652	[6,523 kWh]
First Year Energy Cost Reduction	**$7,629**	

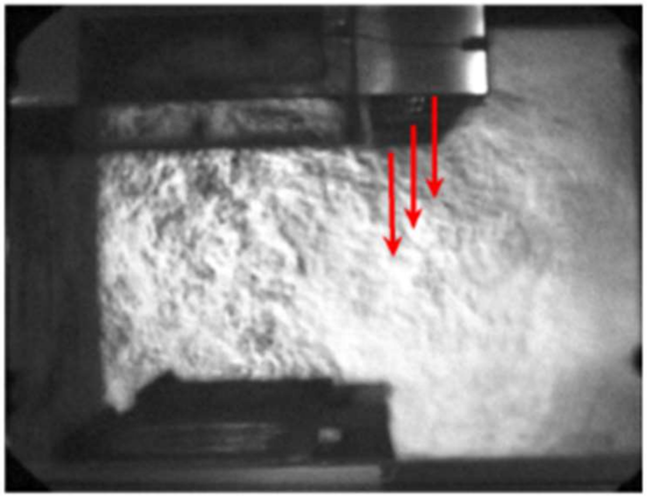
Pay Back Period 2.1 Years	Net Present Value $69,112	Return on Investment 417%
Based on Cumulative Cash Flow Before Tax	NPV Calculated at Year 15	Net Present Value / Cost * 100

(+) Based on cooling equipment price of 2,500 $/Ton

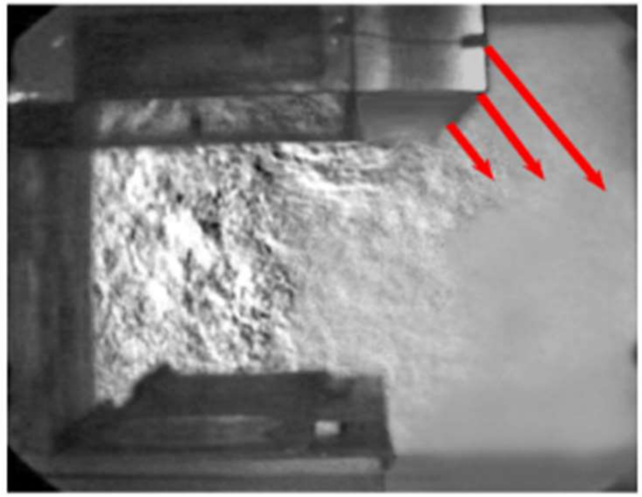
(*) Based on fan & ductwork price of 1.75 $/cfm

1

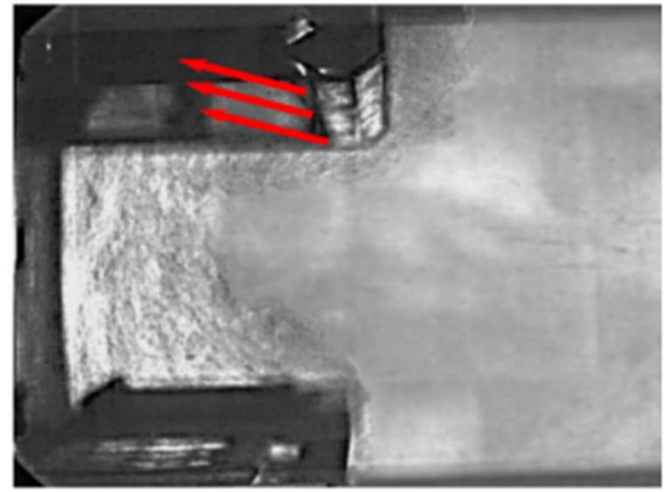
MUA Impact on Hood Performance



Air Curtain MUA Supply



Front Face MUA Supply



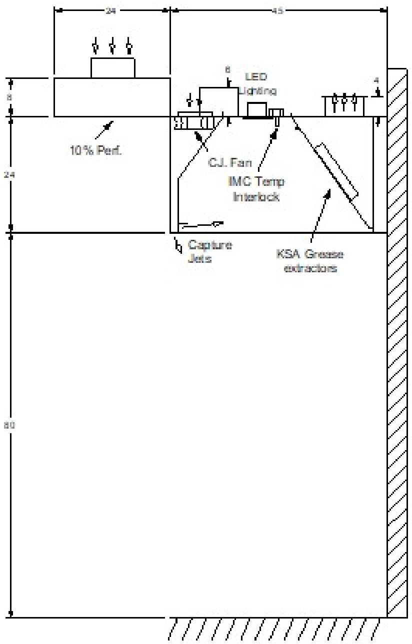
Short Circuit MUA Supply

Images from 2015 ASHRAE Handbook: HVAC Applications, Chapter 33 Kitchen Ventilation

- When delivered improperly, makeup air can result in convective heat and cooking effluent spilling to space.
- Low velocity delivery of supply air near hood is critical for optimizing hood performance. Displacement or low-velocity from ceiling diffusers are best

Low Velocity Diffusers

- 2x2 or 2x4
- Stainless Steel or White finish
- Ability to deliver high volumes of air at low velocity within 2’ of kitchen hood (750 CFM for 2x2 and 1500 CFM for 2x4)
- Low sound levels and low pressure drop
- Compatible with Halton VAV terminal boxes for M.A.R.V.E.L. DVC systems



MUA Temperature

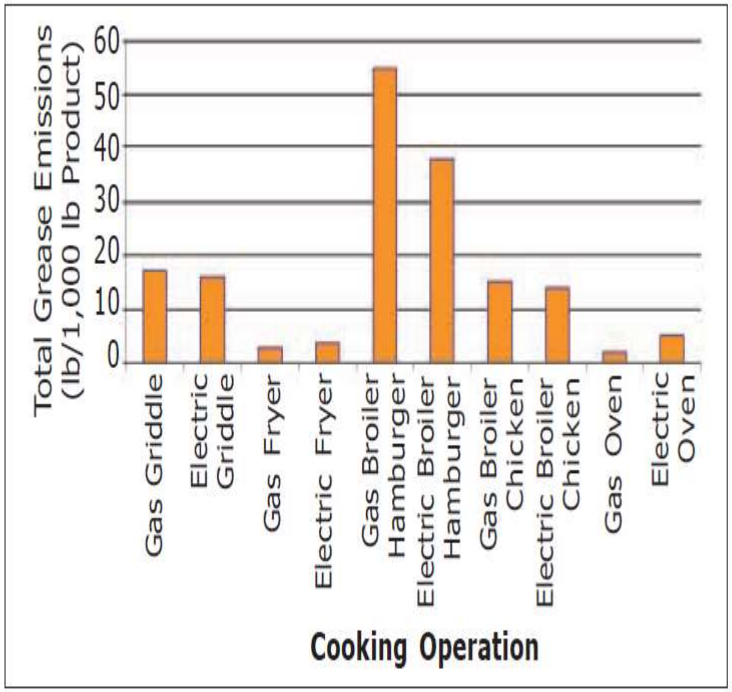
508.1.1 Makeup air temperature. The temperature differential between *makeup air* and the air in the conditioned space shall not exceed 10ºF (6ºC) except where the added heating and cooling loads of the *makeup air* do not exceed the capacity of the HVAC system.

❖ Makeup air that is not introduced directly into or close to the exhaust hood must be tempered to within 10ºF (6ºC) of the temperature of the conditioned air within the space. The intent is to prevent the makeup air from causing employee discomfort, which might encourage employees to shut down or restrict the

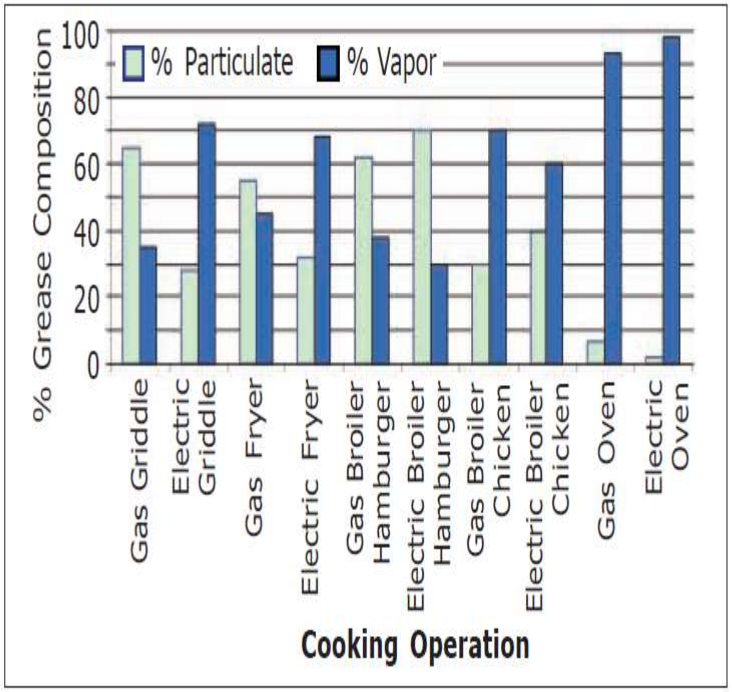
Grease Extraction Efficiency…

- Effluent quantified on 1000 lbs of product cooked
- Characterization based on product cooked and vapor / particulate concentration
- Particle size distribution by cooking process

ASTM 2519: Performance of Grease filters
Baselines and effluent breakdowns



Cooking emissions as a function of cooking process.



Vapor and particulate ratio in cooking emissions.

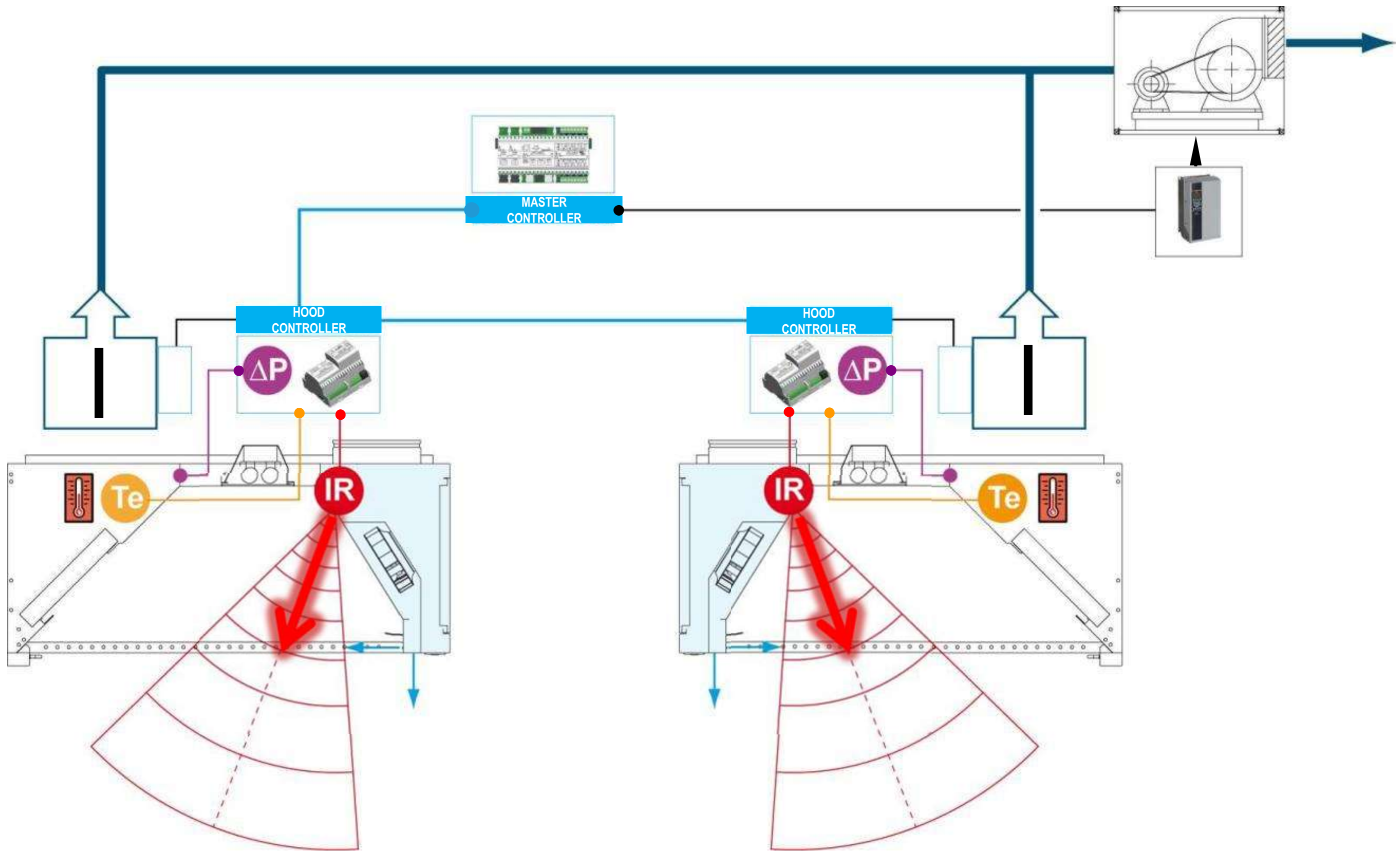
Efficient 1st Stage Grease Extractor

- Grease particles $\geq$ 5 microns separated by centrifugal action of the Multi Cyclone extractor.
- Enhances ability of Capture Ray to act on smaller grease particles and vapors.
- Quieter Hood operation

Advanced Mechanical

KSA Grease Extractor

Demand Control Ventilation



Demand CKV components

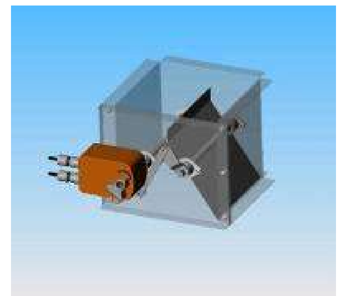
Infrared sensor (IRIS)

Exhaust collar temperature sensor

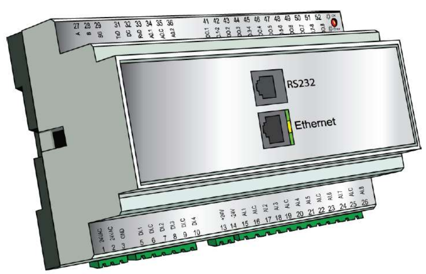
Space temperature sensor

Pressure transducer

Automated damper



VFD



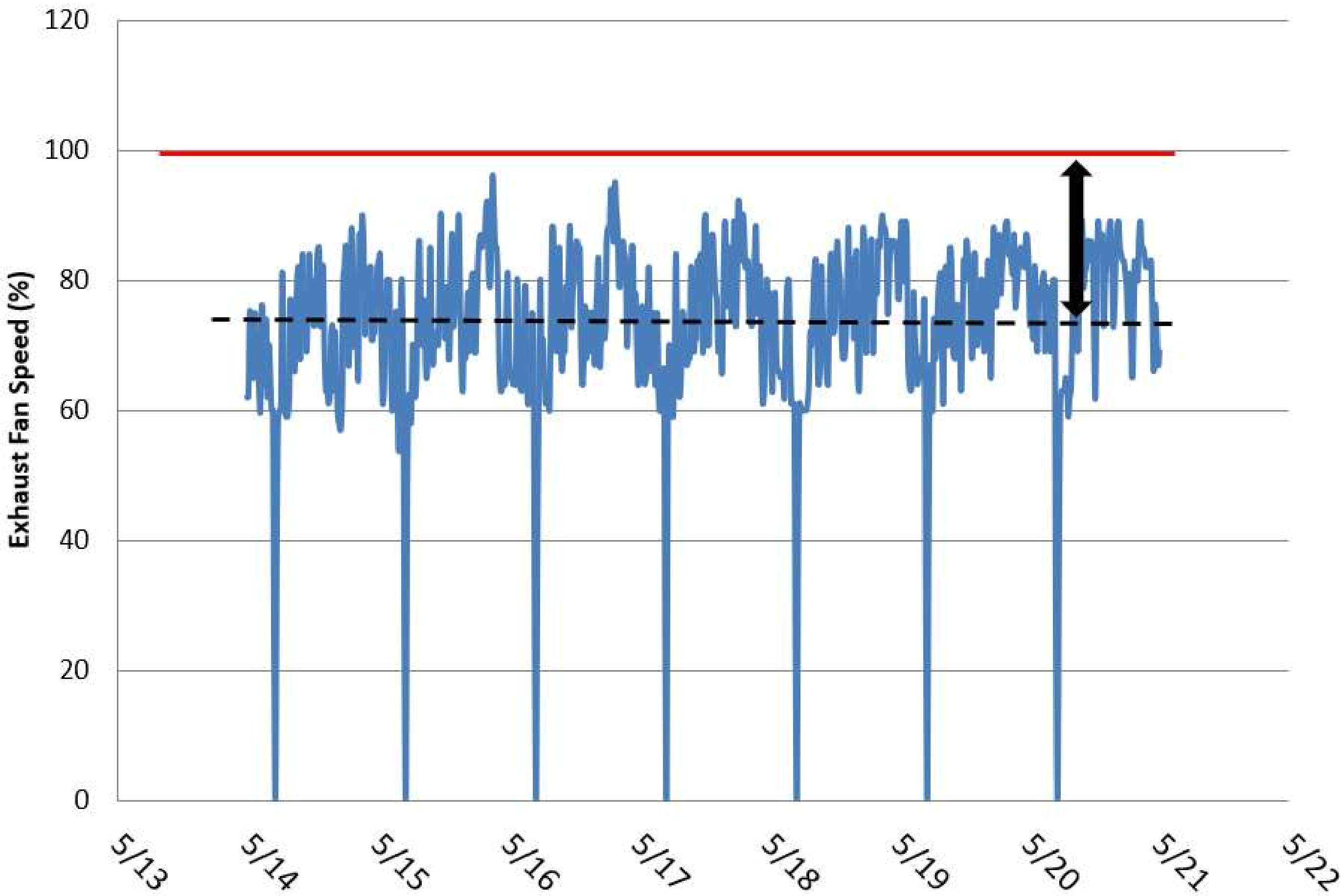
Controller

What does IMC say about DCV?

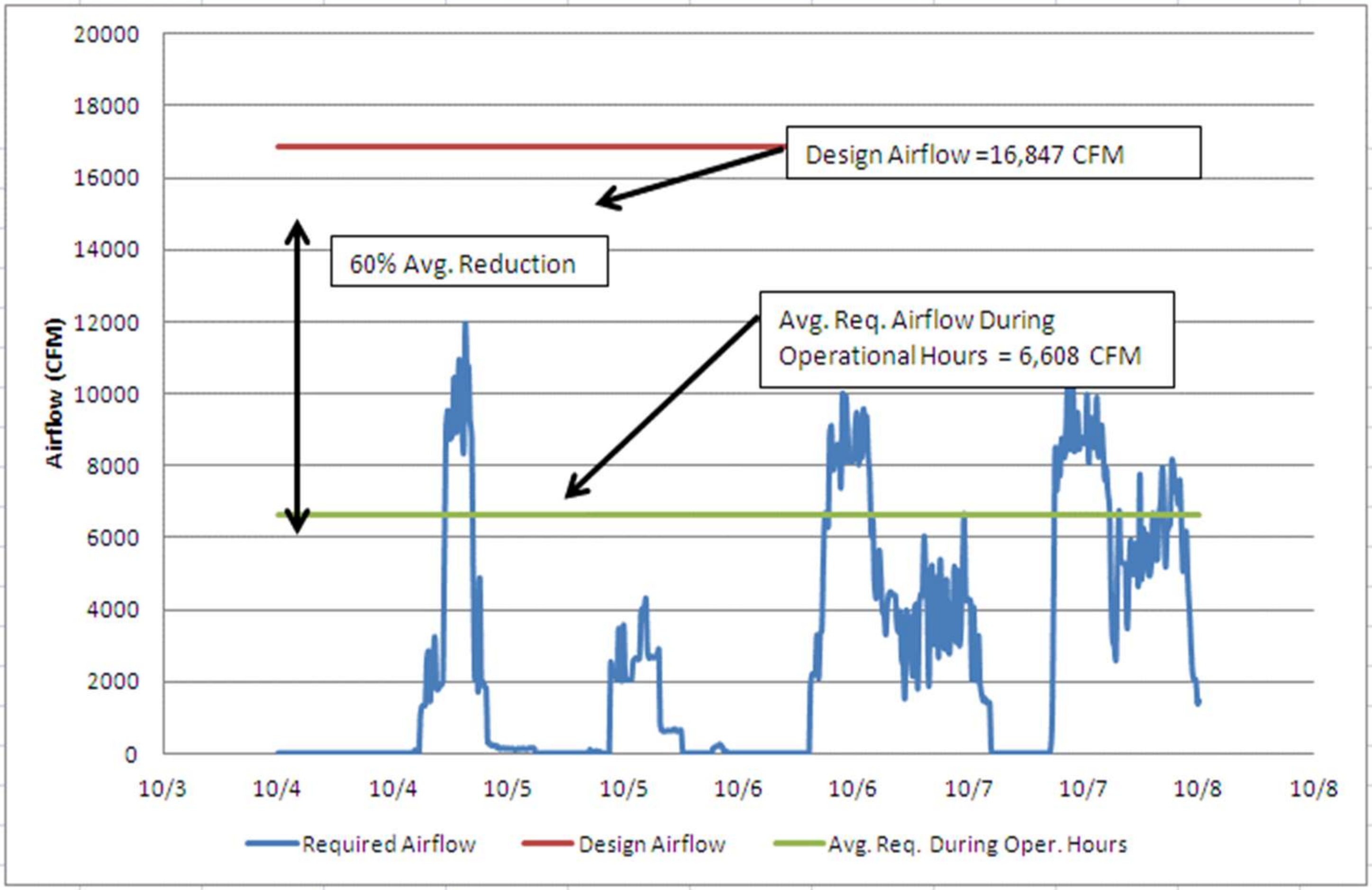
Section 507.1.1: Operation

The net exhaust volumes for hoods shall be permitted to be reduced during part-load cooking conditions, where engineered or *listed* multispeed or variable speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this section. Reduced volumes shall not be below that required to maintain capture and removal of effluents from the idle cooking appliances that are operating in a standby mode.

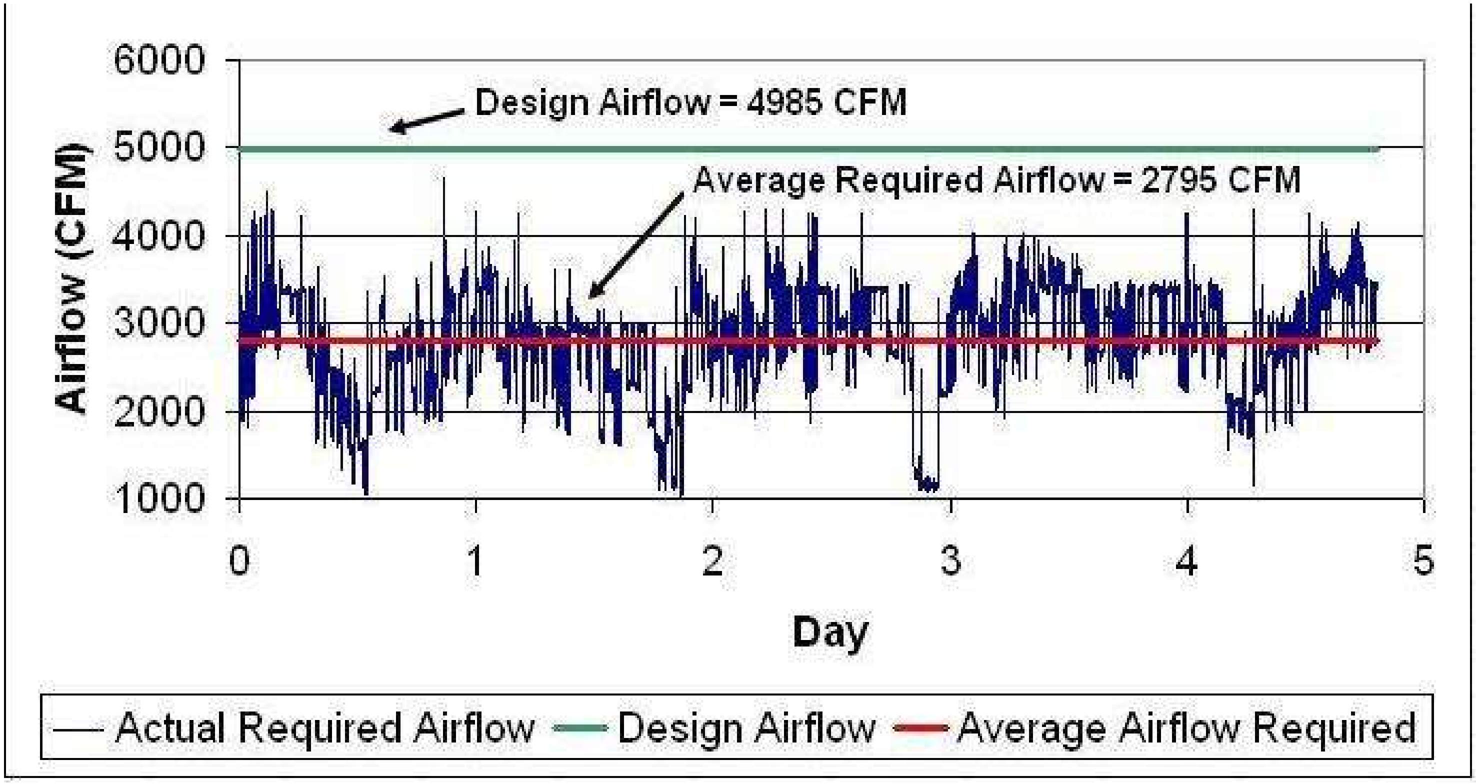
Airflow reduction at a Full Service Restaurant
~ 30% average reduction



Airflow reduction at a College/University ~ 60% average reduction



Airflow reduction Quick Serve Restaurant ~43% reduction



Choose Carefully

- There are various methods to determine cooking activity.
- Most accurate and effective include activity sensing (optical/IR)
- Least accurate, least effective are temperature sensing only

Appliance	Time From Start of Cooking (Seconds) When Design Airflow Reached				
	Temperature + Cooking Activity Sensor	Temperature Only Curve	Constant Temperature, SP=90°F	Constant Temperature, SP=100°F	Constant Temperature, SP=130°F
Charbroiler	23	N/A	N/A	N/A	N/A
Griddle	35	174	N/A	181	N/A
Open-Vat Fryer	23	N/A	297	N/A	N/A

Table 2: Response time comparison.

ASHRAE Journal, Nov 2012

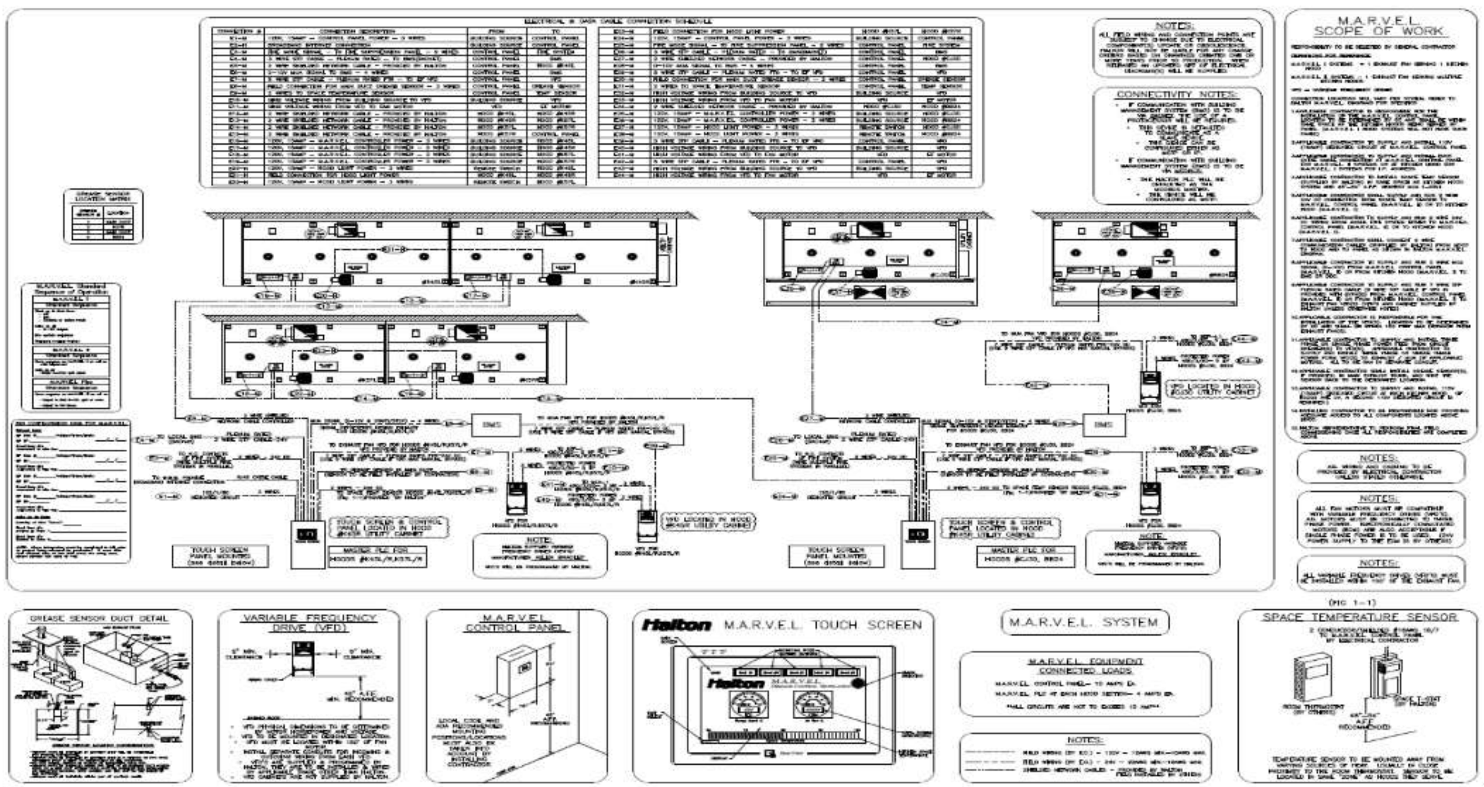
Demand Control Ventilation

Single Fan, Single Hood

Single Fan, Multiple Hoods

Design scope integration is critical…

Demand ventilation system implications and complexity



ASHRAE 90.1 in CKV

- 2010 Changes for Commercial Kitchen Ventilation
- Promotes efficient kitchen hoods and energy efficiency without penalizing indoor environment
  - Re-written with collaboration of TC 5.10 and restaurant industry experts
- Requires at least one energy conservation measure for kitchens that exhaust more than 5000 CFM (e.g. Heat recovery, demand control ventilation, maximum use of transfer air)
- Reduces exhaust requirements from the norm by 30% or more (e.g. norm by ASHRAE 154 Standard)

ASHRAE 90.1-2010/13

6.5.7.1.4 If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 CFM then it shall have one of the following:

A. At least 50% of all replacement air is transfer air that would other wise be exhausted.

B. Demand ventilation system(s) on at least 75% of the exhaust air. Such systems shall be capable of at least 50% reduction in exhaust and replacement air system airflow rates, including controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent and combustion products during cooking and idle.

C. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow.

ASHRAE 90.1-2010/13

TABLE 6.5.7.1.3 Maximum Net Exhaust Flow Rate, CFM per Linear Foot of Hood Length

Type of Hood	Light Duty Equipment	Medium Duty Equipment	Heavy Duty Equipment	Extra Heavy Duty Equipment
Wall-mounted canopy	140	210	280	385
Single island	280	350	420	490
Double island (per side)	175	210	280	385
Eyebrow	175	175	Not Allowed	Not Allowed
Backshelf/ Pass-over	210	210	280	Not Allowed

- Optimizing individual components of a restaurant has limited impact on its energy performance, whole building approach is required.
- Motivated, multidisciplinary team is critical for a successful design of an energy efficient restaurant
- Start optimization from cooking process and equipment
- Design ventilation system that is tailored for this particular cooking process, **minimize hood exhaust airflow**
- Use integrated facility monitoring and control system to optimize performance of mechanical systems for energy efficiency and wellbeing of kitchen personnel

Menu for energy efficient design

Questions?

Thank You!