Seidel Research & Development Company, LLC (SRADCO) Project: EC-08-27CKV

Commercial Kitchen Ventilation Energy Assessment Columbia: The District

August 27, 2012

Prepared For:

Columbia Water & Light Department
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Columbia, Missouri 65201

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1.0 Identification and Certification

<u>Client</u>
City of Columbia
Water & Light Department

<u>Energy Consultant</u>
David L. Seidel P.E.
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The undersigned certifies that this energy efficiency consultation report has been conducted in accordance with the requirements of the Technical Energy Study Procedures Manual, and the data presented is accurate and meets all applicable building codes and standards to the best of the technical energy consultant's knowledge. The undersigned certifies that the data and cost reduction estimates presented are factual, accurate, and reasonable and in accordance with generally accepted engineering practices to the best of the consultant's knowledge, and that this knowledge is based on the consultant's investigation. The undersigned certifies that there is no conflicting financial interest from the completion of the energy efficiency consultation. The undersigned certifies that the undersigned is qualified, or has received qualified assistance, to perform the functions of an energy consultant in accordance with the requirements set forth in the Technical Energy Study Procedures Manual.

David L. Seidel

Energy Consultant

27 August 2012
Date

2.0 Preface and Executive Summary

2.1 Preface

Seidel Research and Development Company LLC (SRADCO) was retained to provide energy efficiency consulting services by the City of Columbia Water & Light Department. The purpose of the energy efficiency consultation is to provide information about the facilities' energy consumption profiles, regarding the kitchen ventilation, and recommend energy efficiency solutions that may reduce its energy cost.

The Columbia Water & Light Utility Services Division has been active in addressing the concerns on their commercial customers, including restaurants. 26 restaurants are participating with the city in the EPA's Climate Showcase Communities Grant. As part of this grant the City is investigating ways to reduce unnecessary energy consumption and reduce greenhouse emissions.

Operating a restaurant's kitchen equipment adds significant utility costs to the operations of a business. Thus, restaurants have very high site energy use intensity per square foot, especially compared to other business or facility types. A restaurant's ventilation system, made up of the HVAC equipment, the exhaust fans and makeup air fans, can adversely affect the energy use as well as the comfort of the restaurant. An imbalance in the kitchen ventilation system would cause unnecessary energy consumption due to heating and cooling the excess air flow. The Columbia Utility Services staff identified a number of restaurants in The District with high negative air pressure and suspected an air imbalance was the cause. SRADCO was hired by the city to investigate this further as a possible means to eliminate unnecessary energy consumption by our commercial restaurant customers.

The Commercial Kitchen Ventilation Energy Assessment for the City of Columbia involving SRADCO began on May 16, 2012 with an initial facility meeting. The facility walkthroughs were conducted throughout the month of May. The areas investigated were the HVAC systems, kitchen hoods, kitchen appliances, and exhaust ventilators.

This report contains the following energy consultation components for developing the recommendations for this client:

- Kitchen Ventilation Profiles
- Energy Usage of the Restaurant Kitchen
- Kitchen Appliances under the Hood
- Commercial Kitchen Ventilation Solutions
- Recommendations

2.2 Executive Summary

This energy assessment profiled eight restaurants in the District Showcase Program with the highest negative building pressures. Twenty-six restaurants were measured by the City of Columbia Water & Light energy efficiency staff.

2.2.1 Commercial Kitchen Ventilation Assessment Inventorying

The commercial kitchen ventilation (CKV) assessment inventory was focused on the kitchen appliances under the hoods, hood type, make-up air, exhaust air, and infiltration air into the restaurant. From the inventory, an air flow and energy balance of the restaurant was calculated with infiltration profiling in a computer simulation. A detailed individual report for each restaurant is available in Appendix A.

SRADCO conducted infrared imaging of the hoods, appliances and the exhaust fans to verify temperature values for exhaust air flow corrections. A display of select IR images can be found in Appendix B.

2.2.2 Commercial Kitchen Ventilation Recommendation Summary

The following commercial kitchen ventilation recommendations are based on the recent science of the modern design of kitchen hood performance:

1. Modify or Replace any Self-compensating (Short Circuit) Hoods
2. Install EMS (Energy Management System) to balance and control fan speeds by exhaust temperature
3. Replace the AHU supply diffusers near hood with low face velocity perforated type
4. Install perforated make-up air supply plenum on front of existing hood
5. Install end panels to current hoods if applicable

The remainder of this report outlines the findings of the energy assessment in greater detail including the investigative procedures, commercial kitchen ventilation profiles, analysis details, and detailed recommended solutions.

3.0 Commercial Kitchen Ventilation Analysis Procedure

After the energy inventory was compiled and the occupancy schedule determined, the following procedures were used to develop the base energy consumption profile and the energy efficiency project simulations:

- Established Boone County weather profiles for the computer simulation
- Inputted the ventilation data into the eQuest computer simulation
- Performed baseline computer runs to simulate energy profiles based on ventilation
- Finalized baseline computer simulation
- Established most feasible and economical energy efficiency projects
- Simulated and evaluated energy efficiency projects
- Established and prioritized energy efficiency projects by savings
- Conducted cost and simple payback analysis on energy efficiency projects
- Presented energy efficiency project recommendations

The above procedures and steps were followed and the results are contained in this report.

4.0 Commercial Kitchen Ventilation Profiles

The eight restaurants selected for this commercial kitchen ventilation assessment were chosen because of the high negative pressure in the restaurant which is an indicator of the imbalanced air ventilation problem.

The following table shows the restaurants and their energy intensity Energy Star ratings based on the most recent 12 months of utility bills and the negative differential pressure readings:

Restaurant ID	Year Built	SF	Total Energy (kBtu)	Energy Intensity (kBtu/SF)	Rest. Nat'l avg. EUI (kBtu/SF)	Pres. Dif. (Pascals)
A	1923	1,380	634,965	460.1	207.0	-38.5
B	1950	4,972	779,874	156.9	207.0	-36.4
C	1997	3,000	821,782	273.9	207.0	-32.5
D	1962	1,700	838,985	493.5	207.0	-32.4
E	2005	3,852	1,109,742	369.9	207.0	-29.9
F	1900	6,000	1,303,481	217.3	207.0	-28.5
G	1935	9,000	5,296,408	588.5	207.0	-14.3
H	1998	2,200	834,701	379.4	207.0	-14.2

The total energy consumption is the combined energy from the 12 months of natural gas and electric utility bills converted into thousands (k) of Btu. The table compares the building's energy intensity (Column 5) with the Energy Star national average for restaurants (Column 6).

The commercial kitchen profiles of the eight restaurants assessed are as follows:

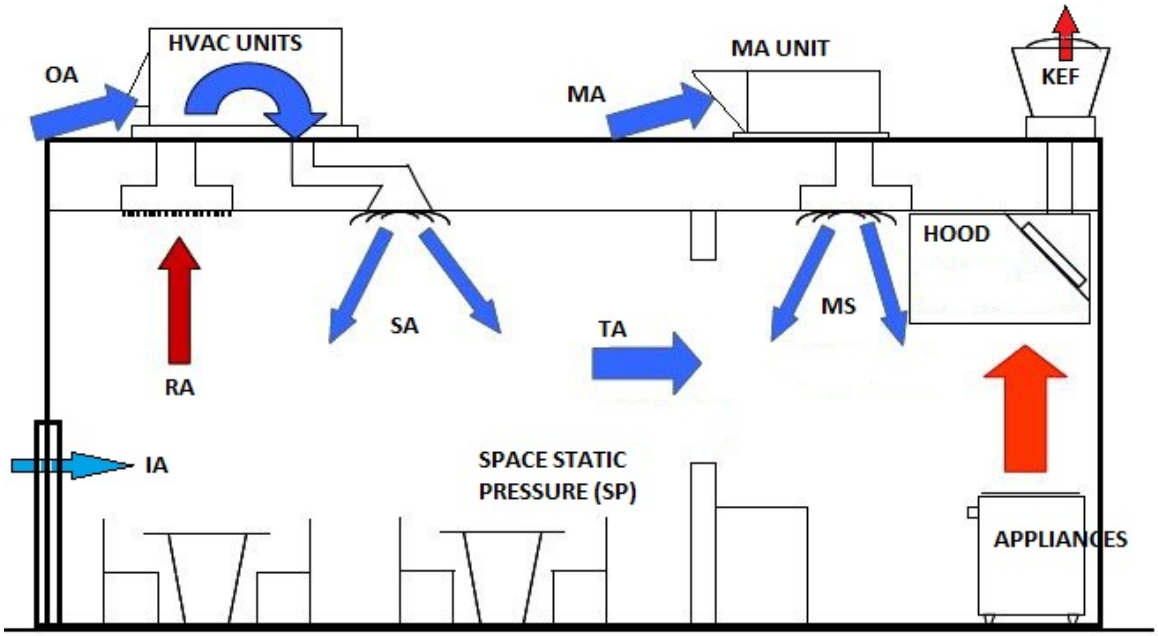
- Total of 13 hoods: one rear makeup air discharge type; one eyebrow hood type; two dishwasher hood types; and nine self-compensating hoods. The self-compensating hood design does not capture appropriately and is banned in most major cities today because of public health concerns such as the grease on floor, surfaces and the food waiting to be served.

- All eight restaurants had high negative pressure readings due to the imbalance between exhaust air and make-up supply air. In many cases, the contractor oversized the exhaust blower greater than the engineer's design specifications to assure enough air flow to capture the appliances' vapors. The oversizing ranged from 6% to 63%. In some cases, the make-up air was reduced drastically, or even turned off, because the hood was not properly capturing with the make-up air activated.

- In all eight restaurants, the kitchen exhaust air flow causes the clientele discomfort in entering and dining due to cold or hot drafts from the doors.

- Clean-up of oil and grease on surfaces due to poor hood capture are evident in each restaurant. Hood and HVAC filters are washed daily in most of the eight restaurants.

The following diagram was designed to illustrate the common air flow and kitchen ventilation systems of the studied restaurants.



IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Transfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply; KEF = Kitchen Exhaust Fan; EF = Exhaust Fan; SP = Static Pressure; CFM = Cubic Feet per Minute

5.0 Operation and Maintenance Procedures

During the investigation, the following practical operation and maintenance procedures were identified which would increase the performance of the HVAC systems and associated kitchen ventilation systems:

- The inspection and joint caulking of ductwork, repair or weather-stripping of the filter excess doors on the HVAC units
- The inspection and replacement of the air filters in the HVAC units should be conducted on a monthly basis
- The inspection and cleaning of fins on condensing units and return air grilles
- Regular inspection of blowers for noise and need for bearing lubrication

6.0 Commercial Kitchen Ventilation Solutions

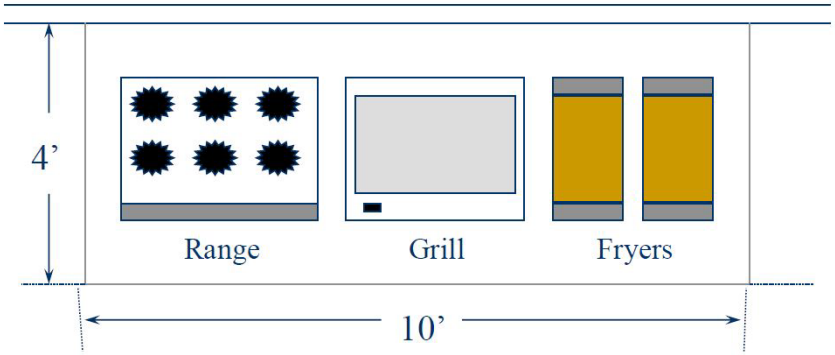
A screening of possible energy efficiency solutions was conducted and is presented at the beginning of Appendix E. After evaluating the possible energy efficiency solutions, the overall most effective and efficient solution is highlighted and explained in the table below:

Restaurant ID	Total Energy Used MMBtu/ Yr	Total Energy Savings MMBtu/ Yr	Electric Energy Saved MMBtu/Yr (kWh) [kW]	Natural Gas Energy Saved MMBtu/Yr (Therms)	Energy Reduced %	Total Savings	Total Cost	Payback Yrs
A	635.0	113.4	30.1 (8810) [0.3]	83.3 (833)	18%	$2,316	$11,800	5.10
B	779.9	176.5	47.4 (13910) [0.6]	129.0 (1290)	23%	$3,614	$14,200	3.93
C	821.8	205.4	54.5 (15960) [0.7]	150.9 (1509)	25%	$4,197	$9,350	2.23
D	839.0	91.6	839.0 (7120) [0.3]	67.3 (673)	11%	$1,872	$8,900	4.75
E	1,109.7	111.8	111.8 (32740) [2.2]	0.0 (00.0)	10%	$3,437	$10,150	2.95
F	1,303.5	156.0	41.4 (12120) [0.4]	114.6 (1146)	12%	$3,188	$9,100	2.85
G	5,296.4	321.5	85.4 (25010) [1.5]	236.1 (2361)	6%	$7,942	$26,150	3.29
H	834.7	113.5	30.2 (8840) [0.4]	83.4 (834)	14%	$2,320	$9,950	4.27

6.1 Illustration

The following Illustration shows the potential value of reducing the ventilation rate.

With today's UL Listed hood testing, the air flows required to capture the cooking vapors has been significantly reduced from earlier years, and the exhaust duct velocity ASHRAE standard has been reduced from 1,500 feet per second to 500 feet per second. This new design parameter allow for an energy management system to idle the blowers when there is no cooking and sense rising heat temperatures to speed them up to maximum capture flows when needed. Ultimately, this optimizes the effectiveness of the hood ventilation design. The following illustration is an example of optimized ventilation design:



Unlisted hood (4 ft x 10 ft)	40 x 100 cfm = 4000 cfm
UL listed hood	10 ft x 250 cfm = 2500 cfm
(with end panels)	9 ft x 250 cfm = 2250 cfm
(optimized hood and end panels)	9 ft x 200 cfm = 1800 cfm

The above illustrated is taken from the published California Energy Commission Document No. P500-03-34F titled" Design Guide: Improving Commercial Kitchen Ventilation System Performance, and is based on the 2003 ASHREA Fundamental Handbook.

7.0 Recommendations

After thorough examination of the most recent commercial kitchen ventilation design guidelines and regulations, we recommend that the restaurants take the following actions in order to optimize their kitchen ventilation and energy consumption:

1. **Modify or replace any self-compensating (Short Circuit) hoods**

   Since the self-compensating hoods are not functioning properly, and are no longer considered reliable by the restaurant industry, it is recommended that the hoods be modified or replaced entirely. New kitchen ventilation hood systems are more efficient and require less air flow to capture the contaminants. If the restaurant cannot afford to replace the hood with a better designed hood and system, the hood can be modified with

side panels, reconfiguring appliances under the hood to add divider panel, and a supply plenum to correct the capture problem to make the system more energy and capture efficiency.

2. **Install EMS (Energy Management System) to balance and control fan speeds by exhaust temperature**

   The installation of a simple energy management system which controls the makeup air and exhaust blowers speeds by the exhaust temperature can reduce the total heating and cooling load on the restaurant space.

3. **Replace supply diffusers near hood with low face velocity perforated type**

   If curved-blade supply air diffusers are identified as being near (within 12 feet) for the hood, it is recommended that the diffusers be replaced with low velocity perforated type diffusers. High velocity air movement across the front of the hooded cooking area may disrupt the smoke/vapor capture effectiveness of the hood system. The air can move the smoke and vapor out the opposite end of the hood.

4. **Install perforated make-up air supply plenum on front of existing hood**

   The best solution for modifying the self-compensating hood is to blank off the inside hood supply diffuser and install a perforated supply plenum to the exterior of the hood. This solution will allow a wall or curtain of air from high above the hood's exterior ceiling to flow downward to the space outside the appliances which prevents the smoke/vapor from escaping the hood. The result is better capture with less exhaust air from the hood exhaust system.

5. **Install end panels to current hoods if applicable**

   If there are no side walls at the end of the hood or 45 degree panels on the hood, then it is recommended that they be installed. The side panels have been proven to prevent the escape of smoke/vapor from the ends of the hood. By installing side panels where no end wall exists, reduces the air flow capture exhaust volume requirements.

If the commercial kitchen ventilation is poor and a large amount of exhaust air causes the building to have a high negative pressure, then the kitchen exhaust and make-up air system must be modified to properly capture smoke/vapor and reduce energy costs.

If ovens and dishwashers do not have hoods or exhaust ductwork and it affects the working conditions in the kitchen, then the owner is advised or even required by building code to install such hooded exhaust systems or exhaust ductwork.

8.0 Reference Resources

The best found resource for the basis of these CKV design recommendations is the California Energy Commission Document titled" Design Guide: Improving Commercial Kitchen Ventilation System Performance," which can be found in Appendix C.

Other resources that are helpful in CKV design are located at the following web links:

http://www.energystar.gov/index.cfm?c=small_business.sb_restaurants
http://www1.eere.energy.gov/femp/program/waterefficiency_bmp11.html
http://www.cee1.org/com/com-kit/com-kit-main.php3
http://www.fishnick.com/
http://conserve.restaurant.org/
http://fypower.org/pdf/BPG_RestaurantEnergyEfficiency.pdf
http://www.wbdg.org/design/232813.php
http://www.energyright.com/business/pdf/Kitchens_SC_ESCD.pdf
http://www.sustainablefoodservice.com/index.html
http://www.foodservicewarehouse.com/education/going-green/

Appendix A

Individual Restaurant CKV Reports

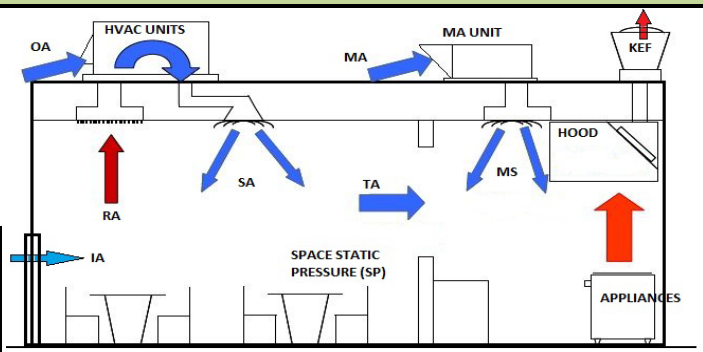
COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/20/2012

Client: Restaurant # 1
Address:

Assessment Date: 16-May-12

Kitchen Ventilation System



HVAC System Parametrics	
HVAC Type	Furn/CU (Roof)
HTG-Tons	3
CLG-Tons	3.5
HTG Type	Nat Gas

Kitchen Parametrics		Kitchen Parametrics	
Exh Sys Type	Short Circuit MA	Exh Sys Type	Short Circuit MA
Hood 1 Type	Wall Mtd /side walls	Hood 2 Type	Wall Mtd /side walls
Hood LxW	4'6"x4'x2'	Hood LxW	8'x3'2"x2'
Appl Arrangemt	F,4R	Appl Arrangemt	Gr, 8R
DW Hood	None	DW Hood	None
Other Hoods	Yes (2nd EXH Hood)	Other Hoods	Yes (1st EXH Hood)
Other Exhaust	None	Other Exhaust	None

HOOD 1	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	1080	270	1350	-	-	-
Installed	0	0	1400	1000	400	1400	-	-	-
Measured	500	-0.15	1400	920	82	1502	31.2	11.3	868
New Design	0	0.02	1400	900	225	1125	10.6	3.8	294
New Design/EMS	0	0.02	1400	576	144	720	6.8	2.4	188
								Total Savings	386
						MMBtu Saved	13.9	5.0	18.9

HOOD 2	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	1920	480	2400	-	-	-
Installed	0	0	1400	2000	400	2400	-	-	-
Measured	1000	-0.15	1400	950	566	2516	100.2	36.2	2788
New Design	0	0.02	1400	1600	400	2000	18.8	6.8	523
New Design/EMS	0	0.02	1400	1024	256	1280	12.0	4.4	335
								Total Savings	1930
						MMBtu Saved	69.4	25.1	94.5

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.

If more than one hood, see attached Multiple Hoods worksheet.

CKV Problem:

1) The system was installed with blowers greater than the engineer's design by 19 percent. (4283/3600)
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.

Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	6200
Two New 3 phase KEF motors (Verify size)	450
Two New 3 phase MA motors (Verify Size)	350
One 4.6 and One 8 ft Foot long Perforated Supply Air Plenum with collar duct transition and LED Lights	2500
Labor (Electrician)	2300
Total COST	$ 11,800
Total Savings $ 2,316	Payback Yrs 5.10

COMMERCIAL KITCHEN VENTILATION (CKV) ASSESSMENT

Client Report - 6/26/2012

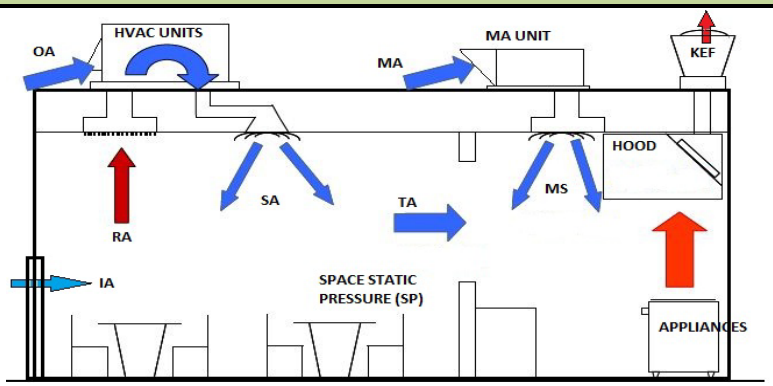
Client: Restaurant # 2
Address:

Assessment Date: 23-Apr-12

Commerical Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	RTU w/OA
HTG-Tons	20
CLG-Tons	10
HTG Type	Nat Gas

Kitchen Parametrics	
Exh Sys Type	Short Circuit/MA
Hood Type	Wall Mtd w/Side P.
Hood LxWxH	6'x4'x2'
Appl Arrangemt	F,F,Gr
DW Hood	None
Other Hoods	None
Other Exhaust	None



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply (MS) CFM	Outside Air (OA) CFM*	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $/yr
Design	0	0	4000	1600	400	2000	-	-	-
Installed	0	0	4000	2200	780	2980	-	-	-
Measured	1700	-0.14	4040	0	960	2660	166.3	61.5	4669
New Design	0	0.02	4000	0	527	980	23.7	9.0	672
New Design/EMS	0	0.02	4000	0	301	627	13.6	5.1	384
								Total Savings	3614
						MMBtu Saved	129.0	47.5	176.5

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.
If more than one hood, see attached Multiple Hoods worksheet.

* = OA is reduced by frequency to 80 fan speed & Restroom Fan rewiring

CKV Problem: Imbalanced Commercial Kitchen Ventilation (CKV) System

1) The system was installed with blowers greater than the engineer's design by 49 percent. (2980/2000)
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.
3) The above measured values are when the MA unit is not running, which is the way the system is presently being operated.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Transfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solution: CKV EMS Controls and MA Perforated Supply Plenum

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.

Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	2000
New Hood with side panel	3300
New 3 phase KEF motor (1/2 HP)	400
Disconnection of MA Unit (Abandon in place)	250
Additional HVAC Duckwork	750
Restrooms exhaust rewiring for split control and 2 new inline blowers	600
Ceiling removal and re-install around hood	300
Permits and general work	800
Labor (Fire Suppression & HVAC Ductwork)	4000
Labor (Electrician)	1800
Total COST	$ 14,200
Total Savings $ 3,614	Payback Yrs 3.93

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/20/2012

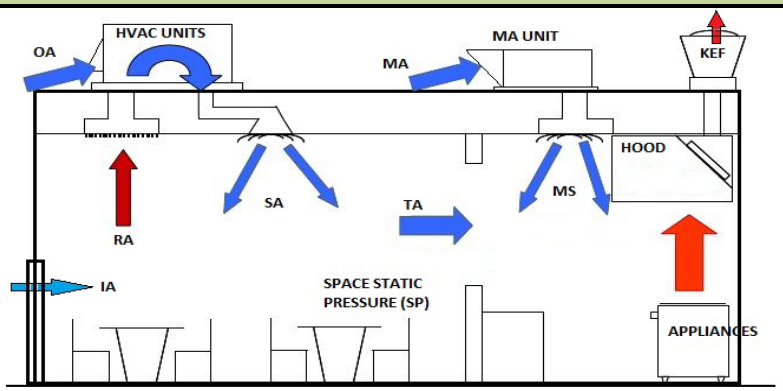
Client: Restaurant # 3
Address:

Assessment Date: 22-May-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	Furnaces/CUs
HTG-Tons	8
CLG-Tons	13
HTG Type	Nat Gas

Kitchen Parametrics	
Exh Sys Type	Short Circuit MA
Hood Type	Wall Mtd w/ 1 wall
Hood LxW	12'x4'x24"
Appl Arrangemt	F,F,6R,8R,Gr
DW Hood	None
Other Hoods	None
Other Exhaust	None



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply (MS) CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	2880	720	3600	-	-	-
Installed	0	0	5200	3000	832	3832	-	-	-
Measured	1200	-0.13	4980	1244	1456	3900	193.3	69.9	5377
New Design	0	0.02	5000	2200	550	2750	25.9	9.4	719
New Design	0	0.02	5000	1408	352	1760	16.5	6.0	460
								Total Savings	4197
						MMBtu Saved	150.9	54.6	205.4

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.

If more than one hood, see attached Multiple Hoods worksheet.

CKV Problem:

1) The system was installed with blowers greater than the engineer's design by 6 percent. (3832/3600)
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.
3) Air flow around the left side of the hood can be improved by adding a 45 degree side panel.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.
5) Add a 45 Degree Side Panel to the Left Side of the Hood.

Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	3500
New 3 phase KEF motor (3/4 HP)	250
New 3 phase MA motor (1/3 HP)	250
12 Foot long Perforated Supply Air Plenum with collar duct transition and LED Lights	2500
One 4' x 4' 45 degree Stainless Steel Side Panel	200
Air Balance Verification Testing (if not included with EMS cost)	350
Labor (Electrician)	2300
Total COST	$ 9,350
Total Savings $ 4,197	Payback Yrs 2.23

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/20/2012

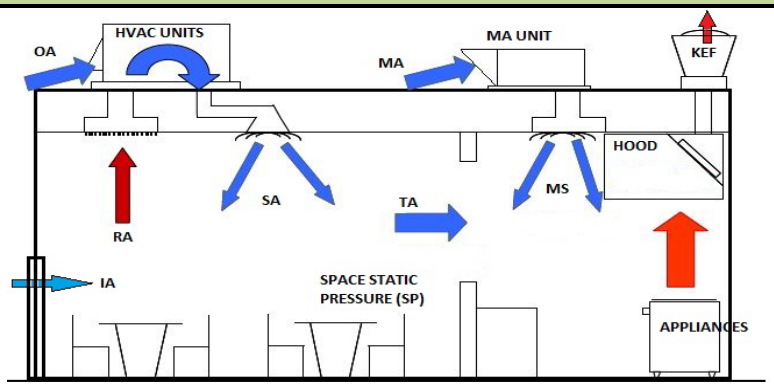
Client: Restaurant # 4
Address:

Assessment Date: 16-May-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	RTU
HTG-Tons	5.7
CLG-Tons	7.5
HTG Type	Electric

Kitchen Parametrics	
Exh Sys Type	Short Ckt - Back Shelf
Hood Type	Wall Mtd / 1 wall
Hood LxW	8'6"x2'X6"
Appl Arrangemt	4R,F,GR
DW Hood	None
Other Hoods	none
Other Exhaust	none



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	1920	480	2400	-	-	-
Installed	0	0	3000	2000	405	2405	-	-	-
Measured	1300	-0.12	3000	950	312	2562	90.4	32.7	2516
New Design	0	0.02	3000	1200	300	1500	14.1	5.1	392
New Design/EMS	0	0.02	3000	768	192	960	9.0	3.3	251
								Total Savings	1872
						MMBtu Saved	67.3	24.3	91.6

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.
If more than one hood, see attached Multiple Hoods worksheet.

CKV Problem:

1) The system was installed with blowers per the engineer's design. Make air was 1/2 because of failed motor.
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.
3) One of the two MA fans was not operating (Failed fan)

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.

Projected Cost:

New backshelf hood from CaptiveAire	2800
Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	3300
New 3 phase KEF motor (1/2 HP)	250
Disconnect MA Blowers	100
Reinstall Fire Suppression System	350
Labor (Electrician)	2100
Total COST	$ 8,900
Total Savings $ 1,872	Payback Yrs 4.75

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/26/2012

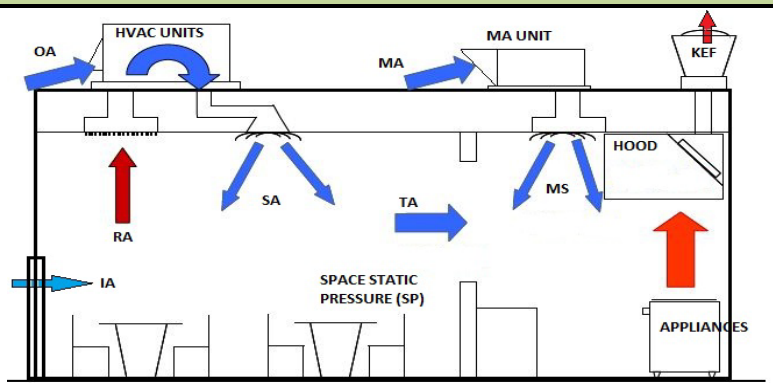
Client: Restaurant # 5
Address:

Assessment Date: 19-Apr-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	AHUs/CUs
HTG-Tons	24/11
CLG-Tons	25
HTG Type	Electric(AHU)/NG(MAU)

Kitchen Parametrics	
Exh Sys Type	Floor MA /Hood Exh
Hood Type	Wall M w/side walls
Hood LxWxH	16'x4'x1.5'
Appl Arrangemt	Gr, 4R, F, 4R
DW Hood	Yes 4'x3'
Other Hoods	None
Other Exhaust	None



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply (MS) CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	7075	2092	61	2153	-	-	-
Installed	0	0	10000	2900	600	3500	-	-	-
Measured	1750	-0.12	9750	2220	657	4627	144.0	52.1	6029
New Design	0	0.02	7600	3213	803	4016	37.8	13.7	1581
New Design/EMS	0	0.02	7600	2056	514	2570	24.2	8.7	1012
								Total Savings	3437
						MMBtu Saved	82.1	29.7	111.8

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.
If more than one hood, see attached Multiple Hoods worksheet.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

CKV Problem: Imbalanced Commercial Kitchen Ventilation (CKV) System

1) The system was installed with blowers greater than the engineer's design by 63 percent. (3500/2153)
2) The design as shown on the drawing was correctly engineered per Code.
3) The Kitchen Exhaust fan is rated to run from 3500 to 11500 cfm.

Proposed Solution: CKV EMS Controls and MA Perforated Supply Plenum

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.

Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	3500
New 3 phase MA motor (2 HP)	450
16 Foot long Perforated Supply Air Plenum with collar ducts transition and LED Lights	2500
Air Balance Verification Testing (if not included with EMS)	500
Labor (Electrician)	3200
Total COST	$ 10,150
Total Savings $ 3,437	Payback Yrs 2.95

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/20/2012

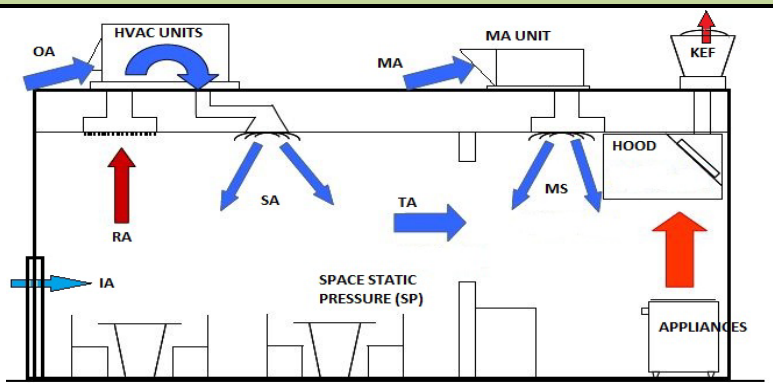
Client: Restaurant # 6
Address:

Assessment Date: 22-May-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	2 RTUs
HTG-Tons	21
CLG-Tons	15
HTG Type	Natural Gas

Kitchen Parametrics	
Exh Sys Type	Short Circuit MA
Hood Type	Wall Mtd /1 wall
Hood LxW	12'6"x4'x2'
Appl Arrangemt	F,Gr,6R,Ov
DW Hood	None
Other Hoods	None
Other Exhaust	None



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	3000	750	3750	-	-	-
Installed	0	0	6000	3000	1283	4283	-	-	-
Measured	1167	-0.11	6000	2352	1107	4626	158.9	57.5	4421
New Design	0	0.02	6000	2300	575	2875	27.0	9.8	752
New Design/EMS	0	0.02	6000	1472	368	1840	17.3	6.3	481
								Total Savings	3188
						MMBtu Saved	114.6	41.4	156.0

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.

If more than one hood, see attached Multiple Hoods worksheet.

CKV Problem:

1) The system was installed with blowers greater than the engineer's design by 14 percent (4283/3750) And running 23 % over design.
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.
3) Air flow around the left side of the hood can be improved by adding a 45 degree side panel.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.
5) Add a 45 Degree Side Panel to the Left Side of the Hood.

Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	3500
New 3 phase KEF motor (1 HP)	300
New 3 phase MA motor (1/2 HP)	250
12'6" Foot long Perforated Supply Air Plenum with collar duct transition and LED Lights	2500
One 4' x 4' 45 degree Stainless Steel Side Panel	250
Labor (Electrician)	2300
Total COST	$ 9,100
Total Savings $ 3,188	Payback Yrs 2.85

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

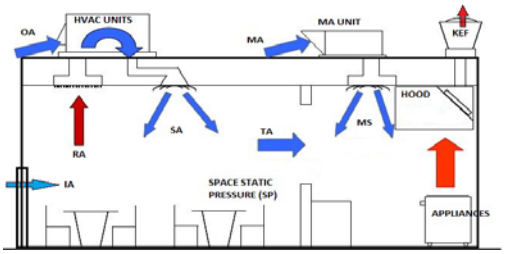
Client Report - 6/26/2012

Client: Restaurant # 7
Address:

Assessment Date: 22-May-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	AHUs/Cus
HTG-Tons	10
CLG-Tons	13.5
HTG Type	Nat Gas



Kitchen Parametrics - Hood 1 (Pizza Oven)	
Exh Sys Type	No MA
Hood Type	Eyebrow
Hood LxWxH	3'3"x 30"x18"
Appl Arrangemt	Ov
DW Hood	Yes
Other Hoods	Yes (5 Total)
Other Exhaust	Yes (Brewery)

Kitchen Parametrics - Hood 2 (Steamer/Oven)	
Exh Sys Type	Short Circuit MA
Hood Type	Wall Mtd Canopy
Hood LxW	11'x4"x20"
Appl Arrangemt	OV,OV, ST,ST
DW Hood	Yes
Other Hoods	Yes (5 Total)
Other Exhaust	Yes (Brewery)

Kitchen Parametrics - Hood 3 (Main A)	
Exh Sys Type	Short Circuit MA
Hood Type	Wall Mtd Canopy
Hood LxW	10'6"x4'x23"
Appl Arrangemt	Ov,GR,F,F,F
DW Hood	Yes
Other Hoods	Yes (5 Total)
Other Exhaust	Yes (Brewery)

Kitchen Parametrics - Hood 4 (Main B)	
Exh Sys Type	Short Circuit MA
Hood 2 Type	Wall Mtd Canopy
Hood LxW	6'6"x4'x23"
Appl Arrangemt	Gr, 6R
DW Hood	Yes
Other Hoods	Yes (5 Total)
Other Exhaust	Yes (Brewery)

Kitchen Parametrics - Hood 5 (Dish Washer)	
Exh Sys Type	No MA
Hood 2 Type	Wall Mtd Canopy
Hood LxW	5'x3'4"x2'
Appl Arrangemt	Dishwasher
DW Hood	This One
Other Hoods	Yes (5 Total)
Other Exhaust	Yes (Brewery)

HOOD 1	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	0	500	500	-	-	-
Installed	0	0	-	0	500	500	-	-	-
Measured	0	-0.06	-	0	300	300	28.2	10.2	785
New Design	0	0.02	-	0	250	250	23.5	8.5	654
								Total Savings	131

HOOD 2	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	2200	550	2750	-	-	-
Installed	0	0	8000	1933	767	2700	-	-	-
Measured	750	-0.06	8000	1250	516	2516	83.8	30.3	2330
New Design	0	0.02	8000	1200	300	1500	14.1	5.1	392
New Design/EMS	0	0.02	8000	768	192	960	9.0	3.3	251
								Total Savings	2079

HOOD 3	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	2940	735	3675	-	-	-
Installed	0	0	8000	2000	750	2750	-	-	-
Measured	750	-0.06	8000	950	816	2516	112.0	40.5	3115
New Design	0	0.02	8000	1900	475	2375	22.3	8.1	621
New Design/EMS	0	0.02	8000	1216	304	1520	14.3	5.2	398
								Total Savings	2717

HOOD 4	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	1820	455	2275	-	-	-
Installed	0	0	8000	2000	400	2400	-	-	-
Measured	750	-0.06	8000	950	816	2516	112.0	40.5	3115
New Design	0	0.02	8000	1100	275	1375	12.9	4.7	360
New Design/EMS	0	0.02	8000	704	176	880	8.3	3.0	230
								Total Savings	2885

HOOD 5	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	0	750	750	-	-	-
Installed	0	0	-	0	800	800	-	-	-
Measured	0	-0.06	-	0	800	800	75.2	27.2	2092
New Design/EMS	0	0.02	-	0	750	750	70.5	25.5	1961
								Total Savings	131
						MMBtu Saved	236.1	85.4	321.5

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.

CKV Problem:

1) The system was installed with blowers greater than the engineer's design by 19 percent. (4283/3600)

2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code. It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.

Projected Cost:

Three Energy Management Systems (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	9750
Three New 3 phase KEF motor (Verify Size)	750
Three New 3 phase MA motor (Verify Size)	750
1 @11' and 1 @ 10'6" and 1 @ 6'6" Foot long Perforated Supply Air Plenums with collar duct transition and LED Lights	7200
Air Balance Verification Testing (if not included with EMS cost)	1200
Labor (Electrician)	6500
Total COST	$ 26,150
Total Savings $ 7,942	Payback Yrs 3.29

COMMERCIAL KITCHEN VENTILATION ASSESSMENT

Client Report - 6/20/2012

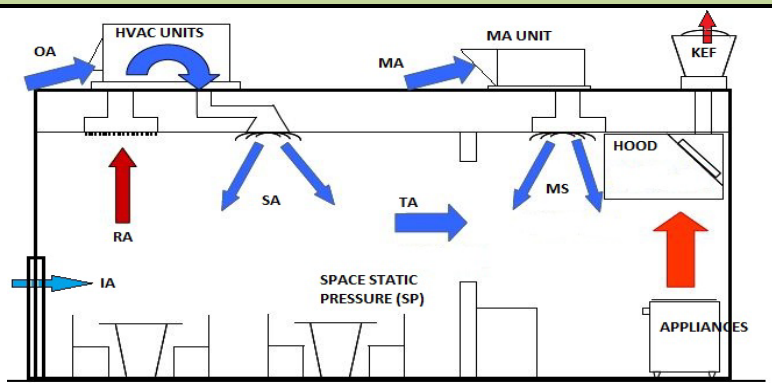
Client: Restaurant # 8
Address:

Assessment Date: 15-May-12

Kitchen Ventilation System

HVAC System Parametrics	
HVAC Type	Furnace/CU
HTG-Tons	8
CLG-Tons	13
HTG Type	Nat Gas

Kitchen Parametrics	
Exh Sys Type	Short Circuit MA
Hood Type	Wall Mtd Canopy
Hood LxW	12'x4'x30"
Appl Arrangemt	Gr, 6R, Ov
DW Hood	None
Other Hoods	None
Other Exhaust	None



	Infiltration (IA) CFM	Building SP Inches W.C.	Supply Air (SA) CFM	Make-Up Supply CFM	Outside Air (OA) CFM	Exhaust Air (KEF) CFM	HTG MMBTU/YR	CLG MMBTU/YR	Total $
Design	0	0	-	2880	720	3600	-	-	-
Installed	0	0	5200	3000	1283	4283	-	-	-
Measured	1420	-0.06	4850	2352	628	4400	125.8	45.5	3499
New Design	0	0.02	5000	2200	550	2750	25.9	9.4	719
New Design/EMS	0	0.02	5000	1408	352	1760	16.5	6.0	460
								Total Savings	2320
						MMBtu Saved	83.4	30.2	113.5

Assumptions:
Electric rate of $0.105 per KWH & Natural Gas rate of $1.67 per CCF.

If more than one hood, see attached Multiple Hoods worksheet.

CKV Problem:

1) The system was installed with blowers greater than the engineer's design by 19 percent (4283/3600) and running 22 % over Design.
2) The short circuit (self-compensating) hood does not capture appropriately. Recently, these type of hoods are not recommended by Code.
It was confirmed that when the MA unit was running, heat and smoke spilled backward into the dining area.
3) Air flow along the both sides of the hood can be improved by adding a 45 degree side panel.

Key: IA = Infiltration Air; RA = Return Air; SA = Supply Air; TA = Tranfer Air from room to kitchen; OA = Outside Air; MA = Makeup Air; MS = Makeup Supply
KEF = Kitchen Exhaust Fan; EF = Exhaust Fan
SP = Static Pressure in inches of W.C (Water Column); CFM = Cubic Feet per Minute of air flow
Gr = griddle; F = Fryer; 4R = 4-burner Range; Ov = oven; ST = steamer

Proposed Solutions:

1) To optimize the new design, install EMS system to speed control MA and KEF blowers by duct temperature probe. (100/80)
2) To correct hood capture problem, install perforated supply plenum in front of hood at ceiling.
3) Adjust MA and KEF blowers to new design speeds by changing belt sheaves (pulleys).
4) If 3) does not achieve new design parameters, re-set EMS frequency drives to new 100/80 cfm level by frequencies.
5) Add a 45 Degree Side Panel to the Both Sides of the Hood.

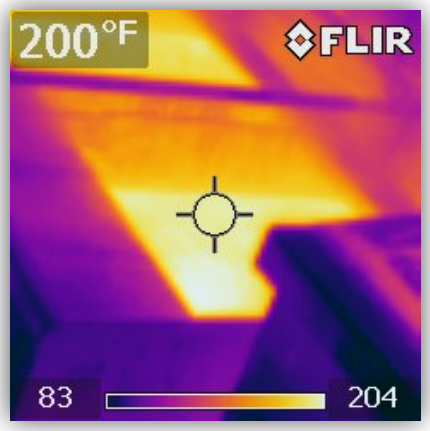
Projected Cost:

Energy Management System (EMS) for Control of MA and KEF blowers by temperature probe. (100% vs. 80% Speed)	3500
New 3 phase KEF motor (1 HP)	350
New 3 phase MA motor (1/4 HP)	350
12 Foot long Perforated Supply Air Plenum with collar duct transition and LED Lights	2750
Air Balance Verification Testing (if not included with EMS cost)	450
Labor (Electrician)	2500
Total COST	$ 9,900
Total Savings $ 2,320	Payback Yrs 4.27

Appendix B

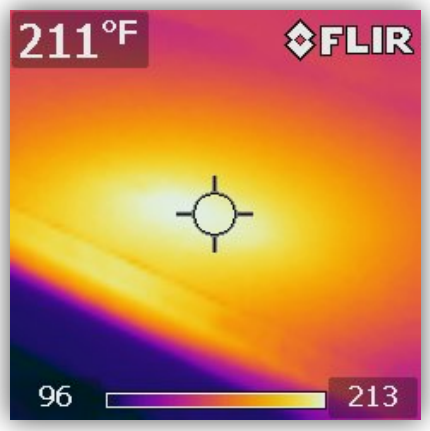
CKV Report Photos & IR Images

CKV IR Images –Page 1

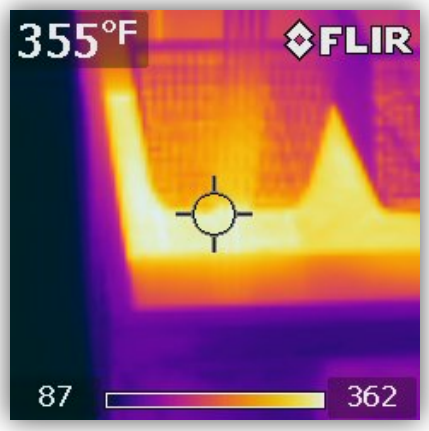


Sample of Cooking Surface Readings

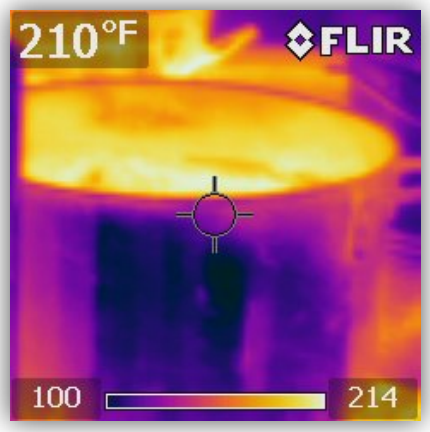
Grille Surface Temps



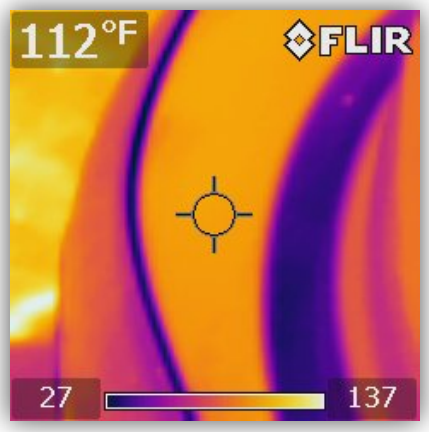
Grille Surface Temps



Fryer Oil Temps

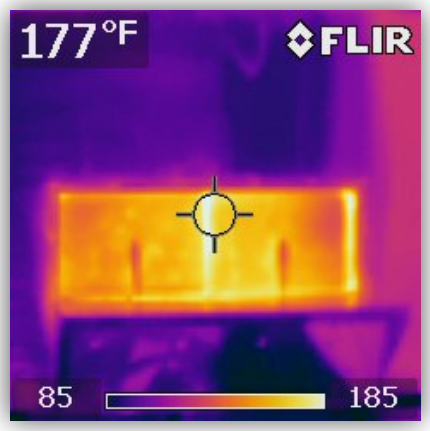


Boiling Water Pots Temps

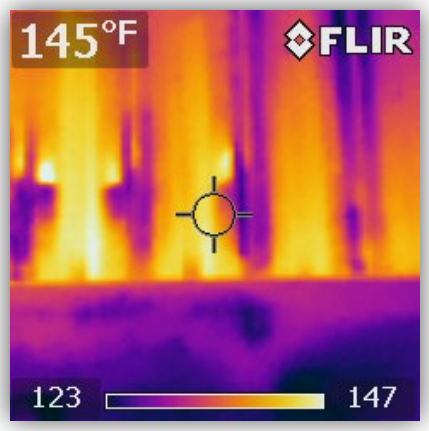


Exhaust Fan on Roof Temps

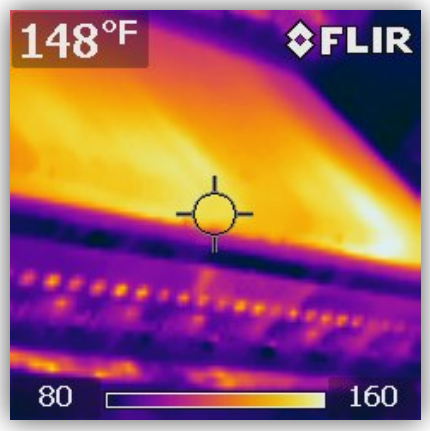
CKV IR Images –Page 2



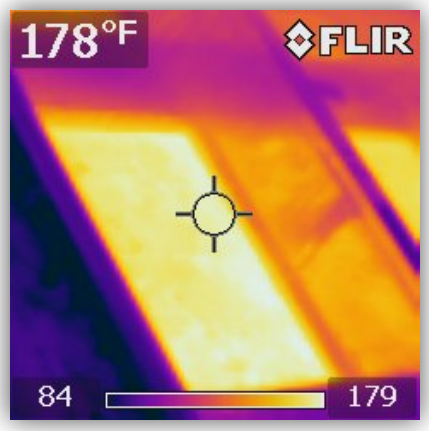
Hot Duct Surfaces



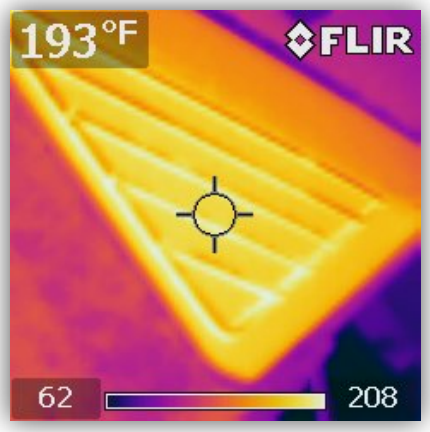
Hood Filter Temps



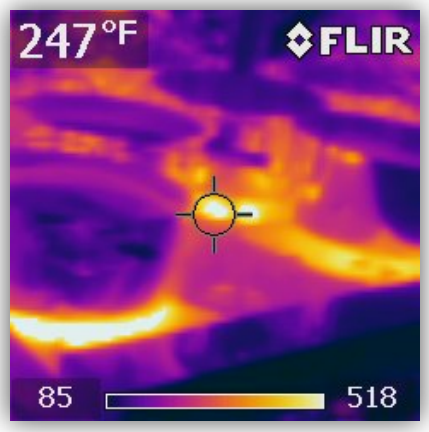
Self Comp Supply and Hood Surface Temps



Hot Cooking Surface Temps



Exhaust Vent On Roof



Hot Pots on a range

Appendix C

Reference Literature & Documents

Table 2. Typical Exhaust Rates for Listed Hoods

	Minimum Exhaust Flow Rates for Listed Hoods (cfm per linear foot of hood)			
Type of Hood	**Light Duty Equipment**	**Medium Duty Equipment**	**Heavy Duty Equipment**	**Extra-Heavy Duty Equipment**
Wall-mounted Canopy	150-200	200-300	200-400	350+
Single Island Canopy	250-300	300-400	300-600	550+
Double Island Canopy	150-200	200-300	250-400	500+
Eye Brow	150-250	150-250	not allowed	not allowed
Backshelf/Passover	100-200	200-300	300-400	not recommended

Source: ASHRAE Handbook

Table 1. Unlisted Hood Exhaust Flow Rates

	IMC Minimum Exhaust Flow Rate for Unlisted Hoods (cfm per linear foot of hood)			
Type of Hood	**Light Duty Equipment**	**Medium Duty Equipment**	**Heavy Duty Equipment**	**Extra-Heavy Duty Equipment**
Wall-mounted Canopy	200	300	400	550
Single Island Canopy	400	500	600	700
Double Island Canopy	250	300	400	550
Eye Brow	250	250	not allowed	not allowed
Backshelf/Passover	250	300	400	not allowed

Source: ASHRAE Handbook

Design Guide
Improving Commercial Kitchen Ventilation System Performance

This design guide provides information that will help achieve optimum performance and energy efficiency in commercial kitchen ventilation systems. The information presented is applicable to new construction and, in many instances, retrofit construction. The audience for this guideline is kitchen designers, mechanical engineers, food service operators, property managers, and maintenance people. This guide is intended to augment comprehensive design information published in the Kitchen Ventilation Chapter in the ASHRAE Handbook on HVAC Applications.

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Introduction

An effective commercial kitchen ventilation (CKV) system requires balance—air balance that is. And as the designer, installer or operator of the kitchen ventilation system, you may be the first person called upon to perform your own "balancing act" when the exhaust hood doesn't work. Unlike a cooking appliance, which can be isolated for troubleshooting, the exhaust hood is only one component of the kitchen ventilation system. To further complicate things, the CKV system is a subsystem of the overall building heating, ventilating and air-conditioning (HVAC) system. Fortunately, there is no "magic" to the relationship between an exhaust hood and its requirement for replacement or makeup air (MUA). The physics are simple: air that exits the building (through exhaust hoods and fans) must be replaced with outside air that enters the building (intentionally or otherwise). The essence of *air balance:* "air in" = "air out!"

Background

If the replacement air doesn't come in, that means it doesn't go out the exhaust hood and problems begin. Not only will the building pressure become too "negative," the hood may not capture and contain (C&C) cooking effluents due to reduced exhaust flow. We have all experienced the "can't-open-the-door" syndrome because the exhaust fan is sucking too hard on the inside of the restaurant. The mechanical design may call for 8000 cubic feet per minute (cfm) of air to be exhausted through the hood. But if only 6000 cfm of outdoor air is able to squeeze in through closed dampers on rooftop units and undesirable pathways in the building envelope, then only 6000 cfm is available to be exhausted through the hood. The exhaust fan creates more suction (negative pressure) in an unsuccessful attempt to pull more air through the hood.

There is no piece of equipment that generates more controversy within the food service equipment supply and design community than the exhaust hood in all its styles and makeup air combinations. The idea that by not installing a dedicated

makeup air supply, the operator is going to save money (in both first cost and operating cost) is short sighted. It may be okay if, by design, all of the makeup air can be provided through the rooftop HVAC units (this strategy has been adopted successfully by several leading quick-service restaurant chains). However, in full-service and institutional kitchens with larger exhaust requirements, it may not be practical (or energy efficient) to supply 100% of the replacement (makeup) air through the building HVAC system.

The solution is to specify an independent makeup air supply. But, once dedicated MUA has been added to the system, the challenge becomes introducing this air into the kitchen without disrupting the ability of the hood to capture and/or without causing discomfort for the kitchen staff. Kitchens are not large and dumping 7000 cfm of MUA, for example, in front of a cook line does not go as smoothly in practice as it does on the *air balance schedule!* Not only can makeup air velocities impact the ability of the hood to capture and contain cooking effluent, locally supplied makeup air that is too cold or too hot can create an uncomfortable working environment. This design guide presents strategies that can minimize the impact that the makeup air introduction will have on hood performance and energy consumption.

Fundamentals of Kitchen Ventilation

Hot air rises! An exhaust fan in the ceiling could easily remove the heat produced by cooking equipment. But mix in smoke, volatile organic compounds, grease particles and vapor from cooking, a means to capture and contain the effluent is needed to avoid health and fire hazards. While an exhaust hood serves that purpose, the key question is always: what is the appropriate exhaust rate? The answer always depends on the type (and use) of the cooking equipment under the hood, the style and geometry of the hood itself, and how the makeup air (conditioned or otherwise) is introduced into the kitchen.

Cooking appliances are categorized as light-, medium-, heavy-, and extra heavy-duty, depending on the strength of the thermal plume and the quantity of grease and smoke produced. The strength of the thermal plume is a major factor in determining the exhaust rate. By their nature, these thermal plumes are very turbulent and different cooking processes have different “surge” characteristics. For example, the plume from hamburger cooking is strongest when flipping the burgers. Ovens and pressure fryers may have very little plume until they are opened to remove food product. Open flame, non-thermostatically controlled appliances, such

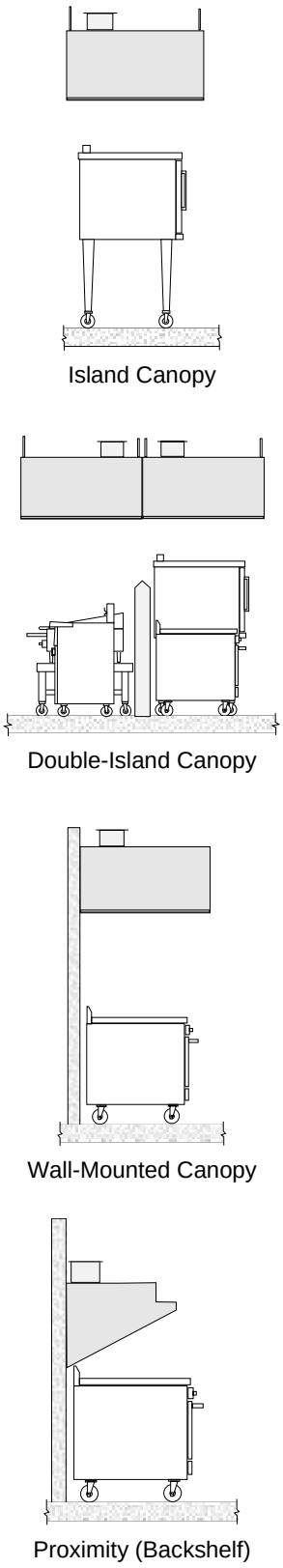


Figure 1. CKV Hood Types.

as underfired broilers and open top ranges, exhibit strong steady plumes. Thermostatically controlled appliances, such as griddles and fryers have weaker plumes that fluctuate in sequence with thermostat cycling (particularly gas-fired equipment). As the plume rises by natural convection, it is captured by the hood and removed by the suction of the exhaust fan. Air in the proximity of the appliances and hood moves in to replace it. This replacement air, which originates as outside air, is referred to as makeup air.

The design exhaust rate also depends on the hood style and design features. Wall-mounted canopy hoods, island (single or double) canopy hoods, and proximity (backshelf, pass-over, or eyebrow) hoods all have different capture areas and are mounted at different heights relative to the cooking equipment (see Figure 1). Generally, a single-island canopy hood requires more exhaust than a wall-mounted hood, and a wall-mounted hood requires more exhaust than a proximity hood. The performance of a double-island canopy tends to emulate the performance of two back-to-back wall-canopy hoods, although the lack of a physical barrier between the two hood sections makes the configuration more susceptible to cross drafts.

Lastly, the layout of the HVAC and MUA distribution points can affect hood performance. These can be sources that disrupt thermal plumes and hinder capture and containment. Location of delivery doors, service doors, pass-through openings and drive-through windows can also be sources of cross drafts. Safety factors are typically applied to the design exhaust rate to compensate for the effect that undesired air movement within the kitchen has on hood performance.

CKV System Performance Testing

The phrase "hood capture and containment" is defined in ASTM F-1704 *Standard Test Method for the Performance of Commercial Kitchen Ventilation Systems* as "the ability of the hood to capture and contain grease-laden cooking vapors, convective heat and other products of cooking processes." Hood capture refers to these products entering the hood reservoir from the area under the hood, while containment refers to these products staying in the hood reservoir and not spilling out into the adjacent space. The phrase "minimum capture and containment" is defined as "the conditions of hood operation in which minimum exhaust flow rates are just sufficient to capture and contain the products generated by the appliance in idle or heavy-load cooking conditions, and at any intermediate prescribed load condition." The abbreviation “C&C” refers to the “minimum capture and containment” flow rate as defined in ASTM F-1704.

Performance testing in accordance with ASTM F-1704 at the CKV Laboratory in Wood Dale, IL, incorporates a schlieren flow-visualization system to verify capture and containment. This system is a major breakthrough for visualizing thermal and effluent plumes from cooking processes. “Schlieren” is derived from the German word for “smear.” A schlieren system presents an amplified optical image (see Figure 2) due to the different air densities, similar to the mirage effect we see over hot pavement.

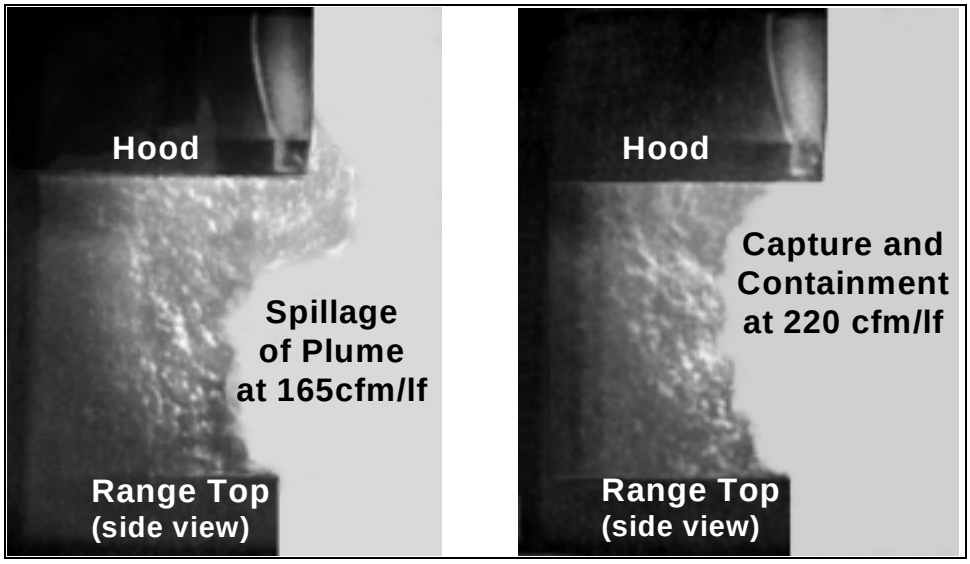


Figure 2. Schlieren images at different exhaust rates per linear foot (lf).

Replacement (Makeup) Air Distribution

Air that is removed from the kitchen through an exhaust hood must be replaced with an equal volume of makeup air through one or more of the following pathways:

- Transfer air (e.g., from the dining room)
- Displacement diffusers (floor or wall mounted)
- Ceiling diffusers with louvers (2-way, 3-way, 4-way)
- Slot diffusers (ceiling)
- Ceiling diffusers with perforated face
- Integrated hood plenum (see Figure 3) including:
    1. Short circuit (internal supply)
    2. Air curtain supply
    3. Front face supply
    4. Perforated perimeter supply
    5. Backwall supply (rear discharge)
    6. Combinations of the above

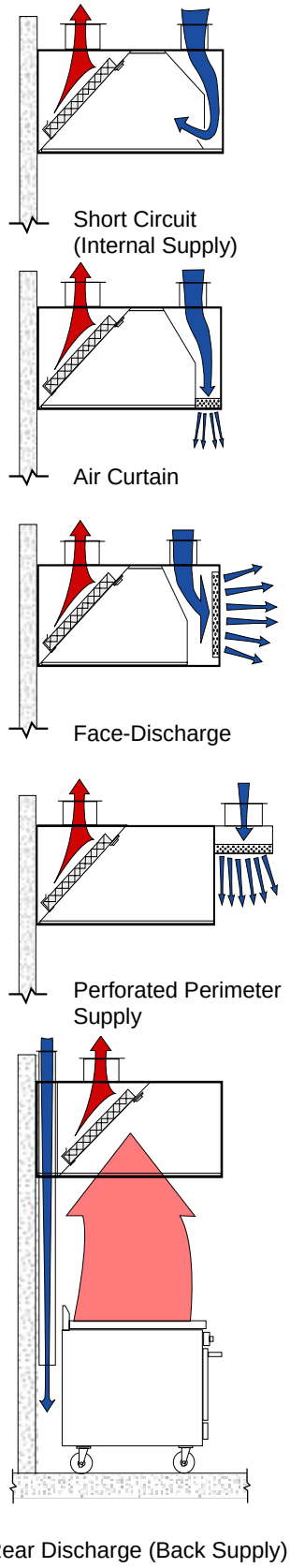


Figure 3. Types of MUA Supply Integrated with the hood.

Influence of Makeup Air on Exhaust Hood Performance

Makeup air that is supplied through displacement ventilation diffusers remote from the hood, perforated diffusers located in the ceiling as far as possible from the hood, or as transfer air from the dining room generally works well if air velocities approaching the hood are less than 75 feet per minute (fpm). Makeup air introduced in close proximity to an exhaust hood has the potential, however, to interfere with the hood's ability to capture and contain. The chances of makeup air affecting hood performance increases as the percentage of the locally supplied MUA (relative to the total exhaust) is increased. In fact, the 80% rule-of-thumb for sizing airflow through a MUA unit can be a recipe for trouble, particularly if the exhaust flow rate has been over-specified to start with.

Temperature of the locally supplied makeup air can also impact hood performance as air density (buoyancy) impacts the dynamics of air movement around the hood. Generally, hotter MUA temperatures (e.g., 90°F) will affect hood performance more adversely than cooler air (e.g., 75°F). In most temperate climates, such as many areas in California, evaporative cooling is an effective method of maintaining MUA temperatures within a range that is comfortable for kitchen staff and does not hamper hood performance. However, the maintenance requirements of evaporative coolers must be factored into the equation.

The primary recommendation for minimizing the impact that locally supplied MUA will have on hood performance is to minimize the velocity (fpm) of the makeup air as it is introduced near the hood. This can be accomplished by minimizing the volume (cfm) of makeup air through any one pathway, by maximizing the area of the grilles or diffusers through which the MUA is supplied, or by using a combination of pathways.

The first step in reducing the MUA requirement is to minimize the design exhaust rate. This can be accomplished by prudent selection and application of UL Listed hoods and taking advantage of the "exhaust flow" recommendations from hood suppliers for the cookline under consideration. Exhaust hood manufacturers' sales and engineering departments have a lot of experience that CKV design consultants can tap to help minimize the "safety factor" applied to exhaust rates.

The second step in reducing MUA flow is to take credit for outside air that must be supplied by the HVAC system to meet code requirements for ventilating the dining room. Depending on the architectural layout between the kitchen and the dining room, it may be practical to transfer most of this air from the dining room to

the kitchen. For example, if 2400 cfm of outdoor air that is being supplied to a 160-seat dining room can be transferred to the kitchen, the local makeup air requirement can be reduced accordingly.

Rather than supplying 80 to 90% of the exhaust rate through one makeup air strategy, designers should make an effort to keep this ratio below 60% (obviously, the other 40% of the replacement air must be derived from another source such as transfer air , another local strategy, or HVAC supply). Although this may contradict past practice, it will be effective! Not only will hood performance be superior, the kitchen environment will benefit from the cooling contribution of the "recycled" dining room air. It is important to realize that the outdoor air required by code is usually conditioned before it is introduced into the dining room. So… why not use this outdoor air as a makeup air credit?

The third step in reducing MUA flow is to select a configuration for introducing this local makeup air into the kitchen that compliments the style and size of hood. If transfer air is not an option, consider a combination of makeup air strategies (e.g., backwall supply and perforated ceiling diffusers). This reduces the velocity of air being supplied through each local pathway, mitigating potential problems with hood capture. Effective options (at 60% or less) include front face supply, backwall supply, and perforated perimeter supply. Short-circuit supply is not recommended, and air-curtains should be used with extreme caution. The pros and cons of the different configurations are discussed below. Note a frequent theme— minimizing MUA discharge velocity is key to avoiding detrimental impacts on hood capture and containment.

Short-Circuit Supply (Internal Makeup Air)

The application of short-circuit makeup air hoods is a controversial topic. These internal makeup air hoods were developed as a strategy to reduce the amount of conditioned air required by an exhaust system. By introducing a portion of the required makeup air in an untempered condition directly into the exhaust hood reservoir, the net amount of conditioned air exhausted from the kitchen is reduced. Research has shown however, that in the cases tested, internal MUA cannot be introduced at a rate that is more than 15% of the threshold C&C exhaust rate without causing spillage (despite what is shown on the air balance schedule or marketing literature). When short circuit hoods are operated at higher percentages of internal MUA they fail to capture and contain the cooking effluent, often spilling at the back of the hood (although front spillage is observed in Figure 5). Dilution of the cook-

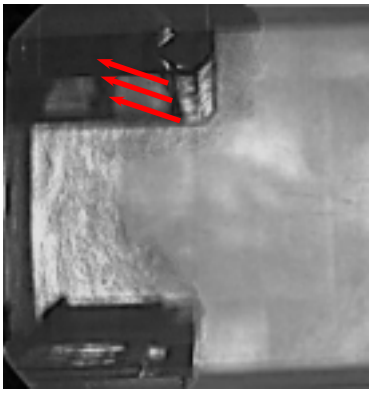


Figure 5. Schlieren image shows the thermal plume being displaced by short circuit supply causing hood to spill.

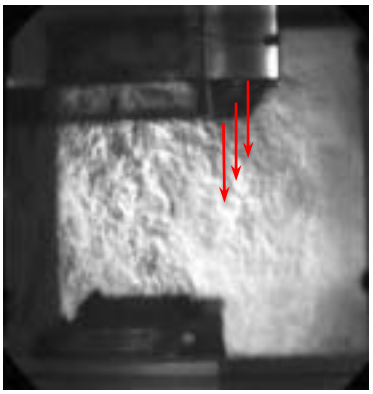


Figure 6. Schlieren image shows the thermal plume being pulled outside the hood by the air curtain.

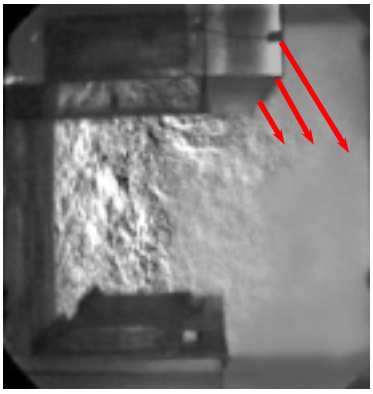


Figure 7. Schlieren image shows the thermal plume being pulled outside the hood by a poorly engineered front face supply.

ing effluent with the internal MUA makes it hard to visualize spillage (even using a schlieren system), but a degraded kitchen environment is confirmation that hood performance has been compromised. If the design exhaust rate is significantly higher than the threshold for C&C(i.e., includes a large safety factor), the percentage of short-circuit air can be increased accordingly, creating a condition of apparent benefit.

Short-circuit hoods are simply not recommended. This recommendation is endorsed by leading hood manufacturers, even though they may still include short-circuit hoods in their catalogue.

Air Curtain Supply

Introducing MUA through an air curtain is a risky design option and most hood manufacturers recommend limiting the percentage of MUA supplied through an air-curtain to less than 20% of the hood's exhaust flow. The negative impact of an air curtain is clearly illustrated in Figure 6 by the schlieren flow visualization recorded during a test of a wall-mounted canopy hood operating over two underfired broilers.

An air curtain (by itself, or in combination with another pathway) is not recommended, unless velocities are kept to a minimum and the designer has access to performance data on the actual air-curtain configuration being specified. It is too easy for the as-installed system to oversupply, creating higher discharge velocities that cause cooking effluent to spill into the kitchen.

Front Face Supply

Supplying air through the front face of the hood is a configuration that has been recommended by many hood manufacturers. However, a front face discharge, with louvers or perforated face, can perform poorly if its design does not consider discharge air velocity and direction. Not all face discharge systems share the same design; internal baffling and/or a double layer of perforated plates improve the uniformity of flow. Face discharge velocities should not exceed 150 fpm and should exit the front face in a horizontal direction. Greater distance between the lower capture edge of the hood and the bottom of the face discharge area may decrease the tendency of the MUA supply to interfere with hood capture and containment. Figure 7 represents a poorly designed face supply, which can negatively affect hood capture in the same fashion as an air-curtain or four-way diffuser.

Backwall Supply (Rear Discharge)

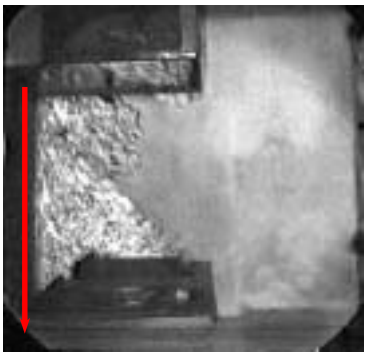


Figure 8. Schlieren image shows the thermal plume being pulled captured with backwall supply.

Lab testing has shown that the backwall supply can be an effective strategy for introducing MUA (see Figure 8). However, the discharge area of the backwall supply should be at least 12 inches below the cooking surfaces of the appliances to prevent the relative high velocity introduction of MUA from interfering with gas burners and pilot lights. As with other local MUA strategies, the quantity of air introduced through the backwall supply should be no more than 60% of the hood's exhaust flow. Hoods with a deeper plenum or increased diffuser area have lower discharge velocities, allowing higher supply airflows. The back supply plenum may offer the advantage of meeting a "clearance to combustibles" code requirement. It may also be an option to convert a single island canopy into a more functional wall-mounted canopy (without actually constructing the wall) as utility distribution can be incorporated within the plenum. If the rear supply utilizes perforated diffusers, it is important that cleanout access be provided (as with any supply diffuser).

Perforated Perimeter Supply

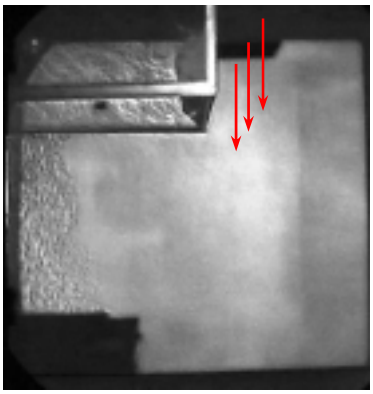


Figure 9. Schlieren image shows effective plume capture with MUA supplied through a 16-in wide perforated perimeter supply.

Perforated supply plenums (with perforated face diffuser) are similar to a front face supply, but the air is directed downward as in Figure 9 toward the hood capture area. This may be advantageous under some conditions, since the air is directed downward into the hood capture zone. Face discharge velocities should not exceed 150 fpm from any section of the diffuser and the distance to lower edge of the hood should be no less than 18 inches (or the system begins to act like an air curtain). Widening the plenum will lower the discharge velocity for a given flow of MUA and reduce the chance of the supply air affecting C&C. If the perforated supply plenum is extended along the sides of the hood as well as the front, the increased area will permit proportionally more MUA to be supplied.

Four-Way Ceiling Diffusers

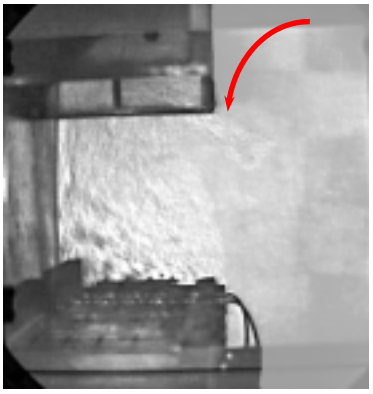


Figure 10. Schlieren image shows the thermal plume being pulled outside the hood by the air discharged from a 4-way diffuser.

Four-way diffusers located close to kitchen exhaust hoods (see Figure 10) can have a detrimental affect on hood performance, particularly when the flow through the diffuser approaches its design limit. Air from a diffuser within the vicinity of the hood should not be directed toward the hood. Discharge velocity at the diffuser face should be set at a design value such that the terminal velocity does not exceed 50 fpm at the edge of the hood capture area. It is recommended that only perforated plate ceiling diffusers be used in the vicinity of the hood, and to reduce air velocities from the diffusers at a given supply rate, the more diffusers the better!

Displacement Diffusers

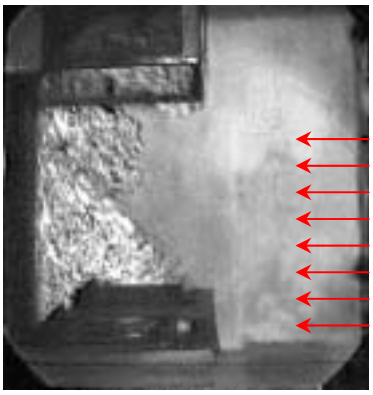


Figure 11. Schlieren image shows the plume being effectively captured when makeup air is supplied at low velocity from displacement diffusers.

Supplying makeup air through displacement diffusers at a good distance away from the hood as illustrated in Figure 11 is an effective strategy for introducing replacement air. It is analogous to low-velocity "transfer air" from the dining room. However, the diffusers require floor or wall space that is usually a premium in the commercial kitchen. A couple of remote displacement diffusers (built into a corner) could help diversify the introduction of makeup air into the kitchen when transfer air is not viable.

Influence of Other Factors on Hood Performance

Cross Drafts

Cross drafts have a detrimental affect on all hood/appliance combinations. Cross-drafts adversely affect island canopy hoods more than wall mounted canopy hoods. A fan in a kitchen, especially pointing at the cooking area, severely degrades hood performance and may make capture impossible. Cross drafts can also be developed when the makeup air system is not working correctly, causing air to be pulled from open drive-through or pass-through windows or doors.

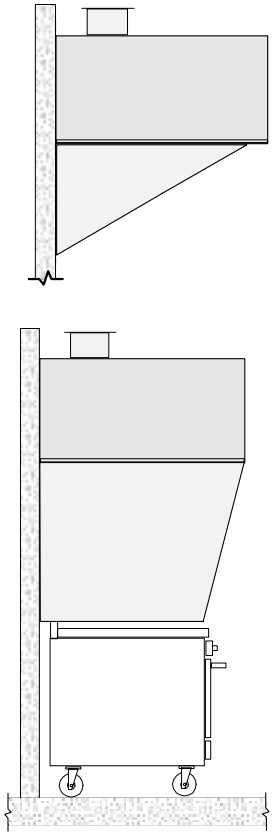


Figure 12. Illustration of partial and full side panels.

Side Panels and Overhang

Side (or end) panels (as represented in Figure 12) permit a reduced exhaust rate in most cases, as they direct the replacement airflow to the front of the equipment. They are a relatively inexpensive way to improve capture and containment and reduce the total exhaust rate. In fact, one of the greatest benefits of end panels is to mitigate the negative effect of cross drafts. It is important to know that partial side panels can provide almost the same benefit as full panels. Although tending to defy its definition as an "island" canopy, end panels can improve the performance of a double-island or single-island canopy hood.

An increase in overhang should improve the ability of the hood to capture, although for unlisted hoods this may mean an increase in the code-required exhaust rate. Larger overhangs are recommended for appliances that create plume surges, such as convection and combination ovens, steamers and pressure fryers.

Safety Factor in Exhaust Rates

Diversity in appliance use, hood reservoir size, as well as the fact that maximum effluent generation from cooking only occurs randomly during normal kitchen operations, may mask the detrimental influence of local MUA sources on

hood performance. Consequently, spillage may be infrequent or simply unobserved. However, better MUA designs allow reduced exhaust rates and minimized energy costs while maintaining a margin of safety with respect to C&C.

Design Considerations for Energy Savings

Hood Style

Wall-mounted canopy hoods function effectively with a lower exhaust flow rate than the single-island hoods. Island canopy hoods are more sensitive to MUA supply and cross drafts than wall mounted canopy hoods. Engineered proximity hoods may exhibit the lowest capture and containment flow rates. In some cases, a proximity hood performs the same job as a wall-mounted canopy hood at one-third the exhaust rate.

Hood Geometry

Interior angles close to, or at, the capture edge of the hood improve C&C performance, allowing reduced exhaust by directing effluent back towards the filters. Hoods designed with these better geometric features require as much as 20% less exhaust rate compared to hoods identical in size and shape without these features. Capture and containment performance may also be enhanced with active “low-flow, high-velocity air jets” along the perimeter of the hood.

Variable Speed Fans and Idle Conditions

Appliances idle much of the day. Using two-speed or variable exhaust flow rates to allow reductions in exhaust (and makeup) while appliances are idling would minimize operating costs. NFPA 96 (Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations) was recently amended to allow minimum exhaust duct velocity as low as 500 fpm (at the exhaust collar and ductwork). Typical design values of 1500 to 1800 fpm at the exhaust collar are still recommended for normal cooking conditions. This code change will facilitate the application of variable speed systems.

Energy Perspective

The exhaust ventilation system can be a major energy user in a commercial kitchen – but it doesn’t need to be in temperate climates like California. Mild climates, such as San Diego, may require no heating or cooling. Some facilities may cool replacement air to improve kitchen comfort. Combined heating and cooling

costs for MUA range from $0.00 to $0.60 per cfm in California climates, assuming 16 hours per day for 360 days per year. California climates are mild compared to other areas in North America so heating and mechanical cooling of MUA often is not necessary. Evaporative cooling can be very effective in desert climates.

Rule-of-thumb figures are useful, but how can designers calculate the costs based on a specific kitchen design and operation? The Outdoor Airload Calculator (OAC) software, freely available for download (www.archenergy.com/ckv/oac) , is the best tool for quickly estimating the energy use for different CKV design and operating strategies. Figure 13 illustrates the OAC program interface and output.

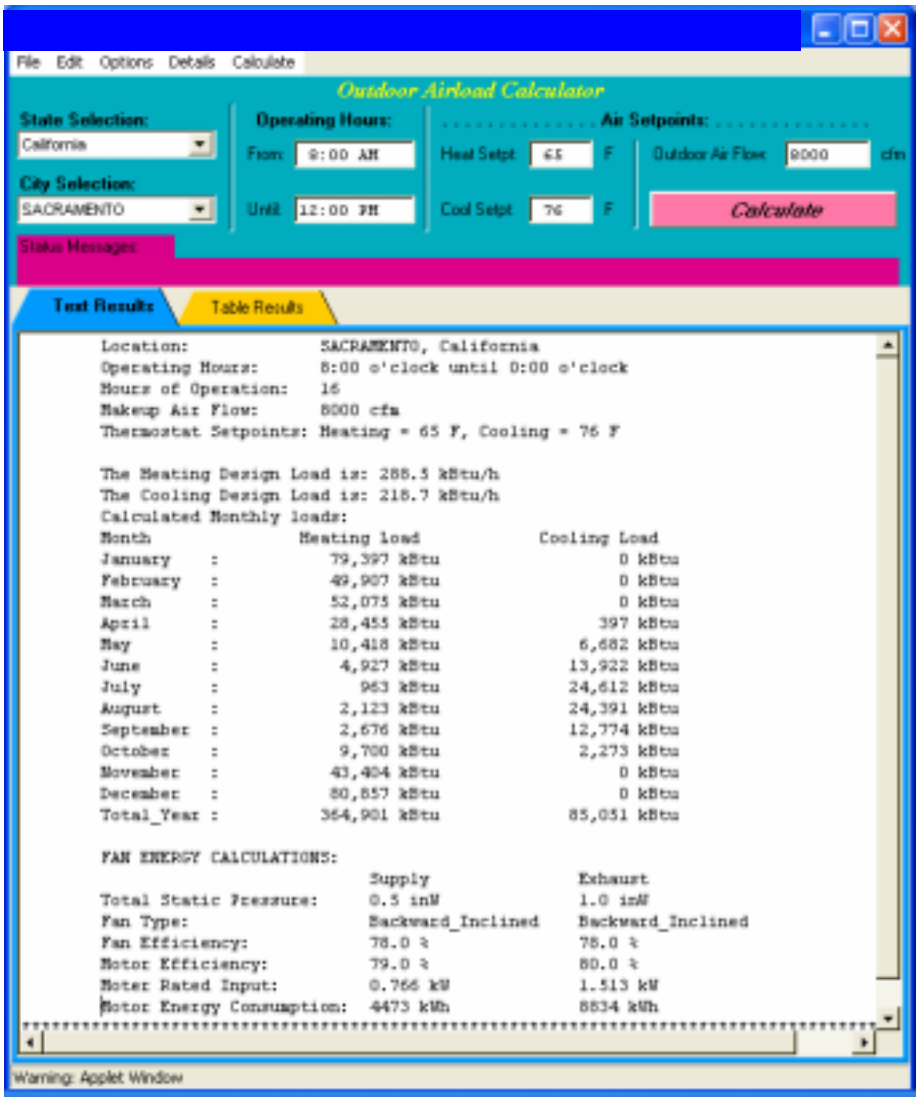


Figure 13. Sample output from Outdoor Airload Calculator screen.

Design Guide Summary

The strategy used to introduce replacement (makeup) air can significantly impact hood performance and should be a key factor in the design of kitchen ventilation systems. Makeup air introduced close to the hood's capture zone may create local air velocities and turbulence that result in periodic or sustained failures in thermal plume capture and containment. Furthermore, the more makeup air supplied (expressed as a percentage of the total replacement air requirement), the more dramatic the negative effect.

The following design suggestions can improve the energy efficiency and performance of commercial kitchen ventilation systems:

- Group appliances according to effluent production and associated ventilation requirements. Specify different ventilation rates for hoods or hood sections over the different duty classification of appliances. Where practical, place heavy-duty appliances such as charbroilers in the center of a hood section, rather than at the end.
- Use UL Listed proximity type hoods where applicable.
- Hood construction details (such as interior angles and flanges along the edge) or high-velocity jets can promote capture and containment at lower exhaust rates.
- Install side and/or back panels on canopy hoods to increase effectiveness and reduce heat gain.
- Integrate the kitchen ventilation with the building HVAC system (i.e., use dining room outdoor air as makeup air for the hood).
- Maximize transfer air/minimize direct makeup air.
- Do not use short-circuit hoods (Figure 14). Use caution with air-curtain designs.
- Avoid 4-way or slot ceiling diffusers in the kitchen, especially near hoods.
- Diversify makeup air pathways (use combination of backwall supply, perforated perimeter supply, face supply, displacement diffusers, etc.).
- Minimize MUA velocity near the hood; it should be less than 75 fpm.
- Use direct-fired MUA heating if heating is necessary. In most temperate climates, including much of California, design for no MUA heating.
- Consider evaporative MUA cooling in dry climates such as California.
- Consider variable or 2-speed exhaust fan control for operations with high diversity of appliances and/or schedule of use.
- Provide air balance requirements to avoid over- or under-supply of MUA.
- Require building air balancing and system commissioning as part of the construction requirements.

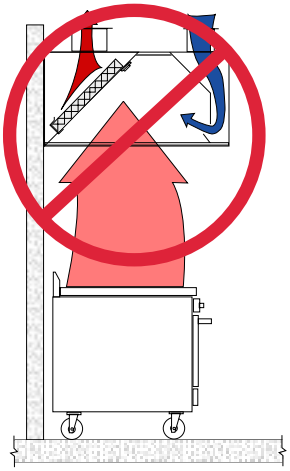


Figure 14. Don't use short circuit hoods.

Case Study: Wall-Mounted Canopy Hood

Challenge: Improve hood C&C and reduce ventilation energy

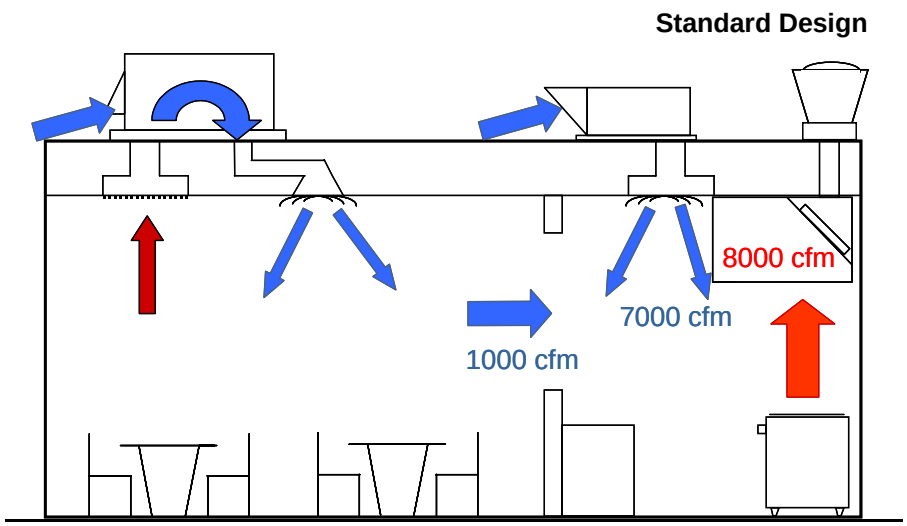
Off-the-Shelf Approach

An un-listed[1] wall mounted canopy hood (20-ft by 4-ft) without side panels: total exhaust 8,000 cfm. Four-way ceiling diffusers supplying air from the kitchen HVAC and MUA unit are located about 2 feet from front and sides of the hood.

Makeup Air Sources:

- 1000 cfm from dining and kitchen HVAC unit (25 Ton refrigeration capacity),
- 7000 cfm from independent MUA (heating only, ductstat set to 65°F) supplied through 4-way ceiling diffusers.

Annual CKV energy cost (including MUA conditioning and exhaust and MUA fan energy) estimated at $6000 ($0.75 per cfm) for Sacramento, CA location (using $0.15/kWh and $0.60 per therm).



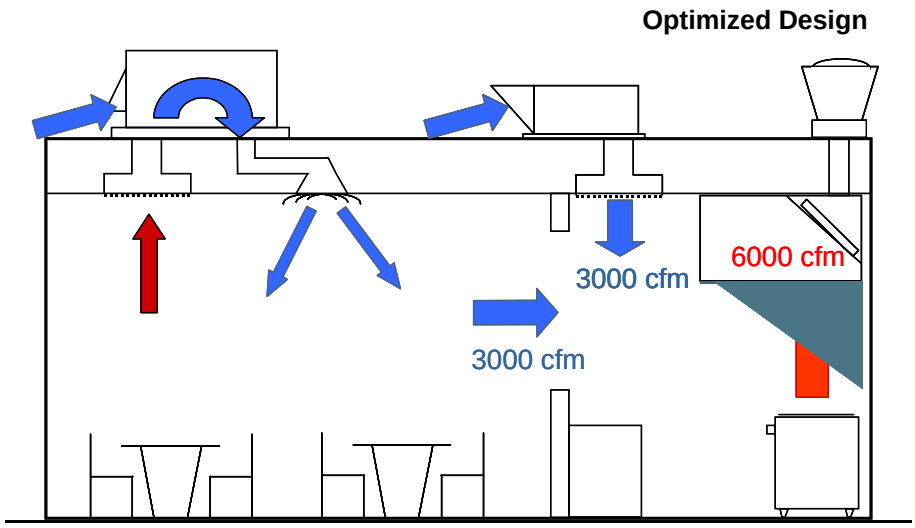
Engineered Approach

A "listed" hood (20-ft by 4.5-ft each) with partial side panels for a total exhaust of 6,000 cfm. Maximized use of transfer air. Perforated ceiling diffusers away from the hoods for the MUA supply.

Makeup Air Sources:

- 1500 cfm from kitchen HVAC unit (15 Ton, 7000 cfm total supply)
- 1500 cfm from dining HVAC unit (10 Ton, 5000 cfm total supply)
- 3000 cfm from independent MUA (no heating with evaporative cooling)

Annual CKV energy cost estimated at $2000 ($0.25 per cfm) for Sacramento, CA location, for a $4000 saving over standard design.



[1] Hoods designed to meet exhaust levels required by building codes, but not listed by a certified laboratory in accordance with a recognized test standard. For identical cooking equipment unlisted hoods typically require higher exhaust flows than listed hoods.

Notes and Acknowledgments

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Architectural Energy Corporation, Boulder, CO, and Fisher-Nickel, inc., San Ramon, CA, prepared this design guide. The first edition of this design guide was included as an attachment in the Energy Commission report titled *Makeup Air Effects on the Performance of Kitchen Exhaust Systems* (publication P500-03-007F, December 2002). Updated editions of this design guide may be downloaded from www.fishnick.com or www.archenergy.com.

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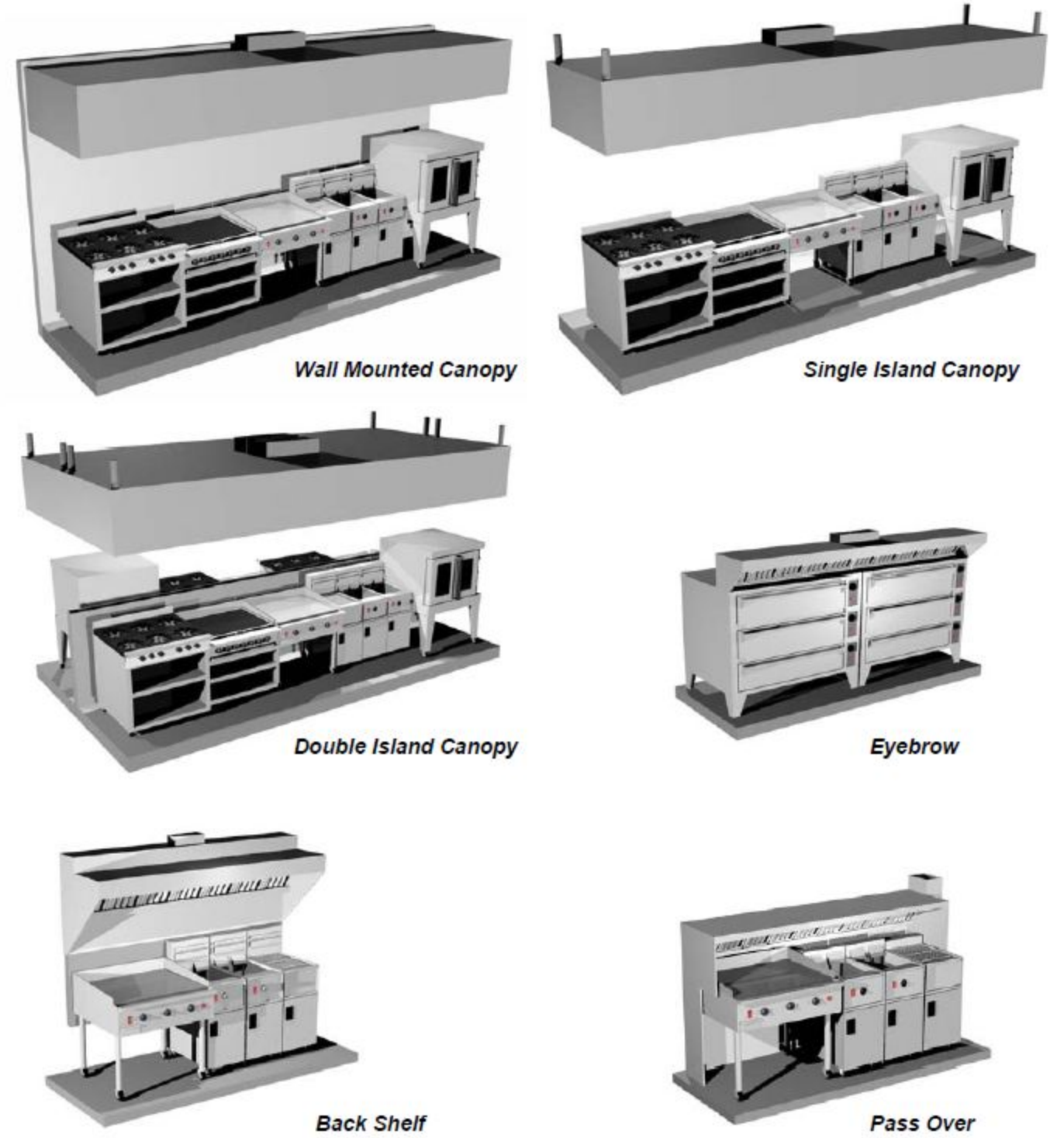

Figure 1. Styles of Exhaust Hoods.

BUSINESS PROGRAMS

Kitchen Ventilation Controls

Variable-Volume Control Ventilation Saves Energy, Money

FACT SHEET

For more information call 800.762.7077 or visit focusonenergy.com

The average food service kitchen exchanges inside air for fresh outside air at least 20 times an hour. It sounds like an effective way to keep a kitchen comfortable and safe, but in most situations it's actually a huge drain on energy resources that provides no real health benefits to employees or guests.

Roughly 25 percent of a food service operation's energy costs go to conditioning the outside air brought in during these air exchanges, and, according to estimates from the American Gas Association, the U.S. food service industry wastes more than $2 billion each year because of excessive ventilation.

EXCESSIVE VENTILATION

Until a few years ago, most kitchen ventilation controls consisted of a manual on/off switch and a magnetic relay or motor starter for each fan. Exhaust and make-up fans either operated at 100 percent speed or not at all. The whirl of the exhaust fan was a common sound in the average commercial kitchen—even when cooking equipment was not in use. Manual two-speed systems that relied on cooks to switch from low- to high-speed and vice versa offered some energy savings but were seldom used efficiently.

VARIABLE VOLUME CONTROL

Today's state-of-the-art ventilation systems have changed all that. With microprocessor-based controls with sensors automatically regulating fan speed based on cooking load, time of day, kitchen comfort and indoor air quality, it's now possible to ensure excellent air quality while minimizing energy usage.

The new systems include a temperature sensor installed in the hood exhaust collar, optic sensors on the ends of the hood that detect the presence of smoke or cooking effluent and variable-frequency drives (VFD) that control the fan(s). The volumetric flow of the hood varies based on two key inputs: temperature and smoke/cooking effluent. The VFD controls the amount of exhaust (and make-up air) based on temperature—the lower the temperature the lower the flow. And, if the optic sensor is triggered by smoke or cooking effluent, the speed of the fan ramps up to 100 percent instantaneously.

Kitchen exhaust ventilation may be the largest single opportunity for reducing energy costs in a food service operation.

Case studies have proven that these systems reduce average flow, typically measured in cubic feet per minute (CFM), by anywhere from 10 percent to 50 percent of a system's design volume and can lead to substantial energy savings.

BENEFITS GO BEYOND ENERGY SAVINGS

Variable volume control can also mean:

A significantly quieter kitchen

Even relatively small decreases in speed can reduce the kitchen noise level. When the fans run at 80 percent speed, the air noise generated at the grease filters decreases more than 20 percent; when the fans run at 50 percent speed, air noise is virtually eliminated. The result: a more pleasant environment for employees and guests (when the hoods are located near customers).

Reduced HVAC equipment wear

Soft-starting the hood fans with a VFD extends belt life and reduces the outside air load on the kitchen air-conditioning units. This reduces compressor run time and extends the life of heating, ventilation and air conditioning systems. This also can apply to refrigeration units inside the kitchen. In addition, reducing the make-up airflow decreases the rate at which the filters become dirty and need to be cleaned or replaced.

Decreased grease entrapment

Excessive fan speeds send grease up the duct, into the fan and out to the building roof—and, sometimes, even into the atmosphere. Slowing down the exhaust fans and reducing the air duct velocity allows the grease to drain back to the hood and into grease cups, where it can be easily disposed of.

FOR MORE INFORMATION

Looking for ways to improve energy efficiency without sacrificing employee and customer comfort? Focus on Energy's Hospitality Team can help. To learn more about available resources and incentives on kitchen ventilation controls and other food service equipment, contact your Focus on Energy advisor at 800.762.7077 or visit our Web site, focusonenergy.com.

CASE STUDY—DEMAND CONTROL VENTILATION

Dos Gringos Mexican Restaurant in Beaver Dam recently underwent a kitchen renovation which included a new exhaust hood. Scott Eberle, owner of Dos Gringos, was concerned about the increasing costs of energy and how it was affecting his bottom line. "I knew that my exhaust hood used a significant amount of energy because it was always running at full speed even if my cooking equipment wasn't on." After doing some research and contacting Focus on Energy's hospitality team, Eberle was introduced to variable-volume ventilation controls for kitchen exhaust hoods.

The installation cut fan speed by 45 percent—for both exhaust and make-up fans—and led to a significant reduction in energy costs. "I'm saving almost $4,000 yearly in energy costs—both because of the lower fan use and because I'm reducing the amount of heated or cooled air that's leaving the building. Plus, the work environment is a lot more pleasant and my grease filters are working more effectively," said Eberle. "Between the energy savings and the financial incentive I received from Focus on Energy, my payback period is minimal. This decision made a lot of sense for my restaurant."

Focus on Energy works with eligible Wisconsin residents and businesses to install cost effective energy efficiency and renewable energy projects. Focus information, resources and financial incentives help to implement projects that otherwise would not be completed, or to complete projects sooner than scheduled. Its efforts help Wisconsin residents and businesses manage rising energy costs, promote in-state economic development, protect our environment and control the state's growing demand for electricity and natural gas. For more information, call **800.762.7077** or visit **focusonenergy.com**.

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AC-PSP Accessory

Features and Benefits

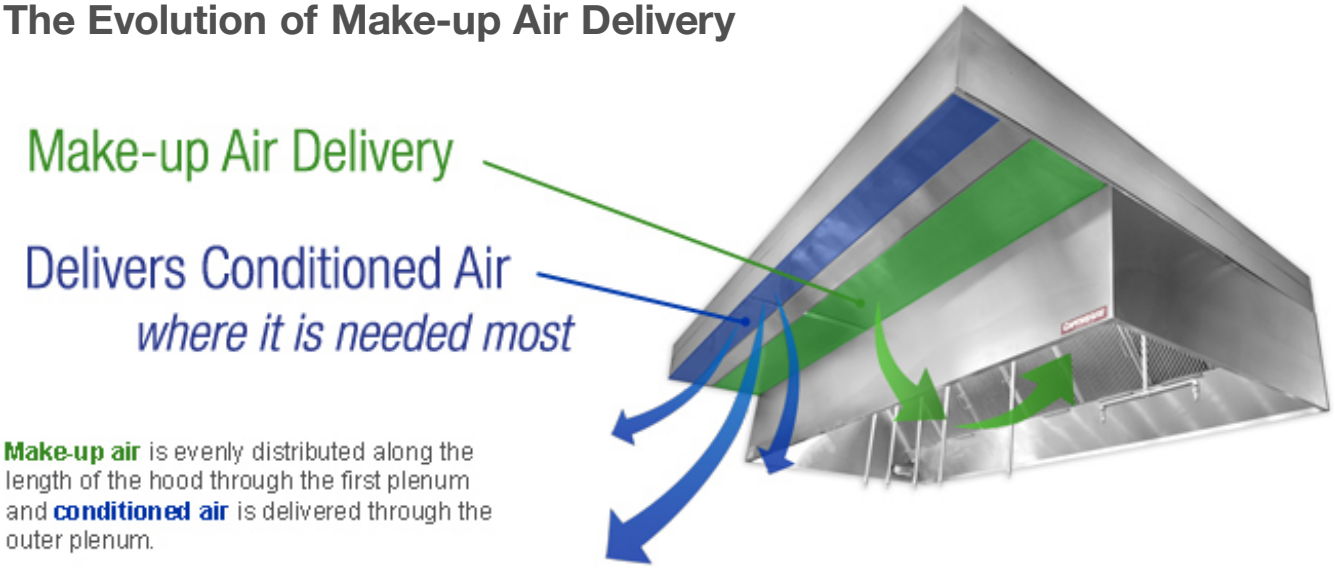
- Stainless steel construction to match the ventilation hood
- Make-up Air Plenum provides up to 80% make-up air
- AC Plenum provides convenient termination for AC ductwork in kitchen and insulated to prevent condensation
- Make-up Air Plenum is located nearest to the hood and AC Plenum is away from the hood
- Make-up air stream and AC stream do not mix until leaving the dual plenum
- Optional LED Lights

PSP Accessory

Features and Benefits

- Stainless steel construction to match the ventilation hood
- Make-up Air Plenum provides up to 80% make-up air
- Evenly distributes make-up air along the length of the hood
- Easy installation
- Optional Insulation for Make-up Air Plenum

The Evolution of Make-up Air Delivery



Optional LED Lights NEW!

The Optional LED Lights accessory for the AC-PSP allows additional lighting around the hood. Choosing this option places round, recessed LED lights in the divider between the Make-up Air and the AC Plenum. The light is a 3.5 watt, warm white 20 cluster LED.