Applying State of the Art Commercial Kitchen Ventilation Technologies for Comfort and Performance

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ASHRAE San Jose Chapter 50

The Design Challenge!

There is no piece of equipment in the commercial kitchen that generates more controversy that the exhaust hood!

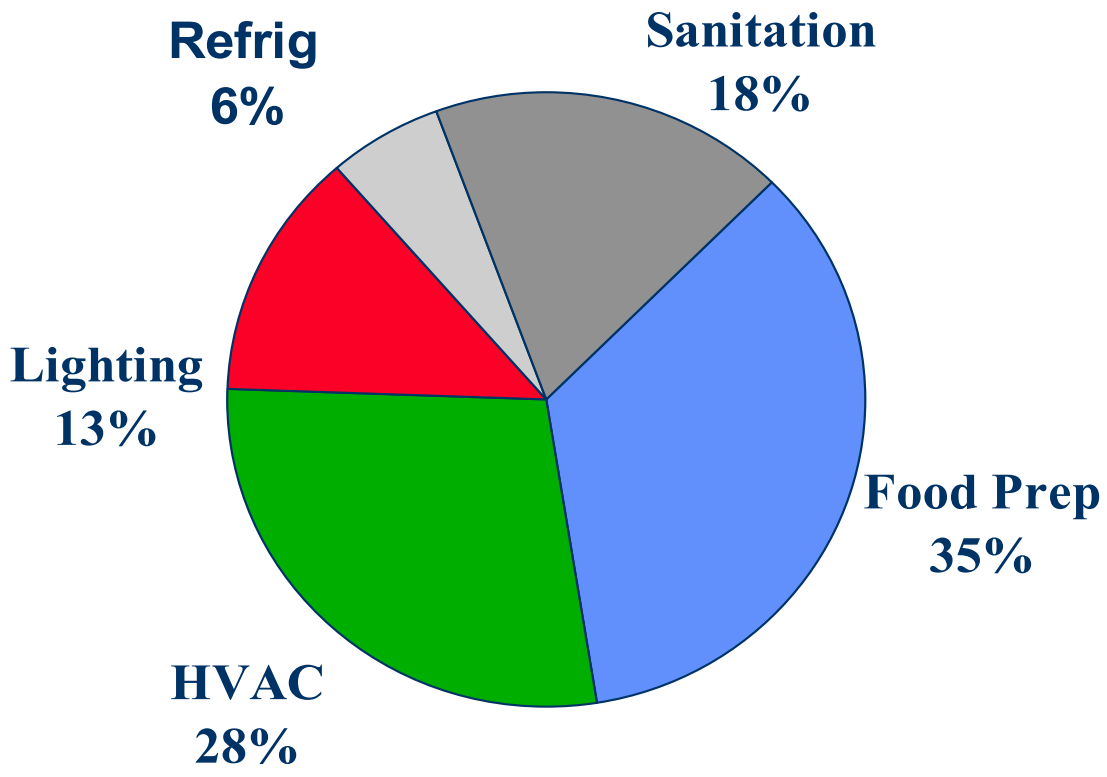
More than 3 Billion CFM…

…exhausted from Commercial Kitchens in the U.S.

…dominated by single-speed systems!

Why care?

How does it break down?



…CKV drives 50 – 75% of HVAC energy!

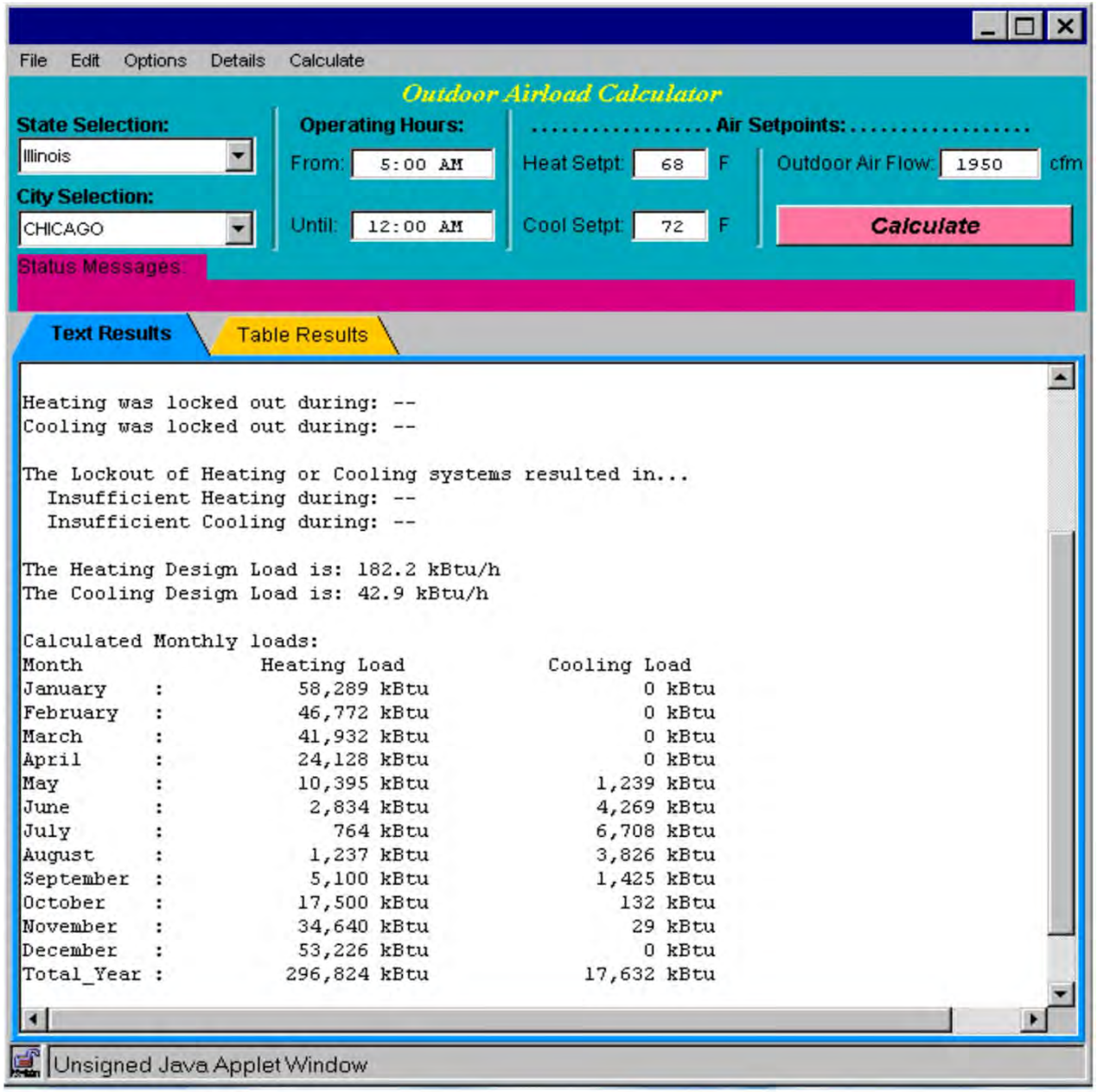
Makeup Air Heating & Cooling

Fan Energy

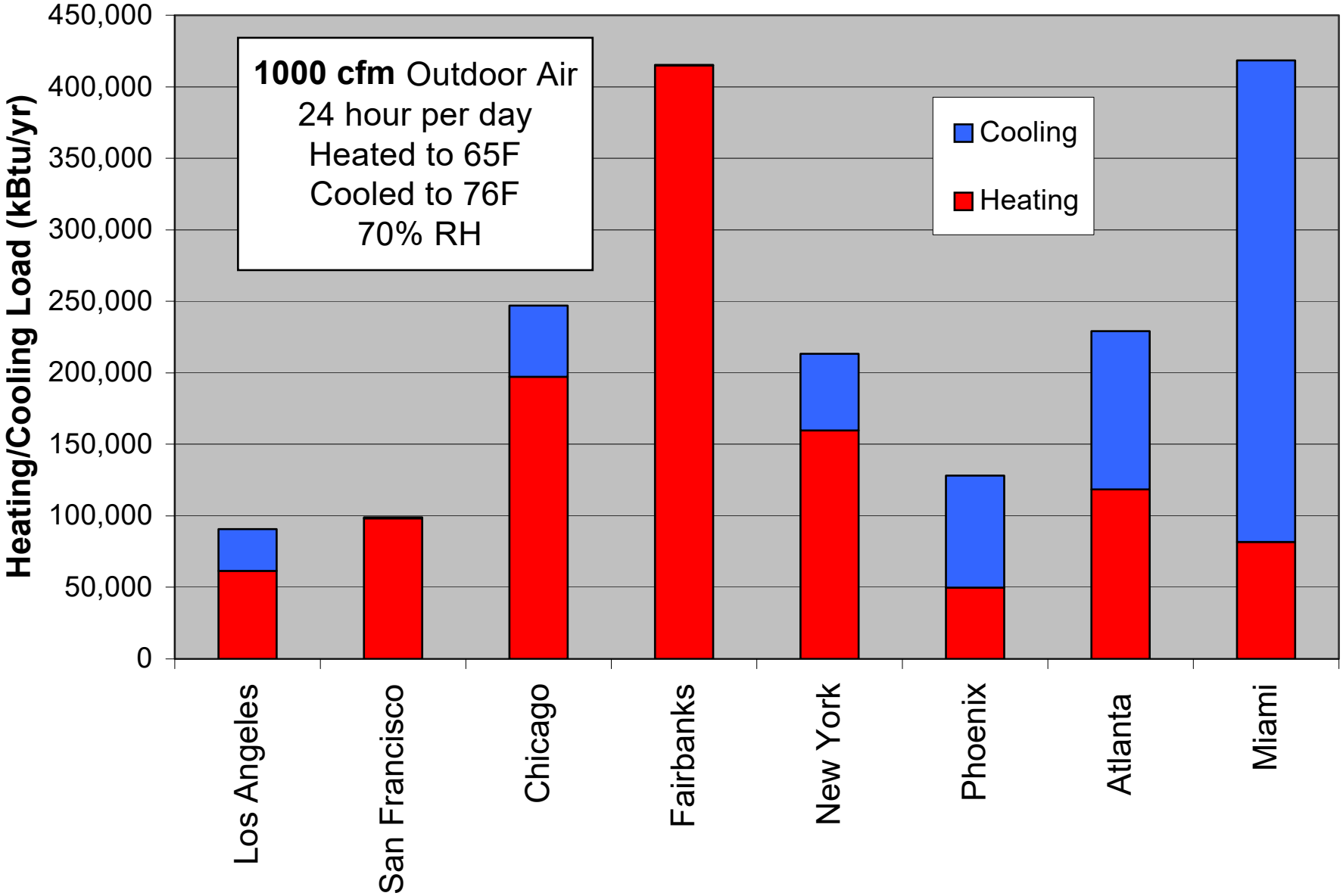
Outdoor Air Load Calculator

and

Fan Energy Estimator



Climate Effect



Hotel Kitchen 3:00 PM
No appliance use…but exhaust at 100%

Back Line

Front Line

Winnipeg Hospital

The Results

21 ft. single island canopy hood over baking line

27 ft. double island canopy hood over cooking line

• Concept Design	34,000 cfm
• Preliminary Design	21,000 cfm
• Final Design	11,000 cfm

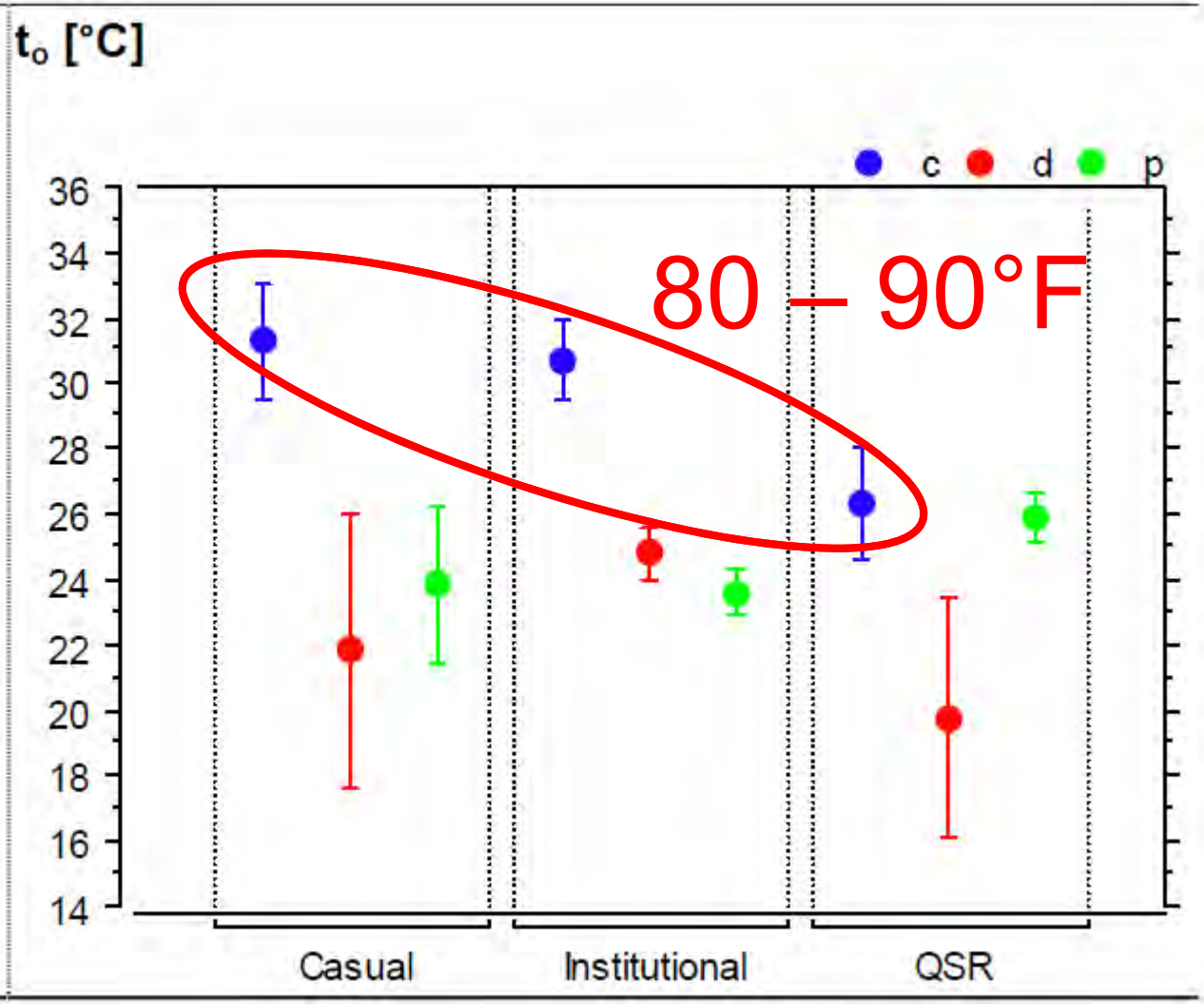
Plus: 2-speed control and exhaust air heat recovery

ASHRAE RP-1469 – Thermal Comfort in Commercial Kitchens

Final Report 01.06.12

Average of Operative Temperature for Kitchen Type and Kitchen Zones with 95% confidence interval (100 kitchens)

t_o [°C]	t_o [°F]
36	97
34	93
32	90
30	86
28	82
26	79
24	75
22	72
20	68
18	64
16	61
14	57



Note: “c” is Cooking, “p” is Preparation, and “d” is Dishwashing zone.

Suggested Thermal Comfort Zone for Commercial Kitchens

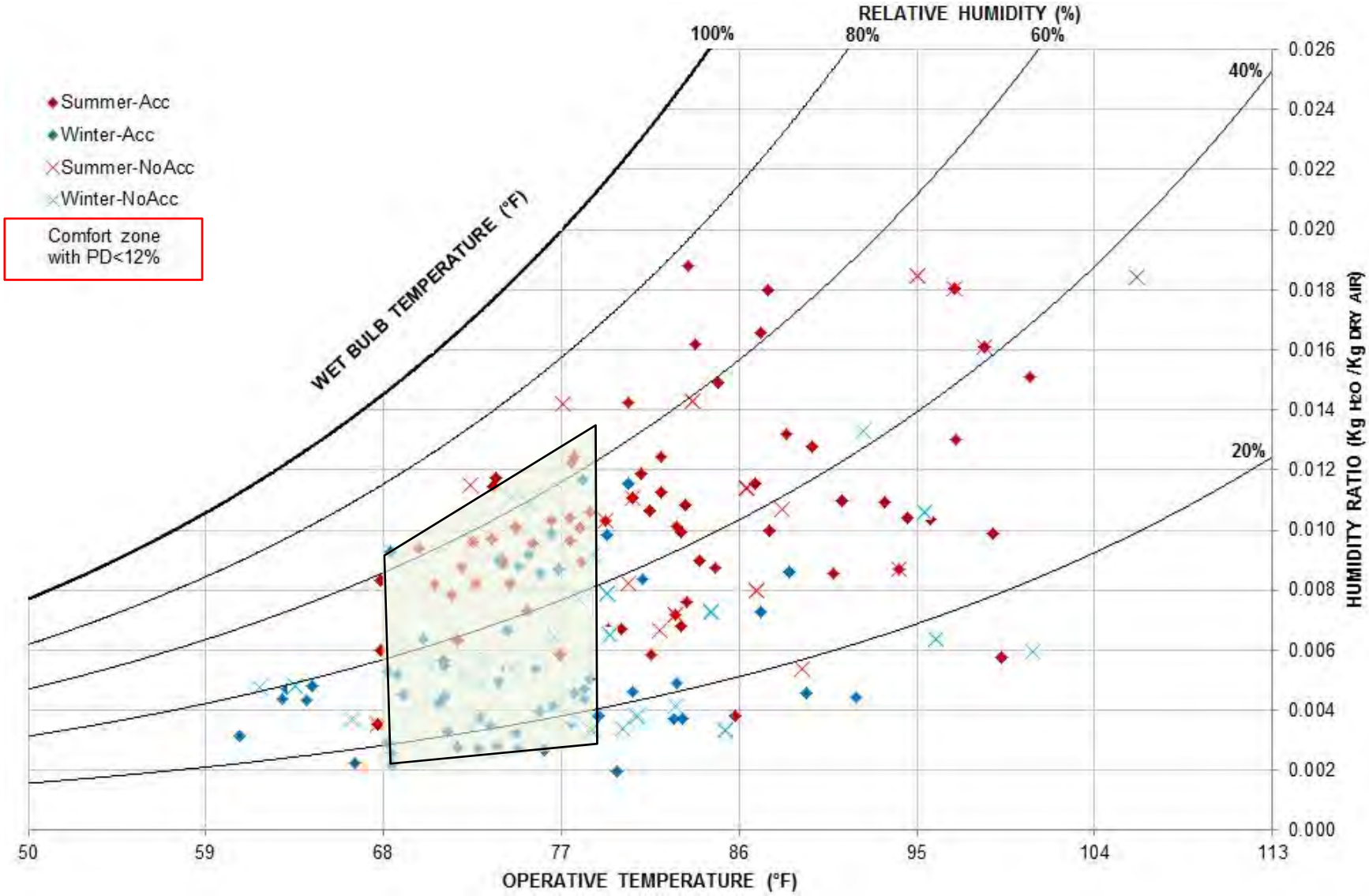


Figure 43: Example of Personal Comments from Survey

Everyone wears more clothes under their 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 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!

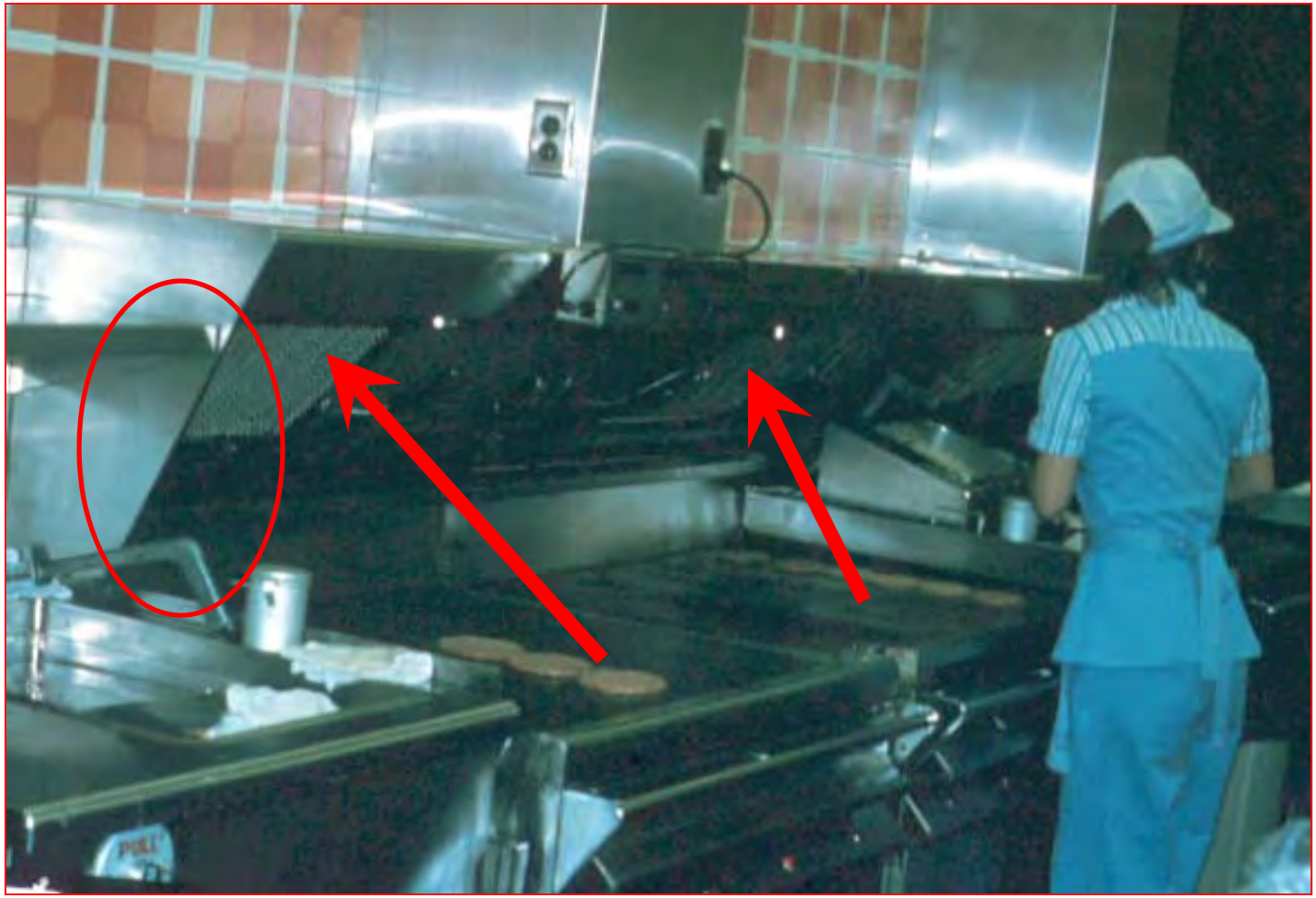
Thank you,

Continue

11

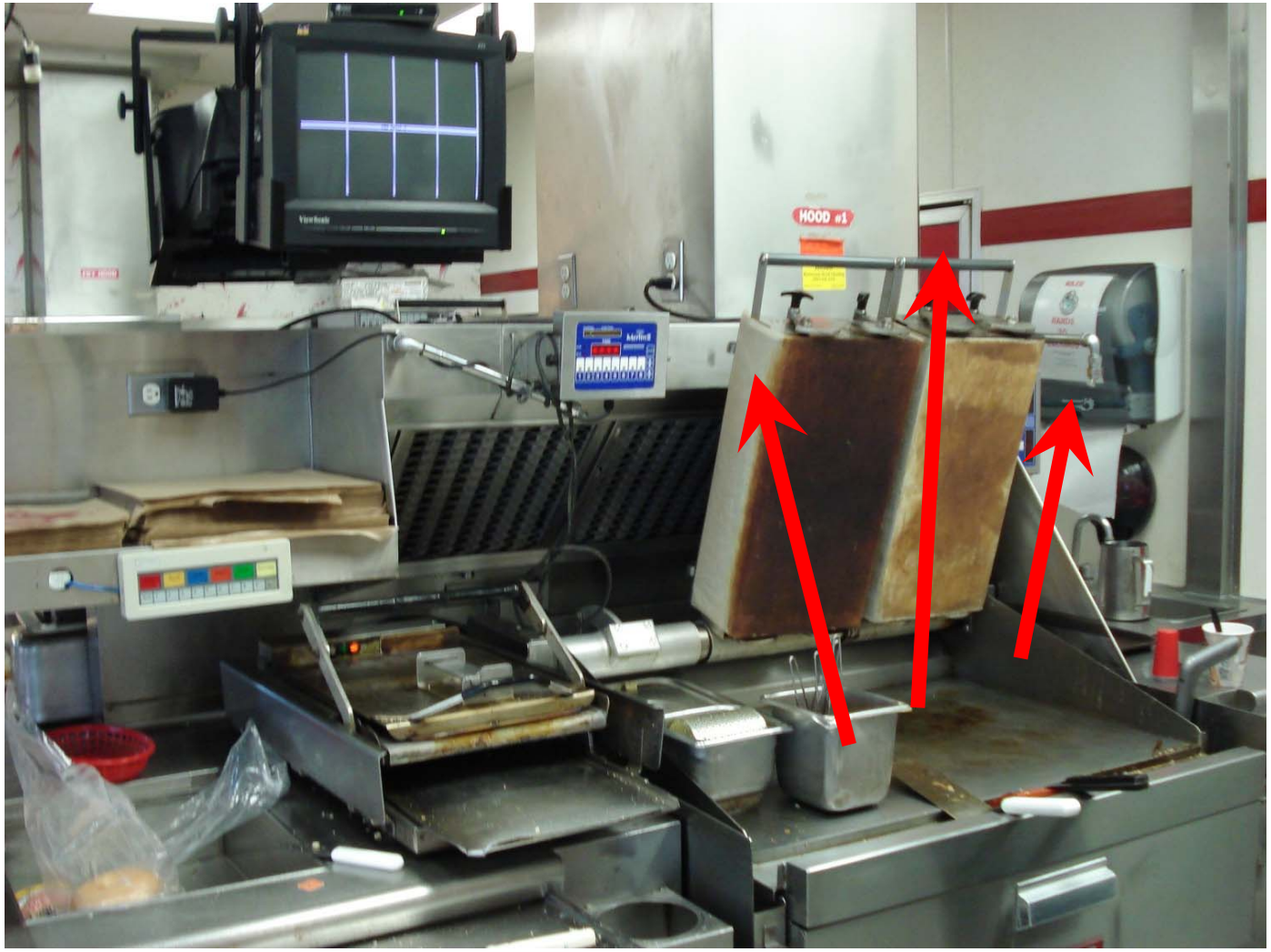
Good intentions!

Good design!



QSR set an industry standard…

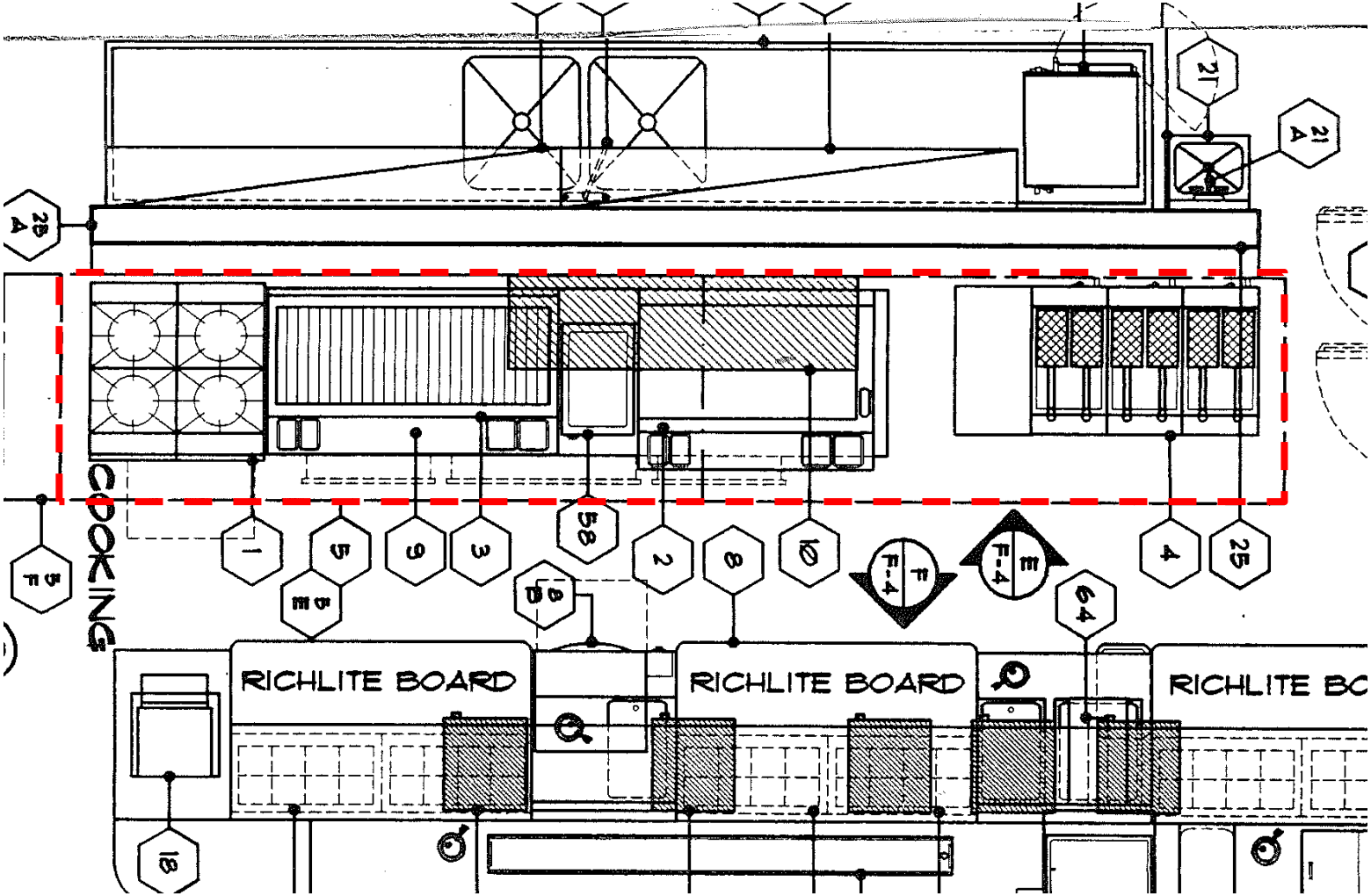
Somebody tried to copy…



Redesigned for Clamshell Grill

LEED design for QSR

The plan view…



The elevation view…

ASHRAE Feature on Tips &Tricks for Capture & Containment!

TECHNICAL FEATURE

Capture and Containment

Commercial Kitchen Ventilation Exhaust Hoods

BY DON FISHER, P.ENG., MEMBER ASHRAE; RICH SWIERCZYNA, ASSOCIATE MEMBER ASHRAE; ANGELO KARAS

The science of commercial kitchen ventilation (CKV) continues to evolve at a rapid pace, driven by ASHRAE research projects,[1–4] an expanding line of high-performance and innovative products, and ongoing testing by various organizations and research facilities.[5] All of this information, along with the results of a California Energy Commission-funded makeup air research project,[6] is leading to updates of the national codes (ASHRAE Standard 154, NFPA 96, UMC, ASHRAE/IES Standard 90.1 and California Title 24)[7–11] and fundamentally changing the way CKV systems are designed and operated (e.g., application of demand-controlled kitchen ventilation).[12]

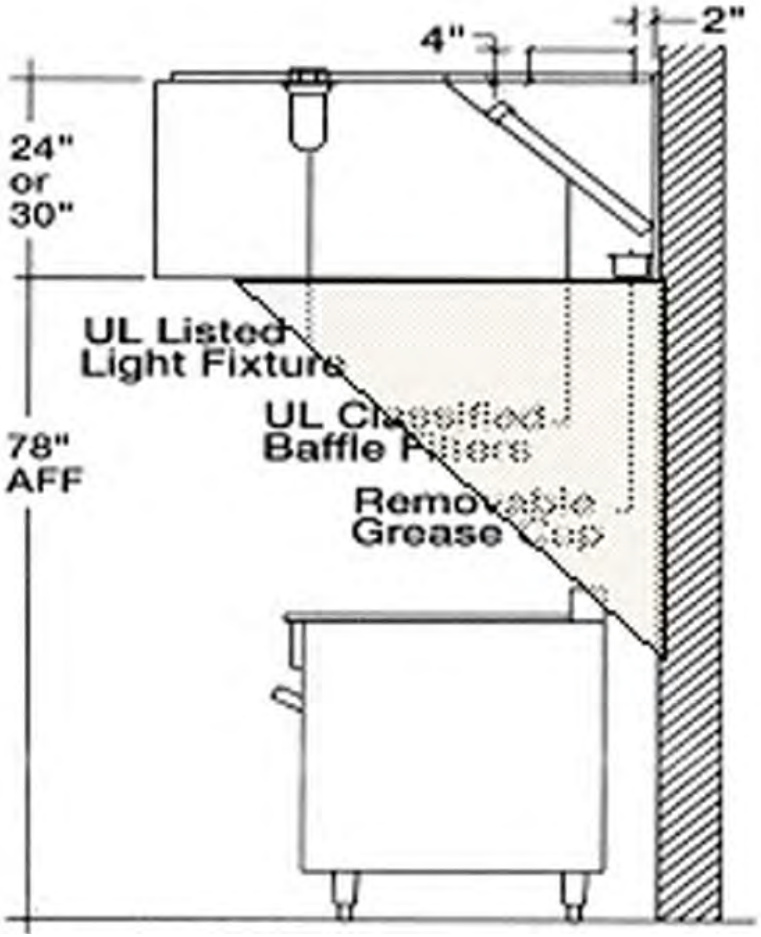
ASHRAE's comprehensive 39-page *Handbook—HVAC Applications* chapter on kitchen ventilation[13] is a dramatic improvement over the two paragraphs in the *Handbook* that existed when the authors began their careers in kitchen ventilation. However, there are still many details associated with the installation of exhaust hoods, makeup air systems, and appliance layout that are overlooked (or not recognized for their importance) within the design and specifications for CKV systems.[14] This article focuses on CKV system attributes and installation best practices that have been identified and/or quantified through public-domain research (as referenced above).

"Hot air rises!" This introductory sentence to a design guide series[14] coordinated by the authors states the obvious. So why then does the thermal plume off cooking equipment sometimes rise and stay within the hood reservoir, while at other times it fills the kitchen with smoke, grease, and heat? Research sponsored by ASHRAE has provided intriguing insights into this question.

In addition to the more obvious "it depends on the amount of exhaust air" factor, research has demonstrated that hood style, construction features and installation configurations, makeup air introduction, as well as the positioning of appliances beneath the hood had a

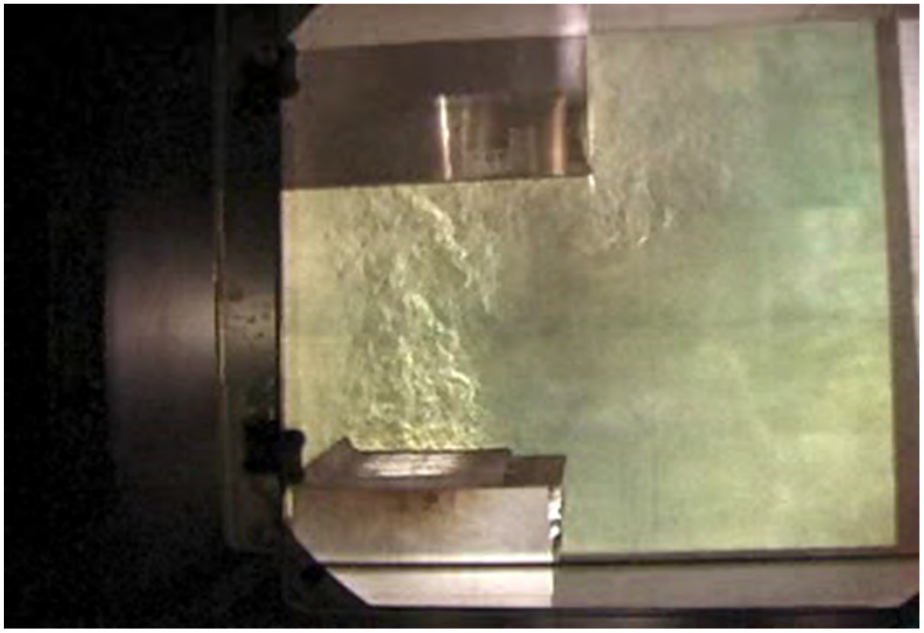
Don Fisher, P.Eng., is principal of Fisher Consultants, LLC, Danville, Calif., which provides technical and management consulting services to the PG&E Food Service Technology Center (FSTC) in San Ramon, Calif. Rich Swierczyna, senior engineer at Fisher-Nickel, Inc., San Ramon, Calif., manages testing at the Commercial Kitchen Ventilation Laboratory and Angelo Karas is a senior lab technician at the PG&E Food Service Technology Center in San Ramon, Calif.

Side panels

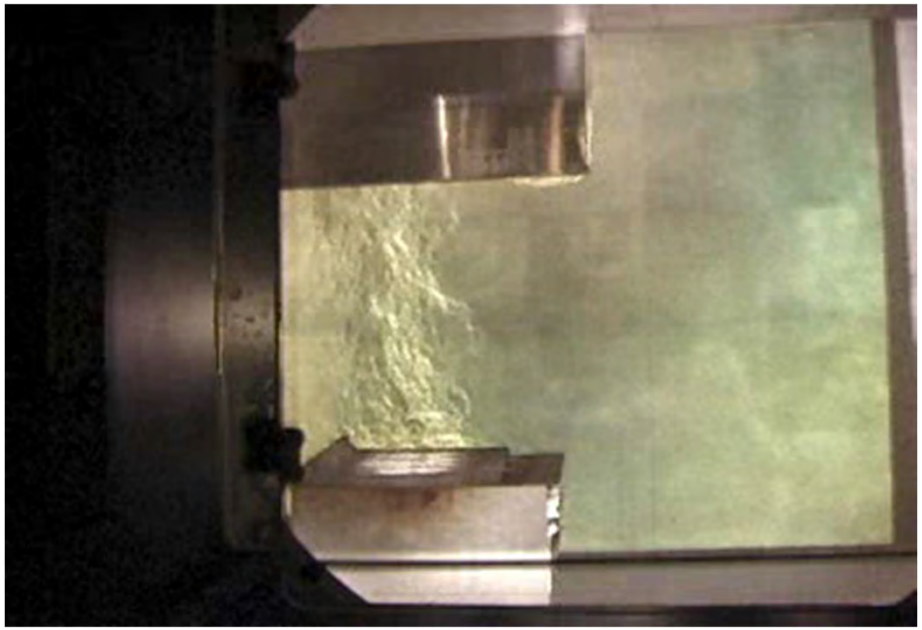


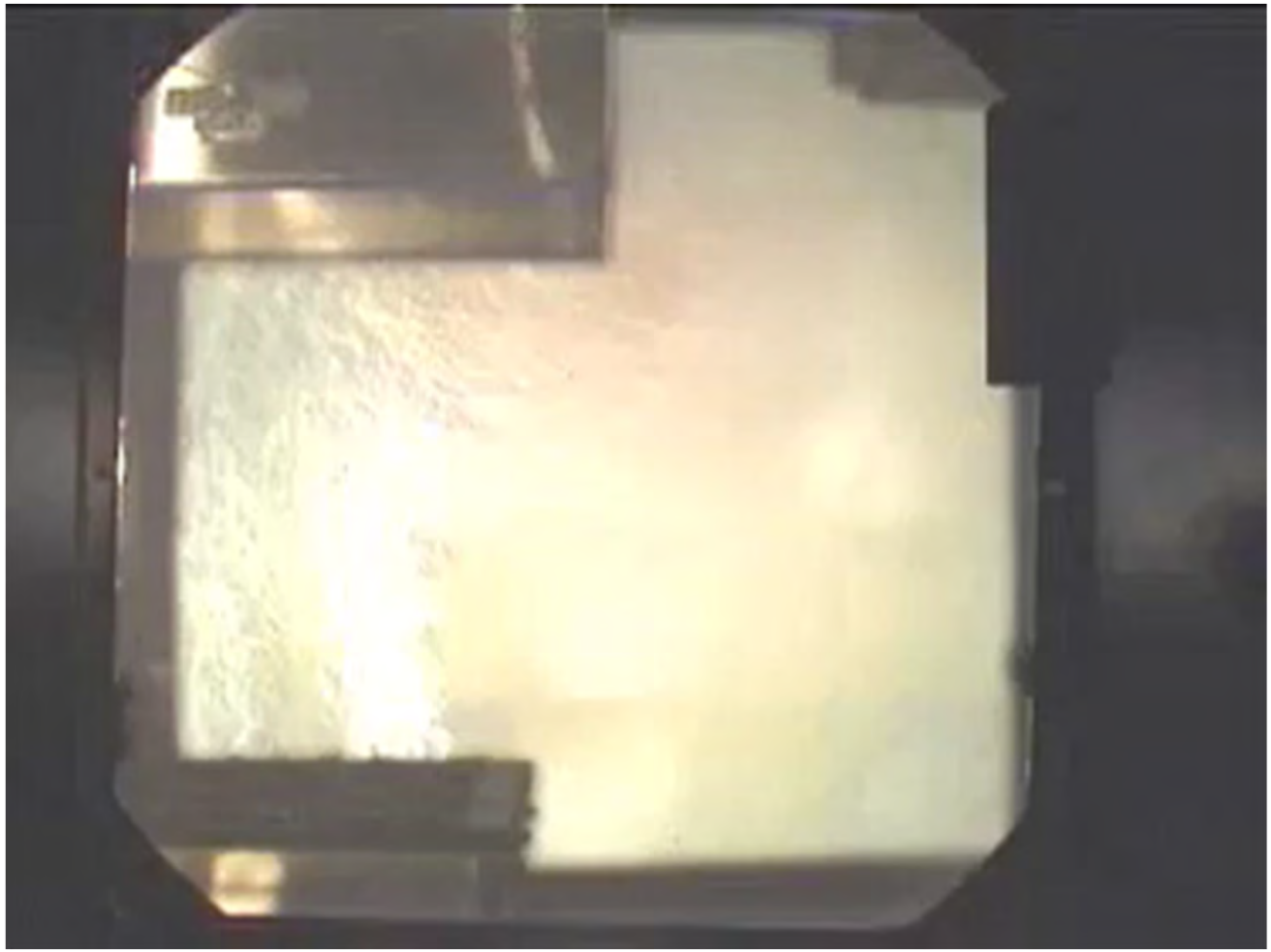
Flow Visualization in Action

Hood Failure = Spillage



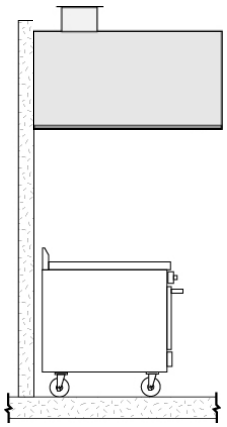
Capture and Containment

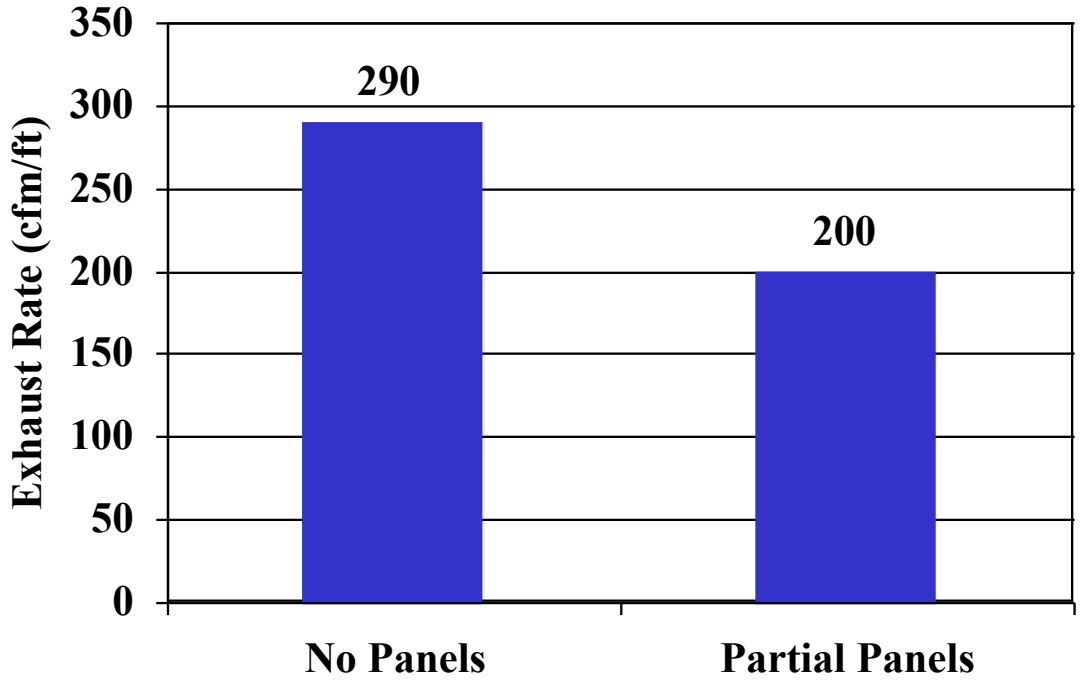


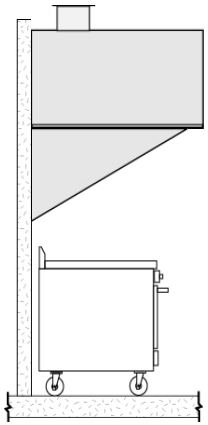


… partial end panels do the job!

Multiple configurations of appliances under various 10-ft. wall canopy hoods (approx. 90 tests) <u>with</u> and <u>without</u> partial side panels

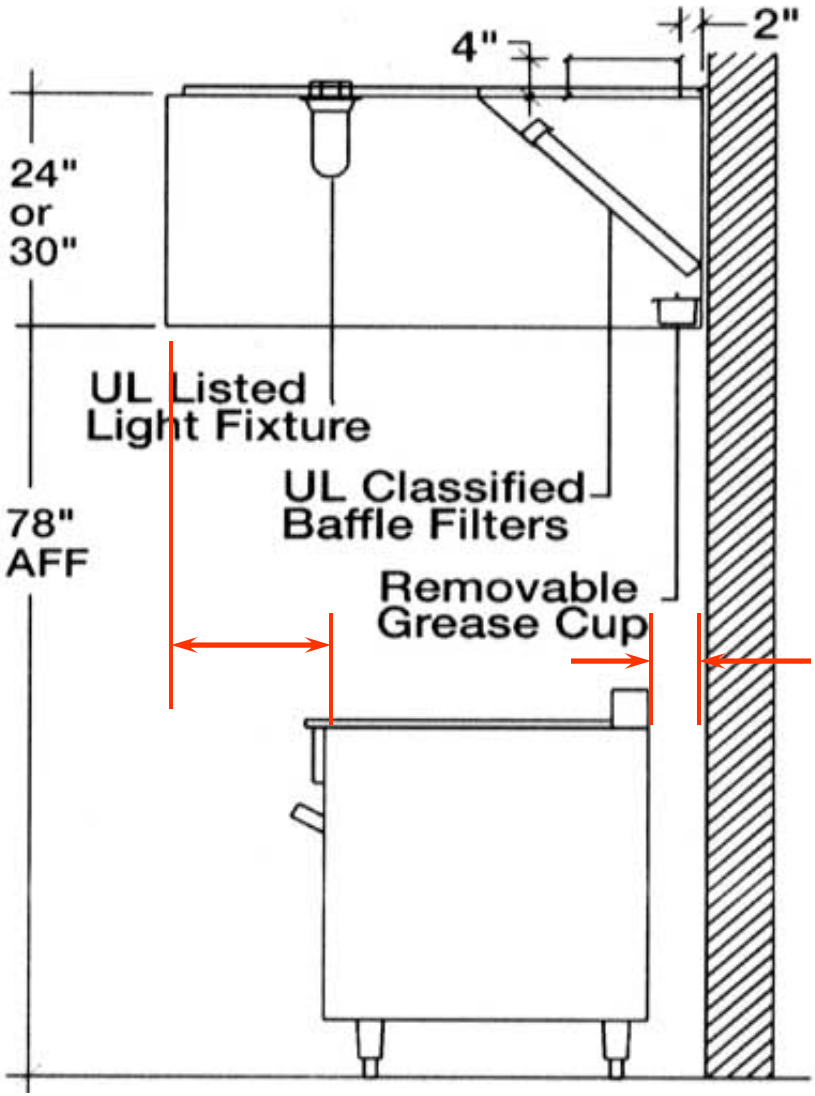






30% reduction in airflow!

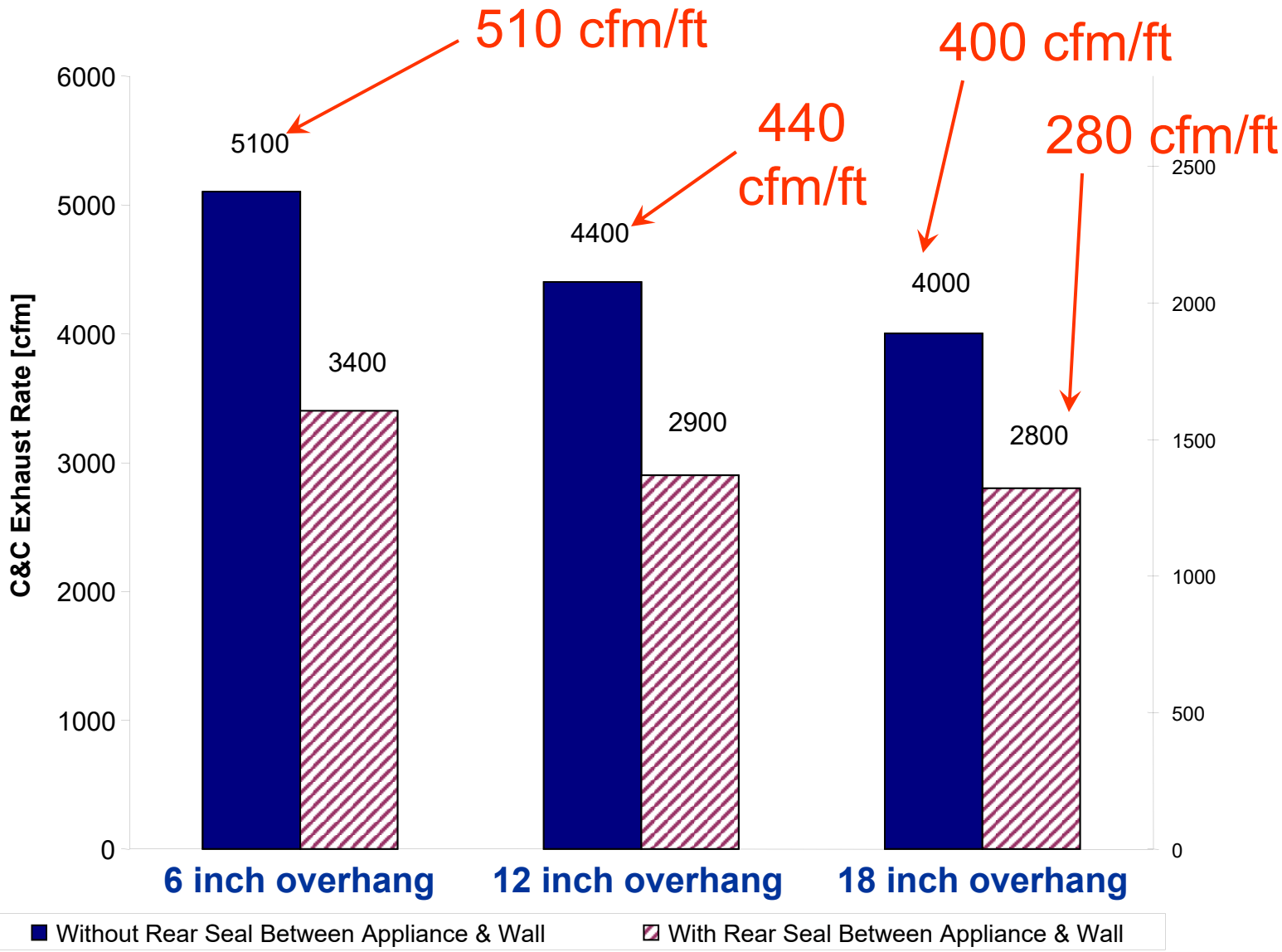
Overhang vs. Rear Gap



Rear Seal Investigation

Front Overhang to Appliance [inches]	Front Overhang to Cooking Surface [inches]	Distance Between the Rear of the Appliance and Backwall [inches]
0	6.0	16.5
6.0	12.0	10.5
12.0	18.0	4.5

Seal gap behind appliances!



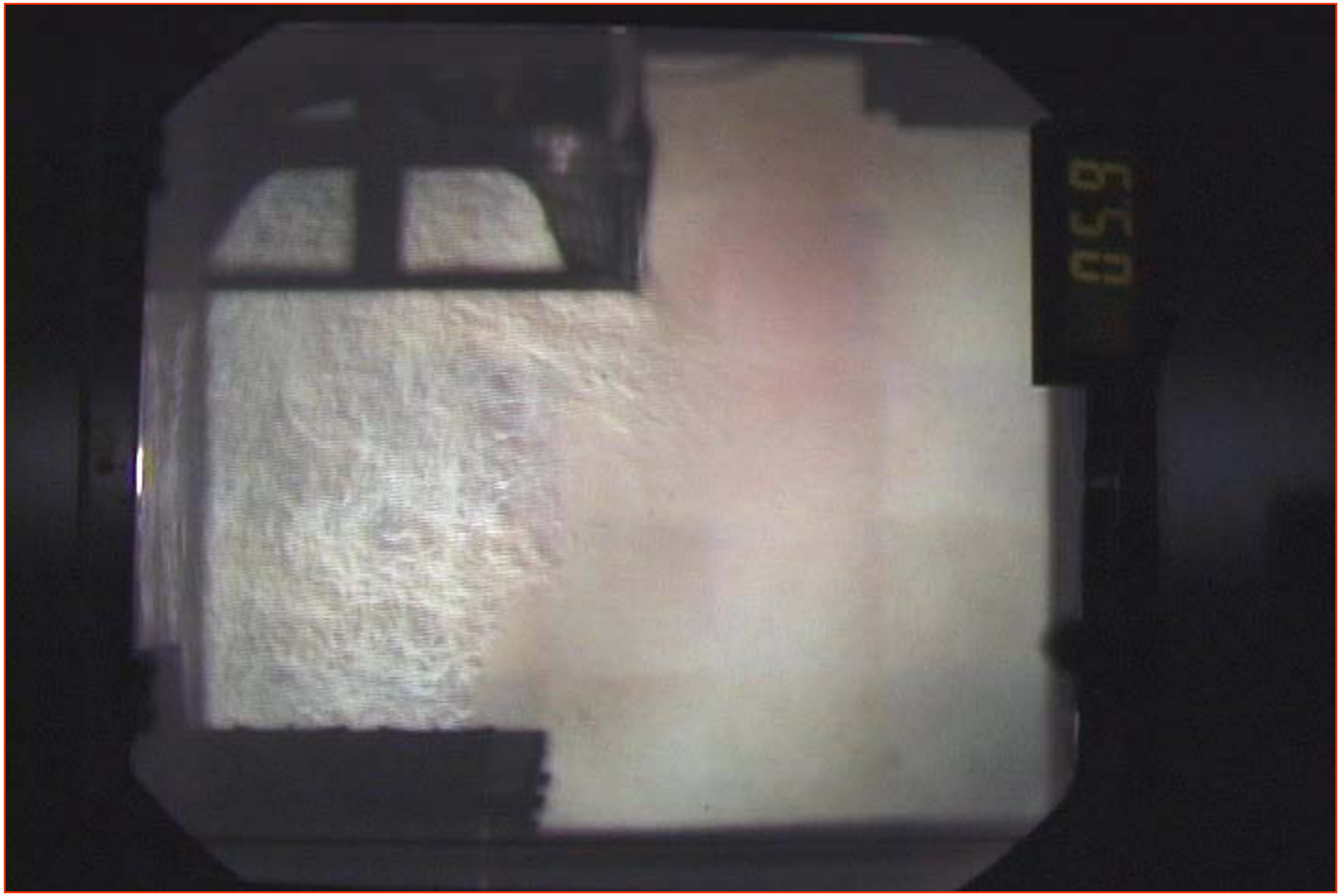
The Makeup Air Disconnect!

Hoods do not like high velocity…

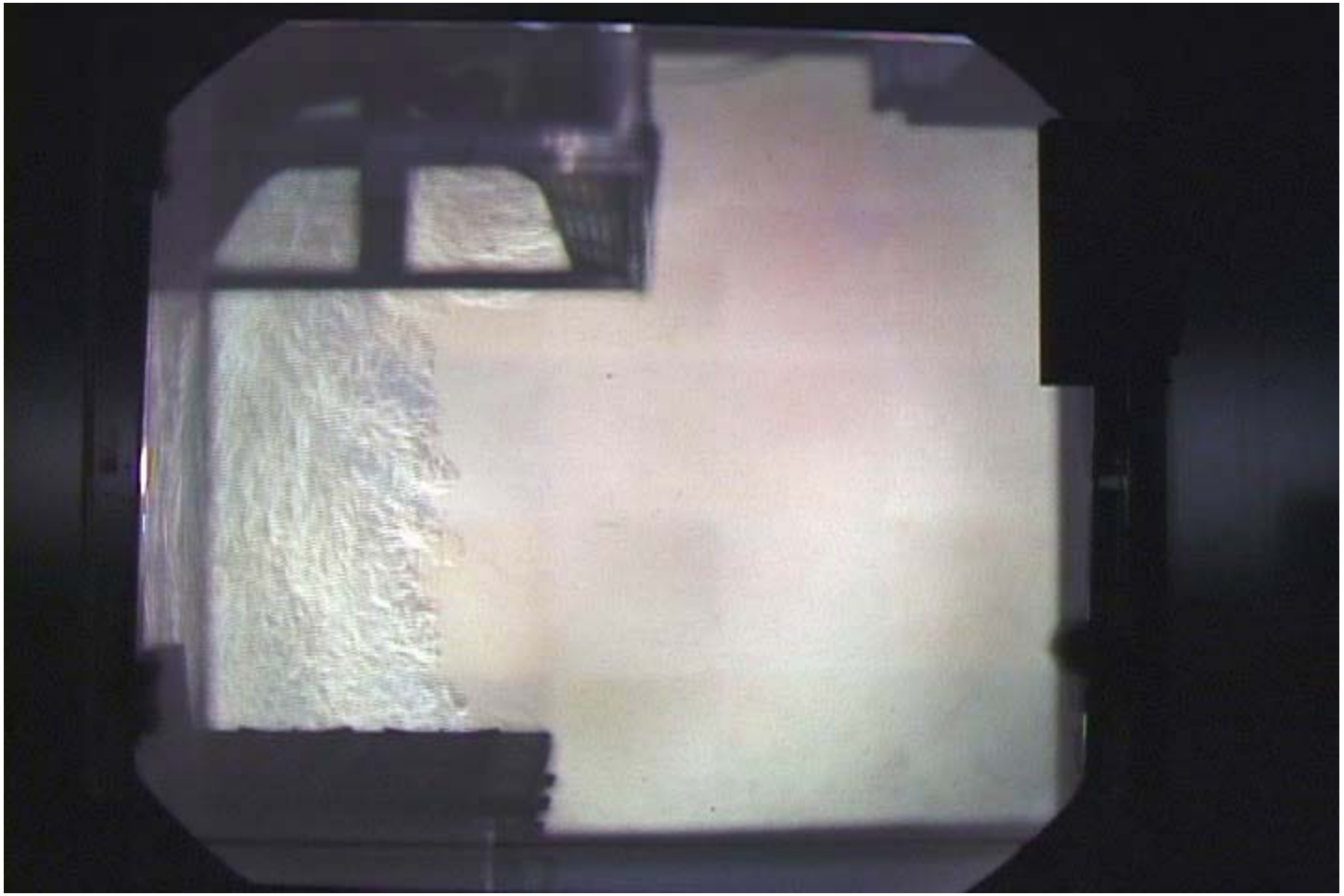
4-Way Diffuser Set-up

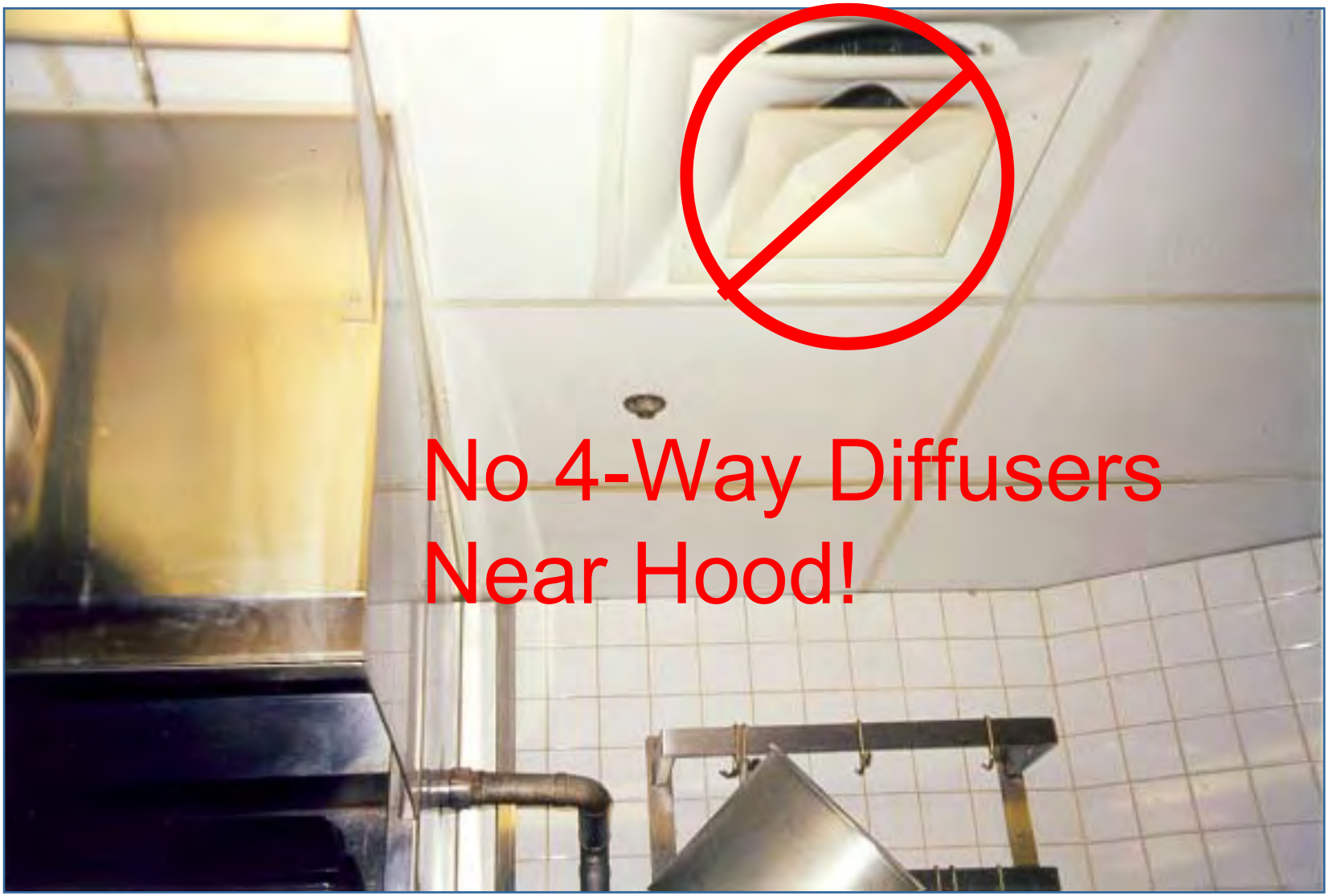
8-Ft Wall Mounted Canopy Hood

1400 SCFM to 4 Way



…and with low-velocity makeup air

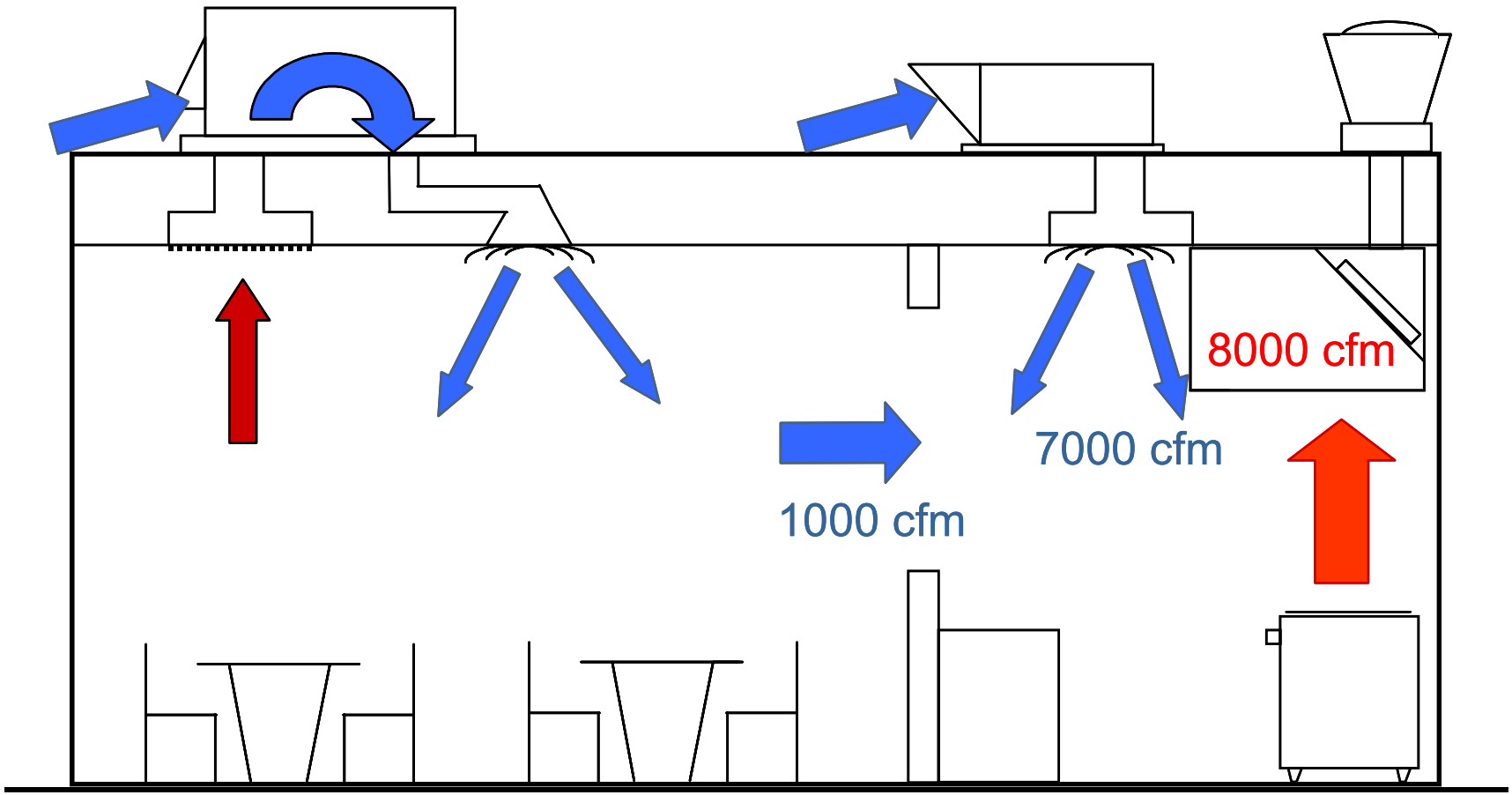



No 4-Way Diffusers
Near Hood!

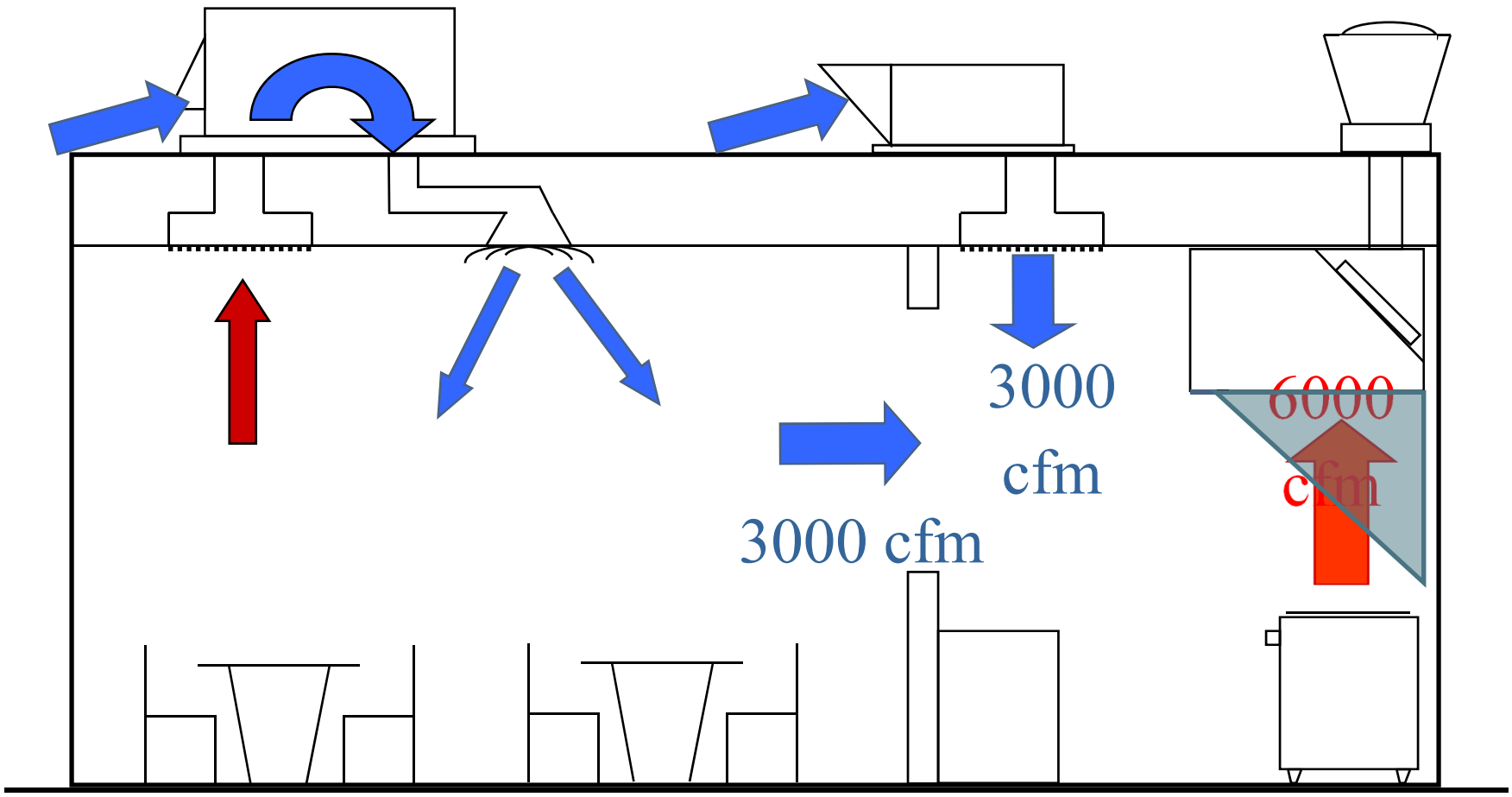
What does CKV-HVAC integration really mean?

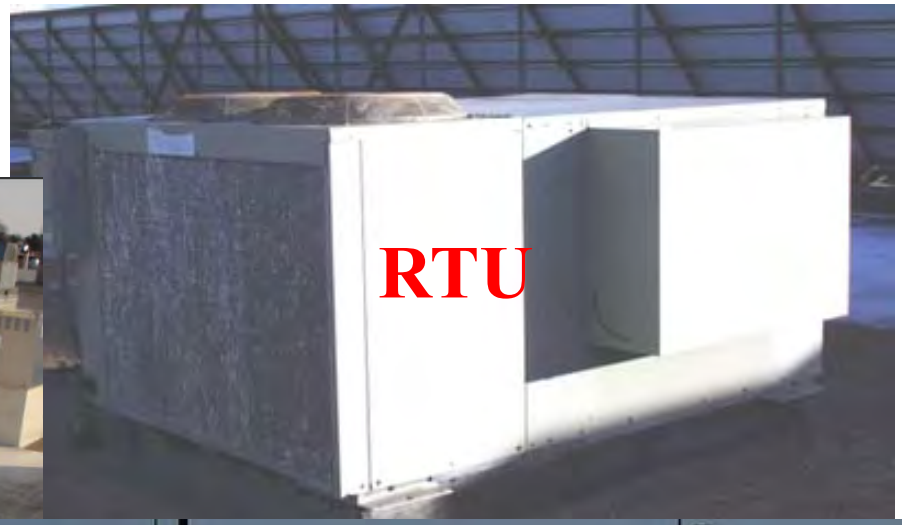
Conversely, what does NOT integrating CKV with HVAC mean?

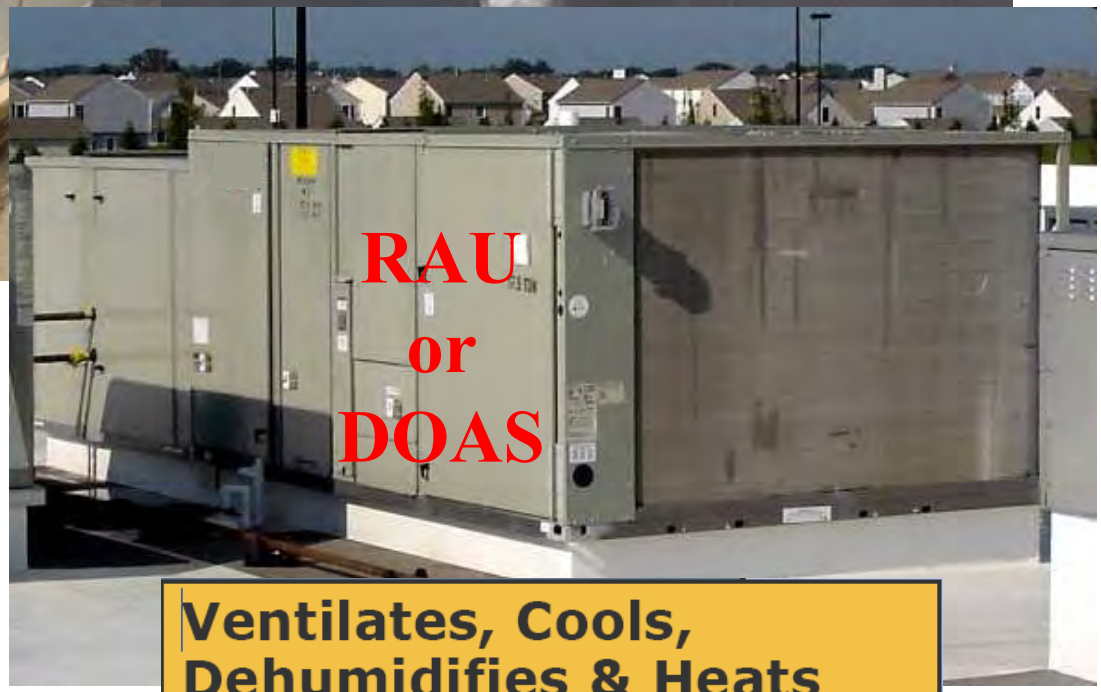
Non-Integrated Approach



Integrated HVAC with CKV!

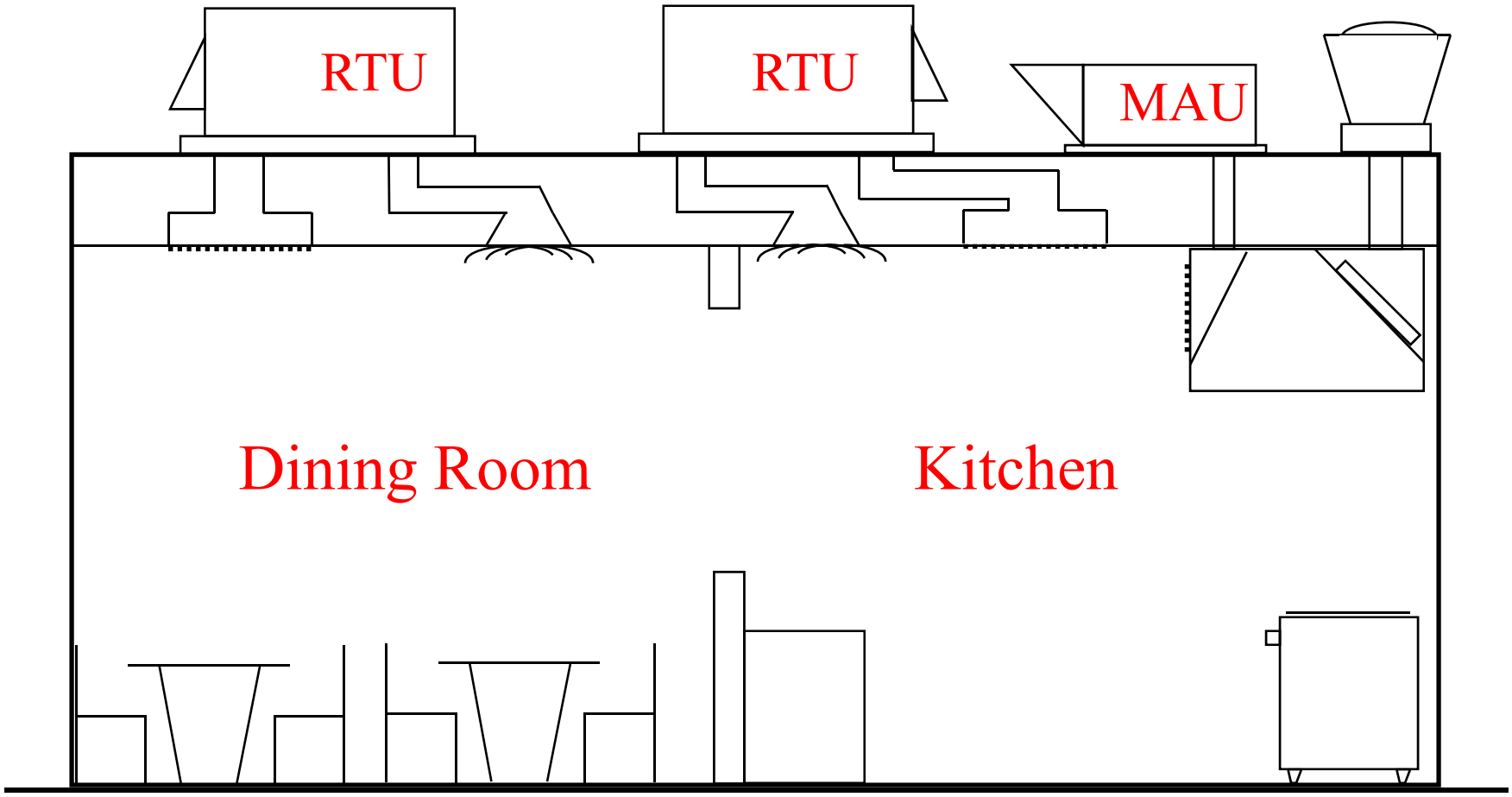




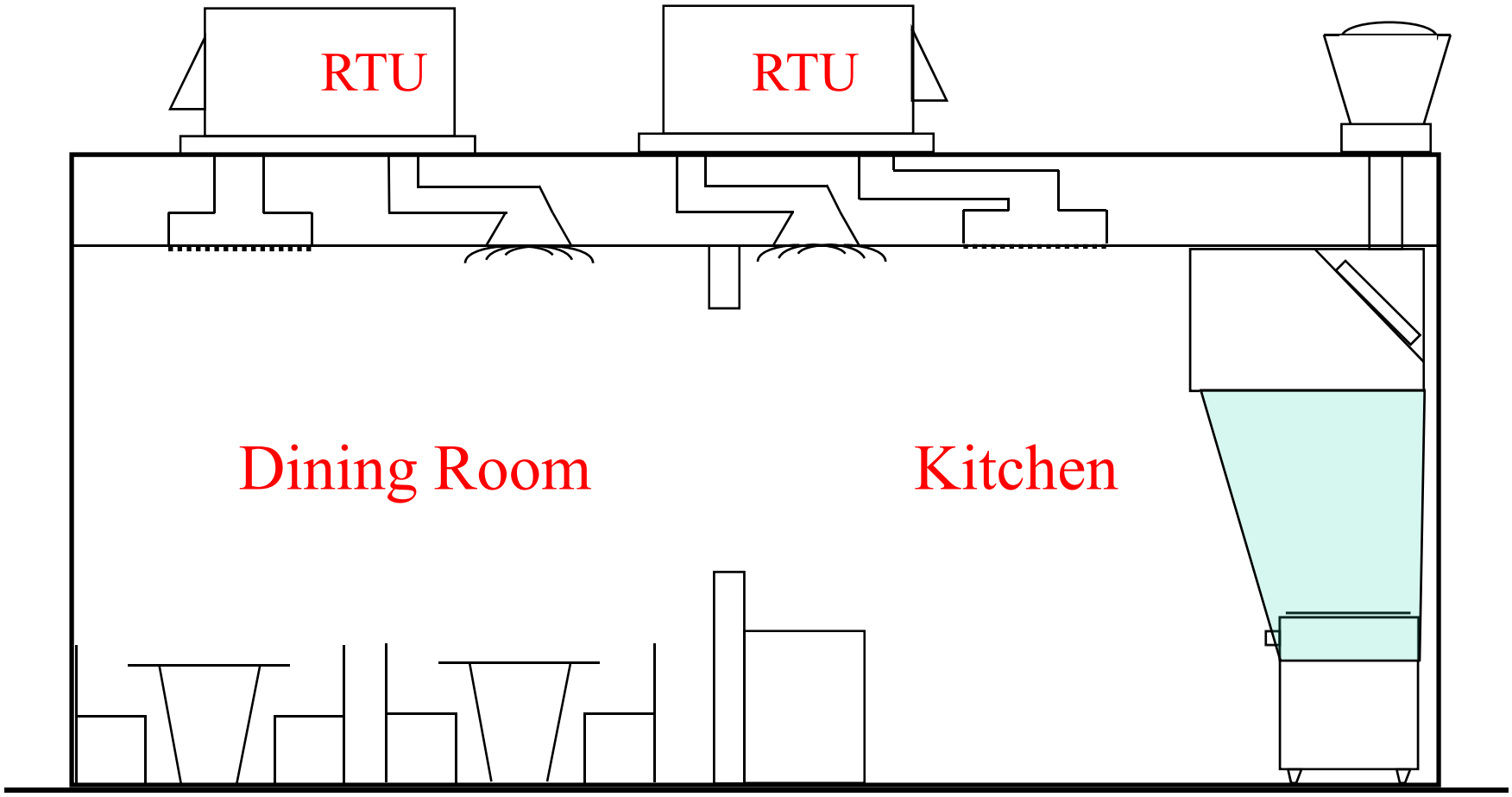


Ventilates, Cools, Dehumidifies & Heats Using 100% Outdoor Air

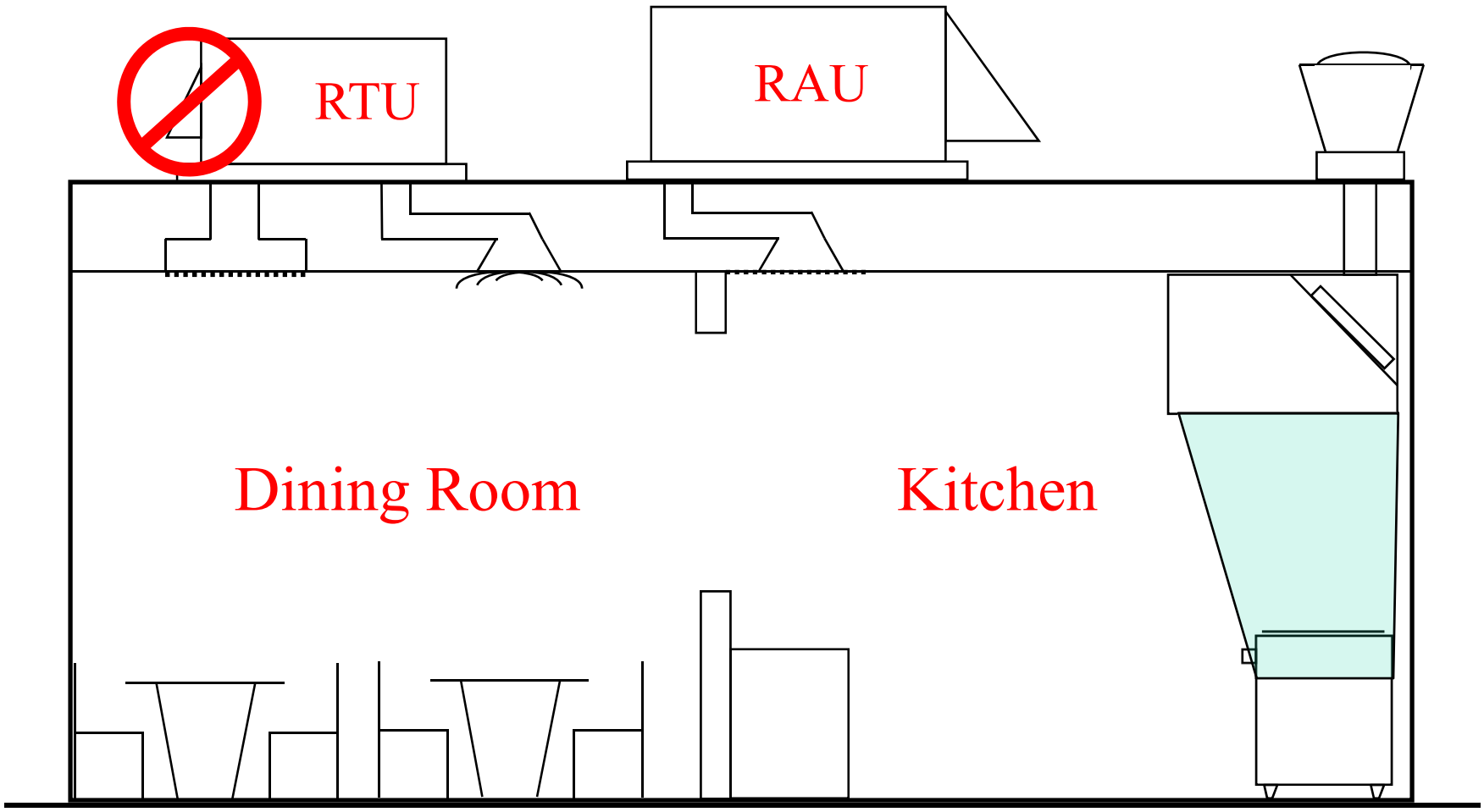
Replacement Air Strategy #1



Replacement Air Strategy #2



Replacement Air Strategy #3



CKV-HVAC Integration Recap:

1. Optimize hood design and reduce the design exhaust airflow rate.
2. Optimize makeup air delivery to kitchen – minimize impact on hood performance.
3. Maximize transfer air/minimize local makeup air.
4. Strive for 100% replacement air through HVAC units (versus using a conventional MAU unit without cooling), or…
5. Consider using a dedicated 100% replacement air unit (RAU).
6. Apply demand controlled kitchen ventilation (DCKV) where cost effective.

And the final touch:

Demand-Controlled Ventilation (DCV)

The Potential…

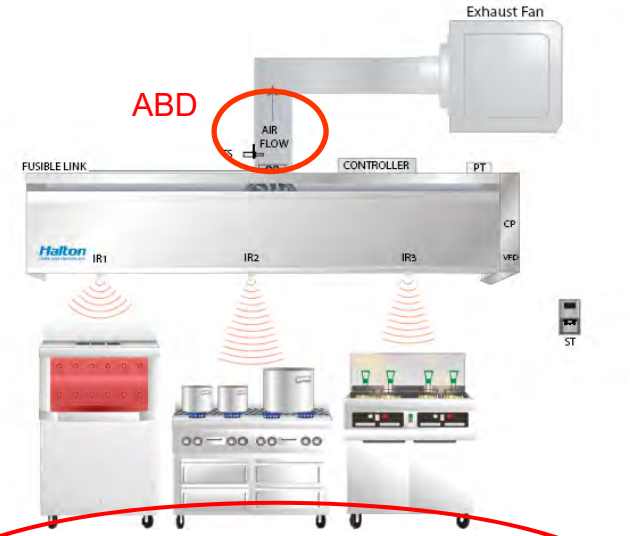
Estimated installed base of 30,000 DCKV systems as this technology has slowly emerged over the last 25 years.

There are 1,000,000 Commercial Foodservice Establishments in the U.S. with CKV systems.

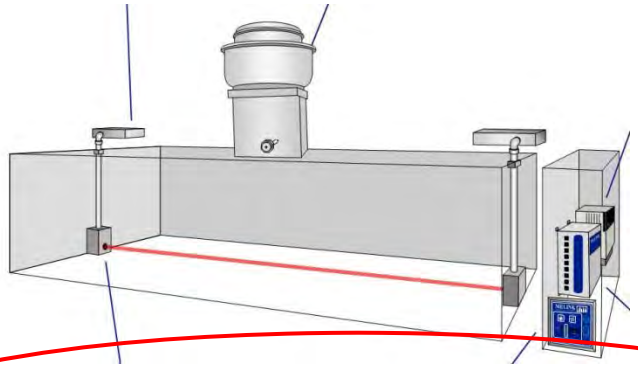
This represents a market penetration of only 3%.

The potential for DCKV is huge!

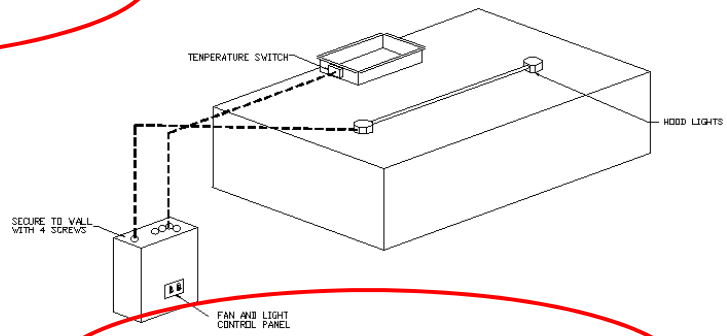
Demand Ventilation Control Technologies



Duct Temperature Sensor & Infrared Sensors

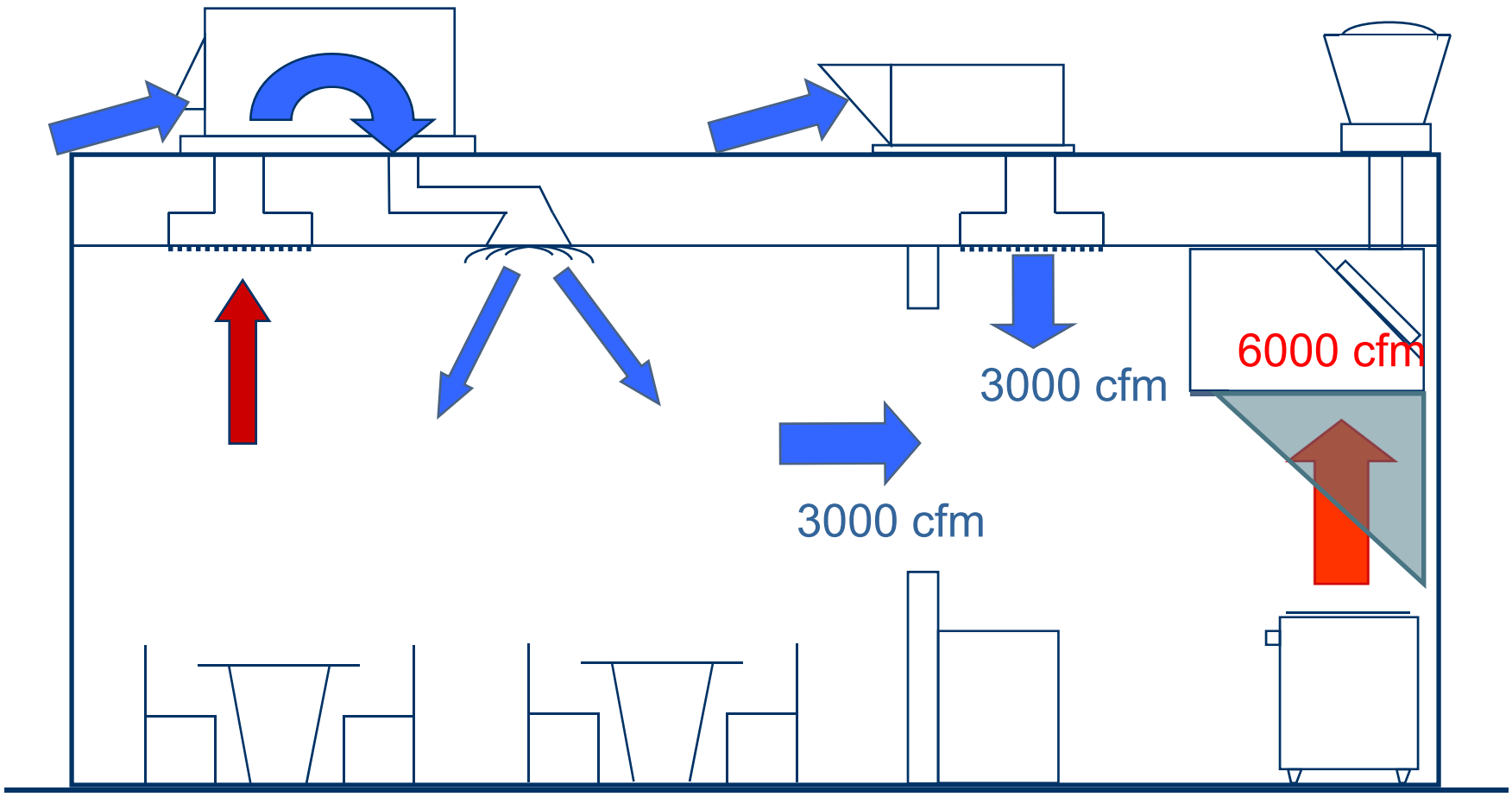


Duct Temperature Sensor & Smoke Detection

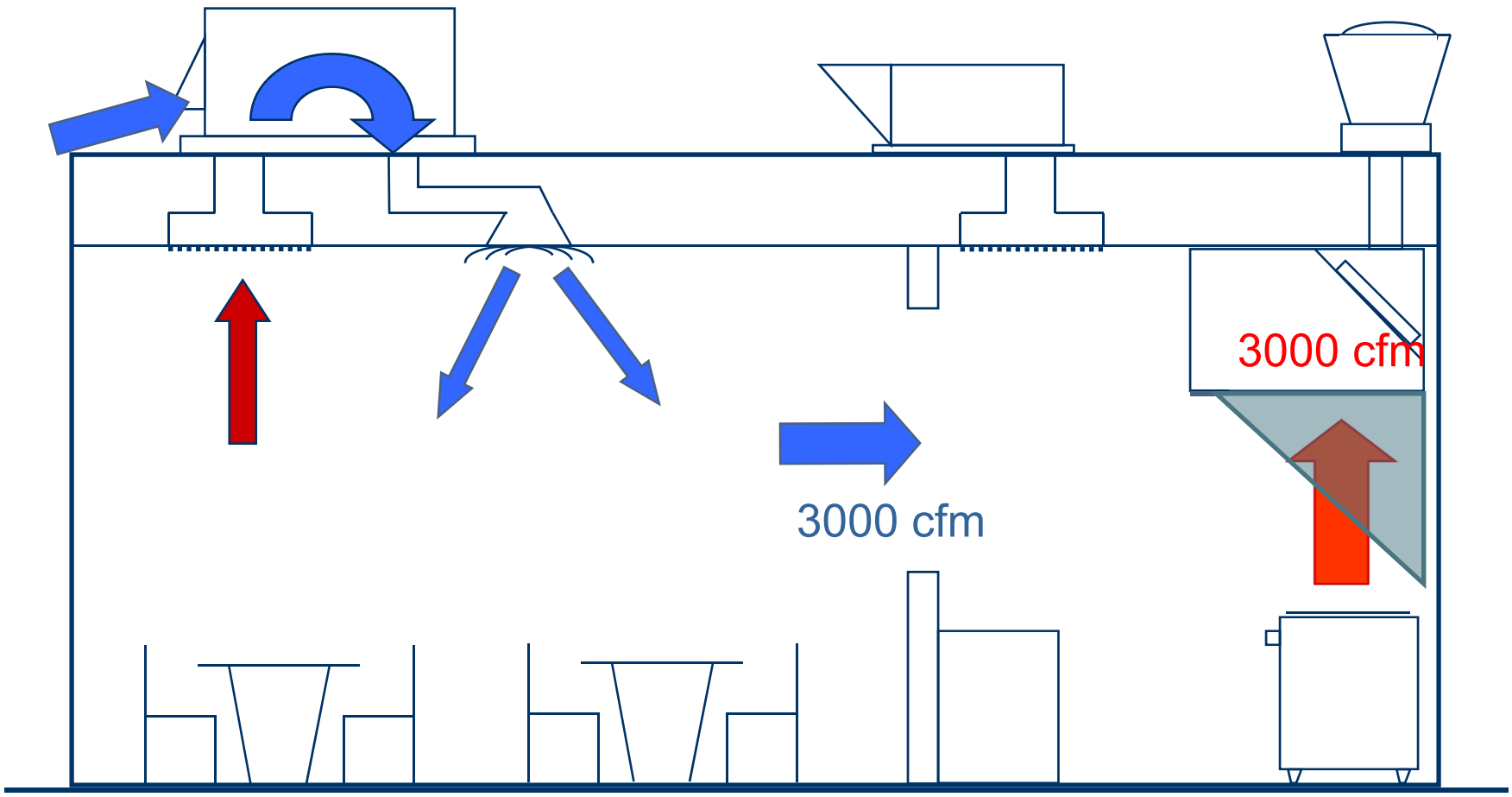


Duct Temperature Sensor

Full Speed!

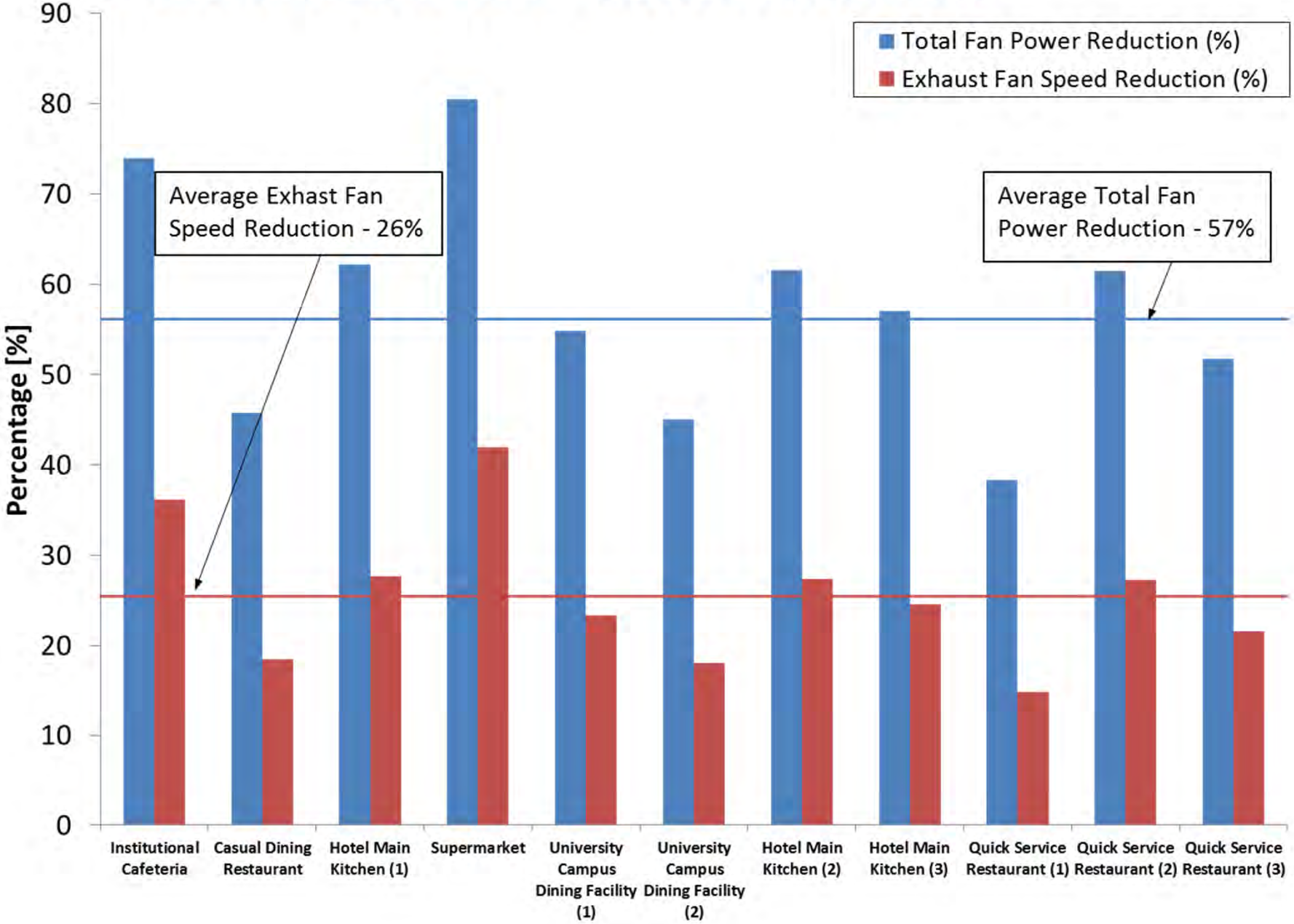


Half Speed!



Technical Feature: ASHRAE Journal February 2013

California DCV Case Studies

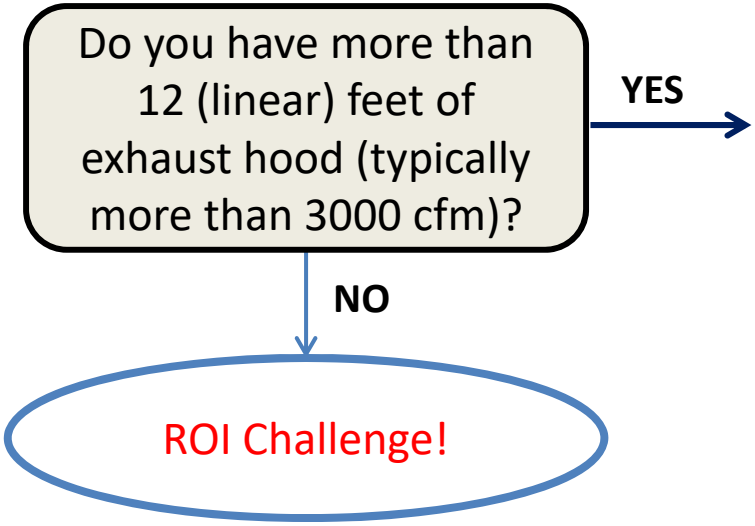


CAUTION:

The CKV system must work effectively as single-speed system before DCKV is applied.

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Foodservice Facility Design?

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



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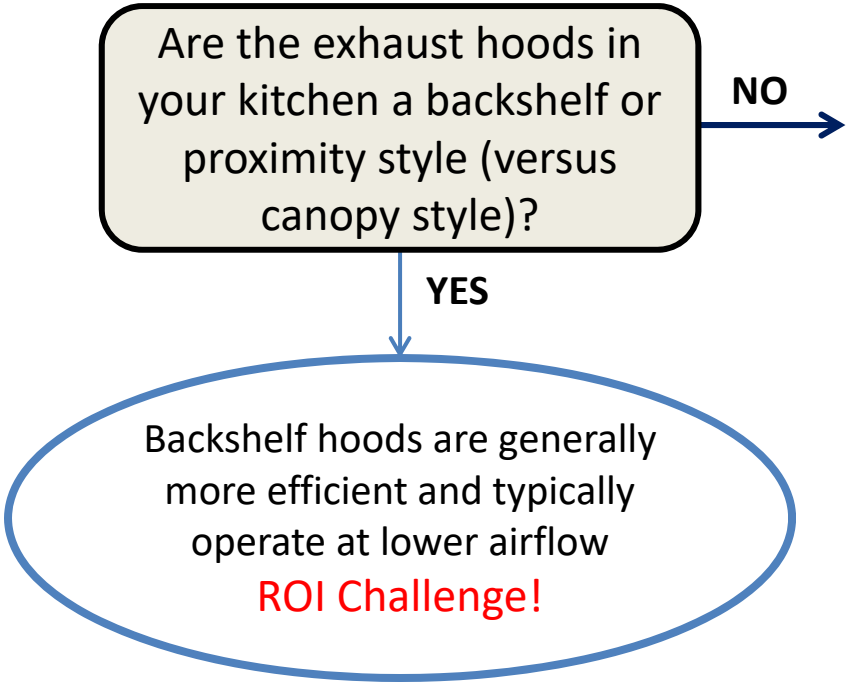

Note: Leading QSR chains are rolling out DCKV systems that communicate directly with the cooking appliances, making the ROI more attractive.

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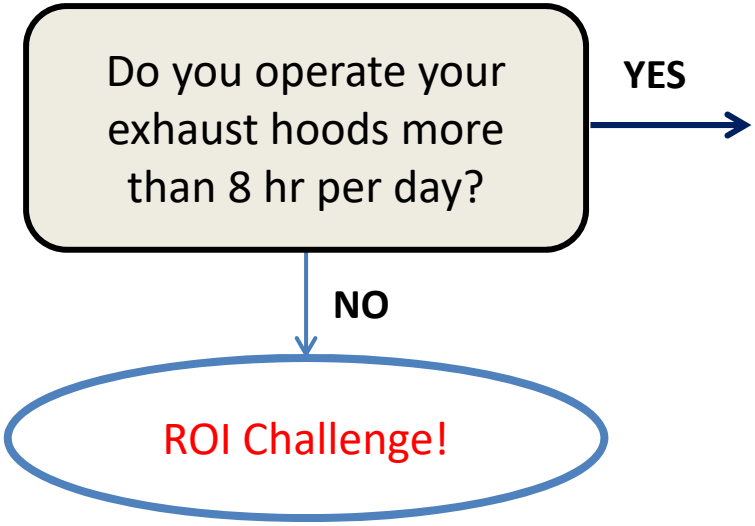

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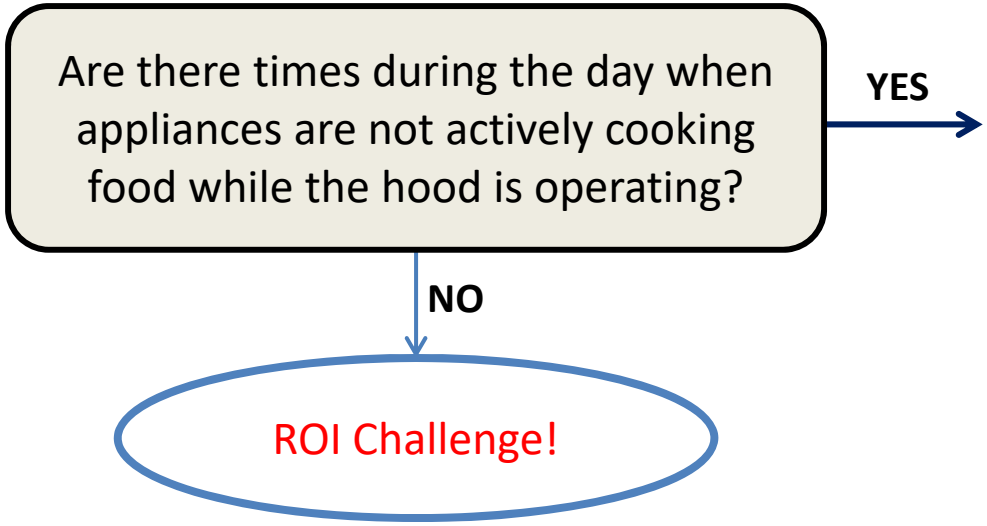

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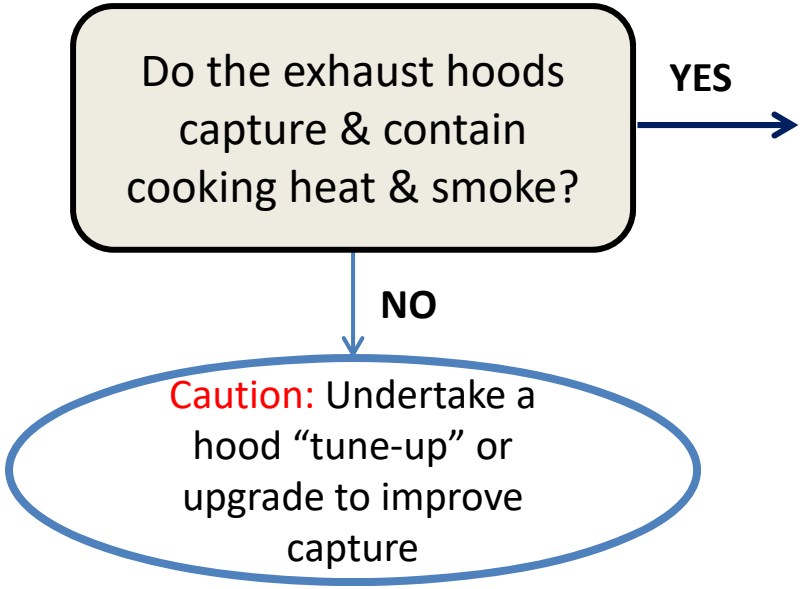
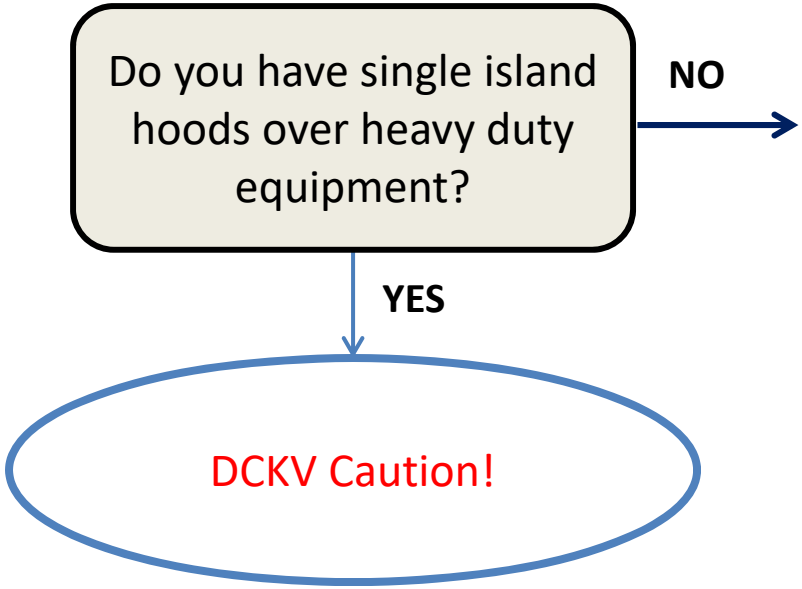


Note: An exhaust hood that is not working satisfactorily at full speed is not going to work well at reduced speed.

The Hood Tune-Up

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?

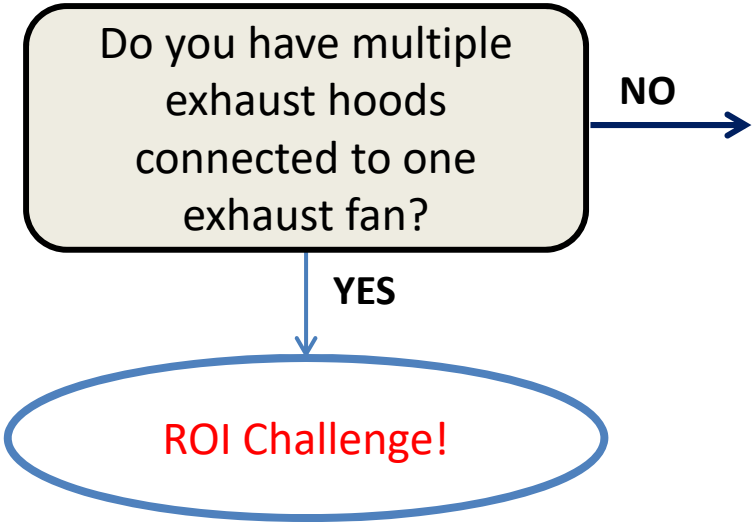


Note: Single island hoods are notorious for not capturing and containing smoke produced by heavy duty cooking equipment.


SHORT ORDERS


SHORT ORDER LINE
VULCAN

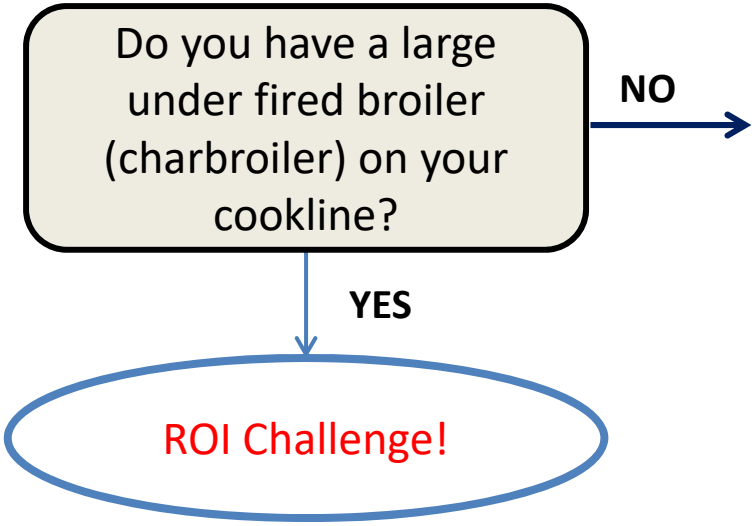
Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



Note: It is difficult to reduce the exhaust airflow from multiple hoods serving different production roles when connected to one exhaust fan. For example, if cooking is going on under one hood, then all hoods need to be operating at full speed.

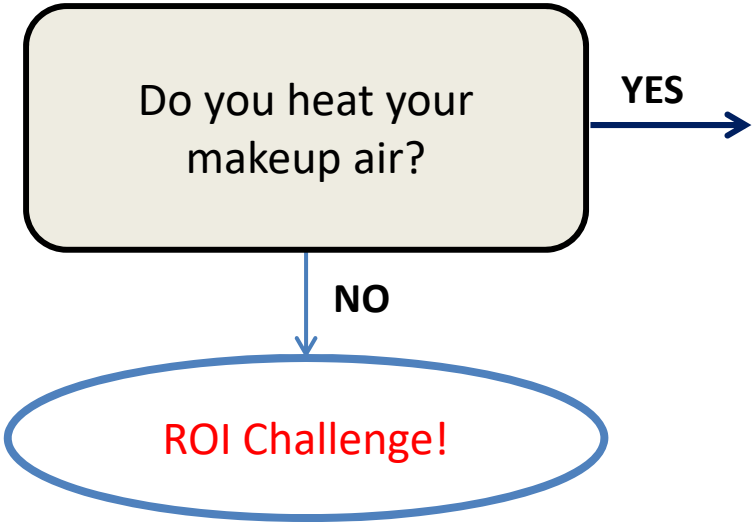
Exception: When the DCKV system incorporates “code approved” or listed dampers to modulate air flow to the individual hoods.

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



Note: A charbroiler needs almost as much exhaust airflow in a “ready-to-cook” mode of operation as it does when cooking meat products. Thus the reduction in exhaust air may be limited and the ROI challenged. However, when the charbroiler part of a larger cookline, this issue is less of an issue.

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



Note: Makeup air heating savings with DCKV can be significant, supporting the ROI.

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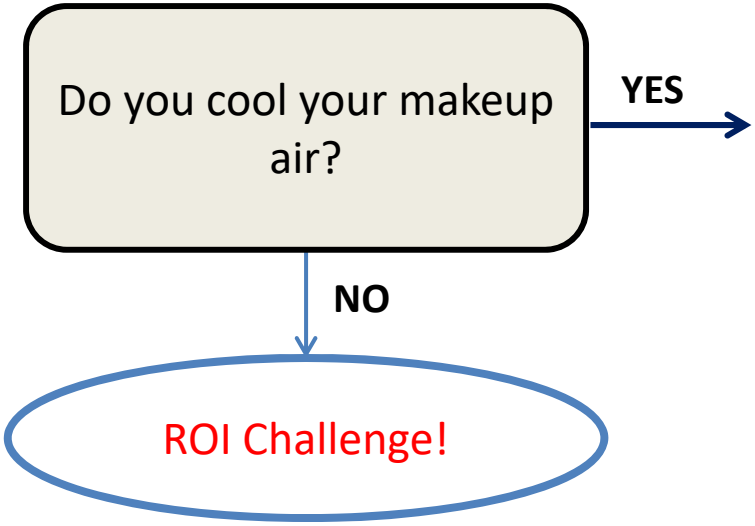
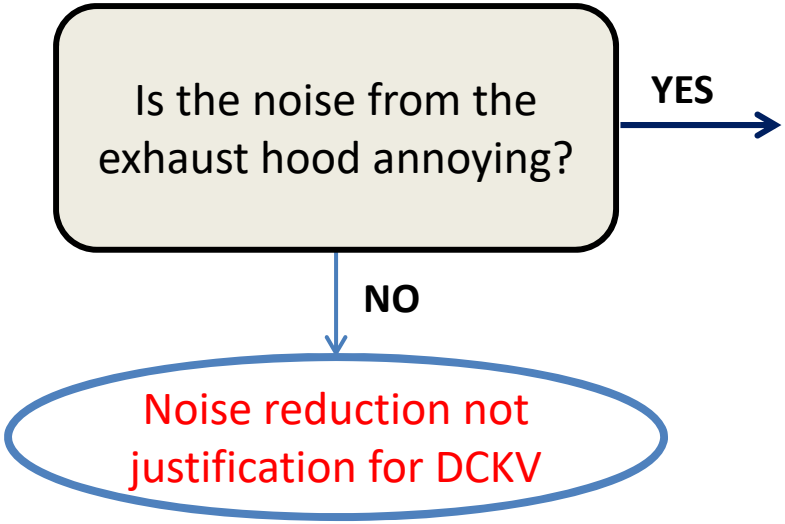
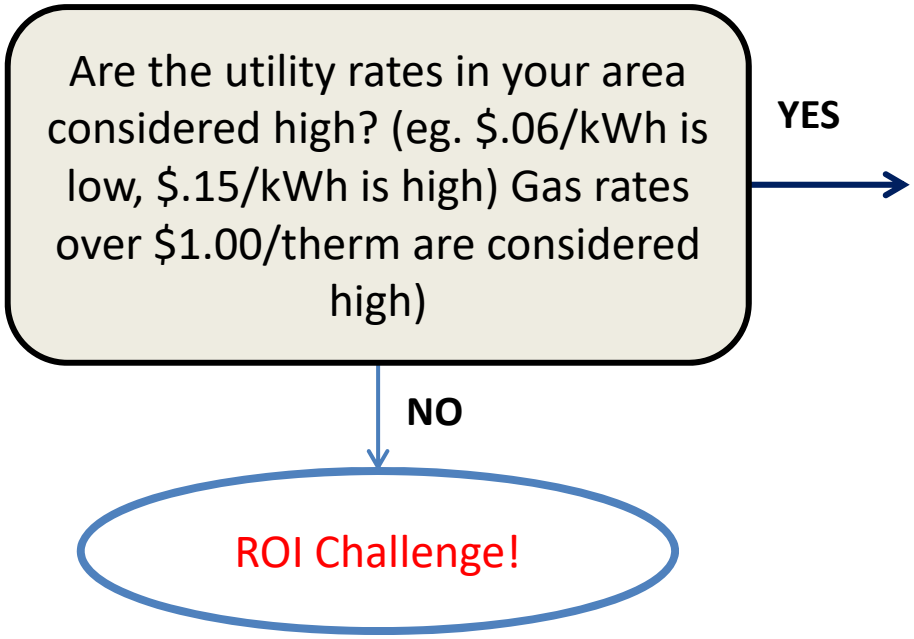


Note: The energy required to cool makeup air in many areas of the country is not significant and does not impact ROI.

Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



Is a Demand-Controlled Kitchen Ventilation (DCKV) System Appropriate for Your Restaurant?



DCKV-ROI Recap:

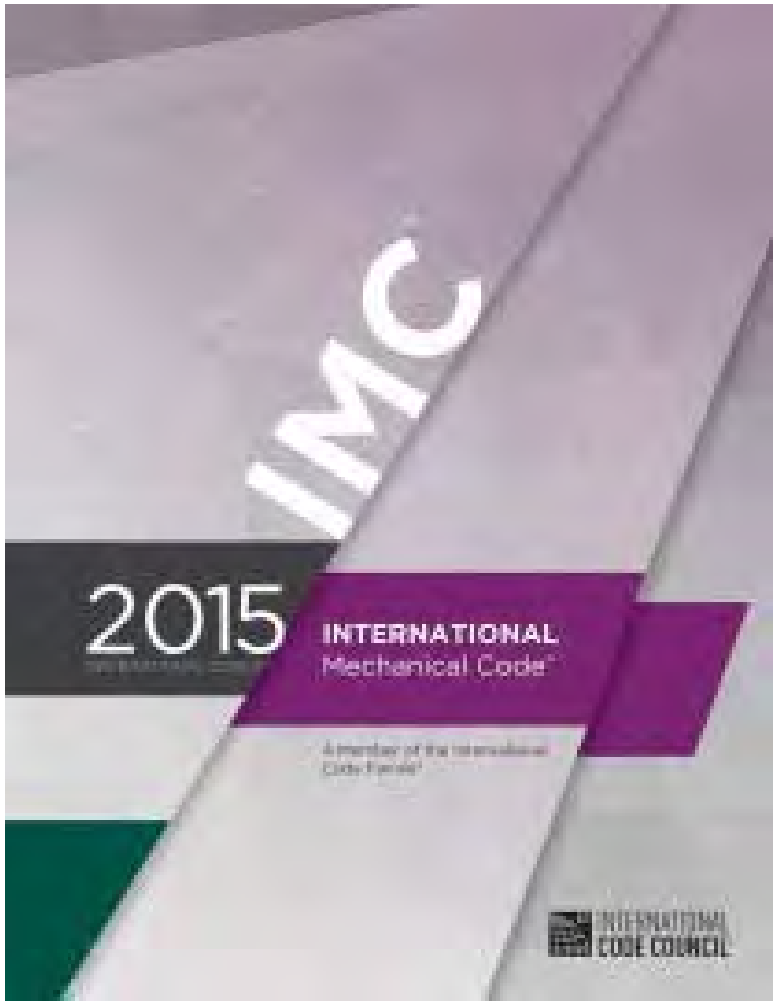
- The larger the exhaust airflow (in cfm), the larger the exhaust and makeup air fans (in H.P.), the longer the operating hours, the higher your utility rates, the more you condition your makeup air, the more often you have appliances in “idle” (typical of 24 hr facilities), if charbroiling is not a major part of food production, the more cost-effective will be the installation of a DCKV system.
- The CKV system must work effectively as single-speed system before DCKV is applied.
- Effective commissioning of a DCKV system will maximize its performance.

Demand-Controlled Kitchen Ventilation (DCKV) in Codes and Standards

- International Mechanical Code (IMC)
- Uniform Mechanical Code (UMC)

- ASHRAE Energy Standard 90.1
- California Energy Standard Title 24

IMC Requirements



IMC
Commercial Kitchen Hoods

SECTION 507
COMMERCIAL KITCHEN HOODS

507.1 General. Commercial kitchen exhaust hoods shall comply with the requirements of this section. Hoods shall be Type I or II and shall be designed to capture and confine cooking vapors and residues. Commercial kitchen exhaust hood systems shall operate during the cooking operation.

Exceptions:

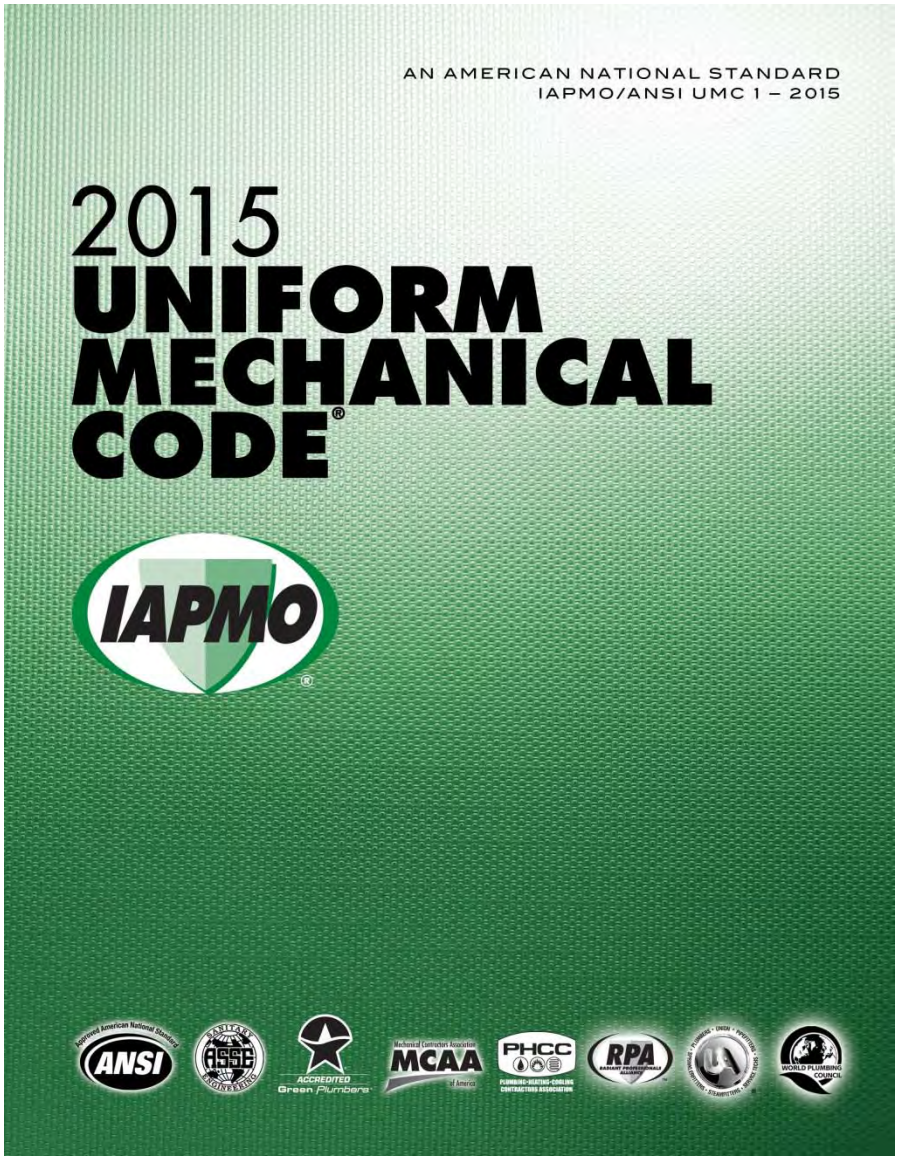
3. Net exhaust volumes for hoods shall be permitted to be reduced during part-load cooking conditions, where engineered or *listed* multispeed or variable-speed controls automatically operate the exhaust system to maintain capture and removal of cooking effluents as required by this section. Reduced 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.

IMC
Performance Test

507.16 Performance test. A performance test shall be conducted upon completion and before final approval of the installation of a ventilation system serving *commercial cooking appliances*. The test shall verify the rate of exhaust airflow required by Section 507.13, makeup airflow required by Section 508 and proper operation as specified in this chapter. The permit holder shall furnish the necessary test *equipment* and devices required to perform the tests.

507.16.1 Capture and containment test. The permit holder shall verify capture and containment performance of the exhaust system. This field test shall be conducted with all appliances under the hood at operating temperatures, with all sources of outdoor air providing *makeup air* for the hood operating and with all sources of recirculated air providing conditioning for the space in which the hood is located operating. Capture and containment shall be verified visually by observing smoke or steam produced by actual or simulated cooking, such as with smoke candles, smoke puffers, etc.

UMC Requirements



UMC / CMC Requirements

511.2 Airflow.

511.2.2 Exhaust-air volumes for hoods shall be of sufficient level to provide for capture and removal of grease-laden cooking vapors. Test data, performance acceptable to the Authority Having Jurisdiction, or both, shall be provided, displayed, or both, upon request.

Exception: Lower exhaust-air volumes shall be permitted during no-load cooking conditions, provided they are sufficient to capture and remove flue gases and residual vapors from cooking equipment.

DCKV Performance Issues

- Per the Model Codes, it is acceptable to operate the hood exhaust under the minimum listing value of the hood when appliances are in operation.
- Issues of decreases in motor efficiency, VFD efficiency and motor overheating while running fans at low speed. There is an optimal turndown that most systems still operate efficiently and perform well.

ASHRAE 90.1

STANDARD

ANSI/ASHRAE/IES Standard 90.1-2013
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2010)
Includes ANSI/ASHRAE/IES Addenda listed in Appendix F

Energy Standard for Buildings Except Low-Rise Residential Buildings

(I-P Edition)

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IES Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site (www.ashrae.org) or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE Web site (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ASHRAE® IES Approved American National Standard ANSI www.ansi.org

ASHRAE 90.1
Kitchen Exhaust Systems
Section 6.5.7.1.3

- If a kitchen/dining facility has a total kitchen hood exhaust airflow rate greater than 5,000 cfm then each hood shall have an exhaust rate that complies with Table 6.5.7.1.3.
  - If a single hood, or hood section, is installed over appliances with different duty ratings, then the maximum allowable flow rate for the hood or hood section shall not exceed the Table 6.5.7.1.3 values for the highest appliance duty rating under the hood or hood section. Refer to ASHRAE Standard 154 for definitions of hood type, appliance duty, and net exhaust flow rate.

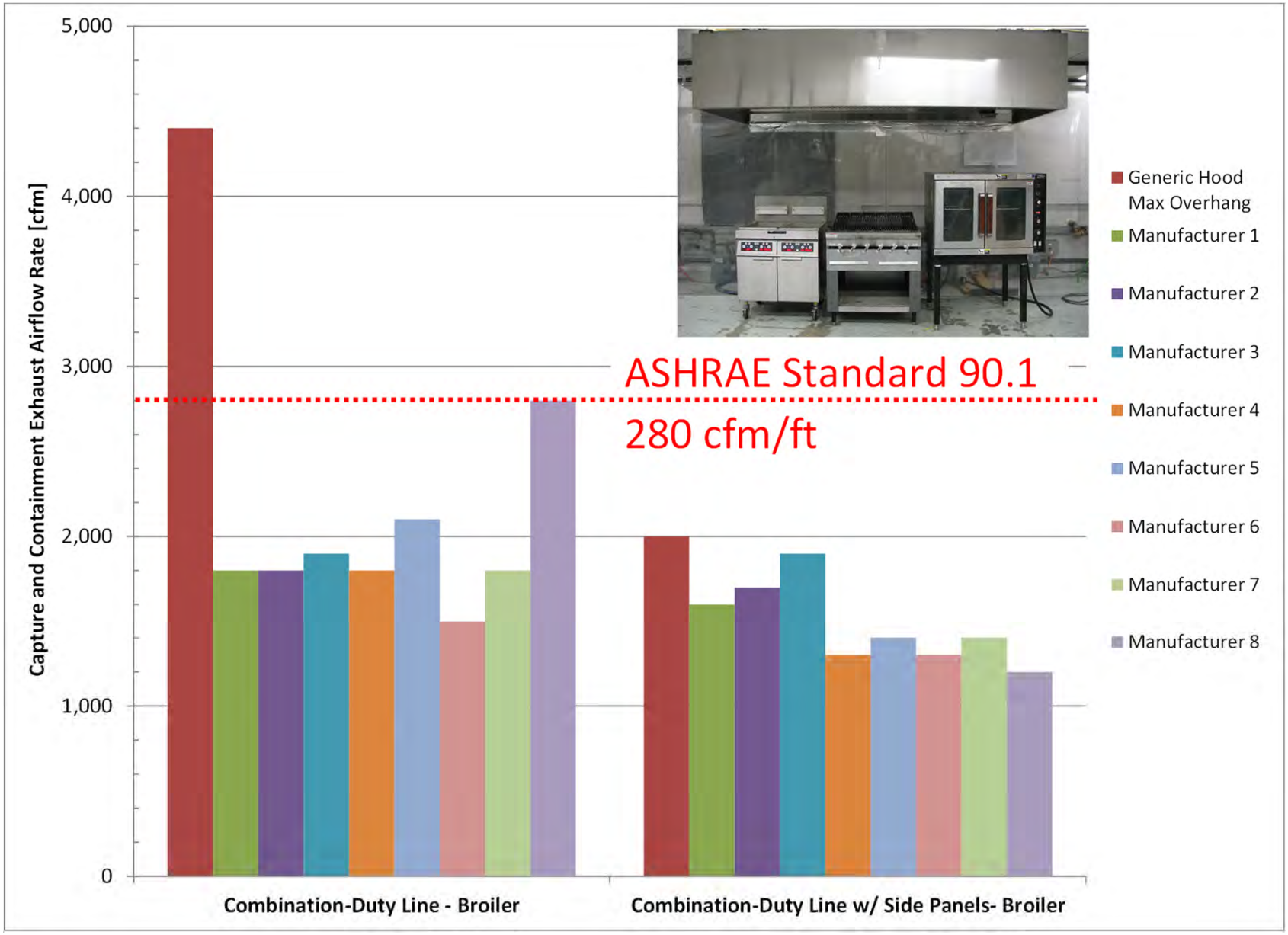
Standard 90.1
Table 6.5.7.1.3

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

Exception: At least 75% of all the *replacement air* is *transfer air* that would otherwise be exhausted.

High Performance Hoods



Standard 90.1
Section 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 otherwise 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.

Standard 90.1
Section 6.5.7.1.5

Performance Testing: An approved field test method shall be used to evaluate design air flow rates and demonstrate proper capture and containment performance of installed commercial kitchen exhaust systems. Where demand ventilation systems are utilized to meet 6.5.7.1.4, additional performance testing shall be required to demonstrate proper capture and containment at minimum airflow.

DCKV Issues

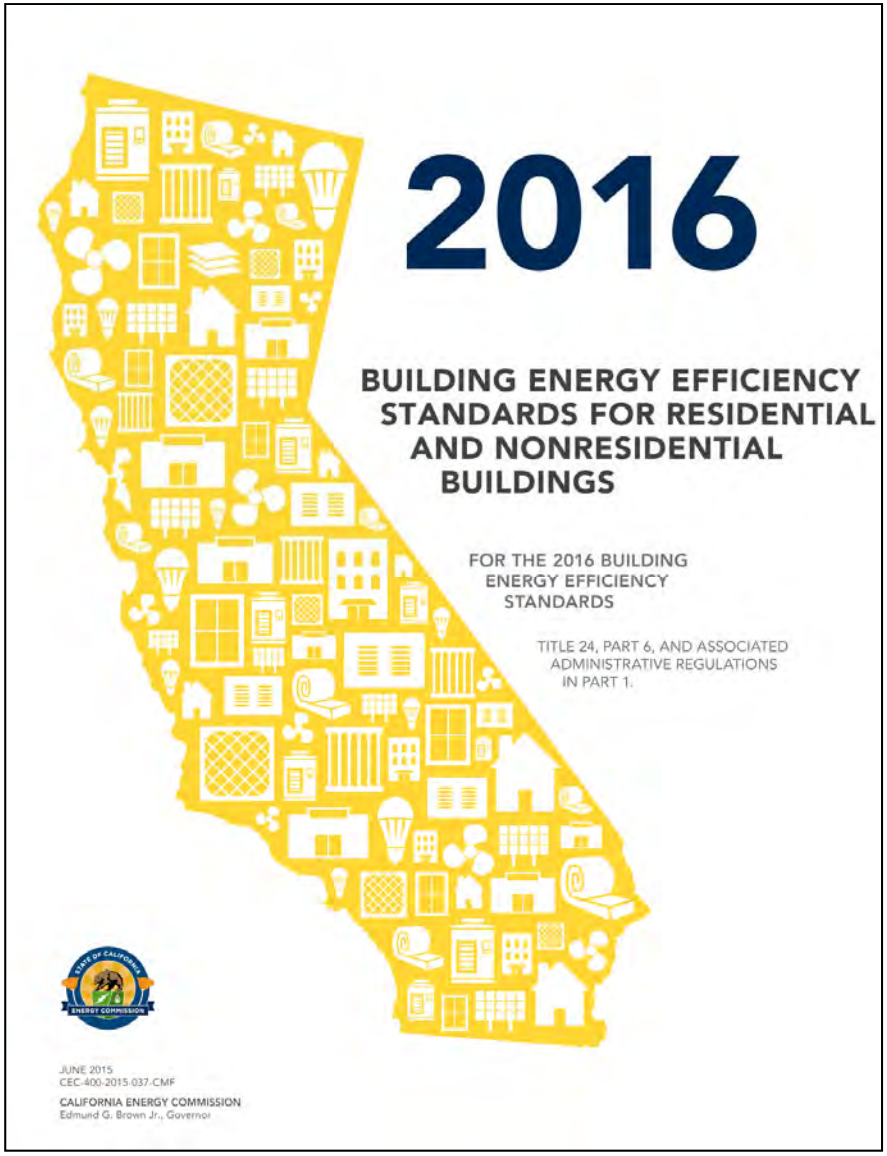
- It is important to recognize that not all CKV systems can be operated at 50% of design flow when all appliances are in an idle or ready-to-cook mode (regardless of the control system installed).
  - This is due to the fact that some cooking appliances such as under-fired charbroilers exhibit a thermal plume under "ready-to-cook" conditions that is almost as aggressive as the plume generated by the cooking activity.
  - But there is also the condition (of hood operation) when most appliances have been turned off (including the charbroiler) yet operation of the hood must be maintained (for one appliance remaining on or during the cool-down and cleanup periods). In such cases, it may be feasible to reduce the exhaust rate to the 50% level without repercussion.

ASTM F26 Committee on Food Service Equipment

- Standard Test Method for Laboratory Evaluation of Capture and Containment and Turn-Down Performance of Commercial Demand Controlled Kitchen Ventilation System
- To evaluate DCKV system turn-down and response to cooking challenges from a typical medium-duty appliance line

Test Set Up

California's Title 24



(b) **Prescriptive Requirements for Commercial Kitchens.**

1. **Kitchen exhaust systems.**

A. Replacement air introduced directly into the hood cavity of kitchen exhaust hoods shall not exceed 10percent of the hood exhaust airflow rate.

B. For kitchen/dining facilities having total Type I and Type II kitchen hood exhaust airflow rates greater than 5,000 cfm, each Type I hood shall have an exhaust rate that complies with TABLE 140.9-A. If a single hood or hood section is installed over appliances with different duty ratings, then the maximum allowable flow rate for the hood or hood section shall not exceed the TABLE 140.9-A values for the highest appliance duty rating under the hood or hood section. Refer to ASHRAE Standard 154-2011 for definitions of hood type, appliance duty and next exhaust flow rate.

EXCEPTION 1 to Section 140.9(b)1B: 75 percent of the total Type I and Type II exhaust replacement air is transfer air that would otherwise be exhausted.

EXCEPTION 2 to Section 140.9(b)1B: Existing hoods not being replaced as part of an addition or alteration.

TABLE 140.9-A 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	175	210	280	385
Eyebrow	175	175	Not Allowed	Not Allowed
Backshelf / Passover	210	210	280	Not Allowed

B. A kitchen/dining facility having a total Type I and Type II kitchen hood exhaust airflow rate greater than 5,000 cfm shall have one of the following:

i. At least 50 percent of all replacement air is transfer air that would otherwise be exhausted; or

ii. Demand ventilation system(s) on at least 75 percent of the exhaust air. Such systems shall:

a. Include 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; and

b. Include failsafe controls that result in full flow upon cooking sensor failure; and

c. Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow; and

d. Be capable of reducing exhaust and replacement air system airflow rates to the larger of:

(i) 50 percent of the total design exhaust and replacement air system airflow rates; or

(ii) The ventilation rate required per Section 120.1.

iii. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on at least 50 percent of the total exhaust airflow; and

iv. A minimum of 75 percent of makeup air volume that is:

a. Unheated or heated to no more than 60°F; and

b. Uncooled or cooled without the use of mechanical cooling.

EXCEPTION to Section 140.9(b)2B: Existing hoods not being replaced as part of an addition or alteration.

B. A kitchen/dining facility having a total Type I and Type II kitchen hood exhaust airflow rate greater than 5,000 cfm shall have one of the following:

i. At least 50 percent of all replacement air is transfer air that would otherwise be exhausted; or

ii. Demand ventilation system(s) on at least 75 percent of the exhaust air. Such systems shall:

a. Include 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; and

b. Include failsafe controls that result in full flow upon cooking sensor failure; and

c. Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow; and

d. Be capable of reducing exhaust and replacement air system airflow rates to the larger of:

(i) 50 percent of the total design exhaust and replacement air system airflow rates; or

(ii) The ventilation rate required per Section 120.1.

iii. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on at least 50 percent of the total exhaust airflow; and

iv. A minimum of 75 percent of makeup air volume that is:

a. Unheated or heated to no more than 60°F; and

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EXCEPTION to Section 140.9(b)2B: Existing hoods not being replaced as part of an addition or alteration.

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i. At least 50 percent of all replacement air is transfer air that would otherwise be exhausted; or

ii. Demand ventilation system(s) on at least 75 percent of the exhaust air. Such systems shall:

a. Include 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; and

b. Include failsafe controls that result in full flow upon cooking sensor failure; and

c. Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow; and

d. Be capable of reducing exhaust and replacement air system airflow rates to the larger of:

(i) 50 percent of the total design exhaust and replacement air system airflow rates; or

(ii) The ventilation rate required per Section 120.1.

iii. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on at least 50 percent of the total exhaust airflow; and

iv. A minimum of 75 percent of makeup air volume that is:

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ii. Demand ventilation system(s) on at least 75 percent of the exhaust air. Such systems shall:

a. Include 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; and

b. Include failsafe controls that result in full flow upon cooking sensor failure; and

c. Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow; and

d. Be capable of reducing exhaust and replacement air system airflow rates to the larger of:

(i) 50 percent of the total design exhaust and replacement air system airflow rates; or

(ii) The ventilation rate required per Section 120.1.

iii. Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40 percent on at least 50 percent of the total exhaust airflow; and

iv. A minimum of 75 percent of makeup air volume that is:

a. Unheated or heated to no more than 60°F; and

b. Uncooled or cooled without the use of mechanical cooling.

EXCEPTION to Section 140.9(b)2B: Existing hoods not being replaced as part of an addition or alteration.

NA7.11 Commercial Kitchen Exhaust System Acceptance Tests

NA7.11.1 Kitchen Exhaust Systems with Type I Hood Systems

The following acceptance tests apply to commercial kitchen exhaust systems with Type I exhaust hoods. All Type I exhaust hoods used in commercial kitchens shall be tested.

NA7.11.1.1 Construction Inspection

Step 1: Verify exhaust and replacement air systems are installed, power is installed and control systems such as demand control ventilation are calibrated.

Step 2: For kitchen/dining facilities having total Type 1 and Type II kitchen hood exhaust airflow rates greater than 5,000 cfm, calculate the maximum allowable exhaust rate for each Type 1 hood per Table 140.9-A.

NA7.11.1.2 Functional Testing at Full Load Conditions

The following acceptance test applies to systems with and without demand control ventilation exhaust systems. These tests shall be conducted at full load conditions.

Step 1: Operate all sources of outdoor air providing replacement air for the hoods.

Step 2: Operate all sources of recirculated air providing conditioning for the space in which the hoods are located.

Step 3: Operate all appliances under the hoods at operating temperatures.

Step 4: Verify that the thermal plume and smoke is completely captured and contained within each hood at full load conditions by observing smoke or steam produced by actual cooking operation and/or by visually seeding the thermal plume using devices such as smoke candles or smoke puffers. Smoke bombs shall not be used (note: smoke bombs typically create a large volume of effluent from a point source and do not necessarily confirm whether the cooking effluent is being captured). For some appliances (e.g., broilers, griddles, fryers), actual cooking at the normal production rate is a reliable method of generating smoke). Other appliances that typically generate hot moist air without smoke (e.g., ovens, steamers) need seeding of the thermal plume with artificial smoke to verify capture and containment.

Step 7: Make adjustments as necessary until full capture and containment and adequate space pressurization are achieved and maximum allowable exhaust rates are not exceeded. Adjustments may include:

(a) Adjust exhaust hood airflow rates

(b) Add hood side panels

(c) Add rear seal (back plate)

(d) Increase hood overhang by pushing equipment back

(e) Relocate supply outlets to improve the capture and containment performance

Step 8: Measure and record final exhaust airflow rate per Type 1 hood.

NA7.11.1.3 Functional Testing for Exhaust Systems with Demand Control Ventilation

The following additional acceptance test shall be performed on all exhaust hoods with demand control ventilation exhaust systems.

Step 1: Turn off all kitchen hoods, makeup air and transfer systems.

Step 2: Turn on one of the appliances on the line and bring to operating temperature. Confirm that:

(a) DCV system automatically switches from off to the minimum flow setpoint.

(b) The minimum flow setpoint does not exceed the larger of:

1. 50% of the design flow, or
2. The ventilation rate required per Section 120.1.

(c) The makeup air and transfer air system flow rates modulate as appropriate to match the exhaust rate.

(d) Appropriate space pressurization is maintained.

Step 3: Press the timed override button. Confirm that system ramps to full speed and back to minimum speed after override times out.

Step 4: Operate all appliances at typical conditions. Apply sample cooking products and/or utilize smoke puffers as appropriate to simulate full load conditions. Confirm that:

(e) DCV system automatically ramps to full speed.

(f) Hood maintains full capture and containment during ramping to and at full-speed.

(g) Appropriate space pressurization is maintained.

Summary

- The Model Codes and Energy Standards recognize that demand-controlled kitchen ventilation (DCKV) systems are an important consideration for an energy efficient kitchen ventilation design.
- There are now more than a dozen manufacturers of DCKV systems supporting the market trend that DCKV is poised to become standard practice within the design of commercial kitchens.

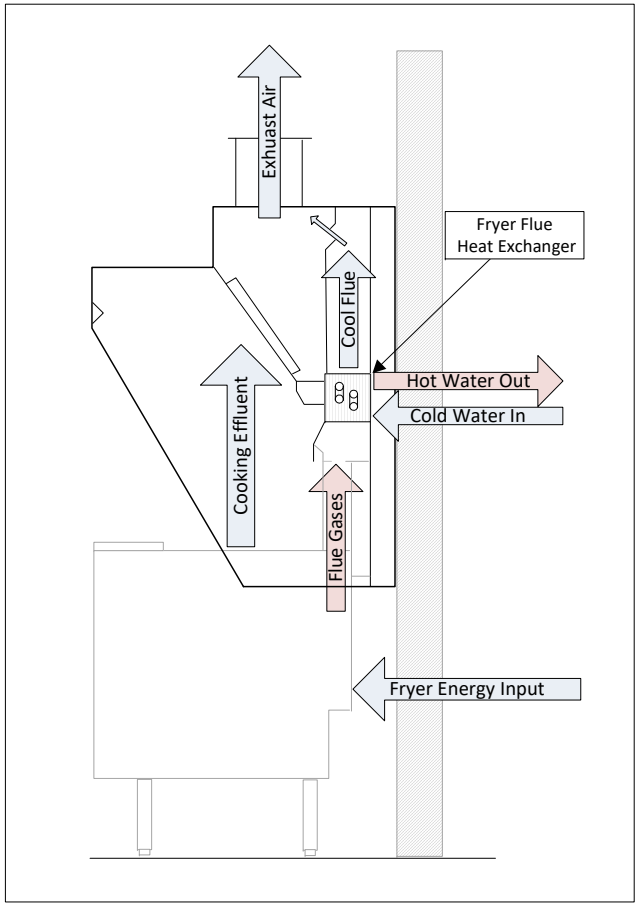
Conclusions

- The Model Codes and Energy Standards reflect an awareness that that all DCKV systems save energy.
- The energy savings will vary (depending on the cookline and DCKV system specified).
- Functionality testing of DCKV systems is required by the Codes and Standards. However, it does not apply if the Standard is met through another compliance option.
- The Model Codes apply to all size systems; the Energy Standards Standard 90.1 and Title 24 do not apply to CKV-DCKV systems < 5000 cfm.

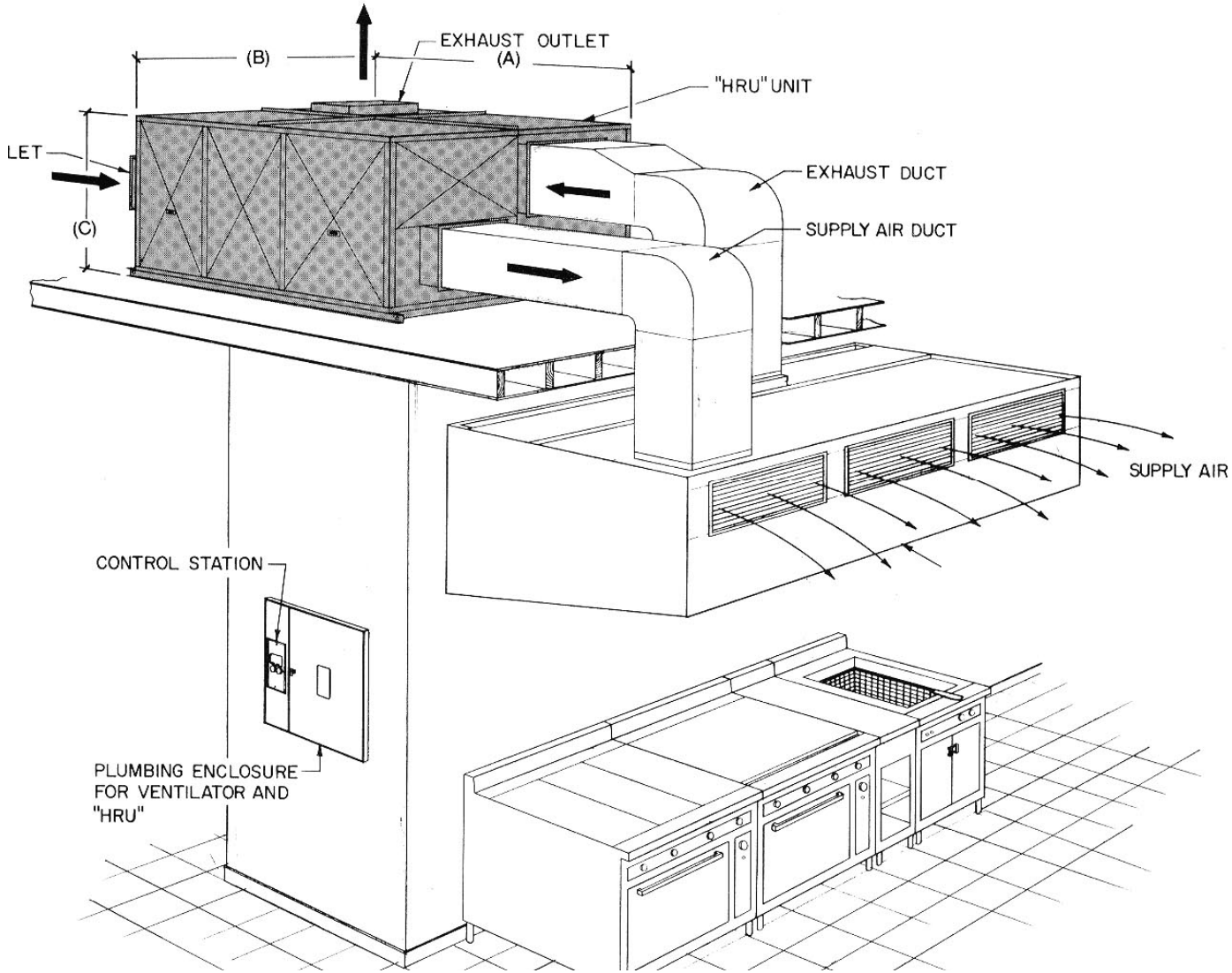
Exhaust Air Heat Recovery

Can It Be Applied to Commercial Kitchen Ventilation?

Flue Gas Heat Recovery

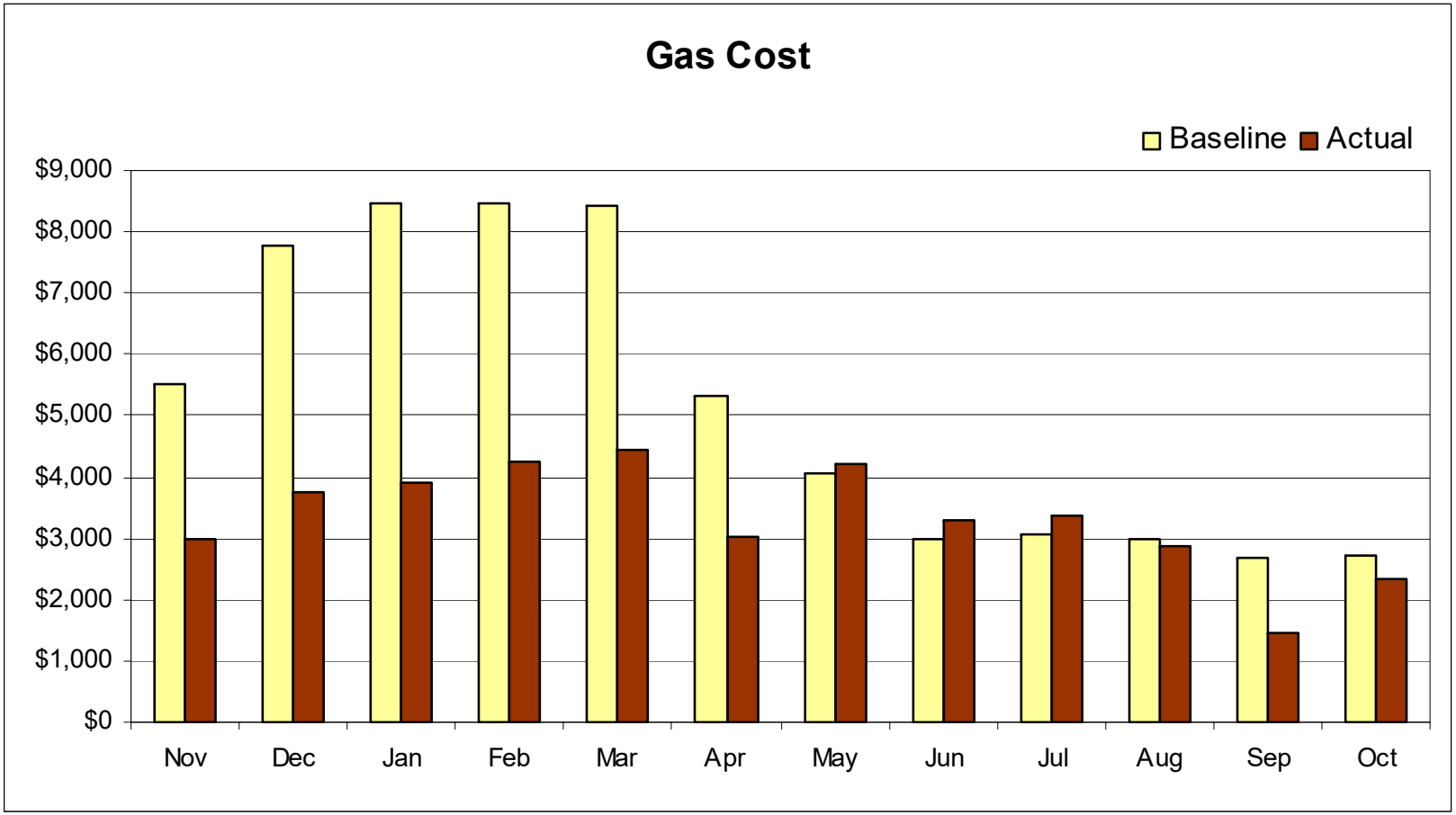


Air-to-Air Heat Recovery Unit



West Point

Air-to-Air HX – Toronto Restaurant



36% reduction = $22,600 per year!
(at $1.30/therm)

DCKV, Heat Recovery & Strategic Introduction of MUA could potentially…

Kitchen Ventilation Publications

Kitchen Hood Performance Reports

These reports document the performance of kitchen exhaust hoods under the controlled conditions of ASTM Standard Test Method F-1704.

ASHRAE Research Project 1480 Report

Island Hood Energy Consumption and Energy Consumption Strategies
The objective of this research project was to expand the exhaust ventilation rate database for the capture and containment of standardized cook lines under four island canopy hood configurations.
Download *(.pdf, 12.7 MB)*

ASHRAE Supplemental Report

Effects of Range Top Diversity, Range Accessories,
and Hood Dimensions on Commercial Kitchen Hood Performance
The objective of the research project was to quantify the impact that appliance position and/or the mix of appliances underneath an exhaust hood on the minimum exhaust airflow required for capture and containment.
Download *(.pdf, 1.6 MB)*

FCSI White Paper

Commercial Kitchen Ventilation "Best Practice" Design & Specification Guidelines
The goal of this white paper is to explain the parameters that impact CKV system performance and provide a strategic plan and specification template that will help the foodservice consultant realize project success. **Download** *(.pdf, 430 KB)*

Grease Filter Efficiency Test Method

Development of a Standard Method of Test for Commercial Kitchen Effluent Grease Removal Systems
The University of Minnesota report detailing the development of the test method is completed and available for download. The appendices of the report are available in a separate file below. There is also an accompanying presentation for the project.

Draft Final Report [**download**] *(.pdf, 640 KB)*
Report Appendices [**download**] *(.pdf, 6.4 MB)*
Presentation [**download**] *(.pdf, 2.5 MB)*

PIER Research Report

Makeup Air Effects on Commercial Kitchen Exhaust System Performance
The objective of this research project was to improve the performance and energy efficiency of commercial kitchen ventilation (CKV) systems by performing flow-visualization research and publishing design guidelines for the food service community. The report is hosted on the **PIER website**.

ASHRAE Journal Articles

Capture and Containment: Commercial Kitchen Ventilation Exhaust Hoods - **download** *(.pdf, 700 KB)*
Author: Donald Fisher, P.E., Rich Swierczyna and Angelo Karas
Published: ASHRAE Journal, November 2015

90.1 and Designing High Performance Commercial Kitchen Ventilation Systems - **download** *(.pdf, 1.91 MB)*
Author: Donald Fisher, P.E. and Rich Swierczyna
Published: ASHRAE Journal, November 2014

Future of DCV for Commercial Kitchens - **download** *(.pdf, 340 KB)*
Author: Donald Fisher, P.E., Rich Swierczyna and Angelo Karas
Published: ASHRAE Journal, February 2013

Predicting Energy Consumption [of Kitchen Ventilation Systems] - **download** *(.pdf, 1.6 MB)*
Author: Donald Fisher, P.E.
Published: ASHRAE Journal, June 2003

The Effect of Makeup Air on Kitchen Hoods - **download** *(.pdf, 1.3 MB)*
Author: Richard T. Swierczyna and Pual A. Sobiski
Published: ASHRAE Journal, June 2003

CKV Design Guides

These design guides provide information that will help achieve optimum performance and energy efficiency in commercial kitchen ventilation systems.

Design Guide 1

Improving Commercial Kitchen Ventilation System Performance

Selecting and Sizing Exhaust Hoods [Download] *(990 KB)*

Design Guide 1 covers the fundamentals of kitchen exhaust, and provides design guidance and examples. This guide was made possible by the efforts and support of Southern California Edison.

Design Guide 2

Improving Commercial Kitchen Ventilation System Performance

Optimizing Makeup Air [Download] *(630 KB)*

Design Guide 2 augments Design Guide 1, with an emphasis on the makeup air side of the equation. This guide was previously published by the California Energy Commission under the title *Improving Commercial Kitchen Ventilation Performance.* The guide is based on a PIER research project conducted by the CKV Lab in Chicago. A copy of the final report from the project is available **here**.

Design Guide 3

Improving Commercial Kitchen Ventilation System Performance

Integrating Kitchen Exhaust Systems with Building HVAC [Download] *(175 KB)*

Design Guide 3 provides information that may help achieve optimum performance and energy efficiency in commercial kitchen ventilation systems by integrating kitchen exhaust with building HVAC. This guide was made possible by the efforts and support of Southern California Edison.

Design Guide 4

Improving Commercial Kitchen Ventilation System Performance

Optimizing Appliance Position and Hood Configuration [Download] *(710 KB)*

Design Guide 4 focuses on the impact that equipment layout, with respect to hood position, can have on the ability of the hood to capture and contain. It describes the importance of subtle details including overhang, gap behind appliances, hood mounting height, and side panels.

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