

KITCHEN VENTILATION SYSTEMS DESIGN

New Ideas & Technologies 2015

THANK YOU FOR ATTENDING

TOO OFTEN, THE KITCHEN IS...

- Hot
- Noisy
- Smelly
- Greasy
- Slippery
- Energy Consuming

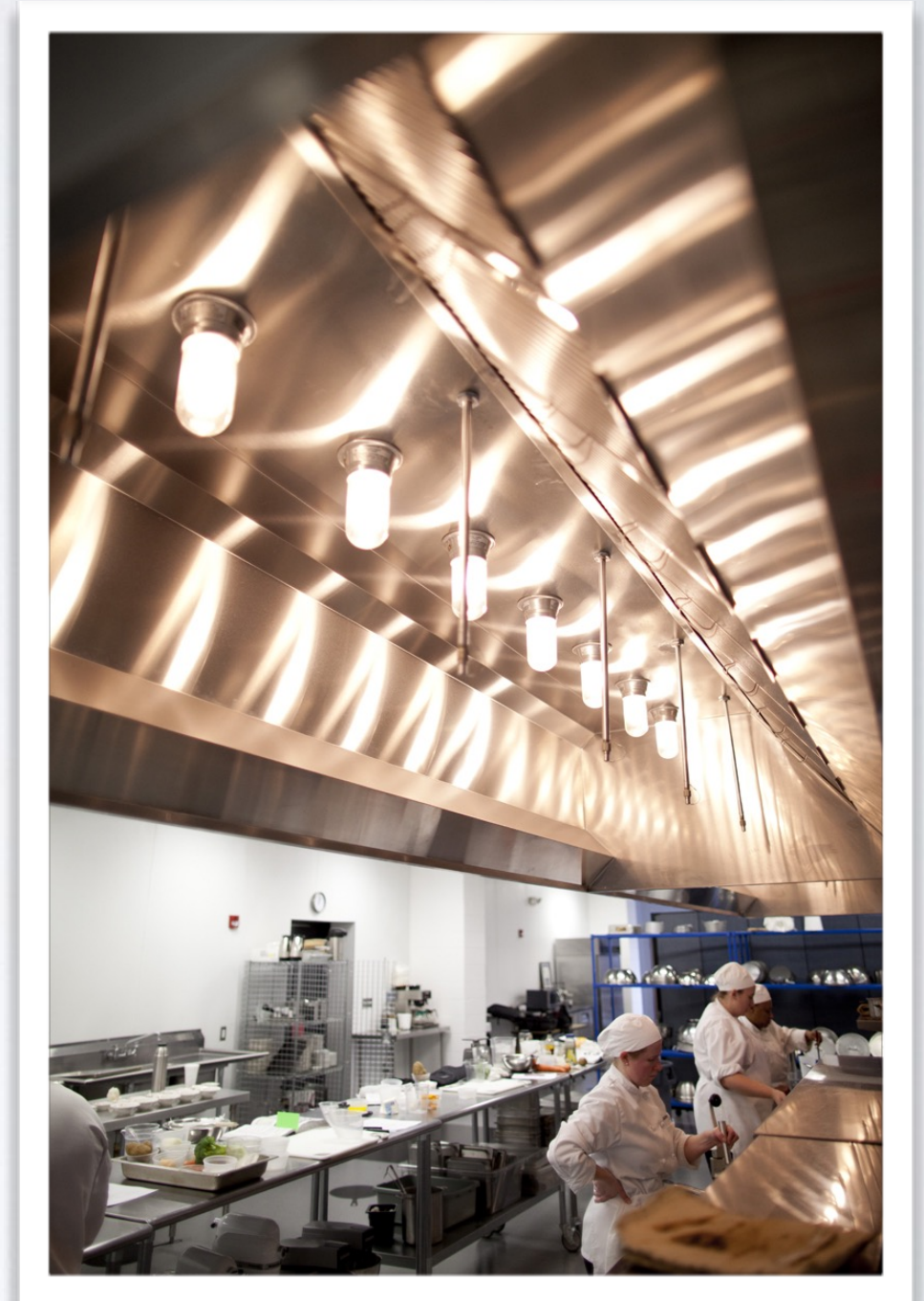


As suggested by John A. Clark, P.E., Minneapolis

MODERN SOLUTIONS

- Lowest Exhaust Rate at Peak Performance
- Robust Filtration
- Dedicated Makeup Air
- Demand Control Ventilation
- Factory-Welded Ductwork
- Water-Based Fire Suppression

RESULT: *Integrated Design*



INTEGRATED KVS DESIGN

- Avoids dynamic effects
- Saves energy costs
- Ensures peak performance
- Focus on safety, comfort, efficiency



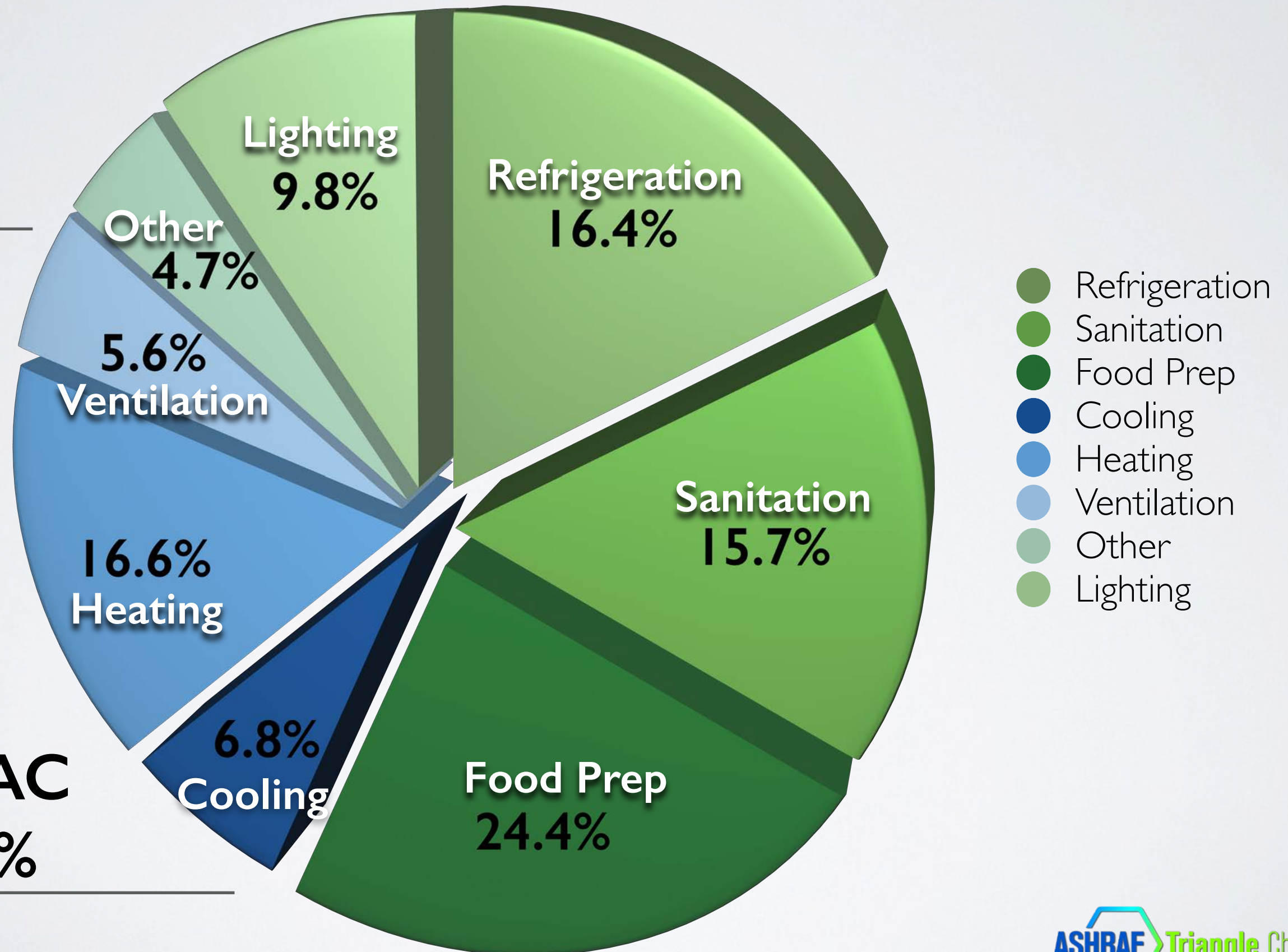
LOW EXHAUST RATES

LOW EXHAUST RATES

- Commercial kitchens are notorious for high energy use
 - Poor design, inefficiency
 - Results in wasted \$\$\$ to restaurant owner
- Maximizing efficiency is crucial
- ASTM I 704 & UL 710



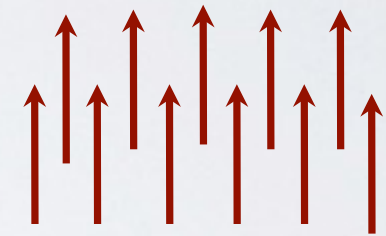
ENERGY USE IN RESTAURANTS



HOW HOODS WORK

“Buoyant Thermal Plume”

- Newton (1687) described gravity, by which hot air rises
- Cooking effluents and products of combustion rise
- Effluent volume expands to fill space



Effluent Rises

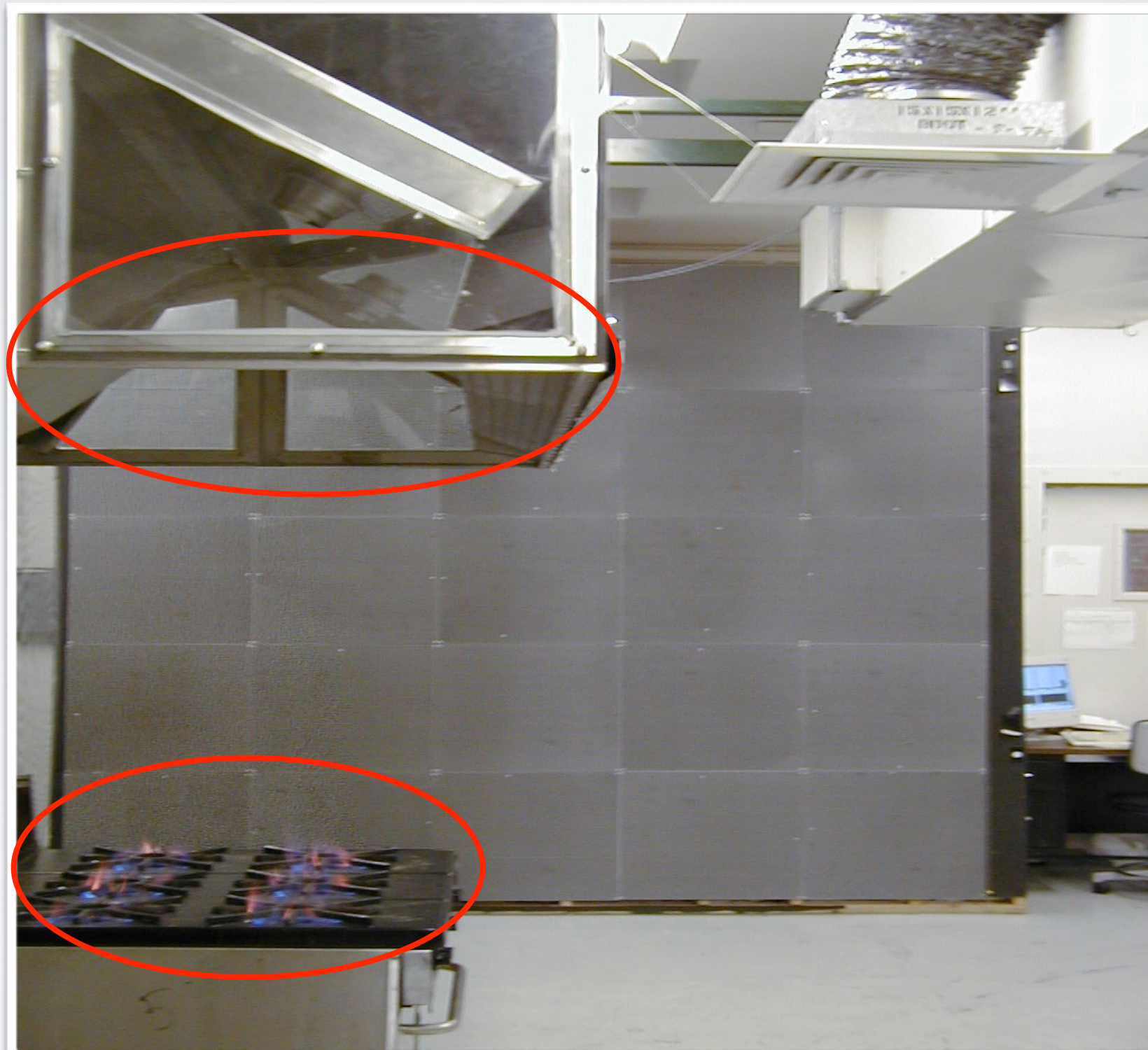


ACHIEVING LOW EXHAUST RATES

- **Adequate overhangs & vertical end panels** reduce exhaust flow and ensure capture and containment
- **Listed duct systems** reduce static pressure



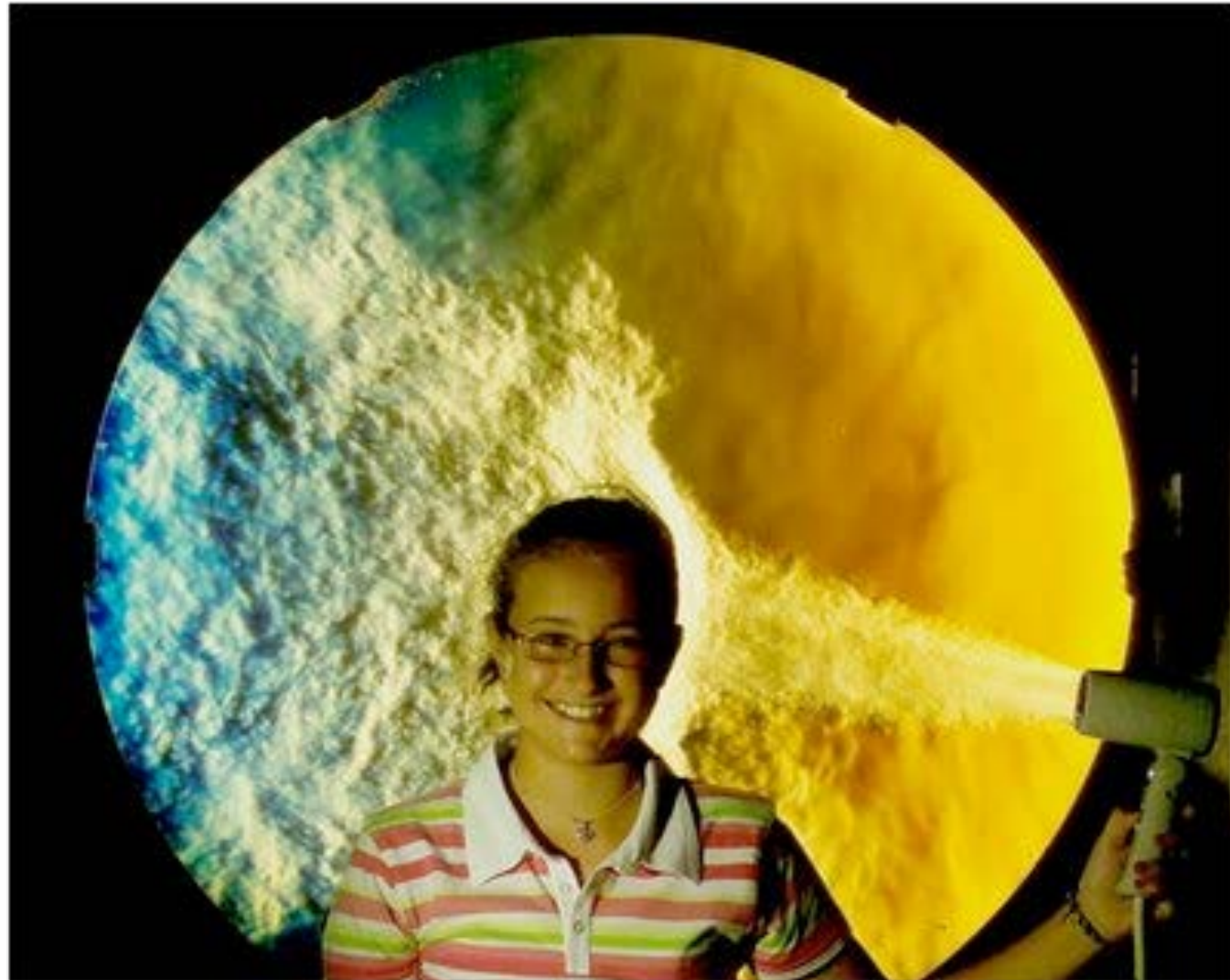
WHAT THE EYE SEES



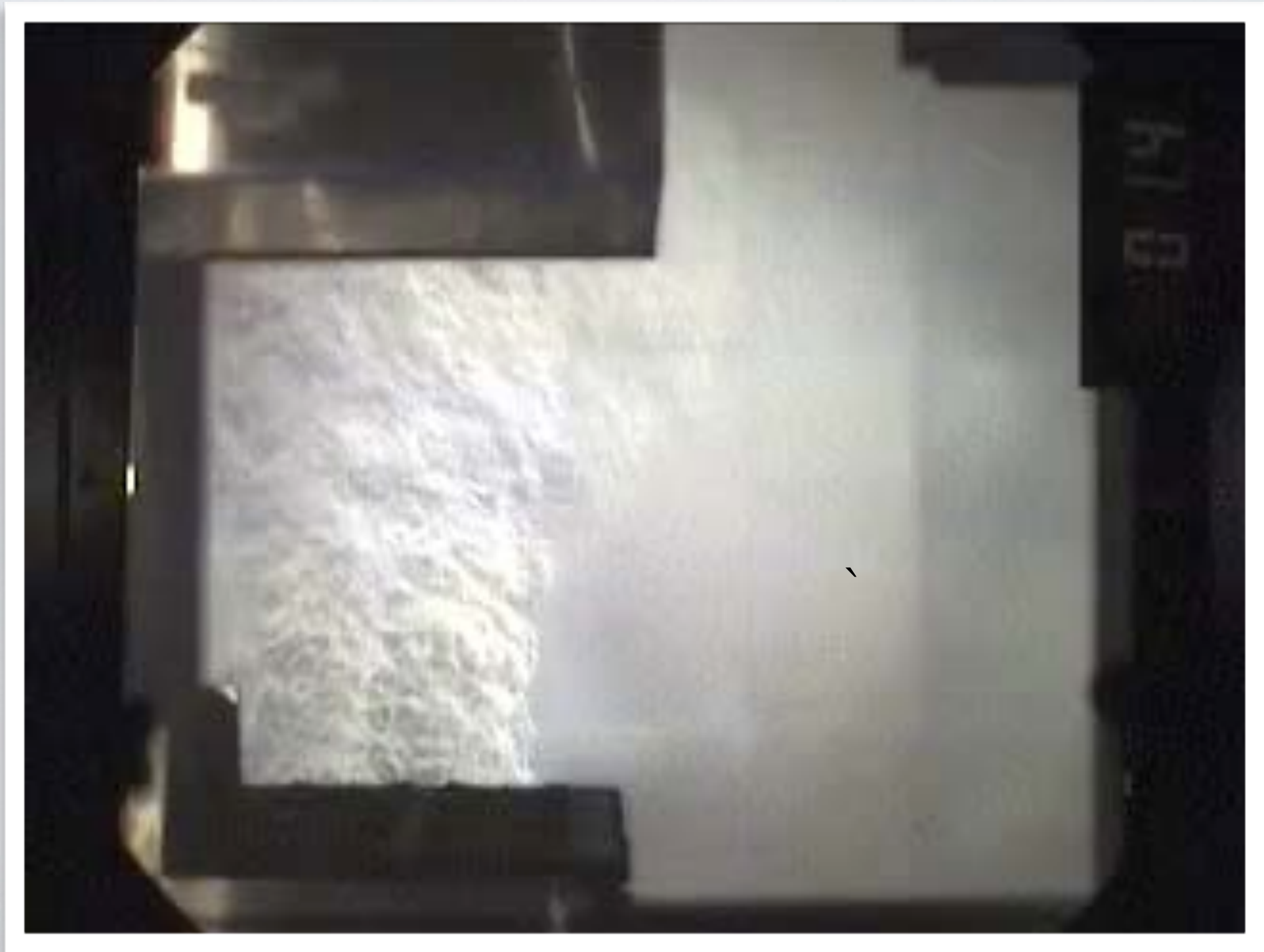
Courtesy of FSTC CKV Lab

SCHLIEREN TECHNOLOGY

Allows for Accurate Visualization of Air Temperature Gradients

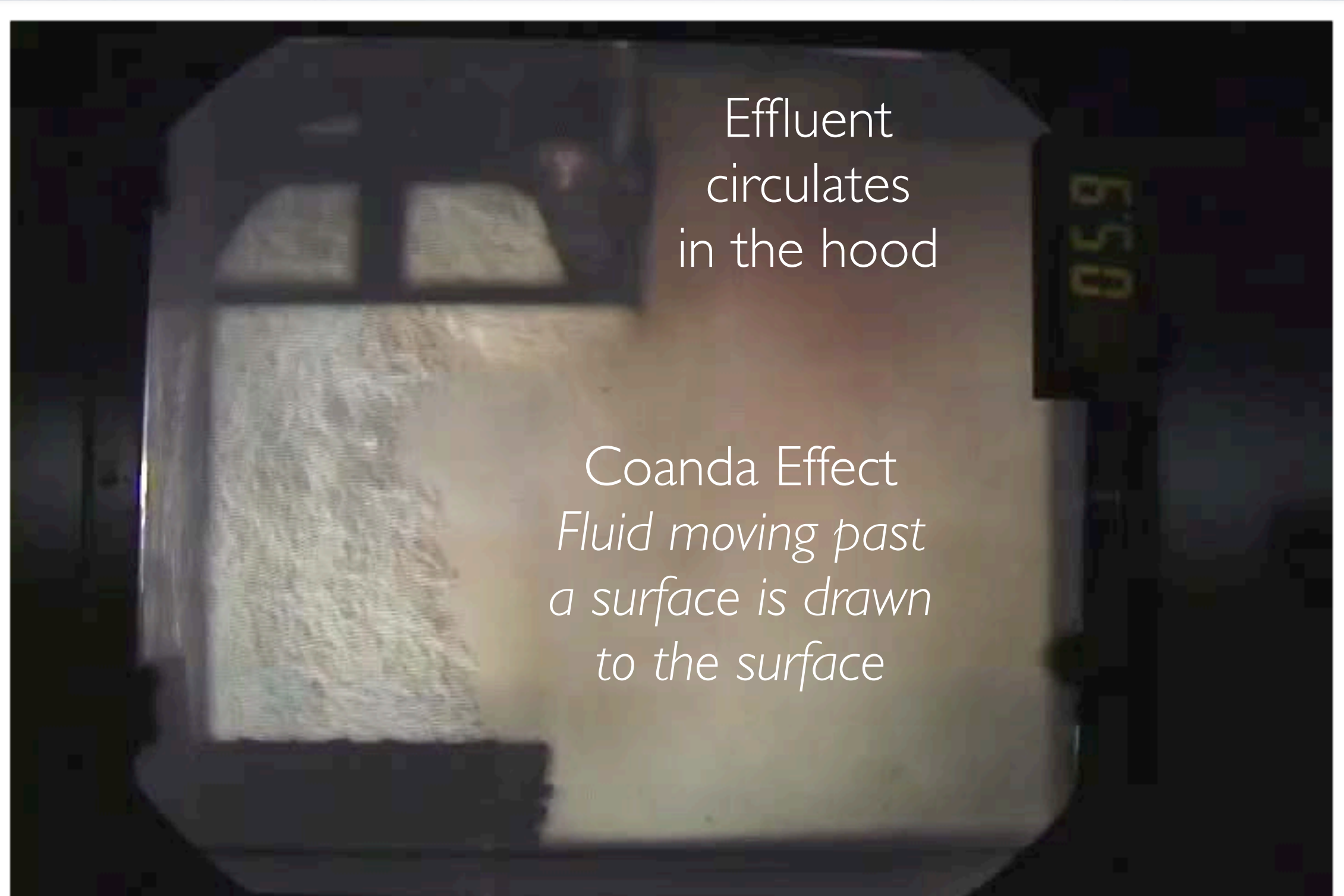


SCHLIEREN TECHNOLOGY



Courtesy of FSTC CKV Lab

EFFLUENT CIRCULATION



Effluent
circulates
in the hood

Coanda Effect
*Fluid moving past
a surface is drawn
to the surface*

Courtesy FSTC

VISUALIZE LACK OF OVERHANG FOR FIRE CONDITIONS

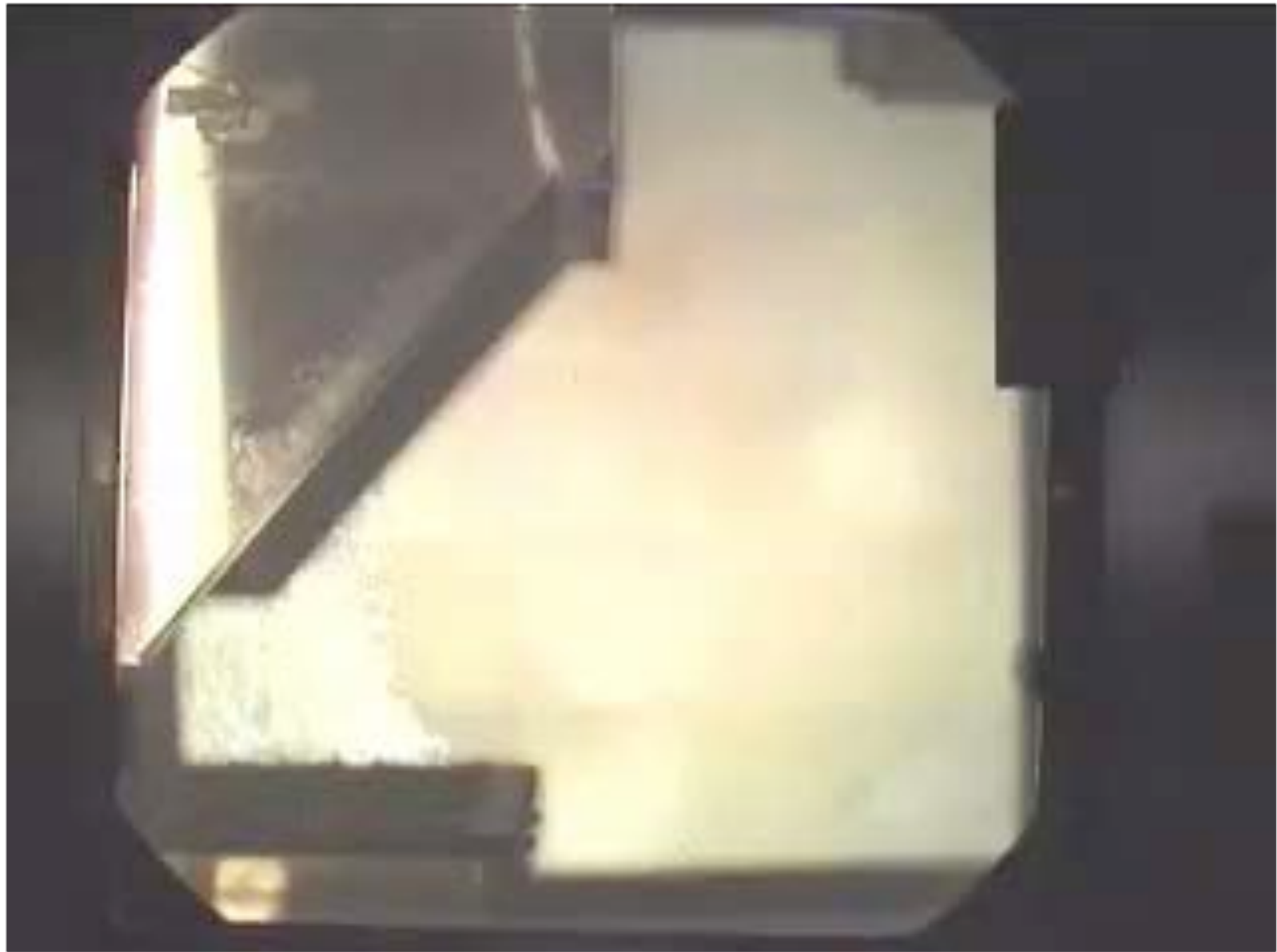


RECOMMENDED OVERHANG

Wall Canopy Hoods

EQUIPMENT	OVERHANG	
	FRONT	SIDE
Charbroiler	18" - 24"	12"
Electric Fryer or Griddle	12"	6"
Gas Fryer or Griddle	12"	12"
Conveyor Oven	12"	12" past conveyor
Convection Oven	24"	6"
Open Burner Range	12"	12"
Range with Shelves or Salamander	24"	12"
Upright Broilers	18" - 24"	12"
Solid Fuel	24"	24"
Woks	24"	24"
Dishwasher	12"	24" inlet & discharge

END PANEL PERFORMANCE



Courtesy FSTC

VERTICAL END PANEL



EXHAUST RATES (LISTED VS. IMC)

Type of Hood UNLISTED	IMC MINIMUM REQUIRED CFM per Linear Foot of Hood			
	Light Duty Equip	Medium Duty Equip	Heavy Duty Equip	Extra Heavy Duty Equip
<i>Unlisted</i> Wall Canopy	200	300	400	550
<i>Unlisted</i> Backshelf	250	300	400	Not allowed

Type of Hood LISTED ETL / UL 710	TYPICAL LISTED CFM per Linear Foot of Hood			
	Light Duty Equip	Medium Duty Equip	Heavy Duty Equip	Extra Heavy Duty Equip
<i>Listed</i> Wall Canopy	150-200	200-300	200-400	350+
<i>Listed</i> Backshelf	100-200	200-300	300-400	Not recommended

LISTED ASTM 1704	Light Duty Equip	Medium Duty Equip	Heavy Duty Equip	Extra Heavy Duty Equip
<i>Listed</i> Wall Canopy	175	220	275	300

EQUIPMENT CLASSIFICATION

Light Duty Equipment (400-450° F)	Medium Duty Equipment (400-450° F)	Heavy Duty Equipment (600° F)	Extra Heavy Duty Equipment (700° F)
Ovens Cheesemelters Rethermalizers Steam-Jacketed Kettles Compartment Steamers	Griddles Fryers Pasta Cookers Tilting Skillets Braising Pans Rotisseries Conveyor (Pizza) Ovens	Open-Burner Ranges Electric/Gas Underfired Broilers Salamander (Upright) Broilers Chain Broilers Wok Ranges	Appliances using Solid Fuel (Wood, Charcoal, Briquettes and Mesquite) to provide all or part of the heat source

Source: IMC

ROBUST FILTRATION

WHY FILTRATION? EFFLUENT

- Includes gaseous, liquid and solid contaminants
- Products of combustion: Carbon monoxide, carbon dioxide and nitrogen oxide
- Harmful to human health, IAQ
- Grease Characteristics:
 - Both Vapor, Small and Large Particles
 - Grease Vapor
 - Hotter cooking process = more grease vapor



GREASE PROBLEMS

- Greasy Exhaust
- Rooftop Damage
- Environmental Impact
- Grease Accumulation Behind Filters
- Significant Buildup on Fusible Links
- Fire Hazard with Grease Accumulation in Duct and Plenum



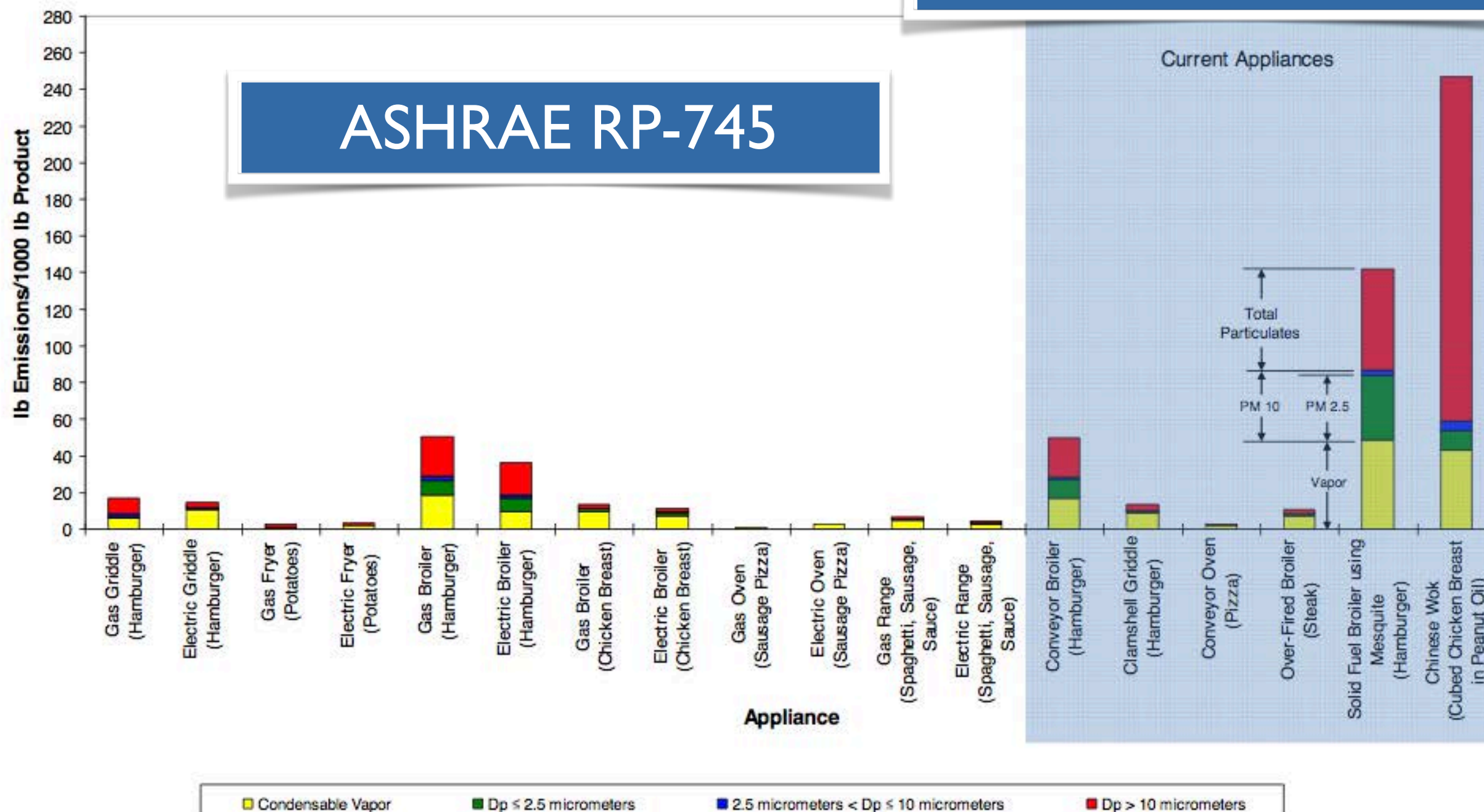
GREASE PROBLEMS



GREASE EMISSIONS

ASHRAE RP-1375

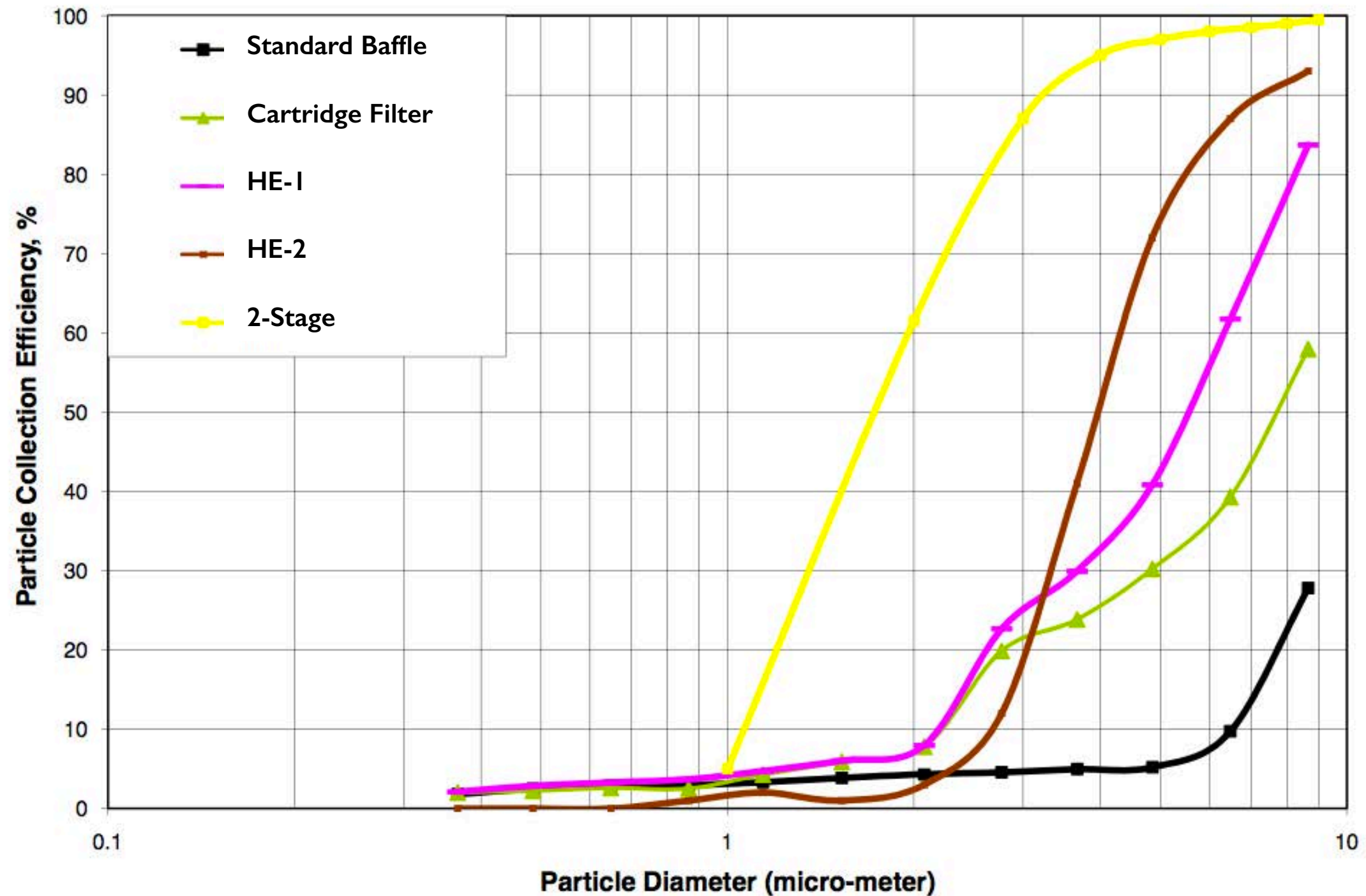
ASHRAE RP-745



FILTER EFFICIENCY TEST

- **ASTM F2519:**
 - *“Grease Particle Capture Efficiency of Commercial Kitchen Filters and Extractors”*
 - Pressure drop as function of airflow through the filter
 - Particulate capture efficiency by particle size
- Incorporation of filter selection and effect on design of entire system, including IAQ

FILTER EFFICIENCY TEST



ROBUST FILTRATION

- Improved baffle design increases grease capture at the source
 - S-Baffle + Slotted Rear Baffle = Multi-Stage Filtration
- Issue of grease on the roof solved
- Fewer duct cleanings required
- Daily manual filter cleaning combined with integrated self-cleaning of hood plenum results in very little grease, reduced fire risk



DEDICATED MAKEUP AIR

MAKEUP AIR PROBLEM?



System design incorporates makeup air tempering
and delivery strategy

MAKEUP AIR

- IMC 508.1.1 The temperature differential between makeup air and the air in the conditioned space shall not exceed 10°F.
 - Exceptions:
 1. Makeup air that is part of the air-conditioning system
 2. Makeup air that does not decrease the comfort conditions of the occupied space

MAKEUP AIR: HOW & WHY

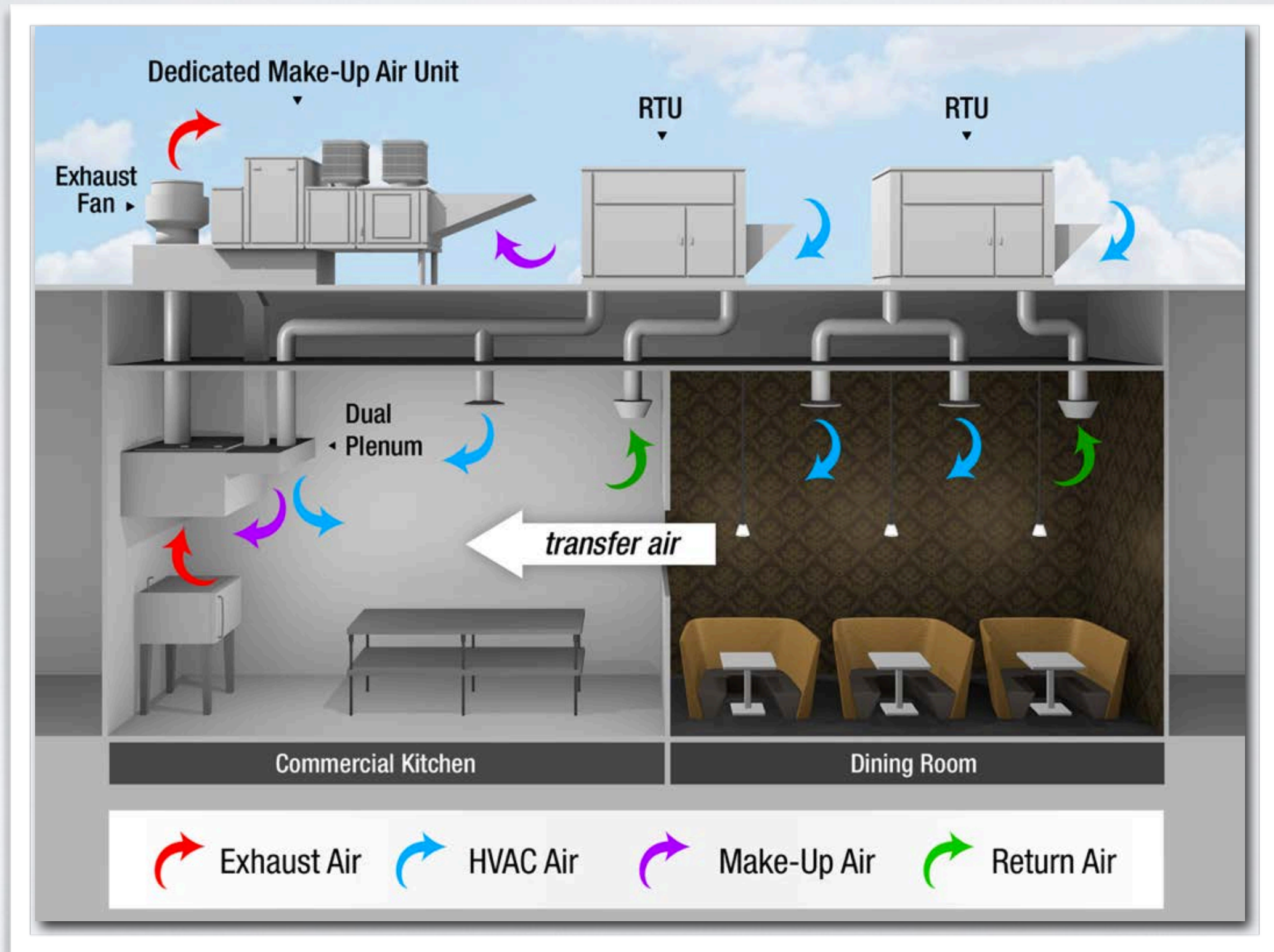
- Do No Harm: Deliver makeup air in an energy efficient manner without harming hood performance
- Makeup Air Options:
 - HVAC air via displacement diffusers, ceiling diffusers, or perforated ceiling diffusers
 - Dedicated MUA: Exhaust hood with integrated makeup air

HVAC AIR PROBLEMS

- Higher energy costs
- Humidity gains with continuous RTU cycling
- May lead to high transfer air velocities
- Must separate HVAC & MUA
 - Directional diffusers must be min. 10' from hood
 - Perforated diffusers must be min. 5' from hood



DEDICATED MAKEUP AIR APPROACH



DEDICATED MAKEUP AIR APPROACH



Makeup Air Delivery



Moderate Heat/Cool

EFFICIENT HEATING

55°
OR BELOW

HEATED MAKE-UP AIR IS RECOMMENDED

NO TEMPER ZONE

HEATING AND COOLING AIR
BROUGHT INTO THE KITCHEN SPACE
IS UNNECESSARY IN THIS
TEMPERATURE ZONE

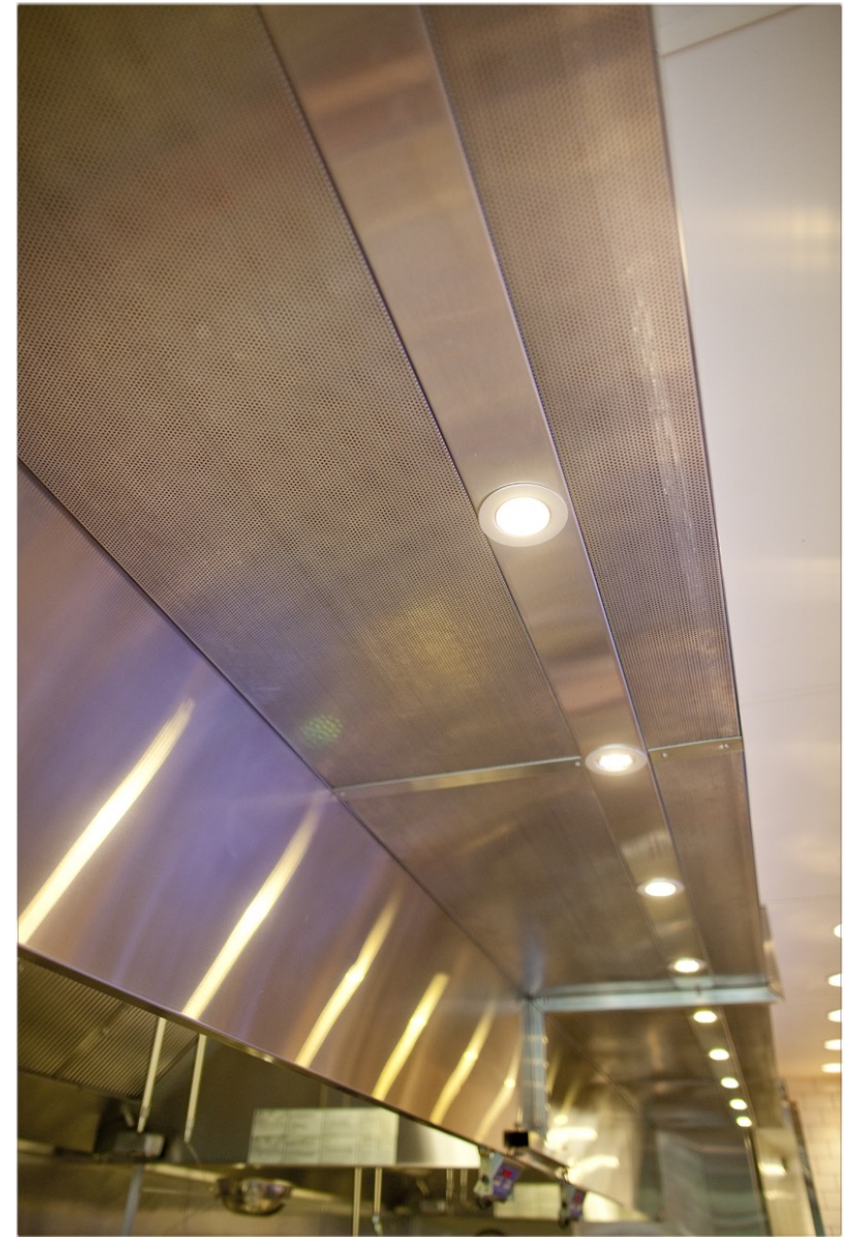
SENSIBLE COOLING

85°
OR ABOVE

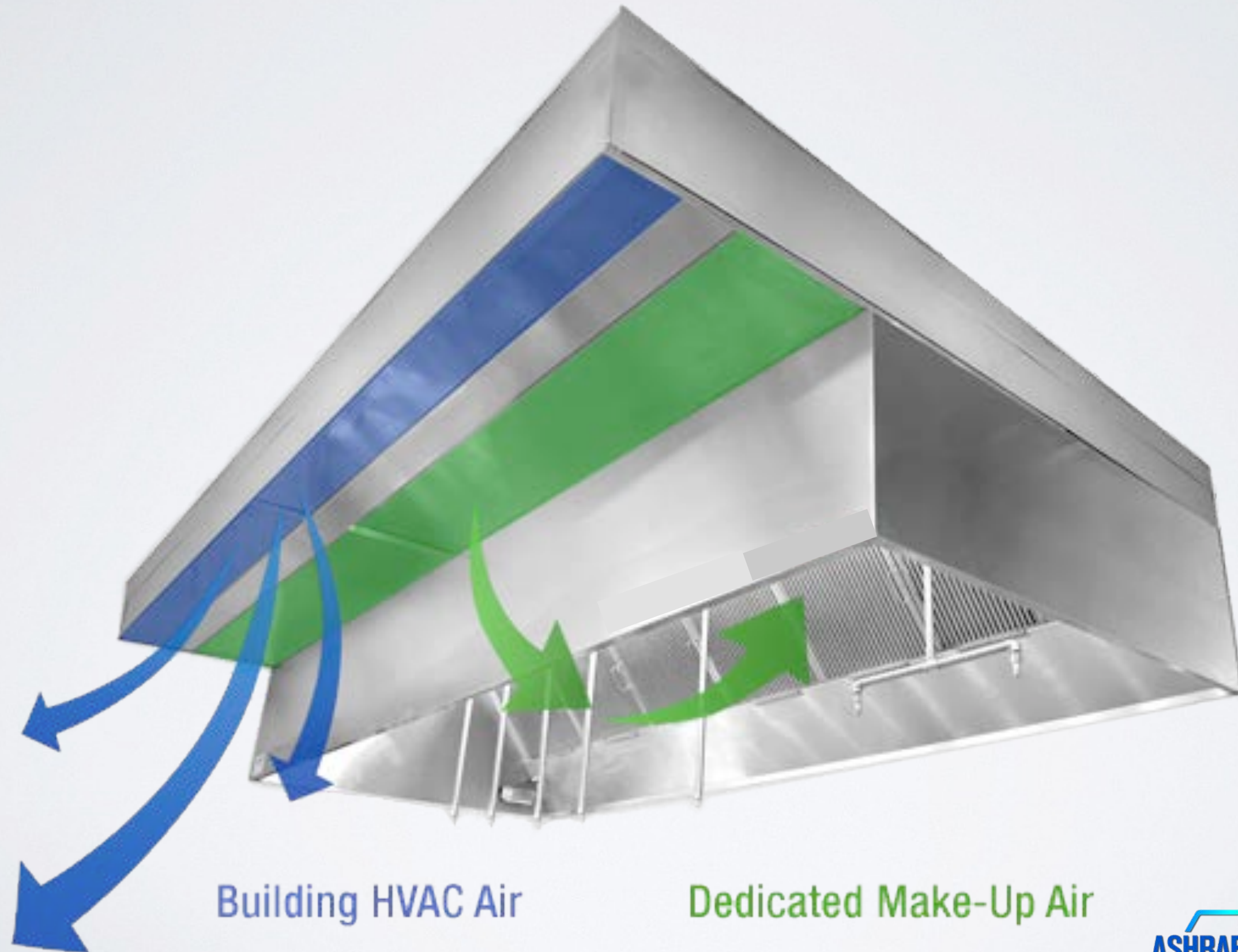
COOLED MAKE-UP AIR IS RECOMMENDED

DEDICATED MAKEUP AIR

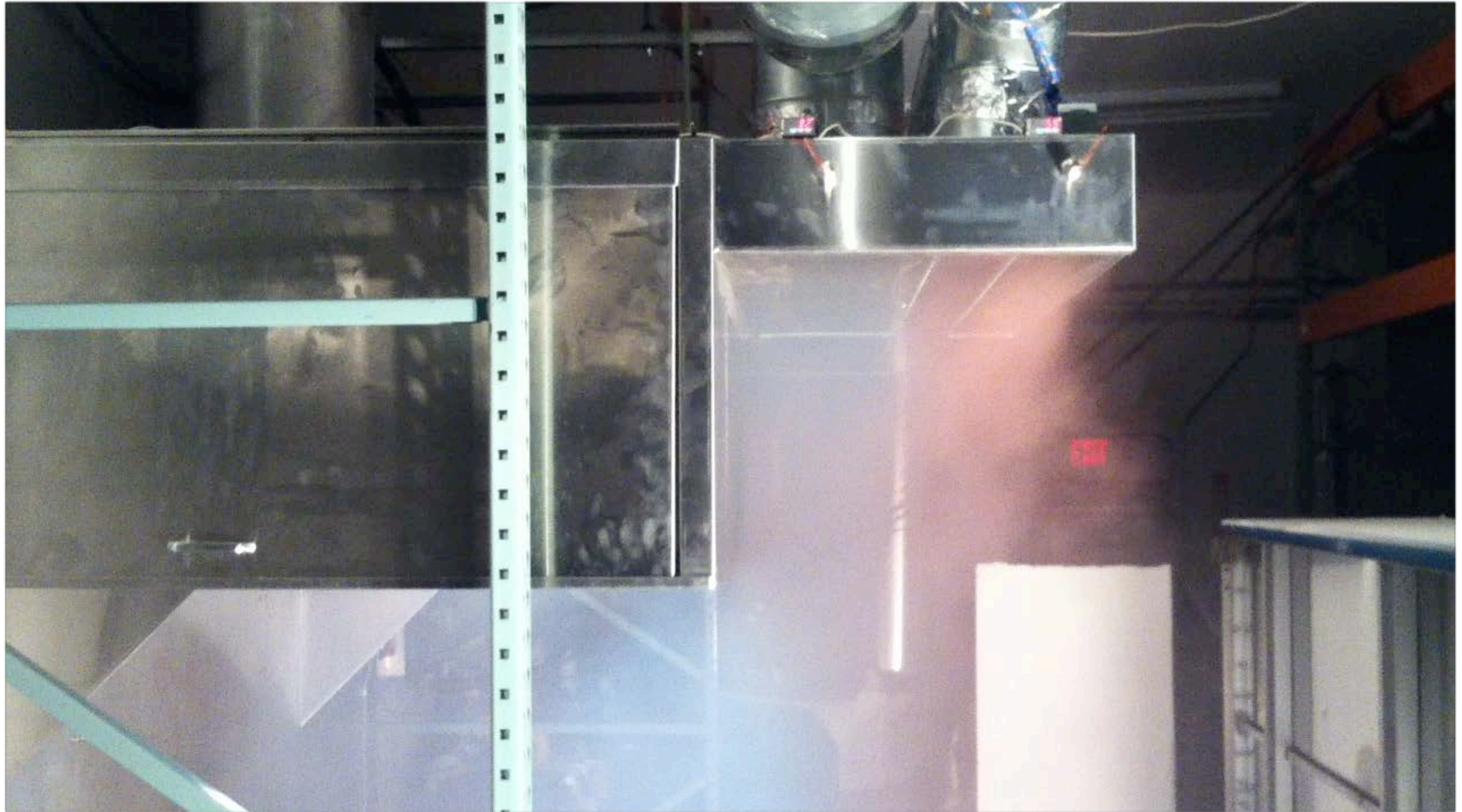
- Use DMUA unless all outside is satisfied by ventilation req's without over-stressing RTUs
- Sensible Heating & Cooling: 55-85° F
- Supply plenum or dual plenum
- 80% DMUA: Additional air provided through HVAC RTU



DUAL PLENUM APPROACH



DUAL PLENUM APPROACH



DUAL PLENUM APPROACH

- Air velocity is critical
 - 140-160 FPM when plenum is placed 18" above front edge of hood
 - 165-185 FPM when plenum is placed 24" above front edge of hood
- Air temperature
 - 55-85° F
- Supply risers
 - Velocity 200-400 FPM
 - Multiple risers on longer hoods for better distribution

VISUAL PERFORMANCE TEST

Supply plenum approach aids in capture & containment performance



PACKAGED MUA UNIT

- 100% outside air applications
- Moderate tempering as needed
- Satisfies IMC 508.1
- Multiple Stage Cooling
- Up to 600 CFM/ton



PROPER TEMPERING

HEATING

- **Direct Fired Heater - 92% efficient**
- Indirect Fired
- Electric
- Steam/Hot Water Coils

COOLING

- **Direct Expansion (DX)**
- Chilled Water Coils

DEMAND CONTROL VENTILATION

DEMAND CONTROL VENTILATION

- Automatically adjusts exhaust & makeup air fans according to cooking load
- Temperature sensor and variable frequency drives modulate fan speed
- Satisfies IMC 507.2.1.1, automatic activation requirement
- Rebates and incentives from many utility companies

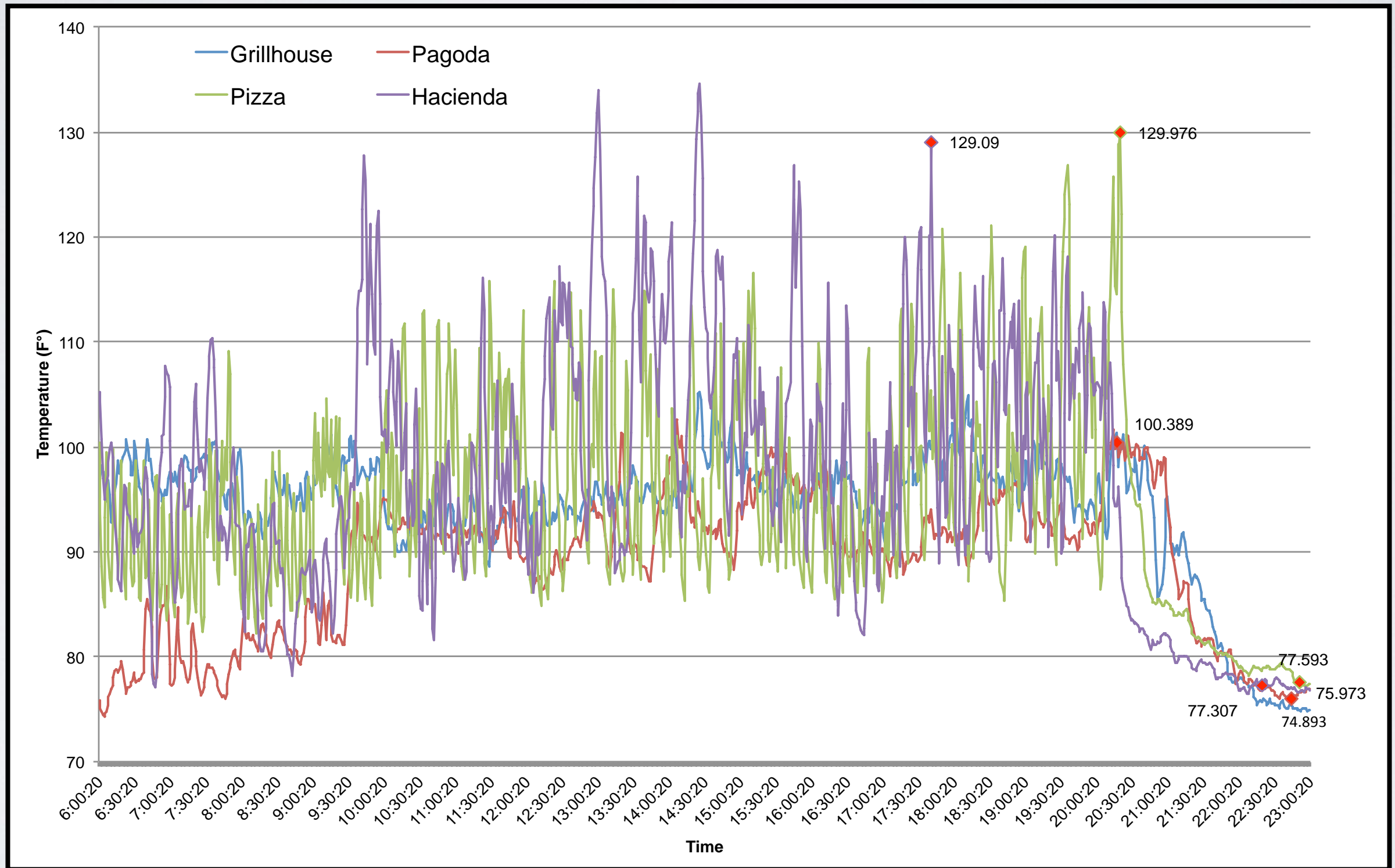


FAN ENERGY SAVINGS & PENALTIES

Reduce Exhaust CFM	Savings in Fan Energy
0.1	0.27
0.2	0.47
0.3	0.66
0.4	0.78
0.5	0.87

Increase Exhaust CFM	Increase in Fan Energy
0.1	0.33
0.2	0.73
0.3	1.2
0.4	1.74
0.5	2.37

EXHAUST TEMPS VARY



Large Buffet Chain Restaurant Raleigh, NC

FACTORY-WELDED DUCTWORK

GREASE DUCT ISSUES

- Liquid-tight welded ducts leak
- Size and velocity
- Static pressure drop
- Integrity of welds and joints
- Number of tees and elbows
- Mitered elbows, non-radius
- Access for cleaning
- Clearance requirements



LEAKING DUCT: FIRE RISK

- IMC: Must be fully welded liquid-tight
- Heavy gauge black iron or stainless steel
- Duct leakage test: light bulb, smoke, pressure



DUCT CONSTRUCTION

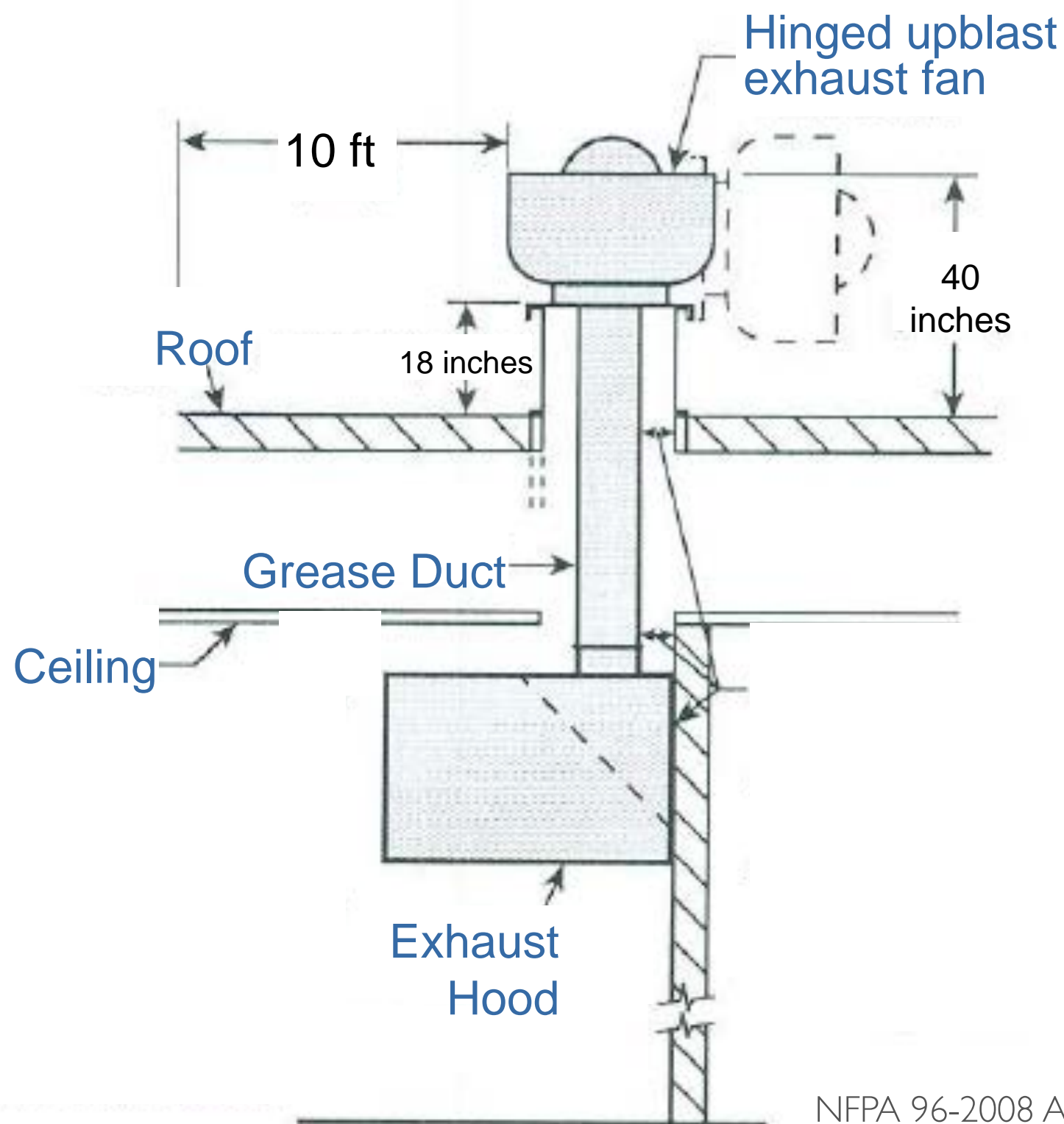
IMC 506.3.2

- Joints, seams and penetrations: continuous liquid-tight weld or braze made on external surface
 - Exceptions: Penetrations shall not be required... where sealed by devices listed for application
 - Internal welding shall not be prohibited provided that the joint is formed or ground smooth and provided with ready access
 - *Factory-built commercial kitchen grease ducts listed and labeled*



CLEARANCE TO COMBUSTIBLES

Ductwork



NFPA 96-2008 Appendix

IMC 2009

- 506.3.6 Grease duct... serving a Type I hood shall have a clearance to combustible construction of not less than 18 inches (457 mm), and shall have a clearance to noncombustible construction and gypsum wallboard attached to noncombustible structures of not less than 3 inches (76 mm).

CLEARANCE TO COMBUSTIBLES

Exhaust Hoods

- New UL 710 version allows for hoods to have a reduced clearance to combustible rating
 - Intended for use adjacent to combustible construction of less than 18" clearance
- Temperatures on adjacent surfaces are measured and limited for rating
 - 2 Tests: limited to max 117° F above ambient
 - 4 Tests: limited to max 175° F above ambient
- Labels include appliance duty classifications

FACTORY-BUILT GREASE DUCT

- Listed to UL1978 (Single)
- Listed to UL2221 (Double)
- 100% Dye Tested at Factory
- Improved Fire Safety
- No Field Welding
- Zero & Reduced Clearance to Combustible for Double Wall Duct



ROBUST DUCTWORK DESIGN

- Correct size and velocity
 - 1500-2000 FPM
- Static pressure drop estimated accurately
- Minimize number of tees and elbows, radius not mitered elbows
- Improved access for cleaning



WATER-BASED FIRE SUPPRESSION

RECENT FIRE



RESTAURANT FIRES

- 5,900 reported restaurant structure fires annually
- \$172 million property loss
- 75 civilian fire injuries
- Cooking is the leading cause of restaurant fires (41%)
- Cooking materials (grease, oil) were the most frequent items first ignited



FIRE SUPPRESSION

60 Years of Commercial Kitchen Fire Suppression

ASHRAE Journal, June 2014

- Proper application and maintenance of suppression systems is an ongoing challenge
- Fires in commercial kitchens most often start in or near appliances
- Fires are often related to inoperative appliance safety devices



60 Years of Commercial Kitchen Fire Suppression

BY BILL GRIFFIN, ASSOCIATE MEMBER ASHRAE; AND MIKE MORGAN, ASSOCIATE MEMBER ASHRAE

Fire suppression systems for commercial kitchens have progressed significantly in the past 60 years to keep up with increasing challenges such as:

- Higher power appliances for faster cooking or cooking larger volumes of food;
- Increased numbers of deep fat fryers, particularly in the quick service sector;
- Expansion of natural gas and solid fuel charbroilers for flavor enhancement; and
- Overall expansion of the number of food service facilities.

FIRE SUPPRESSION

Section 509 - Fire Protection System

509.1 Where Required: Commercial cooking appliances required by section 507.2.1 to have a Type I hood shall be provided with an approved automatic fire suppression system complying with the building code.

System Requirements:

- Tested and Listed to UL300 Standard
- Automatic activation
- Means of manual operation
- Appliance surface protection
- Hood plenum and duct collar

SYSTEM TYPES

- Wet Chemical Systems
 - Discharge chemical agent
 - Appliance-specific protection and/or overlapping protection
- Water-Based Systems
 - Discharge water and surfactant
 - Total flooding of hazard area
- Combination Systems
 - Discharge water and chemical agent

WATER-BASED FIRE SUPPRESSION

- Temperature detection with electronic activation
- Sprays appliances, hood plenum, exhaust duct
- Reliable: Continuous flow until fire is completely extinguished
- Meets UL300, IMC, and NFPA96
- Electronic monitoring and communication



UL300 TESTING FOR HOOD FIRE SUPPRESSION SYSTEM



SUMMARY

- **Exhaust Flow Rates are critical:** Find balance between low exhaust rate and peak performance
- **Robust Filtration** reduces greasy effluent, improves IAQ
- **Dedicated MUA** results in peak efficiency
- **Demand Control Ventilation** allows for greatest fan energy savings
- **Factory-Welded Ductwork** results in best performance, fewest leaks and fires
- **Water-Based Fire Suppression** ensures highest safety, significantly reduced fire risk

RESULT: INTEGRATED KITCHEN DESIGN



*Streamlined KVS Design,
from Hood to Fan*

QUESTIONS?

