Got Exhaust?
Design Considerations

• Fire safety and prevention
• Heat
• Humidity
• Performance
• Comfort
• Energy
CKV – Key Trends and the Future

1. Engineered hoods, robust performance at lowest exhaust (CFM)
2. Demand control ventilation becoming standard for many applications
3. Improved kitchen and building comfort
4. Fire prevention and safety
5. Building integration, computer monitoring, and system controls
Commercial Building Energy

- Food Service
- Food Sales
- Health Care
- Other
- Lodging
- Office
- Education

Thousand BTUs

SustainableFoodservice.com
Energy Use in Restaurants

- Refrigeration: 16.4%
- Sanitation: 15.7%
- Food Prep: 24.4%
- Heating: 16.6%
- Cooling: 5.6%
- Ventilation: 4.7%
- Lighting: 9.8%
- Other: 4.7%

HVAC: 29%
Integrated Design Approach

- Codes & Standards
- Determining Exhaust Rates
- Makeup Air
- Exhaust Fans
- Kitchen Exhaust Duct
- Grease Emissions
- Fire Suppression Systems
United States Code and Standards

- NFPA #96
- International Mechanical Code
- National Sanitation Foundation – NSF # 2
- UL Standard 710 (Hoods)
ASHRAE Energy & Design Standards

- ASHRAE Handbook Chapter 33 – Kitchen Ventilation
- ASHRAE Standard 154
- ASHRAE Standard 62.1
- ASHRAE Standard 90.1
- ASHRAE Standard 189.1
Performance – Hoods shall be designed to work:

507.16.1 Capture and containment test: The permit holder shall verify the 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 with all sources of recirculated air providing conditioning of the space in which the hood is 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.
Visual Performance
Effluent Circulation

Courtesy FSTC
End Panel Performance

Courtesy FSTC
End Panel Design
Minimum 6” overhang

Courtesy FSTC
18” Front Overhang

Courtesy FSTC
# Equipment Classification

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

*Equipment Classifications from IMC*
IMC

- **Section 507.1 General:**
  Commercial kitchen exhaust...
  - **Exceptions:**
    Factor-built commercial exhaust hoods which are tested in accordance with UL710, Listed, Labeled, and installed in accordance shall not be required to comply with sections:
    - 507.4 Type I Materials
    - 507.7 Hood joints, seams, penetrations
    - 507.11 Grease filters
    - 507.12 Size and location
    - 507.13 Capacity (Exhaust Air Rate Calculations)
    - 507.14 Non-canopy size and location
    - 507.15 Exhaust outlets
Exhaust Rates (Listed vs. IMC)

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>IMC MINIMUM REQUIRED CFM per Linear Foot of Hood</th>
<th>TYPICAL LISTED CFM per Linear Foot of Hood</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNLISTED</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unlisted Wall-Mounted Canopy</strong></td>
<td>200 300 400 550</td>
<td>150-200 200-300 200-400 350+</td>
</tr>
<tr>
<td><strong>Unlisted Backshelf</strong></td>
<td>250 300 400 Not allowed</td>
<td>100-200 200-300 300-400 Not recommended</td>
</tr>
<tr>
<td><strong>LISTED</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Listed Wall-Mounted Canopy</strong></td>
<td>150-200 200-300 200-400 350+</td>
<td>100-200 200-300 300-400</td>
</tr>
</tbody>
</table>
ASHRAE Standard 90.1

- Replacement air considerations
- Performance Test Required
- Kitchen hoods 5000 CFM or higher
- Maximum Net Exhaust
### Table 6.5.7.1.3 Maximum Net Exhaust Flow Rate, CFM per Linear Foot of Hood Length

<table>
<thead>
<tr>
<th>Type of Hood</th>
<th>Light Duty Equipment</th>
<th>Medium Duty Equipment</th>
<th>Heavy Duty Equipment</th>
<th>Extra Heavy Duty Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall-mounted canopy</td>
<td>140</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Single island</td>
<td>280</td>
<td>350</td>
<td>420</td>
<td>490</td>
</tr>
<tr>
<td>Double island (per side)</td>
<td>175</td>
<td>210</td>
<td>280</td>
<td>385</td>
</tr>
<tr>
<td>Eyebrow</td>
<td>175</td>
<td>175</td>
<td>Not allowed</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Backshelf/Pass-over</td>
<td>210</td>
<td>210</td>
<td>280</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>
ASHRAE Standard 90.1

- Kitchen hoods 5000 CFM or higher
- Maximum Net Exhaust CFM, and one of the following:
  - At least 50% of all replacement air is transfer air that would otherwise be exhausted.
  - Demand ventilation controls on at least 75% of the exhaust air.
  - Listed energy recovery devices with a sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow
Engineered Exhaust Hood

Aerodynamic Design

Built-In 3" Rear Standoff

Grease Drain with Cup

UL1046 Grease Filters

Mechanical Baffle

Double Wall Insulated Front

ETL Listed

UL Listed
# Recommended Overhang

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>FRONT</th>
<th>SIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charbroiler</td>
<td>18” – 24”</td>
<td>12”</td>
</tr>
<tr>
<td>Fryer or Griddle</td>
<td>12”</td>
<td>6” – 12”</td>
</tr>
<tr>
<td>Conveyor Oven</td>
<td>12”</td>
<td>12” past conveyor</td>
</tr>
<tr>
<td>Convection Oven*</td>
<td>24”</td>
<td>6”</td>
</tr>
<tr>
<td>Upright Broilers</td>
<td>18” – 24”</td>
<td>12”</td>
</tr>
<tr>
<td>Solid Fuel</td>
<td>24”</td>
<td>24”</td>
</tr>
<tr>
<td>Woks</td>
<td>24”</td>
<td>24”</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>12”</td>
<td>24” inlet &amp;</td>
</tr>
</tbody>
</table>

**General overhang recommendations for wall canopy hoods for improved capture and containment performance**
Reducing Exhaust and Makeup

- Hood selection & sizing
- Listed hoods (UL710)
- Generous overhang
- End panels
- Demand Ventilation?
Variable Speed Exhaust?
## Fan Energy – Savings & Penalties

<table>
<thead>
<tr>
<th>Reduce Exhaust CFM</th>
<th>Savings in Fan Energy</th>
<th>Increase Exhaust CFM</th>
<th>Increase in Fan Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>27%</td>
<td>10%</td>
<td>33%</td>
</tr>
<tr>
<td>20%</td>
<td>47%</td>
<td>20%</td>
<td>73%</td>
</tr>
<tr>
<td>30%</td>
<td>66%</td>
<td>30%</td>
<td>120%</td>
</tr>
<tr>
<td>40%</td>
<td>78%</td>
<td>40%</td>
<td>174%</td>
</tr>
<tr>
<td>50%</td>
<td>87%</td>
<td>50%</td>
<td>237%</td>
</tr>
</tbody>
</table>
Cooking Exhaust Temperature

Large Buffet Chain Restaurant
Raleigh, NC
Energy Management System

- Automatically adjusts exhaust and makeup air fans.
- Temperature sensor and variable frequency drives modulate fans speed.
- Satisfies IMC 507.2.1.1, automatic activation requirement.
- Rebates and incentives from many utility companies.
Variable Speed Exhaust & Supply

- Touchscreen for controls, setup and diagnostic.
- Real time fan speeds, CFM monitoring.
- Adjust fan speed settings
- Room temperature sensor
- Integrated gas valve reset
- Programmable schedule
- Building management
Codes and Demand

- 2006 International Mechanical Code – Changes
  - 506.3.4 Air Velocity: Grease duct systems serving a Type I hood shall be designed to provide an air velocity within the duct system of not less than 500 feet per minute (2.5 m/s).
  - 507.2.1.1 Operation: Type I hood systems shall be designed and installed to automatically activate the exhaust fan whenever cooking operations occur.
  - The activation of the exhaust fan shall occur through an interlock with the cooking appliances, by means of heat sensors or by means of other approved methods.
Makeup Air Problem?
• Commercial Kitchen Makeup Air

  508.1 Makeup Air. Makeup air shall be supplied during the operation of commercial kitchen exhaust systems that are provided for commercial cooking appliances. The amount of makeup air supplied shall be approximately equal to the amount of exhaust air. The makeup air shall not reduce the effectiveness of the exhaust system. Makeup air shall be provided by gravity or mechanical means, or both. For mechanical makeup air systems, the exhaust and makeup air systems shall be electrically interlocked to insure that makeup air is provided when the exhaust system is in operation.
IMC

- Commercial Kitchen Makeup Air
  - 508.1.1 Makeup Air temperature. 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

- Air removed from the kitchen through the hood must be replaced.
  This can be achieved by the following pathways:
  - Transfer Air
  - Displacement Diffusers, floor or wall mounted
  - Ceiling Diffusers (4-way, slot diffusers)
  - Perforated Ceiling Diffusers
  - Exhaust Hood with Integrated Makeup Air
    - Front face, air curtain, backwall, short circuit or a combination
    - Perforated perimeter supply plenum
All Makeup through HVAC
4-Way Diffuser – Causing Spillage

Courtesy FSTC
What’s wrong with this picture?
Engineered Makeup System?
Dedicated MUA

http://www.energy.ca.gov/reports/2003-04-10_500-03-007F.PDF
Short Circuit (Internal Supply)
Short Circuit (Internal Supply)
Perforated Perimeter Supply
Designing for Dedicated MUA

Dedicated ‘Local’ Makeup Air:

- Typical 70–80% of exhaust
- Proper air velocity is critical
- Correct design, placement
- Enhanced performance
- Minimal diffusion
- Less heating and cooling
- Temperature 55° to 85°F
- Improved comfort
Minimize HVAC Impact

% PSP MUA Diffused to Space

- 3 Sided 12" PSP
- Front 16" PSP

Average MUA Discharge Velocity (fpm)
Temperature is important!

- Hood performance
- Comfort conditions
- HVAC heating / cooling
Poor capture performance in field
Robust capture performance in field
Integrated Makeup Air

- **Exhaust Fan**
- **Dedicated Makeup Air Unit**
- **RTU**
- **Transfer Air**
- **Kitchen**
- **Dining Room**

**Flow Diagram**: Exhaust → Dedicated Makeup Air Unit → RTU → Return

- **HVAC Air**
- **Makeup Air**
Dual Plenum Integrated

- Secondary plenum for HVAC air
- Delivers ‘the right air in the right place’
- Discharge velocity same as PSP
- Helps direct dedicated MUA into hood
- Provides spot cooling
- Improved comfort
Dual Plenum Perimeter
Dual Plenum (82 / 59 deg)
US Climate Zone Map
US COOLING RECOMMENDATIONS
FOR DEDICATED KITCHEN MAKEUP AIR APPLICATIONS

- SEMIARID: 450-550 CFM/TON AND/OR EVAPORATIVE COOLING
- HUMID SUBTROPICAL: 360-500 CFM/TON
- MARINE WESTCOAST: 500-600 CFM/TON AND/OR EVAPORATIVE COOLING
- MEDITERRANEAN: 500-600 CFM/TON AND/OR EVAPORATIVE COOLING
- WARM SUMMER: 400-500 CFM/TON
- COOL SUMMER: 500-600 CFM/TON
- HIGHLAND ALPINE: 500-600 CFM/TON AND/OR EVAPORATIVE COOLING
- TROPICAL WET: 360-400 CFM/TON
- DESERT: 360-400 CFM/TON AND/OR EVAPORATIVE COOLING
Packaged Heat/Cool Makeup Air

- 100% outside air applications
- Comfort cool kitchen makeup air
- Top mounted condensers
- High efficiency, 14 SEER
- Multiple stage cooling
- Up to 600 CFM per Ton
Packaged Heat/Cool Makeup
Makeup air Delivery

Moderate Heat/Cool only as needed

performance + comfort + efficiency
Exhaust Fans

- Power Roof Ventilator
- UL762 for grease
- Belt and direct drive
- Utility set fans for high grease applications.
Leaking Grease Ducts
Factory Built Grease Duct

- Easy Installation and Maintenance:
  - ETL-listed to UL Standard 1978
  - Single wall/430 SS construction
  - Factory welded duct
  - Improved fire safety
  - Requires no on-site cutting or welding
  - Zero clearance fire wrap available
Factory Built Grease Duct

DUCT IS AUTO-WELDED
Factory Built Grease
Insulated Double Wall Factory Built Grease Duct

Easy Installation and Maintenance:

- ETL Listed; Certified to UL–2221
- Double wall / insulated
- Factory welded duct
- Improved fire safety
- Requires no welding
- Zero clearance to combustible
Grease Emissions
Grease Emissions
Grease Emissions – Research & Testing

ASHRAE Research
RP-745
Field Pictures – Efficient Grease Filters

High Volume Hamburger Restaurant in Tampa, FL – Open for 10 weeks, minimal grease accumulation in exhaust hood plenum and duct.
Fully Integrated Self Cleaning Hood

- Integrates into standard hood
- Automatic cleaning cycle
- Adjustable surfactant injection
- Adjustable wash length
- Water usage is 0.7 GPM per foot of hood
- Controls mounted in utility cabinet on end of hood
Self-Cleaning Hood
Accumulation of Grease in Plenum
Self Cleaning Hood – Field Results
Restaurant Fire – Total Loss

Elements Required:
- Fuel (Grease)
- Heat
- Oxygen

Courtesy of firephoto.org
Restaurant Fires
Reported by US Fire Administration, April 2011

- Estimated 5900 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

Closed

Due to a malfunction of the kitchen’s fire suppression system, we will be closed tonight for clean-up.
We apologize for the inconvenience and thank you for your patronage.
Fire Protection Systems

• 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
UL 300 Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment
System Types

- Wet Chemical Systems
  - Discharge Chemical Agent
  - Appliance Specific Protection and/or Overlapping Protection
- Water Spray Systems
  - Water used for protection
- Combination Systems
  - Use of Water and Chemical Agent for protection
Grease Accumulation = Greater Fire Risk

WARNING

Grease accumulation on fusible-links or in nozzles may delay or prevent discharge of the fire system.

Fire system must be serviced at regular intervals

For service call: Koorsen Fire & Security
Water Based Fire System

- Cooking appliances, hood plenum, and exhaust duct
- Temperature detection with electronic activation
- Meets UL300, IMC, and NFPA96
- Electronic monitoring and communication.
Fire Detection and System Activation

Temperature / Electronic

Mechanical Fusible Link
Water Fire Suppression

- Quickly Extinguishes Fire
  - Total Flood coverage for cooking appliances

- Safety and Performance
  - Water spray system for hood plenum and exhaust duct
  - Rapid cooling
  - Extended operation, unlimited supply of water

- System Reliability
  - Built-in supervision and Remote Monitoring capabilities
  - Temperature/electric detection with battery backup
  - No fusible links
  - Pre-engineered, factory installed
Water – Duct Fire / Rapid Cool
Water – Ductwork Cooling

Thermocouple 1 (12 feet from riser)

Thermocouple 2 (20 feet from riser)
Water – Fryer Cooling

**Vat Fryer Oil Temperature**

- **Auto Ignition occurred**
  - Start of 2-minute pre-burn: 66.3

- ** Activation of Water Protection**: 68.5

- **Oil Temperature Drop of 60 degrees from auto ignition**: 69.5

- **Full extinguishment of fire at 1.5 Minutes**: 70

- **Oil at 225 degrees in 3.5 minutes**: 72

- **Final Temperature**: 191

**Temperature (degrees F)**

**Time (minutes)**: 65, 66, 67, 68, 69, 70, 71, 72, 72.5, 74
Questions?