Kitchen Ventilation Systems
AGENDA...

- Kitchen Ventilation … SYSTEM
  - More than just a kitchen hood...
- Kitchen Effluent…
  - What Is It?
- Hood Types
  - ‘Type I’ vs. ‘Type II’
- Code Driven Exhaust Air Requirements…
  - ‘Old’ design criteria and safe rules of thumb.
- Listed Hoods / UL Standard 710
AGENDA...

• Cooking process and ventilation...
  – Theory of operation
  – Hot vs. cold

• Exhaust air requirements
  – How much air should I exhaust?
  – Size and type of cooking appliances
  – Thermal updraft characteristics
  – Quantity and methods of calculation
AGENDA...

• Make-Up Air…
  – Quantity - *How much?*
  – Quality - *Where’s it coming from?*
    *Is it tempered?*
  – Integral Supply Hoods and External Plenums

• Short Circuit Hoods…
  – History and application
    – *Engineering marvel or myth?*
Kitchen Effluent - What Is It?

• Kitchen Effluent
  – is the by-product of commercial cooking processes that must be captured, contained, and removed from the space by the kitchen ventilation system.

• Kitchen Effluent
  – consists of *heat and contaminants*
  – very small grease particles
  – grease vapor (just like humidity in the air)
  – moisture
  – odor
  – VOC’s (volatile organic compounds).
Kitchen Ventilation... SYSTEM

- Ventilation System
  - Effluent Control
  - Worker Comfort / Productivity
  - Health / Safety
  - Patron Comfort
  - Energy / Costs
• **Kitchen Hood**
  – Contain Effluent
  – Extract Grease
  – Physical Fire Barrier / Protection
Kitchen Ventilation... SYSTEM

- My kitchen hood isn’t working!
- The hood is only a “receiving device”.
- Exhaust fan
- Make-Up Air
Understanding the... SYSTEM

Question:
– What causes smoke and grease laden air to move horizontally and spill out under a kitchen hood…Good Question?

Answers:
• Not enough exhaust air for the cooking load.
• Kitchen hood is undersized for the application.
• Cross drafts in the kitchen.
• Excessive velocities from the make-up air source(s).
• Not enough supply air brought into the kitchen.
• Short circuit??…what’s the ratio (exhaust & supply)?
Hoods Types

“Type I” vs. “Type II”

- **Type I** - Grease laden air applications.
  - Must include UL Classified Filters
  - Must meet NFPA # 96 fully welded duct requirements
  - Must utilize a listed exhaust fan in accordance w/ UL subject 762.

- **Type II** - Non-Grease exhaust applications
  - Heat, moisture, odor only
  - “standard” HVAC ductwork can be used
Hoods Types

“Type I” vs. Type II”

According to the International Mechanical Code, “A Type I hood shall be installed at or above all commercial food heat producing equipment that produces grease vapors or smoke.

A Type I or Type II hood shall be installed at or above all commercial food processing equipment that produces fumes, steam, odor, or heat.
### Exhaust Air Volume

- Old design criteria.
- “Safe rules of thumb”.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Minimum Design Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hood Face Area: Island Canopy</td>
<td>150 cfm/sq.ft.</td>
</tr>
<tr>
<td>Hood Face Area: Wall Canopy</td>
<td>100 cfm/sq.ft.</td>
</tr>
<tr>
<td>Hood Face Area: Corner Canopy</td>
<td>85 cfm/sq.ft.</td>
</tr>
<tr>
<td>Hood Perimeter Area (between hood &amp; appliance)</td>
<td>50 cfm/sq.ft.</td>
</tr>
<tr>
<td>Hood Length (shelf-type only)</td>
<td>200-350 cfm/lin.ft.</td>
</tr>
<tr>
<td>Kitchen Floor Area</td>
<td>4 cfm/sq.ft.</td>
</tr>
<tr>
<td>Kitchen Volume</td>
<td>20-30 air changes/hr.</td>
</tr>
</tbody>
</table>

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International Mechanical Code

• International Mechanical Code (IMC) 2003
  – Authored jointly among members of BOCA, ICBO, and SBCCI.
  – Virtually identical to the Uniform Mechanical Code 1997 edition with only minor changes or enhancements.
How much air should I exhaust?

507.1 General.

• Commercial kitchen exhaust hoods shall comply with the requirements of this section. **Hoods shall be designed for the type of cooking appliance served and shall be designed to confine cooking vapors and residues within the hood.**
  
  – Exception: Factory-built commercial exhaust hoods which are tested in accordance with UL 710, listed, labeled and installed in accordance with Section 304.1 shall not be required to comply with Sections 507.4, 507.5, 507.7, 507.12, 507.13, 507.15 and 507.16.
UL Standard 710 - Test standard for kitchen exhaust hoods

- UL Standard 710 is a safety test, not a performance test.
  - Kitchen hoods are evaluated for *structural integrity* after subjected to intense fire.
  - As a *safety measure*, minimum allowable exhaust flow requirements are established to ensure that contaminated effluent is exhausted to ensure a “safe condition”.
UL Standard 710 - Test standard for kitchen exhaust hoods

- Airflows are established under controlled laboratory conditions, and greater exhaust and/or lessor supply may be required in specific installations.

- Air volumes are minimum and maximum allowable values only, and are not intended to be design criteria.
Exhaust CFM - Codes & Standards

• The “Older” Mechanical Codes required *Arbitrary* exhaust levels (100 CFM / Sq. Ft), without exception.

• UL Standard 710 establishes minimum exhaust values, again which are *Arbitrary* - and has nothing to do with performance, only safety.

• Mechanical Codes today allow for exceptions to these *Arbitrary* formulas for UL Listed Hoods – AND must be designed to work, based on the cooking process below the hood!
So what’s the “correct” Exhaust Air Volume?

- The cooking process and equipment used dictates the hood dimensions and minimum exhaust level.
  - Hot process
  - Hood is a receiving device
  - Sized and located to receive the buoyant plume
  - **Net Exhaust volume must be greater than the thermal updraft**
Exhaust Air Volume

For complete smoke removal, the air quantity exhausted ($Q_E$) must be equal to, or greater than the ($Q_C$), the air quantity generated by the cooking equipment.
Total required exhaust must equal contaminated airflow ($Q_c$) plus minimum face capture airflow ($Q_f$).

$$Q_c = \text{Contaminated air generated by the cooking equipment.}$$

$$Q_f = \text{Quantity of air to contain surges, cross drafts and turbulence.}$$

$$Q_e = Q_c + Q_f$$
Qc - Contaminated Air Quantity

- Equipment type
- Equipment size
- Equipment temperature
- Fuel type
- Cooking product
- Cooking process
- Complex with infinite combinations
Cooking appliances can be grouped into the following general categories, based upon Thermal Updraft Velocity characteristics:

- **Light Duty** ........................................... **50 FPM**
  *(Ovens, Steamers, Ranges)*
- **Medium Duty** ................................. **85 FPM**
  *(Griddles, Fryers)*
- **Heavy Duty** ............................... **150 FPM**
  *(Char-Broilers)*
- **Extra Heavy Duty** ...................... **185 FPM**
  *(Solid Fuel)*
Typical cooking battery and canopy hood.
Assume 3” spacing behind, and between appliances.
Assume typical 6” required overhang at front and ends.
Hood dimensions: 102” x 42”
# Qc - Typical Equipment Battery

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Dimensions</th>
<th>Area</th>
<th>Updraft Velocity Factor</th>
<th>Contaminated Air (CFM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>30&quot; X 24&quot;</td>
<td>5.0</td>
<td>50</td>
<td>250</td>
</tr>
<tr>
<td>Char-Broiler</td>
<td>24&quot; X 24&quot;</td>
<td>4.0</td>
<td>150</td>
<td>600</td>
</tr>
<tr>
<td>Oven</td>
<td>30&quot; X 33&quot;</td>
<td>6.9</td>
<td>50</td>
<td>344</td>
</tr>
</tbody>
</table>

**Total Area:** 15.9  **Total CFM:** 1194
Capture Velocity

- The velocity needed to maintain capture and reduce the effects of equipment surges and cross drafts
Q_F - Quantity of Air to Contain Surges, Cross Drafts and Turbulence

Q_F = (Total Hood Area – Total Appliance Area) X 50

Total Hood Area (102 X 42) / 144 = 29.8 Sq. Ft.

Q_F = (29.8 – 15.9) X 50 = 695 CFM
Exhaust Volume  \( Q_E = Q_C + Q_F \)

Total Hood Area \((102 \times 42) / 144 = 29.8\) Sq. Ft

\[ Q_F = (\text{Total Hood Area} - \text{Total Appliance Area}) \times 50 \]

\[ Q_F = (29.8 - 15.9) \times 50 = 695 \text{ CFM} \]

\[ Q_E = Q_C + Q_F \]

\[ Q_E = 1194 + 695 = 1889 \]

**ASSUMPTIONS:**

- 100% Capture
- Normal Room Cross Drafts
- 100% Equipment Usage
Make-Up Air...

**Question:** When is it necessary to provide make-up air to a system?

**Answer:** Always. Codes and Standards require that make-up air be provided. NFPA # 96 states, “Replacement Air Quantity be adequate to prevent negative pressures in commercial cooking area(s) from exceeding 0.02 in. water column (4.98kPa).”
Make-Up Air
Quality…Quantity…Source…

• Exhaust Only Kitchen Hood
• Dedicated Kitchen Make-Up Air
• Integral Supply Hoods
  – Face Supply
  – Air Curtain Supply
  – Combination Face & Air Curtain Supply
• External Supply Plenums
  – Face Supply Plenum
  – Air Curtain Supply
  – Variable Supply
  – Back Supply
  – Seasoned Air
• Short Circuit Hoods
Exhaust Only Hood System

- Low initial cost
- Make-Up Air available from existing HVAC
- Good performance if Make-Up Air is provided properly
- Lower installation costs
- Small installations
- Make-Up Air “Quality” is Critical
Face Supply (front face discharge)

• Avoids disturbing cooking operation
• Does not direct air at worker
• Registers
  – Longer throws
  – Larger kitchens
  – Not or marginally air conditioned kitchens
• Perforated
  – Short throws
  – Smaller obstructed kitchens
  – Air conditioned kitchens
  – Tempered supply air
Face Supply Plenum

- Provides Make-up Air at a low cost
- Fits on any exhaust only hood.
- Easy retro fit
- 150 CFM/ft max
Face Supply Application

• Utilize Front Face Supply Hoods
  – **Medium to large installations**, such as full service kitchens and dinner houses.
  – **Good room balance**. Exhaust and supply operate together.
  – **Tempered make-up air** - Recognize that the supply air requires heating and / or cooling in most climates (typically 55 - 85 deg. F.) This will yield good performance, good worker comfort, good HVAC balance…**but at a price**.
Air Curtain Supply

- Spot cooling
- Clean air in breathing zone
- Tempered supply air
- Limited quantity of supply air
- Velocity is critical
  - 150 FPM maximum
Air Curtain Supply

• Provides Make-up Air at a low cost
• Fits on any exhaust only hood.
• Air curtain advantages with out the cool spots or pilot light blow outs
• 110 CFM/ft max
Combination Face & Air Curtain

- Spot cooling
- Tempered supply air
- Larger total quantity of supply air
- Adjustment between face and air curtain
- Low velocities (Through air curtain)
Variable Supply

- Provides Make-up Air at a low cost
- Gives the kitchen staff the ability to change the make up air quantity through the face (50-100%) or air curtain (0-50%)
- 160 CFM/ft max
Back Supply - Rear discharge

- Supply air discharges behind and below the cooking equipment
- *Excellent* alternate method for introducing untempered or marginally tempered make-up air.
- Incorporates a 6” clearance to combustibles
- Includes a backsplash panel
- 145 CFM/ft
Rating of MUA methods

Goal is comfort
- Tempered MUA
  - Perf Ceiling
  - Perf Face
  - BSP
  - ASP
  - VSP
  - Register Face
  - 4-way diffuser
  - Short Circuit
  - Air Curtain

Goal is low cost
- No AC for MUA
  - BSP
  - ASP
  - Perf Face
  - Perf Ceiling
  - VSP
  - Air Curtain
  - Short Circuit
  - Register Face
  - 4-way diffuser

Good
Bad
What hood should I use?

- Southwest - dry and hot
  - Perf face or BSP or ceiling perf
  - Swamp cooler
- Southeast - Hot and Humid
  - 50% through a ASP or BSP - heat only
  - 50% through RTU - makes it bearable
    - Nothing good is free
What hood should I use?

• North - cold and short mild summer
  – BSP or perf face - heat only
    • heat only because “it ain’t that bad that long”
  – BSP or perf face - heat and cool
    • If comfort is important
    • cooling MUA to 85°F makes it bearable and inexpensive
    • Short cooling period not that expensive
What hood should I use?

- San Francisco or Hawii
  - Perf face, ceiling perf, or BSP
  - Basically free MUA all year
  - Higher exhaust volumes ok
  - Maybe MUA heat only in San Francisco
Ideal Kitchen

• It will have an exhaust only hood
• It will have an BSP -heat and cool 85°F
• It will have perforated ceiling diffusers
  – Twice as many as the catalog says to use
  – Supplied by the RTU
• Be there during construction to assure no 4 way diffusers are used.
Bring in Supply from Multiple Sources

• When the supply limit is reached on the hood option, then add perforated ceiling diffusers for the remainder

• Supply lower FPM from multiple sources
  – Use ASP on 3 sides of hood
  – Use face supply with perf ceiling diffusers
  – Use BSP with face supply hood
Short Circuit Hoods
History & Issues

• Design to circumvent code driven excessive exhaust levels
• Larger exhaust fan, supply fan and duct
• Condensation, turbulence, noise
• Working short circuit hood example
  – System balance
  – Total exhaust can handle the cooking load and short circuit air.
• Misapplied short circuit hood example
  – Unbalanced system
  – Total exhaust cannot handle the cooking load and short circuit air.
  – The excess heat and contaminated air overflows into the room.
• A short circuit hood is like a bathtub with two faucets.
  – The excess heat and contaminated air “overflows” into the room, just like an overflowing bathtub.
Short Circuit Hoods - Summary

- Failure not always apparent (visible smoke).
- Kitchen is “Extra Hot” in summer, cold in winter (especially in colder climates like Wisconsin)
- The **added heat gain to the space** costs money due to the “extra burden” on the HVAC system.
- Grease film in kitchen
- Games played in design or balance

*The only application is when the hood is over exhausting!!!*
Short Circuit Hoods - Summary

• **The perceived “Energy Savings”** by using inexpensive (untempered) short circuit air actually costs the owner more money.

• **Higher up-front cost**
  – Equipment and initial installation

• **Higher operational cost year after year**
  – Fan energy, tempering cost(s), and factoring in the heat gain to the space by under exhausting the correct NET exhaust amount based on the cooking process.
Design Considerations
Design Considerations

- A minimum overhang of 6 inch is required by code
- Increase the overhang for heavy duty cooking applications
Design Considerations

- Insufficient overhang results in poor capture and additional heat gains in the kitchen
Design Considerations

- End or side skirts are strongly recommended
- Enhanced capture
- Reduces the effect of cross drafts and equipment surges
Design Considerations

- An open door can cause capture problems with the hood
Design Considerations

• End or side skirts can reduce the effects an open door has on hood capture
Design Considerations

- Re-hinging a door may be a simple and economical way to improve hood capture
Design Considerations

• Adding a partition between an open door-way and the hood can improve hood capture
Insufficient Make-Up Air in the kitchen can create hood capture problems.
Design Considerations

Locate ceiling registers a minimum of a throw distance away from the hood
Design Considerations

The use of portable fans to improve employee comfort should be avoided
Design Considerations
Hoods Facing Each Other

- Do not use face registers
± Maybe perf face registers if very low FPM
± Maybe perf ceiling registers if very low FPM
+ Use BSP - least capture problem
Discussion Summary

- Design the exhaust airflows based on the cooking equipment
- Select a hood style best suited for the application
- Provide adequate overhang
- Minimize crossdrafts
Discussion Summary

• Eliminate “System Effects”

• Code Compliance

• System Responsibility
Discussion Summary

• Design the “correct” exhaust CFM based on the cooking process and appliances used.
  – Not arbitrary
  – Not per mechanical code formulas
  – Not per hood manufacturer’s UL values
Discussion Summary

• Utilize exhaust only hoods
  – **Small installations** (HVAC System can handle the load, or
  – **Large installations** - Facilities such as supermarkets where the make-up air required for the kitchen ventilation system is insignificant compared to the overall building load, and the building HVAC system can handle.
• Utilize front face supply hoods
  – **Medium to large installations**, such as full service kitchens and dinner houses.
  – **Good room balance.** Exhaust and supply operate together.
  – **Tempered make-up air** - Recognize that the supply air requires heating and/or cooling in most climates (typically 55 - 85 deg. F.) This will yield good performance, good worker comfort, good HVAC balance…*but at a price.*
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