SIDE BY SIDE EVALUATION OF HIGH PERFORMANCE FUME HOODS

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Presented by:
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Learning Objectives

• Understand Project Purpose
• Definition of High Performance Fume Hood
• Fume Hood Energy Performance
• Understand Fume Hood Testing Methodologies
• Compare Hood Containment Performance under different operating conditions
• Identify additional Fume Hood Performance Challenges
• Life Cycle Cost Comparisons
Campus Background

- **UT Campus Info**
  - 16 Colleges
  - 50,000 students (39,000 undergrad)
  - 350-acre campus, 16 Million SF
  - Research: More than 3,500 projects, annual funding > $400 million.

- **Fume Hood Users**
  - College of Natural Sciences
  - College of Engineering
  - School of Geosciences
  - College of Pharmacy
Program conducted to determine optimal fume hood design standard for use in the new Experimental Sciences Building.

ESB designed to Labs21 performance guidelines for energy efficiency and sustainability.

Over 100 new fume hoods planned.

Expand program to campus retrofit analysis.
UT Campus Energy Master Plan

• DSEMC Annual Savings Targets
  – Lighting – 75M kWh
  – Steam – 26M Lbs
  – Water – 60M gal

• Campus Utilities
  – 100% Self-generating
  – 120 MW electrical capacity
  – 40,800 Tons chilled water capacity
  – 1,150,000 PPH steam capacity
  – Largest university CHP plant in the nation
• High Performance Fume Hood
  – A fume hood designed for superior fume capture performance with face velocities of 60 FPM or less with a fully open sash
• Why High Performance?
  – Labs are often the most demanding energy users of any facility on a University campus
  – Size and quantity of hoods can dictate total lab air volume requirements
  – Energy savings (w/o sacrificing safety!)
    • One of Labs21 “Five Big Hits”
  – Face Velocity ≠ Safety (ANSI Z9.5-2003)
Over 1,000 fume hoods on campus
- Campus standard - 100 FPM face velocity
- Majority of UT hoods are constant volume
- Hood Energy Savings (Standard vs. HP)
  - Exhaust & Supply Fan Energy
  - Makeup Air
  - Reheat
- UT Austin energy cost = $4.60/Hood CFM
- 5 foot hood, 625 CFM (std) vs. 500 CFM (HP)
- $575 Annual Savings/Hood, >$500K Annually
Hood Evaluation Process

- Matrix – 8 manufacturers offering “HP” hoods
- Selection of Hoods (UT criteria)
  - Face Velocity
  - Overall Depth
  - Static Pressure
  - Available Sizes
  - Maintenance
- Three HP Hoods Tested
  - Hoods A, B, C (60 FPM)
  - Standard Hood (100 FPM)
- Evaluate Safety, then Energy
- Testing Facility – J.J. Pickle Research Campus
  - Center for Energy & Environmental Research
- Testing Firm - ENV Services, San Antonio
Evaluation Methodology

- Safety Testing
  - Test static and dynamic containment performance using Owner-developed testing methods adapted from similar established testing procedures used previously at University of Wisconsin at Madison and Lawrence Berkeley National Laboratory.
    - ASHRAE 110 (standard)
    - ASHRAE 110 (modified)
    - Human as Mannequin (LBL-inspired)
  
- Provide data to allow objective evaluation by EHS staff
Evaluation Methodology

- ASHRAE 110-Standard (As Installed- 4.0AI0.10)
  - Face Velocity Measurement (12 readings)
  - Local smoke test
  - Large volume smoke test
  - Tracer gas containment
    - 4 LPM SF6
    - Empty hood
    - Full open sash
    - Sash Movement Effect (SME)
    - 67” mannequin height (breathing zone 26” above work surface)
Evaluation Methodology

- ASHRAE 110-Modified (As Installed- 8.0AI0.10)
  - 8 LPM SF6 (2X ASHRAE 110)
  - 18” and 26” mannequin breathing zone heights (above work surface)
  - 30 & 75 FPM Cross Drafts
- Sash Movement Effect
  - 18” & 26” heights
  - 30 & 75 FPM cross drafts
- Space Pressure Effect
  - 18” & 26” heights
  - 30 & 75 FPM cross drafts
Evaluation Methodology

• Human as Mannequin (HAM) (4.0A10.10)
  – 4 LPM SF6
  – Wide open sash
  – 3 ejector positions (right, center, left)
  – Breathing zone tracer gas detector on tester
  – Apparatus in hood
  – Choreographed movements
    • Hand insertion and removal
    • Move objects front to back
    • Move objects right to left
    • Remove object from hood
Containment Performance

- Standard ASHRAE test (3 ejector positions)
- Modified ASHRAE test (3 ejector positions)
  - 30 FPM Cross Draft – 18” & 26” heights
  - 75 FPM Cross Draft – 18” & 26” heights
  - SME: 30 FPM Cross Draft – 18” height
  - SPE: 30 FPM Cross Draft – 18” height
- HAM (3 ejector positions)
  - Hand Insertion
  - Front to Back
  - Right to Left
  - Water Pour
  - Remove Object

* Focus on containment excursions > 0.10 PPM, in keeping with ANSI Z9.5 for As Installed (AI) condition, for comparison purposes

** All tests conducted with fully open sash, to set standard for “sash abuse”
• ASHRAE test simulates idealized conditions
• All smoke visualization tests passed
Modified – 30 FPM CD, 18” MH

Diagram showing PPM levels over time (t) for Left Ejector, Center Ejector, and Right Ejector with different hoods: HOOD A, HOOD B, HOOD C, and STD HOOD. The y-axis represents PPM levels, and the x-axis represents time in seconds (t). A line at 0.10 PPM is also shown for reference.
Modified - 30 FPM CD, 26” MH

Graph showing PPM levels over time for different hoods and ejectors.
Modified – 75 FPM CD, 18” MH

- LEFT EJECTOR
- CENTER EJECTOR
- RIGHT EJECTOR

PPM vs. t (sec)

- 0.10 PPM

Hoods: A, B, C, STD HOOD
Modified – 75 FPM CD, 26” MH

Graph showing concentration over time for LEFT EJECTOR, CENTER EJECTOR, and RIGHT EJECTOR for HOOD A (green), HOOD B (red), HOOD C (blue), and STD HOOD (orange). The graph includes a 0.10 PPM threshold line.
Modified – SME, 30 FPM CD, 18” MH

Graph showing PPM levels over time for different hood configurations (Hood A, Hood B, Hood C, and STD HOOD) with sash open and sash closed at various intervals.
HAM Test – Move Side to Side
## Safety Performance Summary

<table>
<thead>
<tr>
<th>TEST</th>
<th>CONDITION</th>
<th>CROSS DRAFT, FPM</th>
<th>MANNEQUIN HEIGHT, IN</th>
<th>HOOD A</th>
<th>HOOD B</th>
<th>HOOD C</th>
<th>HOOD D</th>
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</table>

| OVERALL AVERAGE | 0.11 | 0.71 | 0.61 | 0.36 |
| AS INSTALLED AVERAGE | 0.03 | 0.21 | 0.14 | 0.23 |
| MAXIMUM RECORDED PPM | 0.99 | 3.93 | 3.92 | 1.67 |

- Ai test containment, red values exceeded Al 0.10
Safety Performance Conclusions

• Conclusions from safety testing:
  – Cross drafts challenge hood containment, must be dealt with in design (*architects and engineers must work together to mitigate!*)
  – 18” breathing zone height proved more challenging for containment performance
  – Standard ASHRAE test may not predict performance in actual operating conditions
  – Not all high performance hoods are equal!
  – Newer hoods performed better than “standard” 100 FPM hood
Other Considerations

• Understand advertised face velocity
• Differences between manufacturers:
  – Dimensions
  – Static Pressure Requirements
  – Containment Strategies
• Building System Infrastructure (fan capacity)
• Controls (VAV vs. CV)
• Trade-off between hood density and system capacity
• Is a fume hood required?
• Consider lab air change rates!
Life Cycle Cost Performance

- LCCA for prototype lab between 3 options:
  - Standard CV, 100 FPM (18” sash)
  - High Performance CV, 80 FPM (18” sash)
  - VAV (50% sash open, 50% sash closed)

- Inputs:
  - 15 year term
  - $0.077/kWh
  - $0.89/Therm - CHW
  - $0.91/Therm - Natural Gas
  - 6% discount rate, 3% escalation

- BLCC5 program, NIST Office of Applied Economics (http://www1.eere.energy.gov/femp)
Life Cycle Cost Performance

- STD HOOD
- HP HOOD
- VAV HOOD

- CAPITAL COST
- O&M
- ENERGY
Conclusions

• Safety
  – High performance fume hoods can operate safely
  – Face velocity is not an indicator of safety
  – Cross drafts can compromise hood performance
  – Not all hoods are equal
Conclusions

**Energy**
- High performance hoods offer energy savings over standard hoods
- Well suited for retrofit/replacement projects
- High performance hoods yield best LCC performance
- Lab ACH drives energy cost more than hood CFM
QUESTIONS?

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