Taming the Hoods

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Energy Efficiency Working Group
Energy 2006
August 2006

Labs21 Five BIG HITS

1. Tame the hoods
2. Scrutinize the air changes
3. Drop the pressure drop
4. Get real with plug loads
5. Just say no to re-heat

Fume Hoods—Critical But Costly

Critical Equipment

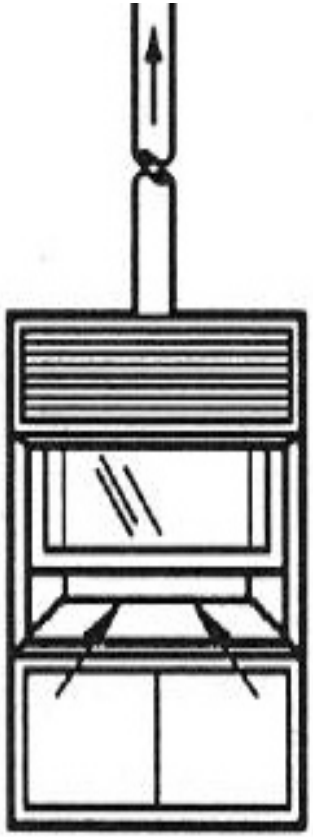
…Protect operators from harmful fumes

High Operating Cost

- *Large exhaust flows*
- *High energy cost for make-up and exhaust air*
  - *…Filtration*
  - *…Circulation*
  - *…Heating/cooling*
  - *…Scrubbing*

Typical 6-foot hood
1200 cfm air flow

Standard Fume Hood Designs

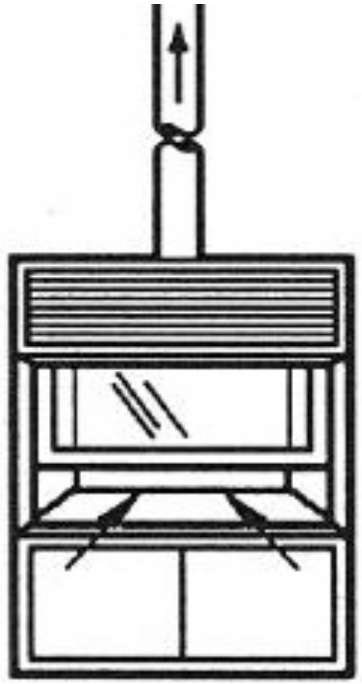


- Exhaust system induces airflow through hood.
- Airflow through hood's open sash is ~100 FPM
- Supply air must "make up" combined hood exhaust
- Consequently, large air volumes are conditioned and expelled from laboratories 24/7

High Air Flow Impacts Other Systems

Typical labs
4–5 times more energy intensive
than typical commercial space

Fume Hood Energy Consumption



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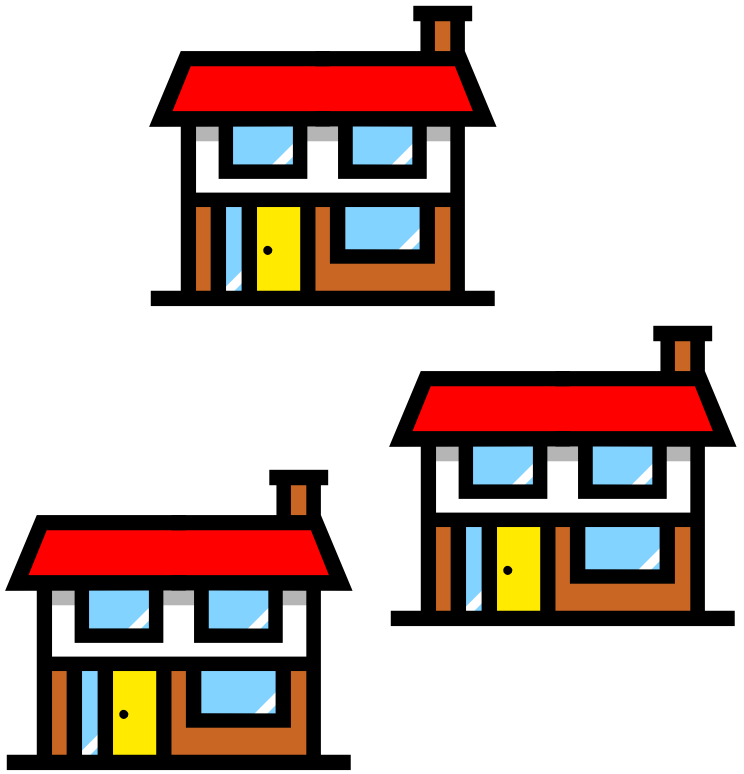
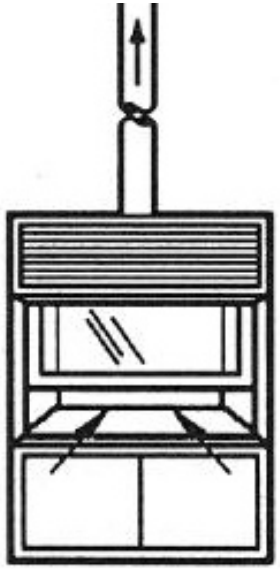


Standard Hood Airflow Modeling

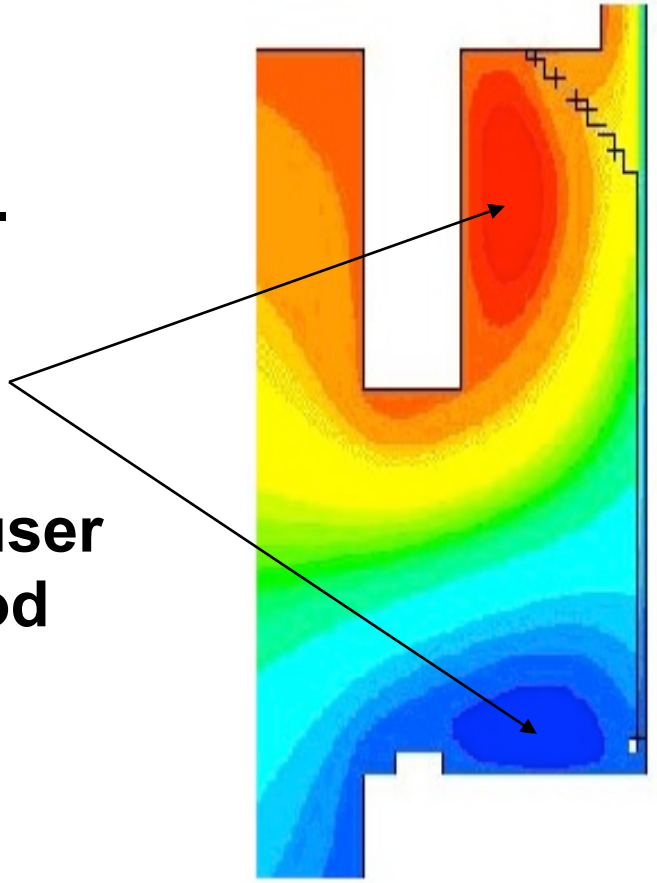


Two-dimensional airflow visualization with Computational Fluid Dynamic (CFD) models.

Note two zones of re-circulation…

Idealized flow shown; user standing in front of hood increases turbulence.

Higher air flow ≠ better containment



Fume hood efficiency technologies

1. Reduce number and size of hoods
2. Restrict sash opening
3. Auxiliary air hoods
4. Two “speed” occupied and un-occupied
5. Variable air volume (VAV)
6. High performance hoods

1. Reduce the number and size of hoods

- **Size distribution for ample capacity**
- **Install only hoods needed immediately**
- **Provide tees, valves, and pressure controls for easy additions/subtractions**
- **Encourage removal of underutilized hoods**
- **Consider hoods as a shared resource**

Is this hood intensity necessary?

2. Restrict sash openings

Sash stops

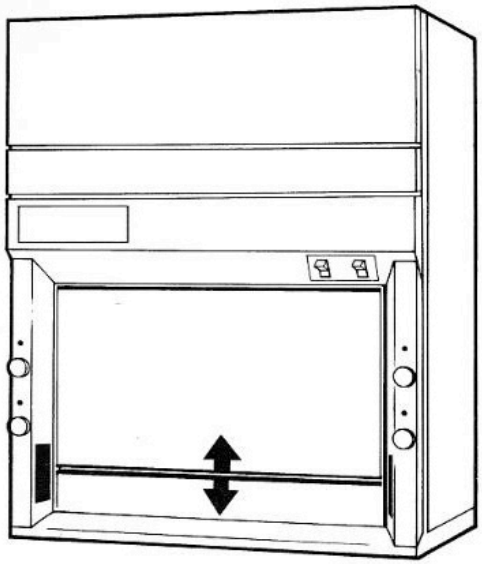


Figure 9. Hood with vertical-rising sash

Horizontal sashes

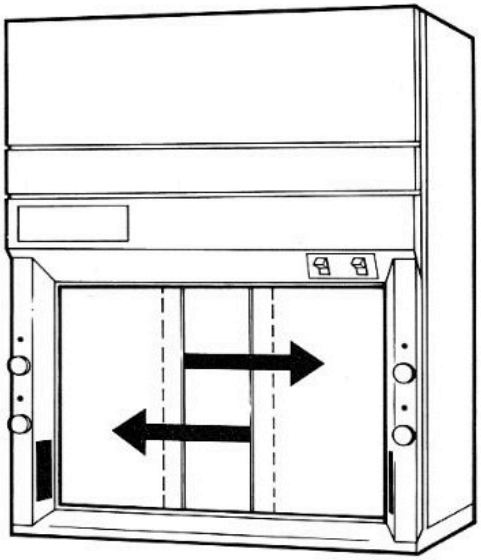


Figure 10. Hood with horizontal-sliding sashes

Combination

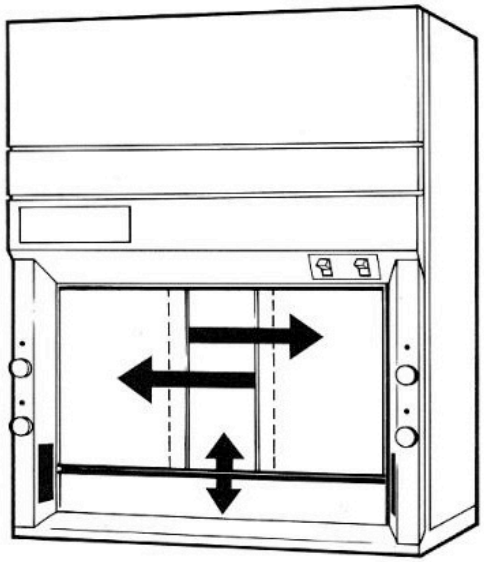


Figure 11. Hood with combination "A-style" sash

2. Restrict sash openings

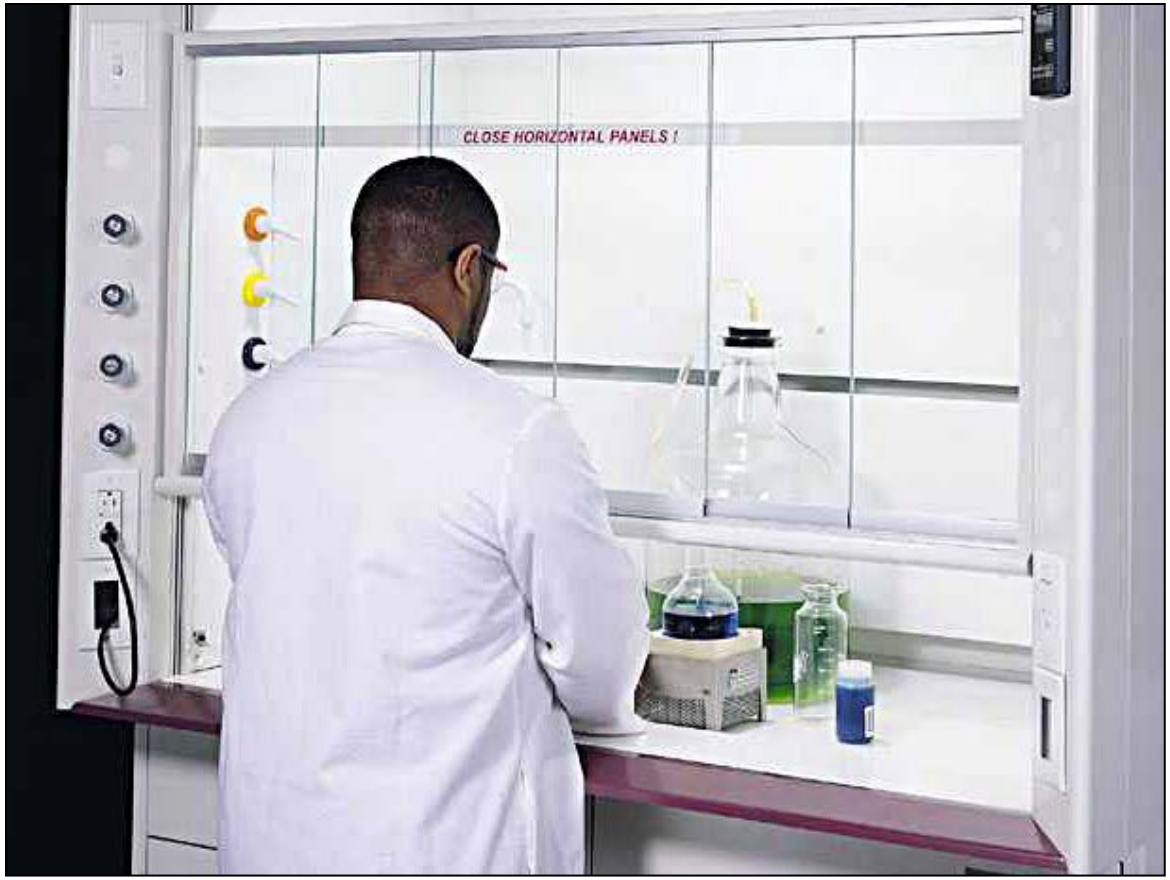
- **Vertical Sash Opening**
  - **Most common sash**
  - **Good horizontal access**
  - **Energy use reduced with sash stop**

Vertical Sash Stop

2. Restrict sash openings

- **Horizontal Sash**
  - **Can be more energy efficient due to reduce airflow volume**
  - **May increase worker safety**
  - **Caution – sash panels can be removed; defeats safety**

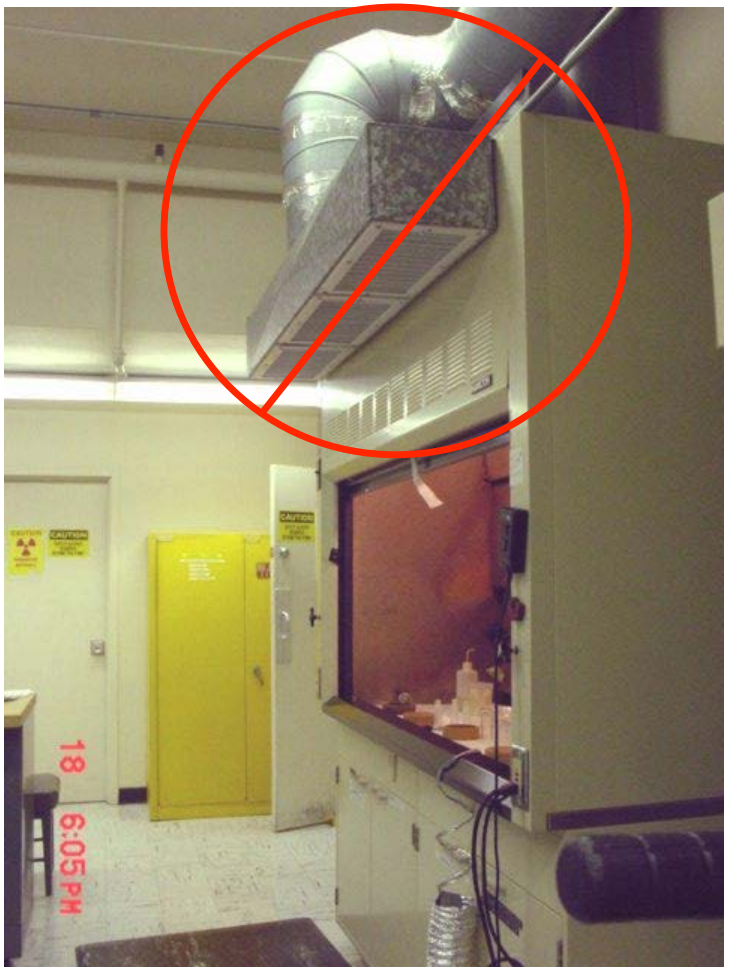
2. Restrict sash openings



Telescoping sash arrangement by:

3. Auxiliary air hoods

- **Auxiliary Air Hood**
  - Wastes energy
  - Reduces containment performance
  - Decreases worker comfort
  - Disrupts lab temperature and humidity
  - **Not Recommended**



4. Two "speed" occupied/un-occupied

Zone Occupancy Sensor

Sash Sensor/Monitor

5. Variable air volume (VAV)

VAV:

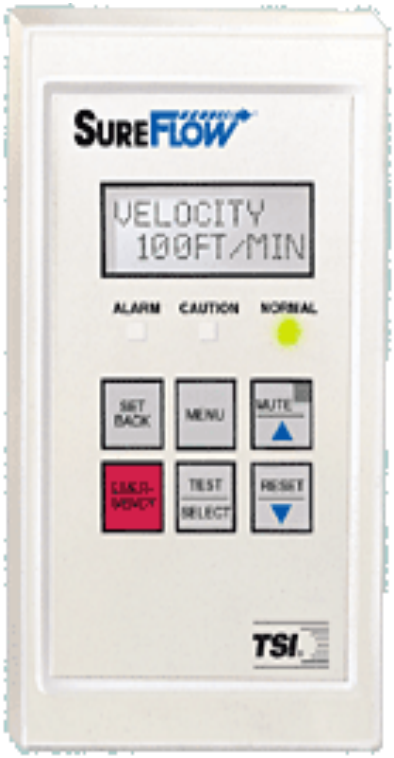
…Combination of sophisticated monitoring sensors and controls

How Do They Operate?

…Communicate between hood and supply/exhaust systems

…Modulate supply/exhaust systems

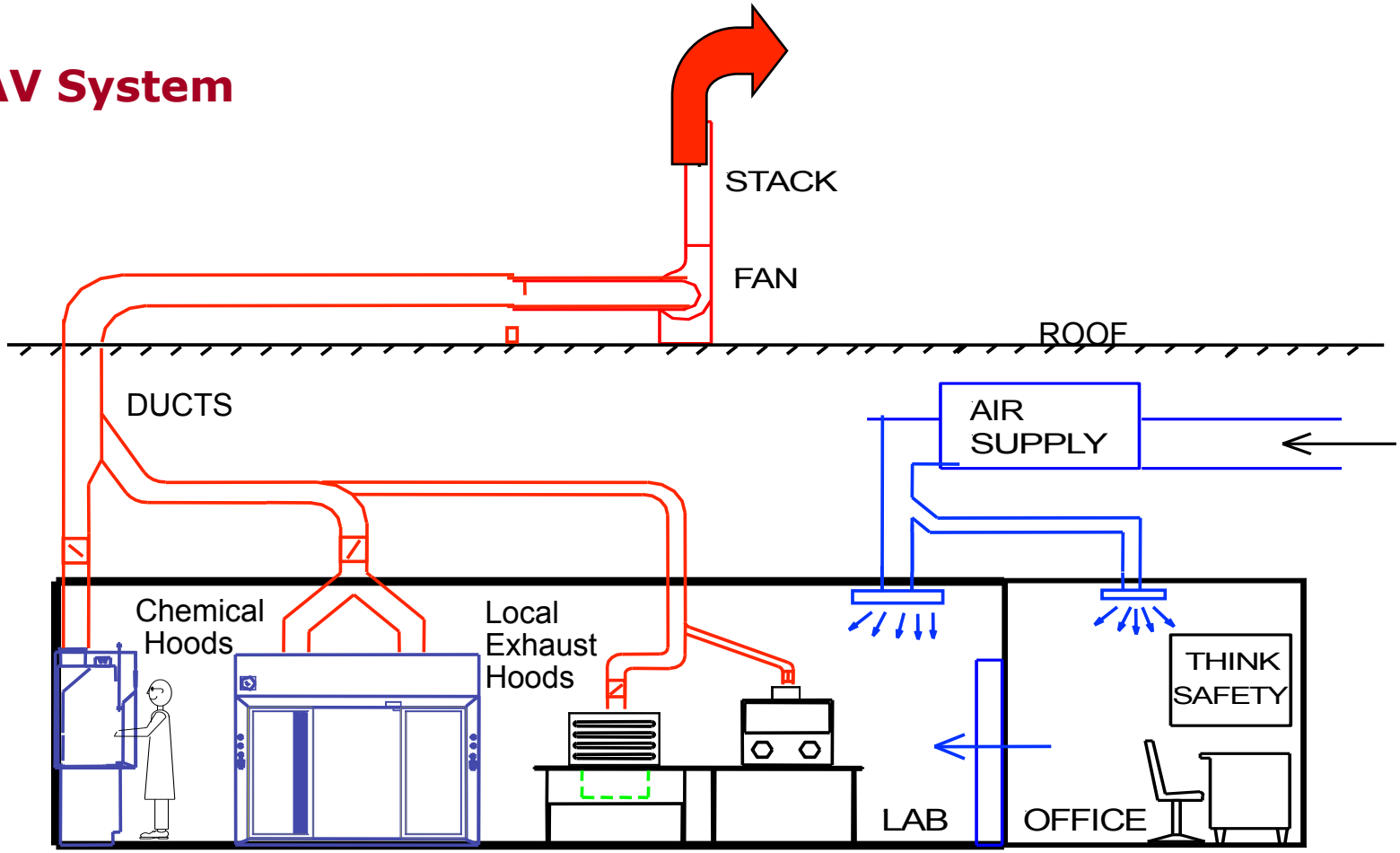
…Maintain constant face velocity and room pressure relationships



TSI Controller

5. Variable air volume (VAV)

VAV System



VAV Drawbacks

Key Requirement

Diligent users must close sash to reduce air flow

Energy Savings

Reduced fan speed with closed sash

Typical Worst Case Sizing

Assume all sashes open 100%

Result

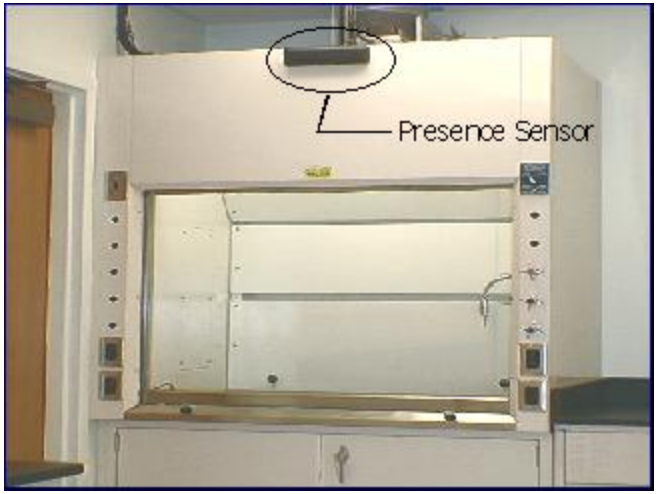
Oversized fans and central plants

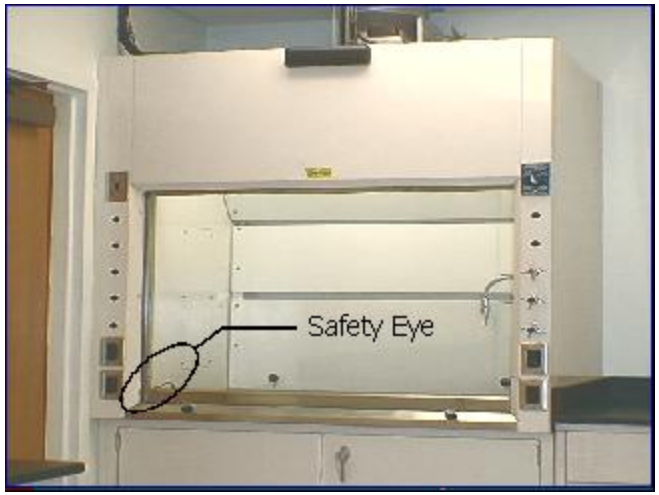
5. VAV sash management

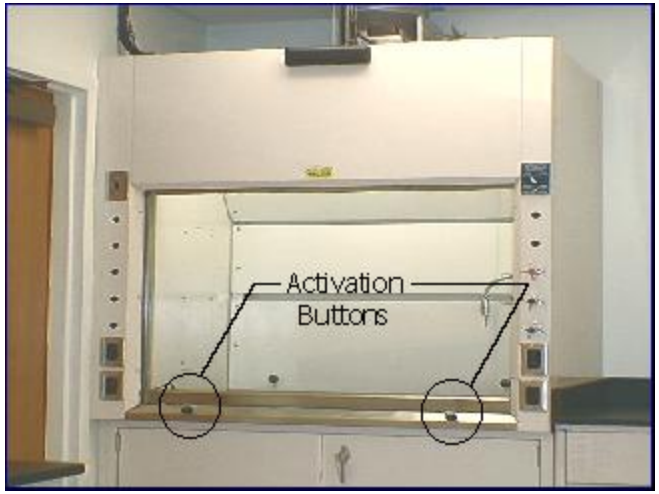
- Training and education
- The stick
- The carrot
- Demand responsive sash management
- Automated sash management
  - occupied and unoccupied set points (reset velocity set point)
  - Auto sash closure system

5. VAV sash management

- **New-Tech Automatic Sash Positioning System**







Different Approaches to Maximizing Effective Containment

- **Does the Low Flow / Low Velocity Hood provide:**
  - **Energy-efficient operation?**
  - **Equivalent or Better Containment at Reduced Face Velocities and Flow Volumes?**
  - **Improved performance for all users, even under misuse conditions?**
  - **More Robust and Less Susceptible to External Factors?**
  - **Better Monitoring and Flow Control?**

If so… = High Performance Hood

6. High Performance Hoods

- Improved Performance Through Better Design…
  - Aerodynamic Entry
  - Directed Air Supply
  - Perforated or Slotted Rear Baffle
  - Airfoil Sill and Sash Handle
  - Integrated Monitors
  - Interior Dimensions
- First Generation: 20 to 40% savings
- Second Generation: 40 to 75% savings

6. High Performance Hoods

- **Current fabricators…**
  - **Lab Crafters**
  - **Labconco**
  - **Fisher Hamilton**
  - **Kewaunee Scientific**
  - **Laboratory Equipment Manufacturers**
  - **Esco Global**
  - **Others**

6. High Performance Hoods

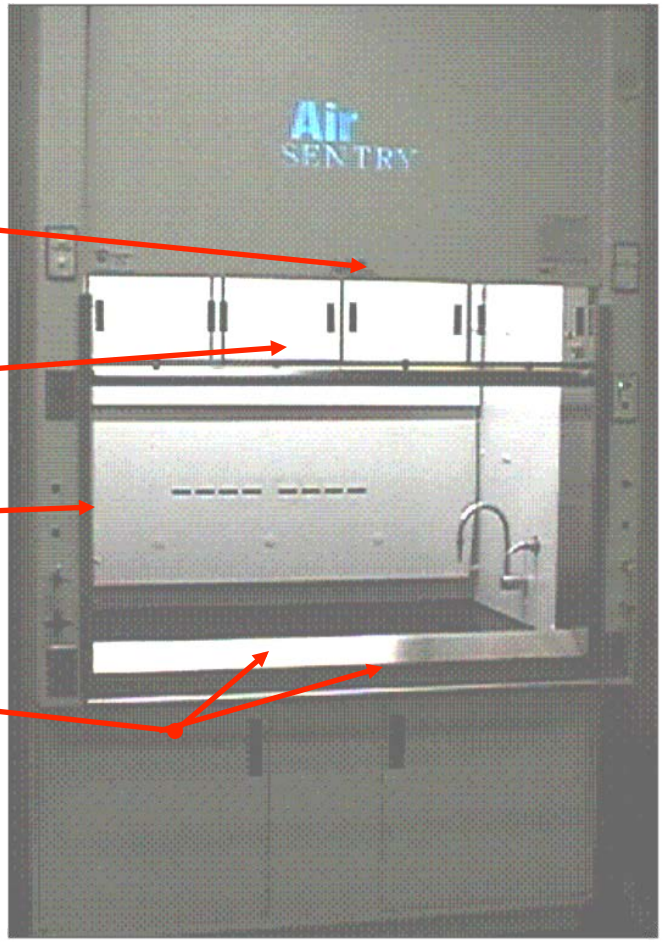
Lab Crafters Air Sentry HPFH

Upper chamber Turning Vane

Aerodynamic Sash Frame

Side Post Airfoils

Multi-Slot Front Airfoil



6. High Performance Hoods

Labconco XStream Hood

Modified Aerodynamic Sash Pull

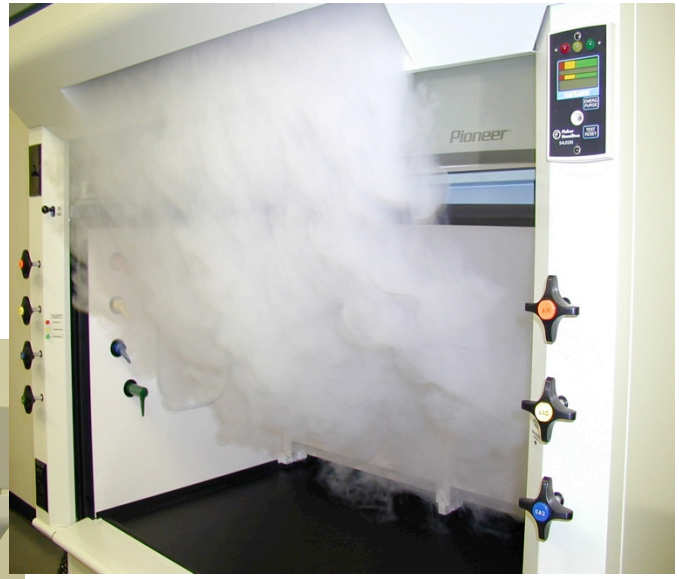
Modified Baffle and Slots

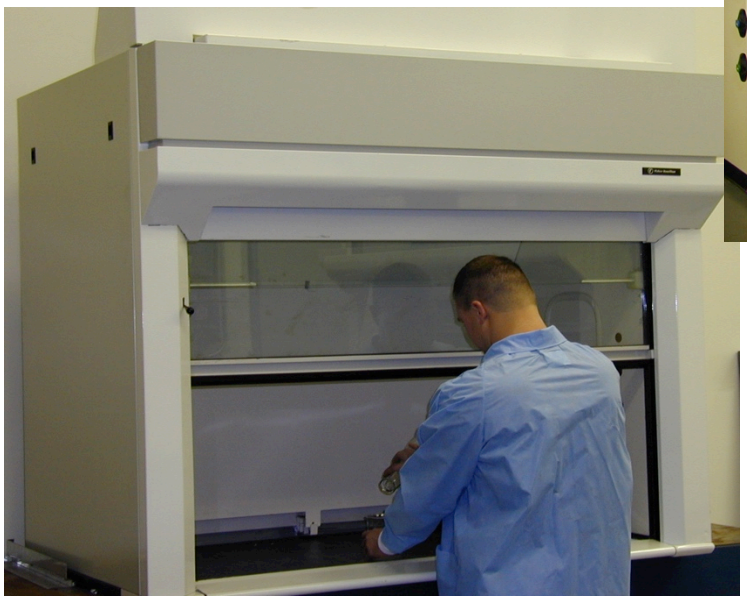
Aerodynamic Airfoil

6. High Performance Hoods

Fisher Hamilton PIONEER

- Automatic sash closer
- Directed supply flow @ full open sash
- Flush Airfoil Sill





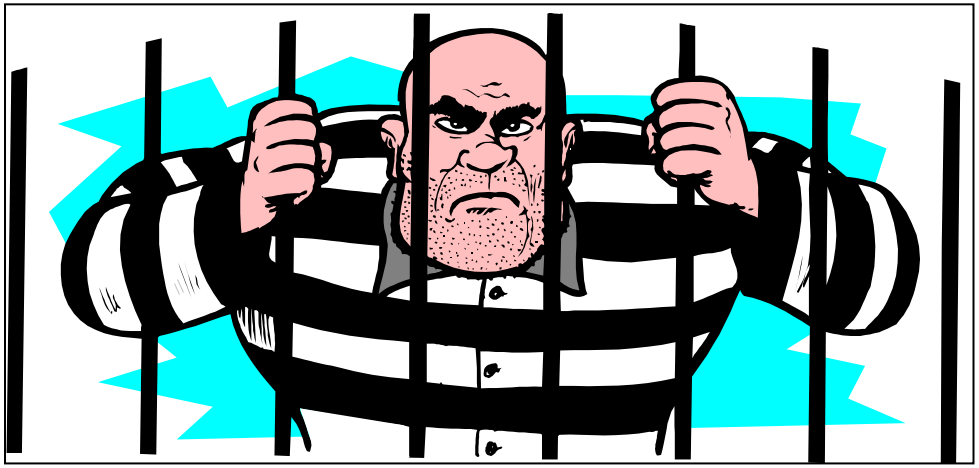
6. High Performance Hoods

Berkeley Hood by LBNL

- Push/Pull Air Divider Technique
- Perimeter Air Supply
- Perforated Rear Baffle
- Slot Exhaust & Optimized Upper Chamber
- Designed to minimize escape by reducing reverse flow
- Reduces air flow 50-75%

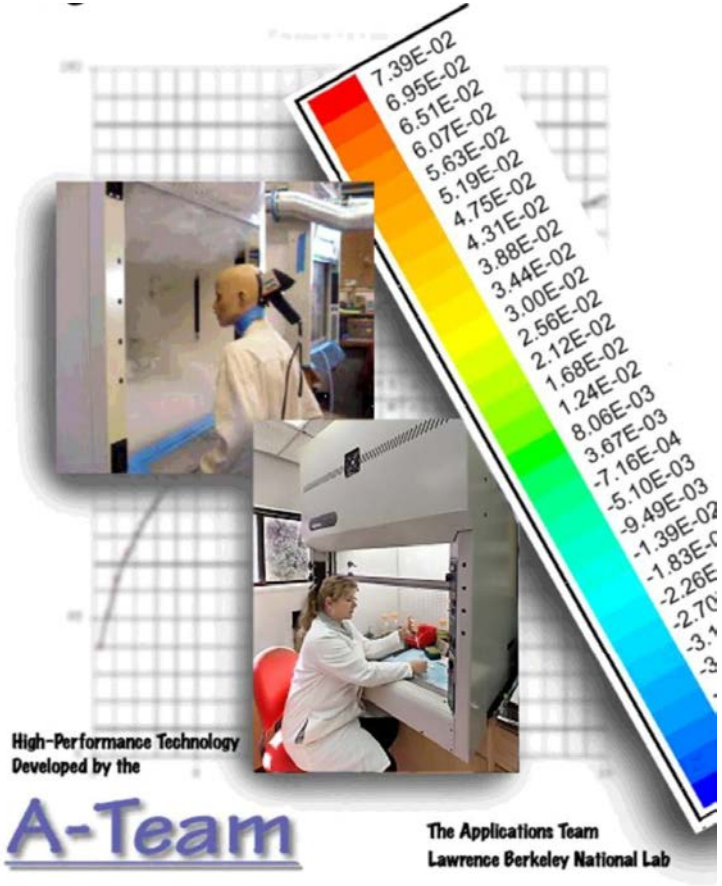
6. High Performance Hoods

What Makes These Fume Hoods Superior to the Manufacturer's Standard Product Offerings?



CONTAINMENT &
EFFICIENCY !

A Revolutionary New Technology



Context of the Berkeley Hood

Part of LBNL's High-Tech Buildings Initiative
… Headed by The Applications Team

- ***Industry Issues/Planning***
  …Roadmaps for Labs, Cleanrooms, and Datacenters of the Future
- ***Technology***
  …Fume Hood Containment
- ***Design Tools***
  …Design Guides, Airflow Design, Design Intent Tool
- ***Information Technologies***
  … Energy-Performance Benchmarking

Objective

Reduce fume hood air flow requirements at least 50% while improving user safety

Supporters

LBNL supported by the following organizations:

California Energy Commission

U.S. Department of Energy

Montana State University

Pacific Gas & Electric Company

San Diego Gas and Electric

California Institute for Energy Efficiency

Partners

Esco Global (licensee)

University of California, San Francisco

San Diego State University

Labconco

Fisher-Hamilton

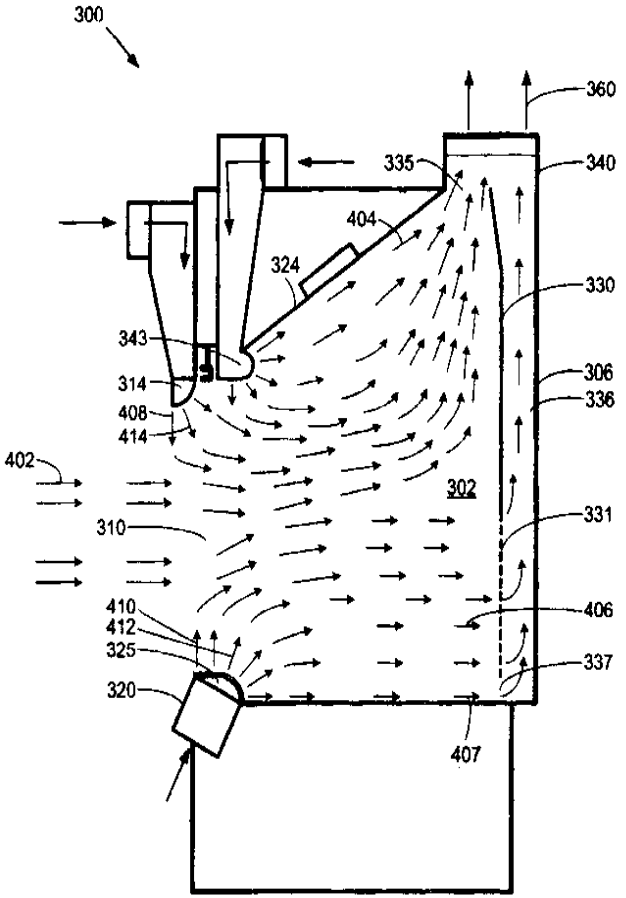
Siemens Controls

Tek-Air

The Invention

"Push-Pull" Design

- Small fans at top and bottom
- Low-turbulence intensity
- Displacement ventilation
- Creates an air divider separating hood interior from exterior
- Push-pull improves containment

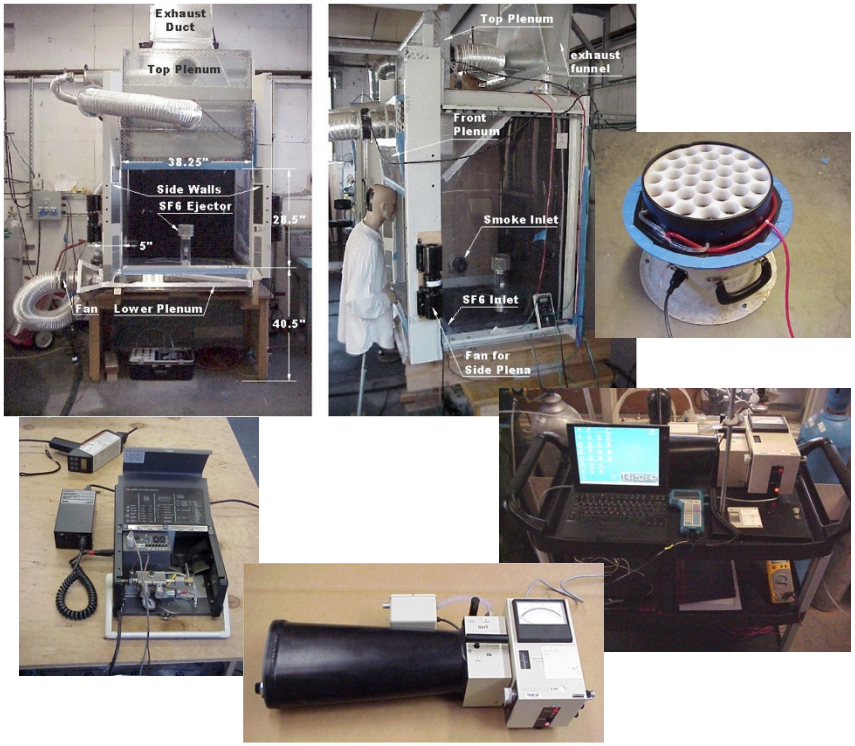


U.S. Patents # 6,089,970, # 6,428,408

Benefits

- Reduces air flow requirements 50–70%
- Enhances worker safety
- Simpler design than VAV systems
  …Easier and less-expensive installations
- Constant volume operation
  …Energy savings not dependant on operator
- Clean air flows into operator's breathing zone
  …Reduces potential hazards
- Airflow patterns reduce eddies and vortices
  …Improving containment

Extensive Testing



- ✓ ASHRAE 110-1995 tracer gas containment
- ✓ Large and small volume smoke
- ✓ Sash-movement effect tests
- ✓ Dry Ice tests
- ✓ Different SF6 flow rates
- ✓ Various mannequin heights
- ✓ Cluttered hood interior
- ✓ Helium Bubbles
- ✓ Schlieren flow studies
- ✓ Envelope testing
- ✓ Expert evaluations
- ✓ New SF6 ejector designs
- ✓ Cross drafts

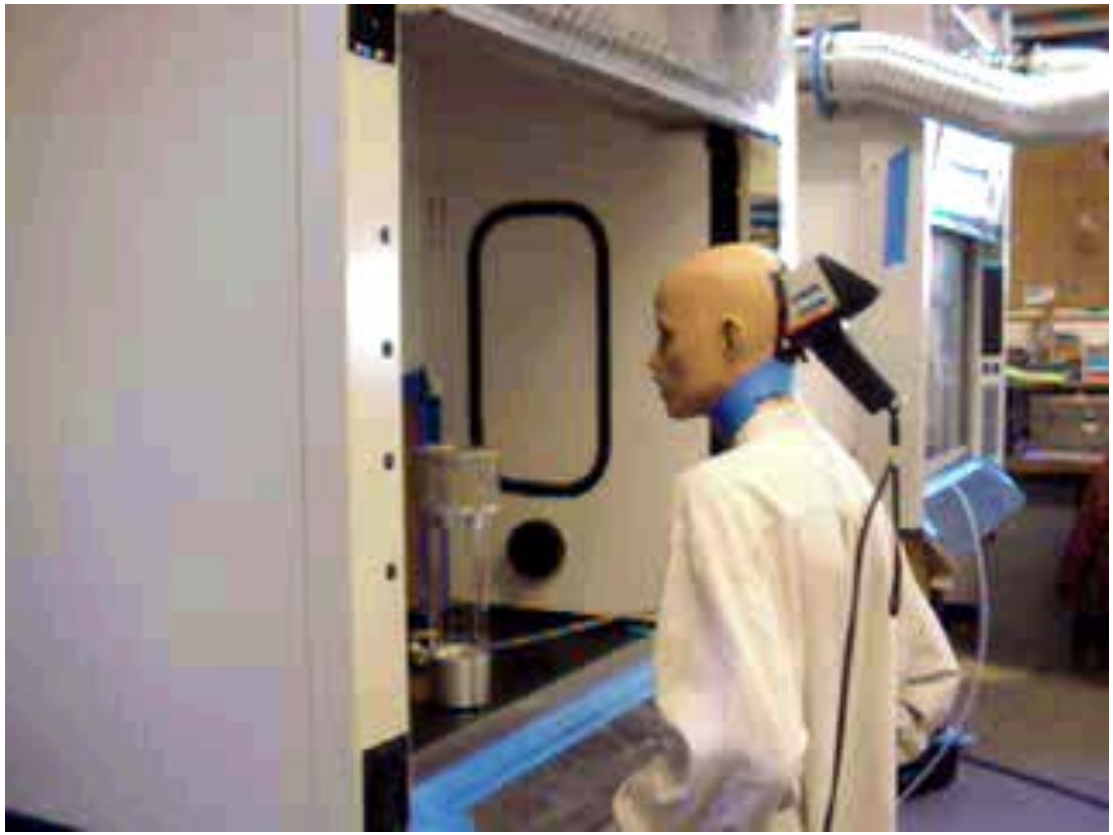
Laboratory Fume Hood Testing for Safety

Smoke in Supply Plenums…

Exhaust:
40% "normal" flow

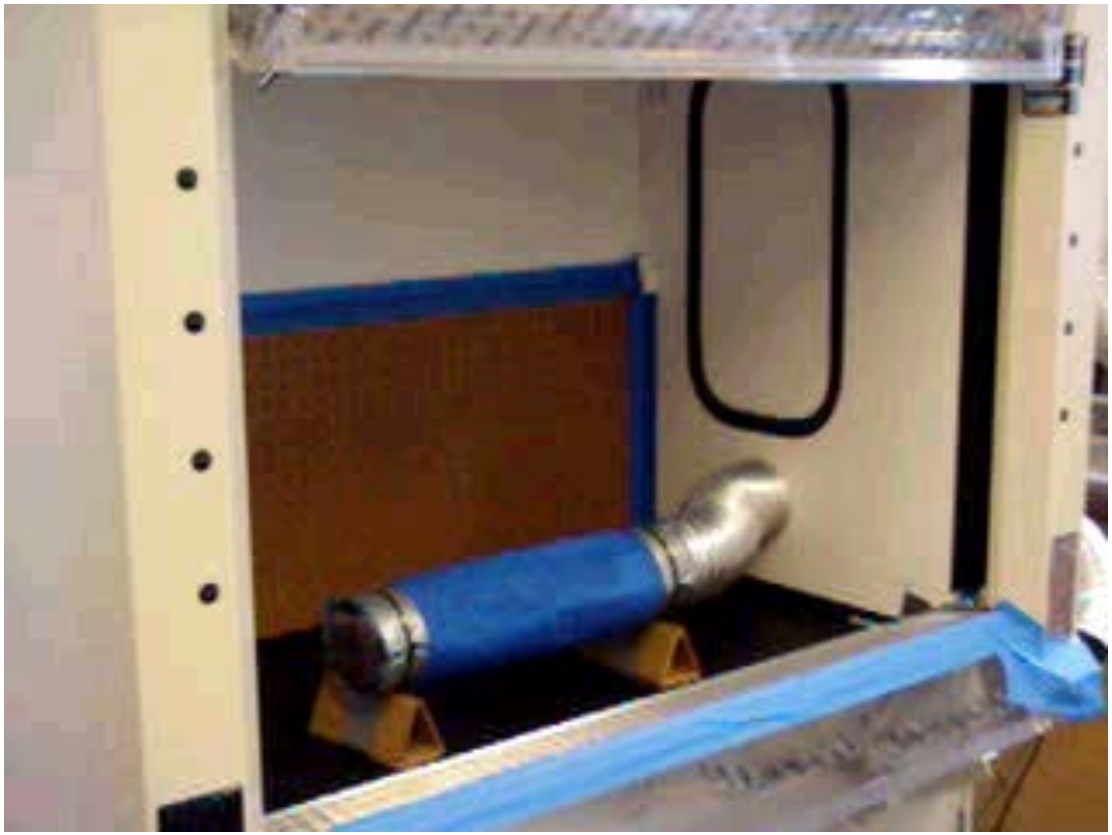
Ejector:
8L/min.

Breathing Zone:
18 inches



Laboratory Fume Hood Testing for Safety

Smoke containment...



Smoke visualization test at 30% “normal” flow

Montana State University

Fisher-Hamilton alpha prototype Berkeley Hood.

- **Adapted standard Fisher-Hamilton hood**
- **Installed Berkeley hood September 2000**
- **Passed standard ASHRAE 110 tests per ANSI Z9.5 recommendations**

University of California, San Francisco

Researcher working at Berkeley hood.

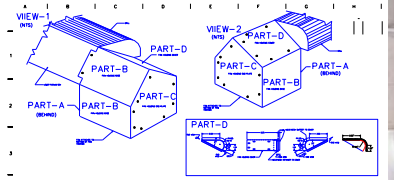
- **Adapted standard Labconco hood**
- **Installed Berkeley hood November 2000**
- **Passed standard ASHRAE 110 tests per ANSI Z9.5 recommendations**

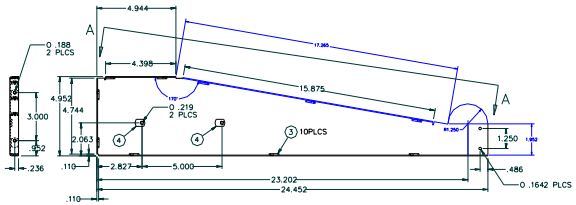
San Diego State University

Berkeley hood in testing and ready for shipping.

- Adapted standard Labconco hood
- Passed standard ASHRAE 110 tests per ANSI Z9.5 recommendations
- Performed advanced challenges including cross drafts
- Evaluated experimental tracer gas devices
- Three experts and inventor contributed

Prototype Work



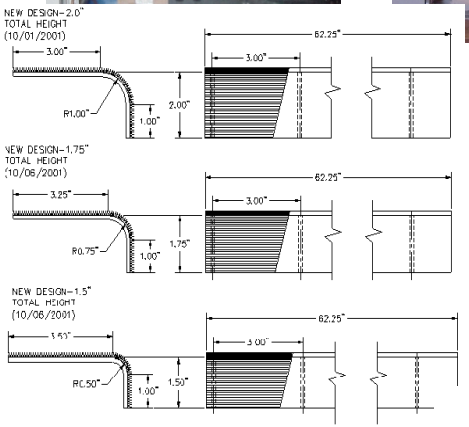


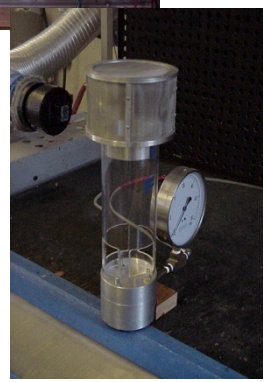
High Performance Fume Hood Status

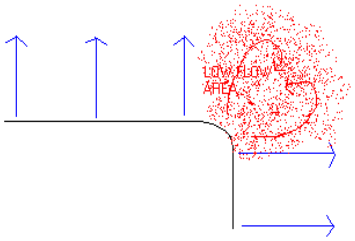
- Patents issued
- Field tests completed
- Scaled up to six foot
- Licensed to Esco Global

Next Steps

- Refine production models
- Overcome institutional barriers







Installation Options/Opportunities

New Construction

- **Specify in place of standard hood**
- **Cost premium expected, but can be offset with**
  …smaller fans and central plants
  …simpler controls

Retrofit

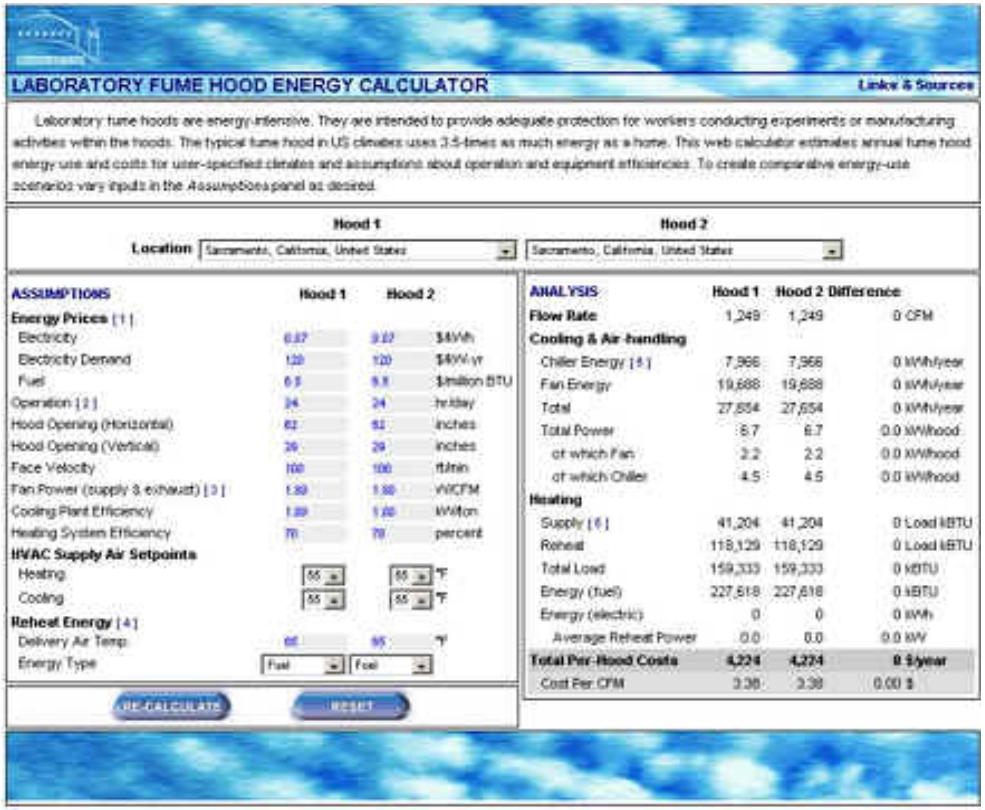
- **Replace existing hoods**
- **Labs "starved for air" can:**
  …Regain air flow capacity
  …Add new hoods
  …Improve exhaust performance

Good Fume Hood Design Practice

- **Choose an efficient device…**
  - VAV and high performance hoods provide additional benefits
- **Consider location and air management…**
  - Locate hood away from traffic flow
  - Flow clean air to dirty
  - Supply air temperature and air change rate can impact hood performance
  - Diffuser type and air "throw" impact hood performance
- **Require full ANSI/ASHRAE 110 testing as installed…**
  - Tracer gas containment
- **Fully commission fume hood systems and room pressure controls…**

Resource…

Fume Hood Energy Calculator:



Calculator web site:

http://fumehoodcalculator.lbl.gov/

The calculator can be used to test the energy and cost impacts of improving component efficiencies (e.g. fans or space conditioning equipment), modifying face velocities, and varying energy prices. Supply air set points can be varied, as can the type of reheat energy. Several hundred weather locations around the world are available. The calculator allows for an instantaneous comparison of two scenarios.

Design Considerations

Anticipate user interface…!

Design Considerations

Know the operating limitations!

Contact Information:

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