Labs21 Advanced Course Series

High-Performance Laboratory Exhaust Devices

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Goal: Select Advanced Exhaust Devices

Objectives: At the end of this session, you will be able to:

- **Identify different types of exhaust devices**
- **Describe the process to select appropriate devices for a given context**
- **Distinguish between standard, good and better practice in selecting devices and assuring their performance**

Outline

- Overview
- Design Considerations
- Device Review
- Selection Process
- Design Practice
- Performance Examples
- Conclusion

Overview

High-Performance System

- SAFE- Meets operating specifications and performance requirements.
- DEPENDABLE - Predictably performs to meet user demands
- EFFICIENT- Minimum energy use and lowest possible operating costs
- FLEXIBLE - Adaptable to changing research needs

Design Considerations

- **Primary Safety Device**
  - Intended to protect operator(s) health and welfare
  - Selected specifically for scientific procedures
- **HVAC System Interface**
  - Influences size and life-time performance of a laboratory's heating, ventilation and air conditioning (HVAC) system
  - Verify performance and proper installation during final test, balance, and commissioning
- **Airflow Requirements**
  - Ensure device containment performance prior to occupying laboratory, especially in "high fume-hood-concentration" labs
  - Verify adequate airflow for either internal load demand or air change rate

Design Considerations

Needs and Opportunities…

- **Improve Containment Capability**
- **Promote Safe Use and Ergonomics**
- **Reduce Required Flow / Energy Consumption**
- **Integrate Monitoring and Control for Dependable Operation**
- **Minimize Maintenance**

Design Considerations

- **Coping with hazardous pollutants**
  - Potential pollutants
  - Sources of pollutants
  - Spill scenarios; device application
  - User/operator skills and experience
  - Egress pathways; device location limitations
- **Meeting space-conditioning requirements**
  - Lab layout/arrangement and equipment
  - Supply diffuser type and placement
  - Return grill location and quantity
  - Differential pressure; airflow between rooms; isolation protection
  - Diversity: factor assessment
  - Hood exhaust flow versus general exhaust flow

Design Considerations

- **Codes**
  - UBC, UMC, IBC, IMC
  - CAL/OSHA 5154.1
- **Standards**
  - ANSI/AIHA Z9.5 - 2003
  - NFPA-45 – 2000
  - ACGIH - Industrial Ventilation – 24th Ed. - 2001
  - ASHRAE Laboratory Design Guide- 2001
  - OSHA - 29 CFR - Part 1910.1450
  - Scientific Equipment & Furniture Association, SEFA 1.2-2003

Design Considerations

Design Considerations

Know the operating limitations!

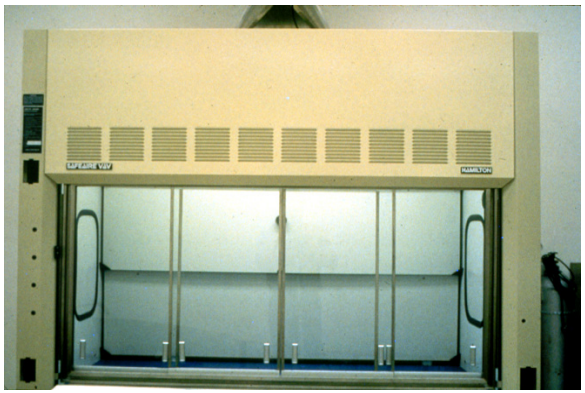
Device Review

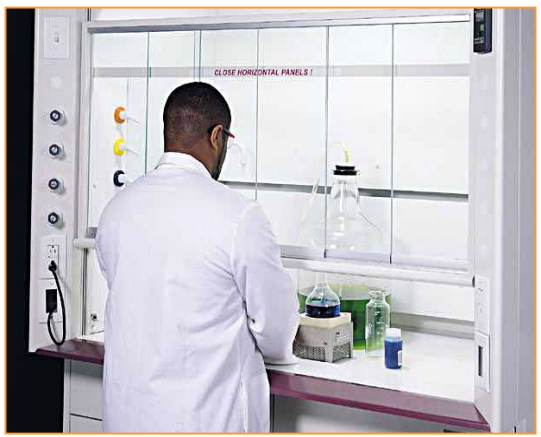
Types of Laboratory Exhaust Devices…

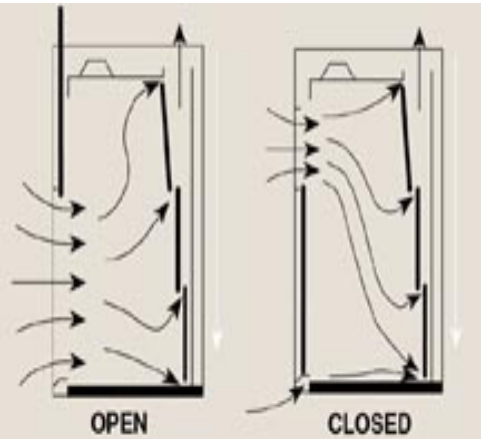
- **Chemical Fume Hoods**
  - Bench-Top, Distillation, Floor mounted (a.k.a. Walk-in), Scale-up
  - Radioactive, Perchloric, Auxiliary Air
  - High Performance, VAV, etc.
- **Biological Safety Cabinets**
  - Class I, Class II, Class III
  - Type A, Type B1, Type B2
- **Laminar Flow Fume Hoods**
- **Balance/Weighing Hoods**
- **Canopy Hoods**
- **Snorkel Exhausts**
- **Glove Boxes**
- **Microelectronic Hoods**
- **Ventilated Enclosures**

Device Review

- **Types of Laboratory Hoods**
  - Conventional Fume Hood
  - Constant Volume Bypass Fume Hood
  - Variable Air Volume Fume Hood
  - Restricted Opening Low-Flow Fume Hood
  - Low-Velocity Low-Flow (LV/LF) Fume Hood







Device Review

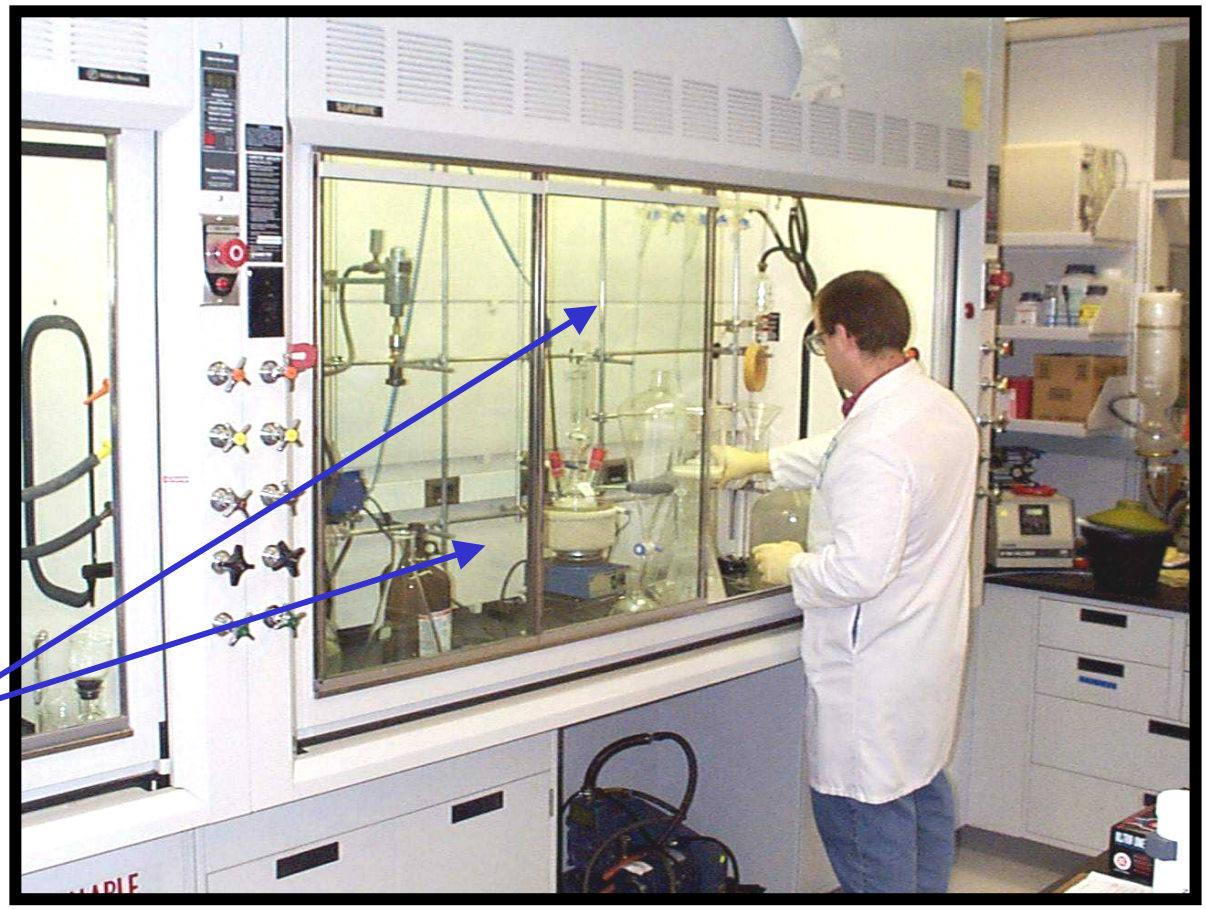
Vertical Sash Opening

- Most common sash
- Good horizontal access
- Best with sash stop

Device Review

Horizontal Sash Opening

- Can reduce airflow volume
- May increase worker safety
- Caution – sash panels can be removed; defeats safety



Device Review

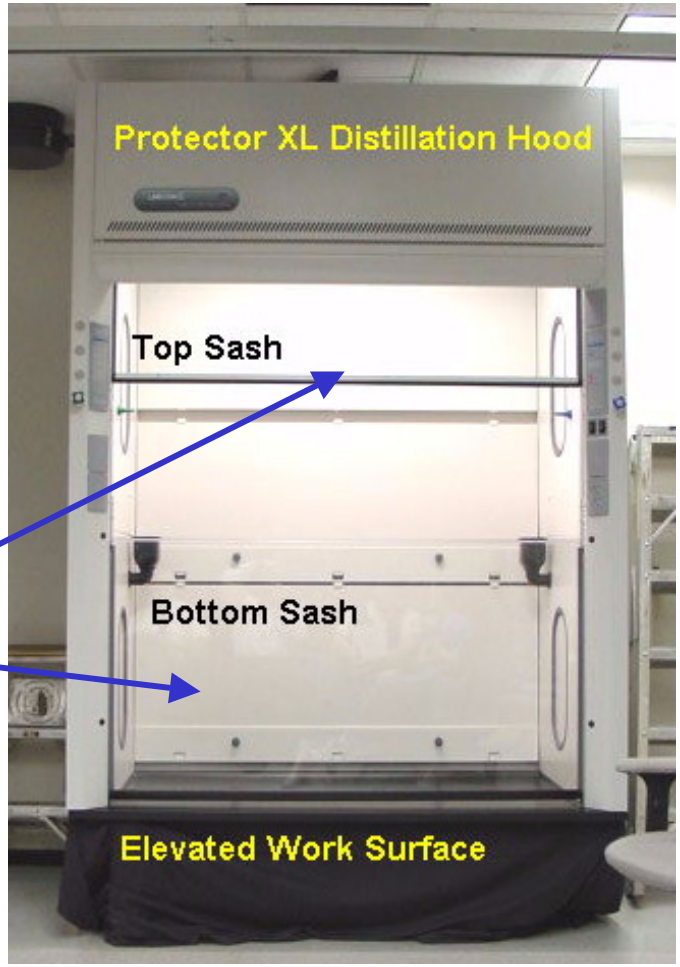
Auxiliary Air Hood…

- Not Recommended
- Reduces containment performance
- Decreases worker comfort
- Disrupts lab temperature and humidity

Device Review

Distillation Hood

- Specific use
- Convenient experiment setup
- Optimizes experiment observation



Dual Sash Panels

Device Review

Floor Mounted Hood (Walk-In Hood)

- –Specific use
- –Optimizes experiment observation
- –Limited containment performance

Device Review

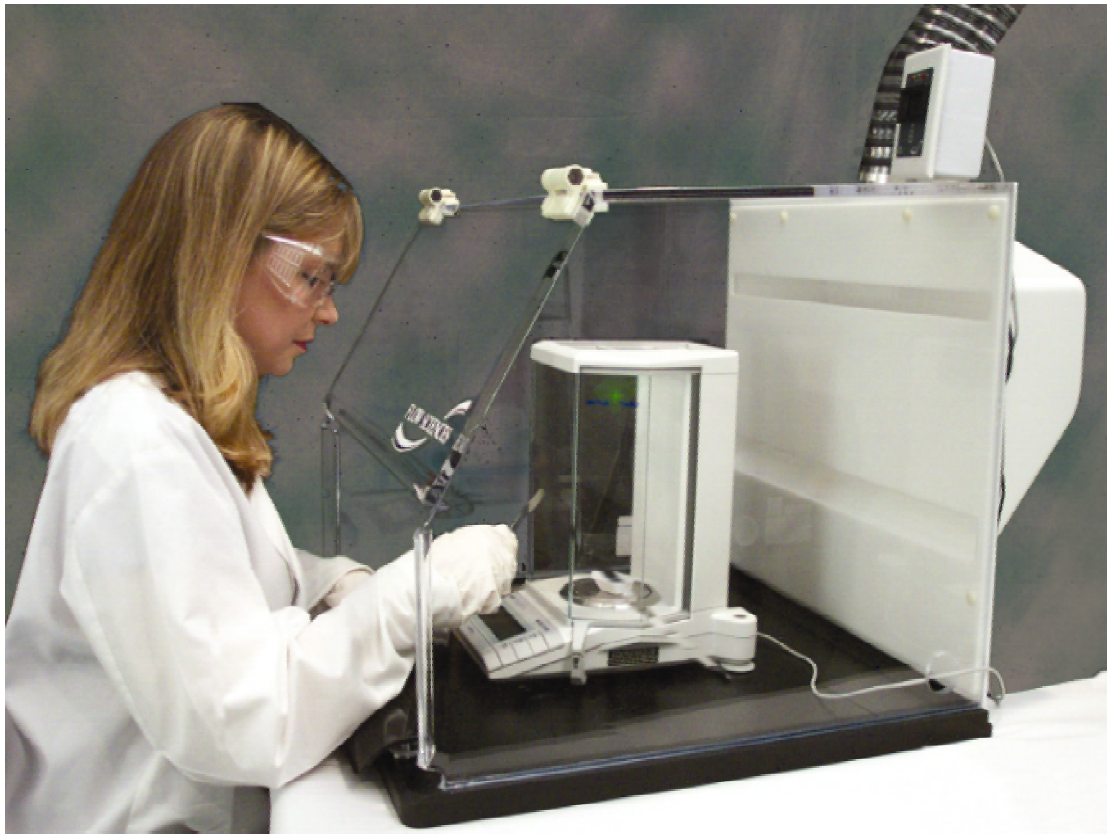
Ductless Fume Hood

- Particulate Use
- Limited for Gas & Vapors
- Not Recommended for Permanent Installation

Device Review

Weighing Enclosure – Balance Hood

- –Low-hazard use
- –Minimal airflow
- –Small footprint
- –Requires exhaust connection



Device Review

Large Canopy Hood

- Heat Removal
- Energy Hog

Device Review

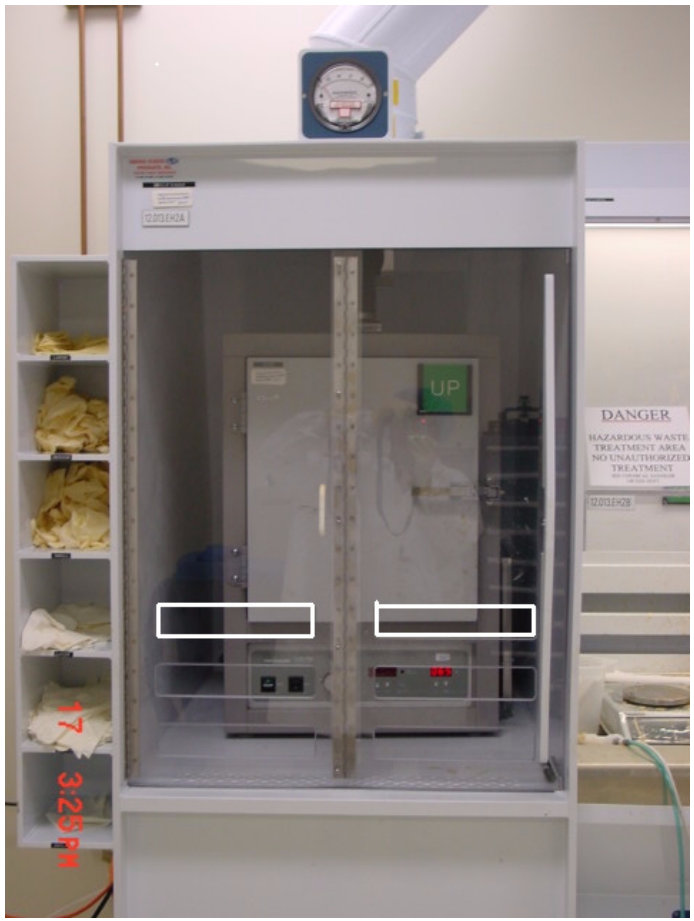
Exhaust Snorkel Hoods

- –Low-hazard application
- –Tasked device for vapors, e.g. soldering
- –Close damper when not in use

Device Review

Ventilated Enclosure

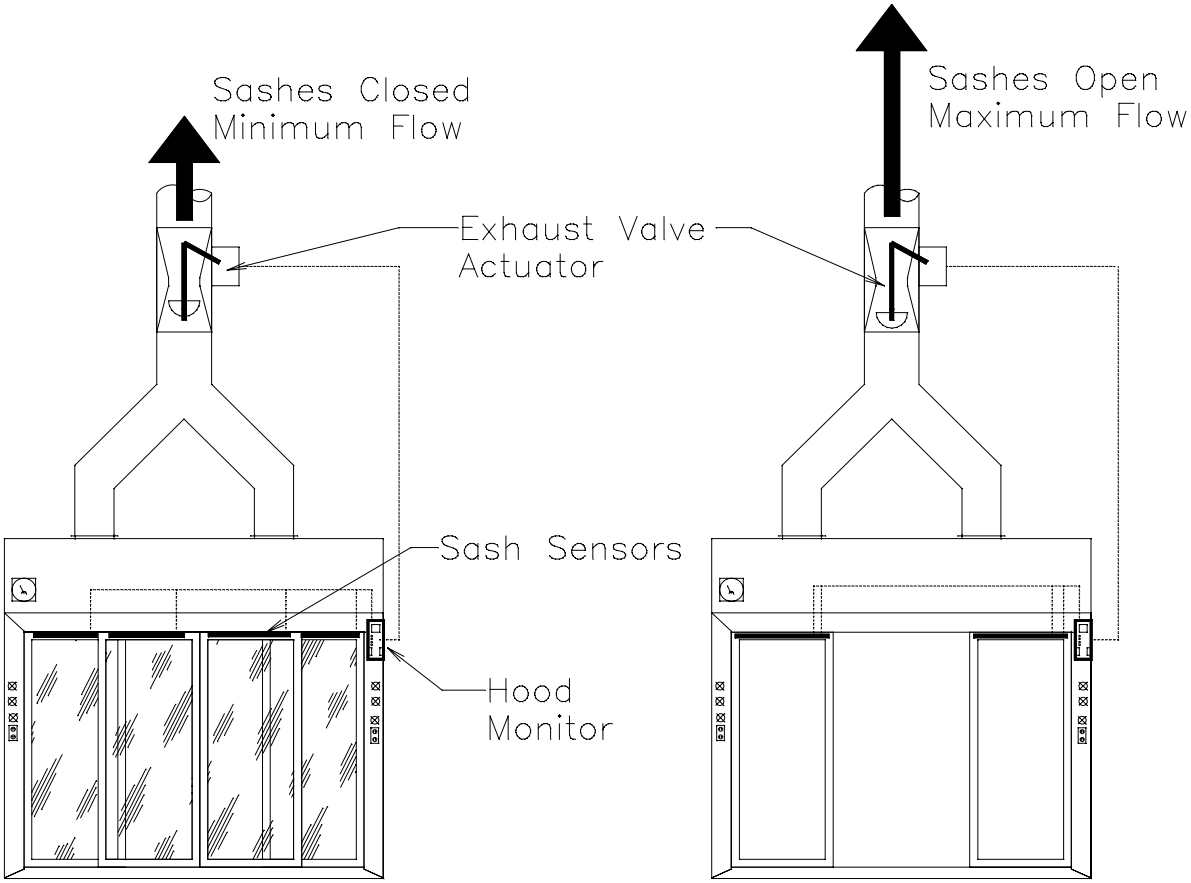
- Minimal airflow volume
- Infrequently accessed
- Requires external exhaust
- Can reduce lab hazard classification



Device Review

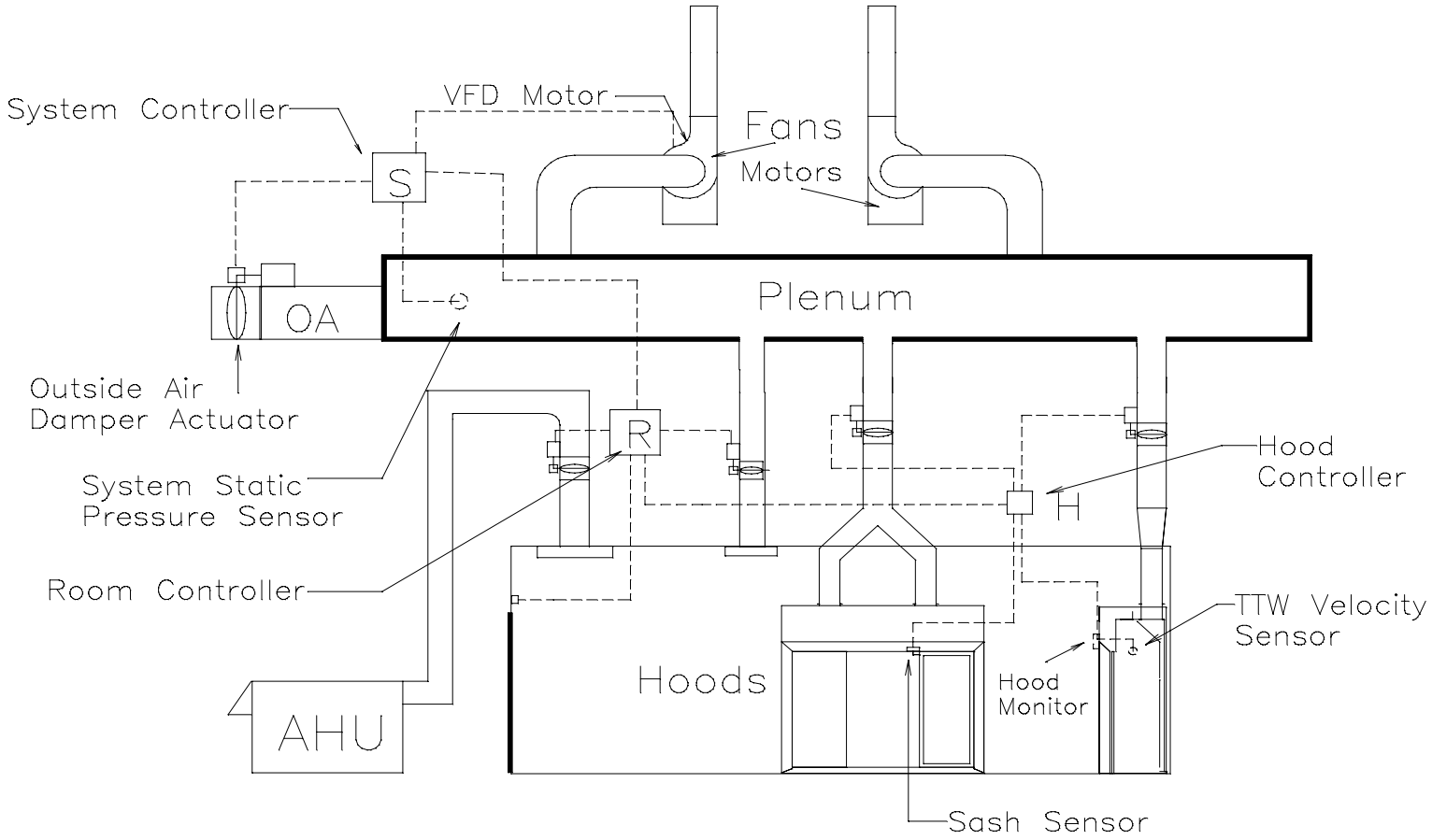
- **Variable Air Volume Fume Hoods:**
  - Decrease laboratory exhaust flow rate
  - Decrease conditioned supply air
  - Reduces heating and cooling costs
  - Reduces supply and exhaust fan horsepower
  - Monitor sash position remotely
  - Check face velocity and laboratory pressurization
  - Provided constant face velocity control

Device Review



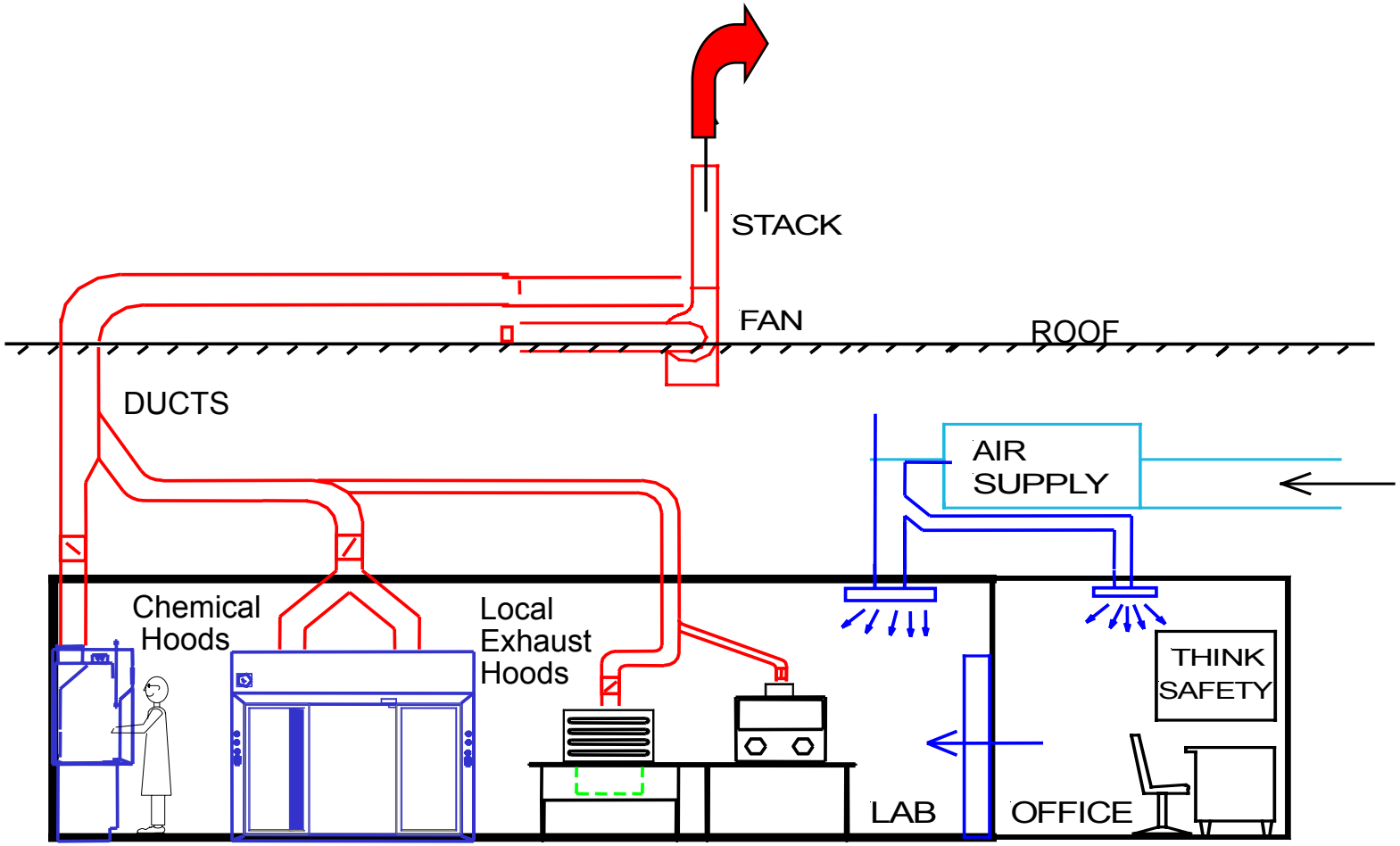
VAV Hood Operation

Device Review



VAV System

Device Review



VAV System

Device Review

- **Does the Low Flow / Low Velocity Hood provide:**
  - 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

Device Review

- **High-Performance Hood:**
  Improved Performance Through Better Design…
  - Aerodynamic Entry
  - Directed Air Supply
  - Perforated or Slotted Rear Baffle
  - Airfoil Sill and Sash Handle
  - Integrated Monitors
  - Interior Dimensions

Device Review

- **High Performance Fume Hoods: current fabricators…**
  - Lab Crafters
  - Labconco
  - Fisher Hamilton
  - Kewaunee Scientific
  - Laboratory Equipment Manufacturers
  - Berkeley Hood
  - Others

Device Review

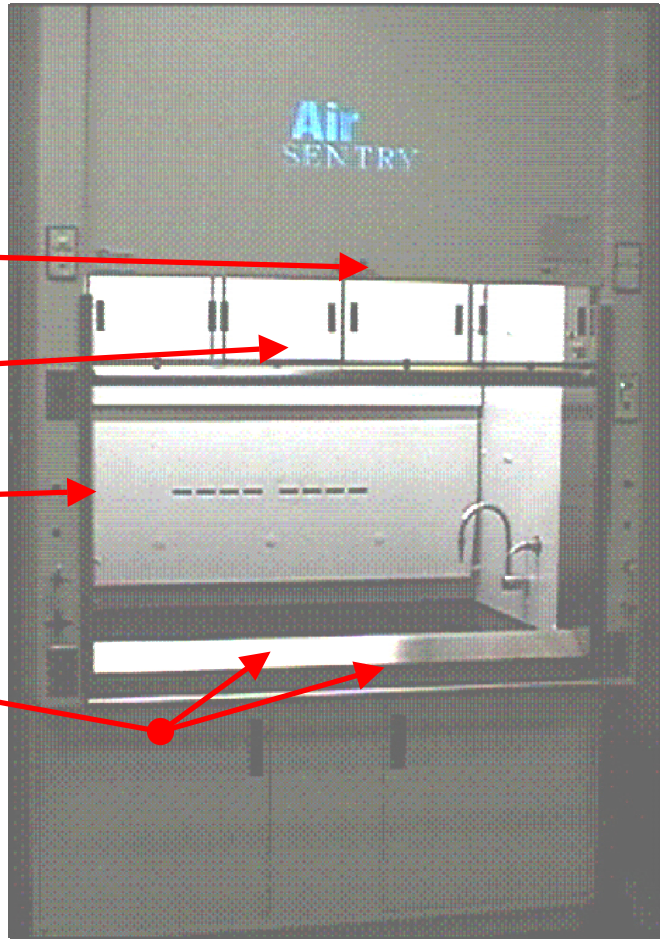
Lab Crafters Air Sentry HPFH

Upper chamber Turning Vane

Aerodynamic Sash Frame

Side Post Airfoils

Multi-Slot Front Airfoil



Device Review

Labconco XStream Hood

Modified Aerodynamic Sash Pull

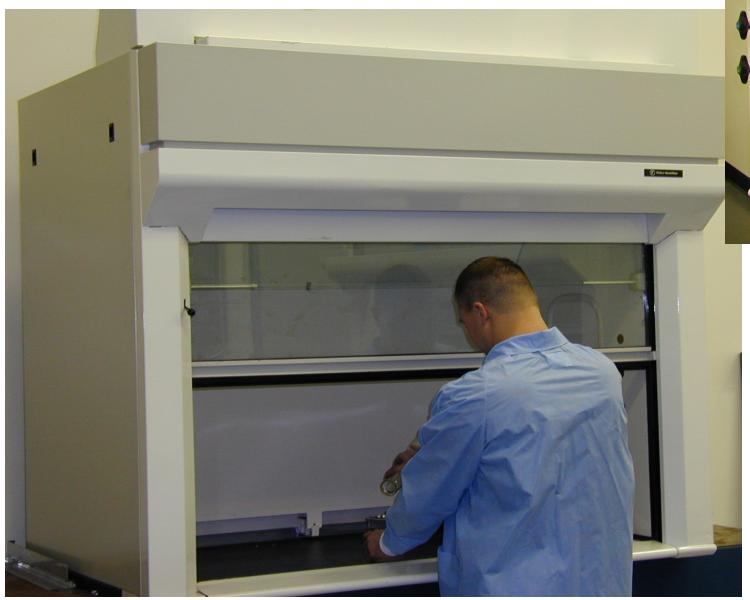
Modified Baffle and Slots

Aerodynamic Airfoil

Device Review

Fisher Hamilton PIONEER

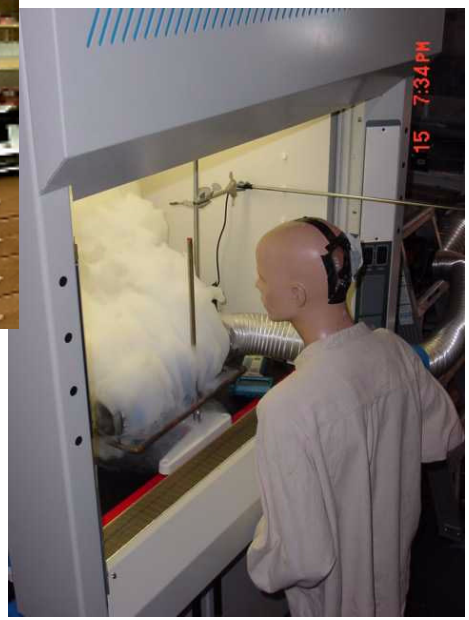
- Automatic sash closer
- Directed supply flow @ full open sash
- Flush Airfoil Sill



Device Review

Berkeley Hood by LBNL

- Air Divider Technique
- Perimeter Air Supply
- Perforated Rear Baffle
- Slot Exhaust
- Optimized Upper Chamber
- Designed to minimize escape by reducing reverse flow



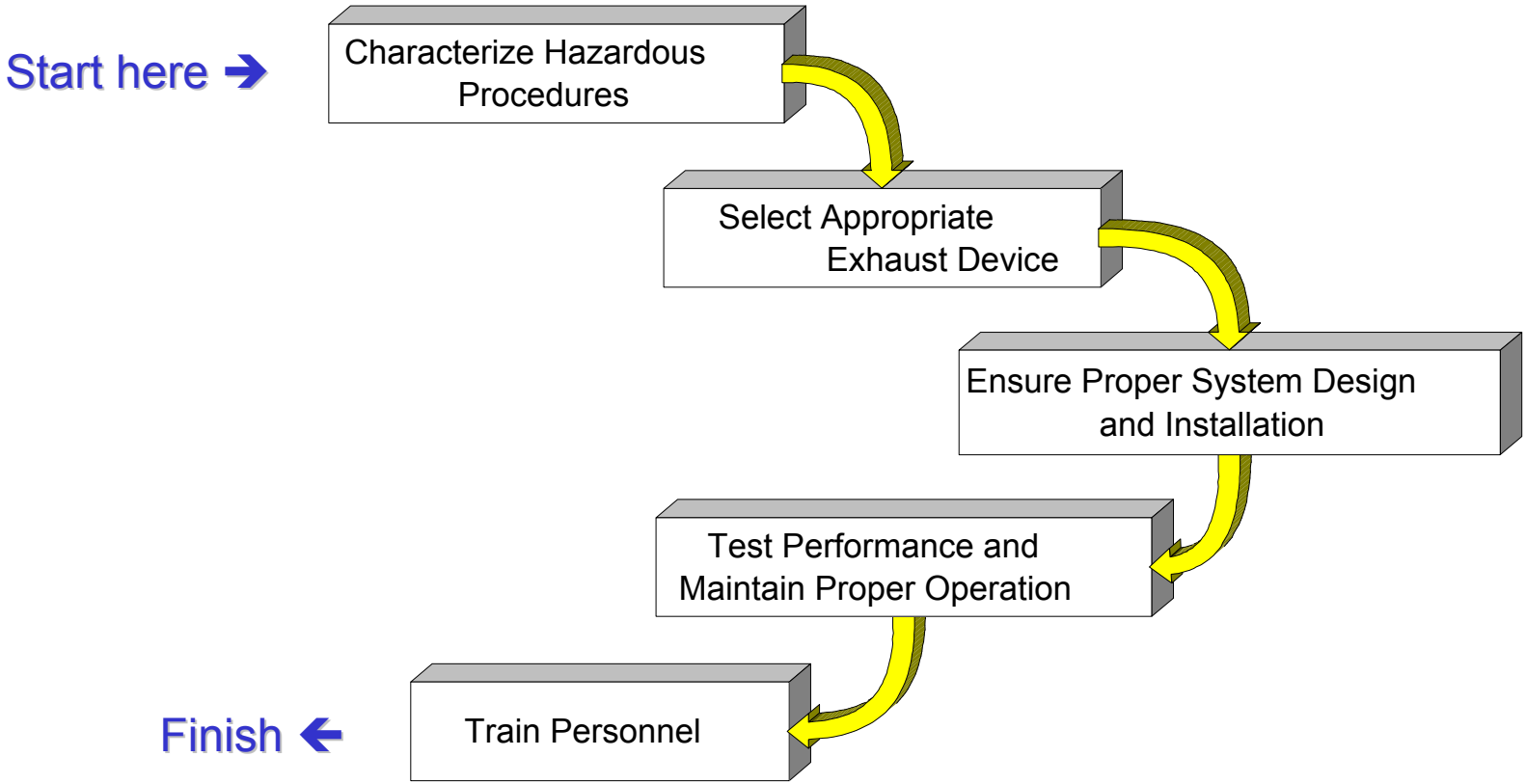
Device Review

Zone Occupancy Sensor

Sash Sensor/Monitor

Selection Process

Basic approach for safe and efficient results…



Selection Process…

- **Understand Hazards and Exhaust Device Use**
  - Type of Hazards
  - Frequency of Use: Dose
  - Duration of Use: Dose
  - Hazard Generation Characteristics
  - Effluent Characteristics

Selection Process…

- **Select Appropriate Laboratory Exhaust Device**
  - Type
  - Size
  - Quantity
  - Manufacturer & Model
  - Operational Specifications
  - Constraints and Limitations

Re-check Hood and System is
<u>suitable for the intended application</u>

Selection Process…

- **Key Factors Affecting Laboratory Exhaust Device Performance…**
  - Design features and installation
  - Lab design and layout
  - Ventilation system design (diffusers) and operation
  - Worker population and practices
  - Traffic patterns
  - Proximity to room egress
  - Laboratory equipment operation

Standard Design Practice

- **Choose Device…**
  - Number
  - Placement
  - Features (verify with user)
  - Chemical Resistance
- **Commissioning Requirements…**
  - Volume Flow Check (TAB)
  - Face Velocity Testing (per authority having jurisdiction)
  - Certification (if required)
  - EMCS tie-in (if available)

Good Design Practice

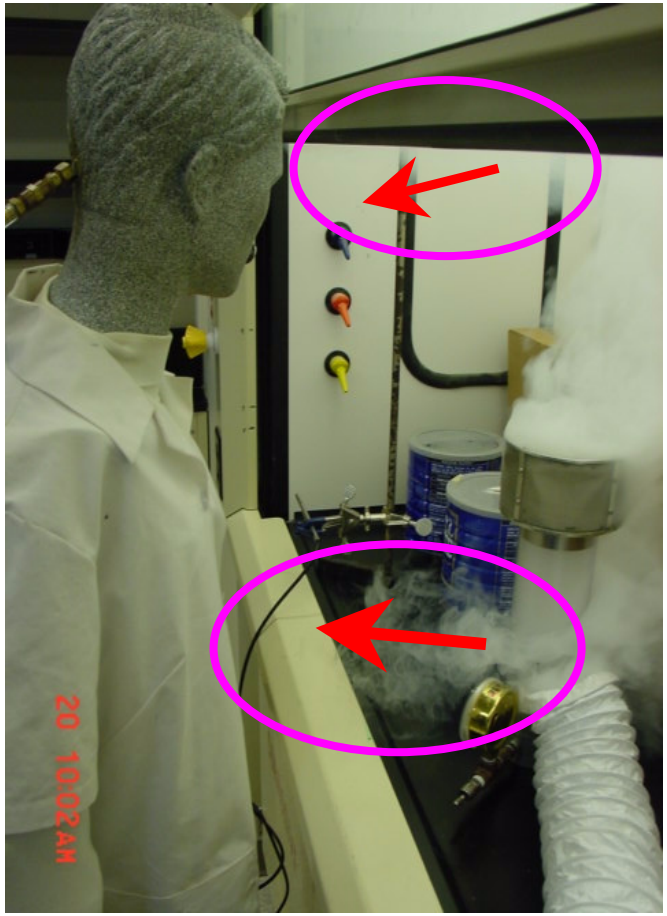
- **Choose efficient device…**
  - VAV hood Low-Flow hood
  - Consider alternative devices
- **Consider aspects of air management…**
  - Supply air temperature rate of change
  - Diffuser type and air "throw"
- **Require full ANSI/ASHRAE 110 testing as installed…**
  - Tracer gas containment
  - Sash movement effect
- **Conduct Operational Assessment Commissioning…**
  - Room differential pressure tests
  - VAV hood recovery tests (from unusual user interface, e.g., door slams)

Better Design Practice

- **Perform Computational Fluid Dynamic (CFD) Modeling…**
  - Model hood containment
  - Simulate lab space during spill event
- **Conduct advanced containment tests…**
  - Human-as-Mannequin (HAM) tests
  - Walk-up, walk-by tests
- **Require Performance Measurement Commissioning…**
  - Simulate "stress conditions", e.g., whole building power failure
  - Test entire facility's "harmony"
- **Arrange Efficiency Assurance Commissioning…**
  - Verify energy efficiency measures
  - Seasonal, full occupancy check

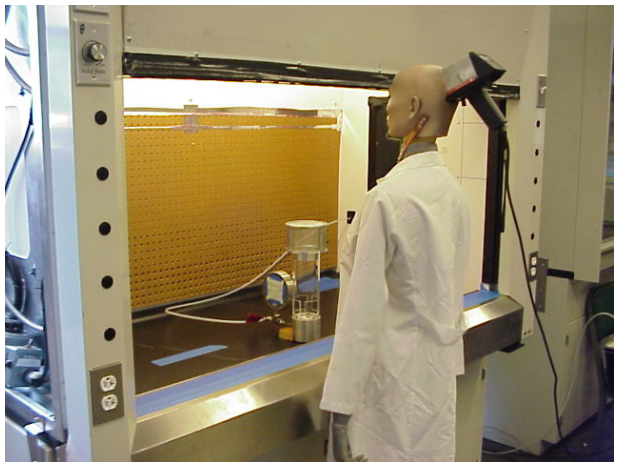
Performance Example: Good Practice

Observing reverse airflow during ANSI/ASHRAE smoke tests

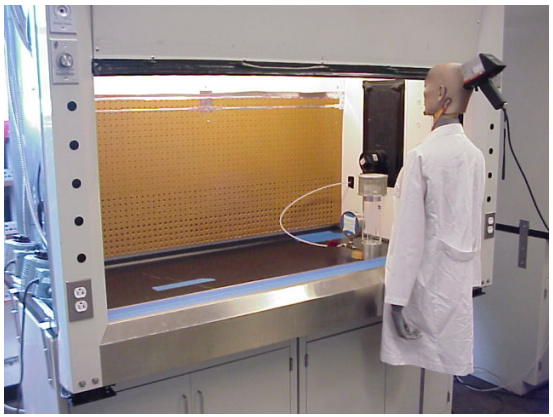


Performance Example: Good Practice

ASHRAE 110
Tracer Gas
Test



Center position



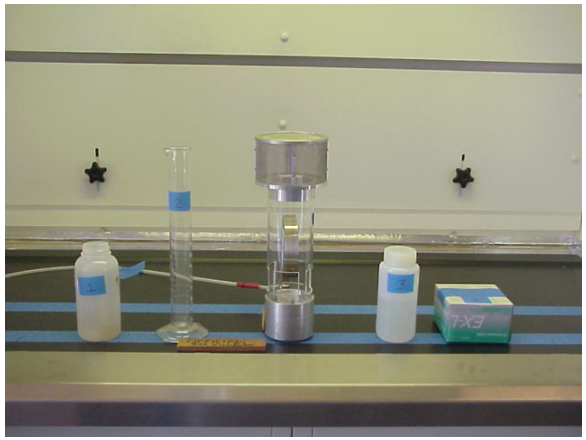
Right position

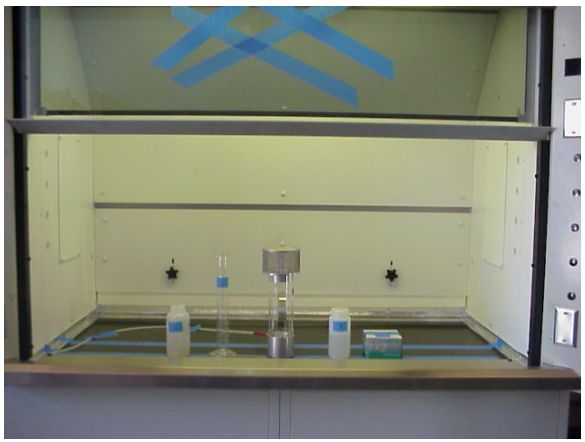
Performance Example: Better Practice

Preparing for Human-as-Mannequin tests

Tracer gas detector mounted on human

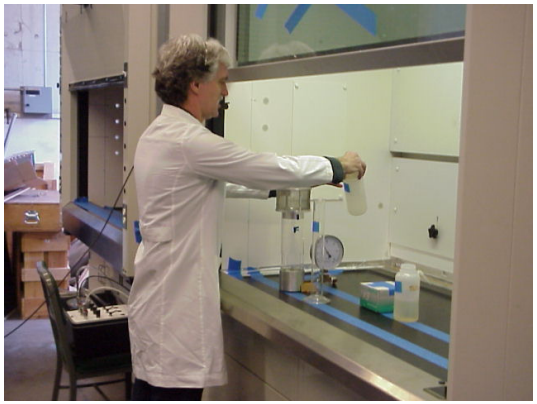
Objects to be manipulated





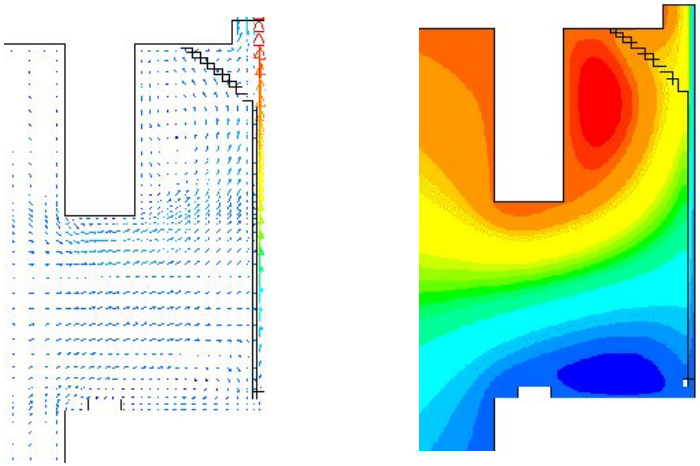
Performance Example: Better Practice

Conducting
Human-as-Mannequin tests



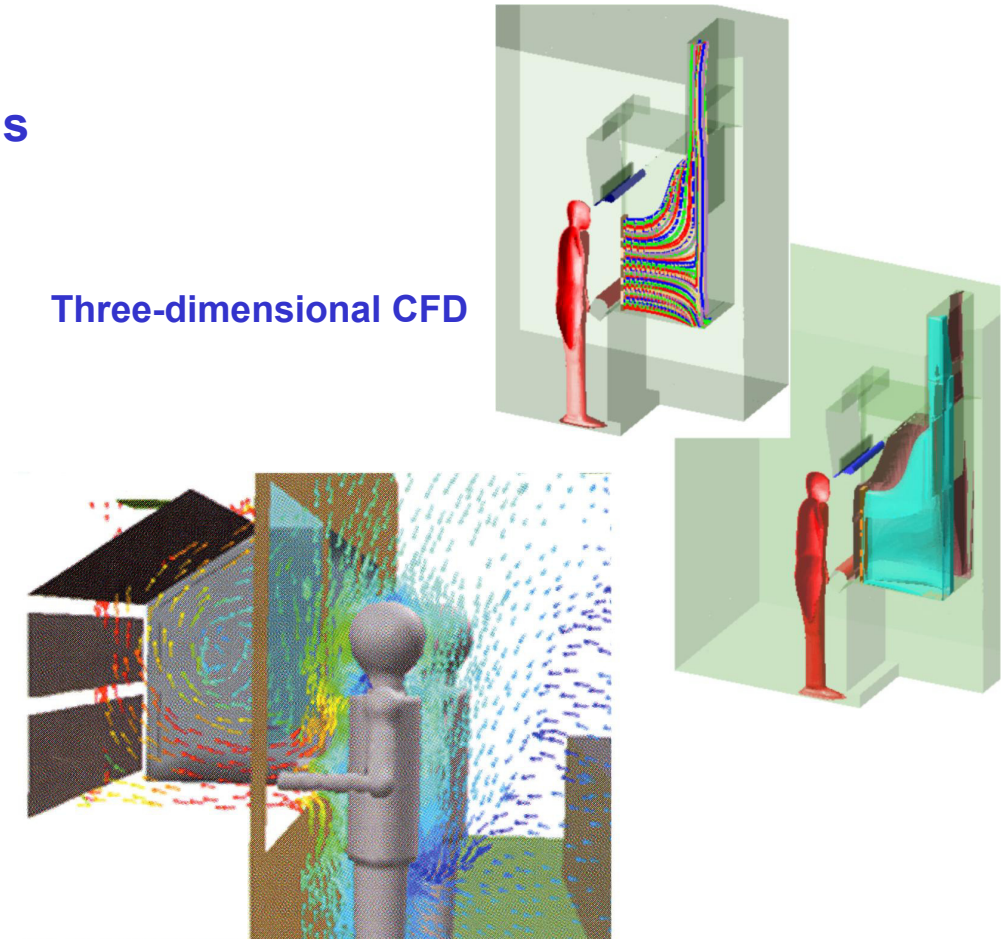
Performance Example: Better Practice

CFD Fume Hood Models



Two-dimensional CFD

Three-dimensional CFD



Performance Example: Better Practice

CFD Lab Models

Princeton University

Conclusion

- **Design Mission a Success…?**
  - Increased operational safety significantly
  - Advanced Ergonomics
  - Minimized effects from external factors
  - Provided remote Monitoring and Control
- **Performance bottom line…**
  - Improved Containment
    - At Face Velocities of 50-60 fpm
    - With Full Range of Sash Opening
    - Independent of User Height

Conclusion

- **Summary Recap:**
  - Design Considerations
  - Device Review
  - Selection Process
  - Design Practice
- **Primary Issues:**
  - Safety – Crucial reason for lab exhaust devices – Removal of Hazard.
  - Temperature and humidity control – heat gain from equipment, computers, people.
  - Productivity of facility – support mission.
  - Cost to Design; to Build; to Operate.

Conclusion

It's a Combined Effort –
A sustainable, energy-efficient facility requires teamwork involving:

- A "user" representative that understands the scientific research.
- A facilities representative that understands the building's HVAC systems.
- An industrial hygiene representative that understands worker health and safety issues.
- A laboratory design representative that understands exhaust device designs and features.

For More Information

Main Labs21 web site:

http://www.labs21century.gov

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