

# Safe and Energy Efficient Labs

How low can flow go?



1

## Learning Objectives

- Recognize the factors that affect lab safety and the occupant demand for ventilation
- Understand what drives minimum airflow requirements and how to establish minimum specifications
- Understand how special tests are used to determine the minimum safe velocity and exhaust flow for fume hoods
- Recognize how to determine the minimum safe air change rates for laboratories and critical workspaces
- Be able to determine and minimize the cost of ventilation.



Copyright © 2025

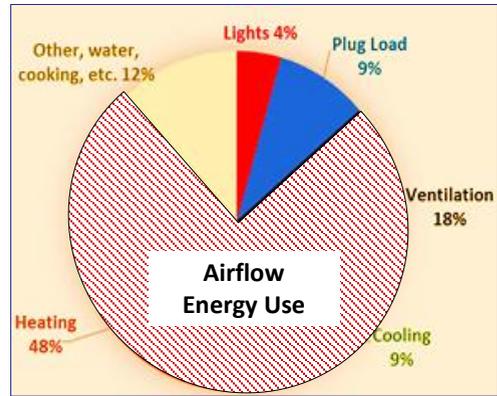


2

## Why consider reducing laboratory airflow?

- Ventilation systems are the largest contributor to **Energy Use and Carbon Footprint**
- Airflow accounts for more than **50% of Building Energy Consumption**
- Conditioning and transporting air through the building **costs \$3 to \$10 per cfm-yr**
- Total building airflow can range from **0.5 cfm/ft<sup>2</sup> to 2 cfm/ft<sup>2</sup>** (1 cfm/ft<sup>2</sup> ≈ 6 ACH)

*A 100k ft<sup>2</sup> building may use 50k cfm to 200k cfm at a cost of more than \$1M per year*



**As much as 50% of the HVAC energy may be wasted by improper airflow and inefficient systems**

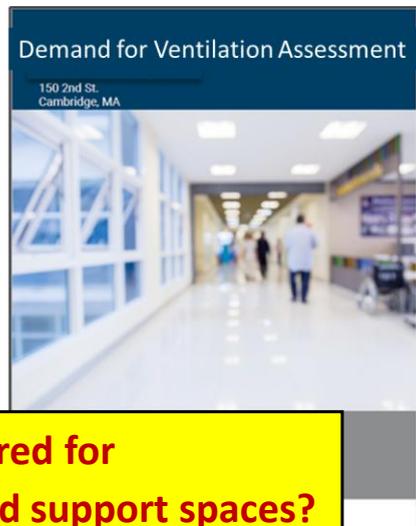
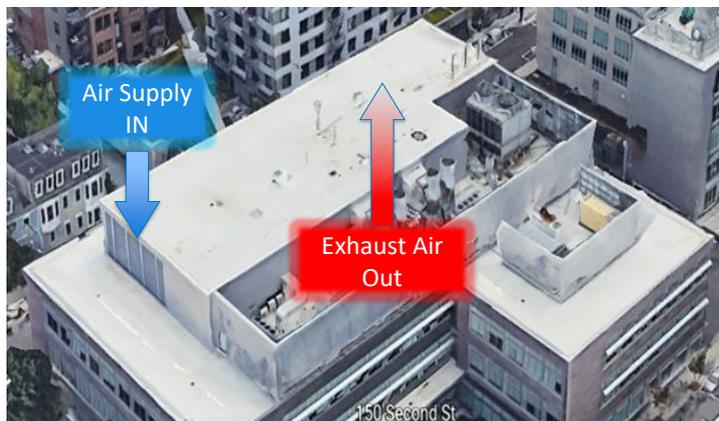


Copyright © 2025



3

## Do you know the total flow through your building?



**How much flow is required for safe and productive labs, offices and support spaces?**



Copyright © 2025



4

## The demand for ventilation determines flow requirements

- **Safety and Risk Mitigation**

- Fume Hoods and ECDs
- Lab Dilution and Contaminant Removal (ACH)
- Isolation and Containment (Lab Pressurization)

- **Productivity and Comfort**

- Conditioning (Temperature and Humidity)
- Cleanliness and IAQ

- **Occupancy and Utilization**



**What is the minimum flow and range of modulation required to meet the safety and functional needs of the occupants**

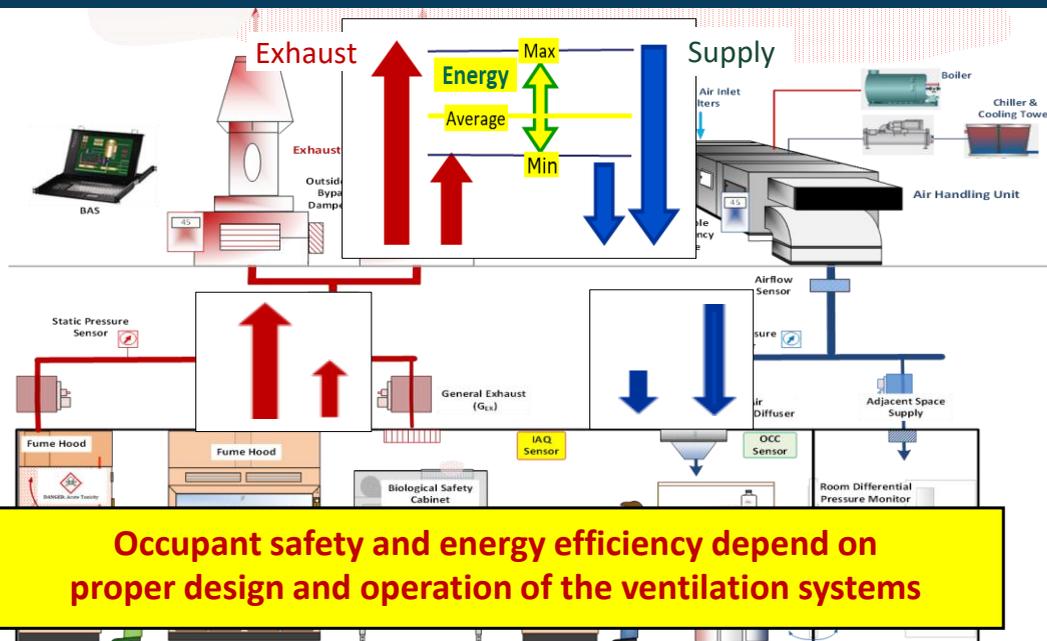


Copyright © 2025

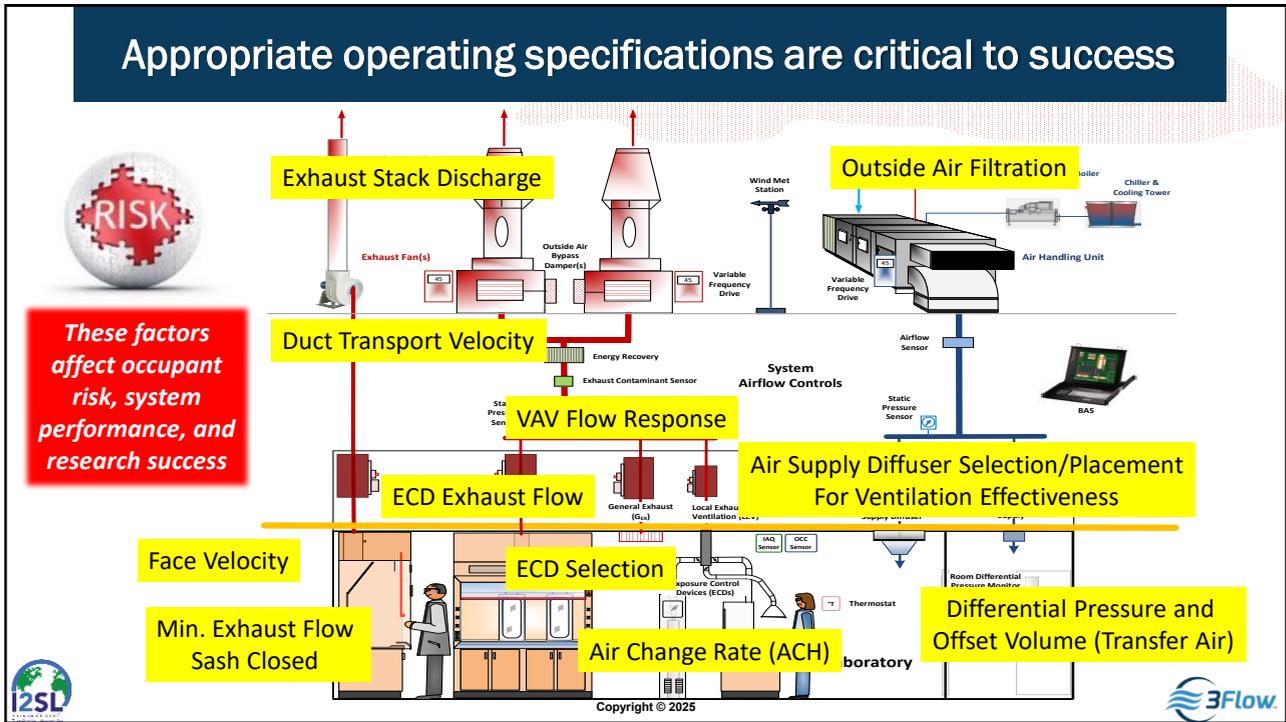


5

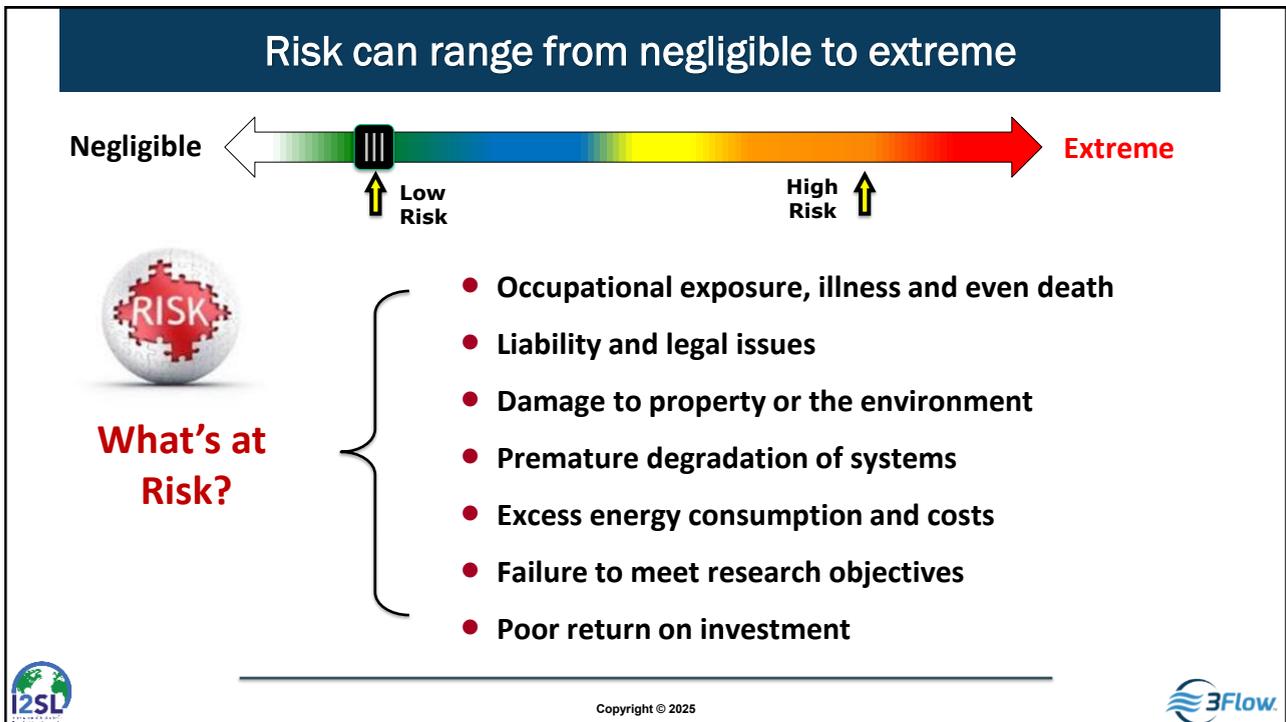
## Modern systems modulate flow to save energy



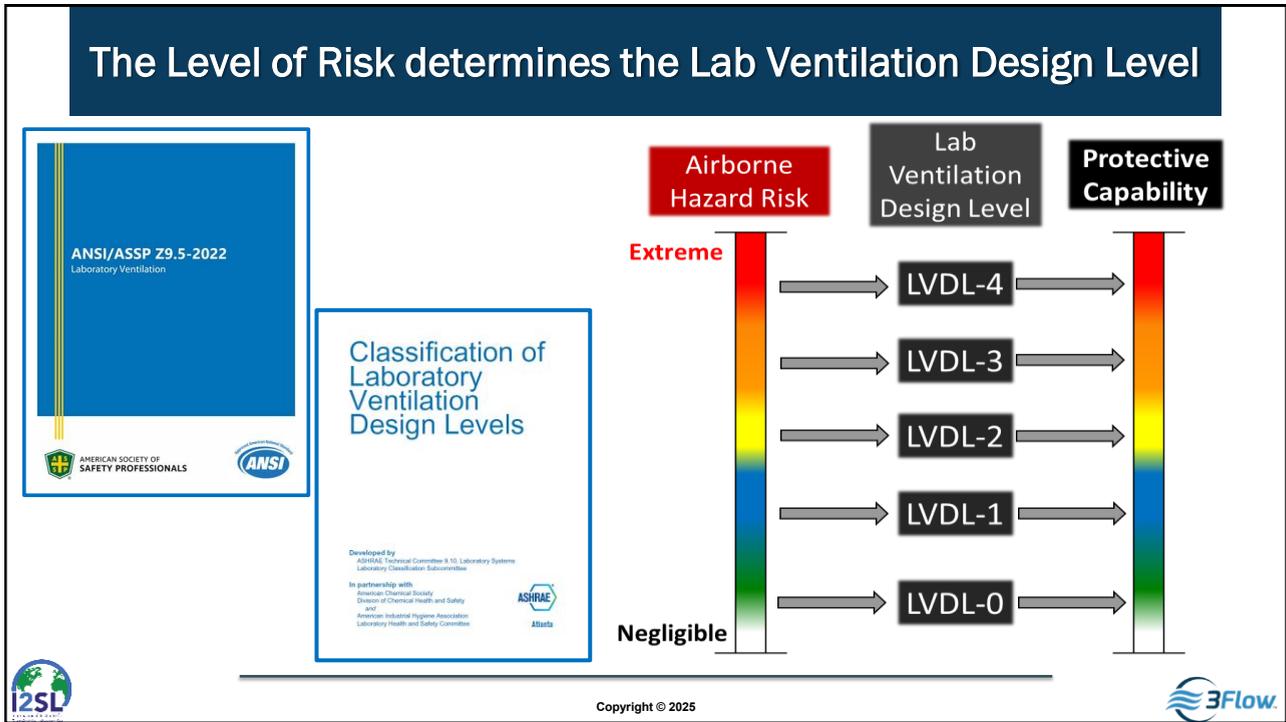
6



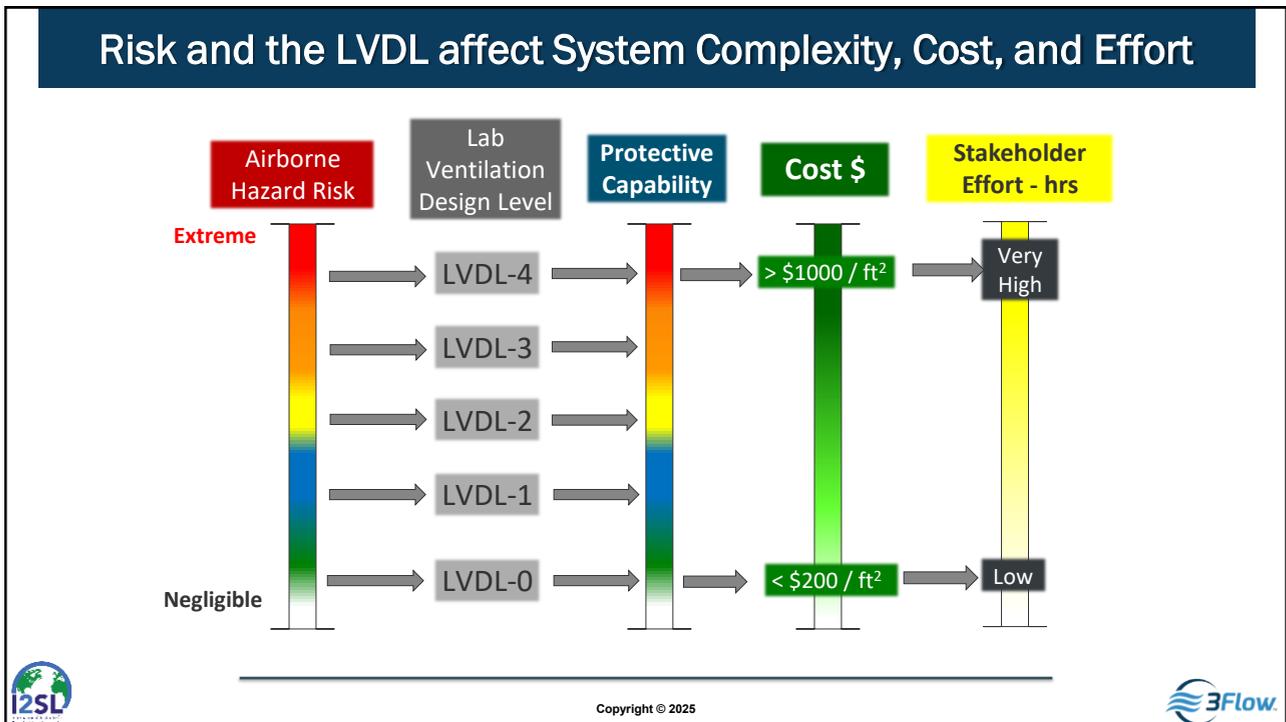
7



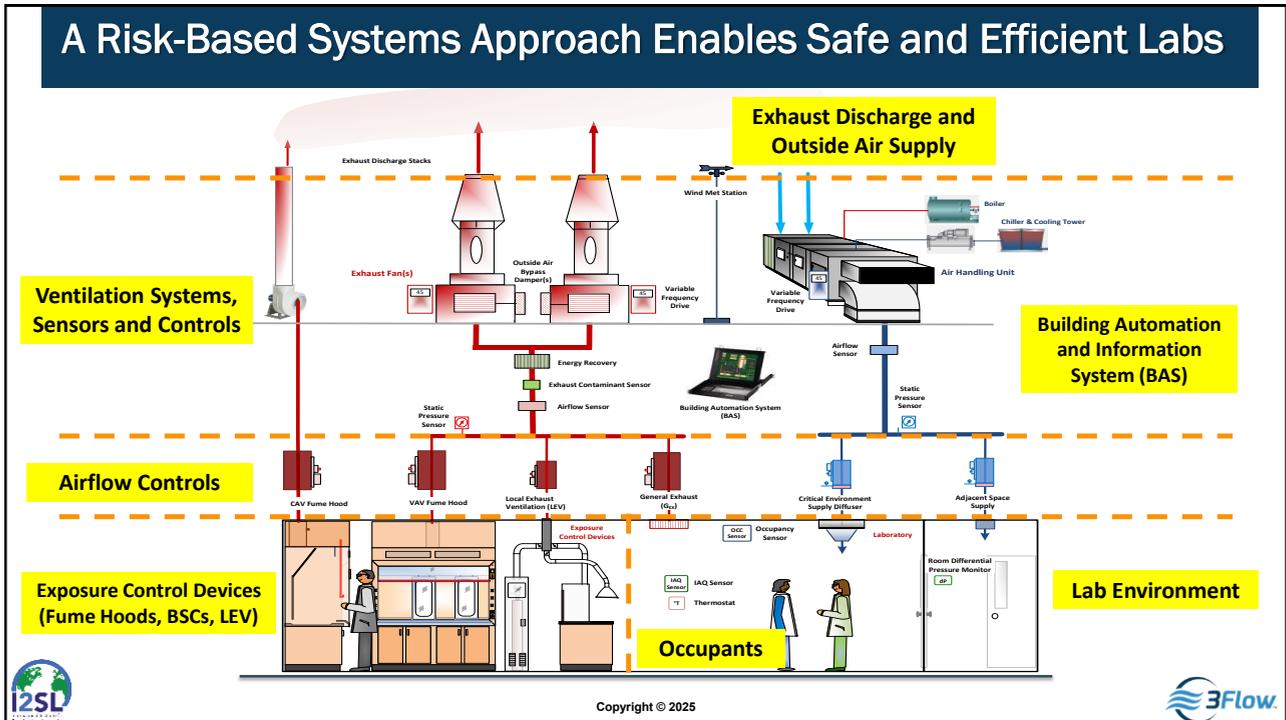
8



9



10



11

## Know the Flow™ - Prove the Flow™

### Know the Flow

- Lab Ventilation Risk Assessment
  - Space Plan and Occupant Schedules
  - Lab Design and Application
  - ECD Type and Application
  - Risk Ratings and Assignments
  - Design and Operating Specifications

### Prove the Flow

- Fume Hood Performance Tests
- Fume Hood VAV Response Test
- Fume Hood Minimum Flow Test
- Lab Ventilation Effectiveness Test
- Ventilation System VAV Function Test
- Demand Control Ventilation Function Test

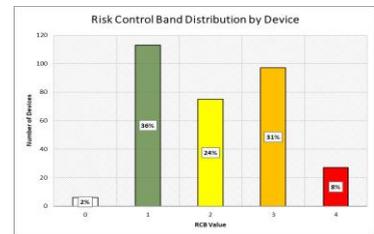
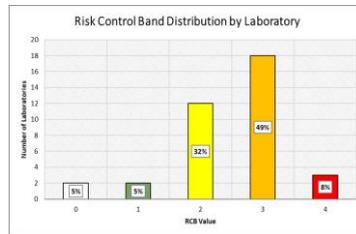
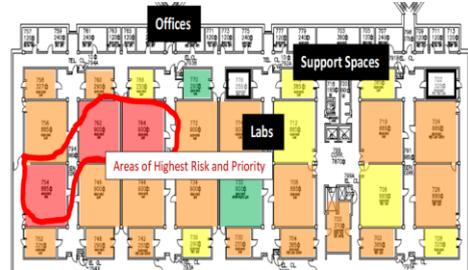
Copyright © 2025

12

## A Lab Ventilation Risk Assessment (LVRA) evaluates occupant activities and their demand for ventilation

- Risk Factors include:
  - Space Size and Configuration
  - Application and Occupancy
  - Hazard Type and Quantity
  - Hazard Generation Potential
  - Available Protection Measures

RCB	Risk Level Description
0	Negligible
1	Low
2	Medium
3	High
4	Special – “Extreme”



The LVRA is the bridge between compliance, safety and energy efficiency



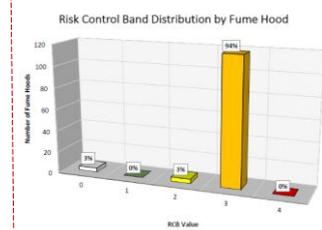
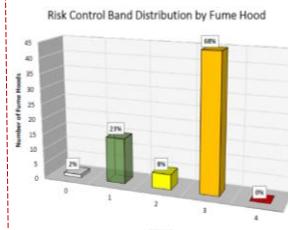
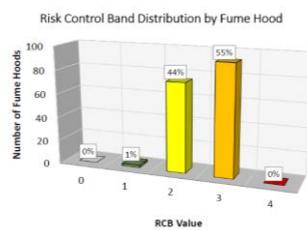
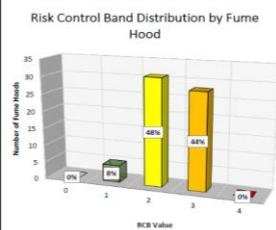
Copyright © 2025



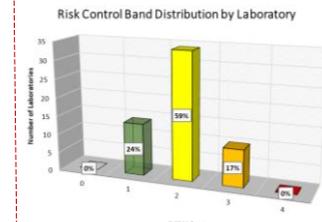
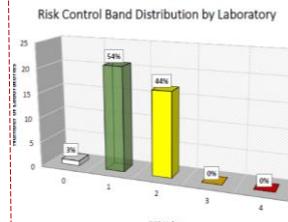
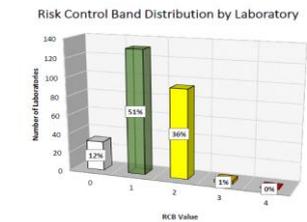
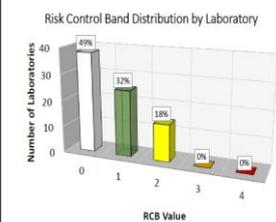
13

## The range of RCBs for different buildings and fume hood systems demonstrate that prescriptive specifications are not appropriate

### Fume Hood Use



### Lab Environment



Physics/Engineering Lab

Biology - Natural Sciences

Bio-Chemistry

Chemistry



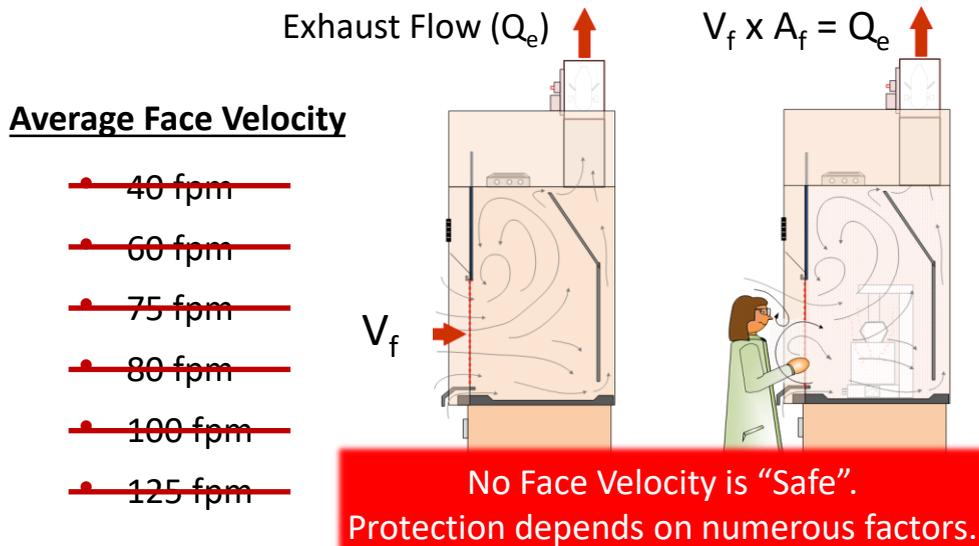
Copyright © 2025



14



## What is the safe average face velocity?



LESSON 4 – FUME HOODS AND ECD'S

Copyright © 2025



17

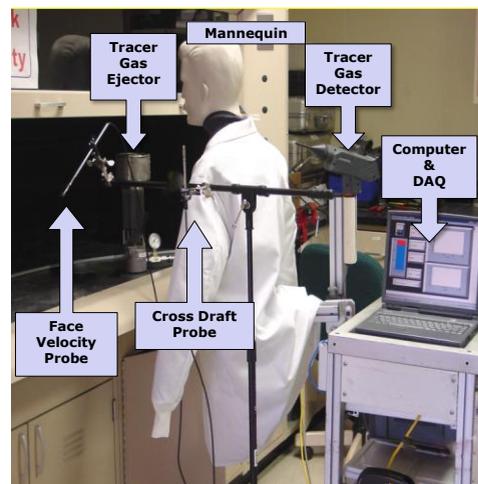
## Fume Hood Tests must be appropriate to verify proper operation and validate performance

### What are the Operating Conditions?

- Hood and Lab Integrity
- Face Velocities
- Cross Draft Velocities
- VAV Flow Response and Stability

### Is Performance Adequate? Does the hood provide proper containment?

- Airflow Visualization (Qualitative)
- Air Tracer Test (Quantitative)
- Protect people from exposure



Copyright © 2025



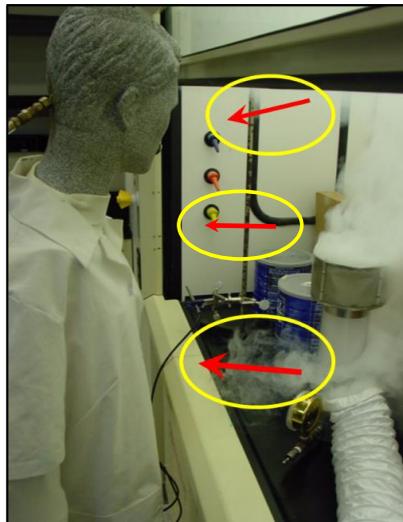
18

More than 50,000 tests indicate 15% to 30% of fume hoods fail to meet performance standards

Primary Factors Affecting Performance

- Hood Design - 20%
  - Lab Design
  - System Operation
  - Work Practices - 25%
- } 55%

Face velocity is not a measure of proper performance



Copyright © 2025



Even if the fume hoods function properly, users must follow proper work practices



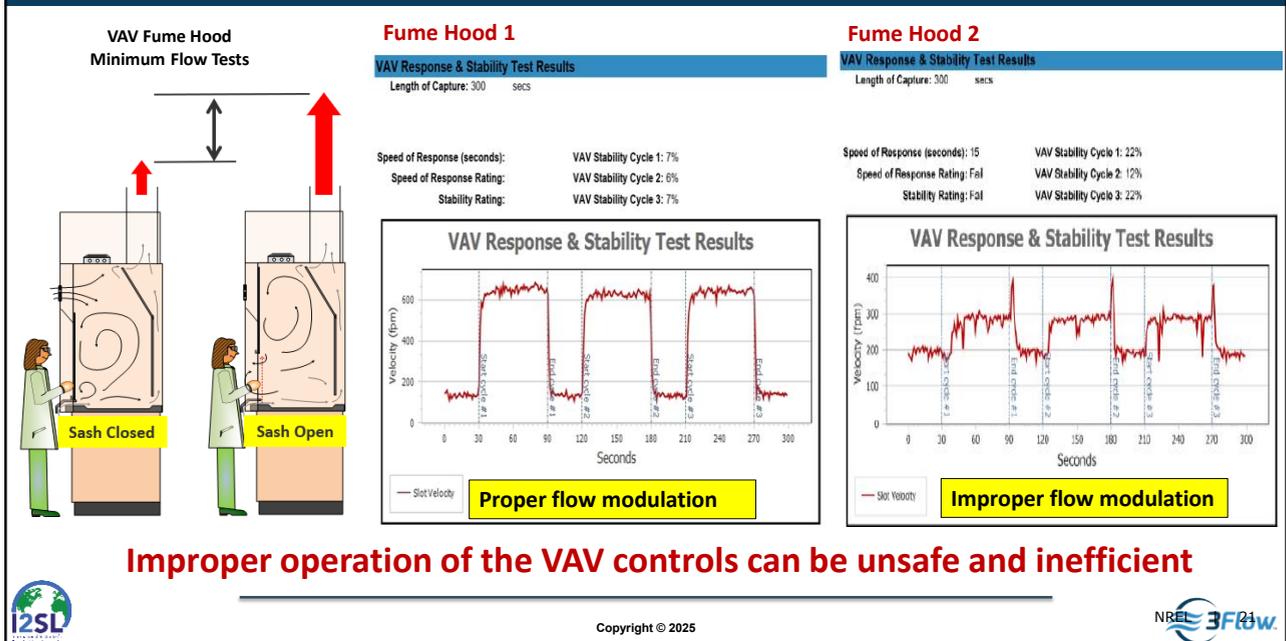
User training is critical for safe and energy efficient labs



Copyright © 2025



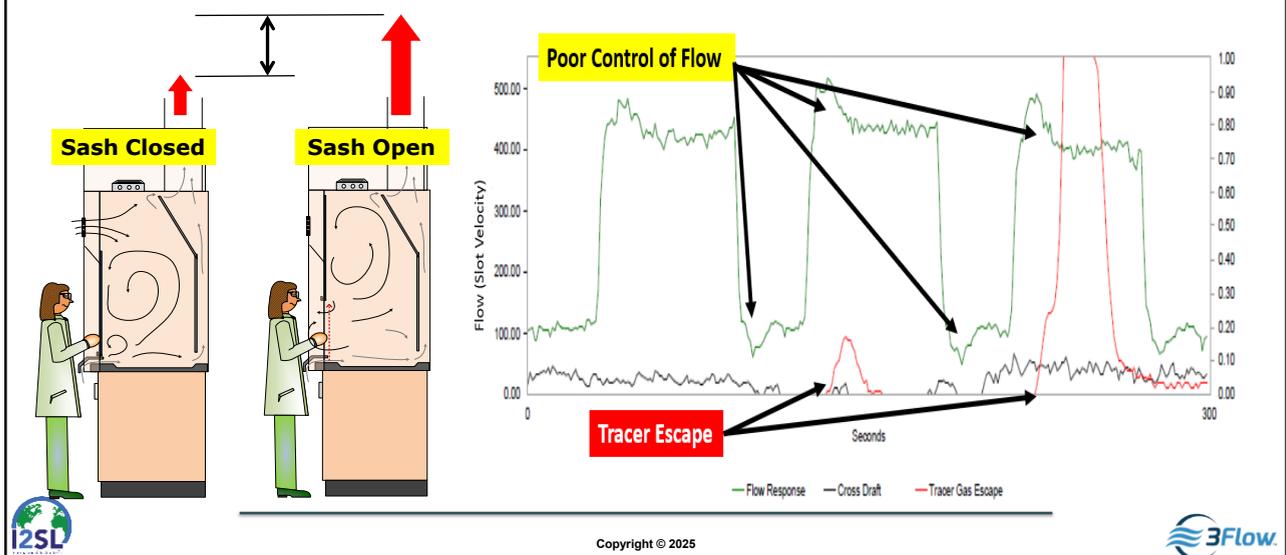
## VAV Response Tests verify flow modulation



21

## Improper VAV Response Threatens Safety and Efficiency

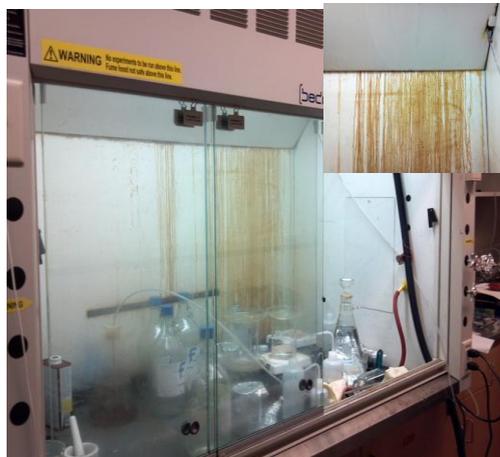
- Min and Max Flow
- Response Time
- Flow Stability
- Containment



22

## The minimum fume hood flow is critical to both safety and energy efficiency

- Containment
- Dilution
- Removal



Copyright © 2025



23

## Internal airflow patterns are affected by the sash configuration, the exhaust flow, and the internal aerodynamic design of the fume hood



Copyright © 2025

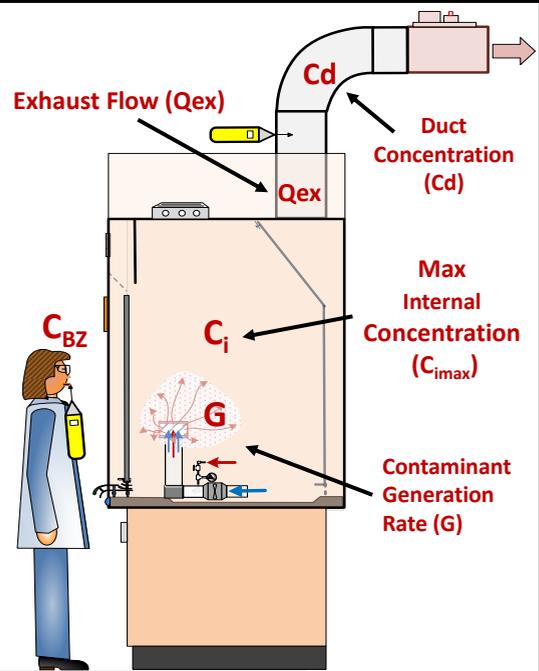


24

## Safe Minimum Fume Hood Flow – How low can you go?

- Contaminant Generation Rate based on LVRA Rating:
- Concentration of concern must be less than 20% of the LEL
- Hood Dilution Factor (DF) =  $C_{imax} / C_d$
- The Minimum Exhaust Flow in Duct ( $Q_{ex_{min}}$ )
- Minimum Required Fume Hood Flow ( $Q_{ex_r}$ ) =  $Q_{ex_{min}} \times DF$

Minimum Exhaust Flow must be greater than 140 cfm for RCB-3 Applications  
 If DF = 2,  
 the Flow  $Q_{ex} = 2 \times 140 \text{ cfm} = 280 \text{ cfm} (\approx 375 \text{ ACH})$

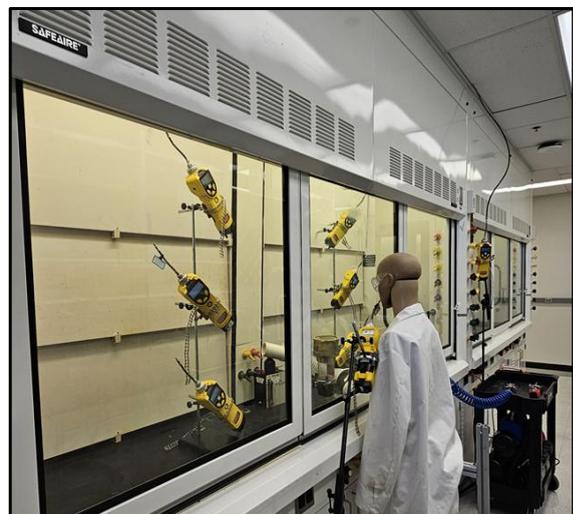
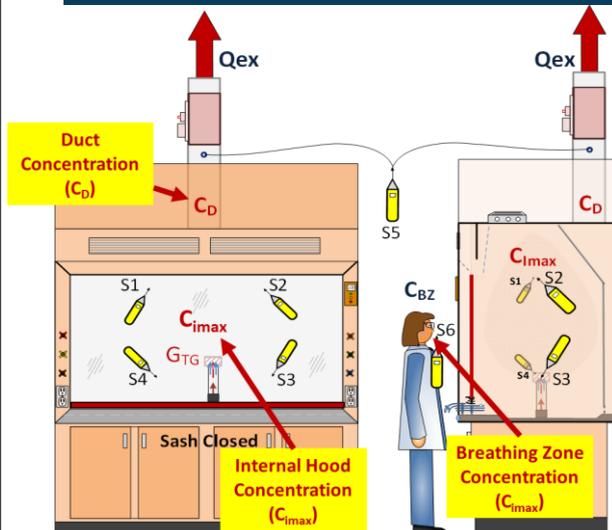


Copyright © 2025



25

## The Minimum Flow Test uses an air tracer to evaluate fume hood dilution and contaminant removal

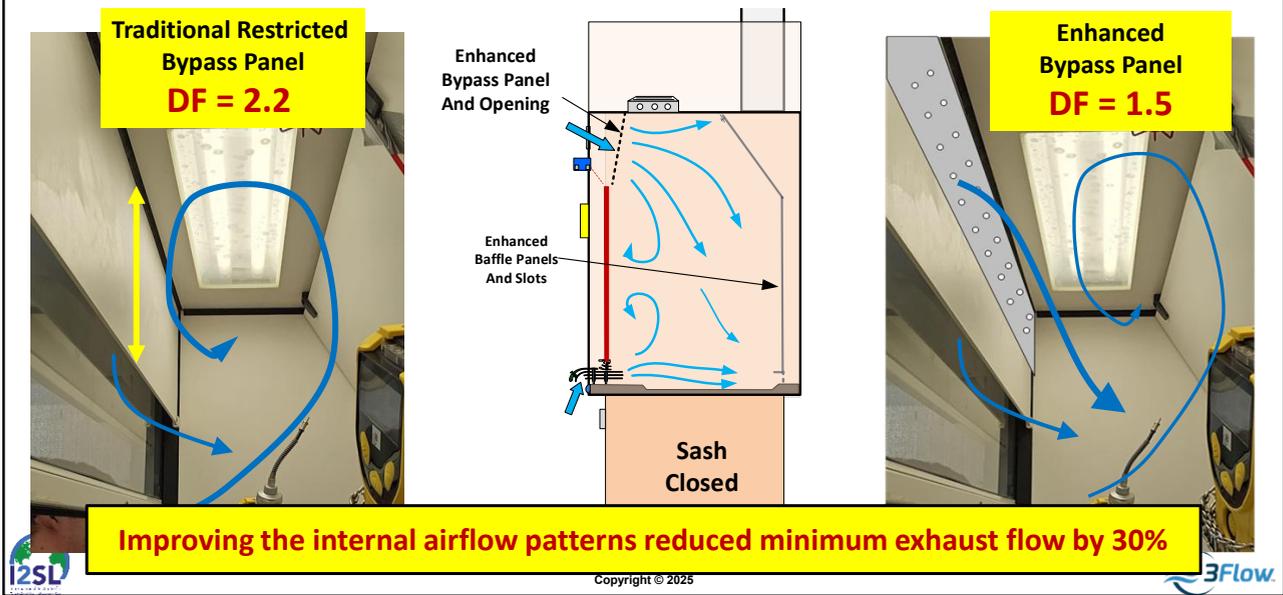


Copyright © 2025



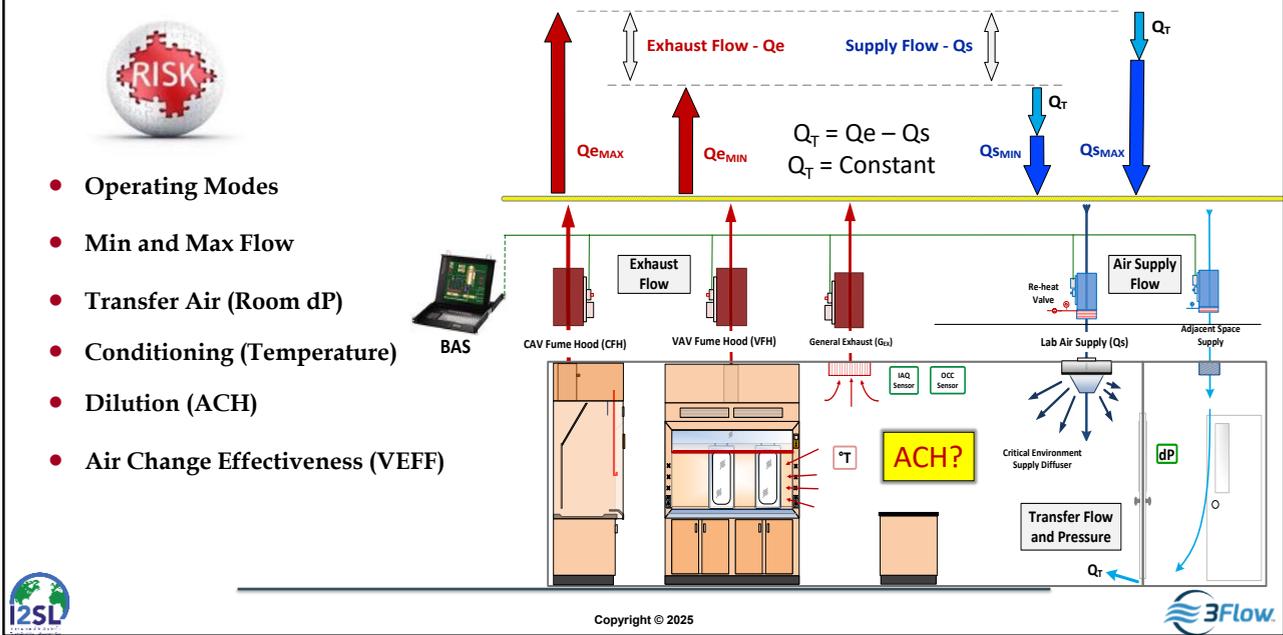
26

Fume hoods can be modified to improve containment, dilution, and removal of contaminants at lower flow



27

How low can you go with flow in the lab?



28

Just like fume hoods, laboratories are not one size fits all. Occupant safety depends on testing and verifying effectiveness

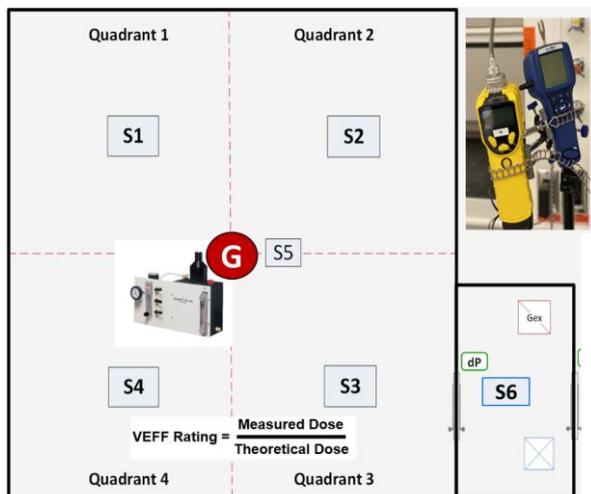


Copyright © 2025



29

Minimum ACH is determined with a Ventilation Effectiveness Test

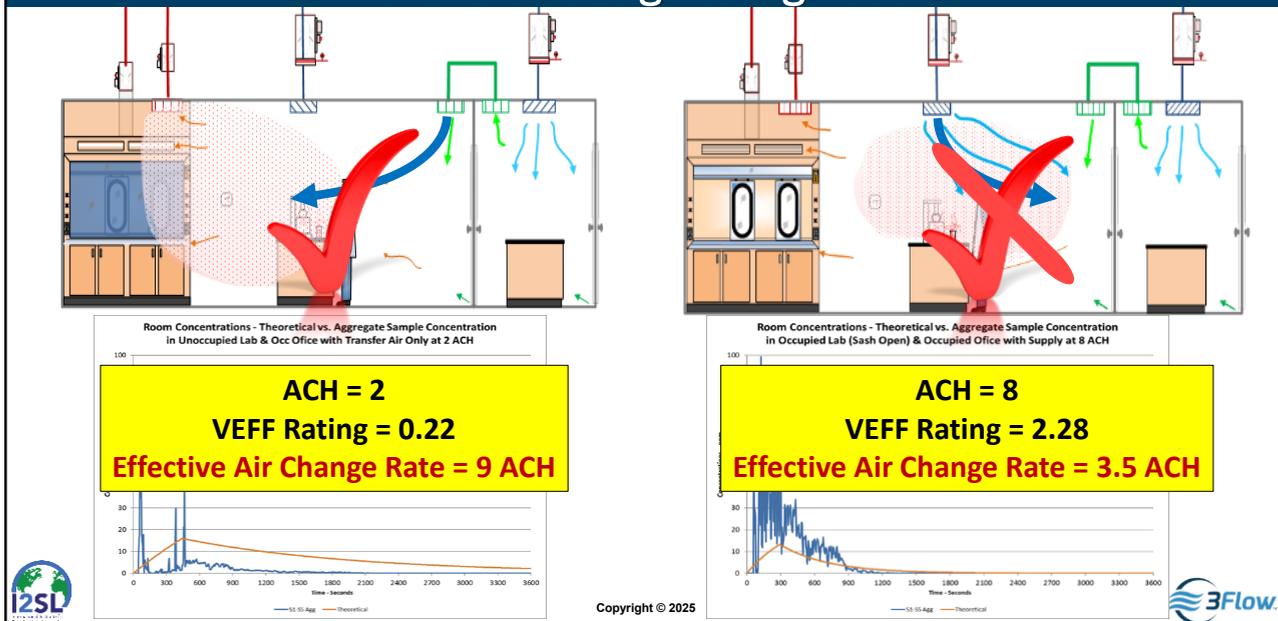


Copyright © 2025



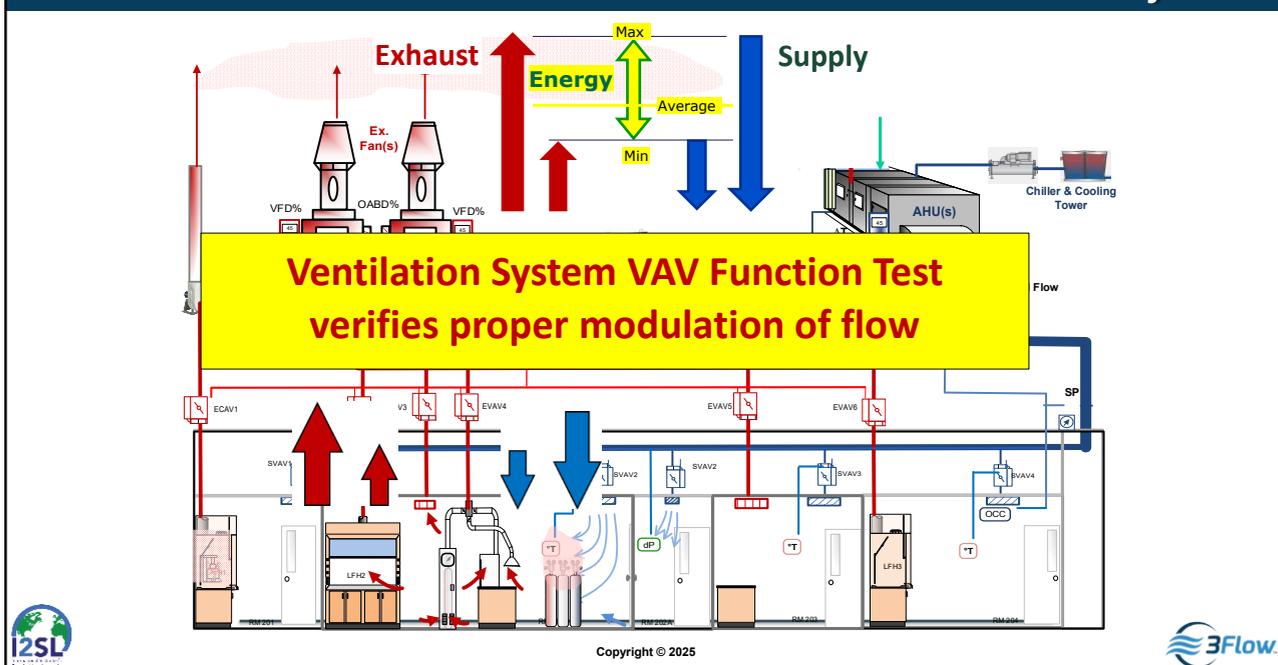
30

## Lab VEFF Tests indicate 2 ACH was more effective than 8 ACH for this lab design configuration



31

## Flow reduction at the hood must translate to the lab and the system



32

## Results of Ventilation System VAV Function Test – Example 1

Expected Flow Modulation = 5,600 cfm

Test Mode	EF#	Duct Size	Pitot Traverse (fpm)	Total Measured (cfm)
Max	1 & 2	Multiple	Multiple	
Max	3 & 4	Multiple	Multiple	
Min (End)	1 & 2	Multiple	Multiple	14,683
Min (End)	3 & 4	Multiple	Multiple	1,225
Max	8 & 9	Multiple	Multiple	10,437
Min (Start)	8 & 9	Multiple	Multiple	5,671
Min (End)	8 & 9	Multiple	Multiple	6,495

Sashes Open = 20,600 cfm  
Sashes Closed = 14,680 cfm

Measured Flow Modulation = 5,920 cfm

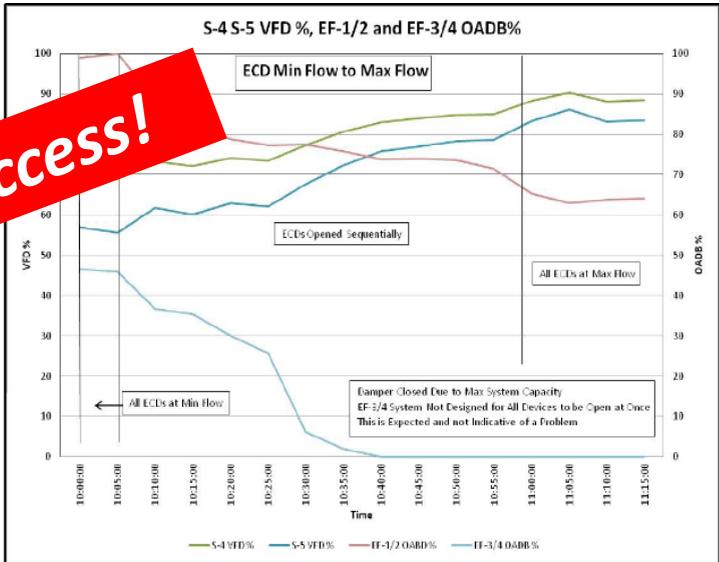


Figure 1 S-4 S-5 VFD %, EF-1/2 and EF-3/4 OADB% Min ECD Flow to Max ECD Flow



Copyright © 2025



## Results of Ventilation System VAV Function Test – Example 2

Sashes Closed to Sashes Open

Expected Flow Modulation = 14,900 cfm

Original Building Supply Air Systems SOMT Results				
Test Mode	AHU	VFD (Hz)	Design Airflow (cfm)	Measured Airflow (cfm)
Minimum Mode Sash Closed	AHU-2	50	76,000	58,653
Maximum Mode Sash Open	AHU-2	50	76,000	59,622

Original Building Exhaust SOMT Results						
	VFD (Hz)	OADB (%)	Design Airflow (cfm)	Calculated Exhaust Airflow (cfm)	Total Lab Exhaust (cfm)	Max-Min (cfm)
Minimum Mode Sash Closed	1A	49	25,500	20,825	41,608	0
	1B	48.9	25,500	20,783		
Maximum Mode Sash Open	1A	49	25,500	20,825	41,608	
	1B	48.9	25,500	20,783		

Measured Flow Modulation = 970 cfm

13,930 cfm (93%) Lower than Expected  
With Extra Cost = \$70,000 per year

Exhaust Modulation = 0 cfm



Copyright © 2025



## Conclusions – How low can flow go? Only as low as safety allows!

### New Tools and Techniques to Define, Test, and Verify Proper Flow and Performance

- **Lab Ventilation Risk Assessment** – Minimum flow and operation specifications for Labs and Fume Hoods
- **Fume Hood Performance Tests** – Minimum face velocity to maintain containment
- **Fume Hood VAV Response Test** – Modulation of flow based on sash position or occupancy
- **Fume Hood Minimum Flow Test** – Minimum flow for dilution and contaminant removal
- **Lab Ventilation Effectiveness Test** – Minimum ACH for dilution and contaminant removal
- **Ventilation System VAV Function Test** – Modulation of flow through the hood system
- **Demand Control Ventilation Function Test** – Detection of contaminants and flow modulation

**Know the Flow™ • Prove the Flow™ • Maintain the Flow**



Copyright © 2025



35

## Thank You!



### Questions



Thomas C. Smith  
919-319-4290  
tcsmith@3flow.com  
www.3flow.com

**Know the Flow™ – Prove the Flow™ – Manage the Flow™**



Copyright © 2025



36