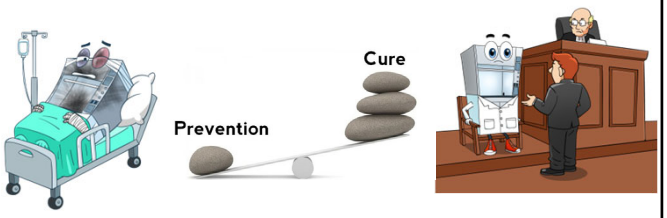
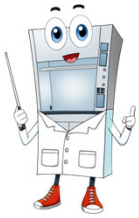
Workshop: Validating Fume Hood Safety and Mitigating Risk

Sun May 11, 2:30 PM - 4:30 PM



Fume Hoods 101: What Architects Need to Know







Since 1980



When people hear "fume hood," they often think it's just a box with an exhaust fan.

In reality, a fume hood is a carefully engineered **containment device** — designed to capture, contain, dilute and exhaust hazardous vapors, gases, and particulates **before** they can enter the room.

ECD- Exposure Control Device



•How many of you have ever been asked about fume hood performance during a project?

•Who here has actually *seen* a fume hood being tested?
(face velocity, containment, tracer gas testing, anything.)

Knowledge is Power



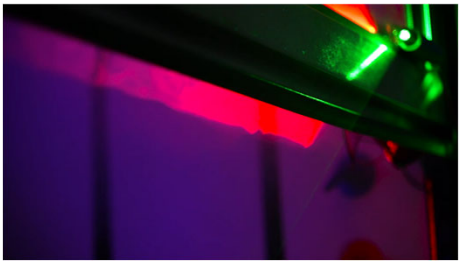
- Laboratories = High-risk environments
- Fume Hoods are standalone, they are the user interface to the mechanical system
- Fume hood failures = Serious accidents, lawsuits, reputational harm, substantial cost
- False sense of security: Face velocity ≠ containment
- Slower face velocities result in less dilution

Loss of containment is a performance failure

Many Things Look Like Fume Hoods but Are Not



Turbulence causes the hood to become unstable and results in loss of containment.



Types of Hoods and Exhaust Devices

- Conventional (Constant Volume) Hoods
- Variable Air Volume (VAV) Hoods
- High-Performance Fume Hoods
- Specialty Hoods (Radioisotope, Perchloric Acid, Acid Digestion)
- Snorkels, Laminar Flow Hoods

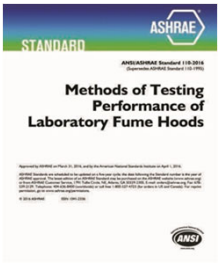
Containment is Dynamic

- Building HVAC influence
- User behavior influence
- Room disturbances (doors, vents, walkways)
- Equipment blocking airflow

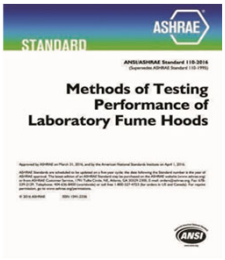
Containment Matters Regardless of Face Velocity

Understanding ASHRAE 110

- Is not a Pass/Fail Standard
- Is not a measure of safety
- Snapshot in time testing
- Simulated conditions, not real-life conditions



ASHRAE110 is a testing protocol, not a safety standard



This standard defines a reproducible method of testing laboratory hoods. It does not define safe procedures. However, laboratory hoods are considered by many to be the primary safety devices in conducting laboratory operations.

There are many important factors in the safe operation of laboratory hoods that are not described in this standard.

More Considerations

- In summary, there are many factors to consider in evaluating the performance of a laboratory hood installation. This standard provides one tool in evaluating such safety
- The procedure is a performance test method and does not constitute a performance specification.
- The desired hood performance should be defined through the cooperative efforts of the user, the chemical hygiene officer, the applications engineer, and other parties affected by the hood performance. It should be noted that the performance test method does not give a direct correlation between testing with a tracer gas and operator exposures.
- The performance test method does, however, give a relative and quantitative determination of the efficiency of the hood containment under a set of specific, although arbitrary, conditions. The same test can be used to evaluate hoods in manufacturer facilities under (presumably) ideal conditions or under some specified condition of room air supply or during the commissioning of a new or renovated laboratory before the user has occupied the laboratory

Meaningful Excerpts

- ANSI/ASHRAE 110 may be used in the laboratory as an accepted test with specific values for the control levels (and the release rate if you depart from the standard). It also may be used for routine periodic testing, but it is somewhat expensive and other less rigorous tests may be adequate if conditions have not changed since commissioning tests.
- The test data should be available from the manufacturer for each specific model and type of hood so a potential buyer to assist with design specifications or compare one manufacturer's hood containment against another.
- Values for control level may not be suitable for establishing hood safety, as the tracer gas test methods may not adequately simulate actual material use, risk, or generation characteristics. In addition, the tracer gas test does not simulate a live operator, who may increase potential for escape due to operator size, movements near the hood opening, or improper hood use.

Test Protocol Details

- The full test procedure (visualization, face velocity, and tracer gas) is a quantitative measurement of a hood's containment ability and is useful for hood development and rigorous evaluation of hood performance.
- This standard does not constitute an engineering investigation of what the causes may be for poor performance or of ways to improve the performance.
- This standard defines a reproducible method of testing laboratory hoods. It does not define safe procedures. However, laboratory hoods are considered by many to be the primary safety devices in conducting laboratory operations

More on tracer gas

- Hood containment should be evaluated at different mannequin heights to represent workers of different height. AM 0.05 can be achieved with a properly designed laboratory fume hood. It should not be implied that this exposure level is safe. Safe exposure levels are application specific and should be evaluated by properly trained personnel (SEFA 1-2010, Recommended Practices for Laboratory Fume Hoods).
- The tracer gas, Sulfur Hexafluoride (SF6), typically used during ANSI/ASHRAE 110 fume hood performance tests has been identified as a very potent Green House Gas (GHG). Generation of SF6 is discouraged and banned in some locations requiring specification and use of alternative tracers. ASHRAE has undertaken an investigation to evaluate alternative tracers but have not approved a more environmentally friendly replacement of SF6. Where SF6 tests are discouraged or banned, alternative methods can be utilized where approved by the owner, responsible person and the design team.

It is important to evaluate the performance of the laboratory hood under dynamic conditions. This performance test method may be modified to evaluate a dynamic challenge.

Specific operations, such as a pedestrian walking past the hood, laboratory doors opening, and specific actions at the hood, are only a few of the challenges that could be expected at the hood.

This test method addresses only the dynamic challenge of sash movement.

VAV hoods place a significant emphasis on the sash movement and the potential effect on hood performance. However, some constant-volume hoods may also experience a decrease in protection when the sash is moved.

Face Velocity ≠ Containment

- 80–100 fpm typical target
- Passing face velocity doesn't guarantee safe containment
- High-performance hoods operate at lower velocities (~60 fpm)

If a hood is losing containment, it is failing

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Key Takeaway

- The fume hood isn't an appliance — it's part of a system.
- (Hood Design + Lab Design + Room airflow + User behavior = Containment success)

When a Fume Hood Fails



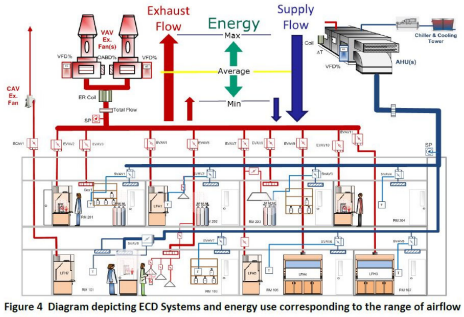


Figure 4 Diagram depicting ECD Systems and energy use corresponding to the range of airflow modulation.

For a fume hood to work properly, you have to look at all these factors



Fume Hood Design

Lab Design /User Work Practices

Laboratory Ventilation System

Why do hoods fail to perform Safely?



25% perform poorly due to design issues. Either hood design issues (10%) or lab design issues (15%).

50% perform poorly because of room conditions. Improper balance, VAV lag time, placement of supply air, etc.

25% perform poorly because of user work practices. We have to consider the user part of the laboratory ventilation system.

Unless we address hood performance in a holistic way and address all three of the above factors, we will not optimize fume hood performance and if hoods are not performing safely, not only are wasting money, but you increasing liability

At a large, well-known university, a brand-new science building opened with state-of-the-art labs. The fume hoods installed were high-efficiency, low-flow models, designed to save energy.

On paper, everything looked great — ASHRAE 110 reports looked good, face velocity was in spec, and the system met LEED standards.

Six months later, a graduate student was working with volatile organic solvents inside a hood.

Despite the hood showing "normal" airflow on the monitor, vapors escaped into the lab. An ignition source was nearby — a small explosion occurred.

The student suffered serious burns. Investigations showed:

- The fume hood **failed to contain vapors** due to turbulence at the sash opening.
- Supply air vents were located directly above the fume hood — causing **cross-drafts** that disrupted containment.
- The building management system had been **adjusted** post-occupancy to optimize energy savings, unintentionally reducing exhaust rates.
- The student was **unaware** of how sensitive hood performance could be to these factors.

Containment is Fragile





Velocity does not indicate or predict containment

In fact, over 70% of hoods that perform poorly on a containment test have acceptable face velocities

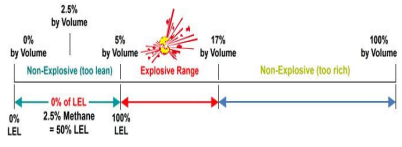
To move from theory into reality, I want to walk you through a real-world fume hood failure.

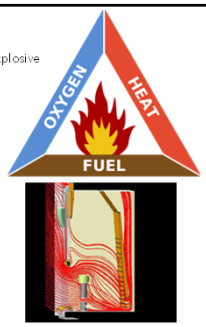
This isn't just about mechanical systems — it's about how small decisions, missed warnings, and lack of coordination can lead to devastating consequences.

Lower Explosion Limit

Small quantities of chemicals can pollute the air and create an explosive atmosphere, potentially in the vortex of a hood.

Methane - LEL: 5% by volume in Air / UEL: 17% by volume in Air





Question:

- Does your client have a plan for retesting hoods periodically or after system changes?
- If not, your design might be setting up future risks without you realizing it.

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A different kind of containment

Fume hoods can also provide passive protection from physical threats.

The sash is a **"safety shield"** - a barrier between the user and the hazards

The sash protects users from hazards such as:

- Chemical splashes
- Sprays
- Runaway experiments
- Small fires
- Minor explosions

If you are hood user, the sash is your best friend!

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Failure to properly select, design, operate, use and maintain ECD systems may:

- Increase the potential for unacceptable impact on the **health of people**
- Increase the potential for **harm to the environment**
- Increase the potential for **premature degradation of the fume hood and equipment**
- Increase the potential for the **loss of productivity and operational efficiency**
- Increase the potential to have **lab work/results compromised** by contamination
- Increase **unnecessary energy consumption** and **operating costs**
- Increase the **risk of non-conformance with regulatory and industry standards**
- Increase the **risk of liability**

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Lessons Learned
From this failure, several critical lessons emerge:

1. Inadequate Testing
•Testing needs to go beyond initial ASHRAE 110.
•**Commissioning must validate containment** with full building airflow in operation.
•Changes to building systems should **trigger retesting**.

2. Poor User Training
•Lab users often assume "the hood will protect me" without understanding how airflow and sash use affect performance.
•**Training must emphasize that hoods are containment tools, not magic shields.**

3. Misaligned Expectations Between Design and Operations
•Architects, engineers, contractors, and owners often treat fume hoods as static equipment.
•But they must be seen as **dynamic systems** — affected by building pressure changes, occupancy, retrofits, and even furniture placement.

•**Question:**
- "Does your client have a plan for retesting hoods periodically or after system changes?"
- If not, your design might be setting up future risks without realizing it.

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If there was an accident and it make it to a jury trial, which of these would you rather have?

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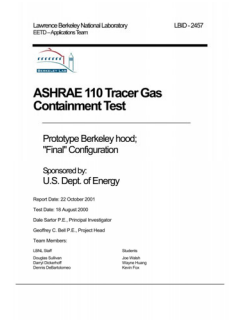

Lawrence Berkeley National Laboratory LBID - 2457
IEETD--Applications Team

ASHRAE 110 Tracer Gas Containment Test

Prototype Berkeley hood;
"Final" Configuration

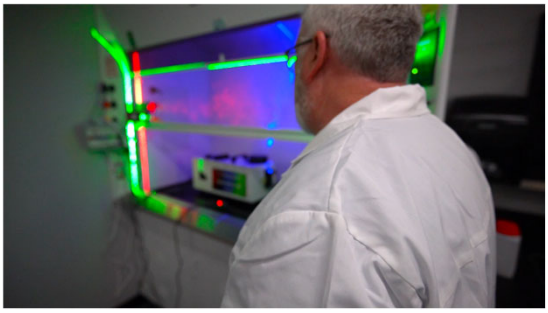
Sponsored by:
U.S. Dept. of Energy

Report Date: 22 October 2001
Test Date: 18 August 2000
Dale Sartor P.E., Principal Investigator
Geoffrey C. Bell P.E., Project Head
Team Members:

LBNL Staff
Douglas Sullivan
Darryl Dickerhoff
Dennis DeBaldelomero

Students
Joe Webb
Wayne Huang
Kevin Fox

A formal, printed report



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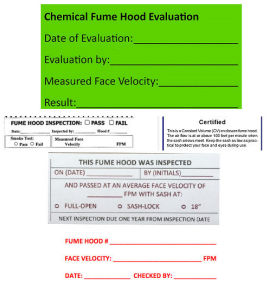
Chemical Fume Hood Evaluation

Date of Evaluation:_____

Evaluation by:_____

Measured Face Velocity:_____

Result:_____

FUME HOOD INSPECTION: ☐ PASS ☐ FAIL

Item _____ Inspected by _____ Room# _____

Smoke Test: ○ Pass ○ Fail

Measured Face Velocity _____ FPM

Certified

This is a Constant Volume (CV) enclosure fume hood. The air flow is at or above 100 feet per minute when the sash is in the operating position. Do not block the bypass. Visit ALWAYS for Safe and Work Activity Level.

THIS FUME HOOD WAS INSPECTED

ON (DATE)_____ BY (INITIALS)_____

AND PASSED AT AN AVERAGE FACE VELOCITY OF _____ FPM WITH SASH AT:

○ FULL-OPEN ○ SASH-LOCK ○ 18"

NEXT INSPECTION DUE ONE YEAR FROM INSPECTION DATE

FUME HOOD # _____

FACE VELOCITY: _____ FPM

DATE: _____ CHECKED BY: _____

Safety Stickers

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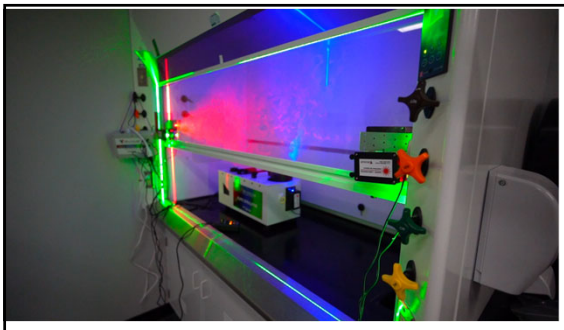

Actual Video Evidence

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The Architect's Risk Profile

How Design Decisions Create Legal Exposure



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As architects, you know you carry liability for life safety — but in laboratories, that risk profile grows exponentially.



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Let's be clear:

•If you specify the wrong type of fume hood for the application

•If your layout contributes to airflow disruptions

•If your documents don't clearly define testing, commissioning, or revalidation requirements

•Or if performance expectations aren't documented properly

You can be named in lawsuits if there is a lab accident involving exposure, injury, fire, or death.

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You don't have to be *solely* responsible to be *held liable*. Joint and several liability applies — meaning you can be pulled into major legal settlements even if others (engineers, contractors, owner) also share blame.

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Common Legal Arguments Against Architects:

•"You designed an unsafe lab environment."

•"You failed to specify proper safety validation."

•"You did not ensure systems matched operational needs."

•"You left risk unaddressed between design and operations."

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This creates a **huge gap** between **what they think they are buying** and **what actually gets delivered**.

If you don't spell out the performance verification, acceptance testing, and maintenance expectations **in writing**, you are setting yourself up for claims later — especially after an accident.

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Owner Expectations vs. Delivered Performance

Owners often assume:

•That the fume hood "works" if it's installed.
•That code compliance means performance safety.
•That architects and engineers have verified operational safety, not just design compliance.
But here's the reality:
•Building codes focus on *minimum life safety*, not chemical containment performance.
•Owners are often **never taught** how fragile fume hood containment is.
•Most owners do not request or budget for full ASHRAE 110 containment testing or periodic retesting.

Owner Expectations vs. Delivered Performance

Owners assume:

- Installed = Safe
- Code compliant = Operationally safe
- Reality:
- Building code ≠ containment
- Gaps in performance expectations

Your Design Decisions = Legal Exposure

- Wrong hood specified
- Layout impacts fume hood performance
- Missing commissioning/testing requirements
- Duty of care: jointly liable even if others share blame

Best Practice: Clear Specification Language

Include In Your Specification:
- Dynamic containment testing
- Fully operational HVAC during testing
- Commissioning documentation
- Periodic revalidation
- Training requirements
- Record Keeping

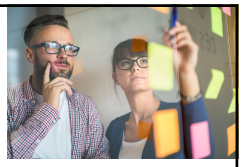
Common Legal Arguments Against Architects

- Unsafe lab design alleged
- Performance not validated
- Operational needs not met
- Risks unaddressed in design documents

Quick Discussion

- What are architects specifying?
  - ?
- What should they be specifying?
  - Dynamic containment
  - Commissioning standards
  - Coordination
  - Record Keeping
  - User education

Let's do a quick exercise!



I'm handing out a sample fume hood specification, take 2 minutes to skim through it.

Your task: Identify what's missing

- ☑ Containment performance specified?
- ☑ Testing method defined beyond face velocity?
- ☑ Room airflow disturbance control addressed?
- ☑ Revalidation requirements stated?
- ☑ User training mentioned?
- ☑ Clear acceptance criteria provided?

Key Takeaway

- Every word you write — or omit — either manages risk or creates it.
- Push toward validated, documented, defensible systems.

Architects must move beyond simply providing systems that "comply" and push toward systems that are **validated, documented, and defensible**.

Mini-Exercise: Spot the Risks

- Skim the sample spec
- Identify what's missing:
- Containment performance?
- Testing method?
- Revalidation?
- User training?
- Acceptance criteria?

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Group Discussion

- What gaps did you find?
- Would this spec protect the architect after an accident?

Validating Performance in the Real World

- How to know a fume hood is really safe — not just compliant.



Earlier we discussed that installed equipment doesn't automatically guarantee safety.
Now we shift to **how performance is validated** — how you can know if a fume hood is truly containing hazards in the real world, not just on paper.
We'll look at standard industry testing methods, show you some real-world containment behavior, and engage you in making some judgment calls yourself.

ASHRAE 110 is *very useful* — but it's **a controlled test under ideal conditions**. It is a static snapshoot under prescribed conditions.

In the real world, room disturbances, poor maintenance, or bad user practices can cause even a well-tested hood to fail.

Introduction: Why Validate?

- Installed ≠ Safe
- Real-world conditions and behavior matters more than design specs.

Key Point

- ASHRAE 110 is essential, but not enough to guarantee real-world containment.
- And to be useful it has to be properly specified

Testing Overview: ASHRAE 110

While ASHRAE 110 is a well-established testing protocol, it does little to ensure safety. Coupled with Z9.5 "Laboratory Ventilation" There are some result recommendations.

While 110 is a useful tool, it is only one of the tools in performance evaluation.

It is very common when 110 is mentioned in a specification it is refenced incorrectly since there is no pass/fail criteria.

In general, 110 is highlighting turbulence.



How many people work at an empty hood in an unoccupied building? Not very realistic.

Laser Airflow Visualizer

- Real-time visualization of airflow behavior
- Colored beams highlight turbulence and containment breaches
- Great for diagnosis, training, and repair validation
- The dynamic challenges are everyday real-world conditions
- Results are highly visible, more dramatic than numbers on paper
- Results are documented with video for future reference

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Design Strategies That Make Hoods More Robust



What can we do?

- Architectural decisions that improve fume hood performance.

Key Takeaway

- If you wouldn't trust standing in front of that hood, don't approve it for others.

Introduction

- Containment success begins with design.
- Small choices → Big impact on safety.

Do's and Don'ts: Hood Placement

- Place on low-traffic walls
- Leave 12–18" side clearance between hoods
- Avoid air disturbance zones
- Don't place across from doors or heavy traffic.

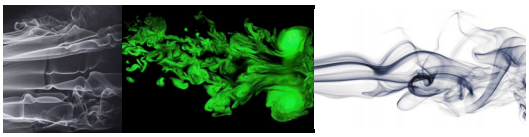
Do's and Don'ts: Avoiding Cross-Drafts

- Diffusers pointing away from hoods, no high velocity diffusers
- Maintain slight negative pressure in room
- Coordinate room airflow balance
- No supply vents near hood face.

Do's and Don'ts: Sash Positioning

- Use vertical sashes, when possible, avoid combo sashes
- Include sash stops
- Automate sash closing if feasible
- Don't assume users will lower sashes manually.

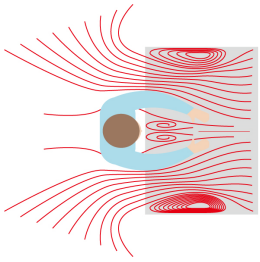
Air is a fluid and follows the laws of fluid dynamics, while water flows downhill, air flows from high pressure to low pressure areas



Do's and Don'ts: Exhaust Routing

- Short, direct exhaust ducts no 90 degree turns
- Be aware of duct velocity and duct noise
- Dedicated exhausts for incompatibles
- Coordinate with MEP early
- Don't overcomplicate duct runs.

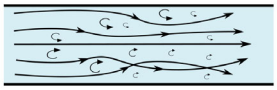
Turbulence is the number one cause of loss of containment



Turbulence



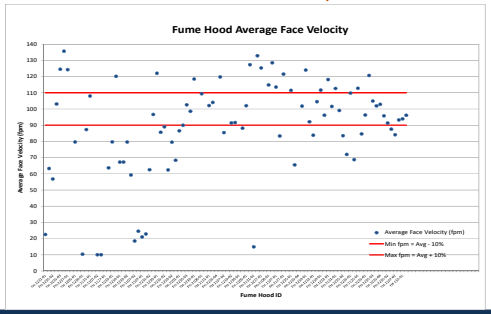
turbulent flow







Fume Hood Face Velocity Tests



Fume Hood "A"

Half/Design Opening				
59	104	88	114	60
52	92	74	102	56

Average Face Velocity: 80

Fume Hood "B"

Half/Design Opening				
80	82	84	82	82
79	81	76	79	78

Average Face Velocity: 80

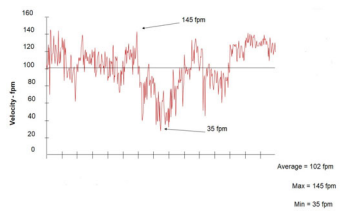
Hood "A", the airflow is very turbulent and would likely fail containment testing.

Whereas "B", is much more laminar and will have more robust containment.

What design actions have you taken to improve fume hood performance?

Why a hood with adequate face velocity could still have unsafe loss of containment.

It isn't about face velocity, there are many reasons that a hood could have an acceptable velocity but still not be performing safely.



Reinforcing Good Practices

Examples:

- Hood orientation
- Auto sash closers
- Airflow zoning
- HVAC integration early in design

Key Takeaway

- Good lab design = Proactive containment engineering.
- Design choices make hoods perform better and protect everyone.

Key Takeaway 1



- Design for performance, not just code compliance.
- Real-world containment > Minimum standards.

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Key Takeaway 2

- Insist on real validation, not just a sticker
- Tracer gas
- Smoke visualization
- Dynamic commissioning



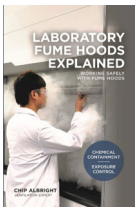
Recap & Open Floor Q&A

Key Takeaway 3

- Partner with testing professionals early.
- Early input = Fewer surprises, safer labs, lower liability.

Handout Details

- 10 Questions Every Architect Should Ask About Fume Hood Safety

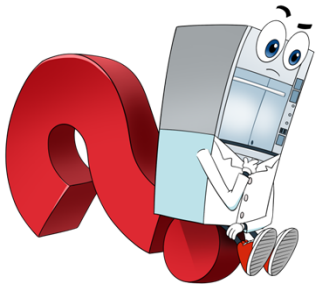


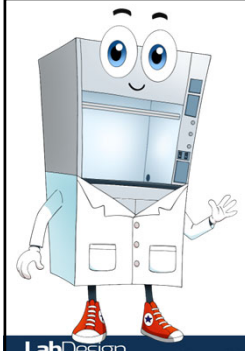
We converted the book…

No, not into a movie, which would be cool,
but into a **free** online course

Check it out, we want everyone who is a fume hood stakeholder to have access to this information.

fumehoodonlinecourse.com





Thank you for your time and attention!

Any Questions?

Slides, videos, and other references can be downloaded at

www.fumehoodcertified.com/ldc2025

Final Closing Thought

- Every lab you help design is a chance to save lives, protect discoveries, and advance science safely.
- Thank you for designing smarter, safer spaces.

Making Labs Safer One Fume Hood at a Time



Chip Albright
Founder and President
Fume Hood Certified, LLC

chip@fumehoodcertified.com



Fume Hood Certified, LLC
PO Box 71477
Phoenix, AZ 85050 USA
+1 (623) 562 - 0907
www.fumehoodcertified.com

www.tricolorlasertesting.com
www.fumehoodtesterscatalog.com
www.fumehoodperformance.com