Fume Hood Design for the 21st Century: Workshop Report

At the beginning of the 21st Century, laboratory design practices have emerged that place new demands on laboratory ventilation systems and more specifically, on fume hood design. **Evolving laboratory chemistries and technologies** (such as nanoscale work, genetic engineering, and 3-D printers), **open plan laboratories**, **automated ventilation control technologies**, and **concerns about facility energy costs** have all impacted fume hood design and operation. These changes mean that institutions that host laboratories are reevaluating their expectations for design, performance, testing and usability criteria for their fume hoods. These expectations are often expressed as **institutional design standards**. The goal of these standards are to assure that a prudent balance of 1) protecting worker safety and health and 2) providing and operating a flexible and sustainable facility is achieved in new and renovated laboratories.

To support institutions in identifying elements that should be included in these design standards, a one-day workshop was held on October 29, 2014 to discuss emerging fume hood design. The focus of the workshop was to **describe key questions** that an institution should consider in developing fume hood design standard and performance testing requirements as well as to **identify potential answers** to these questions. The information collected from the discussions is intended to help a design team identify what issues need to be addressed in programming, planning, designing and commissioning a lab project that includes fume hoods.

Workshop Background

Four organizations partnered to organize the workshop:

- the American Chemical Society's Division of Chemical Health and Safety
- the New England Chapter of the International Institute for Sustainable Laboratories
- the Campus Consortium for Environmental Excellence
- the Campus Safety, Health and Environmental Management Association

The primary organizers for this workshop were Ralph Stuart and Ellen Sweet, on behalf of the ACS Division of Chemical Health and Safety, and Pam Greenley on behalf of the New England Chapter of the International Institute for Sustainable Laboratories. The Workshop was co-sponsored by 5 organizations:

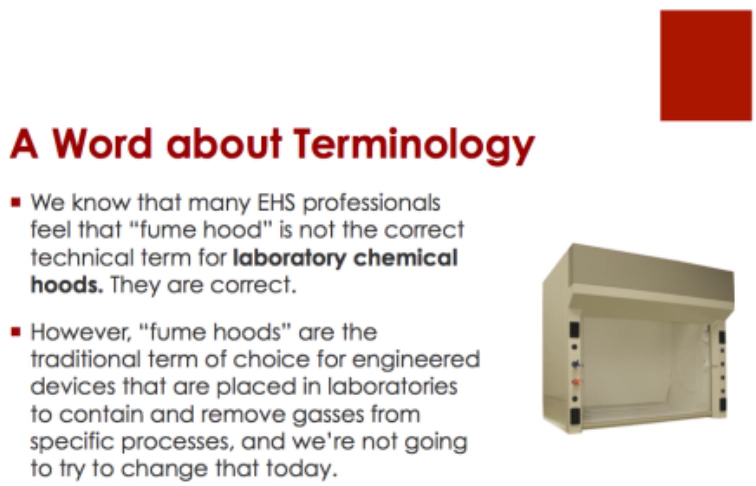
DCHAS	**Kewaunee Scientific Corporation**
Safety Stratus	**Lab Crafters, Inc.**
New England Lab	

In attendance were 32 people from 28 institutions, companies or government agencies, with a diverse mix of Environmental Health and Safety staff, laboratory designers, architects, engineers, hood certification experts, and hood manufacturers attending. The institutions and organizations participating in the workshop were a mix of large, medium and small entities. This diversity of perspectives made for robust discussions during the workshop.

Workshop Structure

The workshop was structured to identify **key questions** that an institution should consider in developing a **fume hood design standard** and provide **potential strategies for answering those questions**. The workshop topics were chosen to address **cutting edge issues** that are not currently well documented in the literature; these topics build on fundamental information that is contained in a variety of resources (see below). We recognize many fume hood design questions are related to larger laboratory ventilation issues at the macro- and meso- scales. These considerations were included as they directly impact fume hood design questions.

In developing the workshop, the goal was to provide extensive opportunities for the participants to share ideas, experiences, and concerns from their perspectives. The workshop planning committee identified four key topics related to fume hoods that would be foci of discussion. These were:



- **Construction and Maintainability**
- **Specifying Design and Operating Parameters**
- **Laboratory Hood Test Methods**
- **Usability Considerations**

Information Resources

During the preparation for this workshop, key public resources about the issues to be discussed were identified. These are listed below.

Non-Commercial Sources

- **USA EPA**
  - EPA Performance Requirements for Lab Fume Hoods
- **National Institutes of Health**
  - A Review of Published Quantitative Experimental Studies on Factors Affecting Laboratory Fume Hood Performance
  - NIH Design Requirements Manual
- **Public Works and Government Services Canada**
  - Laboratory Fume Hoods: Guidelines for Building Owners, Design Professionals, and Maintenance Personnel; April 2013
- **UC Center for Laboratory Safety**
  - Chemical Fume Hood and Laboratory Ventilation: Operation, Design and Performance Testing, 2013

Commercial Guidelines

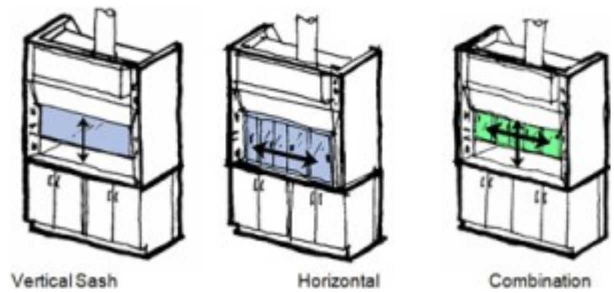
- TSI Laboratory Design Handbook
- Siemens Laboratory Solutions
- A Guide to Fume Hood Codes and Standards

Questions about this report can be addressed to Ralph Stuart at secretary@dchas.org or to the moderators of the discussion sections identified on each report page.

Construction and Maintainability

The first step in understanding what the design goals for fume hoods are is to conduct a **risk assessment** of the processes that need to be controlled. Design options include:

- The type of ventilated enclosure to be specified
- Appropriate functions and associated options to be asked of the equipment (adjustable baffles, automatic sash closure, sash style (vertical/horizontal/combination sash), HEPA filtration)
- Specific monitoring protocols for assessing equipment performance
- Other accessories to be provided (sinks, gases, shelves, rod lattice systems)



from Renovating Research Laboratories for Zero Carbon by 2030

Discussion led by Greg Muth
President, I2SL,
New England Chapter

Discussion Questions

Prudent selection of appropriate local ventilation devices requires a risk assessment of the work to be done in the space being designed. Unfortunately, the information required to fully develop such an assessment may not be available as plans for facility construction or renovation proceed. In this context, it is important to have an informed discussion between the various stakeholders in a laboratory project. Questions to be considered include:

1. What are the required internal and external materials of construction (stainless, PVC, FRP, cement board, etc.)?
2. How should sashes be constructed (options include framed, not framed, horizontal, vertical or combination)?
3. How important are airfoil sills to the aerodynamic design?
4. Should baffles be adjustable, fixed or automated?

5. Should automatic sash closure devices be installed and what are the desirable attributes? Do they really save enough money to justify the cost of installation, maintenance and training?
6. What is the purpose of the bypass and how much bypass is required to minimize velocities, ensure hood static pressure, and promote dilution within the hood?
7. Where should use feedback mechanisms such as face velocity monitors and signage be located?
8. How bright should the lights be and how can they be accessed to replace bulbs without entering the hood?
9. What is the best outlet collar: square, rectangular or round?
10. What is the necessary duct transport velocity and internal airflow patterns required to minimize accumulation and deposition of materials within the hood or duct?
11. Where should sinks and faucets be located, if they are necessary?
12. Can shelves be used in hoods and if so, how should they be designed and how might they affect hood performance?

Discussion by Small Group Participants

The group discussed a number of topics related to Construction and Maintainability. Key topics that arose and thoughts collected relative to them are enumerated below.

Materials of Construction

- Should have a 20-50 year life cycle
- Exterior: Powder coated steel; Specialty Hoods may require polypropylene or stainless steel
- Must be suitable for widest range of applications
- Interior should have the following characteristics:

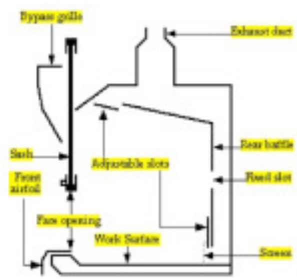
Work Surface	Liners	Sash
○ Epoxy Resin ○ Stainless Steel ○ Polypropylene ○ Phenolic Resin	○ Fiberglass Reinforced Polyester (FRP) ○ Epoxy Resin ○ Stainless Steel ○ Polypropylene ○ Powder Coated Steel ○ Phenolic Resin	○ Laminated Safety Glass ○ Tempered Glass ○ Lexan

- UL 1805 Certification
- Tests for chemical resistance, flame spread smoke generation, etc.

Fume Hood Components

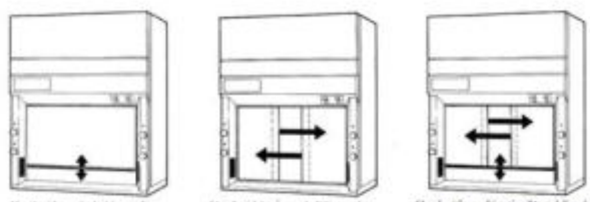
Materials

- •Liner Material
- •Work Surface
- •Duct Collar
- •Distillation Racks



Sashes - Ergonomics and Safety

- **Combination Sash**
    - Use of horizontal panels as safety shield is impacted by the width of panel
    - High and low access to the workspace is necessary
    - For all sash types, it is important to train users on expected sash use
    - Some uses require an extra height vision panel



Hood with vertical-rising sash — *Hood with horizontal-sliding sashes* — *Hood with combination "A-style" sash*

Source: Labconco, Inc.

- **Cost Implications of Combination Sashes**
    - o Premium for sash
    - o Additional horizontal sensors for VAV controls
    - o Additional sash positions for testing & balancing
- **Sash Drive Mechanism Options to Consider**
    - ▪ Cable & pulley
    - ▪ Chain & sprocket
    - ▪ Belt
    - ▪ Sash stop 18 inches (as opposed to 16 or 12 inches, etc.)
    - ▪ Auto sash return
    - ▪ Administrative controls and training
    - o Air foils should be required on all hoods
    - o Ergonomics is a secondary design consideration, but critical in its impact on how the hood is used

Electric Cord Management Options

- Flip foil
- Post pass through

Service Access

- Front Panel controls
- Interior access panels (gaskets are a problem in corrosive atmospheres)
- Use of front-load plumbing valves

Baffle Adjustment

- Users should not be expected to adjust baffles to maintain containment; design must not rely on user adjustment.
- The degree of baffle adjustment available may be manufacturer specific, so these should be designated in the hood specifications if they are to be operated by the hood user.

Automatic Sash Closers

- There are financial cost/payback questions around these devices.
- When used, they require safety features to prevent closure on objects and training for users.
- User acceptance is key to successful use of these systems.
- The cost savings are conditional based on the type of VAV system, hood density, etc.
- This may not be needed if an effective sash management training program exists.

Bypass

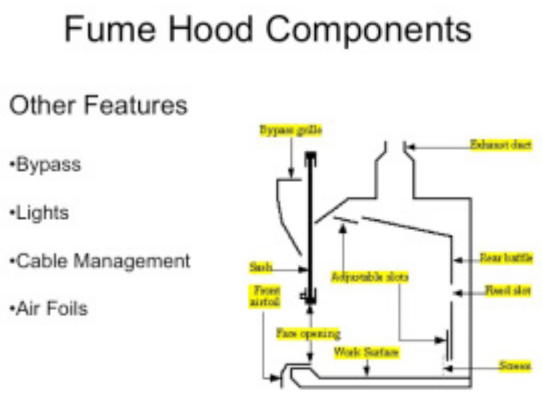
- In Constant Air Volume hoods, the bypass reduces increase in face velocity as sash is closed.
- Typical design target is that face velocity shall not increase more than 2.5 to 3.5X from velocity at full open sash (i.e. up to 250 FPM to 300 FPM)
- In Variable Air Volume hoods, the bypass area is based on minimum setback flow controls; bypass should not be a factor until sash closes to point where minimum flow is reached.

Face Velocity Monitors Location

- Place at 48" from the floor.
- Digital or analog monitors should be specified as part of the hood standard.
- Should purge buttons be provided? The effectiveness of purge for containing spills is questionable.

User Instruction Signage Options

- On front panel
- On sash glass



Hood Lights

- Must be accessible from outside the hood for maintenance purposes
- 80 foot-candles average at the work surface
- T8, T5 bulbs or LED are the most energy efficient

Duct and Duct Velocity Considerations

- For the collar connection, a Bell Mouth is preferred
- Round ducts are best if space on hood roof allows
- Rectangular ducts are possible if space considerations on the roof or to match the plenum behind baffle make them necessary
- If non-round duct is provided, then the manufacturer should provide transition piece to round
- Duct Velocity requirements can be found in the current ACGIH Industrial Ventilation Manual

Sinks

- Should only be provided when specific use is identified
- A cup sink have berms to prevent a spill going down the drain
- An alternative is to wall mount cup sinks
- Sink location is user preference; typical location is at hood rear

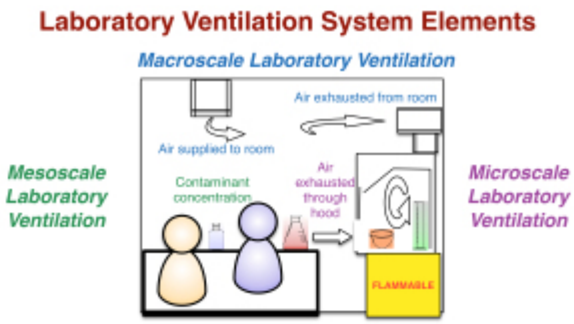
Shelves

- Must be designed to not disturb airflow patterns in hood chamber
- Shelf designs should be validated through performance testing

Specifying Design and Operating Parameters

Once a fume hood has been determined to be the appropriate ventilated enclosure to install in a laboratory, defining the operating parameters for it must include consideration of how the performance of the fume hood is impacted by the physical environment it is located in. Key questions to be answered in this area:

- Where in the room should the hood be placed?
- Where are supply and exhaust diffusers to be located relative to the hood?
- What is the proper minimum face velocity?
- What should the design operating sash height be?
- What are acceptable ranges and tolerances for operation of the flow monitors, static pressure, face velocity, VAV controls response time?



Ventilation Scale	Parameters of Interest
Macroscale (building-wide air movement)	Amount of air delivered and exhausted from each room; relative pressurization between labs and other spaces
Mesoscale (general room air movement)	Decay rate of the concentration of air contaminants in occupied spaces
Microscale (air flow requirements for specific equipment)	Chemical hood face velocity; pressurization of storage cabinets

Discussion led by Jim Coogan, Siemens

An **effective fume hood contains gases released inside the hood** in order to protect the worker and the laboratory environment. It also removes those gases through the exhaust system to be dispersed from the building, preventing high concentrations in the hood. These containment and removal functions are described by a set of operating parameters. The primary operating parameters are:

- **exhaust flow rate**
- **open area of the hood**

- **average face velocity**

The **fume hood operating specification** establishes values and ranges for the primary parameters, as well as other relevant quantities, both in steady state operation and in changing situations. The work to establish those values includes defining the relationships among the physical parameters and their effect on the functions of containment and removal. It also includes considering proper and improper use cases; both types of these can be expected to occur.

Questions to be addressed in this section include:

- What is the required average face velocity and allowable range of variation, from the average of the readings and across the face of the hood (uniformity)?
- Are specifications required for spatial and temporal (turbulent) variations of face velocity at the plane of the sash?
- What defines the plane of the sash?
- What is the maximum allowable cross draft velocity and is the direction and angle of incidence of concern (horizontal, vertical, perpendicular)?
- What is the minimum flow when the sash is closed?
- What is the maximum inlet face velocity when the sash is nearly closed?
- What is the required hood static pressure (max and min)?
- What is minimum VAV response time and how is it defined?
- Is the stability of flow at a fixed opening important and what is the right metric (Coefficient of variation?)
- What are the containment criteria and should it be associated with generation rate and the dilution factor (i.e. internal concentration versus external concentration)?
- How is smoke containment and airflow patterns observed and rated?
- What is the required tolerance for accuracy and precision of hood monitors?

Key take home points from the discussion are:

Start with the users of the hood

- What is needed in the work station? What size enclosure and openings will allow adequate access to the work area while maintaining chemical containment?
- Hood makers can work with performance specifications more usefully than a specific face velocity requirement. As an example, a specification of a ppm measurement relative to the ASHRAE containment test provides more specific guidance to lab designers. Is 0.01 ppm release acceptable? 0.05? What's behind determining this value?

- The design plans should include an **airflow budget** for the room as a whole.
    - Who would use such a budget?
    - The HVAC designer wants the number to appropriately size ventilation equipment.
    - The commissioning agents and operating staff of the facility also need to understand the design parameters to be implemented after the laboratory is built.
- Some renovation jobs go that way; others use an airflow budget or cap, not a set value.
- How sensitive is the **ASHRAE 110** test to spatial details of the test?
    - Would we need a containment test on each hood?
    - If this is to be done that way at commissioning, follow with face velocity tests later.
    - **Ways that a hood is likely to fail a containment test should be identified and corrective actions addressed as part of the design plan**. This is a key element in determining whether lower flow hoods can be used in a particular laboratory.
    - Specifications for the test can be both as manufactured (AM) and as installed (AI).

Discussion Notes

The group discussed a number of topics related to Specifying Design and Operating Parameters:

Priority of Containment vs. Face Velocity

- Priority Considerations for Control Systems
- Airflow budget (max - affects house exhaust design)
- Ordering of Specification Parameters
- Access dimensions (Width, Height, and Depth)
- Operating sash dimensions (W and H), and configuration
- Containment criterion

ASHRAE 110 (As Manufactured) factory type - testing by width

- ASHRAE 110 (As Installed) (Tracer Gas)
- Limits on room environment
- Cross drafts
- Temperature gradient (Floor to Ceiling)
- No internal heat sources in hood
- Comprehensive Energy Performance

- Automatic sash closers
- User reminders
- Occupancy sensors
- VAV turn-down
- Limit on Static Pressure drop

What is the Acceptable Face Velocity Range Over Face Area?

- Historically this range is plus or minus 20% with the lower the face velocity the tighter
- This requirement becomes critical for High Performance hoods (for example if the face velocity is set for 80 fpm average face velocity design, 75 fpm to 88 fpm is accepted).
- Reminder: some hoods are non-uniform by design

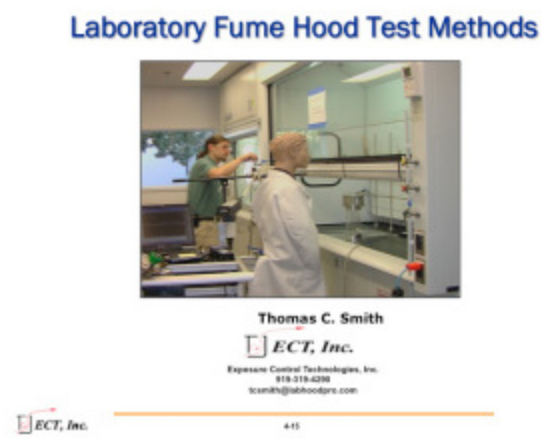
Spatial and Time-Varying Face Velocity

- Exhaust variations are commonly found over minutes, hours, and seasons due to varying electrical voltages
- If the hoods are in a connected battery, moving one sash can affect other hoods
- Room pressure variations can also be significant in impacting face velocities; can this concern be addressed within the Hood Specification?
- Aerodynamic components: what part should be in Mechanical Spec?
- Should flow volume regulation become integral to hood package, by specifying spatial variation
- Relate to the "As Manufactured" test conditions

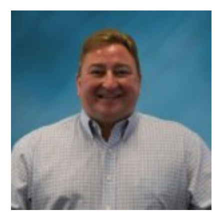
Laboratory Hood Test Methods

Laboratory hoods must be tested to verify proper operation and validate performance over the range of expected operating conditions.

- ***As Manufactured*** tests to evaluate design of the hood itself, regardless of where it is installed
- ***As Installed*** tests verify performance once the hood is installed in the lab to assess how it interacts with other components of the ventilation system
- ***As Used*** tests verify continued performance as the ventilation system and hood age and to capture and repair operation of the equipment outside of acceptable ranges
- Training and certifications of the technicians performing these tests



Group led by Tom Smith
Exposure Controls Technology

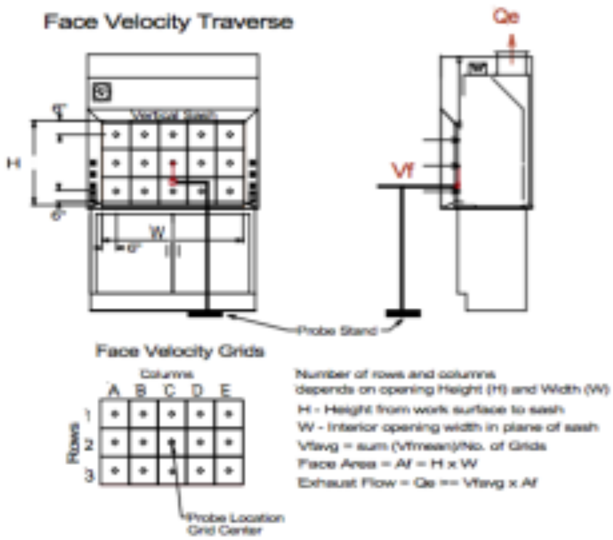


Laboratory hoods must be tested to verify proper operation and validate their performance over the range of expected operating conditions. The tests can be conducted **as manufactured** to evaluate the design of the hood, **as installed** to evaluate the impact of the laboratory environment on hood performance, and **as used** to evaluate the impact of the experimental apparatus on hood performance. The challenge tests generally include measurement of face velocity, cross draft velocity, VAV controls response and stability, visualization of airflow patterns and tracer gas containment tests. The hoods can also be subject to various simulations and dynamic challenges such as equipment loading, pedestrian walk-by, door opening/closing and thermal stratification. This section will review the various test methods and provide guidance on specifying and conducting laboratory hood tests pre-purchase, following installation and during routine tests.

Questions to be addressed include:

1. What tests are required to evaluate the hood as manufactured prior to purchase and installation?
2. What information should be provided to those selecting hoods and designing the systems?
3. What tests are required to conduct during commissioning to validate operation and verify performance prior to occupancy and hood use?
4. What tests are appropriate for routine testing and how often should tests be conducted?
5. What is the difference between As Installed, As Used and routine maintenance tests?
6. Should routine tests include more than face velocity tests, particularly for complex VAV systems?
7. If hood performance can be affected by room conditions, should room conditions be documented and tested during commissioning and routine tests?
8. What test data should be stored for future use?
9. How do you calibrate and verify proper operation of hood monitors?
10. Should hoods be tested as found or under worst-case test scenarios (i.e. all hoods open in a laboratory at maximum flow)?
11. Should hoods be tested while simulating hood loading or walk-bys?
12. Should hoods be tested while modulating room temperature and supply diffuser discharge temperatures from full heating to full cooling and when?
13. Should a performance envelope be developed for all laboratory hoods and provided by the manufacturer to determine the required operating specifications?
14. How does the presence of occupancy sensors in the control system impact testing strategies?
15. How much training, experience or certification is required to qualify people conducting tests?
16. Should hood testers be certified and, if so, by whom?

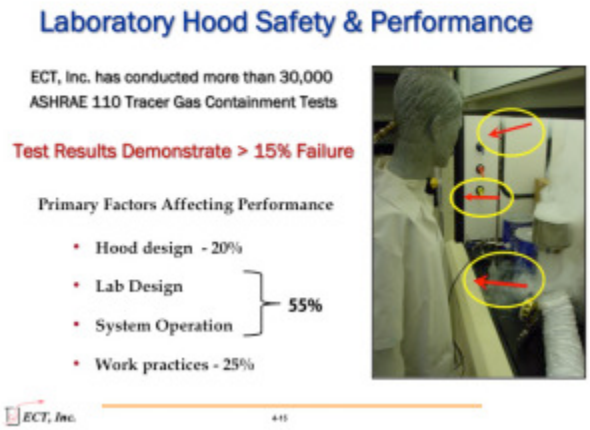
Figure 8. Sample Grid Configurations With Fixed Probe at Center of Traverse Grid



Discussion Notes from Small Group Participants

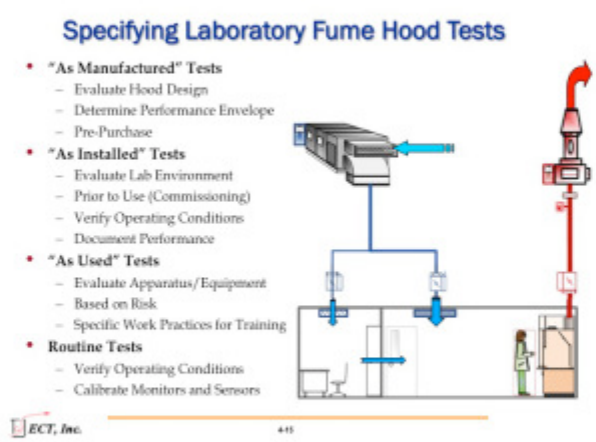
The group discussed a number of topics related to Laboratory Hood Test Methods:

- **Key Questions to Consider:**
  1. What are the objectives of testing?
  2. When to test?
  3. What tests should be conducted?
  4. Test conditions and challenges
  5. Who should conduct tests (what qualifications should they have)?
  6. Interpretation of results: Pass/Fail: uniformity of reporting;
  7. An Important Factor in answering questions is identifying testing that allows a **Reasonable Cost** for this process
- **Objectives**
  1. Containment of what - chemicals, particles, heat, other factors?
  2. Normally this is in terms of chemical/airborne contaminants
  3. Contain, capture, exhaust
  4. Airflow direction and patterns
  5. Dilution of the contaminants is the ultimate strategy in meeting the Key Goal of ***Protecting the user from over exposure***



- **Operating Conditions that affect containment**
  1. Face velocity - magnitude, distribution, turbulence, flow
  2. Sash position, configurations, area, permutations/combinations
  3. Loading - large pieces of equipment, piping lattices
  4. Cross drafts from room air movement
  5. Heat load in the hood
  6. Flow stability, response time after perturbations, total volume flow changes
  7. The Operator: Body Zone is defined by the height and size of body as well as its movement
  8. Differential pressure

- **As Manufactured** testing can provide a Performance Envelope
- **As Installed** means a Commissioning Test in place in the lab
- What does **Representative Sample** mean in practice?



- What tests are appropriate to implement routinely?
  - Routine testing: Can **As Used** testing be used as a Proxy?

- Defining **As Used** can be a complicated process in some labs

Fume Hood Tests and Frequency

Laboratory Fume Hood Performance Test Procedures	AM Tests	AI/AU Tests	Routine
Inspections			
Hood inspection	X	X	X
Laboratory inspection	X	X	X
Exhaust system inspection	X	N/A	N/A
Operating Conditions Tests			
Lab Environment Tests: Lab dP, Room Temp, etc.	X	X	X
Cross-draft velocity tests	X	X	X
Face velocity test	X	X	X
Hood monitor	X (1)	X	X
Exhaust flow and hood static pressure	X	TAB	N/A
Auxiliary air velocity tests	X	X	X
Dynamic VAV response and stability tests	X (1)	X	X
Containment Performance Tests			
Airflow visualization tests (smoke)	X	X	X
Tracer gas containment test (static mannequin)	X	X	N/A
Sash movement effect test	X	X	N/A
Hood Loading	X	N/A (1)	N/A
Other Dynamic Challenges (Thermal, Walk-By Challenge, Room Pressurization, etc.)	X	N/A (1)	N/A

Notes: 1 – If applicable

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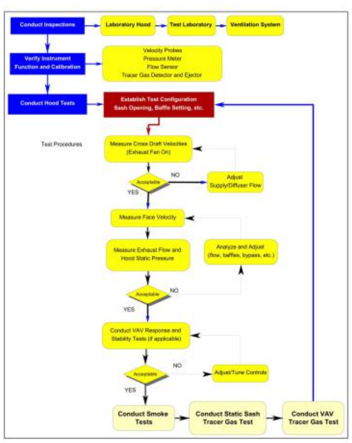
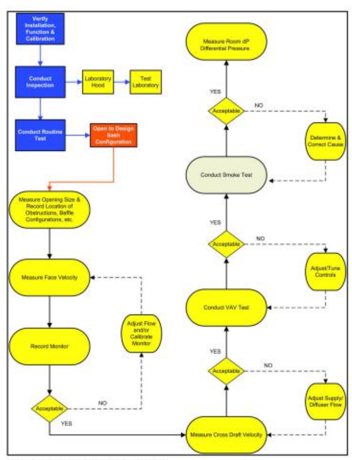


Sequence of Conducting AI Performance Tests



Sequence for Conducting AU Performance Tests

Diagrams from [EPA Performance Requirements for Lab Fume Hoods]

Fume Hood Usability Considerations

The fume hood and other containment devices are part of the ventilation system and the user understanding of how these interact impacts the performance of the hoods in containing airborne contaminants.

- How do the users best understand the protection that fume hoods offer?
- What constitutes improper use of this equipment and what are the consequences?
- How can users identify when the ventilation system is not functioning properly?

Discussion led by Dan Ghidoni,
Northeast Scientific Associates

Fume hood usability, by definition, involves **the actions of the users with the fume hood**, who may or may not have had input during the programming phase of the project. A significant amount of time and design decisions will have occurred before occupancy. Is the deliverable consistent with the intended use? The fume hood is only one component of a system. The building's ventilation system, processes that are enclosed in ventilated equipment and user techniques all contribute to the safety and efficiency of the system. This section will review the use factors affecting fume hood performance.

- Review of types of engineering controls and their types of protection afforded.
- Components of the containment system - engineering controls, air flow systems and controls, user procedures.
- Things that can make the containment system fail.
- Energy and Safety considerations for use and non-use times.
- SOPs for operating equipment

Questions:

1. Is the product delivered consistent with a risk assessment for the work being performed?
2. Are there any equipment stored in the hood that was not anticipated, procedures being performed, or occupancy changes?
3. Have SOPs been established for the procedures using the equipment?

4. Are flow / velocity alarms and sash stops in place and working?
5. Are there ambient conditions that were not considered or that have changed?
6. What limits should be place on the fume hood operation?
7. Should "as used" testing be performed?
8. What factors determine if a combination horizontal/vertical sash or vertical sash best fit the needs of the work being conducted?
9. What is design opening for both configurations?
10. Does the hood provide the researcher adequate visibility to equipment located up high on the monkey bars if this will be the set-up? (sometimes folks just need to view up high and reach only occasionally).
11. What utilities should be directly piped into the hood?
12. What options are there for supplying electricity to the hood??
13. What hood depth is best given the activities that normally take place in the hood?
14. Will the hood be used to store chemicals or wastes awaiting pickup?
15. Will researchers routinely need to reach to the back of the hood both at the work surface and higher?

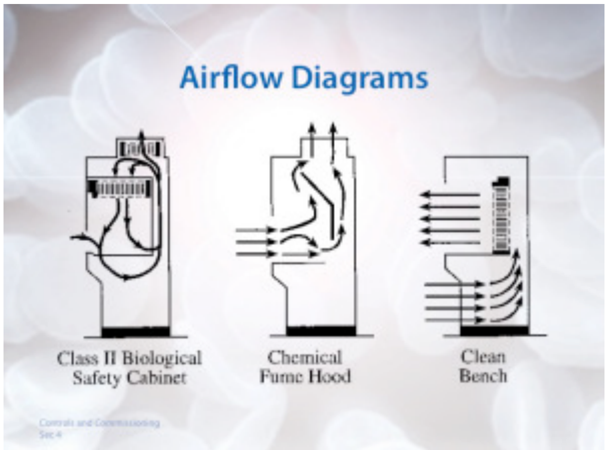
Discussion by Small Group Participants

The group discussed a number of topics related to Usability Considerations:

- The fundamental flow equation of **Flowrate(Q) = Velocity * Area** guides proper use of the hood
    - It is generally safer to reduce Area than Velocity unless Area is so restrictive that hood is routinely used in abuse conditions.
    - Using diversity to allow 1 sash open while the other sash is closed (split sashes) is an important energy conservation strategy.
    - As part of the design process, one should evaluate existing sash practices to determine system diversity.
    - Reviewing Building Management System data to study sash diversity can be a fruitful avenue when one is available.

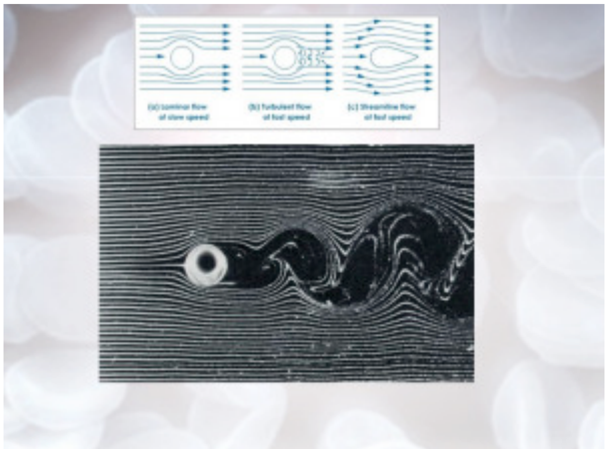
What Type of Hood Is Needed

- How do we communicate diversity and other use restrictions to users?
- Hood alarm (probably not common operating condition)
- Training program
- CFM display
- Signage for the room
- Number of hoods
- Sash restriction mechanisms



Hood Management Communication Mechanisms

- Getting users to close sash is key for both safety and sustainability
- Automated sash closers
- Communicate back to users on their practices and maybe how they compare to their peers (send emails)
- Alarm hoods when they are open too long; this alarm should be clearly distinct from face velocity alarms
- Recognition of good behavior through parties and training
- Institutional consistency vs. innovation (should we standardize or customize based on hood use)?
- How do we get feedback from users on sash height / sash type
- Lab mock-up
- Establish need in programming
- End-users included in program decision making
- EHS can help and need to be in programming decision making discussions
- Users sometimes just ask for what they had
- Use assessment / risk assessment step is required
- A Hood Use SOP may be another communication tool
- Process for getting effective feedback from users to determine best hood type and configuration
- **The Bottom Line: Tell us what you do; not what you need**



What Can Go Wrong in an Operating Lab?

- Users need to be trained on hood limitations / restrictions
- How can they tell that the hood is on?
- How does an automatic sash closure work?
- What does hood alarm mean? What user actions does it indicate are needed?
- What are the requirements for prior approval of specific processes in a specific hood?
- What are the communication methods for inspection findings addressing issues such as clutter, sash height and functionality of the fume hood?

Training Program for Users

- Criteria/Scope of Training
  - relate energy use of hood to home utility
  - training tied to funding
  - use smoke to show sash height containment limitations
  - Clear Signage on expected maximum sash height for use
  - what stays in the hood permanently?
  - sash stop
  - authorized use
  - annual hood survey sign off by lab manager
  - training each semester
  - lab-specific training of users
- How do we make such a program sustainable?

Other Factors to Consider

- User specifications - front vision panel, side vision panel, lighting inside of hood, hood depth (architectural, ergo, lab automation)
- The utilities required tend to be research dependent; examples include

  - cup sink
  - external controls preferred
  - quick disconnect vs. barbed for pressurized lines
  - provide adequate chemical storage in lab and organize regular clean-outs to minimize storage in hood
  - hazardous waste processing is OK in hood but hazardous waste storage is better provided somewhere else
- Pharmaceutical industry is for-profit vs. Education not for profit setting and have different levels of staff turnover and expected life cycles for people and projects; this will all influence the appropriate approach to fume hood design
- A containment test (maybe smoke) that users can conduct themselves could be useful for certain use conditions; although some users prefer this testing be done by an EHS expert