Laboratories Project Team
Activities, Member Stories, Lessons Learned

Agenda

- Welcome and Introductions (10 mins)
- Overview 2012/2013 labs team activities and products (Paul Mathew, LBNL) (10 mins)
- Lab team member "show and tell" (30 mins)
  - What you set out to implement from four labs team activities (or related efforts)
  - What worked, what didn't
  - Results and key takeaways
- Group discussion: lab team activities going forward (25 mins)
  - What are member "pain points"?
  - Where can we make a big impact beyond current activities?

Laboratory Team Members

ASU Arizona State University

Clark Atlanta University

Cleveland Clinic

Cornell University

Duke University

Grand Valley State University

Stanford University

Tulane University

Berkeley University of California

UC Davis University of California

University of California · Irvine

UPMC

University of Colorado Boulder

University of Maryland

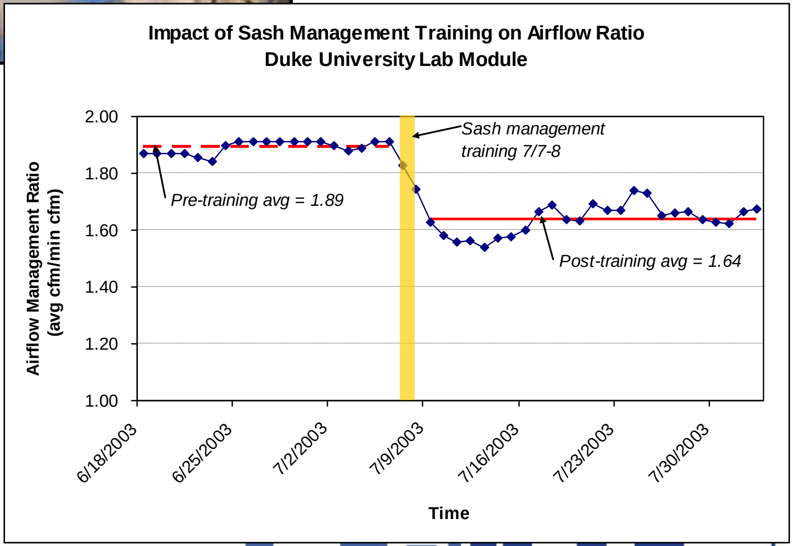
2012/13 Focus on Four High-Impact Measures

1. **Shut the sash**
   Fume hood sash management

2. **Spare the air**
   Optimize minimum air change rates

3. **Just say no to reheat**
   Reduce simultaneous heating & cooling

4. **Ease the freeze**
   Laboratory freezer energy management



Fume hood Sash Management Guide and Resource Kit

- Sash Management Guide provides step-by-step guidance on how to run a sash management campaign or competition
- Resource kit includes BBA member examples of:
  - Campaign posters
  - Sash stickers

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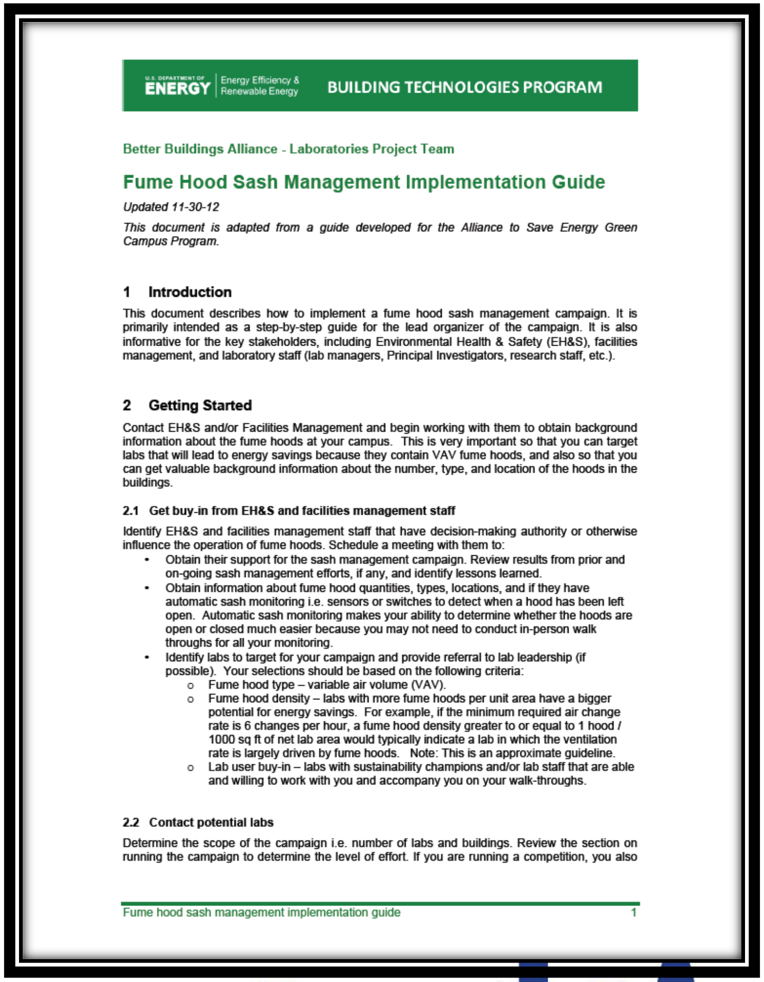

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy — BUILDING TECHNOLOGIES PROGRAM

Better Buildings Alliance - Laboratories Project Team

Fume Hood Sash Management Implementation Guide

Updated 11-30-12

This document is adapted from a guide developed for the Alliance to Save Energy Green Campus Program.

1 Introduction

This document describes how to implement a fume hood sash management campaign. It is primarily intended as a step-by-step guide for the lead organizer of the campaign. It is also informative for the key stakeholders, including Environmental Health & Safety (EH&S), facilities management, and laboratory staff (lab managers, Principal Investigators, research staff, etc.).

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Contact EH&S and/or Facilities Management and begin working with them to obtain background information about the fume hoods at your campus. This is very important so that you can target labs that will lead to energy savings because they contain VAV fume hoods, and also so that you can get valuable background information about the number, type, and location of the hoods in the buildings.

2.1 Get buy-in from EH&S and facilities management staff

Identify EH&S and facilities management staff that have decision-making authority or otherwise influence the operation of fume hoods. Schedule a meeting with them to:

- Obtain their support for the sash management campaign. Review results from prior and on-going sash management efforts, if any, and identify lessons learned.
- Obtain information about fume hood quantities, types, locations, and if they have automatic sash monitoring i.e. sensors or switches to detect when a hood has been left open. Automatic sash monitoring makes your ability to determine whether the hoods are open or closed much easier because you may not need to conduct in-person walk throughs for all your monitoring.
- Identify labs to target for your campaign and provide referral to lab leadership (if possible). Your selections should be based on the following criteria:
  - Fume hood type – variable air volume (VAV).
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Determine the scope of the campaign i.e. number of labs and buildings. Review the section on running the campaign to determine the level of effort. If you are running a competition, you also

Fume hood sash management implementation guide 1

Optimizing Minimum Air Change Rates - Highlights from BBA Members

- Highlights how three BBA members optimized air changes rates to below 6 air changes per hour (ACH)
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  - University of California Irvine
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- Includes spill analysis and energy savings
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Better Buildings Alliance - Laboratories Project Team

Getting Below Six Air Changes:
Highlights from BBA members who optimized air change rates in labs

Updated 1-4-13

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Laboratories are highly energy intensive, often using four to six times more energy per square foot than a typical office building. One of the key factors affecting energy use in labs is the minimum air change rate (ACR) requirement. Existing standards and guidelines provide wide latitude in determining minimum ACR in labs (see appendix A). For example, the Occupational Safety and Health Administration specifies a room ventilation rate of 4 to 12 air changes per hour (ACH), which "is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control." The ASHRAE lab design guide has similar recommendations. Other standards recommend greater than 8 ACH. This range is very broad and provides stakeholders with little guidance on how to select an appropriate ACR. As a result, the highest value from the range is often chosen, with the implicit assumption that "more is better". Standard practice also entails the blanket adoption of ventilation guidelines as constant values, with the ACR rarely being dynamically controlled or otherwise tailored to the occupancy or conditions of the site, or optimized for energy efficiency or safety. The result can be excessive (or inadequate) ventilation for the lab in question, causing unnecessary energy expenditures.

The purpose of this document is to provide highlights from Better Buildings Alliance (BBA) members that have optimized minimum ACR to reduce energy use while maintaining or improving safety – especially cases where the ACR has been reduced below 6 ACH[1].

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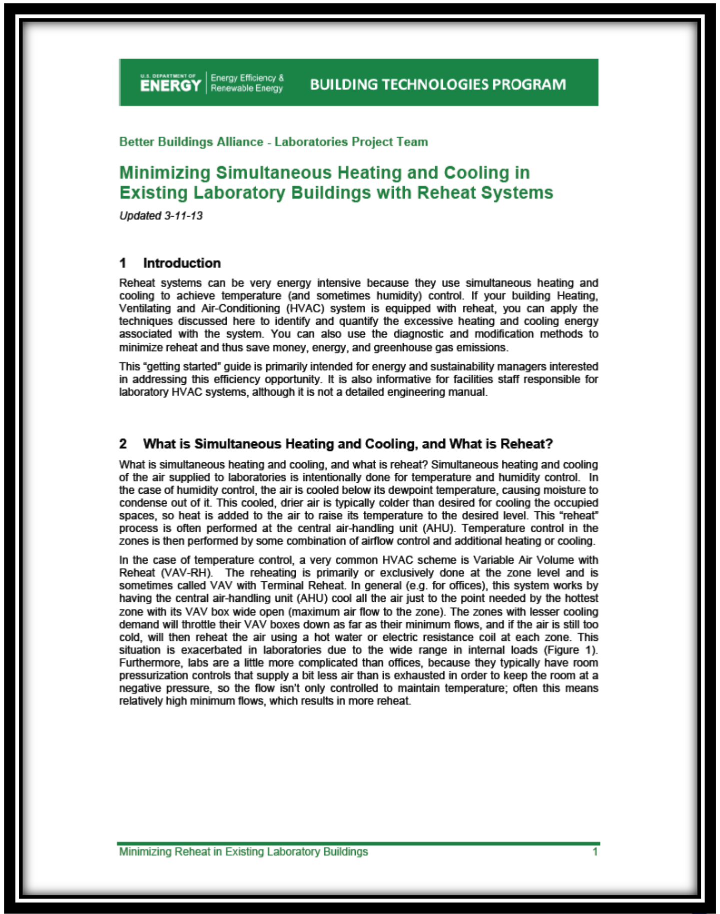
Cornell University has a multi-phase plan for energy conservation, with a goal is to reduce their annual energy use by 20% compared to that of year 2000. A significant portion of the savings can come from reducing laboratory ventilation system energy use (fan power, cooling and heating of outside air). They retrofitted and reduced the lab ACR from 8/4 ACH (occupied/unoccupied) to 6/3 ACH in one of their biotechnology laboratories. Cornell modified the general exhaust ductwork and relocated the registers for more effective exhaust and lower decay time. They used occupancy sensors to reduce the ACR during unoccupied times. Figures 1 and 2 illustrate the pre- and post-retrofit configurations of the air distribution system in the lab. Computational fluid dynamics (CFD) modeling showed that after retrofit of the lab exhaust system, spills were cleared well enough at 6/3 ACH to avoid exceeding the OSHA permissible exposure limit (PEL). Before the implementation of new ACR and retrofit, the CFD modeling had shown that 8/4 ACH was not clearing the spills effectively.

[1] Note that the focus of this document is on minimum requirements for general exhaust. In some laboratories, fume hoods or thermal conditioning are the primary driver for air change rates. In such cases, the minimum ACR for general exhaust is less relevant for reducing energy use.

Optimizing Minimum Air Change Rates in Labs 1

Minimizing Reheat Energy Use - Guide

- How to identify if your lab has a reheat system
- How to determine if reheat is minimized
- How to quantify the amount of reheat
  - Different approaches based on level of metering.
- Solutions: Strategies to minimize reheat



U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy BUILDING TECHNOLOGIES PROGRAM

Better Buildings Alliance - Laboratories Project Team

Minimizing Simultaneous Heating and Cooling in Existing Laboratory Buildings with Reheat Systems

Updated 3-11-13

1 Introduction

Reheat systems can be very energy intensive because they use simultaneous heating and cooling to achieve temperature (and sometimes humidity) control. If your building Heating, Ventilating and Air-Conditioning (HVAC) system is equipped with reheat, you can apply the techniques discussed here to identify and quantify the excessive heating and cooling energy associated with the system. You can also use the diagnostic and modification methods to minimize reheat and thus save money, energy, and greenhouse gas emissions.

This "getting started" guide is primarily intended for energy and sustainability managers interested in addressing this efficiency opportunity. It is also informative for facilities staff responsible for laboratory HVAC systems, although it is not a detailed engineering manual.

2 What is Simultaneous Heating and Cooling, and What is Reheat?

What is simultaneous heating and cooling, and what is reheat? Simultaneous heating and cooling of the air supplied to laboratories is intentionally done for temperature and humidity control. In the case of humidity control, the air is cooled below its dewpoint temperature, causing moisture to condense out of it. This cooled, drier air is typically colder than desired for cooling the occupied spaces, so heat is added to the air to raise its temperature to the desired level. This "reheat" process is often performed at the central air-handling unit (AHU). Temperature control in the zones is then performed by some combination of airflow control and additional heating or cooling.

In the case of temperature control, a very common HVAC scheme is Variable Air Volume with Reheat (VAV-RH). The reheating is primarily or exclusively done at the zone level and is sometimes called VAV with Terminal Reheat. In general (e.g. for offices), this system works by having the central air-handling unit (AHU) cool all the air just to the point needed by the hottest zone with its VAV box wide open (maximum air flow to the zone). The zones with lesser cooling demand will throttle their VAV boxes down as far as their minimum flows, and if the air is still too cold, will then reheat the air using a hot water or electric resistance coil at each zone. This situation is exacerbated in laboratories due to the wide range in internal loads (Figure 1). Furthermore, labs are a little more complicated than offices, because they typically have room pressurization controls that supply a bit less air than is exhausted in order to keep the room at a negative pressure, so the flow isn't only controlled to maintain temperature; often this means relatively high minimum flows, which results in more reheat.

Minimizing Reheat in Existing Laboratory Buildings 1

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Ultra low Temperature Freezer Energy Management Guide

- Jointly authored by staff from National Institutes of Health and University of California Davis
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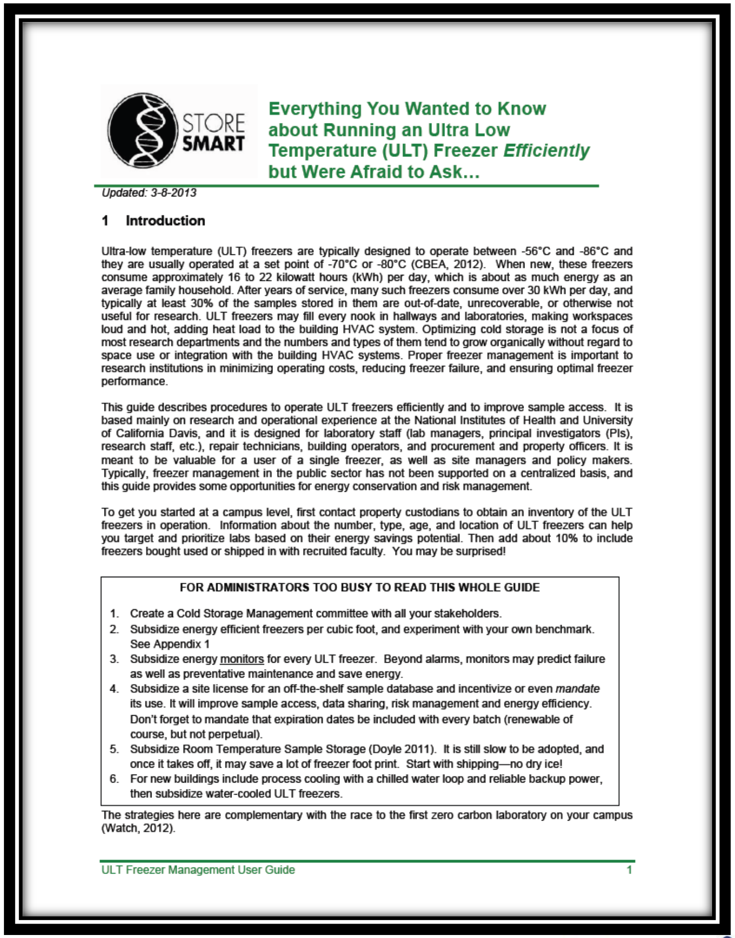

STORE SMART

Everything You Wanted to Know about Running an Ultra Low Temperature (ULT) Freezer *Efficiently* but Were Afraid to Ask…

Updated: 3-8-2013

1 Introduction

Ultra-low temperature (ULT) freezers are typically designed to operate between -56°C and -86°C and they are usually operated at a set point of -70°C or -80°C (CBEA, 2012). When new, these freezers consume approximately 16 to 22 kilowatt hours (kWh) per day, which is about as much energy as an average family household. After years of service, many such freezers consume over 30 kWh per day, and typically at least 30% of the samples stored in them are out-of-date, unrecoverable, or otherwise not useful for research. ULT freezers may fill every nook in hallways and laboratories, making workspaces loud and hot, adding heat load to the building HVAC system. Optimizing cold storage is not a focus of most research departments and the numbers and types of them tend to grow organically without regard to space use or integration with the building HVAC systems. Proper freezer management is important to research institutions in minimizing operating costs, reducing freezer failure, and ensuring optimal freezer performance.

This guide describes procedures to operate ULT freezers efficiently and to improve sample access. It is based mainly on research and operational experience at the National Institutes of Health and University of California Davis, and it is designed for laboratory staff (lab managers, principal investigators (PIs), research staff, etc.), repair technicians, building operators, and procurement and property officers. It is meant to be valuable for a user of a single freezer, as well as site managers and policy makers. Typically, freezer management in the public sector has not been supported on a centralized basis, and this guide provides some opportunities for energy conservation and risk management.

To get you started at a campus level, first contact property custodians to obtain an inventory of the ULT freezers in operation. Information about the number, type, age, and location of ULT freezers can help you target and prioritize labs based on their energy savings potential. Then add about 10% to include freezers bought used or shipped in with recruited faculty. You may be surprised!

FOR ADMINISTRATORS TOO BUSY TO READ THIS WHOLE GUIDE

1. Create a Cold Storage Management committee with all your stakeholders.
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6. For new buildings include process cooling with a chilled water loop and reliable backup power, then subsidize water-cooled ULT freezers.

The strategies here are complementary with the race to the first zero carbon laboratory on your campus (Watch, 2012).

ULT Freezer Management User Guide 1

Lab team member “show and tell”

What you set out to implement from four labs team activities (or related efforts)

What worked, what didn’t

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Looking Ahead:

What are member "pain points"?

Where can we make a big impact beyond current activities?

Laboratories Project Team:
Strategies for effective collaboration between facilities staff, lab users and EHS personnel

Agenda

- Welcome and Introductions (10 mins)
- Intro to the labs team (Paul Mathew, LBNL) (10 mins)
- Two perspectives on implementing efficiency in labs
  - Users (Kathryn Ramirez-Aguillar, CU Boulder) (15 mins)
  - EHS (Tom Smith, Exposure Control technologies) (15 mins)
- Group discussion: How can facilities, lab users and EHS personnel work collaboratively to increase energy efficiency? (30 mins)
  - Safety and usability are not just "non-energy benefits" – how do we use them as the starting point for strategies and technologies that also improve energy efficiency?
  - What can the BBA labs team do to support this?
- Wrap up: Action items and sign ups (10 mins)

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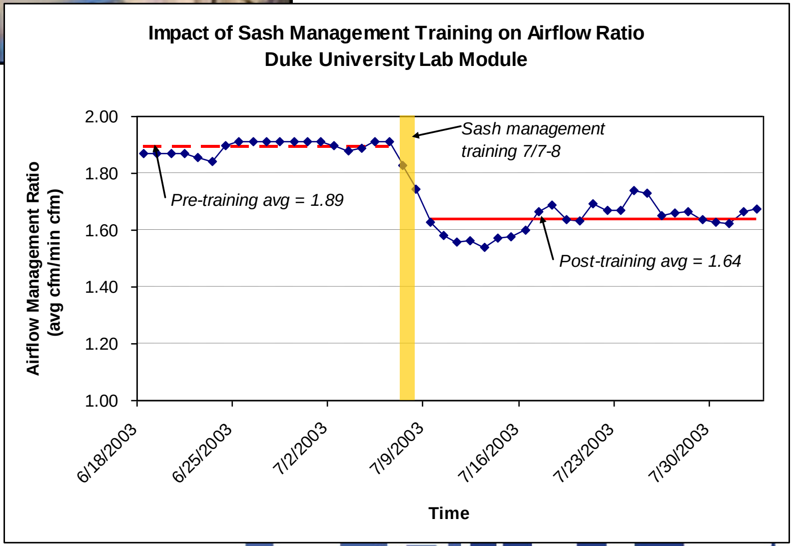

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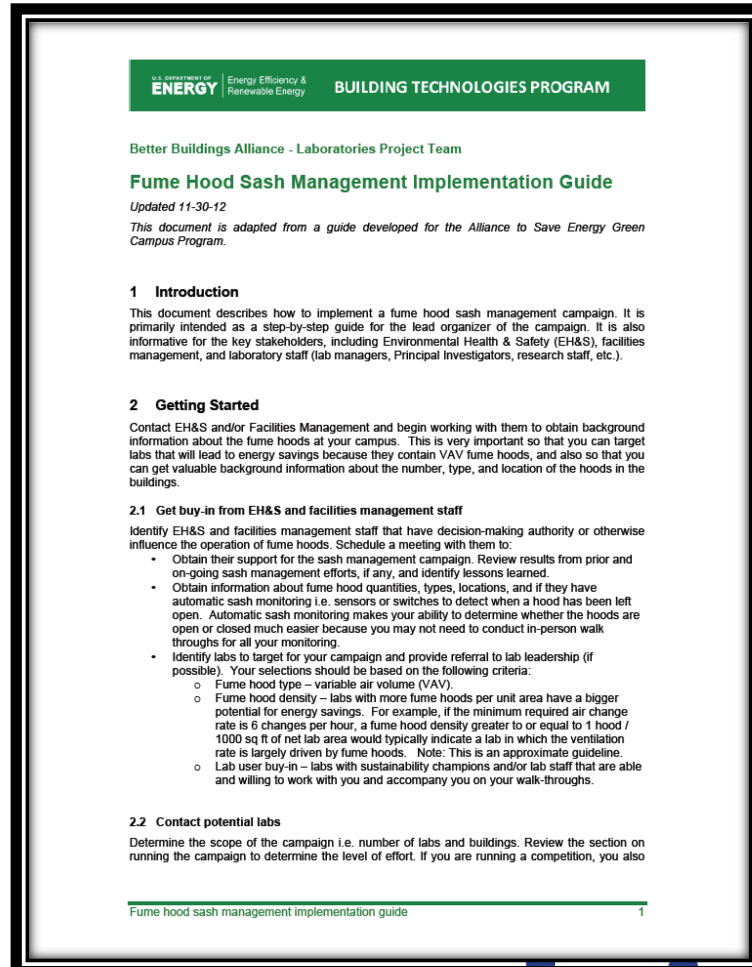

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Optimizing Minimum Air Change Rates in Labs 1

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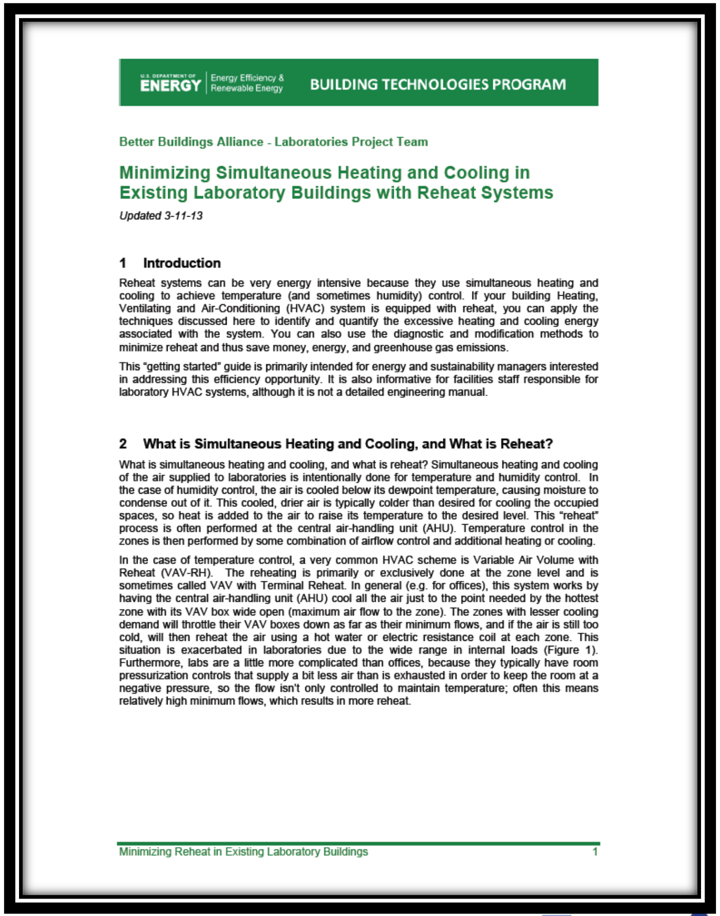

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Minimizing Reheat in Existing Laboratory Buildings 1

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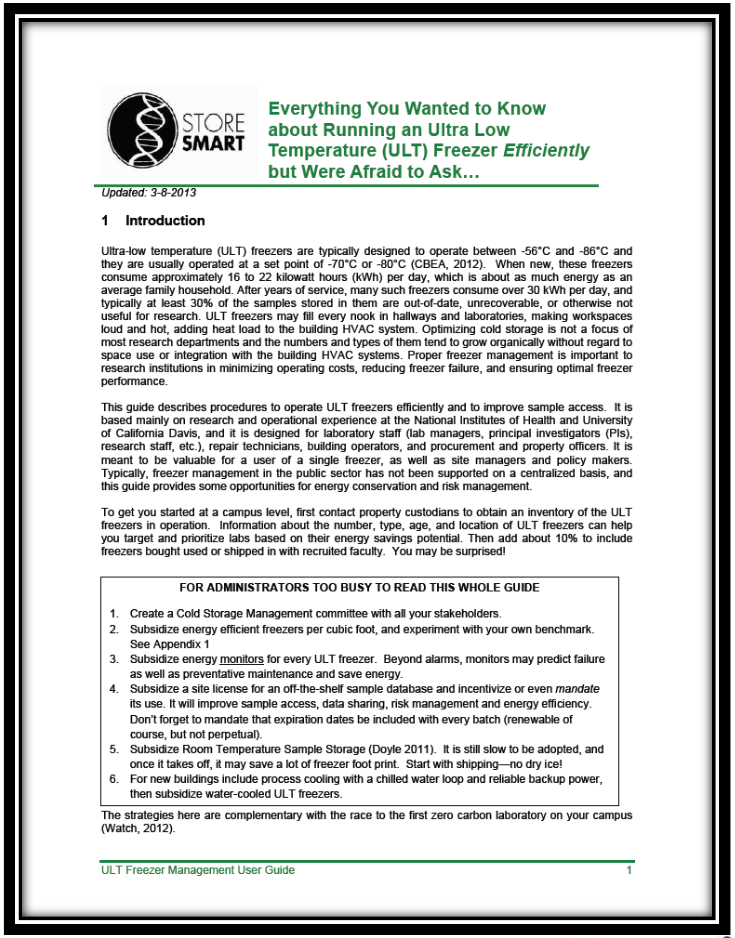

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ULT Freezer Management User Guide 1

Two perspectives on implementing efficiency in labs

Users

Kathryn Ramirez-Aguillar, CU Boulder

Environmental Health and Safety

Tom Smith, Exposure Control technologies

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Group Discussion: How can facilities, lab users and EHS work collaboratively to increase energy efficiency?

Safety and usability are not just "non-energy benefits" – how do we use them as the starting point for strategies and technologies that also improve energy efficiency?

What can the BBA labs team do to support this?

CHANGING THE CULTURE: Importance of Engaging Lab Users in Lab Conservation Efforts

Kathy Ramirez-Aguilar, Ph.D.

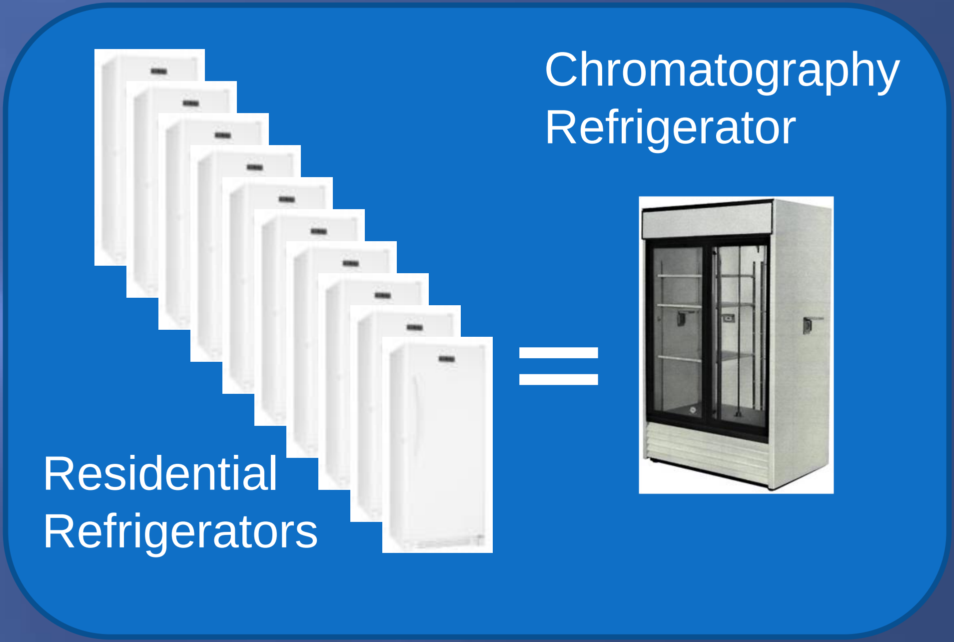
Green Labs Program Manager
Univ. of Colorado - Boulder
(CU-Boulder)

University of Colorado
Boulder

BBA Forum – May 2013

Scientists make decisions that…

- impact existing building operation & consumption
- drive future research facility needs



Conservation is not part of the culture

<u>RESOURCE USE NOT INCLUDED IN:</u>

- Research decisions
- Dissemination of information
- Purchasing decisions

<u>RESULTS</u>: Lack of awareness of impact of research decisions on resource consumption

Examples with cold storage

- discoveries upon failure of two ULT freezers
- incubator used as refrigerator (14.2 kWh/day)

CU-Boulder has ~100 ULT freezers

=

Electricity

=

Full size Energy Star -20 ˚C Freezers

LABS HAVE A LARGE FOOTPRINT

2010-2011	Area Portion	Energy Portion
CU-Boulder	20%	43%

MCDB DEPARTMENT

- ~45 labs
- 10.6 GWh in 2009-2010
- 8.3% of campus electricity

1200 X  electricity

(25 kWh/day/house)

Examples of Impact from Engaged Scientists

House = 25 kWh/day in electricity

Ultra Low Temperature Freezer Efforts

Retiring
Sharing
Unplugging
Energy Efficient
Raise from $-80^{\circ}C$ to $-70^{\circ}C$

EBio Scanning Electron Microscope & Chiller Off






Six Diffusion Pumps on Timers

(also saving 1 million gallons of water/year)

Incubator Energy Efficiency Upgrade

- Replaced two low temp incubators for single “heating only” incubator = 22.6 kWh/day savings
- 99% reduction in electricity for lab’s 30^{o}C needs

14.6 kWh/day
(+ 8.2 kWh/day small unit)

0.23 kWh/day

CU GREEN LABS PROGRAM

Created in 2009

(by the Office of Sustainability and the Environmental Center)

Energy Conservation

Water Conservation

Material Waste Reduction

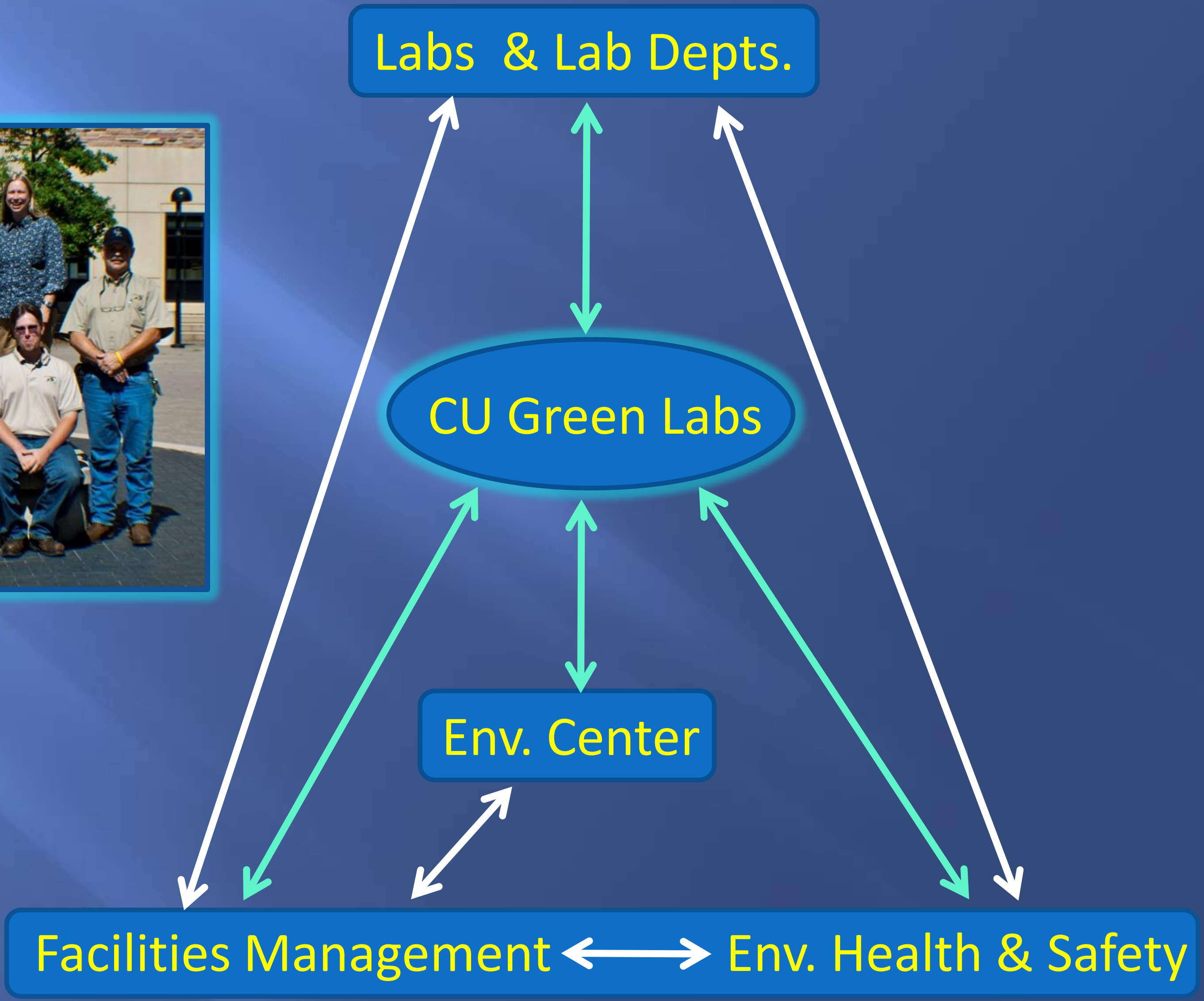
Participation is voluntary

A benefit to labs and conservation

Not compromising safety or research integrity

Utilize expertise of our scientists, EH&S, Fac. Man.

Campus-wide, collaborative team approach



Changing the culture at CU-Boulder

Inviting scientists to join the conversation

Giving scientists a voice

Acting as a resource

Building community

Raising awareness

Lab Eco-Leaders – backbone of program

LAB ECO-LEADER
a volunteer interested in encouraging the efficient use of resources in his/her lab and department

BENEFITS:

- **Insider**
- **Knowledgeable about their particular lab**
- **Always present in lab**

30% of CU-Boulder Labs have Eco-Leaders

Ahn
Anseth
Barger
Batey
Bierbaum
Blumenthal
Boswell
Bowers
Bowman, C.
Bowman, W.
Breed
Bryant/Mahoney
Campeau
Caruthers
Cech
Collinge
Copley
DeDecker
DeSouza
Diggle
Dowell
Dukovic
Eaton
Ehringer
Falke
Feldheim
Fierer
Flowers

Friedman
Garcea
George
Gin
Greenberg
Guralnick
Han
Jimenez, J.L.
Johnson
Jones
Keck
Knight
Koch
Krauter
Kuchta
Leinwand
Linden
Liu
Lowry
Maier-Watkins
Martin, A.
McCain
McHenry
McIntosh
McKenzie
Medeiros
Medlin
Melbourne

Michl
Mitton
Montoya
Moore
Nemergut
Noble
Nosil
Odorizzi
Olwin
Pace
Palmer
Pardi
Poyton
Randolph
Ryan
Safran
Sammakia
Saunders
Schmidt
Schwartz
Seals
Seastedt
Shen
Singh
Smolen
Sousa
Spencer
Staehelin

Stein
Stowell
Stoykovich
Su
Taatjes
Tolbert
Townsend
Tsai
Van Blerkom
Voeltz
Volkamer
Walba
Wang
Weimer
Wessman
Winey
Wright
Wuttke
Xue
Yarus
Y.C. Lee
Yi
Zhang

Biochem Cell Culture
Biochem Teaching Lab
Chem/Biochem Dept IT
Chem/Biochem Mass Spec Facility
CHEM Stores
CINC Creative Labs
Fly Food Autoclave Room
General Biology Teaching Labs
General Chem Teaching Labs
INSTAAR Sedimentology Lab
IPHY Environmental Endocrinology
IPHY Teaching Labs
MCDB Electron Microscopy Service
MCDB Stores
MCDB Teaching Labs
Membrane & Catalyst Facility
NMR Facility
Organic Chem Teaching Labs
Paleontology Lab
Physics Learning Labs
Stable Isotope Lab
Thermal Ionization Mass Spec Lab
(U-Th)/He Lab

130 labs in total

Enhancing the Network Structure

DEPARTMENTAL GREEN LABS
TEAM LEADS

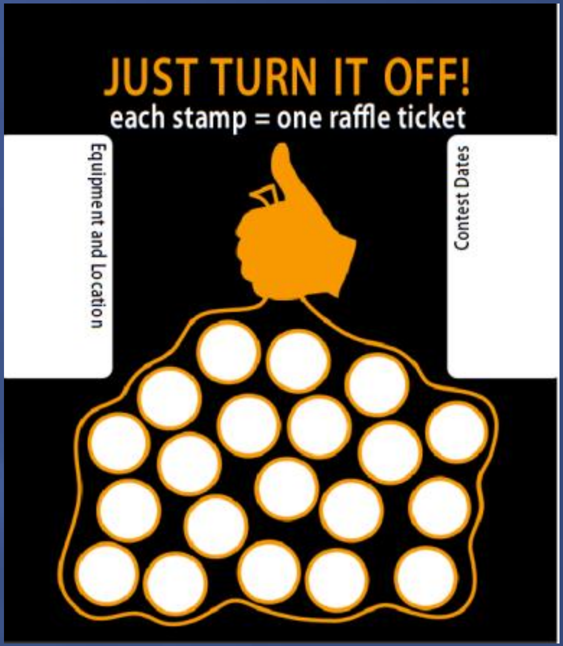
a paid graduate student who leads Lab Eco-Leaders and works on conservation efforts within his/her own department

- Insiders
- Support from department chair
- Greater depth of engagement
- Frees up time to expand program

Contests make participation fun!
and grab people's attention

Raffle Contest for Gift Cards of $125

- VAV fume hoods
- Large Plug Load Off
- Fridge/Freezer Maintenance
- Autoclave
- Drying Oven
- Biological Freezer Temperature



Modified graphic from
Univ. of Toronto
Sustainability Office

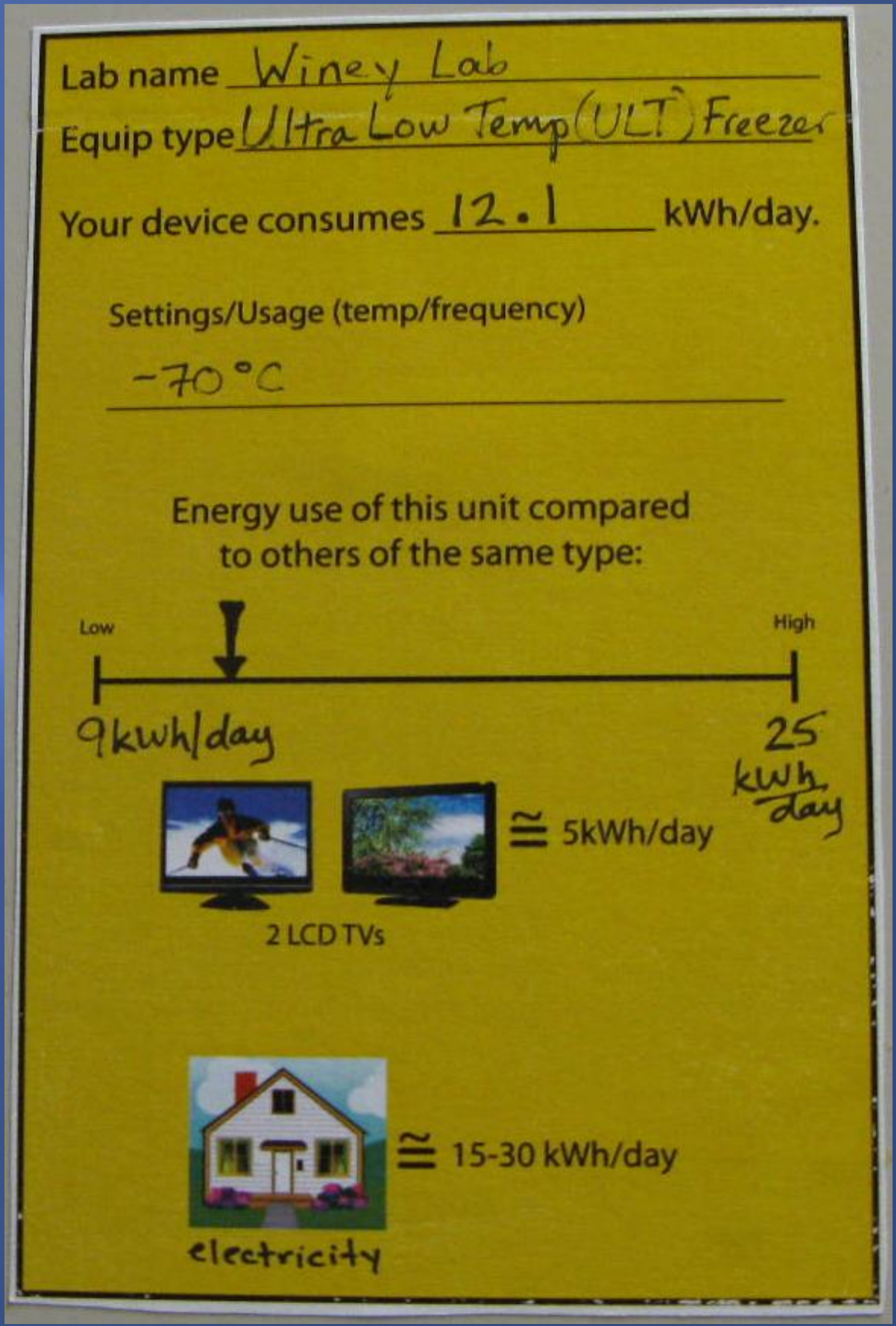
Contests with Incentives to Win

- Bright Idea Contest for Energy Savings
- National Freezer Challenge

Being a REAL Resource to Labs
…& Lab Departments!

- Help with freezer failures
- Equipment disposals
- Equipment sharing
- Reputation for answering questions
- Following up on ideas
- Source of incentives/funding

Providing Feedback



Power of Positive, Public Recognition

Give Your Compressor a Break!

Increase the temperature of your ULT(Ultra Low Temperature) Freezer to -70º C

-70º C

Extend Freezer Life

-80º C

=

2-4 kWh/day saved

same as a LCD TV

Save Energy While Extending Freezer Lifetime

- Increasing the temperature means the compressor does not have to work as hard.
- Since the compressor works less, there is reduced risk for compressor failure.
- 34 ULT freezers at CU-Boulder and 40 at UC-Davis are already at -70° C or warmer.

Join These CU-Boulder Labs That Are Already at -70˚ C

- Anseth
- Blumenthal
- Chen/Junge
- Collins/Stitzel
- Copley
- Ehringer/Marks
- Garcea
- Han
- Martin
- Moore
- Poyton
- Seals
- Schmidt
- Shen
- Smolen
- Stein
- Taatjes
- Winey
- Xue

For info on samples that labs are storing at -70˚ C or warmer go to ecenter.colorado.edu/greenlabs

CU Green Labs Contact:
Kathy Ramirez
greenlabs@colorado.edu
303-492-5562

Environmental Health & Safety — Facilities Management — University of Colorado Environmental Center — Turn Off Climate Change

Labs campus-wide are joining CU Green Labs!

Labs with Eco-Leaders as of January 2012

Ahn
Anseth
Barger
Batey
Bierbaum
Blumenthal
Boswell
Bowers
Bowman, C.
Bowman, W.
Breed
Bryant/Mahoney
Campeau
Caruthers
Cech
Collinge
Copley
DeDecker
DeSouza
Diggle
Dowell
Dukovic
Eaton
Ehringer
Falke
Feldheim
Fierer
Friedman
Garcea
George
Gin
Greenberg
Guralnick
Han
Jimenez, J.L.
Johnson
Jones
Keck
Knight
Koch
Krauter
Kuchta
Lee, Y.C.
Leinwand
Linden
Liu
Lowry
Maier-Watkins
Martin, A.
McCain
McHenry
McIntosh
McKenzie
Medeiros
Medlin
Melbourne
Michl
Mitton
Montoya
Moore
Nemergut
Noble
Nosil
Odorizzi
Olwin
Pace
Palmer
Pardi
Poyton
Randolph
Rosario
Ryan
Safran
Sammakia
Saunders
Schmidt
Schwartz
Seals
Seastedt
Shen
Singh
Smolen
Sousa
Spencer
Staehelin
Stein
Stowell
Stoykovich
Su
Taatjes
Tolbert
Townsend
Tsai
Van Bierkom
Voeltz
Volkamer
Walba
Wang
Weimer
Wessman
Winey
Wright
Wuttke
Xue
Yarus
Yi
Zhang
Biochem Cell Culture
Biochem Teaching Lab
Chem/Biochem Dept IT
Chem/Biochem Mass Spec
CHEM Stores
CINC Creative Labs
Fly Food Autoclave Room
General Bio. Teaching Labs
General Chem Teaching Labs
IPHY Enviro. Endocrinology
IPHY Teaching Labs
MCDB Electron Microscopy
MCDB Stores
MCDB Teaching Labs
Membrane & Catalyst Facility
NMR Facility
Organic Chem Teaching Labs
Paleontology Lab
Physics Learning Labs
Sedimentology Lab
Stable Isotope Lab
Thermal Ionization Mass Spec
Trades Teaching Lab
(U-Th)/He Lab

Departments with Eco-Leaders

Civil, Environmental, & Architectural Engineering (CEAE)
Chemical & Biological Engineering (ChBE)
Chemistry & Biochemistry (CHEM)
College of Architecture & Planning (CAP)
Cooperative Institute for Research in Environmental Sciences (CIRES)
Department of Geological Sciences
Ecology & Evolutionary Biology (EBIO)
Institute foe Behavioral Genetics (IBG)
Institute of Arctic & Alpine Research (INSTAAR)
Integrative Physiology (IPHY)
Joint Institute for Laboratory Astrophysics (JILA)
Mechanical Engineering (ME)
Molecular, Cellular, & Developmental Biology (MCDB)
Museum of Natural History
Psychology (PSYCH)
Physics (PHYS)

YOUR LAB NAME AND DEPARTMENT HERE!

Does your lab have an Eco-Leader?

If not, get involved today! Sign up to be an Eco-Leader for your lab or department! For more information, contact Kathy Ramirez below.

Let's work together...

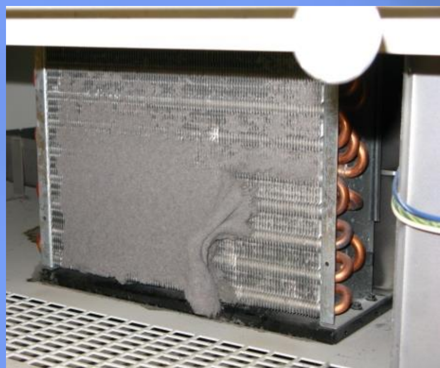
to green campus labs and push for energy efficient, environmentally friendly products from manufacturers.

Your decisions and dollars have impact!

CU Green Labs Contact:
Kathy Ramirez
greenlabs@colorado.edu
303-492-5562
ecenter.colorado.edu/greenlabs

Environmental Health & Safety — Facilities Management — University of Colorado Environmental Center — Turn Off Climate Change

Third Year Participating in StoreSmart FREEZER CHALLENGE



- Improved Sample Access
- Improved Freezer Performance
- Energy Conservation
- Gift Cards, Pizza Parties
- It is the RIGHT THING TO DO

~50 CU-Boulder Labs Participated Last Two Years

Utilizing the expertise of scientists

- Incentive for energy efficient equipment replacements
- Working or broken equipment
- Submission for X-ray diffraction
  23kW to 0.5 kW

Changing the culture on a national level

NEED FOR CONNECTION BETWEEN RESOURCES CONSUMED & LAB FINANCES

FEDERAL GRANTING PROCESS GOING "GREEN"?

resource consumption considerations in

- experimental design
- selection process
- procurement

HHS Code of Federal Regulations
Title 45, 74.44 (a) (3) (vi)

requiring green spending of federal grant $$$

Scientists can change the culture

INCLUDING "GREEN" IN:

- Experimental design
- Grants
- Presentations
- Papers
- Lab Discussions
- Classrooms
- Purchasing

Writing a Grant?

Include GREEN considerations in your grant proposal!

- Design experiments to minimize energy & water use
- Micro-scale experiments to reduce chemical use
- Propose equipment purchases that are energy efficient
- Choose lab practices that reduce material needs & waste
- Suggest sharing of equipment & skills for efficient use of $

CU Green Labs is here to help!
Contact us for discussion on green ideas

CU Green Labs Contact:
Kathy Ramirez
greenlabs@colorado.edu
ecenter.colorado.edu/greenlabs
303-492-8308

Facilities Management
Office of Sustainability
Environmental Health and Safety
Environmental Center
UNIVERSITY OF COLORADO BOULDER

Positive, public recognition on campus & national level

PLEDGE for scientists with public display

- Competition between departments?
- National campaign?

CERTIFICATION or other recognition tool at national level?

Acknowledgements

University of Colorado at Boulder

Lab Eco-Leaders & Lab Departments

Office of Sustainability

Environmental Center

CU Green Labs Staff

Environmental Health & Safety (EH&S)

Facilities Management (Admin. Staff, Prof. Staff, Technical Staff, and Shops)

Collaborators

Allen Doyle – UC-Davis

I2SL

DOE & BBA

NIH, CDC

Other US Universities

International Colleagues

My family

QUESTIONS?

Contact Information:

Kathy Ramirez-Aguilar, Ph.D.
CU Green Labs Program Manager
University of Colorado at Boulder
kramirez@colorado.edu, 303-859-2068

GREEN LABS PLANNING GROUP:

Go to Google Groups & search for "Green Labs Planning" and then apply for membership

Safe, Dependable, Energy Efficient Laboratory Buildings

Thomas C. Smith

ECT, Inc.

Exposure Control Technologies, Inc.
919-319-4290
tcsmith@labhoodpro.com

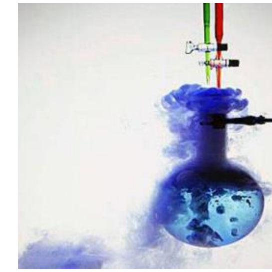
Better Buildings U.S. DEPARTMENT OF ENERGY

Introduction

- **Thomas C. Smith**
  - President, Exposure Control Technologies, Inc.
  - BSME (NCSU), MSEE – Industrial Hygiene (UNC-CH)
  - Chair, AIHA/ANSI Z9 Health and Safety Standards for Ventilation Systems
  - Vice Chair, ASHRAE/ANSI 110 – Method of Testing Performance of Laboratory Fume Hoods
  - Chair, ASHRAE TC 9.10 – Laboratory Systems
  - Member , ANSI/AIHA Z9.5 Committee

- **Topics**
  - Laboratory Hoods and Ventilation Systems
  - Demand For Ventilation
  - ANSI/AIHA Z9.5 Standard
  - Specifications for Safe & Efficient Labs
  - Environmental Health and Safety -Issues & Concerns

Goal: High Performance Laboratories



- Chemistry Labs
- Radiological Labs
- Nanotechnology Labs
- Biology Labs (high containment)
- Animal Vivariums
- Cleanrooms

- **Safe**
  - Compliance with Codes & Standards
- **Productive (Flexible)**
- **Energy Efficient**
- **Sustainable**

Better Buildings
U.S. DEPARTMENT OF ENERGY

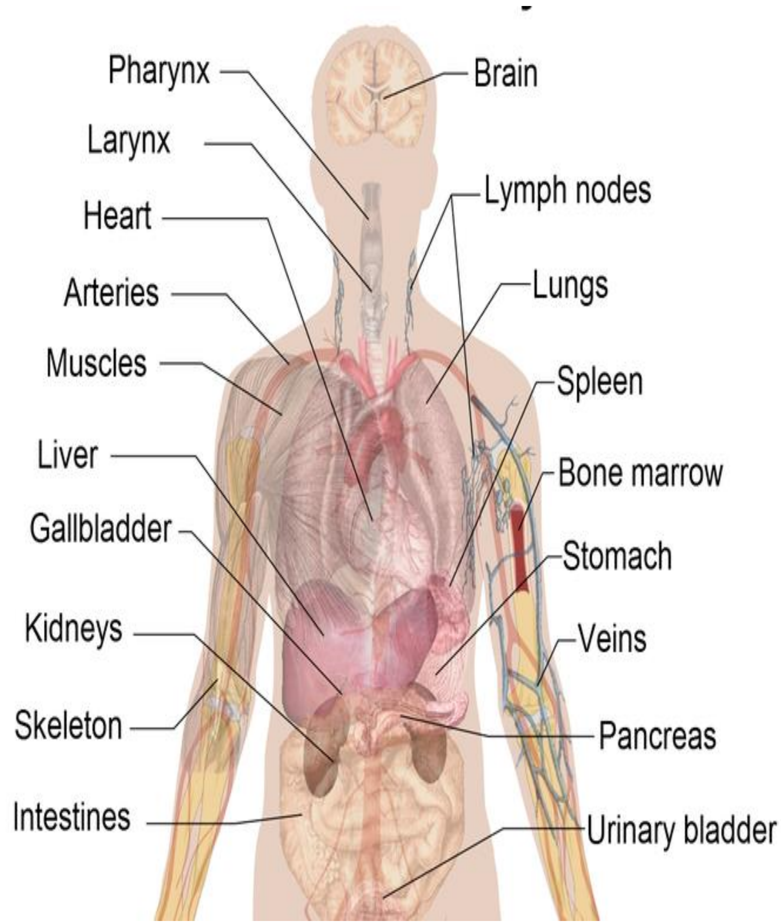
Laboratory Hazards
Risk of Adverse Health Effects

Inhalation Hazards

- Airborne Materials
- Toxicity
- Generation Rate & Concentration
- Duration of Exposure

Physical Hazards

- Contact - Dermal Exposure
- Fire & Explosion



Dose = Concentration x Duration

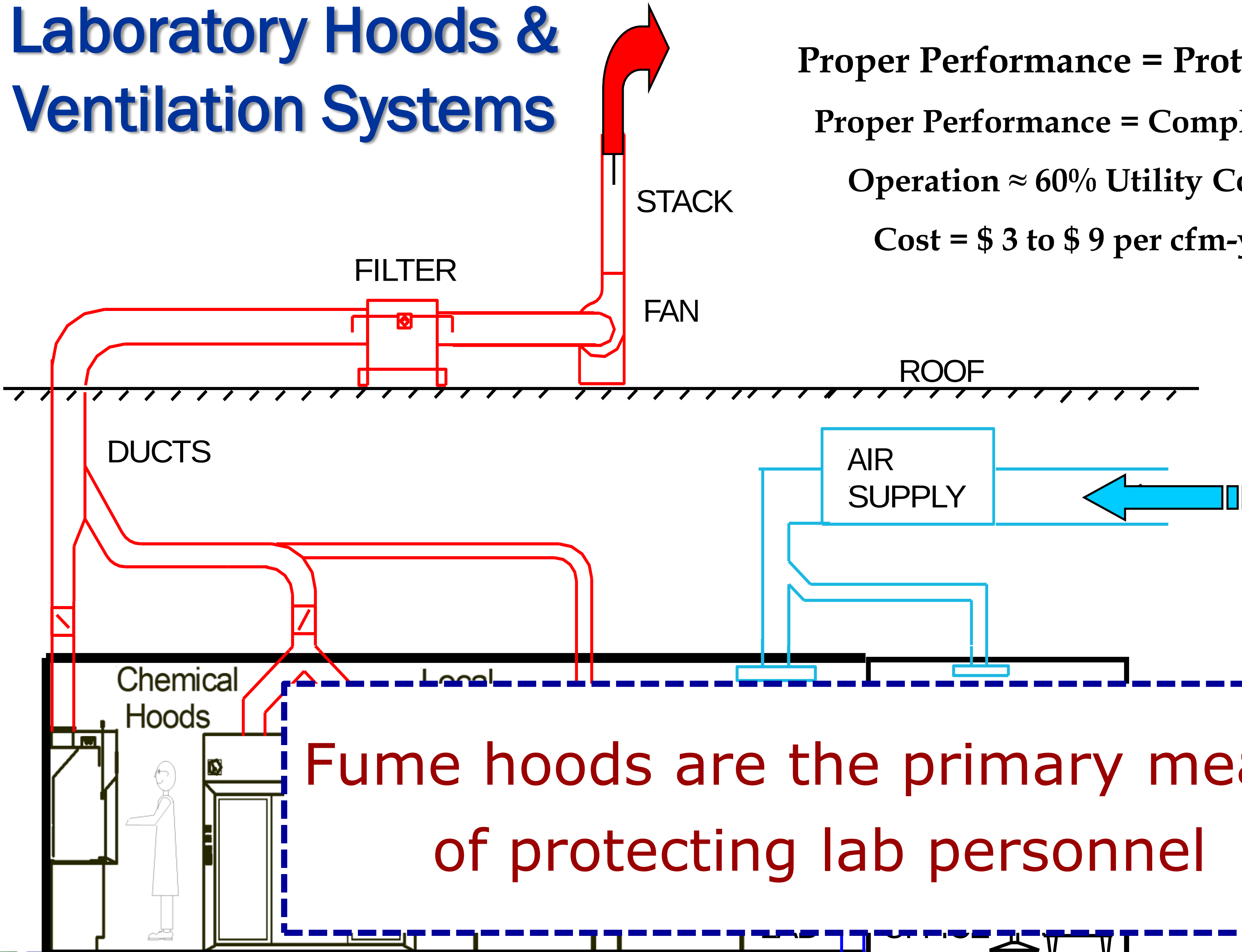
Laboratory Hoods & Ventilation Systems

Proper Performance = Protection

Proper Performance = Compliance

Operation ≈ 60% Utility Costs

Cost = $ 3 to $ 9 per cfm-yr



Fume hoods are the primary means of protecting lab personnel

Evaluating Fume Hood Safety

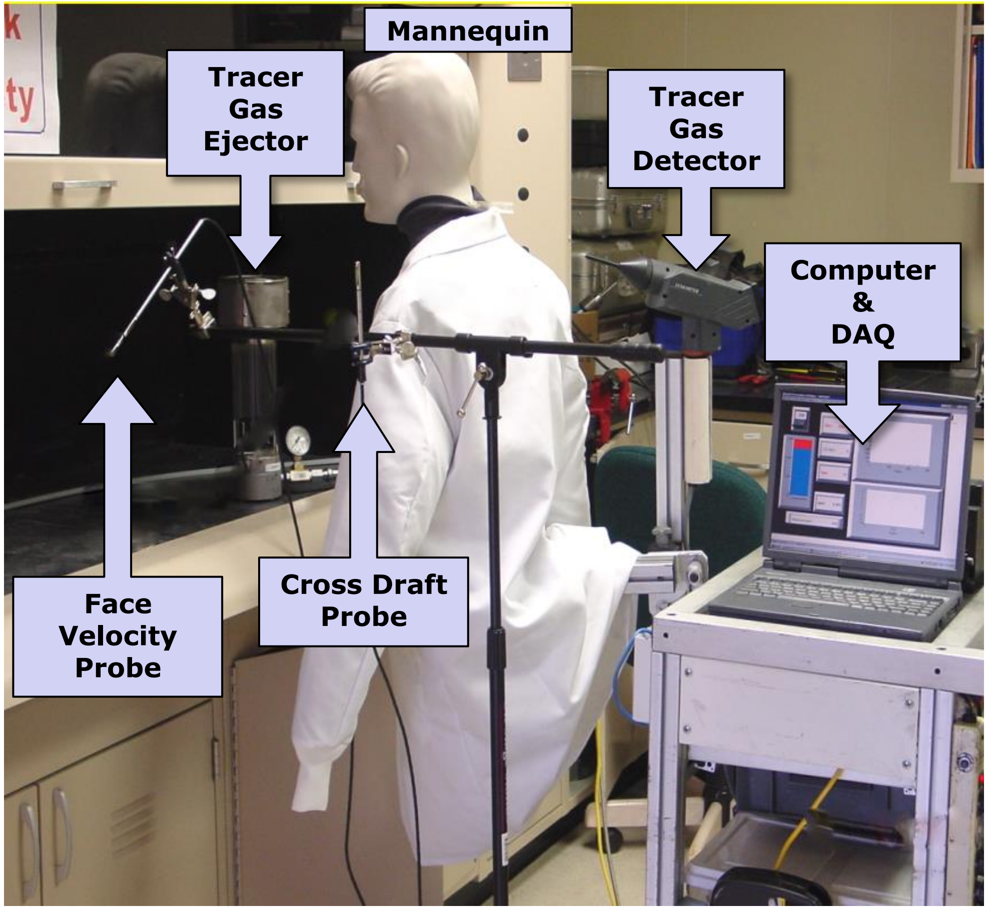
ANSI/ASHRAE 110 "Method of Testing Performance of Laboratory Fume Hoods"

Determine Operating Conditions

- Hood and Lab Inspection
- Face Velocity Measurements
- Cross Draft Velocity Tests
- VAV Response and Stability

Determine Performance (Containment)

- Flow Visualization Smoke Tests
- Tracer Gas Containment Tests



Methods to Evaluate Containment Performance and Ensure Safe Hoods

Laboratory Hood Safety & Performance

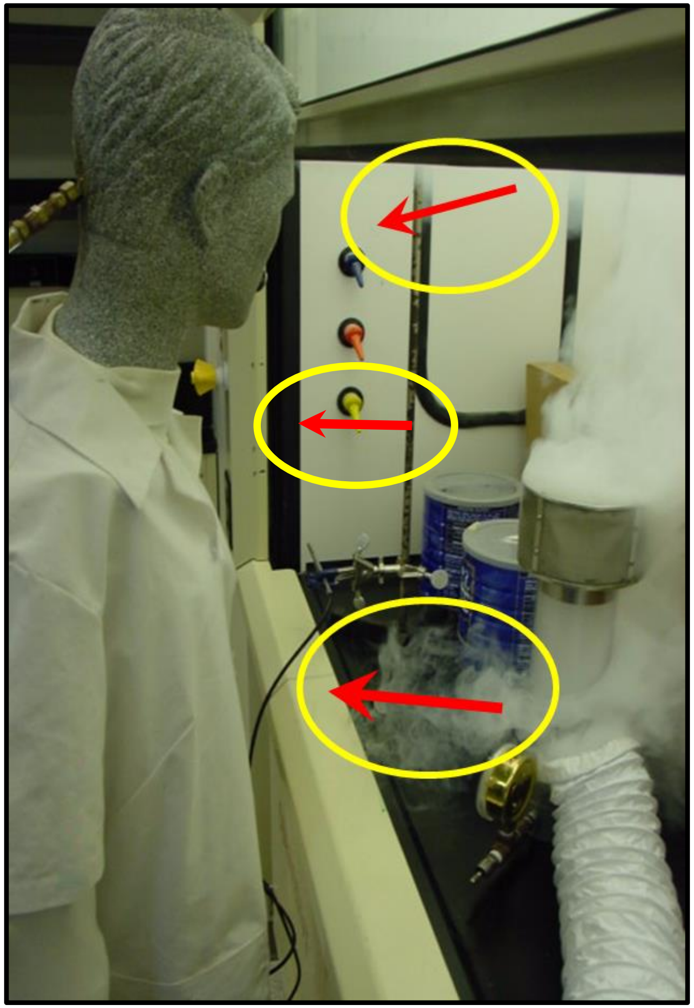
ECT, Inc. has conducted more than 30,000 ASHRAE 110 Tracer Gas Containment Tests

Test Results Demonstrate > 15% Failure

Primary Factors Affecting Performance

- Hood design - 20%
- Lab Design
- System Operation
- Work practices - 25%

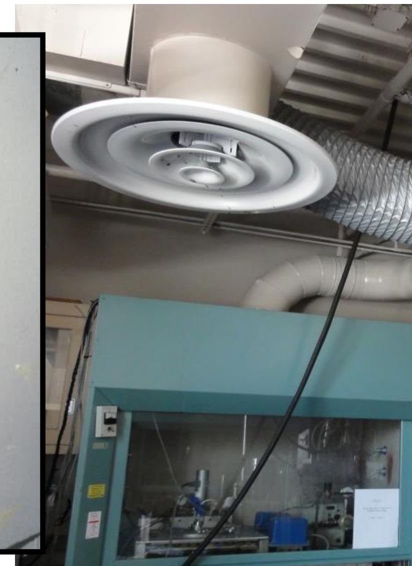
(Lab Design and System Operation: 55%)

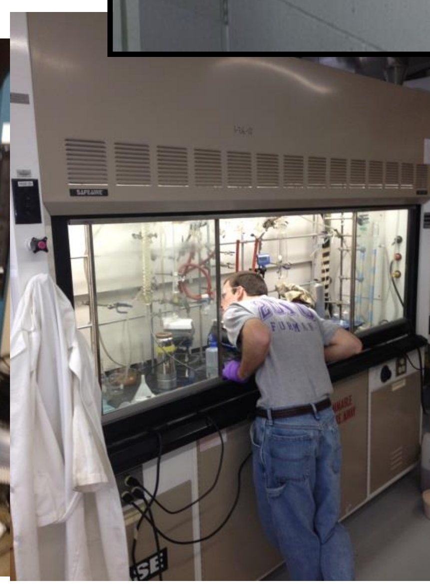


Causes of Inadequate Performance

Improper:

- Design
- Operation
- Maintenance
- Use

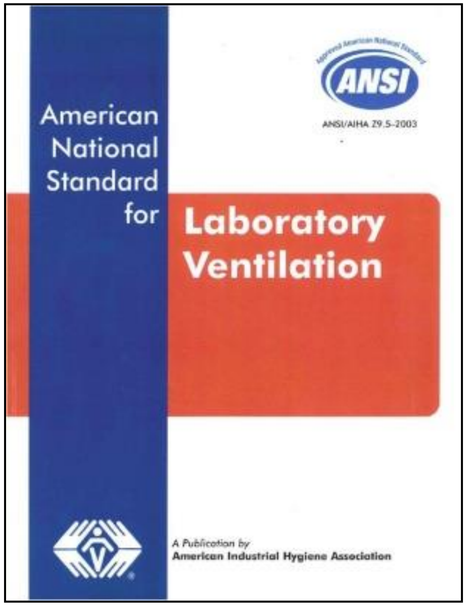




ANSI/AIHA –Z9.5 - 2012
American National Standard for Laboratory Ventilation

AIHA
Protecting Worker Health

- **Newly Revised & Published September 2012**
- **Minimum Requirements and Best Practices**
  - Protect People
  - Ensure Dependable Operation
  - Operate Energy Efficient Labs
- **Recommendations & Specifications for New and Renovated Laboratories**
  - Hood Design & Operation
  - Laboratory Design
  - Ventilation System Design
  - Commissioning and Routine Testing
  - Work Practices and Training
  - Preventative Maintenance



The American Society of Safety Engineers

Types of Laboratory Fume Hoods

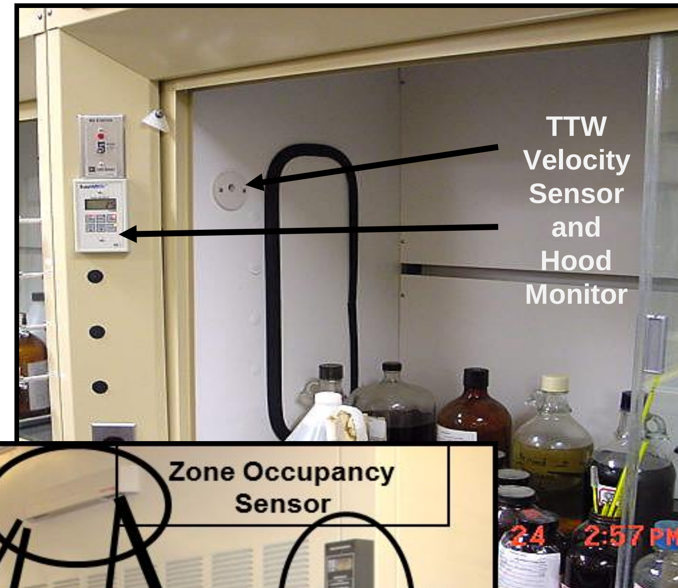
- **Bench-Top**
  - Traditional Bypass
  - Low Velocity / High Performance
  - VAV – Restricted Bypass
- **Distillation**
- **Floor Mounted (Walk-in)**

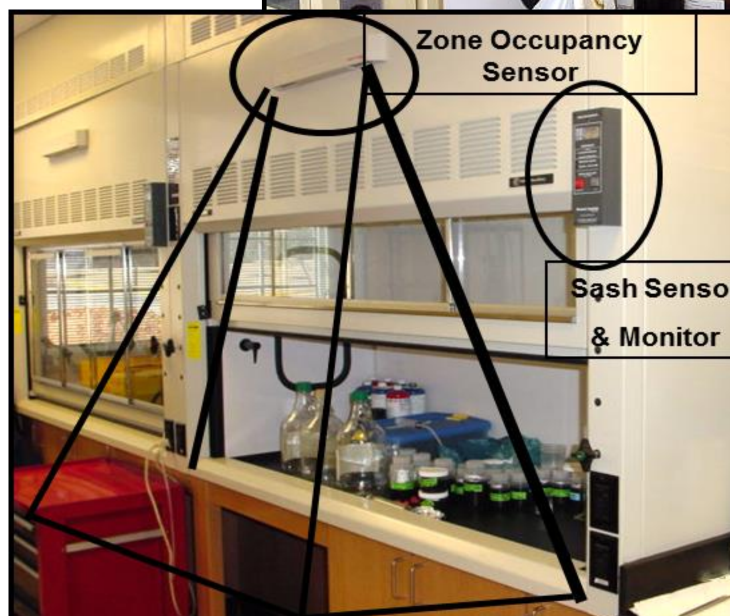
Better Buildings
U.S. DEPARTMENT OF ENERGY

Flow Monitors and VAV Controls

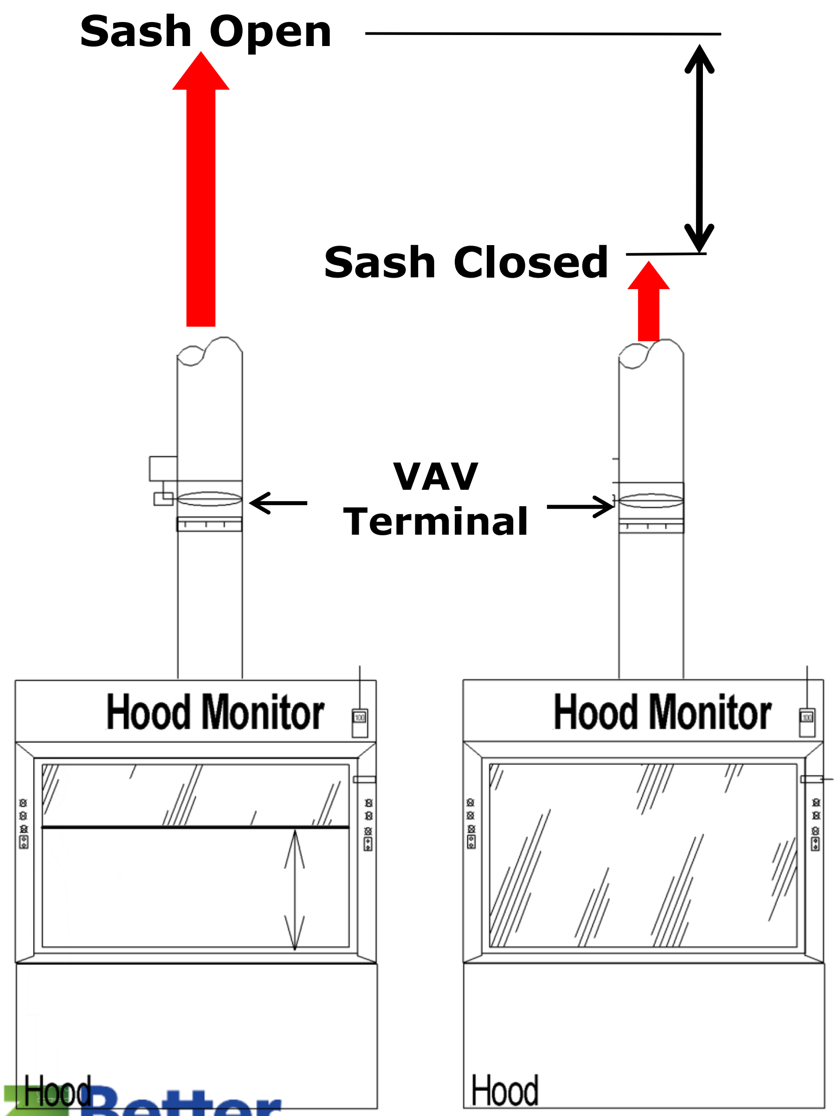
- **Hood Monitors (Flow Measuring Device)**
  - Flow
  - Velocity
  - Pressure
- **Flow Control Types**
  - Through the Wall Velocity
  - Sash Position
  - Occupancy
  - Manual
- **VAV Modes**
  - Two State
  - Full VAV
  - VAV Hybrid

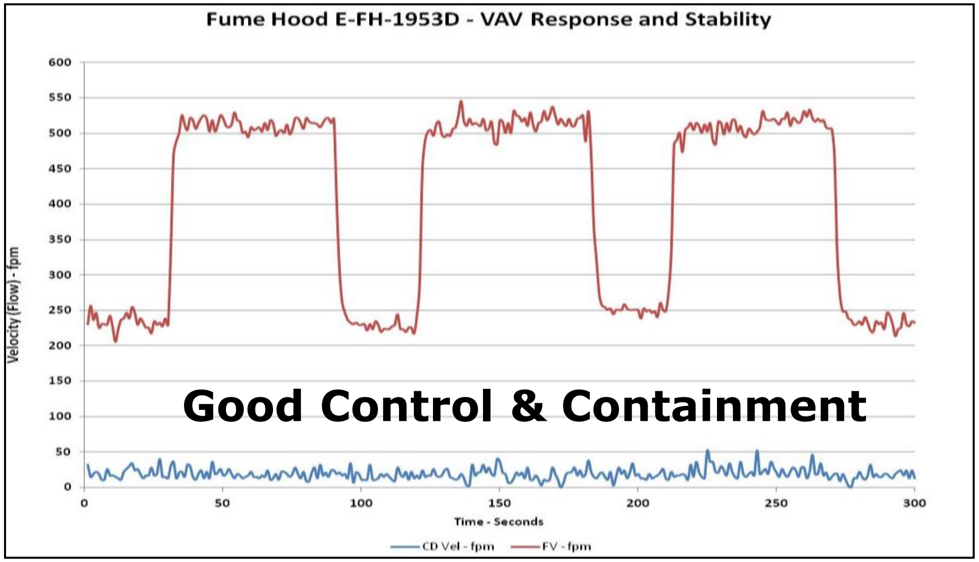
Monitors are required on all fume hoods

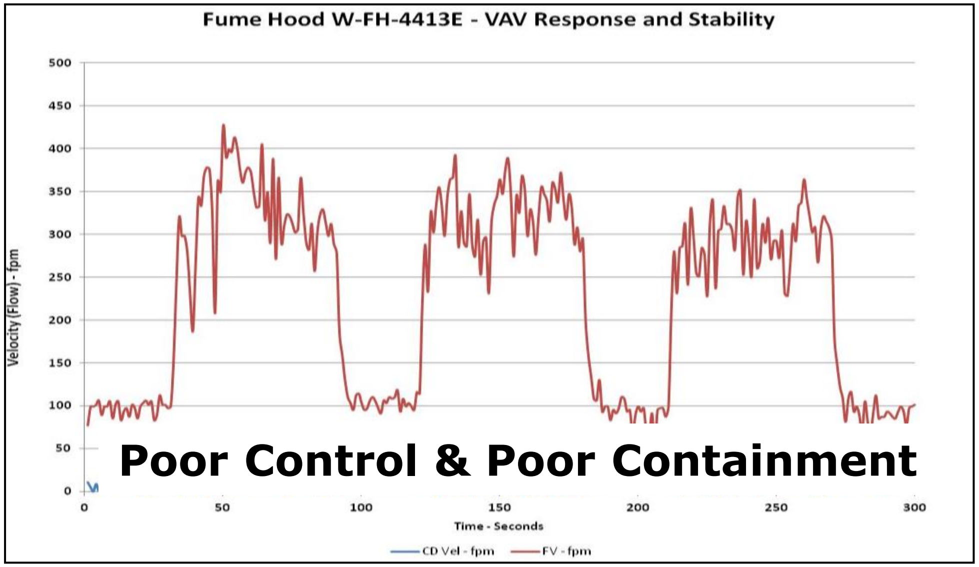




VAV Flow Response and Stability







Minimum Flow for VAV Fume Hoods

- Containment
- Dilution
- Removal

1990s - EPA – 50 cfm / ft of Hood Width

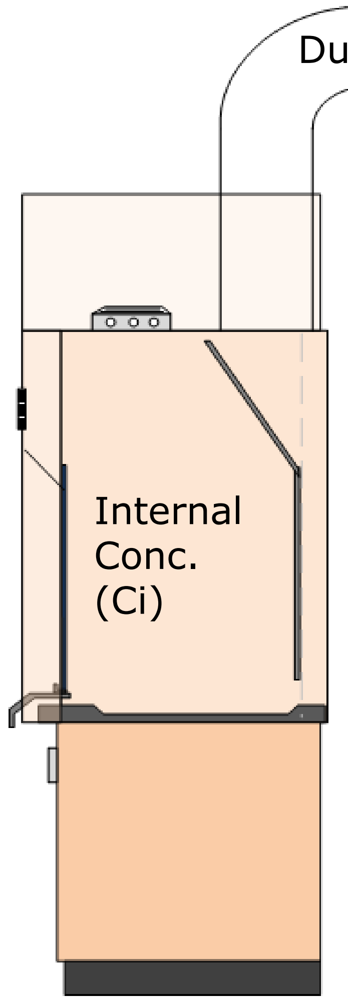
2004 - NFPA 45 – Work Surface

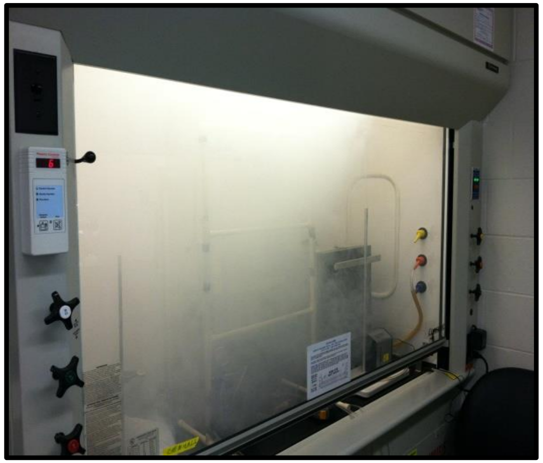
- 25 cfm / sq. ft. of ws
- 2010 - Defers to ANSI Z9.5

2012 - ANSI Z9.5 (must be appropriate)

- Internal ACH (150 ACH to 375 ACH)
- 150 ACH ~ 10 cfm / sq. ft. ws
- 375 ACH ~ 25 cfm / sq. ft. ws

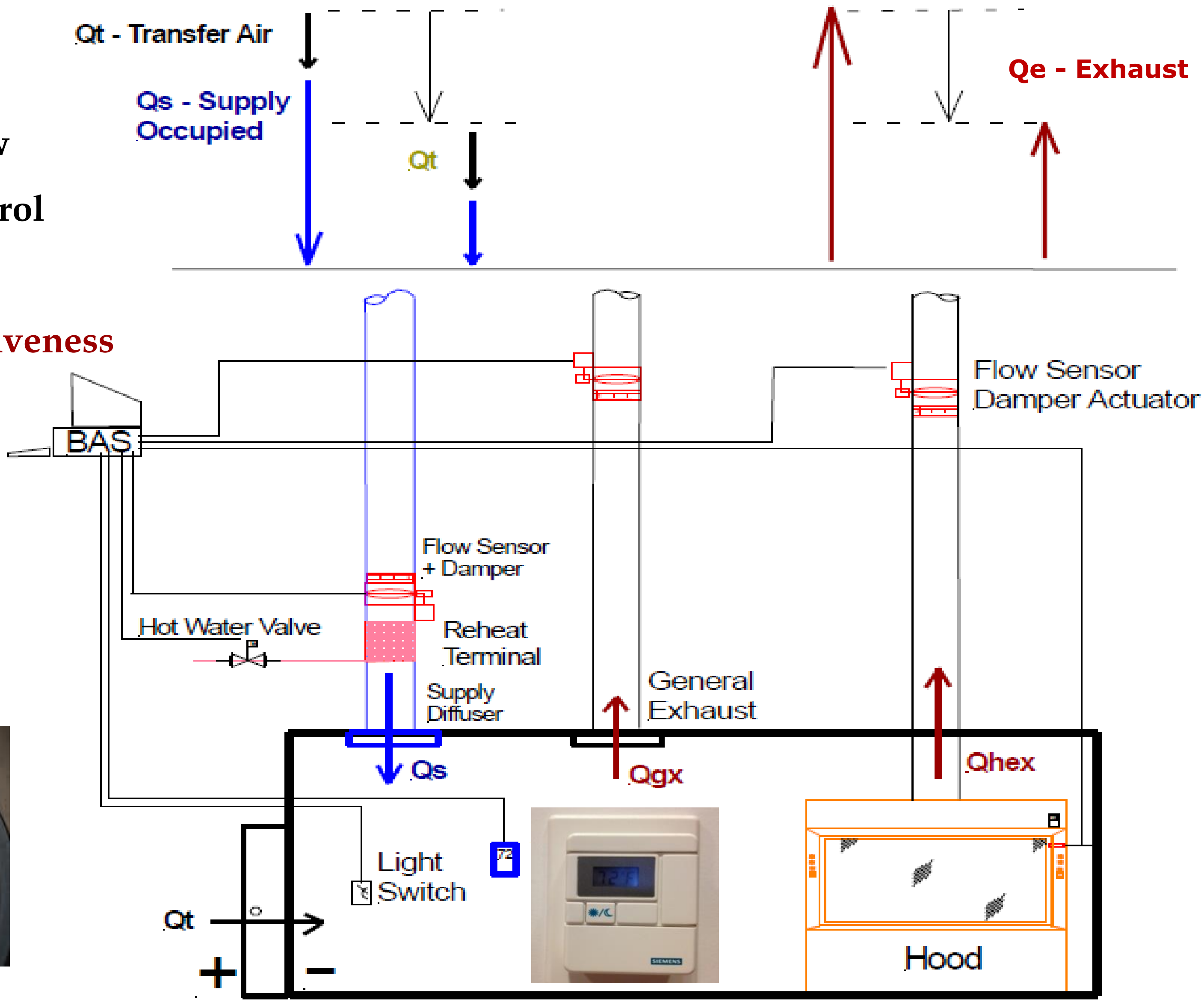
Caution: ECT finds 150 ACH too low





Laboratory Airflow Specifications

- **Operating Modes**
- **Min and Max Flow**
- **Temperature Control**
- **Dilution – ACH**
- **Air Change Effectiveness**
- **Room Pressure**
- **Transfer Volume**



$Qt = Qe - Qs$

$Qt = Constant$

Room Pressure

Derivation & Specification of Airflow Rates

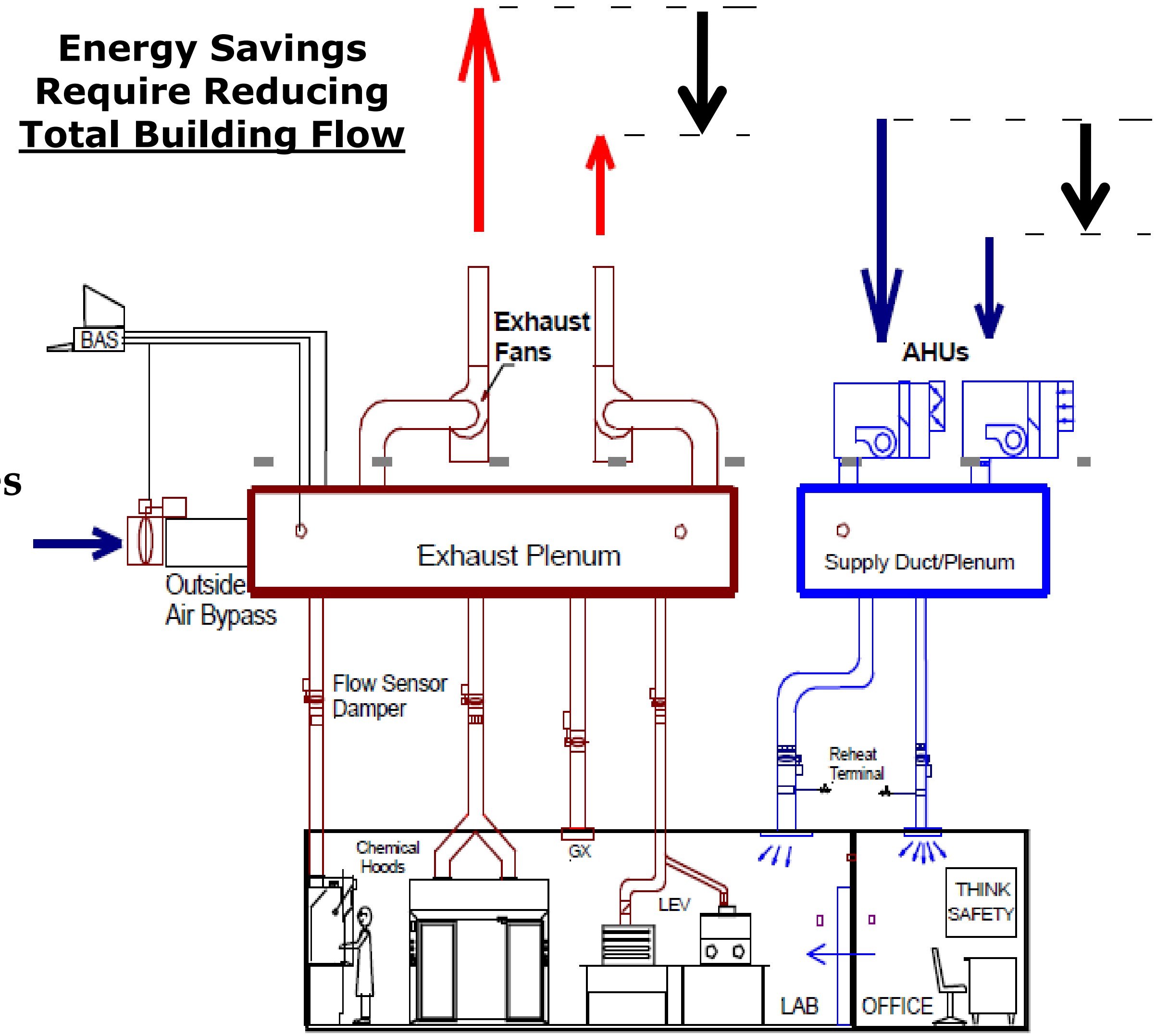
Air Change Rate (ACH)?

- **Evaluate hazardous emissions**
- **Ensure appropriate laboratory hoods**
- **Capture hazards at the source**
- **Ensure air change effectiveness**
- **Base airflow rates on:**
  - Hood Exhaust Requirements
  - IAQ Requirements
  - Comfort (Temperature)
  - Pressurization/Isolation

Ventilation System Operating Specifications

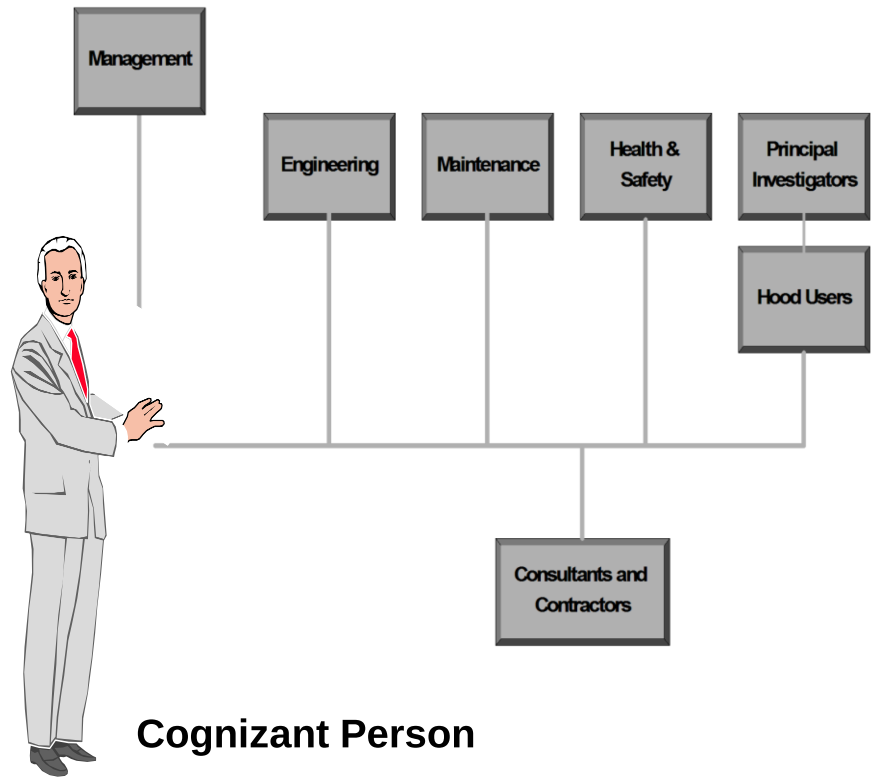
- Max and Min Flows
- Exhaust Manifolds
  - Fan Redundancy
  - Emergency Power
- System Static Pressure
- VAV Control Capabilities
  - Diversity
  - Sensitivity
- Duct Transport Velocity
- Exhaust Stack Discharge

Energy Savings Require Reducing <u>Total Building Flow</u>



Laboratory Ventilation Management Program (LVMP)

- **Required By ANSI Z9.5**
- **System Management and Sustainability Plan**
  - Organization and Responsibilities
  - Effective Collaboration/Integration
  - SOP's for Testing and Maintenance
  - Metrics and Monitoring
  - BAS Utilization
- **Management of Change**
- **Personnel Training**



Training of Personnel
Ensure Proper Work Practices

- Lab Personnel
- Facility Maintenance
- Building Operators

EH&S Primary Issues & Concerns

- **Occupational Exposure**
- **Risk & Liability**
- **Laboratory Hood Selection & Design**
- **Laboratory & Ventilation System Design**
- **Operation & Performance**
  - Commissioning Prior to Use
  - Routine Test and Maintenance
- **Management of Change**
- **Training Personnel**

END

QUESTIONS?

Thomas C. Smith

Exposure Control Technologies, Inc.

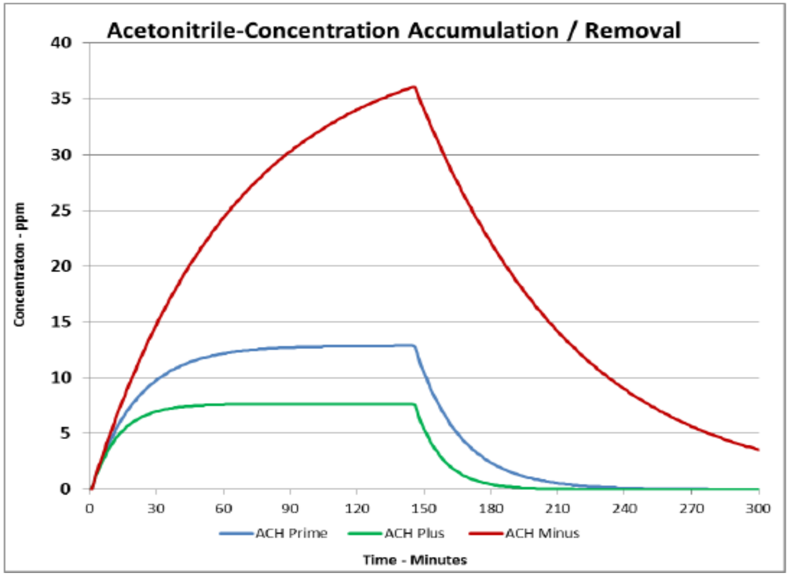
919-319-4290

tcsmith@labhoodpro.com

Appendix

Emissions in Labs Requiring Dilution

- **Escape from Lab Hoods**
- **Improper Bench Top Procedures**
- **Unventilated Equipment**
- **Fugitive Emissions**
  - Chemical Bottles & Containers
  - Gas Cylinders
- **Accidental Spills**



Typical Generation Rates

<0.1 lpm to 10 lpm

Catastrophic Failure of a Gas Cylinder

1400 lpm

Typical ACH Guidelines

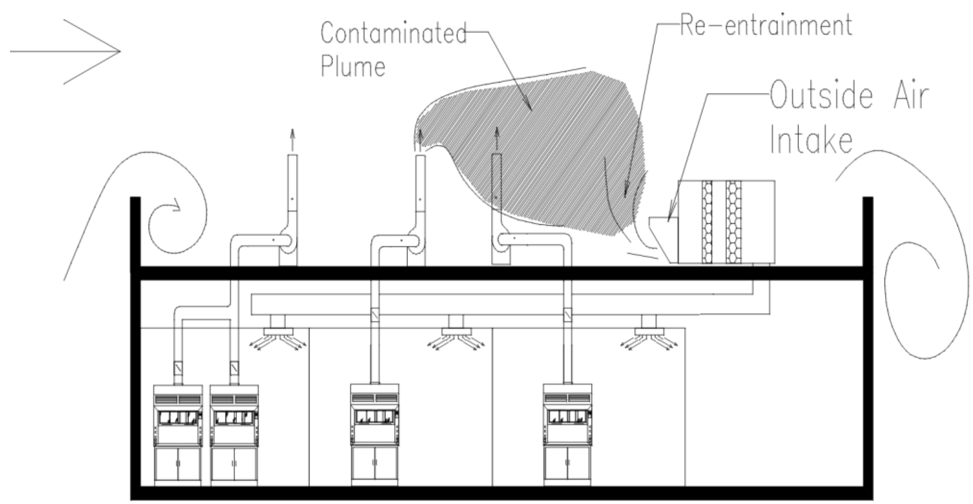
Agency	Ventilation Rate
OSHA 29 CFR Part 1910.1450	4-12 ACH
ASHRAE Lab Guides	4-12 ACH
UBC – 1997	1 cfm/ft2
IBC – 2003	1 cfm /ft2
IMC – 2003	1 cfm/ft2
U.S. EPA	4 ACH Unoccupied Lab - 8 ACH Occupied Lab
AIA	4-12 ACH
NFPA-45-2004	4 ACH Unoccupied Lab - 8 ACH Occupied Lab
NRC Prudent Practices	4-12 ACH
ACGIH 24th Edition, 2001	Ventilation depends on the generation rate and toxicity of the contaminant and not the size of the room.
ANSI/AIHA Z9.5	Prescriptive ACH is not appropriate. Rate shall be established by the owner. Dilution is seldom effective – source capture preferred

Contaminant Concentration, ACH & Level of Concern

Material	LOC PEL, TLV (PPM)	Required ACH for Dilution to LOC: Gen. Rate = 0.1 lpm	Gen. Rate = 0.5 lpm	Gen. Rate = 1.0 lpm	Gen. Rate = 4 lpm	Gen. Rate = 8 lpm	Gen. Rate = 20 lpm
Acetone	750	0.1	0.7	1.3	5.2	10	26
Ethyl acetate	400	0.2	1.2	2.5	10	20	49
Methyl ethylketone	200	0.5	2.5	4.9	20	39	98
Toluene	100	1.0	4.9	10	39	79	196
Ammonia (STEL)	35	3	14	28	112	224	561
Acetic acid	10	10	49	98	393	785	1963
Phenol	5	20	98	196	785	1570	3926
Formaldehyde	3	33	164	327	1309	2617	6544
Carbon tetrachloride	2	49	245	491	1963	3926	9815
Chlorine	0.5	196	982	1963	7852	15705	39262
Phosgene	0.1	982	4908	9815	39262	78524	196309
Toluene diisocyanate	0.005	19,631	98,155	196,309	785,238	1,570,475	3,926,188

Stack Discharge and Plume Dispersion

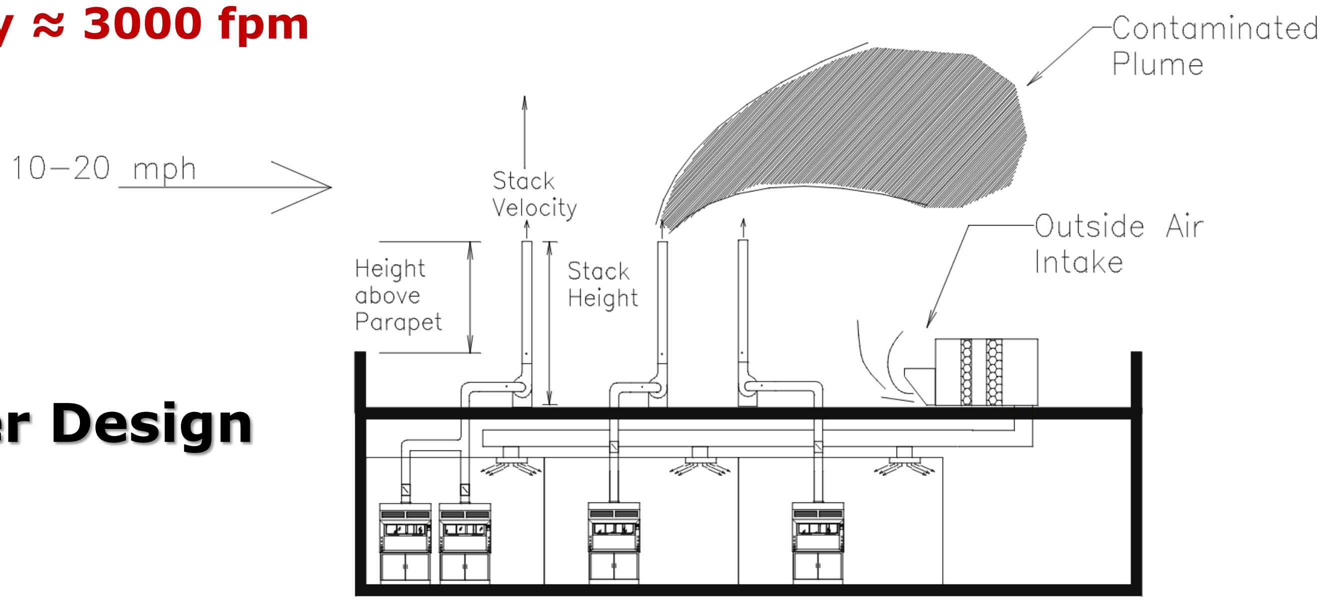
Re-entrainment



Stack Height ≥ 10 ft.

Stack Velocity ≈ 3000 fpm

Better Design

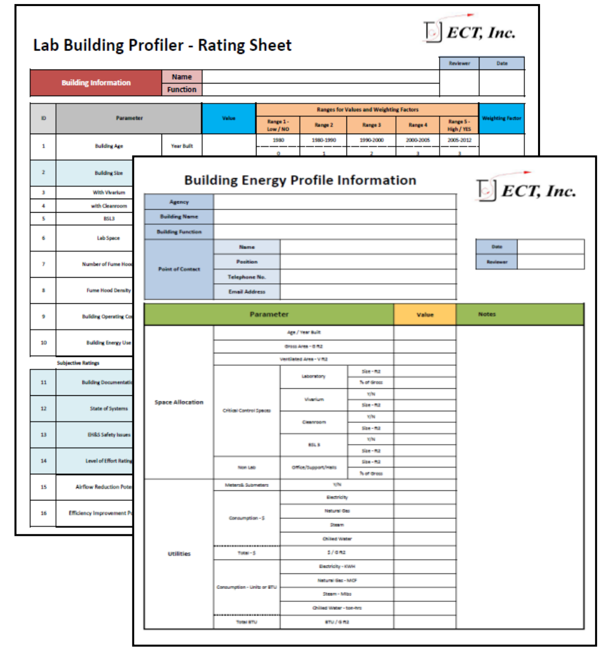


Lab Safety and Energy Programs

- **Rapid Energy & Lab Safety Assessment (RELSA)**
  - Facility Readiness
  - Strategic Project Planning
  - Building Profiler
- **Lab Ventilation Optimization Project (LVOP™)**
  - Phase 1 – Detailed Safety & Energy Assessment
  - Phase 2 – Optimization and Energy Reduction Project
- **Lab Ventilation Management Program (LVMP)**
  - Operations Management & Sustainability Plan
  - Protect Return on Investment

Rapid Energy & Lab Safety Assessment (RELSA)

- **Facility and Building Qualifying Tool**
  - Select & Prioritize Best Projects First
- **Key Metrics & Weighting Factors**
  - Size & Space Allocation
  - Energy Use & Operating Costs
  - State of the Systems
  - Energy Reduction Potential
- **Lab Energy Profile Report**
  - Building Classification
  - Assessment of Energy Reduction
  - Estimated Project Costs & Payback



Attribute	Lab Building Profile Category				
• **State of the Systems** • **Energy Reduction Potential** • **Project LOE & Complexity** • **Return on Investment (Payback)**	Class A	Class B	Class C	Class D	Class E

RELSA Profile & Project Prioritization

Profile	Building	Total Annual Utility Cost	% Utility Reduction	Annual Savings $	Investment to Realize Savings $	Payback Period
A	Bldg D	$1,950,000	24	$468,000	$1,404,000	3
B+	Bldg A	$800,000	16	$128,000	$512,000	4
B	Bldg F	$600,000	21	$126,000	$567,000	5
B	Bldg E	$980,000	16	$156,800	$784,000	5
B-	Bldg B	$450,000	9	$40,500	$202,500	5
C-	Bldg C	$300,000	7	$21,000	$189,000	9
	Totals	$5,080,000	19	$940,300	$3,658,500	4

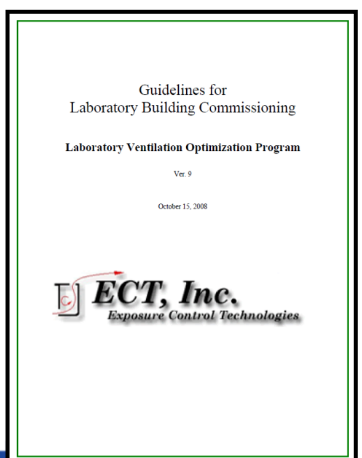
Lab Ventilation Optimization Project (LVOP™)

- **Phase 1 – Safety and Energy Assessment**
  - Evaluate Demand for Ventilation
  - Establish Safety and Health Specifications
  - Analyze Utilities & Operating Costs
  - Propose Energy Conservation Measures (ECMs)

- **Phase 2 A&B – Energy Reduction Project**

  2 A - Scope of Work & Engineering

  2 B – Project to Implement Selected ECMs
  - Verify Performance and Energy Savings



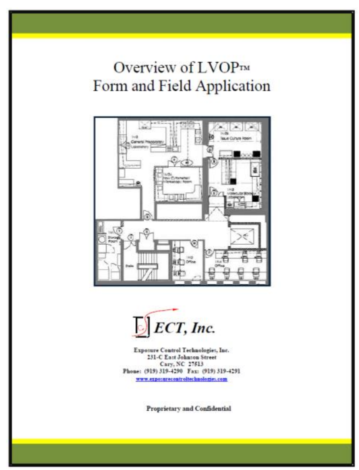
Guidelines for
Laboratory Building Commissioning

Laboratory Ventilation Optimization Program

Ver. 9

October 15, 2008

ECT, Inc.
Exposure Control Technologies



Overview of LVOP™
Form and Field Application

ECT, Inc.

Exposure Control Technologies, Inc.
231-C East Johnson Street
Cary, NC 27513
Phone: (919) 319-4290 Fax: (919) 319-4291
www.exposurecontroltechnologies.com

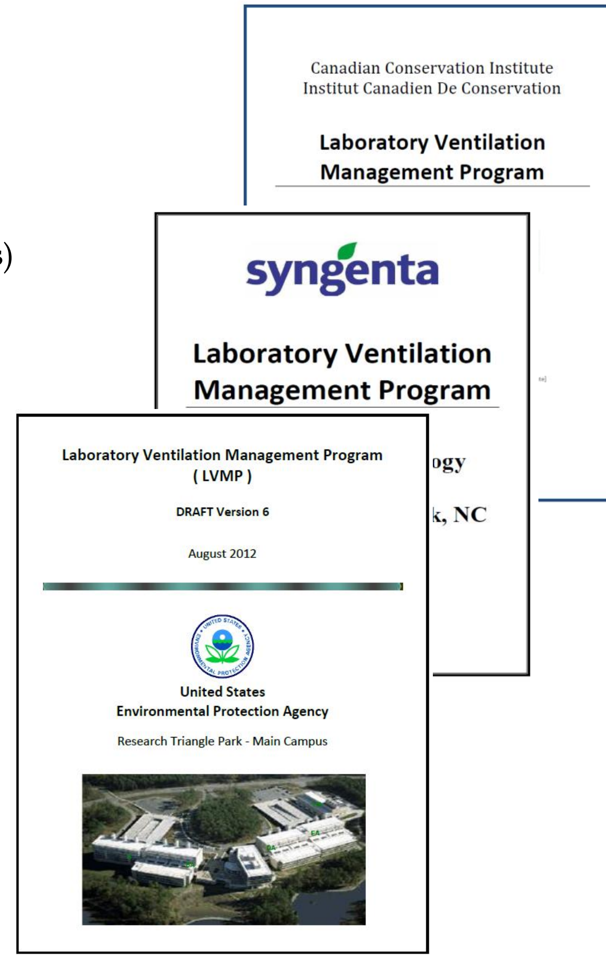
Proprietary and Confidential

RELSA Profile and LVOP Tasks

	Attribute	Building Profile				
Profile	State of the Systems Building Operating Cost Energy Reduction Potential Energy Project Complexity (LOE)	A	B	C	D	E
	ROI - Project Payback	< 5	5-10	10-15	>15	N/A
Project Phase & Task						
Planning	RELSA	X	X	X	X	X
LVOP Phase 1	LVOP Phase 1 Investigation	X	X	X	X	
LVOP Phase 2	Minor Engineering	X	X			
	Major Engineering			X	X	
	Component Repair Maintenance	X	X	X	X	
	Retrofits & Component Upgrades		X	X	X	
	Component Replacement			X	X	
	New Equipment Installation				X	
	TAB	X	X	X	X	
	CX	X	X	X	X	
LVOP Phase 3	LVMP	X	X	X	X	X
	Routine T&M Services	X	X	X	X	X

Critical Elements of a LVMP

- **Building Information - Documentation and Specifications**
- **Management and Personnel (Roles and Responsibilities)**
- **Test and Maintenance Tasks**
  - Schedule of Activities
  - Preventive & Repair Maintenance
    - AHUs / Exhaust Fans
    - Control Components (Flow Terminals, Sensors, dP Transducers)
  - System, Environment & Hood Performance Tests
    - System Operating Mode Tests (SOMTs)
    - Lab Environment Tests (LETs)
    - Lab Hood Tests
- **BAS Utilization (Monitoring and Reports)**
  - Real-time Data and Alarms
  - Trend Reports
- **Management of Change (MOC)**
- **Record Keeping**
- **Training Programs**



Specifications for Safe & Energy Efficient Labs

- **Laboratory Hood Operation**
  - Construction, Specs & Performance Criteria
- **Monitors & VAV Controls**
  - Types, Accuracy and Operating Modes
- **Laboratory Design & Operation**
  - ACH & Air Change Effectiveness
  - Diffuser Type and Location
  - Temperature & Humidity Control
- **Ventilation Design & Operation**
  - Duct Velocity & Static Pressure
  - Stack Discharge
  - Recirculation & Energy Recovery
- **Commissioning and Routine Tests**
  - Lab Hood Tests
  - Lab Environment Tests
  - System Operating Mode Tests

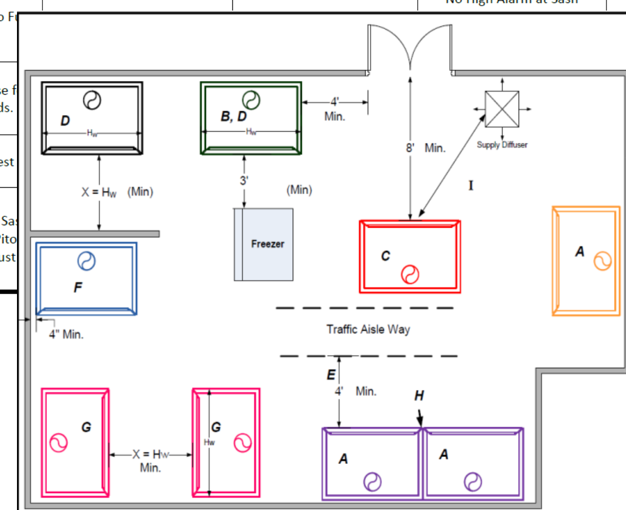
syngenta

Design & Test Requirements for Laboratory Fume Hoods

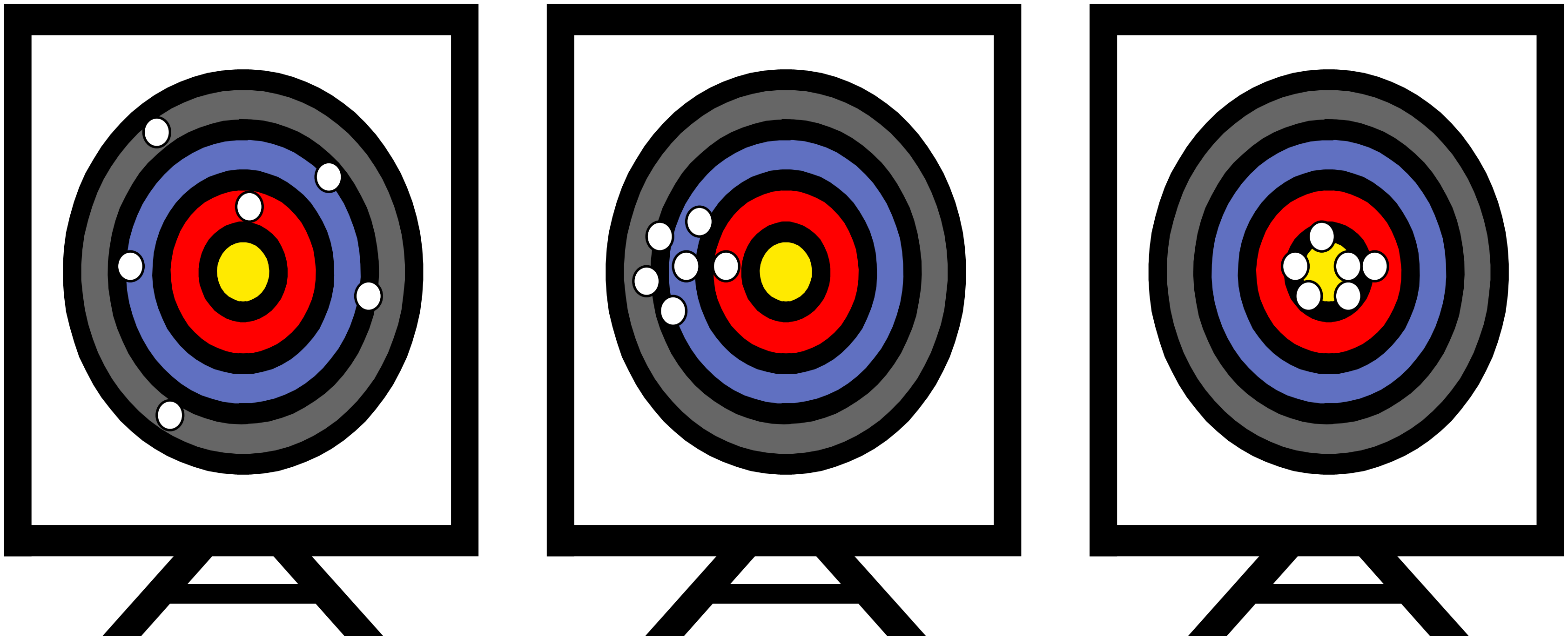
Commissioning – "As Installed" Performance Tests

Routine – "As Used" Performance Tests

Device	Test / Parameter	Industry Recommended Criteria/Specs (Unless otherwise specified in the Design Documents)	Syngenta Recommended Occupied Criteria/Specs	Syngenta Recommended Unoccupied Criteria/Specs
High Performance Fume Hood	High Performance Hoods Face Velocity Design Sash Opening	Vfavg ≥ 60 fpm	Vfavg ≥ 60 fpm	Sash Closed
Retro-Fit Fume Hoods	Face Velocity Maximum Sash Opening	Vfavg ≥ 65 fpm Vfmax ≤ 80 fpm	Vfavg ≥ 65 fpm Vfmax ≤ 80 fpm	Sash Closed
	Face Velocity Design Sash Opening	Vfavg ≥ 65 fpm Vfmax ≤ 80 fpm	Vfavg ≥ 65 fpm Vfmax ≤ 80 fpm	Sash Closed
Hood Flow, Face Velocity or Pressure Monitor	6" opening to F Open			No High Alarm at Sash
VAV Controls	VAV Response f fume hoods.			
	Stability Test			
Fume Hood ACH or Min. Flow	Min. Flow at Sa Closed via Pito Tube Exhaust			



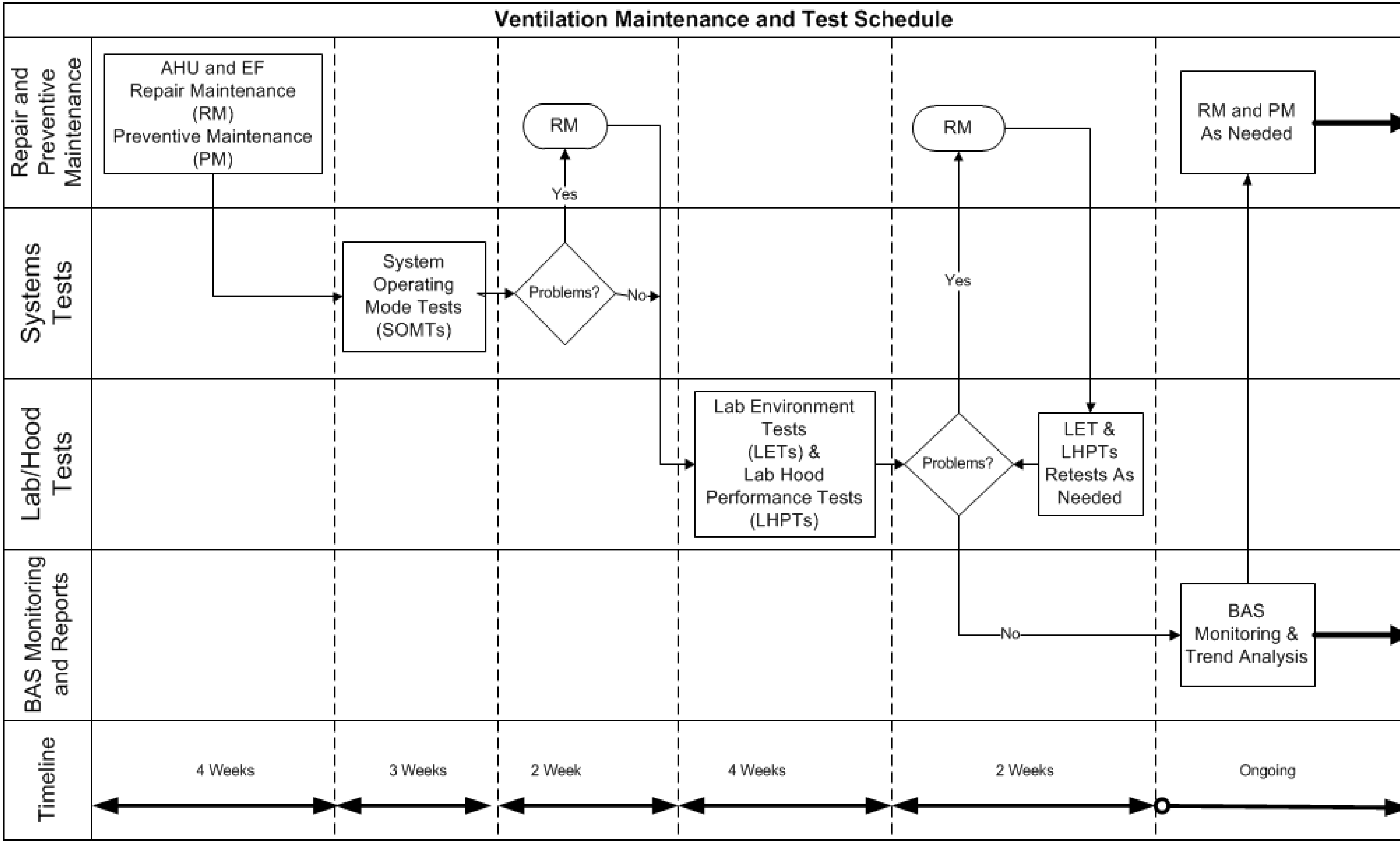
Quality Data - Accuracy and Precision



VAV Controls Can degrade

30-50% within 5 years

Ventilation Maintenance and Test Schedule



Better Buildings U.S. DEPARTMENT OF ENERGY